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Autoridad Del Canal De Panama
Division de Proyectos de Capacidad del Canal

Work Order No.3 Feasibility Design For The Río Indio Water Supply Project

Contract Number CC-3-536

Panama Canal

VOLUME 3: APPENDICES

MWH
In association with
TAMS
AN EARTH TECH COMPANY

April 2003

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capicidad del Canal

THE PANAMA CANAL

ENGINEERING SERVICES

Work Order No. 3
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Feasibility Study

Volume 3 APPENDICES E-G

APRIL 2003

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In association with
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Feasibility Design For
The Río Indio Water Supply Project

Volume	Title
1	Main Report
2	Appendix A – Hydrology, Meteorology and River Hydraulics Appendix B – Geology, Geotechnical and Seismological Studies Appendix C – Operation Simulation Studies Appendix D – Project Facilities Studies
3	**Appendix E – Power and Energy Studies** **Appendix F – Agriculture and Irrigation Potential** **Appendix G – Cost Estimates**

Appendix E
Power and Energy

Part 1
Power Market

FEASIBILITY DESIGN FOR THE RÍO INDIO WATER SUPPLY PROJECT

APPENDIX E
PART 1

POWER MARKET STUDY

Prepared by

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In association with

TAMS
AN EARTH TECH COMPANY

FEASIBILITY DESIGN FOR THE RÍO INDIO WATER SUPPLY PROJECT

APPENDIX E, PART 1 – POWER MARKET STUDY

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

1 INTRODUCTION

The Canal Capacity Projects Office of the Panama Canal Authority plans to construct the Río Indio Project to augment sources of water supply for meeting the growing municipal and industrial water uses of the Canal Zone, and increased lock operation.

The Río Indio Project will consist of construction of a dam to form a reservoir, and a diversion tunnel to convey the water from the Río Indio reservoir to the existing Gatun Lake. Construction of power facilities was considered in the previous studies of the Río Indio Project. These facilities may include a power plant at the downstream toe of the Río Indio dam, and a power plant at the downstream exit of the diversion tunnel. The capacity of each of the power plants will be determined as a part of on-going operation studies. Earlier estimates resulted in each power plant containing two generating units with a total installed capacity of 25 MW.

A power market survey of Panama was conducted to determine the future power needs of the Panama national electric system. The results of this survey will be used in evaluation of the economic attractiveness of the Río Indio hydroelectric power plants.

A draft report, prepared in November, 2000, contained information received from the Electricity Department and taken from the following two reports:

(1) *Revision del Plan de Expansion Indicativo del Sistema de* Generation, ETESA, August 1998
(2) *Plan de Expansion del Sistema de Generacion 1999-2015,* ETESA, 1999

Due to a delay in the Río Indio studies, the Power Market Report was not finalized until September 2002. In the interim, four additional reports were made available:

(3) *Informe Indicativo de Demanda 2001-2010*, ETESA, November 2000
(4) *Informe de Indisponibilidad Unidades de Generacion, Noviembre 1999-Octubre 2000*, ETESA
(5) *Planiamiento Operativo del Sistema Integrado Nacional,* ETESA, July 2002
(6) *Plan de Expansion de Transmission*, ETESA, 2002

In addition, current information is available from the ETESA web site.

Some of the information from the four sources is conflicting, especially with respect to the generation companies and the installed capacities of the individual units. However to present a better picture of the situation, information was taken from all sources. It is recognized that some of the information presented herein is outdated or even incorrect. This information is considered to be adequately representative to present the power market picture in Panama.

We also are aware of a newer expansion plan report, however, we have not been able to obtain a copy either through the APC or our own contacts.

2 ECONOMIC SETTING

The economy of the Panama has experienced continued growth over recent years. Annual Gross Domestic Product (GDP) has grown at an average annual rate of 6.7 percent during the period of 1989-1994, and the annual rate of growth of GDP was reduced to 3.3 percent for the 5-year period of 1994 through 1999. The GDP reached U. S. $ 9,130.3 million in 1999 at the 1995 price level.

Total population of Panama has slightly increased from 2.35 million in 1989 to 2.58 million in 1994 and 2.81 million in 1999. Average annual rates of growth in total population for the periods of 1989-1994 and 1994-1999 were at 1.9 percent and 1.7 percent, respectively.

The GDP values per capita, at the 1995 price level, were U.S. $ 2,383 for year 1989, $ 3,009 for year 1994, and $ 3,249 for year 1999. Average annual growth rate of the GDP per capita was at 4.8 percent for the period of 1989 through 1994, and the rate was reduced to 1.5 percent during the subsequent period of 1994 through 1999.

The annual GDP values, per capita GDP values, and annual growth rates of these values of Panama for the period of 1980 through 1999 are shown in Table 1.

The main changes in the structure of the Panama economy over the recent years occurred in the shares of Agriculture, Industry, Commerce, and Governmental Service sectors in the total GDP. The Agriculture Sector includes farming and fishery, and the Industry Sector consists of mining, manufacturing, electricity generation and supply, water supply, gas and construction. The Commerce Sector includes imports and exports, hotels and restaurants, transportation and communications, financial and banking services, and housing and rentals.

The shares of the Agriculture sector in the GDP of Panama shrank from 10.2% in 1989 to 8.1% in 1994 and 7.6% in 1999, and shares of the Governmental Services decreased from 15.2% in 1989 to 10.4% in 1994 and 10.1% in 1999. The shares of Industry and Commerce sectors increased. The shares of the Industry sector increased from 15.5% in 1989 to 18.5% in 1994, and remained unchanged at 18.5% in 1999, and shares of the Commerce sector increased from 50.2% in 1989 to 53.4% in 1994 and 53.9% in 1999.

Table 1 GDP and Per Capita GDP Values and Annual Growth Rates of Panama for Period of 1980-1999

(Values are in U.S. Dollars at the 1995 Price Level)

Year	GDP Values		Per Capita GDP Values	
	GDP in $ million	Growth Rate in Percent	GDP/Capita in Dollars	Growth Rate in Percent
1980	5,282.9	-	2,709	-
1981	5,769.2	9.2	2,897	6.9
1982	6,077.8	5.3	2,989	3.2
1983	5,804.8	-4.5	2,794	-6.5
1984	5,962.1	2.7	2,810	0.6
1985	6,256.8	4.9	2,887	2.7
1986	6,480.0	3.6	2,930	1.5
1987	6,362.8	-1.8	2,819	-3.8
1988	5,511.4	-13.4	2,393	-15.1
1989	5,597.5	1.6	2,383	-0.4
1990	6,050.9	8.1	2,524	5.9
1991	6,620.8	9.4	2,711	7.4
1992	7,163.8	8.2	2,879	6.2
1993	7,554.7	5.5	2,980	3.5
1994	7,770.0	2.9	3,009	1.0
1995	7,906.1	1.8	3,005	-0.1
1996	8,128.3	2.8	3,040	1.1
1997	8,492.2	4.5	3,124	3.0
1998	8,843.5	4.1	3,200	2.2
1999	9,130.3	3.2	3,249	1.5

3 THE EXISTING ELECTRIC SYSTEM IN PANAMA

Until 1998, electric energy was produced by the *Instituto de Recursos Hidraulicos y Electrificacion* (IRHE), and some small private industries generate electricity for their own uses. The IRHE was also responsible for the operation and maintenance of the transmission and distribution systems, and sales to electricity consumers in Panama. NIS). With the restructuring of electricity sector in 1998, the IRHE was abolished and the generation and distribution facilities were privatized. Transmission was assigned to a new government agency, the *Empresa de Transmision Electrica, S.A.* (ETESA), which was also responsible for load forecasts, planning of generation and transmission facilities to meet forecasted electrical needs of Panama, and operation of the National Dispatch Center (CND) of the Panama National Integrated System (PNIS).

3.1 System in 1998

With the abolition of IHREE, 10 generation companies and 3 distribution firms were formed to produce and sale electricity to consumers.

The generation companies of the PNIS as of early year 2000 included:

- EGE-Bayano: *Empresa de Generacion Electrica Bayano, S.A.*
- EGE-Fortuna: *Empresa de Generacion Electrica Fortuna, S.A.*
- EGE-Bahia Las Minas: *Empresa de Generacion Electrica Bahia Las Minas, S.A.*
- EGE-Chiriqui: *Empresa de Generacion Electrica Chiriqui, S.A.*
- COPESA: *Corporacion Panamena de Energia, S.A.*
- PanAm: IGC/ERI Pan Am Thermal Generating Ltd.
- Pana Energy
- Hidro Panama
- Petroelectrica de Panama, S.A.
- Petroterminales de Panama, S.A.

The three distribution companies were:

- EDE-Metro Oeste (EDEMET): *Empresa de Distribucion Electrica Metro Oeste, S.A.*
- EDE-Chiriqui (EDECHI): *Empresa de Distribucion Electrica Chiriqui, S.A.*

- EDE-Elektra Noreste (ELEKTRA): *Empresa de Distribucion Electrica Elektra Noreste, S.A.*

The newly formed distribution companies forecast electricity needs of their individual distribution systems, and submit these forecasts to ETESA.

It is the responsibility of ETESA to develop generation and transmission system expansion plans for the PNIS on the basis of the electricity forecasts by the distribution companies, and to operate and maintain the transmission system and dispatch center.

A map of Panama with locations of existing major generating and transmission facilities are shown in Exhibit 1.

3.1.1 The Generation System

As reported in ETESA's *Plan de Expansion del Sistema de Generacion, 1999* (1), the installed capacity of the generation companies was 998.8 MW. This capacity, based on anticipated additions and plant retirements, is now (November 2000) estimated to be 1,184.3 MW as shown in Table 2.

Table 2 Generation Company Power Facilities

Company and Power Plant	Number of Units and Unit Capacity, MW	Type of Power Plant	Type of Fuel	Installed Capacity, MW
EGE- Las Minas				
BLM #1- #4	1x20, 3x40	Steam	Bunker C	140.0
Catepillar	7	I.C.	Diesel	30.0
Monte Esperanze	1x 20	G.T.	Diesel	20.0
San Francisco	3	Steam	Bunker C	10.0
TG-CCBLM	4	I.C	Bunker C	34.8
Ciclo-Comb. BLM[1]		GT/Steam	M. Diesel Bunker C	160.0
Subtotal	1			394.8
EGE-Bayano				
Sub Estacion Panama	2x 20	G.T.	Diesel	40.0
Bayano	2x75	H	-	150.0
Subtotal				190.0

Company and Power Plant	Number of Units and Unit Capacity, MW	Type of Power Plant	Type of Fuel	Installed Capacity, MW
EGE-Chiriqui				
La Estrella	2x21	H	-	42.0
Los Valles	2x24	H	-	48.0
Subtotal				90.0
EGE-Fortuna				
Fortuna	3x100	H	-	300.0
Petroelectrica	12	I.C.	Diesel	55.0
Petroterminales	7	I.C.	Diesel	15.0
COPESA	1x42	I.C.	Diesel	42.0
Pan Am	6x16.0	I.C.	Bunker C	96.0
Hidro Panama				
Anton 1	1	H	-	1.5
Total				**1,184.3**
(1) Replaces John Brown 1 and 2 and includes 35 MW of new gas turbine generation and 60 MW of steam generation				

I.C. = Internal Combustion Units, G.T. = Gas Turbines Units, H = Hydroelectric Units.

About 45 percent of the total installed capacity of the generation companies is from hydropower.

Two of the three distribution companies also own and operate a number of hydro and thermal power plants. Of the 49 MW in this category, about 35 MW are connected to the PNIS system and 14 MW are not. A tabulation of these plants are presented in Table 3.

Table 3 Distribution Company Power Facilities

Company and Power Plant	Number of Units and Unit Capacity, MW	Type of Power Plant	Type of Fuel	Installed Capacity MW
Connected to the PNIS				
EDE-Metro Oeste				
La Yeguada	2x3.0, 1x1.0	H	-	7.0
Chitre	1x2.0, 5x2.5	I.C.	Diesel	14.5
Capira	2x0.55,1x1.0,3x2.5	I.C.	Diesel	9.6
Macho Monte	1x0.77	H	-	0.77
Dolega	2x1.12,2x0.4	H	-	3.04
Total connected to the PNIS				**34.9**

Company and Power Plant	Number of Units and Unit Capacity, MW	Type of Power Plant	Type of Fuel	Installed Capacity MW
Not Connected to the PNIS				
EDE-Elektra Noreste				
Taboga	2x0.365, 1x0.545	I.C.	Diesel	1.275
Chepillo	1x0.060, 1x0.075	I.C.	Diesel	0.135
Otoque	1x0.150, 1x0.125	I.C.	Diesel	0.275
San Miguel	1x0.090,1x0.160	I.C.	Diesel	0.250
Condadora	1x1.200,1x0.650, 1x0.850,1x.545, 1x0.912	I.C.	Diesel	4.157
Garachine	1x0.150,1x0.155,1x0.175	I.C.	Diesel	0.480
Jaque	1x0.160, 1x0.125	I.C.	Diesel	0.285
Yaviza	2x0.160, 1x0.250	I.C.	Diesel	0.570
La Palma	1x0.425,1x0.600,1x0.525	I.C.	Diesel	1.550
Tucuti	2x 0.035	I.C.	Diesel	0.070
Boca de Cupe	2x0.035	I.C.	Diesel	0.070
Sante Fe	1x0.160, 1x0.225, 1x0.250,1x0.600	I.C.	Diesel	1.235
Nargana	1x0.055, 1x0.100	I.C.	Diesel	0.155
Río Azucar	2x0.035	I.C.	Diesel	0.070
Subtotal				10.8
EDE-Metro Oeste				
Bocas del Toro	2x0.545, x1.000, 1x0.600	I.C.	Diesel	2.690
Chiriqui Grande	1x0.272,1x0.250,1x0.400	I.C.	Diesel	0.922
Subtotal				3.4
Total Not Connected to the PNIS				**14.2**

I.C. = Internal Combustion Units

The total energy production amounted to 4,191.6 million kWh in 1998 including energy produced at the plants owned by the distribution companies. Hydroelectric power plants produced 2,140.3 million kWh of energy, about 51.1 % of the system total energy production.

3.1.2 The Panama Canal Authority Power Plants

The Panama Canal Authority (ACP) owns and operates three power plants, the Gatun and Madden Hydroelectric Plants, and Miraflores Thermal Plant. The three plants have a total combined installed capacity of 153 MW. Total number of generating units, unit capacity, and fuel type for each of the three plants are shown in Table 4.

Table 4 Panama Canal Authority Power Plants

Power Plant	Number of Units and Unit Capacity, MW	Type of Power Plant	Type of Fuel	Installed Capacity, MW
Gatun	3x3.0, 3x5.0	H	-	24.0
Madden	3x12.0	H	-	36.0
Miraflores	2x10.0, 1x8.0. 1x22.0, 1x33.0	G.T. Steam	Diesel Bunker C	38.0 55.0
Total				**153.0**

The Gatun hydroelectric plant is located adjacent to the Gatun Spillway on the Atlantic side of the Panama Canal. Water surplus to canal operational requirements is used for power generation. The Madden hydroelectric plant is located at the downstream toe of the Madden Dam. The Madden Dam was constructed to form a reservoir for providing an adequate water supply to the Gatun Lake to maintain the minimum draft essential to passing ships through the Canal. The water released from the Madden reservoir to the Gatun Lake is used to generate power.

Historically, the power generated at the Gatun and Madden power plants was used for canal operations, supplied to U.S. government agencies operating in the Canal area, and sold in the spot market. Currently, generation is used to meet the electricity needs of the canal operation and any surplus can be sold into the Panama national electrical system. The Miraflores plant serves as backup for the hydroelectric plants in times of high water, and supplies electricity in times of low water, if needed.

3.1.3 Transmission Company and System

The *Empresa de Transmision Electrica* (ETESA) has the responsibility for the operation and maintenance of the PNIS transmission system and the National Dispatch Center, and the development of generation and transmission expansion plans for the PNIS.

The existing transmission system consists of 578 km of 230 kV line, 134 km of 115 kV line, and ten 230-kV substations with a total capacity of 885 MVA (6).

For the six-month period of July-December 1998, ETESA's revenues, received from the generation and distribution companies for use of the transmission system, amounted to $17.0 million.

Transmission energy losses of the PNIS for the period of July-December 1998 were estimated at 72,1 GWh, or about 3.4 percent of total energy supply. This corresponds to a loss of $ 4.12 million with a unit cost of energy at $ 0.057/kWh. The transmission energy losses for year 1999 were reported at 150.8 GWh, or about 3.4 percent of the total energy production of 4,455 GWh.

3.2 System in Year 2002

After the restructuring, there were ten generation companies as described in Section 3.1. Currently, there are six companies generating a total of 1,060 MW that are providing the bulk of the electricity to Panama.

Two of the original ten companies, EGE Bayano and EGE Chiriqui were bought by the AES Corporation and merged into AES Panama. As reported in a 1999 plan of expansion (12), two additional generation companies, Petroterminales and Hidro Panama operated 15 MW and 1.5 MW respectively. It is not known whether these units were retired or just not considered as major producers for the 2002 operation plan (5).

In the 1999 expansion plan, it was also reported that the distribution companies operated a series of thermal plants. EDE Metro Oeste operated five plants totaling 35 MW that were connected to the Panama National Integrated System (PNIS) and 3.4 MW that were not connected. EDE Elektra Noreste operated 14 plants with a total capacity of 10.8 MW that were not connected to the grid.

The 2002 Operation Plan indicates that an additional installed capacity of 344 MW will be on line by the end of 2003, consisting of 224 MW of hydro and 120 MW of thermal (although the tabulated expansion plan only shows 206 MW of hydro). Therefore, the major generation companies will have an installed capacity of about 1,404 MW by the end of 2003.

The total installed capacity and distribution between thermal and hydro is presented in Table 5.

Table 5 Generation facilities

(MW)

Company	Hydro Capacity	Thermal Capacity	Total Capacity	Connected to PNIS
Major Generation Companies				
AES Panama	240.0	40.0	280.0	Yes
EGE Fortuna	300.0	0.0	300.0	Yes
EGE Bahia Las Minas	0.0	280.0	280.0	Yes
Petroelectrica de Panama	0.0	60.0	60.0	Yes
COPESA	0.0	44.0	44.0	Yes
PanAm	0.0	96.0	96.0	Yes
Subtotal	540.0	520.0	1,060	
Planned Expansion				
2002	86.0	0.0	86.0	Yes
2003	120.0	120.0	240.0	Yes
Other Generation (may or may not be still available)				
ACP	60.0	93.0	153.0	Yes
Petroterminales	0.0	15.0	15.0	Yes
Hidro Panama	1.5	0.0	1.5	Yes
EDE Metro Oeste	0.0	34.9	34.9	Yes
EDE Metro Oeste	0.0	3.4	3.4	No
EDE Elektra Noreste	0.0	10.8	10.8	No

The major generation companies, including their planned expansions, have a total installed capacity of 1,386 MW.

In 1998, 2000, and 2002, the total net energy production, which is defined as gross generation less station use, amounted to about 4,192 GWh, 4,511 GWh, and 4,686 GWh respectively.

3.2.1 Energy Consumption

Three distribution companies were formed in 1998 to purchase energy from generation companies and to sell energy to consumers. The total energy consumption, number of consumers, and energy consumption by sector in year 1998 for each of three distribution companies are shown in Table 6.

Table 6 Energy Consumption and Customers in 1998

Company	Metro Oeste	Chiriqui	Elecktra Noreste	Total
Energy Consumption in MWh				
Residential	491.84	90.47	422.34	1,004.65
Commercial	809.39	91.03	441.64	1,342.06
Industrial	170.02	45.92	271.70	487.64
Governmental	257.87	37.86	181.52	477.25
Public Lighting	35.04	9.76	19.63	64.43
Own Uses	8.92	2.29	5.59	16.80
Total	1,773.08	277.33	1,342.42	3,392.83
% Total System	52%	8%	40%	100%
Number of Customers				
Total	216,283	68,301	167,445	452,029
% Total System	47.85%	15.11%	37%	100%

In 1999, the energy consumption and number of customers for each of the three distribution companies increased as shown in Table 7. The total number of customers for the three distribution companies increased by 5.3% during the 1998-1999 period, and the total energy consumption increased at the relatively low rate of 3.8 percent during the same period.

Table 7 Comparison of Energy Consumption and Number of Customers of the Three Distribution Companies in 1998 and 1999

Company	Metro Oeste	Chiriqui	Elecktra Noreste	Total
Energy Consumption in MWh				
Year 1998	1,773.08	277.33	1,342.42	3,392.83
% of Total System	52	8	40	100.0
Year 1999	1,784.99	287.64	1,448.74	3,521.37
% of Total System	51	8	41	100
Annual Growth Rate	0.7%	3.7%	7.9%	3.8%
Number of Consumers				
Year 1998	216,283	68,301	167,445	452,029
% of Total System	48	15	37	100
Year 1999	228,866	72,229	174,876	475,971
% of Total System	48	15	37	100
Annual Growth Rate	5.8%	5.8%	4.4%	5.3%

Total distribution system energy losses of the three distribution companies for the period of July-December 1998 were estimated at 379 million kWh, about 18% of purchased energy. These losses are shown by distribution company in Table 8.

Table 8 Distribution System Losses for July-December 1998

Company	Metro Oeste	Chiriqui	Elektra Noreste	Total
Energy Losses, MWh	113,768	9,218	255,978	378,964
Percent of Purchased Energy, %	11	5	27	18

Firm capacity contracts among the generation and distribution companies for year 1999 are shown in Table 9.

Table 9 Firm Capacity Contracts in 1999 in MW

Company	Metro Oeste	Chiriqui	Elektra Noreste	Total
Hydro Generation				
Fortuna	140	24	120	284
Bayano	51	-	31	82
EGE-Chiriqui	19	22	18	59
Total Hydro Generation	210	46	169	425
Thermal Generation				
Bahia Las Minas	156.5	-	98	254.5
IGC/ERI	30	-	-	30
COPESA	-	-	42	42
Total Thermal Generation	186.5	-	140	326.5
Total Hydro/Thermal	**396.5**	**46**	**309**	**751.5**

3.2.2 Electricity Tariff

Each of the three distribution companies has established a tariff structure including capacity and energy charges for various types of energy consumers. The tariff structure also includes clauses dealing with escalation of the capacity and energy charges on the basis of consumer price indices. The EDE-Metro Oeste and EDE-Chiriqui update their tariff structures every six months, and the existing EDE-Elektra Noreste tariff structure will be valid until June 2003.

Each of the three distribution companies has individual contracts for capacity and energy purchases/sales with the generation companies. The duration of these contracts varies from two to five years.

The average unit energy sale price for the three distribution companies was $0.111/kWh in 1998 and $0.103/kWh in 1999. The average unit energy sale price for each consumer sector in 1998 is given in Table 10.

Table 10 Average Unit Energy Sales Price by Sector in 1998

($/kWh)

Sector	Residential	Commercial	Industrial	Government	System
Sale Prices	0.119	0.116	0,097	0.111	0.111

The unit energy sale prices in Panama have decreased slightly over the last decade. From 1990 through 1999, the price has decreased at a rate of 1.4% p.a.

4 LOAD AND ENERGY DEMANDS OF THE PANAMA ELECTRIC SYSTEM

Energy demand, peak load and the annual growth rates for the PNIS over the last 10 years are shown in Table 11. The average annual growth rate of the energy demand was at 5.5% for the period and the average annual growth rate for the peak load was 5.5%. The annual system load factor averaged about 67.4 percent over the period.

Table 11 Energy Demand, Peak Load, and Load Factor in the PNIS System

	Energy Demand, GWh	Annual Growth Rate, %	Peak Load, MW	Annual Growth Rate, %	Load Factor, %
1990	2,746.1	-	464.4	-	67.5
1991	2,896.6	5.48	488.5	5.19	67.7
1992	3,011.6	3.97	518.0	6.04	66.2
1993	3,199.1	6.23	541.2	4.48	67.5
1994	3,400.0	6.28	591.5	9.29	65.6
1995	3,619.4	6.45	619.2	4.68	66.7
1996	3,795.8	4.87	639.9	3.34	67.5
1997	4,254.4	12.08	706.6	10.42	68.7
1998	4,295.8	0.97	726.4	2.80	67.5
1999	4,456.8	4.76	754.5	3.87	67.4
2002[1]	4,998.5	3.90	857	4.33	67

[1] ETESA Web site

The total energy demands of the Panama Canal Authority for the period of 1992 through 1999 are shown in Table 12. The total energy demands include energy sales to the PNIS. The energy demand was decreased from 643.6 million kWh in year 1992 to 548.0 million kWh in 1998, and 450.0 million kWh in 1999. Fluctuations in energy demand for the period of 1992 through 1998 were partially dependent on the amount of energy sales to the PNIS. The decrease in energy demand for 1999 was due to the planned transfer of Panama Canal operation from U.S. to Panama. The peak load demand was reduced from 86 MW in 1992 to about 68 MW in year 1999.

Table 12 Historical Peak Load and Energy Demands of the ACP, 1992-1999

	1992	1993	1994	1995	1996	1997	1998	1999
Energy Demand GWh	643	624	599	635	570	522	548	450
Annual Rate of Change, %	-	-3.04	-4.00	6.01	-10.2	-8.43	9.16	-17.88
Peak Load, MW	86	86	87	86	79	83	71	68
Annual Rate of Change, %	-	0.0	1.16	-1.16	-8.14	5.06	-14.5	-4.23

4.1 Load Demand Characteristics

There are minor variations among monthly peak loads and energy demands of the PNIS as monthly temperatures and rainfall in Panama remain relatively constant throughout the year. The monthly peak loads for 1999, expressed in term of percent of the annual peak load, are shown in Table 13. The monthly energy demands of the PNIS for year 1999 in term of percentage of total annual energy demand are also shown in Table 13.

Table 13 Monthly Peak Loads and Energy Demands of the PNIS in 1999 and 2000

	Peak Load in Percent of Annual Peak Load		**Energy Demands in Percent of Total Demand**	
	1999	2000	1999	2000
January	93.5	89.8	8.0	7.9
February	93.6	90.5	7.4	7.7
March	97.2	94.8	8.8	8.3
April	99.7	95.9	8.7	8.2
May	98.6	96.0	8.6	8.7
June	98.9	94.8	8.2	8.3
July	96.4	98.1	8.2	8.5
August	98.9	98.9	8.4	8.6
September	97.9	95.1	8.2	8.2
October	97.8	96.6	8.6	8.5
November	96.4	95.4	8.3	8.1
December	100.0	100.0	8.8	8.9
Total	-		**100.0**	**100.0**

Daily peak loads of the PNIS occur during the period of 11 A.M. through 3 P.M. on weekdays and Saturdays, and at 7 P.M. or 8 P.M. on Sundays. Hourly loads of typical weekdays and Sundays of the PNIS for the months of September 1999 and March 2000, expressed in terms of percent of the daily peaks, are given in Table 14.

Table 14 Hourly Loads of Typical Weekdays and Sundays

Date	Thurs. 9/16/99		Sun. 9/19/99		Mon. 3/20/00		Sun. 3/19/00	
Hour	Load, MW	Percent of Peak. %	Load, MW	Percent of Peak, %	Load, MW	Percent of Peak, %	Load, MW	Percent of Peak, %
1	413.4	57.9	413.4	77.7	408.2	55.5	435.4	79.7
2	396.8	55.6	389.7	73.2	383.9	52.2	407.4	74.6
3	388.2	54.3	376.6	70.8	380.9	51.8	390.4	71.5
4	382.0	53.5	368.4	69.2	373.1	50.7	380.2	69.6
5	385.0	53.9	354.6	66.6	378.4	51.4	376.9	69.0
6	415.6	58.2	353.7	66.5	412.7	56.1	372.9	68.3
7	435.3	60.9	340.5	64.0	431.8	58.7	358.6	65.7
8	519.9	72.8	357.2	67.1	505.3	68.7	352.2	64.5
9	627.5	87.8	378.7	71.2	628.8	85.4	365.1	66.9
10	676.3	94.7	403.5	75.8	693.6	94.2	398.6	73.0
11	702.0	98.3	420.7	79.1	723.7	98.3	425.7	78.0
12	710.8	99.5	433.3	81.4	729.7	99.1	428.4	78.4
13	699.5	97.9	432.2	81.2	714.8	97.1	440.0	80.6
14	714.3	100.0	433.5	81.5	731.5	99.4	444.0	81.3
15	713.3	99.9	437.4	82.2	736.0	100.0	445.9	81.7
16	704.3	98.6	436.1	82.0	718.4	97.6	440.2	80.6
17	669.3	93.7	434.1	81.6	673.8	91.5	446.3	81.7
18	612.7	85.8	440.3	82.7	599.8	81.5	440.4	80.6
19	640.7	89.7	493.5	92.7	607.9	82.6	493.9	90.4
20	630.7	88.3	531.9	100.0	638.3	86.7	546.1	100.0
21	607.1	85.0	532.1	100.0	622.2	84.5	538.8	98.7
22	574.9	80.5	505.1	94.9	570.7	77.5	522.3	95.6
23	519.2	72.7	474.1	89.1	502.4	68.3	479.8	87.9
24	467.5	65.4	429.7	80.8	447.5	60.8	435.7	79.8

5 FORECAST OF POWER DEMAND OF THE PANAMA ELECTRIC SYSTEM

Three demand forecasts are available for each of two economic assumptions, moderate growth and high growth. One forecast was developed in 1998 (reference 1), one in 1999 (reference 2) and the third in November 2000 (reference 3). The earlier estimates were developed using a multiple regression analysis to define the relationship between energy consumption and economic parameters for each consumer sector including residential, commercial, industrial, government, and public lighting. A regression equation was defined for each sector. The economic parameters included population, GDP per capita, unit energy sale price for each sector, and energy efficiency. The energy efficiency is the unit energy consumption rate for producing the GDP of the industry sector, and computed by dividing the GDP by total energy consumption of the sector. The peak load demands were estimated on the basis of the forecasted energy demand and a system load factor at 67.9 %.

The more recent demand estimate was developed using a simplified relation of total energy sales as a function of gross national product. The coefficient of determination for the two samples (total energy and GNP) was highest using a polynomial function. The simplified approach was taken due to the difficulty in obtaining accurate economic information.

The estimated energy losses of the transmission and distribution systems, in terms of percentage of the total energy consumption, for the two scenarios was estimated to decrease from about 22% in 1997 to about 14% in 2015. The most recent estimated total energy demands of the PNIS developed in 2000 for the medium and high growth scenarios are shown in Table 15.

Table 15 Demand Forecast Developed in 2000 for the PNIS

Year	Medium Growth Scenario		High Growth Scenario	
	Capacity MW	Energy GWh	Capacity MW	Energy GWh
2000 (Actual)	790	4,732		4,732
2002 (Actual)	857	4998		
2005	1,107	5,304	1,177	5,655
2010	1,608	7,616	1,832	8,691

For comparison, the energy production estimates for the medium growth scenario are shown for all three estimated in Table 16.

Table 16 Energy Forecast for Three Recent Estimates

	Medium Growth Scenario – GWh		
Year	1998 Estimate	1999 Estimate	2000 Estimate
2001	4,981	4,907	4,028
2005	6,280	6,431	5,304
2010	8,154	8,435	7,616

Average annual growth rates of the most recent forecasted energy demands of the PNIS for the period of 2001-2010 were 7.3 % for the medium scenario forecast, and 8.8 % for the high scenario. These compare with the historical average annual growth rate of the energy demand at 5.5 % for the period of 1990-1999 and 5.6% and 7.0% for the corresponding period and scenario of the 1998 estimate. The comparison indicates a reduction in the forecast of about 18% in the early years and about 10% in 2010.

The average annual load factor of the PNIS was at 67.2 % for the period of 1990-1999. In recent years, the system load factor has increased from 65.6 % in 1994 to 68.5 % in 1997, and decreased to 67.4% in 1999. The PNIS has forecasted that the annual system factor will be in the low 50th percentile through year 2010.

6 INDIO'S ROLE IN PNIS EXPANSION PLANS

The earliest commissioning date of the Río Indio power plants will probably be after 2010 especially if implementation is contingent upon the installation of a third set of locks. The peak loads in 2010 for the medium forecast will be about 1,230 MW or about equal to the current installed capacity. The ACP demand, which according to the ACP Electricity Department is not included, is another 30 MW.

The generation expansion plan of the PNIS for the period of 1999-2015 was developed and recommended by the EDESA in a 1999 study. Contribution from the ACP facilities was not included. The recommended generation expansion plan with private hydro development is shown in Table 17.

Table 17 Generation Expansion Plan 2000-2015

Operation Date	Type	Name of Plant	Capacity (MW)
1999 September	Hydro	Anton 1	1.5
November	Thermal	Combined Cycle	160
December	Thermal	Gas Turbine	96
2000	-	-	-
2001	-	-	-
2002 October	Hydro	Guasquitas	84
2003 April	Hydro	Canjilones	34.8
2004	Thermal	Gas turbine	50
2005	Thermal	Combined Cycle	100
2006	Hydro	Gualaca	27
2007	Hydro	Los Aniles	34
	Hydro	Chiriqui	56
2008	Hydro	Baru	150
2009	Thermal	Gas Turbine	50
2010	Thermal	Combined Cycle	150
2011	Thermal	Combined Cycle	100
2012	Thermal	Gas Turbine	50
	Hydro	Changuinola 5	120
2013	Thermal	Combined Cycle	250
2014	Thermal	Combined Cycle	100
2015	Thermal	Combined Cycle	100

In a personal communication with staff of the Electricity Department, it was indicated that the expansion plan is out of date and that they did not expect the new plants to come on line as indicated. However, the important part of the expansion plan is that hydro is expected to be a very important component of future development - the 1999 expansion plan suggests that new capacity will include about 386 MW of hydro capacity during the period of 2002 – 2008. The installed capacities, average annual energy production, and estimated construction costs of these hydroelectric projects and the Indio Project are shown in Table 18. Note that the Indio estimate of costs is taken from the USACE Reconnaissance Report and has to be confirmed as a part of the feasibility report.

Table 18 Pertinent Data of the Indio and Candidate Expansion Plan Hydro Project for the Period 2002 through 2008

Project	Type of Plant	Installed Capacity, MW	Average Annual Energy, GWh	Estimated Construction Cost, $/kW
Indio	Run of River	30	54	1435
Guasquitas	Storage	84	449	1618
Canjilones	Run of River	35	178	1816
Gualaca	Run of River	27	138	1656
Los Aniles	Run of River	34	172	1938
Chiriqui	Run of River	56	290	1635
Baru	Storage	150	800	1989

The cost of the 30-MW installation at Indio, 25 MW at the dam and 5 MW at the transfer tunnel, was estimated at about $ 1,400 per kW of installed capacity. This would be lower than the estimated costs of the six candidate hydroelectric plants to be added to the PNIS for the period of 2002 – 2008. Current planning suggest that the final configuration for the Indio hydro will be substantially modified. However, it can be concluded that a system expansion plan study should be conducted with consideration of the Indio hydroelectric project as a candidate project. This study will confirm the apparent benefit of adding the Indio Project to the system.

6.1 Marginal Costs

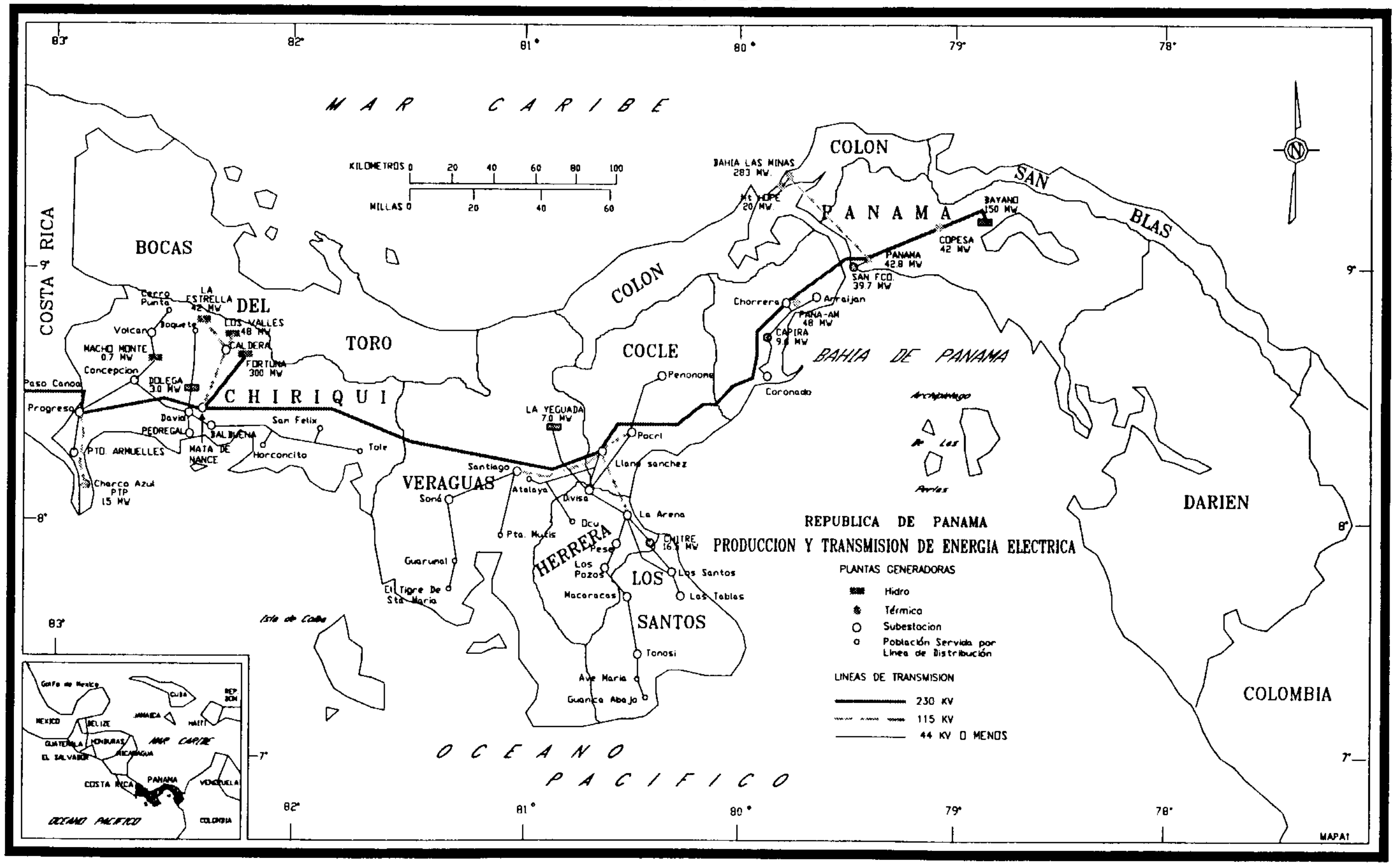
The marginal costs for each calendar month of the PNIS for the period of 1999 – 2015 were estimated on the basis of the recommended generation expansion program and 1999 oil prices. These estimates indicated that the marginal costs will decrease over the period from $45/MWh in 1999 to about $42/MWh in 2015 and average about $43/MWh. This value could be used to represent the energy benefit of the Indio Project hydro.

7 CONCLUSIONS

As a result of this analysis, it can be concluded that:

- The existing system recognizes the importance of hydro to the extent that it provides about one-half of the available capacity.
- The current expansion plans for the period through 2015 include hydro as a major component.
- Demand for power is expected to grow at a rate of more than 4% per year.
- Based on the available information, the Indio power and energy will be competitive in the national power system.
- Indio capacity and energy will be easily absorbed into the system and will provide a very cost-effective addition – replacing any of the projects identified in the 1999 expansion plan

SISTEMA DE TRANSMISION ACTUAL
AÑO 1999



Part 2
Power Development

FEASIBILITY DESIGN FOR THE RÍO INDIO WATER SUPPLY PROJECT

APPENDIX E
PART 2

POTENTIAL FOR POWER DEVELOPMENT

Prepared by

MWH

In association with

TAMS
AN EARTH TECH COMPANY

FEASIBILITY DESIGN FOR THE RÍO INDIO WATER SUPPLY PROJECT

APPENDIX E – POWER AND ENERGY STUDIES
PART 2 – POTENTIAL FOR POWER DEVELOPMENT

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

LIST OF EXHIBITS

ATTACHMENTS

1 BACKGROUND AND SCOPE

The Panama Canal Authority (ACP) is evaluating several sources of additional water supply to meet future demand for the Canal operation and for municipal and industrial use in the Lake Gatun watershed. A Reconnaissance Study performed by the US Army Corps of Engineers, Mobil District, in December 1999 has identified a number of options in the "Western Watershed" as promising sources of water for the Canal. These options include the Río Indio Water Supply Project in combination with other reservoirs such as Caño Sucio, Río Toabre and Coclé del Norte. The Río Indio is a river located west of the Panama Canal; it flows northward from the Continental Divide to the Caribbean Sea. The project primarily consists of a dam approximately 70 meter high, which creates a reservoir with a 44-km^2 surface area. The proposed dam is located 21 km inland. At the dam site, the Río Indio watershed has an area of 381 km^2, and an average annual flow of approximately 25.8 m^3/sec.

Based on the outcome of the Reconnaissance Study, the ACP has selected the Río Indio project to be evaluated at the feasibility level. As part of the Feasibility Study, the project hydroelectric potential identified in the Reconnaissance Study must be assessed. This report presents the analysis performed to evaluate this potential.

The present power and energy studies for the Río Indio Water Supply Project were performed by TAMS Consultants, Inc., an Earth Tech company, under the Sub-consultant Services Agreement No.15593 S-1 for MWH. A separate report covering the power market study was prepared in a draft form in November 2000 by MWH, and is presented as Part 1 of this Appendix E – Power and Energy Studies. The report presents a power market survey of Panama and the future power needs of the Panama national electric system.

The hydroelectric potential of the Río Indio water supply project has been evaluated on the basis set forth in the Reconnaissance Study and further specified in the Scope of Work for the present Feasibility Study developed by the Autoridad del Canal de Panamá (ACP). The primary objective of the Río Indio project is to supply water to meet the growing demand of the Panama Canal for navigation, and of the municipal and industrial consumption in the Lake Gatun watershed. This objective will be achieved by storing and regulating runoff water from the Río Indio watershed and transferring it into the Lake Gatun via an 8.4-km long transfer tunnel. The Reconnaissance Study has stated that navigation benefits resulting from additional supply of water are significantly larger than hydropower benefits; as such the benefits of hydropower are incidental to the project and are not expected to govern its development.

The Reconnaissance Study has identified the hydropower potential of the project and quantified it as a total capacity of 30 MW installed in two separate power plants:

- 25 MW at the toe of the dam; and,

- 5 MW at the end of the transfer tunnel.

The energy generated by these projects was estimated at approximately 70 GWh per year. The Reconnaissance Study considered that the flows that are in excess to the needs of the Panama Canal operation would be used to generate at the Río Indio dam. Both power plants would be designed and configured to function as part of the national power grid. A 115-kV transmission line would be required to carry the energy to a connection with the grid at La Chorrera Substation.

The conclusions of the power market studies indicate that the demand for power in the Panama National Integrated System (PNIS) is expected to grow at a rate of more than 5% per year. It is also stated that the PNIS recognizes the importance of hydropower, as the current expansion plan for the period through 2015 includes six new hydroelectric power plants (not including Río Indio) totaling 386 MW at an average construction cost of $1,813 per kW of installed capacity. The report also recommends a value of $45 per MWh for the current marginal cost of energy for the period up to 2015.

It is anticipated that the navigation benefits provided by the Río Indio Project will not be fully useable for the first 15 to 20 years of the project life as the water demand grows at an approximate rate of 1.7% per year. While the navigation benefits are growing progressively, the flow regulation provided by the Río Indio dam can be use to generate hydroelectric energy either primarily at the dam, as suggested in the Reconnaissance Study, or primarily at the end of the transfer tunnel. The first alternative presents the advantage of a larger generating head (approximately 20 meters greater) as the tailwater level at the dam site normally is between El. 5.0 and 6.0 and the tailwater level at the end of the transfer tunnel is lake Gatun level, which is between El. 24.0 and El.26.8. For the second alternative however, water transferred through the tunnel can also be used to generate at the existing 24-MW Gatun hydropower plant. Furthermore, as the demand for navigation grows the water available for power generation at the dam site diminishes.

The objective of the present study is to compare these alternatives and estimate the hydropower benefits for the selected Río Indio scheme.

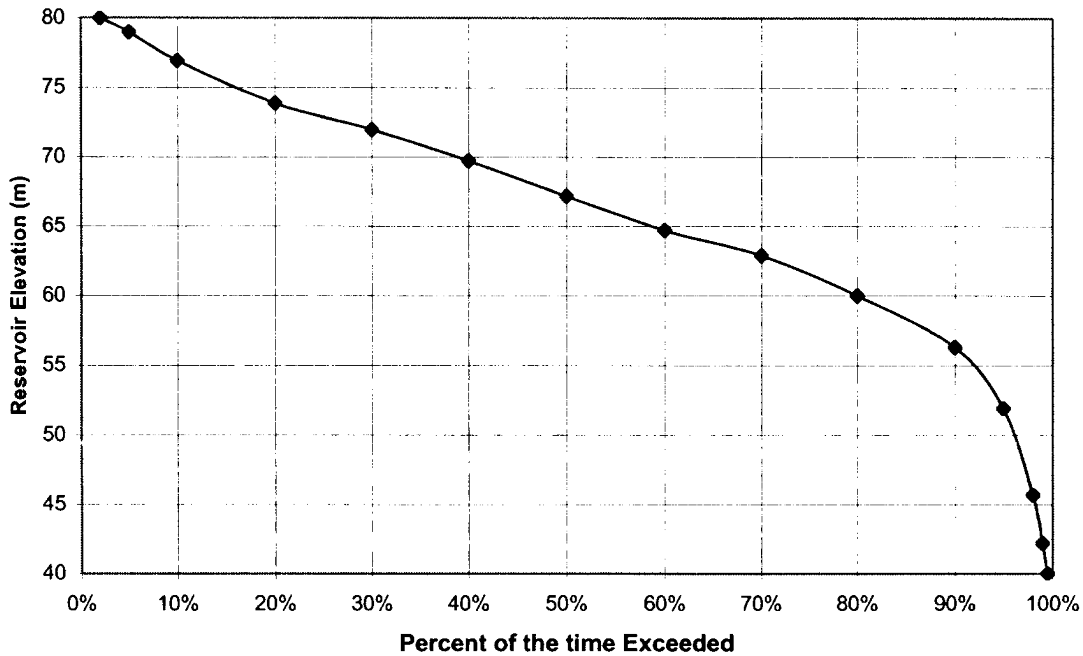
2 SELECTED RÍO INDIO RESERVOIR

The Río Indio reservoir has been sized without consideration for hydroelectric power and is anticipated to supply water to the Panama Canal reservoir system to meet the system water demand up to Year 2028 at a reliability of 99.6%. This is based on the projection for unconstrained water demand for Navigation presented in the Reconnaissance Study and the M&I and tourism water demand presented in the report entitled "Long Term Forecast for M&I Demand" prepared by MWH, January 2001. The Panama Canal water supply system considered for this study consists of Lake Gatun operating between El.23.93 (78.5 ft) and El.26.75 (87.75 ft) and the Madden reservoir, operating between El.57.91 (190 ft) and El.76.81 (252 ft). It is assumed that the deepening of Lake Gatun will be completed and will allow draw down of the Lake three feet lower than it is currently allowed for normal operation with a minimum water level at El.24.84 (81.5 ft). The reservoir operation studies conducted by the ACP with the HEC-5 simulation program have demonstrated that the demand of 60.4 lockage per day (145.6 m^3/sec) can be met at the required reliability, with the Río Indio reservoir operating between El.40 and El.80. The Río Indio reservoir active storage provided is 1,294 million cubic meters (mcm). The HEC-5 simulations considered releases from the Indio reservoir according to rule curves developed by the ACP, which consist of transferring from Indio to Lake Gatun during the four-month period from February to May at a minimum rate of 43 m^3/sec (1,518.8 cfs). The resulting minimum volume of water released in four months is approximately equal to 56% of the Río Indio mean annual runoff (25.8 m^3/sec). Overall the reservoir simulation indicates that under that water demand condition (60.4 lockage per day), an average of 21.7 m^3/sec would be transferred into Lake Gatun. In addition, the reservoir operation studies (HEC-5 simulations) have assumed that a release of 2.3 m^3/s (81.2 cfs) is made downstream of the Río Indio dam.

The results of the Río Indio reservoir simulations under these conditions are shown in a tabular form in Attachment 2. It should be noted that over the 52-year simulation, water is only transferred into Lake Gatun 45% of the time (278 months out of 624). The transfer tunnel has been sized for the purpose of delivering water into Lake Gatun, and consists of a 4.35-meter diameter, horseshoe-shaped, concrete-lined tunnel approximately 8,400 meters long. It is shown to have a discharge capacity of approximately 50 m^3/sec with 15 meters of gross head. This condition corresponds to the situation when the Río Indio reservoir is near minimum pool (El. 40). The tunnel capacity increases as the reservoir rises, up to a capacity of approximately 98 m^3/sec when the reservoir is at maximum pool El 80.

Figure 1 below shows the Indio reservoir elevation frequency curve derived from the HEC-5 simulation. It indicates that the median reservoir level is approximately at El.67.0, and that 90% of the time the reservoir is above El. 56.0. This curve in combination with the transfer tunnel head loss estimates is to be used to select the best turbine operating range.

Figure 1 Río Indio Reservoir Elevation Duration Curve



3 POTENTIAL ENERGY PRODUCTION

3.1 Introduction

This section presents the potential energy production of the Río Indio Hydroelectric scheme under several scenarios of development during the initial phase of operation and under the ultimate use of the Indio storage. The hydroelectric development could consist of two power plants one at the foot of the dam, the Río Indio power plant, and a second at the downstream end of the transfer tunnel, the Isla Pablon power plant.

The Indio reservoir has been sized for the purpose of navigation, and therefore only the operation under this ultimate use of storage has been previously simulated. The energy potential of the site has been determined under this scenario. An alternative mode of water transfer from Indio to Gatun that would maximize energy production has also been evaluated.

Additionally, the transfer tunnel has been sized (4.35-meter diameter) to have a discharge capacity equal to the maximum water requirement of the system of reservoirs: under these conditions the head losses along the tunnel are equal to the gross head on the tunnel and no hydropower can be generated. Increasing the size of the tunnel would lower the head losses, and therefore could allow energy production during these periods when the water is transferred at the maximum capacity of the 4.35-meter diameter tunnel. A larger size transfer tunnel would also improve the regulation characteristics of the hydraulic turbines at the Isla Pablon power plant. The energy production has been estimated for the proposed tunnel size (4.35-meter diameter) and two additional sizes (5.00 meters and 6.00 meters)

Prior to the time when the storage in the Indio reservoir is fully needed (estimated to be in 2029), the reservoir operation and water transfer schedule could be altered to favor hydroelectric production as long as the navigation and M&I water demands are satisfied at a 99.6% reliability. Three different strategies that would maximize hydropower benefit during that period have been evaluated and compared.

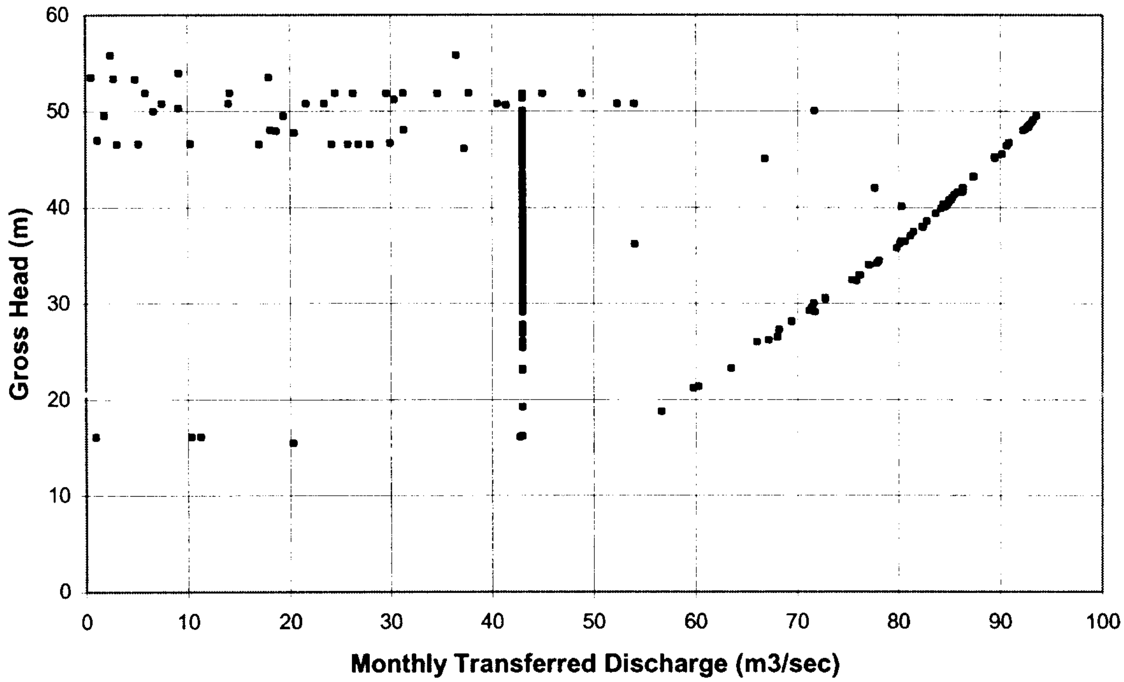
It should be noted that in this section, references are made to the power plant capacity in MW. These numbers are used for the purpose of computing energy production through simulation based on monthly step intervals. The referred plant capacity is the product of the monthly discharge through the power plant by the design head and the assumed overall plant efficiency of 85%. The actual power plant installed capacity will be larger in order to provide the plant with peaking capability.

3.2 Energy Production under Maximum Navigation Water Demand

3.2.1 Energy Production using the ACP Operating Rules

For the purpose of evaluating hydropower development at the end of the transfer tunnel, a plot of gross head versus monthly transferred discharge is presented on Figure 2.

Figure 2 - Río Indio Reservoir Operations – Transferred Discharge

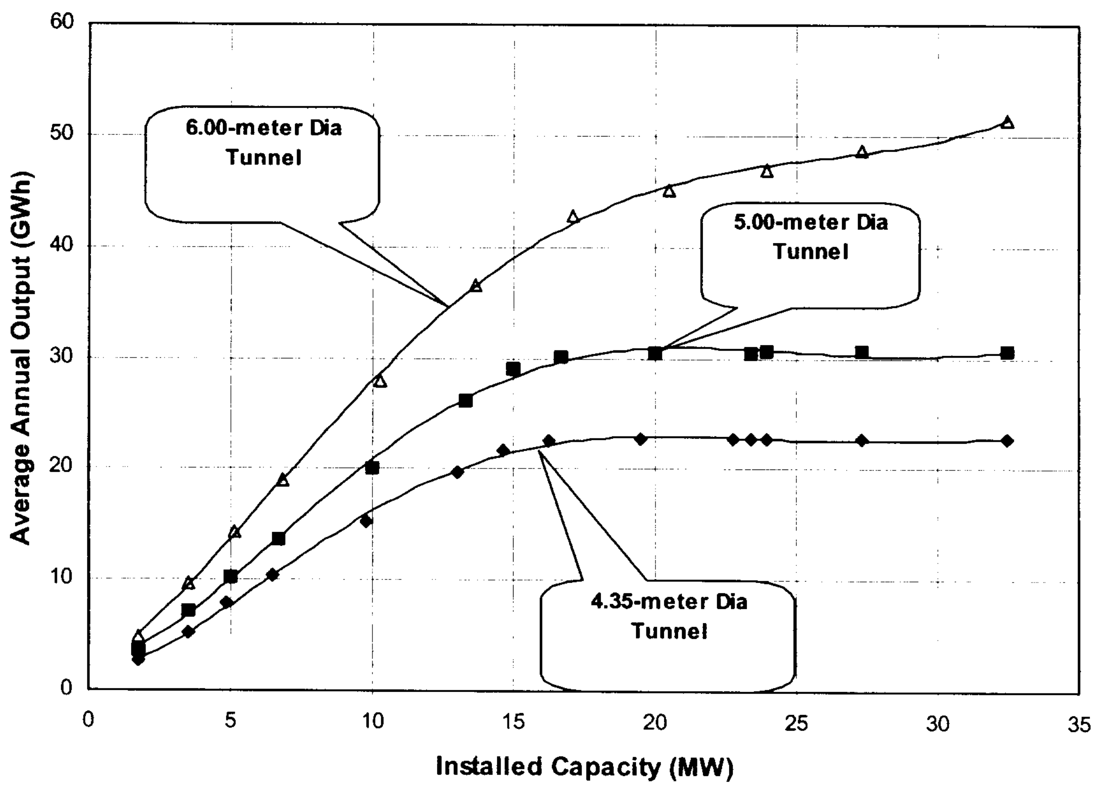


The graph shows three distinctive patterns of releases:

- A large number of points (56% of the month with releases) when the discharge in the tunnel is equal to 43 m^3/sec, with a gross head between 15 meters and 53 meters: this corresponds to the months of February to May when the discharge is governed by the Río Indio rule curve.
- A small number of points (17% of the months with releases) with nearly full reservoir (gross head in excess of 46 meters) and discharges varying between 0 and approximately 55 m^3/sec: in these circumstances water was released to satisfied demand at Gatun, but the tunnel is not discharging at full capacity.
- A third set of points (27% of the months with releases) shows the discharges equal to the maximum tunnel capacity (along the curve on the right of the graph). When the tunnel is operated at maximum capacity, all hydraulic energy is dissipated in the waterways and therefore no hydropower can be generated.

It is apparent on this graph, that there are practically no circumstances when the monthly discharge is in excess of 43 m^3/sec and the gross head is sufficient to develop hydropower. Based on these operating conditions and standard hydraulic turbine characteristics, computations show that the maximum average annual energy that could be generated by a hydropower plant at the end of the transfer tunnel would be approximately 22.5 GWh. It would require a 16.3-MW power plant sized to pass a maximum turbine discharge of 50 m^3/sec under 39 meters of net head and operating at 15.8% plant factor. The plant would only be able to run 23% of the time. Reducing the plant capacity of the power plant to 5 MW would only increase the plant factor to 18.3% for an average annual output of 8.0 GWh.

Figure 3 Isla Pablon Power Plant Output with ACP Operating Rules



For the purpose of comparison, the average annual energy was also computed for a power plant passing 50 m^3/sec with two larger size tunnels, 5.00-meter diameter and 6.00-meter diameter horseshoe sections. With a 5.00-meter tunnel the maximum average annual energy would be increased to 30.1 GWh, with 16.7-MW power plant operating at 20.6% plant factor. The plant would operate approximately 30% of the time. With a 6.00-meter tunnel the maximum average annual energy would be increased to 42.9 GWh, with 17.1-MW power plant operating at 28.6% plant factor. The plant would operate approximately 38% of the time.

The maximum output that can be reached with the 5.00-meter diameter tunnel is 30.4 GWh per year with a 20-MW plant capacity, and with the 6.00-meter diameter tunnel it is approximately 51.3 GWh per year with a 32.7-MW power plant.

The low operating time of the power plant, on average less than three months per year, makes it unlikely to be an economically feasible hydroelectric project.

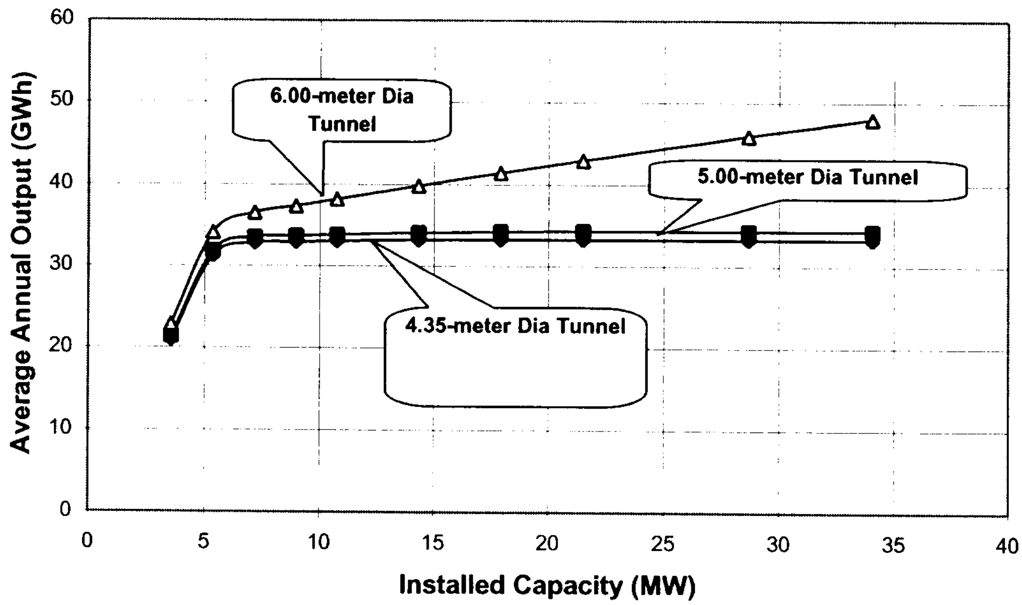
3.2.2 Energy Production using Alternative Operating Rules

For the purpose of investigating the hydroelectric potential of the project, additional reservoir operation simulations were undertaken using the HEC-5 program. In particular, the four-month release pattern was modified: the same minimum volume of water (452.1 mcm) would be released annually from Indio to Gatun but it would be transferred over twelve months instead of four. The minimum mean monthly flow transferred would be 14.3 m^3/sec. Using the same active storage in the Indio reservoir, between El.40.0 and El.80.0, the HEC-5 simulation indicates that for a demand of 60.4 lockage per day, the reliability of the water supply for the purpose of navigation remain practically unchanged at 99.6%. The transfer tunnel operates at all time: it releases 14.3 m^3/sec 87% of the time and for the remaining 13% of the time the tunnel discharges at full capacity.

Under these new operating rules, a 9.0-MW power plant would generate on average 33.0 GWh per year at a plant factor of 42.0%. The power plant would be capable of passing a maximum turbine discharge of 25 m^3/sec under 43 meters of net head. This energy production corresponds to an increase of 47% over the proposed operating rule curves. A similar analysis with a 5.00-meter diameter tunnel shows that the power generation would increase to 33.7 GWh/yr, corresponding to a plant factor of 42.9%. This would be an increase of energy generation of 12.5% over that with the proposed reservoir operating rule curves. The average annual output is however only marginally greater than that with a 4.35-meter diameter tunnel. For a 6-meter diameter tunnel, a 9.0-MW power plant would generate on average 37.4 GWh per year corresponding to a plant factor of 47.6%. The maximum annual energy production that could be reached with a 6.00-meter diameter tunnel under these operating conditions would be of 48.1 GWh with a 34.1-MW power plant discharging up to 95 m^3/sec under a net head of 43 meters. The plant would operate at a plant factor of 16.1%.

Under all these scenarios, the simulation considered a monthly discharge of 2.3 m^3/s is released at the dam site into the Río Indio valley. A small power plant with an installed capacity of 2.5 MW would produce 9.7 GWh per year at a plant factor of 44%. The plant would discharge a maximum flow of 2.85 m^3/s under a net head of 62 meters. The plant would operate 97.5% of the time: the turbine could not operate when the reservoir level is below El. 46 approximately.

Figure 4 Isla Pablon Power Plant Output with Modified Operating Rules



As a result of the reduced spillage in the system, both at the Madden reservoir and at Lake Gatun, the energy production at both power plants, Madden and Gatun, would be reduced from the present operation. Under the existing conditions when the system meets a demand of 38.8 lockage per day, the HEC-5 simulation indicates that Gatun power plant generates on average 95.5 GWh per year, and Madden 199.3 GWh per year. These outputs would be reduced to 77.6 GWh and 196.0 GWh, respectively when the Lake Gatun is deepened to operate between El.23.93 (78.5 ft) and El.26.75 (87.75 ft) and the water demand rises to 44.3 lockage per day. Ultimately when the storage in the Río Indio reservoir is fully utilized to meet the water demand of 60.4 lockage per day, the average energy production at the Gatun and Madden power plants would be 54.5 and 187.9 GWh per year respectively.

3.3 Energy Production under Intermediate Navigation Water Demand

3.3.1 General

The initial phase of operations, immediately after completion of the Indio project, until the water demand grows to fully utilize the Indio storage, is expected to last approximately 18 years (from 2010 to 2028). Table 1 below summarizes the projected demand for Navigation and M&I water. The projected Navigation water demands were obtained from the Reconnaissance Study report and the M&I water demands are those presented in the report entitled "Long Term Forecast for M&I Demand" prepared by MWH, January 2001. The existing system complemented with the deepening of Lake Gatun will yield 44.3 lockage per day, which will be sufficient to meet the projected demand until 2010. The water demand in 2029 is 60.8 lockage per day, which is marginally larger than the yield of the system including the Río Indio operating between El. 40 and El. 80. For the purpose of this analysis, it is considered that an additional project will need to be implemented prior to 2029 to meet the projected water demand; at that time the hydropower benefit resulting from the development of Indio will remain constant and equal to those determined based on a demand of 60.4 lockage per day.

Table 1 - Navigation and M&I Water Demand

Year	Total Water Demand		
	(lock/day)	(cfs)	(m^3/sec)
2010	44.34	3,773	106.8
2015	48.47	4,125	116.8
2020	52.58	4,475	126.7
2025	57.14	4,863	137.7
2030	61.70	5,251	148.7
2035	66.25	5,638	159.6
2040	70.80	6,025	170.6
2045	74.96	6,379	180.6
2050	79.12	6,733	190.7
2055	82.08	6,985	197.8
2060	85.04	7,237	204.9

The initial phase (2010 to 2028) is the period when hydropower benefits are the greatest. As long as the demand for Navigation and M&I water does not reach the maximum planned yield of the Gatun-Madden-Indio system of reservoirs, the ACP will have a number of options to maximize hydropower benefits while still meeting the water demand of the system.

The available operating options includes the following strategies:

1. The ACP could transfer regulated flows from Indio to Gatun such that the required demand is met with a 99.6%-reliability, while maintaining Indio reservoir level as high as possible to maximize the generating head on the Isla Pablon power plant. The output of the Isla Pablon power plant would be larger during the intermediate period as the head on the plant is greater. Under this scenario the release through the Indio dam would be maintained and power would be generated through a 2.5-MW power plant. This plant would also benefit from a higher reservoir level.
2. Alternatively, the maximum storage at Indio could be use to transfer as much water as possible to maximize energy production at the Gatun power plant. The power plants at Isla Pablon and Indio would generate approximately the same annual energy during the intermediate period as they would under the ultimate water demand condition. Additional output would be generated at the Gatun 24-MW power plant.

3. A third alternative would be to transfer the minimum volume of water at all time to meet the Navigation and M&I demand, and maximize hydropower production at the Indio site.

3.3.2 Maximize Output at The Isla Pablon Power Plant

For the purpose of evaluating the benefits of Strategy No.1, several HEC-5 simulations have been performed with smaller Indio reservoir active storage. This was accomplished by raising the Indio minimum pool above the ultimate dead storage requirement of El. 40. Table 2 below provides the Indio reservoir active storage for the minimum operating pool considered for this analysis.

The results of these simulations are presented in Table 3 below. For all these simulations an approach similar to that presented above for operation under ultimate utilization of Indio has been followed. In particular, the targeted discharge through the transfer tunnel is constant through the year and Indio release is maintained equal to 2.3 m^3/s. The selected transfer tunnel with a diameter of 4.35 meters was used for all the energy computations. The table indicates the reservoir system yield in terms of lockage per day that corresponds to a reliability of 99.6%.

Table 2 - Río Indio Active Storage

Minimum Operating Pool	Maximum Operating Pool	Active Storage (mcm)
75.0	80.0	212
70.0	80.0	423
65.0	80.0	599
60.0	80.0	774
55.0	80.0	925
50.0	80.0	1,075
40.0	80.0	1,294

The basis for this strategy is to maintain the Indio reservoir level as high as possible and to have a system yield compatible with the projected water demand.

Table 3 - Energy Production with smaller active storage at Indio

Reservoir Operation System	Lockage per day	Annual Output (GWh/yr)				
		Gatun	Madden	Isla Pablon	Río Indio	Total
Existing System	38.8	95.5	199.3	-	-	**294.8**
With Deepened Gatun	44.3	77.6	196.0	-	-	**273.6**
With Río Indio bet. El.75 and El.80	48.8	89.0	195.0	65.0	11.9	**359.7**
With Río Indio bet. El.70 and El.80	51.0	83.2	194.2	64.6	11.6	**353.6**
With Río Indio bet. El.60 and El.80	54.8	72.5	192.0	58.1	10.7	**333.3**
With Río Indio bet. El.55 and El.80	56.5	67.0	190.9	53.6	10.2	**321.7**
With Río Indio bet. El.50 and El.80	58.4	61.8	189.2	43.1	9.7	**303.8**
With Río Indio bet. El.40 and El.80	60.4	54.5	187.9	33.0	9.7	**285.1**

The average annual energy output of Madden and Gatun power plants were directly obtained from the HEC-5 simulations. Flows and reservoir levels series for each simulation were also extracted from the HEC-5 output files, and incorporated into a spreadsheet in order to calculate the monthly energy production at Isla Pablon and Indio power plants. For the purpose of this analysis, a 9-MW power plant has been selected for the Isla Pablon: the plant is capable of discharging 25 m^3/sec under a net head of 43 meters. This is not considered to be the optimized size of the power plant, but it maximizes the average energy production; this analysis will provide the information that is needed to compare the operation strategies.

Based on the projected water demand presented on Table 1, and the yield (lockage per day) of the systems of reservoirs shown on Table 3, a sequence of projected minimum Indio reservoir operating levels can be developed as shown on Table 4. Table 4 below also presents the associated projected energy production.

Table 4 – Strategy No.1 Energy Production Sequence

Year	Demand (Lock per day)	Yield (Lock per day)	Minimum Indio Level	Isla Pablon Output (GWh/yr)	Indio Output (GWh/yr)
2015	48.5	48.8	75.0	65.0	11.9
2018	50.9	51.0	70.0	64.6	11.6
2022	54.4	54.9	60.0	58.1	10.7
2026	58.1	58.4	50.0	43.1	9.7
2028	59.9	60.4	40.0	33.0	9.7

3.3.3 Reservoir Operation to Maximize Gatun Energy Production

For the purpose of this operating strategy the Río Indio reservoir was considered to operate between El. 55 and El. 80, in the initial period. This minimum pool level is the approximate minimum turbine operating level when the transfer tunnel passes the maximum discharge of a 9.0-MW power plant at Isla Pablon. These reservoir levels provide an active storage of 925 mcm. With that storage, the reservoir system will have a yield of approximately 56.5 lockage per day, which is sufficient to meet the water demand up until 2024. In the interim period between the project completion and 2024, the excess water transferred from Indio to Gatun can be used at the Gatun power plant. The HEC-5 model was used to simulate the reservoir operation under the following intermediate water demand conditions:

1. 2015 when the demand is 48.5 lockage per day;
2. 2020 when the demand is 52.6 lockage per day.

The anticipated energy productions for this strategy are presented in Table 5 below. Beyond 2024, the system of reservoir will be similar to that of Strategy 1, presented above.

Table 5 – Energy Production with Min. Pool at El.55

Lockage per day	Average Annual Output (GWh/yr)				
	Gatun	Madden	Isla Pablon	Río Indio	Total
48.5	94.4	194.3	53.3	10.2	**352.2**
52.6	81.0	192.6	53.5	10.2	**337.3**
56.5	67.0	190.9	53.6	10.2	**321.7**

3.3.4 Maximize Output at the Indio Power Plant

The third operating strategy for the intermediate period would consist of transferring the minimum water required meeting the water supply demand for Navigation and M&I, while maximizing the release at the Río Indio dam to produce energy at that location. Two operating rules have been evaluated for that strategy:

- Strategy No.3a: Maintaining a minimum level in the Indio reservoir at El. 55;
- Strategy No.3b: Maintaining the minimum level in the Indio reservoir at El. 50.

As previously stated, El 55 is approximately the minimum reservoir level for which a hydropower plant can operate at the end of the transfer tunnel; and therefore the second operating rule would limit the time when the Isla Pablon hydroelectric station is able to operate. Reservoir operations have been simulated using the HEC-5 computer model for both rules.

Table 6 below shows the reservoir system yield (lockage per day) achieved under the two operating rules with release of water at Indio larger than 2.30 m^3/s.

Table 6 – Reservoir Operation to Maximize Indio Energy Production

Reservoir Operation at Indio	Minimum Release at Indio	Yield (lockage per day)
Minimum Operating Level at El.55	20.00	49.6
Minimum Operating Level at El.55	14.00	50.8
Minimum Operating Level at El.55	8.00	53.1
Minimum Operating Level at El.55	2.30	56.5
Minimum Operating Level at El.50	20.00	50.1
Minimum Operating Level at El.50	14.00	52.2
Minimum Operating Level at El.50	8.00	54.9
Minimum Operating Level at El.50	2.30	58.4

The reservoir releases downstream of the Indio dam were considered uniform from month to month. In Table 6, the yield (lockage per day) achieved was met at 99.6% reliability.

The operation rules presented in this section will need to be implemented at different time dictated by the water demand in Lake Gatun. The expected year of implementation are shown below in Table 7, which also shows the maximum average annual energy production for each of the considered power plant. The outputs shown are the maximum achievable as it would be limited by the installed capacities at Isla Pablon and Indio, which remain to be optimized. For the purpose of this comparison, the power plants have been assumed to be able to generate with a discharge of up to 25 m^3/sec.

Table 7 – Strategies Nos.3a and 3b Energy Production Sequence

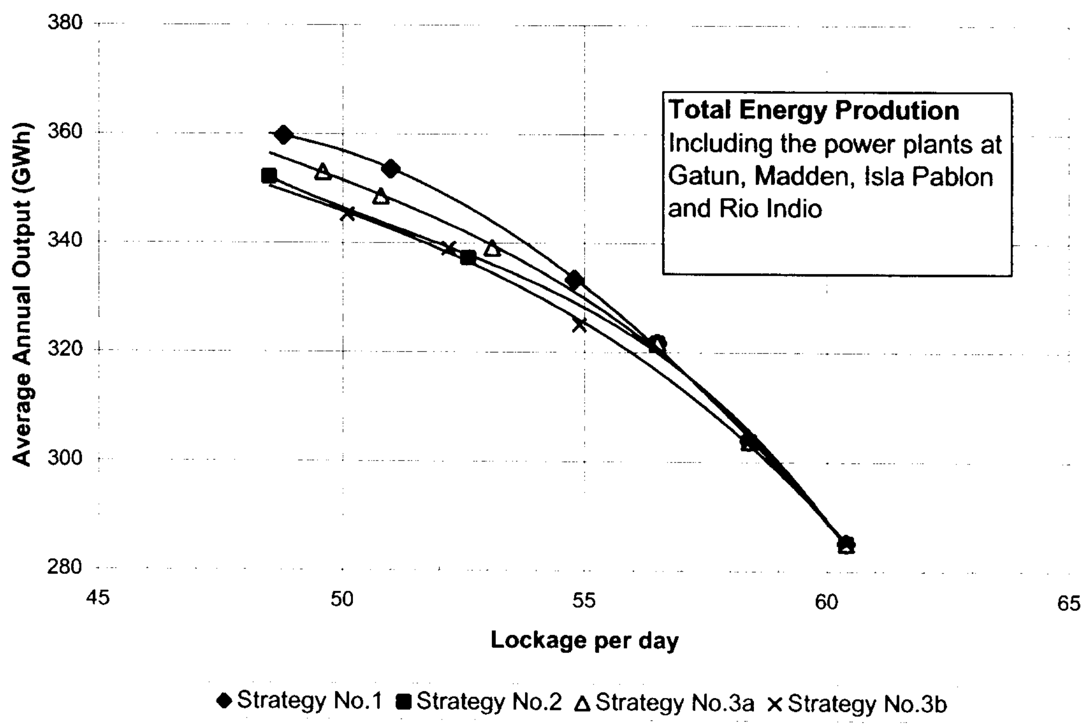
Oper. Rule	Year	Demand (Lock/ day)	Yield (Lock/ day)	Average Annual Output (GWh/yr)				
				Gatun	Madden	Isla Pablon	Río Indio	Total
Res. Oper. Bet. El.55 & El.80	2016	49.3	49.6	66.0	193.9	6.9	86.3	353.1
	2017	50.1	50.8	70.4	193.6	23.4	61.3	348.7
	2020	52.6	53.1	71.1	192.7	39.9	35.5	339.2
	2024	56.2	56.5	67.0	190.9	53.6	10.2	321.7
Res. Oper. Bet. El.50 & El.80	2017	50.1	50.1	64.4	193.2	6.4	81.3	345.3
	2019	51.8	52.2	65.8	192.6	21.8	58.8	339.0
	2022	54.4	54.9	65.2	191.1	34.9	33.8	325.0
	2026	58.1	58.4	61.0	189.4	43.1	9.7	303.2

3.4 Comparison of Intermediate Operation Strategies

3.4.1 General

In order to compare the various strategies described above, they must be compared on the basis of an equal navigation benefit provided by the reservoir system. For that purpose a plot of total annual output in GWh of the four power plants versus yield of the system (lockage per day) was prepared and is shown on Figure 5. This plot indicates that strategy No.1 and No.3a would generate the most energy. Strategies No.2 and No.3b involve similar cost than Strategies No.1 and No.3a, respectively, but they produce less energy and therefore they will not be evaluated any further. To identify the best strategy, return and cost must be compared: for that purpose both strategies Nos.1 and 3a are further investigated below.

Figure 5 – Energy Production during the Intermediate Period



3.4.2 Review of Strategy No.1

Strategy No. 1 output would be achieved with a 2.5-MW power plant located at the Indio dam and a 9.0-MW power plant at the end of the 4.35-meter diameter transfer tunnel. The energy produced at this power plant will average 10.9 GWh per year for the first 18 years, declining from 11.9 GWh/yr in 2010 to 9.7 GWh/yr in 2028, and remain approximately constant thereafter and equal to 9.7 GWh/yr.

The output of the Isla Pablon plant in 2029 when the system yields 60.4 lockage per day is 33.0 GWh per year. This output could almost be reached with a 5.4-MW power plant: 31.2 GWh/yr. The average annual energy production over the 18-year intermediate period for the 5.4-MW plant however would be 41.4 GWh/yr, instead of 54.1 GWh/yr for a 7.2-MW power plant and 58.4 GWh/yr for a 9.0-MW power plant.

Similarly, the size of the transfer tunnel affects the output of the Isla Pablon power plant as shown on Table 8 below. The energy computations have been performed using the HEC-5 monthly output for spillage, transferred discharge, downstream releases, Indio reservoir level and Lake Gatun level, and a project-specific spreadsheet considering tunnel friction and other singular losses, and turbine operating head and discharge limitations.

Table 8 – Isla Pablon Power Plant Energy Production (Strategy No.1)

		Average Annual Output (GWh/yr)		
		4.35-m Dia Tunnel	**5.00-m Dia. Tunnel**	**6.00-m Dia Tunnel**
2011 – 2028	**5.4-MW Power Plant**	41.4	41.7	42.4
	7.2-MW Power Plant	54.1	54.5	55.5
	9.0-MW Power Plant	58.4	59.6	61.3
2029 and after	**5.4-MW Power Plant**	31.2	31.9	34.1
	7.2-MW Power Plant	32.8	33.5	36.5
	9.0-MW Power Plant	33.0	33.7	37.4

3.4.3 Review of Strategy No.3a

For Strategy No.3a, a plant capacity of approximately 15 MW would be necessary to maximize energy production at the Indio power plant during the intermediate period. The plant would discharge a maximum flow of 30 m^3/sec under a net head of 62 meters. A tunnel diameter of 3.0 meters would be required. Under these conditions, the average annual energy produced at the Indio dam for the first 18 years would be approximately 52.8 GWh. For the following period when the Indio reservoir is fully utilized to supply water in Lake Gatun, the Indio plant will generate 9.7 GWh per year.

At the Isla Pablon site, a power plant capacity of 5.4 MW would generate an average annual output of 22.4 GWh over the first 18 years of operations. The same plant is anticipated to generate an average of 31.2 GWh/yr after that period.

3.5 Firm Capacity

The plant capacity referred to in the above paragraph is used to calculate the energy production and was used in connection with the average monthly flows. For the purpose of estimating the firm capacity and the revenues associated with it, it is assumed that the power plant will have a plant factor of approximately 65%.

The firm capacity benefits were estimated based on conversation with the ACP Power Division. The firm capacity was calculated on the basis of the projected monthly energy production. For storage projects, the firm capacity is the capacity that could be delivered 8 hours per day, every day of the month with the monthly energy exceeded 95% of the time.

The Isla Pablon project will not be capable of delivering firm power when the Río Indio project is utilized at its ultimate yield, i.e., with the reservoir exploited down to El. 40. This level is below the minimum power generating pool and therefore there will be extended periods when the power plant will not be capable of operating. For Isla Pablon, the minimum operating level is estimated to be approximately El.55.0. The reservoir is expected to operate below this level approximately 8% of the time as shown on Figure 1. It is estimated that the hydraulic turbines at Río Indio will not be able to operate when the reservoir falls below approximately El. 46: this is expected to occur only 2 to 3% of the time and therefore a power plant at dam site will be capable of delivering firm capacity to the system.

In the initial years of the project, the navigation, municipal and industrial supply will not require lowering the reservoir to levels below the minimum operating pool. It is estimated that the Indio reservoir will not be lowered below El. 55.0 until the water demand reaches 56.5 lockage per day in 2024. Lowering of the reservoir below El. 46.0 is not expected to be required until the demand reaches 58.7 lockage per day in about 2027.

In the interim period, both power plants will be capable of delivering firm power. For each HEC-5 simulation, a monthly energy duration curve was prepared to determine the value exceeded 95% of the time. The results are presented below in Table 9 for Strategy No.1 and in Table 10 for Strategy No.3a.

Table 9 – Monthly Energy (MWh) Exceeded 95% for Strategy No.1

Reservoir Operating Range	Río Indio	Isla Pablon				
	2.5-MW	8.4-MW	11.2-MW	14.0-MW	16.8-MW	19.6-MW
5.00-meter Diameter Tunnel						
El.40 – El.80	607	-	-	-	-	-
El.50 – El.80	645	-	-	-	-	-
El.55 – El.80	714	2,183	2,892	3,512	3,512	3,512
El.60 – El.80	773	2,729	3,612	4,088	4,088	4,088
El.70 – El.80	902	3,215	4,256	4,697	4,724	4,724
6.00-meter Diameter Tunnel						
El.40 – El.80	607	-	-	-	-	-
El.50 – El.80	645	-	-	-	-	-
El.55 – El.80	714	2,329	3,105	3,695	3,698	3,698
El.60 – El.80	773	2,831	3,752	4,217	4,228	4,228
El.70 – El.80	902	3,254	4,310	4,822	4,858	4,858

Table 10 - Monthly Energy (MWh) Exceeded 95% for Strategy No.3a

Reservoir Operating Range	Release at Indio (m^3/sec)	Río Indio				
		2.5-MW	6.4-MW	11.1-MW	15.9-MW	18.4-MW
El.40 – El.80	2.30	607	607	607	607	607
El.50 – El.80	2.30	645	645	645	645	645
El.55 – El.80	2.30	714	714	714	714	714
El.55 – El.80	8.00	1,308	2,131	2,468	2,468	2,468
El.55 – El.80	14.00	1,313	2,172	3,802	4,243	4,243
El.55 – El.80	20.00	1,329	2,199	3,848	5,497	6,110
		Isla Pablon				
		8.4-MW	**11.2-MW**	**14.0-MW**	**16.8-MW**	**19.6-MW**
El.40 – El.80	2.30	-	-	-	-	-
El.50 – El.80	2.30	-	-	-	-	-
El.55 – El.80	2.30	2,183	2,892	3,512	3,512	3,512
El.55 – El.80	8.00	2,215	2,556	2,556	2,556	2,556
El.55 – El.80	14.00	1,502	1,502	1,502	1,502	1,502
El.55 – El.80	20.00	-	-	-	-	-

For each of the power plant considered above, a second limiting factor should be considered to determine its ability to deliver firm power. The referred installed capacity is the maximum capacity of the turbine at the design net head. For net head lower than the design head, the maximum turbine output is reduced. It is estimated that for the Francis turbines considered on this project, the minimum operating head is 65% of the design head; under these condition the maximum output is approximately 50% of the maximum output at design head. Therefore regardless of the monthly energy exceeded 95%, the firm power can not above approximately 50% of the maximum output when the reservoir operates at the power minimum pool. Computations have shown that the tunnel diameter has practically no impact on the determination of firm capacity.

As previously stated the reservoir range of operation will be dictated by the water demand for navigation; based on that demand and the above table the plant firm capacity were estimated as shown on Table 11 and Table 12 below.

Table 11 – Power Plant Firm Capacity (MW) for Strategy No.1

Period of Operation	Río Indio	Isla Pablon				
	2.5-MW	8.4-MW	11.2-MW	14.0-MW	16.8-MW	19.6-MW
2027 & after	1.3	-	-	-	-	-
2025 – 2026	1.5	-	-	-	-	-
2023 – 2024	1.7	4.4	5.9	7.3	8.8	10.3
2019 – 2022	2.0	6.0	8.0	10.0	12.1	14.1
2011 – 2018	2.5	8.4	11.2	14.0	16.8	19.3

Table 12 - Power Plant Firm Capacity (MW) for Strategy No.3a

Period of Operation	Río Indio				
	2.5-MW	6.4-MW	11.1-MW	15.9-MW	18.4-MW
2027 & after	1.3	2.5	2.5	2.5	2.5
2025 – 2026	1.5	2.7	2.7	2.7	2.7
2023 – 2024	1.7	2.9	2.9	2.9	2.9
2011 – 2022	1.7	3.4	5.8	8.3	9.6
	Isla Pablon				
	8.4-MW	11.2-MW	14.0-MW	16.8-MW	19.6-MW
2025 & after	-	-	-	-	-
2023 – 2024	4.4	5.9	7.3	8.8	10.3
2019 – 2022	4.4	5.9	7.3	8.8	10.3
2017 – 2018	4.4	5.9	6.2	6.2	6.2
2011 – 2016	-	-	-	-	-

3.6 Energy and Capacity Revenues

For both strategies, the sequences of expected energy production for several installed capacities have been developed and are presented in Attachment 3 (pages AT3-28 to AT3-31). Based on the current value of energy presented in the power market studies ($45 per MWh), an estimate of the average revenues over the 50-year economic life of the hydropower component of the project has been calculated and is presented Table 13 and Table 14 below.

The firm capacity benefits were estimated based on conversation with the ACP Power Division and valued at $60 per kW-year.

Table 13 – Isla Pablon Power Plant – Average Revenues ($,000)

	8.4-MW	11.2-MW	14.0-MW	16.8-MW	19.6-MW
5.00-m Diameter Tunnel					
Strategy No.1	$1,717	$2,013	$2,142	$2,194	$2,237
Strategy No.3a	$1,383	$1,506	$1,549	$1,562	$1,574
6.00-m Diameter Tunnel					
Strategy No.1	$1,792	$2,116	$2,276	$2,336	$2,385
Strategy No.3a	$1,463	$1,616	$1,682	$1,700	$1,716

It should be noted that for the Isla Pablon power plant, the 4.35-meter diameter tunnel is not considered for this comparison as it is shown (see section 4.1 below) that for this diameter the selected water release schedule and maximum rate would have to be modified to allow for hydroelectric power operation.

Table 14 - Río Indio Power Plant –Average Revenues ($,000)

Installed Capacity	2.5-MW	6.4-MW	11.1-MW	15.9-MW	18.4-MW
Strategy No.1	$564	$644	$665	$687	$704
Strategy No.3a	$642	$864	$1,098	$1,274	$1,320

4 SCHEME SELECTION

4.1 Introduction

The two strategies retained from Section 3 above correspond to different size power plants and both involve modifications to the water-only project. In general the Río Indio Hydroelectric development consists of the following main features:

1. Powerhouse and Intake associated with the transfer tunnel;
2. Powerhouse and Intake associated with the dam and the release tunnel for Río Indio.
3. Power Transmission system interconnecting all of the project features and connecting the project to the Panama National Power Grid.

The purpose of this section is to evaluate the viability of each power plant on an individual basis, and to select the best strategy to be followed. The evaluation of the projects will be done on the basis of incremental cost to the water-only project. The major modifications to the project would include increasing the size of the transfer tunnel and providing a surge tank near the downstream end of the transfer tunnel.

4.2 Hydraulic Constraints

For hydroelectric development at the end of a long tunnel, a surge tank is generally required. As a rule of thumb, the provision of a surge tank should be investigated when the ratio $K = (L \times V)/H$ is greater than 3 to 5. In the case of Isla Pablon project, the tunnel is approximately 8,400 meters long, 4.35 meters in diameter for a discharge of approximately 25 to 50 m^3/sec under a design head of 43 meters. The K-ratio would be in the range of two orders of magnitude greater than recommended by this criterion, and therefore a surge tank will be needed to develop hydropower at Isla Pablon. The cross-sectional area of the surge tank is determined based on the following criteria:

1. Provide stable dampening oscillation of the water surface level in the tank;
2. The tank does not drain under the most critical down surge conditions; and,
3. The tank does not overflow, unless a weir and evacuation chute is provided.

At the preliminary level, the stability of the oscillations is evaluated using the Thoma's criterion, which establishes the minimum cross-sectional area, and applying a safety factor depending on the type of surge tank considered.

The second criterion implies that the minimum water level in the tank should not fall to the crown of the tunnel under any circumstances. In the case of the Isla Pablon power plant it should be noted that the transfer tunnel is also required to discharge water even when the Indio reservoir level does not allow hydropower operation: the tunnel discharge capacity is 50 m^3/sec when the reservoir is at El.40. Under these conditions, the water level in the surge tank under steady state operation would be approximately at El.26, allowing for 14.1 meters of head losses with a 4.35-meter tunnel diameter. The crown of the tunnel is anticipated to be at approximately at El 31. Lowering further the tunnel to place the crown below El 26 would imply the construction of the tunnel with an invert 3 to 4 meters below the normal Lake Gatun level. This is not considered as a practical solution as the dewatering of the tunnel for maintenance or repair could not be done by gravity. With a 5.00-meter diameter transfer tunnel the head losses at 50 m^3/sec would be reduced to 6.8 meters, resulting in a water level in the surge tank at approximately El.33. It is therefore considered that the tank would not be drained under normal operations. Further investigations are required to define safe operation procedures and minimum surge level in the tank, but it is considered that for safe operation of a hydropower plant at Isla Pablon the transfer tunnel should have a minimum diameter of 5.00 meters.

The third criterion requires establishing the main operating conditions of the transfer tunnel and of the power plant. Containment of the upsurge may impose the location of the surge tank as the higher the surrounding ground is, the least visible and invasive the structure will be. At the preliminary feasibility level, the surge tank was dimensioned for the 5.00-meter and the 6.00-meter diameter transfer tunnel.

For the 5.00-meter tunnel, a 21-meter diameter tank will provide the required incipient stability with 1.25 factor of safety recommended for throttled surge tank. The maximum down surge for rapid opening to full capacity of the downstream valves, with the reservoir at El 40 is approximately 9.8 meters. Minor adjustments to the tunnel invert may be required to accommodate this level if detailed investigations confirm the magnitude of the down surge. Also it is not anticipated that operations of the Indio reservoir for the purpose of transferring water to Lake Gatun would require a rapid opening of the transfer tunnel. For these reasons, this condition appears extreme and the bottom of the tank will be taken at El 30. The maximum upsurge for rapid closure of the downstream valves, with the reservoir at El. 80 and the tunnel at full discharge capacity of 98 m^3/sec is approximately 13 meters, resulting in a surge tank rim at El 93 approximately. Further investigation may be required to compare the cost of such tank, with a surge tank with larger surface area and with the cost of a weir at a lower level followed by a chute and the implication of the weir on the dampening of the oscillations. For the purpose of estimating the cost of the project, the surge tank was selected with an enlarged surface area at upper level. With diameter of 40 meters above El 75.0 the maximum water level reached is El.86.9

For a 6.00-meter diameter transfer tunnel a 28-meter diameter surge tank would meet the same criterion. The minimum level reached in the surge tank would be approximately El 34, as rapid opening of the downstream valve would create a down surge of 6.1 meters. The maximum upsurge at full reservoir would be 14.3 meters for a surge tank rim at El 95 approximately. With a tank diameter of 50 meters above El.75, the maximum water level would reach El 86.2

4.3 Recommended Tunnel Diameter for Hydropower Operation

Preliminary cost estimates of the transfer tunnel for four tunnel sizes have been prepared based on the spreadsheets shown in Appendix D, and are presented below on Table 15.

Table 15 – Transfer Tunnel Construction Cost

	Tunnel Diameter (m)			
	4.35-m Dia.	**5.00-m Dia.**	**5.50-m Dia.**	**6.00-m Dia.**
Excavation Cost ($,000)	$21,705	$22,572	$23,286	$24,042
Lining Cost ($,000)	$7,628	$9,732	$11,522	$13,462
Total Cost ($,000)	$29,333	$32,304	$34,808	$37,504

Revenue calculations presented in the previous section show that the incremental benefits (present value of revenues) for increasing the tunnel diameter from 5 meters to 6 meters is estimated at most at approximately $700,000 regardless of strategy or plant capacity. Table 15 above shows the incremental cost of the tunnel alone above the minimum diameter required for hydropower is approximately $5,200,000. Therefore no significant increase in tunnel diameter can be justified for the purpose of hydropower development, and the selected tunnel diameter is the minimum required for hydropower, estimated to be at this feasibility level, 5.00 meters.

4.4 Hydropower Component Cost Estimates

Isla Pablon Power Plant

For the Isla Pablon power development the major cost items common to all the schemes and additional to the water-only scheme are:

- The increase in tunnel diameter from 4.35 meters to 5.00 meters;
- The surge tank located approximately 280 meters upstream of the power plant;
- The 5.00-meter diameter steel liner between the surge tank and the tunnel portal;
- The 47-km long transmission line from Isla Pablon to the La Chorrera Substation.

Other minor modifications and costs will also be required to implement the hydropower component of the project, but are not considered in detail at this level. These include the power intake structure and its equipment, the tailrace and the access and site preparation.

The powerhouse and hydroelectric equipment costs are dependent on the selected installed capacity and the subject of this selection. As indicated previously, the plant capacity used for the purpose of computing the energy production will not be the actual plant capacity of the power plant: for the purpose of cost estimating it is assumed that the power plant will have a plant factor of approximately 65%.

The proposed hydroelectric scheme substitutes the outlet structure proposed for the water-only with a set of two Howell-Bunger-type valves located in the powerhouse under the erection\service bay. The valves will meet the discharge requirement established by the ACP:

- Capable of discharging 98 m^3/sec when the reservoir is full, i.e., at El.80.0; and,
- Capable of discharging 50 m^3/sec when the reservoir at the minimum operating level at El.40.0.

Two 2.00-meter diameter axial flow control valves will be capable of meeting that requirement even when the turbines are not generating. The costs of these valves, the penstocks leading to them and the two guard valves (2.20-meter diameter butterfly valves) have been included in this comparative evaluation; an estimate of the outlet work for the water-only scheme has been deducted from the total cost. A summary of the cost estimate of the Isla Pablon hydroelectric component for a range capacity is presented on Table 16 below; additional details are presented in Attachment 4. The cost of transmission to La Chorrera and the work needed at the existing switchyard have not been included in Table 16 below. The total costs for that work including 20% contingencies and 10% for engineering and administration are estimated to be $4,588,000; a detailed computation is shown in Attachment 4.

Table 16 – Isla Pablon Hydropower Component Costs ($,000)

	8.4-MW	11.2-MW	14.0-MW	16.8-MW	19.6-MW
Transfer Tunnel Increase Diameter	$2,971	$2,971	$2,971	$2,971	$2,971
Water-Only Outlet Work	($2,082)	($2,082)	($2,082)	($2,082)	($2,082)
Surge Tank	$2,607	$2,607	$2,607	$2,607	$2,607
Tunnel Steel Liner	$1,391	$1,391	$1,391	$1,391	$1,391
Powerhouse Structure	$1,720	$1,902	$2,109	$2,263	$2,437
Powerhouse Equipment	$7,856	$8,741	$9,560	$10,369	$10,922
115-kV Substation	$1,084	$1,144	$1,234	$1,383	$1,532
Subtotal	$15,547	$16,674	$17,790	$18,902	$19,779
Contingencies (20%)	$3,109	$3,335	$3,558	$3,780	$3,956
Engineering & Administration (10%)	$1,866	$2,001	$2,135	$2,268	$2,373
Total Cost	$20,552	$22,010	$23,483	$24,951	$26,108

Río Indio Power Plant

The Río Indio power plant will be built at the downstream end of a tunnel located in the dam right abutment. The 250-meter long tunnel will slope down from an intake invert level at El 37 to an outlet at approximately El.12.0. The tunnel outlet will be located slightly downstream of the toe of the dam, to the left of the proposed spillway chute. For the purpose of estimating the cost of hydroelectric development at the dam site a range of installed capacity covering Strategies No.1 and No.3a were considered.

All power plants include a small size turbine (2.5-MW) to accommodate power generation with the release through the Rio Indio dam when most of the water is transferred into the Lake Gatun. The total installed capacity evaluated ranged from 2.5-MW to 18.4-MW, with a small unit and one, two or three larger size units. The tunnel has been sized to result in a maximum water velocity of 4.20 meter per second but in no case it will have a finished D-shaped cross section smaller than 2.50-meter diameter. For the smaller size plant (2.5 MW), it has been estimated that a concrete plug will be built in the tunnel at the location where it crosses the dam axis; the water will be conveyed to the power plant via a 1.20-meter diameter steel penstock inside the tunnel. For all the other size plants, the tunnel will be steel lined for approximately the last 130 meters. An embedded penstock and manifold will be located between the tunnel portal and the power plant.

The plant will also house a 0.40-meter diameter axial valve to release water when the turbine may be inoperable either for maintenance or if the reservoir is below the minimum level for hydropower operation estimated at El.46. Water will be released from the powerhouse into the Río Indio downstream of the cofferdam via a short (50-meter) tailrace channel with bottom level at El. 4.0, approximately.

Also included in the costs, are the costs of the transmission system between the Indio dam site and the Isla Pablon substation. It has been determined that a 13.8-kV transmission line could carry energy over the 12.6-km distance from Indio to Pablon for a maximum installed capacity of approximately 2.5 MW. For this capacity the transformer and substation costs would also be eliminated, as the powerhouse would be equipped with an indoor 13.8-kV switchgear. For larger power plant, a substation and a 115-kV transmission will be required. A summary of the cost estimate for the Río Indio hydroelectric power plant, for a range of capacities, is presented on Table 17 below; additional details are presented in Appendix D.

Table 17 – Río Indio Hydropower Component Costs ($,000)

Total Installed Capacity	2.5-MW	6.4-MW	11.1-MW	15.9-MW	18.3-MW
Unit Sizes	One 2.5-MW	One 2.5-MW One 3.9-MW	One 2.5-MW Two 4.3-MW	One 2.5-MW Two 6.7-MW	One 2.5-MW Three 5.3-MW
Power Intake	$1,059	$1,176	$1,251	$1,524	$1,678
Power Tunnel and Penstock	$1,225	$1,377	$1,440	$2,025	$2,168
Tailrace Channel	$32	$37	$45	$52	$54
Powerhouse Structure	$280	$464	$726	$877	$1,037
Powerhouse Equipment	$2,360	$5,006	$7,141	$8,184	$9,649
Transmission System to Pablon	$208	$1,690	$1,825	$2,064	$2,064
Subtotal	$5,164	$9,751	$12,429	$14,726	$16,650
Contingencies (20%)	$1,033	$1,950	$2,486	$2,945	$3,330
Eng. & Administration (10%)	$620	$1,170	$1,491	$1,767	$1,998
Total Cost	$6,816	$12,871	$16,406	$19,438	$21,978

4.5 Comparison of Alternatives

For each of the strategies, the hydropower developments were optimized both at the Río Indio site and at the Isla Pablon site. The optimization consisted in determining the Internal Rate of Return (IRR) for each scheme based the construction cost of the hydropower component, the stream of revenues (energy and capacity) and the cost of operation and maintenance over the life of the project. It is estimated that the hydropower component of the project will be built in two and one half years and be completed by the end of 2010. It is also assumed for the purpose of projecting revenues that the Indio reservoir will have been filled by that time. The revenues component were calculated on the basis of current value of energy and capacity as presented in the power market study, and as per conversation with the ACP power division. These include the sale of energy at $45 per MWh and of firm capacity at the rate of $60 per KW-yr.

The operation and maintenance costs were estimated on the basis of the construction cost as follows:

- 0.5% of the civil costs;
- 1.25% of the equipment costs; and,
- 1.0% of the transmission line costs.

In addition, it is also assumed that 75% of the equipment cost is to be replaced after 30 years of operation.

For the Isla Pablon project, the calculated IRR are shown on Table 18 and Table 19. It should be noted that the construction costs do not include the cost of the 47.1 km of transmission line from the Isla Pablon to the La Chorrera substation. Detailed computations are shown in Attachment 5.

Table 18 – Strategy No.1 – Isla Pablon Power Plant

Installed Capacity	Construction Cost	O&M Annual Cost	Average Annual Energy (GWh)	Internal Rate of Return
8.4 – MW	$20,522,000	$170,000	35.4	9.0%
11.2 – MW	$22,009,000	$186,000	41.1	11.5%
14.0 – MW	$23,482,000	$200,000	43.0	12.2%
16.8 – MW	$24,951,000	$215,000	43.3	11.9%
19.6 - MW	$26,108,000	$226,000	43.4	11.7%

From the value shown on Table 18, a 14.0-MW power plant consisting of two 7-MW units at the end of the transfer tunnel would be recommended for strategy No.1.

Table 19 – Strategy No.3a – Isla Pablon Power Plant

Installed Capacity	Construction Cost	O&M Annual Cost	Average Annual Energy (GWh)	Internal Rate of Return
8.4 – MW	$20,522,000	$170,000	29.8	4.3%
11.2 – MW	$22,009,000	$186,000	32.2	4.5%
14.0 – MW	$23,482,000	$200,000	32.9	4.3%
16.8 – MW	$24,951,000	$215,000	33.0	3.9%
19.6 - MW	$26,108,000	$226,000	33.1	3.7%

Under Strategy No.3a, the best IRR is obtained with a 11.2-MW; it is however so low that it is doubtful that any power plant could be considered at the end of the transfer tunnel if a strategy which favors energy production at the Río Indio dam were to be followed. For that reason, if Strategy No.3a were to be followed, no hydropower development would recommended at the end of the transfer tunnel.

For the Río Indio project the rate of return of the hydro component under strategy No.1 is also relatively low (see Table 20); however the installation of a single small unit appears justified on the basis that the reservoir guarantees a minimum release flow for the entire life of the project. Further optimization of the unit size may be required for strategy No.1 when the mode of operation of the reservoir is finalized. At this stage a single 2.5-MW unit would be recommended for Strategy No.1. It should be noted that for the Río Indio hydro component the cost of transmission, between the dam site and the Isla Pablon substation including the Río Indio substation if required, is included in the cost of construction shown in Table 20 and Table 21. The transmission line voltage would be 13.8 kV for the 2.5-MW power plant and 115 kV for all others.

Table 20 – Strategy No.1 – Río Indio Power Plant

Installed Capacity	Construction Cost	O&M Annual Cost	Average Annual Energy (GWh)	Internal Rate of Return
2.5 – MW	$6,816,000	$57,000	10.4	7.5%
6.4 - MW	$12,871,000	$118,000	10.6	2.7%

Table 21 presents the Internal rate for the Río Indio power component under Strategy No.3a. The 15.9-MW power plant shows the best return of 13.6%

Table 21 – Strategy No.3a – Río Indio Project

Installed Capacity	Construction Cost	O&M Annual Cost	Average Annual Energy (GWh)	Internal Rate of Return
2.5 – MW	$6,816,000	$57,000	12.2	11.2%
6.4 – MW	$12,871,000	$118,000	15.3	8.4%
11.1 – MW	$16,406,000	$155,000	19.6	11.5%
15.9 – MW	$19,438,000	$181,000	22.7	13.6%
18.4 - MW	$21,978,000	$207,000	23.4	12.0%

In order to select the best strategy and the associated power plant, the cost of transmission to the La Chorrera substation should be included. For either strategy it consists of the 47.1 km of 115-kV transmission line between Isla Pablon and La Chorrera, and the work in the La Chorrera switchyard. The total cost of that work including contingencies and engineering and administration is estimated to be $4,588,000. The comparison of the two strategies is shown on Table 22 below: as previously noted Strategy No.3a is presented without development at Pablon as this development would significantly lower the internal rate of return of that strategy.

Table 22 – Comparison of Alternatives

	Hydropower Component	Construction Cost	O&M Annual Cost	Annual Energy (GWh)	Internal Rate of Return
Strategy No.1	Indio 2.5–MW	$6,816,000	$57,000	12.2	9.1%
	Pablon 14.0-MW	$23,482,000	$200,000	43.0	
	Transmission	$4,588,000	$45,000	-	
Strategy No.3a	Indio 15.9–MW	$19,438,000	$181,000	22.7	9.0%
	Transmission	$4,588,000	$45,000	-	

On the basis of the table presented above the two strategies yield a similar rate of return. Although the rate of return may be insufficient to justify the project, it should be noted that no benefits where accounted for the energy production associated with further development of the Panama Canal expansion. Water transferred from projects such as Caño Sucio, Toabre and/or Cocle del Norte would directly benefit the hydropower component of the project at no additional development costs.

On that basis Strategy No.1 is recommended as it produces nearly 2.5 times the energy produced under Strategy No3.a over the life of the project. Furthermore for the initial period from 2011 to 2028, the excess water transferred from Indio to Gatun would be used to generate at the Gatun power plant: the energy so produced is estimated to be approximately 190 GWh. It should also be noted that as the Canal expansion proceeds with additional reservoirs, they would further favor the Isla Pablon project as the intent would necessarily be to transferred more water into Lake Gatun.

5 RECOMMENDED SCHEME

5.1 General

The primary objective of the project is water supply for the Lake Gatun, in order to provide hydropower facilities several additions and modifications to the project are required. These are:

1. Modify the transfer tunnel intake structure to provide trash screen compatible with turbines, and provide a trash rake to keep the intake clear of trash.
2. Enlarge the transfer tunnel cross section to reduce friction losses for satisfactory operation of generating equipment and flow regulating valves under a wide range of heads and flows.
3. Eliminate the transfer tunnel outlet facility and equipment and replace it with a powerhouse that will serve both the requirements of power generation and the transfer of water.
4. Add a surge tank near the downstream end of the long transfer tunnel to allow normal start/stop and regulation of the turbines on load.
5. Modify the minimum release facility at the dam to include a separate short tunnel through the right abutment of the dam to serve both minimum water releases and power generation.
6. Add the minimum release intake which include a trash screen and trash rake.
7. Add a powerhouse at the toe of the dam that will serve both the requirements of power generation and the minimum release of water.

It is not clear how it was originally intended to serve electric power needs at transfer tunnel intake, transfer tunnel outlet and at Río Indio dam. However, as part of the hydropower development the following facilities would be added:

1. A transmission line to connect the powerhouse at the end of the transfer tunnel with the Panama national grid;
2. A switchyard near the end of the transfer tunnel;
3. Additional bays at the existing La Chorrera substation
4. A transmission line interconnecting the two powerhouses
5. A line feeding the transfer tunnel intake area from the Río Indio powerhouse.

5.2 Isla Pablon Power Plant

5.2.1 Civil Works

Intake Structure

The intake of the transfer tunnel for the water-only project would provide coarse screening sufficient for transfer of water through the large openings of the sliding gates at the tunnel outlet. This facility is accessible only when the reservoir was at minimum pool, El. 40. However, for the purpose of hydropower a much more trash free water is required hence a fine screen is provided which must be frequently cleaned.

To support this equipment an intake structure is provided. It is a reinforced concrete structure with a foundation at El.30 attached to the tunnel portal and extended to El.85. The lower portion will be anchored to the excavated rock slope and the upper portion will be free standing. The top of the structure will form a working platform for the trash rake and trash removal. The platform will be connected to the reservoir shoreline by a reinforced concrete bridge supported by intermediate piers. (See Exhibit E7)

The intake structure is adjacent to the top of the transfer tunnel gate shaft at El.85. This area will be served by an access road and requires a small control building to house the power and control equipment for the intake and tunnel gates as well as space for the operation and maintenance staff.

Transfer Tunnel

It has been determined that a 4.35 meter diameter tunnel is required to maximize the benefits of the transferred water from Indio to Lake Gatun for the purpose of navigation water supply. This is not compatible with the development of hydropower at the end of the transfer tunnel. The tunnel must be enlarged for proper operation of the hydroelectric plant. A diameter of 5.0 meter was selected on the basis of technical and economical consideration. The last 250 meters downstream of the surge tank will be a 5.00-meter diameter steel lined tunnel, leading to and embedded penstock and manifold immediately upstream of the powerhouse.

Powerhouse/Tunnel Outlet

The proposed tunnel outlet structure for water transfer will be modified. The bonneted sliding gates will be eliminated and replaced by power generating equipment and axial flow control valves located in the proposed powerhouse. This equipment is described in more detail in the following section.

A steel penstock and a steel manifold with three branches will connect the tunnel portal to the proposed powerhouse located some 75 meter downstream. The powerhouse will be a conventional 40-meter by 18-meter reinforced concrete structure founded on rock with the deepest point at El.18 and the erection bay at El.34. The superstructure will be made of structural steel with metal cladding. The powerhouse will house the mechanical and electrical equipment in three bays and on three levels below grade. The superstructure will support a 30-ton gantry crane with rails mounted on El.41.

The two turbines and the axial flow control valves will discharge into an excavated tailrace channel approximately 40 meter wide and 400 meters long and 15 meter deep.

Surge Tank

The addition of hydraulic turbines at the end of the long transfer tunnel can result in rapidly changing flow conditions in the tunnel and the undesirable pressure fluctuations or water hammer. To protect the tunnel from the excessive pressure rise as well as to limit the turbine/generator speed rise, each unit is provided with a pressure relief valve.

However, in order to provide for a reasonable unit starting time and stable operation while on load, a surge tank of substantial dimensions is also required. The surge tank will be of reinforced concrete construction located about 250m upstream of the powerhouse where the topography is favorable for its construction, and it will be connected directly to the tunnel. It will consist of a vertical shaft with cross-sectional areas of approximately 350 m^2 (equivalent to approximately 21-meter in diameter) from El.30 to El.74 and 1,260 m^2 (40-meter diameter) from El.75 to El.88.

5.2.2 Mechanical And Electrical Equipment

Intake

The transfer tunnel is designed to meet the Panama Canal navigation requirements. The tunnel intake gates and stop logs remain unchanged and hence are not included in our estimate.

The tunnel intake will include a trash screen consisting of four bays, each with two 4-meter by 2-meter removable screen panels and associated supports and guides. At the top of the concrete intake structure a rail mounted trash rake will be provided. The trash rake will also serve to install and remove the trash screen panels.

A 13.8-kV transmission line from the Río Indio powerhouse will be provided to serve the equipment of transfer tunnel intake. This line will terminate at a three-phase oil filled 200-kVA step-down transformer. Power will be distributed at 480 volts to the intake gates and trash rake power and control equipment as well as to the incidental power and lighting of the intake area. A 100-kW stand –by diesel generator will be provided to serve critical loads during power outages.

Powerhouse

Main Inlet Valves

At the end of each penstock branch a butterfly valve will be provided in the powerhouse. Two 1.90-meter diameter inlet valves will serve the two turbines and two 2.70-meter diameter inlet valves will serve as guard valves for two axial flow control valves. Inlet valves will be provided with the required hydraulic power units and control devices, and the various tapings for filling and draining of the associated waterways.

Turbine/Generator Units

For this powerhouse we have selected two turbine/generator units rated at 7 MW each. The turbine is of the vertical shaft Francis type with a runner diameter of 1.50 meters and a steel spiral case. The runner centerline is tentatively set at El. 24.5m or 0.6m above minimum water level at lake Gatun. The synchronous generator will be rated at 7,800 kVA, 360-rpm, 13.8-kV, 0.9 pf and will be directly coupled to the turbine.

Turbine/Generator Auxiliaries

Each unit will be provided with the necessary auxiliaries such as bearings, servomotor, hydraulic power unit, digital governor, cooling water system for turbine bearing, shaft seal and generator bearings and coolers, lubricating oil system, excitation system, voltage regulator, automatic synchronizer, brakes, and SCADA and protection system.

Axial Flow Control Valves
Each turbine/generator unit will have one 1.30-meter diameter axial flow control valve for turbine regulation, which will be connected to the spiral case inlet section and will discharge directly into the tailrace. This valve will also operate in a synchronous by-pass mode to provide uniform water flow during varying power generation requirements.

To provide for water transfer capability at times when turbine/generator units are not available due to head limitations or for other reasons, two additional 2.0 meter diameter axial flow control valves will be provided. Each will be fed through a separate penstock branch, a main inlet valve described above, and associated waterways.

All axial flow control valves will be provided with their operating and control devices and will be accessible by crane thru openings in the draft tube deck.

Draft Tube Gates
Each unit will have two welded steel sliding gates 2.40 meters wide and 1.60 meters high to allow for unit and tunnel dewatering. The semi-gantry crane provided at the draft tube deck will handle the draft tube gates.

Cranes
A 30-ton bridge crane spanning the powerhouse and running on rails located at El.41.0 will be provided to handle turbine and generator components and inlet valves during erection and maintenance. An 18-ton semi-gantry crane will be provided at the draft tube deck to handle the turbine draft tube gates and all four of the axial flow control valves.

Dewatering system
The dewatering system will consist of two dewatering pumps and two station drainage pumps in a centrally located station sump pit, and associated piping and valves to enable dewatering of each turbine independently or to dewater the whole system including the transfer tunnel. To prevent powerhouse flooding pumps will be sized to cope with failure of largest penstock tapping in the powerhouse and upstream of main inlet valves.

13.8-kV Switchgear
The generating voltage will be 13.8-kV, so a line-up of metal clad 13.8-kV switchgear will be provided. It will include the two generator main circuit breakers, one main power transformer circuit breaker, a circuit breaker for the station service transformer and one circuit breaker for the 13.8-kV tie line between Isla Pablon powerhouse and Río Indio powerhouse. The switchgear will be connected to the generators, transformers and tie line

take-off by bus ducts or cables. Switchgear will be provided with all associated control and protection devices.

Transformers
One Main Power Transformer to serve both generating units will be provided. It will be located adjacent to the powerhouse and connected to the switchyard by overhead line.
The main power transformer will be a three-phase oil filled step up transformer 13.8kV/115kV rated 15/20-MVA OA/FA. A Station Service Transformer, located next to the main power transformer, to serve power requirements in the area, will be provided. The transformer will be a three-phase oil filled step down transformer 13.8kV/480V rated 1000 kVA.

Station Auxiliaries
Other station auxiliaries will include a 250-kW stand-by diesel generator, station battery, lighting system, HVAC, fire alarm and protection, communication, grounding and lightning protection.

5.3 Río Indio Power Plant

5.3.1 Civil Works

Power Tunnel
Before the construction of the Río Indio dam a diversion tunnel will be constructed at the site. After construction this tunnel will serve as the low level outlet for draw down of the reservoir in emergencies.

Due to the very low position of the diversion tunnel intake, this tunnel cannot easily be adapted for power generation. A separate minimum release tunnel will be built in the right abutment of the dam. The 250-meter long tunnel will be 2.50-meter diameter D-shaped section or the minimum size that can be constructed with conventional equipment. It will have the intake invert at El 37.0 and invert of downstream portal at about El 12.0 where it will be connected to a steel penstock with a bifurcation feeding the powerhouse. The tunnel will be reinforced concrete lined with a concrete plug at the right of the dam centerline. A 4.00-meter diameter gate shaft will be excavated from a platform at El.86m near the tunnel intake to intercept the tunnel where a 2.00-meter by 1.00-meter wheeled gate will be installed.

Power Intake
At the upstream end of the power tunnel an intake structure will be provided to allow installation of intake screen compatible with the turbine operation and to maintain the intake screen free using the trash rake. The intake structure will be of reinforced concrete construction connected to the tunnel with the foundation at about El.35 and anchored to the excavated rock face. The intake structure will have the supports and guides for the 4.00-meter by 2.00-meter intake screen. It will be topped by a concrete platform at El

84.0 where a fixed position trash rake will be mounted. An access ramp will be provided to El 90.0.

Río Indio Powerhouse

The Río Indio powerhouse will be located at the foot of the dam on the right bank of the existing river channel. It will contain one 2.5-MW turbine/generator unit and one axial flow control valve for minimum release.

A 1.20-meter diameter steel penstock, a steel bifurcation and two steel branches will connect the tunnel plug at the dam centerline to the equipment in the proposed powerhouse. The powerhouse will be a conventional 16m x 10m reinforced concrete structure founded on rock with the deepest point at about El.3 and the erection bay at El.13. The superstructure will be of structural steel with metal cladding. The plant will house the mechanical and electrical equipment in two bays and on two levels below grade. The superstructure will support a 12-ton semi-gantry crane with rails mounted on El 16.0 and 13.0.

The turbine and the axial flow control valve will discharge into an excavated tailrace channel approximately 16-meter wide, 70-meter long and 8-meter deep.

5.3.2 Mechanical And Electrical Equipment

Power Intake

A tunnel of 2.50-metre diameter (minimum diameter that can be excavated by conventional means) is required at the Río Indio dam location to provide for minimum releases into the river. The tunnel will be provided with wheeled slide gate and hoist at the intake shaft. This tunnel will also serve the powerhouse with one 2.5-MW turbine/generator unit at its downstream end. For this purpose a trash screen and a trash rake are required at the tunnel intake. The trash screen will be a single bay with a 2-meter by 4-meter removable screen panels and associated supports and guides. At the top of the concrete intake structure, a fixed position trash rake will be provided, which will also serve to install and remove the trash screen panels.

The intake area will be provided with 480-volt power, from the powerhouse downstream of the dam, for the power and control requirements of the minimum flow tunnel gate and intake as well as those of the low-level outlet tunnel gates.

Powerhouse

At the downstream end the minimum release tunnel will be connected to the proposed powerhouse by a steel penstock and a bifurcation. The main branch will be 1.00-meter diameter feeding the 2.5-MW unit and the other branch will be 0.50-meter diameter feeding the axial flow control valve to serve as the minimum release by pass valve.

Main Inlet Valves
Two main inlet valves will be provided: a 1.00-meter diameter butterfly valve for the turbine/generator unit and a 0.50-meter diameter butterfly valve for the axial flow control valve. Inlet valves will be provided with the required hydraulic power units and control devices, and the various tapings for filling and draining of the associated waterways.

Turbine/Generator Unit
The turbine is of the horizontal shaft Francis type with a runner diameter of 0.80 meter and a steel spiral case. The runner centerline is tentatively set at El. 7.5 or 2.1 meters above minimum tail water level in the Río Indio. The synchronous generator will be rated at 2,777 kVA, 600 rpm, 13,8 kV, 0.9 pf and will be directly coupled to the turbine.

Turbine/Generator Auxiliaries
The unit will be provided with the necessary auxiliaries such as bearings, servomotor hydraulic power unit, digital governor, cooling water system for turbine bearing, shaft seal and generator bearings and coolers, lubricating oil system, excitation system, voltage regulator, automatic synchronizer, brakes, and SCADA and protection system.

Axial Flow Control Valve
To provide for minimum release capability at times when turbine/generator unit is not available due to head limitations or for other reasons, a 0.40-meter diameter axial flow control valve will be provided. It will be fed through a separate penstock branch, a main inlet valve described above, and associated waterways. The axial flow control valve will be provided with operating and control devices and will be accessible by crane thru opening in the draft tube deck.

Draft Tube Gate
The unit will have a welded steel sliding gates 2.65m wide and 1.0 m high to allow for unit and tunnel dewatering. The semi-gantry crane provided in the powerhouse will handle the draft tube gate.

Crane
A 12-ton semi gantry crane spanning the powerhouse and running on rails located at elevations 16.0 and 13.0 will be provided to handle turbine and generator components, inlet valves as well as the draft tube gate and axial flow control valve during erection and maintenance.

Dewatering system
The dewatering system will consist a dewatering pump and a station drainage pump in a centrally located station sump pit, and associated piping and valves to enable dewatering of the turbine independently or to dewater the whole system including the minimum flow tunnel. To prevent powerhouse flooding pumps will be sized to cope with failure of largest penstock tapping in the powerhouse and upstream of main inlet valves.

13.8-kV Switchgear
The generating voltage will be 13.8 kV so a line-up of metal clad 13.8kV switchgear will be provided. It will include the a generator main circuit breaker, a circuit breaker for the station service transformer, one circuit breaker for the 13.8 kV tie line between Isla Pablon powerhouse and Río Indio powerhouse, one circuit breaker for the 13.8 kV line to the intake area of the transfer tunnel, and a circuit breaker for future local supply. The switchgear will be connected to the generator, transformer and lines take-off by cable. Switchgear will be provided with all associated control and protection devices.

Transformer
A Station Service Transformer, located near the powerhouse, to serve power requirements in the area, will be provided. The transformer will be a three-phase oil filled step down transformer 13.8 kV/480 V rated 200 kVA.

Station Auxiliaries
Other station auxiliaries will include a 100kW stand -by diesel generator, station battery, lighting system, HVAC, fire alarm and protection, communication, grounding and lightning protection.

5.4 Transmission System

The transmission system is depicted in the simplified one-line diagram in Exhibit F10, and includes the step-up transformer yard and 115-kV switchyard at the Isla Pablon site, the new 115-kV switchyard at La Chorrera substation and the single-circuit overhead transmission line connecting both switchyards.

Given the small generating capacity to be developed at the Río Indio site (2.5 MW) and its relatively close distance (12.6 km) to the Isla Pablon site, it is possible to tie both plants through a 13.8-kV transmission line, thus eliminating the need for a costlier step-up transformer. A 13.8-kV metal-enclosed indoor switchgear provided with five feeders and one incoming generator cubicle will be located inside the powerhouse. The switchgear will be provided with air-magnetic breakers, protections and metering. A general arrangement and layout dimensions of the 13.8-kV switchgear is shown in Exhibit F11.

The 13.8-kV tie between the two sites will be a single circuit supported on single reinforced concrete poles 14-16 m high with concrete block foundations. This tie line would be capable of transporting up to approximately to 2.5 MW. A separate 13.8-kV line, about 5 kilometers long will feed the power required at the transfer tunnel intake from the powerhouse at the Indio dam.

At the Isla Pablon site the main transformer yard adjacent to the powerhouse will contain one three-phase step-up transformer 13.8-kV/115-kV rated 15/20 MVA OA/FA capacity occupying an 8-meter by 15-meter area approximately. The high voltage connection between the main transformer and the 115-kV switchyard, 200 meters away, will be by an overhead transmission line segment of similar design as described further below.

The 115-kV switchyard for the Isla Pablon site will be located in a convenient level piece of land at El. 35.0. The land requirements to locate this open-air switchyard will be approximately 80 meters by 40 meters. The switching arrangement will be of single 115 kcmil bus where initially one 3-phase breaker bay and disconnects for the incoming transformer line and one outgoing line bay with disconnects only, will be installed with space provided for future 3-phase breaker installation. Space will also be provided for a third spare bay for a future line connection.

The station service at 480 volts will be provided via overhead line from the powerhouse where an emergency stand-by diesel-generating unit will also be installed. An unattended control house will be provided for the housing of the control, protection, metering and communication panels. The plan and section views of the switchyard are shown in Exhibits F12 and F13.

The transmission line that will connect the Isla Pablon switchyard with the receiving switchyard at La Chorrera substation will be designed and built for 115-kV operation with one circuit of three 266.8 kV 26/7 ACSR conductors capable of carrying in excess of the maximum combined Pablon and Indio plants.

The total length of the transmission line, including the segment between the main transformer and the switchyard, will be 47.1 km. The line route was over flown by helicopter and studied with the help of available geographic and topographic maps at various scales that depict the roads and main features of the land. Except for the last 3 kilometers approaching the Isla Pablon site showing more hilly and forested terrain, for the major part the terrain is of gentle topography with low hills showing marked signs of deforestation, traversed by dirt road accesses and few paved roads, where scattered buildings and little agricultural farming (pineapple, vineyards and fruit trees) and some large chicken houses are present. The area is accessible by land and of relatively easy line construction. The line route is shown in Exhibits F14, F15 and F16.

The shield wire and conductors will be supported by single shaft lattice steel towers with steel arms, each tower provided with four reinforced concrete caissons or spread footing and pier type foundations. The average height of the towers will be 25 meters for a normal span of 300 meters. A typical design for a single circuit tangent tower is shown in Exhibit F17.

The connection to the utility (ETESA S.A.) national grid will require the installation of a new 115-kV switchyard at La Chorrera 230-kV Substation owned by ETESA. This substation has at present two empty bays at 230 kV and also two operating 230/115/13.8 kV step-down transformers that feed a 34.5-kV distribution switchyard. However, the 115-kV yard has never been developed although land space has been provided for such purpose. ETESA does not have immediate plans to develop the 115 kV yard and is waiting for a private generator or the private distribution companies to generate the need for it. A connection for Río Indio at 115-kV would entail to build the 115-kV yard as part of this project cost.

Initially, the new 115-kV yard will require only the necessary breakers to connect the Río Indio transmission line and the two existing autotransformers to the switchyard busses; but the design should have provisions for ultimate breaker and a half scheme as this is ETESA's requirement. The new 115-kV switchyard will be of a breaker and a half switching scheme with one bay having two breakers and necessary disconnects to provide for the line connection and to bring in the connection of the 115-kV taps of the two existing autotransformers. Space is provided for the installation of a third breaker and associated disconnects in this bay, if and when a second line connection is required. Additionally, the two end busses and main supporting structures of this breaker and a half scheme will be extended to allow for a future second parallel bay provided as space only.

The outline dimensions of the 115-kV switchyard will be 40 meters by 60 meters. All auxiliary services will be provided from the existing substation services. The existing control room at La Chorrera substation has ample space to locate the necessary panels for relays, metering and communications. Typical plan and section views are shown in Exhibits F18 and F19.

6 PROJECT COST ESTIMATE

Detailed cost estimate of the hydropower component of the project are presented in Attachment 4 and are summarized below. The costs shown do not include the cost of access, general mobilization and other site preparation costs as the power component would be only a small portion of the Río Indio development and would not significantly affect these general costs.

An overall 20% contingency factor has been used, as there is limited available information on the topography, the geology and the geotechnical characteristics of the Isla Pablon site. It should be noted that contingencies on equipments and transmission line could be slightly lowered, while contingencies on the civil work component could be higher. An engineering and administration cost of 10% has been added to the overall construction cost.

The development cost of the hydropower component of the Río Indio Project, consisting of two power plants, one at the toe of the Río Indio dam equipped with one 2.5-MW unit, and the second at the downstream end of the transfer tunnel near Isla Pablon, equipped with two 7.0-MW units, would increase the overall cost of the project by an estimated amount of $34,889,000. This amount includes the costs of 12.6 km of 13.8-kV transmission line from the Río Indio dam to the Isla Pablon site, the cost of 47.1 km of 115-kV transmission line from Isla Pablon to La Chorrera substation, and the cost of the connection to the National Grid at the La Chorrera substation.

Estimated Development Cost

Isla Pablon Power Plant

Civil Works	
• Transfer Tunnel Diameter Increase to 5.00 meter	$2,971,000
• Water-Only Scheme Outlet Work	($2,082,000)
• Surge Tank	$2,607,000
• Tunnel Steel Liner	$1,391,000
• Powerhouse at Isla Pablon	$2,109,000
Subtotal	**$6,996,000**
Electrical & Mechanical Equipment	
• Tunnel Release Equipment	$1,800,000
• Generating Equipment	$5,460,000
• Auxiliary Powerhouse Equipment	$631,000
• Auxiliary Electrical	$1,669,000
• 115-kV Substation	$1,233,000
Subtotal	**$10,793,000**

Río Indio Power Plant

Civil Works	
• Power Intake	$697,000
• Power Tunnel and Penstock	$1,225,000
• Tailrace	$32,000
• Powerhouse at Río Indio	$280,000
Subtotal	**$2,234,000**
Electrical & Mechanical Equipment	
• Power Intake	$363,000
• Generating Equipment	$1,329,000
• Auxiliary Powerhouse Equipment	$288,000
• Auxiliary Electrical	$744,000
• 13.8-kV Transmission to Isla Pablon	$208,000
Subtotal	**$2,932,000**

Transmission System

• 115-kV Line from Pablon to LaChorrera	$2,321,000
• La Chorrera Substation	$1,155,000
Subtotal	**$3,476,000**
Subtotal	**$26,431,000**
Contingencies (20%)	$5,286,000
Total Estimated Construction Cost of Hydropower Component	$31,717,000
Engineering & Administration (10%)	$3,172,000
Total Estimated Development Cost	**$34,889,000**

7 ECONOMIC EVALUATION

The economic analysis presented in the comparison of alternatives shows an internal rate of return of 9.1%, for the recommended hydropower scheme, which is likely to be insufficient for development. It also shows that the IRR for the Isla Pablon plant alone is slightly higher than that for the Río Indio component: excluding the transmission line to La Chorrera it would have a return of 12.2%.

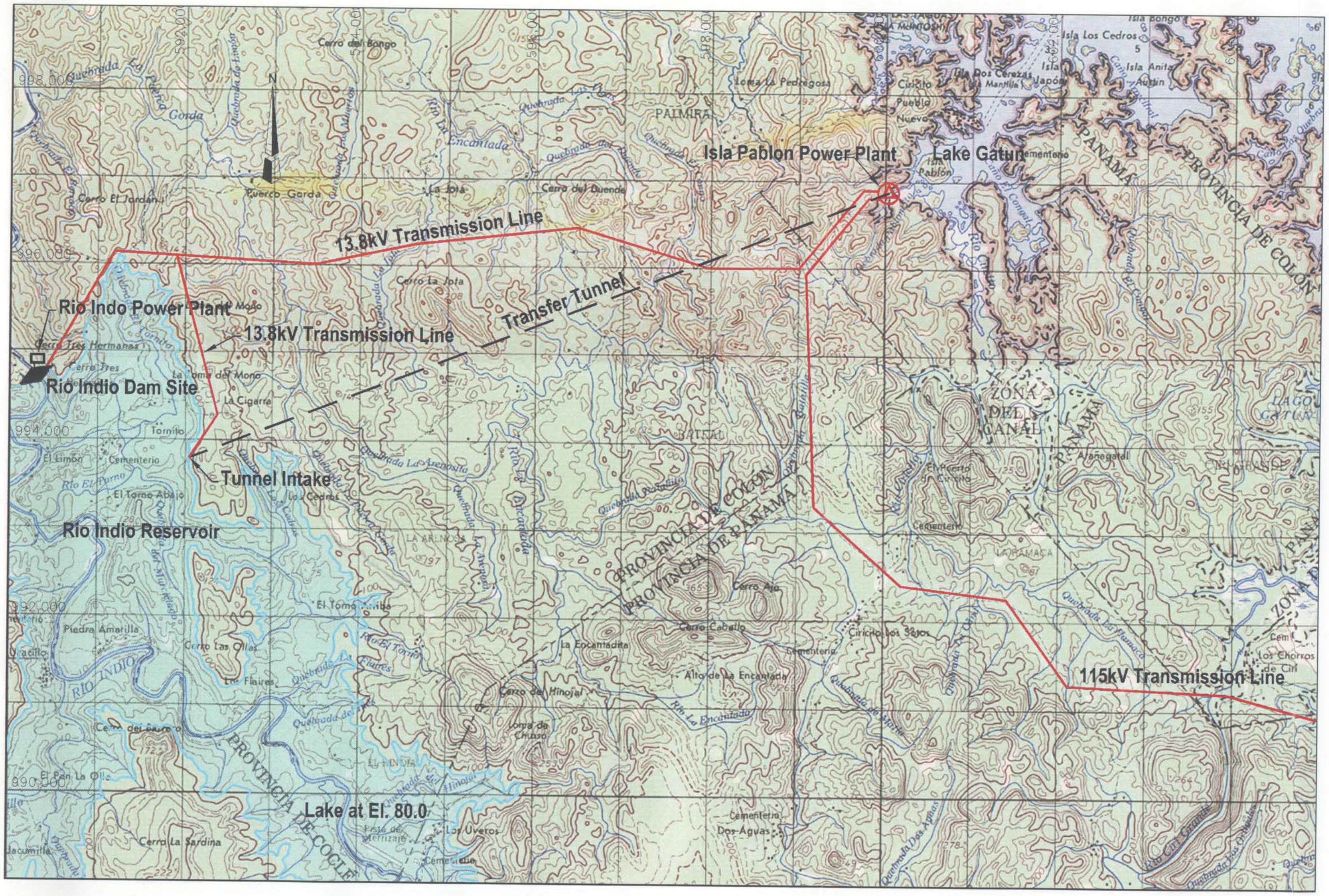
It should be noted that the 115-kV transmission line maybe used for any future development associated with the transfer of water into Lake Gatun. These developments could include hydropower at either Toabre or Cocle del Norte. Furthermore the Pablon plant would be capable of generating with any additional water that would be transferred from reservoirs at Caño Sucio, Toabre and\or Cocle del Norte. For example, the transfer of an average 10 m^3/sec in addition to that presently contemplated would increase the annual energy production after 2029 at Pablon from 33.7 to 51.6 GWh per year and result in a present IRR of 12.8%.

A sensitivity analysis of the rate of return to the costs of development and the value of energy is presented in Table 23 below.

Table 23 – Sensitivity Analysis

Variables	Internal Rate of Return
Base Case	9.1%
General Costs Increased by 10%	7.8%
Civil Works Costs Increased by 20%	8.2%
Equipment Costs Increased by 20%	7.4%
Civil Works Costs Increased by 10%	8.6%
Equipment Costs Increased by 10%	8.2%
Civil Works Costs Reduced by 10%	9.5%
Equipment Costs Reduced by 10%	10.0%
General Costs Reduced by 10%	10.6%
Value of Energy and Power Reduced by 20%	6.3%
Value of Energy and Power Reduced by 10%	7.7%
Value of Energy and Power Increased by 10%	10.4%
Value of Energy and Power Increased by 20%	11.7%

EXHIBITS



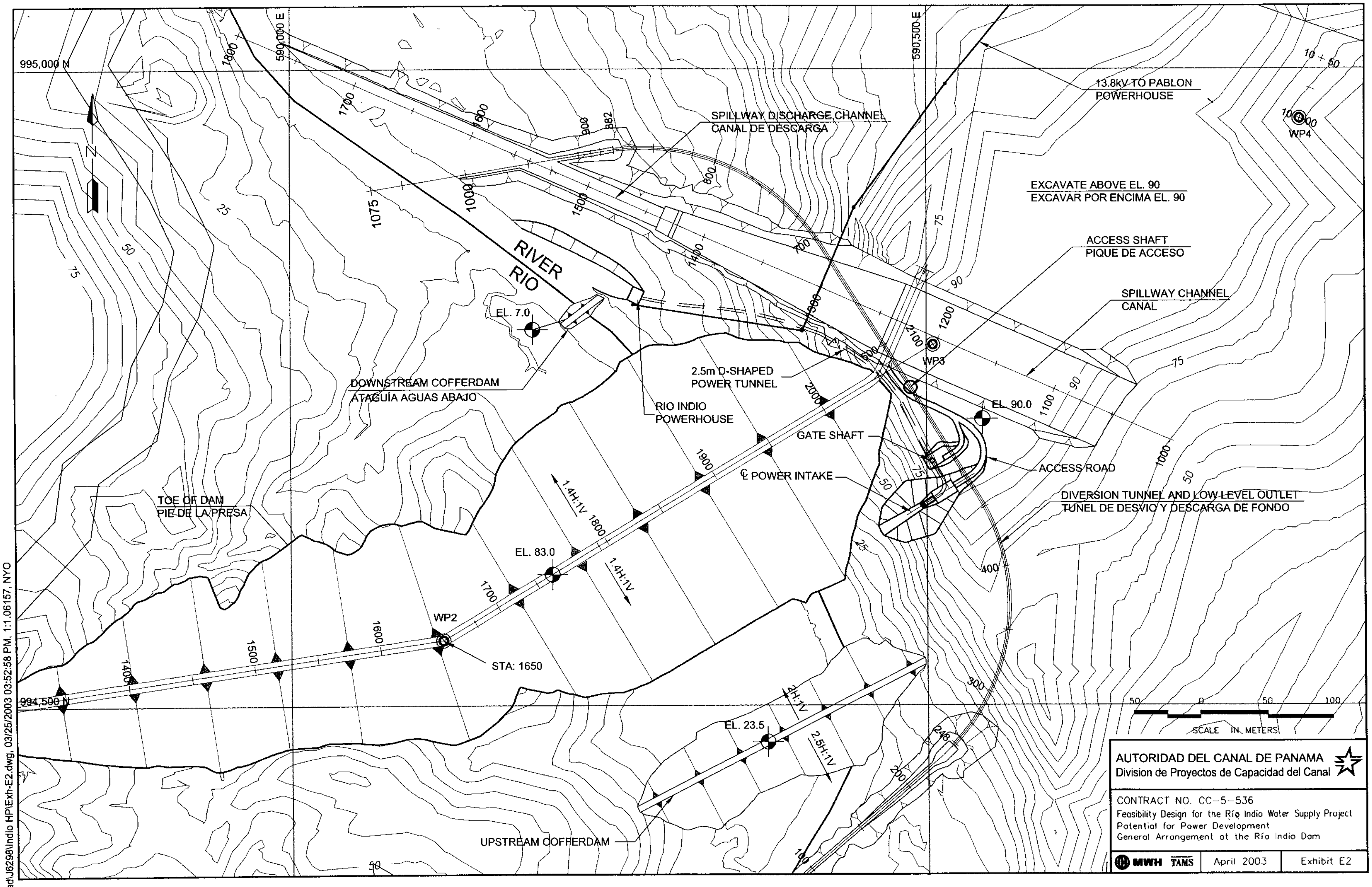
1000 0 1000 2000

SCALE IN METERS

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Potential for Power Development
Location Map

MWH TAMS	April 2003	Exhibit E1



AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Potential for Power Development
General Arrangement at the Río Indio Dam

MWH TAMS | April 2003 | Exhibit E2

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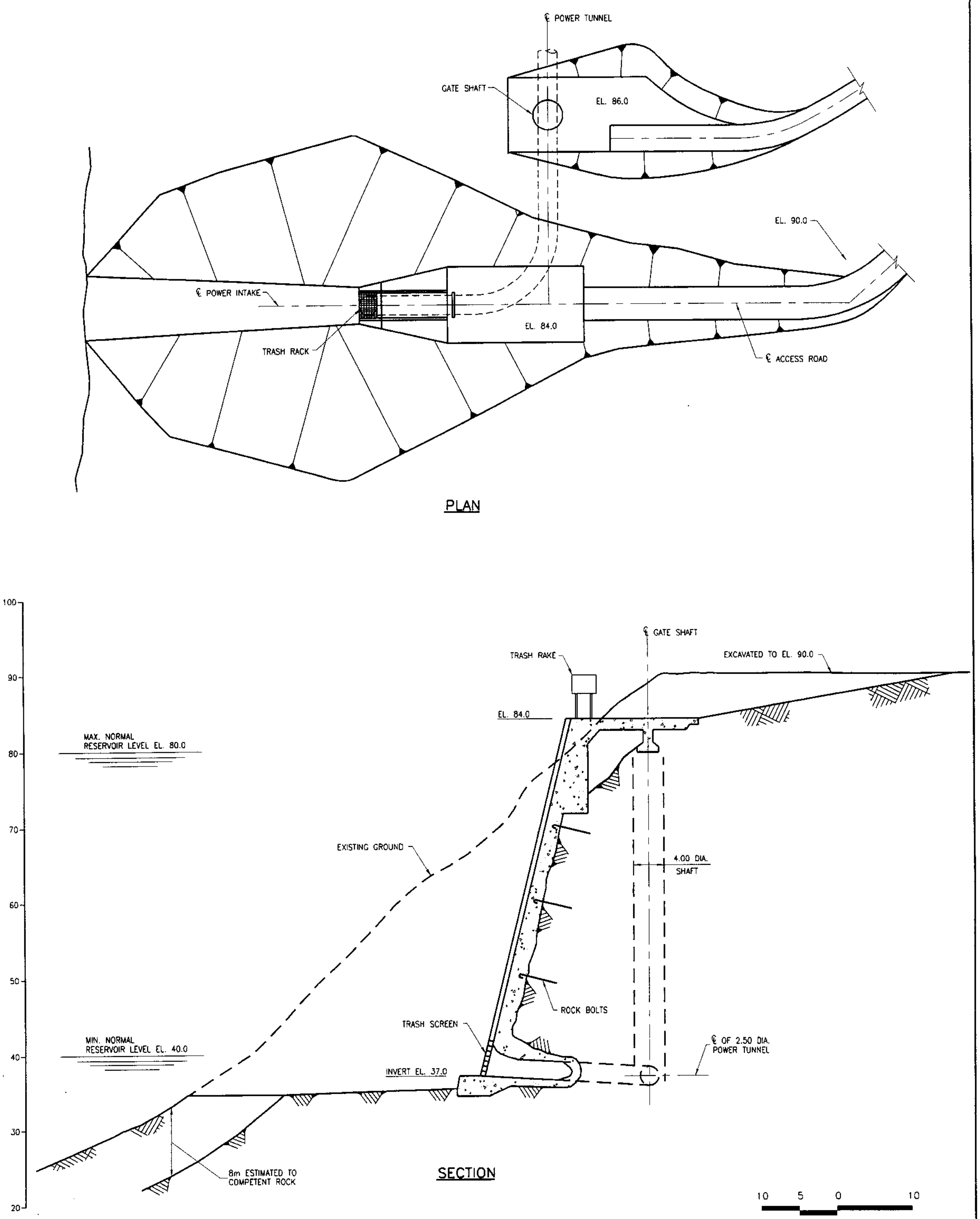
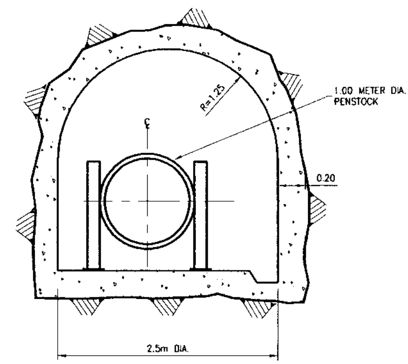


AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

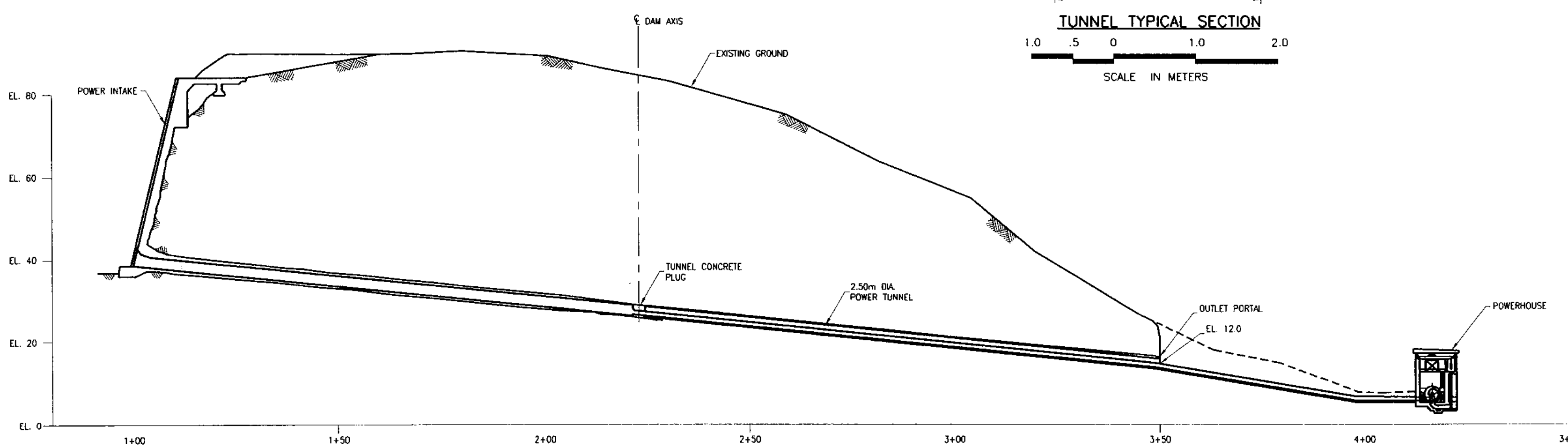
CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Potential for Power Development
Power Intake at the Río Indio Dam
Plan and Section

MWH TAMS | April 2003 | Exhibit E3



TUNNEL TYPICAL SECTION

1.0 .5 0 1.0 2.0
SCALE IN METERS



TUNNEL PROFILE

20 10 0 20 40
SCALE IN METERS

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Potential for Power Development
Power Tunnel at Rio Indio Dam Site
Profile and Section

MWH TAMS | April 2003 | Exhibit E4

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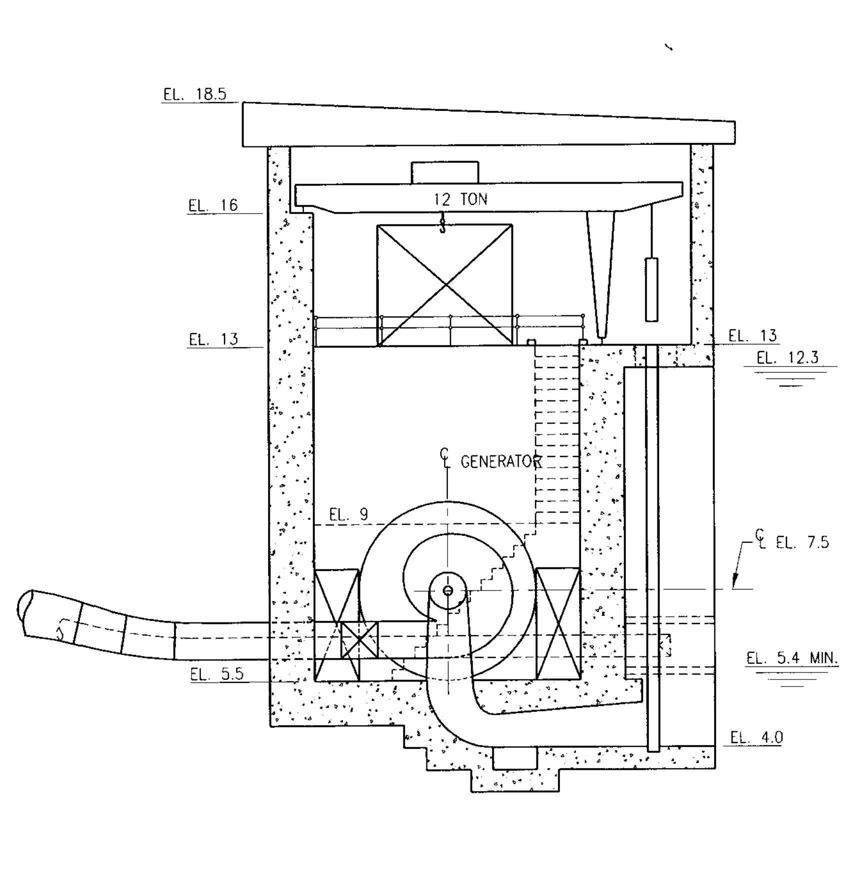
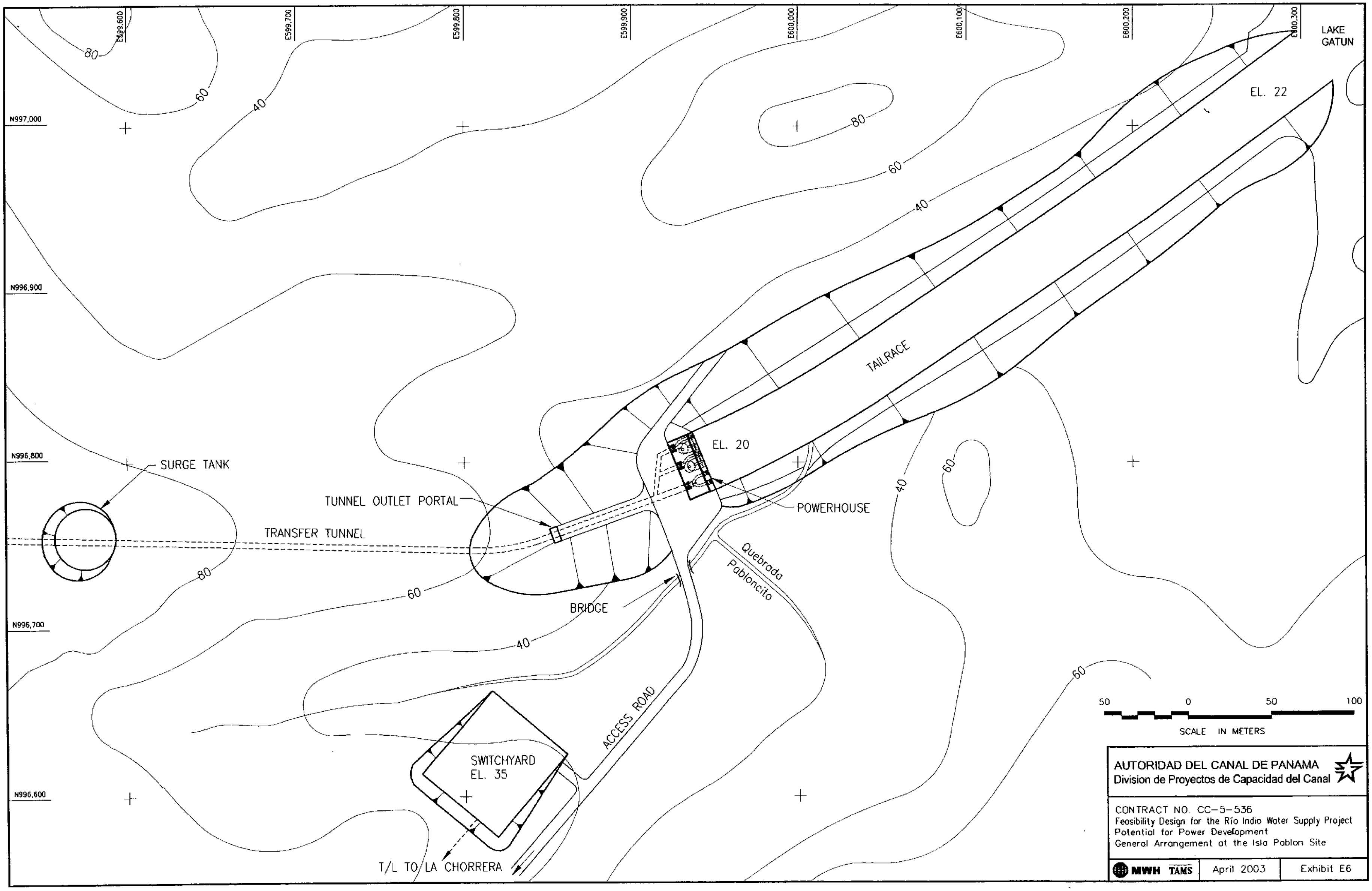


AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Potential for Power Development
Powerhouse at the Río Indio Dam Site
Plan and Section

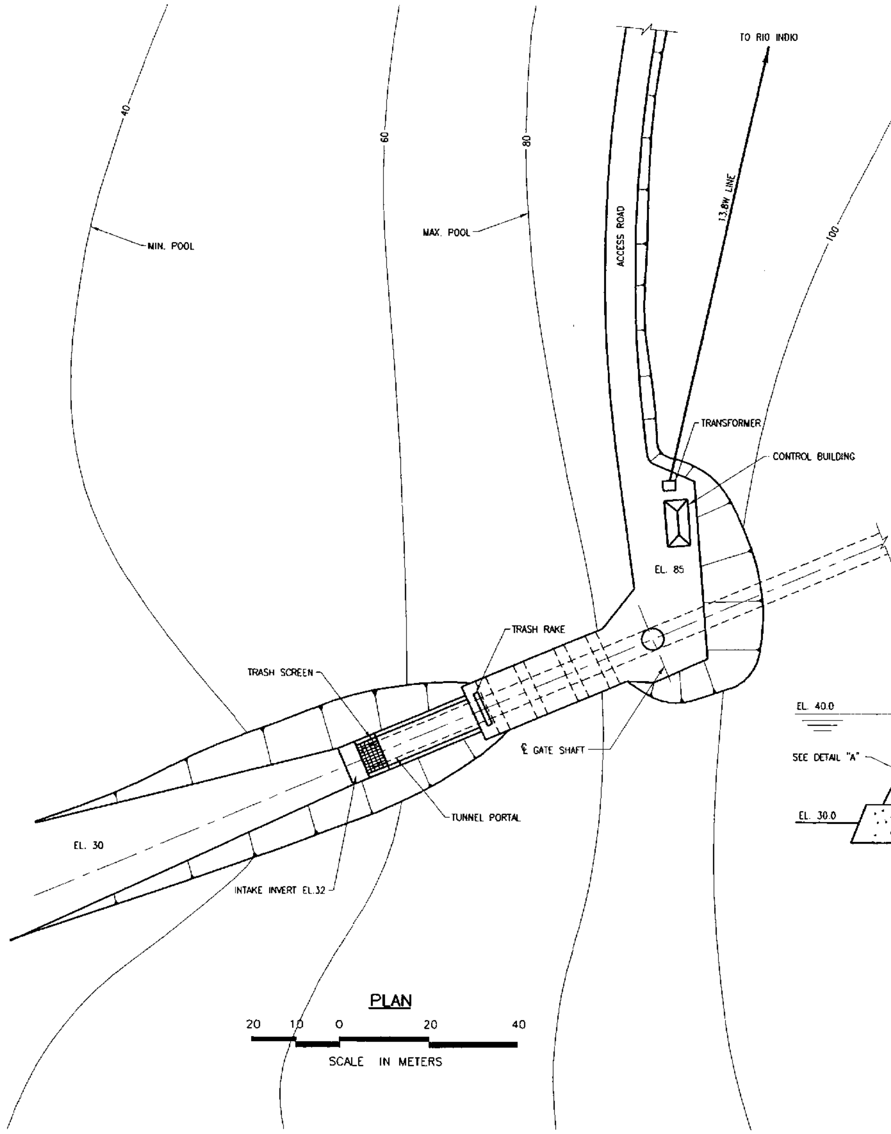
MWH TAMS | April 2003 | Exhibit E5

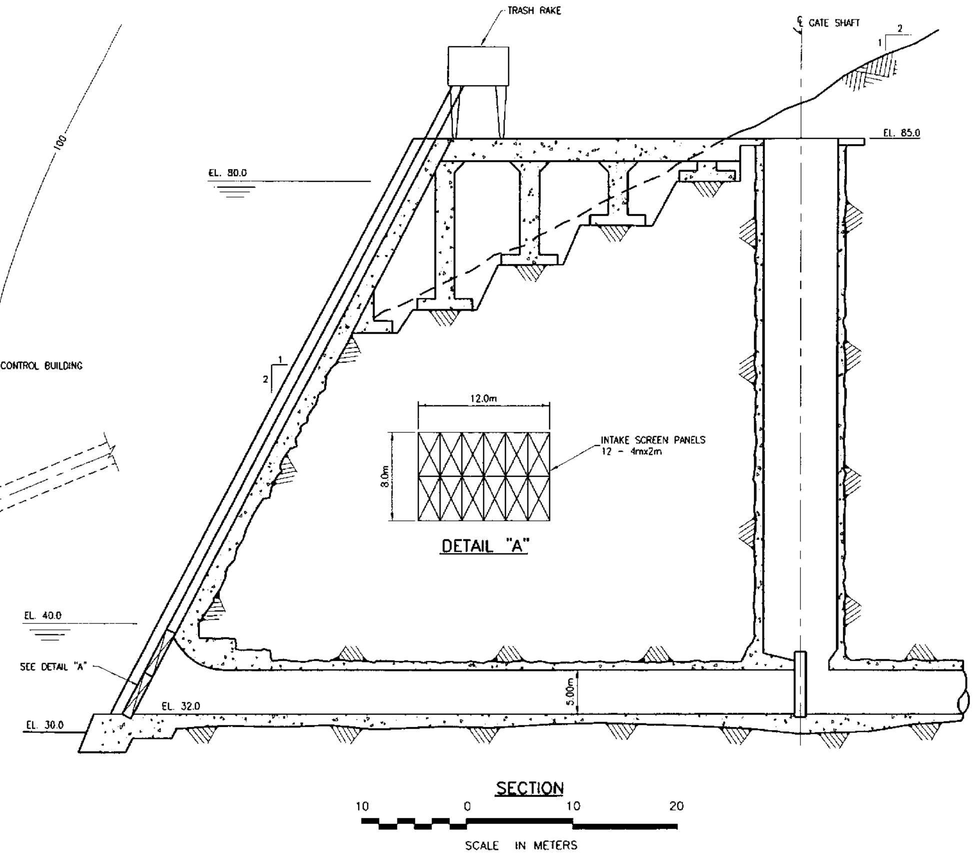


AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Potential for Power Development
General Arrangement at the Isla Pablon Site

MWH TAMS | April 2003 | Exhibit E6

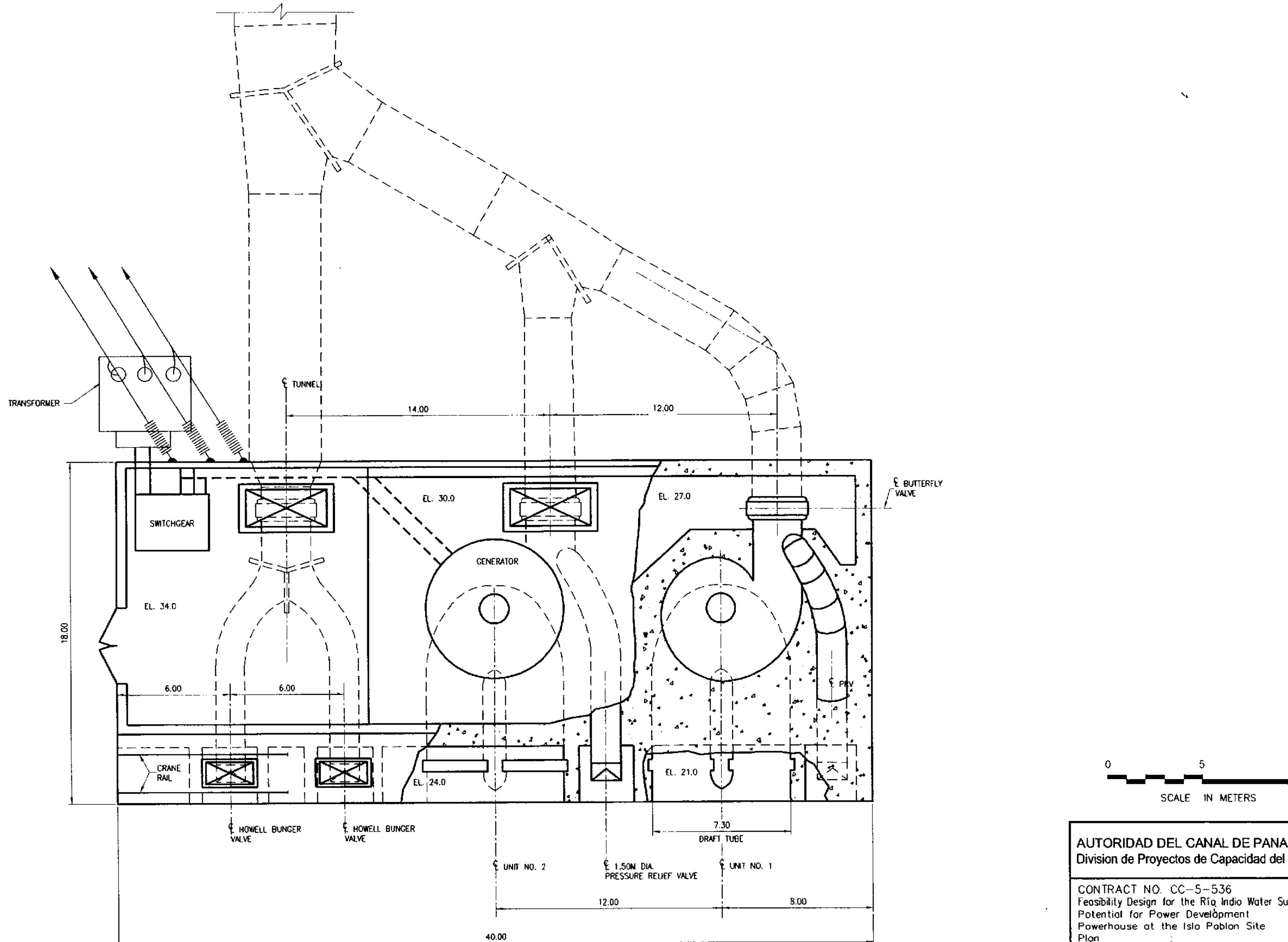




AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Potential for Power Development
Power Intake at the Transfer Tunnel
Plan and Section.

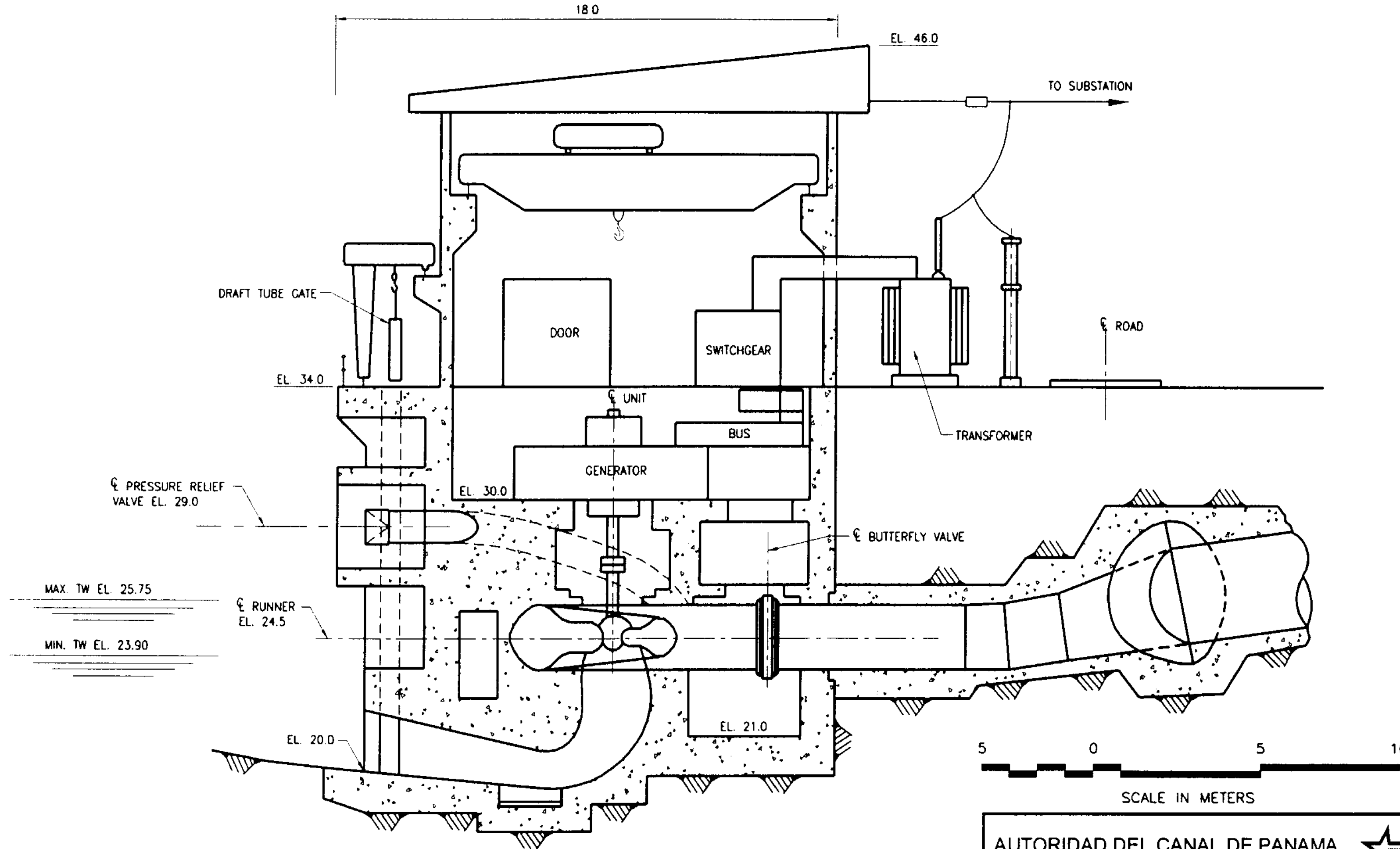
MWH TAMS | April 2003 | Exhibit E7



AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Potential for Power Development
Powerhouse at the Isla Pablon Site
Plan

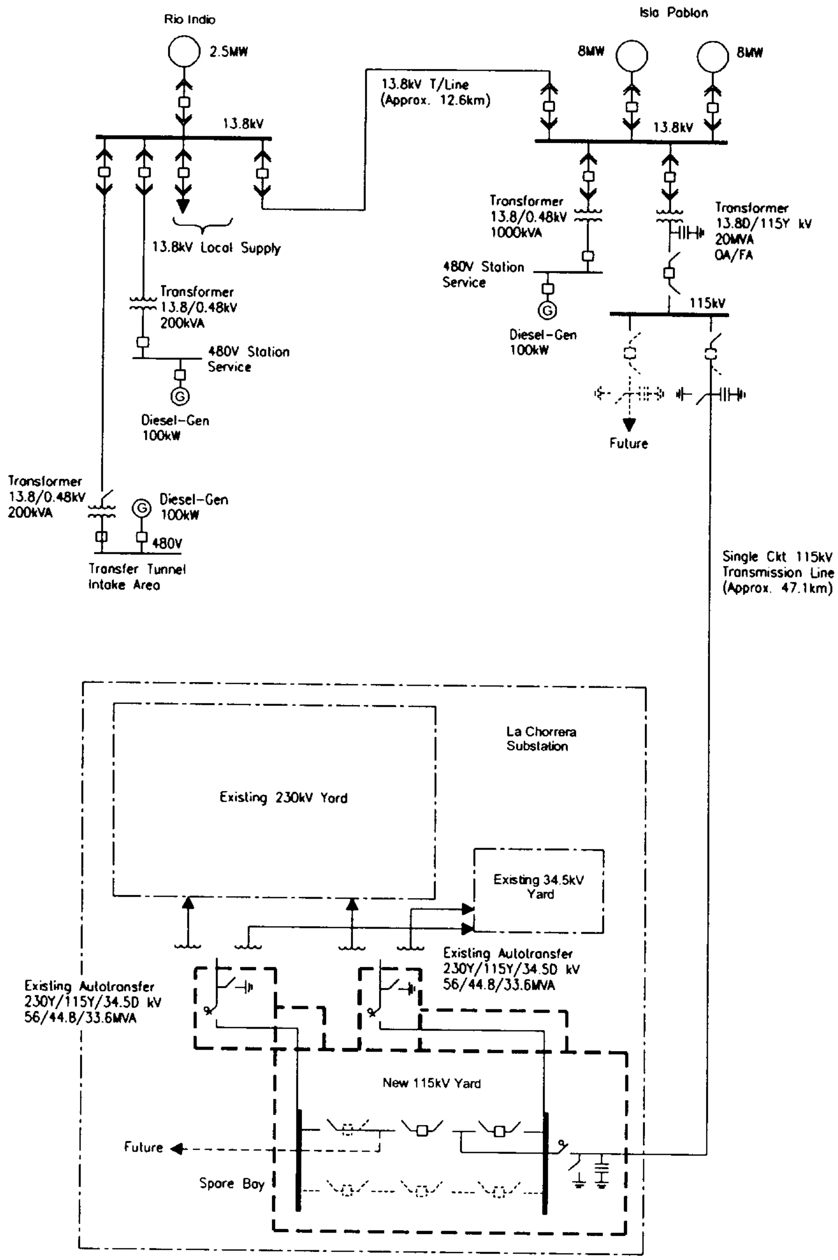
MWH TAMS | April 2003 | Exhibit E8



AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Potential for Power Development
Powerhouse at the Isla Pablon Site
Section

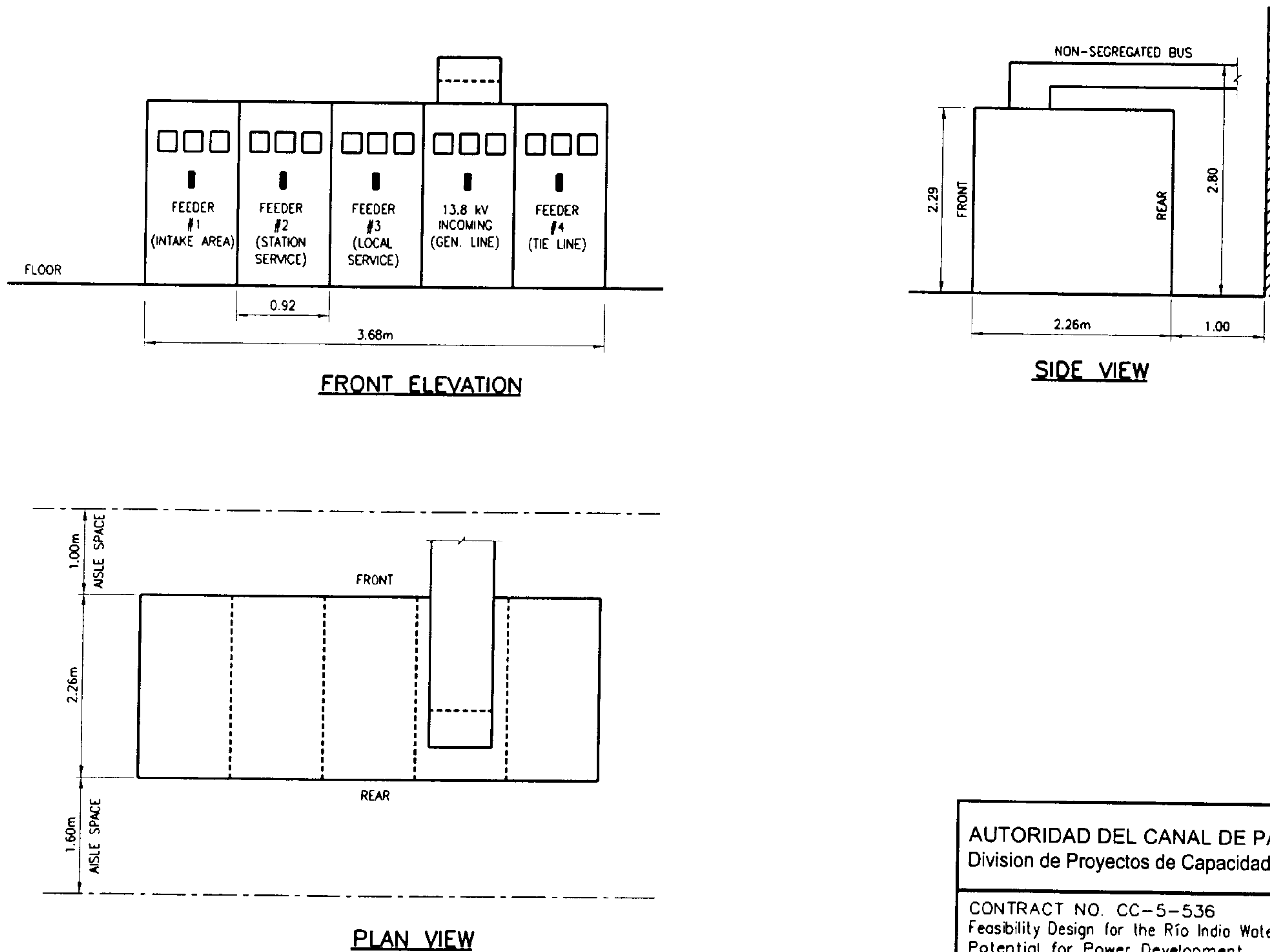
MWH TAMS	April 2003	Exhibit E9



AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Potential for Power Development
Río Indio Transmission System
One-Line Diagram

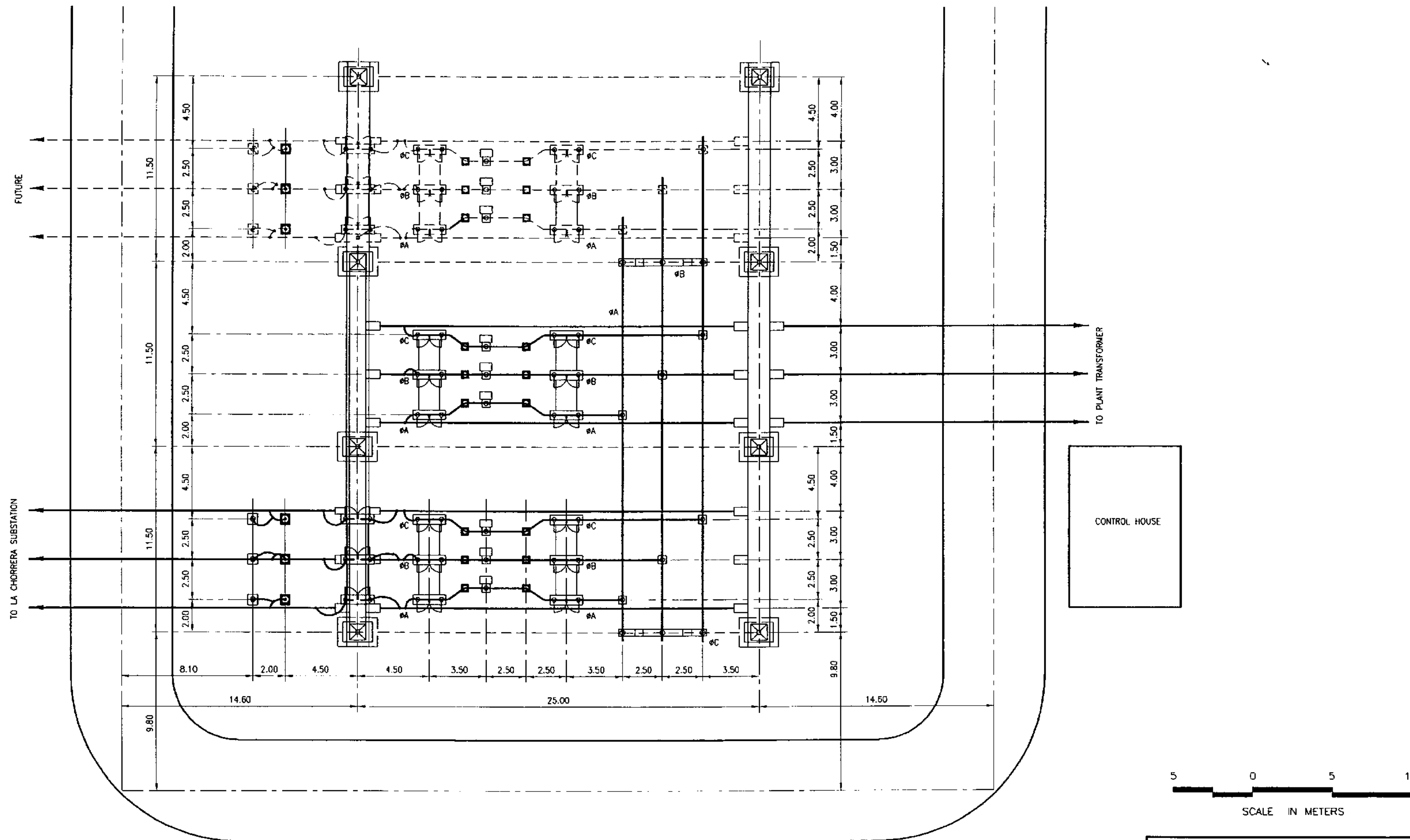
MWH TAMS	April 2003	Exhibit E10



AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Potential for Power Development
Río Indio Transmission System
13.8kV Switchgear

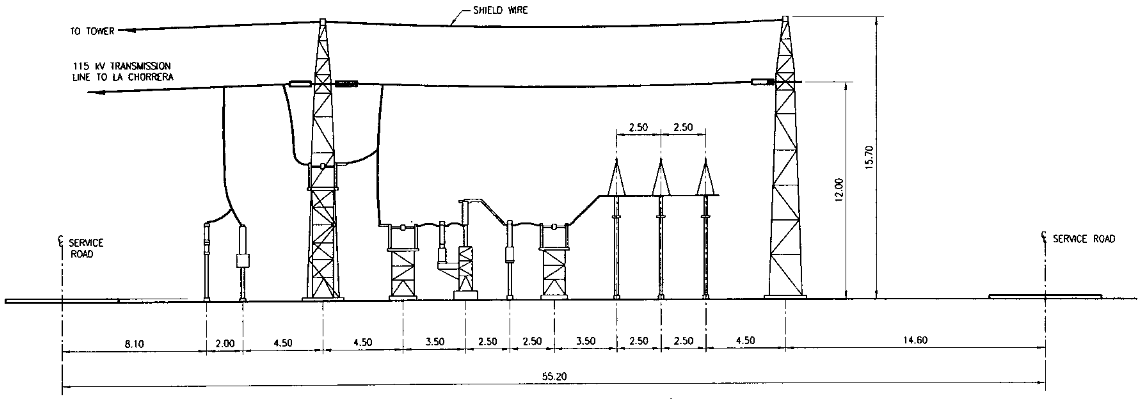
MWH TAMS | April 2003 | Exhibit E11



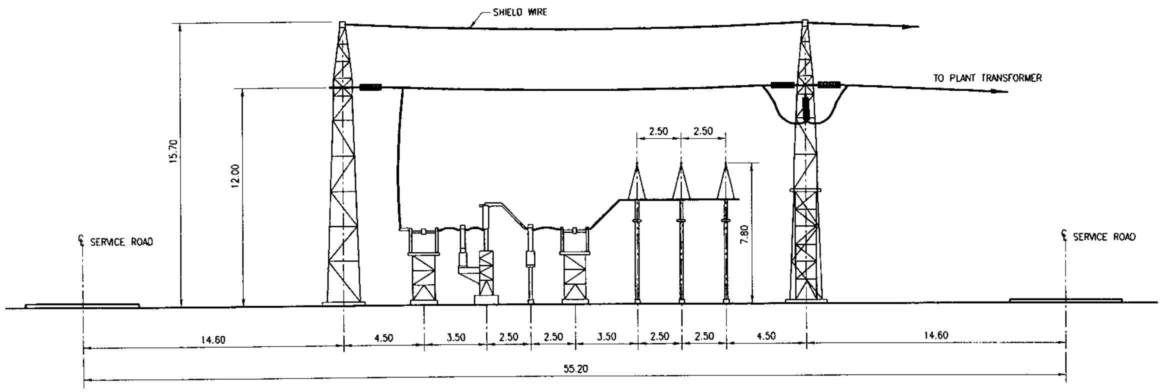
AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Potential for Power Development
Isla Pablon Substation
Plan

MWH TAMS | April 2003 | Exhibit E12



115 kV ELEVATION – TYPICAL T/L BAY



115 kV ELEVATION – TYPICAL GENERATOR BAY

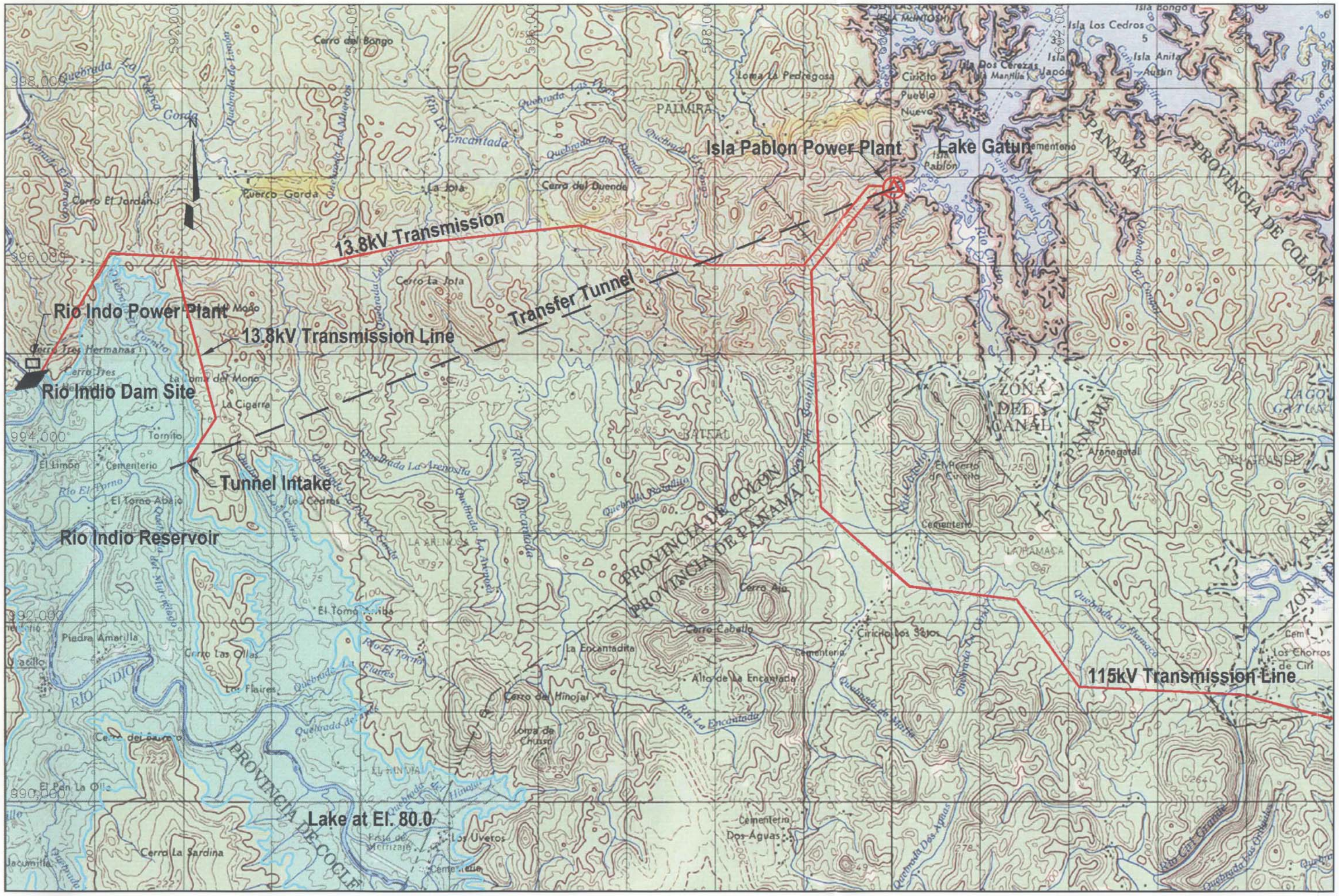
5 0 5 10

SCALE IN METERS

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Potential for Power Development
Isla Pablon Substation
Elevation Views

MWH TAMS | April 2003 | Exhibit E13



KEY MAP

1000 0 1000 2000

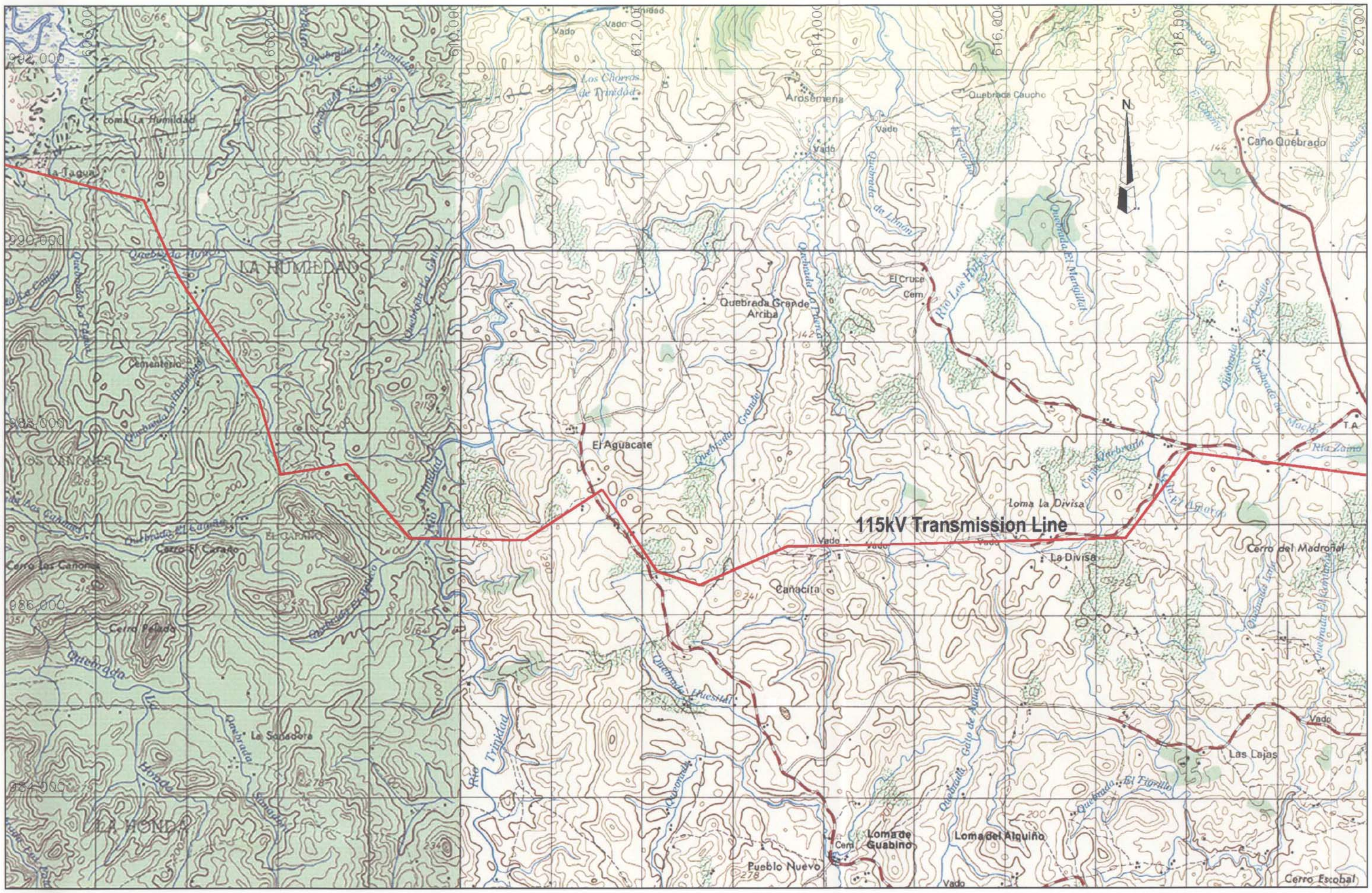
SCALE IN METERS

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Potential for Power Development
Transmission Line Route

Sheet 1 of 3

MWH TAMS	April 2003	Exhibit E14



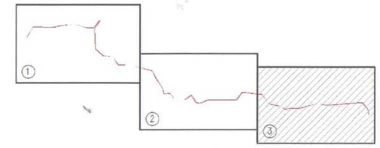
AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Potential for Power Development
Transmission Line Route

Sheet 2 of 3

MWH TAMS	April 2003	Exhibit E15

Match Line - See Sheet 2



KEY MAP

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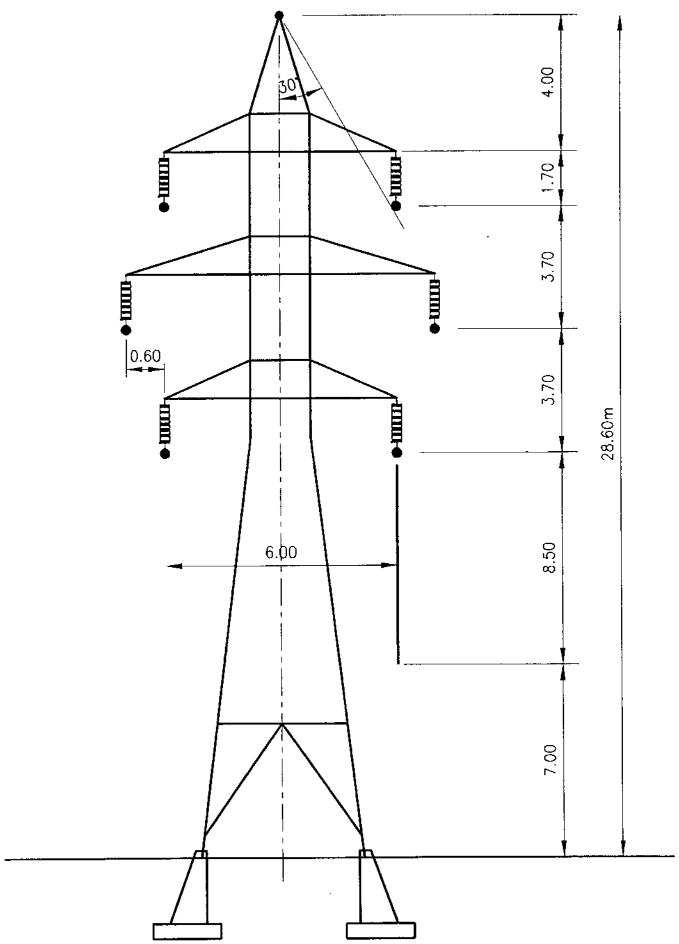
SCALE IN METERS

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

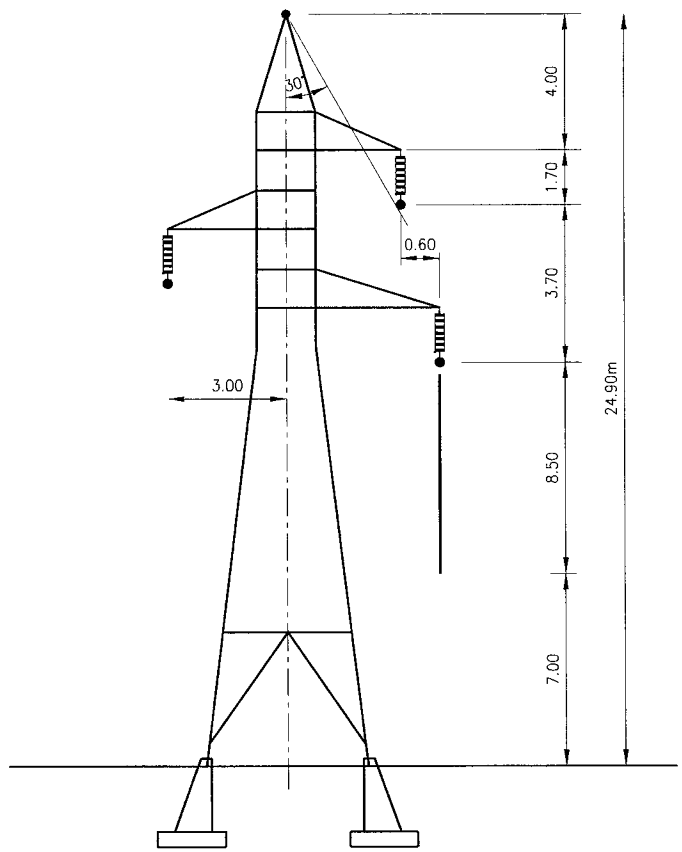
CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Potential for Power Development
Transmission Line Route

Sheet 3 of 3

MWH TAMS	April 2003	Exhibit E16



TYPICAL 115kV D/C TANGENT TOWER
NOT TO SCALE

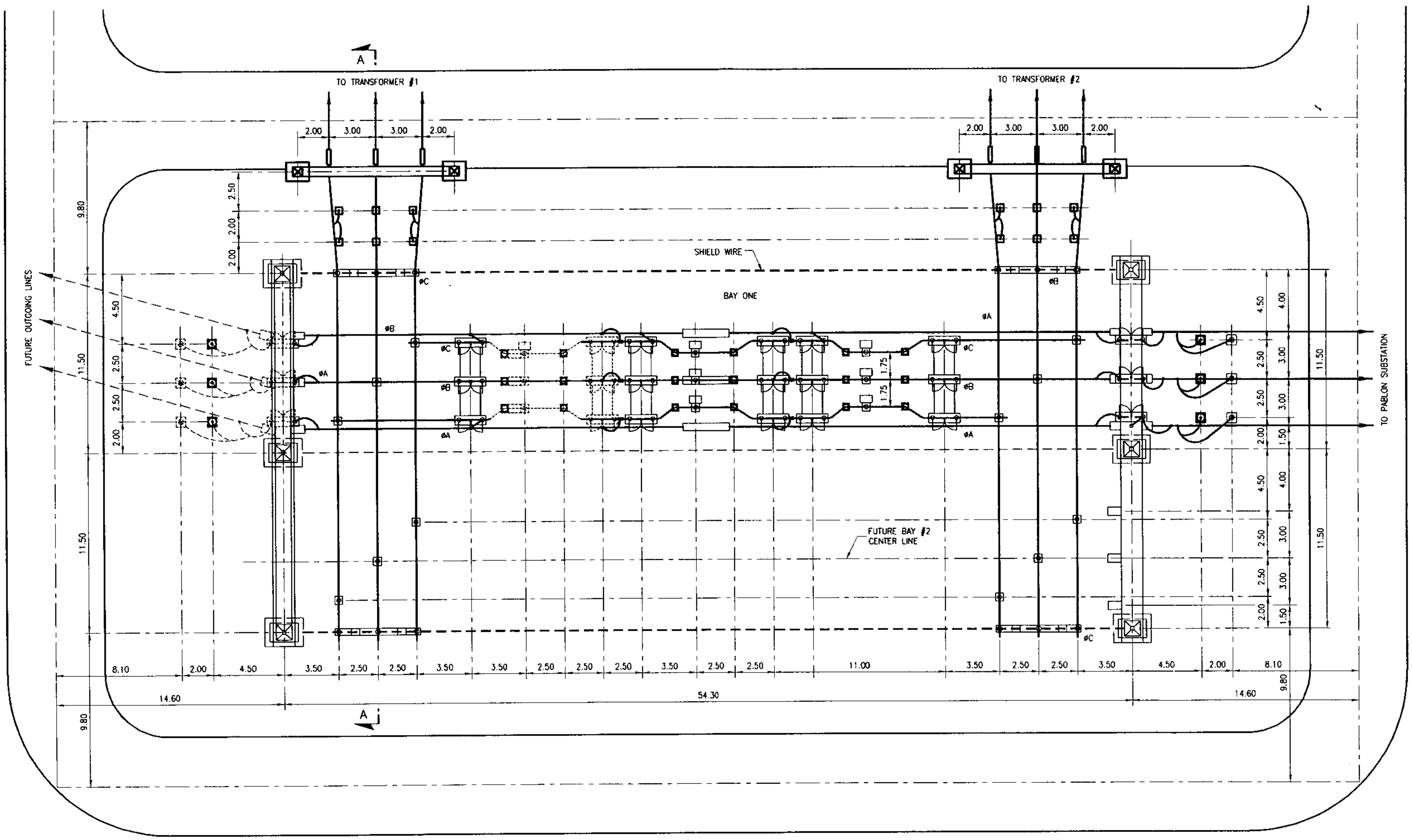


TYPICAL 115kV S/C TANGENT TOWER
NOT TO SCALE

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Potential for Power Development
Transmission Line
Typical 115kV Towers

MWH TAMS | April 2003 | Exhibit E17



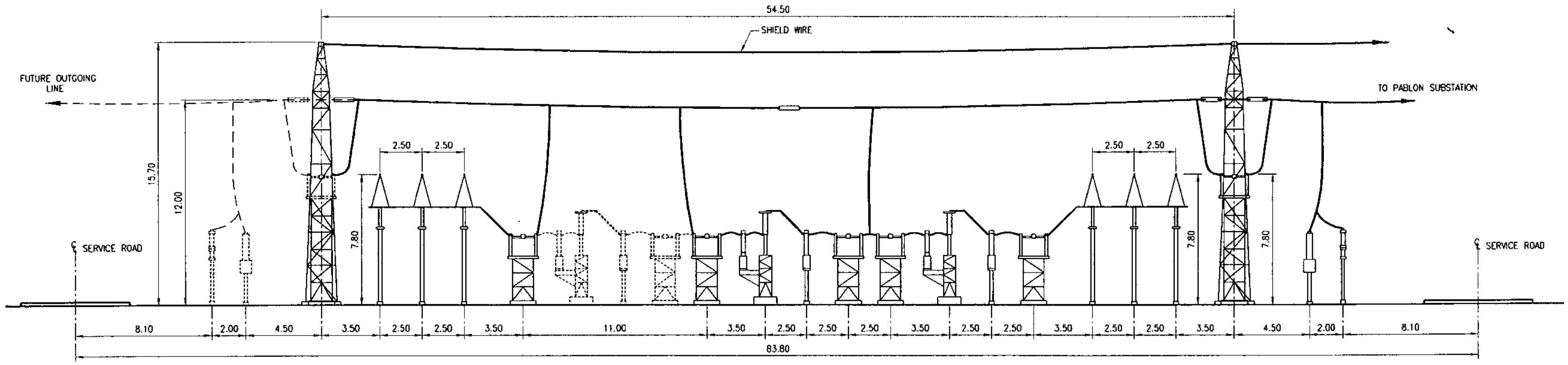
115 kV YARD AT LA CHORRERA SUBSTATION – PLAN VIEW

SCALE IN METERS

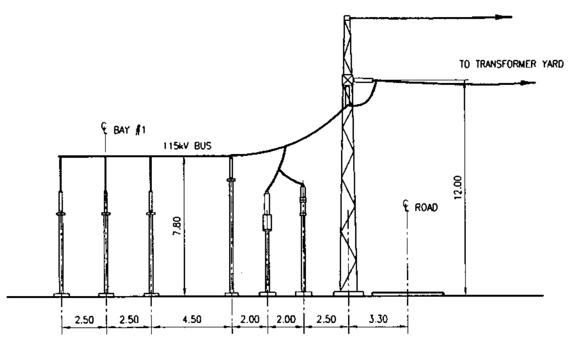
AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Potential for Power Development
115kV Yard at La Chorrera Substation
Plan

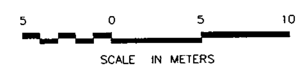
MWH TAMS | April 2003 | Exhibit E18



115 kV ELEVATION (BAY #1)



115 kV TRANSFORMER CONNECTION
SECTION A–A



AUTORIDAD DEL CANAL DE PANAMA
División de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Potential for Power Development
115kV Yard at LaChorrera Substation
Elevation Views

MWH TAMS	April 2003	Exhibit E19

ATTACHMENTS

ATTACHMENT 1

SITE RECONNAISSANCE REPORT

Site Reconnaissance Report

Site Trip From February 17 to February 21, 2002

The writer arrived to Panama City the night of Sunday February 17, 2002. Site visits and interviews were performed during the following week to gather information for the proposed feasibility study, as follows:

Monday, February 18

1) Met with Mr. Roderick E. Lee of the ACP Canal Capacity Projects office and Ing. Rodrigo Chanis assigned to act as liaison and ACP counterpart for the electrical work associated with the transmission feasibility study.

2) As told by Mr. Lee, the initial plan was to visit ACP's Gatun substation as the possible point of connection for the Rio Indio development and ACP's Madden and Miraflores substations as possible points of connections for the Upper Chagres river development. However, during the meeting with Ing. Enrique Tejera, ACP electrical system operation and maintenance, it was revealed that ACP's 44 kV system would not be capable of receiving 30 MW from Rio Indio neither 35 MW from Upper Chagres. Therefore the initial plan of visits was abandoned and the search for feasible points of connection with 115/230 kV capabilities concentrated in ETESA's La Chorrera substation for Rio Indio and Cocle del Norte projects and Panama II substation for the Upper Chagres project.

3) Visited ETESA's Ing. Jose M.Lopez and Ing. Delano E. James of operation and maintenance to obtain system information and review possibilities for interconnection at both 115 and 230 kV voltages. Copy of an up-to-date ETESA's electrical system map was provided to the writer. The discussion revealed the following:

   - La Chorrera substation has at present two empty bays at 230 kV and also two operating 230/115/13.8 kV step down transformers that feed a 13.8 kV distribution switchyard. However, the 115 kV yard has never been developed although land space has been provided for such purpose. ETESA does not have immediate plans to develop the 115 kV yard and is waiting for a private generator or the private distribution companies to generate the need for it. A connection for Rio Indio at 115 kV would entail to build the 115 kV yard as part of the project cost.

   - Regarding the connection of the Upper Chagres river project, ETESA's Panama II substation has capabilities and empty bays at 115 kV for that purpose. Another possibility for interconnection would be to intersect and open one of the four (4) 115 kV circuits running between Panama City and Colon and to extend its length with a double circuit line to the Upper Chagres substation to be provided with a breaker and a half scheme which is typical of the ETESA's substation arrangements.

4) ACP provided an array of topographic maps at the 1:25,000 scale for routing the transmission lines for the proposed project sites.

Tuesday, February 19

5) The morning was dedicated to make a visit to the Panama II substation together with ETESA's Ing. Jose M. Lopez. There are two (2) empty bays in the 115-kV switchyard one of which could be used for the interconnection to the Upper Chagres project. The crossing of the 115-kV line under the future second 230-kV transmission line from Llano Sanchez substation should be made underground, as ETESA does not allow aerial line crossings inside the substations.

6) A review of ETESA's system map revealed that besides Panama II there are no other 115-kV substations owned by ETESA in the area to connect the Upper Chagres project. However, there are two privately owned 115-kV substations connected to the ETESA system close to Madden, namely, Chilibre (owned by ELECTRA Distribution Company) and Cemento Panama. Chilibre is a tap of two 115-kV circuits and from system reliability is not considered adequate to hook the proposed 35-MW Upper Chagres generation. Cemento Panama substation, instead, is a promising point of interconnection since the ETESA 115-kV line is sectionalized.

7) Both Chilibre and Cemento Panama as well as Madden substations were visited during the same morning with the following results:

- Chilibre is not acceptable since it is a tap to the 115-kV system. Two ETESA line circuits are tapped, one serves a 13.8-kV step down transformer, and the other is used to extend a 115-kV single circuit line to another Cement plant. Additionally, it does not have space availability for expansion.

- Cemento Panama has a spare bay for connection of a 115-kV line circuit with the need of only minor additional switching equipment. This substation is located some 8 km north of the Chagres River and would require extending the length of the transmission line that much to a total of about 18 km.

- Madden substation was looked from the dam top and it is an exclusive 44-kV switchyard located immediately adjacent to the power plant with no room for expansion. Two aerial circuits connect this substation to ACP's 44-kV transmission system.

8) In the afternoon the ETESA's Substation Engineering Division was visited and the writer met Ing. Eduardo N. Brugiatti, Head of Substation Design. The alternative of opening one circuit of the 115-kV Panama-Colon transmission line to connect the Upper Chagres river project appeared acceptable to ETESA as long as the plant substation at Upper Chagres is built following their standards using a breaker and a half switching scheme.

Prints of typical substation plans, elevations and one lines with protection schemes at 115-kV and 230-kV were obtained.

Wednesday, February 20

9) The transmission line routes and site locations were flown over by helicopter together with ACP's personnel Ing. Roderick Lee and Rodrigo Chanis.

10) The writer provided the preliminary routes between La Chorrera substation and Rio Indio and Cocle del Norte sites. ACP furnished new tunnel coordinates for the Indio River tunnel and the writer corrected the route in the affected section.

11) The helicopter landed first at La Chorrera substation where ETESA's engineers Jose M. Lopez, O&M, Eduardo N. Brugiatti, Engineering, and Moses Cano, Planning, were awaiting the party. The substation yards were walked and ETESA showed two (2) 230-kV empty bays were the ACP line could be connected. The 115-kV yard was never developed but the space is available. If required to connect at 115-kV ACP should bare the cost for building the 115-kV yard where initially only one breaker would be installed for the ACP line; but the design should have provisions for ultimate breaker and a half scheme. The control room of the substation has ample space to locate the necessary panels for relays, metering and communications.

12) The party continued the flight over the proposed line route to the Rio Indio tunnel and plant sites. The terrain is of gentle topography with low hills showing marked signs of deforestation, traversed by dirt road accesses and few paved roads, where scattered buildings and little agricultural farming (pineapple, vineyards and fruit trees) and some large chicken houses are present. The area is accessible by land and of relatively easy line construction.

13) The foot of the tunnel is now at a new location facing the Pablon Island in the Gatun Lake, about 8 km east of the proposed Rio Indio dam.

14) After circling the location around the Pablon Island and the Rio Indio dam sites the party proceeded almost due west toward Cocle del Norte site. The flight deviated slightly to go over an intermediate site at the Cano Sucio River, which will not be developed for power.

15) As the helicopter moved west the topography became more hilly and the ground were covered by dense and thick where deforestation has been less active in this more remote and un-inhabited region. After circling the Rio Cocle del Norte site the helicopter turned due south toward the locality of Coclecito for refueling.

16) The party left Coclecito in a general northeast direction toward Rio Indio but passing first by the Toabre river site under study by another consultant. The flight headed toward the Rio Chagres crossing the Gatun Lake. ETESA's 115-kV transmission line circuits running from Panama City to Colon were intersected and a convenient space of land was

spotted adjacent to the crossing of the Chagres River at the southern bank where one of the line circuits could be cut in. The ACP double circuit transmission line would be running from this point in and out the plant site following the south margin of the Alahuela Lake in a general SW-NE direction for about 10 km.

17) The helicopter moved around the southern margin of Alahuela Lake where the transmission line route presents a gentle rolling type country with rounded hills, with short vegetation and practically no population, crossed by few scattered dirt roads. At one point some 2-3 km from the proposed site the line route enters a heavily wooded area of high hilly terrain in jurisdiction of the National Parks agency.

18) From the Upper Chagre site the party proceeded to fly south by Southwest to the Panama II substation that provides an option for connection of this power project to the national grid. The flown area is very hilly and steep at times, thickly wooded for most of the area and with no apparent roads, of difficult access. In the last part of the route near the Panama II substation, for about 5 km, the land becomes gentler, of lower elevations and occupied by scattered housing and roads. The Panama II substation was spotted and circled, after that the party returned and finally landed at the local airport.

Thursday, February 21

19) A number of documents were obtained from ETESA and ACP as well as pictures that were developed as follows:

- Typical Plan and Elevation drawings of the Panama II substation from ETESA
- Typical one-line diagrams w/protection schemes for 115-kV and 230-kV substation bays from ETESA.
- Typical 115-kV and 230-kV transmission line and substation costs from ETESA.
- ETESA's one-line electric interconnected system map.
- Physical location maps of the La Chorrera and Panama II substations and 115 kV and 230 kV transmission lines from ETESA.
- Typical 115 kV and 230 kV transmission line structure outlines from ACP
- Maps at 1:25,000 scale from ACP.
- ACP's one-line diagram for their 44 kV system.
- ACP's physical location map of their 44 kV lines and substations.

Photo 1 – Downstream End of Transfer Tunnel – Isla Pablon

Photo 2 – La Chorrera Substation ***(Note bottom left corner dedicated to future 115-kV yard)***

Photo 3 – La Chorrera Substation – Land area for future 115-kV yard

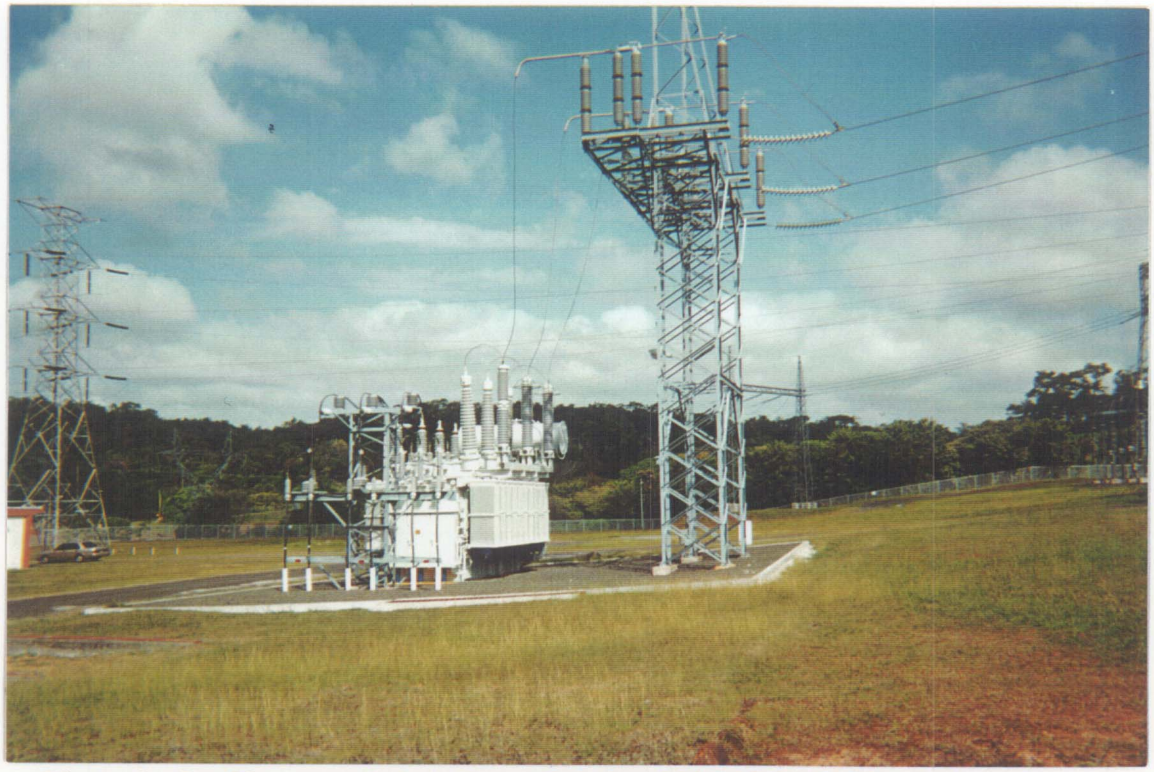


Photo 4 – La Chorrera Substation – Existing 230/115/34.5 kV Autotransformer

ATTACHMENT 2

PROPOSED RÍO INDIO RESERVOIR OPERATION

PROPOSED RÍO INDIO RESERVOIR OPERATION
(As simulated by the ACP)

	Indio Reservoir Inflow (cms)	Indio Reservoir WS Elev (m)	Spillage (cms)	Downstream Release (cms)	Transferred Discharge (cms)	Lake Gatun WS Elev (m)	Gross Head (m)
Jan-48	12.20	68.33	0.00	2.30	0.00	26.18	42.16
Feb-48	4.81	65.32	0.00	2.30	43.01	26.05	39.27
Mar-48	3.45	62.00	0.00	2.30	43.01	25.33	36.67
Apr-48	2.58	58.53	0.00	2.30	43.01	25.19	33.34
May-48	5.47	54.90	0.00	2.30	43.01	24.95	29.95
Jun-48	7.76	55.30	0.00	2.30	0.00	24.39	30.90
Jul-48	28.63	51.59	0.00	2.30	67.21	25.41	26.18
Aug-48	33.33	54.27	0.00	2.30	0.00	25.74	28.53
Sep-48	31.74	56.73	0.00	2.30	0.00	25.69	31.03
Oct-48	29.45	59.06	0.00	2.30	0.00	25.67	33.39
Nov-48	58.56	63.28	0.00	2.30	0.00	26.55	36.73
Dec-48	16.37	64.28	0.00	2.30	0.00	26.75	37.53
Jan-49	6.88	64.51	0.00	2.30	0.00	25.86	38.66
Feb-49	4.16	61.57	0.00	2.30	43.01	25.73	35.84
Mar-49	2.72	57.91	0.00	2.30	43.01	25.54	32.37
Apr-49	2.49	54.11	0.00	2.30	43.01	24.89	29.22
May-49	7.42	50.66	0.00	2.30	43.01	24.60	26.06
Jun-49	40.21	53.85	0.00	2.30	0.00	25.11	28.74
Jul-49	28.40	56.09	0.00	2.30	0.00	25.60	30.49
Aug-49	35.51	58.96	0.00	2.30	0.00	25.82	33.14
Sep-49	49.78	62.54	0.00	2.30	0.00	25.91	36.63
Oct-49	47.18	65.89	0.00	2.30	0.00	26.18	39.71
Nov-49	81.52	71.38	0.00	2.30	0.00	26.64	44.74
Dec-49	64.62	75.24	0.00	2.30	0.00	26.75	48.50
Jan-50	11.38	75.71	0.00	2.30	0.00	26.23	49.48
Feb-50	6.43	73.37	0.00	2.30	43.01	26.21	47.16
Mar-50	3.88	70.62	0.00	2.30	43.01	25.57	45.05
Apr-50	2.80	67.47	0.00	2.30	43.01	25.52	41.95
May-50	19.43	65.40	0.00	2.30	43.01	25.36	40.04
Jun-50	35.59	67.78	0.00	2.30	0.00	25.82	41.96
Jul-50	37.07	70.28	0.00	2.30	0.00	25.84	44.44
Aug-50	53.86	73.47	0.00	2.30	0.00	26.03	47.44
Sep-50	35.91	75.45	0.00	2.30	0.00	25.91	49.55
Oct-50	48.76	76.95	0.00	2.30	21.60	26.18	50.76
Nov-50	63.15	78.47	0.00	2.30	34.69	26.64	51.83
Dec-50	63.37	81.83	51.48	2.30	0.00	26.75	55.09
Jan-51	20.25	80.00	0.00	2.30	0.00	26.26	53.74
Feb-51	11.27	76.29	0.00	2.30	71.71	26.30	49.99
Mar-51	6.43	73.70	0.00	2.30	43.01	26.03	47.67
Apr-51	4.25	71.07	0.00	2.30	43.01	25.82	45.25
May-51	19.94	69.25	0.00	2.30	43.01	25.82	43.43
Jun-51	24.32	70.66	0.00	2.30	0.00	25.82	44.84
Jul-51	22.65	71.86	0.00	2.30	0.00	25.82	46.05
Aug-51	24.55	73.19	0.00	2.30	0.00	25.82	47.38
Sep-51	41.65	75.42	0.00	2.30	1.87	25.91	49.51
Oct-51	35.31	76.95	0.00	2.30	7.56	26.18	50.76
Nov-51	52.92	78.47	0.00	2.30	24.47	26.61	51.86
Dec-51	30.70	80.00	0.17	2.30	2.80	26.67	53.33

PROPOSED RÍO INDIO RESERVOIR OPERATION
(As simulated by the ACP)

	Indio Reservoir Inflow (cms)	Indio Reservoir WS Elev (m)	Spillage (cms)	Downstream Release (cms)	Transferred Discharge (cms)	Lake Gatun WS Elev (m)	Gross Head (m)
Jan-52	13.56	80.00	0.00	2.30	9.18	26.11	53.89
Feb-52	6.48	74.64	0.00	2.30	92.81	26.30	48.33
Mar-52	3.45	71.86	0.00	2.30	43.01	25.60	46.26
Apr-52	3.06	65.91	0.00	2.30	84.64	25.82	40.10
May-52	11.38	63.23	0.00	2.30	43.01	25.59	37.64
Jun-52	28.91	65.12	0.00	2.30	0.00	25.79	39.33
Jul-52	22.43	66.57	0.00	2.30	0.00	25.82	40.76
Aug-52	23.70	68.12	0.00	2.30	0.00	25.82	42.31
Sep-52	39.87	70.67	0.00	2.30	0.00	25.91	44.77
Oct-52	56.92	74.05	0.00	2.30	0.00	26.46	47.60
Nov-52	35.79	76.04	0.00	2.30	0.00	26.61	49.43
Dec-52	50.63	79.01	0.00	2.30	0.00	26.67	52.34
Jan-53	37.89	80.00	0.00	2.30	17.93	26.52	53.49
Feb-53	14.72	78.13	0.00	2.30	43.01	26.30	51.83
Mar-53	7.90	75.63	0.00	2.30	43.01	25.96	49.66
Apr-53	5.61	73.07	0.00	2.30	43.01	25.75	47.32
May-53	23.50	71.61	0.00	2.30	43.01	25.82	45.79
Jun-53	21.07	72.36	0.00	2.30	5.27	25.77	46.59
Jul-53	20.59	72.36	0.00	2.30	17.03	25.82	46.54
Aug-53	17.02	73.21	0.00	2.30	0.00	25.82	47.40
Sep-53	21.07	74.29	0.00	2.30	0.00	25.91	48.38
Oct-53	59.61	76.95	0.00	2.30	14.02	26.18	50.76
Nov-53	59.72	78.47	0.00	2.30	31.26	26.61	51.86
Dec-53	32.88	80.00	0.17	2.30	4.98	26.75	53.26
Jan-54	16.71	80.64	0.80	2.30	0.00	25.92	54.72
Feb-54	7.90	75.59	0.00	2.30	93.54	26.09	49.49
Mar-54	4.96	72.90	0.00	2.30	43.01	25.37	47.53
Apr-54	4.02	67.15	0.00	2.30	85.80	25.57	41.58
May-54	18.80	65.04	0.00	2.30	43.01	25.82	39.22
Jun-54	19.85	66.26	0.00	2.30	0.00	25.82	40.44
Jul-54	46.78	69.56	0.00	2.30	0.00	26.11	43.45
Aug-54	35.40	71.66	0.00	2.30	0.00	26.00	45.66
Sep-54	48.00	74.38	0.00	2.30	0.00	26.19	48.19
Oct-54	40.92	76.75	0.00	2.30	0.00	26.18	50.56
Nov-54	76.74	78.47	0.00	2.30	44.99	26.64	51.83
Dec-54	40.92	80.67	52.64	2.30	0.00	26.75	53.93
Jan-55	43.83	80.00	0.00	2.30	0.00	26.52	53.49
Feb-55	13.90	78.08	0.00	2.30	43.01	26.30	51.78
Mar-55	6.88	75.52	0.00	2.30	43.01	25.95	49.57
Apr-55	5.47	72.95	0.00	2.30	43.01	25.82	47.14
May-55	10.85	70.69	0.00	2.30	43.01	25.64	45.04
Jun-55	41.12	72.36	0.00	2.30	10.30	25.75	46.61
Jul-55	29.34	72.36	0.00	2.30	25.78	25.82	46.54
Aug-55	48.14	73.89	0.00	2.30	20.44	26.15	47.74
Sep-55	58.76	77.27	0.00	2.30	0.00	25.91	51.36
Oct-55	50.86	76.95	0.00	2.30	52.35	26.18	50.76
Nov-55	77.36	78.47	0.00	2.30	48.91	26.64	51.83
Dec-55	45.11	80.89	58.52	2.30	0.00	26.75	54.14

PROPOSED RÍO INDIO RESERVOIR OPERATION
(As simulated by the ACP)

	Indio Reservoir Inflow (cms)	Indio Reservoir WS Elev (m)	Spillage (cms)	Downstream Release (cms)	Transferred Discharge (cms)	Lake Gatun WS Elev (m)	Gross Head (m)
Jan-56	45.53	80.00	0.00	2.30	0.00	26.52	53.49
Feb-56	14.19	78.04	0.00	2.30	43.01	26.30	51.73
Mar-56	8.27	75.56	0.00	2.30	43.01	26.03	49.53
Apr-56	7.65	73.13	0.00	2.30	43.01	25.82	47.31
May-56	28.71	71.99	0.00	2.30	43.01	25.82	46.17
Jun-56	41.46	72.48	0.00	2.30	29.95	25.82	46.66
Jul-56	38.94	72.36	0.00	2.30	37.27	26.26	46.10
Aug-56	29.11	73.98	0.00	2.30	0.00	25.82	48.16
Sep-56	46.44	75.42	0.00	2.30	19.40	25.96	49.46
Oct-56	69.32	77.66	0.00	2.30	30.36	26.46	51.20
Nov-56	49.27	80.37	32.12	2.30	0.00	26.64	53.73
Dec-56	28.71	80.00	0.17	2.30	0.00	26.75	53.26
Jan-57	11.47	80.37	0.00	2.30	0.00	25.95	54.42
Feb-57	5.95	75.21	0.00	2.30	93.24	26.14	49.07
Mar-57	3.88	72.45	0.00	2.30	43.01	25.45	47.00
Apr-57	2.80	66.57	0.00	2.30	85.27	25.55	41.02
May-57	11.81	63.92	0.00	2.30	43.01	25.21	38.71
Jun-57	11.92	64.55	0.00	2.30	0.00	25.14	39.42
Jul-57	11.69	59.19	0.00	2.30	77.18	25.20	33.99
Aug-57	22.85	60.80	0.00	2.30	0.00	25.09	35.72
Sep-57	24.95	62.40	0.00	2.30	0.00	24.97	37.43
Oct-57	56.80	62.36	0.00	2.30	54.05	26.18	36.18
Nov-57	37.38	64.88	0.00	2.30	0.00	26.57	38.31
Dec-57	30.19	66.93	0.00	2.30	0.00	26.67	40.26
Jan-58	18.89	68.07	0.00	2.30	0.00	26.43	41.64
Feb-58	14.61	65.84	0.00	2.30	43.01	26.30	39.54
Mar-58	7.84	62.85	0.00	2.30	43.01	26.03	36.82
Apr-58	5.61	59.78	0.00	2.30	43.01	25.80	33.98
May-58	17.33	57.20	0.00	2.30	43.01	25.82	31.39
Jun-58	20.78	58.71	0.00	2.30	0.00	25.72	32.99
Jul-58	28.49	60.82	0.00	2.30	0.00	25.82	35.00
Aug-58	38.31	63.49	0.00	2.30	0.00	25.82	37.67
Sep-58	37.15	65.99	0.00	2.30	0.00	25.91	40.08
Oct-58	48.54	69.43	0.00	2.30	0.00	26.18	43.25
Nov-58	39.47	71.74	0.00	2.30	0.00	26.37	45.37
Dec-58	20.98	72.84	0.00	2.30	0.00	26.67	46.17
Jan-59	9.43	73.18	0.00	2.30	0.00	25.87	47.32
Feb-59	5.78	67.99	0.00	2.30	86.36	25.94	42.06
Mar-59	4.11	64.72	0.00	2.30	43.01	25.25	39.47
Apr-59	3.60	61.52	0.00	2.30	43.01	25.23	36.30
May-59	5.47	58.14	0.00	2.30	43.01	24.84	33.30
Jun-59	83.62	64.33	0.00	2.30	0.00	24.86	39.47
Jul-59	93.45	65.07	0.00	2.30	80.32	24.96	40.11
Aug-59	14.19	59.96	0.00	2.30	77.90	25.75	34.20
Sep-59	16.59	60.95	0.00	2.30	0.00	25.84	35.11
Oct-59	50.12	64.52	0.00	2.30	0.00	26.08	38.45
Nov-59	34.66	66.84	0.00	2.30	0.00	26.61	40.23
Dec-59	43.95	69.93	0.00	2.30	0.00	26.67	43.26

PROPOSED RÍO INDIO RESERVOIR OPERATION
(As simulated by the ACP)

	Indio Reservoir Inflow (cms)	Indio Reservoir WS Elev (m)	Spillage (cms)	Downstream Release (cms)	Transferred Discharge (cms)	Lake Gatun WS Elev (m)	Gross Head (m)
Jan-60	21.07	71.02	0.00	2.30	0.00	26.52	44.51
Feb-60	8.78	68.50	0.00	2.30	43.01	26.23	42.27
Mar-60	9.12	65.60	0.00	2.30	43.01	25.98	39.62
Apr-60	11.27	62.97	0.00	2.30	43.01	25.82	37.15
May-60	11.27	60.29	0.00	2.30	43.01	25.82	34.47
Jun-60	28.18	62.12	0.00	2.30	0.00	25.82	36.31
Jul-60	27.86	64.00	0.00	2.30	0.00	25.82	38.18
Aug-60	28.71	65.93	0.00	2.30	0.00	25.82	40.12
Sep-60	25.29	67.55	0.00	2.30	0.00	25.91	41.64
Oct-60	40.21	70.30	0.00	2.30	0.00	26.18	44.11
Nov-60	55.84	73.51	0.00	2.30	0.00	26.61	46.90
Dec-60	92.99	79.16	0.00	2.30	0.00	26.67	52.49
Jan-61	15.74	79.89	0.00	2.30	0.00	26.13	53.76
Feb-61	8.21	74.80	0.00	2.30	92.84	26.30	48.50
Mar-61	4.70	72.10	0.00	2.30	43.01	25.63	46.48
Apr-61	4.79	66.31	0.00	2.30	84.97	25.82	40.50
May-61	8.33	63.40	0.00	2.30	43.01	25.44	37.96
Jun-61	20.87	64.69	0.00	2.30	0.00	25.82	38.88
Jul-61	18.49	65.85	0.00	2.30	0.00	25.82	40.03
Aug-61	20.44	67.15	0.00	2.30	0.00	25.82	41.33
Sep-61	32.68	69.31	0.00	2.30	0.00	25.91	43.40
Oct-61	50.43	72.40	0.00	2.30	0.00	26.18	46.21
Nov-61	44.46	74.91	0.00	2.30	0.00	26.61	48.30
Dec-61	35.91	76.95	0.00	2.30	0.00	26.75	50.21
Jan-62	13.25	77.53	0.00	2.30	0.00	25.97	51.57
Feb-62	7.14	72.51	0.00	2.30	90.65	26.11	46.40
Mar-62	4.22	69.74	0.00	2.30	43.01	25.43	44.30
Apr-62	3.91	63.65	0.00	2.30	82.38	25.62	38.02
May-62	5.80	60.55	0.00	2.30	43.01	25.60	34.95
Jun-62	8.78	60.96	0.00	2.30	0.00	25.74	35.21
Jul-62	12.01	61.62	0.00	2.30	0.00	25.59	36.03
Aug-62	29.99	63.66	0.00	2.30	0.00	25.82	37.84
Sep-62	25.77	65.32	0.00	2.30	0.00	25.91	39.41
Oct-62	34.66	67.70	0.00	2.30	0.00	26.18	41.52
Nov-62	35.91	70.09	0.00	2.30	0.00	26.61	43.48
Dec-62	27.35	71.59	0.00	2.30	0.00	26.67	44.92
Jan-63	11.04	72.04	0.00	2.30	0.00	26.52	45.52
Feb-63	7.45	69.72	0.00	2.30	43.01	26.30	43.42
Mar-63	4.11	66.44	0.00	2.30	43.01	26.03	40.41
Apr-63	8.33	63.58	0.00	2.30	43.01	25.77	37.81
May-63	18.07	61.42	0.00	2.30	43.01	25.82	35.61
Jun-63	21.61	62.77	0.00	2.30	0.00	25.82	36.96
Jul-63	26.00	64.50	0.00	2.30	0.00	25.82	38.69
Aug-63	33.73	66.82	0.00	2.30	0.00	25.97	40.85
Sep-63	34.15	69.09	0.00	2.30	0.00	25.91	43.18
Oct-63	48.45	72.09	0.00	2.30	0.00	26.18	45.91
Nov-63	54.20	75.20	0.00	2.30	0.00	26.61	48.59
Dec-63	18.15	76.12	0.00	2.30	0.00	26.75	49.37

PROPOSED RÍO INDIO RESERVOIR OPERATION
(As simulated by the ACP)

	Indio Reservoir Inflow (cms)	Indio Reservoir WS Elev (m)	Spillage (cms)	Downstream Release (cms)	Transferred Discharge (cms)	Lake Gatun WS Elev (m)	Gross Head (m)
Jan-64	9.12	76.44	0.00	2.30	0.00	25.89	50.54
Feb-64	4.90	71.18	0.00	2.30	89.49	26.03	45.15
Mar-64	3.23	68.06	0.00	2.30	43.01	25.32	42.74
Apr-64	3.65	62.08	0.00	2.30	80.68	25.60	36.48
May-64	13.37	59.49	0.00	2.30	43.01	25.61	33.89
Jun-64	43.01	62.50	0.00	2.30	0.00	25.82	36.68
Jul-64	42.39	65.48	0.00	2.30	0.00	25.96	39.52
Aug-64	43.21	68.51	0.00	2.30	0.00	25.82	42.70
Sep-64	51.88	71.73	0.00	2.30	0.00	25.91	45.82
Oct-64	55.84	75.04	0.00	2.30	0.00	26.18	48.86
Nov-64	65.44	78.47	0.00	2.30	5.95	26.61	51.86
Dec-64	20.36	79.53	0.00	2.30	0.00	26.75	52.78
Jan-65	15.66	80.21	0.00	2.30	0.00	26.06	54.15
Feb-65	7.79	75.12	0.00	2.30	93.13	26.26	48.87
Mar-65	4.47	72.41	0.00	2.30	43.01	25.53	46.87
Apr-65	2.63	66.50	0.00	2.30	85.21	25.67	40.82
May-65	4.11	63.26	0.00	2.30	43.01	25.45	37.82
Jun-65	8.13	63.62	0.00	2.30	0.00	24.96	38.66
Jul-65	7.25	57.83	0.00	2.30	75.87	25.46	32.36
Aug-65	16.40	59.00	0.00	2.30	0.00	25.21	33.79
Sep-65	13.17	59.85	0.00	2.30	0.00	25.67	34.19
Oct-65	26.93	61.68	0.00	2.30	0.00	25.91	35.77
Nov-65	33.41	63.91	0.00	2.30	0.00	26.64	37.27
Dec-65	35.40	66.35	0.00	2.30	0.00	26.75	39.61
Jan-66	12.54	67.02	0.00	2.30	0.00	26.52	40.50
Feb-66	6.23	64.21	0.00	2.30	43.01	25.90	38.31
Mar-66	4.22	60.95	0.00	2.30	43.01	25.73	35.23
Apr-66	4.47	57.47	0.00	2.30	43.01	25.22	32.25
May-66	25.57	55.63	0.00	2.30	43.01	25.82	29.82
Jun-66	35.08	58.37	0.00	2.30	0.00	25.82	32.56
Jul-66	28.29	60.51	0.00	2.30	0.00	25.82	34.70
Aug-66	24.75	62.15	0.00	2.30	0.00	25.82	36.34
Sep-66	17.64	63.21	0.00	2.30	0.00	25.91	37.30
Oct-66	53.04	67.00	0.00	2.30	0.00	26.18	40.82
Nov-66	70.68	71.63	0.00	2.30	0.00	26.64	44.99
Dec-66	54.28	74.84	0.00	2.30	0.00	26.75	48.10
Jan-67	17.64	75.71	0.00	2.30	0.00	26.45	49.26
Feb-67	8.67	73.49	0.00	2.30	43.01	25.88	47.61
Mar-67	4.59	67.65	0.00	2.30	86.35	25.97	41.68
Apr-67	7.14	64.71	0.00	2.30	43.01	25.48	39.22
May-67	21.41	62.79	0.00	2.30	43.01	25.74	37.05
Jun-67	50.01	66.24	0.00	2.30	0.00	25.82	40.42
Jul-67	37.77	68.86	0.00	2.30	0.00	25.82	43.04
Aug-67	41.46	71.46	0.00	2.30	0.00	25.82	45.64
Sep-67	55.22	74.62	0.00	2.30	0.00	25.91	48.72
Oct-67	63.68	76.95	0.00	2.30	23.41	26.18	50.76
Nov-67	42.59	78.47	0.00	2.30	14.13	26.61	51.86
Dec-67	20.16	79.52	0.00	2.30	0.00	26.75	52.77

PROPOSED RÍO INDIO RESERVOIR OPERATION
(As simulated by the ACP)

	Indio Reservoir Inflow (cms)	Indio Reservoir WS Elev (m)	Spillage (cms)	Downstream Release (cms)	Transferred Discharge (cms)	Lake Gatun WS Elev (m)	Gross Head (m)
Jan-68	9.54	79.85	0.00	2.30	0.00	25.90	53.96
Feb-68	6.91	74.52	0.00	2.30	92.68	26.19	48.33
Mar-68	4.47	71.80	0.00	2.30	43.01	25.57	46.24
Apr-68	4.02	65.92	0.00	2.30	84.62	25.73	40.19
May-68	10.85	63.20	0.00	2.30	43.01	25.56	37.64
Jun-68	30.38	65.20	0.00	2.30	0.00	25.82	39.38
Jul-68	22.85	66.68	0.00	2.30	0.00	25.82	40.87
Aug-68	32.17	68.88	0.00	2.30	0.00	25.82	43.06
Sep-68	33.73	70.92	0.00	2.30	0.00	25.91	45.01
Oct-68	56.46	74.27	0.00	2.30	0.00	26.20	48.08
Nov-68	54.60	77.41	0.00	2.30	0.00	26.61	50.80
Dec-68	26.50	78.85	0.00	2.30	0.00	26.75	52.10
Jan-69	11.38	79.31	0.00	2.30	0.00	25.96	53.35
Feb-69	6.68	74.16	0.00	2.30	92.26	26.14	48.02
Mar-69	3.45	71.38	0.00	2.30	43.01	25.43	45.95
Apr-69	5.24	65.54	0.00	2.30	84.21	25.63	39.91
May-69	10.65	62.80	0.00	2.30	43.01	25.50	37.30
Jun-69	21.61	64.15	0.00	2.30	0.00	25.61	38.54
Jul-69	15.55	65.08	0.00	2.30	0.00	25.44	39.65
Aug-69	25.29	66.75	0.00	2.30	0.00	25.74	41.01
Sep-69	51.59	70.26	0.00	2.30	0.00	25.91	44.35
Oct-69	44.06	72.82	0.00	2.30	0.00	26.18	46.64
Nov-69	48.00	75.55	0.00	2.30	0.00	26.57	48.98
Dec-69	29.25	77.18	0.00	2.30	0.00	26.67	50.51
Jan-70	24.01	78.43	0.00	2.30	0.00	26.68	51.76
Feb-70	10.76	76.34	0.00	2.30	43.01	26.30	50.03
Mar-70	9.12	73.91	0.00	2.30	43.01	26.03	47.88
Apr-70	9.63	71.61	0.00	2.30	43.01	25.82	45.79
May-70	28.49	70.46	0.00	2.30	43.01	25.82	44.64
Jun-70	19.23	71.42	0.00	2.30	0.00	25.82	45.60
Jul-70	21.49	72.36	0.00	2.30	3.14	25.82	46.54
Aug-70	46.35	73.89	0.00	2.30	18.66	25.99	47.90
Sep-70	39.36	76.08	0.00	2.30	0.00	25.91	50.17
Oct-70	58.67	76.95	0.00	2.30	41.42	26.30	50.65
Nov-70	46.24	79.56	0.00	2.30	0.00	26.64	52.92
Dec-70	95.71	82.50	85.91	2.30	36.49	26.75	55.76
Jan-71	41.65	80.00	0.00	2.30	0.00	26.52	53.49
Feb-71	14.92	78.14	0.00	2.30	43.01	26.30	51.84
Mar-71	8.47	75.68	0.00	2.30	43.01	26.03	49.65
Apr-71	6.34	73.16	0.00	2.30	43.01	25.67	47.49
May-71	24.95	71.79	0.00	2.30	43.01	25.82	45.97
Jun-71	36.95	72.36	0.00	2.30	24.14	25.82	46.54
Jul-71	31.52	72.36	0.00	2.30	27.96	25.82	46.54
Aug-71	45.82	73.89	0.00	2.30	18.12	25.87	48.01
Sep-71	50.43	76.20	0.00	2.30	9.15	25.91	50.29
Oct-71	55.95	76.95	0.00	2.30	40.56	26.18	50.76
Nov-71	66.21	78.47	0.00	2.30	37.75	26.61	51.86
Dec-71	19.43	79.47	0.00	2.30	0.00	26.67	52.80

PROPOSED RÍO INDIO RESERVOIR OPERATION
(As simulated by the ACP)

	Indio Reservoir Inflow (cms)	Indio Reservoir WS Elev (m)	Spillage (cms)	Downstream Release (cms)	Transferred Discharge (cms)	Lake Gatun WS Elev (m)	Gross Head (m)
Jan-72	13.25	80.00	0.00	2.30	0.59	26.52	53.49
Feb-72	8.78	77.72	0.00	2.30	43.01	26.29	51.43
Mar-72	5.44	75.06	0.00	2.30	43.01	26.03	49.03
Apr-72	14.53	73.05	0.00	2.30	43.01	25.82	47.23
May-72	12.32	70.88	0.00	2.30	43.01	25.82	45.06
Jun-72	22.34	72.03	0.00	2.30	0.00	25.82	46.21
Jul-72	9.94	72.36	0.00	2.30	1.20	25.38	46.98
Aug-72	14.30	67.15	0.00	2.30	85.50	25.82	41.33
Sep-72	32.68	69.31	0.00	2.30	0.00	25.91	43.40
Oct-72	32.99	71.29	0.00	2.30	0.00	26.18	45.11
Nov-72	34.55	73.20	0.00	2.30	0.00	26.20	47.00
Dec-72	14.19	73.87	0.00	2.30	0.00	26.60	47.27
Jan-73	8.16	74.13	0.00	2.30	0.00	25.73	48.41
Feb-73	5.13	69.02	0.00	2.30	87.34	25.86	43.16
Mar-73	2.49	65.62	0.00	2.30	43.01	25.16	40.46
Apr-73	2.72	59.73	0.00	2.30	78.09	25.29	34.45
May-73	9.68	56.48	0.00	2.30	43.01	24.96	31.52
Jun-73	39.05	59.56	0.00	2.30	0.00	24.84	34.72
Jul-73	40.41	56.40	0.00	2.30	72.75	25.81	30.59
Aug-73	32.45	59.00	0.00	2.30	0.00	25.81	33.19
Sep-73	57.54	63.15	0.00	2.30	0.00	25.91	37.24
Oct-73	64.00	67.77	0.00	2.30	0.00	26.18	41.59
Nov-73	75.80	72.59	0.00	2.30	0.00	26.64	45.95
Dec-73	37.38	74.72	0.00	2.30	0.00	26.75	47.98
Jan-74	16.91	75.54	0.00	2.30	0.00	26.28	49.26
Feb-74	10.45	73.43	0.00	2.30	43.01	26.15	47.27
Mar-74	7.62	70.92	0.00	2.30	43.01	25.45	45.47
Apr-74	4.59	64.97	0.00	2.30	83.67	25.59	39.38
May-74	8.83	62.10	0.00	2.30	43.01	25.20	36.90
Jun-74	19.00	63.26	0.00	2.30	0.00	24.94	38.32
Jul-74	23.05	58.77	0.00	2.30	76.24	25.82	32.96
Aug-74	26.65	60.73	0.00	2.30	0.00	25.73	35.00
Sep-74	31.32	62.80	0.00	2.30	0.00	25.63	37.17
Oct-74	87.39	69.22	0.00	2.30	0.00	26.18	43.03
Nov-74	50.12	72.21	0.00	2.30	0.00	26.61	45.60
Dec-74	26.50	73.66	0.00	2.30	0.00	26.75	46.92
Jan-75	11.81	74.15	0.00	2.30	0.00	25.84	48.31
Feb-75	6.97	69.17	0.00	2.30	87.43	25.96	43.21
Mar-75	4.73	65.94	0.00	2.30	43.01	25.28	40.66
Apr-75	2.97	62.69	0.00	2.30	43.01	25.12	37.58
May-75	7.93	59.72	0.00	2.30	43.01	24.87	34.85
Jun-75	15.55	54.61	0.00	2.30	71.77	25.53	29.08
Jul-75	22.85	56.36	0.00	2.30	0.00	25.36	31.00
Aug-75	43.55	59.94	0.00	2.30	0.00	25.82	34.13
Sep-75	60.46	64.17	0.00	2.30	0.00	25.91	38.26
Oct-75	66.80	69.01	0.00	2.30	0.00	26.46	42.55
Nov-75	101.69	75.20	0.00	2.30	0.00	26.64	48.56
Dec-75	54.28	78.40	0.00	2.30	0.00	26.75	51.66

PROPOSED RÍO INDIO RESERVOIR OPERATION
(As simulated by the ACP)

	Indio Reservoir Inflow (cms)	Indio Reservoir WS Elev (m)	Spillage (cms)	Downstream Release (cms)	Transferred Discharge (cms)	Lake Gatun WS Elev (m)	Gross Head (m)
Jan-76	21.29	79.49	0.00	2.30	0.00	26.27	53.21
Feb-76	11.38	74.43	0.00	2.30	92.47	26.30	48.12
Mar-76	6.80	71.86	0.00	2.30	43.01	25.58	46.28
Apr-76	5.97	66.13	0.00	2.30	84.75	25.82	40.31
May-76	13.90	63.64	0.00	2.30	43.01	25.52	38.11
Jun-76	12.74	64.33	0.00	2.30	0.00	25.65	38.68
Jul-76	6.68	64.58	0.00	2.30	0.00	24.96	39.63
Aug-76	8.18	58.93	0.00	2.30	77.04	24.93	34.00
Sep-76	23.93	60.61	0.00	2.30	0.00	25.00	35.62
Oct-76	55.76	64.61	0.00	2.30	0.00	25.84	38.78
Nov-76	38.74	67.23	0.00	2.30	0.00	25.97	41.26
Dec-76	15.46	68.15	0.00	2.30	0.00	26.44	41.71
Jan-77	9.49	68.58	0.00	2.30	0.00	25.52	43.05
Feb-77	5.97	63.10	0.00	2.30	81.49	25.62	37.48
Mar-77	3.77	59.77	0.00	2.30	43.01	24.87	34.90
Apr-77	2.97	53.59	0.00	2.30	71.18	24.38	29.22
May-77	8.10	47.77	0.00	2.30	63.53	24.52	23.25
Jun-77	12.01	48.83	0.00	2.30	0.00	24.07	24.76
Jul-77	11.47	42.92	0.00	2.30	56.67	24.17	18.75
Aug-77	25.68	45.71	0.00	2.30	0.00	24.50	21.21
Sep-77	29.53	48.86	0.00	2.30	0.00	25.10	23.76
Oct-77	54.93	53.78	0.00	2.30	0.00	25.60	28.18
Nov-77	41.03	57.04	0.00	2.30	0.00	26.54	30.50
Dec-77	22.65	58.77	0.00	2.30	0.00	26.67	32.10
Jan-78	11.19	59.44	0.00	2.30	0.00	25.85	33.59
Feb-78	7.36	56.28	0.00	2.30	43.01	25.80	30.48
Mar-78	4.90	52.57	0.00	2.30	43.01	25.09	27.47
Apr-78	26.93	50.88	0.00	2.30	43.01	25.50	25.38
May-78	23.50	48.43	0.00	2.30	43.01	25.41	23.01
Jun-78	32.88	51.42	0.00	2.30	0.00	25.82	25.61
Jul-78	31.74	53.96	0.00	2.30	0.00	25.82	28.15
Aug-78	42.82	57.49	0.00	2.30	0.00	25.82	31.67
Sep-78	44.80	60.91	0.00	2.30	0.00	25.91	35.00
Oct-78	51.14	64.56	0.00	2.30	0.00	26.18	38.38
Nov-78	43.64	67.54	0.00	2.30	0.00	26.61	40.93
Dec-78	25.57	69.23	0.00	2.30	0.00	26.18	43.05
Jan-79	14.30	70.02	0.00	2.30	0.00	25.83	44.18
Feb-79	11.04	67.53	0.00	2.30	43.01	25.30	42.24
Mar-79	10.08	61.87	0.00	2.30	80.30	25.38	36.49
Apr-79	11.38	59.13	0.00	2.30	43.01	25.11	34.02
May-79	18.15	56.63	0.00	2.30	43.01	25.09	31.54
Jun-79	29.25	58.87	0.00	2.30	0.00	25.03	33.84
Jul-79	28.91	60.98	0.00	2.30	0.00	25.55	35.44
Aug-79	36.42	63.51	0.00	2.30	0.00	25.65	37.86
Sep-79	38.94	66.14	0.00	2.30	0.00	25.89	40.25
Oct-79	36.67	68.68	0.00	2.30	0.00	26.16	42.52
Nov-79	27.04	70.35	0.00	2.30	0.00	26.54	43.82
Dec-79	26.00	71.78	0.00	2.30	0.00	26.60	45.18

PROPOSED RÍO INDIO RESERVOIR OPERATION
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	Indio Reservoir Inflow (cms)	Indio Reservoir WS Elev (m)	Spillage (cms)	Downstream Release (cms)	Transferred Discharge (cms)	Lake Gatun WS Elev (m)	Gross Head (m)
Jan-80	24.21	73.05	0.00	2.30	0.00	26.52	46.54
Feb-80	8.72	70.78	0.00	2.30	43.01	26.05	44.73
Mar-80	4.11	67.65	0.00	2.30	43.01	25.92	41.74
Apr-80	2.78	64.39	0.00	2.30	43.01	25.31	39.08
May-80	14.10	61.92	0.00	2.30	43.01	25.72	36.20
Jun-80	19.09	63.08	0.00	2.30	0.00	25.57	37.51
Jul-80	20.98	64.43	0.00	2.30	0.00	25.75	38.68
Aug-80	49.27	67.93	0.00	2.30	0.00	25.82	42.11
Sep-80	24.75	69.50	0.00	2.30	0.00	25.64	43.87
Oct-80	37.58	71.75	0.00	2.30	0.00	25.77	45.98
Nov-80	33.81	68.62	0.00	2.30	77.67	26.61	42.01
Dec-80	29.02	70.47	0.00	2.30	0.00	26.47	44.00
Jan-81	20.98	71.55	0.00	2.30	0.00	26.52	45.03
Feb-81	13.56	69.55	0.00	2.30	43.01	26.04	43.51
Mar-81	12.32	66.89	0.00	2.30	43.01	25.94	40.95
Apr-81	30.19	65.65	0.00	2.30	43.01	25.83	39.82
May-81	30.89	64.46	0.00	2.30	43.01	26.14	38.32
Jun-81	34.55	66.76	0.00	2.30	0.00	26.37	40.40
Jul-81	41.54	69.66	0.00	2.30	0.00	26.37	43.30
Aug-81	39.25	71.98	0.00	2.30	0.00	26.33	45.66
Sep-81	29.99	73.61	0.00	2.30	0.00	25.91	47.70
Oct-81	50.12	76.56	0.00	2.30	0.00	26.18	50.37
Nov-81	61.16	78.47	0.00	2.30	26.31	26.64	51.83
Dec-81	78.92	82.50	63.68	2.30	2.51	26.75	55.76
Jan-82	19.43	80.00	0.00	2.30	0.00	26.52	53.49
Feb-82	6.03	77.64	0.00	2.30	43.01	26.30	51.33
Mar-82	3.99	74.88	0.00	2.30	43.01	25.86	49.02
Apr-82	5.47	70.87	0.00	2.30	66.81	25.82	45.05
May-82	9.51	68.21	0.00	2.30	43.01	25.68	42.53
Jun-82	22.14	69.59	0.00	2.30	0.00	25.75	43.85
Jul-82	28.18	71.22	0.00	2.30	0.00	25.40	45.82
Aug-82	18.07	66.15	0.00	2.30	84.42	25.82	40.33
Sep-82	29.02	68.04	0.00	2.30	0.00	25.75	42.30
Oct-82	52.84	71.50	0.00	2.30	0.00	26.17	45.34
Nov-82	27.27	72.96	0.00	2.30	0.00	26.53	46.43
Dec-82	9.29	73.32	0.00	2.30	0.00	25.79	47.53
Jan-83	6.09	67.59	0.00	2.30	86.22	26.00	41.60
Feb-83	3.17	64.57	0.00	2.30	43.01	25.36	39.22
Mar-83	1.90	61.13	0.00	2.30	43.01	24.55	36.58
Apr-83	1.59	54.88	0.00	2.30	72.79	24.46	30.42
May-83	16.28	50.17	0.00	2.30	66.04	24.20	25.97
Jun-83	24.32	45.67	0.00	2.30	59.79	24.47	21.20
Jul-83	17.25	47.41	0.00	2.30	0.00	24.47	22.94
Aug-83	19.31	49.41	0.00	2.30	0.00	24.46	24.95
Sep-83	47.09	53.35	0.00	2.30	0.00	24.78	28.57
Oct-83	36.76	56.34	0.00	2.30	0.00	25.44	30.90
Nov-83	31.21	58.75	0.00	2.30	0.00	25.63	33.12
Dec-83	40.10	61.74	0.00	2.30	0.00	26.41	35.33

PROPOSED RÍO INDIO RESERVOIR OPERATION
(As simulated by the ACP)

	Indio Reservoir Inflow (cms)	Indio Reservoir WS Elev (m)	Spillage (cms)	Downstream Release (cms)	Transferred Discharge (cms)	Lake Gatun WS Elev (m)	Gross Head (m)
Jan-84	16.37	62.71	0.00	2.30	0.00	26.30	36.41
Feb-84	10.36	60.11	0.00	2.30	43.01	25.82	34.29
Mar-84	6.74	56.57	0.00	2.30	43.01	25.69	30.87
Apr-84	3.71	52.87	0.00	2.30	43.01	25.11	27.77
May-84	17.64	50.33	0.00	2.30	43.01	24.91	25.43
Jun-84	28.63	52.53	0.00	2.30	0.00	25.35	27.18
Jul-84	32.17	55.10	0.00	2.30	0.00	25.12	29.99
Aug-84	50.63	59.32	0.00	2.30	0.00	25.82	33.50
Sep-84	41.54	62.24	0.00	2.30	0.00	25.91	36.34
Oct-84	46.55	65.54	0.00	2.30	0.00	26.18	39.36
Nov-84	39.36	68.21	0.00	2.30	0.00	26.61	41.60
Dec-84	13.37	68.96	0.00	2.30	0.00	26.22	42.74
Jan-85	8.95	69.35	0.00	2.30	0.00	25.98	43.37
Feb-85	5.58	66.48	0.00	2.30	43.01	25.41	41.07
Mar-85	4.30	63.22	0.00	2.30	43.01	25.28	37.94
Apr-85	2.78	59.97	0.00	2.30	43.01	24.56	35.40
May-85	8.75	54.09	0.00	2.30	71.59	24.86	29.23
Jun-85	31.52	56.53	0.00	2.30	0.00	24.59	31.93
Jul-85	18.07	51.80	0.00	2.30	68.07	25.31	26.49
Aug-85	40.72	55.14	0.00	2.30	0.00	25.12	30.02
Sep-85	39.25	58.24	0.00	2.30	0.00	25.83	32.41
Oct-85	36.53	61.03	0.00	2.30	0.00	25.86	35.17
Nov-85	42.28	63.92	0.00	2.30	0.00	26.31	37.61
Dec-85	27.67	65.77	0.00	2.30	0.00	26.64	39.13
Jan-86	9.83	66.23	0.00	2.30	0.00	26.36	39.87
Feb-86	5.13	63.35	0.00	2.30	43.01	25.77	37.57
Mar-86	3.14	60.01	0.00	2.30	43.01	25.60	34.41
Apr-86	16.71	57.43	0.00	2.30	43.01	25.16	32.27
May-86	19.85	55.08	0.00	2.30	43.01	25.30	29.78
Jun-86	31.01	57.47	0.00	2.30	0.00	25.51	31.96
Jul-86	23.16	59.24	0.00	2.30	0.00	25.10	34.14
Aug-86	19.62	60.60	0.00	2.30	0.00	25.30	35.30
Sep-86	28.71	62.47	0.00	2.30	0.00	25.16	37.32
Oct-86	58.56	66.69	0.00	2.30	0.00	26.18	40.51
Nov-86	64.00	70.97	0.00	2.30	0.00	26.58	44.39
Dec-86	15.66	71.73	0.00	2.30	0.00	26.52	45.22
Jan-87	7.70	71.97	0.00	2.30	0.00	25.63	46.34
Feb-87	5.21	66.59	0.00	2.30	85.04	25.79	40.80
Mar-87	3.00	63.23	0.00	2.30	43.01	25.06	38.17
Apr-87	5.24	57.40	0.00	2.30	75.44	24.94	32.46
May-87	14.92	54.62	0.00	2.30	43.01	25.55	29.06
Jun-87	23.93	56.40	0.00	2.30	0.00	25.82	30.58
Jul-87	26.84	58.50	0.00	2.30	0.00	25.82	32.68
Aug-87	32.45	60.94	0.00	2.30	0.00	25.82	35.12
Sep-87	41.77	63.78	0.00	2.30	0.00	25.91	37.87
Oct-87	75.27	69.27	0.00	2.30	0.00	26.33	42.94
Nov-87	33.41	71.23	0.00	2.30	0.00	26.61	44.62
Dec-87	18.49	72.18	0.00	2.30	0.00	26.62	45.56

PROPOSED RÍO INDIO RESERVOIR OPERATION
(As simulated by the ACP)

	Indio Reservoir Inflow (cms)	Indio Reservoir WS Elev (m)	Spillage (cms)	Downstream Release (cms)	Transferred Discharge (cms)	Lake Gatun WS Elev (m)	Gross Head (m)
Jan-88	7.84	72.42	0.00	2.30	0.00	26.23	46.19
Feb-88	5.30	69.93	0.00	2.30	43.01	25.58	44.35
Mar-88	2.97	63.55	0.00	2.30	82.43	25.60	37.95
Apr-88	2.72	60.30	0.00	2.30	43.01	24.91	35.39
May-88	12.32	57.32	0.00	2.30	43.01	24.55	32.78
Jun-88	24.64	53.20	0.00	2.30	69.45	25.12	28.08
Jul-88	26.31	55.25	0.00	2.30	0.00	24.91	30.34
Aug-88	34.55	58.04	0.00	2.30	0.00	25.50	32.54
Sep-88	34.77	60.65	0.00	2.30	0.00	25.91	34.74
Oct-88	54.93	64.59	0.00	2.30	0.00	26.37	38.21
Nov-88	42.70	67.50	0.00	2.30	0.00	26.61	40.89
Dec-88	23.05	68.99	0.00	2.30	0.00	26.67	42.32
Jan-89	13.17	69.70	0.00	2.30	0.00	25.92	43.78
Feb-89	7.28	66.96	0.00	2.30	43.01	25.83	41.12
Mar-89	5.01	63.75	0.00	2.30	43.01	25.66	38.08
Apr-89	2.92	60.50	0.00	2.30	43.01	24.92	35.59
May-89	13.79	57.70	0.00	2.30	43.01	24.91	32.79
Jun-89	19.31	59.08	0.00	2.30	0.00	24.30	34.77
Jul-89	29.02	55.01	0.00	2.30	71.65	25.04	29.97
Aug-89	37.27	58.03	0.00	2.30	0.00	25.05	32.98
Sep-89	36.13	60.74	0.00	2.30	0.00	25.44	35.30
Oct-89	38.00	63.39	0.00	2.30	0.00	26.11	37.28
Nov-89	56.18	67.30	0.00	2.30	0.00	26.61	40.69
Dec-89	31.32	69.42	0.00	2.30	0.00	26.67	42.75
Jan-90	15.89	70.28	0.00	2.30	0.00	26.16	44.12
Feb-90	7.11	67.58	0.00	2.30	43.01	26.03	41.55
Mar-90	4.84	64.36	0.00	2.30	43.01	25.34	39.01
Apr-90	3.31	61.14	0.00	2.30	43.01	25.24	35.90
May-90	25.77	59.50	0.00	2.30	43.01	25.56	33.93
Jun-90	18.69	60.71	0.00	2.30	0.00	25.05	35.66
Jul-90	23.93	62.28	0.00	2.30	0.00	25.43	36.85
Aug-90	24.83	63.92	0.00	2.30	0.00	25.32	38.61
Sep-90	43.35	66.88	0.00	2.30	0.00	25.91	40.97
Oct-90	62.33	71.14	0.00	2.30	0.00	26.43	44.71
Nov-90	41.97	73.50	0.00	2.30	0.00	26.61	46.89
Dec-90	64.70	77.36	0.00	2.30	0.00	26.67	50.69
Jan-91	10.76	77.78	0.00	2.30	0.00	25.87	51.92
Feb-91	6.03	72.68	0.00	2.30	90.85	25.97	46.72
Mar-91	7.33	70.16	0.00	2.30	43.01	25.33	44.83
Apr-91	3.26	64.02	0.00	2.30	82.79	25.43	38.59
May-91	14.61	61.59	0.00	2.30	43.01	25.36	36.23
Jun-91	20.78	62.88	0.00	2.30	0.00	25.54	37.34
Jul-91	15.35	63.80	0.00	2.30	0.00	25.75	38.05
Aug-91	19.00	65.00	0.00	2.30	0.00	25.44	39.55
Sep-91	40.30	67.72	0.00	2.30	0.00	25.67	42.05
Oct-91	50.94	71.11	0.00	2.30	0.00	26.11	45.00
Nov-91	34.77	73.04	0.00	2.30	0.00	26.61	46.43
Dec-91	46.04	75.72	0.00	2.30	0.00	26.54	49.18

PROPOSED RÍO INDIO RESERVOIR OPERATION
(As simulated by the ACP)

	Indio Reservoir Inflow (cms)	Indio Reservoir WS Elev (m)	Spillage (cms)	Downstream Release (cms)	Transferred Discharge (cms)	Lake Gatun WS Elev (m)	Gross Head (m)
Jan-92	9.54	76.07	0.00	2.30	0.00	26.22	49.85
Feb-92	3.54	73.48	0.00	2.30	43.01	25.58	47.89
Mar-92	3.85	67.58	0.00	2.30	86.30	25.64	41.94
Apr-92	5.75	64.53	0.00	2.30	43.01	25.14	39.39
May-92	27.86	63.11	0.00	2.30	43.01	25.28	37.83
Jun-92	29.11	65.01	0.00	2.30	0.00	25.81	39.20
Jul-92	27.98	66.89	0.00	2.30	0.00	25.82	41.07
Aug-92	48.14	70.25	0.00	2.30	0.00	25.82	44.43
Sep-92	45.00	72.79	0.00	2.30	0.00	25.98	46.81
Oct-92	39.13	75.04	0.00	2.30	0.00	26.18	48.86
Nov-92	32.99	76.85	0.00	2.30	0.00	26.41	50.44
Dec-92	20.25	72.20	0.00	2.30	90.17	26.67	45.53
Jan-93	12.20	72.72	0.00	2.30	0.00	25.97	46.74
Feb-93	6.97	70.41	0.00	2.30	43.01	25.88	44.53
Mar-93	5.66	67.33	0.00	2.30	43.01	25.26	42.07
Apr-93	9.09	61.80	0.00	2.30	80.15	25.55	36.24
May-93	11.58	59.00	0.00	2.30	43.01	25.26	33.74
Jun-93	31.21	61.21	0.00	2.30	0.00	25.61	35.59
Jul-93	22.77	62.69	0.00	2.30	0.00	25.82	36.87
Aug-93	17.64	63.78	0.00	2.30	0.00	25.82	37.97
Sep-93	36.95	66.27	0.00	2.30	0.00	25.94	40.33
Oct-93	51.48	69.93	0.00	2.30	0.00	26.18	43.75
Nov-93	65.67	73.76	0.00	2.30	0.00	26.61	47.15
Dec-93	34.55	75.72	0.00	2.30	0.00	26.67	49.05
Jan-94	12.63	76.26	0.00	2.30	0.00	25.93	50.33
Feb-94	7.33	71.31	0.00	2.30	89.48	26.08	45.24
Mar-94	5.97	68.44	0.00	2.30	43.01	25.42	43.02
Apr-94	6.48	62.63	0.00	2.30	81.17	25.58	37.05
May-94	13.99	60.16	0.00	2.30	43.01	25.42	34.74
Jun-94	21.95	61.54	0.00	2.30	0.00	25.76	35.77
Jul-94	16.28	62.53	0.00	2.30	0.00	25.82	36.71
Aug-94	12.63	63.24	0.00	2.30	0.00	25.82	37.42
Sep-94	12.63	63.93	0.00	2.30	0.00	25.91	38.02
Oct-94	37.58	66.54	0.00	2.30	0.00	26.18	40.36
Nov-94	38.51	69.13	0.00	2.30	0.00	26.61	42.53
Dec-94	13.90	69.93	0.00	2.30	0.00	26.16	43.77
Jan-95	8.58	70.24	0.00	2.30	0.00	26.03	44.20
Feb-95	4.56	67.35	0.00	2.30	43.01	25.40	41.96
Mar-95	3.00	61.19	0.00	2.30	79.82	25.42	35.77
Apr-95	4.19	57.72	0.00	2.30	43.01	24.80	32.93
May-95	24.01	55.74	0.00	2.30	43.01	24.78	30.96
Jun-95	37.49	58.69	0.00	2.30	0.00	25.22	33.47
Jul-95	32.88	61.13	0.00	2.30	0.00	25.82	35.32
Aug-95	30.07	63.18	0.00	2.30	0.00	25.82	37.36
Sep-95	38.20	65.75	0.00	2.30	0.00	25.91	39.84
Oct-95	32.17	67.95	0.00	2.30	0.00	26.05	41.90
Nov-95	43.64	70.77	0.00	2.30	0.00	26.61	44.16
Dec-95	30.81	72.49	0.00	2.30	0.00	26.67	45.82

PROPOSED RÍO INDIO RESERVOIR OPERATION
(As simulated by the ACP)

	Indio Reservoir Inflow (cms)	Indio Reservoir WS Elev (m)	Spillage (cms)	Downstream Release (cms)	Transferred Discharge (cms)	Lake Gatun WS Elev (m)	Gross Head (m)
Jan-96	59.92	76.03	0.00	2.30	0.00	26.75	49.28
Feb-96	27.86	74.88	0.00	2.30	43.01	26.30	48.57
Mar-96	14.19	72.78	0.00	2.30	43.01	26.03	46.75
Apr-96	7.67	70.35	0.00	2.30	43.01	25.82	44.54
May-96	21.95	68.55	0.00	2.30	43.01	25.82	42.73
Jun-96	43.55	71.25	0.00	2.30	0.00	25.82	45.43
Jul-96	47.91	72.36	0.00	2.30	26.83	25.82	46.54
Aug-96	58.98	73.89	0.00	2.30	31.29	25.85	48.04
Sep-96	42.82	75.88	0.00	2.30	6.74	25.91	49.97
Oct-96	74.45	76.95	0.00	2.30	54.01	26.18	50.76
Nov-96	58.02	78.47	0.00	2.30	29.57	26.64	51.83
Dec-96	53.77	81.34	33.45	2.30	0.00	26.67	54.67
Jan-97	11.81	80.00	0.00	2.30	0.00	26.06	53.95
Feb-97	7.36	74.86	0.00	2.30	92.91	26.25	48.61
Mar-97	4.84	72.17	0.00	2.30	43.01	25.49	46.68
Apr-97	3.57	66.30	0.00	2.30	84.99	25.60	40.70
May-97	5.89	63.20	0.00	2.30	43.01	25.21	37.99
Jun-97	7.16	63.48	0.00	2.30	0.00	25.23	38.25
Jul-97	8.35	63.86	0.00	2.30	0.00	24.66	39.21
Aug-97	6.85	58.06	0.00	2.30	76.14	25.10	32.96
Sep-97	16.65	59.22	0.00	2.30	0.00	24.75	34.46
Oct-97	21.69	54.52	0.00	2.30	71.42	25.04	29.47
Nov-97	26.25	56.51	0.00	2.30	0.00	24.90	31.60
Dec-97	11.53	57.24	0.00	2.30	0.00	24.63	32.61
Jan-98	5.32	51.35	0.00	2.30	68.22	24.09	27.26
Feb-98	4.42	45.28	0.00	2.30	60.31	23.93	21.35
Mar-98	3.00	40.00	0.00	2.30	42.75	23.93	16.08
Apr-98	4.11	40.00	0.00	2.30	0.96	23.93	16.08
May-98	14.19	40.00	0.00	2.30	11.29	23.93	16.08
Jun-98	13.22	40.00	0.00	2.30	10.38	23.93	16.08
Jul-98	23.19	40.00	0.00	2.30	20.34	24.53	15.47
Aug-98	18.97	41.98	0.00	2.30	0.00	24.73	17.25
Sep-98	26.31	44.76	0.00	2.30	0.00	25.30	19.46
Oct-98	41.12	49.43	0.00	2.30	0.00	25.49	23.94
Nov-98	24.24	51.41	0.00	2.30	0.00	26.04	25.37
Dec-98	35.91	54.32	0.00	2.30	0.00	26.48	27.84
Jan-99	18.55	55.66	0.00	2.30	0.00	26.37	29.29
Feb-99	10.14	52.73	0.00	2.30	43.01	25.84	26.88
Mar-99	7.67	48.99	0.00	2.30	43.01	25.81	23.17
Apr-99	8.75	44.52	0.00	2.30	43.01	25.29	19.23
May-99	24.55	41.89	0.00	2.30	43.01	25.70	16.18
Jun-99	33.81	45.55	0.00	2.30	0.00	25.82	19.74
Jul-99	23.79	48.10	0.00	2.30	0.00	25.82	22.28
Aug-99	53.26	53.08	0.00	2.30	0.00	25.88	27.20
Sep-99	66.15	58.49	0.00	2.30	0.00	25.91	32.59
Oct-99	35.06	61.14	0.00	2.30	0.00	26.18	34.95
Nov-99	50.38	64.62	0.00	2.30	0.00	26.61	38.01
Dec-99	67.28	69.49	0.00	2.30	0.00	26.75	42.74

ATTACHMENT 3

ENERGY PRODUCTION ANALYSIS

ISLA PABLON POWER PLANT - OUTPUT ANALYSIS

4.35 m Dia Transfer Tunnel

(ACP Operating Rules)

Average Annual Output (GWh)

Maximum Power Discharge (cms)	Design Head (m)						
	30	35	38	39	40	42	45
15	6.19	7.36	7.66	7.81	7.79	7.57	6.73
20	8.25	9.81	10.18	10.38	10.30	9.95	8.75
30	12.37		15.04	15.29	15.05		12.39
40	16.50		19.57	19.71	19.30		15.51
45	18.47	21.64	21.58	21.69	21.20	19.90	16.95
50	19.52	22.63	22.43	22.53	22.04	20.80	17.84
60	19.88		22.59	22.70	22.24		18.02
70	19.94	22.78	22.59	22.70	22.24	21.03	18.03

Installed Capacity (MW)

Maximum Power Discharge (cms)	Design Head (m)						
	30	35	38	39	40	42	45
15	3.8	4.4	4.8	4.9	5.0	5.3	5.6
20	5.0	5.8	6.3	6.5	6.7	7.0	7.5
30	7.5	8.8	9.5	9.8	10.0	10.5	11.3
40	10.0	11.7	12.7	13.0	13.3	14.0	15.0
45	11.3	13.1	14.3	14.6	15.0	15.8	16.9
50	12.5	14.6	15.8	16.3	16.7	17.5	18.8
60	15.0	17.5	19.0	19.5	20.0	21.0	22.5
70	17.5	20.4	22.2	22.8	23.3	24.5	26.3

Output computations are based on monthly transferred discharges from Rio Indio reservoir to Lake Gatun as specified by the HEC-5 run performed by the ACP in July 2002. The system consists of Rio Indio operating between El. 40 and El. 80 and a deepened Lake Gatun to allow operation between El. 23.93 (78.5 ft) and 26.75 (87.75 ft) and it supplies 60.4 Lockages/day at a reliability of 99.6%.

The following assumption were made:

1- The Max Power Discharge occurs at the Design head
2- The Installed Capacity is that at Max Power Discharge and Design Head
3- For net head greater than the design head the maximum output is limited by the Inst. Cap.
4- The plan overall efficiency is equal to 85%
5- Maximum net head on turbine is 125% of the design head
6- Minimum net head on turbine is 65% of the design head
7- The head losses are based on a 4.35-m dia., 8.4-km long tunnel
8- The simulation cover 52 years; water is transferred to Gatun 278 months out of 624.

ISLA PABLON POWER PLANT - OUTPUT ANALYSIS

5.00 m Dia Transfer Tunnel

(ACP Operating Rules)

Average Annual Output (GWh)

Maximum Power Discharge (cms)	Design Head (m)						
	30	36	39	40	41	43	46
15	6.13	8.97	9.98	10.25	10.43	10.60	9.94
20	8.17		13.27	13.62	13.80	13.96	13.04
30	12.25	17.95	19.66	20.12	20.28	20.28	18.80
40	16.33		25.79	26.21	26.28	26.10	24.06
45	18.27	26.55	28.64	28.97	28.95	28.68	26.43
50	19.42	27.98	29.91	30.14	30.08	29.80	27.57
60	20.45		30.29	30.42	30.34		27.85
70	21.35	29.03	30.43	30.51	30.43	30.15	27.92

Installed Capacity (MW)

Maximum Power Discharge (cms)	Design Head (m)						
	30	36	39	40	41	43	46
15	3.8	4.5	4.9	5.0	5.1	5.4	5.8
20	5.0	6.0	6.5	6.7	6.8	7.2	7.7
30	7.5	9.0	9.8	10.0	10.3	10.8	11.5
40	10.0	12.0	13.0	13.3	13.7	14.3	15.3
45	11.3	13.5	14.6	15.0	15.4	16.1	17.3
50	12.5	15.0	16.3	16.7	17.1	17.9	19.2
60	15.0	18.0	19.5	20.0	20.5	21.5	23.0
70	17.5	21.0	22.8	23.3	23.9	25.1	26.8

Output computations are based on monthly transferred discharges from Rio Indio reservoir to Lake Gatun as specified by the HEC-5 run performed by the ACP in July 2002. The system consists of Rio Indio operating between El. 40 and El. 80 and a deepened Lake Gatun to allow operation between El. 23.93 (78.5 ft) and 26.75 (87.75 ft) and it supplies 60.4 Lockages/day at a reliability of 99.6%.

The following assumption were made:

1- The Max Power Discharge occurs at the Design head
2- The Installed Capacity is that at Max Power Discharge and Design Head
3- For net head greater than the design head the maximum output is limited by the Inst. Cap.
4- The plan overall efficiency is equal to 85%
5- Maximum net head on turbine is 125% of the design head
6- Minimum net head on turbine is 65% of the design head
7- The head losses are based on a 5.0-m dia., 8.4-km long tunnel
8- The simulation cover 52 years; water is transferred to Gatun 278 months out of 624.

ISLA PABLON POWER PLANT - OUTPUT ANALYSIS

6.00 m Dia Transfer Tunnel

(ACP Operating Rules)

Average Annual Output (GWh)

Maximum Power Discharge (cms)	Design Head (m) 30	35	38	40	41	42	46
15	6.62	9.70	12.12	13.48	14.26	14.27	13.91
20	8.83	12.93	16.13	17.92	18.91	18.89	18.33
30	13.24	19.41	24.09	26.62	27.96	27.83	26.76
40	17.65	25.88	31.85	35.03	36.58	36.31	34.68
50	21.45	30.83	37.71	41.43	42.87	42.41	40.22
60	23.35			43.74	45.05	44.48	41.93
70	25.03			45.70	46.93	46.29	43.46
80	26.70	37.32	43.88	47.60	48.74	48.02	44.90
95	27.93	39.24	46.15	50.06	51.32	50.52	47.00

Installed Capacity (MW)

Maximum Power Discharge (cms)	Design Head (m) 30	35	38	40	41	42	46
15	3.8	4.4	4.8	5.0	5.1	5.3	5.8
20	5.0	5.8	6.3	6.7	6.8	7.0	7.7
30	7.5	8.8	9.5	10.0	10.3	10.5	11.5
40	10.0	11.7	12.7	13.3	13.7	14.0	15.3
50	12.5	14.6	15.8	16.7	17.1	17.5	19.2
60	15.0	17.5	19.0	20.0	20.5	21.0	23.0
70	17.5	20.4	22.2	23.3	23.9	24.5	26.8
80	20.0	23.3	25.3	26.7	27.4	28.0	30.7
95	23.8	27.7	30.1	31.7	32.5	33.3	36.4

Output computations are based on monthly transferred discharges from Rio Indio reservoir to Lake Gatun as specified by the HEC-5 run performed by the ACP in July 2002. The system consists of Rio Indio operating between El. 40 and El. 80 and a deepened Lake Gatun to allow operation between El. 23.93 (78.5 ft) and 26.75 (87.75 ft) and it supplies 60.4 Lockages/day at a reliability of 99.6%.

The following assumption were made:

1- The Max Power Discharge occurs at the Design head
2- The Installed Capacity is that at Max Power Discharge and Design Head
3- For net head greater than the design head the maximum output is limited by the Inst. Cap.
4- The plan overall efficiency is equal to 85%
5- Maximum net head on turbine is 125% of the design head
6- Minimum net head on turbine is 65% of the design head
7- The head losses are based on a 6.0-m dia., 8.4-km long tunnel
8- The simulation cover 52 years; water is transferred to Gatun 278 months out of 624.

ISLA PABLON POWER PLANT - OUTPUT ANALYSIS

4.35 m Dia Transfer Tunnel

(Modified Operating Rules with Indio between El 40 and El 80)

Average Annual Output (GWh)

Maximum Power Discharge (cms)	Design Head (m): 40	42	43	44	46
10	19.48	20.70	20.97	20.88	20.31
15	29.00	30.85	31.24	31.08	30.23
20	30.45	32.44	32.84	32.65	31.78
25	30.52	32.56	32.96	32.78	31.92
30	30.59	32.67	33.07	32.88	32.00
40	30.73	32.81	33.21	33.02	32.14
50	30.81	32.87	33.25	33.06	32.18
60	30.81	32.87	33.25	33.06	32.18

Installed Capacity (MW)

Maximum Power Discharge (cms)	Design Head (m): 40	42	43	44	46
10	3.3	3.5	3.6	3.7	3.8
15	5.0	5.3	5.4	5.5	5.8
20	6.7	7.0	7.2	7.3	7.7
25	8.3	8.8	9.0	9.2	9.6
30	10.0	10.5	10.8	11.0	11.5
40	13.3	14.0	14.3	14.7	15.3
50	16.7	17.5	17.9	18.3	19.2
60	20.0	21.0	21.5	22.0	23.0

Output computations are based on monthly transferred discharges from Rio Indio reservoir to Lake Gatun as specified by the HEC-5 run performed by TAMS in August 2002. The system consists of Rio Indio operating between El. 40 and El. 80 and a deepened Lake Gatun to allow operation between El. 23.93 (78.5 ft) and 26.75 (87.75 ft) and it supplies 60.4 Lockages/day at a reliability of 99.6%. The targeted transfer of 14.3 cms from Indio to Gatun is achieved 100% of the time.

The following assumption were made:

1- The Max Power Discharge occurs at the Design head
2- The Installed Capacity is that at Max Power Discharge and Design Head
3- For net head greater than the design head the maximum output is limited by the Inst. Cap.
4- The plan overall efficiency is equal to 85%
5- Maximum net head on turbine is 125% of the design head
6- Minimum net head on turbine is 65% of the design head
7- The head losses are based on a 4.35-m dia., 8.4-km long tunnel
8- The simulation cover 52 years; water is transferred to Gatun 623 months out of 624.

ISLA PABLON POWER PLANT - OUTPUT ANALYSIS

5.00 m Dia Transfer Tunnel

(Modified Operating Rules with Indio between El 40 and El 80)

Average Annual Output (GWh)

Maximum Power Discharge (cms)	Design Head (m) 40	42	43	44	46
10	19.53	20.59	21.39	21.41	21.00
15	29.10	30.67	31.87	31.90	31.25
20	30.55	32.17	33.54	33.53	32.86
25	30.62	32.31	33.70	33.70	33.03
30	30.68	32.45	33.85	33.84	33.17
40	30.81	32.67	34.07	34.07	33.39
50	30.93	32.86	34.25	34.24	33.54
60	31.03	32.95	34.33	34.31	33.61

Installed Capacity (MW)

Maximum Power Discharge (cms)	Design Head (m) 40	42	43	44	46
10	3.3	3.5	3.6	3.7	3.8
15	5.0	5.3	5.4	5.5	5.8
20	6.7	7.0	7.2	7.3	7.7
25	8.3	8.8	9.0	9.2	9.6
30	10.0	10.5	10.8	11.0	11.5
40	13.3	14.0	14.3	14.7	15.3
50	16.7	17.5	17.9	18.3	19.2
60	20.0	21.0	21.5	22.0	23.0

Output computations are based on monthly transferred discharges from Rio Indio reservoir to Lake Gatun as specified by the HEC-5 run performed by TAMS in August 2002. The system consists of Rio Indio operating between El. 40 and El. 80 and a deepened Lake Gatun to allow operation between El. 23.93 (78.5 ft) and 26.75 (87.75 ft) and it supplies 60.4 Lockages/day at a reliability of 99.6%. The targeted transfer of 14.3 cms from Indio to Gatun is achieved 100% of the time.

The following assumption were made:

1- The Max Power Discharge occurs at the Design head
2- The Installed Capacity is that at Max Power Discharge and Design Head
3- For net head greater than the design head the maximum output is limited by the Inst. Cap.
4- The plan overall efficiency is equal to 85%
5- Maximum net head on turbine is 125% of the design head
6- Minimum net head on turbine is 65% of the design head
7- The head losses are based on a 5.00-m dia., 8.4-km long tunnel
8- The simulation cover 52 years; water is transferred to Gatun 623 months out of 624.

ISLA PABLON POWER PLANT - OUTPUT ANALYSIS

6.00 m Dia Transfer Tunnel

(Modified Operating Rules with Indio between El 40 and El 80)

Average Annual Output (GWh)

Maximum Power Discharge (cms)	Design Head (m) 40	42	43	44	46
10	21.32	22.09	22.90	23.08	22.42
20	34.09	35.14	36.51	36.74	35.54
30	35.79	36.82	38.21	38.40	36.95
40	37.48	38.50	39.83	39.98	38.29
50	39.18	40.15	41.41	41.51	39.56
60	40.87	41.77	42.95	42.95	40.75
80	44.19	44.88	45.92	45.74	43.03
95	46.35	47.11	48.05	47.72	44.65

Installed Capacity (MW)

Maximum Power Discharge (cms)	Design Head (m) 40	42	43	44	46
10	3.3	3.5	3.6	3.7	3.8
20	6.7	7.0	7.2	7.3	7.7
30	10.0	10.5	10.8	11.0	11.5
40	13.3	14.0	14.3	14.7	15.3
50	16.7	17.5	17.9	18.3	19.2
60	20.0	21.0	21.5	22.0	23.0
80	26.7	28.0	28.7	29.4	30.7
95	31.7	33.3	34.1	34.9	36.4

Output computations are based on monthly transferred discharges from Rio Indio reservoir to Lake Gatun as specified by the HEC-5 run performed by TAMS in August 2002. The system consists of Rio Indio operating between El. 40 and El. 80 and a deepened Lake Gatun to allow operation between El. 23.93 (78.5 ft) and 26.75 (87.75 ft) and it supplies 60.4 Lockages/day at a reliability of 99.6%. The targeted transfer of 14.3 cms from Indio to Gatun is achieved 100% of the time.

The following assumption were made:

1- The Max Power Discharge occurs at the Design head
2- The Installed Capacity is that at Max Power Discharge and Design Head
3- For net head greater than the design head the maximum output is limited by the Inst. Cap.
4- The plan overall efficiency is equal to 85%
5- Maximum net head on turbine is 125% of the design head
6- Minimum net head on turbine is 65% of the design head
7- The head losses are based on a 6.00-m dia., 8.4-km long tunnel
8- The simulation cover 52 years; water is transferred to Gatun 623 months out of 624.

ISLA PABLON POWER PLANT - OUTPUT ANALYSIS

4.35 m Dia Transfer Tunnel

(Modified Operating Rules with Indio between El 50 and El 80)

Average Annual Output (GWh)

Maximum Power Discharge (cms)	Design Head (m) 40	42	43	44	46
10	19.97	19.99	19.60	19.16	18.13
15	34.06	34.09	33.50	31.84	30.30
20	39.94	39.99	39.21	38.32	36.26
25	43.55	44.02	43.12	42.13	39.93
30	44.02	44.09	43.19	42.20	40.00
40	44.14	44.20	43.29	42.29	40.08
50	44.20	44.26	43.35	42.36	40.16
60	44.21	44.27	43.37	42.38	40.18

Installed Capacity (MW)

Maximum Power Discharge (cms)	Design Head (m) 40	42	43	44	46
10	3.3	3.5	3.6	3.7	3.8
15	5.0	5.3	5.4	5.5	5.8
20	6.7	7.0	7.2	7.3	7.7
25	8.3	8.8	9.0	9.2	9.6
30	10.0	10.5	10.8	11.0	11.5
40	13.3	14.0	14.3	14.7	15.3
50	16.7	17.5	17.9	18.3	19.2
60	20.0	21.0	21.5	22.0	23.0

Output computations are based on monthly transferred discharges from Rio Indio reservoir to Lake Gatun as specified by the HEC-5 run performed by TAMS in August 2002. The system consists of Rio Indio operating between El. 40 and El. 80 and a deepened Lake Gatun to allow operation between El. 23.93 (78.5 ft) and 26.75 (87.75 ft) and it supplies 58.4 Lockages/day at a reliability of 99.6%. The targeted transfer of 20 cms from Indio to Gatun is achieved 99% of the time.

The following assumption were made:

1- The Max Power Discharge occurs at the Design head
2- The Installed Capacity is that at Max Power Discharge and Design Head
3- For net head greater than the design head the maximum output is limited by the Inst. Cap.
4- The plan overall efficiency is equal to 85%
5- Maximum net head on turbine is 125% of the design head
6- Minimum net head on turbine is 65% of the design head
7- The head losses are based on a 4.35-m dia., 8.4-km long tunnel
8- The simulation cover 52 years; water is transferred to Gatun 623 months out of 624.

ISLA PABLON POWER PLANT - OUTPUT ANALYSIS

4.35 m Dia Transfer Tunnel

(Modified Operating Rules with Indio between El 60 and El 80)

Average Annual Output (GWh)

Maximum Power Discharge (cms)	Design Head (m) 40	42	43	44	46
10	25.00	27.00	27.20	27.33	27.13
15	37.40	40.42	40.70	40.75	40.61
20	49.76	53.79	54.17	54.24	54.05
25	53.68	57.88	58.14	58.14	58.08
30	53.81	58.02	58.27	58.27	58.19
40	54.02	58.23	58.48	58.47	58.34
50	54.11	58.30	58.54	58.54	58.42
60	54.14	58.33	58.57	58.57	58.45

Installed Capacity (MW)

Maximum Power Discharge (cms)	Design Head (m) 40	42	43	44	46
10	3.3	3.5	3.6	3.7	3.8
15	5.0	5.3	5.4	5.5	5.8
20	6.7	7.0	7.2	7.3	7.7
25	8.3	8.8	9.0	9.2	9.6
30	10.0	10.5	10.8	11.0	11.5
40	13.3	14.0	14.3	14.7	15.3
50	16.7	17.5	17.9	18.3	19.2
60	20.0	21.0	21.5	22.0	23.0

Output computations are based on monthly transferred discharges from Rio Indio reservoir to Lake Gatun as specified by the HEC-5 run performed by TAMS in August 2002. The system consists of Rio Indio operating between El. 40 and El. 80 and a deepened Lake Gatun to allow operation between El. 23.93 (78.5 ft) and 26.75 (87.75 ft) and it supplies 54.9 Lockages/day at a reliability of 99.6%. The targeted transfer of 20 cms from Indio to Gatun is achieved 98% of the time.

The following assumption were made:

1- The Max Power Discharge occurs at the Design head
2- The Installed Capacity is that at Max Power Discharge and Design Head
3- For net head greater than the design head the maximum output is limited by the Inst. Cap.
4- The plan overall efficiency is equal to 85%
5- Maximum net head on turbine is 125% of the design head
6- Minimum net head on turbine is 65% of the design head
7- The head losses are based on a 4.35-m dia., 8.4-km long tunnel
8- The simulation cover 52 years; water is transferred to Gatun 622 months out of 624.

ISLA PABLON POWER PLANT - OUTPUT ANALYSIS

4.35 m Dia Transfer Tunnel

(Modified Operating Rules with Indio between El 70 and El 80)

Average Annual Output (GWh)

Maximum Power Discharge (cms)	Design Head (m) 40	42	43	44	46
10	24.96	29.29	30.27	30.78	31.40
15	37.20	43.67	45.13	45.88	46.82
20	49.27	57.81	59.75	60.75	62.03
25	56.17	63.74	64.64	64.68	64.74
30	56.43	64.06	64.98	65.00	65.05
40	56.80	64.40	65.29	65.29	65.28
50	56.94	64.51	65.40	65.39	65.38
60	57.04	64.61	65.50	65.49	65.48

Installed Capacity (MW)

Maximum Power Discharge (cms)	Design Head (m) 40	42	43	44	46
10	3.3	3.5	3.6	3.7	3.8
15	5.0	5.3	5.4	5.5	5.8
20	6.7	7.0	7.2	7.3	7.7
25	8.3	8.8	9.0	9.2	9.6
30	10.0	10.5	10.8	11.0	11.5
40	13.3	14.0	14.3	14.7	15.3
50	16.7	17.5	17.9	18.3	19.2
60	20.0	21.0	21.5	22.0	23.0

Output computations are based on monthly transferred discharges from Rio Indio reservoir to Lake Gatun as specified by the HEC-5 run performed by TAMS in August 2002. The system consists of Rio Indio operating between El. 40 and El. 80 and a deepened Lake Gatun to allow operation between El. 23.93 (78.5 ft) and 26.75 (87.75 ft) and it supplies 51.0 Lockages/day at a reliability of 99.6%. The targeted transfer of 20 cms from Indio to Gatun is achieved 93% of the time.

The following assumption were made:

1- The Max Power Discharge occurs at the Design head
2- The Installed Capacity is that at Max Power Discharge and Design Head
3- For net head greater than the design head the maximum output is limited by the Inst. Cap.
4- The plan overall efficiency is equal to 85%
5- Maximum net head on turbine is 125% of the design head
6- Minimum net head on turbine is 65% of the design head
7- The head losses are based on a 4.35-m dia., 8.4-km long tunnel
8- The simulation cover 52 years; water is transferred to Gatun 617 months out of 624.

ISLA PABLON POWER PLANT - OUTPUT ANALYSIS

4.35 m Dia Transfer Tunnel

(Modified Operating Rules with Indio between El 75 and El 80)

Average Annual Output (GWh)

		Design Head (m)				
		40	42	43	44	46
Maximum Power Discharge (cms)	10	24.66	27.44	28.05	28.65	29.82
	15	36.08	40.00	40.87	41.73	43.37
	20	46.86	51.80	52.86	53.91	55.92
	25	56.76	62.59	63.78	64.96	67.20
	30	64.70	69.22	69.26	69.27	69.29
	40	65.34	69.56	69.55	69.55	69.55
	50	65.51	69.72	69.72	69.70	69.70
	60	65.57	69.78	69.78	69.78	69.77

Installed Capacity (MW)

		Design Head (m)				
		40	42	43	44	46
Maximum Power Discharge (cms)	10	3.3	3.5	3.6	3.7	3.8
	15	5.0	5.3	5.4	5.5	5.8
	20	6.7	7.0	7.2	7.3	7.7
	25	8.3	8.8	9.0	9.2	9.6
	30	10.0	10.5	10.8	11.0	11.5
	40	13.3	14.0	14.3	14.7	15.3
	50	16.7	17.5	17.9	18.3	19.2
	60	20.0	21.0	21.5	22.0	23.0

Output computations are based on monthly transferred discharges from Rio Indio reservoir to Lake Gatun as specified by the HEC-5 run performed by TAMS in August 2002. The system consists of Rio Indio operating between El. 40 and El. 80 and a deepened Lake Gatun to allow operation between El. 23.93 (78.5 ft) and 26.75 (87.75 ft) and it supplies 48.8 Lockages/day at a reliability of 99.6%. The targeted transfer of 25 cms from Indio to Gatun is achieved 64% of the time.

The following assumption were made:

1- The Max Power Discharge occurs at the Design head
2- The Installed Capacity is that at Max Power Discharge and Design Head
3- For net head greater than the design head the maximum output is limited by the Inst. Cap.
4- The plan overall efficiency is equal to 85%
5- Maximum net head on turbine is 125% of the design head
6- Minimum net head on turbine is 65% of the design head
7- The head losses are based on a 4.35-m dia., 8.4-km long tunnel
8- The simulation cover 52 years; water is transferred to Gatun 594 months out of 624.

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.40 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**5,378 kW**
Maximum Turbine Discharge	**15.00 cms**
Tunnel Diameter (horseshoe)	**4.35 meters**
Tunnel Area	**16.89 sq. m**
Hydraulic Radius	**1.09 meters**
Head Loss Coefficient	**0.0155**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**1.27 meters**
Average Annual Output	**31,235 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**2,500 kW**
Maximum Turbine Discharge	**4.84 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**0.14 meters**
Average Annual Output	**9,882 MWh**
Gatun Power Plant	
Average Annual Output	**54,451 MWh**
Madden Power Plant	
Average Annual Output	**187,930 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.40 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**7,171 kW**
Maximum Turbine Discharge	**20.00 cms**
Tunnel Diameter (horseshoe)	**4.35 meters**
Tunnel Area	**16.89 sq. m**
Hydraulic Radius	**1.09 meters**
Head Loss Coefficient	**0.0155**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**2.25 meters**
Average Annual Output	**32,838 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**2,500 kW**
Maximum Turbine Discharge	**4.84 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**0.14 meters**
Average Annual Output	**9,882 MWh**
Gatun Power Plant	
Average Annual Output	**54,451 MWh**
Madden Power Plant	
Average Annual Output	**187,930 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.40 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**8,964 kW**
Maximum Turbine Discharge	**25.00 cms**
Tunnel Diameter (horseshoe)	**4.35 meters**
Tunnel Area	**16.89 sq. m**
Hydraulic Radius	**1.09 meters**
Head Loss Coefficient	**0.0155**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**3.51 meters**
Average Annual Output	**32,964 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**2,500 kW**
Maximum Turbine Discharge	**4.84 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**0.14 meters**
Average Annual Output	**9,882 MWh**
Gatun Power Plant	
Average Annual Output	**54,451 MWh**
Madden Power Plant	
Average Annual Output	**187,930 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.40 and El.80

Isla Pablon Power Plant	
Design head	43.00 meters
Installed Capacity	5,378 kW
Maximum Turbine Discharge	15.00 cms
Tunnel Diameter (horseshoe)	5.00 meters
Tunnel Area	22.32 sq. m
Hydraulic Radius	1.25 meters
Head Loss Coefficient	0.015
Tunnel Length	8,415 meters
Tunnel Loss at Max Turb Discharge	0.62 meters
Average Annual Output	31,870 MWh
Rio Indio Power Plant	
Design head	62.00 meters
Installed Capacity	2,500 kW
Maximum Turbine Discharge	4.84 cms
Tunnel Diameter (horseshoe)	2.50 meters
Tunnel Area	5.58 sq. m
Hydraulic Radius	0.63 meters
Head Loss Coefficient	0.0175
Tunnel Length	300 meters
Tunnel Loss at Max Turb Discharge	0.14 meters
Average Annual Output	9,882 MWh
Gatun Power Plant	
Average Annual Output	54,451 MWh
Madden Power Plant	
Average Annual Output	187,930 MWh

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.40 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**7,171 kW**
Maximum Turbine Discharge	**20.00 cms**
Tunnel Diameter (horseshoe)	**5.00 meters**
Tunnel Area	**22.32 sq. m**
Hydraulic Radius	**1.25 meters**
Head Loss Coefficient	**0.015**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**1.09 meters**
Average Annual Output	**33,535 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**2,500 kW**
Maximum Turbine Discharge	**4.84 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**0.14 meters**
Average Annual Output	**9,882 MWh**
Gatun Power Plant	
Average Annual Output	**54,451 MWh**
Madden Power Plant	
Average Annual Output	**187,930 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.40 and El.80

Isla Pablon Power Plant	
Design head	43.00 meters
Installed Capacity	8,964 kW
Maximum Turbine Discharge	25.00 cms
Tunnel Diameter (horseshoe)	5.00 meters
Tunnel Area	22.32 sq. m
Hydraulic Radius	1.25 meters
Head Loss Coefficient	0.015
Tunnel Length	8,415 meters
Tunnel Loss at Max Turb Discharge	1.71 meters
Average Annual Output	33,699 MWh
Rio Indio Power Plant	
Design head	62.00 meters
Installed Capacity	2,500 kW
Maximum Turbine Discharge	4.84 cms
Tunnel Diameter (horseshoe)	2.50 meters
Tunnel Area	5.58 sq. m
Hydraulic Radius	0.63 meters
Head Loss Coefficient	0.0175
Tunnel Length	300 meters
Tunnel Loss at Max Turb Discharge	0.14 meters
Average Annual Output	9,882 MWh
Gatun Power Plant	
Average Annual Output	54,451 MWh
Madden Power Plant	
Average Annual Output	187,930 MWh

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.40 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**5,378 kW**
Maximum Turbine Discharge	**15.00 cms**
Tunnel Diameter (horseshoe)	**6.00 meters**
Tunnel Area	**32.14 sq. m**
Hydraulic Radius	**1.50 meters**
Head Loss Coefficient	**0.0145**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**0.24 meters**
Average Annual Output	**34,142 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**2,500 kW**
Maximum Turbine Discharge	**4.84 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**0.14 meters**
Average Annual Output	**9,882 MWh**
Gatun Power Plant	
Average Annual Output	**54,451 MWh**
Madden Power Plant	
Average Annual Output	**187,930 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.40 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**7,171 kW**
Maximum Turbine Discharge	**20.00 cms**
Tunnel Diameter (horseshoe)	**6.00 meters**
Tunnel Area	**32.14 sq. m**
Hydraulic Radius	**1.50 meters**
Head Loss Coefficient	**0.0145**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**0.43 meters**
Average Annual Output	**36,505 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**2,500 kW**
Maximum Turbine Discharge	**4.84 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**0.14 meters**
Average Annual Output	**9,882 MWh**
Gatun Power Plant	
Average Annual Output	**54,451 MWh**
Madden Power Plant	
Average Annual Output	**187,930 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.40 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**8,964 kW**
Maximum Turbine Discharge	**25.00 cms**
Tunnel Diameter (horseshoe)	**6.00 meters**
Tunnel Area	**32.14 sq. m**
Hydraulic Radius	**1.50 meters**
Head Loss Coefficient	**0.0145**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**0.67 meters**
Average Annual Output	**37,364 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**2,500 kW**
Maximum Turbine Discharge	**4.84 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**0.14 meters**
Average Annual Output	**9,882 MWh**
Gatun Power Plant	
Average Annual Output	**54,451 MWh**
Madden Power Plant	
Average Annual Output	**187,930 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.50 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**5,378 kW**
Maximum Turbine Discharge	**15.00 cms**
Tunnel Diameter (horseshoe)	**4.35 meters**
Tunnel Area	**16.89 sq. m**
Hydraulic Radius	**1.09 meters**
Head Loss Coefficient	**0.0155**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**1.27 meters**
Average Annual Output	**29,404 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**2,500 kW**
Maximum Turbine Discharge	**4.84 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**0.14 meters**
Average Annual Output	**9,755 MWh**
Gatun Power Plant	
Average Annual Output	**61,833 MWh**
Madden Power Plant	
Average Annual Output	**189,201 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.50 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**7,171 kW**
Maximum Turbine Discharge	**20.00 cms**
Tunnel Diameter (horseshoe)	**4.35 meters**
Tunnel Area	**16.89 sq. m**
Hydraulic Radius	**1.09 meters**
Head Loss Coefficient	**0.0155**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**2.25 meters**
Average Annual Output	**39,205 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**2,500 kW**
Maximum Turbine Discharge	**4.84 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**0.14 meters**
Average Annual Output	**9,755 MWh**
Gatun Power Plant	
Average Annual Output	**61,833 MWh**
Madden Power Plant	
Average Annual Output	**189,201 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.50 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**8,964 kW**
Maximum Turbine Discharge	**25.00 cms**
Tunnel Diameter (horseshoe)	**4.35 meters**
Tunnel Area	**16.89 sq. m**
Hydraulic Radius	**1.09 meters**
Head Loss Coefficient	**0.0155**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**3.51 meters**
Average Annual Output	**43,117 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**2,500 kW**
Maximum Turbine Discharge	**4.84 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**0.14 meters**
Average Annual Output	**9,755 MWh**
Gatun Power Plant	
Average Annual Output	**61,833 MWh**
Madden Power Plant	
Average Annual Output	**189,201 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.60 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**5,378 kW**
Maximum Turbine Discharge	**15.00 cms**
Tunnel Diameter (horseshoe)	**4.35 meters**
Tunnel Area	**16.89 sq. m**
Hydraulic Radius	**1.09 meters**
Head Loss Coefficient	**0.0155**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**1.27 meters**
Average Annual Output	**40,702 MWh**
95% Monthly Energy	**2,590 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**2,500 kW**
Maximum Turbine Discharge	**4.84 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**0.14 meters**
Average Annual Output	**10,844 MWh**
95% Monthly Energy	**773 MWh**
Gatun Power Plant	
Average Annual Output	**72,514 MWh**
Madden Power Plant	
Average Annual Output	**191,984 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.60 and El.80

Isla Pablon Power Plant		
Design head	**43.00**	**meters**
Installed Capacity	**7,171**	**kW**
Maximum Turbine Discharge	**20.00**	**cms**
Tunnel Diameter (horseshoe)	**4.35**	**meters**
Tunnel Area	**16.89**	**sq. m**
Hydraulic Radius	**1.09**	**meters**
Head Loss Coefficient	**0.0155**	
Tunnel Length	**8,415**	**meters**
Tunnel Loss at Max Turb Discharge	**2.25**	**meters**
Average Annual Output	**54,170**	**MWh**
95% Monthly Energy	**3,427**	**MWh**
Rio Indio Power Plant		
Design head	**62.00**	**meters**
Installed Capacity	**2,500**	**kW**
Maximum Turbine Discharge	**4.84**	**cms**
Tunnel Diameter (horseshoe)	**2.50**	**meters**
Tunnel Area	**5.58**	**sq. m**
Hydraulic Radius	**0.63**	**meters**
Head Loss Coefficient	**0.0175**	
Tunnel Length	**300**	**meters**
Tunnel Loss at Max Turb Discharge	**0.14**	**meters**
Average Annual Output	**10,844**	**MWh**
95% Monthly Energy	**773**	**MWh**
Gatun Power Plant		
Average Annual Output	**72,514**	**MWh**
Madden Power Plant		
Average Annual Output	**191,984**	**MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.60 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**8,964 kW**
Maximum Turbine Discharge	**25.00 cms**
Tunnel Diameter (horseshoe)	**4.35 meters**
Tunnel Area	**16.89 sq. m**
Hydraulic Radius	**1.09 meters**
Head Loss Coefficient	**0.0155**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**3.51 meters**
Average Annual Output	**58,137 MWh**
95% Monthly Energy	**3,947 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**2,500 kW**
Maximum Turbine Discharge	**4.84 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**0.14 meters**
Average Annual Output	**10,844 MWh**
95% Monthly Energy	**773 MWh**
Gatun Power Plant	
Average Annual Output	**72,514 MWh**
Madden Power Plant	
Average Annual Output	**191,984 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.70 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**5,378 kW**
Maximum Turbine Discharge	**15.00 cms**
Tunnel Diameter (horseshoe)	**4.35 meters**
Tunnel Area	**16.89 sq. m**
Hydraulic Radius	**1.09 meters**
Head Loss Coefficient	**0.0155**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**1.27 meters**
Average Annual Output	**45,134 MWh**
95% Monthly Energy	**2,738 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**11,999 kW**
Maximum Turbine Discharge	**23.21 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**3.18 meters**
Average Annual Output	**14,404 MWh**
95% Monthly Energy	**902 MWh**
Gatun Power Plant	
Average Annual Output	**83,226 MWh**
Madden Power Plant	
Average Annual Output	**194,203 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.70 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**7,171 kW**
Maximum Turbine Discharge	**20.00 cms**
Tunnel Diameter (horseshoe)	**4.35 meters**
Tunnel Area	**16.89 sq. m**
Hydraulic Radius	**1.09 meters**
Head Loss Coefficient	**0.0155**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**2.25 meters**
Average Annual Output	**59,745 MWh**
95% Monthly Energy	**3,294 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**11,999 kW**
Maximum Turbine Discharge	**23.21 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**3.18 meters**
Average Annual Output	**14,404 MWh**
95% Monthly Energy	**902 MWh**
Gatun Power Plant	
Average Annual Output	**83,226 MWh**
Madden Power Plant	
Average Annual Output	**194,203 MWh**

RIO INDIO HYDROELECTRIC SCHEME

Indio Reservoir Operation between El.70 and El.80

Isla Pablon Power Plant	
Design head	**43.00 meters**
Installed Capacity	**8,964 kW**
Maximum Turbine Discharge	**25.00 cms**
Tunnel Diameter (horseshoe)	**4.35 meters**
Tunnel Area	**16.89 sq. m**
Hydraulic Radius	**1.09 meters**
Head Loss Coefficient	**0.0155**
Tunnel Length	**8,415 meters**
Tunnel Loss at Max Turb Discharge	**3.51 meters**
Average Annual Output	**64,642 MWh**
95% Monthly Energy	**3,450 MWh**
Rio Indio Power Plant	
Design head	**62.00 meters**
Installed Capacity	**11,999 kW**
Maximum Turbine Discharge	**23.21 cms**
Tunnel Diameter (horseshoe)	**2.50 meters**
Tunnel Area	**5.58 sq. m**
Hydraulic Radius	**0.63 meters**
Head Loss Coefficient	**0.0175**
Tunnel Length	**300 meters**
Tunnel Loss at Max Turb Discharge	**3.18 meters**
Average Annual Output	**14,404 MWh**
95% Monthly Energy	**902 MWh**
Gatun Power Plant	
Average Annual Output	**83,226 MWh**
Madden Power Plant	
Average Annual Output	**194,203 MWh**

ENERGY PRODUCTION ESTIMATE

Strategy No.1
Isla Pablon Power Plant

Year	5.00-m Diameter Tunnel					6.00-m Diameter Tunnel			5.00-m Diameter Tunnel					6.00-m Diameter Tunnel		
	5.4-MW	7.2-MW	9.0-MW	10.8-MW	12.6-MW	5.4-MW	7.2-MW	9.0-MW	5.4-MW	7.2-MW	9.0-MW	10.8-MW	12.6-MW	5.4-MW	7.2-MW	9.0-MW
2011	45.1	60.0	66.0	66.4	66.6	45.1	60.0	67.0	$2,030	$2,700	$2,970	$2,988	$2,997	$2,030	$2,700	$3,015
2012	45.1	60.0	66.0	66.4	66.6	45.1	60.0	67.0	$2,030	$2,700	$2,970	$2,988	$2,997	$2,030	$2,700	$3,015
2013	45.1	60.0	66.0	66.4	66.6	45.1	60.0	67.0	$2,030	$2,700	$2,970	$2,988	$2,997	$2,030	$2,700	$3,015
2014	45.1	60.0	66.0	66.4	66.6	45.1	60.0	67.0	$2,030	$2,700	$2,970	$2,988	$2,997	$2,030	$2,700	$3,015
2015	45.1	60.0	66.0	66.4	66.6	45.1	60.0	67.0	$2,030	$2,700	$2,970	$2,988	$2,997	$2,030	$2,700	$3,015
2016	45.1	60.0	66.0	66.4	66.6	45.1	60.0	67.0	$2,030	$2,700	$2,970	$2,988	$2,997	$2,030	$2,700	$3,015
2017	45.1	59.6	65.8	66.2	66.4	45.1	59.8	66.8	$2,030	$2,682	$2,961	$2,979	$2,988	$2,030	$2,691	$3,006
2018	44.8	59.2	65.4	65.8	66.0	45.0	59.6	66.5	$2,016	$2,664	$2,943	$2,961	$2,970	$2,025	$2,682	$2,993
2019	44.2	58.7	64.5	64.8	64.9	44.7	59.3	65.8	$1,989	$2,642	$2,903	$2,916	$2,921	$2,012	$2,669	$2,961
2020	43.7	58.0	63.5	63.8	63.9	44.2	58.8	65.0	$1,967	$2,610	$2,858	$2,871	$2,876	$1,989	$2,646	$2,925
2021	42.9	57.1	62.0	62.2	62.3	43.7	58.2	63.5	$1,931	$2,570	$2,790	$2,799	$2,804	$1,967	$2,619	$2,858
2022	42.2	56.2	60.7	60.9	61.0	43.0	57.4	62.4	$1,899	$2,529	$2,732	$2,741	$2,745	$1,935	$2,583	$2,808
2023	40.8	54.4	58.8	59.0	59.1	41.9	56.0	60.7	$1,836	$2,448	$2,646	$2,655	$2,660	$1,886	$2,520	$2,732
2024	39.1	51.8	56.7	56.9	57.0	40.3	53.8	58.7	$1,760	$2,331	$2,552	$2,561	$2,565	$1,814	$2,421	$2,642
2025	36.7	48.0	52.3	52.5	52.6	38.3	50.3	54.7	$1,652	$2,160	$2,354	$2,363	$2,367	$1,724	$2,264	$2,462
2026	34.6	43.2	47.7	47.9	48.0	36.7	45.8	50.5	$1,557	$1,944	$2,147	$2,156	$2,160	$1,652	$2,061	$2,273
2027	33.0	39.2	42.2	42.4	42.5	35.2	41.8	45.4	$1,485	$1,764	$1,899	$1,908	$1,913	$1,584	$1,881	$2,043
2028	32.2	35.8	37.4	37.6	37.7	34.4	38.9	40.8	$1,449	$1,611	$1,683	$1,692	$1,697	$1,548	$1,751	$1,836
2029	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2030	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2031	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2032	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2033	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2034	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2035	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2036	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2037	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2038	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2039	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2040	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2041	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2042	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2043	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2044	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2045	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2046	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2047	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2048	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2049	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2050	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2051	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2052	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2053	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2054	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2055	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2056	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2057	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2058	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2059	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
2060	31.9	33.5	33.7	33.9	34.0	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,526	$1,530	$1,535	$1,643	$1,683
Net Present Value at 12%									$15,725	$20,377	$22,212	$22,335	$22,395	$15,946	$20,688	$22,814

ENERGY PRODUCTION ESTIMATE

Strategy No.1

Rio Indio Power Plant

Year	2.5-MW	4.1-MW	7.2-MW	10.3-MW	12.0-MW	2.5-MW	4.1-MW	7.2-MW	10.3-MW	12.0-MW
2011	12.3	12.7	13.6	14.4	14.8	$551	$572	$611	$647	$666
2012	12.3	12.7	13.6	14.4	14.8	$551	$572	$611	$647	$666
2013	12.3	12.7	13.6	14.4	14.8	$551	$572	$611	$647	$666
2014	12.3	12.7	13.6	14.4	14.8	$551	$572	$611	$647	$666
2015	12.3	12.7	13.6	14.4	14.8	$551	$572	$611	$647	$666
2016	12.1	12.6	13.5	14.3	14.7	$546	$567	$606	$642	$660
2017	12.0	12.5	13.4	14.1	14.5	$541	$563	$601	$636	$654
2018	11.9	12.4	13.3	14.0	14.4	$537	$558	$596	$631	$648
2019	11.7	12.1	12.8	13.5	13.8	$525	$543	$575	$605	$620
2020	11.4	11.7	12.3	12.9	13.2	$513	$527	$554	$580	$592
2021	11.1	11.4	11.9	12.3	12.5	$500	$512	$533	$554	$563
2022	10.8	11.0	11.4	11.7	11.9	$488	$496	$512	$528	$535
2023	10.6	10.7	11.0	11.2	11.4	$476	$482	$494	$506	$511
2024	10.3	10.4	10.6	10.7	10.8	$464	$468	$476	$483	$487
2025	10.0	10.1	10.3	10.4	10.5	$451	$455	$462	$469	$472
2026	9.8	9.8	10.0	10.1	10.1	$439	$442	$448	$454	$456
2027	9.8	9.9	10.2	10.4	10.5	$442	$447	$457	$467	$471
2028	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2029	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2030	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2031	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2032	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2033	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2034	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2035	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2036	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2037	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2038	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2039	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2040	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2041	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2042	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2043	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2044	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2045	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2046	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2047	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2048	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2049	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2050	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2051	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2052	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2053	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2054	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2055	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2056	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2057	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2058	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2059	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2060	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
				Net Present Value 12%		$4,298	$4,432	$4,678	$4,910	$5,027

ENERGY PRODUCTION ESTIMATE

Strategy No.3a
Isla Pablon Power Plant

Year	5.00-m Diameter Tunnel			6.00-m Diameter Tunnel			5.00-m Diameter Tunnel			6.00-m Diameter Tunnel		
	5.4-MW	7.2-MW	9.0-MW	5.4-MW	7.2-MW	9.0-MW	5.4-MW	7.2-MW	9.0-MW	5.4-MW	7.2-MW	9.0-MW
2011	7.3	7.6	7.9	7.7	8.1	8.5	$329	$342	$356	$347	$365	$383
2012	7.3	7.6	7.9	7.7	8.1	8.5	$329	$342	$356	$347	$365	$383
2013	7.3	7.6	7.9	7.7	8.1	8.5	$329	$342	$356	$347	$365	$383
2014	7.3	7.6	7.9	7.7	8.1	8.5	$329	$342	$356	$347	$365	$383
2015	7.3	7.6	7.9	7.7	8.1	8.5	$329	$342	$356	$347	$365	$383
2016	15.5	15.7	15.9	16.1	16.5	16.8	$698	$707	$716	$725	$743	$756
2017	23.7	23.8	24.0	24.5	24.9	25.2	$1,067	$1,071	$1,080	$1,103	$1,121	$1,134
2018	28.7	29.4	29.6	29.6	30.6	30.9	$1,292	$1,323	$1,332	$1,332	$1,377	$1,391
2019	33.6	34.9	35.0	34.6	36.2	36.6	$1,512	$1,571	$1,575	$1,557	$1,629	$1,647
2020	38.5	40.4	40.5	39.6	41.8	42.2	$1,733	$1,818	$1,823	$1,782	$1,881	$1,899
2021	38.7	43.4	44.7	39.8	45.0	46.5	$1,742	$1,953	$2,012	$1,791	$2,025	$2,093
2022	38.9	46.3	48.8	40.0	48.1	50.7	$1,751	$2,084	$2,196	$1,800	$2,165	$2,282
2023	39.0	49.1	52.8	40.2	51.0	54.7	$1,755	$2,210	$2,376	$1,809	$2,295	$2,462
2024	39.1	51.8	56.7	40.3	53.8	58.7	$1,760	$2,331	$2,552	$1,814	$2,421	$2,642
2025	36.7	48.0	52.3	38.3	50.3	54.7	$1,652	$2,160	$2,354	$1,724	$2,264	$2,462
2026	34.6	43.2	47.7	36.7	45.8	50.5	$1,557	$1,944	$2,147	$1,652	$2,061	$2,273
2027	33.0	39.2	42.2	35.2	41.8	45.4	$1,485	$1,764	$1,899	$1,584	$1,881	$2,043
2028	32.2	35.8	37.4	34.4	38.9	40.8	$1,449	$1,611	$1,683	$1,548	$1,751	$1,836
2029	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2030	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2031	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2032	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2033	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2034	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2035	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2036	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2037	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2038	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2039	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2040	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2041	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2042	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2043	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2044	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2045	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2046	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2047	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2048	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2049	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2050	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2051	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2052	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2053	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2054	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2055	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2056	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2057	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2058	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2059	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
2060	31.9	33.5	33.7	34.1	36.5	37.4	$1,436	$1,508	$1,517	$1,535	$1,643	$1,683
					Net Present Value 12%		$7,831	$8,609	$8,909	$8,185	$9,089	$9,466

ENERGY PRODUCTION ESTIMATE

Strategy No.3a

Year	Rio Indio Power Plant									
	2.5-MW	4.1-MW	7.2-MW	10.3-MW	12.0-MW	2.5-MW	4.1-MW	7.2-MW	10.3-MW	12.0-MW
2011	19.6	32.5	56.9	81.2	86.3	$883	$1,463	$2,561	$3,654	$3,884
2012	19.6	32.5	56.9	81.2	86.3	$883	$1,463	$2,561	$3,654	$3,884
2013	19.6	32.5	56.9	81.2	86.3	$883	$1,463	$2,561	$3,654	$3,884
2014	19.6	32.5	56.9	81.2	86.3	$883	$1,463	$2,561	$3,654	$3,884
2015	19.6	32.5	56.9	81.2	86.0	$883	$1,462	$2,558	$3,654	$3,870
2016	19.8	32.7	57.2	71.3	73.8	$889	$1,472	$2,574	$3,209	$3,319
2017	19.9	32.9	57.6	61.4	61.5	$895	$1,481	$2,591	$2,762	$2,768
2018	20.0	33.2	50.3	52.9	53.0	$899	$1,492	$2,262	$2,380	$2,385
2019	20.1	33.3	43.0	44.4	44.5	$903	$1,498	$1,933	$1,997	$2,002
2020	20.2	33.3	35.7	35.9	36.0	$907	$1,500	$1,604	$1,614	$1,619
2021	17.7	27.6	29.4	29.6	29.7	$796	$1,242	$1,323	$1,332	$1,336
2022	15.2	21.9	23.1	23.3	23.4	$685	$984	$1,040	$1,049	$1,053
2023	12.8	16.1	16.9	17.0	17.1	$575	$726	$758	$766	$770
2024	10.3	10.4	10.6	10.7	10.8	$464	$468	$476	$483	$487
2025	10.0	10.1	10.3	10.4	10.5	$451	$455	$462	$469	$472
2026	9.8	9.8	10.0	10.1	10.1	$439	$442	$448	$454	$456
2027	9.8	9.9	10.2	10.4	10.5	$442	$447	$457	$467	$471
2028	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2029	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2030	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2031	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2032	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2033	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2034	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2035	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2036	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2037	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2038	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2039	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2040	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2041	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2042	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2043	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2044	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2045	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2046	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2047	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2048	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2049	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2050	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2051	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2052	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2053	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2054	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2055	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2056	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2057	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2058	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2059	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
2060	9.9	10.1	10.4	10.7	10.8	$445	$453	$466	$479	$486
				Net Present Value 12%		$6,397	$9,941	$15,527	$19,970	$20,867

ATTACHMENT 4

COMPARATIVE COST ESTIMATES

PANAMA CANAL INDIO-GATUN PROJECT

Panama

Feasibility Level Cost for Tunneling

Unit Cost Estimate for Typical Tunnel Alignment

Feature: **Power Tunnel**

Length **8,400 meters (Intake portal to outlet portal)**

Diameter **4.35 meters (D-shaped Section)**

Does not include construction adits — Basic Drill/Blast — **Project # 15593**

SUMMARY

The following summary is prepared from the detailed analysis that follows

	Total
Total Tunnel Excavation Price	**$21,386,100**
Total Tunnel Concrete Lining Price	**$7,587,000**
Total at January 1999 Level	**$28,973,100**

	Analysis				Totals
Method of Excavation	Drill and Blast Method				
Type of Support Requirements	Type I	Type II	Type III	Type IV	
Finished Diameter	4.35	4.35	4.35	4.35	4.35
ID area	16.89	16.89	16.89	16.89	
Finished Tunnel radius	2.18	2.18	2.18	2.18	2.18
Excavated Tunnel radius	2.52	2.52	2.52	2.52	
Excavated tunnel diameter	5.05	5.05	5.05	5.05	
Excavated area	22.73	22.73	22.73	22.73	
Tunnel Length for analysis	2,100	3,360	2,520	420	8,400
Excavation Volume/m	22.7	22.7	22.7	22.7	22.7
Excavation Pay Volume	47,700	76,400	57,300	9,500	190,900
Concrete Lining Thickness, m	0.35	0.35	0.35	0.35	
Overbreak assumed, m	0.10	0.10	0.15	0.15	
Shotcrete Lining Thickness, m	0.0	0.0	0.05	0.05	
Shotcrete Area, Sqm	0	26,600	32,700	5,400	64,700
Excavated Volume for lining/m (inc invert)	24.6	24.6	25.5	25.5	25.0
Tunnel Length, m	2,100	3,360	2,520	420	8,400
Total Excavated Volume, Cu.m.	51,600	82,500	64,300	10,700	209,100
Loose Volume, Cu.m., Mucking	82,560	132,000	102,880	17,120	334,560
Invert concrete volume	1,589	2,543	1,907	318	6,358
Concrete Lining Volume	14,529	23,246	19,818	3,303	60,896
Pay Concrete Volume	16,118	25,790	21,725	3,621	67,254
2 M #8 Rockbolts	800	8,400	11,800	400	21,400
Steel Sets, kg				211,400	211,400
Production, days for one Heading	311	672	630	210	1,823
Excavation Manhours, Local	136,889	295,680	277,200	92,400	802,169
Excavation Manhours, Foreign	0	0	0	0	0
Labor Cost - Excavation, Local	1,102,100	2,380,500	2,231,700	743,900	6,458,200
Labor Cost - Excavation, Foreign	0	0	0	0	0
Tunnel Concrete Lining Cost, Local	1,398,035	2,236,916	1,886,856	314,376	5,836,183
Tunnel Concrete Lining Cost,Foreign	0	0	0	0	0
Equipment Cost, Local	903,327	1,951,186	1,829,237	609,746	5,293,494
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	655,196	1,662,383	1,712,862	668,723	4,699,165
Material Cost, Foreign	0	0	0	0	0
Tunnel Excavation Cost, Local Total	2,660,623	5,994,069	5,773,799	2,022,369	16,450,859
Tunnel Excavation Cost, Foreign Total	$0	$0	$0	$0	$0
Concrete Lining Cost, Total	**1,398,035**	**2,236,916**	**1,886,856**	**314,376**	**5,836,183**
Tunnel Excavation Cost	**2,660,623**	**5,994,069**	**5,773,799**	**2,022,369**	**16,450,859**
With Contractors OH&P of 30%	**30%**	**30%**	**30%**	**30%**	
Tunnel Excavation Price	**$3,458,800**	**$7,792,300**	**$7,505,900**	**$2,629,100**	**$21,386,100**
Tunnel Lining Price	**$1,817,446**	**$2,907,991**	**$2,452,912**	**$408,689**	**$7,587,037**
Tunnel Price					**$28,973,137**
Concrete Lining Price, Local	1,817,446	2,907,991	2,452,912	408,689	7,587,037
Concrete Lining Price, Foreign	0	0	0	0	0
Tunnel Excavation Price, Local	3,458,810	7,792,289	7,505,938	2,629,080	21,386,117
Tunnel Excavation Price, Foreign	0	0	0	0	0
					Avg. Price
Price/CuM, excavation only/CuM	$72.51	$101.99	$130.99	$276.75	$112.03
Price/CuM, Concrete Lining/CuM	$112.76	$112.76	$112.91	$112.87	$112.81

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature:	**Power Tunnel**
Length	**8,400 meters (Intake portal to outlet portal)**
Diameter	**4.35 meters (D-shaped Section)**

Does not include construction adits **Basic Drill/Blast** **Project # 15593**

GEOLOGY

Rock type as interpreted from site visits and geol mapping suggests four types of supports for the following lengths

Tunneling Condition	Segment 1
Roca Buena - Designation Type I	25%
Roca Regular - Designation Type II	40%
Roca Mala - Designation Type III	30%
Roca Muy Mala - Designation Type IV	5%
	100%

Type I - Roca Buena best rock conditions, minimal overbreak, generally self-supporting or requiring minimal support with shotcrete and spot bolting; full face excavation with normal advance

Type II - Roca Regular, good to fair rock conditions, moderate overbreak with rockbolt support and shotcrete; normal advance possible with proper bolting and shotcreting

Type III - Roca Mala, poor rock conditions, weathered or weak rock, loosely jointed, possible water inflows; Full face excavation with slower short advance and large overbreaks. Requires prompt support with pattern rockbolting and shotcrete

Type IV - Roca Muy Mala/Pesima, very poor rock conditions, full of fault and shear zones, mod to highly weathered, potential squeezing condi in gouge; water inflows; possibly top heading and benching; prompt support within the open face with steel ribs and lagging, backpacking and shotcete with fabric; grouting may be necessary to control water; spiling possible in worst conditions.

Type V - Not mentioned above but worse than type IV and with high waterflows. Specific areas are not identified for above tunnels at this time

Condition/Rock Type	Q Values	Rock Mass Rating (RMR)
I	> 7	>60
II	7 > Q >1	60>RMR>40
III	1 > Q >.4	40>RMR>35
IV	.4> Q	35 > RMR

Blastability		Good	Medium
	SPR =	0.38	0.47
		Basalt/Sandstones	

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature:	**Power Tunnel**	
Length	**8,400**	**meters (Intake portal to outlet portal)**
Diameter	**4.35**	**meters (D-shaped Section)**

Does not include construction adits — **Basic Drill/Blast** — **Project # 15593**

SUPPORT

Shotcrete Thickness	5	cm Layers Fiber or wire reinf
Rockbolts	25	mm X 2 meter long w/epoxy
Steel Ribs	6" X 12"	I section @ .5 to 1.5 spacing
Lagging	5	cm corrugated
Dry Pack	0.5	in. from Tunnel Muck

All tunnel analysis is based on assumed/interpreted geology from initial site visits and mapping
No results from any investigations are input

Length of Segment	8,400	Meters	
Finished Diameter	4.35	Meters	
Horse Shoe Section			
Concrete Lining Thickness	0.35	Meters	0.15 m invert slab
Length of tunnel for each type			
Type I	2,100	Meters	
Type II	3,360	Meters	
Type III	2,520	Meters	
Type IV	420	Meters	

Shotcrete with wire(or fibrous), 5 cm layers	0	SqM, Type I	None
	26,600	SqM, Type II	Crown only
	32,700	SqM, Type III	Crown and Ribs
	5,400	SqM, Type IV	Crown and Ribs
Total Shotcrete	64,700	SqM	

Rockbolts, 25 mm X 2 M Long	800	EA, Type I	3 Bolts/@ 7.5 M Spacing
As per typical Harza	8,400	EA, Type II	5 Bolts/@ 2 M Spacing
	11,800	EA, Type III	7 Bolts/@ 1.5 M Spacing
	400	EA, Type IV	5 Bolts/@ 5 M Spacing
Total Rockbolts	21,400	EA	
Steel ribs, 6" X 12" X 45 KG/M	211,400	KG, Type IV	

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature:	Power Tunnel	
Length	8,400 meters (Intake portal to outlet portal)	
Diameter	4.35 meters (D-shaped Section)	
Does not include construction adits	Basic Drill/Blast	Project # 15593

TUNNEL EXCAVATION

	Tunnel Crew	Local $$/HR Production	Local $$/HR Production	Foreign $$/HR Foreign
1	Walker	$10.00	$10.00	
1	Foreman	$10.00	$10.00	
	Jumbo Drill Foreman	$10.00	$0.00	
8	Miners	$5.50	$44.00	
1	Blaster	$7.90	$7.90	
1	Compressor Operator	$7.90	$7.90	
1	Mucker Operator	$7.90	$7.90	
2	Truck Drivers	$6.20	$12.40	
	Dozer Operator	$7.90	$0.00	
1	HVAC Electrician/Mechanics	$6.60	$3.30	
1	Oilers	$6.60	$3.30	
2	Rockbolters	$6.60	$13.20	
2	Shotcreters	$6.60	$13.20	
1	Pump Operators	$7.90	$7.90	
1	Mechanics	$6.60	$3.30	
1	Electricians	$6.60	$3.30	
22	Total Crew, $$/Hr		$147.60	$0.00
	Total Labor Cost, Local		$6,458,200	
	Total Labor Cost, Foreign		$0	

ROUNDS	Type I	Type II	Type III	Type IV	
Meters/Round	3.0	3.0	2.0	1.0	
Vol/Round	68.2	68.2	45.5	22.7	
Holes/SqM	2.5	2.3	2.2	2.0	
Length of Holes (total, cum.)	122	125	84	43	
Drill Holes, Meters/Hr	10	10	10	10	
No. of drills	4	4	4	4	
Total Drilling/Hr	40	40	40	40	
Drilling Time	3.1	3.1	2.1	1.1	
Move in	0.3	0.3	0.3	0.3	
Total drilling Time	3.4	3.4	2.4	1.4	
Blasting					
Kg/CuM	2.0	1.8	1.7	1.5	
Kg/Round	136	123	77	34	
Load Time @ 80 Kg/Hr	1.7	1.5	1.0	0.4	
Add for blasting & Ventilating	1.0	1.0	1.0	1.0	
Total Blast time	2.7	2.5	2.0	1.4	
Excavation Supports					
Scaling	0.3	0.3	0.3	0.5	
Place supports	0.2	0.5	1.0	3.0	
Total Support Time	0.5	0.8	1.3	3.5	
Muck					
Move in	0.5	0.5	0.5	0.5	
Mucking at 25 CM/hr	2.7	2.7	1.8	0.9	
Total Muck Cycle	3.2	3.2	2.3	1.4	
Total Cycle Hours	9.8	10.0	8.0	7.7	
No of Rds with of 2 X 10 Hr Shifts+ 4 Hrs	2.5	2.4	3.0	3.1	
Advance/Day	7.4	7.2	6.0	3.1	
Realistic rds/day	2.3	2.0	2.0	2.0	
Realistic advance/day	6.8	5.0	4.0	2.0	
Total number of Days for one Crew	311	672	630	210	1,823
Total explosives required	95,500	137,500	97,400	14,300	
Detonators	33,425	61,875	73,050	11,440	
Drill Bits & Steel	85,674	139,734	105,933	18,089	

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature: **Power Tunnel**
Length **8,400 meters (Intake portal to outlet portal)**
Diameter **4.35 meters (D-shaped Section)**
Basic Drill/Blast
Does not include construction adits **Project # 15593**

Plant & Equipment	L. Cost/Hr	F. Cost/Hr
1 4 Drill Jumbo	$55.00	$0.00
1 4 CuM Mucker	$31.25	$0.00
2 Trucks, 5 CuM	$24.46	$0.00
1 Shotcrete Pump	$45.20	$0.00
Dozer		
2 Compressors, Electrical	$10.13	$0.00
1 Dewatering Equipment	$7.53	$0.00
2 100 HP Fans	$6.04	$0.00
1 Drifters	$0.61	$0.00
1 Flatbeds	$13.35	$0.00
Equipment Cost per hour	$193.57	$0.00
Utilization Factor	75%	60%
Actual Cost/Hr	$145.18	$0.00

	Type I	Type II	Type III	Type IV
Equipment & Plant, Local	$903,327	$1,951,186	$1,829,237	$609,746
Equipment & Plant, Foreign	$0	$0	$0	$0

Materials		
Explosives	$1.50	$$/KG
Detonators	$2.50	$$/EA
Bits & Steel	$2.50	$$/LM
Spiling	$150.00	$$/EA
Shotcrete Cement	$110.00	$$/TON
Shotcrete Aggregate	$5.00	$$/TON
Steel Fibers	$1.20	$$/KG
Wiremesh	$1.00	$$/KG
Timber	$0.35	$$/BF
Rockbolts	$45.00	$$/EA
Steel Sets	$2.00	$$/KG
Vent air line	$40.00	$$/LM
Utility lines	$30.00	$$/LM
ST&S	5.00%	

	Type I	Type II	Type III	Type IV	Total
Explosives	$143,250	$206,250	$146,100	$21,450	$517,050
Detonators	$83,563	$154,688	$182,625	$28,600	$449,475
Bits & Steel	$214,184	$349,336	$264,832	$45,223	$873,575
Spiling	$0	$0	$0	$15,000	$15,000
Shotcrete Cement	$0	$87,780	$107,910	$17,820	$213,510
Shotcrete Aggregate	$0	$21,945	$26,978	$4,455	$53,378
Steel Fibers	$0	$86,184	$105,948	$17,496	$209,628
Wiremesh	$0	$63,840	$78,480	$12,960	$155,280
Timber	$0	$0	$11,025	$3,675	$14,700
Rockbolts	$36,000	$378,000	$531,000	$18,000	$963,000
Steel Sets	$0	$0	$0	$422,800	$422,800
Vent air line	$84,000	$134,400	$100,800	$16,800	$336,000
Utility lines	$63,000	$100,800	$75,600	$12,600	$252,000
ST&S	$31,200	$79,161	$81,565	$31,844	$223,770
Total Materials for tunnel work	$655,196	$1,662,383	$1,712,862	$668,723	$4,699,165
Materials, Local	$0	$0	$0	$0	
Materials, Foreign	$0	$0	$0	$0	

Tunnel Excavation Cost/CuM, Local	$86.18		
Tunnel Excavation Cost/CuM, Foreign	$0.00	Dec 2000 Cost	Days
		$2,660,623	1,823

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment
Feature: **Power Tunnel**
Length **8,400 meters (intake portal to outlet portal)**
Diameter **4.35 meters (D-shaped Section)**
Does not include construction adits — Basic Drill/Blast — Project # 15593

TUNNEL INVERT CONCRETE LINING

					Total CuM
Quantity	1,589	2,543	1,907	318	6,358
Average placing Rate (cu m/day)	200	200	200	200	
Number of work days	8	13	10	2	32

Concrete Lining Crew

		Local	Local Total	Foreign
1	Walker	$10.00	$10.00	
1	Foreman	$10.00	$10.00	
0	Form Foreman	$10.00	$0.00	
4	Miners	$5.50	$22.00	
1	Carpenters	$6.60	$6.60	
1	Compressor Operator	$7.90	$7.90	
1	Mucker Operator	$7.90	$7.90	
2	Concrete Truck Operators	$6.20	$12.40	
0	HVAC Electrician/Mechanics	$6.60	$0.00	
1	Pump Operators	$7.90	$7.90	
0	Mechanics	$6.60	$0.00	
0	Electricians	$6.60	$0.00	
12	Total Crew, $$/Hr		$84.70	$0.00
	Total Labor Cost, Local (10 hr day)		$26,926	
	Total Labor Cost, foreign		0	

	Plant & Equipment	Local	Foreign
1	Johnson Type Low Profile + Ice Plant	$52.00	$0.00
2	Concrete Haulers	$25.00	$0.00
1	Lot Pumping Equipment	$48.95	$0.00
1	Lot fans	$13.83	$0.00
		$139.78	$0.00
	Utility Factor	75.00%	65.00%
	Actual Cost/Hr	$104.84	$0.00
	Equipment Cost/Day	$2,096.70	$0.00

MATERIALS

Cement @ 30% of Volume	1,907	Tons @	$110.00	209,813
Aggregate & Sand (see Quarryco.xls)	13,988	Tons @	$10.00	139,875
Admixtures	3,179	Gals @	$15.00	47,685
				397,373

Concrete Costs by Sections	Type I	Type II	Type III	Type IV	
Labor Cost - Concrete, Local @ 10 hrs/day	6,700	10,800	8,100	1,300	26,900
Labor Cost - Concrete, Foreign @ 10 hrs/day	0	0	0	0	0
Equipment Cost, Local	16,663	26,661	19,996	3,333	66,654
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	99,343	158,949	119,212	19,869	397,373
Material Cost, Foreign	0	0	0	0	0
					490,900
TOTAL CONCRETE COST	$122,700	$196,400	$147,300	$24,500	$490,900
Tunnel concrete Lining Cost, Local	$122,707	$196,410	$147,308	$24,501	$490,926
Tunnel concrete Lining Cost, Foreign	$0	$0	$0	$0	$0
$$/CuM	$77.19	$77.23	$77.23	$77.07	
Local Cost/CuM	$77.21				
Foreign Cost/CuM	$0.00				

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment
Feature: **Power Tunnel**
Length **8,400 meters (intake portal to outlet portal)**
Diameter **4.35 meters (D-shaped Section)**
Does not include construction adits **Basic Drill/Blast** **Project # 15593**

TUNNEL CONCRETE LINING

					Total
Length	2100	3360	2520	420	8,400
Quantity	14,529	23,246	19,818	3,303	60,896
Use Prefabricated Steel Forms on Dolly Each set 20 M Long and a 24 hour concrete placing will be used with 8 hours for placing forms and reinforcing (if any), 8 hours of concrete placing and 8 hours to cure, clean and move					
Average placing Rate (cu. M / day)	150	150	150	150	
No. of Steel Sets	0	0	0	0	0
Number of 10 hour work days	97	155	132	22	406

Concrete Lining Crew

		Local	Local Total	Foreign	
1	Walker	$10.00	$10.00	$0.00	0
1	Foreman	$10.00	$10.00		
0	Form Foreman	$10.00	$0.00		
8	Miners	$5.50	$44.00		
8	Carpenters	$6.60	$52.80		
1	Compressor Operator	$7.90	$7.90		
1	Mucker Operator	$7.90	$7.90		
2	Flat Bed Operators	$6.20	$12.40		
1	HVAC Electrician/Mechanics	$6.60	$3.30		
1	Pump Operators	$7.90	$7.90		
1	Mechanics	$6.60	$3.30		
1	Electricians	$6.60	$3.30		
25	Total Crew, $$/Hr		$162.80	$0.00	
	Total Labor Cost, Local		$660,922		
	Total Labor Cost, foreign		0		

	Plant & Equipment	Local	Foreign
1	Johnson Type Low Profile + Ice Plant	$52.00	$0.00
2	Concrete Haulers	$25.00	$0.00
1	Lot Pumping Equipment	$45.00	$0.00
1	Lot fans	$4.53	$0.00
		$126.53	$0.00
	Utility Factor	75.00%	65.00%
	Actual Cost/Hr	$94.90	$0.00
	Equipment Cost/Day	$1,897.95	$0.00

MATERIALS

Cement	18,269	Tons @	$110.00	2,009,559	
Aggregate & Sand (see Quarryco.xls)	133,971	Tons @	$10.00	1,339,706	
Admixtures	30,448	Gals @	$15.00	456,718	
Steel Forms	0	KG @	$1.50	0	
Timber for Bulkheads	4,314	SqM @	$25.00	107,860	564,578
				3,913,843	

Concrete Costs by Sections	Type I	Type II	Type III	Type IV	
Labor Cost - Concrete, Local	157,700	252,300	215,100	35,800	660,900
Labor Cost - Concrete, Foreign	0	0	0	0	0
Equipment Cost, Local	183,835	294,136	250,751	41,792	770,514
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	933,794	1,494,070	1,273,697	212,283	3,913,843
Material Cost, Foreign	0	0	0	0	0
					5,345,300
TOTAL CONCRETE COST	$1,275,300	$2,040,500	$1,739,500	$289,900	$5,345,256
Tunnel concrete Lining Cost, Local	$1,275,328	$2,040,506	$1,739,548	$289,875	$5,345,256
Tunnel concrete Lining Cost, Foreign	$0	$0	$0	$0	$0
$$/CuM	$79.12	$79.12	$80.07	$80.06	
Local Cost/CuM	$79.48				
Foreign Cost/CuM	$0.00				

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment
Feature: **Power Tunnel**
Length **8,400 meters (Intake portal to outlet portal)**
Diameter **5.00 meters (D-shaped Section)**
Does not include construction adits **Basic Drill/Blast** **Project # 15593**

SUMMARY
The following summary is prepared from the detailed analysis that follows

	Total
Total Tunnel Excavation Price	$22,253,000
Total Tunnel Concrete Lining Price	$9,679,300
Total at January 1999 Level	$31,932,300

	Analysis				Totals
Method of Excavation	Drill and Blast Method				
Type of Support Requirements	Type I	Type II	Type III	Type IV	
Finished Diameter	5.00	5.00	5.00	5.00	5.00
ID area	22.32	22.32	22.32	22.32	
Finished Tunnel radius	2.50	2.50	2.50	2.50	2.50
Excavated Tunnel radius	2.90	2.90	2.90	2.90	
Excavated tunnel diameter	5.80	5.80	5.80	5.80	
Excavated area	30.03	30.03	30.03	30.03	
Tunnel Length for analysis	2,100	3,360	2,520	420	8,400
Excavation Volume/m	30.0	30.0	30.0	30.0	30.0
Excavation Pay Volume	63,100	100,900	75,700	12,600	252,300
Concrete Lining Thickness, m	0.40	0.40	0.40	0.40	
Overbreak assumed, m	0.10	0.10	0.15	0.15	
Shotcrete Lining Thickness, m	0.0	0.0	0.05	0.05	
Shotcrete Area, Sqm	0	30,600	37,600	6,300	74,500
Excavated Volume for lining/m (inc invert)	32.1	32.1	33.2	33.2	32.7
Tunnel Length, m	2,100	3,360	2,520	420	8,400
Total Excavated Volume, Cu.m.	67,500	108,000	83,700	14,000	273,200
Loose Volume, Cu.m., Mucking	108,000	172,800	133,920	22,400	437,120
Invert concrete volume	1,827	2,923	2,192	365	7,308
Concrete Lining Volume	18,794	30,071	25,275	4,213	78,353
Pay Concrete Volume	20,621	32,994	27,468	4,578	85,661
2 M #8 Rockbolts	800	8,400	11,800	400	21,400
Steel Sets, kg				242,900	242,900
Production, days for one Heading	311	672	630	210	1,823
Excavation Manhours, Local	136,889	295,680	277,200	92,400	802,169
Excavation Manhours, Foreign	0	0	0	0	0
Labor Cost - Excavation, Local	1,102,100	2,380,500	2,231,700	743,900	6,458,200
Labor Cost - Excavation, Foreign	0	0	0	0	0
Tunnel Concrete Lining Cost, Local	1,791,676	2,866,761	2,389,090	398,115	7,445,642
Tunnel Concrete Lining Cost,Foreign	0	0	0	0	0
Equipment Cost, Local	903,327	1,951,186	1,829,237	609,746	5,293,494
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	773,718	1,894,727	1,927,312	770,254	5,366,011
Material Cost, Foreign	0	0	0	0	0
Tunnel Excavation Cost, Local Total	2,779,145	6,226,413	5,988,249	2,123,899	17,117,706
Tunnel Excavation Cost, Foreign Total	$0	$0	$0	$0	$0
Concrete Lining Cost, Total	**1,791,676**	**2,866,761**	**2,389,090**	**398,115**	**7,445,642**
Tunnel Excavation Cost	**2,779,145**	**6,226,413**	**5,988,249**	**2,123,899**	**17,117,706**
With Contractors OH&P of 30%	**30%**	**30%**	**30%**	**30%**	
Tunnel Excavation Price	**$3,612,900**	**$8,094,300**	**$7,784,700**	**$2,761,100**	**$22,253,000**
Tunnel Lining Price	**$2,329,179**	**$3,726,790**	**$3,105,817**	**$517,549**	**$9,679,334**
Tunnel Price					**$31,932,334**
Concrete Lining Price, Local	2,329,179	3,726,790	3,105,817	517,549	9,679,334
Concrete Lining Price, Foreign	0	0	0	0	0
Tunnel Excavation Price, Local	3,612,888	8,094,337	7,784,723	2,761,069	22,253,017
Tunnel Excavation Price, Foreign	0	0	0	0	0
					Avg. Price
Price/CuM, excavation only/CuM	$57.26	$80.22	$102.84	$219.13	$88.20
Price/CuM, Concrete Lining/CuM	$112.95	$112.95	$113.07	$113.05	$113.00

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature:	**Power Tunnel**
Length	**8,400 meters (Intake portal to outlet portal)**
Diameter	**5.00 meters (D-shaped Section)**

Does not include construction adits — **Basic Drill/Blast** — **Project # 15593**

GEOLOGY

Rock type as interpreted from site visits and geol mapping suggests four types of supports for the following lengths

Tunneling Condition	Segment 1
Roca Buena - Designation Type I	25%
Roca Regular - Designation Type II	40%
Roca Mala - Designation Type III	30%
Roca Muy Mala - Designation Type IV	5%
	100%

Type I - Roca Buena best rock conditions, minimal overbreak, generally self-supporting or requiring minimal support with shotcrete and spot bolting; full face excavation with normal advance

Type II - Roca Regular, good to fair rock conditions, moderate overbreak with rockbolt support and shotcrete; normal advance possible with proper bolting and shotcreting

Type III - Roca Mala, poor rock conditions, weathered or weak rock, loosely jointed, possible water inflows; Full face excavation with slower short advance and large overbreaks. Requires prompt support with pattern rockbolting and shotcrete

Type IV - Roca Muy Mala/Pesima, very poor rock conditions, full of fault and shear zones, mod to highly weathered, potential squeezing condi in gouge; water inflows; possibly top heading and benching; prompt support within the open face with steel ribs and lagging, backpacking and shotcete with fabric; grouting may be necessary to control water; spiling possible in worst conditions.

Type V - Not mentioned above but worse than type IV and with high waterflows. Specific areas are not identified for above tunnels at this time

Condition/Rock Type	Q Values	Rock Mass Rating (RMR)
I	> 7	>60
II	7 > Q >1	60>RMR>40
III	1 > Q >.4	40>RMR>35
IV	.4> Q	35 > RMR

Blastability .	Good	Medium
SPR =	0.38	0.47
	Basalt/Sandstones	

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment
Feature: **Power Tunnel**
Length **8,400 meters (Intake portal to outlet portal)**
Diameter **5.00 meters (D-shaped Section)**
Does not include construction adits Basic Drill/Blast **Project # 15593**

SUPPORT			
Shotcrete Thickness	5	cm Layers	Fiber or wire reinf
Rockbolts	25	mm X 2 meter long w/epoxy	
Steel Ribs	6" X 12"	I section @ .5 to 1.5 spacing	
Lagging	5	cm corrugated	
Dry Pack	0.5	in. from Tunnel Muck	

All tunnel analysis is based on assumed/interpreted geology from initial site visits and mapping
No results from any investigations are input

Length of Segment	8,400	Meters	
Finished Diameter	5.00	Meters	
Horse Shoe Section			
Concrete Lining Thickness	0.40	Meters	**0.15 m invert slab**
Length of tunnel for each type			
Type I	2,100	Meters	
Type II	3,360	Meters	
Type III	2,520	Meters	
Type IV	420	Meters	
Shotcrete with wire(or fibrous), 5 cm layers	0	SqM, Type I	None
	30,600	SqM, Type II	Crown only
	37,600	SqM, Type III	Crown and Ribs
	6,300	SqM, Type IV	Crown and Ribs
Total Shotcrete	74,500	SqM	
Rockbolts, 25 mm X 2 M Long	800	EA, Type I	3 Bolts/@ 7.5 M Spacing
As per typical Harza	8,400	EA, Type II	5 Bolts/@ 2 M Spacing
	11,800	EA, Type III	7 Bolts/@ 1.5 M Spacing
	400	EA, Type IV	5 Bolts/@ 5 M Spacing
Total Rockbolts	21,400	EA	
Steel ribs, 6" X 12" X 45 KG/M	242,900	KG, Type IV	

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature:	Power Tunnel
Length	8,400 meters (intake portal to outlet portal)
Diameter	5.00 meters (D-shaped Section)

Does not include construction adits — Basic Drill/Blast — Project # 15593

TUNNEL EXCAVATION

	Tunnel Crew	Local $$/HR Production	Local $$/HR Production	Foreign $$/HR Foreign
1	Walker	$10.00	$10.00	
1	Foreman	$10.00	$10.00	
	Jumbo Drill Foreman	$10.00	$0.00	
8	Miners	$5.50	$44.00	
1	Blaster	$7.90	$7.90	
1	Compressor Operator	$7.90	$7.90	
1	Mucker Operator	$7.90	$7.90	
2	Truck Drivers	$6.20	$12.40	
	Dozer Operator	$7.90	$0.00	
1	HVAC Electrician/Mechanics	$6.60	$3.30	
1	Oilers	$6.60	$3.30	
2	Rockbolters	$6.60	$13.20	
2	Shotcreters	$6.60	$13.20	
1	Pump Operators	$7.90	$7.90	
1	Mechanics	$6.60	$3.30	
1	Electricians	$6.60	$3.30	
22	Total Crew, $$/Hr		$147.60	$0.00
	Total Labor Cost, Local		$6,458,200	
	Total Labor Cost, Foreign		$0	

ROUNDS	Type I	Type II	Type III	Type IV	
Meters/Round	3.0	3.0	2.0	1.0	
Vol/Round	90.1	90.1	60.1	30.0	
Holes/SqM	2.5	2.3	2.2	2.0	
[redacted]					
Length of Holes (total, cum.)	145	148	100	51	
Drill Holes, Meters/Hr	10	10	10	10	
No. of drills	4	4	4	4	
Total Drilling/Hr	40	40	40	40	
Drilling Time	3.6	3.7	2.5	1.3	
Move in	0.3	0.3	0.3	0.3	
Total drilling Time	3.9	4.0	2.8	1.6	
Blasting					
Kg/CuM	2.0	1.8	1.7	1.5	
Kg/Round	180	162	102	45	
Load Time @ 80 Kg/Hr	2.3	2.0	1.3	0.6	
Add for blasting & Ventilating	1.0	1.0	1.0	1.0	
Total Blast time	3.3	3.0	2.3	1.6	
Excavation Supports					
Scaling	0.3	0.3	0.3	0.5	
Place supports	0.2	0.5	1.0	3.0	
Total Support Time	0.5	0.8	1.3	3.5	
Muck					
Move in	0.5	0.5	0.5	0.5	
Mucking at 25 CM/hr	3.6	3.6	2.4	1.2	
Total Muck Cycle	4.1	4.1	2.9	1.7	
Total Cycle Hours	11.8	11.9	9.3	8.4	
No of Rds with of 2 X 10 Hr Shifts+ 4 Hrs	2.0	2.0	2.6	2.9	
Advance/Day	6.1	6.0	5.2	2.9	
Realistic rds/day	2.3	2.0	2.0	2.0	
Realistic advance/day	6.8	5.0	4.0	2.0	
Total number of Days for one Crew	311	672	630	210	1,823
Total explosives required	126,100	181,600	128,700	18,900	
Detonators	44,135	81,720	96,525	15,120	
Drill Bits & Steel	101,755	166,317	126,234	21,612	

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature: Power Tunnel
Length 8,400 meters (Intake portal to outlet portal)
Diameter 5.00 meters (D-shaped Section)
Basic Drill/Blast

Does not include construction adits

Project # 15593

Plant & Equipment	L. Cost/Hr	F. Cost/Hr
1 4 Drill Jumbo	$55.00	$0.00
1 4 CuM Mucker	$31.25	$0.00
2 Trucks, 5 CuM	$24.46	$0.00
1 Shotcrete Pump	$45.20	$0.00
Dozer		
2 Compressors, Electrical	$10.13	$0.00
1 Dewatering Equipment	$7.53	$0.00
2 100 HP Fans	$6.04	$0.00
1 Drifters	$0.61	$0.00
1 Flatbeds	$13.35	$0.00
Equipment Cost per hour	$193.57	$0.00
Utilization Factor	75%	60%
Actual Cost/Hr	$145.18	$0.00

	Type I	Type II	Type III	Type IV
Equipment & Plant, Local	$903,327	$1,951,186	$1,829,237	$609,746
Equipment & Plant, Foreign	$0	$0	$0	$0

Materials		
Explosives	$1.50	$$/KG
Detonators	$2.50	$$/EA
Bits & Steel	$2.50	$$/LM
Spiling	$150.00	$$/EA
Shotcrete Cement	$110.00	$$/TON
Shotcrete Aggregate	$5.00	$$/TON
Steel Fibers	$1.20	$$/KG
Wiremesh	$1.00	$$/KG
Timber	$0.35	$$/BF
Rockbolts	$45.00	$$/EA
Steel Sets	$2.00	$$/KG
Vent air line	$40.00	$$/LM
Utility lines	$30.00	$$/LM
ST&S	5.00%	

	Type I	Type II	Type III	Type IV	Total
Explosives	$189,150	$272,400	$193,050	$28,350	$682,950
Detonators	$110,338	$204,300	$241,313	$37,800	$593,750
Bits & Steel	$254,387	$415,793	$315,584	$54,031	$1,039,794
Spiling	$0	$0	$0	$15,000	$15,000
Shotcrete Cement	$0	$100,980	$124,080	$20,790	$245,850
Shotcrete Aggregate	$0	$25,245	$31,020	$5,198	$61,463
Steel Fibers	$0	$99,144	$121,824	$20,412	$241,380
Wiremesh	$0	$73,440	$90,240	$15,120	$178,800
Timber	$0	$0	$11,025	$3,675	$14,700
Rockbolts	$36,000	$378,000	$531,000	$18,000	$963,000
Steel Sets	$0	$0	$0	$485,800	$485,800
Vent air line	$84,000	$134,400	$100,800	$16,800	$336,000
Utility lines	$63,000	$100,800	$75,600	$12,600	$252,000
ST&S	$36,844	$90,225	$91,777	$36,679	$255,524
Total Materials for tunnel work	$773,718	$1,894,727	$1,927,312	$770,254	$5,366,011
Materials, Local	$0	$0	$0	$0	
Materials, Foreign	$0	$0	$0	$0	

		Dec 2000 Cost	Days
Tunnel Excavation Cost/CuM, Local	$67.85	$2,779,145	1,823
Tunnel Excavation Cost/CuM, Foreign	$0.00		

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment
Feature: **Power Tunnel**
Length **8,400 meters (intake portal to outlet portal)**
Diameter **5.00 meters (D-shaped Section)**
Does not include construction adits **Basic Drill/Blast** **Project # 15593**

TUNNEL INVERT CONCRETE LINING					Total CuM
Quantity	1,827	2,923	2,192	365	7,308
Average placing Rate (cu m/day)	200	200	200	200	
Number of work days	9	15	11	2	37

Concrete Lining Crew

	Crew	Local	Local Total	Foreign
1	Walker	$10.00	$10.00	
1	Foreman	$10.00	$10.00	
0	Form Foreman	$10.00	$0.00	
4	Miners	$5.50	$22.00	
1	Carpenters	$6.60	$6.60	
1	Compressor Operator	$7.90	$7.90	
1	Mucker Operator	$7.90	$7.90	
2	Concrete Truck Operators	$6.20	$12.40	
0	HVAC Electrician/Mechanics	$6.60	$0.00	
1	Pump Operators	$7.90	$7.90	
0	Mechanics	$6.60	$0.00	
0	Electricians	$6.60	$0.00	
12	Total Crew, $$/Hr		$84.70	$0.00
	Total Labor Cost, Local (10 hr day)		$30,949	
	Total Labor Cost, foreign		0	

	Plant & Equipment	Local	Foreign
1	Johnson Type Low Profile + Ice Plant	$52.00	$0.00
2	Concrete Haulers	$25.00	$0.00
1	Lot Pumping Equipment	$48.95	$0.00
1	Lot fans	$13.83	$0.00
		$139.78	$0.00
	Utility Factor	75.00%	65.00%
	Actual Cost/Hr	$104.84	$0.00
	Equipment Cost/Day	$2,096.70	$0.00

MATERIALS				
Cement @ 30% of Volume	2,192	Tons @	$110.00	241,164
Aggregate & Sand (see Quarryco.xls)	16,078	Tons @	$10.00	160,776
Admixtures	3,654	Gals @	$15.00	54,810
				456,750

Concrete Costs by Sections	Type I	Type II	Type III	Type IV	
Labor Cost - Concrete, Local @ 10 hrs/day	7,700	12,400	9,300	1,500	30,900
Labor Cost - Concrete, Foreign @ 10 hrs/day	0	0	0	0	0
Equipment Cost, Local	19,153	30,645	22,984	3,831	76,613
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	114,188	182,700	137,025	22,838	456,750
Material Cost, Foreign	0	0	0	0	0
					564,300
TOTAL CONCRETE COST	$141,000	$225,700	$169,300	$28,200	$564,200
Tunnel concrete Lining Cost, Local	$141,041	$225,745	$169,309	$28,168	$564,263
Tunnel concrete Lining Cost, Foreign	$0	$0	$0	$0	$0
$$/CuM	$77.18	$77.21	$77.22	$77.18	
Local Cost/CuM	$77.21				
Foreign Cost/CuM	$0.00				

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature: **Power Tunnel**
Length **8,400 meters (Intake portal to outlet portal)**
Diameter **5.00 meters (D-shaped Section)**

Does not include construction adits — Basic Drill/Blast — Project # 15593

TUNNEL CONCRETE LINING

						Total
Length		2100	3360	2520	420	8,400
Quantity		18,794	30,071	25,275	4,213	78,353

Use Prefabricated Steel Forms on Dolly
Each set 20 M Long and a 24 hour concrete placing will be used with 8 hours for placing forms and reinforcing (if any), 8 hours of concrete placing and 8 hours to cure, clean and move

Average placing Rate (cu. M / day)	150	150	150	150	
No. of Steel Sets	0	0	0	0	0
Number of 10 hour work days	125	200	169	28	522

Concrete Lining Crew

		Local	Local Total	Foreign	
1	Walker	$10.00	$10.00	$0.00	0
1	Foreman	$10.00	$10.00		
0	Form Foreman	$10.00	$0.00		
8	Miners	$5.50	$44.00		
8	Carpenters	$6.60	$52.80		
1	Compressor Operator	$7.90	$7.90		
1	Mucker Operator	$7.90	$7.90		
2	Flat Bed Operators	$6.20	$12.40		
1	HVAC Electrician/Mechanics	$6.60	$3.30		
1	Pump Operators	$7.90	$7.90		
1	Mechanics	$6.60	$3.30		
1	Electricians	$6.60	$3.30		
25	Total Crew, $$/Hr		$162.80	$0.00	
	Total Labor Cost, Local		$850,393		
	Total Labor Cost, foreign		0		

	Plant & Equipment	Local	Foreign
1	Johnson Type Low Profile + Ice Plant	$52.00	$0.00
2	Concrete Haulers	$25.00	$0.00
1	Lot Pumping Equipment	$45.00	$0.00
1	Lot fans	$4.53	$0.00
		$126.53	$0.00
	Utility Factor	75.00%	65.00%
	Actual Cost/Hr	$94.90	$0.00
	Equipment Cost/Day	$1,897.95	$0.00

MATERIALS					
Cement	23,506	Tons @	$110.00	2,585,655	
Aggregate & Sand (see Quarryco.xls)	172,377	Tons @	$10.00	1,723,770	
Admixtures	39,177	Gals @	$15.00	587,649	
Steel Forms	0	KG @	$1.50	0	
Timber for Bulkheads	5,700	SqM @	$25.00	142,503	730,151
				5,039,576	

Concrete Costs by Sections	Type I	Type II	Type III	Type IV	
Labor Cost - Concrete, Local	204,000	326,400	274,300	45,700	850,400
Labor Cost - Concrete, Foreign	0	0	0	0	0
Equipment Cost, Local	237,805	380,488	319,808	53,301	991,403
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	1,208,830	1,934,128	1,625,673	270,945	5,039,576
Material Cost, Foreign	0	0	0	0	0
					6,881,400
TOTAL CONCRETE COST	$1,650,600	$2,641,000	$2,219,800	$369,900	$6,881,379
Tunnel concrete Lining Cost, Local	$1,650,635	$2,641,016	$2,219,781	$369,947	$6,881,379
Tunnel concrete Lining Cost, Foreign	$0	$0	$0	$0	$0
$$/CuM	$80.04	$80.04	$80.82	$80.80	
Local Cost/CuM	$80.33				
Foreign Cost/CuM	$0.00				

PANAMA CANAL INDIO-GATUN PROJECT

Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature:	**Power Tunnel**
Length	**8,400 meters (Intake portal to outlet portal)**
Diameter	**5.50 meters (D-shaped Section)**

Does not include construction adits — **Basic Drill/Blast** — **Project # 15593**

SUMMARY

The following summary is prepared from the detailed analysis that follows

	Total
Total Tunnel Excavation Price	$22,967,400
Total Tunnel Concrete Lining Price	$11,459,500
Total at January 1999 Level	$34,426,900

Method of Excavation	Analysis Drill and Blast Method				Totals
Type of Support Requirements	Type I	Type II	Type III	Type IV	
Finished Diameter	5.50	5.50	5.50	5.50	5.50
ID area	27.00	27.00	27.00	27.00	
Finished Tunnel radius	2.75	2.75	2.75	2.75	2.75
Excavated Tunnel radius	3.19	3.19	3.19	3.19	
Excavated tunnel diameter	6.38	6.38	6.38	6.38	
Excavated area	36.34	36.34	36.34	36.34	
Tunnel Length for analysis	2,100	3,360	2,520	420	8,400
Excavation Volume/m	36.3	36.3	36.3	36.3	36.3
Excavation Pay Volume	76,300	122,100	91,600	15,300	305,300
Concrete Lining Thickness, m	0.44	0.44	0.44	0.44	
Overbreak assumed, m	0.10	0.10	0.15	0.15	
Shotcrete Lining Thickness, m	0.0	0.0	0.05	0.05	
Shotcrete Area, Sqm	0	33,700	41,300	6,900	81,900
Excavated Volume for lining/m (inc invert)	38.7	38.7	39.8	39.8	39.2
Tunnel Length, m	2,100	3,360	2,520	420	8,400
Total Excavated Volume, Cu.m.	81,200	129,900	100,400	16,700	328,200
Loose Volume, Cu.m., Mucking	129,920	207,840	160,640	26,720	525,120
Invert concrete volume	2,010	3,216	2,412	402	8,039
Concrete Lining Volume	22,448	35,917	29,921	4,987	93,272
Pay Concrete Volume	24,458	39,132	32,332	5,389	101,311
2 M #8 Rockbolts	800	8,400	11,800	400	21,400
Steel Sets, kg				267,200	267,200
Production, days for one Heading	311	672	630	210	1,823
Excavation Manhours, Local	136,889	295,680	277,200	92,400	802,169
Excavation Manhours, Foreign	0	0	0	0	0
Labor Cost - Excavation, Local	1,102,100	2,380,500	2,231,700	743,900	6,458,200
Labor Cost - Excavation, Foreign	0	0	0	0	0
Tunnel Concrete Lining Cost, Local	2,127,308	3,403,732	2,814,843	469,124	8,815,007
Tunnel Concrete Lining Cost,Foreign	0	0	0	0	0
Equipment Cost, Local	903,327	1,951,186	1,829,237	609,746	5,293,494
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	873,797	2,088,127	2,103,999	849,630	5,915,553
Material Cost, Foreign	0	0	0	0	0
Tunnel Excavation Cost, Local Total	2,879,224	6,419,813	6,164,936	2,203,275	17,667,247
Tunnel Excavation Cost, Foreign Total	$0	$0	$0	$0	$0
Concrete Lining Cost, Total	**2,127,308**	**3,403,732**	**2,814,843**	**469,124**	**8,815,007**
Tunnel Excavation Cost	**2,879,224**	**6,419,813**	**6,164,936**	**2,203,275**	**17,667,247**
With Contractors OH&P of 30%	30%	30%	30%	30%	
Tunnel Excavation Price	**$3,743,000**	**$8,345,800**	**$8,014,400**	**$2,864,300**	**$22,967,500**
Tunnel Lining Price	**$2,765,500**	**$4,424,852**	**$3,659,296**	**$609,861**	**$11,459,509**
Tunnel Price					**$34,427,009**
Concrete Lining Price, Local	2,765,500	4,424,852	3,659,296	609,861	11,459,509
Concrete Lining Price, Foreign	0	0	0	0	0
Tunnel Excavation Price, Local	3,742,991	8,345,756	8,014,416	2,864,258	22,967,422
Tunnel Excavation Price, Foreign	0	0	0	0	0
					Avg. Price
Price/CuM, excavation only/CuM	$49.06	$68.35	$87.49	$187.21	$75.23
Price/CuM, Concrete Lining/CuM	$113.07	$113.07	$113.18	$113.17	$113.11

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment
Feature: **Power Tunnel**
Length **8,400 meters (intake portal to outlet portal)**
Diameter **5.50 meters (D-shaped Section)**
Does not include construction adits **Basic Drill/Blast** **Project # 15593**

GEOLOGY

Rock type as interpreted from site visits and geol mapping suggests four types of supports for the following lengths

Tunneling Condition	Segment 1
Roca Buena - Designation Type I	25%
Roca Regular - Designation Type II	40%
Roca Mala - Designation Type III	30%
Roca Muy Mala - Designation Type IV	5%
	100%

Type I - Roca Buena best rock conditions, minimal overbreak, generally self-supporting or requiring minimal support with shotcrete and spot bolting; full face excavation with normal advance

Type II - Roca Regular, good to fair rock conditions, moderate overbreak with rockbolt support and shotcrete; normal advance possible with proper bolting and shotcreting

Type III - Roca Mala, poor rock conditions, weathered or weak rock, loosely jointed, possible water inflows; Full face excavation with slower short advance and large overbreaks. Requires prompt support with pattern rockbolting and shotcrete

Type IV - Roca Muy Mala/Pesima, very poor rock conditions, full of fault and shear zones, mod to highly weathered, potential squeezing c in gouge; water inflows; possibly top heading and benching; prompt support within the open face with steel ribs and lagging, backpacking a shotcete with fabric; grouting may be necessary to control water; spiling possible in worst conditions.

Type V - Not mentioned above but worse than type IV and with high waterflows. Specific areas are not identified for above tunnels at this time

Condition/Rock Type	Q Values	Rock Mass Rating (RMR)
I	> 7	>60
II	7 > Q >1	60>RMR>40
III	1 > Q >.4	40>RMR>35
IV	.4> Q	35 > RMR

Blastability		Good	Medium
	SPR =	0.38	0.47
		Basalt/Sandstones	

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature:	Power Tunnel	
Length	8,400	meters (Intake portal to outlet portal)
Diameter	5.50	meters (D-shaped Section)

Does not include construction adits — Basic Drill/Blast — Project # 15593

SUPPORT

Shotcrete Thickness	5	cm Layers Fiber or wire reinf
Rockbolts	25	mm X 2 meter long w/epoxy
Steel Ribs	6" X 12"	I section @ .5 to 1.5 spacing
Lagging	5	cm corrugated
Dry Pack	0.5	in. from Tunnel Muck

All tunnel analysis is based on assumed/interpreted geology from initial site visits and mapping
No results from any investigations are input

Length of Segment	8,400	Meters	
Finished Diameter	5.50	Meters	
Horse Shoe Section			
Concrete Lining Thickness	0.44	Meters	0.15 m invert slab
Length of tunnel for each type			
Type I	2,100	Meters	
Type II	3,360	Meters	
Type III	2,520	Meters	
Type IV	420	Meters	

Shotcrete with wire(or fibrous), 5 cm layers	0	SqM, Type I		None
	33,700	SqM, Type II		Crown only
	41,300	SqM, Type III		Crown and Ribs
	6,900	SqM, Type IV		Crown and Ribs
Total Shotcrete	81,900	SqM		
Rockbolts, 25 mm X 2 M Long	800	EA, Type I	3	Bolts/@ 7.5 M Spacing
As per typical Harza	8,400	EA, Type II	5	Bolts/@ 2 M Spacing
	11,800	EA, Type III	7	Bolts/@ 1.5 M Spacing
	400	EA, Type IV	5	Bolts/@ 5 M Spacing
Total Rockbolts	21,400	EA		
Steel ribs, 6" X 12" X 45 KG/M	267,200	KG, Type IV		

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment
Feature: **Power Tunnel**
Length **8,400 meters (Intake portal to outlet portal)**
Diameter **5.50 meters (D-shaped Section)**
Does not include construction adits Basic Drill/Blast **Project # 15593**

TUNNEL EXCAVATION

	Tunnel Crew	Local $$/HR Production	Local $$/HR Production	Foreign $$/HR Foreign
1	Walker	$10.00	$10.00	
1	Foreman	$10.00	$10.00	
	Jumbo Drill Foreman	$10.00	$0.00	
8	Miners	$5.50	$44.00	
1	Blaster	$7.90	$7.90	
1	Compressor Operator	$7.90	$7.90	
1	Mucker Operator	$7.90	$7.90	
2	Truck Drivers	$6.20	$12.40	
	Dozer Operator	$7.90	$0.00	
1	HVAC Electrician/Mechanics	$6.60	$3.30	
1	Oilers	$6.60	$3.30	
2	Rockbolters	$6.60	$13.20	
2	Shotcreters	$6.60	$13.20	
1	Pump Operators	$7.90	$7.90	
1	Mechanics	$6.60	$3.30	
1	Electricians	$6.60	$3.30	
22	Total Crew, $$/Hr		$147.60	$0.00
	Total Labor Cost, Local		$6,458,200	
	Total Labor Cost, Foreign		$0	

ROUNDS	Type I	Type II	Type III	Type IV	
Meters/Round	3.0	3.0	2.0	1.0	
Vol/Round	109.0	109.0	72.7	36.3	
Holes/SqM	2.5	2.3	2.2	2.0	
Length of Holes (total, cum.)	164	168	113	58	
Drill Holes, Meters/Hr	10	10	10	10	
No. of drills	4	4	4	4	
Total Drilling/Hr	40	40	40	40	
Drilling Time	4.1	4.2	2.8	1.5	
Move in	0.3	0.3	0.3	0.3	
Total drilling Time	4.4	4.5	3.1	1.8	
Blasting					
Kg/CuM	2.0	1.8	1.7	1.5	
Kg/Round	218	196	124	55	
Load Time @ 80 Kg/Hr	2.7	2.5	1.5	0.7	
Add for blasting & Ventilating	1.0	1.0	1.0	1.0	
Total Blast time	3.7	3.5	2.5	1.7	
Excavation Supports					
Scaling	0.3	0.3	0.3	0.5	
Place supports	0.2	0.5	1.0	3.0	
Total Support Time	0.5	0.8	1.3	3.5	
Muck					
Move in	0.5	0.5	0.5	0.5	
Mucking at 25 CM/hr	4.4	4.4	2.9	1.5	
Total Muck Cycle	4.9	4.9	3.4	2.0	
Total Cycle Hours	13.5	13.6	10.4	8.9	
No of Rds with of 2 X 10 Hr Shifts+ 4 Hrs	1.8	1.8	2.3	2.7	
Advance/Day	5.3	5.3	4.6	2.7	
Realistic rds/day	2.3	2.0	2.0	2.0	
Realistic advance/day	6.8	5.0	4.0	2.0	
Total number of Days for one Crew	311	672	630	210	1,823
Total explosives required	152,600	219,800	155,700	22,900	
Detonators	53,410	98,910	116,775	18,320	
Drill Bits & Steel	114,705	187,775	142,641	24,467	

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment
Feature: **Power Tunnel**
Length **8,400 meters (Intake portal to outlet portal)**
Diameter **5.50 meters (D-shaped Section)**
Does not include construction adits **Basic Drill/Blast** **Project # 15593**

Plant & Equipment	L. Cost/Hr	F. Cost/Hr
1 4 Drill Jumbo	$55.00	$0.00
1 4 CuM Mucker	$31.25	$0.00
2 Trucks, 5 CuM	$24.46	$0.00
1 Shotcrete Pump	$45.20	$0.00
Dozer		
2 Compressors, Electrical	$10.13	$0.00
1 Dewatering Equipment	$7.53	$0.00
2 100 HP Fans	$6.04	$0.00
1 Drifters	$0.61	$0.00
1 Flatbeds	$13.35	$0.00
Equipment Cost per hour	$193.57	$0.00
Utilization Factor	75%	60%
Actual Cost/Hr	$145.18	$0.00

	Type I	Type II	Type III	Type IV
Equipment & Plant, Local	$903,327	$1,951,186	$1,829,237	$609,746
Equipment & Plant, Foreign	$0	$0	$0	$0

Materials		
Explosives	$1.50	$$/KG
Detonators	$2.50	$$/EA
Bits & Steel	$2.50	$$/LM
Spiling	$150.00	$$/EA
Shotcrete Cement	$110.00	$$/TON
Shotcrete Aggregate	$5.00	$$/TON
Steel Fibers	$1.20	$$/KG
Wiremesh	$1.00	$$/KG
Timber	$0.35	$$/BF
Rockbolts	$45.00	$$/EA
Steel Sets	$2.00	$$/KG
Vent air line	$40.00	$$/LM
Utility lines	$30.00	$$/LM
ST&S	5.00%	

	Type I	Type II	Type III	Type IV	Total
Explosives	$228,900	$329,700	$233,550	$34,350	$826,500
Detonators	$133,525	$247,275	$291,938	$45,800	$718,538
Bits & Steel	$286,763	$469,437	$356,602	$61,168	$1,173,969
Spiling	$0	$0	$0	$15,000	$15,000
Shotcrete Cement	$0	$111,210	$136,290	$22,770	$270,270
Shotcrete Aggregate	$0	$27,803	$34,073	$5,693	$67,568
Steel Fibers	$0	$109,188	$133,812	$22,356	$265,356
Wiremesh	$0	$80,880	$99,120	$16,560	$196,560
Timber	$0	$0	$11,025	$3,675	$14,700
Rockbolts	$36,000	$378,000	$531,000	$18,000	$963,000
Steel Sets	$0	$0	$0	$534,400	$534,400
Vent air line	$84,000	$134,400	$100,800	$16,800	$336,000
Utility lines	$63,000	$100,800	$75,600	$12,600	$252,000
ST&S	$41,609	$99,435	$100,190	$40,459	$281,693
Total Materials for tunnel work	$873,797	$2,088,127	$2,103,999	$849,630	$5,915,553
Materials, Local	$0	$0	$0	$0	
Materials, Foreign	$0	$0	$0	$0	

Tunnel Excavation Cost/CuM, Local	$57.87		
Tunnel Excavation Cost/CuM, Foreign	$0.00	Dec 2000 Cos	Days
		$2,879,224	1,823

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature: **Power Tunnel**
Length **8,400 meters (Intake portal to outlet portal)**
Diameter **5.50 meters (D-shaped Section)**

Does not include construction adits — Basic Drill/Blast — Project # 15593

TUNNEL INVERT CONCRETE LINING

					Total CuM
Quantity	2,010	3,216	2,412	402	8,039
Average placing Rate (cu m/day)	200	200	200	200	
Number of work days	10	16	12	2	40

Concrete Lining Crew

		Local	Local Total	Foreign
1	Walker	$10.00	$10.00	
1	Foreman	$10.00	$10.00	
0	Form Foreman	$10.00	$0.00	
4	Miners	$5.50	$22.00	
1	Carpenters	$6.60	$6.60	
1	Compressor Operator	$7.90	$7.90	
1	Mucker Operator	$7.90	$7.90	
2	Concrete Truck Operators	$6.20	$12.40	
0	HVAC Electrician/Mechanics	$6.60	$0.00	
1	Pump Operators	$7.90	$7.90	
0	Mechanics	$6.60	$0.00	
0	Electricians	$6.60	$0.00	
12	Total Crew, $$/Hr		$84.70	$0.00
	Total Labor Cost, Local (10 hr day)		$34,044	
	Total Labor Cost, foreign		0	

	Plant & Equipment	Local	Foreign
1	Johnson Type Low Profile + Ice Plant	$52.00	$0.00
2	Concrete Haulers	$25.00	$0.00
1	Lot Pumping Equipment	$48.95	$0.00
1	Lot fans	$13.83	$0.00
		$139.78	$0.00
	Utility Factor	75.00%	65.00%
	Actual Cost/Hr	$104.84	$0.00
	Equipment Cost/Day	$2,096.70	$0.00

MATERIALS				
Cement @ 30% of Volume	2,412	Tons @	$110.00	265,280
Aggregate & Sand (see Quarryco.xls)	17,685	Tons @	$10.00	176,854
Admixtures	4,019	Gals @	$15.00	60,291
				502,425

Concrete Costs by Sections	Type I	Type II	Type III	Type IV	
Labor Cost - Concrete, Local @ 10 hrs/day	8,500	13,600	10,200	1,700	34,000
Labor Cost - Concrete, Foreign @ 10 hrs/day	0	0	0	0	0
Equipment Cost, Local	21,069	33,710	25,282	4,214	84,275
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	125,606	200,970	150,728	25,121	502,425
Material Cost, Foreign	0	0	0	0	0
					620,700
TOTAL CONCRETE COST	$155,200	$248,300	$186,200	$31,000	$620,700
Tunnel concrete Lining Cost, Local	$155,175	$248,280	$186,210	$31,035	$620,700
Tunnel concrete Lining Cost, Foreign	$0	$0	$0	$0	$0
$$/CuM	$77.23	$77.22	$77.21	$77.13	
Local Cost/CuM	$77.21				
Foreign Cost/CuM	$0.00				

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature: **Power Tunnel**
Length **8,400 meters (Intake portal to outlet portal)**
Diameter **5.50 meters (D-shaped Section)**
Does not include construction adits — **Basic Drill/Blast** — **Project # 15593**

TUNNEL CONCRETE LINING					Total
Length	2100	3360	2520	420	8,400
Quantity	22,448	35,917	29,921	4,987	93,272
Use Prefabricated Steel Forms on Dolly Each set 20 M Long and a 24 hour concrete placing will be used with 8 hours for placing forms and reinforcing (if any), 8 hours of concrete placing and 8 hours to cure, clean and move					
Average placing Rate (cu. M / day)	150	150	150	150	
No. of Steel Sets	0	0	0	0	0
Number of 10 hour work days	150	239	199	33	622

Concrete Lining Crew

		Local	Local Total	Foreign	
1	Walker	$10.00	$10.00	$0.00	0
1	Foreman	$10.00	$10.00		
0	Form Foreman	$10.00	$0.00		
8	Miners	$5.50	$44.00		
8	Carpenters	$6.60	$52.80		
1	Compressor Operator	$7.90	$7.90		
1	Mucker Operator	$7.90	$7.90		
2	Flat Bed Operators	$6.20	$12.40		
1	HVAC Electrician/Mechanics	$6.60	$3.30		
1	Pump Operators	$7.90	$7.90		
1	Mechanics	$6.60	$3.30		
1	Electricians	$6.60	$3.30		
25	Total Crew, $$/Hr		$162.80	$0.00	
	Total Labor Cost, Local		$1,012,313		
	Total Labor Cost, foreign		0		

	Plant & Equipment	Local	Foreign
1	Johnson Type Low Profile + Ice Plant	$52.00	$0.00
2	Concrete Haulers	$25.00	$0.00
1	Lot Pumping Equipment	$45.00	$0.00
1	Lot fans	$4.53	$0.00
		$126.53	$0.00
	Utility Factor	75.00%	65.00%
	Actual Cost/Hr	$94.90	$0.00
	Equipment Cost/Day	$1,897.95	$0.00

MATERIALS					
Cement	27,982	Tons @	$110.00	3,077,980	
Aggregate & Sand (see Quarryco.xls)	205,199	Tons @	$10.00	2,051,987	
Admixtures	46,636	Gals @	$15.00	699,541	
Steel Forms	0	KG @	$1.50	0	
Timber for Bulkheads	6,897	SqM @	$25.00	172,428	871,969
				6,001,935	

Concrete Costs by Sections	Type I	Type II	Type III	Type IV	
Labor Cost - Concrete, Local	243,600	389,800	324,700	54,100	1,012,200
Labor Cost - Concrete, Foreign	0	0	0	0	0
Equipment Cost, Local	284,034	454,455	378,585	63,097	1,180,172
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	1,444,498	2,311,197	1,925,348	320,891	6,001,935
Material Cost, Foreign	0	0	0	0	0
					8,194,300
TOTAL CONCRETE COST	$1,972,100	$3,155,500	$2,628,600	$438,100	$8,194,308
Tunnel concrete Lining Cost, Local	$1,972,133	$3,155,452	$2,628,633	$438,089	$8,194,308
Tunnel concrete Lining Cost, Foreign	$0	$0	$0	$0	$0
$$/CuM	$80.63	$80.64	$81.30	$81.30	
Local Cost/CuM	$80.88				
Foreign Cost/CuM	$0.00				

PANAMA CANAL INDIO-GATUN PROJECT

Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature: **Power Tunnel**
Length **8,400 meters (Intake portal to outlet portal)**
Diameter **6.00 meters (D-shaped Section)**
Basic Drill/Blast

Does not include construction adits — **Project # 15593**

SUMMARY

The following summary is prepared from the detailed analysis that follows

	Total
Total Tunnel Excavation Price	$23,723,400
Total Tunnel Concrete Lining Price	$13,388,700
Total at January 1999 Level	$37,112,100

Method of Excavation	Analysis Drill and Blast Method				Totals
Type of Support Requirements	Type I	Type II	Type III	Type IV	
Finished Diameter	6.00	6.00	6.00	6.00	6.00
ID area	32.14	32.14	32.14	32.14	
Finished Tunnel radius	3.00	3.00	3.00	3.00	3.00
Excavated Tunnel radius	3.48	3.48	3.48	3.48	
Excavated tunnel diameter	6.96	6.96	6.96	6.96	
Excavated area	43.24	43.24	43.24	43.24	
Tunnel Length for analysis	2,100	3,360	2,520	420	8,400
Excavation Volume/m	43.2	43.2	43.2	43.2	43.2
Excavation Pay Volume	90,800	145,300	109,000	18,200	363,300
Concrete Lining Thickness, m	0.48	0.48	0.48	0.48	
Overbreak assumed, m	0.10	0.10	0.15	0.15	
Shotcrete Lining Thickness, m	0.0	0.0	0.05	0.05	
Shotcrete Area, Sqm	0	36,700	45,100	7,500	89,300
Excavated Volume for lining/m (inc invert)	45.8	45.8	47.1	47.1	46.4
Tunnel Length, m	2,100	3,360	2,520	420	8,400
Total Excavated Volume, Cu.m.	96,100	153,800	118,600	19,800	388,300
Loose Volume, Cu.m., Mucking	153,760	246,080	189,760	31,680	621,280
Invert concrete volume	2,192	3,508	2,631	438	8,770
Concrete Lining Volume	26,426	42,281	34,955	5,826	109,487
Pay Concrete Volume	28,618	45,789	37,585	6,264	118,256
2 M #8 Rockbolts	800	8,400	11,800	400	21,400
Steel Sets, kg				291,500	291,500
Production, days for one Heading	311	672	630	210	1,823
Excavation Manhours, Local	136,889	295,680	277,200	92,400	802,169
Excavation Manhours, Foreign	0	0	0	0	0
Labor Cost - Excavation, Local	1,102,100	2,380,500	2,231,700	743,900	6,458,200
Labor Cost - Excavation, Foreign	0	0	0	0	0
Tunnel Concrete Lining Cost, Local	2,491,597	3,986,595	3,274,967	545,845	10,299,004
Tunnel Concrete Lining Cost,Foreign	0	0	0	0	0
Equipment Cost, Local	903,327	1,951,186	1,829,237	609,746	5,293,494
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	981,435	2,292,451	2,292,731	930,440	6,497,057
Material Cost, Foreign	0	0	0	0	0
Tunnel Excavation Cost, Local Total	2,986,861	6,624,137	6,353,668	2,284,085	18,248,751
Tunnel Excavation Cost, Foreign Total	$0	$0	$0	$0	$0
Concrete Lining Cost, Total	**2,491,597**	**3,986,595**	**3,274,967**	**545,845**	**10,299,004**
Tunnel Excavation Cost	**2,986,861**	**6,624,137**	**6,353,668**	**2,284,085**	**18,248,751**
With Contractors OH&P of 30%	30%	30%	30%	30%	
Tunnel Excavation Price	**$3,882,900**	**$8,611,400**	**$8,259,800**	**$2,969,300**	**$23,723,400**
Tunnel Lining Price	**$3,239,076**	**$5,182,574**	**$4,257,457**	**$709,598**	**$13,388,705**
Tunnel Price					**$37,112,105**
Concrete Lining Price, Local	3,239,076	5,182,574	4,257,457	709,598	13,388,705
Concrete Lining Price, Foreign	0	0	0	0	0
Tunnel Excavation Price, Local	3,882,920	8,611,378	8,259,768	2,969,311	23,723,377
Tunnel Excavation Price, Foreign	0	0	0	0	0
					Avg. Price
Price/CuM, excavation only/CuM	$42.76	$59.27	$75.78	$163.15	$65.30
Price/CuM, Concrete Lining/CuM	$113.18	$113.18	$113.27	$113.28	$113.22

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature:	**Power Tunnel**
Length	**8,400 meters (Intake portal to outlet portal)**
Diameter	**6.00 meters (D-shaped Section)**

Does not include construction adits **Basic Drill/Blast** **Project # 15593**

GEOLOGY

Rock type as interpreted from site visits and geol mapping suggests four types of supports for the following lengths

Tunneling Condition	Segment 1
Roca Buena - Designation Type I	25%
Roca Regular - Designation Type II	40%
Roca Mala - Designation Type III	30%
Roca Muy Mala - Designation Type IV	5%
	100%

Type I - Roca Buena best rock conditions, minimal overbreak, generally self-supporting or requiring minimal support with shotcrete and spot bolting; full face excavation with normal advance

Type II - Roca Regular, good to fair rock conditions, moderate overbreak with rockbolt support and shotcrete; normal advance possible with proper bolting and shotcreting

Type III - Roca Mala, poor rock conditions, weathered or weak rock, loosely jointed, possible water inflows; Full face excavation with slower short advance and large overbreaks. Requires prompt support with pattern rockbolting and shotcrete

Type IV - Roca Muy Mala/Pesima, very poor rock conditions, full of fault and shear zones, mod to highly weathered, potential squeezing conditi in gouge; water inflows; possibly top heading and benching; prompt support within the open face with steel ribs and lagging, backpacking and shotcete with fabric; grouting may be necessary to control water; spiling possible in worst conditions.

Type V - Not mentioned above but worse than type IV and with high waterflows. Specific areas are not identified for above tunnels at this time

Condition/Rock Type	Q Values	Rock Mass Rating (RMR)
I	> 7	>60
II	7 > Q >1	60>RMR>40
III	1 > Q >.4	40>RMR>35
IV	.4> Q	35 > RMR

Blastability	Good	Medium
SPR =	0.38	0.47
	Basalt/Sandstones	

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature:	Power Tunnel	
Length	8,400	meters (Intake portal to outlet portal)
Diameter	6.00	meters (D-shaped Section)
Does not include construction adits	Basic Drill/Blast	Project # 15593

SUPPORT			
Shotcrete Thickness	5	cm Layers	Fiber or wire reinf
Rockbolts	25	mm X 2 meter long w/epoxy	
Steel Ribs	6" X 12"	I section @ .5 to 1.5 spacing	
Lagging	5	cm corrugated	
Dry Pack	0.5	in. from Tunnel Muck	

All tunnel analysis is based on assumed/interpreted geology from initial site visits and mapping
No results from any investigations are input

Length of Segment		8,400	Meters	
Finished Diameter		6.00	Meters	
Horse Shoe Section				
Concrete Lining Thickness		0.48	Meters	0.15 m invert slab
Length of tunnel for each type				
	Type I	2,100	Meters	
	Type II	3,360	Meters	
	Type III	2,520	Meters	
	Type IV	420	Meters	
Shotcrete with wire(or fibrous), 5 cm layers		0	SqM, Type I	None
		36,700	SqM, Type II	Crown only
		45,100	SqM, Type III	Crown and Ribs
		7,500	SqM, Type IV	Crown and Ribs
	Total Shotcrete	89,300	SqM	
Rockbolts, 25 mm X 2 M Long		800	EA, Type I	3 Bolts/@ 7.5 M Spacing
As per typical Harza		8,400	EA, Type II	5 Bolts/@ 2 M Spacing
		11,800	EA, Type III	7 Bolts/@ 1.5 M Spacing
		400	EA, Type IV	5 Bolts/@ 5 M Spacing
	Total Rockbolts	21,400	EA	
Steel ribs, 6" X 12" X 45 KG/M		291,500	KG, Type IV	

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment
Feature: **Power Tunnel**
Length **8,400 meters (intake portal to outlet portal)**
Diameter **6.00 meters (D-shaped Section)**
Does not include construction adits **Basic Drill/Blast** **Project # 15593**

TUNNEL EXCAVATION

	Tunnel Crew	Local $$/HR Production	Local $$/HR Production	Foreign $$/HR Foreign
1	Walker	$10.00	$10.00	
1	Foreman	$10.00	$10.00	
	Jumbo Drill Foreman	$10.00	$0.00	
8	Miners	$5.50	$44.00	
1	Blaster	$7.90	$7.90	
1	Compressor Operator	$7.90	$7.90	
1	Mucker Operator	$7.90	$7.90	
2	Truck Drivers	$6.20	$12.40	
	Dozer Operator	$7.90	$0.00	
1	HVAC Electrician/Mechanics	$6.60	$3.30	
1	Oilers	$6.60	$3.30	
2	Rockbolters	$6.60	$13.20	
2	Shotcreters	$6.60	$13.20	
1	Pump Operators	$7.90	$7.90	
1	Mechanics	$6.60	$3.30	
1	Electricians	$6.60	$3.30	
22	Total Crew, $$/Hr		$147.60	$0.00
	Total Labor Cost, Local		$6,458,200	
	Total Labor Cost, Foreign		$0	

ROUNDS	Type I	Type II	Type III	Type IV	
Meters/Round	3.0	3.0	2.0	1.0	
Vol/Round	129.7	129.7	86.5	43.2	
Holes/SqM	2.5	2.3	2.2	2.0	
[redacted]					
Length of Holes (total, cum.)	183	188	127	65	
Drill Holes, Meters/Hr	10	10	10	10	
No. of drills	4	4	4	4	
Total Drilling/Hr	40	40	40	40	
Drilling Time	4.6	4.7	3.2	1.6	
Move in	0.3	0.3	0.3	0.3	
Total drilling Time	4.9	5.0	3.5	1.9	
Blasting					
Kg/CuM	2.0	1.8	1.7	1.5	
Kg/Round	259	234	147	65	
Load Time @ 80 Kg/Hr	3.2	2.9	1.8	0.8	
Add for blasting & Ventilating	1.0	1.0	1.0	1.0	
Total Blast time	4.2	3.9	2.8	1.8	
Excavation Supports					
Scaling	0.3	0.3	0.3	0.5	
Place supports	0.2	0.5	1.0	3.0	
Total Support Time	0.5	0.8	1.3	3.5	
Muck					
Move in	0.5	0.5	0.5	0.5	
Mucking at 25 CM/hr	5.2	5.2	3.5	1.7	
Total Muck Cycle	5.7	5.7	4.0	2.2	
Total Cycle Hours	15.3	15.4	11.6	9.5	
No of Rds with of 2 X 10 Hr Shifts+ 4 Hrs	1.6	1.6	2.1	2.5	
Advance/Day	4.7	4.7	4.1	2.5	
Realistic rds/day	2.3	2.0	2.0	2.0	
Realistic advance/day	6.8	5.0	4.0	2.0	
Total number of Days for one Crew	311	672	630	210	1,823
Total explosives required	181,600	261,500	185,300	27,200	
Detonators	63,560	117,675	138,975	21,760	
Drill Bits & Steel	128,160	210,110	159,736	27,448	

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature: Power Tunnel
Length 8,400 meters (intake portal to outlet portal)
Diameter 6.00 meters (D-shaped Section)
Basic Drill/Blast

Does not include construction adits — Project # 15593

Plant & Equipment	L. Cost/Hr	F. Cost/Hr
1 4 Drill Jumbo	$55.00	$0.00
1 4 CuM Mucker	$31.25	$0.00
2 Trucks, 5 CuM	$24.46	$0.00
1 Shotcrete Pump	$45.20	$0.00
Dozer		
2 Compressors, Electrical	$10.13	$0.00
1 Dewatering Equipment	$7.53	$0.00
2 100 HP Fans	$6.04	$0.00
1 Drifters	$0.81	$0.00
1 Flatbeds	$13.35	$0.00
Equipment Cost per hour	$193.57	$0.00
Utilization Factor	75%	60%
Actual Cost/Hr	$145.18	$0.00

	Type I	Type II	Type III	Type IV
Equipment & Plant, Local	$903,327	$1,951,186	$1,829,237	$609,746
Equipment & Plant, Foreign	$0	$0	$0	$0

Materials		
Explosives	$1.50	$$/KG
Detonators	$2.50	$$/EA
Bits & Steel	$2.50	$$/LM
Spiling	$150.00	$$/EA
Shotcrete Cement	$110.00	$$/TON
Shotcrete Aggregate	$5.00	$$/TON
Steel Fibers	$1.20	$$/KG
Wiremesh	$1.00	$$/KG
Timber	$0.35	$$/BF
Rockbolts	$45.00	$$/EA
Steel Sets	$2.00	$$/KG
Vent air line	$40.00	$$/LM
Utility lines	$30.00	$$/LM
ST&S	5.00%	

	Type I	Type II	Type III	Type IV	Total
Explosives	$272,400	$392,250	$277,950	$40,800	$983,400
Detonators	$158,900	$294,188	$347,438	$54,400	$854,925
Bits & Steel	$320,400	$525,274	$399,340	$68,621	$1,313,634
Spiling	$0	$0	$0	$15,000	$15,000
Shotcrete Cement	$0	$121,110	$148,830	$24,750	$294,690
Shotcrete Aggregate	$0	$30,278	$37,208	$6,188	$73,673
Steel Fibers	$0	$118,908	$146,124	$24,300	$289,332
Wiremesh	$0	$88,080	$108,240	$18,000	$214,320
Timber	$0	$0	$11,025	$3,675	$14,700
Rockbolts	$36,000	$378,000	$531,000	$18,000	$963,000
Steel Sets	$0	$0	$0	$583,000	$583,000
Vent air line	$84,000	$134,400	$100,800	$16,800	$336,000
Utility lines	$63,000	$100,800	$75,600	$12,600	$252,000
ST&S	$46,735	$109,164	$109,178	$44,307	$309,384
Total Materials for tunnel work	$981,435	$2,292,451	$2,292,731	$930,440	$6,497,057
Materials, Local	$0	$0	$0	$0	
Materials, Foreign	$0	$0	$0	$0	

		Dec 2000 Cost	Days
Tunnel Excavation Cost/CuM, Local	$50.23	$2,986,861	1,823
Tunnel Excavation Cost/CuM, Foreign	$0.00		

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature:	Power Tunnel
Length	8,400 meters (intake portal to outlet portal)
Diameter	6.00 meters (D-shaped Section)
	Basic Drill/Blast

Does not include construction adits — Project # 15593

TUNNEL INVERT CONCRETE LINING

					Total CuM
Quantity	2,192	3,508	2,631	438	8,770
Average placing Rate (cu m/day)	200	200	200	200	
Number of work days	11	18	13	2	44

Concrete Lining Crew

No.	Crew	Local	Local Total	Foreign
1	Walker	$10.00	$10.00	
1	Foreman	$10.00	$10.00	
0	Form Foreman	$10.00	$0.00	
4	Miners	$5.50	$22.00	
1	Carpenters	$6.60	$6.60	
1	Compressor Operator	$7.90	$7.90	
1	Mucker Operator	$7.90	$7.90	
2	Concrete Truck Operators	$6.20	$12.40	
0	HVAC Electrician/Mechanics	$6.60	$0.00	
1	Pump Operators	$7.90	$7.90	
0	Mechanics	$6.60	$0.00	
0	Electricians	$6.60	$0.00	
12	Total Crew, $$/Hr		$84.70	$0.00
	Total Labor Cost, Local (10 hr day)		$37,139	
	Total Labor Cost, foreign		0	

No.	Plant & Equipment	Local	Foreign
1	Johnson Type Low Profile + Ice Plant	$52.00	$0.00
2	Concrete Haulers	$25.00	$0.00
1	Lot Pumping Equipment	$48.95	$0.00
1	Lot fans	$13.83	$0.00
		$139.78	$0.00
	Utility Factor	75.00%	65.00%
	Actual Cost/Hr	$104.84	$0.00
	Equipment Cost/Day	$2,096.70	$0.00

MATERIALS	Quantity	Unit	Price	Total
Cement @ 30% of Volume	2,631	Tons @	$110.00	289,397
Aggregate & Sand (see Quarryco.xls)	19,293	Tons @	$10.00	192,931
Admixtures	4,385	Gals @	$15.00	65,772
				548,100

Concrete Costs by Sections	Type I	Type II	Type III	Type IV	
Labor Cost - Concrete, Local @ 10 hrs/day	9,300	14,900	11,100	1,900	37,200
Labor Cost - Concrete, Foreign @ 10 hrs/day	0	0	0	0	0
Equipment Cost, Local	22,984	36,774	27,581	4,597	91,936
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	137,025	219,240	164,430	27,405	548,100
Material Cost, Foreign	0	0	0	0	0
					677,200
TOTAL CONCRETE COST	$169,300	$270,900	$203,100	$33,900	$677,200
Tunnel concrete Lining Cost, Local	$169,309	$270,914	$203,111	$33,902	$677,236
Tunnel concrete Lining Cost, Foreign	$0	$0	$0	$0	$0
$$/CuM	$77.22	$77.23	$77.20	$77.31	
Local Cost/CuM	$77.23				
Foreign Cost/CuM	$0.00				

PANAMA CANAL INDIO-GATUN PROJECT
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature:	**Power Tunnel**
Length	**8,400 meters (Intake portal to outlet portal)**
Diameter	**6.00 meters (D-shaped Section)**
	Basic Drill/Blast

Does not include construction adits — **Project # 15593**

TUNNEL CONCRETE LINING

					Total
Length	2100	3360	2520	420	8,400
Quantity	26,426	42,281	34,955	5,826	109,487

Use Prefabricated Steel Forms on Dolly
Each set 20 M Long and a 24 hour concrete placing will be used with 8 hours for placing forms and reinforcing (if any), 8 hours of concrete placing and 8 hours to cure, clean and move

Average placing Rate (cu. M / day)	150	150	150	150	
No. of Steel Sets	0	0	0	0	0
Number of 10 hour work days	176	282	233	39	730

Concrete Lining Crew

No.	Crew	Local	Local Total	Foreign	
1	Walker	$10.00	$10.00	$0.00	0
1	Foreman	$10.00	$10.00		
0	Form Foreman	$10.00	$0.00		
8	Miners	$5.50	$44.00		
8	Carpenters	$6.60	$52.80		
1	Compressor Operator	$7.90	$7.90		
1	Mucker Operator	$7.90	$7.90		
2	Flat Bed Operators	$6.20	$12.40		
1	HVAC Electrician/Mechanics	$6.60	$3.30		
1	Pump Operators	$7.90	$7.90		
1	Mechanics	$6.60	$3.30		
1	Electricians	$6.60	$3.30		
25	Total Crew, $$/Hr		$162.80	$0.00	
	Total Labor Cost, Local		$1,188,297		
	Total Labor Cost, foreign		0		

No.	Plant & Equipment	Local	Foreign
1	Johnson Type Low Profile + Ice Plant	$52.00	$0.00
2	Concrete Haulers	$25.00	$0.00
1	Lot Pumping Equipment	$45.00	$0.00
1	Lot fans	$4.53	$0.00
		$126.53	$0.00
	Utility Factor	75.00%	65.00%
	Actual Cost/Hr	$94.90	$0.00
	Equipment Cost/Day	$1,897.95	$0.00

MATERIALS	Quantity	Unit	Price	Cost	Total
Cement	32,846	Tons @	$110.00	3,613,065	
Aggregate & Sand (see Quarryco.xls)	240,871	Tons @	$10.00	2,408,710	
Admixtures	54,743	Gals @	$15.00	821,151	
Steel Forms	0	KG @	$1.50	0	
Timber for Bulkheads	8,208	SqM @	$25.00	205,204	1,026,355
				7,048,131	

Concrete Costs by Sections	Type I	Type II	Type III	Type IV	
Labor Cost - Concrete, Local	286,800	458,900	379,400	63,200	1,188,300
Labor Cost - Concrete, Foreign	0	0	0	0	0
Equipment Cost, Local	334,363	534,980	442,281	73,713	1,385,337
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	1,701,125	2,721,800	2,250,176	375,029	7,048,131
Material Cost, Foreign	0	0	0	0	0
					9,621,800
TOTAL CONCRETE COST	$2,322,300	$3,715,700	$3,071,900	$511,900	$9,621,768
Tunnel concrete Lining Cost, Local	$2,322,288	$3,715,681	$3,071,856	$511,943	$9,621,768
Tunnel concrete Lining Cost, Foreign	$0	$0	$0	$0	$0
$$/CuM	$81.15	$81.15	$81.73	$81.72	
Local Cost/CuM	$81.36				
Foreign Cost/CuM	$0.00				

COMPARATIVE COST ESTIMATES

Isla Pablon Hydropower Component Cost

	8.4-MW Isla Pablon Power Plant	11.2-MW Isla Pablon Power Plant	14.0-MW Isla Pablon Power Plant	16.8-MW Isla Pablon Power Plant	19.6-MW Isla Pablon Power Plant
Increase Diam of Transfer Tunnel	$2,971,000	$2,971,000	$2,971,000	$2,971,000	$2,971,000
Surge Tank	$2,607,000	$2,607,000	$2,607,000	$2,607,000	$2,607,000
Tunnel Steel Liner	$1,391,000	$1,391,000	$1,391,000	$1,391,000	$1,391,000
Powerhouse Civil Works	$1,720,000	$1,902,000	$2,109,000	$2,263,000	$2,437,000
Powerhouse Equipment	$7,856,000	$8,741,000	$9,560,000	$10,369,000	$10,922,000
Transmission System	$4,560,000	$4,619,000	$4,709,000	$4,859,000	$5,008,000
Subtotal	**$21,105,000**	**$22,231,000**	**$23,347,000**	**$24,460,000**	**$25,336,000**
Water-Only Scheme Outlet Work	$2,082,000	$2,082,000	$2,082,000	$2,082,000	$2,082,000
Net Hydroelectric Component Cost	**$19,023,000**	**$20,149,000**	**$21,265,000**	**$22,378,000**	**$23,254,000**
Contingencies (20%)	$3,804,600	$4,029,800	$4,253,000	$4,475,600	$4,650,800
Engineering & Administration (10%)	$2,282,760	$2,417,880	$2,551,800	$2,685,360	$2,790,480
Total	**$25,110,000**	**$26,597,000**	**$28,070,000**	**$29,539,000**	**$30,695,000**
Total Excluding Transmission	$14,463,000	$15,530,000	$16,556,000	$17,519,000	$18,246,000
Substation	$0	$0	$0	$0	$0
Subtotal	**$14,463,000**	**$15,530,000**	**$16,556,000**	**$17,519,000**	**$18,246,000**
Contingencies (20%)	$2,892,600	$3,106,000	$3,311,200	$3,503,800	$3,649,200
Engineering & Administration (10%)	$1,735,560	$1,863,600	$1,986,720	$2,102,280	$2,189,520
Total	**$19,091,000**	**$20,500,000**	**$21,854,000**	**$23,125,000**	**$24,085,000**

COMPARATIVE COST ESTIMATES

Outlet Structure

	Unit	Unit Cost	Quantity	Amount
Civil Work				
Mass Concrete	cu.m	$115.00	1,924	$221,260
Structural Concrete	sq.m	$140.00	852	$119,280
Formwork	sq.m	$46.20	1,326	$61,261
Steel Reinforcement	Ton	$1,360	82.2	$111,792
Steel Liner	Ton	$3,200	27.4	$87,680
Rock Anchors	L.m	$67	2,040	$136,680
Subtotal				$737,953
Equipment				
Bonneted Gates (with Hyd Hoist) 3.00 x 1.80	Each	$320,000	4	$1,280,000
Miscellaneous Equipment		5%		$64,000
Subtotal				$1,344,000
			TOTAL	$2,081,953

COMPARATIVE COST ESTIMATES

5.00-meter diameter Steel Liner

	Unit	Unit Cost	Quantity	Amount
Civil Work				
Steel Plate	T	$3,200	414	$1,324,800
Miscellaneous	%	5%		$66,240
Subtotal				$1,391,040

COMPARATIVE COST ESTIMATES

Surge Tank

	Unit	Unit Cost	Quantity	Amount
Civil Work				
Site Preparation	sq.m	$0.50	6,400	$3,200
Overburden Excavation	cu.m	$3.20	37,000	$118,400
Rock Excavation	cu.m	$8.75	10,032	$87,780
Large Diameter Shaft Excavation	cu.m	$14.50	17,534	$254,243
Pilot Shaft Excavation	cu.m	$295.00	375	$110,625
Shotcrete	sq.m	$43.00	1,500	$64,500
Mass Concrete	cu.m	$115.00	0	$0
Structural Concrete	cu.m	$140.00	6,496	$909,440
Formwork	sq.m	$46.20	7,326	$338,461
Steel Reinforcement	Ton	$1,360	259.8	$353,328
Rock Anchors	L.m	$67	3,630	$243,210
Miscellaneous Support	%	5%		$124,159
Subtotal				$2,607,347

COMPARATIVE COST ESTIMATES

8.4-MW Isla Pablon Power Plant

POWERHOUSE	Unit	Unit Cost	Quantity	Amount
Civil Work				
Site Preparation	sq.m	$0.50	4,200	$2,100
Overburden Excavation	cu.m	$3.20	15,487	$49,558
Rock Excavation	cu.m	$8.75	14,221	$124,434
Mass Concrete	cu.m	$115.00	1,570	$180,550
Structural Concrete	cu.m	$140.00	1,868	$261,520
Formwork	sq.m	$46.20	7,326	$338,461
Steel Reinforcement	Ton	$1,360	114.0	$155,040
Steel Penstock	Ton	$3,200	115.6	$369,920
Roof, siding, windows, doors, etc	sq.m	$300	521	$156,300
Miscellaneous Metal Works	%	5%		$81,894
Subtotal				$1,719,778
Equipment				
Power Generating				
Main Inlet Valves	Each	$180,000	2	$360,000
Turbine/Generator Units	Each	$1,355,000	2	$2,710,000
Unit Auxiliaries	Each	$135,500	2	$271,000
Axial Flow Regulating Valves	Each	$147,500	2	$295,000
Draft Tube Gates	Each	$64,000	4	$256,000
Tunnel Release				
Main Inlet Valves	Each	$500,000	2	$1,000,000
Axial Flow Control Valves	Each	$400,000	2	$800,000
Miscellaneous Mechanical				
Dewatering System	LS	$250,000	1	$250,000
Bridge Crane	LS	$287,500	1	$287,500
Gantry Crane	LS	$93,750	1	$93,750
Miscellaneous Electrical				
Switchgear - 13.8 kV	LS	$375,000	1	$375,000
Station Service Transformer	Each	$56,000	1	$56,000
Stand-by Diesel Generator	Each	$143,750	1	$143,750
Station Auxiliaries (light, HVAC, etc.)	LS	$187,500	1	$187,500
Control and Communication Equip	LS	$120,000	1	$120,000
Cabling, MV & LV Power, Cont/Comm	LS	$650,000	1	$650,000
Subtotal				$7,855,500
Transmission System				
115-kV Substation				
Main Transformer	MVA	$29,900	10	$299,000
Breakers, Disconnects, etc.	LS	$225,000	1	$225,000
Control Panels and other Equipment	LS	$350,000	1	$350,000
Steel Structures and Civil Works	LS	$210,000	1	$210,000
La Chorrera Substation				
Breakers, Disconnects, etc.	LS	$400,000	1	$400,000
Control Panels and other Equipment	LS	$465,000	1	$465,000
Steel Structures and Civil Works	LS	$290,000	1	$290,000
115-kV Transmission Line				
Civil Works (survey, Found., Struc.)	km	$31,550	47.1	$1,486,005
Conductors and Shield Wire	km	$10,620	47.1	$500,202
Insulators and Accessories	km	$5,900	47.1	$277,890
Grounding and Miscellaneous	%	2.50%		$56,602
Subtotal				$4,559,699
			TOTAL	$14,134,977

COMPARATIVE COST ESTIMATES

11.2-MW Isla Pablon Power Plant

POWERHOUSE	Unit	Unit Cost	Quantity	Amount
Civil Work				
Site Preparation	sq.m	$0.50	4,200	$2,100
Overburden Excavation	cu.m	$3.20	16,175	$51,760
Rock Excavation	cu.m	$8.75	15,606	$136,553
Mass Concrete	cu.m	$115.00	1,917	$220,455
Structural Concrete	cu.m	$140.00	1,988	$278,320
Formwork	sq.m	$46.20	8,294	$383,183
Steel Reinforcement	Ton	$1,360	127.4	$173,264
Steel Penstock	Ton	$3,200	120.9	$386,880
Roof, siding, windows, doors, etc	sq.m	$300	595	$178,500
Miscellaneous Metal Works	%	5%		$90,551
Subtotal				$1,901,565
Equipment				
Power Generating				
Main Inlet Valves	Each	$205,000	2	$410,000
Turbine/Generator Units	Each	$1,670,000	2	$3,340,000
Unit Auxiliaries	Each	$167,000	2	$334,000
Axial Flow Regulating Valves	Each	$167,500	2	$335,000
Draft Tube Gates	Each	$72,500	4	$290,000
Tunnel Release				
Main Inlet Valves	Each	$500,000	2	$1,000,000
Axial Flow Control Valves	Each	$400,000	2	$800,000
Miscellaneous Mechanical				
Dewatering System	LS	$250,000	1	$250,000
Bridge Crane	LS	$287,500	1	$287,500
Gantry Crane	LS	$93,750	1	$93,750
Miscellaneous Electrical				
Switchgear - 13.8 kV	LS	$375,000	1	$375,000
Station Service Transformer	Each	$62,000	1	$62,000
Stand-by Diesel Generator	Each	$143,750	1	$143,750
Station Auxiliaries (light, HVAC, etc.)	LS	$187,500	1	$187,500
Control and Communication Equip	LS	$132,000	1	$132,000
Cabling, MV & LV Power, Cont/Comm	LS	$700,000	1	$700,000
Subtotal				$8,740,500
Transmission System				
115-kV Substation				
Main Transformer	MVA	$29,900	12	$358,800
Breakers, Disconnects, etc.	LS	$225,000	1	$225,000
Control Panels and other Equipment	LS	$350,000	1	$350,000
Steel Structures and Civil Works	LS	$210,000	1	$210,000
La Chorrera Substation				
Breakers, Disconnects, etc.	LS	$400,000	1	$400,000
Control Panels and other Equipment	LS	$465,000	1	$465,000
Steel Structures and Civil Works	LS	$290,000	1	$290,000
115-kV Transmission Line				
Civil Works (survey, Found., Struc.)	km	$31,550	47.1	$1,486,005
Conductors and Shield Wire	km	$10,620	47.1	$500,202
Insulators and Accessories	km	$5,900	47.1	$277,890
Grounding and Miscellaneous	%	2.50%		$56,602
Subtotal				$4,619,499
			TOTAL	$15,261,564

COMPARATIVE COST ESTIMATES

14.0-MW Isla Pablon Power Plant

POWERHOUSE	Unit	Unit Cost	Quantity	Amount
Civil Work				
Site Preparation	sq.m	$0.50	4,200	$2,100
Overburden Excavation	cu.m	$3.20	16,887	$54,038
Rock Excavation	cu.m	$8.75	17,148	$150,045
Mass Concrete	cu.m	$115.00	2,315	$266,225
Structural Concrete	cu.m	$140.00	2,126	$297,640
Formwork	sq.m	$46.20	9,418	$435,112
Steel Reinforcement	Ton	$1,360	142.9	$194,344
Steel Penstock	Ton	$3,200	127.2	$407,040
Roof, siding, windows, doors, etc	sq.m	$300	673	$201,900
Miscellaneous Metal Works	%	5%		$100,422
Subtotal				$2,108,866
Equipment				
Power Generating				
Main Inlet Valves	Each	$230,000	2	$460,000
Turbine/Generator Units	Each	$1,955,000	2	$3,910,000
Unit Auxiliaries	Each	$195,500	2	$391,000
Axial Flow Regulating Valves	Each	$187,500	2	$375,000
Draft Tube Gates	Each	$81,000	4	$324,000
Tunnel Release				
Main Inlet Valves	Each	$500,000	2	$1,000,000
Axial Flow Control Valves	Each	$400,000	2	$800,000
Miscellaneous Mechanical				
Dewatering System	LS	$250,000	1	$250,000
Bridge Crane	LS	$287,500	1	$287,500
Gantry Crane	LS	$93,750	1	$93,750
Miscellaneous Electrical				
Switchgear - 13.8 kV	LS	$375,000	1	$375,000
Station Service Transformer	Each	$68,750	1	$68,750
Stand-by Diesel Generator	Each	$143,750	1	$143,750
Station Auxiliaries (light, HVAC, etc.)	LS	$187,500	1	$187,500
Control and Communication Equip	LS	$143,750	1	$143,750
Cabling, MV & LV Power, Cont/Comm	LS	$750,000	1	$750,000
Subtotal				$9,560,000
Transmission System				
115-kV Substation				
Main Transformer	MVA	$29,900	15	$448,500
Breakers, Disconnects, etc.	LS	$225,000	1	$225,000
Control Panels and other Equipment	LS	$350,000	1	$350,000
Steel Structures and Civil Works	LS	$210,000	1	$210,000
La Chorrera Substation				
Breakers, Disconnects, etc.	LS	$400,000	1	$400,000
Control Panels and other Equipment	LS	$465,000	1	$465,000
Steel Structures and Civil Works	LS	$290,000	1	$290,000
115-kV Transmission Line				
Civil Works (survey, Found., Struc.)	km	$31,550	47.1	$1,486,005
Conductors and Shield Wire	km	$10,620	47.1	$500,202
Insulators and Accessories	km	$5,900	47.1	$277,890
Grounding and Miscellaneous	%	2.50%		$56,602
Subtotal				$4,709,199
			TOTAL	$16,378,066

COMPARATIVE COST ESTIMATES

16.8-MW Isla Pablon Power Plant

POWERHOUSE	Unit	Unit Cost	Quantity	Amount
Civil Work				
Site Preparation	sq.m	$0.50	4,200	$2,100
Overburden Excavation	cu.m	$3.20	17,437	$55,798
Rock Excavation	cu.m	$8.75	18,414	$161,123
Mass Concrete	cu.m	$115.00	2,651	$304,865
Structural Concrete	cu.m	$140.00	2,195	$307,300
Formwork	sq.m	$46.20	10,235	$472,857
Steel Reinforcement	Ton	$1,360	154.1	$209,576
Steel Penstock	Ton	$3,200	131.6	$421,120
Roof, siding, windows, doors, etc	sq.m	$300	735	$220,500
Miscellaneous Metal Works	%	5%		$107,762
Subtotal				$2,263,001
Equipment				
Power Generating				
Main Inlet Valves	Each	$270,000	2	$540,000
Turbine/Generator Units	Each	$2,200,000	2	$4,400,000
Unit Auxiliaries	Each	$220,000	2	$440,000
Axial Flow Regulating Valves	Each	$220,000	2	$440,000
Draft Tube Gates	Each	$95,000	4	$380,000
Tunnel Release				
Main Inlet Valves	Each	$500,000	2	$1,000,000
Axial Flow Control Valves	Each	$400,000	2	$800,000
Miscellaneous Mechanical				
Dewatering System	LS	$250,000	1	$250,000
Bridge Crane	LS	$287,500	1	$287,500
Gantry Crane	LS	$93,750	1	$93,750
Miscellaneous Electrical				
Switchgear - 13.8 kV	LS	$375,000	1	$375,000
Station Service Transformer	Each	$75,250	1	$75,250
Stand-by Diesel Generator	Each	$143,750	1	$143,750
Station Auxiliaries (light, HVAC, etc.)	LS	$187,500	1	$187,500
Control and Communication Equip	LS	$156,000	1	$156,000
Cabling, MV & LV Power, Cont/Comm	LS	$800,000	1	$800,000
Subtotal				$10,368,750
Transmission System				
115-kV Substation				
Main Transformer	MVA	$29,900	20	$598,000
Breakers, Disconnects, etc.	LS	$225,000	1	$225,000
Control Panels and other Equipment	LS	$350,000	1	$350,000
Steel Structures and Civil Works	LS	$210,000	1	$210,000
La Chorrera Substation				
Breakers, Disconnects, etc.	LS	$400,000	1	$400,000
Control Panels and other Equipment	LS	$465,000	1	$465,000
Steel Structures and Civil Works	LS	$290,000	1	$290,000
115-kV Transmission Line				
Civil Works (survey, Found., Struc.)	km	$31,550	47.1	$1,486,005
Conductors and Shield Wire	km	$10,620	47.1	$500,202
Insulators and Accessories	km	$5,900	47.1	$277,890
Grounding and Miscellaneous	%	2.50%		$56,602
Subtotal				$4,858,699
			TOTAL	$17,490,450

COMPARATIVE COST ESTIMATES

19.6-MW Isla Pablon Power Plant

POWERHOUSE	Unit	Unit Cost	Quantity	Amount
Civil Work				
Site Preparation	sq.m	$0.50	4,200	$2,100
Overburden Excavation	cu.m	$3.20	18,000	$57,600
Rock Excavation	cu.m	$8.75	19,775	$173,031
Mass Concrete	cu.m	$115.00	3,020	$347,300
Structural Concrete	cu.m	$140.00	2,288	$320,320
Formwork	sq.m	$46.20	11,177	$516,377
Steel Reinforcement	Ton	$1,360	167.0	$227,120
Steel Penstock	Ton	$3,200	136.6	$437,120
Roof, siding, windows, doors, etc	sq.m	$300	800	$240,000
Miscellaneous Metal Works	%	5%		$116,048
Subtotal				$2,437,017
Equipment				
Power Generating				
Main Inlet Valves	Each	$305,000	2	$610,000
Turbine/Generator Units	Each	$2,440,000	2	$4,880,000
Unit Auxiliaries	Each	$244,000	2	$488,000
Axial Flow Regulating Valves	Each	$250,000	2	$500,000
Draft Tube Gates	Each	$107,500	4	$430,000
Tunnel Release				
Main Inlet Valves	Each	$500,000	2	$1,000,000
Axial Flow Control Valves	Each	$400,000	2	$800,000
Miscellaneous Mechanical				
Dewatering System	LS	$250,000	1	$250,000
Bridge Crane	LS	$287,500	1	$287,500
Gantry Crane	LS	$93,750	1	$93,750
Miscellaneous Electrical				
Switchgear - 13.8 kV	LS	$375,000	1	$375,000
Station Service Transformer	Each	$56,000	1	$56,000
Stand-by Diesel Generator	Each	$143,750	1	$143,750
Station Auxiliaries (light, HVAC, etc.)	LS	$187,500	1	$187,500
Control and Communication Equip	LS	$170,000	1	$170,000
Cabling, MV & LV Power, Cont/Comm	LS	$650,000	1	$650,000
Subtotal				$10,921,500
Transmission System				
115-kV Substation				
Main Transformer	MVA	$29,900	25	$747,500
Breakers, Disconnects, etc.	LS	$225,000	1	$225,000
Control Panels and other Equipment	LS	$350,000	1	$350,000
Steel Structures and Civil Works	LS	$210,000	1	$210,000
La Chorrera Substation				
Breakers, Disconnects, etc.	LS	$400,000	1	$400,000
Control Panels and other Equipment	LS	$465,000	1	$465,000
Steel Structures and Civil Works	LS	$290,000	1	$290,000
115-kV Transmission Line				
Civil Works (survey, Found., Struc.)	km	$31,550	47.1	$1,486,005
Conductors and Shield Wire	km	$10,620	47.1	$500,202
Insulators and Accessories	km	$5,900	47.1	$277,890
Grounding and Miscellaneous	%	2.50%		$56,602
Subtotal				$5,008,199
			TOTAL	$18,366,717

COMPARATIVE COST ESTIMATES

Rio Indio Hydropower Component Cost

	2.5-MW Rio Indio Power Plant	6.4-MW Rio Indio Power Plant	11.1-MW Rio Indio Power Plant	15.9-MW Rio Indio Power Plant	18.4-MW Rio Indio Power Plant
Power Intake - Civil Work	$696,524	$696,524	$696,524	$746,331	$762,984
Power Intake - Equipment	$362,500	$480,000	$555,000	$777,500	$915,000
Power Tunnel and Penstock	$1,225,370	$1,377,320	$1,440,170	$2,025,361	$2,167,662
Tailrace	$32,335	$36,551	$45,224	$52,016	$54,281
Powerhouse - Civil Work	$279,706	$464,198	$726,006	$876,586	$1,036,991
Powerhouse - Equipment	$2,359,750	$5,006,250	$7,141,250	$8,184,250	$9,649,250
Transmission System	$207,648	$5,116,502	$5,251,052	$5,490,252	$5,490,252
Subtotal	**$5,164,000**	**$13,177,000**	**$15,855,000**	**$18,152,000**	**$20,076,000**
Contingencies (20%)	$1,032,800	$2,635,400	$3,171,000	$3,630,400	$4,015,200
Engineering & Administration (10%)	$619,680	$1,581,240	$1,902,600	$2,178,240	$2,409,120
Total	**$6,816,000**	**$17,394,000**	**$20,929,000**	**$23,961,000**	**$26,500,000**
Total Excluding Transmission	$4,956,186	$8,060,843	$10,604,174	$12,662,045	$14,586,167
Transmission to Pablon	$207,648	$0	$0	$0	$0
Subtotal	**$5,164,000**	**$8,061,000**	**$10,604,000**	**$12,662,000**	**$14,586,000**
Contingencies (20%)	$1,032,800	$1,612,200	$2,120,800	$2,532,400	$2,917,200
Engineering & Administration (10%)	$619,680	$967,320	$1,272,480	$1,519,440	$1,750,320
Total	**$6,816,000**	**$10,641,000**	**$13,997,000**	**$16,714,000**	**$19,254,000**

COMPARATIVE COST ESTIMATES

2.5-MW Rio Indio Power Plant

	Unit	Unit Cost	Quantity	Amount
POWER INTAKE				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	11,775	$37,680
Rock Excavation	cu.m	$8.75	4,200	$36,750
Portal Excavation	cu.m	$14.70	525	$7,718
Shaft Excavation	cu.m	$295.00	748	$220,660
Structural Concrete	cu.m	$140.00	680	$95,200
Shaft Concrete Lining	cu.m	$180.00	182	$32,760
Formwork	sq.m	$46.20	1,465	$67,683
Steel Reinforcement	Ton	$1,360	48.1	$65,416
Steel Liner	Ton	$3,200	4.5	$14,400
Rock Anchors	L.m	$67	1,270	$85,090
Miscellaneous	%	5%		$33,168
Subtotal				$696,524
Equipment				
Wheeled Intake Gate (2.50 x 2.00) and Hoist	Each	$175,000	1	$175,000
Trash Screen Bays	Each	$50,000	1	$50,000
Trash Rake	Each	$75,000	1	$75,000
Power and Control Equipment	LS	$37,500	1	$37,500
Cabling, MV & LV Power, Cont/Comm	LS	$25,000	1	$25,000
Subtotal				$362,500
POWER TUNNEL & PENSTOCK				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	5,215	$16,688
Rock Excavation	cu.m	$8.75	525	$4,594
Portal Excavation	cu.m	$14.70	375	$5,513
Tunnel Excavation	cu.m	$220.00	2,285	$502,700
Shotcrete	sq.m	$43.00	1,500	$64,500
Rockbolts	L.m	$67.00	1,600	$107,200
Steel Ribs	kg	$6.00	14,500	$87,000
Tunnel Concrete Lining	cu.m	$172.00	890	$153,080
Formwork (tunnel)	sq.m	$46.20	1,607	$74,243
Steel Reinforcement (tunnel)	Ton	$1,360	44.5	$60,520
Structural Concrete (penstock)	cu.m	$140.00	96	$13,440
Formwork (penstock)	sq.m	$46.20	228	$10,534
Steel Reinforcement (penstock)	Ton	$1,360	4.8	$6,528
Steel Penstock	Ton	$3,200	18.9	$60,480
Miscellaneous	%	5%		$58,351
Subtotal				$1,225,370
TAILRACE				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	9,722	$31,110
Rock Excavation	cu.m	$8.75	140	$1,225
Subtotal				$32,335

COMPARATIVE COST ESTIMATES

2.5-MW Rio Indio Power Plant

	Unit	Unit Cost	Quantity	Amount
POWERHOUSE & TRANSMISSION				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	4,340	$13,888
Rock Excavation	cu.m	$8.75	340	$2,975
Mass Concrete	cu.m	$115.00	450	$51,750
Structural Concrete	cu.m	$140.00	279	$39,060
Formwork	sq.m	$46.20	1,737	$80,249
Steel Reinforcement	Ton	$1,360	22.4	$30,464
Roof, siding, windows, doors, etc	sq.m	$300	160	$48,000
Miscellaneous	%	5%		$13,319
Subtotal				$279,706
Equipment				
Power Generating				
Main Inlet Valves (1.00 m dia)	Each	$115,000	1	$115,000
Turbine/Generator Units (2.5 MW)	Each	$1,035,000	1	$1,035,000
2.5-MW Unit Auxiliaries	Each	$103,500	1	$103,500
Draft Tube Gates (2.5 MW)	Each	$75,000	1	$75,000
Tunnel Release				
Main Inlet Valves (0.40 m dia)	Each	$62,500	1	$62,500
Axial Flow Control Valves (0.40 m dia)	Each	$62,500	1	$62,500
Miscellaneous Mechanical				
Dewatering System	LS	$68,750	1	$68,750
Bridge Crane	LS	$93,750	1	$93,750
Miscellaneous Electrical				
Switchgear - 13.8 kV	LS	$343,750	1	$343,750
Station Service Transformer	Each	$25,000	1	$25,000
Stand-by Diesel Generator	Each	$75,000	1	$75,000
Station Auxiliaries (light, HVAC, etc.)	LS	$62,500	1	$62,500
Control and Communication Equip	LS	$50,000	1	$50,000
Cabling, MV & LV Power, Cont/Comm	LS	$187,500	1	$187,500
Subtotal				$2,359,750
Transmission System				
13.8-kV Transmission Line				
Civil Works (survey, Found., Struc.)	km	$10,500	12.6	$132,300
Conductors and Shield Wire	km	$3,500	12.6	$44,100
Insulators and Accessories	km	$2,000	12.6	$25,200
Grounding and Miscellaneous	%	3.00%		$6,048
Subtotal				$207,648
			TOTAL	$2,847,104

COMPARATIVE COST ESTIMATES

6.4-MW Rio Indio Power Plant

	Unit	Unit Cost	Quantity	Amount
POWER INTAKE				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	11,775	$37,680
Rock Excavation	cu.m	$8.75	4,200	$36,750
Portal Excavation	cu.m	$14.70	525	$7,718
Shaft Excavation	cu.m	$295.00	748	$220,660
Structural Concrete	cu.m	$140.00	680	$95,200
Shaft Concrete Lining	cu.m	$180.00	182	$32,760
Formwork	sq.m	$46.20	1,465	$67,683
Steel Reinforcement	Ton	$1,360	48.1	$65,416
Steel Liner	Ton	$3,200	4.5	$14,400
Rock Anchors	L.m	$67	1,270	$85,090
Miscellaneous Metal Works	%	5%		$33,168
Subtotal				$696,524
Equipment				
Wheeled Intake Gate (2.50 x 2.00) and Hoist	Each	$175,000	1	$175,000
Trash Screen Bays	Each	$62,500	2	$125,000
Trash Rake	Each	$90,000	1	$90,000
Power and Control Equipment	LS	$45,000	1	$45,000
Cabling, MV & LV Power, Cont/Comm	LS	$45,000	1	$45,000
Subtotal				$480,000
POWER TUNNEL & PENSTOCK				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	5,387	$17,238
Rock Excavation	cu.m	$8.75	599	$5,241
Portal Excavation	cu.m	$14.70	375	$5,513
Tunnel Excavation	cu.m	$220.00	2,285	$502,700
Shotcrete	sq.m	$43.00	1,500.0	$64,500
Rockbolts	L.m	$67.00	1,600.0	$107,200
Steel Ribs	kg	$6.00	14,500.0	$87,000
Tunnel Concrete Lining	sq.m	$172.00	1,241	$213,452
Formwork (tunnel)	sq.m	$46.20	784	$36,221
Steel Reinforcement (tunnel)	Ton	$1,360	62.1	$84,456
Structural Concrete (penstock)	cu.m	$140.00	157	$21,980
Formwork (penstock)	sq.m	$46.20	312	$14,414
Steel Reinforcement (penstock)	Ton	$220	7.9	$1,738
Steel Penstock	cu.m	$3,200	46.9	$150,080
Miscellaneous	%	5%		$65,587
Subtotal				$1,377,320
TAILRACE				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	10,465	$33,488
Rock Excavation	cu.m	$8.75	350	$3,063
Subtotal				$36,551

COMPARATIVE COST ESTIMATES

6.4-MW Rio Indio Power Plant

	Unit	Unit Cost	Quantity	Amount
POWERHOUSE & TRANSMISSION				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	5,721	$18,307
Rock Excavation	cu.m	$8.75	752	$6,580
Mass Concrete	cu.m	$115.00	798	$91,770
Structural Concrete	cu.m	$140.00	477	$66,780
Formwork	sq.m	$46.20	3,022	$139,616
Steel Reinforcement	Ton	$1,360	39.0	$53,040
Roof, siding, windows, doors, etc	sq.m	$300	220	$66,000
Miscellaneous	%	5%		$22,105
Subtotal				$464,198
Equipment				
Power Generating				
Main Inlet Valves (1.00 m dia)	Each	$115,000	1	$115,000
Turbine/Generator Unit (2.5 MW)	Each	$1,035,000	1	$1,035,000
2.5-MW Unit Auxiliaries	Each	$103,500	1	$103,500
Draft Tube Gate (2.5 MW)	Each	$75,000	1	$75,000
Main Inlet Valve (1.35 m dia)	Each	$175,000	1	$175,000
Turbine/Generator Unit (3.9 MW)	Each	$1,240,000	1	$1,240,000
3.9-MW Unit Auxiliaries	Each	$124,000	1	$124,000
Draft Tube Gates (3.9 MW)	Each	$60,000	2	$120,000
Tunnel Release				
Main Inlet Valves (0.40 m dia)	Each	$62,500	1	$62,500
Axial Flow Control Valves (0.40 m dia)	Each	$62,500	1	$62,500
Miscellaneous Mechanical				
Dewatering System	LS	$187,500	1	$187,500
Bridge Crane	LS	$250,000	1	$250,000
Miscellaneous Electrical				
Switchgear - 13.8 kV	LS	$375,000	1	$375,000
Station Service Transformer	Each	$50,000	1	$50,000
Stand-by Diesel Generator	Each	$143,750	1	$143,750
Station Auxiliaries (light, HVAC, etc.)	LS	$187,500	1	$187,500
Control and Communication Equip	LS	$100,000	1	$100,000
Cabling, MV & LV Power, Cont/Comm	LS	$600,000	1	$600,000
Subtotal				$5,006,250
Transmission System				
115-kV Substation				
Main Transformer	MVA	$29,900	7.5	$224,250
Breakers, Disconnects, etc.	LS	$186,000	1	$186,000
Control Panels and other Equipment	LS	$414,000	1	$414,000
Steel Structures and Civil Works	LS	$245,000	1	$245,000
La Chorrera Substation				
Breakers, Disconnects, etc.	LS	$400,000	1	$400,000
Control Panels and other Equipment	LS	$465,000	1	$465,000
Steel Structures and Civil Works	LS	$290,000	1	$290,000
115-kV Transmission Line				
Civil Works (survey, Found., Struc.)	km	$31,550	58.7	$1,851,985
Conductors and Shield Wire	km	$10,620	58.7	$623,394
Insulators and Accessories	km	$5,900	58.7	$346,330
Grounding and Miscellaneous	%	2.50%		$70,543
Subtotal				$5,116,502
			TOTAL	$10,586,950

COMPARATIVE COST ESTIMATES

11.1-MW Rio Indio Power Plant

	Unit	Unit Cost	Quantity	Amount
POWER INTAKE				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	11,775	$37,680
Rock Excavation	cu.m	$8.75	4,200	$36,750
Portal Excavation	cu.m	$14.70	525	$7,718
Shaft Excavation	cu.m	$295.00	748	$220,660
Structural Concrete	cu.m	$140.00	680	$95,200
Shaft Concrete Lining	cu.m	$180.00	182	$32,760
Formwork	sq.m	$46.20	1,465	$67,683
Steel Reinforcement	Ton	$1,360	48.1	$65,416
Steel Liner	Ton	$3,200	4.5	$14,400
Rock Anchors	L.m	$67	1,270	$85,090
Miscellaneous Metal Works	%	5%		$33,168
Subtotal				$696,524
Equipment				
Wheeled Intake Gate (2.50 x 2.00) and Hoist	Each	$175,000	1	$175,000
Trash Screen Bays	Each	$50,000	4	$200,000
Trash Rake	Each	$90,000	1	$90,000
Power and Control Equipment	LS	$45,000	1	$45,000
Cabling, MV & LV Power, Cont/Comm	LS	$45,000	1	$45,000
Subtotal				$555,000
POWER TUNNEL & PENSTOCK				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	5,558	$17,786
Rock Excavation	cu.m	$8.75	662	$5,793
Portal Excavation	cu.m	$14.70	375	$5,513
Tunnel Excavation	cu.m	$220.00	2,285	$502,700
Shotcrete	sq.m	$43.00	1,500.0	$64,500
Rockbolts	L.m	$67.00	1,600.0	$107,200
Steel Ribs	kg	$6.00	14,500.0	$87,000
Tunnel Concrete Lining	sq.m	$172.00	972	$167,184
Formwork (tunnel)	sq.m	$46.20	784	$36,221
Steel Reinforcement (tunnel)	Ton	$1,360	48.6	$66,096
Structural Concrete (penstock)	cu.m	$140.00	219	$30,660
Formwork (penstock)	sq.m	$46.20	384	$17,741
Steel Reinforcement (penstock)	Ton	$220	10.9	$2,398
Steel Penstock	cu.m	$3,200	81.5	$260,800
Miscellaneous	%	5%		$68,580
Subtotal				$1,440,170
TAILRACE				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	12,027	$38,486
Rock Excavation	cu.m	$8.75	770	$6,738
Subtotal				$45,224

COMPARATIVE COST ESTIMATES

11.1-MW Rio Indio Power Plant

	Unit	Unit Cost	Quantity	Amount
POWERHOUSE & TRANSMISSION				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	7,533	$24,106
Rock Excavation	cu.m	$8.75	1,318	$11,533
Mass Concrete	cu.m	$115.00	1,255	$144,325
Structural Concrete	cu.m	$140.00	736	$103,040
Formwork	sq.m	$46.20	4,716	$217,879
Steel Reinforcement	Ton	$1,360	60.7	$82,552
Roof, siding, windows, doors, etc	sq.m	$300	360	$108,000
Miscellaneous	%	5%		$34,572
Subtotal				$726,006
Equipment				
Power Generating				
Main Inlet Valves (1.00 m dia)	Each	$115,000	1	$115,000
Turbine/Generator Units (2.5 MW)	Each	$1,035,000	1	$1,035,000
2.5-MW Unit Auxiliaries	Each	$103,500	1	$103,500
Draft Tube Gates (2.5 MW)	Each	$75,000	1	$75,000
Main Inlet Valve (1.45 m dia)	Each	$200,000	2	$400,000
Turbine/Generator Unit (4.3 MW)	Each	$1,300,000	2	$2,600,000
4.3-MW Unit Auxiliaries	Each	$130,000	2	$260,000
Draft Tube Gates (4.3 MW)	Each	$60,000	4	$240,000
Tunnel Release				
Main Inlet Valves (0.40 m dia)	Each	$62,500	1	$62,500
Axial Flow Control Valves (0.40 m dia)	Each	$62,500	1	$62,500
Miscellaneous Mechanical				
Dewatering System	LS	$187,500	1	$187,500
Bridge Crane	LS	$250,000	1	$250,000
Miscellaneous Electrical				
Switchgear - 13.8 kV	LS	$525,000	1	$525,000
Station Service Transformer	Each	$62,000	1	$62,000
Stand-by Diesel Generator	Each	$143,750	1	$143,750
Station Auxiliaries (light, HVAC, etc.)	LS	$187,500	1	$187,500
Control and Communication Equip	LS	$132,000	1	$132,000
Cabling, MV & LV Power, Cont/Comm	LS	$700,000	1	$700,000
Subtotal				$7,141,250
Transmission System				
115-kV Substation				
Main Transformer	MVA	$29,900	12	$358,800
Breakers, Disconnects, etc.	LS	$186,000	1	$186,000
Control Panels and other Equipment	LS	$414,000	1	$414,000
Steel Structures and Civil Works	LS	$245,000	1	$245,000
La Chorrera Substation				
Breakers, Disconnects, etc.	LS	$400,000	1	$400,000
Control Panels and other Equipment	LS	$465,000	1	$465,000
Steel Structures and Civil Works	LS	$290,000	1	$290,000
115-kV Transmission Line				
Civil Works (survey, Found., Struc.)	km	$31,550	58.7	$1,851,985
Conductors and Shield Wire	km	$10,620	58.7	$623,394
Insulators and Accessories	km	$5,900	58.7	$346,330
Grounding and Miscellaneous	%	2.50%		$70,543
Subtotal				$5,251,052
			TOTAL	$13,118,308

COMPARATIVE COST ESTIMATES

15.9-MW Rio Indio Power Plant

	Unit	Unit Cost	Quantity	Amount
POWER INTAKE				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	11,775	$37,680
Rock Excavation	cu.m	$8.75	4,200	$36,750
Portal Excavation	cu.m	$14.70	651	$9,570
Shaft Excavation	cu.m	$295.00	748	$220,660
Structural Concrete	cu.m	$140.00	843	$118,020
Shaft Concrete Lining	cu.m	$180.00	182	$32,760
Formwork	sq.m	$46.20	1,681	$77,662
Steel Reinforcement	Ton	$1,360	57.5	$78,200
Steel Liner	Ton	$3,200	4.5	$14,400
Rock Anchors	L.m	$67	1,270	$85,090
Miscellaneous Metal Works	%	5%		$35,540
Subtotal				$746,331
Equipment				
Wheeled Intake Gate (3.10 x 2.30) and Hoist	Each	$285,000	1	$285,000
Trash Screen Bays	Each	$62,500	5	$312,500
Trash Rake	Each	$90,000	1	$90,000
Power and Control Equipment	LS	$45,000	1	$45,000
Cabling, MV & LV Power, Cont/Comm	LS	$45,000	1	$45,000
Subtotal				$777,500
POWER TUNNEL & PENSTOCK				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	5,705	$18,256
Rock Excavation	cu.m	$8.75	725	$6,344
Portal Excavation	cu.m	$14.70	420	$6,174
Tunnel Excavation	cu.m	$220.00	3,388	$745,360
Shotcrete	sq.m	$43.00	2,000.0	$86,000
Rockbolts	L.m	$67.00	1,600.0	$107,200
Steel Ribs	kg	$6.00	19,100.0	$114,600
Tunnel Concrete Lining	sq.m	$172.00	1,374	$236,328
Formwork (tunnel)	sq.m	$46.20	972	$44,906
Steel Reinforcement (tunnel)	Ton	$1,360	68.7	$93,432
Structural Concrete (penstock)	cu.m	$140.00	288	$40,320
Formwork (penstock)	sq.m	$46.20	456	$21,067
Steel Reinforcement (penstock)	Ton	$220	14.4	$3,168
Steel Penstock	cu.m	$3,200	126.8	$405,760
Miscellaneous	%	5%		$96,446
Subtotal				$2,025,361
TAILRACE				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	13,518	$43,258
Rock Excavation	cu.m	$8.75	1,001	$8,759
Subtotal				$52,016

COMPARATIVE COST ESTIMATES

15.9-MW Rio Indio Power Plant

	Unit	Unit Cost	Quantity	Amount
POWERHOUSE & TRANSMISSION				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	8,692	$27,814
Rock Excavation	cu.m	$8.75	1,680	$14,700
Mass Concrete	cu.m	$115.00	1,546	$177,790
Structural Concrete	cu.m	$140.00	902	$126,280
Formwork	sq.m	$46.20	5,798	$267,868
Steel Reinforcement	Ton	$1,360	74.7	$101,592
Roof, siding, windows, doors, etc	sq.m	$300	396	$118,800
Miscellaneous	%	5%		$41,742
Subtotal				$876,586
Equipment				
Power Generating				
Main Inlet Valves (1.00 m dia)	Each	$115,000	1	$115,000
Turbine/Generator Units (2.5 MW)	Each	$1,035,000	1	$1,035,000
2.5-MW Unit Auxiliaries	Each	$103,500	1	$103,500
Draft Tube Gates (2.5 MW)	Each	$75,000	1	$75,000
Main Inlet Valve (1.80 m dia)	Each	$310,000	2	$620,000
Turbine/Generator Unit (6.7 MW)	Each	$1,560,000	2	$3,120,000
6.7-MW Unit Auxiliaries	Each	$156,000	2	$312,000
Draft Tube Gates (6.7 MW)	Each	$90,000	4	$360,000
Tunnel Release				
Main Inlet Valves (0.40 m dia)	Each	$62,500	1	$62,500
Axial Flow Control Valves (0.40 m dia)	Each	$62,500	1	$62,500
Miscellaneous Mechanical				
Dewatering System	LS	$187,500	1	$187,500
Bridge Crane	LS	$250,000	1	$250,000
Miscellaneous Electrical				
Switchgear - 13.8 kV	LS	$525,000	1	$525,000
Station Service Transformer	Each	$75,000	1	$75,000
Stand-by Diesel Generator	Each	$143,750	1	$143,750
Station Auxiliaries (light, HVAC, etc.)	LS	$187,500	1	$187,500
Control and Communication Equip	LS	$150,000	1	$150,000
Cabling, MV & LV Power, Cont/Comm	LS	$800,000	1	$800,000
Subtotal				$8,184,250
Transmission System				
115-kV Substation				
Main Transformer	MVA	$29,900	20	$598,000
Breakers, Disconnects, etc.	LS	$186,000	1	$186,000
Control Panels and other Equipment	LS	$414,000	1	$414,000
Steel Structures and Civil Works	LS	$245,000	1	$245,000
La Chorrera Substation				
Breakers, Disconnects, etc.	LS	$400,000	1	$400,000
Control Panels and other Equipment	LS	$465,000	1	$465,000
Steel Structures and Civil Works	LS	$290,000	1	$290,000
115-kV Transmission Line				
Civil Works (survey, Found., Struc.)	km	$31,550	58.7	$1,851,985
Conductors and Shield Wire	km	$10,620	58.7	$623,394
Insulators and Accessories	km	$5,900	58.7	$346,330
Grounding and Miscellaneous	%	2.50%		$70,543
Subtotal				$5,490,252
			TOTAL	$14,551,088

COMPARATIVE COST ESTIMATES

18.4-MW Rio Indio Power Plant

	Unit	Unit Cost	Quantity	Amount
POWER INTAKE				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	11,775	$37,680
Rock Excavation	cu.m	$8.75	4,200	$36,750
Portal Excavation	cu.m	$14.70	693	$10,187
Shaft Excavation	cu.m	$295.00	748	$220,660
Structural Concrete	cu.m	$140.00	898	$125,720
Shaft Concrete Lining	cu.m	$180.00	182	$32,760
Formwork	sq.m	$46.20	1,753	$80,989
Steel Reinforcement	Ton	$1,360	60.6	$82,416
Steel Liner	Ton	$3,200	4.5	$14,400
Rock Anchors	L.m	$67	1,270	$85,090
Miscellaneous Metal Works	%	5%		$36,333
Subtotal				$762,984
Equipment				
Wheeled Intake Gate (3.30 x 2.50) and Hoist	Each	$360,000	1	$360,000
Trash Screen Bays	Each	$62,500	6	$375,000
Trash Rake	Each	$90,000	1	$90,000
Power and Control Equipment	LS	$45,000	1	$45,000
Cabling, MV & LV Power, Cont/Comm	LS	$45,000	1	$45,000
Subtotal				$915,000
POWER TUNNEL & PENSTOCK				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	5,754	$18,413
Rock Excavation	cu.m	$8.75	746	$6,528
Portal Excavation	cu.m	$14.70	435	$6,395
Tunnel Excavation	cu.m	$220.00	3,803	$836,660
Shotcrete	sq.m	$43.00	1,500.0	$64,500
Rockbolts	L.m	$67.00	1,600.0	$107,200
Steel Ribs	kg	$6.00	14,500.0	$87,000
Tunnel Concrete Lining	sq.m	$172.00	1,522	$261,784
Formwork (tunnel)	sq.m	$46.20	1,035	$47,817
Steel Reinforcement (tunnel)	Ton	$1,360	76.1	$103,496
Structural Concrete (penstock)	cu.m	$140.00	312	$43,680
Formwork (penstock)	sq.m	$46.20	480	$22,176
Steel Reinforcement (penstock)	Ton	$220	15.6	$3,432
Steel Penstock	cu.m	$3,200	142.3	$455,360
Miscellaneous	%	5%		$103,222
Subtotal				$2,167,662
TAILRACE				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	14,015	$44,848
Rock Excavation	cu.m	$8.75	1,078	$9,433
Subtotal				$54,281

COMPARATIVE COST ESTIMATES

18.4-MW Rio Indio Power Plant

	Unit	Unit Cost	Quantity	Amount
POWERHOUSE & TRANSMISSION				
Civil Work				
Site Preparation	sq.m	$0.50	0	$0
Overburden Excavation	cu.m	$3.20	9,805	$31,376
Rock Excavation	cu.m	$8.75	2,030	$17,763
Mass Concrete	cu.m	$115.00	1,827	$210,105
Structural Concrete	cu.m	$140.00	1,063	$148,820
Formwork	sq.m	$46.20	6,834	$315,731
Steel Reinforcement	Ton	$1,360	88.1	$119,816
Roof, siding, windows, doors, etc	sq.m	$300	480	$144,000
Miscellaneous	%	5%		$49,381
Subtotal				$1,036,991
Equipment				
Power Generating				
Main Inlet Valves (1.00 m dia)	Each	$115,000	1	$115,000
Turbine/Generator Units (2.5 MW)	Each	$1,035,000	1	$1,035,000
2.5-MW Unit Auxiliaries	Each	$103,500	1	$103,500
Draft Tube Gates (2.5 MW)	Each	$75,000	1	$75,000
Main Inlet Valve (1.60 m dia)	Each	$241,500	3	$724,500
Turbine/Generator Unit (5.3 MW)	Each	$1,410,000	3	$4,230,000
5.3-MW Unit Auxiliaries	Each	$141,000	3	$423,000
Draft Tube Gates (5.3 MW)	Each	$75,000	6	$450,000
Tunnel Release				
Main Inlet Valves (0.40 m dia)	Each	$62,500	1	$62,500
Axial Flow Control Valves (0.40 m dia)	Each	$62,500	1	$62,500
Miscellaneous Mechanical				
Dewatering System	LS	$187,500	1	$187,500
Bridge Crane	LS	$250,000	1	$250,000
Miscellaneous Electrical				
Switchgear - 13.8 kV	LS	$525,000	1	$525,000
Station Service Transformer	Each	$81,500	1	$81,500
Stand-by Diesel Generator	Each	$143,750	1	$143,750
Station Auxiliaries (light, HVAC, etc.)	LS	$187,500	1	$187,500
Control and Communication Equip	LS	$168,000	1	$168,000
Cabling, MV & LV Power, Cont/Comm	LS	$825,000	1	$825,000
Subtotal				$9,649,250
Transmission System				
115-kV Substation				
Main Transformer	MVA	$29,900	20	$598,000
Breakers, Disconnects, etc.	LS	$186,000	1	$186,000
Control Panels and other Equipment	LS	$414,000	1	$414,000
Steel Structures and Civil Works	LS	$245,000	1	$245,000
La Chorrera Substation				
Breakers, Disconnects, etc.	LS	$400,000	1	$400,000
Control Panels and other Equipment	LS	$465,000	1	$465,000
Steel Structures and Civil Works	LS	$290,000	1	$290,000
115-kV Transmission Line				
Civil Works (survey, Found., Struc.)	km	$31,550	58.7	$1,851,985
Conductors and Shield Wire	km	$10,620	58.7	$623,394
Insulators and Accessories	km	$5,900	58.7	$346,330
Grounding and Miscellaneous	%	2.50%		$70,543
Subtotal				$5,490,252
			TOTAL	$16,176,493

ATTACHMENT 5

ECONOMIC ANALYSIS

ECONOMIC ANALYSIS

Isla Pablon Power Plant
Strategy No.1

	Construction Cost	O&M Annual Cost	Average Annual Energy (GWh)	Internal Rate of Return
8.4-MW Isla Pablon Power Plant	$25,110,000	$212,000	35.4	6.6%
11.2-MW Isla Pablon Power Plant	$26,597,000	$227,000	41.1	8.9%
14.0-MW Isla Pablon Power Plant	$28,070,000	$242,000	43.0	9.5%
16.8-MW Isla Pablon Power Plant	$29,539,000	$257,000	43.3	9.4%
19.6-MW Isla Pablon Power Plant	$30,695,000	$268,000	43.4	9.3%

ECONOMIC ANALYSIS

8.4-MW Isla Pablon Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,766,500				-$3,766,500
2009	$6,277,500				-$6,277,500
2010	$15,066,000				-$15,066,000
2011		$212,000	$2,029,500	$504,000	$2,321,500
2012		$212,000	$2,029,500	$504,000	$2,321,500
2013		$212,000	$2,029,500	$504,000	$2,321,500
2014		$212,000	$2,029,500	$504,000	$2,321,500
2015		$212,000	$2,029,500	$504,000	$2,321,500
2016		$212,000	$2,029,500	$504,000	$2,321,500
2017		$212,000	$2,029,500	$504,000	$2,321,500
2018		$212,000	$2,016,000	$504,000	$2,308,000
2019		$212,000	$1,989,000	$339,000	$2,116,000
2020		$212,000	$1,966,500	$339,000	$2,093,500
2021		$212,000	$1,930,500	$339,000	$2,057,500
2022		$212,000	$1,899,000	$339,000	$2,026,000
2023		$212,000	$1,836,000	$265,000	$1,889,000
2024		$212,000	$1,759,500	$265,000	$1,812,500
2025		$212,000	$1,651,500	$265,000	$1,704,500
2026		$212,000	$1,557,000	$0	$1,345,000
2027		$212,000	$1,485,000	$0	$1,273,000
2028		$212,000	$1,449,000	$0	$1,237,000
2029		$212,000	$1,435,500	$0	$1,223,500
2030		$212,000	$1,435,500	$0	$1,223,500
2031		$212,000	$1,435,500	$0	$1,223,500
2032		$212,000	$1,435,500	$0	$1,223,500
2033		$212,000	$1,435,500	$0	$1,223,500
2034		$212,000	$1,435,500	$0	$1,223,500
2035		$212,000	$1,435,500	$0	$1,223,500
2036		$212,000	$1,435,500	$0	$1,223,500
2037		$212,000	$1,435,500	$0	$1,223,500
2038		$212,000	$1,435,500	$0	$1,223,500
2039		$212,000	$1,435,500	$0	$1,223,500
2040	$5,499,200	$212,000	$1,435,500	$0	-$4,275,700
2041		$212,000	$1,435,500	$0	$1,223,500
2042		$212,000	$1,435,500	$0	$1,223,500
2043		$212,000	$1,435,500	$0	$1,223,500
2044		$212,000	$1,435,500	$0	$1,223,500
2045		$212,000	$1,435,500	$0	$1,223,500
2046		$212,000	$1,435,500	$0	$1,223,500
2047		$212,000	$1,435,500	$0	$1,223,500
2048		$212,000	$1,435,500	$0	$1,223,500
2049		$212,000	$1,435,500	$0	$1,223,500
2050		$212,000	$1,435,500	$0	$1,223,500
2051		$212,000	$1,435,500	$0	$1,223,500
2052		$212,000	$1,435,500	$0	$1,223,500
2053		$212,000	$1,435,500	$0	$1,223,500
2054		$212,000	$1,435,500	$0	$1,223,500
2055		$212,000	$1,435,500	$0	$1,223,500
2056		$212,000	$1,435,500	$0	$1,223,500
2057		$212,000	$1,435,500	$0	$1,223,500
2058		$212,000	$1,435,500	$0	$1,223,500
2059		$212,000	$1,435,500	$0	$1,223,500
2060		$212,000	$1,435,500	$0	$1,223,500

Cost Summary

Civil Work Cost	$6,607,000
Equipment Cost	$7,856,000
Transmission System	$4,560,000
Subtotal	**$19,023,000**
Contingencies (20%)	$3,804,600
Engineering & Administration (10%)	$2,282,760
Project Development Cost	**$25,110,000**
Annual Operation & Maintenance Costs	
Civil Work Maintenance	$39,642
Equipment Maintenance	$117,840
Transmission Maintenance	$54,720
Total O&M	**$212,000**
Internal Rate of Return	**6.6%**

ECONOMIC ANALYSIS

11.2-MW Isla Pablon Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,989,550				-$3,989,550
2009	$6,649,250				-$6,649,250
2010	$15,958,200				-$15,958,200
2011		$227,000	$2,700,000	$672,000	$3,145,000
2012		$227,000	$2,700,000	$672,000	$3,145,000
2013		$227,000	$2,700,000	$672,000	$3,145,000
2014		$227,000	$2,700,000	$672,000	$3,145,000
2015		$227,000	$2,700,000	$672,000	$3,145,000
2016		$227,000	$2,700,000	$672,000	$3,145,000
2017		$227,000	$2,682,000	$672,000	$3,127,000
2018		$227,000	$2,664,000	$672,000	$3,109,000
2019		$227,000	$2,641,500	$452,000	$2,866,500
2020		$227,000	$2,610,000	$452,000	$2,835,000
2021		$227,000	$2,569,500	$452,000	$2,794,500
2022		$227,000	$2,529,000	$452,000	$2,754,000
2023		$227,000	$2,448,000	$353,000	$2,574,000
2024		$227,000	$2,331,000	$353,000	$2,457,000
2025		$227,000	$2,160,000	$353,000	$2,286,000
2026		$227,000	$1,944,000	$0	$1,717,000
2027		$227,000	$1,764,000	$0	$1,537,000
2028		$227,000	$1,611,000	$0	$1,384,000
2029		$227,000	$1,507,500	$0	$1,280,500
2030		$227,000	$1,507,500	$0	$1,280,500
2031		$227,000	$1,507,500	$0	$1,280,500
2032		$227,000	$1,507,500	$0	$1,280,500
2033		$227,000	$1,507,500	$0	$1,280,500
2034		$227,000	$1,507,500	$0	$1,280,500
2035		$227,000	$1,507,500	$0	$1,280,500
2036		$227,000	$1,507,500	$0	$1,280,500
2037		$227,000	$1,507,500	$0	$1,280,500
2038		$227,000	$1,507,500	$0	$1,280,500
2039		$227,000	$1,507,500	$0	$1,280,500
2040	$6,118,700	$227,000	$1,507,500	$0	-$4,838,200
2041		$227,000	$1,507,500	$0	$1,280,500
2042		$227,000	$1,507,500	$0	$1,280,500
2043		$227,000	$1,507,500	$0	$1,280,500
2044		$227,000	$1,507,500	$0	$1,280,500
2045		$227,000	$1,507,500	$0	$1,280,500
2046		$227,000	$1,507,500	$0	$1,280,500
2047		$227,000	$1,507,500	$0	$1,280,500
2048		$227,000	$1,507,500	$0	$1,280,500
2049		$227,000	$1,507,500	$0	$1,280,500
2050		$227,000	$1,507,500	$0	$1,280,500
2051		$227,000	$1,507,500	$0	$1,280,500
2052		$227,000	$1,507,500	$0	$1,280,500
2053		$227,000	$1,507,500	$0	$1,280,500
2054		$227,000	$1,507,500	$0	$1,280,500
2055		$227,000	$1,507,500	$0	$1,280,500
2056		$227,000	$1,507,500	$0	$1,280,500
2057		$227,000	$1,507,500	$0	$1,280,500
2058		$227,000	$1,507,500	$0	$1,280,500
2059		$227,000	$1,507,500	$0	$1,280,500
2060		$227,000	$1,507,500	$0	$1,280,500

Cost Summary

Civil Work Cost	$6,789,000
Equipment Cost	$8,741,000
Transmission System	$4,619,000
Subtotal	**$20,149,000**
Contingencies (20%)	$4,029,800
Engineering & Administration (10%)	$2,417,880
Project Development Cost	**$26,597,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$40,734
Equipment Maintenance	$131,115
Transmission Maintenance	$55,428
Total O&M	**$227,000**

Internal Rate of Return **8.9%**

ECONOMIC ANALYSIS

14.0-MW Isla Pablon Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$4,210,500				-$4,210,500
2009	$7,017,500				-$7,017,500
2010	$16,842,000				-$16,842,000
2011		$242,000	$2,970,000	$840,000	$3,568,000
2012		$242,000	$2,970,000	$840,000	$3,568,000
2013		$242,000	$2,970,000	$840,000	$3,568,000
2014		$242,000	$2,970,000	$840,000	$3,568,000
2015		$242,000	$2,970,000	$840,000	$3,568,000
2016		$242,000	$2,970,000	$840,000	$3,568,000
2017		$242,000	$2,961,000	$840,000	$3,559,000
2018		$242,000	$2,943,000	$840,000	$3,541,000
2019		$242,000	$2,902,500	$565,000	$3,225,500
2020		$242,000	$2,857,500	$565,000	$3,180,500
2021		$242,000	$2,790,000	$565,000	$3,113,000
2022		$242,000	$2,731,500	$565,000	$3,054,500
2023		$242,000	$2,646,000	$442,000	$2,846,000
2024		$242,000	$2,551,500	$442,000	$2,751,500
2025		$242,000	$2,353,500	$442,000	$2,553,500
2026		$242,000	$2,146,500	$0	$1,904,500
2027		$242,000	$1,899,000	$0	$1,657,000
2028		$242,000	$1,683,000	$0	$1,441,000
2029		$242,000	$1,516,500	$0	$1,274,500
2030		$242,000	$1,516,500	$0	$1,274,500
2031		$242,000	$1,516,500	$0	$1,274,500
2032		$242,000	$1,516,500	$0	$1,274,500
2033		$242,000	$1,516,500	$0	$1,274,500
2034		$242,000	$1,516,500	$0	$1,274,500
2035		$242,000	$1,516,500	$0	$1,274,500
2036		$242,000	$1,516,500	$0	$1,274,500
2037		$242,000	$1,516,500	$0	$1,274,500
2038		$242,000	$1,516,500	$0	$1,274,500
2039		$242,000	$1,516,500	$0	$1,274,500
2040	$6,692,000	$242,000	$1,516,500	$0	-$5,417,500
2041		$242,000	$1,516,500	$0	$1,274,500
2042		$242,000	$1,516,500	$0	$1,274,500
2043		$242,000	$1,516,500	$0	$1,274,500
2044		$242,000	$1,516,500	$0	$1,274,500
2045		$242,000	$1,516,500	$0	$1,274,500
2046		$242,000	$1,516,500	$0	$1,274,500
2047		$242,000	$1,516,500	$0	$1,274,500
2048		$242,000	$1,516,500	$0	$1,274,500
2049		$242,000	$1,516,500	$0	$1,274,500
2050		$242,000	$1,516,500	$0	$1,274,500
2051		$242,000	$1,516,500	$0	$1,274,500
2052		$242,000	$1,516,500	$0	$1,274,500
2053		$242,000	$1,516,500	$0	$1,274,500
2054		$242,000	$1,516,500	$0	$1,274,500
2055		$242,000	$1,516,500	$0	$1,274,500
2056		$242,000	$1,516,500	$0	$1,274,500
2057		$242,000	$1,516,500	$0	$1,274,500
2058		$242,000	$1,516,500	$0	$1,274,500
2059		$242,000	$1,516,500	$0	$1,274,500
2060		$242,000	$1,516,500	$0	$1,274,500

Cost Summary

Civil Work Cost	$6,996,000
Equipment Cost	$9,560,000
Transmission System	$4,709,000
Subtotal	**$21,265,000**
Contingencies (20%)	$4,253,000
Engineering & Administration (10%)	$2,551,800
Project Development Cost	**$28,070,000**
Annual Operation & Maintenance Costs	
Civil Work Maintenance	$41,976
Equipment Maintenance	$143,400
Transmission Maintenance	$56,508
Total O&M	**$242,000**

Internal Rate of Return **9.5%**

ECONOMIC ANALYSIS

16.8-MW Isla Pablon Power Plant

Year	Project Cost	Annual Operation O&M	Energy Revenue	Capacity Revenue	Total
2008	$4,430,850				-$4,430,850
2009	$7,384,750				-$7,384,750
2010	$17,723,400				-$17,723,400
2011		$257,000	$2,988,000	$1,008,000	$3,739,000
2012		$257,000	$2,988,000	$1,008,000	$3,739,000
2013		$257,000	$2,988,000	$1,008,000	$3,739,000
2014		$257,000	$2,988,000	$1,008,000	$3,739,000
2015		$257,000	$2,988,000	$1,008,000	$3,739,000
2016		$257,000	$2,988,000	$1,008,000	$3,739,000
2017		$257,000	$2,979,000	$1,008,000	$3,730,000
2018		$257,000	$2,961,000	$1,008,000	$3,712,000
2019		$257,000	$2,916,000	$678,000	$3,337,000
2020		$257,000	$2,871,000	$678,000	$3,292,000
2021		$257,000	$2,799,000	$678,000	$3,220,000
2022		$257,000	$2,740,500	$678,000	$3,161,500
2023		$257,000	$2,655,000	$530,000	$2,928,000
2024		$257,000	$2,560,500	$530,000	$2,833,500
2025		$257,000	$2,362,500	$530,000	$2,635,500
2026		$257,000	$2,155,500	$0	$1,898,500
2027		$257,000	$1,908,000	$0	$1,651,000
2028		$257,000	$1,692,000	$0	$1,435,000
2029		$257,000	$1,525,500	$0	$1,268,500
2030		$257,000	$1,525,500	$0	$1,268,500
2031		$257,000	$1,525,500	$0	$1,268,500
2032		$257,000	$1,525,500	$0	$1,268,500
2033		$257,000	$1,525,500	$0	$1,268,500
2034		$257,000	$1,525,500	$0	$1,268,500
2035		$257,000	$1,525,500	$0	$1,268,500
2036		$257,000	$1,525,500	$0	$1,268,500
2037		$257,000	$1,525,500	$0	$1,268,500
2038		$257,000	$1,525,500	$0	$1,268,500
2039		$257,000	$1,525,500	$0	$1,268,500
2040	$7,258,300	$257,000	$1,525,500	$0	-$5,989,800
2041		$257,000	$1,525,500	$0	$1,268,500
2042		$257,000	$1,525,500	$0	$1,268,500
2043		$257,000	$1,525,500	$0	$1,268,500
2044		$257,000	$1,525,500	$0	$1,268,500
2045		$257,000	$1,525,500	$0	$1,268,500
2046		$257,000	$1,525,500	$0	$1,268,500
2047		$257,000	$1,525,500	$0	$1,268,500
2048		$257,000	$1,525,500	$0	$1,268,500
2049		$257,000	$1,525,500	$0	$1,268,500
2050		$257,000	$1,525,500	$0	$1,268,500
2051		$257,000	$1,525,500	$0	$1,268,500
2052		$257,000	$1,525,500	$0	$1,268,500
2053		$257,000	$1,525,500	$0	$1,268,500
2054		$257,000	$1,525,500	$0	$1,268,500
2055		$257,000	$1,525,500	$0	$1,268,500
2056		$257,000	$1,525,500	$0	$1,268,500
2057		$257,000	$1,525,500	$0	$1,268,500
2058		$257,000	$1,525,500	$0	$1,268,500
2059		$257,000	$1,525,500	$0	$1,268,500
2060		$257,000	$1,525,500	$0	$1,268,500

Cost Summary

Civil Work Cost	$7,150,000
Equipment Cost	$10,369,000
Transmission System	$4,859,000
Subtotal	**$22,378,000**
Contingencies (20%)	$4,475,600
Engineering & Administration (10%)	$2,685,360
Project Development Cost	**$29,539,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$42,900
Equipment Maintenance	$155,535
Transmission Maintenance	$58,308
Total O&M	**$257,000**

Internal Rate of Return	**9.4%**

ECONOMIC ANALYSIS

19.6-MW Isla Pablon Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$4,604,250				-$4,604,250
2009	$7,673,750				-$7,673,750
2010	$18,417,000				-$18,417,000
2011		$268,000	$2,997,000	$1,158,000	$3,887,000
2012		$268,000	$2,997,000	$1,158,000	$3,887,000
2013		$268,000	$2,997,000	$1,158,000	$3,887,000
2014		$268,000	$2,997,000	$1,158,000	$3,887,000
2015		$268,000	$2,997,000	$1,158,000	$3,887,000
2016		$268,000	$2,997,000	$1,158,000	$3,887,000
2017		$268,000	$2,988,000	$1,158,000	$3,878,000
2018		$268,000	$2,970,000	$1,158,000	$3,860,000
2019		$268,000	$2,920,500	$791,000	$3,443,500
2020		$268,000	$2,875,500	$791,000	$3,398,500
2021		$268,000	$2,803,500	$791,000	$3,326,500
2022		$268,000	$2,745,000	$791,000	$3,268,000
2023		$268,000	$2,659,500	$618,000	$3,009,500
2024		$268,000	$2,565,000	$618,000	$2,915,000
2025		$268,000	$2,367,000	$618,000	$2,717,000
2026		$268,000	$2,160,000	$0	$1,892,000
2027		$268,000	$1,912,500	$0	$1,644,500
2028		$268,000	$1,696,500	$0	$1,428,500
2029		$268,000	$1,530,000	$0	$1,262,000
2030		$268,000	$1,530,000	$0	$1,262,000
2031		$268,000	$1,530,000	$0	$1,262,000
2032		$268,000	$1,530,000	$0	$1,262,000
2033		$268,000	$1,530,000	$0	$1,262,000
2034		$268,000	$1,530,000	$0	$1,262,000
2035		$268,000	$1,530,000	$0	$1,262,000
2036		$268,000	$1,530,000	$0	$1,262,000
2037		$268,000	$1,530,000	$0	$1,262,000
2038		$268,000	$1,530,000	$0	$1,262,000
2039		$268,000	$1,530,000	$0	$1,262,000
2040	$7,645,400	$268,000	$1,530,000	$0	-$6,383,400
2041		$268,000	$1,530,000	$0	$1,262,000
2042		$268,000	$1,530,000	$0	$1,262,000
2043		$268,000	$1,530,000	$0	$1,262,000
2044		$268,000	$1,530,000	$0	$1,262,000
2045		$268,000	$1,530,000	$0	$1,262,000
2046		$268,000	$1,530,000	$0	$1,262,000
2047		$268,000	$1,530,000	$0	$1,262,000
2048		$268,000	$1,530,000	$0	$1,262,000
2049		$268,000	$1,530,000	$0	$1,262,000
2050		$268,000	$1,530,000	$0	$1,262,000
2051		$268,000	$1,530,000	$0	$1,262,000
2052		$268,000	$1,530,000	$0	$1,262,000
2053		$268,000	$1,530,000	$0	$1,262,000
2054		$268,000	$1,530,000	$0	$1,262,000
2055		$268,000	$1,530,000	$0	$1,262,000
2056		$268,000	$1,530,000	$0	$1,262,000
2057		$268,000	$1,530,000	$0	$1,262,000
2058		$268,000	$1,530,000	$0	$1,262,000
2059		$268,000	$1,530,000	$0	$1,262,000
2060		$268,000	$1,530,000	$0	$1,262,000

Cost Summary

Civil Work Cost	$7,324,000
Equipment Cost	$10,922,000
Transmission System	$5,008,000
Subtotal	**$23,254,000**
Contingencies (20%)	$4,650,800
Engineering & Administration (10%)	$2,790,480
Project Development Cost	**$30,695,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$43,944
Equipment Maintenance	$163,830
Transmission Maintenance	$60,096
Total O&M	**$268,000**

Internal Rate of Return	**9.3%**

ECONOMIC ANALYSIS

Isla Pablon Power Plant
Strategy No.1

	Construction Cost	O&M Annual Cost	Average Annual Energy (MWh)	Internal Rate of Return
8.4-MW Isla Pablon Power Plant	$20,522,000	$170,000	35,414	9.0%
11.2-MW Isla Pablon Power Plant	$22,009,000	$186,000	41,064	11.5%
14.0-MW Isla Pablon Power Plant	$23,482,000	$200,000	43,028	12.2%
16.8-MW Isla Pablon Power Plant	$24,951,000	$215,000	43,264	11.9%
19.6-MW Isla Pablon Power Plant	$26,108,000	$226,000	43,380	11.7%

Note:
Excluding costs of Transmission Line to La Chorrera and work at the La Chorrera Substation

ECONOMIC ANALYSIS

8.4-MW Isla Pablon Power Plant

Excluding costs of Transmission Line to La Chorrera and work at the La Chorrera Substation

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,078,300				-$3,078,300
2009	$5,130,500				-$5,130,500
2010	$12,313,200				-$12,313,200
2011		$170,000	$2,029,500	$504,000	$2,363,500
2012		$170,000	$2,029,500	$504,000	$2,363,500
2013		$170,000	$2,029,500	$504,000	$2,363,500
2014		$170,000	$2,029,500	$504,000	$2,363,500
2015		$170,000	$2,029,500	$504,000	$2,363,500
2016		$170,000	$2,029,500	$504,000	$2,363,500
2017		$170,000	$2,029,500	$504,000	$2,363,500
2018		$170,000	$2,016,000	$504,000	$2,350,000
2019		$170,000	$1,989,000	$339,000	$2,158,000
2020		$170,000	$1,966,500	$339,000	$2,135,500
2021		$170,000	$1,930,500	$339,000	$2,099,500
2022		$170,000	$1,899,000	$339,000	$2,068,000
2023		$170,000	$1,836,000	$265,000	$1,931,000
2024		$170,000	$1,759,500	$265,000	$1,854,500
2025		$170,000	$1,651,500	$265,000	$1,746,500
2026		$170,000	$1,557,000	$0	$1,387,000
2027		$170,000	$1,485,000	$0	$1,315,000
2028		$170,000	$1,449,000	$0	$1,279,000
2029		$170,000	$1,435,500	$0	$1,265,500
2030		$170,000	$1,435,500	$0	$1,265,500
2031		$170,000	$1,435,500	$0	$1,265,500
2032		$170,000	$1,435,500	$0	$1,265,500
2033		$170,000	$1,435,500	$0	$1,265,500
2034		$170,000	$1,435,500	$0	$1,265,500
2035		$170,000	$1,435,500	$0	$1,265,500
2036		$170,000	$1,435,500	$0	$1,265,500
2037		$170,000	$1,435,500	$0	$1,265,500
2038		$170,000	$1,435,500	$0	$1,265,500
2039		$170,000	$1,435,500	$0	$1,265,500
2040	$5,499,200	$170,000	$1,435,500	$0	-$4,233,700
2041		$170,000	$1,435,500	$0	$1,265,500
2042		$170,000	$1,435,500	$0	$1,265,500
2043		$170,000	$1,435,500	$0	$1,265,500
2044		$170,000	$1,435,500	$0	$1,265,500
2045		$170,000	$1,435,500	$0	$1,265,500
2046		$170,000	$1,435,500	$0	$1,265,500
2047		$170,000	$1,435,500	$0	$1,265,500
2048		$170,000	$1,435,500	$0	$1,265,500
2049		$170,000	$1,435,500	$0	$1,265,500
2050		$170,000	$1,435,500	$0	$1,265,500
2051		$170,000	$1,435,500	$0	$1,265,500
2052		$170,000	$1,435,500	$0	$1,265,500
2053		$170,000	$1,435,500	$0	$1,265,500
2054		$170,000	$1,435,500	$0	$1,265,500
2055		$170,000	$1,435,500	$0	$1,265,500
2056		$170,000	$1,435,500	$0	$1,265,500
2057		$170,000	$1,435,500	$0	$1,265,500
2058		$170,000	$1,435,500	$0	$1,265,500
2059		$170,000	$1,435,500	$0	$1,265,500
2060		$170,000	$1,435,500	$0	$1,265,500

Cost Summary

Civil Work Cost	$6,607,000
Equipment Cost	$7,856,000
Transmission System	$1,084,000
Subtotal	**$15,547,000**
Contingencies (20%)	$3,109,400
Engineering & Administration (10%)	$1,865,640
Project Development Cost	**$20,522,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$39,642
Equipment Maintenance	$117,840
Transmission Maintenance	$13,008
Total O&M	**$170,000**

Internal Rate of Return	**9.0%**

ECONOMIC ANALYSIS

11.2-MW Isla Pablon Power Plant

Excluding costs of Transmission Line to La Chorrera and work at the La Chorrera Substation

Year	Project Cost	Annual Operation O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,301,350				-$3,301,350
2009	$5,502,250				-$5,502,250
2010	$13,205,400				-$13,205,400
2011		$186,000	$2,700,000	$672,000	$3,186,000
2012		$186,000	$2,700,000	$672,000	$3,186,000
2013		$186,000	$2,700,000	$672,000	$3,186,000
2014		$186,000	$2,700,000	$672,000	$3,186,000
2015		$186,000	$2,700,000	$672,000	$3,186,000
2016		$186,000	$2,700,000	$672,000	$3,186,000
2017		$186,000	$2,682,000	$672,000	$3,168,000
2018		$186,000	$2,664,000	$672,000	$3,150,000
2019		$186,000	$2,641,500	$452,000	$2,907,500
2020		$186,000	$2,610,000	$452,000	$2,876,000
2021		$186,000	$2,569,500	$452,000	$2,835,500
2022		$186,000	$2,529,000	$452,000	$2,795,000
2023		$186,000	$2,448,000	$353,000	$2,615,000
2024		$186,000	$2,331,000	$353,000	$2,498,000
2025		$186,000	$2,160,000	$353,000	$2,327,000
2026		$186,000	$1,944,000	$0	$1,758,000
2027		$186,000	$1,764,000	$0	$1,578,000
2028		$186,000	$1,611,000	$0	$1,425,000
2029		$186,000	$1,507,500	$0	$1,321,500
2030		$186,000	$1,507,500	$0	$1,321,500
2031		$186,000	$1,507,500	$0	$1,321,500
2032		$186,000	$1,507,500	$0	$1,321,500
2033		$186,000	$1,507,500	$0	$1,321,500
2034		$186,000	$1,507,500	$0	$1,321,500
2035		$186,000	$1,507,500	$0	$1,321,500
2036		$186,000	$1,507,500	$0	$1,321,500
2037		$186,000	$1,507,500	$0	$1,321,500
2038		$186,000	$1,507,500	$0	$1,321,500
2039		$186,000	$1,507,500	$0	$1,321,500
2040	$6,118,700	$186,000	$1,507,500	$0	-$4,797,200
2041		$186,000	$1,507,500	$0	$1,321,500
2042		$186,000	$1,507,500	$0	$1,321,500
2043		$186,000	$1,507,500	$0	$1,321,500
2044		$186,000	$1,507,500	$0	$1,321,500
2045		$186,000	$1,507,500	$0	$1,321,500
2046		$186,000	$1,507,500	$0	$1,321,500
2047		$186,000	$1,507,500	$0	$1,321,500
2048		$186,000	$1,507,500	$0	$1,321,500
2049		$186,000	$1,507,500	$0	$1,321,500
2050		$186,000	$1,507,500	$0	$1,321,500
2051		$186,000	$1,507,500	$0	$1,321,500
2052		$186,000	$1,507,500	$0	$1,321,500
2053		$186,000	$1,507,500	$0	$1,321,500
2054		$186,000	$1,507,500	$0	$1,321,500
2055		$186,000	$1,507,500	$0	$1,321,500
2056		$186,000	$1,507,500	$0	$1,321,500
2057		$186,000	$1,507,500	$0	$1,321,500
2058		$186,000	$1,507,500	$0	$1,321,500
2059		$186,000	$1,507,500	$0	$1,321,500
2060		$186,000	$1,507,500	$0	$1,321,500

Cost Summary

Civil Work Cost	$6,789,000
Equipment Cost	$8,741,000
Transmission System	$1,143,800
Subtotal	**$16,673,800**
Contingencies (20%)	$3,334,760
Engineering & Administration (10%)	$2,000,856
Project Development Cost	**$22,009,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$40,734
Equipment Maintenance	$131,115
Transmission Maintenance	$13,726
Total O&M	**$186,000**

Internal Rate of Return **11.5%**

ECONOMIC ANALYSIS

14.0-MW Isla Pablon Power Plant

Excluding costs of Transmission Line to La Chorrera and work at the La Chorrera Substation

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,522,300				-$3,522,300
2009	$5,870,500				-$5,870,500
2010	$14,089,200				-$14,089,200
2011		$200,000	$2,970,000	$840,000	$3,610,000
2012		$200,000	$2,970,000	$840,000	$3,610,000
2013		$200,000	$2,970,000	$840,000	$3,610,000
2014		$200,000	$2,970,000	$840,000	$3,610,000
2015		$200,000	$2,970,000	$840,000	$3,610,000
2016		$200,000	$2,970,000	$840,000	$3,610,000
2017		$200,000	$2,961,000	$840,000	$3,601,000
2018		$200,000	$2,943,000	$840,000	$3,583,000
2019		$200,000	$2,902,500	$565,000	$3,267,500
2020		$200,000	$2,857,500	$565,000	$3,222,500
2021		$200,000	$2,790,000	$565,000	$3,155,000
2022		$200,000	$2,731,500	$565,000	$3,096,500
2023		$200,000	$2,646,000	$442,000	$2,888,000
2024		$200,000	$2,551,500	$442,000	$2,793,500
2025		$200,000	$2,353,500	$442,000	$2,595,500
2026		$200,000	$2,146,500	$0	$1,946,500
2027		$200,000	$1,899,000	$0	$1,699,000
2028		$200,000	$1,683,000	$0	$1,483,000
2029		$200,000	$1,516,500	$0	$1,316,500
2030		$200,000	$1,516,500	$0	$1,316,500
2031		$200,000	$1,516,500	$0	$1,316,500
2032		$200,000	$1,516,500	$0	$1,316,500
2033		$200,000	$1,516,500	$0	$1,316,500
2034		$200,000	$1,516,500	$0	$1,316,500
2035		$200,000	$1,516,500	$0	$1,316,500
2036		$200,000	$1,516,500	$0	$1,316,500
2037		$200,000	$1,516,500	$0	$1,316,500
2038		$200,000	$1,516,500	$0	$1,316,500
2039		$200,000	$1,516,500	$0	$1,316,500
2040	$6,692,000	$200,000	$1,516,500	$0	-$5,375,500
2041		$200,000	$1,516,500	$0	$1,316,500
2042		$200,000	$1,516,500	$0	$1,316,500
2043		$200,000	$1,516,500	$0	$1,316,500
2044		$200,000	$1,516,500	$0	$1,316,500
2045		$200,000	$1,516,500	$0	$1,316,500
2046		$200,000	$1,516,500	$0	$1,316,500
2047		$200,000	$1,516,500	$0	$1,316,500
2048		$200,000	$1,516,500	$0	$1,316,500
2049		$200,000	$1,516,500	$0	$1,316,500
2050		$200,000	$1,516,500	$0	$1,316,500
2051		$200,000	$1,516,500	$0	$1,316,500
2052		$200,000	$1,516,500	$0	$1,316,500
2053		$200,000	$1,516,500	$0	$1,316,500
2054		$200,000	$1,516,500	$0	$1,316,500
2055		$200,000	$1,516,500	$0	$1,316,500
2056		$200,000	$1,516,500	$0	$1,316,500
2057		$200,000	$1,516,500	$0	$1,316,500
2058		$200,000	$1,516,500	$0	$1,316,500
2059		$200,000	$1,516,500	$0	$1,316,500
2060		$200,000	$1,516,500	$0	$1,316,500

Cost Summary

Civil Work Cost	$6,996,000
Equipment Cost	$9,560,000
Transmission System	$1,233,500
Subtotal	**$17,789,500**
Contingencies (20%)	$3,557,900
Engineering & Administration (10%)	$2,134,740
Project Development Cost	**$23,482,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$41,976
Equipment Maintenance	$143,400
Transmission Maintenance	$14,802
Total O&M	**$200,000**

Internal Rate of Return	**12.2%**

ECONOMIC ANALYSIS

16.8-MW Isla Pablon Power Plant

Excluding costs of Transmission Line to La Chorrera and work at the La Chorrera Substation

Year	Project Cost	Annual Operation O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,742,650				-$3,742,650
2009	$6,237,750				-$6,237,750
2010	$14,970,600				-$14,970,600
2011		$215,000	$2,988,000	$1,008,000	$3,781,000
2012		$215,000	$2,988,000	$1,008,000	$3,781,000
2013		$215,000	$2,988,000	$1,008,000	$3,781,000
2014		$215,000	$2,988,000	$1,008,000	$3,781,000
2015		$215,000	$2,988,000	$1,008,000	$3,781,000
2016		$215,000	$2,988,000	$1,008,000	$3,781,000
2017		$215,000	$2,979,000	$1,008,000	$3,772,000
2018		$215,000	$2,961,000	$1,008,000	$3,754,000
2019		$215,000	$2,916,000	$678,000	$3,379,000
2020		$215,000	$2,871,000	$678,000	$3,334,000
2021		$215,000	$2,799,000	$678,000	$3,262,000
2022		$215,000	$2,740,500	$678,000	$3,203,500
2023		$215,000	$2,655,000	$530,000	$2,970,000
2024		$215,000	$2,560,500	$530,000	$2,875,500
2025		$215,000	$2,362,500	$530,000	$2,677,500
2026		$215,000	$2,155,500	$0	$1,940,500
2027		$215,000	$1,908,000	$0	$1,693,000
2028		$215,000	$1,692,000	$0	$1,477,000
2029		$215,000	$1,525,500	$0	$1,310,500
2030		$215,000	$1,525,500	$0	$1,310,500
2031		$215,000	$1,525,500	$0	$1,310,500
2032		$215,000	$1,525,500	$0	$1,310,500
2033		$215,000	$1,525,500	$0	$1,310,500
2034		$215,000	$1,525,500	$0	$1,310,500
2035		$215,000	$1,525,500	$0	$1,310,500
2036		$215,000	$1,525,500	$0	$1,310,500
2037		$215,000	$1,525,500	$0	$1,310,500
2038		$215,000	$1,525,500	$0	$1,310,500
2039		$215,000	$1,525,500	$0	$1,310,500
2040	$7,258,300	$215,000	$1,525,500	$0	-$5,947,800
2041		$215,000	$1,525,500	$0	$1,310,500
2042		$215,000	$1,525,500	$0	$1,310,500
2043		$215,000	$1,525,500	$0	$1,310,500
2044		$215,000	$1,525,500	$0	$1,310,500
2045		$215,000	$1,525,500	$0	$1,310,500
2046		$215,000	$1,525,500	$0	$1,310,500
2047		$215,000	$1,525,500	$0	$1,310,500
2048		$215,000	$1,525,500	$0	$1,310,500
2049		$215,000	$1,525,500	$0	$1,310,500
2050		$215,000	$1,525,500	$0	$1,310,500
2051		$215,000	$1,525,500	$0	$1,310,500
2052		$215,000	$1,525,500	$0	$1,310,500
2053		$215,000	$1,525,500	$0	$1,310,500
2054		$215,000	$1,525,500	$0	$1,310,500
2055		$215,000	$1,525,500	$0	$1,310,500
2056		$215,000	$1,525,500	$0	$1,310,500
2057		$215,000	$1,525,500	$0	$1,310,500
2058		$215,000	$1,525,500	$0	$1,310,500
2059		$215,000	$1,525,500	$0	$1,310,500
2060		$215,000	$1,525,500	$0	$1,310,500

Cost Summary

Civil Work Cost	$7,150,000
Equipment Cost	$10,369,000
Transmission System	$1,383,000
Subtotal	**$18,902,000**
Contingencies (20%)	$3,780,400
Engineering & Administration (10%)	$2,268,240
Project Development Cost	**$24,951,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$42,900
Equipment Maintenance	$155,535
Transmission Maintenance	$16,596
Total O&M	**$215,000**

Internal Rate of Return **11.9%**

ECONOMIC ANALYSIS

19.6-MW Isla Pablon Power Plant

Excluding costs of Transmission Line to La Chorrera and work at the La Chorrera Substation

		Annual Operation			
Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,916,200				-$3,916,200
2009	$6,527,000				-$6,527,000
2010	$15,664,800				-$15,664,800
2011		$226,000	$2,997,000	$1,158,000	$3,929,000
2012		$226,000	$2,997,000	$1,158,000	$3,929,000
2013		$226,000	$2,997,000	$1,158,000	$3,929,000
2014		$226,000	$2,997,000	$1,158,000	$3,929,000
2015		$226,000	$2,997,000	$1,158,000	$3,929,000
2016		$226,000	$2,997,000	$1,158,000	$3,929,000
2017		$226,000	$2,988,000	$1,158,000	$3,920,000
2018		$226,000	$2,970,000	$1,158,000	$3,902,000
2019		$226,000	$2,920,500	$791,000	$3,485,500
2020		$226,000	$2,875,500	$791,000	$3,440,500
2021		$226,000	$2,803,500	$791,000	$3,368,500
2022		$226,000	$2,745,000	$791,000	$3,310,000
2023		$226,000	$2,659,500	$618,000	$3,051,500
2024		$226,000	$2,565,000	$618,000	$2,957,000
2025		$226,000	$2,367,000	$618,000	$2,759,000
2026		$226,000	$2,160,000	$0	$1,934,000
2027		$226,000	$1,912,500	$0	$1,686,500
2028		$226,000	$1,696,500	$0	$1,470,500
2029		$226,000	$1,530,000	$0	$1,304,000
2030		$226,000	$1,530,000	$0	$1,304,000
2031		$226,000	$1,530,000	$0	$1,304,000
2032		$226,000	$1,530,000	$0	$1,304,000
2033		$226,000	$1,530,000	$0	$1,304,000
2034		$226,000	$1,530,000	$0	$1,304,000
2035		$226,000	$1,530,000	$0	$1,304,000
2036		$226,000	$1,530,000	$0	$1,304,000
2037		$226,000	$1,530,000	$0	$1,304,000
2038		$226,000	$1,530,000	$0	$1,304,000
2039		$226,000	$1,530,000	$0	$1,304,000
2040	$7,645,400	$226,000	$1,530,000	$0	-$6,341,400
2041		$226,000	$1,530,000	$0	$1,304,000
2042		$226,000	$1,530,000	$0	$1,304,000
2043		$226,000	$1,530,000	$0	$1,304,000
2044		$226,000	$1,530,000	$0	$1,304,000
2045		$226,000	$1,530,000	$0	$1,304,000
2046		$226,000	$1,530,000	$0	$1,304,000
2047		$226,000	$1,530,000	$0	$1,304,000
2048		$226,000	$1,530,000	$0	$1,304,000
2049		$226,000	$1,530,000	$0	$1,304,000
2050		$226,000	$1,530,000	$0	$1,304,000
2051		$226,000	$1,530,000	$0	$1,304,000
2052		$226,000	$1,530,000	$0	$1,304,000
2053		$226,000	$1,530,000	$0	$1,304,000
2054		$226,000	$1,530,000	$0	$1,304,000
2055		$226,000	$1,530,000	$0	$1,304,000
2056		$226,000	$1,530,000	$0	$1,304,000
2057		$226,000	$1,530,000	$0	$1,304,000
2058		$226,000	$1,530,000	$0	$1,304,000
2059		$226,000	$1,530,000	$0	$1,304,000
2060		$226,000	$1,530,000	$0	$1,304,000

Cost Summary

Civil Work Cost	$7,324,000
Equipment Cost	$10,922,000
Transmission System	$1,532,500
Subtotal	**$19,778,500**
Contingencies (20%)	$3,955,700
Engineering & Administration (10%)	$2,373,420
Project Development Cost	**$26,108,000**
Annual Operation & Maintenance Costs	
Civil Work Maintenance	$43,944
Equipment Maintenance	$163,830
Transmission Maintenance	$18,390
Total O&M	**$226,000**
Internal Rate of Return	**11.7%**

ECONOMIC ANALYSIS

Isla Pablon Power Plant
Strategy No.3a

	Construction Cost	O&M Annual Cost	Average Annual Energy (MWh)	Internal Rate of Return
8.4-MW Isla Pablon Power Plant	$20,522,000	$170,000	29,790	4.3%
11.2-MW Isla Pablon Power Plant	$22,009,000	$186,000	32,220	4.5%
14.0-MW Isla Pablon Power Plant	$23,482,000	$200,000	32,910	4.3%
16.8-MW Isla Pablon Power Plant	$24,951,000	$215,000	33,038	3.9%
19.6-MW Isla Pablon Power Plant	$26,108,000	$226,000	33,102	3.7%

Note:
Excluding costs of Transmission Line to La Chorrera and work at the La Chorrera Substation

ECONOMIC ANALYSIS

8.4-MW Isla Pablon Power Plant

Excluding costs of Transmission Line to La Chorrera and work at the La Chorrera Substation

Strategy No.3a

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,078,300				-$3,078,300
2009	$5,130,500				-$5,130,500
2010	$12,313,200				-$12,313,200
2011		$170,000	$328,500	$0	$158,500
2012		$170,000	$328,500	$0	$158,500
2013		$170,000	$328,500	$0	$158,500
2014		$170,000	$328,500	$0	$158,500
2015		$170,000	$328,500	$0	$158,500
2016		$170,000	$697,500	$0	$527,500
2017		$170,000	$1,066,500	$264,100	$1,160,600
2018		$170,000	$1,291,500	$264,100	$1,385,600
2019		$170,000	$1,512,000	$264,100	$1,606,100
2020		$170,000	$1,732,500	$264,100	$1,826,600
2021		$170,000	$1,741,500	$264,100	$1,835,600
2022		$170,000	$1,750,500	$264,100	$1,844,600
2023		$170,000	$1,755,000	$264,100	$1,849,100
2024		$170,000	$1,759,500	$264,100	$1,853,600
2025		$170,000	$1,651,500	$0	$1,481,500
2026		$170,000	$1,557,000	$0	$1,387,000
2027		$170,000	$1,485,000	$0	$1,315,000
2028		$170,000	$1,449,000	$0	$1,279,000
2029		$170,000	$1,435,500	$0	$1,265,500
2030		$170,000	$1,435,500	$0	$1,265,500
2031		$170,000	$1,435,500	$0	$1,265,500
2032		$170,000	$1,435,500	$0	$1,265,500
2033		$170,000	$1,435,500	$0	$1,265,500
2034		$170,000	$1,435,500	$0	$1,265,500
2035		$170,000	$1,435,500	$0	$1,265,500
2036		$170,000	$1,435,500	$0	$1,265,500
2037		$170,000	$1,435,500	$0	$1,265,500
2038		$170,000	$1,435,500	$0	$1,265,500
2039		$170,000	$1,435,500	$0	$1,265,500
2040	$5,499,200	$170,000	$1,435,500	$0	-$4,233,700
2041		$170,000	$1,435,500	$0	$1,265,500
2042		$170,000	$1,435,500	$0	$1,265,500
2043		$170,000	$1,435,500	$0	$1,265,500
2044		$170,000	$1,435,500	$0	$1,265,500
2045		$170,000	$1,435,500	$0	$1,265,500
2046		$170,000	$1,435,500	$0	$1,265,500
2047		$170,000	$1,435,500	$0	$1,265,500
2048		$170,000	$1,435,500	$0	$1,265,500
2049		$170,000	$1,435,500	$0	$1,265,500
2050		$170,000	$1,435,500	$0	$1,265,500
2051		$170,000	$1,435,500	$0	$1,265,500
2052		$170,000	$1,435,500	$0	$1,265,500
2053		$170,000	$1,435,500	$0	$1,265,500
2054		$170,000	$1,435,500	$0	$1,265,500
2055		$170,000	$1,435,500	$0	$1,265,500
2056		$170,000	$1,435,500	$0	$1,265,500
2057		$170,000	$1,435,500	$0	$1,265,500
2058		$170,000	$1,435,500	$0	$1,265,500
2059		$170,000	$1,435,500	$0	$1,265,500
2060		$170,000	$1,435,500	$0	$1,265,500

Cost Summary

Civil Work Cost	$6,607,000
Equipment Cost	$7,856,000
Transmission System	$1,084,000
Subtotal	**$15,547,000**
Contingencies (20%)	$3,109,400
Engineering & Administration (10%)	$1,865,640
Project Development Cost	**$20,522,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$39,642
Equipment Maintenance	$117,840
Transmission Maintenance	$13,008
Total O&M	**$170,000**

Internal Rate of Return	**4.3%**

ECONOMIC ANALYSIS

11.2-MW Isla Pablon Power Plant

Excluding costs of Transmission Line to La Chorrera and work at the La Chorrera Substation

Strategy No.3a

Year	Project Cost	Annual Operation O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,301,350				-$3,301,350
2009	$5,502,250				-$5,502,250
2010	$13,205,400				-$13,205,400
2011		$186,000	$342,000	$0	$156,000
2012		$186,000	$342,000	$0	$156,000
2013		$186,000	$342,000	$0	$156,000
2014		$186,000	$342,000	$0	$156,000
2015		$186,000	$342,000	$0	$156,000
2016		$186,000	$706,500	$0	$520,500
2017		$186,000	$1,071,000	$352,200	$1,237,200
2018		$186,000	$1,323,000	$352,200	$1,489,200
2019		$186,000	$1,570,500	$352,200	$1,736,700
2020		$186,000	$1,818,000	$352,200	$1,984,200
2021		$186,000	$1,953,000	$352,200	$2,119,200
2022		$186,000	$2,083,500	$352,200	$2,249,700
2023		$186,000	$2,209,500	$352,200	$2,375,700
2024		$186,000	$2,331,000	$352,200	$2,497,200
2025		$186,000	$2,160,000	$0	$1,974,000
2026		$186,000	$1,944,000	$0	$1,758,000
2027		$186,000	$1,764,000	$0	$1,578,000
2028		$186,000	$1,611,000	$0	$1,425,000
2029		$186,000	$1,507,500	$0	$1,321,500
2030		$186,000	$1,507,500	$0	$1,321,500
2031		$186,000	$1,507,500	$0	$1,321,500
2032		$186,000	$1,507,500	$0	$1,321,500
2033		$186,000	$1,507,500	$0	$1,321,500
2034		$186,000	$1,507,500	$0	$1,321,500
2035		$186,000	$1,507,500	$0	$1,321,500
2036		$186,000	$1,507,500	$0	$1,321,500
2037		$186,000	$1,507,500	$0	$1,321,500
2038		$186,000	$1,507,500	$0	$1,321,500
2039		$186,000	$1,507,500	$0	$1,321,500
2040	$6,118,700	$186,000	$1,507,500	$0	-$4,797,200
2041		$186,000	$1,507,500	$0	$1,321,500
2042		$186,000	$1,507,500	$0	$1,321,500
2043		$186,000	$1,507,500	$0	$1,321,500
2044		$186,000	$1,507,500	$0	$1,321,500
2045		$186,000	$1,507,500	$0	$1,321,500
2046		$186,000	$1,507,500	$0	$1,321,500
2047		$186,000	$1,507,500	$0	$1,321,500
2048		$186,000	$1,507,500	$0	$1,321,500
2049		$186,000	$1,507,500	$0	$1,321,500
2050		$186,000	$1,507,500	$0	$1,321,500
2051		$186,000	$1,507,500	$0	$1,321,500
2052		$186,000	$1,507,500	$0	$1,321,500
2053		$186,000	$1,507,500	$0	$1,321,500
2054		$186,000	$1,507,500	$0	$1,321,500
2055		$186,000	$1,507,500	$0	$1,321,500
2056		$186,000	$1,507,500	$0	$1,321,500
2057		$186,000	$1,507,500	$0	$1,321,500
2058		$186,000	$1,507,500	$0	$1,321,500
2059		$186,000	$1,507,500	$0	$1,321,500
2060		$186,000	$1,507,500	$0	$1,321,500

Cost Summary

Civil Work Cost	$6,789,000
Equipment Cost	$8,741,000
Transmission System	$1,143,800
Subtotal	**$16,673,800**
Contingencies (20%)	$3,334,760
Engineering & Administration (10%)	$2,000,856
Project Development Cost	**$22,009,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$40,734
Equipment Maintenance	$131,115
Transmission Maintenance	$13,726
Total O&M	**$186,000**

Internal Rate of Return **4.5%**

ECONOMIC ANALYSIS

14.0-MW Isla Pablon Power Plant

Excluding costs of Transmission Line to La Chorrera and work at the La Chorrera Substation

Strategy No.3a

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,522,300				-$3,522,300
2009	$5,870,500				-$5,870,500
2010	$14,089,200				-$14,089,200
2011		$200,000	$355,500	$0	$155,500
2012		$200,000	$355,500	$0	$155,500
2013		$200,000	$355,500	$0	$155,500
2014		$200,000	$355,500	$0	$155,500
2015		$200,000	$355,500	$0	$155,500
2016		$200,000	$715,500	$0	$515,500
2017		$200,000	$1,080,000	$370,400	$1,250,400
2018		$200,000	$1,332,000	$370,400	$1,502,400
2019		$200,000	$1,575,000	$440,200	$1,815,200
2020		$200,000	$1,822,500	$440,200	$2,062,700
2021		$200,000	$2,011,500	$440,200	$2,251,700
2022		$200,000	$2,196,000	$440,200	$2,436,200
2023		$200,000	$2,376,000	$440,200	$2,616,200
2024		$200,000	$2,551,500	$440,200	$2,791,700
2025		$200,000	$2,353,500	$0	$2,153,500
2026		$200,000	$2,146,500	$0	$1,946,500
2027		$200,000	$1,899,000	$0	$1,699,000
2028		$200,000	$1,683,000	$0	$1,483,000
2029		$200,000	$1,516,500	$0	$1,316,500
2030		$200,000	$1,516,500	$0	$1,316,500
2031		$200,000	$1,516,500	$0	$1,316,500
2032		$200,000	$1,516,500	$0	$1,316,500
2033		$200,000	$1,516,500	$0	$1,316,500
2034		$200,000	$1,516,500	$0	$1,316,500
2035		$200,000	$1,516,500	$0	$1,316,500
2036		$200,000	$1,516,500	$0	$1,316,500
2037		$200,000	$1,516,500	$0	$1,316,500
2038		$200,000	$1,516,500	$0	$1,316,500
2039		$200,000	$1,516,500	$0	$1,316,500
2040	$6,692,000	$200,000	$1,516,500	$0	-$5,375,500
2041		$200,000	$1,516,500	$0	$1,316,500
2042		$200,000	$1,516,500	$0	$1,316,500
2043		$200,000	$1,516,500	$0	$1,316,500
2044		$200,000	$1,516,500	$0	$1,316,500
2045		$200,000	$1,516,500	$0	$1,316,500
2046		$200,000	$1,516,500	$0	$1,316,500
2047		$200,000	$1,516,500	$0	$1,316,500
2048		$200,000	$1,516,500	$0	$1,316,500
2049		$200,000	$1,516,500	$0	$1,316,500
2050		$200,000	$1,516,500	$0	$1,316,500
2051		$200,000	$1,516,500	$0	$1,316,500
2052		$200,000	$1,516,500	$0	$1,316,500
2053		$200,000	$1,516,500	$0	$1,316,500
2054		$200,000	$1,516,500	$0	$1,316,500
2055		$200,000	$1,516,500	$0	$1,316,500
2056		$200,000	$1,516,500	$0	$1,316,500
2057		$200,000	$1,516,500	$0	$1,316,500
2058		$200,000	$1,516,500	$0	$1,316,500
2059		$200,000	$1,516,500	$0	$1,316,500
2060		$200,000	$1,516,500	$0	$1,316,500

Cost Summary

Civil Work Cost	$6,996,000
Equipment Cost	$9,560,000
Transmission System	$1,233,500
Subtotal	**$17,789,500**
Contingencies (20%)	$3,557,900
Engineering & Administration (10%)	$2,134,740
Project Development Cost	**$23,482,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$41,976
Equipment Maintenance	$143,400
Transmission Maintenance	$14,802
Total O&M	**$200,000**

Internal Rate of Return **4.3%**

ECONOMIC ANALYSIS

16.8-MW Isla Pablon Power Plant

Excluding costs of Transmission Line to La Chorrera and work at the La Chorrera Substation

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,742,650				-$3,742,650
2009	$6,237,750				-$6,237,750
2010	$14,970,600				-$14,970,600
2011		$215,000	$355,500	$0	$140,500
2012		$215,000	$355,500	$0	$140,500
2013		$215,000	$355,500	$0	$140,500
2014		$215,000	$355,500	$0	$140,500
2015		$215,000	$355,500	$0	$140,500
2016		$215,000	$715,500	$0	$500,500
2017		$215,000	$1,080,000	$370,400	$1,235,400
2018		$215,000	$1,332,000	$370,400	$1,487,400
2019		$215,000	$1,575,000	$499,900	$1,859,900
2020		$215,000	$1,822,500	$499,900	$2,107,400
2021		$215,000	$2,011,500	$499,900	$2,296,400
2022		$215,000	$2,196,000	$499,900	$2,480,900
2023		$215,000	$2,376,000	$499,900	$2,660,900
2024		$215,000	$2,551,500	$499,900	$2,836,400
2025		$215,000	$2,353,500	$0	$2,138,500
2026		$215,000	$2,146,500	$0	$1,931,500
2027		$215,000	$1,899,000	$0	$1,684,000
2028		$215,000	$1,683,000	$0	$1,468,000
2029		$215,000	$1,525,500	$0	$1,310,500
2030		$215,000	$1,525,500	$0	$1,310,500
2031		$215,000	$1,525,500	$0	$1,310,500
2032		$215,000	$1,525,500	$0	$1,310,500
2033		$215,000	$1,525,500	$0	$1,310,500
2034		$215,000	$1,525,500	$0	$1,310,500
2035		$215,000	$1,525,500	$0	$1,310,500
2036		$215,000	$1,525,500	$0	$1,310,500
2037		$215,000	$1,525,500	$0	$1,310,500
2038		$215,000	$1,525,500	$0	$1,310,500
2039		$215,000	$1,525,500	$0	$1,310,500
2040	$7,258,300	$215,000	$1,525,500	$0	-$5,947,800
2041		$215,000	$1,525,500	$0	$1,310,500
2042		$215,000	$1,525,500	$0	$1,310,500
2043		$215,000	$1,525,500	$0	$1,310,500
2044		$215,000	$1,525,500	$0	$1,310,500
2045		$215,000	$1,525,500	$0	$1,310,500
2046		$215,000	$1,525,500	$0	$1,310,500
2047		$215,000	$1,525,500	$0	$1,310,500
2048		$215,000	$1,525,500	$0	$1,310,500
2049		$215,000	$1,525,500	$0	$1,310,500
2050		$215,000	$1,525,500	$0	$1,310,500
2051		$215,000	$1,525,500	$0	$1,310,500
2052		$215,000	$1,525,500	$0	$1,310,500
2053		$215,000	$1,525,500	$0	$1,310,500
2054		$215,000	$1,525,500	$0	$1,310,500
2055		$215,000	$1,525,500	$0	$1,310,500
2056		$215,000	$1,525,500	$0	$1,310,500
2057		$215,000	$1,525,500	$0	$1,310,500
2058		$215,000	$1,525,500	$0	$1,310,500
2059		$215,000	$1,525,500	$0	$1,310,500
2060		$215,000	$1,525,500	$0	$1,310,500

Cost Summary

Civil Work Cost	$7,150,000
Equipment Cost	$10,369,000
Transmission System	$1,383,000
Subtotal	**$18,902,000**
Contingencies (20%)	$3,780,400
Engineering & Administration (10%)	$2,268,240
Project Development Cost	**$24,951,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$42,900
Equipment Maintenance	$155,535
Transmission Maintenance	$16,596
Total O&M	**$215,000**

Internal Rate of Return	**3.9%**

ECONOMIC ANALYSIS

19.6-MW Isla Pablon Power Plant

Excluding costs of Transmission Line to La Chorrera and work at the La Chorrera Substation

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,916,200				-$3,916,200
2009	$6,527,000				-$6,527,000
2010	$15,664,800				-$15,664,800
2011		$226,000	$355,500	$0	$129,500
2012		$226,000	$355,500	$0	$129,500
2013		$226,000	$355,500	$0	$129,500
2014		$226,000	$355,500	$0	$129,500
2015		$226,000	$355,500	$0	$129,500
2016		$226,000	$715,500	$0	$489,500
2017		$226,000	$1,080,000	$370,400	$1,224,400
2018		$226,000	$1,332,000	$370,400	$1,476,400
2019		$226,000	$1,575,000	$578,500	$1,927,500
2020		$226,000	$1,822,500	$578,500	$2,175,000
2021		$226,000	$2,011,500	$578,500	$2,364,000
2022		$226,000	$2,196,000	$578,500	$2,548,500
2023		$226,000	$2,376,000	$578,500	$2,728,500
2024		$226,000	$2,551,500	$578,500	$2,904,000
2025		$226,000	$2,353,500	$0	$2,127,500
2026		$226,000	$2,146,500	$0	$1,920,500
2027		$226,000	$1,899,000	$0	$1,673,000
2028		$226,000	$1,683,000	$0	$1,457,000
2029		$226,000	$1,530,000	$0	$1,304,000
2030		$226,000	$1,530,000	$0	$1,304,000
2031		$226,000	$1,530,000	$0	$1,304,000
2032		$226,000	$1,530,000	$0	$1,304,000
2033		$226,000	$1,530,000	$0	$1,304,000
2034		$226,000	$1,530,000	$0	$1,304,000
2035		$226,000	$1,530,000	$0	$1,304,000
2036		$226,000	$1,530,000	$0	$1,304,000
2037		$226,000	$1,530,000	$0	$1,304,000
2038		$226,000	$1,530,000	$0	$1,304,000
2039		$226,000	$1,530,000	$0	$1,304,000
2040	$7,645,400	$226,000	$1,530,000	$0	-$6,341,400
2041		$226,000	$1,530,000	$0	$1,304,000
2042		$226,000	$1,530,000	$0	$1,304,000
2043		$226,000	$1,530,000	$0	$1,304,000
2044		$226,000	$1,530,000	$0	$1,304,000
2045		$226,000	$1,530,000	$0	$1,304,000
2046		$226,000	$1,530,000	$0	$1,304,000
2047		$226,000	$1,530,000	$0	$1,304,000
2048		$226,000	$1,530,000	$0	$1,304,000
2049		$226,000	$1,530,000	$0	$1,304.000
2050		$226,000	$1,530,000	$0	$1,304,000
2051		$226,000	$1,530,000	$0	$1,304,000
2052		$226,000	$1,530,000	$0	$1,304,000
2053		$226,000	$1,530,000	$0	$1,304,000
2054		$226,000	$1,530,000	$0	$1,304,000
2055		$226,000	$1,530,000	$0	$1,304,000
2056		$226,000	$1,530,000	$0	$1,304,000
2057		$226,000	$1,530,000	$0	$1,304,000
2058		$226,000	$1,530,000	$0	$1,304,000
2059		$226,000	$1,530,000	$0	$1,304,000
2060		$226,000	$1,530,000	$0	$1,304,000

Cost Summary

Civil Work Cost	$7,324,000
Equipment Cost	$10,922,000
Transmission System	$1,532,500
Subtotal	**$19,778,500**
Contingencies (20%)	$3,955,700
Engineering & Administration (10%)	$2,373,420
Project Development Cost	**$26,108,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$43,944
Equipment Maintenance	$163,830
Transmission Maintenance	$18,390
Total O&M	**$226,000**

Internal Rate of Return	**3.7%**

ECONOMIC ANALYSIS

Strategy No.3a

Rio Indio is developed without Pablon

	Construction Cost	O&M Annual Cost	Average Annual Energy (GWh)	Internal Rate of Return
6.4-MW Rio Indio Power Plant	$17,394,000	$159,000	15.3	4.4%
11.1-MW Rio Indio Power Plant	$20,929,000	$196,000	19.6	7.0%
15.9-MW Rio Indio Power Plant	$23,961,000	$223,000	22.7	9.0%
18.4-MW Rio Indio Power Plant	$26,501,000	$248,000	23.4	8.0%
Developed in Combination with Isla Pablon				
2.5-MW Rio Indio Power Plant	$6,816,000	$57,000	12.2	11.2%
6.4-MW Rio Indio Power Plant	$12,871,000	$118,000	15.3	8.4%
11.1-MW Rio Indio Power Plant	$16,406,000	$155,000	19.6	11.5%
15.9-MW Rio Indio Power Plant	$19,438,000	$181,000	22.7	13.6%
18.4-MW Rio Indio Power Plant	$21,978,000	$207,000	23.4	12.0%
Strategy No.1				
Developed in Combination with Isla Pablon				
2.5-MW Rio Indio Power Plant	$6,816,000	$57,000	10.4	7.5%
6.4-MW Rio Indio Power Plant	$12,871,000	$118,000	10.6	2.7%

APPENDIX E - ECONOMIC ANALYSIS

2.5-MW Rio Indio Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$1,022,400				-$1,022,400
2009	$1,704,000				-$1,704,000
2010	$4,089,600				-$4,089,600
2011		$57,000	$883,350	$150,000	$976,350
2012		$57,000	$883,350	$150,000	$976,350
2013		$57,000	$883,350	$150,000	$976,350
2014		$57,000	$883,350	$150,000	$976,350
2015		$57,000	$883,350	$150,000	$976,350
2016		$57,000	$889,200	$150,000	$982,200
2017		$57,000	$894,600	$150,000	$987,600
2018		$57,000	$898,650	$105,000	$946,650
2019		$57,000	$902,700	$105,000	$950,700
2020		$57,000	$906,750	$105,000	$954,750
2021		$57,000	$796,050	$105,000	$844,050
2022		$57,000	$685,350	$105,000	$733,350
2023		$57,000	$574,650	$105,000	$622,650
2024		$57,000	$463,950	$105,000	$511,950
2025		$57,000	$451,350	$105,000	$499,350
2026		$57,000	$439,200	$105,000	$487,200
2027		$57,000	$441,900	$89,400	$474,300
2028		$57,000	$444,600	$89,400	$477,000
2029		$57,000	$444,600	$78,600	$466,200
2030		$57,000	$444,600	$78,600	$466,200
2031		$57,000	$444,600	$78,600	$466,200
2032		$57,000	$444,600	$78,600	$466,200
2033		$57,000	$444,600	$78,600	$466,200
2034		$57,000	$444,600	$78,600	$466,200
2035		$57,000	$444,600	$78,600	$466,200
2036		$57,000	$444,600	$78,600	$466,200
2037		$57,000	$444,600	$78,600	$466,200
2038		$57,000	$444,600	$78,600	$466,200
2039		$57,000	$444,600	$78,600	$466,200
2040	$2,041,688	$57,000	$444,600	$78,600	-$1,575,488
2041		$57,000	$444,600	$78,600	$466,200
2042		$57,000	$444,600	$78,600	$466,200
2043		$57,000	$444,600	$78,600	$466,200
2044		$57,000	$444,600	$78,600	$466,200
2045		$57,000	$444,600	$78,600	$466,200
2046		$57,000	$444,600	$78,600	$466,200
2047		$57,000	$444,600	$78,600	$466,200
2048		$57,000	$444,600	$78,600	$466,200
2049		$57,000	$444,600	$78,600	$466,200
2050		$57,000	$444,600	$78,600	$466,200
2051		$57,000	$444,600	$78,600	$466,200
2052		$57,000	$444,600	$78,600	$466,200
2053		$57,000	$444,600	$78,600	$466,200
2054		$57,000	$444,600	$78,600	$466,200
2055		$57,000	$444,600	$78,600	$466,200
2056		$57,000	$444,600	$78,600	$466,200
2057		$57,000	$444,600	$78,600	$466,200
2058		$57,000	$444,600	$78,600	$466,200
2059		$57,000	$444,600	$78,600	$466,200
2060		$57,000	$444,600	$78,600	$466,200

Cost Summary
In combination with Isla Pablon

Civil Work Cost	$2,233,936
Equipment Cost	$2,722,250
Transmission System	$207,648
Subtotal	**$5,163,834**
Contingencies (20%)	$1,032,767
Engineering & Administration (10%)	$619,660
Project Development Cost	**$6,816,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$13,404
Equipment Maintenance	$40,834
Transmission Maintenance	$2,492
Total O&M	**$57,000**

Internal Rate of Return	**11.2%**

APPENDIX E - ECONOMIC ANALYSIS

2.5-MW Rio Indio Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$1,022,400				-$1,022,400
2009	$1,704,000				-$1,704,000
2010	$4,089,600				-$4,089,600
2011		$57,000	$551,250	$150,000	$644,250
2012		$57,000	$551,250	$150,000	$644,250
2013		$57,000	$551,250	$150,000	$644,250
2014		$57,000	$551,250	$150,000	$644,250
2015		$57,000	$551,250	$150,000	$644,250
2016		$57,000	$546,300	$150,000	$639,300
2017		$57,000	$541,350	$150,000	$634,350
2018		$57,000	$536,850	$150,000	$629,850
2019		$57,000	$524,700	$121,800	$589,500
2020		$57,000	$512,550	$121,800	$577,350
2021		$57,000	$500,400	$121,800	$565,200
2022		$57,000	$487,800	$121,800	$552,600
2023		$57,000	$476,100	$105,000	$524,100
2024		$57,000	$463,950	$105,000	$511,950
2025		$57,000	$451,350	$105,000	$499,350
2026		$57,000	$439,200	$105,000	$487,200
2027		$57,000	$441,900	$89,400	$474,300
2028		$57,000	$444,600	$89,400	$477,000
2029		$57,000	$444,600	$78,600	$466,200
2030		$57,000	$444,600	$78,600	$466,200
2031		$57,000	$444,600	$78,600	$466,200
2032		$57,000	$444,600	$78,600	$466,200
2033		$57,000	$444,600	$78,600	$466,200
2034		$57,000	$444,600	$78,600	$466,200
2035		$57,000	$444,600	$78,600	$466,200
2036		$57,000	$444,600	$78,600	$466,200
2037		$57,000	$444,600	$78,600	$466,200
2038		$57,000	$444,600	$78,600	$466,200
2039		$57,000	$444,600	$78,600	$466,200
2040	$2,041,688	$57,000	$444,600	$78,600	-$1,575,488
2041		$57,000	$444,600	$78,600	$466,200
2042		$57,000	$444,600	$78,600	$466,200
2043		$57,000	$444,600	$78,600	$466,200
2044		$57,000	$444,600	$78,600	$466,200
2045		$57,000	$444,600	$78,600	$466,200
2046		$57,000	$444,600	$78,600	$466,200
2047		$57,000	$444,600	$78,600	$466,200
2048		$57,000	$444,600	$78,600	$466,200
2049		$57,000	$444,600	$78,600	$466,200
2050		$57,000	$444,600	$78,600	$466,200
2051		$57,000	$444,600	$78,600	$466,200
2052		$57,000	$444,600	$78,600	$466,200
2053		$57,000	$444,600	$78,600	$466,200
2054		$57,000	$444,600	$78,600	$466,200
2055		$57,000	$444,600	$78,600	$466,200
2056		$57,000	$444,600	$78,600	$466,200
2057		$57,000	$444,600	$78,600	$466,200
2058		$57,000	$444,600	$78,600	$466,200
2059		$57,000	$444,600	$78,600	$466,200
2060		$57,000	$444,600	$78,600	$466,200

Cost Summary
In combination with Isla Pablon

Civil Work Cost	$2,233,936
Equipment Cost	$2,722,250
Transmission System	$207,648
Subtotal	**$5,163,834**
Contingencies (20%)	$1,032,767
Engineering & Administration (10%)	$619,660
Project Development Cost	**$6,816,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$13,404
Equipment Maintenance	$40,834
Transmission Maintenance	$2,492
Total O&M	**$57,000**

Internal Rate of Return **7.5%**

APPENDIX E - ECONOMIC ANALYSIS

6.4-MW Rio Indio Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$2,609,100				-$2,609,100
2009	$4,348,500				-$4,348,500
2010	$10,436,400				-$10,436,400
2011		$159,000	$1,462,500	$265,200	$1,568,700
2012		$159,000	$1,462,500	$265,200	$1,568,700
2013		$159,000	$1,462,500	$265,200	$1,568,700
2014		$159,000	$1,462,500	$265,200	$1,568,700
2015		$159,000	$1,462,050	$265,200	$1,568,250
2016		$159,000	$1,471,500	$265,200	$1,577,700
2017		$159,000	$1,480,500	$265,200	$1,586,700
2018		$159,000	$1,491,750	$265,200	$1,597,950
2019		$159,000	$1,498,050	$265,200	$1,604,250
2020		$159,000	$1,500,300	$265,200	$1,606,500
2021		$159,000	$1,242,450	$175,800	$1,259,250
2022		$159,000	$984,150	$175,800	$1,000,950
2023		$159,000	$726,300	$175,800	$743,100
2024		$159,000	$468,000	$175,800	$484,800
2025		$159,000	$454,950	$159,000	$454,950
2026		$159,000	$441,900	$159,000	$441,900
2027		$159,000	$447,300	$159,000	$447,300
2028		$159,000	$452,700	$159,000	$452,700
2029		$159,000	$452,700	$150,000	$443,700
2030		$159,000	$452,700	$150,000	$443,700
2031		$159,000	$452,700	$150,000	$443,700
2032		$159,000	$452,700	$150,000	$443,700
2033		$159,000	$452,700	$150,000	$443,700
2034		$159,000	$452,700	$150,000	$443,700
2035		$159,000	$452,700	$150,000	$443,700
2036		$159,000	$452,700	$150,000	$443,700
2037		$159,000	$452,700	$150,000	$443,700
2038		$159,000	$452,700	$150,000	$443,700
2039		$159,000	$452,700	$150,000	$443,700
2040	$4,114,688	$159,000	$452,700	$150,000	-$3,670,988
2041		$159,000	$452,700	$150,000	$443,700
2042		$159,000	$452,700	$150,000	$443,700
2043		$159,000	$452,700	$150,000	$443,700
2044		$159,000	$452,700	$150,000	$443,700
2045		$159,000	$452,700	$150,000	$443,700
2046		$159,000	$452,700	$150,000	$443,700
2047		$159,000	$452,700	$150,000	$443,700
2048		$159,000	$452,700	$150,000	$443,700
2049		$159,000	$452,700	$150,000	$443,700
2050		$159,000	$452,700	$150,000	$443,700
2051		$159,000	$452,700	$150,000	$443,700
2052		$159,000	$452,700	$150,000	$443,700
2053		$159,000	$452,700	$150,000	$443,700
2054		$159,000	$452,700	$150,000	$443,700
2055		$159,000	$452,700	$150,000	$443,700
2056		$159,000	$452,700	$150,000	$443,700
2057		$159,000	$452,700	$150,000	$443,700
2058		$159,000	$452,700	$150,000	$443,700
2059		$159,000	$452,700	$150,000	$443,700
2060		$159,000	$452,700	$150,000	$443,700

Cost Summary

Rio Indio is developed without Pablon

Civil Work Cost	$2,574,593
Equipment Cost	$5,486,250
Transmission System	$5,116,502
Subtotal	**$13,177,345**
Contingencies (20%)	$2,635,469
Engineering & Administration (10%)	$1,581,281
Project Development Cost	**$17,394,000**
Annual Operation & Maintenance Costs	
Civil Work Maintenance	$15,448
Equipment Maintenance	$82,294
Transmission Maintenance	$61,398
Total O&M	**$159,000**
Internal Rate of Return	**4.4%**

APPENDIX E - ECONOMIC ANALYSIS

6.4-MW Rio Indio Power Plant

Year	Project Cost	Annual Operation O&M	Energy Revenue	Capacity Revenue	Total
2008	$1,930,650				-$1,930,650
2009	$3,217,750				-$3,217,750
2010	$7,722,600				-$7,722,600
2011		$118,000	$1,462,500	$265,200	$1,609,700
2012		$118,000	$1,462,500	$265,200	$1,609,700
2013		$118,000	$1,462,500	$265,200	$1,609,700
2014		$118,000	$1,462,500	$265,200	$1,609,700
2015		$118,000	$1,462,050	$265,200	$1,609,250
2016		$118,000	$1,471,500	$265,200	$1,618,700
2017		$118,000	$1,480,500	$265,200	$1,627,700
2018		$118,000	$1,491,750	$265,200	$1,638,950
2019		$118,000	$1,498,050	$265,200	$1,645,250
2020		$118,000	$1,500,300	$265,200	$1,647,500
2021		$118,000	$1,242,450	$175,800	$1,300,250
2022		$118,000	$984,150	$175,800	$1,041,950
2023		$118,000	$726,300	$175,800	$784,100
2024		$118,000	$468,000	$175,800	$525,800
2025		$118,000	$454,950	$159,000	$495,950
2026		$118,000	$441,900	$159,000	$482,900
2027		$118,000	$447,300	$159,000	$488,300
2028		$118,000	$452,700	$159,000	$493,700
2029		$118,000	$452,700	$150,000	$484,700
2030		$118,000	$452,700	$150,000	$484,700
2031		$118,000	$452,700	$150,000	$484,700
2032		$118,000	$452,700	$150,000	$484,700
2033		$118,000	$452,700	$150,000	$484,700
2034		$118,000	$452,700	$150,000	$484,700
2035		$118,000	$452,700	$150,000	$484,700
2036		$118,000	$452,700	$150,000	$484,700
2037		$118,000	$452,700	$150,000	$484,700
2038		$118,000	$452,700	$150,000	$484,700
2039		$118,000	$452,700	$150,000	$484,700
2040	$4,114,688	$118,000	$452,700	$150,000	-$3,629,988
2041		$118,000	$452,700	$150,000	$484,700
2042		$118,000	$452,700	$150,000	$484,700
2043		$118,000	$452,700	$150,000	$484,700
2044		$118,000	$452,700	$150,000	$484,700
2045		$118,000	$452,700	$150,000	$484,700
2046		$118,000	$452,700	$150,000	$484,700
2047		$118,000	$452,700	$150,000	$484,700
2048		$118,000	$452,700	$150,000	$484,700
2049		$118,000	$452,700	$150,000	$484,700
2050		$118,000	$452,700	$150,000	$484,700
2051		$118,000	$452,700	$150,000	$484,700
2052		$118,000	$452,700	$150,000	$484,700
2053		$118,000	$452,700	$150,000	$484,700
2054		$118,000	$452,700	$150,000	$484,700
2055		$118,000	$452,700	$150,000	$484,700
2056		$118,000	$452,700	$150,000	$484,700
2057		$118,000	$452,700	$150,000	$484,700
2058		$118,000	$452,700	$150,000	$484,700
2059		$118,000	$452,700	$150,000	$484,700
2060		$118,000	$452,700	$150,000	$484,700

Cost Summary
In combination with Isla Pablon

Civil Work Cost	$2,574,593
Equipment Cost	$5,486,250
Transmission System Excl. La Chorrera	$1,690,074
Subtotal	**$9,750,917**
Contingencies (20%)	$1,950,183
Engineering & Administration (10%)	$1,170,110
Project Development Cost	**$12,871,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$15,448
Equipment Maintenance	$82,294
Transmission Maintenance	$20,281
Total O&M	**$118,000**

Internal Rate of Return	**8.4%**

APPENDIX E - ECONOMIC ANALYSIS

6.4-MW Rio Indio Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$1,930,650				-$1,930,650
2009	$3,217,750				-$3,217,750
2010	$7,722,600				-$7,722,600
2011		$118,000	$571,950	$222,400	$676,350
2012		$118,000	$571,950	$222,400	$676,350
2013		$118,000	$571,950	$222,400	$676,350
2014		$118,000	$571,950	$222,400	$676,350
2015		$118,000	$571,950	$222,400	$676,350
2016		$118,000	$567,000	$222,400	$671,400
2017		$118,000	$562,500	$222,400	$666,900
2018		$118,000	$558,000	$222,400	$662,400
2019		$118,000	$542,700	$190,600	$615,300
2020		$118,000	$527,400	$190,600	$600,000
2021		$118,000	$512,100	$190,600	$584,700
2022		$118,000	$496,350	$190,600	$568,950
2023		$118,000	$482,400	$175,800	$540,200
2024		$118,000	$468,000	$175,800	$525,800
2025		$118,000	$454,950	$159,000	$495,950
2026		$118,000	$441,900	$159,000	$482,900
2027		$118,000	$447,300	$159,000	$488,300
2028		$118,000	$452,700	$159,000	$493,700
2029		$118,000	$452,700	$150,000	$484,700
2030		$118,000	$452,700	$150,000	$484,700
2031		$118,000	$452,700	$150,000	$484,700
2032		$118,000	$452,700	$150,000	$484,700
2033		$118,000	$452,700	$150,000	$484,700
2034		$118,000	$452,700	$150,000	$484,700
2035		$118,000	$452,700	$150,000	$484,700
2036		$118,000	$452,700	$150,000	$484,700
2037		$118,000	$452,700	$150,000	$484,700
2038		$118,000	$452,700	$150,000	$484,700
2039		$118,000	$452,700	$150,000	$484,700
2040	$4,114,688	$118,000	$452,700	$150,000	-$3,629,988
2041		$118,000	$452,700	$150,000	$484,700
2042		$118,000	$452,700	$150,000	$484,700
2043		$118,000	$452,700	$150,000	$484,700
2044		$118,000	$452,700	$150,000	$484,700
2045		$118,000	$452,700	$150,000	$484,700
2046		$118,000	$452,700	$150,000	$484,700
2047		$118,000	$452,700	$150,000	$484,700
2048		$118,000	$452,700	$150,000	$484,700
2049		$118,000	$452,700	$150,000	$484,700
2050		$118,000	$452,700	$150,000	$484,700
2051		$118,000	$452,700	$150,000	$484,700
2052		$118,000	$452,700	$150,000	$484,700
2053		$118,000	$452,700	$150,000	$484,700
2054		$118,000	$452,700	$150,000	$484,700
2055		$118,000	$452,700	$150,000	$484,700
2056		$118,000	$452,700	$150,000	$484,700
2057		$118,000	$452,700	$150,000	$484,700
2058		$118,000	$452,700	$150,000	$484,700
2059		$118,000	$452,700	$150,000	$484,700
2060		$118,000	$452,700	$150,000	$484,700

Cost Summary

In combination with Isla Pablon - Strategy No.1

Civil Work Cost	$2,574,593
Equipment Cost	$5,486,250
Transmission System Excl. La Chorrera	$1,690,074
Subtotal	**$9,750,917**
Contingencies (20%)	$1,950,183
Engineering & Administration (10%)	$1,170,110
Project Development Cost	**$12,871,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$15,448
Equipment Maintenance	$82,294
Transmission Maintenance	$20,281
Total O&M	**$118,000**

Internal Rate of Return	**2.7%**

APPENDIX E - ECONOMIC ANALYSIS

11.1-MW Rio Indio Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,139,350				-$3,139,350
2009	$5,232,250				-$5,232,250
2010	$12,557,400				-$12,557,400
2011		$196,000	$2,560,500	$460,800	$2,825,300
2012		$196,000	$2,560,500	$460,800	$2,825,300
2013		$196,000	$2,560,500	$460,800	$2,825,300
2014		$196,000	$2,560,500	$460,800	$2,825,300
2015		$196,000	$2,558,250	$460,800	$2,823,050
2016		$196,000	$2,574,450	$460,800	$2,839,250
2017		$196,000	$2,590,650	$460,800	$2,855,450
2018		$196,000	$2,262,150	$460,800	$2,526,950
2019		$196,000	$1,933,200	$460,800	$2,198,000
2020		$196,000	$1,604,250	$460,800	$1,869,050
2021		$196,000	$1,322,550	$175,800	$1,302,350
2022		$196,000	$1,040,400	$175,800	$1,020,200
2023		$196,000	$758,250	$175,800	$738,050
2024		$196,000	$476,100	$175,800	$455,900
2025		$196,000	$462,150	$159,000	$425,150
2026		$196,000	$448,200	$159,000	$411,200
2027		$196,000	$457,200	$159,000	$420,200
2028		$196,000	$466,200	$159,000	$429,200
2029		$196,000	$466,200	$150,000	$420,200
2030		$196,000	$466,200	$150,000	$420,200
2031		$196,000	$466,200	$150,000	$420,200
2032		$196,000	$466,200	$150,000	$420,200
2033		$196,000	$466,200	$150,000	$420,200
2034		$196,000	$466,200	$150,000	$420,200
2035		$196,000	$466,200	$150,000	$420,200
2036		$196,000	$466,200	$150,000	$420,200
2037		$196,000	$466,200	$150,000	$420,200
2038		$196,000	$466,200	$150,000	$420,200
2039		$196,000	$466,200	$150,000	$420,200
2040	$5,772,188	$196,000	$466,200	$150,000	-$5,351,988
2041		$196,000	$466,200	$150,000	$420,200
2042		$196,000	$466,200	$150,000	$420,200
2043		$196,000	$466,200	$150,000	$420,200
2044		$196,000	$466,200	$150,000	$420,200
2045		$196,000	$466,200	$150,000	$420,200
2046		$196,000	$466,200	$150,000	$420,200
2047		$196,000	$466,200	$150,000	$420,200
2048		$196,000	$466,200	$150,000	$420,200
2049		$196,000	$466,200	$150,000	$420,200
2050		$196,000	$466,200	$150,000	$420,200
2051		$196,000	$466,200	$150,000	$420,200
2052		$196,000	$466,200	$150,000	$420,200
2053		$196,000	$466,200	$150,000	$420,200
2054		$196,000	$466,200	$150,000	$420,200
2055		$196,000	$466,200	$150,000	$420,200
2056		$196,000	$466,200	$150,000	$420,200
2057		$196,000	$466,200	$150,000	$420,200
2058		$196,000	$466,200	$150,000	$420,200
2059		$196,000	$466,200	$150,000	$420,200
2060		$196,000	$466,200	$150,000	$420,200

Cost Summary

Rio Indio is developed without Pablon

Civil Work Cost	$2,907,924
Equipment Cost	$7,696,250
Transmission System	$5,251,052
Subtotal	**$15,855,226**
Contingencies (20%)	$3,171,045
Engineering & Administration (10%)	$1,902,627
Project Development Cost	**$20,929,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$17,448
Equipment Maintenance	$115,444
Transmission Maintenance	$63,013
Total O&M	**$196,000**

Internal Rate of Return	**7.0%**

APPENDIX E - ECONOMIC ANALYSIS

11.1-MW Rio Indio Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$2,460,900				-$2,460,900
2009	$4,101,500				-$4,101,500
2010	$9,843,600				-$9,843,600
2011		$155,000	$2,560,500	$460,800	$2,866,300
2012		$155,000	$2,560,500	$460,800	$2,866,300
2013		$155,000	$2,560,500	$460,800	$2,866,300
2014		$155,000	$2,560,500	$460,800	$2,866,300
2015		$155,000	$2,558,250	$460,800	$2,864,050
2016		$155,000	$2,574,450	$460,800	$2,880,250
2017		$155,000	$2,590,650	$460,800	$2,896,450
2018		$155,000	$2,262,150	$460,800	$2,567,950
2019		$155,000	$1,933,200	$460,800	$2,239,000
2020		$155,000	$1,604,250	$460,800	$1,910,050
2021		$155,000	$1,322,550	$175,800	$1,343,350
2022		$155,000	$1,040,400	$175,800	$1,061,200
2023		$155,000	$758,250	$175,800	$779,050
2024		$155,000	$476,100	$175,800	$496,900
2025		$155,000	$462,150	$159,000	$466,150
2026		$155,000	$448,200	$159,000	$452,200
2027		$155,000	$457,200	$159,000	$461,200
2028		$155,000	$466,200	$159,000	$470,200
2029		$155,000	$466,200	$150,000	$461,200
2030		$155,000	$466,200	$150,000	$461,200
2031		$155,000	$466,200	$150,000	$461,200
2032		$155,000	$466,200	$150,000	$461,200
2033		$155,000	$466,200	$150,000	$461,200
2034		$155,000	$466,200	$150,000	$461,200
2035		$155,000	$466,200	$150,000	$461,200
2036		$155,000	$466,200	$150,000	$461,200
2037		$155,000	$466,200	$150,000	$461,200
2038		$155,000	$466,200	$150,000	$461,200
2039		$155,000	$466,200	$150,000	$461,200
2040	$5,772,188	$155,000	$466,200	$150,000	-$5,310,988
2041		$155,000	$466,200	$150,000	$461,200
2042		$155,000	$466,200	$150,000	$461,200
2043		$155,000	$466,200	$150,000	$461,200
2044		$155,000	$466,200	$150,000	$461,200
2045		$155,000	$466,200	$150,000	$461,200
2046		$155,000	$466,200	$150,000	$461,200
2047		$155,000	$466,200	$150,000	$461,200
2048		$155,000	$466,200	$150,000	$461,200
2049		$155,000	$466,200	$150,000	$461,200
2050		$155,000	$466,200	$150,000	$461,200
2051		$155,000	$466,200	$150,000	$461,200
2052		$155,000	$466,200	$150,000	$461,200
2053		$155,000	$466,200	$150,000	$461,200
2054		$155,000	$466,200	$150,000	$461,200
2055		$155,000	$466,200	$150,000	$461,200
2056		$155,000	$466,200	$150,000	$461,200
2057		$155,000	$466,200	$150,000	$461,200
2058		$155,000	$466,200	$150,000	$461,200
2059		$155,000	$466,200	$150,000	$461,200
2060		$155,000	$466,200	$150,000	$461,200

Cost Summary
In combination with Isla Pablon

Civil Work Cost	$2,907,924
Equipment Cost	$7,696,250
Transmission System Excl. La Chorrera	$1,824,624
Subtotal	**$12,428,798**
Contingencies (20%)	$2,485,760
Engineering & Administration (10%)	$1,491,456
Project Development Cost	**$16,406,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$17,448
Equipment Maintenance	$115,444
Transmission Maintenance	$21,895
Total O&M	**$155,000**

Internal Rate of Return	**11.5%**

APPENDIX E - ECONOMIC ANALYSIS

15.9-MW Rio Indio Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,594,150				-$3,594,150
2009	$5,990,250				-$5,990,250
2010	$14,376,600				-$14,376,600
2011		$223,000	$3,654,000	$660,000	$4,091,000
2012		$223,000	$3,654,000	$660,000	$4,091,000
2013		$223,000	$3,654,000	$660,000	$4,091,000
2014		$223,000	$3,654,000	$660,000	$4,091,000
2015		$223,000	$3,654,450	$660,000	$4,091,450
2016		$223,000	$3,208,500	$660,000	$3,645,500
2017		$223,000	$2,762,100	$660,000	$3,199,100
2018		$223,000	$2,379,600	$660,000	$2,816,600
2019		$223,000	$1,996,650	$608,400	$2,382,050
2020		$223,000	$1,614,150	$608,400	$1,999,550
2021		$223,000	$1,331,550	$175,800	$1,284,350
2022		$223,000	$1,048,950	$175,800	$1,001,750
2023		$223,000	$766,350	$175,800	$719,150
2024		$223,000	$483,300	$175,800	$436,100
2025		$223,000	$468,900	$159,000	$404,900
2026		$223,000	$454,050	$159,000	$390,050
2027		$223,000	$466,650	$159,000	$402,650
2028		$223,000	$479,250	$159,000	$415,250
2029		$223,000	$479,250	$150,000	$406,250
2030		$223,000	$479,250	$150,000	$406,250
2031		$223,000	$479,250	$150,000	$406,250
2032		$223,000	$479,250	$150,000	$406,250
2033		$223,000	$479,250	$150,000	$406,250
2034		$223,000	$479,250	$150,000	$406,250
2035		$223,000	$479,250	$150,000	$406,250
2036		$223,000	$479,250	$150,000	$406,250
2037		$223,000	$479,250	$150,000	$406,250
2038		$223,000	$479,250	$150,000	$406,250
2039		$223,000	$479,250	$150,000	$406,250
2040	$6,721,313	$223,000	$479,250	$150,000	-$6,315,063
2041		$223,000	$479,250	$150,000	$406,250
2042		$223,000	$479,250	$150,000	$406,250
2043		$223,000	$479,250	$150,000	$406,250
2044		$223,000	$479,250	$150,000	$406,250
2045		$223,000	$479,250	$150,000	$406,250
2046		$223,000	$479,250	$150,000	$406,250
2047		$223,000	$479,250	$150,000	$406,250
2048		$223,000	$479,250	$150,000	$406,250
2049		$223,000	$479,250	$150,000	$406,250
2050		$223,000	$479,250	$150,000	$406,250
2051		$223,000	$479,250	$150,000	$406,250
2052		$223,000	$479,250	$150,000	$406,250
2053		$223,000	$479,250	$150,000	$406,250
2054		$223,000	$479,250	$150,000	$406,250
2055		$223,000	$479,250	$150,000	$406,250
2056		$223,000	$479,250	$150,000	$406,250
2057		$223,000	$479,250	$150,000	$406,250
2058		$223,000	$479,250	$150,000	$406,250
2059		$223,000	$479,250	$150,000	$406,250
2060		$223,000	$479,250	$150,000	$406,250

Cost Summary
Rio Indio is developed without Pablon

Civil Work Cost	$3,700,295
Equipment Cost	$8,961,750
Transmission System	$5,490,252
Subtotal	**$18,152,297**
Contingencies (20%)	$3,630,459
Engineering & Administration (10%)	$2,178,276
Project Development Cost	**$23,961,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$22,202
Equipment Maintenance	$134,426
Transmission Maintenance	$65,883
Total O&M	**$223,000**

Internal Rate of Return	**9.0%**

APPENDIX E - ECONOMIC ANALYSIS

15.9-MW Rio Indio Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$2,915,700				-$2,915,700
2009	$4,859,500				-$4,859,500
2010	$11,662,800				-$11,662,800
2011		$181,000	$3,654,000	$660,000	$4,133,000
2012		$181,000	$3,654,000	$660,000	$4,133,000
2013		$181,000	$3,654,000	$660,000	$4,133,000
2014		$181,000	$3,654,000	$660,000	$4,133,000
2015		$181,000	$3,654,450	$660,000	$4,133,450
2016		$181,000	$3,208,500	$660,000	$3,687,500
2017		$181,000	$2,762,100	$660,000	$3,241,100
2018		$181,000	$2,379,600	$660,000	$2,858,600
2019		$181,000	$1,996,650	$608,400	$2,424,050
2020		$181,000	$1,614,150	$608,400	$2,041,550
2021		$181,000	$1,331,550	$175,800	$1,326,350
2022		$181,000	$1,048,950	$175,800	$1,043,750
2023		$181,000	$766,350	$175,800	$761,150
2024		$181,000	$483,300	$175,800	$478,100
2025		$181,000	$468,900	$159,000	$446,900
2026		$181,000	$454,050	$159,000	$432,050
2027		$181,000	$466,650	$159,000	$444,650
2028		$181,000	$479,250	$159,000	$457,250
2029		$181,000	$479,250	$150,000	$448,250
2030		$181,000	$479,250	$150,000	$448,250
2031		$181,000	$479,250	$150,000	$448,250
2032		$181,000	$479,250	$150,000	$448,250
2033		$181,000	$479,250	$150,000	$448,250
2034		$181,000	$479,250	$150,000	$448,250
2035		$181,000	$479,250	$150,000	$448,250
2036		$181,000	$479,250	$150,000	$448,250
2037		$181,000	$479,250	$150,000	$448,250
2038		$181,000	$479,250	$150,000	$448,250
2039		$181,000	$479,250	$150,000	$448,250
2040	$6,721,313	$181,000	$479,250	$150,000	-$6,273,063
2041		$181,000	$479,250	$150,000	$448,250
2042		$181,000	$479,250	$150,000	$448,250
2043		$181,000	$479,250	$150,000	$448,250
2044		$181,000	$479,250	$150,000	$448,250
2045		$181,000	$479,250	$150,000	$448,250
2046		$181,000	$479,250	$150,000	$448,250
2047		$181,000	$479,250	$150,000	$448,250
2048		$181,000	$479,250	$150,000	$448,250
2049		$181,000	$479,250	$150,000	$448,250
2050		$181,000	$479,250	$150,000	$448,250
2051		$181,000	$479,250	$150,000	$448,250
2052		$181,000	$479,250	$150,000	$448,250
2053		$181,000	$479,250	$150,000	$448,250
2054		$181,000	$479,250	$150,000	$448,250
2055		$181,000	$479,250	$150,000	$448,250
2056		$181,000	$479,250	$150,000	$448,250
2057		$181,000	$479,250	$150,000	$448,250
2058		$181,000	$479,250	$150,000	$448,250
2059		$181,000	$479,250	$150,000	$448,250
2060		$181,000	$479,250	$150,000	$448,250

Cost Summary
In combination with Isla Pablon

Civil Work Cost	$3,700,295
Equipment Cost	$8,961,750
Transmission System Excl. La Chorrera	$2,063,824
Subtotal	**$14,725,869**
Contingencies (20%)	$2,945,174
Engineering & Administration (10%)	$1,767,104
Project Development Cost	**$19,438,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$22,202
Equipment Maintenance	$134,426
Transmission Maintenance	$24,766
Total O&M	**$181,000**

Internal Rate of Return	**13.6%**

APPENDIX E - ECONOMIC ANALYSIS

18.4-MW Rio Indio Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,975,150				-$3,975,150
2009	$6,625,250				-$6,625,250
2010	$15,900,600				-$15,900,600
2011		$248,000	$3,883,500	$763,800	$4,399,300
2012		$248,000	$3,883,500	$763,800	$4,399,300
2013		$248,000	$3,883,500	$763,800	$4,399,300
2014		$248,000	$3,883,500	$763,800	$4,399,300
2015		$248,000	$3,870,450	$763,800	$4,386,250
2016		$248,000	$3,319,200	$763,800	$3,835,000
2017		$248,000	$2,767,500	$763,800	$3,283,300
2018		$248,000	$2,385,000	$763,800	$2,900,800
2019		$248,000	$2,002,050	$608,400	$2,362,450
2020		$248,000	$1,619,100	$608,400	$1,979,500
2021		$248,000	$1,336,050	$175,800	$1,263,850
2022		$248,000	$1,053,000	$175,800	$980,800
2023		$248,000	$769,950	$175,800	$697,750
2024		$248,000	$486,900	$175,800	$414,700
2025		$248,000	$471,600	$159,000	$382,600
2026		$248,000	$456,300	$159,000	$367,300
2027		$248,000	$470,700	$159,000	$381,700
2028		$248,000	$485,550	$159,000	$396,550
2029		$248,000	$485,550	$150,000	$387,550
2030		$248,000	$485,550	$150,000	$387,550
2031		$248,000	$485,550	$150,000	$387,550
2032		$248,000	$485,550	$150,000	$387,550
2033		$248,000	$485,550	$150,000	$387,550
2034		$248,000	$485,550	$150,000	$387,550
2035		$248,000	$485,550	$150,000	$387,550
2036		$248,000	$485,550	$150,000	$387,550
2037		$248,000	$485,550	$150,000	$387,550
2038		$248,000	$485,550	$150,000	$387,550
2039		$248,000	$485,550	$150,000	$387,550
2040	$7,923,188	$248,000	$485,550	$150,000	-$7,535,638
2041		$248,000	$485,550	$150,000	$387,550
2042		$248,000	$485,550	$150,000	$387,550
2043		$248,000	$485,550	$150,000	$387,550
2044		$248,000	$485,550	$150,000	$387,550
2045		$248,000	$485,550	$150,000	$387,550
2046		$248,000	$485,550	$150,000	$387,550
2047		$248,000	$485,550	$150,000	$387,550
2048		$248,000	$485,550	$150,000	$387,550
2049		$248,000	$485,550	$150,000	$387,550
2050		$248,000	$485,550	$150,000	$387,550
2051		$248,000	$485,550	$150,000	$387,550
2052		$248,000	$485,550	$150,000	$387,550
2053		$248,000	$485,550	$150,000	$387,550
2054		$248,000	$485,550	$150,000	$387,550
2055		$248,000	$485,550	$150,000	$387,550
2056		$248,000	$485,550	$150,000	$387,550
2057		$248,000	$485,550	$150,000	$387,550
2058		$248,000	$485,550	$150,000	$387,550
2059		$248,000	$485,550	$150,000	$387,550
2060		$248,000	$485,550	$150,000	$387,550

Cost Summary
Rio Indio is developed without Pablon

Civil Work Cost	$4,021,917
Equipment Cost	$10,564,250
Transmission System	$5,490,252
Subtotal	**$20,076,419**
Contingencies (20%)	$4,015,284
Engineering & Administration (10%)	$2,409,170
Project Development Cost	**$26,501,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$24,132
Equipment Maintenance	$158,464
Transmission Maintenance	$65,883
Total O&M	**$248,000**

Internal Rate of Return	**8.0%**

18.4-MW Rio Indio Power Plant

Annual Operation

Year	Project Cost	O&M	Energy Revenue	Capacity Revenue	Total
2008	$3,296,700				-$3,296,700
2009	$5,494,500				-$5,494,500
2010	$13,186,800				-$13,186,800
2011		$207,000	$3,883,500	$763,800	$4,440,300
2012		$207,000	$3,883,500	$763,800	$4,440,300
2013		$207,000	$3,883,500	$763,800	$4,440,300
2014		$207,000	$3,883,500	$763,800	$4,440,300
2015		$207,000	$3,870,450	$763,800	$4,427,250
2016		$207,000	$3,319,200	$763,800	$3,876,000
2017		$207,000	$2,767,500	$763,800	$3,324,300
2018		$207,000	$2,385,000	$763,800	$2,941,800
2019		$207,000	$2,002,050	$608,400	$2,403,450
2020		$207,000	$1,619,100	$608,400	$2,020,500
2021		$207,000	$1,336,050	$175,800	$1,304,850
2022		$207,000	$1,053,000	$175,800	$1,021,800
2023		$207,000	$769,950	$175,800	$738,750
2024		$207,000	$486,900	$175,800	$455,700
2025		$207,000	$471,600	$159,000	$423,600
2026		$207,000	$456,300	$159,000	$408,300
2027		$207,000	$470,700	$159,000	$422,700
2028		$207,000	$485,550	$159,000	$437,550
2029		$207,000	$485,550	$150,000	$428,550
2030		$207,000	$485,550	$150,000	$428,550
2031		$207,000	$485,550	$150,000	$428,550
2032		$207,000	$485,550	$150,000	$428,550
2033		$207,000	$485,550	$150,000	$428,550
2034		$207,000	$485,550	$150,000	$428,550
2035		$207,000	$485,550	$150,000	$428,550
2036		$207,000	$485,550	$150,000	$428,550
2037		$207,000	$485,550	$150,000	$428,550
2038		$207,000	$485,550	$150,000	$428,550
2039		$207,000	$485,550	$150,000	$428,550
2040	$7,923,188	$207,000	$485,550	$150,000	-$7,494,638
2041		$207,000	$485,550	$150,000	$428,550
2042		$207,000	$485,550	$150,000	$428,550
2043		$207,000	$485,550	$150,000	$428,550
2044		$207,000	$485,550	$150,000	$428,550
2045		$207,000	$485,550	$150,000	$428,550
2046		$207,000	$485,550	$150,000	$428,550
2047		$207,000	$485,550	$150,000	$428,550
2048		$207,000	$485,550	$150,000	$428,550
2049		$207,000	$485,550	$150,000	$428,550
2050		$207,000	$485,550	$150,000	$428,550
2051		$207,000	$485,550	$150,000	$428,550
2052		$207,000	$485,550	$150,000	$428,550
2053		$207,000	$485,550	$150,000	$428,550
2054		$207,000	$485,550	$150,000	$428,550
2055		$207,000	$485,550	$150,000	$428,550
2056		$207,000	$485,550	$150,000	$428,550
2057		$207,000	$485,550	$150,000	$428,550
2058		$207,000	$485,550	$150,000	$428,550
2059		$207,000	$485,550	$150,000	$428,550
2060		$207,000	$485,550	$150,000	$428,550

Cost Summary
In combination with Isla Pablon

Civil Work Cost	$4,021,917
Equipment Cost	$10,564,250
Transmission System Excl. La Chorrera	$2,063,824
Subtotal	**$16,649,991**
Contingencies (20%)	$3,329,998
Engineering & Administration (10%)	$1,997,999
Project Development Cost	**$21,978,000**

Annual Operation & Maintenance Costs

Civil Work Maintenance	$24,132
Equipment Maintenance	$158,464
Transmission Maintenance	$24,766
Total O&M	**$207,000**

Internal Rate of Return	**12.0%**

Appendix F
Agriculture & Irrigation

FEASIBILITY DESIGN FOR THE RÍO INDIO WATER SUPPLY PROJECT

APPENDIX F

AGRICULTURE AND IRRIGATION POTENTIAL

Prepared by

MWH

In association with

TAMS

AN EARTH TECH COMPANY

FEASIBILITY DESIGN FOR THE RÍO INDIO WATER SUPPLY PROJECT

APPENDIX F – AGRICULTURE AND IRRIGATION POTENTIAL

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

LIST OF EXHIBITS

ATTACHMENTS

1 BACKGROUND AND SCOPE

The Panama Canal Authority (ACP) is evaluating several sources of additional water supply to meet future demand for the Canal operation and for municipal and industrial use in the Gatun Lake watershed. A Reconnaissance Study performed by the US Army Corps of Engineers, Mobil District, has identified the Rio Indio Water Supply Project as a promising source of water for the Canal. The Rio Indio is a river located west of the Panama Canal; it flows northward from the Continental Divide to the Caribbean Sea. The project primarily consists of a dam, approximately 70 meter high, which creates a reservoir with a 46.7-km^2 surface area. At the maximum pool level, i.e., El. 80, the reservoir has a gross storage capacity of 1,580 million cubic meters. The proposed dam is located 21 km inland. At the dam location, the Rio Indio watershed has an area of 381 km^2, and the average annual flow is approximately 26 m^3/sec. An 8.4 km long tunnel is used to transfer the regulated flows from the Rio Indio watershed into the Gatun Lake.

Based on the outcome of the Reconnaissance Study, the ACP has selected the Rio Indio project to be evaluated at the feasibility level. As part of the Feasibility Study, the ACP has decided to assess the agricultural and irrigation potential of the basin. This report presents the analysis performed to evaluate this potential. The study was divided in eight tasks as follows:

- Data Collection and Site Reconnaissance;
- Mapping of Present Land Use;
- Mapping of Land Capability for Irrigation;
- Identification of Potential Irrigable Areas;
- Crop Pattern Definition;
- Water Requirement Estimate;
- Agriculture Net Benefit Estimate;
- Preliminary Definition of Irrigation Developments (Engineering and Cost).

The study of the agricultural and irrigation potential in the Rio Indio basin was performed by TAMS Consultants, Inc. under the Subconsultant Services Agreement No.15593 S-1 for MWH.

2 PROJECT LOCATION AND INITIAL RECONNAISSANCE

The study area is located in the lower and middle reaches of the Rio Indio Basin, some 75 km northwest of Panama City in the Provinces of Colon, Cocle and Panama. The Rio Indio Basin itself is adjacent to and West of the Panama Canal Basin. Its total population is approximately 10,000.The study area is mainly accessible by helicopter. An all-weather coastal road from the city of Colon, some 50 km to the East, can reach the mouth of the Rio Indio on the Caribbean Coast. The inland areas in the lower part of the basin are accessible by boat while the middle portion can be reached by a dry-weather road from the town of La Trinidad which in turn can be accessed to by paved road from the town of Santa Rita, some 40 km West of Panama City.

The proposed reservoir would have its normal operating water level at El.80 meters MSL and would flood an area of 46.7 km^2 .The population in the reservoir area has been estimated at approximately 2,300.The population downstream of the reservoir has been estimated at approximately 500.The balance of the population in the basin is scattered throughout the areas upstream of the proposed reservoir.

The Rio Indio Basin is a largely undeveloped rural area with a total surface area of approximately 570 km^2 at its mouth on the Caribbean Sea. The apparently more promising areas for agriculture and irrigation development were initially identified on the available 1:50,000 scale maps. Subsequently, on January 20, 2000, the ACP and TAMS personnel conducted a helicopter site reconnaissance of several of these areas (see Attachment 1).

3 LAND RESOURCES

3.1 Methodology

The evaluation of the land resources includes a review of the present land use in the Rio Indio watershed and an estimate of the land capability for agriculture and irrigation.

The current land use was initially evaluated by reviewing the available aerial photographs followed by verification through a field reconnaissance. The most recent aerial photographs that covered the study area were obtained from the "Instituto Geografico Nacional - Tommy Guardia". To cover completely the area, it was necessary to use available aerial photographs taken at different years and various scales. These were:

Table 1 – Aerial Photograph Coverage

Number of Photographs	Year	Scale
9	1979	1:60,000
30	1983	1:30,000
10	1987	1:15,000
19	1992	1:30,000
14	1993	1:30,000

Before going to the field, interpretation of the aerial photographs was undertaken to identify occurring land use patterns. A tentative legend was constructed based on the initial interpretation. The patterns as such, were transferred to a base map at a scale of 1:50,000 of the Río Indio basin.

The interpretation of the aerial photographs was based on the delineation of representative observable elements, readily identifiable on a 1:50,000-scale map. In order to overcome the constraint that surface area of less than 6.25 hectares cannot be adequately represented at that scale, areas were united into association of dominant vegetation features. The land use pattern and geographic elements identified from the aerial photographs included forest, pastures, stubble, rivers and streams, communities, landing strips and roads. Special attention was taken to separate areas of forest, stubble and pastures: these elements have been subjected to the most drastic changes in terms of use over time, and therefore, it is assumed that they are indicative of the present land use.

The preliminary land use map prepared on the basis of the aerial photographs was subsequently validated or adjusted in the field. These adjustments to the land use were based on transects and random observations made at various locations in the Río Indio basin in the course of two field trips. The first field trip started in the town of Río Indio located on the Caribbean coast: it covered the lower valley area up to the community of El Limón, near the proposed dam site, and the intermediate basin. Elements of land use in the area from the Sardina Hill, to the southeast of Uracillo, and to the North, were also recorded during this trip. The second field trip entered the basin from the East through Tres Hermanas and covered the intermediate watershed. Elements of present land use were recorded and photographs of the landscape were taken, where relevant.

3.2 Present Land Use

In the lower and intermediate Río Indio basin, between the Coast and the Piedmont, mature forests are generally non-existent or negligible. The vegetation consists mostly of pasture, secondary forest and stubble. Farming is nearly exclusively at a subsistence level, except for an abandoned Oil Palm plantation located between the towns of Río Indio and Salud, at the northernmost sector of the Río Indio basin along the coastline.

Crops are not discretely differentiated from stubble, mostly because of the nature of the area under cultivation, the landscape position, and the size of the farm holdings. The farming systems found consist mainly of two cropping cycles as follows:

- First cropping cycle
  - Main crops: Rice, Maize
  - Ancillary crops: Root crops (Cassava, Yams, etc.), plantains.
- Second cropping cycle:
  - Main crop: Maize.
  - Ancillary crops: Bean in association with Maize.

Small farms are predominant: the prevailing size of the holdings is about 0.5 hectare, and it is rare to encounter one-hectare holdings, in part because of difficulty in obtaining labor. The farmer draws a major portion of his subsistence from his own crops or livestock, and the family is the main source of labor. There is no access to farm machinery and little access to work animals as a supplementary power source.

Most of the cleared holdings are covered with native pasture that eventually evolves from the rotational method of slash and burn used for subsistence farming. The cleared land is predominantly covered with native pasture (Ratana). Livestock is scarce; Brown Swiss/Cebú or mainly Cebú, is the predominant type of livestock observed in the field. The livestock seems mostly adapted to the environmental conditions in the area. The farmers that raise livestock mostly migrate from the Azuero region and maintain the extensive management practices used in that part of the country. Most of them have around 25 to 50 heads of cattle grazing at a rate of approximately one hectare per animal. In the Uracillo vicinity, there is also one farmer with about hundred head of cattle. During the dry season, when possible, livestock farmers use out-of-farm labor for some activities.

Table 2 – Present Land Use Categories

Primary Categories: B-Forest: Includes mature forest of more than 30 years, and secondary forest of more than 15 years of age. R-Stubble: Succession forest or in an initial growth stage after slashing of secondary or mature forest. The estimate of the stubble age fluctuates between 3 to 10 years. Subsistence agriculture is included in this category. P-Natural pasturelands: In the Río Indio basin a pasture known as "ratana", is predominant. Cp-Oil Palm, an industrial crop plantation, has since been abandoned. The fields are currently in the process of conversion to pasture. **Mixed Categories:** B / P, B / R, R / P, P / B, P / R

Coffee is also grown in the lower and intermediate basin, on small, dispersed farm holdings. It is mostly organically grown, because of absence of outside farm inputs. Coffee planted known as "Robusta", is grown under secondary forest growth, with no pruning or any other maintenance. The observed plantations were mostly about 3 to 5 meters high, with growth some up to 8 meters. Once harvested and dried, some is retained for consumption, and the remainder is sold to one of the industrial processors in the country when the climatic conditions permit.

Based on the present land use, four primary and five mixed categories have been identified, and are shown on Exhibit 1 - Land Use Map. The association of primary usages is represented by a composite symbol such as "B/P" indicating a 70/30 predominance of forest over pasture. The different categories are listed in Table 2. The present land use of the project area is shown on Table 3 below.

Table 3 - Present Land Use

Land Use	Area (hectares)	Percentage of Total
Forest (B)	2,900	4.8%
Stubble (R)	190	0.3%
Natural Pasture (P)	20	0.04%
Oil Palm (CP)	580	1.0%
Forest/Natural Pasture	4,500	7.5%
Forest/Stubble	340	0.6%
Stubble/Natural Pasture	3,500	5.9%
Natural Pasture/Forest	46,400	77.4%
Natural Pasture/Stubble	1,500	2.5%

3.3 Land Capability for Irrigation

The evaluation of the land capability for irrigation was based on a semi-detailed soil study accomplished by a National Rural Cadastre Project (CATAPAN 1970), which covered the Río Indio watershed. Based on the above, the characteristics and properties of the mapping units were interpreted to assess their capability for irrigation. Supplementary random field observations of soil pedons were carried out, with an auger or from exposed surface, to validate or adjust the soil-mapping units from the land Cadastre study. Ten composite soil samples were collected to determine the fertility status of different landscape position. In addition 3 water samples were collected and analyzed in the laboratory to assess the water suitability for irrigation. The soil sample locations are presented in Table 4.

Table 4 – Soil Sample Locations

Sample Number	Site
1	El Limón - near the river.
2	Boca de Uracillo - on hill.
3	Sardina community - Sardina hill.
4	Boca de Uracillo – Recent alluvial.
5	Nuevo Progreso – East.
6	Between El Cruce and Tres Hermanas – Terrace.
7	Tres Hermanas – Alluvium, Teria river.
8	Between Tres Hermanas and Los Uveros – Terrace.
9	Near Los Uveros – High terrace.
10	Near Teria and Los Uveros – Low landscape position.

Analyses of the conditions that define arable and non-arable lands, and determine the land classes, were made in accordance with the US Bureau of Reclamation Land Classification Specifications, Irrigated Land Use (see Attachment 2). The physical factors, used as criteria in the classification of land for irrigation purposes, are: climate, soils, topography, and drainage.

Land classes for irrigation and symbols were selected among Classes 1, 2, 3, and 6, due to the semi-detailed nature of the base study. Classes 1, 2, and 3 are arable and suitable for irrigation. Class 6 is non-arable and unsuitable for irrigated agriculture. The land classes and subclasses are shown in Table 5 below.

Table 5 – Land Classification for Irrigation

Land Class & Subclass

Arable

- Class 1 – 1
- Class 2 - 2s, 2t, 2d, 2st, 2sd, 2td, 2std
- Class 3 - 3s, 3t, 3d, 3st, 3sd, 3td, 3std

Non Arable

- Class 6 - 6s, 6t, 6d, 6st, 6sd, 6td, 6std

Land Use

- L - Cultivated & non-irrigated
- G - Permanent pasture & non-irrigated
- D - Stubble - Forest

Productivity

- A - High
- B - Moderate
- C – Low

Arrangement of Symbols

Land Class
Soil Deficiency
Unsuitable Topography
Unsuitable Drainage

3 s t d
GB

Productivity
Land Use

The land areas and classes suitable for irrigation were delineated and are shown on Exhibit 2 - Land Capability for Irrigation Map. The land classes suitable for irrigation development in the Río Indio Project area are: Subclasses 2s, 3s, 3t, and 3sd. The areas unsuitable for irrigation development are those delineated areas in the Subclasses 6t, 6d, and 6st. Areas in each class found in the project area are presented in Table 6 below.

Table 6 – Land Capability Classes in Project Area

Class	Description	Area (hectares)	Percentage of Total
2s/GA	Texture: Moderately fine	2,800	4.7%
3s/LA	Texture: Very Fine	270	0.5%
3sd/GB	Texture: Very fine, Internal Drainage: high water table	480	0.8%
3t/GB	Slope	4,900	8.2%
6	Bedrock	120	0.2%
6d/LB	External Drainage: Inundation, Internal drainage: high water table	360	0.6%
6st/DB	Soil Depth: shallow, slope	2,300	3.9%
6st/DC	Soil Depth: shallow, Slope & Stoniness	16,600	27.7%
6st/GB	Texture: Very Fine, Slope & Stoniness	5,100	8.5%
6st/GC	Soil Depth: shallow, Texture: Very Fine, Slope & Stoniness	15,900	26.6%
6t/DB	Texture: Very Fine	10,900	18.2%

The results of the soil fertility analysis of the 10 soil samples are presented in Table 7. The soils are moderate to fine and include loam, silty loam, silty clay loam, clay loam, and clay textured surface horizons. The chemical analysis of the collected samples show that the soil characteristics vary from slightly acid to extremely acid. Samples from sites 5, 6, and 9 are highly acidic and may present toxicity problems to present and future upland crops. This will also impose restriction on the selection process of pasture and forest species.

Table 7 – Soil Fertility Test Results

Attributes	Soil Samples									
	1	2	3	4	5	6	7	8	9	10
Sand %	35.10	57.60	25.10	70.10	51.70	24.20	27.60	50.10	37.60	40.10
Silt %	44.10	26.60	24.10	14.10	18.40	15.90	32.50	17.50	25.00	27.50
Clay %	20.80	15.80	50.80	15.80	29.90	59.90	39.90	32.40	37.40	22.40
Texture	L[1]	SL[3]	C[4]	SL	SCL[5]	C	C	SCL	CL[6]	CL
Color	YB	DYB	RY	B	CYB	YR	YB	CYB	R	CYB
Organic Matter %	6.50	8.71	5.46	9.23	6.36	4.73	5.23	1.07	1.13	1.26
Phosphorus ppm	10	4	4	6	2	Tr.	2	7	2	3
Potassium ppm	85	108	90	120	141	128	60	110	120	110
PH	6.2	5.3	5.5	5.1	4.7	4.1	5.2	5.2	3.96	5.17
Acidity me $100g^{-1}$	0.30	0.50	0.30	0.90	22.00	13.30	0.80	0.70	12.70	1.20
Aluminum me $100g^{-1}$	Tr[2]	Tr.	Tr.	Tr.	17.90	10.00	Tr.	0.30	8.80	1.00
Calcium me $100g^{-1}$	21.97	9.99	7.99	11.99	3.99	0.99	21.98	3.99	0.99	21.98
Magnesium me $100g^{-1}$	13.92	5.98	3.96	10.93	0.83	3.98	14.00	5.83	4.00	13.00
Iron ppm	65	55	48	66	80	60	75	50	60	66
Manganese ppm	38	40	39	36	48	40	30	35	49	50
Copper ppm	3	3	2	3	1	1	2	3	1	2

[1/] L = Loam; [2/] Tr. = Trace; [3/] SL = Sandy Loam; [4/] C = Clay; [5/] SCL = Sandy Clay Loam; [6/] CL = Clay Loam; YB = Yellowish Brown; DYB = Dark Yellowish Brown; RY = Reddish Yellow; B = Brown; CYB = Clear Yellowish Brown; YR = Yellowish Red; R = Red.

The results obtained from the 3 water sample analyses suggest that all surface waters can be used for irrigation purposes with little risk of salt accumulation that cannot be overcome with normal infiltration of water through the soil pedon. The only restriction of use is for poorly drained soils (Attachment 3).

4 WATER RESOURCES

4.1 Precipitation

A listing of the rainfall gauging stations in the vicinity of the project was collected from the ACP. The seven stations listed in Table 8 characterize the rainfall pattern in the Rio Indio basin. Daily and monthly data for these stations were collected from the ACP.

Table 8 – Rainfall Stations

Name of the Station	Location and Altitude			Station No.	Period of Record	Mean Annual Rainfall
	Latitude	Longitude	Elevation			
Icacal	9°12'	80°09'	11	113-001	1959-1998	3,919
Miguel de la Borda	9°09'	80°19'	2	109-001	1975-1998	3,752
Boca de Uracillo	8°58'	80°11'	20	111-001	1975-1998	2,967
Santa Ana	8°49'	80°16'	200	105-010	1981-1999	2,247
Chiguiri Arriba	8°40'	80°11'	180	105-002	1959-1999	3,465
El Cacao	8°46'	80°01'	180	115-081	1974-1998	2,209
Ciri Grande	8°46'	80°03'	200	115-083	1974-1999	2,476

Table 9 – Monthly Precipitation Reliability

	Monthly Precipitation (mm) Exceeded 80% of the Time											
Name of the Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Icacal	50	30	20	50	305	280	380	330	260	300	400	180
Miguel de la Borda	55	30	20	50	270	240	300	310	220	290	355	180
Boca de Uracillo	55	30	20	65	235	235	195	195	200	300	280	115
Santa Ana	50	20	20	55	150	170	125	145	180	210	175	75
Chiguiri Arriba	30	20	14	45	255	300	290	360	315	380	270	90
El Cacao	12	7	4	20	195	160	125	185	230	250	175	45
Ciri Grande	18	9	3	35	205	205	150	170	220	260	210	50

	Monthly Precipitation (mm) Exceeded 50% of the Time											
Name of the Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Icacal	90	55	65	150	420	390	430	370	320	430	520	370
Miguel de la Borda	120	80	65	190	360	380	390	420	300	400	480	380
Boca de Uracillo	95	55	60	125	325	310	250	295	315	390	340	205
Santa Ana	75	40	50	90	225	230	220	200	215	295	255	135
Chiguiri Arriba	75	40	25	110	370	410	370	420	400	440	380	190
El Cacao	40	20	18	60	260	225	190	225	300	350	275	100
Ciri Grande	45	25	18	90	310	250	205	210	315	370	270	120

Monthly rainfall series for these stations are presented in Attachment 4. Statistical analysis of the monthly precipitation at these stations were performed to evaluate the degree of reliability with which rainfall can be expected. For that purpose, the monthly precipitation exceeded 50% and 80% of the time were estimated and are presented on Table 9.

4.2 River Flows

There is only one stream gauging station in the Rio Indio watershed: it is located on the Rio Indio itself, near Boca de Uracillo, 4 kilometer upstream of the proposed dam site. At that location the drainage area is 365 km^2. Flow records at that station are available from 1979 to 1998. Using statistical analysis and linear regression with flow records at gauging station in adjacent river basins, the monthly flow series at Boca de Uracillo has been extended to 51 years from 1948 to 1998. This procedure was developed in the course of the Reconnaissance Study and is presented in the Hydrology Report. The extended monthly flow series is presented in Attachment 5. This series has been used to estimate the minimum monthly flows available in other streams in the watershed. For the purpose of irrigation, the available monthly flow in a stream was defined as the monthly discharge exceeded 80% of the time. Table 10 below presents the results of this analysis for the Rio Indio and the monthly discharge per unit area used for other streams in the watershed.

Table 10 – Rio Indio Monthly Flows at Boca de Uracillo

Name of the Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Monthly Flow (m^3/s)	15.7	7.9	5.1	5.9	15.0	25.6	25.5	29.7	35.5	47.5	46.8	33.1
Monthly Flow Exceeded 80% Of the time (m^3/s)	9.1	5.2	3.3	2.8	8.8	18.3	16.9	18.6	26.5	36.0	33.8	19.0
Monthly Flow Exceeded 80% of the time (liter/s/km^2)	24.9	14.2	9.0	7.7	24.1	50.1	46.3	51.0	72.6	98.6	92.6	52.1

5 CROPPING PATTERNS AND ON-FARM WATER DEMANDS

5.1 Climate

The environmental complex of the Rio Indio watershed was analyzed to determine the factors affecting the cropping patterns. Monthly rainfall distribution, potential evapotranspiration (PET), radiation and mean temperature for three meteorological stations were collected: Icacal, Santa Ana and Boca de Uracillo. These parameters were used to define the beginning of the growing season, the duration of the growing season, the dependable rainfall and the water requirements.

The meteorological records collected from the Icacal station are assumed to represent those of the coastal area near the mouth of the Rio Indio. The climatic characteristics observed at the Boca de Uracillo station are considered to be representative of the entire Río Indio Valley downstream of the proposed dam site at El Limon, the flat area in the valley of the Río La Encantada, just East of the Río Indio Valley floodplain. The Santa Ana station represents the climate in the flat areas above and East of the proposed reservoir, in the vicinity of Nuevo Paraiso, the relatively flat areas Southwest of the proposed reservoir area, just East of Río Uracillo, and the flat areas in the vicinity of La Maceta de Río Indio, Río Indio Abajo, Quebrada Las Claras, and Río Teria.

For the purpose of cropping pattern design, onset is assumed to be the period at which the monthly precipitation (P) exceeds half of the evapotranspiration (PET/2). Offset of rains is considered as the period when PET/2 decreases below P, plus the period required to extract by evapotranspiration a maximum of 100 mm of water stored in the soil if available. Since the radiation and temperature are relatively uniform over the year, rainfall is the most important parameter of climate. Bimodal distribution of rainfall is typical except for Icacal on the coast with a distinct dip in June known locally as the "Veranito de San Juan". For all the stations, the onset of rains and growing period is about the second half of April, and extends approximately eight months, to about mid-December.

5.2 Land Types

The proposed cropping patterns must be selected to represent land types or predominant production environments in the study area. For the purpose of this report, the study area has been broken down into two fairly homogeneous land systems; the plain and the hilly land systems those roughly coincide with the lower and the intermediate Río Indio basin respectively. Farming activities are different for each land system, and therefore the description of landscape and related land features are used for the classification of the land type and cropping systems.

The plain land system of colluvial/alluvial origin, molded by rivers and streams has formed a secondary alluvium of recent origin on the banks of the Río Indio and its tributaries. Delimited to the North by the Caribbean Ocean, it follows the Río Indio, South to the proposed dam site, near the Tres Hermanas Hill, North of El Limón (see Table 11).

Table 11 – Lower Rio Indio Basin Land Characteristics

Land Characteristics	Fluvial Terraces	Side Slopes & Bench/Terraces
Location	Fluvial terraces formed by Río Indio, as the waterway transects the flood plain.	Modeled over the sedimentary substratum. Oriented predominantly to the north/landscape.
Topography	Unidirectional surface, constant slope plain, not interrupted significantly by elevations or depressions. Elevation: 5 to 15 m.	Short slope relief with up to 100 m elevation.
Soil depth	> 150 cm	50-90 cm, somewhat shallow to moderate.
Texture	Fine clay loam to silt clay loam.	Fine to medium soil; substratum fine.
Drainage	Moderately well to somewhat poorly drained.	Well to moderately drained.
Available water	Mainly Río Indio & subterranean source.	Tributaries commonly occur.
Flooding risk	Occasional flooding dependant on landscape position relative to the river.	None existence.

North of El Gaital on the central mountain chain, the Piedmont delimits the southern most extreme of the hilly land system, which lies south of the plains. The proposed reservoir and surrounding environment are within this land system (Table 12).

Table 12 – Intermediate Rio Indio Basin Land Characteristics

Land Characteristics	Fluvial Terraces [a]	Side Slopes & Mini Plains
Location	Fluvial terraces formed mostly by Río Indio, Teria, and Uracillo, near Boca de Uracillo village.	Soil originated from sedimentary substratum. Follows fault system orientation.
Topography	Unidirectional surfaces, constant slope plain on the Río Indio that narrows toward Teria, and abruptly ends in a channel land element, as the Uracillo flows into Río Indio.	Gently to moderately relief with inclined short slopes. Elevation: 100 - 300m.
Soil depth	> 150 cm	10 - 50 cm, very superficial to moderately deep.
Texture	Loam to permeable clay loam.	Medium to fine soil, fine subsoil.
Drainage	Moderately, well drained.	Well to moderately drained.
Available water	Río Indio tributaries & subterranean source.	Common, intermittent available during rainy season; water available in subsurface at some depth, but at high soil tension.
Flooding risk	Rare	None

a / The landscape position will not be considered for the cropping pattern discussion, due to the fact that it's expected to be part of the proposed reservoir.

5.3 Existing Cropping Patterns

The approach to describe the cropping system in the Río Indio watershed is based on the dominant cropping patterns that occur. Major crops and varieties for each land type recognized, and time period when grown are presented in Table 13. If more than one crop schedule is followed, each has been numbered. When the same varieties and crops are grown at the same time on different systems, the crops are listed separately and identified by numbers.

Table 13 – Existing Crops

Land Type	Crop	Varieties	Time period	Yield Estimate (tons/ha)
Rainfed wetland	Rice 1	Chino, Sedina, Peruano	Apr to Aug	1.0
Dry-land 1	Rice 2	Chino, Sedina, Peruano	May to Sept	0.7
Dry-land 2	Maize	Calillo, Local variety	15 Sept to 15 Jan	0.6 to 0.9
Dry-land 2	Bean	Chiricano	15 Oct to 15 Jan	0.75
Dry-land 1	Root crops [a]	Brasileña, Baboso, Cartagenero	15 May to 30 Jan	10, 5.0, 3.0
Dry-land	Coffee	Caracolillo, Robusta	May- perennial	0.25

[a] / Cassava, Yam, and Dasheen or a combination of the previous

Major cropping patterns for each cropping system including crops, pasture, forest or a combination of forest, stubble, and pasture are listed in Table 14. Approximate percentage area and land use intensity is estimated per pattern. The overall aggregate land use intensity index computed for the target area suggests a high anthropogenic intervention. Crops planting arrangements in time and space are separated with a hyphen (-) when in sequence, and separated with a plus (+) when simultaneously planted and overlapped 2/3 of the growing season.

Table 14 – Existing Cropping Pattern Description

Cropping Pattern	Duration (months)	Land Type	Land Use Estimate (%)	Land Use Intensity
A Rice	5	Rainfed wetland	1	0.004
B Rice+Roots-Maize+Beans	8	Dry land	8	0.053
C Coffee+Stubble	12	Dry land	2	0.020
D Oil Palm	12	Dry land - wetland	1	0.010
E Pasture [a]	12	Dry land - wetland	70	0.700
F Other [b]	12	Dry land - wetland	18	0.180
			Aggregate for the site	0.967

a/ Ratana = Ischaenum ciliares.
b/ Forest, or a combination of forest, stubble, and pasture.

Table 15 contains estimated overall occupancy of observed land holdings for principle cropping systems that represents a combination of cropping patterns in the target area. The cropping systems are identified according to an important environmental complex feature.

Table 15 – Cropping System Description

Cropping System	System Name	Cropping Pattern	Observed on Holding (%)
1	Wetland Rice	A	20
2	Mixed dryland – wetland	A, B, C, D, E	65
3	Mixed dryland	B, C	5
4	Mixed dryland - wetland	F	10

5.4 Cropping pattern design.

Because of its effect upon future direct usage of the Río Indio water resources, suitable crop selection was necessary. Two levels of input were imposed on the selected crops, and landscape positions within the basin. Critical factors such as: sustainability of the land system with respect to land use requirements and the need for coexistence of the population with the environment were considered. Accordingly, crop options were identified based on actual land use, soil adaptability, and climate.

Pertinent considerations in the definition of crops are as follows:

- The cereals are produced for dry grain only.
- The rice considered is lowland bunded irrigated.
- Bean considered is of the Vigna sinensis species.
- Readily available local crops (low input) and high yielding crops (high input) will both be considered.
- The forest and pasture management plan is mainly directed at a low input level. It is expected that crop selection would be adaptable to the predominant marginal soil condition.
- Clean production is also an adequate alternative because of the possible added value such as considerations of the reservoir water quality. Coffee is suggested to be managed as a clean crop when planted to the plain or hill land system of the Río Indio basin.

5.5 Pattern design development

Biological feasibility of pattern selection was based on matching crops with the physical condition of the land type. Technical feasibility considered the erodability of the terrain, and its effect on sedimentation of the proposed reservoir. Best management practices in the pattern design are incorporated, so as to minimize stressors originated from grazing lands, animal holding areas, crops, and other associated lands.

Irrigated bunded rice, mini sprinkler irrigation for high-density plantain crop, pasture seedbed and nursery sprinkler irrigation, are the main sources for supplementary water demand, when considering the cropping patterns design suggested, given the 3 terrain types.

The matching process of cropping patterns and landscape positions gave rise to 12 cropping systems that do not create major changes in farmers crop preferences, but guaranties the production of marketable surplus, after immediate necessities are met. The introduction of systems that contains forest tries that have multiple uses (firewood, wood, and other industrial uses), meets the sustainability criteria for the proposed watershed, by introduction of forestation practices, and the reduction of human migration thus, containment of environmental degradation at a reasonable order of magnitude (Table 16).

Table 16 – Cropping Pattern Design

Pattern [a]	Landscape Position		
	Fluvial Terraces	Side Slopes & Bench/Terraces	Side Slopes & Mini Plains
1 DSR – TPR	X		
2 TPR – TPR		X	X
3 M + RC – M + B		X	X
4 P	X	X	
5 PL	X		
6 Coffee		X	X
7 AF		X	X

[a/] DSR = Dry seeded rice, TPR = Transplanted rice, RC = Root crops, M = Maize, B = Bean, P = Pasture, PL = Plantain, AF = Agroforestry (Pinus caribeae, Acacia mangium, Byrsonima crassiofolia, Anacardium occidentale)

Crop diagram distribution in time and space, within year, is presented in Table 17. Each crop monthly occurrence and sequence can be observed. Plantains and Cassava are plotted biannually; pasture and perennial crops and/or species are included in terms of their prevalence in a nursery for stand establishment, and necessary supplementary water requirements.

5.6 Water Requirements

Because non-uniform rainfall is common in the target area, and not reasonably well distributed throughout the proposed field crops growing season, nursery demand, and old landscape positions with marginal soil attributes, are suggested as an integral part of the management system. Bunds to minimize seepage and maintain water depth are incorporated in the scheme as best management practices for rice culture. Another aspect that deserves serious attention is the consideration of water requirements for a high-density plantain system, pasture seedbed, and nursery for coffee and agro-forestry.

The supplementary irrigation water requirements for listed food crops, pasture, and perennials are estimated from PET adjusted by an appropriate crop coefficient (K_c), dependable rainfall, and appropriate irrigation system on-farm overall efficiency. That is, water readily available after infiltration through the soil profile to the root zone and plant demand. Attachment 6 presents climate variables for the Icacal, Boca de Uracillo, and Santa Ana stations. Attachment 7 contains appropriate monthly K_c for listed crop, planting season, and cropping system used for the water requirement estimation. Attachment 8 shows the assumed on-farm irrigation efficiencies.

Supplementary water requirements per crop and production practice during each growing season, for areas represented by the 3 climate stations used in the report, are calculated in Attachment 9. The water requirements have been computed for an average rainfall condition (50% exceedance) and drought conditions (80% exceedance). Soil moisture monitoring to measure the current water status in the root zone with an appropriate device, should provide an excellent check to ensure that proposed irrigation is keeping up with crop water demand.

The Icacal station with the highest dependable rainfall presents the lowest supplementary irrigation water requirement. On the other hand, the Santa Ana station that has the lowest dependable rainfall presents the highest water requirement. The water requirement presented by the Boca de Uracillo station falls between the two above extremes, which is in line with the amount of dependable rainfall estimated at this station.

Table 17 – Cropping Pattern Diagram

Crop	Month											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rice DSR – TPR												
Rice TPR – TRP												
Beans												
Maize												
Plantain yr. 1												
Plantain yr. 2												
Cassava yr. 1												
Cassava yr. 2												
Vegetables (blend)												
Yams												
Pasture - Field												
SEEDBED Pasture												
NURSERY Organic Coffee;												
Pinus caribaea;												
Acacia mangium;												
Byrsonima cras.;												
Anacardium occ.;												

6 AGRICULTURE BENEFITS

6.1 Introduction

Cost-and-return analysis and partial budget are used to calculate the return above variable cost (RAVC) for subsistence agriculture, and improved technology production, given the land types described in the preceding section. These are presented in Attachment 10. A marginal benefit-cost ratio (MBCR) of the prevalent pattern (a) and the proposed cropping pattern replacement (b) was computed as:

$$MBCR = \frac{GR(b) - GR(a)}{TVC(b) - TVC(a)} = \frac{MVP}{MVC}$$

where GR is the gross return, TVC the total variable cost, MVP is the marginal value product, and MVC the marginal value cost. The economic evaluation of cropping pattern performance comparison with the existing ones defines criteria to judge the acceptability of the proposed cropping pattern to farmer's patterns.

6.2 Present Land Use Cropping Patterns

The cropping patterns observed in the Rio Indio basin have characterized as follows:

- Rice, grown on the fluvial terraces land type of the Río Indio, down from Tres Hermanas Hills.
- Rice + Root Crops – Maize + Beans cropping pattern, grown on side slopes, bench/terraces or mini plains, of residual formation.
- Coffee, grown with nil use of chemical inputs within secondary vegetative growth, on similar land type as the before mentioned.
- Pasture of the Ischaenum ciliare species. According to the local extension service, production of cattle is limited to 1 head per hectare, to obtain a marketable product after 3 years.

6.3 Proposed Cropping Patterns

The following describes the general characteristics of the proposed croppimg patterns:

- Dry Seeded Rice - Transplanted Rice culture, on the fluvial terraces of the lower Río Indio watershed North of Tres Hermanas Hills.
- Transplanted Rice - Transplanted Rice cropping pattern proposed for the land type of residual formation.
- Maize + Root Crops - Maize + Beans, proposed for the identical environmental complex as the above.

- Pasture of Braccharia humbidicola species that may maintain 2 – 3 cattle per hectare. To obtain marketable conditions, a turnaround period of 2 years is estimated to obtain physical development. The proposal is limited to the lower Río Indio watershed fluvial terraces land type. The reason, possible increase of reduced water infiltration because of destruction of soil pore space of the predominant soil type of the residual terraces, if cattle are maintained in the highly erodable terrain.
- Plantain intensive cropping pattern proposal for the fluvial terraces at the lower Río Indio watershed.
- Coffee, clean culture cropping pattern proposal for the residual terraces land type, at the lower or intermediate Río Indio watershed.
- Timber of the Pinus caribaea var. hondurensis cropping pattern option, for the environmental complex of residual origin. The species selection is based on the soil attribute associated with a probable occurrence of high aluminum saturation, and predominant acidic soil condition.

6.4 Marginal benefit-cost ratio for cropping patterns comparisons.

For the purpose of the following discussion, the present cropping pattern comparison with its replacement is the following:

- Rice subsistence (Fluvial Terraces) versus DSR – TPR (Fluvial Terraces) or Plantains (Fluvial Terraces).
- M + RC – M + B subsistence (Residual Terraces) versus M + RC – M + B improved technology (Residual Terraces) or TPR –TPR (Residual Terraces).
- Coffee subsistence versus Coffee improved technology - low input or Timber.

Overall land use conversion of the intermediate and upper Río Indio basin, is intended to transform the present landscape to a Timber environmental complex, that will be ideal to the general long term purpose of the Río Indio Project. For that reason, it is necessary to meet the inhabitant's demands for food in the immediate future by introducing improved technology. Eventually, the main present activity of this population would evolve to be that off service providers of other non-agricultural or secure environmental activities, that would guarantee a better quality of life.

As a result of the MBCR per comparison, the cropping patterns most likely to replace the existing is the option that offers the highest MBCR, for the switch from the present pattern to the proposed alternative (Table 18).

For the rice subsistence present cropping pattern on fluvial terraces, Plantains gave the best MBCR. However, DSR - TPR with also an above 30 % return, has the highest RAVC. The second comparison of net return (equal or more than 30 %) and MBCR, allows to determine that the alternative M + RC – M + B improved technology high input of the plain land system, will be favored to expand on the residual terraces. For the intermediate basin, farmers may not be willing to invest on more labor and materials per hectare than for the prevalent land use. Alternatively, the prospective shift among farmer's present cropping patterns on similar land type for clean production of Coffee and Timber, were exceedingly the best option shift possible for the land type.

It is expected that the best management practice for the intermediate Río Indio watershed is the Timber option, because of the economic evaluation. However, but more important, it is the most environmentally secure pattern, given the purpose for the creation of the reservoir, and the immediate aim to maintain it's effectiveness as a sustainable water source.

Table 18 – Cropping Patterns Marginal Benefit-Cost Ratio

Pattern	Gross Return	Total Variable Cost	Return Above Variable Cost	Marginal Value Product	Marginal Value Cost	Marginal Benefit-Cost Ratio
Subsistence						
Maize	163.80	141.43	22.37			
Beans	273.00	158.54	114.46			
Cassava	409.50	244.80	164.70			
Total	1010.10	686.20	323.90			
Rice – Fluvial Terraces	213.48	140.23	73.25			
Coffee	350	403.00	-53			
Proposed Rice Subsistence Replacement Pattern						
DSR - TPR (a)	5241.60	3619.84	1621.76	5028.96	3479.61	1.44
Plantains 2° YR (a, c)	756.00	429.15	326.85	542.52	288.92	1.88
Pasture (a, c)	646.95	528.98	117.97	433.47	388.75	1.11
Proposed M + RC - M + B Subsistence Replacement Pattern						
M + RC [1] – M + B (b, c)	2656.00	1617.35	1038.65	1645.90	931.15	1.77
M + RC - M + B (b, d)	1815.50	1324.14	491.36	805.40	637.94	1.26
TDR - TPR (b, d)	4368.00	4093.06	274.94	3357.90	3406.86	0.99
Proposed Coffee ReplacementPattern						
Timber Annualized (b)	2458.01	481.13	1976.88	2108.01	78.13	26.98
Coffee 2° YR (b, c)	1261.00	705.86	555.14	911.00	302.86	3.01

(a) Fluvial Terraces; (b) Residual Terraces; (c) Improved Technology. High Input; (d) Improved Technology. Low Input.
[1/] RC = Cassava.

7 POTENTIAL DEVELOPMENTS

7.1 Potential Development Areas

As a result of the land resources investigation, eight potential development areas having a combined gross surface area of approximately 5,500 hectares were outlined on the 1:50,000 scale maps on the basis of the Land Capability for Irrigation Map. The location of the potential development areas is presented on Exhibit 3.

The potential development areas are generally located on Class 2 and Class 3 lands identified as arable land in the Land Capability for Irrigation Map. The potential development areas, the gross surface areas in hectares and the estimated net surface areas in hectares are as follows:

Table 19 - Potential Development Areas

Area No.	Area Location	Gross Area (ha)	Net Area (ha)
1	Mouth of Rio Indio	377	300
2	Rio Indio valley	1,249	1,025
3A	La Encantada	445	250
3B	La Encantada	2,263	1,000
4	El Papayo	307	200
5	Nuevo Paraiso	878	450
6	Las Marias	118	100
7	Rio Indio Abajo	63	50
8	Tierra Buena	266	150

The net surface areas were estimated after deducting part of the gross areas to account for the off-farm hydraulic and other infrastructure, the on-farm infrastructure and other unusable land such as land occupied by rivers and other streams and water bodies, unsuitable micro relief, areas with poor drainage or soils conditions. In addition, in the case of Nuevo Paraiso, the net area was further reduced because it is estimated that the minimum flow in the Rio Teria would be insufficient to fully develop the area. In the case of La Encantada, two alternatives 3A and 3B were considered.

Area No.1 - Mouth of Rio Indio The area is located in the lowest part of the Rio Indio valley, immediately upstream of the mouth at its point of discharge in the Caribbean Sea. Part of this area is located on the right bank, on class 3s/LA lands and part of it lies on the left bank. The area is below El.20. The area water supply would be taken from the Rio Indio.

Area No.2 - Rio Indio Valley This area consists of the approximately 20 km long stretch of the Rio Indio Valley downstream of the proposed dam site and immediately upstream of Area No.1 and the 6 km long lowest portion of the Rio Jobo, a left tributary of the Rio

Indio. The area consists of class 2s/GA lands. The area that could be developed along the downstream portion and all along the right bank of the Rio Indio Valley lies below El.20, whereas the area in the upper part of the left bank of the Rio Indio valley and along the Rio Jobo is located below El.40. The source of water supply would be the Rio Indio. Because of the long and narrow configuration, several water intakes will be needed to supply this area.

Area No.3 - La Encantada This area, in the valley formed by the Quebrada La Encantada, a right tributary of the Rio Indio, is situated east of the Rio Indio Valley and downstream from the proposed dam. As stated above, two development alternatives are envisaged. Alternative 3A, the smaller option, would consist of development of class 3sd/GB lands located approximately below El. 40 with water supplied from the Rio Indio, downstream of the proposed dam. Alternative 3B, the larger option, would develop both the 2sd/GB lands and the higher 3t/GB lands below El. 80. Because of its higher position, the water supply could be tapped directly from the proposed reservoir.

Area 4 - El Papayo This area is located on class 3t/GB lands, in the headwaters of the Rio Jobo, to the west and downstream of the proposed dam. The area that could be developed lies approximately below El. 100. Because of the reduced low flow in the Rio Jobo, and considering its position with respect to the proposed reservoir, the water supply from the Rio Jobo would be supplemented by supply taken from the proposed reservoir. Otherwise the development of this area would not be feasible or the development area would have to be substantially reduced by about 75%.

Area 5 - Nuevo Paraiso This area is located to the east of the proposed Rio Indio Reservoir, some 12 km southeast of the proposed dam site, approximately 2 km east of the reservoir portion that would be created along the Valley of the Rio Teria, a right tributary of the Indio. The area that could be developed consists of class 3t/GB lands located below El.155 outside the boundaries of the Rio Indio watershed, in the Rio Ciri watershed that drains into Gatun Lake. The water supply for this area would be taken from the Rio Teria. Despite the fact that the area is outside the Rio Indio watershed, the area is considered as being favorably located with respect to several of the populated areas in the proposed reservoir and could compensate part of the arable lands that would be flooded by the reservoir. The net area that could be developed was reduced by 4% considering the available low flow estimated at Rio Teria.

Area 6 - Las Marias This area is located on class 3t/GB lands, approximately 5 km upstream from the proposed reservoir, in the upper valley of the Rio Uracillo. The area that could be developed lies approximately below El.170 and would be supplied from Rio Uracillo.

Area7 - Rio Indio Abajo This area is located on class 3t/GB land in the upper valley of the Rio Indio, some 15 km upstream from the proposed reservoir. The lands that could be developed are situated below El.220. Water supply for this area would be from the Rio Indio.

Area 8 - Tierra Buena This area is located on class 3t/GB lands, just upstream from the proposed reservoir, some 2 km downstream from Las Marias (Area 6), in the upper valley of the Rio Uracillo. The lands that could be developed are situated below El. 180. The area water supply source would be the Rio Uracillo.

7.2 Available Flows

The minimum flows available at the streams other than those which flows would be controlled by the proposed storage dam, after deducting the minimum flow required for environmental purposes, were estimated at 6.6 liters per second per square kilometer.

The estimated minimum flows available, which could be used for supplying water to the areas located upstream of the proposed Rio Indio Dam and Reservoir and in the headwaters of the Rio Jobo, are as follows:

Table 20 – Estimated Available Flows

Proposed Area	Source of Water	Catchment Area (km^2)	Available Min. Flow (liter/sec)
El Papayo	Rio Jobo at El 65	7	46
Nuevo Paraiso	Rio Teria at El 80	70	460
Las Marias	Rio Uracillo at El 125	23	152
Rio Indio Abajo	Rio Indio at El 220	40	264
Tierra Buena	Rio Indio at El 120	50	330

The water supply for Areas 1, 2 and 3 would be either the reservoir regulated releases into the Rio Indio, downstream of the dam through the power plant, or in the case of Alternative 3-B, it would be extracted directly out of the reservoir through a pumping station located in the vicinity of the dam.

7.3 Water Requirements

The supplemental irrigation water requirements vary according to crops grown, the growing season, the precipitation (rainfall) occurrence, the method of irrigation used and the irrigation efficiencies. Estimated overall irrigation efficiencies vary from 50% in the case of surface/flood irrigation for rice to 60% for sprinkle systems in crops such as maize and 65% for micro-sprinkler systems used in tree crops and drip systems used in vegetables and tree crops. Surface irrigation methods require on-farm open channels whereas sprinkler, micro-sprinkle and drip systems or combinations thereof require on-farm pressure pipe. All crops can be irrigated by surface methods but not all crops can be irrigated by pressure systems. Water losses are usually lower in the case of pressure systems thus resulting in higher irrigation efficiencies.

Monthly and annual supplemental irrigation water requirements were estimated for 80% rainfall exceedance for the purpose of establishing design flows and for sizing the irrigation facilities and for 50% exceedance to estimate the mean water and energy requirements.

A summary of the annual supplemental irrigation requirements is given below, expressed in cubic meters per hectare per year.

Table 21 – Average Annual Supplemental Water Requirements (m^3/ha/yr)

Crops	Area 1	Areas 2, 3 and 4	Areas 5, 6, 7, and 8
Rice DSR-TPR	0	162	950
Rice TPR-TPR	440	700	1,208
Plantains-Yr 1	3,041	3,634	4,984
Plantains-Yr 2	3,184	3,791	5,143
Pastures-Field	2,782	3,272	4,782
Associated Crops: (Maize, beans, roots Crops)	90	282	744
Vegetables	1,103	1,268	1,128
Pineapple	85	231	638
Misc. Fruit Trees	1,320	1,666	1,953
Cacao	2,200	2,507	3,846
Pasture-Seed	1,792	2,210	3,370
Nursery:			
Coffee	662	852	1,382
Pinus Caribaea	1,088	1,286	2,325
Acacia Mangium	735	924	1,523
Byrsonima C.	735	924	1,523
Anacardium Occ.	735	924	1,523

In order to establish the design flows, the peak month requirements for 80% rainfall exceedance were estimated for various options regarding crops and crop distributions in percentage of the total net areas. A summary of the peak monthly supplemental irrigation water requirements per hectare expressed in cubic meters per month is given in Table 22.

Table 22 – Peak Monthly Supplemental Irrigation Water Requirements (m^3/ha/mth)

Crop	Area 1	Areas 2, 3 and 4	Areas 5, 6, 7 and 8
Rice DSR-TPR	1,710 (4)	1,360 (4)	1,650 (4)
Rice TPR-TPR	1,240 (1)	1,500 (1)	1,600 (1)
Plantains-Yr 1	2,050 (3)	2,070 (3)	2,050 (3)
Plantains-Yr 2	2,070 (3)	2,090 (3)	2,070 (3)
Pastures-Field	2,013 (3)	2,150 (3)	2,130 (3)
Associated Crops:			
(Maize, beans, roots Crops)	820 (1)	1,010 (1)	1,190 (12)
Vegetables	1,590 (3)	1,600 (3)	1,590 (3)
Pineapple	750 (3)	750 (3)	750 (3)
Misc. Fruit Trees	1,360 (3)	1,370 (3)	1,360 (3)
Cacao	1,800 (3)	1,820 (3)	1,800 (3)
Pasture-Seed	1,750 (3)	1,770 (3)	1,750 (3)
Nursery:			
Coffee	1,280 (3)	1,290 (3)	1,280 (3)
Pinus Caribaea	1,580 (3)	1,590 (3)	1,580 (3)
Acacia Mangium	1,330 (3)	1,340 (3)	1,330 (3)
Byrsonima C.	1,330 (3)	1,340 (3)	1,330 (3)
Anacardium Occ.	1,330 (3)	1,340 (3)	1,330 (3)

(1) January; (2) February; (3) March; (4) April; (12) December.

As can be seen in the above table, most of the peaks occur in March. The following options were considered for estimating the peak design flows:

Area 1 - Three options were considered for area 1,as follows:

- Option 1:consisting of rice, plantains(or bananas) and pastures, each crop planted over 1/3 of the area
- Option 2: consisting of pastures only over the entire area.
- Option 3: plantains (or bananas) over the entire area.

The average peak water demand for the 3 options, assuming an irrigation system operating during 18 hours per day, would be 0.9 liters per second per hectare. The peak design flow adopted in this study was 1 liter per second per hectare in order to provide flexibility in the choice of crops and system operation.

Areas 2,3 and 4 - Four options were considered for there areas:

- Option 1,consisting of rice, plantains (or bananas), pasture, vegetables, fruit trees and agro-forestry nurseries, with these crops equally distributed over each of these areas, i.e., each crop planted on 20% of the land, in each area.
- Option 2,including plantains (or bananas), pastures, vegetables and fruit trees equally distributed in each area, with each crop planted on 25% of the land ,in each area.
- Option 3,plantain (or bananas),pastures and fruit trees equally distributed ,with each crop planted on 1/3 of the land, in each area.
- Option 4,made of pastures, fruit trees and vegetables equally distributed ,with each crop planted on 1/3 of the land, in each area.

The average peak water demand for the 4 options, assuming an irrigation system operating during 18 hours per day, would be 0.85 liters per second per hectare. The peak design flow adopted in this study was 1 liter per second per hectare in order to provide flexibility in the choice of crops and system operation.

Areas 5, 6, 7 and 8 - Three options were considered for these areas. In order to minimize erosion and sediment production, pastures were not included among the crops considered. The options were as follows:

- Option 1:consisting of vegetables, fruit trees and nurseries, plantains (or bananas), and associated crops (maize, beans, root crops) equally distributed over each of these areas, with each crop planted over 1/4 of the land, in each area.
- Option 2: including rice, fruit trees, plantains (or bananas),and vegetables equally distributed, i.e., each crop planted over 1/4 of the land , in each area.
- Option 3: Vegetables, plantains (or bananas) and fruit trees, with each crop planted over 1/3 of the land, in each area.

The average peak demand for the 3 options, assuming an irrigation system operating during 18 hours per day, would be 0.7 liters per second per hectare. The peak design flow adopted in this study was 0.8 liters per second per hectare in order to provide flexibility in the choice of crops and system operation.

For each of the potential areas, the monthly water demand for an average year and a drought year were calculated based on the considerations developed above. These demands are presented on Table 23.

Table 23 – Monthly Water requirements for the Potential Areas (,000 m^3)

Monthly water demand during an average year

	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Area No1 - Boca del Rio Indio	300	152	299	359	-	-	-	-	-	-	-	-	-	810
Area No.2 - Rio Indio Valley	1,025	457	866	1,116	25	-	-	-	-	-	-	-	-	2,464
Area No.3A - La Encantada	250	111	211	272	6	-	-	-	-	-	-	-	-	601
Area No.3B - La Encantada	1,000	445	845	1,089	24	-	-	-	-	-	-	-	-	2,404
Area No.4 - El Papayo	200	89	169	218	5	-	-	-	-	-	-	-	-	481
Area No.5 - Nuevo Paraiso	450	280	392	454	101	-	-	-	-	-	-	-	14	1,240
Area No.6 - Las Marias	100	62	87	101	22	-	-	-	-	-	-	-	3	276
Area No.7 - Rio Indio Abajo	50	31	44	50	11	-	-	-	-	-	-	-	2	138
Area No.8 - Tierra Buena	150	93	131	151	34	-	-	-	-	-	-	-	5	413

Monthly water demand during a drought year

	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Area No1 - Boca del Rio Indio	300	358	411	560	352	-	-	-	-	-	-	-	-	1,681
Area No.2 - Rio Indio Valley	1,025	1,006	1,261	1,747	681	-	-	-	-	-	-	-	88	4,783
Area No.3A - La Encantada	250	245	308	426	166	-	-	-	-	-	-	-	21	1,167
Area No.3B - La Encantada	1,000	981	1,230	1,705	665	-	-	-	-	-	-	-	85	4,666
Area No.4 - El Papayo	200	196	246	341	133	-	-	-	-	-	-	-	17	933
Area No.5 - Nuevo Paraiso	450	415	507	628	298	-	-	1.4	-	-	-	-	260	2,109
Area No.6 - Las Marias	100	92	113	140	66	-	-	0.3	-	-	-	-	58	469
Area No.7 - Rio Indio Abajo	50	46	56	70	33	-	-	0.2	-	-	-	-	29	234
Area No.8 - Tierra Buena	150	138	169	209	99	-	-	0.5	-	-	-	-	87	703

7.4 Irrigation Schemes

For all cases, except Area 7, the water has to be lifted at the main intake by means of a pumping station because of the lands position with respect to the probable water source. If the latter was not provided, a gravity intake on the same water source would have to be located further upstream, at a site with considerably smaller available minimum flow, thus rendering such system largely insufficient to meet the peak water demands. Area 7 is the only area that lends itself to taking the water from the source by gravity.

For all areas, by assuming an irrigation system operating during 18 hours per day, the hydraulic system would have the capability of pumping water at the intake area during the off-peak hours of the day only, assuming the pumps are driven by electric motors.

Each irrigation scheme would consist of a main hydraulic system including a water intake, a pumping station if required, a main canal, one or more branch canals, canal structures, a water distribution system between the canals and the farm gates ,off farm drainage and roads and on-farm irrigation and drainage systems. The principal canal structures include turnouts/off-takes to supply the distribution system, check structures to control water levels and flows along the canals, flow division structures to distribute the flows between the main canal and a branch or between two branch canals, drop or chute structures in case of a sudden drop in canal water levels, inverted siphon crossings, safety spillways along the canals, wasteways at the lower end of the canals, and bridge structures. In some cases, relift pump stations to supply higher areas are also required.

A layout of the main irrigation systems for the 8 study areas was done on the 1:50,000-scale maps. The main system layouts are presented on Exhibits 4 through 14.

Area 1. The proposed main irrigation system layout for Area 1, Boca del Rio Indio, is shown on Exhibit 4. The layout consists of two separate irrigation systems, one in the right bank and another one on the left bank. Each of these systems includes a pumping station on the Rio Indio, a main canal and several canal structures: the main characteristics of the system are outlined in Table 24.

Table 24 – Irrigation System Characteristics of Potential Area 1

Potential Area	Sectors	Net Area (ha)	Design Discharge (m3/s)	Pumping Station		Canal Length (Km)	Siphon Length (m)
				No.	Hp		
Area No1 - Boca del Rio Indio	Right Bank	150	0.150	3	40	1.8	-
	Left Bank	150	0.150	3	40	1.5	-

Area 2. The proposed main irrigation system layout for Area 2, Rio Indio Valley, is presented in Exhibits 4, 5 and 6.Because of the land configuration consisting of narrow long strips along the Rio Indio and Rio Jobo valleys, the layout consists of 12 individual subsystems, each comprising a pumping station on the Rio Indio, a main canal and several canal structures. One of these canals (main canal C), supplying part of the Rio Indio and Rio Jobo Valleys includes two branch canals. Main canal D includes one branch. The main characteristics of the system are outlined in Table 25.

Table 25 - Irrigation System Characteristics of Potential Area 2

Potential Area	Sectors	Net Area (ha)	Design Discharge (m3/s)	Pumping Station		Canal Length (Km)	Siphon Length (m)
				No.	Hp		
Area No.2 - Rio Indio Valley	Main Canal A	70	0.100	3	30	5.1	700
	Main Canal B	10	0.010	3	15	1.9	150
	Branch Canal B-1	10	0.010			1.2	
	Main Canal C	20	0.300	3	100	1.9	
	Branch Canal C-1	90	0.100			3.4	550
	Branch Canal C-2	190	0.200			9.6	1045
	Main Canal D	180	0.200	3	50	8.6	635
	Branch Canal D-1	20	0.025			2.5	
	Main Canal E	20	0.025	3	3	0.6	
	Main Canal F	20	0.025	3	3	1.4	
	Main Canal G	200	0.200	3	50	7.9	910
	Main Canal H	85	0.100	3	30	4.4	105
	Main Canal I	50	0.050	3	8	1.1	
	Main Canal J	20	0.025	3	3	0.4	
	Main Canal K	20	0.025	3	3	1.0	
	Main Canal L	20	0.025	3	3	0.9	

Area 3A. As stated above, two alternative developments were considered for Area 3, La Encantada: a smaller 3A alternative and a larger 3B alternative. The proposed layout for alternative Area 3A is shown in Exhibit 7. The main irrigation system consists of a pumping station on the Rio Indio, a main canal and several canal structures, the main characteristics of the system are presented in Table 26. The potential areas 1, 2 and 3A will use water from the regulated releases from Rio Indio reservoir.

Table 26 - Irrigation System Characteristics of Potential Area 3A

Potential Area	Sectors	Net Area (ha)	Design Discharge (m3/s)	Pumping Station		Canal Length (Km)	Siphon Length (m)
				No.	Hp		
Area No.3A - La Encantada	Main Canal Sect 1	100	0.250	3	100	6.0	
	Main Canal Sect 2	115	0.150			5.1	410
	Main Canal Sect 3	35	0.050			2.7	120

Area 3B. The proposed layout for alternative Area 3B is presented on Exhibits 8 and 9. The principal irrigation system comprises a pumping station installed on the shore of the proposed reservoir, a main canal, three branch canals and several canal structures; the characteristics of the system are presented in Table 27.

Table 27 - Irrigation System Characteristics of Potential Area 3B

Potential Area	Sectors	Net Area (ha)	Design Discharge (m3/s)	Pumping Station		Canal Length (Km)	Siphon Length (m)
				No.	Hp		
Area No.3B - La Encantada	Main Canal Sect 1	-	1.000	5	150	4.6	690
	Main Canal Sect 2	80	0.600			2.2	
	Branch Canal 1 Sect 1	330	0.500			7.5	165
	Branch Canal 1 Sect 2	90	0.200			2.7	275
	Branch Canal 2 Sect 1	120	0.400			8.4	440
	Branch Canal 2 Sect 2	100	0.200			8.2	530
	Branch Canal 3	280	0.300			3.5	1130

Area 4. The proposed principal hydraulic system layout for Area 4, El Papayo, is shown on Exhibit 10. This system has two main components: an irrigation system and a water-transfer system. The main irrigation system includes a pump station on the Rio Jobo, a main canal, two branch canals, a re-lift pump station and related canal structures. The transfer system consists of a pump station on the proposed reservoir and related waterway to transfer water from the proposed reservoir to the headwaters of the Rio Jobo: the characteristics are given in Table 28.

Table 28 - Irrigation System Characteristics of Potential Area 4

Potential Area	Sectors	Net Area (ha)	Design Discharge (m3/s)	Pumping Station		Canal Length (Km)	Siphon Length (m)
				No.	Hp		
Area No.4 - El Papayo	Main Canal	125	0.200	3	125	5.5	510
	Branch Canal 1	25	0.025	3	100	1.0	
	Branch Canal 2	50	0.050	3	15	1.5	

Area 5. The layout of the main irrigation system proposed in Area 5, Nuevo Paraiso, can be seen on Exhibit 11. The main system components are a pump station on the Rio Teria immediately upstream from the proposed reservoir, a main canal, two branch canals and several canal structures. The main canal would transfer water from the Rio Indio Basin to the neighboring Rio Ciri Basin, which is part of the present Panama Canal Basin, for irrigation of Area 5. the characteristics of the system are shown in Table 29.

Table 29 - Irrigation System Characteristics of Potential Area 5

Potential Area	Sectors	Net Area (ha)	Design Discharge (m3/s)	Pumping Station		Canal Length (Km)	Siphon Length (m)
				No.	Hp		
Area No.5 - Nuevo Paraiso	Main Canal	-	0.450	4	250	3.6	
	Branch Canal 1-Sect 1	150	0.250			2.4	1120
	Branch Canal 1-Sect 2	100	0.100			4.1	240
	Branch Canal 2	200	0.200			3.7	120

Area 6. Exhibit 12 shows the layout of the main irrigation system proposed for Area 6, Las Marias. The proposed hydraulic system would consist of a pumping station on the Rio Uracillo, a main canal, two branch canals, a re-lift pump station and several canal structures; their characteristics are shown on Table 30.

Table 30 - Irrigation System Characteristics of Potential Area 6

Potential Area	Sectors	Net Area (ha)	Design Discharge (m3/s)	Pumping Station		Canal Length (Km)	Siphon Length (m)
				No.	Hp		
Area No.6 - Las Marias	Main Canal	50	0.100	3	40	1.8	180
	Branch Canal 1	25	0.025	3	15	1.5	360
	Branch Canal 2	25	0.025			1.1	420

Area 7. The proposed main irrigation system layout for Area 7, Rio Indio Abajo, is presented on Exhibit 13. This is a completely gravity system and it comprises an intake, including a small weir on the upper Rio Indio, a main canal, two branch canals, and related canal structures those characteristics are shown on Table 31.

Table 31 - Irrigation System Characteristics of Potential Area 7

Potential Area	Sectors	Net Area (ha)	Design Discharge (m3/s)	Pumping Station		Canal Length (Km)	Siphon Length (m)
				No.	Hp		
Area No.7 - Rio Indio Abajo	Main Canal	15	0.050			2.0	
	Right Branch Canal	10	0.010			0.8	
	Left Branch Canal	25	0.025			1.3	300

Area 8. Exhibit 14 shows the proposed layout of the main irrigation system in Area 8, Tierra Buena. The main facilities include a pump station on the Rio Uracillo, upstream of the proposed reservoir and downstream of Area 6, a main canal and related canal structures. The characteristics of the system are given in Table 32.

Table 32 - Irrigation System Characteristics of Potential Area 8

Potential Area	Sectors	Net Area (ha)	Design Discharge (m3/s)	Pumping Station		Canal Length (Km)	Siphon Length (m)
				No.	Hp		
Area No.8 - Tierra Buena	Main Canal Sect 1	100	0.150	3	100	4.6	
	Main Canal Sect 2	50	0.050			1.2	300

7.5 Construction Cost Estimates

Based on the proposed developments and the water requirements for irrigation the primary conveyance systems including pump stations, primary canals, siphons and hydraulic structures were sized. For each irrigation sector, a cost estimate was developed for the primary conveyance system. Typical canal sections, pump stations and structures as shown on Exhibits 15 to 24 were used to estimate quantities and costs. Details of the cost estimates are presented in Attachment 11. Table 33 below shows a summary of the development cost for each potential area.

Table 33 – Construction Cost Estimate (US$,000)

Potential Area	Net Area (ha)	Primary Conveyance Cost	Off-Farm System Cost	On-farm System Cost	Cont. (25%)	Eng & Adm (10%)	Total Const. Cost
Area No1 - Boca del Rio Indio	300	$ 1,331	$ 525	$ 450	$ 577	$ 288	$ 3,171
Area No.2 - Rio Indio Valley	1025	$10,340	$ 1,138	$ 1,538	$ 3,254	$ 1,627	$ 17,895
Area No.3A - La Encantada	250	$ 2,418	$ 438	$ 375	$ 808	$ 404	$ 4,442
Area No.3B - La Encantada	1000	$ 8,465	$ 1,750	$ 1,500	$ 2,929	$ 1,464	$ 16,107
Area No.4 - El Papayo	200	$ 2,434	$ 222	$ 300	$ 739	$ 370	$ 4,065
Area No.5 - Nuevo Paraiso	450	$ 3,229	$ 788	$ 675	$ 1,173	$ 586	$ 6,451
Area No.6 - Las Marias	100	$ 1,082	$ 111	$ 150	$ 336	$ 168	$ 1,847
Area No.7 - Rio Indio Abajo	50	$ 461	$ 56	$ 75	$ 148	$ 74	$ 814
Area No.8 - Tierra Buena	150	$ 1,161	$ 167	$ 225	$ 388	$ 194	$ 2,135

7.6 Operation and Maintenance Cost Estimates

The operation and maintenance (O&M) cost have been estimated on an annual basis as a percentage of the construction cost as follows:

- Primary Conveyance System:
  - Civil Works: 0.5%
  - Mechanical and Electrical: 4.0%
  - Energy Cost: $0.07/KWh
- Distribution (Secondary and Tertiary), Drainage and Roads:
  - Total Cost: 1.5%
- On-Farm Irrigation:
  - Total Cost: 2.0%

- Energy Cost: $0.07/KWh

For each of the potential area, the annual energy requirements for the off-farm system (main pump station) and the on-farm distribution, have been calculated on the basis of the water demand in an average year in terms of precipitation. These energy requirements are shown on Table 34 below. For the purpose of these estimates, in the case of Areas 3B and 4 where the irrigation water is extracted directly from the Rio Indio reservoir, it has been assumed that it was operated to a minimum pool level at El. 50.

Table 34 – Average Annual Energy Requirements

Potential Area	Primary Conveyance Energy Requirement (KWh/yr)	On-Farm System Energy Requirement (KWh/yr)
Area 1 - Boca del Rio Indio	103,100	92,100
Area 2 - Rio Indio Valley	153,000	159,500
Area 3A – La Encantada	115,400	61,400
Area 3B – La Encantada	353,600	245,500
Area 4 – El Papayo	235,400	46,000
Area 5 – Nuevo Paraiso	459,100	135,000
Area 6 – Las Marias	66,300	27,600
Area 7 – Rio Indio Abajo	-	15,500
Area 8 – Tierra Buena	121,500	46,000

The total annual O&M cost are presented in Table 35 below.

Table 35 – Annual Operation and Maintenance Cost Estimates (US$)

Potential Area	Primary Conveyance	Off-Farm Distribution	On-Farm System	Total
Area 1 - Boca del Rio Indio	21,500	7,900	15,400	44,800
Area 2 - Rio Indio Valley	97,000	17,100	42,000	156,100
Area 3A – La Encantada	25,700	6,600	11,800	44,100
Area 3B – La Encantada	81,300	26,300	47,200	154,800
Area 4 – El Papayo	42,800	3,300	9,200	55,300
Area 5 – Nuevo Paraiso	61,800	11,800	23,000	96,600
Area 6 – Las Marias	15,700	1,700	4,900	22,300
Area 7 – Rio Indio Abajo	2,300	800	2,600	5,700
Area 8 – Tierra Buena	19,600	2,500	7,700	29,800

7.7 Estimated Agricultural Net Benefits

Based on the cropping pattern options for each area (7.3), and the estimated net benefits per hectare (Attachment 10), the average net benefits for each potential area were calculated and are presented in Table 36 below. The average annual crop productions were adjusted to take into consideration the class of soil and the topography of each area.

For each area, the construction cost, annual O&M costs and annual net benefits are summarized in Table 37.

Table 36 – Estimated Net Benefits

Potential Area	Net Area	Net Benefit (US$/yr)
Area 1 – Boca del Rio Indio	300	380,000
Area 2 - Rio Indio Valley	1,025	2,608,000
Area 3A – La Encantada	250	509,000
Area 3B – La Encantada	1,000	2,035,000
Area 4 -- El Papayo	200	356,000
Area 5 – Nuevo Paraiso	450	822,000
Area 6 – Las Marias	100	182,600
Area 7 – Rio Indio Abajo	50	91,300
Area 8 – Tierra Buena	150	273,800

For the purpose of comparing the potential areas, an internal rate of return has also been calculated for each area. In general, the construction period of the developments has been estimated to be one year, except for Area 2 and Area 3B for which it is estimated thyat two years will be required. The net benefits have been assumed to grow progressively from 50% the first year of production to 75% the second year and 100% thereafter. It should be noted that the costs of development exclude the construction cost of the Rio Indio dam and auxiliary structures as well as the cost of land acquisition for the potential irrigated areas.

Table 37 – Internal Rate of Return for Potential Areas

Potential Area	Construction Cost	O&M Cost	Net Benefit	Internal Rate of Return
Area 1 – Boca del Rio Indio	3,171,000	44,800	380,000	9.7%
Area 2 - Rio Indio Valley	17,895,000	156,100	2,608,000	11.8%
Area 3A – La Encantada	4,442,000	44,100	509,000	9.5%
Area 3B – La Encantada	16,107,000	154,800	2,035,000	10.2%
Area 4 – El Papayo	4,065,000	55,300	356,000	6.7%
Area 5 – Nuevo Paraiso	6,451,000	96,600	822,000	10.3%
Area 6 – Las Marias	1,847,000	22,300	182,600	8.0%
Area 7 – Rio Indio Abajo	814,000	5,700	91,300	9.7%
Area 8 – Tierra Buena	2,135,000	29,800	273,800	10.5%

8 TECHNICAL ASSISTANCE AND TECHNOLOGY TRANSFER

A program of technical assistance, training and technology transfer to the farmers would benefit the human resources available and increase the chance of success in accomplishing the productive activities planned for the development of the agricultural and irrigation potential in the Rio Indio study area.

Its objectives would be to promote the farm management, increase productivity levels, reduce production costs, adopt new and improved technologies and modernize the existing agriculture, agro-forestry and livestock activities, which are the principal economic activities in the project area.

The present model used in research and technology transfer is based on improving the offer of technical know-how to the farmers by means of technical assistance and training.

A great responsibility will be imposed on the technical personnel that will implement such program, considering the limitations of the farmers in the project area. The implementation of the technical assistance should consider the adoption of valid technologies by the farmers considering their needs and possibilities, the site conditions and the farmers organization; priorities should be established by the extensionists and recommendations should be given for the solution of the main technological issues/ problems regarding the farming, agro-forestry and livestock activities, with the farmers in the field. Practical alternatives should be recommended for their implementation by the farmers. The results of the various methods and actions should be evaluated in order to improve learning based on actual experience. The training and technology transfer should be designed and implemented as part of and to supplement the overall strategy.

The farmers that will benefit from the program should be selected carefully, so as to accept those who appear to be the most appropriate.

The Executing Agency could be established in a major nearby town such as La Chorrera and could be moved to a town such as Penonomé in the future, when the project is expanded to the Rio Coclé del Norte basin and a road linkage is built between Penonomé and the Rio Indio basin.

The ACP activities related to agricultural and irrigation development should be coordinated with related activities by other government agencies such as the Ministry of Agricultural Development (MIDA), Ministry of Public Health, Ministry of Education, Ministry of Public Works, Autoridad Nacional del Ambiente, Instituto de Investigaciones Agropecuarias.

The estimated requirements of technical and administrative personnel are given in Table 38. A 10 - year budget estimate is given in Table 39.

Table 38 - Estimated Personnel Requirements for Technical Assistance

Description	Quantity	Monthly Salary US$	Annual Cost US$ [1]
Chief Engineer	1	1,000	15,000
Agronomist Eng.	4	800	48,000
Forestry Eng.	2	800	24,000
Livestock Veterinarian	2	800	24,000
Sociologist	3	600	27,000
Secretary	1	450	6,750
Accountant	1	450	6,750
Book keeper	1	400	6,000
Store keeper	1	500	7,500
Clerk	1	350	5,250
Watchman	2	350	10,500
TOTALS			**180,750**

[1] The annual costs include a 25% allowance for social benefits.

Table 39 – Ten-Year Budget Estimate for Technical Assistance ($,000)

Description	Years									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Personnel	181	181	181	181	181	181	181	181	181	181
Office Supplies and Materials	100	100	100	100	100	100	100	100	100	100
Mobilization Exp. (Per diem, etc)	66	66	66	66	66	66	66	66	66	66
Vehicles (12) (all-terrain, 4wd)	360	0	0	0	0	0	0	0	0	0
Fuel and lubricants	13	13	13	13	13	13	13	13	13	13
Vehicle maintenance and Repairs	15	15	23	38	38	38	38	38	38	38
Utilities (electricity, water, telecom.)	2	2	2	2	2	2	2	2	2	2
Miscellaneous (10%)	74	38	38	40	40	40	40	40	40	40
TOTALS	**811**	**415**	**423**	**440**	**440**	**440**	**440**	**440**	**440**	**440**

9 PROPOSED ROAD DEVELOPMENT PROGRAM

The study area lacks a suitable access system. Only part of the Eastern boundary of the Rio Indio Basin, in the vicinity of Nuevo Paraiso, Tres Hermanas and El Limon, have dry weather roads. Access along the coast and inland, along the navigable portion of the Rio Indio is by boat.

In order to improve access to the potential irrigable areas, a network of new, rehabilitated and improved roads is proposed. The existing and proposed roads in the Rio Indio area are shown on Exhibit 3. It is assumed that the proposed development of agriculture and irrigation in the Rio Indio, including road construction, will proceed following the Rio Indio dam and transfer tunnel work, and therefore access road to the dam has not been accounted for in this inventory.

In order to estimate the magnitude of the cost of road improvement, rehabilitation and new construction, three levels of costs are assumed:

1. New all weather road, with gravel roadway, base, side berms of similar characteristics of the maintenance roads proposed along the canals, including sufficient drainage and related structures (culverts, short bridge crossings, side drains). Estimated cost per kilometer: $100,000.
2. Upgrading existing dry weather earth roads, including base, gravel surfacing, side berms, drainage and related structures (culverts, short bridge crossings, side drains). Estimated cost per kilometer: $60, 000.
3. Rehabilitation of existing gravel surface roads, including rehabilitation of base, gravel surface, berms, drainage. Assumes no rehabilitation of existing structures or construction of new structures is necessary. Estimated cost per kilometer length: $ 40,000.

The proposed road development program in the Rio Indio study area, is shown on Table 40 below.

Table 40 - Proposed Road Development Program in the Rio Indio Study Area

Description	Unit Price (US$/km)	Approx. Quantity (Km)	Cost (US$)
1.Rehabilitate existing gravel surface roads: El Cigual – El Cacao – Rio Ciri Grande	$40,000	40	$1,600,000
2.Rehabilitate existing gravel surface roads: From Road N0.3030 to La Encantada (next to Rio Indio)	$40,000	12	$480,000
3.Upgrade existing dry weather earth roads: • From near Road No.3030 to Los Cedros: 8 km • From Road No.3030 to Nueva Arenosa: 5 km • From Rehabilitated road in 1, above, to Nuevo Paraiso: 4 km	$60,000	17	$1,020,000
4.Construct new roads: • From North of Rio Indio to Lan Encantada (Right Bank of Rio Indio): 12 km • From North of Rio Indio to Dam Site plus short spur: 26 km • From Dam Site to La Tollosa plus short spur on Right Bank of Rio Indio: 22 km	$100,000	60	$6,000,000
Subtotal			**$9,300,000**
Contingencies (25%)			$2,325,000
Subtotal			**$11,625,000**
Engineering and Administration (10%)			$1,162,500
Total			**$12,787,500**

10 DEVELOPMENT POWER SUPPLY

The cost associated with power supply for irrigation as been estimated assuming a 13.8-kV transmission line will be provided from a location in the approximate vicinity of the dam to the pumping stations of the proposed agriculture development Areas No.1, 2, 3A, 4, 6 and 8. A 24.5-km long transmission line will bring power from the dam to the northern development areas (1, 2 and 3A). A second line, 19 km in length will serve the areas located West of the reservoir (areas 4, 6 and 8).

The proposed Area 3B pump station is located near the Indio reservoir between the dam and the intake to the transfer tunnel. It is anticipated that a 13.8-kV line will connect the dam and intake to the transfer tunnel: the proposed pumping station will also be connected to that line.

The proposed Area 5 around Nuevo Paraiso is located at a distance in excess of 20 km from any other agricultural development and at about 18 km from the intake of the transfer tunnel. It is therefore proposed that a diesel generator (600-kW) be provided near the pumping station for Area 5.

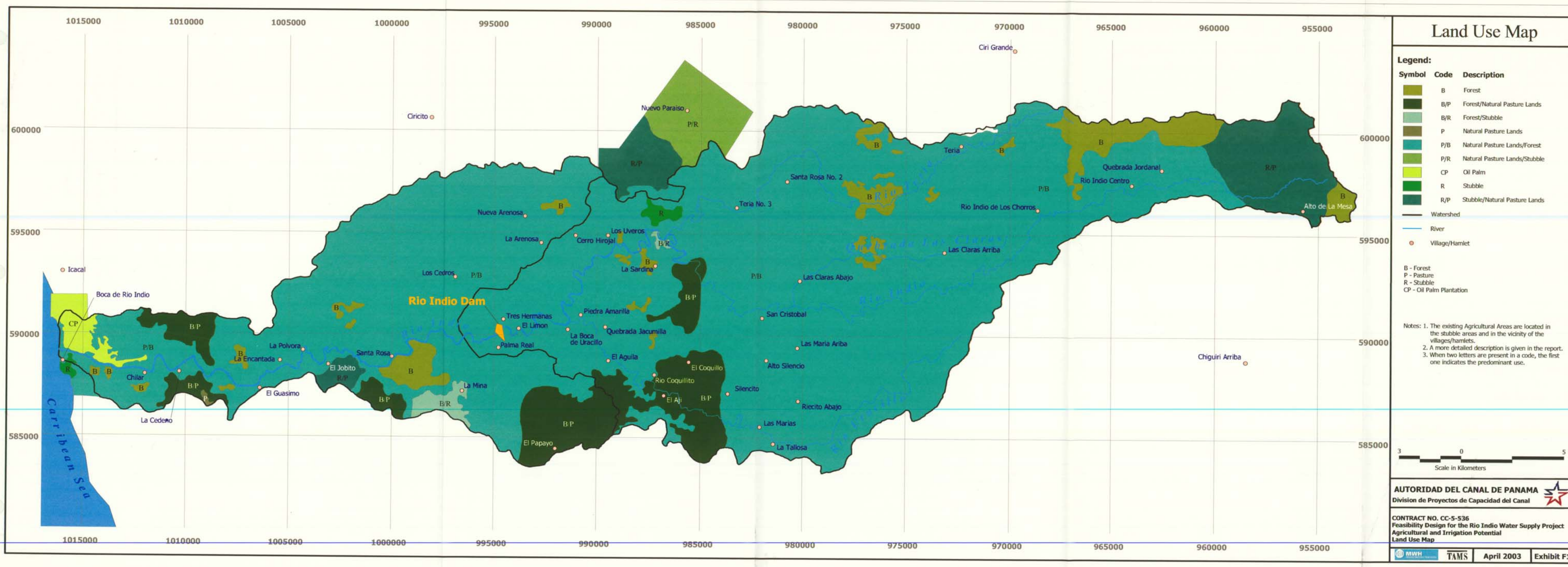
The proposed Area 7 does not required electric power, as the water supply system is entirely a gravity system.

The total cost associated with power supply for irrigation development is estimated to be $1,200,000. Table 41 below provides a breakdown of the cost allocation for each area if all the areas are developed.

Table 41 – Power Supply Costs

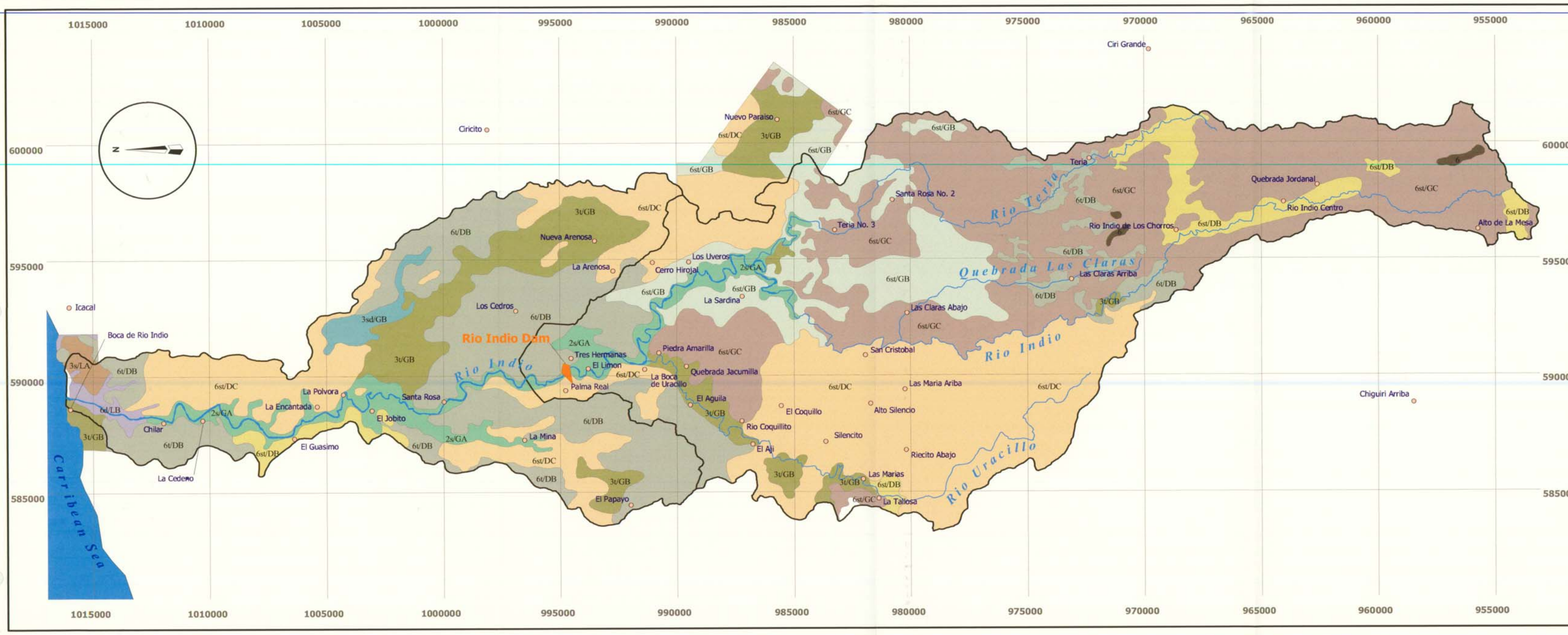
Potential Area	Estimated Electrical Power Supply Cost	Observation
Area 1	$250,000	13.8-kV Transmission Line for Area 1, 2 and 3A
Area 2	$185,000	13.8-kV Transmission Line for Area 1, 2 and 3A
Area 3A	$80,000	13.8-kV Transmission Line for Area 1, 2 and 3A
Area 3B	-	Connected to dam and tunnel operation power line
Area 4	$155,000	13.8-kV Transmission Line for Area 4, 6 and 8
Area 5	$185,000	600-kW Diesel generator with housing
Area 6	$205,000	13.8-kV Transmission Line for Area 4, 6 and 8
Area 7	-	No power required
Area 8	$140,000	13.8-kV Transmission Line for Area 4, 6 and 8

EXHIBITS



Land Use Map
Legend:
Symbol Code Description
B Forest
B/P Forest/Natural Pasture Lands
B/R Forest/Stubble
P Natural Pasture Lands
P/B Natural Pasture Lands/Forest
P/R Natural Pasture Lands/Stubble
CP Oil Palm
R Stubble
R/P Stubble/Natural Pasture Lands
Watershed
River
Village/Hamlet
B - Forest
P - Pasture
R - Stubble
CP - Oil Palm Plantation
Notes: 1. The existing Agricultural Areas are located in the stubble areas and in the vicinity of the villages/hamlets.
2. A more detailed description is given in the report.
3. When two letters are present in a code, the first one indicates the predominant use.
3 0 5
Scale in Kilometers
AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal
CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Agricultural and Irrigation Potential
Land Use Map
MWH
TAMS
April 2003
Exhibit F1
Rio Indio Dam
Caribbean Sea
Icacal
Boca de Rio Indio
Ciri Grande
Ciricito
Nuevo Paraiso
Teria
Santa Rosa No. 2
Teria No. 3
Quebrada Jordanal
Rio Indio Centro
Rio Indio de Los Chorros
Alto de La Mesa
Nueva Arenosa
La Arenosa
Cerro Hirojal
Los Uveros
La Sardina
Los Cedros
Las Claras Arriba
Las Claras Abajo
Tres Hermanas
El Limon
Palma Real
Piedra Amarilla
Quebrada Jacumilla
La Boca de Uracillo
El Aguila
San Cristobal
Las Maria Ariba
Alto Silencio
Chiguiri Arriba
La Polvora
La Encantada
Santa Rosa
El Jobito
Chilar
El Guasimo
La Cedero
La Mina
El Papayo
El Coquillo
Rio Coquillito
El Ali
Silencito
Riecito Abajo
Las Marias
La Tallosa

Land Capability for Irrigation Map



Legend:

Symbol	Class	Description / Limiting Factors
	2s/GA	Texture - moderately fine
	3s/LA	Texture - very fine
	3sd/GB	Texture - very fine, Internal Drainage - high water table
	3t/GB	Slope
	6	Bedrock
	6d/LB	External Drainage - inundation, Internal Drainage - high water table
	6st/DB	Soil Depth - shallow, slope
	6st/DC	Soil Depth - shallow, Slope & Stoniness
	6st/GB	Texture - very fine, Slope & Stoniness
	6st/GC	Soil Depth - shallow, Texture - very fine, Slope & Stoniness
	6t/DB	Texture - very fine
		Watershed
		River
		Village/Hamlet

2,3,6 - Land Class
t,s,d - Limiting Factors (Topography; Soil; Drainage)
L,D,G - Land Use (Cultivated, Non-irrigated; Stubble and Forest; Permanent Pasture, Non-irrigated)
A,B,C - Potential Productivity (High; Moderate; Low)

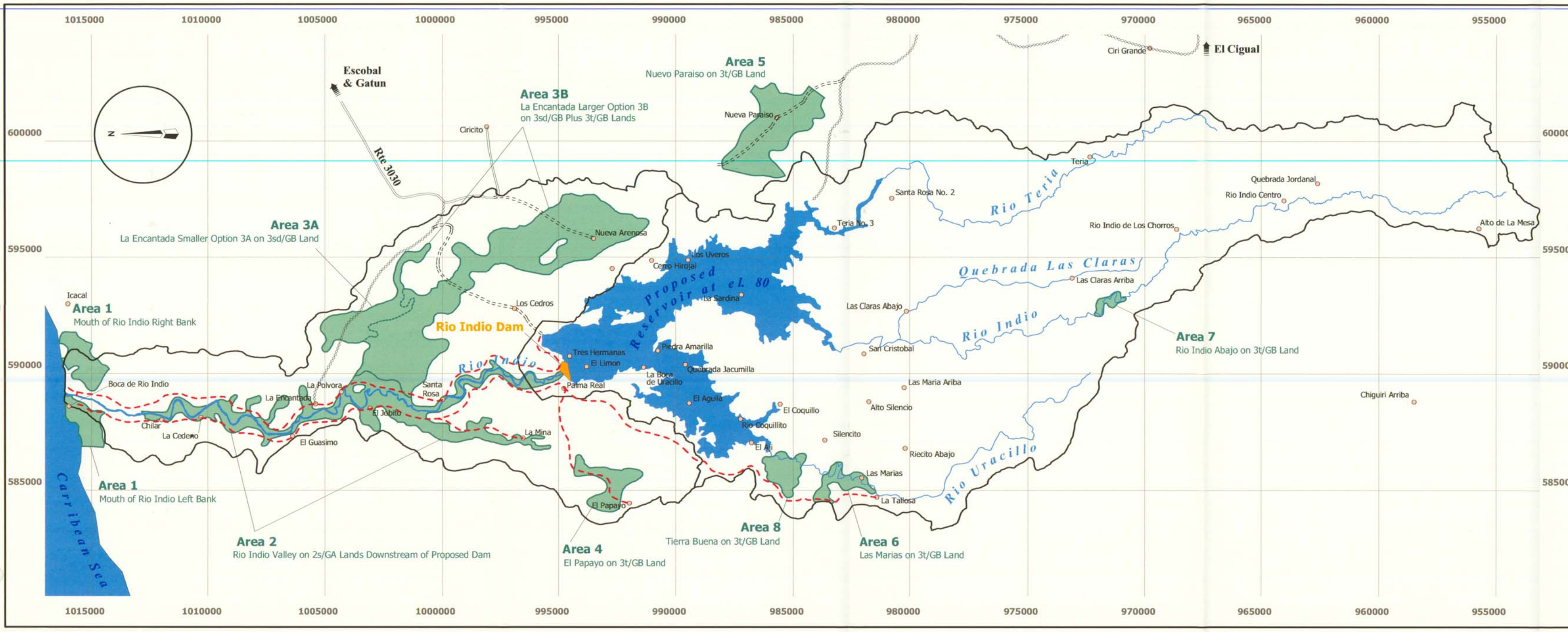
Note: Further description of land classes is given in the report.

3 0 5
Scale in Kilometers

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Agricultural and Irrigation Potential
Land Capability for Irrigation Map

MWH	TAMS	April 2003	Exhibit F2



Potential Development Areas Location Map

Legend:

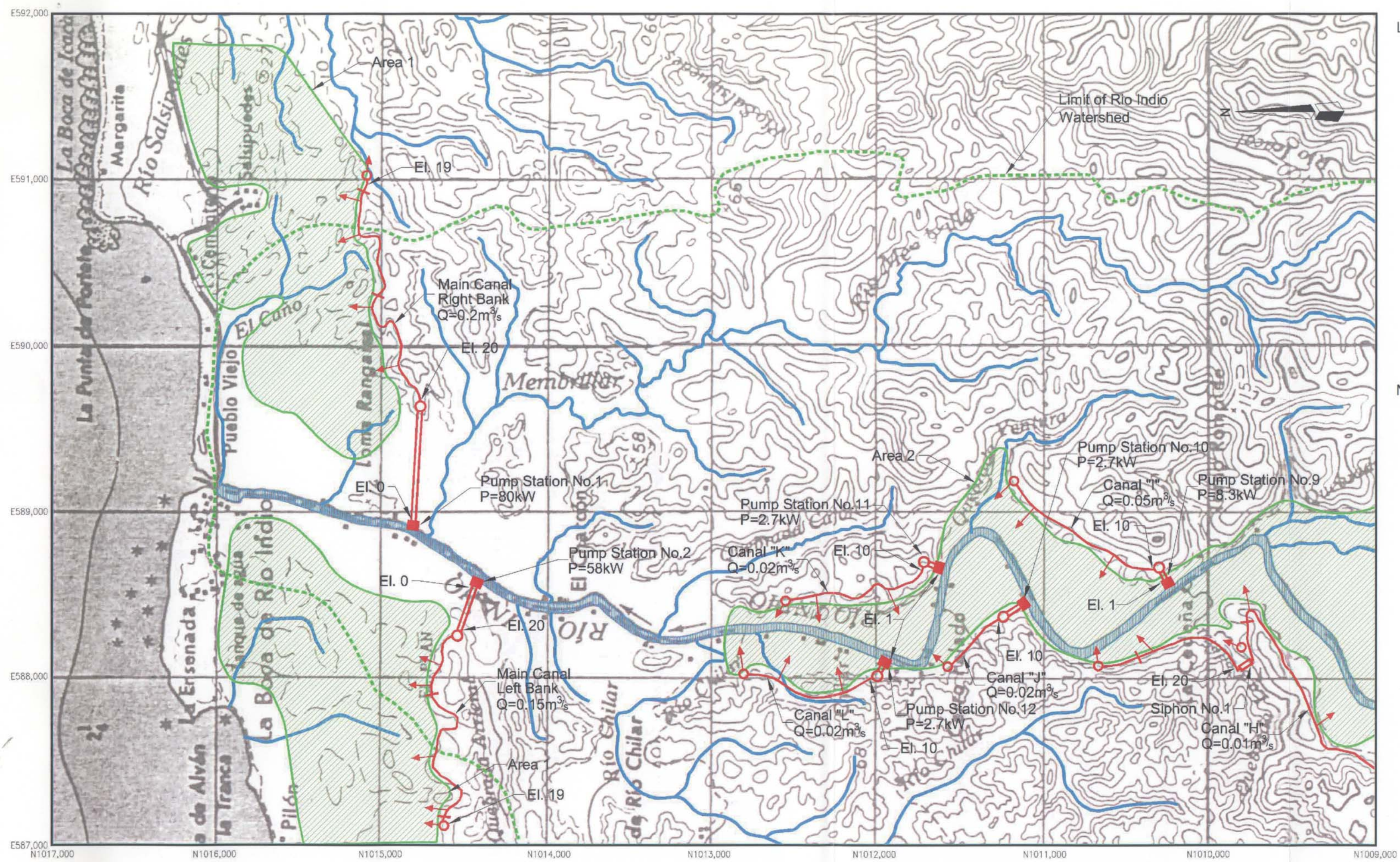
Symbol	Description
	Potential Development Area
	Watershed
	River
	Existing Paved Road
	Existing Gravel Road to be Rehabilitated
	Dry Weather Road to be Upgraded
	Proposed New Road
	Village/Hamlet

3 0 5
Scale in Kilometers

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Agricultural and Irrigation Potential
Potential Development Areas Location Map

MWH | TAMS | April 2003 | Exhibit F3



LEGEND:

- Existing Dry-weather Access
- Existing Village
- Turnouts/Off-takes to Distribution
- Wasteway or Spillway
- Check Structure
- Flow Division Structure
- Siphon Crossing
- Lined Canal
- Pump Station
- Irrigated Area
- Limit of Rio Indio Watershed

NOTES:

1. Elevations are given in meters above mean sea level.
2. Topographic background is based on "Tommy Guardia" IGN maps with contours every 20m.

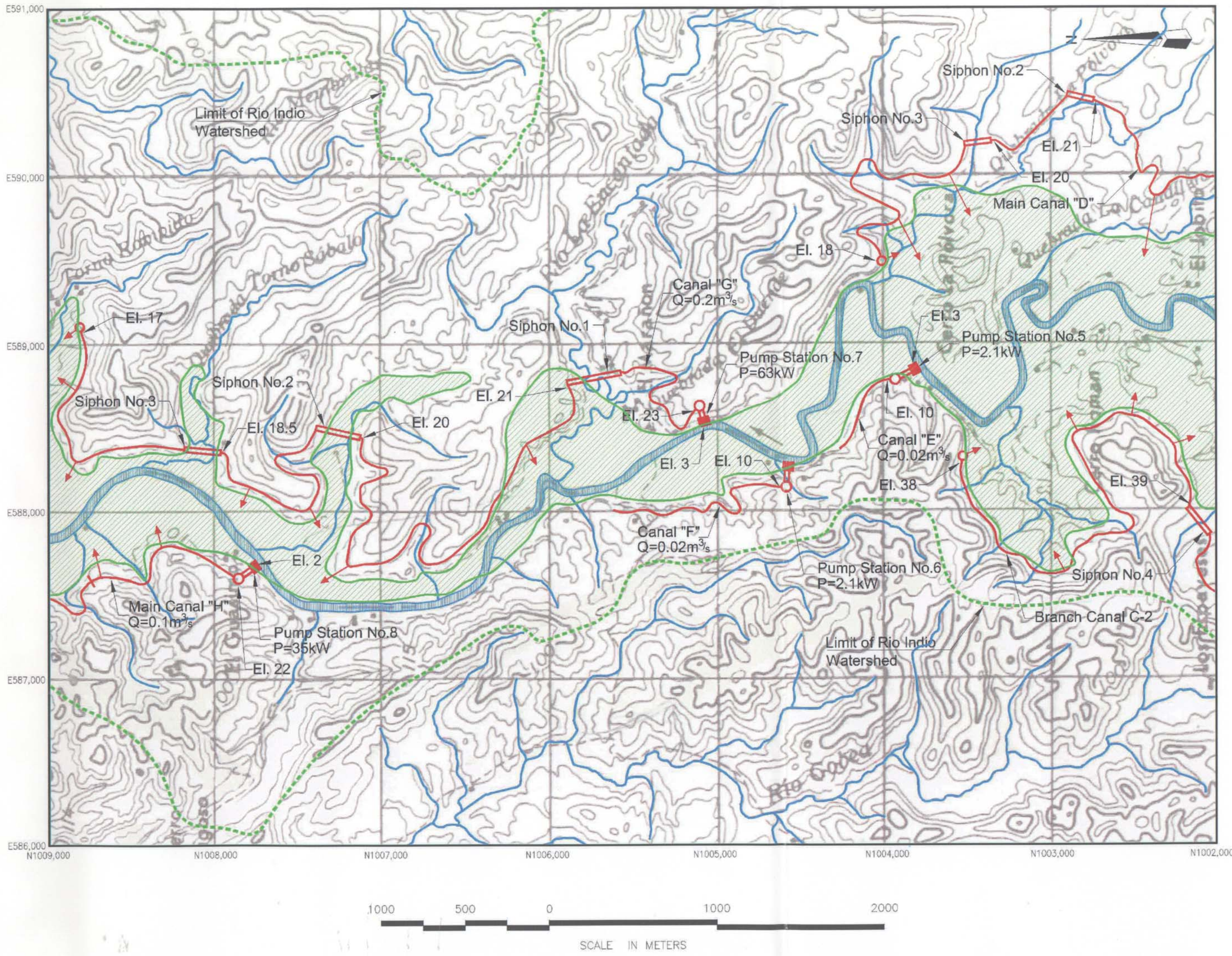
1000 500 0 1000 2000

SCALE IN METERS

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Agriculture and Irrigation Potential
Proposed Area No. 1 - Boca Del Rio Indio and
Area No. 2 - Rio Indio Valley (1 of 3)

MWH TAMS	April 2003	Exhibit F4



LEGEND:

- Existing Dry-weather Access
- Existing Village
- Turnouts/Off-takes to Distribution
- Wasteway or Spillway
- Check Structure
- Flow Division Structure
- Siphon Crossing
- Lined Canal
- Pump Station
- Irrigated Area
- Limit of Rio Indio Watershed

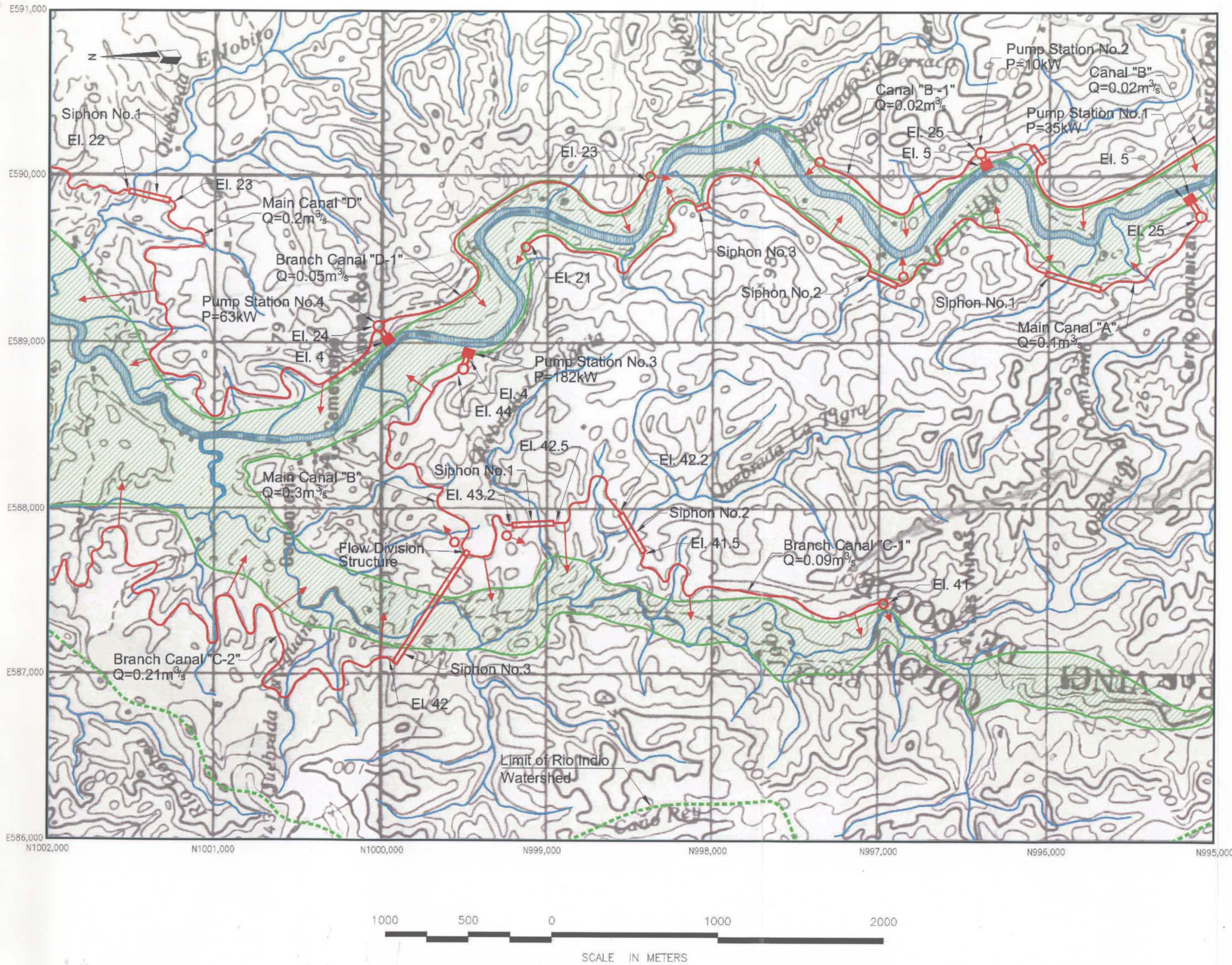
NOTES:

1. Elevations are given in meters above mean sea level.
2. Topographic background is based on "Tommy Guardia" IGN maps with contours every 20m.

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Agriculture and Irrigation Potential
Proposed Area No. 2 - Rio Indio Valley (2 of 3)

MWH TAMS	April 2003	Exhibit F5



LEGEND:

- Existing Dry-weather Access
- Existing Village
- Turnouts/Off-takes to Distribution
- Wasteway or Spillway
- Check Structure
- Flow Division Structure
- Siphon Crossing
- Lined Canal
- Pump Station
- Irrigated Area
- Limit of Rio Indio Watershed

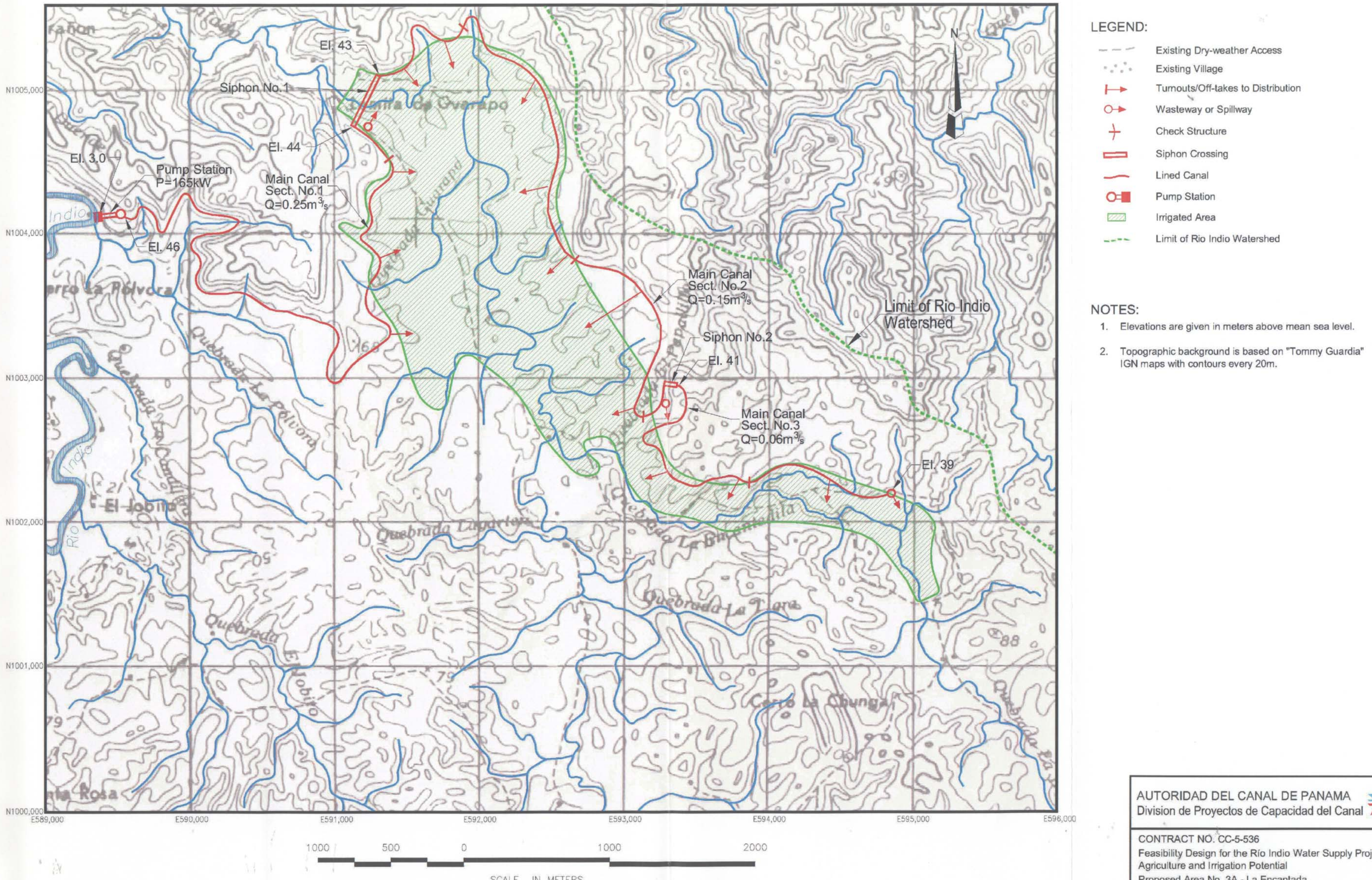
NOTES:

1. Elevations are given in meters above mean sea level.
2. Topographic background is based on "Tommy Guardia" IGN maps with contours every 20m.

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Agriculture and Irrigation Potential
Proposed Area No. 2 Río Indio Valley (3 of 3)

MWH TAMS	April 2003	Exhibit F6



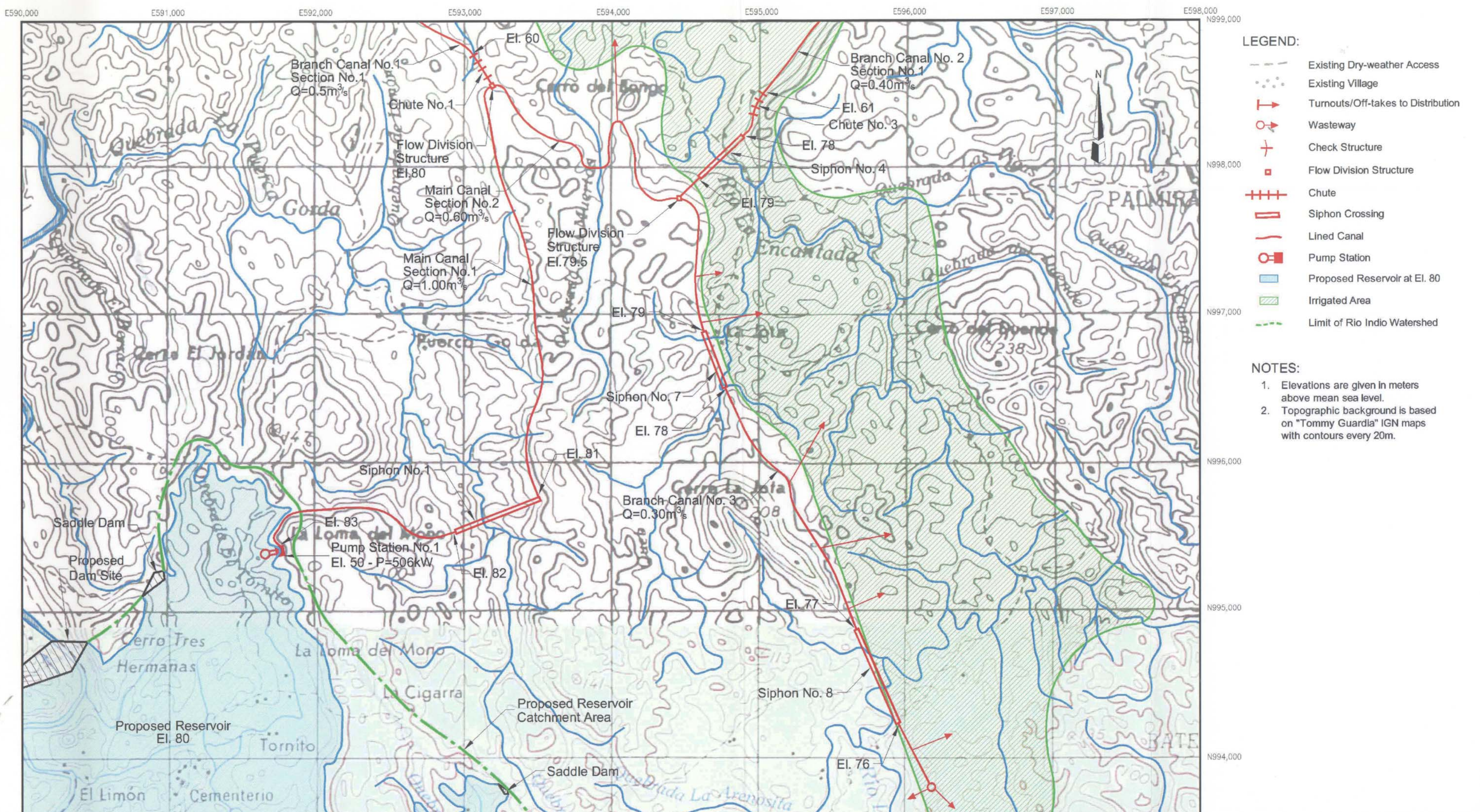
NOTES:

1. Elevations are given in meters above mean sea level.
2. Topographic background is based on "Tommy Guardia" IGN maps with contours every 20m.

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Agriculture and Irrigation Potential
Proposed Area No. 3A - La Encantada

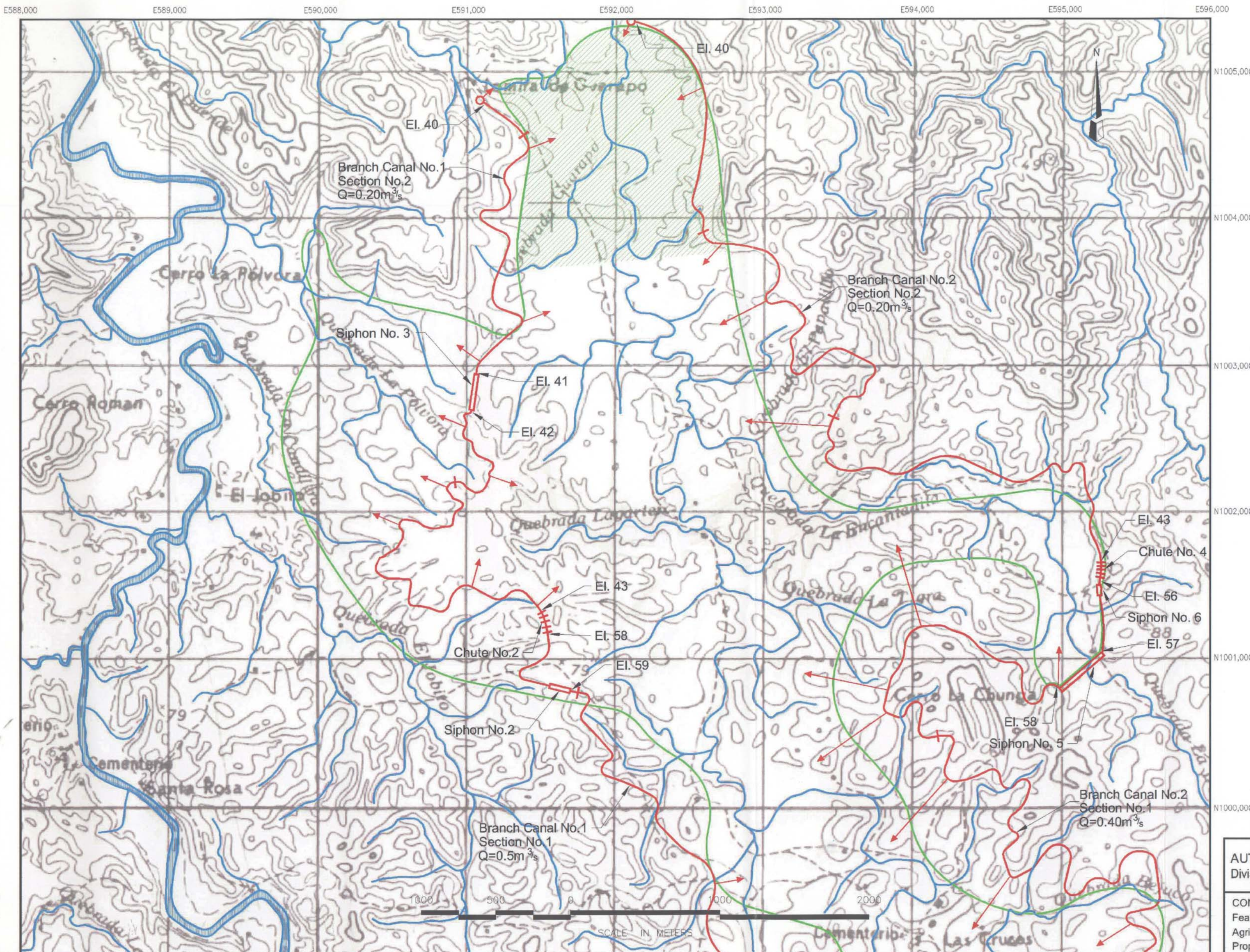
MWH TAMS | April 2003 | Exhibit F7



AUTORIDAD DEL CANAL DE PANAMA
División de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Agriculture and Irrigation Potential
Proposed Area No.3B - La Encantada (1 of 2)

MWH TAMS | April 2003 | Exhibit F8



LEGEND:

- Existing Dry-weather Access
- Existing Village
- Turnouts/Off-takes to Distribution
- Wasteway or Spillway
- Check Structure
- Siphon Crossing
- Lined Canal
- Pump Station
- Chute
- Irrigated Area
- Limit of Rio Indio Watershed

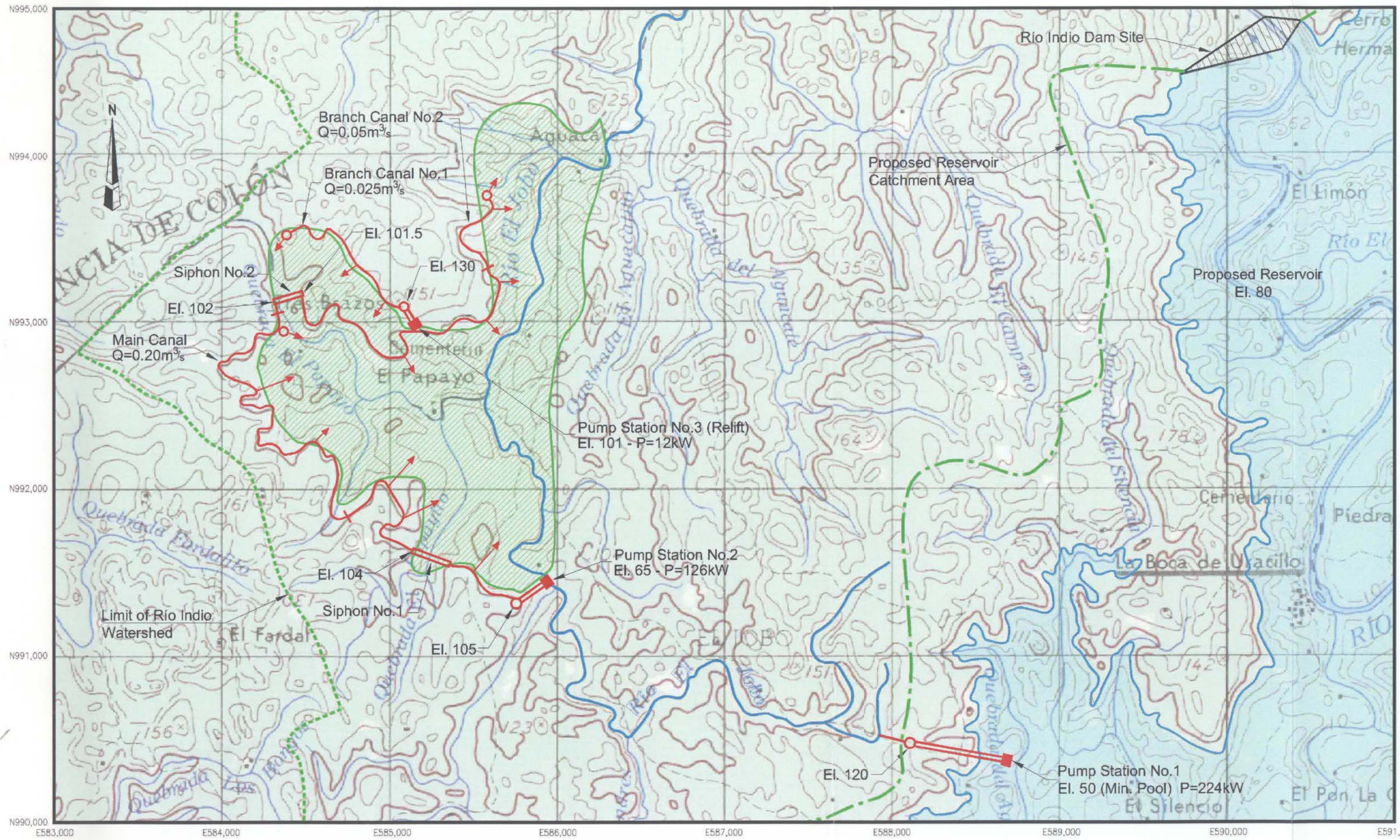
NOTES:

1. Elevations are given in meters above mean sea level.
2. Topographic background is based on "Tommy Guardia" IGN maps with contours every 20m.

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Agriculture and Irrigation Potential
Proposed Area No.3B - La Encantada (2 of 2)

MWH TAMS	April 2003	Exhibit F9



LEGEND:

- Existing Dry-weather Access
- Existing Village
- Turnouts/Off-takes to Distribution
- Wasteway or Spillway
- Check Structure
- Flow Division Structure
- Siphon Crossing
- Lined Canal
- Pump Station
- Proposed Reservoir at El. 80
- Irrigated Area
- Limit of Rio Indio Watershed
- Proposed Dam Catchment Area

NOTES:

1. Elevations are given in meters above mean sea level.
2. Topographic background is based on "Tommy Guardia" IGN maps with contours every 20m.

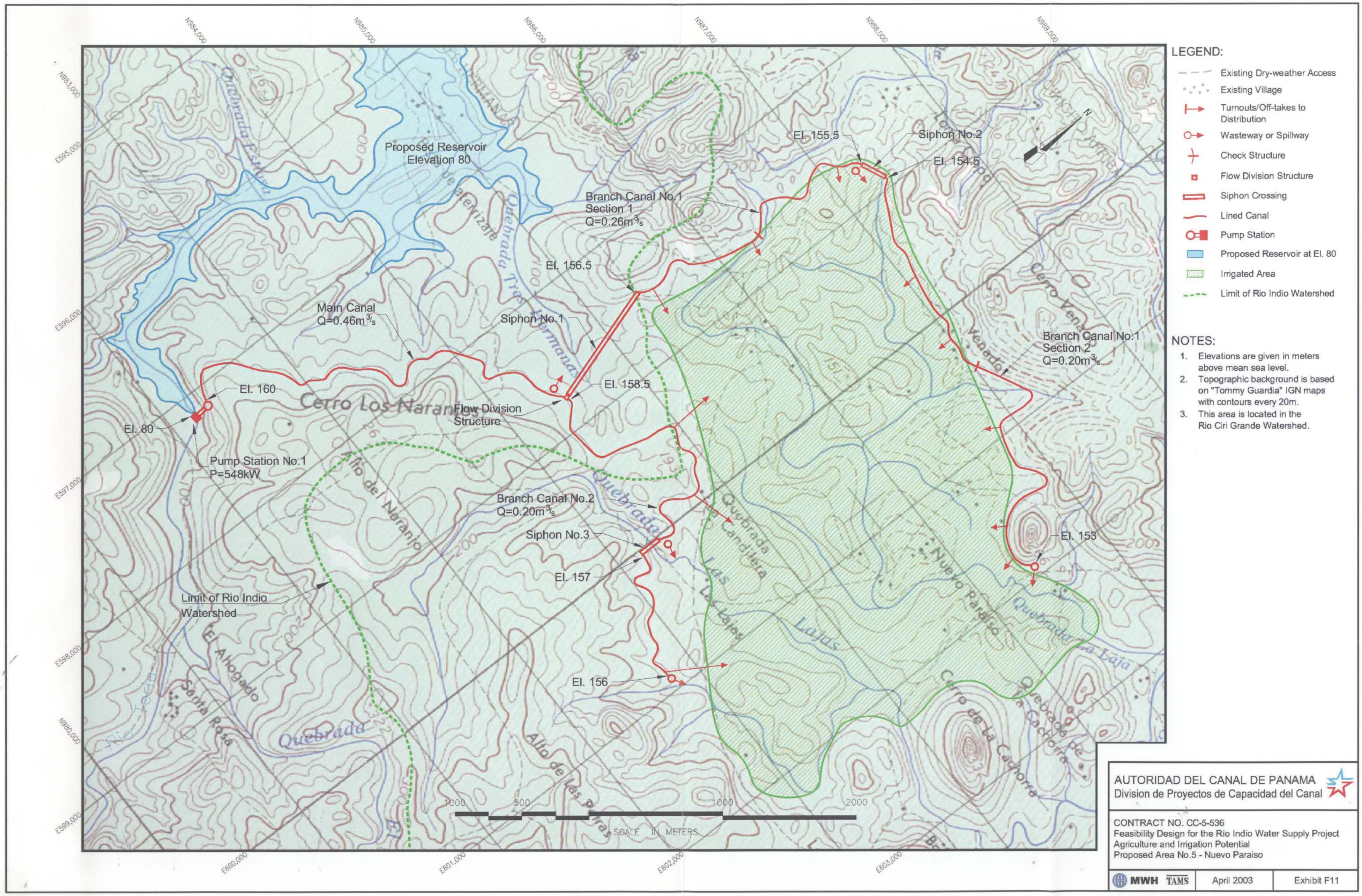
1000 500 0 1000 2000

SCALE IN METERS

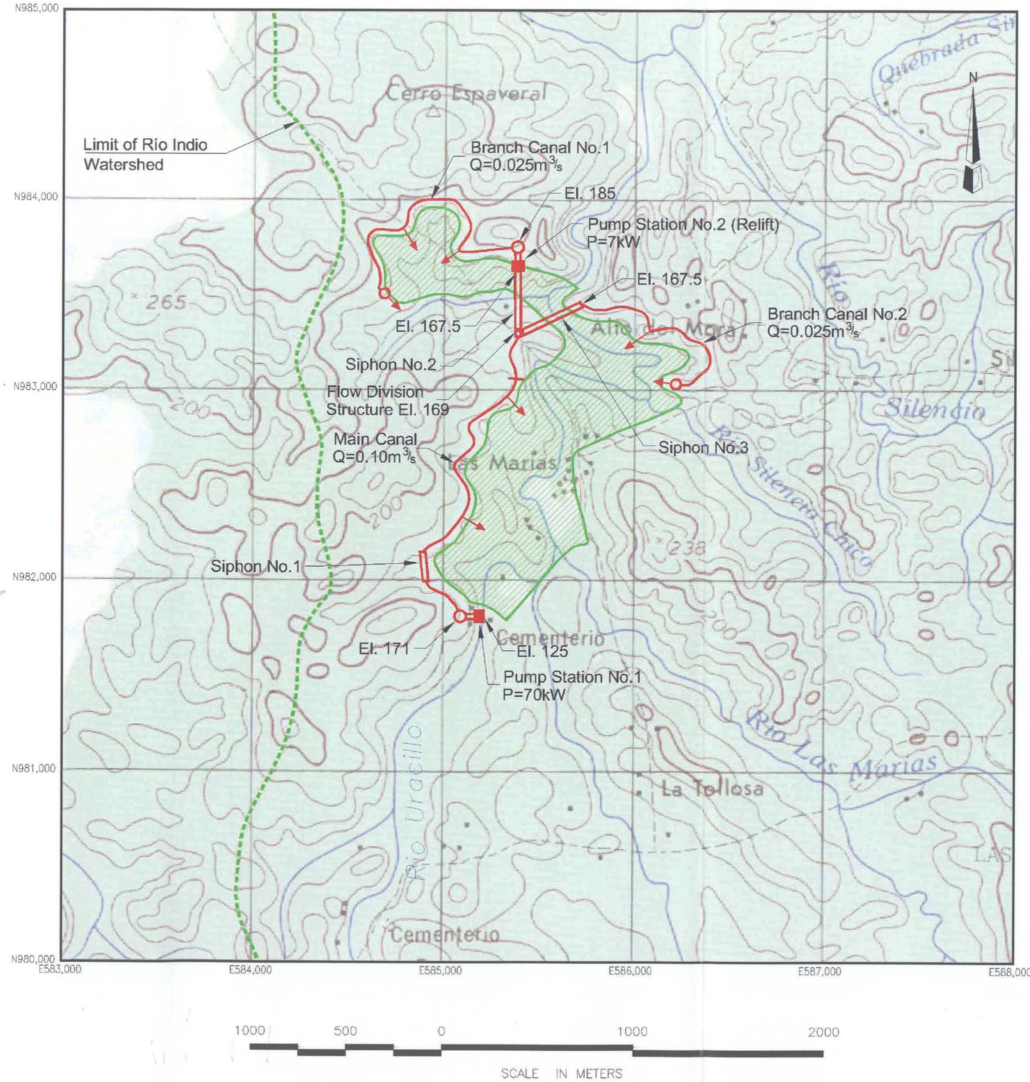
AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Agriculture and Irrigation Potential
Proposed Area No. 4 El Papayo

MWH TAMS | April 2003 | Exhibit F10



LEGEND:
Existing Dry-weather Access
Existing Village
Turnouts/Off-takes to Distribution
Wasteway or Spillway
Check Structure
Flow Division Structure
Siphon Crossing
Lined Canal
Pump Station
Proposed Reservoir at El. 80
Irrigated Area
Limit of Rio Indio Watershed
NOTES:
1. Elevations are given in meters above mean sea level.
2. Topographic background is based on "Tommy Guardia" IGN maps with contours every 20m.
3. This area is located in the Rio Ciri Grande Watershed.
Proposed Reservoir Elevation 80
Branch Canal No.1 Section 1 Q=0.26m³/s
El. 155.5
Siphon No.2
El. 154.5
El. 156.5
Main Canal Q=0.46m³/s
Siphon No.1
Branch Canal No.1 Section 2 Q=0.20m³/s
El. 160
El. 158.5
El. 80
Cerro Los Naranjos
Flow Division Structure
Pump Station No.1 P=548kW
Branch Canal No.2 Q=0.20m³/s
Siphon No.3
El. 157
El. 153
Limit of Rio Indio Watershed
El. 156
Quebrada Candilera
Nuevo Paraiso
Quebrada La Laja
Cerro de La Cachorra
Quebrada de La Cachorra
Alto del Naranjo
El Ahogado
Santa Rosa
Alto de las Parras
Quebrada Tres Hermanas
Cerro Venado
SCALE IN METERS
1000 500 0 1000 2000
N
AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal
CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Agriculture and Irrigation Potential
Proposed Area No.5 - Nuevo Paraiso
MWH TAMS
April 2003
Exhibit F11



LEGEND:

- Existing Dry-weather Access
- Existing Village
- Turnouts/Off-takes to Distribution
- Wasteway or Spillway
- Check Structure
- Flow Division Structure
- Siphon Crossing
- Lined Canal
- Pump Station
- Irrigated Area
- Limit of Rio Indio Watershed

NOTES:

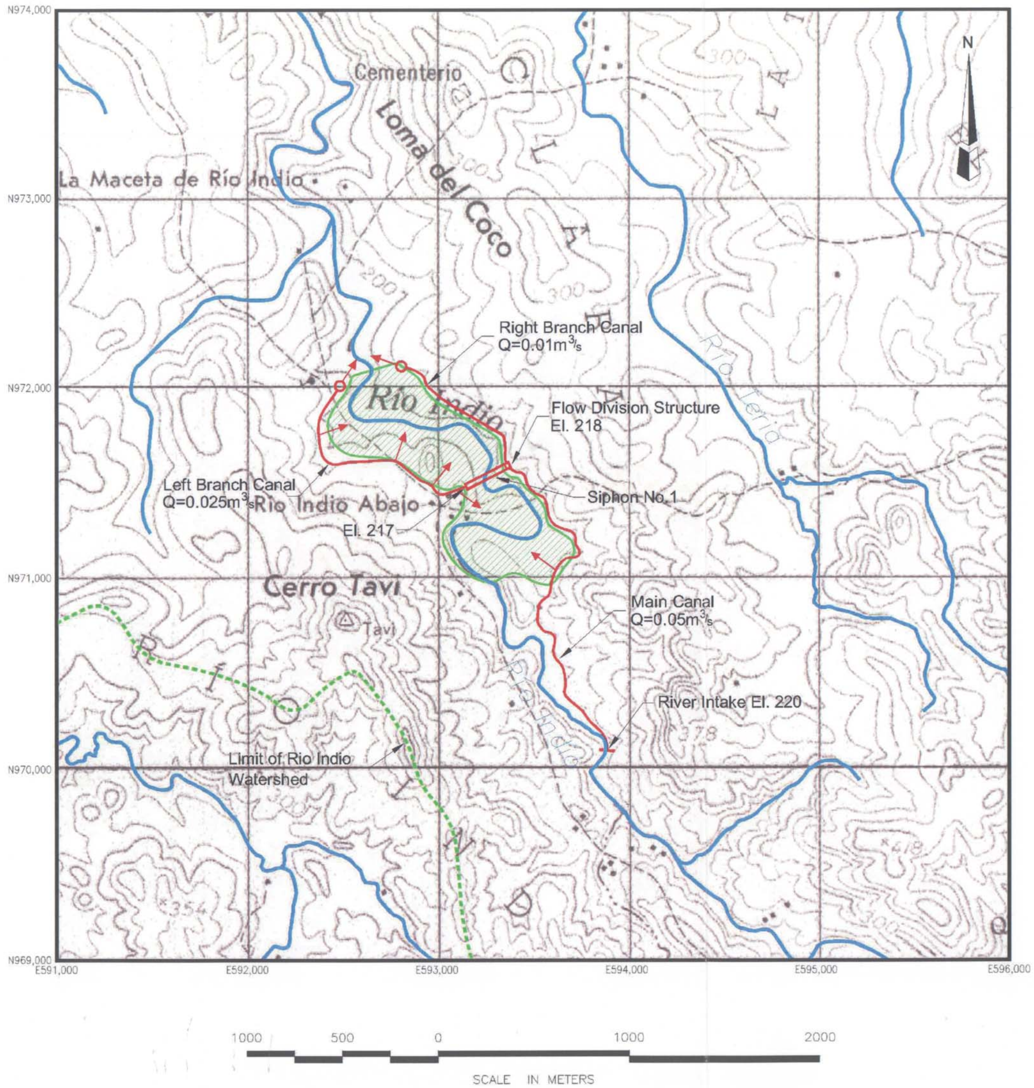
1. Elevations are given in meters above mean sea level.
2. Topographic background is based on "Tommy Guardia" IGN maps with contours every 20m.

Limit of Rio Indio Watershed

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Agriculture and Irrigation Potential
Proposed Area No. 6 Las Marias

MWH TAMS	April 2003	Exhibit F12



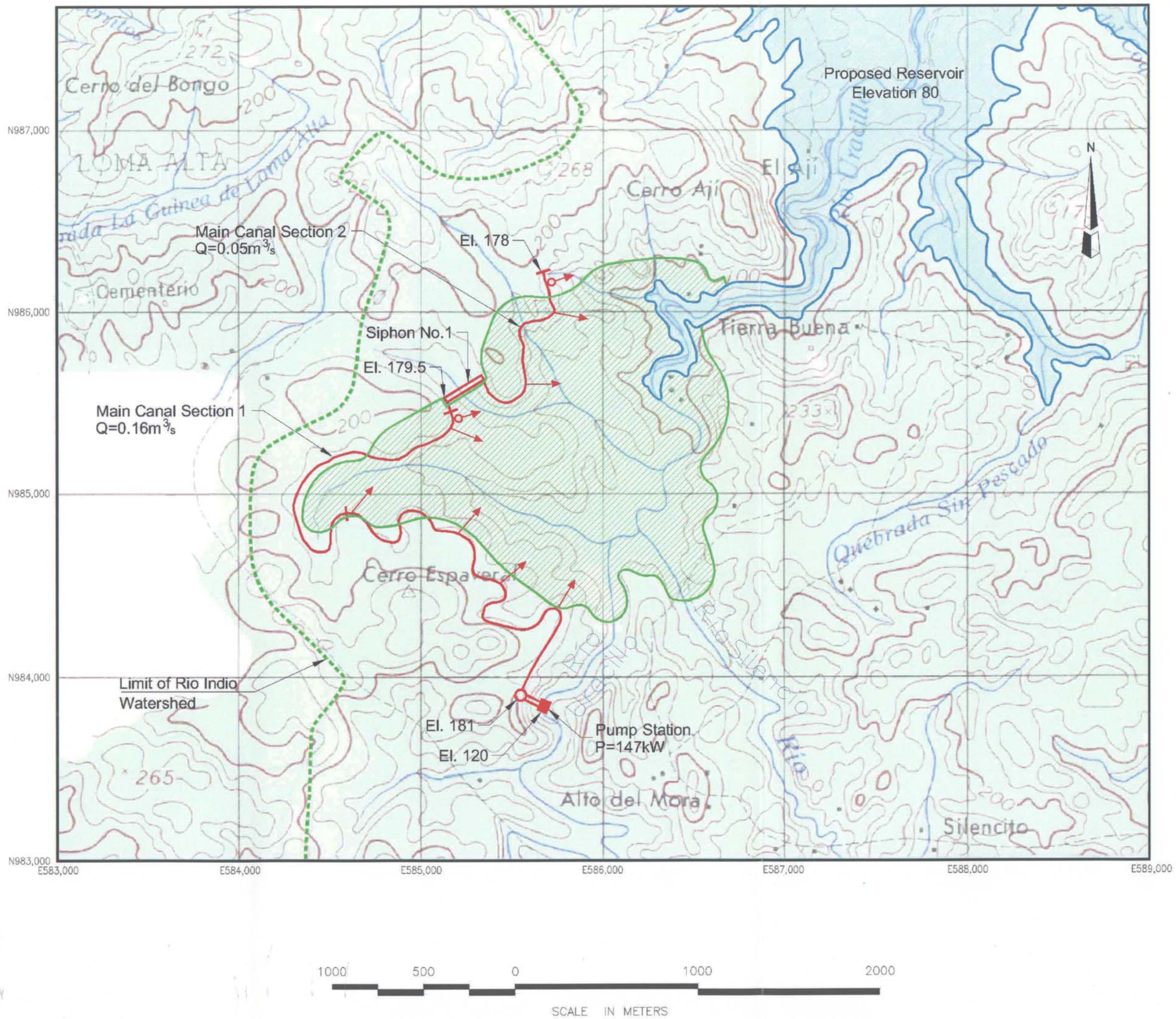
LEGEND:

- Existing Dry-weather Access
- Existing Village
- Turnouts/Off-takes to Distribution
- Wasteway or Spillway
- Check Structure
- Flow Division Structure
- Siphon Crossing
- Lined Canal
- Pump Station
- Irrigated Area
- Limit of Rio Indio Watershed

NOTES:

1. Elevations are given in meters above mean sea level.
2. Topographic background is based on "Tommy Guardia" IGN maps with contours every 20m.

AUTORIDAD DEL CANAL DE PANAMA Division de Proyectos de Capacidad del Canal		
CONTRACT NO. CC-5-536 Feasibility Design for the Rio Indio Water Supply Project Agriculture and Irrigation Potential Proposed Area No.7 - Rio Indio Abajo		
MWH TAMS	April 2003	Exhibit F13



LEGEND:

- Existing Dry-weather Access
- Existing Village
- Turnouts/Off-takes to Distribution
- Wasteway or Spillway
- Check Structure
- Flow Division Structure
- Siphon Crossing
- Lined Canal
- Pump Station
- Proposal Reservoir at El. 80
- Irrigated Area
- Limit of Rio Indio Watershed

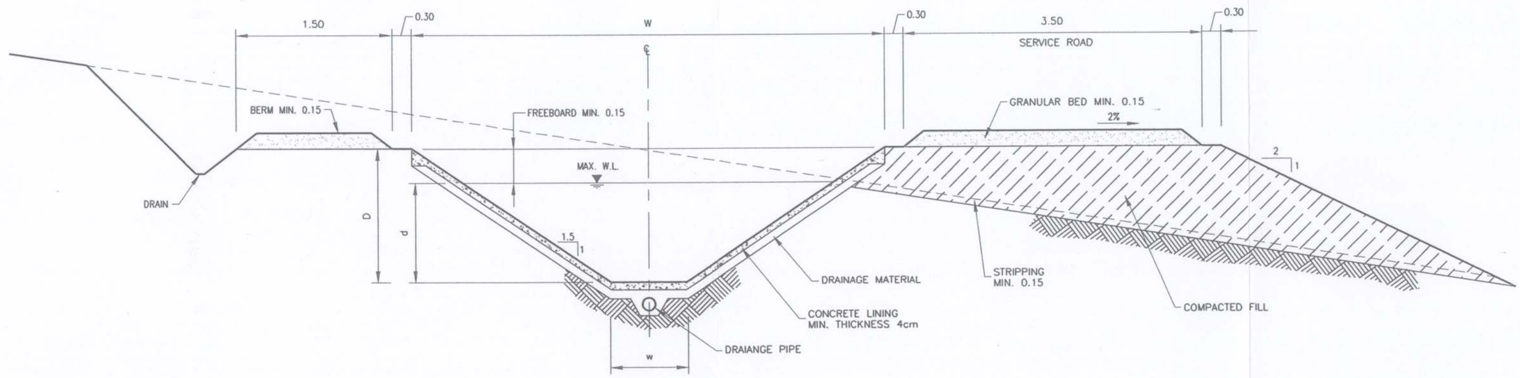
NOTES:

1. Elevations are given in meters above mean sea level.
2. Topographic background is based on "Tommy Guardia" IGN maps with contours every 20m.

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Agriculture and Irrigation Potential
Proposed Area No.8 - Tierra Buena

MWH TAMS | April 2003 | Exhibit F14



LEGEND:

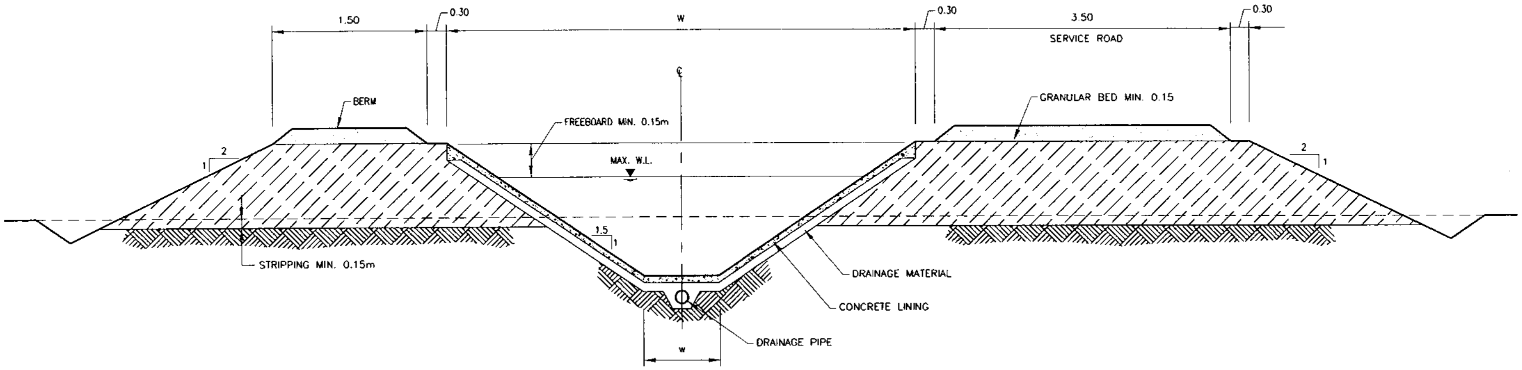
w = VARIABLE BOTTOM WIDTH
W = VARIABLE TOP WIDTH
d = VARIABLE WATER DEPTH
D = VARIABLE TOTAL DEPTH

TYPICAL CANAL SECTION
NOT TO SCALE

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Agriculture and Irrigation Potential
Typical Canal Section (Cut and Fill)

MWH TAMS | April 2003 | Exhibit F15



TYPICAL CANAL SECTION
NOT TO SCALE

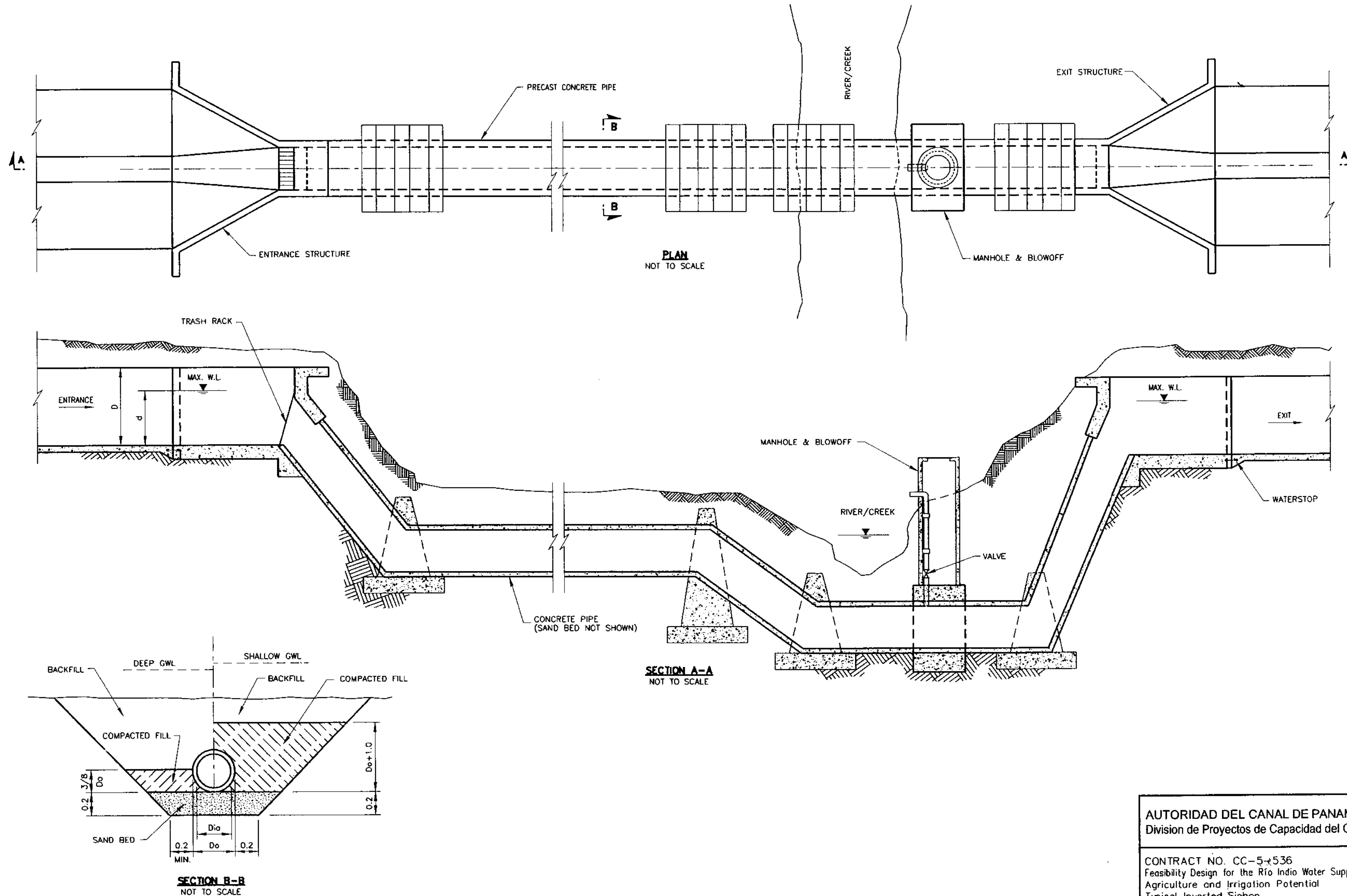
LEGEND:

w = VARIABLE BOTTOM WIDTH
W = VARIABLE TOP WIDTH
d = VARIABLE WATER DEPTH
D = VARIABLE TOTAL DEPTH

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Agriculture and Irrigation Potential
Typical Canal Section (Fill)

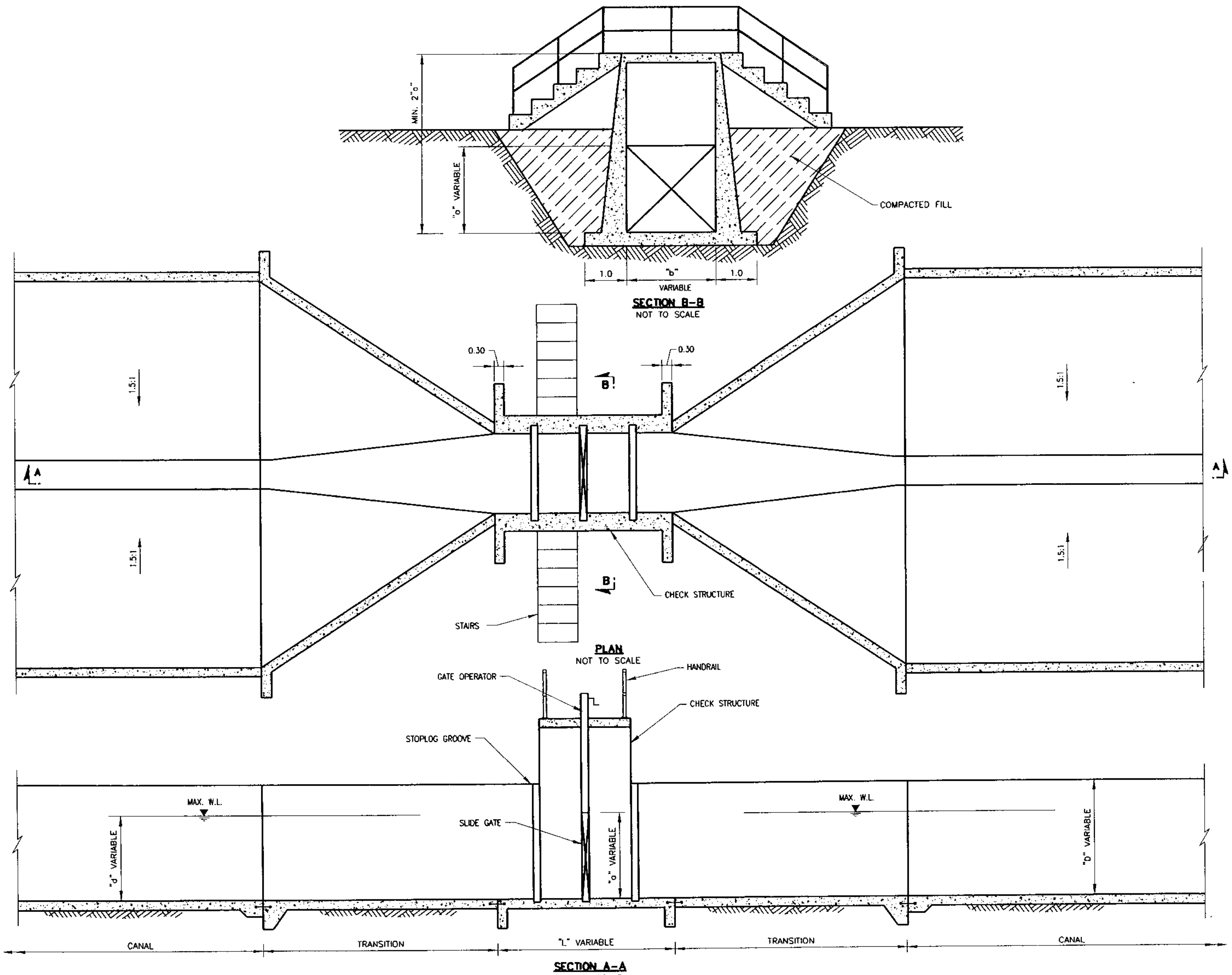
MWH TAMS | April 2003 | Exhibit F16



AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Agriculture and Irrigation Potential
Typical Inverted Siphon

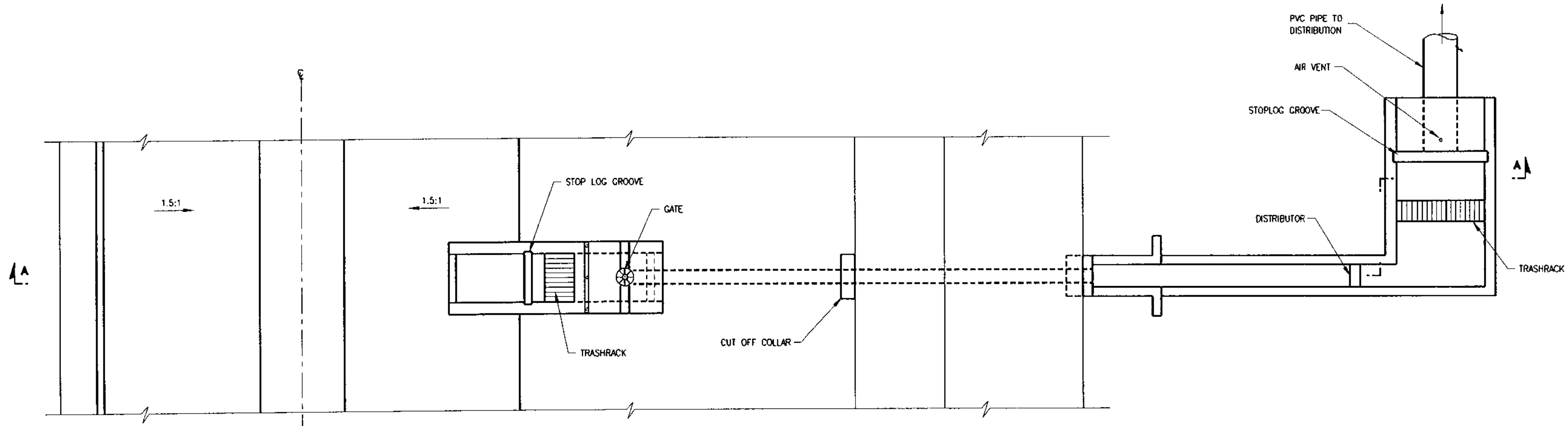
MWH TAMS	April 2003	Exhibit F17



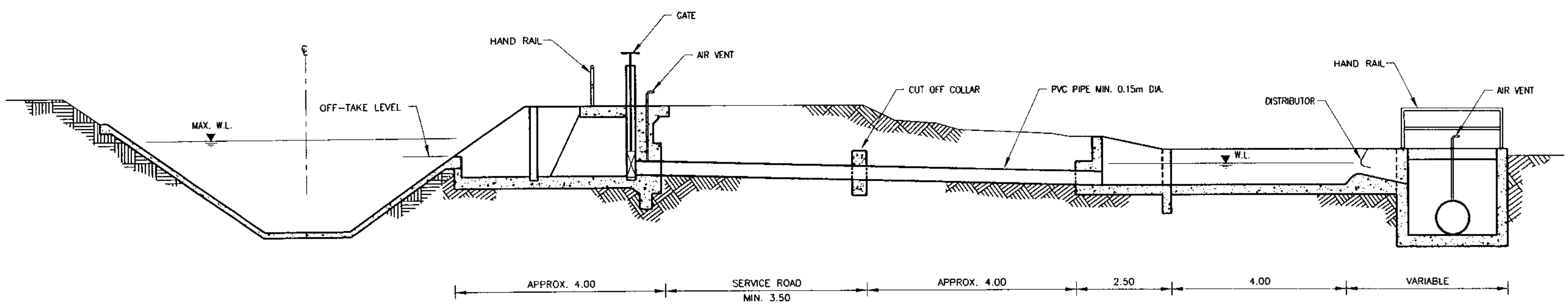
AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Agriculture and Irrigation Potential
Typical Check Structure

MWH TAMS | April 2003 | Exhibit F18



PLAN
NOT TO SCALE

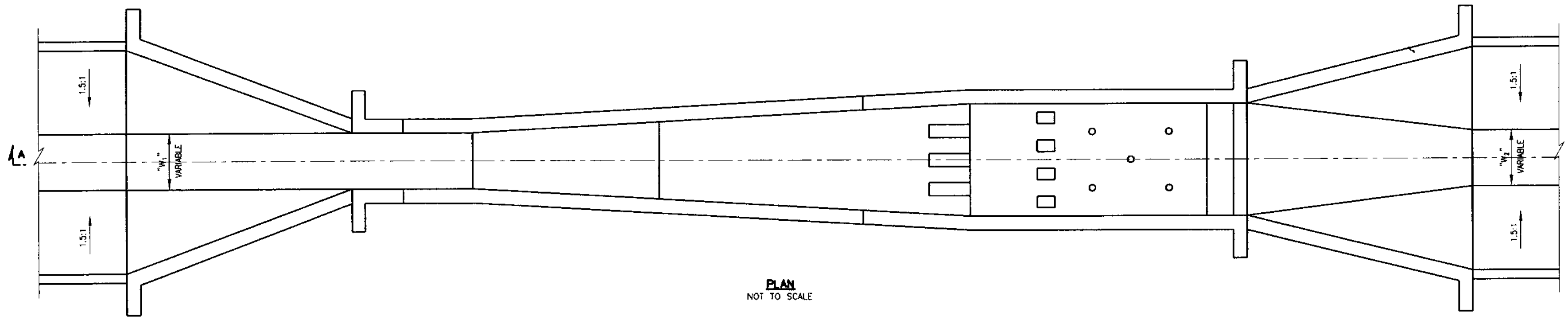


SECTION A-A
NOT TO SCALE

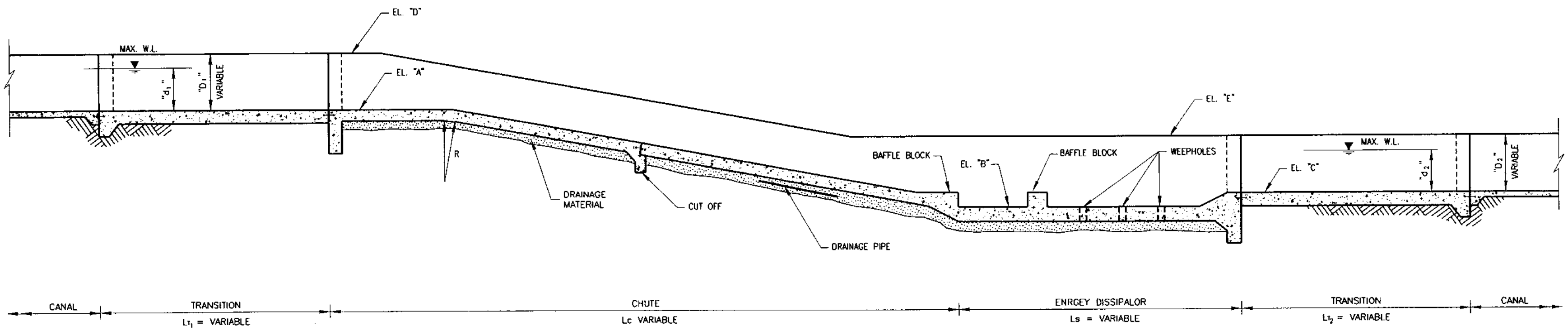
AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Rio Indio Water Supply Project
Agriculture and Irrigation Potential
Typical Turnout/Off-take Structure

MWH TAMS | April 2003 | Exhibit F19



PLAN
NOT TO SCALE

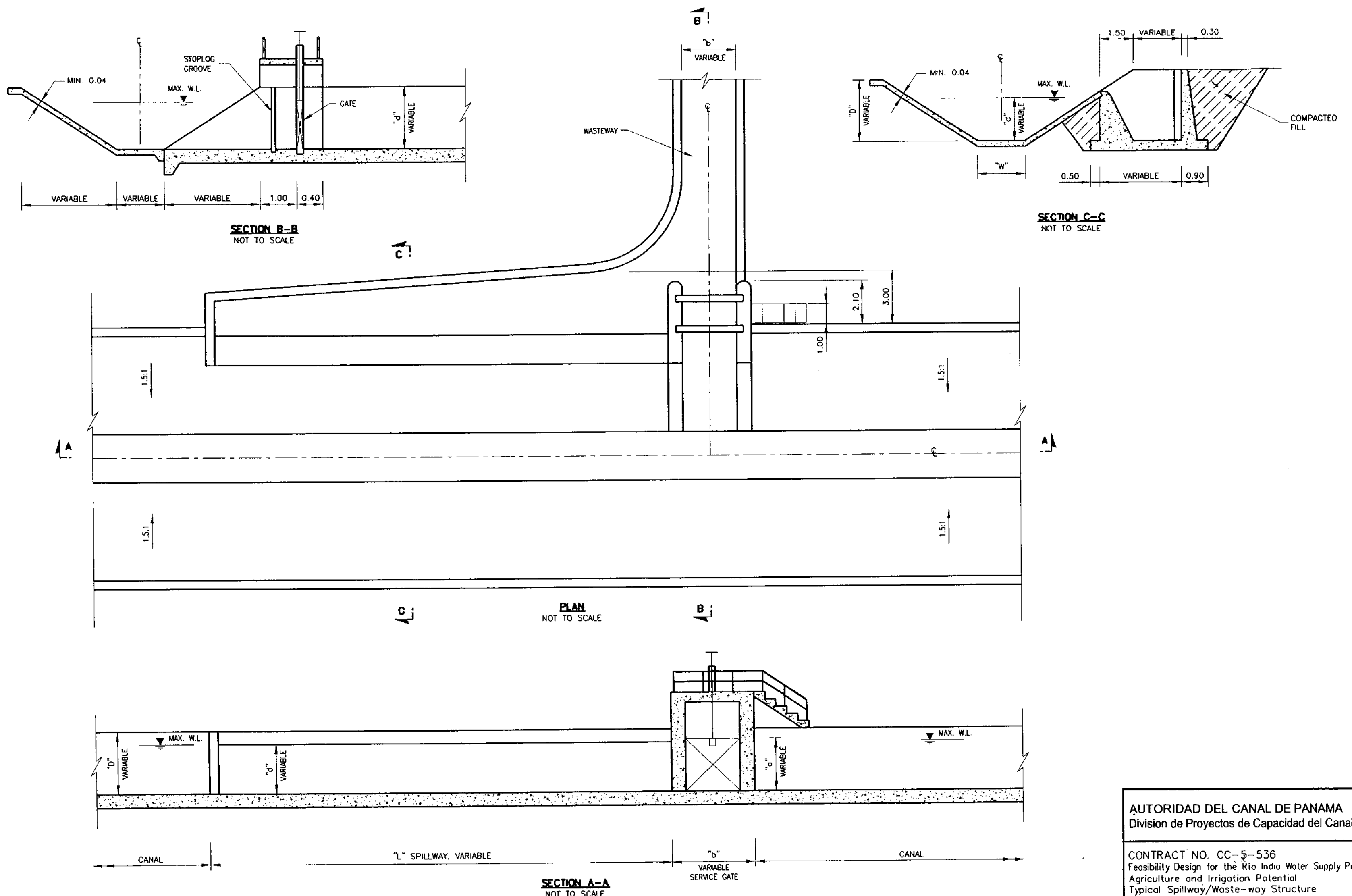


SECTION A-A
NOT TO SCALE

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Agriculture and Irrigation Potential
Typical Chute Structure

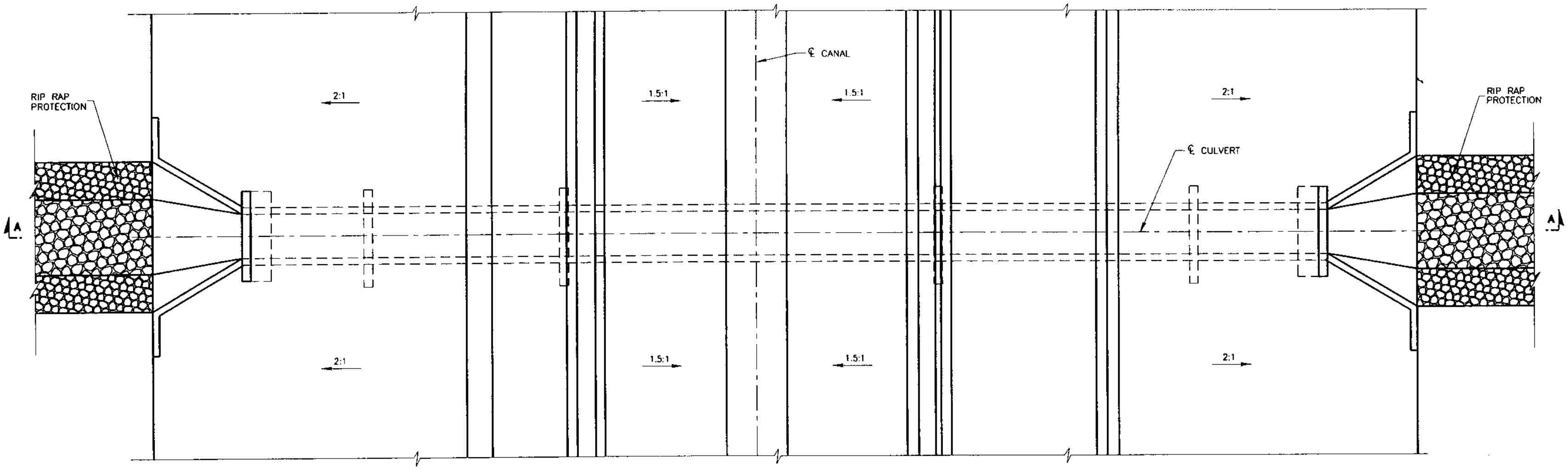
MWH TAMS | April 2003 | Exhibit F20



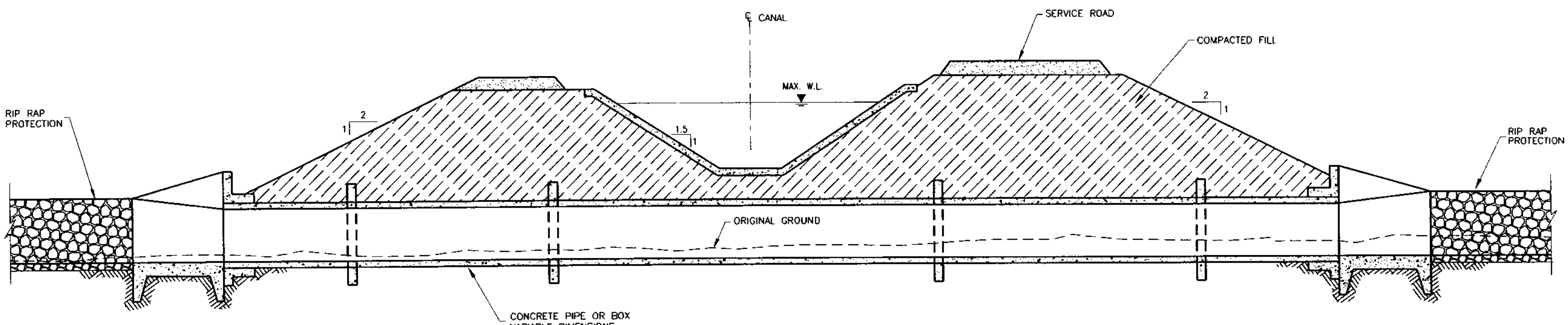
AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Agriculture and Irrigation Potential
Typical Spillway/Waste-way Structure

MWH TAMS	April 2003	Exhibit F21



PLAN
NOT TO SCALE

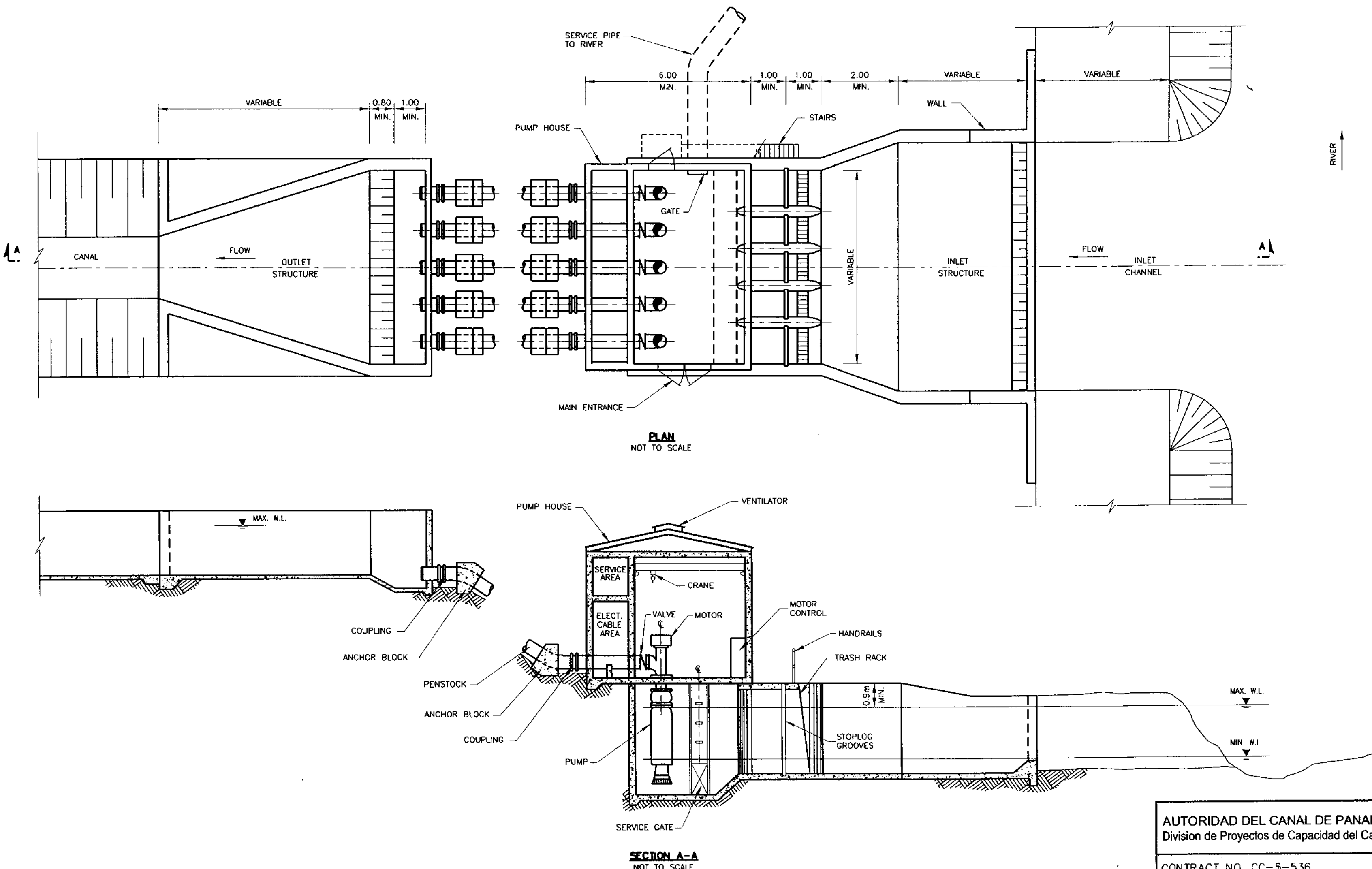


SECTION A-A
NOT TO SCALE

AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Agriculture and Irrigation Potential
Typical Culvert

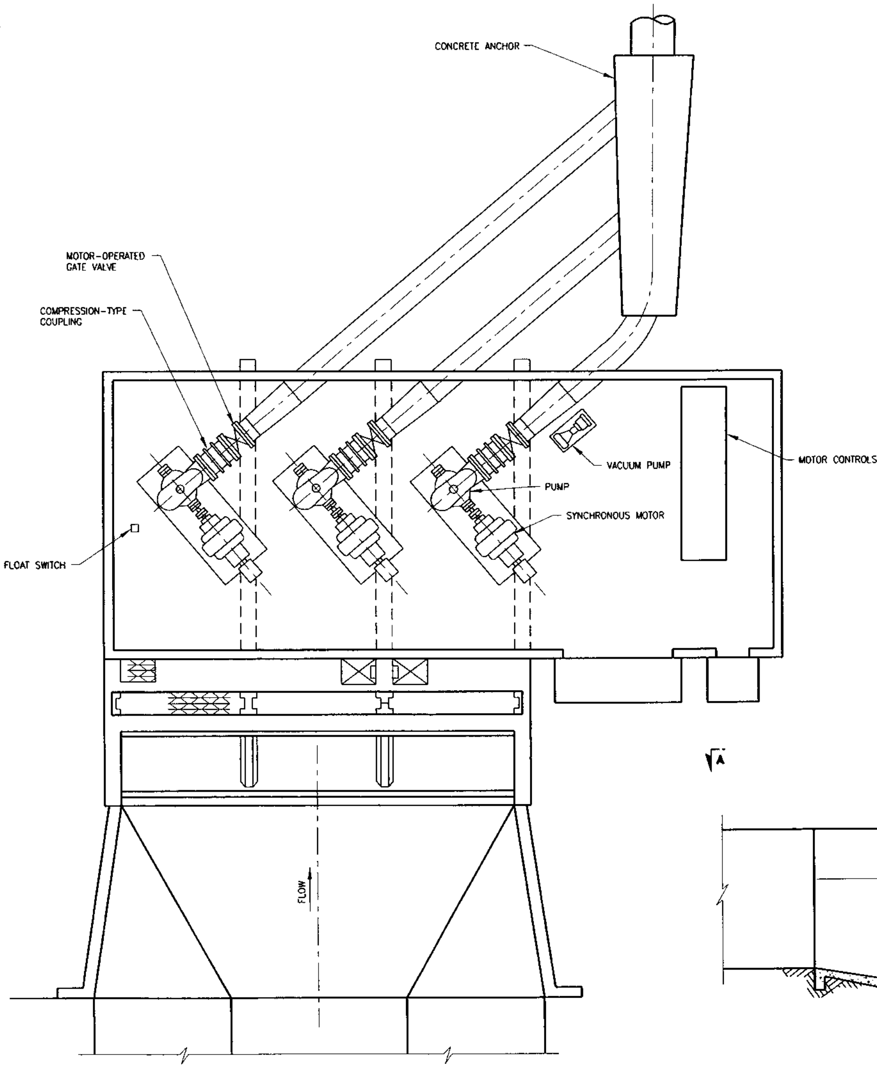
MWH TAMS | April 2003 | Exhibit F22



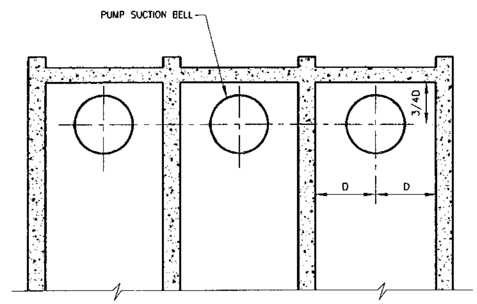
AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Agriculture and Irrigation Potential
Typical River Pump Station

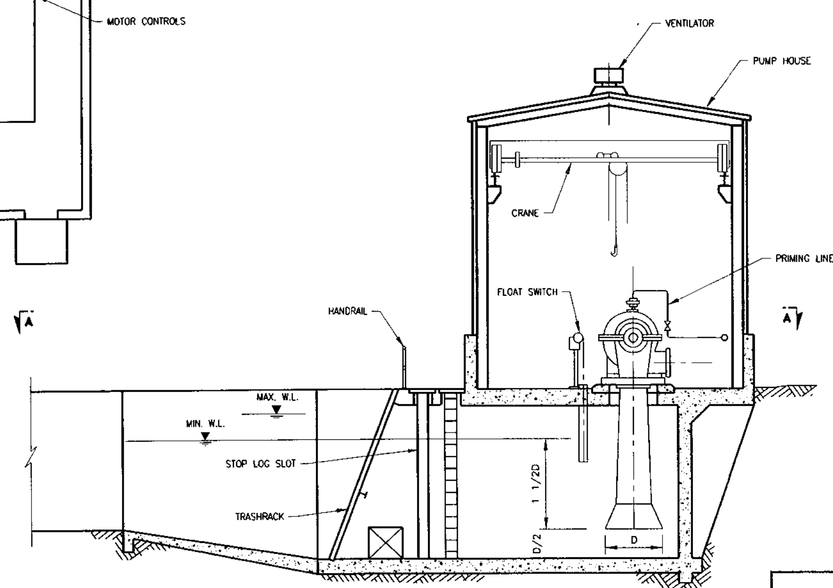
MWH TAMS | April 2003 | Exhibit F23



SECTION A-A
NOT TO SCALE



SUMP PLAN
NOT TO SCALE



SECTION B-B
NOT TO SCALE

AUTORIDAD DEL CANAL DE PANAMA
División de Proyectos de Capacidad del Canal

CONTRACT NO. CC-5-536
Feasibility Design for the Río Indio Water Supply Project
Agriculture and Irrigation Potential
Typical Re-Lift Pump Station

MWH TAMS	April 2003	Exhibit F24

ATTACHMENTS

ATTACHMENT 1

INITIAL SITE RECONNAISSANCE REPORT

Initial Site reconnaissance Report

The site visit party included Abelardo Bal from the PCA-CC, Federico Yearwood from PCA-Environmental, Dr Jorge Jonas, a subconsultant to TAMS and Gustavo Sobrino from TAMS. The helicopter departed around 8:45 Am from Albrook airport. The helicopter flew straight to the mouth of the Rio Indio. In the coastal areas we observed an oil palm tree plantation (Photo No.1). We proceeded with the reconnaissance in the upstream direction over the narrow valley along the Rio Indio and landed near the dam site. At that location we took a water sample from the Rio Indio, and observed what appeared to be imperfectly drained clay loam soils. Despite being during the low-flow season, the river carries substantial flow. The water is clear. Along the valley, we observed grown rattan pastures; no livestock was seen.

Next we flew over to El Limon, just upstream of the dam site. We continued the flight upstream towards the proposed reservoir area, flew over Los Uveros, where a teak tree plantation was observed, the Tres Hermanas area (Photo No.2), where we observed the presence of red soils and landed at the Nuevo Paraiso area (Photos Nos. 3, 4, 5 and 6). At this location we observed maize, crop, watering pools for livestock and/or upland rice. From conversation with a resident, crops grown in this area include name, coffee, upland rice, maize yucca, papaya, oranges, avocados, beans (guandul), royal palm. The red soils were observed by hand and appear to have good internal drainage. It appears that some supplemental irrigation is practiced in crops such as upland rice, maize. Development of agriculture is at subsistence level supplemented by some cash crops, home grown poultry, some livestock. Poor access is a limitation according to the people we talked to.

Next we flew over and landed at the village of Tres Hermanas. According to a conversation with a local farmer "caracotillo" coffee is grown in sheltered/shaded/humid areas near streams. Families raise chickens, pigs and some cattle. Pools are built to provide supplemental irrigation of upland rice and for fisheries (tilapia), with assistance by the NGO Caritas under a sustainable farm project. Pineapple would be a potential crop since it grows well under irrigation in similar areas. However pineapple is not cultivated in this area, although Caritas tried it and got good results, because of poor access. For the same reason most crops are grown at subsistence level. An all-weathered road would motivate farmers to produce more. The wet season starts in April/May and continues though December. There is an elementary scholl with three teachers, 96 students and a new kindergarten. There is concern about flooding by reservoir at Tres Hermanas.

Subsequently we flew over and the landed at Coquillo-El Chorrito village, where the population have expressed opposition to building of the proposed dam on Rio Indio. This village lies on the left bank of the Rio Uracillo, a left tributary of the Rio Indio. It is likely that this stream could also be tapped as a source of water.

Photo 1 – Oil palm plantation – Boca del Río Indio in background

Photo 2 – Tres Hermanas

Photo 3 – Existing dry weather access road

Photo 4 – Typical buildings at Nuevo Paraíso

Photo 5 – Landing at Nuevo Paraíso

Photo 6 – Observing existing red soils – Nuevo Paraíso

Photo 7 – Río Terial – water sample. Pebble beach in background

Photo 8 – Río Terial – deep soil terrace in background (right bank)

ATTACHMENT 2

LAND CLASSIFICATION SPECIFICATIONS

Land Classification Specifications

Land Classification Specifications			
Land Characteristics	**Class 1 - Arable**	**Class 2 – Arable**	**Class 3 . Arable**
	Soils		
Texture	Sand loam to friable clay loam.	Loamy sand, to very permeable clay.	Loamy sand, to permeable clay.
Depth: To sand, gravel, or cobble.	36° plus - good free working soil of fine sandy loam or finer; or 42° of sandy loam.	24° plus - good free working of fine sandy loam or finer; or 30 - 36° of sandy loam to loamy sand.	18° plus - good free working soil of fine sandy loam or finer; or 24 - 30° of coarser textured soil.
To shale, raw soil from shale, or similar material (6" less in each instance to rock and similar material).	60" plus; or 54" with minimum of 6" of gravel overlying impervious material or sandy loam throughout.	48" plus; or 42" with minimum of 6" of gravel overlying impervious material or loamy sand throughout.	42" plus or 36" with minimum of 6" of gravel overlying impervious material or loamy sand throughout.
To penetrable lime zone.	18" with 60" penetrable.	14" with 48" penetrable.	10" to 36" penetrable-
Alkalinity	pH 9.0 or less, unless soil is calcareous, total salts are low and evidence of black alkali is absent.	pH 9.0 or less, unless soil is calcareous, total salts are low and evidence of black alkali is absent.	pH 9.0 or less, unless soil is calcareous, total salts are low and evidence of black alkali is absent.
Salinity	Total salts not to exceed 0.2%. May be higher in open permeable soil and under good drainage conditions.	Total salts not to exceed 0.5%. May be higher in open permeable soil and under good drainage conditions.	Total salts not to exceed 0.5%. May be higher in open permeable soil and under good drainage conditions.
	Topography		
Slopes	Smooth slopes up to 4% in general gradient in reasonably large sized bodies sloping in the same plane.	Smooth slopes up to 8% in general gradient in reasonably large sized bodies sloping in the same plane; or rougher slopes which are less than 4% in general gradient.	Smooth slopes up to 12% in general gradient in reasonably large sized bodies sloping in the same plane; or rougher slopes which are less than 8% in general gradient.
Surface	Even enough to require only small amount of leveling and no heavy grading.	Moderate grading required but in amounts found feasible at reasonable cost in comparable irrigated areas.	Heavy and expensive grading required in spots but in amounts found feasible in comparable irrigated areas.
Cover (loose rocks and vegetation).	Insufficient to modify productivity or cultural practices, or clearing cost small.	Sufficient to reduce productivity and interfere with cultural practices. Clearing required but at moderate cost.	Present in sufficient amounts to require expensive but feasible clearing.
	Drainage		
Soil and topography	Soil and topographic conditions such that no specific farm drainage requirement is anticipated.	Soil and topographic conditions such that some farm drainage will probably be required but with reclamation by artificial means appearing feasible at reasonable cost..	Soil and topographic conditions such that significant farm drainage will probably be required but with reclamation by artificial means appearing expensive but feasible.
	Class 4 - Limited Arable		
Includes lands having excessive deficiencies and restricted utility but whit special economic and engineering studies have shown to be irrigable.			
	Class 5 – Nonarable		
Includes lands which will require additional economic and engineering studies to determine their irrigability and lands classified as temporarily nonproductive pending construction of corrective works and reclamation.			
	Class 6 – Nonarable		
Includes lands, which do not meet the minimum requirements of the next higher class mapped in a particular survey and small areas of arable land lying within larger bodies of nonarable land.			

Source: USBR Irrigated Land Use.

ATTACHMENT 3

WATER SAMPLES

Water Samples

Water Sample W - 1					
Classification (**C-1**, **S-1**)					
Conductivity EC x 10^6 at 25° C Percent Sodium Sodium Absorption		130 26.56 0.52	Dissolved Solids ppm pH		140 7.4
Cations	Milligram Equivalent per Liter	ppm	Anions	Milligram Equivalent per Liter	ppm
Calcium (Ca)	0.32	6.4	Carbonate (CO_3)	Nil	Nil
Magnesium (Mg)	0.12	1.5	Bicarbonate (HCO_3)	0.78	40.0
Sodium (Na)	0.17	4.0	Sulfate (SO_4)	u	u
Potassium (K)	0.03	1.0	Chloride (Cl)	0.20	7.0
Sum	0.64	12.9	Sum	0.98	47.0

u = Undetermined.

Water Sample W - 2					
Classification (**C-1**, **S-1**)					
Conductivity EC x 10^6 at 25° C Percent Sodium Sodium Absorption		170 27.71 0.43	Dissolved Solids ppm pH		120 6.9
Cations	Milligram Equivalent per Liter	ppm	Anions	Milligram Equivalent per Liter	ppm
Calcium (Ca)	0.32	6.4	Carbonate (CO_3)	Nil	Nil
Magnesium (Mg)	0.25	3.0	Bicarbonate (HCO_3)	0.78	40.0
Sodium (Na)	0.23	5.2	Sulfate (SO_4)	u	u
Potassium (K)	0.03	1.0	Chloride (Cl)	0.24	8.4
Sum	0.83	15.6	Sum	1.02	48.4

u = Undetermined.

Water Sample W - 3					
Classification (**C-1**, **S-1**)					
Conductivity EC x 10^6 at 25° C Percent Sodium Sodium Absorption		100 24.44 0.39	Dissolved Solids ppm pH		180 7.4
Cations	Milligram Equivalent per Liter	ppm	Anions	Milligram Equivalent per Liter	Ppm
Calcium (Ca)	0.28	5.6	Carbonate (CO_3)	Nil	Nil
Magnesium (Mg)	0.36	4.4	Bicarbonate (HCO_3)	0.59	30.0
Sodium (Na)	0.22	5.1	Sulfate (SO_4)	u	u
Potassium (K)	0.04	1.5	Chloride (Cl)	0.24	8.4
Sum	0.90	16.6	Sum	0.83	38.4

u = Undetermined.

ATTACHMENT 4

MONTHLY RAINFALL RECORDS

Rainfall Station
at

Icacal

Monthly Precipitation in mm

Lat: 9°12' Long: 80°09' Elev: 11msnm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1959	50	11		82	484	424	427	308	586	243	685	463	
1960	134	65	395	531	489	359	495	271	296	627	597	1016	**5,274**
1961	68				303	543	339	950	317	575	691	388	
1962	155	73	48	142	625	345	791				736		
1963	185	176	39	139	715		476	361	362	450	526	176	
1964	193	36	48	115	538	492	453	378	294	518	564	196	**3,823**
1965	222	35	8	136	451	457	370	538	291	689	1166	415	**4,778**
1966	75	7	70	225	665	286	461	652	290	615	1081	468	**4,896**
1967	167	35	71	160	338	527	497	671	257	272	620	304	**3,919**
1968	10	205	115	48	409	266	580	510	308	668	515		
1969		107	36	156	516	222	493	327	313	421	384	612	
1970	284	51	134	509	572	278	380	252	311	423	1005	757	**4,956**
1971	156	112	146	9	457	602	587	367	227	315	398	167	**3,543**
1972	408	73	112	627	454	196	341	393	325	673	273	236	**4,112**
1973	46	29	20	104	424	412	376	466	292	343	516	417	**3,445**
1974	63	67	72	40	461	348	699	484	117	284	955	130	**3,719**
1975	43	37	137	34	418	770	669	342	353	438	451	668	**4,359**
1976	64	60	9	155	355	290	343	393	502	502	329	207	**3,210**
1977	23	31	8	40	339	426	313	568	416	728	601	480	**3,972**
1978	102	72	147	369	250	556	464	375	269	401	473	109	**3,586**
1979	22	137	7	214	565	512	364	358	354	359	550	399	**3,839**
1980	206	79	18	14	431	144	374	323	457	548	283	449	**3,324**
1981	158	96	81	677	553	334	534	389	352	416	926	656	**5,171**
1982	271	52	220	114	106	291	565	373	418			167	
1983	63	30	74	240	551	299	410	473	346	199	237	547	**3,468**
1984			78	71	423	386	405	339	229	346	547	142	
1985	183	56	52	25	439	393	444		367	407			
1986			89	413	403	478	783	546	455	575	505	185	
1987	73	47	33	522	608	324	510	373	572	840	366	423	**4,689**
1988	48	67	32	77	411	295	446	356	218	373	590	314	**3,227**
1989	28	55	70	18	207	425	288	740	481	677	484	220	**3,693**
1990	79	10	59	170	412	246	432	425	496	587	433	467	**3,816**
1991	119	60	126	190	816	442	395	309	435	552	755	196	**4,394**
1992	49				249			472	366	343	524	278	
1993	94	32	203	278	290	30	86	226	236	354	582	373	**2,785**
1994	72	46	62	78	322	565	439	364	405	288	597	149	**3,386**
1995	178	34		193	498	528	490	137	152	227	707	645	
1996		168	121	159	345	437	476	369	257	223	542	361	
1997	178	59	5	67	215	223	339	354	411	316	333	23	**2,522**
1998	70	26	34	454	379	462	439		172		514	609	
Avg	120	65	83	200	437	385	456	420	341	454	580	373	**3,919**
Std	86	45	75	180	142	141	131	150	106	161	215	212	**704**
Max	408	205	395	677	816	770	791	950	586	840	1,166	1,016	**5,274**
Min	10	7	5	9	106	30	86	137	117	199	237	23	**2,522**
50% exc	90	55	65	150	420	390	430	370	320	430	520	370	
80% exc	50	30	20	50	305	280	380	330	260	300	400	180	
90% exc	32	20	10	25	230	220	320	270	200	240	310	140	

Rainfall Station
at

Miguel de la Borda

Monthly Precipitation in mm

Lat: 9°09' Long: 80°19' Elev: 2msnm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1975			148	28	398	576	402	481	194	316	461	643	
1976	126	91	11	299	351	128	325	542	743	561	555	491	**4,223**
1977	52	95	47	44	484	490	356	562	357	737	733	442	**4,400**
1978	118	39	218	415	200	393	698	532	395	472	473	125	**4,077**
1979	47	162	45	174	478	467	235	314	286	309	492	462	**3,471**
1980	188	143	19	37	335	388	336	423	430	425	290	524	**3,536**
1981	261	244	118	750	415	237	377	397	272	456	746	747	**5,019**
1982	171	100	114	184	168	432	496	537	423	536	421	201	**3,782**
1983	93	24	17	215	433	311	477	350	588	341	362	711	**3,921**
1984	314	219	79	79	444	459	366	380	255	310	432	176	**3,513**
1985	145	67	96	39	420			309	537	491	556	408	
1986	102		81	491	337	317	487	401	229	327	321	80	
1987	44	31	27	226	279	242	298	261	256	501	407	334	**2,906**
1988	46	25	19	116	236	304	360				478	381	
1989	54	60	82	115	340	463	373	504	246	658	439	184	**3,519**
1990	126	55	48	185	430	255	327	500	297	422	338	462	**3,444**
1991	158	52	183	99	474	511	456	341	559	391	867	196	**4,285**
1992	134	112	20	460	324	119	572	436	283	310	504	168	**3,442**
1993	104	68	138	475	122	405	260	516	259	334	536	438	**3,653**
1994	165	65	113	203	496	418	358	647	145	269	421	142	**3,441**
1995	129	6	111	308	330	328	322	264	328	265	523	588	**3,503**
1996	422	192		229	408	528	421	384	258	493	688	297	
1997	169	299	4	87	324	318	248	309	309	449	268	26	**2,810**
1998	104	53	90	405	454	640	525	556	133	210	488	691	**4,347**
1999													
Avg	142	100	79	236	362	379	394	432	338	417	492	372	**3,752**
Std	88	77	57	179	101	130	108	105	147	127	144	209	**524**
Max	422	299	218	750	496	640	698	647	743	737	867	747	**5,019**
Min	44	6	4	28	122	119	235	261	133	210	268	26	**2,810**
50% exc	120	80	65	190	360	380	390	420	300	400	480	380	
80% exc	55	30	20	50	270	240	300	310	220	290	355	180	
90% exc	45	25	10	40	180	180	250	280	170	250	300	100	

Rainfall Station
at

Boca de Uracillo

Monthly Precipitation in mm

Lat: 8°58' Long: 80°11' Elev: 20msnm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1975	65	35	60	27	418	247	241	451	364	567	610	616	**3,700**
1976	101	74	32	126	310	243	142	198	431	365	303	166	**2,490**
1977	59	64	25	77		309	229	337		477	337	222	
1978	196	110	185	388	404	222	374	287	306	380	363	97	**3,309**
1979	36	134	31	216	416	433	471	533	327	323	258	219	**3,396**
1980	195	125	19	68	438	371	391	246	170	291	329	310	**2,954**
1981	222	122	169	396	352	386	407	378	190	330	520	466	**3,939**
1982	163	41	56	139	183	216	347	366	244	514	197	74	**2,540**
1983	58	23	10	105	413	313	251	248	395	411	314	320	**2,860**
1984	144	126	73	63	608	358	263	431	323	406	358	111	**3,263**
1985	201	44	79	37	306	435	315	311	286	411	349	248	**3,021**
1986	105	21	54	517	257	297	196	249	288	462	405	77	**2,928**
1987	74	61	14	234	319	253	353	287	338	473	307	187	**2,900**
1988	38	87	20	126	325	250	313	495	390	472	446	154	**3,114**
1989	55	103	40	77	232	258	236	438	193	475	391	168	**2,665**
1990	160	22	115	116	561	235	235	305	566	586	282	408	**3,590**
1991	60	60	140	106	295	225	180	131	440	355	288	268	**2,547**
1992	70	56	22	200	396	328	301	303	254	315	327	164	**2,734**
1993	109	59	122	323	212	332	181	173	343	432	397	282	**2,964**
1994	78	39	161	148	526	389	212	186	394	366	368	128	**2,995**
1995	151	28	79	257	319	509	345	257	320	312	344	260	**3,181**
1996	305	217	141	118	373	355	235	186	225	427	366	280	**3,229**
1997	67	37	10	54	168	232	134	137	193	206	178	36	**1,452**
1998	36	22	56	195	224	333	239	344	100	223	246	442	**2,461**
Avg	114	71	71	171	350	314	274	303	308	399	345	238	**2,967**
Std	70	47	54	124	113	78	85	109	103	95	91	137	**498**
Max	305	217	185	517	608	509	471	533	566	586	610	616	**3,939**
Min	36	21	10	27	168	216	134	131	100	206	178	36	**1,452**
50% exc	95	55	60	125	325	310	250	295	315	390	340	205	**2,960**
80% exc	55	30	20	65	235	235	195	195	200	300	280	115	**2,550**
90% exc	37	22	12	45	195	220	160	155	170	255	220	70	**2,480**

Rainfall Station
at

Santa Ana

Monthly Precipitation in mm

Lat: 8°49' Long: 80°16' Elev: 200msnm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1980											381	377	
1981	188	115	95	261	457	245	402	412	119	414	438	404	**3,549**
1982	174	35	38	153	161	258	249	203	208	424	107	95	**2,103**
1983	60	12	28	87	381	178	104	255	311	316	250	251	**2,233**
1984	70	149	47	21	305	345	359	349	358	339	238	77	**2,655**
1985	142	32	72	41	215	308	192	348	199	228	287	98	**2,162**
1986	103	15	70	301	132	415	277	273	207	489	403	50	**2,733**
1987	49	37	12	187	189	147	249	137	233	418	184	120	**1,961**
1988	46	62	12	89	319	180	292	303	188	356	309	109	**2,265**
1989	67	51	79	51	248	350	296	248	220	280	349	139	**2,376**
1990	67	23	84	71	207	192	133	158	387	442	408	225	**2,397**
1991	56	47	332	62	309	227	234	209	369	424	266	133	**2,668**
1992	43	51	16	123	308	238	157	200	313	225	229	117	**2,021**
1993	162	36	88	91	80	151	108	163	200	321	274	168	**1,843**
1994	62	29	133	133	266	205	210	236	345	291	185	71	**2,165**
1995	71	23	95	111	256	275	243	214	258	264	224	136	**2,170**
1996	163	191	30	69	194	226	221	138	225	216	374	216	**2,262**
1997	81	116	27	57	233	105	125	58	136	205	151	65	**1,358**
1998	20	25	20	64	153	501	90	142	36	90	89	294	**1,524**
1999	124		91	159	138								
Avg	92	58	72	112	239	253	219	225	240	319	271	165	**2,247**
Std	49	49	70	72	91	98	86	87	91	101	100	100	**469**
Max	188	191	332	301	457	501	402	412	387	489	438	404	**3,549**
Min	20	12	12	21	80	105	90	58	36	90	89	50	**1,358**
50% exc	75	40	50	90	225	230	220	200	215	295	255	135	**2,200**
80% exc	50	20	20	55	150	170	125	145	180	210	175	75	**1,950**
90% exc	43	15	15	40	130	140	100	135	90	190	105	60	**1,550**

Rainfall Station
at

Chiguiri Arriba

Monthly Precipitation in mm

Lat: 8°40' Long: 80°11' Elev: 180msnm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1959	51	15	20	112	220	463	367	403	347	542	224	369	**3,131**
1960	150	50	68	189	414	424	511	513	341	371	619	434	**4,083**
1961	79	28	6	60	179	421	366	449	307	445	364	364	**3,065**
1962	86	27	39	204	353	412	239	673	289	425	492	216	**3,453**
1963	81	99	21	262	308	405	484	371	261	381	353	162	**3,186**
1964	46	191	61	293	364	398	527	493	392	608	319	93	**3,783**
1965	140	42	15	3	188	288	374	448	239	297	404	310	**2,746**
1966	123	34	32	196	489	507	614	412	519	430	545	516	**4,414**
1967	96	48	25	193	298	623	417	430	536	554	475	308	**4,001**
1968	13	105	102	85	350	489	454	255	399	540	418	241	**3,448**
1969	85	41	23	84	310	370	351	364	503	290	506	196	**3,120**
1970	215	85	137	198	551	271	619	353	493	475	343	577	**4,315**
1971	145	160	264	72	492	520	600	668	412	485	453	94	**4,363**
1972	193	49	34	348	287	377	290	261	370	370	185	87	**2,847**
1973	30	38	14	79	390	635	380	469	400	526	689	176	**3,824**
1974	116	32	30	48	264	285	342	334	432	613	365	54	**2,912**
1975	40	20	22	25	336	436	290	591	343	491	807	384	**3,782**
1976	82	35	12	81	318	247	172	382	348	426	189	66	**2,355**
1977	28	29	19	78	408	394	356	409	344	504	211	102	**2,878**
1978	68	61	215	203	486	349	317	422	293	458	624	68	**3,562**
1979	16	32	15	289	311	303	324	442	390	338	263	405	**3,125**
1980	119	51	12	52	415	362	373	482	315	517	319	171	**3,186**
1981	131	99	82	303	557	328	462	510	459	407	536	462	**4,335**
1982	113	18	25	270	372	363	321	361	207	426	306	69	**2,848**
1983	41	10	15	148	744	566	278	509	670	402	242	350	**3,975**
1984	78	229	32	2	302	382	405	424	497	487	238	66	**3,142**
1985	69	22	18	14	142	487	194	412	353	488	353	203	**2,754**
1986	30	4	15	158	124	525	345	386	318	427	393	59	**2,784**
1987	56	48	6	159	168	237	215	241	556	479	145	96	**2,407**
1988	31	64	13	113	409	421	434	396	430	485	354	226	**3,376**
1989	72	57	40	24	424	328	428	574	314	374	447	176	**3,259**
1990	120	93	55	37	398	261	354	395	468	467	308	241	**3,196**
1991	31	35	125	58	382	311	326	464	412	442	208	144	**2,938**
1992	35	33	11	191	379	423	293	324	482	349	306	153	**2,978**
1993	125	31	126	101	164	517	350	359	413	435	716	244	**3,580**
1994	32	23	26	182	636	520	612	433	605	685	378	172	**4,304**
1995	60	15	87	218	750	700	488	724		606	693	414	
1996	544	244	83	97	784	817	616	485	609	327	518	579	**5,703**
1997	87	176	5	45	255	319	317	292	508	434	375	67	**2,880**
1998	9	17	35	187	465	637	557	740	413	629	712	696	**5,097**
1999	123	58	47	255	938	648							
Avg	92	62	49	139	393	433	394	441	410	461	410	245	**3,465**
Std	86	58	55	92	178	132	118	116	104	90	165	166	**713**
Max	544	244	264	348	938	817	619	740	670	685	807	696	**5,703**
Min	9	4	5	2	124	237	172	241	207	290	145	54	**2,355**
50% exc	75	40	25	110	370	410	370	420	400	440	380	190	**3,190**
80% exc	30	20	14	45	255	300	290	360	315	380	270	90	**2,880**
90% exc	20	15	9	24	170	270	240	290	280	340	200	65	**2,760**

Rainfall Station
at

El Cacao

Monthly Precipitation in mm

Lat: 8°46' Long: 80°01' Elev: 180msnm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1974						179	246	188	226	693	226	35	
1975	34	3	8	10	233	187	268	369	383	328	426	234	**2,481**
1976	34	6	8	169	290	116	63	201	332	511	176	92	**1,997**
1977	86	25	9	18	241	303	156	442	306	434	279	68	**2,366**
1978	47	29		238	263	213	300	364	278	425	342		
1979	6	15	7	38	208	281	124	246	331	264	324		
1980	16	35	0	17	285	233	183	273	371	323	310	77	**2,123**
1981	79	1	282	397	260	244							
1982					137	110	177	130	238	352	161	25	
1983	23	5	0	38	333	157	124	208	315	311	215	251	**1,981**
1984	53	101	29	56	392	299	208	249	219	397	258	35	**2,294**
1985	75		19	12	354	220	228	242	366	249	246	146	
1986	46	6	20	179	170	277	118	226	212	466	311	42	**2,071**
1987	24	26	4	171	227	191	175	208	480	464	145	96	**2,210**
1988	15	16	2	73	323	246	212	248	283	260	230	155	**2,063**
1989	88	60	28	22	329	162	198	301	181	624	312	276	**2,580**
1990	85	9	39	57	397	282	267	314	411	570	271	120	**2,822**
1991	17	19	32	49	107	195	160	123	244	323	246	103	**1,619**
1992	12	19	15	162	210	370	189	261	460	245	305	95	**2,342**
1993	99	29	59	114	196	401	165	188	356	189	370	177	**2,343**
1994	9	20	64	39	320	185	128	187	336	409	326	117	**2,140**
1995	23	17	42	144	421	280	215	201	229	194	119	95	**1,981**
1996	334	68	95	16	259	379	322	310	368	470	236	115	**2,970**
1997	99	16	0	71	104	154	83	141	202	299	171	32	**1,372**
1998	2	63		71	205	134	147	203	274	282	331		
Avg	57	27	36	94	261	232	186	243	308	378	264	113	2,209
Std	67	24	60	91	85	78	64	76	80	130	74	70	372
Max	334	101	282	397	421	401	322	442	480	693	426	276	2,970
Min	2	1	0	10	104	110	63	123	181	189	119	25	1,372
50% exc	40	20	18	60	260	225	190	225	300	350	275	100	
80% exc	12	7	4	20	195	160	125	185	230	250	175	45	
90% exc	5	3	1	14	130	130	95	145	200	220	150	30	

Rainfall Station
at

Ciri Grande

Monthly Precipitation in mm

Lat: 8°46' Long: 80°03' Elev: 180msnm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1974								202	252	582	232	39	
1975	16	25	10	8	330	232	275	380	469	459	432	412	**3,048**
1976	40	32	4	168	185	61	56	301	376	488	210	67	**1,987**
1977	47	14	5	61		195	137	307	216	303	253	121	
1978	79	58	91	330	241	218	257	394	300	421	294	111	**2,794**
1979	24	9	1	230	198	353	212	467	476	379	213		
1980	44	49	1	27	327	263	219	208	214	351			
1981													
1982			15	189	195	240	148	96	215	370	222	8	
1983	45	4	0	77	394	243	138	220	411	226	369	380	**2,506**
1984	91	130	48	20	413	287	198	309	274	417	318		
1985	84	4	35	22	373	316	235	260	571	340	278	133	**2,653**
1986	71	12	27	326	179	451	181	242	176	398	370	41	**2,474**
1987	36	50	3	206	277	308	198	144	397	431	131	113	**2,292**
1988	10	53	8	70	296	213	252	713	327	345	296	258	**2,839**
1989	110	81	18	33	513	197	264	387	251	416	262	214	**2,746**
1990	67	8	63	51	352	201	209	271	353	469	282	146	**2,471**
1991	20	18	73	51	257	254	165	137	272	499	192	58	**1,995**
1992	16	13	6	130	311	318	212		537	225	260	106	
1993	73	19	60	143	245	435	194	149	364	215	510	146	**2,552**
1994	23	24	119	88	316	255	153	168	277	356	250	63	**2,093**
1995	35	9	35	155	367	240	315	311	243	239	242	163	**2,353**
1996	497	91	140	52	311	332	311	393	415	467	270	270	**3,549**
1997	83	28	0	47	114	111	86	138	226	296	135	6	**1,269**
1998	9	29	46	112	223	186	212	167	262		291	245	
1999	140	94	119	147	354	389	192	474	590	203	401		
Avg	72	37	39	114	294	262	201	285	339	371	280	148	2,476
Std	97	33	42	89	89	89	62	139	116	99	86	110	497
Max	497	130	140	330	513	451	315	713	590	582	510	412	3,549
Min	9	4	0	8	114	61	56	96	176	203	131	6	1,269
50% exc	45	25	18	90	310	250	205	210	315	370	270	120	
80% exc	18	9	3	35	205	205	150	170	220	260	210	50	
90% exc	14	6	1	25	180	150	105	140	200	230	160	20	

ATTACHMENT 5

MONTHLY FLOWS AT BOCA DE URACILLO

Rio Indio at Boca de Uracillo

Mean Monthly Discharges (m^3/s)

Drainage Area: 365 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1948	11.7	4.6	3.3	2.5	5.2	7.4	27.4	31.9	30.4	28.2	56.1	15.7	**18.7**
1949	6.6	4.0	2.6	2.4	7.1	38.5	27.2	34.0	47.7	45.2	78.1	61.9	**29.6**
1950	10.9	6.1	3.7	2.7	18.6	34.1	35.5	51.6	34.4	46.7	60.5	60.7	**30.5**
1951	19.4	10.8	6.1	4.1	19.1	23.3	21.7	23.5	39.9	33.8	50.7	29.4	**23.5**
1952	13.0	6.2	3.3	2.9	10.9	27.7	21.5	22.7	38.2	54.5	34.3	48.5	**23.6**
1953	36.3	14.1	7.6	5.4	22.5	20.2	19.7	16.3	20.2	57.1	57.2	31.5	**25.7**
1954	16.0	7.6	4.8	3.9	18.0	19.0	44.8	33.9	46.0	39.2	73.5	39.2	**28.8**
1955	42.0	13.3	6.6	5.2	10.4	39.4	28.1	46.1	56.3	48.7	74.1	43.2	**34.4**
1956	43.6	13.6	7.9	7.3	27.5	39.7	37.3	27.9	44.5	66.4	47.2	27.5	**32.5**
1957	11.0	5.7	3.7	2.7	11.3	11.4	11.2	21.9	23.9	54.4	35.8	28.9	**18.5**
1958	18.1	14.0	7.5	5.4	16.6	19.9	27.3	36.7	35.6	46.5	37.8	20.1	**23.8**
1959	9.0	5.5	3.9	3.5	5.2	80.1	89.5	13.6	15.9	48.0	33.2	42.1	**29.1**
1960	20.2	8.4	8.7	10.8	25.5	27.0	26.7	27.5	24.2	38.5	53.5	89.1	**30.0**
1961	15.1	7.9	4.5	4.6	8.0	20.0	17.7	19.6	31.3	48.3	42.6	34.4	**21.2**
1962	12.7	6.8	4.1	3.7	5.6	8.4	11.5	28.7	24.7	33.2	34.4	26.2	**16.7**
1963	10.6	7.1	3.9	8.0	17.3	20.7	24.9	32.3	32.7	46.4	51.9	17.4	**22.8**
1964	8.7	4.7	3.1	3.5	12.8	41.2	40.6	41.4	49.7	53.5	62.7	19.5	**28.5**
1965	15.0	7.5	4.3	2.5	3.9	7.8	6.9	15.7	12.6	25.8	32.0	33.9	**14.0**
1966	12.0	6.0	4.1	4.3	24.5	33.6	27.1	24.2	17.6	50.8	67.7	52.0	**27.0**
1967	16.9	8.3	4.4	6.8	20.5	47.9	36.2	39.7	52.9	61.0	40.8	19.3	**29.6**
1968	9.1	6.6	4.3	3.8	10.4	29.1	21.9	30.8	32.3	54.1	52.3	25.4	**23.3**
1969	10.9	6.4	3.3	5.0	10.2	20.7	14.9	24.2	49.4	42.2	46.0	28.0	**21.8**
1970	23.0	10.3	8.7	9.2	27.3	18.4	20.6	44.4	37.7	56.2	44.3	91.7	**32.7**
1971	39.9	14.3	8.1	6.1	23.9	35.4	30.2	43.9	48.3	53.6	63.4	18.6	**32.1**
1972	12.7	8.4	5.2	13.9	11.8	21.4	9.5	13.7	31.3	31.6	33.1	13.6	**17.2**
1973	7.8	4.9	2.4	2.6	9.3	37.4	38.7	31.1	55.1	61.3	72.6	35.8	**29.9**
1974	16.2	10.0	7.3	4.4	8.5	18.2	22.1	25.5	30.0	83.7	48.0	25.4	**24.9**
1975	11.3	6.7	4.5	2.9	7.6	14.9	21.9	41.7	57.9	64.0	97.4	52.0	**31.9**
1976	20.4	10.9	6.5	5.7	13.3	12.2	6.4	7.8	22.9	53.4	37.1	14.8	**17.6**
1977	9.1	5.7	3.6	2.8	7.8	11.5	11.0	24.6	28.3	52.6	39.3	21.7	**18.2**
1978	10.7	7.1	4.7	25.8	22.5	31.5	30.4	41.0	42.9	49.0	41.8	24.5	**27.7**
1979	13.7	10.6	9.7	10.9	17.4	28.0	27.7	34.9	37.3	35.1	25.9	24.9	**23.0**
1980	23.2	8.4	3.9	2.7	13.5	18.3	20.1	47.2	23.7	36.0	32.4	27.8	**21.4**
1981	20.1	13.0	11.8	28.9	29.6	33.1	39.8	37.6	28.7	48.0	58.6	75.6	**35.4**
1982	18.6	5.8	3.8	5.2	9.1	21.2	27.0	17.3	27.8	50.6	26.1	8.9	**18.4**
1983	5.8	3.0	1.8	1.5	15.6	23.3	16.5	18.5	45.1	35.2	29.9	38.4	**19.6**
1984	15.7	10.0	6.5	3.6	16.9	27.4	30.8	48.5	39.8	44.6	37.7	12.8	**24.5**
1985	8.6	5.3	4.1	2.7	8.4	30.2	17.3	39.0	37.6	35.0	40.5	26.5	**21.3**
1986	9.4	4.9	3.0	16.0	19.0	29.7	22.2	18.8	27.5	56.1	61.3	15.0	**23.6**
1987	7.4	5.0	2.9	5.0	14.3	22.9	25.7	31.1	40.0	72.1	32.0	17.7	**23.0**
1988	7.5	5.1	2.9	2.6	11.8	23.6	25.2	33.1	33.3	52.6	40.9	22.1	**21.7**
1989	12.6	7.0	4.8	2.8	13.2	18.5	27.8	35.7	34.6	36.4	53.8	30.0	**23.1**
1990	15.2	6.8	4.7	3.2	24.7	17.9	22.9	23.8	41.5	59.7	40.2	62.0	**26.9**
1991	10.3	5.8	7.0	3.1	14.0	19.9	14.7	18.2	38.6	48.8	33.3	44.1	**21.5**
1992	9.1	3.4	3.7	5.5	26.7	27.9	26.8	46.1	43.1	37.5	31.6	19.4	**23.4**
1993	11.7	6.7	5.4	8.7	11.1	29.9	21.8	16.9	35.4	49.3	62.9	33.1	**24.4**
1994	12.1	7.0	5.7	6.2	13.4	21.0	15.6	12.1	25.5	36.0	36.9	13.3	**17.1**
1995	8.2	4.4	2.9	4.0	23.0	35.9	31.5	28.8	36.6	30.8	41.8	29.5	**23.1**
1996	57.4	26.7	13.6	7.4	21.0	41.7	45.9	56.5	41.0	71.3	55.6	51.5	**40.8**
1997	11.3	7.1	4.6	3.4	5.6	6.9	8.0	6.6	15.9	20.8	25.1	11.0	**10.5**
1998	5.1	4.2	2.9	3.9	13.6	12.7	22.2	18.2	25.2	39.4	23.2	34.4	**17.1**
Avg	15.7	7.9	5.1	5.9	15.0	25.6	25.5	29.6	35.2	47.5	46.8	33.1	**24.4**

ATTACHMENT 6

CLIMATIC DATA IN THE RÍO INDIO BASIN

Monthly Climatic Data in the Rio Indio Basin

Table F-1 – Icacal Meteorological Station

Icacal [a] Lat.: 9° 12' N / Long: 80° 9' W / Elev.: 11m						
Month	**P**		**PET**	**PET / 2**	**R**	**T**
	mm				**Cal / cm²**	**° C**
1	50 [b]	90 [c]	112	56	386	26.4
2	30	55	114	57	428	26.9
3	20	65	137	68	457	27.5
4	50	150	123	61	424	27.6
5	305	420	106	53	362	27.2
6	280	390	87	43	315	26.7
7	380	430	95	47	329	26.9
8	330	370	99	49	343	26.8
9	260	320	99	49	354	26.6
10	300	430	94	47	328	26.5
11	400	520	78	39	288	26.5
12	180	370	99	49	344	26.6
Total	2585	3610	1243			

a/ Record period: 1959–1998 for P; 1959–1993 for the estimate of PET, R & T.
b/ Dependable rainfall. Exceeded 80 % of the time.
c/ P exceeded 50 % of the time.

Monthly Climatic Data in the Rio Indio Basin

Table F-2 – Santa Ana Meteorological Station

Santa Ana[a] Lat.: 8° 49' N / Long: 80° 16' W / Elev.: 200 m						
Month	**P**		**PET**	**PET / 2**	**R**	**T**
	mm				**Cal / cm²**	**° C**
1	50[b]	75[c]	130	65	451	25.3
2	20	40	126	63	477	25.8
3	20	50	137	68	465	26.3
4	55	90	125	62	438	26.6
5	150	225	101	50	356	25.7
6	170	230	99	49	359	25.7
7	125	220	105	52	368	25.6
8	145	200	102	51	358	25.6
9	180	215	98	49	356	25.4
10	210	295	81	40	294	25.3
11	175	255	91	45	334	25.2
12	75	135	117	58	407	25.3
Total	1375	2030	1312			

a/ Record period: 1981–1999 for P; 1980–1993 for the estimate of PET, R & T.
b/ Dependable rainfall. Exceeded 80 % of the time.
c/ P exceeded 50 % of the time.

Monthly Climatic Data in the Rio Indio Basin

Table F-3 – Boca de Uracillo Meteorological Station

Boca de Uracillo [a] Lat.: 8° 58' N / Long: 80° 11' W / Elev.: 150 m						
Month	**P**		**PET**	**PET / 2**	**R**	**T**
	mm				**Cal / cm²**	**° C**
1	55 [b]	95 [c]	130	65	442	26.3
2	30	55	122	61	457	26.9
3	20	60	138	69	459	27.4
4	65	125	121	60	418	27.6
5	235	325	101	50	348	27.1
6	235	310	104	52	370	26.7
7	195	250	110	55	376	26.8
8	195	295	105	52	360	26.8
9	200	315	103	51	366	26.5
10	300	390	93	46	324	26.4
11	280	340	96	48	345	26.4
12	115	205	115	57	395	26.5
Total	1925	2765	1338			

a/ Record period: 1975–1998 for P; 1974–1993 for the estimate of PET, R & T.
b/ Dependable rainfall. Exceeded 80 % of the time.
c/ P exceeded 50 % of the time.

ATTACHMENT 7

CROP COEFFICIENTS

Crop Coefficients

Crop	Month											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rice DSR				1.10	1.15	1.20	1.00		1.10	1.15	1.20	1.00
Rice TPR	1.00				1.10	1.15	1.20	1.00		1.10	1.15	1.20
Plantain yr 1	1.13	1.12	1.12	1.10	0.50	0.61	0.72	0.82	0.93	1.04	1.15	1.14
Plantain yr 2	1.17	1.15	1.13	1.10	0.70	0.78	0.87	0.95	1.03	1.12	1.20	1.18
Vegetables	0.40	0.60	0.90	0.70	0.15							
Associated Crops	0.85				0.40	1.20	1.20	1.25	1.10	1.20	1.25	1.20
Fruit Trees	0.84	0.82	0.79	0.76	0.75	0.76	0.78	0.81	0.84	0.80	0.84	0.84
Pasture Field	1.0	1.0	1.0	1.0	0.4	0.4	0.4	0.4	0.4	0.4	1.0	1.0
SEEDBED												
Pasture	0.85	0.85	0.85	0.85	0.40	0.40	0.40	0.40	0.40	0.40	0.85	0.85
NURSERY												
Organic Coffee	0.50	0.58	0.66	0.74	0.82	0.90	0.50	0.58	0.66	0.74	0.82	0.90
Pinus caribaea	0.50	0.64	0.78	0.92	1.06	1.20	0.50	0.64	0.78	0.92	1.06	1.20
Acacia mangium	0.50	0.59	0.68	0.77	0.86	0.95	0.50	0.59	0.68	0.77	0.86	0.95
Byrsonima crassiofolia	0.50	0.59	0.68	0.77	0.86	0.95	0.50	0.59	0.68	0.77	0.86	0.95
Anacardium occidentale	0.50	0.59	0.68	0.77	0.86	0.95	0.50	0.59	0.68	0.77	0.86	0.95

[a/] According to FAO mean crop coefficients, Kc.

ATTACHMENT 8

IRRIGATION EFFICIENCY

Irrigation Efficiency

System	Overall Efficiency
Surface	0.50
Micro Sprinkler	0.65
Sprinkler	0.55

ATTACHMENT 9

SUPPLEMENTARY WATER REQUIREMENTS

Supplementary Water Requirements

Monthly Requirements per Crop (mm)

Coastal Area - Drought Conditions

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice DSP-TRP				170.6									170.6
Rice TPR-TPR	124.0												124.0
Plantain - Yr 1	117.8	150.3	205.3	131.2									604.6
Plantain - Yr 2	124.7	155.5	207.4	131.2									618.9
Vegetables (blend)		59.1	158.9	55.5									273.5
Fruit Trees	67.7	97.7	135.7	66.9									368.0
Associated Crops	81.8												81.8
Pasture - Field	112.7	152.7	212.7	132.7									610.9
Pasture - Seedbed	82.2	121.6	175.4	99.2									478.4
Pinus Caribean - Nursery	10.9	78.1	157.9	114.8									361.8

Lower Rio Indio Basin - Drought Conditions

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice DSP-TRP				136.2									136.2
Rice TPR-TPR	150.0											46.0	196.0
Plantain - Yr 1	141.4	164.1	207.0	104.8								24.8	642.0
Plantain - Yr 2	149.4	169.7	209.1	104.8								31.9	664.8
Vegetables (blend)		66.5	160.3	30.3									257.1
Fruit Trees	83.4	107.8	137.0	41.5									369.6
Associated Crops	100.9											41.8	142.7
Pasture - Field	136.4	167.3	214.6	101.8									620.0
Pasture - Seedbed	100.9	134.0	176.9	68.8									480.6
Pinus Caribean - Nursery	18.2	87.4	159.4	84.2								41.8	391.0

Intermediate Rio Indio Basin - Drought Conditions

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice DSP-TRP				165.0								84.0	249.0
Rice TPR-TPR	160.0						2.0					130.8	292.8
Plantain - Yr 1	149.1	186.3	205.3	126.9								89.8	757.5
Plantain - Yr 2	157.1	192.2	207.4	126.9								97.0	780.6
Vegetables (blend)	3.1	85.5	158.9	50.0									297.5
Fruit Trees	91.0	128.2	135.7	61.5								35.8	452.3
Associated Crops	110.0						1.8					118.9	230.7
Pasture - Field	145.5	192.7	212.7	127.3									678.2
Pasture - Seedbed	110.0	158.4	175.4	93.2								44.5	581.4
Pinus Caribean - Nursery	27.3	110.3	157.9	109.1								118.9	523.5

Supplementary Water Requirements

Monthly Requirements per Crop (mm)

Coastal Area - Average Conditions

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice DSP-TRP													0.0
Rice TPR-TPR	44.0												44.0
Plantain - Yr 1	56.3	111.8	136.1										304.1
Plantain - Yr 2	63.1	117.1	138.2										318.4
Vegetables (blend)		20.6	89.7										110.3
Fruit Trees	6.3	59.2	66.5										132.0
Associated Crops	9.1												9.1
Pasture - Field	40.0	107.3	130.9										278.2
Pasture - Seedbed	9.5	76.2	93.6										179.2
Pinus Caribean - Nursery		32.7	76.1										108.8

Lower Rio Indio Basin - Average Conditions

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice DSP-TRP				16.2									16.2
Rice TPR-TPR	70.0												70.0
Plantain - Yr 1	79.9	125.6	145.5	12.5									363.4
Plantain - Yr 2	87.9	131.2	147.6	12.5									379.1
Vegetables (blend)		28.0	98.8										126.8
Fruit Trees	21.9	69.3	75.4										166.6
Associated Crops	28.2												28.2
Pasture - Field	63.5	121.8	141.8										327.2
Pasture - Seedbed	28.2	88.6	104.2										220.9
Pinus Caribean - Nursery		42.0	86.6										128.6

Intermediate Rio Indio Basin - Average Conditions

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice DSP-TRP				95.0									95.0
Rice TPR-TPR	110.0											10.8	120.8
Plantain - Yr 1	110.6	155.6	159.1	73.1									498.4
Plantain - Yr 2	118.6	161.4	161.3	73.1								4.7	519.0
Vegetables (blend)		54.8	112.8										167.5
Fruit Trees	52.6	97.4	89.5	7.7									247.3
Associated Crops	64.6											9.8	74.4
Pasture - Field	100.0	156.4	158.2	63.6									478.2
Pasture - Seedbed	64.6	122.0	120.8	29.6									336.9
Pinus Caribean - Nursery		73.9	103.4	45.5								9.8	232.5

Supplementary Water Requirements

Area No1 - Boca del Rio Indio

Monthly Water Requirement (,000 m^3)
Average Year

Net Irrigable Area (hectares): 300

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice	100	44.0	-	-	-	-	-	-	-	-	-	-	-	44.0
Plantain	100	63.1	117.1	138.2	-	-	-	-	-	-	-	-	-	318.4
Pasture	100	40.0	107.3	130.9	-	-	-	-	-	-	-	-	-	278.2
	Total	147.1	224.4	269.1	-	-	-	-	-	-	-	-	-	640.6

Option No.2

Crops	Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pasture	300	120.0	321.8	392.7	-	-	-	-	-	-	-	-	-	834.5

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	300	189.4	351.2	414.5	-	-	-	-	-	-	-	-	-	955.2

Average Year Demand (,000 m^3)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
300	152.2	299.1	358.8	-	-	-	-	-	-	-	-	-	810.1

Monthly Water Requirement (,000 m^3)
Drought Year

Net Irrigable Area (hectares): 300

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice	100	124.0	-	-	-	-	-	-	-	-	-	-	-	124.0
Plantain	100	124.7	155.5	207.4	131.2	-	-	-	-	-	-	-	-	618.9
Pasture	100	112.7	152.7	212.7	132.7	-	-	-	-	-	-	-	-	610.9
	Total	361.4	308.3	420.1	264.0	-	-	-	-	-	-	-	-	1,353.8

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pasture	300	338.2	458.2	638.2	398.2	-	-	-	-	-	-	-	-	1,832.8

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	300	374.0	466.6	622.2	393.7	-	-	-	-	-	-	-	-	1,856.6

Drought Year Demand (,000 m^3)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
300	357.9	411.0	560.2	351.9	-	-	-	-	-	-	-	-	1,681.0

Supplementary Water Requirements

Area No.2 - Rio Indio Valley

Monthly Water Requirement (,000 m³)

Average Year

Net Irrigable Area (hectares): 1025

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice	205	143.5	-	-	-	-	-	-	-	-	-	-	-	143.5
Plantain	205	180.1	269.0	302.6	25.5	-	-	-	-	-	-	-	-	777.2
Pasture	205	130.3	249.7	290.7	-	-	-	-	-	-	-	-	-	670.7
Vegetable	205	-	57.4	202.5	-	-	-	-	-	-	-	-	-	259.9
Fruit Trees	205	44.8	142.0	154.6	-	-	-	-	-	-	-	-	-	341.4
	Total	498.6	718.2	950.4	25.5	-	-	-	-	-	-	-	-	2,192.8

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	256	225.1	336.3	378.2	31.9	-	-	-	-	-	-	-	-	971.5
Pasture	256	162.8	312.2	363.4	-	-	-	-	-	-	-	-	-	838.4
Vegetable	256	-	71.8	253.1	-	-	-	-	-	-	-	-	-	324.8
Fruit Trees	256	56.0	177.6	193.3	-	-	-	-	-	-	-	-	-	426.8
	Total	443.9	897.7	1,188.0	31.9	-	-	-	-	-	-	-	-	2,561.6

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	342	300.2	448.4	504.3	42.6	-	-	-	-	-	-	-	-	1,295.4
Pasture	342	217.1	416.2	484.6	-	-	-	-	-	-	-	-	-	1,117.9
Fruit Trees	342	74.7	236.7	257.7	-	-	-	-	-	-	-	-	-	569.1
	Total	591.9	1,101.3	1,246.5	42.6	-	-	-	-	-	-	-	-	2,982.3

Option No.4

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pasture	342	217.1	416.2	484.6	-	-	-	-	-	-	-	-	-	1,117.9
Fruit Trees	342	74.7	236.7	257.7	-	-	-	-	-	-	-	-	-	569.1
Vegetable	342	-	95.7	337.5	-	-	-	-	-	-	-	-	-	433.1
	Total	291.7	748.6	1,079.7	-	-	-	-	-	-	-	-	-	2,120.1

Average Year Demand (,000 m³)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1025	456.6	866.5	1,116.2	25.0	-	-	-	-	-	-	-	-	2,464.2

Monthly Water Requirement (,000 m³)

Drought Year

Net Irrigable Area (hectares): 1025

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice	205	307.5	-	-	-	-	-	-	-	-	-	-	94.3	401.8
Plantain	205	306.2	347.9	428.7	214.8	-	-	-	-	-	-	-	65.3	1,362.9
Pasture	205	279.5	342.9	439.8	208.7	-	-	-	-	-	-	-	-	1,271.0
Vegetable	205	-	136.2	328.6	62.1	-	-	-	-	-	-	-	-	527.0
Fruit Trees	205	170.9	220.9	280.7	85.0	-	-	-	-	-	-	-	-	757.6
	Total	1,064.2	1,047.9	1,477.9	570.7	-	-	-	-	-	-	-	159.6	4,320.3

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	256	382.8	434.8	535.9	268.5	-	-	-	-	-	-	-	81.6	1,703.6
Pasture	256	349.4	428.6	549.8	260.9	-	-	-	-	-	-	-	-	1,588.8
Vegetable	256	-	170.3	410.8	77.7	-	-	-	-	-	-	-	-	658.8
Fruit Trees	256	213.7	276.1	350.9	106.3	-	-	-	-	-	-	-	-	947.0
	Total	945.9	1,309.9	1,847.4	713.3	-	-	-	-	-	-	-	81.6	4,898.1

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	342	510.4	579.8	714.6	358.0	-	-	-	-	-	-	-	108.8	2,271.5
Pasture	342	465.9	571.5	733.0	347.9	-	-	-	-	-	-	-	-	2,118.3
Fruit Trees	342	284.9	368.1	467.9	141.7	-	-	-	-	-	-	-	-	1,262.7
	Total	1,261.2	1,519.4	1,915.5	847.6	-	-	-	-	-	-	-	108.8	5,652.5

Option No.4

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pasture	342	465.9	571.5	733.0	347.9	-	-	-	-	-	-	-	-	2,118.3
Fruit Trees	342	284.9	368.1	467.9	141.7	-	-	-	-	-	-	-	-	1,262.7
Vegetable	342	-	227.1	547.7	103.6	-	-	-	-	-	-	-	-	878.4
	Total	750.8	1,166.7	1,748.7	593.2	-	-	-	-	-	-	-	-	4,259.4

Drought Year Demand (,000 m³)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1025	1,005.5	1,261.0	1,747.4	681.2	-	-	-	-	-	-	-	87.5	4,782.6

Supplementary Water Requirements

Area No.3A - La Encantada

Monthly Water Requirement (,000 m³)

Average Year

Net Irrigable Area (hectares): 250

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice	50	35.0	-	-	-	-	-	-	-	-	-	-	-	35.0
Plantain	50	43.9	65.6	73.8	6.2	-	-	-	-	-	-	-	-	189.6
Pasture	50	31.8	60.9	70.9	-	-	-	-	-	-	-	-	-	163.6
Vegetable	50	-	14.0	49.4	-	-	-	-	-	-	-	-	-	63.4
Fruit Trees	50	10.9	34.6	37.7	-	-	-	-	-	-	-	-	-	83.3
	Total	121.6	175.2	231.8	6.2	-	-	-	-	-	-	-	-	534.8

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	63	54.9	82.0	92.3	7.8	-	-	-	-	-	-	-	-	237.0
Pasture	63	39.7	76.1	88.6	-	-	-	-	-	-	-	-	-	204.5
Vegetable	63	-	17.5	61.7	-	-	-	-	-	-	-	-	-	79.2
Fruit Trees	63	13.7	43.3	47.1	-	-	-	-	-	-	-	-	-	104.1
	Total	108.3	219.0	289.8	7.8	-	-	-	-	-	-	-	-	624.8

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	83	73.2	109.4	123.0	10.4	-	-	-	-	-	-	-	-	316.0
Pasture	83	53.0	101.5	118.2	-	-	-	-	-	-	-	-	-	272.7
Fruit Trees	83	18.2	57.7	62.9	-	-	-	-	-	-	-	-	-	138.8
	Total	144.4	268.6	304.0	10.4	-	-	-	-	-	-	-	-	727.4

Option No.4

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pasture	83	53.0	101.5	118.2	-	-	-	-	-	-	-	-	-	272.7
Fruit Trees	83	18.2	57.7	62.9	-	-	-	-	-	-	-	-	-	138.8
Vegetable	83	-	23.3	82.3	-	-	-	-	-	-	-	-	-	105.6
	Total	71.2	182.6	263.3	-	-	-	-	-	-	-	-	-	517.1

Average Year Demand (,000 m³)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
250	111.4	211.3	272.2	6.1	-	-	-	-	-	-	-	-	601.0

Monthly Water Requirement (,000 m³)

Drought Year

Net Irrigable Area (hectares): 250

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice	50	75.0	-	-	-	-	-	-	-	-	-	-	23.0	98.0
Plantain	50	74.7	84.8	104.6	52.4	-	-	-	-	-	-	-	15.9	332.4
Pasture	50	68.2	83.6	107.3	50.9	-	-	-	-	-	-	-	-	310.0
Vegetable	50	-	33.2	80.2	15.2	-	-	-	-	-	-	-	-	128.5
Fruit Trees	50	41.7	53.9	68.5	20.7	-	-	-	-	-	-	-	-	184.8
	Total	259.6	255.6	360.5	139.2	-	-	-	-	-	-	-	38.9	1,053.7

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	63	93.4	106.1	130.7	65.5	-	-	-	-	-	-	-	19.9	415.5
Pasture	63	85.2	104.5	134.1	63.6	-	-	-	-	-	-	-	-	387.5
Vegetable	63	-	41.5	100.2	18.9	-	-	-	-	-	-	-	-	160.7
Fruit Trees	63	52.1	67.3	85.6	25.9	-	-	-	-	-	-	-	-	231.0
	Total	230.7	319.5	450.6	174.0	-	-	-	-	-	-	-	19.9	1,194.7

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	83	124.5	141.4	174.3	87.3	-	-	-	-	-	-	-	26.5	554.0
Pasture	83	113.6	139.4	178.8	84.9	-	-	-	-	-	-	-	-	516.7
Fruit Trees	83	69.5	89.8	114.1	34.6	-	-	-	-	-	-	-	-	308.0
	Total	307.6	370.6	467.2	206.7	-	-	-	-	-	-	-	26.5	1,378.7

Option No.4

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pasture	83	113.6	139.4	178.8	84.9	-	-	-	-	-	-	-	-	516.7
Fruit Trees	83	69.5	89.8	114.1	34.6	-	-	-	-	-	-	-	-	308.0
Vegetable	83	-	55.4	133.6	25.3	-	-	-	-	-	-	-	-	214.2
	Total	183.1	284.6	426.5	144.7	-	-	-	-	-	-	-	-	1,038.9

Drought Year Demand (,000 m³)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
250	245.2	307.6	426.2	166.1	-	-	-	-	-	-	-	21.3	1,166.5

Supplementary Water Requirements

Area No.3B - La Encantada

Monthly Water Requirement (,000 m³)

Average Year

Net Irrigable Area (hectares): 1000

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice	200	140.0	-	-	-	-	-	-	-	-	-	-	-	140.0
Plantain	200	175.7	262.5	295.2	24.9	-	-	-	-	-	-	-	-	758.3
Pasture	200	127.1	243.6	283.6	-	-	-	-	-	-	-	-	-	654.4
Vegetable	200	-	56.0	197.5	-	-	-	-	-	-	-	-	-	253.5
Fruit Trees	200	43.7	138.6	150.8	-	-	-	-	-	-	-	-	-	333.1
Total		486.5	700.7	927.2	24.9	-	-	-	-	-	-	-	-	2,139.3

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	250	219.6	328.1	369.0	31.2	-	-	-	-	-	-	-	-	947.9
Pasture	250	158.9	304.6	354.6	-	-	-	-	-	-	-	-	-	818.0
Vegetable	250	-	70.0	246.9	-	-	-	-	-	-	-	-	-	316.9
Fruit Trees	250	54.6	173.2	188.6	-	-	-	-	-	-	-	-	-	416.4
Total		433.1	875.9	1,159.0	31.2	-	-	-	-	-	-	-	-	2,499.1

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	333	292.8	437.4	492.0	41.5	-	-	-	-	-	-	-	-	1,263.8
Pasture	333	211.8	406.1	472.7	-	-	-	-	-	-	-	-	-	1,090.6
Fruit Trees	333	72.8	231.0	251.4	-	-	-	-	-	-	-	-	-	555.2
Total		577.5	1,074.5	1,216.1	41.5	-	-	-	-	-	-	-	-	2,909.6

Option No.4

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pasture	333	211.8	406.1	472.7	-	-	-	-	-	-	-	-	-	1,090.6
Fruit Trees	333	72.8	231.0	251.4	-	-	-	-	-	-	-	-	-	555.2
Vegetable	333	-	93.3	329.2	-	-	-	-	-	-	-	-	-	422.6
Total		284.6	730.4	1,053.4	-	-	-	-	-	-	-	-	-	2,068.4

Average Year Demand (,000 m³)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1000	445.4	845.3	1,088.9	24.4	-	-	-	-	-	-	-	-	2,404.1

Monthly Water Requirement (,000 m³)

Drought Year

Net Irrigable Area (hectares): 1000

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice	200	300.0	-	-	-	-	-	-	-	-	-	-	92.0	392.0
Plantain	200	298.8	339.4	418.3	209.5	-	-	-	-	-	-	-	63.7	1,329.7
Pasture	200	272.7	334.5	429.1	203.6	-	-	-	-	-	-	-	-	1,240.0
Vegetable	200	-	132.9	320.6	60.6	-	-	-	-	-	-	-	-	514.2
Fruit Trees	200	166.8	215.5	273.9	83.0	-	-	-	-	-	-	-	-	739.1
Total		1,038.2	1,022.3	1,441.9	556.8	-	-	-	-	-	-	-	155.7	4,214.9

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	250	373.5	424.2	522.9	261.9	-	-	-	-	-	-	-	79.6	1,662.1
Pasture	250	340.9	418.2	536.4	254.6	-	-	-	-	-	-	-	-	1,550.0
Vegetable	250	-	166.2	400.8	75.8	-	-	-	-	-	-	-	-	642.7
Fruit Trees	250	208.5	269.4	342.4	103.7	-	-	-	-	-	-	-	-	923.9
Total		922.8	1,277.9	1,802.4	696.0	-	-	-	-	-	-	-	79.6	4,778.7

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	333	497.9	565.6	697.1	349.2	-	-	-	-	-	-	-	106.2	2,216.1
Pasture	333	454.5	557.6	715.2	339.4	-	-	-	-	-	-	-	-	2,066.7
Fruit Trees	333	277.9	359.2	456.5	138.3	-	-	-	-	-	-	-	-	1,231.9
Total		1,230.4	1,482.4	1,868.8	826.9	-	-	-	-	-	-	-	106.2	5,514.6

Option No.4

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pasture	333	454.5	557.6	715.2	339.4	-	-	-	-	-	-	-	-	2,066.7
Fruit Trees	333	277.9	359.2	456.5	138.3	-	-	-	-	-	-	-	-	1,231.9
Vegetable	333	-	221.5	534.4	101.0	-	-	-	-	-	-	-	-	856.9
Total		732.5	1,138.3	1,706.0	578.7	-	-	-	-	-	-	-	-	4,155.5

Drought Year Demand (,000 m³)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1000	981.0	1,230.2	1,704.8	664.6	-	-	-	-	-	-	-	85.4	4,665.9

Supplementary Water Requirements

Area No.4 - El Papayo

Monthly Water Requirement (,000 m^3)

Average Year

Net Irrigable Area (hectares): 200

Option No. 1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice	40	28.0	-	-	-	-	-	-	-	-	-	-	-	28.0
Plantain	40	35.1	52.5	59.0	5.0	-	-	-	-	-	-	-	-	151.7
Pasture	40	25.4	48.7	56.7	-	-	-	-	-	-	-	-	-	130.9
Vegetable	40	-	11.2	39.5	-	-	-	-	-	-	-	-	-	50.7
Fruit Trees	40	8.7	27.7	30.2	-	-	-	-	-	-	-	-	-	66.6
	Total	97.3	140.1	185.4	5.0	-	-	-	-	-	-	-	-	427.9

Option No. 2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	50	43.9	65.6	73.8	6.2	-	-	-	-	-	-	-	-	189.6
Pasture	50	31.8	60.9	70.9	-	-	-	-	-	-	-	-	-	163.6
Vegetable	50	-	14.0	49.4	-	-	-	-	-	-	-	-	-	63.4
Fruit Trees	50	10.9	34.6	37.7	-	-	-	-	-	-	-	-	-	83.3
	Total	86.6	175.2	231.8	6.2	-	-	-	-	-	-	-	-	499.8

Option No. 3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	67	58.6	87.5	98.4	8.3	-	-	-	-	-	-	-	-	252.8
Pasture	67	42.4	81.2	94.5	-	-	-	-	-	-	-	-	-	218.1
Fruit Trees	67	14.6	46.2	50.3	-	-	-	-	-	-	-	-	-	111.0
	Total	115.5	214.9	243.2	8.3	-	-	-	-	-	-	-	-	581.9

Option No. 4

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pasture	67	42.4	81.2	94.5	-	-	-	-	-	-	-	-	-	218.1
Fruit Trees	67	14.6	46.2	50.3	-	-	-	-	-	-	-	-	-	111.0
Vegetable	67	-	18.7	65.8	-	-	-	-	-	-	-	-	-	84.5
	Total	56.9	146.1	210.7	-	-	-	-	-	-	-	-	-	413.7

Average Year Demand (,000 m^3)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
200	89.1	169.1	217.8	4.9	-	-	-	-	-	-	-	-	480.8

Monthly Water Requirement (,000 m^3)

Drought Year

Net Irrigable Area (hectares): 200

Option No. 1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rice	40	60.0	-	-	-	-	-	-	-	-	-	-	18.4	78.4
Plantain	40	59.8	67.9	83.7	41.9	-	-	-	-	-	-	-	12.7	265.9
Pasture	40	54.5	66.9	85.8	40.7	-	-	-	-	-	-	-	-	248.0
Vegetable	40	-	26.6	64.1	12.1	-	-	-	-	-	-	-	-	102.8
Fruit Trees	40	33.4	43.1	54.8	16.6	-	-	-	-	-	-	-	-	147.8
	Total	207.6	204.5	288.4	111.4	-	-	-	-	-	-	-	31.1	843.0

Option No. 2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	50	74.7	84.8	104.6	52.4	-	-	-	-	-	-	-	15.9	332.4
Pasture	50	68.2	83.6	107.3	50.9	-	-	-	-	-	-	-	-	310.0
Vegetable	50	-	33.2	80.2	15.2	-	-	-	-	-	-	-	-	128.5
Fruit Trees	50	41.7	53.9	68.5	20.7	-	-	-	-	-	-	-	-	184.8
	Total	184.6	255.6	360.5	139.2	-	-	-	-	-	-	-	15.9	955.7

Option No. 3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	67	99.6	113.1	139.4	69.8	-	-	-	-	-	-	-	21.2	443.2
Pasture	67	90.9	111.5	143.0	67.9	-	-	-	-	-	-	-	-	413.3
Fruit Trees	67	55.6	71.8	91.3	27.7	-	-	-	-	-	-	-	-	246.4
	Total	246.1	296.5	373.8	165.4	-	-	-	-	-	-	-	21.2	1,102.9

Option No. 4

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pasture	67	90.9	111.5	143.0	67.9	-	-	-	-	-	-	-	-	413.3
Fruit Trees	67	55.6	71.8	91.3	27.7	-	-	-	-	-	-	-	-	246.4
Vegetable	67	-	44.3	106.9	20.2	-	-	-	-	-	-	-	-	171.4
	Total	146.5	227.7	341.2	115.7	-	-	-	-	-	-	-	-	831.1

Drought Year Demand (,000 m^3)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
200	196.2	246.0	341.0	132.9	-	-	-	-	-	-	-	17.1	933.2

Supplementary Water Requirements

Area No.5 - Nuevo Paraiso

Monthly Water Requirement (,000 m^3)

Average Year

Net Irrigable Area (hectares): 450

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Associated Crops	113	72.6	-	-	-	-	-	-	-	-	-	-	11.0	83.7
Plantain	113	133.4	181.6	181.4	82.2	-	-	-	-	-	-	-	5.3	583.9
Vegetable	113	-	61.6	126.9	-	-	-	-	-	-	-	-	-	188.5
Fruit Trees	113	59.2	109.6	100.7	8.7	-	-	-	-	-	-	-	-	278.2
Total		265.3	352.8	409.0	90.9	-	-	-	-	-	-	-	16.3	1,134.2

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	113	133.4	181.6	181.4	82.2	-	-	-	-	-	-	-	5.3	583.9
Rice	113	123.8	-	-	-	-	-	-	-	-	-	-	12.2	135.9
Vegetable	113	-	61.6	126.9	-	-	-	-	-	-	-	-	-	188.5
Fruit Trees	113	59.2	109.6	100.7	8.7	-	-	-	-	-	-	-	-	278.2
Total		316.4	352.8	409.0	90.9	-	-	-	-	-	-	-	17.4	1,186.5

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	150	177.9	242.1	241.9	109.6	-	-	-	-	-	-	-	7.1	778.6
Fruit Trees	150	78.9	146.1	134.3	11.5	-	-	-	-	-	-	-	-	370.9
Vegetable	150	-	82.2	169.2	-	-	-	-	-	-	-	-	-	251.3
Total		256.9	470.4	545.3	121.2	-	-	-	-	-	-	-	7.1	1,400.7

Average Year Demand (,000 m^3)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
450	279.5	392.0	454.4	101.0	-	-	-	-	-	-	-	13.6	1,240.5

Monthly Water Requirement (,000 m^3)

Drought Year

Net Irrigable Area (hectares): 450

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Associated Crops	113	123.8	-	-	-	-	-	2.0	-	-	-	-	133.8	259.6
Plantain	113	176.7	216.2	233.3	142.8	-	-	-	-	-	-	-	109.1	878.1
Vegetable	113	3.5	96.2	178.8	56.3	-	-	-	-	-	-	-	-	334.7
Fruit Trees	113	102.4	144.2	152.7	69.2	-	-	-	-	-	-	-	40.3	508.8
Total		406.3	456.6	564.8	268.3	-	-	2.0	-	-	-	-	283.2	1,981.3

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	113	176.7	216.2	233.3	142.8	-	-	-	-	-	-	-	109.1	878.1
Rice	113	180.0	-	-	-	-	-	2.3	-	-	-	-	147.2	329.4
Vegetable	113	3.5	96.2	178.8	56.3	-	-	-	-	-	-	-	-	334.7
Fruit Trees	113	102.4	144.2	152.7	69.2	-	-	-	-	-	-	-	40.3	508.8
Total		462.6	456.6	564.8	268.3	-	-	2.3	-	-	-	-	296.6	2,051.1

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	150	235.6	288.2	311.1	190.4	-	-	-	-	-	-	-	145.5	1,170.9
Fruit Trees	150	136.5	192.3	203.6	92.3	-	-	-	-	-	-	-	53.7	678.4
Vegetable	150	4.6	128.3	238.4	75.0	-	-	-	-	-	-	-	-	446.3
Total		376.8	608.8	753.1	357.7	-	-	-	-	-	-	-	199.3	2,295.6

Drought Year Demand (,000 m^3)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
450	415.2	507.3	627.6	298.1	-	-	1.4	-	-	-	-	259.7	2,109.3

Supplementary Water Requirements

Area No.6 - Las Marias

Monthly Water Requirement (,000 m^3)

Average Year

Net Irrigable Area (hectares): 100

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Associated Crops	25	16.1	-	-	-	-	-	-	-	-	-	-	2.5	18.6
Plantain	25	29.7	40.3	40.3	18.3	-	-	-	-	-	-	-	1.2	129.8
Vegetable	25	-	13.7	28.2	-	-	-	-	-	-	-	-	-	41.9
Fruit Trees	25	13.2	24.4	22.4	1.9	-	-	-	-	-	-	-	-	61.8
	Total	58.9	78.4	90.9	20.2	-	-	-	-	-	-	-	3.6	252.1

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	25	29.7	40.3	40.3	18.3	-	-	-	-	-	-	-	1.2	129.8
Rice	25	27.5	-	-	-	-	-	-	-	-	-	-	2.7	30.2
Vegetable	25	-	13.7	28.2	-	-	-	-	-	-	-	-	-	41.9
Fruit Trees	25	13.2	24.4	22.4	1.9	-	-	-	-	-	-	-	-	61.8
	Total	70.3	78.4	90.9	20.2	-	-	-	-	-	-	-	3.9	263.7

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	33	39.5	53.8	53.8	24.4	-	-	-	-	-	-	-	1.6	173.0
Fruit Trees	33	17.5	32.5	29.8	2.6	-	-	-	-	-	-	-	-	82.4
Vegetable	33	-	18.3	37.6	-	-	-	-	-	-	-	-	-	55.8
	Total	57.1	104.5	121.2	26.9	-	-	-	-	-	-	-	1.6	311.3

Average Year Demand (,000 m^3)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
100	62.1	87.1	101.0	22.4	-	-	-	-	-	-	-	3.0	275.7

Monthly Water Requirement (,000 m^3)

Drought Year

Net Irrigable Area (hectares): 100

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Associated Crops	25	27.5	-	-	-	-	-	0.5	-	-	-	-	29.7	57.7
Plantain	25	39.3	48.0	51.9	31.7	-	-	-	-	-	-	-	24.3	195.1
Vegetable	25	0.8	21.4	39.7	12.5	-	-	-	-	-	-	-	-	74.4
Fruit Trees	25	22.8	32.0	33.9	15.4	-	-	-	-	-	-	-	9.0	113.1
	Total	90.3	101.5	125.5	59.6	-	-	0.5	-	-	-	-	62.9	440.3

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	25	39.3	48.0	51.9	31.7	-	-	-	-	-	-	-	24.3	195.1
Rice	25	40.0	-	-	-	-	-	0.5	-	-	-	-	32.7	73.2
Vegetable	25	0.8	21.4	39.7	12.5	-	-	-	-	-	-	-	-	74.4
Fruit Trees	25	22.8	32.0	33.9	15.4	-	-	-	-	-	-	-	9.0	113.1
	Total	102.8	101.5	125.5	59.6	-	-	0.5	-	-	-	-	65.9	455.8

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	33	52.4	64.1	69.1	42.3	-	-	-	-	-	-	-	32.3	260.2
Fruit Trees	33	30.3	42.7	45.2	20.5	-	-	-	-	-	-	-	11.9	150.8
Vegetable	33	1.0	28.5	53.0	16.7	-	-	-	-	-	-	-	-	99.2
	Total	83.7	135.3	167.4	79.5	-	-	-	-	-	-	-	44.3	510.1

Drought Year Demand (,000 m^3)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
100	92.3	112.7	139.5	66.2	-	-	0.3	-	-	-	-	57.7	468.7

Supplementary Water Requirements

Area No.7 - Rio Indio Abajo

Monthly Water Requirement (,000 m^3)
Average Year
Net Irrigable Area (hectares): 50

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Associated Crops	13	8.1	-	-	-	-	-	-	-	-	-	-	1.2	9.3
Plantain	13	14.8	20.2	20.2	9.1	-	-	-	-	-	-	-	0.6	64.9
Vegetable	13	-	6.8	14.1	-	-	-	-	-	-	-	-	-	20.9
Fruit Trees	13	6.6	12.2	11.2	1.0	-	-	-	-	-	-	-	-	30.9
	Total	29.5	39.2	45.4	10.1	-	-	-	-	-	-	-	1.8	126.0

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	13	14.8	20.2	20.2	9.1	-	-	-	-	-	-	-	0.6	64.9
Rice	13	13.8	-	-	-	-	-	-	-	-	-	-	1.4	15.1
Vegetable	13	-	6.8	14.1	-	-	-	-	-	-	-	-	-	20.9
Fruit Trees	13	6.6	12.2	11.2	1.0	-	-	-	-	-	-	-	-	30.9
	Total	35.2	39.2	45.4	10.1	-	-	-	-	-	-	-	1.9	131.8

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	17	19.8	26.9	26.9	12.2	-	-	-	-	-	-	-	0.8	86.5
Fruit Trees	17	8.8	16.2	14.9	1.3	-	-	-	-	-	-	-	-	41.2
Vegetable	17	-	9.1	18.8	-	-	-	-	-	-	-	-	-	27.9
	Total	28.5	52.3	60.6	13.5	-	-	-	-	-	-	-	0.8	155.6

Average Year Demand (,000 m^3)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
50	31.1	43.6	50.5	11.2	-	-	-	-	-	-	-	1.5	137.8

Monthly Water Requirement (,000 m^3)
Drought Year

Net Irrigable Area (hectares): 50

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Associated Crops	13	13.8	-	-	-	-	-	0.2	-	-	-	-	14.9	28.8
Plantain	13	19.6	24.0	25.9	15.9	-	-	-	-	-	-	-	12.1	97.6
Vegetable	13	0.4	10.7	19.9	6.3	-	-	-	-	-	-	-	-	37.2
Fruit Trees	13	11.4	16.0	17.0	7.7	-	-	-	-	-	-	-	4.5	56.5
	Total	45.1	50.7	62.8	29.8	-	-	0.2	-	-	-	-	31.5	220.1

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	13	19.6	24.0	25.9	15.9	-	-	-	-	-	-	-	12.1	97.6
Rice	13	20.0	-	-	-	-	-	0.3	-	-	-	-	16.4	36.6
Vegetable	13	0.4	10.7	19.9	6.3	-	-	-	-	-	-	-	-	37.2
Fruit Trees	13	11.4	16.0	17.0	7.7	-	-	-	-	-	-	-	4.5	56.5
	Total	51.4	50.7	62.8	29.8	-	-	0.3	-	-	-	-	33.0	227.9

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	17	26.2	32.0	34.6	21.2	-	-	-	-	-	-	-	16.2	130.1
Fruit Trees	17	15.2	21.4	22.6	10.3	-	-	-	-	-	-	-	6.0	75.4
Vegetable	17	0.5	14.3	26.5	8.3	-	-	-	-	-	-	-	-	49.6
	Total	41.9	67.6	83.7	39.7	-	-	-	-	-	-	-	22.1	255.1

Drought Year Demand (,000 m^3)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
50	46.1	56.4	69.7	33.1	-	-	0.2	-	-	-	-	28.9	234.4

Supplementary Water Requirements

Area No.8 - Tierra Buena

Monthly Water Requirement (,000 m^3)

Average Year

Net Irrigable Area (hectares): 150

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Associated Crops	38	24.2	-	-	-	-	-	-	-	-	-	-	3.7	27.9
Plantain	38	44.5	60.5	60.5	27.4	-	-	-	-	-	-	-	1.8	194.6
Vegetable	38	-	20.5	42.3	-	-	-	-	-	-	-	-	-	62.8
Fruit Trees	38	19.7	36.5	33.6	2.9	-	-	-	-	-	-	-	-	92.7
	Total	88.4	117.6	136.3	30.3	-	-	-	-	-	-	-	5.4	378.1

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	38	44.5	60.5	60.5	27.4	-	-	-	-	-	-	-	1.8	194.6
Rice	38	41.3	-	-	-	-	-	-	-	-	-	-	4.1	45.3
Vegetable	38	-	20.5	42.3	-	-	-	-	-	-	-	-	-	62.8
Fruit Trees	38	19.7	36.5	33.6	2.9	-	-	-	-	-	-	-	-	92.7
	Total	105.5	117.6	136.3	30.3	-	-	-	-	-	-	-	5.8	395.5

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	50	59.3	80.7	80.6	36.5	-	-	-	-	-	-	-	2.4	259.5
Fruit Trees	50	26.3	48.7	44.8	3.8	-	-	-	-	-	-	-	-	123.6
Vegetable	50	-	27.4	56.4	-	-	-	-	-	-	-	-	-	83.8
	Total	85.6	156.8	181.8	40.4	-	-	-	-	-	-	-	2.4	466.9

Average Year Demand (,000 m^3)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
150	93.2	130.7	151.5	33.7	-	-	-	-	-	-	-	4.5	413.5

Monthly Water Requirement (,000 m^3)

Drought Year

Net Irrigable Area (hectares): 150

Option No.1

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Associated Crops	38	41.3	-	-	-	-	-	0.7	-	-	-	-	44.6	86.5
Plantain	38	58.9	72.1	77.8	47.6	-	-	-	-	-	-	-	36.4	292.7
Vegetable	38	1.2	32.1	59.6	18.8	-	-	-	-	-	-	-	-	111.6
Fruit Trees	38	34.1	48.1	50.9	23.1	-	-	-	-	-	-	-	13.4	169.6
	Total	135.4	152.2	188.3	89.4	-	-	0.7	-	-	-	-	94.4	660.4

Option No.2

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	38	58.9	72.1	77.8	47.6	-	-	-	-	-	-	-	36.4	292.7
Rice	38	60.0	-	-	-	-	-	0.8	-	-	-	-	49.1	109.8
Vegetable	38	1.2	32.1	59.6	18.8	-	-	-	-	-	-	-	-	111.6
Fruit Trees	38	34.1	48.1	50.9	23.1	-	-	-	-	-	-	-	13.4	169.6
	Total	154.2	152.2	188.3	89.4	-	-	0.8	-	-	-	-	98.9	683.7

Option No.3

Crops	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Plantain	50	78.5	96.1	103.7	63.5	-	-	-	-	-	-	-	48.5	390.3
Fruit Trees	50	45.5	64.1	67.9	30.8	-	-	-	-	-	-	-	17.9	226.1
Vegetable	50	1.5	42.8	79.5	25.0	-	-	-	-	-	-	-	-	148.8
	Total	125.6	202.9	251.0	119.2	-	-	-	-	-	-	-	66.4	765.2

Drought Year Demand (,000 m^3)

Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
150	138.4	169.1	209.2	99.4	-	-	0.5	-	-	-	-	86.6	703.1

ATTACHMENT 10

AGRICULTURE NET BENEFITS

Agriculture Net Benefits

Present land use agriculture input / output tables.

RICE - SUBSISTENCE PRODUCTION COST (1 ha)					
Resource	**Details**	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**
A. TRANSPORT					
Sub-Total					-
B. MATERIALS					
Planting	Seed	kg	45.5	0.26	11.83
Harvesting	Bags	-	17.0	0.30	5.10
	Other	-	0.6	5.50	3.30
Sub-Total					**20.23**
C. LABOR					
Clearing		wage	4.0	6.00	24.00
Planting		wage	6.0	6.00	36.00
Harvesting		wage	10.0	6.00	60.00
Sub-Total					**120.00**
TOTAL COST					**140.23**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS		
	Residual Terraces	Fluvial Terraces
1. Total Cost	140.23	140.23
2. Yield: kg ha^{-1}	773.50	889.52
3. Price kg	0.24	0.24
4. Gross Return.	185.64	213.48
5. Return Above Variable Cost	45.41	73.25

MAIZE - SUBSISTENCE
PRODUCTION COST (1 ha)

Resource	Detail	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORT					
Sub-Total					-
B. MATERIALS					
Planting	Seed	kg	18.2	1.54	28.03
Harvesting	Bags, others	-	18.00	0.30	5.40
Sub-Total					**33.43**
C. LABOR					
Clearing		wage	6.00	6.00	36.00
Planting		wage	4.00	6.00	24.00
Weed Control		wage	3.00	6.00	18.00
Harvesting		wage	4.00	6.00	24.00
Loading		wage	1	6.00	6.00
Sub-Total					**108.00**
TOTAL COST					**141.43**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS

1. Total Cost	141.43
2. Yield: kg ha^{-1}	819.00
3. Price kg	0.20
4. Gross Return	163.80
5. Return Above Variable Cost	22.37

BEANS - SUBSISTENCE PRODUCTION COST (1 ha)					
Resource	**Detail**	**Unit**	**Coefficients**	**Unit Cost**	**Total Cost**
A. TRANSPORT					
Sub-Total					-
B. MATERIALS					
Planting	Seed	kg	45.5	0.88	40.04
Harvesting	Bags	-	15	0.30	4.50
Sub-Total					**44.54**
C. LABOR					
Planting		wage	8	6.00	48.00
Theshing		wage	2	6.00	12.00
Harvesting		wage	8	6.00	48.00
Loading		wage	1	6.00	6.00
Sub-Total					**114.00**
TOTAL COST					**158.54**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	158.54
2. Yield: kg ha^{-1}	682.50
3. Price kg.	0.40
4. Gross Return	273.00
5. Return above Variable Cost	114.46

CASSAVA – SUBSISTENCE PRODUCTION COST (1 ha)					
Resource	**Detail**	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**
A. TRANSPORT					
Sub-Total					-
B. MATERIALS					
Planting	Cuttings	-	5,000	0.02	100.00
Harvesting	Bags	kg	100	0.01	0.80
Sub-Total					**100.80**
C. LABOR					
Seeding		wage	2	6.00	12.00
Seed Treatment		wage	1	6.00	6.00
Planting		wage	4	6.00	24.00
Weeding (2)		wage	12	6.00	72.00
Harvesting		wage	5	6.00	30.00
Sub-Total					**144.00**
TOTAL COST					**244.80**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	244.80
2. Yield: kg ha^{-1}	2275.00
3. Price kg	0.18
4. Gross return	409.50
5. Return above Variable Cost	164.70

YAMS - SUBSISTENCE
PRODUCTION COST (1 ha)

Resource	Detail	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORT					
Sub-Total					-
B. MATERIALS					
Planting	Seed	kg	910	0.66	600.60
Harvesting	Bags	kg	100	0.35	35.00
Sub-Total					**635.60**
C. LABOR					
Seeding		wage	2	6.00	12.00
Seed Treatment		wage	1	6.00	6.00
Planting		wage	6	6.00	36.00
Weed Control		wage	7	6.00	42.00
Harvesting		wage	10	6.00	60.00
Loading		wage	1	6.00	6.00
Sub-Total					**162.00**
TOTAL COST					**797.60**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS

1. Total Cost	797.60
2. Yield: kg ha^{-1}	4,550.00
3. Price kg.	0.26
4. Gross Return	1,183.00
5. Return above Variable Cost	385.4

DASHEEN - SUBSISTENCE PRODUCTION COST (1 ha)					
Resource	**Detail**	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**
A. TRANSPORT					
Sub-Total					-
B. MATERIALS					
Planting	Seed	-	8,000	0.01	80.00
Harvesting	Bags	-	60	0.35	21.00
Sub-Total					**101.00**
C. LABOR					
Land Preparation		wage	2	6.00	12.00
Plant		wage	8	6.00	48.00
Weed Control		wage	7	6.00	42.00
Hilling		wage	8	6.00	48.00
Harvest		wage	10	6.00	60.00
Harvest Transport		wage	2	6.00	12.00
Loading		wage	1	6.00	6.00
Sub-Total					**228.00**
TOTAL COST					**329.00**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	329.00
2. Yield: kg ha^{-1}	1456.00
3. Price kg	0.48
4. Gross Return	698.88
5. Return Above Variable Cost	369.88

COFFEE - SUBSISTENCE
PRODUCTIONS COST (1ha)

Resource	Description	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORT					
Sub-total					
B. MATERIALS					
Plants			300	0.50	150.00
Tools	Various		-	25.00	25.00
Sub-total					**175.00**
C. LABOR					
Planting		wage	6.0	6.00	36.00
Clearing		wage	23.0	6.00	138.00
Weed Control		wage	8.0	6.00	48.00
Harvest / Loading		wage	1.0	6.00	6.00
Sub-total					228.00
TOTAL COST					**403.00**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS

DESCRIPTION	YEAR 1
1. Total Cost	403.00
2. Yield: kg ha^{-1}	227.50
3. Price kg	1.54
4. Gross return	350.00
5. Return above Variable Cost	-53.00

45.5 kg. = 20 "Latas"

Input / output tables for proposed improved technology agriculture.

RICE IRRIGATED LOWLAND - FLUVIAL TERRACES. HIGH INPUT PRODUCTION COST (1 ha)

Resource	Detail	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORT					
Materials		kg	375	0.011	4.12
Product		kg	10920	0.011	120.12
Sub-total					**124.24**
B. MATERIALS					
Seed		kg	67.5	1.11	74.93
Fertilizer	12 - 24 - 12	kg	227.5	0.40	91.00
Fertilizer	Urea	kg	91.0	0.35	31.85
Insecticide	Sumithon	Liter	1.0	7.00	7.00
Fungicide	Dithane	kg	1.0	5.50	5.50
Sub-total					**210.28**
C. LABOR AND POWER					
Land Preparation		wage	19.0	6.00	114.00
Machinary		Hour	9.0	18.00	162.00
Seedbed		wage	25.0	6.00	150.00
Transplanting		wage	75.0	6.00	450.00
Fertilizing		wage	0.4	6.00	2.40
Weed Control		wage	12.0	6.00	72.00
Insect Control		wage	12.0	6.00	72.00
Water Management		wage	2.5	6.00	15.00
Harvesting		wage	100.0	6.00	600.00
Sub-total					**1637.4**
TOTAL COST					**1809.92**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	1809.92
2. Yield: kg ha^{-1}	10920
3. Price kg	0.24
4. Gross Return	2620.80
5. Return Above Variable Cost	810.88

RICE IRRIGATED LOWLAND - RESIDUAL TERRACES. LOW INPUT. PRODUCTION COST (1 ha)

Resource	Detail	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORT					
Materials		Kg	341	0.011	3.75
Product		Kg	9100	0.011	100.10
Sub-total					**103.85**
B. MATERIALS					
Seed		Kg	67.5	1.11	74.93
Compost		Kg	250.0	0.20	50.00
Fertilizer	Urea	Kg	91.0	0.35	31.85
Natural Barriers		Liters	1.0	10.50	10.50
Sub-total					**167.28**
C. LABOR AND POWER					
Land Preparation		wage	19.0	6.00	114.00
Spreading		wage	50.0	6.00	300.00
Seedbed		wage	25.0	6.00	150.00
Transplanting		wage	75.0	6.00	450.00
Fertilizing		wage	0.4	6.00	2.40
Weed Control		wage	12.0	6.00	72.00
Insect Control		wage	12.0	6.00	72.00
Water Management		wage	2.5	6.00	15.00
Harvesting		wage	100.0	6.00	600.00
Sub-total					**1,775.40**
TOTAL COST					**2046.53**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	2046.53
2. Yield: kg ha^{-1}	9100.00
3. Price kg	0.24
4. Gross Return	2184.00
5. Return Above Variable Cost	137.47

MAIZE CERO TILLAGE / IMPROVED TECHNOLOGY. HIGH INPUT. PRODUCTION COST (1 ha)					
Resource	**Detail**	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**
A. TRANSPORT					
Materials Transport		kg	250	0.01	2.50
Threshing		kg	2275	0.01	22.75
Product		kg	2502.5	0.02	50.05
Sub-Total					**75.30**
B. MATERIALS					
Planting	Seed	kg	11.37	3.03	34.45
Fertilizer	12 - 24 -12	Kg	91.00	0.31	28.21
Fertilizer	Urea 46%	Kg	136.50	0.30	40.95
Weeding	Gesaprim	Liters	3.00	5.25	15.75
Weeding	Gramoxone	Liters	2.00	4.50	9.00
Harvest	Bags	-	50.00	0.22	11.00
	Needle	-	5.00	0.30	1.50
	Cone	-	0.30	5.20	1.56
Sub-Total					**142.42**
C. LABOR & POWER					
Weeding		Wage	5.00	6.00	30.00
Planting		Wage	6.00	6.00	36.00
Fertilizing		Wage	3.00	6.00	18.00
Weed Control		Wage	2.00	6.00	12.00
Harvesting		Wage	10.00	6.00	60.00
Threshing		Wage	3.00	6.00	18.00
Sub-Total					**174.00**
TOTAL COST					**394.42**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	394.42
2. Yield: * kg ha $^{-1}$	2502.50
3. Price kg	0.20
4. Gross Return	500.50
5. Return Above Variable Cost	106.08

* 35,000 Corncobs

**MAIZE CERO TILLAGE / IMPROVED TECHNOLOGY. LOW INPUT.
PRODUCTION COST (1 ha)**

Resource	Detail	Unit	Coefficients	Unit Cost	Total Cost
A. TRANSPORT					
Materials Transport		kg	175.00	0.01	1.75
Product		kg	1933.75	0.02	38.68
Sub-Total					**40.43**
B. MATERIALS					
Planting	Seed	kg	11.37	3.03	34.45
Compost		kg	150.00	0.20	30.00
Natural Barries		Liters	1.00	10.50	10.50
Harvesting	Bags	-	50.00	0.22	11.00
	Needle	-	5.00	0.30	1.50
	Cone	-	0.30	5.20	1.56
Sub-Total					**89.01**
C. LABOR & POWER					
Weeding		wage	5.00	6.00	30.00
Planting		wage	6.00	6.00	36.00
Fertilizing		wage	3.00	6.00	18.00
Weed Control		wage	4.00	6.00	24.00
Harvesting		wage	10.00	6.00	60.00
Threshing		wage	3.00	6.00	18.00
Sub-Total					**186.00**
TOTAL COST					**315.44**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	315.44
2. Yield: *kg ha $^{-1}$	1933.75
3. Price kg	0.20
4. Gross Return	386.75
5. Return Above Variable Cost	71.31

* 35,000 Corncobs

BEAN IMPROVED TECHNOLOGY. HIGH INPUT. PRODUCTION COST (1 ha)					
Resource	**Detail**	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**
A. TRANSPORT					
Materials		kg	48	0.01	0.48
Products		kg	1137.5	0.01	7.51
Thesher		Hour	1	12.50	11.37
Sub-Total					**19.36**
B. MATERIALS					
Planting	Seed	kg	36.4	0.88	32.03
Harvesting	Bags	-	15	0.30	4.50
Herbicide		Liter	3	7.00	21.00
Insecticide		Liter	2	6.00	12.00
Fungicide		Liter	1	7.00	7.00
Sub-Total					**76.53**
C. LABOR & POWER					
Planting		wage	8	6.00	48.00
Harvesting		wage	8	6.00	48.00
Insect Control		wage	3	6.00	18.00
Sub-Total					**114.00**
TOTAL COST					**209.89**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	209.89
2. Yield: kg ha^{-1}	1137.50
3. Price kg	0.40
4. Gross Return	455.00
5. Return Above Variable Cost	245.11

BEAN IMPROVED TECHNOLOGY. LOW INPUT.
PRODUCTION COST (1 ha)

Resource	Detail	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORT					
Materials		kg	45.5	0.01	0.50
Products		kg	967	0.01	10.64
Shelling	Tresher	Hour	1	12.50	12.50
Sub-Total					**23.64**
B. MATERIALS					
Planting	Seed	kg	36.4	0.88	32.03
Harvesting	Bags	-	15	0.30	4.50
Compost		kg	200	0.20	40.00
Natural Barriers		Liter	1	10.50	10.50
Sub-Total					**87.03**
C. LABOR & POWER					
Plant		wage	8	6.00	48.00
Harvest		wage	8	6.00	48.00
Insect Control		wage	3	6.00	18.00
Sub-Total					**114.00**
TOTAL COST					**224.67**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	224.67
2. Yield: kg ha^{-1}	967.00
3. Price kg	0.40
4. Gross Return	386.80
5. Return Above Variable Cost	162.13

CASSAVA IMPROVED TECHNOLOGY. HIGH INPUT. PRODUCTION COST (1 ha)					
Resource	**Detail**	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**
A. TRANSPORT					
Materials		kg	910	0.01	10.01
Product		kg	7962.5	0.01	87.59
Sub-Total					**97.60**
B. MATERIALS					
Planting	Cutting	-	5,000	0.02	100.00
Harvesting	Bags	-	200	0.35	70.00
Fertilizer	12 - 24 - 12	Kg	182	0.06	10.92
Insecticide	Sumition	Liter	1	10.00	10.00
Fungicide	Mansate	kg	1	9.00	9.00
Herbicide	Clifosate	Liter	1	13.00	13.00
Insecticide	Cebomirex	kg	2.3	26.09	60.01
Herbicide	Karmex	kg	4.5	17.80	80.10
Sub-Total					**353.03**
C. LABOR					
Seed Selection		wage	2	6.00	12.00
Seed Treatment		wage	1	6.00	6.00
Planting		wage	4	6.00	24.00
Weed Control		wage	12	6.00	72.00
Insect Control		wage	4	6.00	24.00
Harvesting		wage	5	6.00	30.00
Sub-Total					**168.00**
TOTAL COST					**618.62**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	618.62
2. Yield: kg ha^{-1}	7,962.50
3. Price kg	0.09
4. Gross Return	1,200.00
5. Return Above Variable Cost	581.38

CASSAVA IMPROVED TECHNOLOGY. LOW INPUT.
PRODUCTION COST (1 ha)

Resource	Detail	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORT					
Materials		Kg	910	0.01	10.01
Products		Kg	7280	0.01	80.08
Sub-Total					**90.09**
B. MATERIALS					
Planting	Cutting	-	5,000	0.02	100.00
Harvesting	Bags	-	200	0.35	70.00
Compost		Kg	150	0.20	30.00
Natural Barrier		Liter	1	10.50	10.50
Sub-Total					**210.50**
C. LABOR					
Seed Selection		Wage	2	6.00	12.00
Seed Treatment		Wage	1	6.00	6.00
Planting		Wage	4	6.00	24.00
Weed Control		Wage	12	6.00	72.00
Insect Control		Wage	4	6.00	24.00
Harvesting		Wage	5	6.00	30.00
Sub-Total					**168.00**
TOTAL COST					**468.59**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS

1. Total Cost	468.59
2. Yield: kg ha $^{-1}$	7,280.00
3. Price kg	0.09
4. Gross Return	655.20
5. Return Above Variable Cost	186.61

YAMS IMPROVED TECHNOLOGY. HIGH INPUT.
PRODUCTION COST (1 ha)

Resource	Detail	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORT					
Materials		kg	925	0.01	9.25
Harvest		kg	8645	0.01	86.45
Sub-Total					**95.70**
B. MATERIALS					
Plant	Seed	kg	910	0.66	600.60
Insecticide		Liter	2	7.00	14.00
Fungincide		kg	1	8.00	8.00
Herbicide		Liter	1	7.00	7.00
Harvest	Bags	-	100	0.35	35.00
Sub-Total					**664.60**
C. LABOR					
Seed Selection		Wage	2	6.00	12.00
Seed Treatment		Wage	1	6.00	6.00
Planting		Wage	6	6.00	36.00
Weed Control		Wage	7	6.00	42.00
Harvesting		Wage	10	6.00	60.00
Insect Control		Wage	3	6.00	18.00
Sub-Total					**174.00**
TOTAL COST					**934.20**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	934.20
2. Yield: kg ha^{-1}	8645.00
3. Price kg	0.26
4. Gross return	2247.70
5. Return above Variable Cost	1313.50

YAMS IMPROVED TECHNOLOGY. LOW INPUT.
PRODUCTION COST (1 ha)

Resource	Detail	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORT					
Materials		kg	975	0.01	9.75
Harvest		kg	6142.5	0.01	61.42
Sub-Total					**71.17**
B. MATERIALS					
Plant	Seed	kg	910	0.66	600.60
Compost		kg	150	0.20	30.00
Natural Barrier		Liter	1	10.50	10.50
Harvest	Bags	-	100	0.35	35.00
Sub-Total					**676.10**
C. LABOR					
Seed Selection		Wage	2	6.00	12.00
Seed Treatment		Wage	1	6.00	6.00
Planting		Wage	6	6.00	36.00
Weed Control		Wage	7	6.00	42.00
Harvesting		Wage	10	6.00	60.00
Insect Control		Wage	3	6.00	18.00
Sub-Total					**174.00**
TOTAL COST					**921.27**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	921.27
2. Yield: kg ha $^{-1}$	6142.5
3. Price kg	0.26
4. Gross return	1597.05
5. Return above Variable Cost	675.78

DASHEEN IMPROVED TECHNOLOGY. HIGH INPUT.
PRODUCTION COST (1 ha)

Resource	Detail	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORT					
Materials		kg	1191	0.01	11.91
Product		kg	1934	0.01	19.34
Sub-Total					**31.25**
B. MATERIALS					
Planting	Seed	-	8,000	0.01	80.00
Harvesting	Bags	-	60	0.35	21.00
Fertilizer	12 - 24 - 12	Kg	182	0.06	10.92
Insecticide		Liter	2	7.00	14.00
Fungicide		Kg	1	8.00	8.00
Herbicide			1	7.00	7.00
Sub-Total					**140.92**
C. LABOR					
Land Preparation		Wage	2	6.00	12.00
Planting		Wage	8	6.00	48.00
Weed Control		Wage	7	6.00	42.00
Hilling		Wage	8	6.00	48.00
Harvesting		Wage	12	6.00	72.00
Insects Control			3	6.00	18.00
Sub-Total					**240.00**
TOTAL COST					**412.17**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	412.17
2. Yield: kg ha^{-1}	1934.00
3. Price kg	0.48
4. Gross Return	928.32
5. Return Above Variable Cost	516.15

DASHEEN IMPROVED TECHNOLOGY. LOW INPUT. PRODUCTION COST (1 ha)					
Resource	**Detail**	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**
A. TRANSPORT					
Materials		kg	1162	0.01	11.62
Product		kg	1820	0.01	18.20
Sub-Total					**29.82**
B. MATERIALS					
Planting	Seed	-	8,000	0.01	80.00
Harvesting	Bags	-	60	0.35	21.00
Compost		Kg	150	0.20	30.00
Natural Barrier		Liter	1	10.50	10.50
Sub-Total					**141.50**
C. LABOR					
Land Preparation		Wage	2	6.00	12.00
Planting		Wage	8	6.00	48.00
Weed Control		Wage	7	6.00	42.00
Hilling		Wage	8	6.00	48.00
Harvesting		Wage	12	6.00	72.00
Insects Control			3	6.00	18.00
Sub-Total					**240.00**
TOTAL COST					**411.32**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS	
1. Total Cost	411.32
2. Yield: kg ha^{-1}	1820.00
3. Price kg	0.48
4. Gross Return	928.32
5. Return Above Variable Cost	462.28

COFFEE IMPROVED TECHNOLOGY. LOW INPUT.
PRODUCTIONS COST (1ha)

Resource	Description	Unit	Unit Cost	I AÑO		II AÑO	
				Quantity	Total Cost	Quantity	Total Cost
A. TRANSPORT							
Product		kg	0.01	682.5	7.50	819	9.00
Materials		kg	0.01	864.5	9.50	865	9.50
Sub-total					**17.00**		**18.50**
B. MATERIALS							
Plants		Plants	0.18	1,111	199.98	0.0	-
Compost		kg	0.20	200.0	40.00	150.0	30.00
Natural Barrier		Liter	10.50	2.0	21.00	2.0	21.00
Tools	Various		25.00	-	25.00	-	-
Sub-total					**285.98**		**51.00**
C. LABOR							
Land Clearing		wage	6.00	40.0	240.00	-	-
Alirement		wage	6.00	20.0	120.00	-	-
Planting		wage	6.00	80.0	480.00	-	-
Weed Control		wage	6.00	20.0	120.00	25.0	150.00
Pesticide Control		wage	6.00	5.0	30.00	7.0	42.00
Fertilizer		wage	6.00	6.0	36.00	6.0	36.00
Prune		wage	6.00	8.0	48.00	8.0	48.00
Harvest		kg	0.44	682.5	300.30	819.0	360.36
Sub-total					1,374.30		636.36
TOTAL COST					**1677.28**		**705.86**

FINANCIAL ANALYSIS

DESCRIPTION	YEAR 1	YEAR 2 *
1. Total Cost	**1677.28**	705.86
2. Yield: kg ha $^{-1}$	682.50	819.00
3. Price kg	1.54	1.54
4. Gross return	1,051	1,261
5. Return above Variable Cost	-626.28	555.14

* Situation up to 10 years.

45.5 kg. = 20 "Latas"

PASTURE IMPROVED TECHNOLOGY
PRODUCTION COST (1 ha)

Resource	Detail	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORT					
Materials		kg	375.5	0.012	4.51
Product	Cattle [a]	kg	1000	0.012	12.00
Sub-total					**124.51**
B. MATERIALS					
Fence apportion					55.49
Seed		kg	1.5	20.00	30.00
Fertilizer	Urea	kg	136.5	0.20	27.30
Fertilizer	Triple Superfosfate	kg	136.5	0.34	46.41
Fertilizer	KCI	kg	45.5	0.34	15.47
Herbicide		Liter	3.9	2.00	7.80
Sub-total					**182.47**
C. LABOR & POWER					
Land Preparation		Hour	8	18.00	144.00
Harvesting		wage	4	6.00	24.00
Fertilizing		wage	2	6.00	12.00
Planting		wage	6	6.00	36.00
Weed Control		wage	1	6.00	6.00
Sub-total					**222.00**
TOTAL COST					**528.98**

[a] / Plot rotation: 2 - 3 head on average per ha. Turn around time of seed bead, 10 years. Marketable product development: after 2 years. Average estimated weight at development: 454 kg. Price young bull per kg^{-1}: 1.14. Therefore, on average 1 ha produces 567.5 kg – cattle.

SOURCE: Ministry of Agriculture - Extension Service

PLANTAIN 1st YEAR
PRODUCTION COST (1 ha)

Resource	Detail	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORT					
Materials		Kg	2475	0.01	27.23
Product		x100	64	0.01	0.70
Sub-Total					**27.93**
B. MATERIALS					
Plant	Rhizome	-	1,100	0.15	165.00
Fertilizer	12-24-12	kg	182	0.31	56.00
Fertilizer	Urea	kg	91	0.30	27.30
Herbicide		Liter	6	4.50	27.00
Sub-Total					**275.30**
C. LABOR					
Clearing		Wage	10	6.00	60.00
Alignment		Wage	2	6.00	12.00
Seed Cleaning		Wage	4	6.00	24.00
Seed Distribution		Wage	2	6.00	12.00
Holes		Wage	12	6.00	72.00
Planting		Wage	9	6.00	54.00
Replanting		Wage	1	6.00	6.00
Fertilizing		Wage	2	6.00	12.00
Cleaning		Wage	20	6.00	120.00
Regrowth Elimination		Wage	14	6.00	84.00
Wee Control		Wage	8	6.00	48.00
Harvesting		Wage	17	6.00	102.00
Sub-Total					**606.00**
TOTAL COST					**909.23**

SOURCE: Ministry of Agriculture - Extension Service

PLANTAIN - 2nd YEAR
PRODUCTION COST (1 ha)

Resource	Detail	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORTATION					
Materials		Kg	91	0.01	1.00
Product		x100	168	0.01	1.85
Sub-Total					**2.85**
B. MATERIALS					
Fertilizer	Urea	Kg	91	0.30	27.30
Herbicide	Gramoxone	Liter	6	4.50	27.00
Sub-Total					**54.30**
C. LABOR					
Fertilizing		wage	3	6.00	18.00
Cleaning		wage	10	6.00	60.00
Trunk Clearing		wage	10	6.00	60.00
Regrowth Elimination		wage	14	6.00	84.00
Weed Control		wage	8	6.00	48.00
Harvesting		wage	17	6.00	102.00
Sub-Total					**372.00**
TOTAL COST					**429.15**

SOURCE: Ministry of Agriculture - Extension Service

PLANTAIN - 3rd YEAR PRODUCTION COST (1 ha)					
Resource	**Detail**	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**
A. TRANSPORT					
Materials		Kg	91	0.01	1.00
Product		x100	168	0.01	1.85
Sub-Total					**2.85**
B. MATERIALS					
Fertilizer (N)	Urea	kg.	91	0.30	27.30
Herbicide		Liter	6	4.50	27.00
Sub-Total					**54.30**
C. LABOR					
Fertilizing		wage	3	6.00	18.00
Cleaning		wage	10	6.00	60.00
Month Clening		wage	10	6.00	60.00
Regrowth Elimination		wage	14	6.00	84.00
Weed Control		wage	8	6.00	48.00
Harvest		wage	17	6.00	102.00
Sub-Total					**372.00**
TOTAL COST					**429.15**

SOURCE: Ministry of Agriculture - Extension Service

FINANCIAL ANALYSIS			
DESCRIPTION	**1st YEAR**	**2nd YEAR**	**3rd YEAR**
1. Total Cost	909.23	429.15	429.15
2. Yield: 100 units ha $^{-1}$	64.00	168.00	168.00
3. Price 100 units	4.50	4.50	4.50
4. Gross return	288.00	756.00	756.00
5. Return above Variable Cost	-621.23	326.85	326.85

Pinus caribaea var. hondurensis. 25 YEARS
PRODUCTION COST (1 ha)

Resource	Detail	Unit	Quantity	Unit Cost	Total Cost
A. TRANSPORT					
Materials	Various		2	60	120.00
Product	Firewood/Posts		10	60	600.00
Sub-total					**720.00**
B. MATERIALS					
Plants			1111.0	0.35	388.85
Fertilizer	12 - 24 - 12	Kg	55.6	0.06	3.33
Foliar Fertilizer		Liters	10.0	9.00	90.00
Insecticide		Liters	10.0	7.00	70.00
Tool		Various			1000.00
Sub-total					**1,552.18**
C. LABOR & POWER					
Land Preparation		Wage	25.0	6.00	150.00
Loading		Wage	75.0	6.00	450.00
Weed Control		Wage	160.0	6.00	960.00
Planting/Replanting		Wage	180.0	6.00	1,080.00
Fertilizing		Wage	120.0	6.00	720.00
Fire Control		Wage	140.0	6.00	840.00
Insect Control		Wage	10.0	6.00	60.00
Thining/Prune		Wage	23.0	6.00	138.00
Harvesting		Wage	450.0	6.00	2,700.00
Administration		Wage	443.0	6.00	2,658.00
Sub-total					**9,756.00**
TOTAL COST					12028.18

SOURCE: Adapted - Rojas, J. A. 1993 and Rojas, F. & E. Ortíz. 1991-

FINANCIAL ANALYSIS

Description	Total	Apportion Yr^{-1}
1. Total Cost	12028.18	481.13
2. Yield: Foot – plank ha^{-1}	122900.40	4916.02
3. Price Foot – plank	0.50	0.50
4. Gross Return	61450.20	2458.01
5. Return Above Variable Cost	49422.02	1976.88

ATTACHMENT 11

COST ESTIMATES

Table ATT11- 1 - Cost Estimate

Area No1 - Boca del Rio Indio

Net Irrigable Area (hectares): 300

Construction Cost (2000 US$)

Primary Conveyance		
Pumping Stations (including Penstocks)	$	849,600
Canals and Siphons	$	368,300
Structures	$	113,300
Subtotal	***$***	***1,331,200***
Off-farm System		
Distribution System (Off-farm)	$	384,000
Drainage (Off-farm)	$	66,000
Roads (Off-farm)	$	75,000
Subtotal	***$***	***525,000***
On-farm Irrigation System	***$***	***450,000***
Contingencies (25%)	$	576,600
Direct Construction Cost	***$***	***2,882,800***
Engineering and Administration (10%)	$	288,300
Total Construction Cost	**$**	**3,171,100**

Table ATT11- 2 - Cost Estimate

Area No.2 - Rio Indio Valley

Net Irrigable Area (hectares): 1025

Construction Cost (2000 US$)

Primary Conveyance		
Pumping Stations (including Penstocks)	$	3,140,000
Canals and Siphons	$	6,086,200
Structures	$	1,113,400
Subtotal	***$***	***10,339,600***
Off-farm System		
Distribution System (Off-farm)	$	656,000
Drainage (Off-farm)	$	225,500
Roads (Off-farm)	$	256,300
Subtotal	***$***	***1,137,800***
On-farm Irrigation System	***$***	***1,537,500***
Contingencies (25%)	$	3,253,700
Direct Construction Cost	***$***	***16,268,600***
Engineering and Administration (10%)	$	1,626,900
Total Construction Cost	**$**	**17,895,500**

Table ATT11- 3 - Cost Estimate

Area No.3A - La Encantada

Net Irrigable Area (hectares): 250

Construction Cost (2000 US$)

Primary Conveyance		
Pumping Stations (including Penstocks)	$	467,400
Canals and Siphons	$	1,661,500
Structures	$	289,200
Subtotal	***$***	***2,418,100***
Off-farm System		
Distribution System (Off-farm)	$	320,000
Drainage (Off-farm)	$	55,000
Roads (Off-farm)	$	62,500
Subtotal	***$***	***437,500***
On-farm Irrigation System	***$***	***375,000***
Contingencies (25%)	$	807,700
Direct Construction Cost	***$***	***4,038,300***
Engineering and Administration (10%)	$	403,800
Total Construction Cost	**$**	**4,442,100**

Table ATT11- 4 - Cost Estimate
Area No.3B - La Encantada
Net Irrigable Area (hectares): 1000

Construction Cost (2000 US$)

Primary Conveyance		
Pumping Stations (including Penstocks)	$	1,077,800
Canals and Siphons	$	6,411,800
Structures	$	974,900
Subtotal	***$***	***8,464,500***
Off-farm System		
Distribution System (Off-farm)	$	1,280,000
Drainage (Off-farm)	$	220,000
Roads (Off-farm)	$	250,000
Subtotal	***$***	***1,750,000***
On-farm Irrigation System	***$***	***1,500,000***
Contingencies (25%)	$	2,928,600
Direct Construction Cost	***$***	***14,643,100***
Engineering and Administration (10%)	$	1,464,300
Total Construction Cost	**$**	**16,107,400**

Table ATT11- 5 - Cost Estimate

Area No.4 - El Papayo

Net Irrigable Area (hectares): 200

Construction Cost (2000 US$)

Primary Conveyance		
Pumping Stations (including Penstocks)	$	1,317,400
Canals and Siphons	$	943,300
Structures	$	173,400
Subtotal	***$***	***2,434,100***
Off-farm System		
Distribution System (Off-farm)	$	128,000
Drainage (Off-farm)	$	44,000
Roads (Off-farm)	$	50,000
Subtotal	***$***	***222,000***
On-farm Irrigation System	***$***	***300,000***
Contingencies (25%)	$	739,000
Direct Construction Cost	***$***	***3,695,100***
Engineering and Administration (10%)	$	369,500
Total Construction Cost	**$**	**4,064,600**

Table ATT11- 6 - Cost Estimate

Area No.5 - Nuevo Paraiso

Net Irrigable Area (hectares): 450

Construction Cost (2000 US$)

Primary Conveyance		
Pumping Stations (including Penstocks)	$	971,400
Canals and Siphons	$	1,984,700
Structures	$	272,900
Subtotal	***$***	***3,229,000***
Off-farm System		
Distribution System (Off-farm)	$	576,000
Drainage (Off-farm)	$	99,000
Roads (Off-farm)	$	112,500
Subtotal	***$***	***787,500***
On-farm Irrigation System	***$***	***675,000***
Contingencies (25%)	$	1,172,900
Direct Construction Cost	***$***	***5,864,400***
Engineering and Administration (10%)	$	586,400
Total Construction Cost	**$**	**6,450,800**

Table ATT11- 7 - Cost Estimate

Area No.6 - Las Marias

Net Irrigable Area (hectares): 100

Construction Cost (2000 US$)

Primary Conveyance		
Pumping Stations (including Penstocks)	$	505,100
Canals and Siphons	$	465,400
Structures	$	111,600
Subtotal	***$***	***1,082,100***
Off-farm System		
Distribution System (Off-farm)	$	64,000
Drainage (Off-farm)	$	22,000
Roads (Off-farm)	$	25,000
Subtotal	***$***	***111,000***
On-farm Irrigation System	***$***	***150,000***
Contingencies (25%)	$	335,800
Direct Construction Cost	***$***	***1,678,900***
Engineering and Administration (10%)	$	167,900
Total Construction Cost	**$**	**1,846,800**

Table ATT11- 8 - Cost Estimate

Area No.7 - Rio Indio Abajo

Net Irrigable Area (hectares): 50

Construction Cost (2000 US$)

Primary Conveyance		
Pumping Stations (including Penstocks)	$	-
Canals and Siphons	$	354,900
Structures	$	106,400
Subtotal	***$***	***461,300***
Off-farm System		
Distribution System (Off-farm)	$	32,000
Drainage (Off-farm)	$	11,000
Roads (Off-farm)	$	12,500
Subtotal	***$***	***55,500***
On-farm Irrigation System	***$***	***75,000***
Contingencies (25%)	$	148,000
Direct Construction Cost	***$***	***739,800***
Engineering and Administration (10%)	$	74,000
Total Construction Cost	**$**	**813,800**

Table ATT11- 9 - Cost Estimate
Area No.8 - Tierra Buena
Net Irrigable Area (hectares): 150

Construction Cost (2000 US$)

Primary Conveyance			
Pumping Stations (including Penstocks)		$	402,300
Canals and Siphons		$	648,800
Structures		$	109,900
	Subtotal	***$***	***1,161,000***
Off-farm System			
Distribution System (Off-farm)		$	96,000
Drainage (Off-farm)		$	33,000
Roads (Off-farm)		$	37,500
	Subtotal	***$***	***166,500***
On-farm Irrigation System		***$***	***225,000***
Contingencies (25%)		$	388,100
Direct Construction Cost		***$***	***1,940,600***
Engineering and Administration (10%)		$	194,100
Total Construction Cost		**$**	**2,134,700**

Table ATT11 - 10 - Conveyance Construction Cost

Potential Area	Sectors	Net Area (ha)	Cost of Canals	Cost of Siphons	Cost of Structures	Cost of Pump Stations	Cost of Penstocks	Total Conveyance Cost
Area No1 - Boca del Rio Indio	Right Bank	150	$ 200,900	$ -	$ 61,400	$ 141,600	$ 331,200	$ 735,100
	Left Bank	150	$ 167,400	$ -	$ 51,900	$ 141,600	$ 235,200	$ 596,100
Area No.2 - Rio Indio Valley	Main Canal A	70	$ 507,000	$ 85,100	$ 133,400	$ 130,000	$ 175,700	$ 1,031,200
	Main Canal B	10	$ 134,100	$ 11,600	$ 45,500	$ 97,400	$ 103,800	$ 392,400
	Branch Canal B-1	10	$ 84,700	$ -	$ 40,400	$ -	$ -	$ 125,100
	Main Canal C	20	$ 243,000	$ -	$ 73,400	$ 191,000	$ 264,200	$ 771,600
	Branch Canal C-1	90	$ 338,000	$ 66,800	$ 77,000	$ -	$ -	$ 481,800
	Branch Canal C-2	190	$ 1,147,900	$ 180,800	$ 193,200	$ -	$ -	$ 1,521,900
	Main Canal D	180	$ 1,028,400	$ 96,000	$ 153,800	$ 142,700	$ 203,700	$ 1,624,600
	Branch Canal D-1	20	$ 196,700	$ -	$ 51,400	$ -	$ -	$ 248,100
	Main Canal E	20	$ 47,200	$ -	$ 14,400	$ 90,700	$ 109,900	$ 262,200
	Main Canal F	20	$ 110,200	$ -	$ 24,400	$ 90,700	$ 104,400	$ 329,700
	Main Canal G	200	$ 944,700	$ 137,700	$ 119,900	$ 142,700	$ 187,400	$ 1,532,400
	Main Canal H	85	$ 437,400	$ 12,800	$ 89,600	$ 130,000	$ 169,200	$ 839,000
	Main Canal I	50	$ 95,100	$ -	$ 31,300	$ 100,200	$ 118,200	$ 344,800
	Main Canal J	20	$ 31,500	$ -	$ 16,900	$ 90,700	$ 109,900	$ 249,000
	Main Canal K	20	$ 78,700	$ -	$ 24,400	$ 90,700	$ 104,400	$ 298,200
	Main Canal L	20	$ 70,800	$ -	$ 24,400	$ 90,700	$ 101,700	$ 287,600
Area No.3A - La Encantada	Main Canal Sect 1	100	$ 767,400	$ -	$ 112,000	$ 191,000	$ 276,400	$ 1,346,800
	Main Canal Sect 2	115	$ 569,100	$ 73,300	$ 116,300	$ -	$ -	$ 758,700
	Main Canal Sect 3	35	$ 233,500	$ 18,200	$ 60,900	$ -	$ -	$ 312,600
Area No.3B - La Encantada	Main Canal Sect 1	-	$ 908,100	$ 382,500	$ 95,000	$ 447,400	$ 630,400	$ 2,463,400
	Main Canal Sect 2	80	$ 379,900	$ -	$ 62,600	$ -	$ -	$ 442,500
	Branch Canal 1 Sect 1	330	$ 1,211,500	$ 45,700	$ 256,500	$ -	$ -	$ 1,513,700
	Branch Canal 1 Sect 2	90	$ 322,900	$ 47,000	$ 114,700	$ -	$ -	$ 484,600
	Branch Canal 2 Sect 1	120	$ 1,212,400	$ 150,400	$ 180,600	$ -	$ -	$ 1,543,400
	Branch Canal 2 Sect 2	100	$ 980,500	$ 90,600	$ 195,100	$ -	$ -	$ 1,266,200
	Branch Canal 3	280	$ 447,700	$ 232,600	$ 70,400	$ -	$ -	$ 750,700
Area No.4 - El Papayo	Main Canal	125	$ 657,700	$ 77,200	$ 101,400	$ 404,100	$ 702,000	$ 1,942,400
	Branch Canal 1	25	$ 78,700	$ -	$ 40,700	$ 97,400	$ 113,900	$ 330,700
	Branch Canal 2	50	$ 129,700	$ -	$ 31,300	$ -	$ -	$ 161,000
Area No.5 - Nuevo Paraiso	Main Canal	-	$ 549,600	$ -	$ 79,200	$ 424,700	$ 546,700	$ 1,600,200
	Branch Canal 1-Sect 1	150	$ 307,000	$ 209,500	$ 48,600	$ -	$ -	$ 565,100
	Branch Canal 1-Sect 2	100	$ 407,600	$ 36,300	$ 81,000	$ -	$ -	$ 524,900
	Branch Canal 2	200	$ 442,400	$ 32,300	$ 64,100	$ -	$ -	$ 538,800
Area No.6 - Las Marias	Main Canal	50	$ 178,900	$ 21,900	$ 50,200	$ 132,000	$ 164,600	$ 547,600
	Branch Canal 1	25	$ 118,000	$ 27,700	$ 30,700	$ 97,400	$ 111,100	$ 384,900
	Branch Canal 2	25	$ 86,600	$ 32,300	$ 30,700	$ -	$ -	$ 149,600
Area No.7 - Rio Indio Abajo	Main Canal	15	$ 173,000	$ -	$ 41,800	$ -	$ -	$ 214,800
	Right Branch Canal	10	$ 56,500	$ -	$ 24,700	$ -	$ -	$ 81,200
	Left Branch Canal	25	$ 102,300	$ 23,100	$ 39,900	$ -	$ -	$ 165,300
Area No.8 - Tierra Buena	Main Canal Sect 1	100	$ 513,300	$ -	$ 84,600	$ 182,700	$ 219,600	$ 1,000,200
	Main Canal Sect 2	50	$ 103,800	$ 31,700	$ 25,300	$ -	$ -	$ 160,800

Pumping Station Cost

Irrigable Area	Pump Station	Pump Cap. (m^3/s)	Total Head (m)	No. of Pumps	Pumping Station Cost				Pipe Dia. (in)	Pipe Length (m)	Pipe Cost (US$/m)	Pipe Cost	Total Cost
					Civil	Mech.	Elect.	Total					
Area No1 - Boca del Rio Indio	Right Bank from Rio Indio	0.150	28.0	3	$ 33,300	$ 50,800	$ 57,500	$ 141,600	16	770	$ 246	$189,600	$ 331,200
	Left Bank from Rio Indio	0.150	27.3	3	$ 33,300	$ 50,800	$ 57,500	$ 141,600	16	380	$ 246	$ 93,600	$ 235,200
Area No.2 - Rio Indio Valley	Main Canal A from Rio Indio	0.100	25.1	3	$33,300	$ 39,200	$ 57,500	$130,000	14	210	$ 218	$ 45,700	$ 175,700
	Main Canal B from Rio Indio	0.030	22.9	3	$33,300	$ 24,600	$ 39,500	$ 97,400	8	70	$ 92	$ 6,400	$ 103,800
	Main Canal C from Rio Indio	0.300	43.4	3	$33,300	$ 85,200	$ 72,500	$191,000	24	180	$ 407	$ 73,200	$ 264,200
	Main Canal D from Rio Indio	0.250	22.4	3	$33,300	$ 51,900	$ 57,500	$142,700	24	150	$ 407	$ 61,000	$ 203,700
	Main Canal E from Rio Indio	0.020	7.5	3	$33,300	$ 18,000	$ 39,500	$ 90,700	8	210	$ 92	$ 19,200	$ 109,900
	Main Canal F from Rio Indio	0.020	7.5	3	$33,300	$ 18,000	$ 39,500	$ 90,700	8	150	$ 92	$ 13,700	$ 104,400
	Main Canal G from Rio Indio	0.200	22.4	3	$33,300	$ 51,900	$ 57,500	$142,700	18	150	$ 298	$ 44,700	$ 187,400
	Main Canal H from Rio Indio	0.100	24.5	3	$33,300	$ 39,200	$ 57,500	$130,000	14	180	$ 218	$ 39,200	$ 169,200
	Main Canal I from Rio Indio	0.050	11.9	3	$33,300	$ 27,400	$ 39,500	$100,200	10	150	$ 120	$ 18,000	$ 118,200
	Main Canal J from Rio Indio	0.020	9.6	3	$33,300	$ 18,000	$ 39,500	$ 90,700	8	210	$ 92	$ 19,200	$ 109,900
	Main Canal K from Rio Indio	0.020	9.5	3	$33,300	$ 18,000	$ 39,500	$ 90,700	8	150	$ 92	$ 13,700	$ 104,400
	Main Canal L from Rio Indio	0.020	9.6	3	$33,300	$ 18,000	$ 39,500	$ 90,700	8	120	$ 92	$ 11,000	$ 101,700
Area No.3A - La Encantada	Main Canal from Rio Indio	0.250	47.0	3	$33,300	$ 85,200	$ 72,500	$191,000	24	210	$ 407	$ 85,400	$ 276,400
Area No.3B - La Encantada	From Reservoir (at El. 50)	1.000	36.0	5	$43,200	$275,800	$128,500	$447,400	3 x 24	150	$ 1,220	$183,000	$ 630,400
Area No.4 - El Papayo	Transfer from Reservoir (at El. 50)	0.200	80.0	3	$33,300	$ 80,600	$107,500	$221,400	18	700	$ 298	$208,500	$ 429,900
	Main Canal from Rio El Jobo	0.200	45.0	3	$33,300	$ 76,900	$ 72,500	$182,700	18	300	$ 298	$ 89,400	$ 272,100
	Relift Station	0.025	32.2	3	$33,300	$ 24,600	$ 39,500	$ 97,400	8	180	$ 92	$ 16,500	$ 113,900
Area No.5 - Nuevo Paraiso	Main Canal from Rio Teria	0.450	85.0	4	$38,200	$230,000	$156,500	$424,700	2 x 24	150	$ 813	$122,000	$ 546,700
Area No.6 - Las Marias	Main Canal from Rio Uracillo	0.100	50.0	3	$33,300	$ 41,200	$ 57,500	$132,000	14	150	$ 218	$ 32,600	$ 164,600
	Relift Station	0.025	21.1	3	$33,300	$ 24,600	$ 39,500	$ 97,400	8	150	$ 92	$ 13,700	$ 111,100
Area No.8 - Tierra Buena	Main Canal from Rio Uracillo	0.160	65.5	3	$33,300	$ 76,900	$ 72,500	$182,700	16	150	$ 246	$ 36,900	$ 219,600

Construction Cost of Primary Canals

Irrigable Area	Canal	Canal Capacity (m^3/sec)	Canal Length (km)	Canal Cost per meter	Canal Cost
Area No.1 - Boca del Rio Indio	Right Bank Main Canal	0.150	1.8	$ 112	$ 200,900
	Left Bank Main Canal	0.150	1.5	$ 112	$ 167,400
Area No.2 - Rio Indio Valley	Main Canal A	0.100	5.1	$ 99	$ 507,000
	Main Canal B	0.010	1.9	$ 71	$ 134,100
	Main Canal B-1	0.010	1.2	$ 71	$ 84,700
	Main Canal C	0.300	1.9	$ 128	$ 243,000
	Branch Canal C-1	0.100	3.4	$ 99	$ 338,000
	Branch Canal C-2	0.200	9.6	$ 120	$ 1,147,900
	Main Canal D	0.200	8.6	$ 120	$ 1,028,400
	Branch Canal D-1	0.025	2.5	$ 79	$ 196,700
	Main Canal E	0.025	0.6	$ 79	$ 47,200
	Main Canal F	0.025	1.4	$ 79	$ 110,200
	Main Canal G	0.200	7.9	$ 120	$ 944,700
	Main Canal H	0.100	4.4	$ 99	$ 437,400
	Main Canal I	0.050	1.1	$ 86	$ 95,100
	Main Canal J	0.025	0.4	$ 79	$ 31,500
	Main Canal K	0.025	1.0	$ 79	$ 78,700
	Main Canal L	0.025	0.9	$ 79	$ 70,800
Area No.3A - La Encantada	Main Canal Sect. 1	0.250	6.0	$ 128	$ 767,400
	Main Canal Sect. 2	0.150	5.1	$ 112	$ 569,100
	Main Canal Sect. 3	0.050	2.7	$ 86	$ 233,500
Area No.3B - La Encantada	Main Canal Sect. 1	1.000	4.6	$ 197	$ 908,100
	Main Canal Sect. 2	0.600	2.2	$ 173	$ 379,900
	Branch Canal No.1 Sect. 1	0.500	7.5	$ 162	$ 1,211,500
	Branch Canal No.1 Sect. 2	0.200	2.7	$ 120	$ 322,900
	Branch Canal No.2 Sect. 1	0.400	8.4	$ 144	$ 1,212,400
	Branch Canal No.2 Sect. 2	0.200	8.2	$ 120	$ 980,500
	Branch Canal No.3	0.300	3.5	$ 128	$ 447,700
Area No.4 - El Papayo	Main Canal	0.200	5.5	$ 120	$ 657,700
	Branch Canal No.1	0.025	1.0	$ 79	$ 78,700
	Branch Canal No.2	0.050	1.5	$ 86	$ 129,700
Area No.5 - Nuevo Paraiso	Main Canal	0.450	3.6	$ 153	$ 549,600
	Branch Canal No.1 Sect. 1	0.250	2.4	$ 128	$ 307,000
	Branch Canal No.1 Sect. 2	0.100	4.1	$ 99	$ 407,600
	Branch Canal No.2	0.200	3.7	$ 120	$ 442,400
Area No.6 - Las Marias	Main Canal	0.100	1.8	$ 99	$ 178,900
	Branch Canal No.1	0.025	1.5	$ 79	$ 118,000
	Branch Canal No.2	0.025	1.1	$ 79	$ 86,600
Area No.7 - Rio Indio Abajo	Main Canal	0.050	2.0	$ 86	$ 173,000
	Right Branch Canal	0.010	0.8	$ 71	$ 56,500
	Left Branch Canal	0.025	1.3	$ 79	$ 102,300
Area No.8 - Tierra Buena	Main Canal - Sect. 1	0.150	4.6	$ 112	$ 513,300
	Main Canal - Sect. 2	0.050	1.2	$ 86	$ 103,800

Siphon Construction Cost

Irrigable Area	Siphon	Pipe Diameter (in)	Pipe Length (meter)	Pipe Cost per meter	Siphon Cost
Area No.2 - Rio Indio Valley	Main Canal A - Siphon 1	14	385	$ 122	$ 46,800
	Main Canal A - Siphon 2	14	210	$ 122	$ 25,500
	Main Canal A - Siphon 3	14	105	$ 122	$ 12,800
	Main Canal B	8	150	$ 77	$ 11,600
	Branch Canal C-1 - Siphon 1	14	275	$ 122	$ 33,400
	Branch Canal C-1 - Siphon 2	14	275	$ 122	$ 33,400
	Branch Canal C-2 - Siphon 3	21	825	$ 179	$ 147,500
	Branch Canal C-2 - Siphon 4	18	220	$ 151	$ 33,300
	Main Canal D - Siphon 1	18	275	$ 151	$ 41,600
	Main Canal D - Siphon 2	18	180	$ 151	$ 27,200
	Main Canal D - Siphon 3	18	180	$ 151	$ 27,200
	Main Canal G - Siphon 1	18	360	$ 151	$ 54,500
	Main Canal G - Siphon 2	18	300	$ 151	$ 45,400
	Main Canal G - Siphon 3	18	250	$ 151	$ 37,800
	Main Canal H	14	105	$ 122	$ 12,800
Area No.3A - La Encantada	Main Canal Siphon 1	21	410	$ 179	$ 73,300
	Main Canal Siphon 2	18	120	$ 151	$ 18,200
Area No.3B - La Encantada	Main Canal Sect. 1 Siphon 1	2 x 30	690	$ 554	$ 382,500
	Branch Canal 1 Sect.1 - Siphon 2	30	165	$ 277	$ 45,700
	Branch Canal 1 Sect.2 - Siphon 3	20	275	$ 171	$ 47,000
	Branch Canal 2 Sect.1 - Siphon 4	2 x 20	440	$ 342	$ 150,400
	Branch Canal 2 Sect.2 - Siphon 5	20	410	$ 171	$ 70,100
	Branch Canal 2 Sect.2 - Siphon 6	20	120	$ 171	$ 20,500
	Branch Canal 3 Sect.1 - Siphon 7	24	440	$ 206	$ 90,600
	Branch Canal 3 Sect.1 - Siphon 8	24	690	$ 206	$ 142,000
Area No.4 - El Papayo	Main Canal - Siphon 1	18	300	$ 151	$ 45,400
	Main Canal - Siphon 2	18	210	$ 151	$ 31,800
Area No.5 - Nuevo Paraiso	Branch Canal No.1 Sect. 1 - Siphon 1	24	1018	$ 206	$ 209,500
	Branch Canal No.1 Sect. 2 - Siphon 2	18	240	$ 151	$ 36,300
	Branch Canal - Siphon 3	18	120	$ 151	$ 18,200
Area No.6 - Las Marias	Main Canal - Siphon 1	14	180	$ 122	$ 21,900
	Branch Canal No.1 - Siphon 2	8	360	$ 77	$ 27,700
	Branch Canal No.2 - Siphon 3	8	420	$ 77	$ 32,300
Area No.7 - Rio Indio Abajo	Left Branch Canal	8	300	$ 77	$ 23,100
Area No.8 - Tierra Buena	Main Canal - Sect. 2	12	300	$ 106	$ 31,700

Construction Costs of Canal Structures

Potential Area	Sectors	Net Area (ha)	Checks	Turnouts	Chutes	Flow Division	Spillways	Culverts	Foot Bridges	Vehicular Bridges	Total per Sector
Area No1 - Boca del Rio Indio	Right Bank	150	$ 7,800	$ 16,000	$ -	$ -	$ 6,600	$ 12,000	$ 7,000	$ 12,000	$ 61,400
	Left Bank	150	$ 7,800	$ 16,000	$ -	$ -	$ 6,600	$ 6,000	$ 3,500	$ 12,000	$ 51,900
Area No.2 - Rio Indio Valley	Main Canal A	70	$ 13,200	$ 32,000	$ -	$ -	$ 13,200	$ 30,000	$ 21,000	$ 24,000	$ 133,400
	Main Canal B	10	$ 1,600	$ 8,000	$ -	$ -	$ 4,900	$ 12,000	$ 7,000	$ 12,000	$ 45,500
	Branch Canal B-1	10	$ 1,600	$ 8,000	$ -	$ -	$ 3,300	$ 12,000	$ 3,500	$ 12,000	$ 40,400
	Main Canal C	20	$ 10,800	$ 12,000	$ -	$ 7,000	$ 6,600	$ 18,000	$ 7,000	$ 12,000	$ 73,400
	Branch Canal C-1	90	$ 6,000	$ 16,000	$ -	$ -	$ 12,000	$ 24,000	$ 7,000	$ 12,000	$ 77,000
	Branch Canal C-2	190	$ 18,000	$ 32,000	$ -	$ -	$ 13,200	$ 78,000	$ 28,000	$ 24,000	$ 193,200
	Main Canal D	180	$ 17,600	$ 24,000	$ -	$ -	$ 13,200	$ 54,000	$ 21,000	$ 24,000	$ 153,800
	Branch Canal D-1	20	$ 4,000	$ 8,000	$ -	$ -	$ 4,900	$ 12,000	$ 10,500	$ 12,000	$ 51,400
	Main Canal E	20	$ 2,000	$ 4,000	$ -	$ -	$ 4,900	$ -	$ 3,500	$ -	$ 14,400
	Main Canal F	20	$ 2,000	$ 8,000	$ -	$ -	$ 4,900	$ 6,000	$ 3,500	$ -	$ 24,400
	Main Canal G	200	$ 13,200	$ 28,000	$ -	$ -	$ 13,200	$ 36,000	$ 17,500	$ 12,000	$ 119,900
	Main Canal H	85	$ 9,900	$ 20,000	$ -	$ -	$ 13,200	$ 12,000	$ 10,500	$ 24,000	$ 89,600
	Main Canal I	50	$ 2,900	$ 8,000	$ -	$ -	$ 4,900	$ 12,000	$ 3,500	$ -	$ 31,300
	Main Canal J	20	$ 2,000	$ 4,000	$ -	$ -	$ 4,900	$ 6,000	$ -	$ -	$ 16,900
	Main Canal K	20	$ 2,000	$ 8,000	$ -	$ -	$ 4,900	$ 6,000	$ 3,500	$ -	$ 24,400
	Main Canal L	20	$ 2,000	$ 8,000	$ -	$ -	$ 4,900	$ 6,000	$ 3,500	$ -	$ 24,400
Area No.3A - La Encantada	Main Canal Sect 1	100	$ 4,900	$ 12,000	$ -	$ -	$ 6,600	$ 54,000	$ 10,500	$ 24,000	$ 112,000
	Main Canal Sect 2	115	$ 11,700	$ 24,000	$ -	$ -	$ 6,600	$ 36,000	$ 14,000	$ 24,000	$ 116,300
	Main Canal Sect 3	35	$ 3,000	$ 16,000	$ -	$ -	$ 4,900	$ 18,000	$ 7,000	$ 12,000	$ 60,900
Area No.3B - La Encantada	Main Canal Sect 1	-	$ 21,600	$ -	$ -	$ 14,000	$ 26,400	$ 18,000	$ -	$ 15,000	$ 95,000
	Main Canal Sect 2	80	$ 8,000	$ 12,000	$ -	$ 10,400	$ 10,700	$ 18,000	$ 3,500	$ -	$ 62,600
	Branch Canal 1 Sect 1	330	$ 14,200	$ 40,000	$ 116,900	$ -	$ 8,400	$ 48,000	$ 14,000	$ 15,000	$ 256,500
	Branch Canal 1 Sect 2	90	$ 4,400	$ 12,000	$ 66,700	$ -	$ 6,600	$ 18,000	$ 7,000	$ -	$ 114,700
	Branch Canal 2 Sect 1	120	$ 13,200	$ 32,000	$ 59,500	$ -	$ 8,400	$ 42,000	$ 10,500	$ 15,000	$ 180,600
	Branch Canal 2 Sect 2	100	$ 8,800	$ 20,000	$ 85,700	$ -	$ 6,600	$ 48,000	$ 14,000	$ 12,000	$ 195,100
	Branch Canal 3	280	$ 10,800	$ 28,000	$ -	$ -	$ 6,600	$ 18,000	$ 7,000	$ -	$ 70,400
Area No.4 - El Papayo	Main Canal	125	$ 8,800	$ 24,000	$ -	$ -	$ 6,600	$ 36,000	$ 14,000	$ 12,000	$ 101,400
	Branch Canal 1	25	$ 2,300	$ 12,000	$ -	$ -	$ 4,900	$ 18,000	$ 3,500	$ -	$ 40,700
	Branch Canal 2	50	$ 2,900	$ 8,000	$ -	$ -	$ 4,900	$ 12,000	$ 3,500	$ -	$ 31,300
Area No.5 - Nuevo Paraiso	Main Canal	-	$ 7,100	$ -	$ -	$ 9,200	$ 8,400	$ 36,000	$ 3,500	$ 15,000	$ 79,200
	Branch Canal 1-Sect 1	150	$ 5,000	$ 12,000	$ -	$ -	$ 6,600	$ 18,000	$ 7,000	$ -	$ 48,600
	Branch Canal 1-Sect 2	100	$ 4,400	$ 20,000	$ -	$ -	$ 6,600	$ 24,000	$ 14,000	$ 12,000	$ 81,000
	Branch Canal 2	200	$ 4,400	$ 12,000	$ -	$ -	$ 13,200	$ 24,000	$ 10,500	$ -	$ 64,100
Area No.6 - Las Marias	Main Canal	50	$ 3,300	$ 12,000	$ -	$ 4,300	$ 6,600	$ 12,000	$ -	$ 12,000	$ 50,200
	Branch Canal 1	25	$ 2,300	$ 8,000	$ -	$ -	$ 4,900	$ 12,000	$ 3,500	$ -	$ 30,700
	Branch Canal 2	25	$ 2,300	$ 8,000	$ -	$ -	$ 4,900	$ 12,000	$ 3,500	$ -	$ 30,700
Area No.7 - Rio Indio Abajo	Main Canal	15	$ 2,900	$ 4,000	$ -	$ -	$ 4,900	$ 18,000	$ -	$ 12,000	$ 41,800
	Right Branch Canal	10	$ 2,300	$ 8,000	$ -	$ -	$ 4,900	$ 6,000	$ 3,500	$ -	$ 24,700
	Left Branch Canal	25	$ 1,600	$ 16,000	$ -	$ -	$ 3,300	$ 12,000	$ 7,000	$ -	$ 39,900
Area No.8 - Tierra Buena	Main Canal Sect 1	100	$ 8,000	$ 20,000	$ -	$ -	$ 6,600	$ 24,000	$ 14,000	$ 12,000	$ 84,600
	Main Canal Sect 2	50	$ 2,900	$ 8,000	$ -	$ -	$ 4,900	$ 6,000	$ 3,500	$ -	$ 25,300

Appendix G
Cost Estimates

FEASIBILITY DESIGN FOR THE RÍO INDIO WATER SUPPLY PROJECT

APPENDIX G

COST ESTIMATE

Prepared by

MWH

In association with

TAMS

AN EARTH TECH COMPANY

Project Management and Support

Description	Monthly Salary ($)	Cost of Salary	Number	Duration (month) Pre	Const.	Post	Total
Project Manager	$8,500	$12,750	1	6	42	3	$650,250
Superintendent	$7,500	$11,250	1	6	42	3	$573,750
Staff Engineers	$5,500	$8,250	3	2	42		$1,089,000
Purchasing Agent	$6,500	$9,750	1	6	42		$468,000
Coordinator (subs)	$6,000	$9,000	1	6	42		$432,000
Accountant	$6,500	$9,750	1	2	42	3	$458,250
Administrative Assistant	$2,000	$3,000	3	3	42	2	$423,000
Secretary	$1,000	$1,500	2	3	42	2	$141,000
							$4,235,250
Airfare for Expatriate and Family							
	$1,200		130 RT				**$156,000**
Office Equipment							
Computers	$2,500		14 each				**$35,000**
Copiers, printers, video, etc.	$20,000		1 LS				**$20,000**
Supplies	$1,000		50 mth				**$50,000**
Telephone (satellite, other)	$1,500		50 mth				**$75,000**
Vehicles							
Compact Pickup	$415		5 each		45 mth		**$93,375**
3/4 ton pickup	$615		3 each		45 mth		**$83,025**

Local Labor Hourly Rates

Description	Rate ($/hr)	Stanby Rate	Comments
Crew Leader	$ 10.00		Estimate
Equipment Operator	$ 7.90		Estimate
Truck Driver	$ 6.20		Estimate
Skilled Labor	$ 6.60		Guidance from the COE for Estimates in Panama: $3.50/hr (Apr 98) escalated at 2%p.a. plus 50% for social cost and adjusted for overtime (60-hr work week)
Unskilled Labor	$ 5.50		Guidance from the COE for Estimates in Panama: $2.90/hr (Apr 98) escalated at 2%p.a. plus 50% for social cost and adjusted for overtime (60-hr work week)

Equipment Hourly Rates

Equipment Description	Ownership Cost		Operating Cost			Repair Cost		Total Hourly Rate ($/hr)
	Depr.	FCCM	Fuel	FOG	Tire	Tire	General	
Compressor 375cfm	$ 3.20	$ 0.90	$ 5.79	$ 1.43	$ 0.16	$ 0.02	$ 2.55	$ 14.05
Batching Plant 45 cm/hr	$ 9.39	$ 2.31	$ 18.46	$ 9.20	$ 1.91	$ 0.24	$ 10.60	$ 52.11
Cement Silo & loading	$ 2.51	$ 0.56	$ 1.86	$ 1.80	$ -	$ -	$ 2.77	$ 9.50
Pugmill, 10cm feederhopper, twin shaft, etc	$ 21.56	$ 4.92	$ 9.01	$ 3.57	$ 0.43	$ 0.05	$ 23.96	$ 63.50
Concrete Pump	$ 5.68	$ 1.07	$ 3.72	$ 0.92	$ 0.03	$ -	$ 5.54	$ 16.96
15-ton Yard Crane	$ 6.98	$ 2.43	$ 5.53	$ 1.46	$ 0.53	$ 0.07	$ 5.74	$ 22.74
50-ton Crane (Crawler)	$ 19.91	$ 9.47	$ 3.98	$ 0.70	$ -	$ -	$ 16.25	$ 50.31
80-ton Crane (Crawler)	$ 30.87	$ 13.13	$ 9.50	$ 2.84	$ -	$ -	$ 28.55	$ 84.89
Tower Crane	$ 19.52	$ 7.58	$ 5.12	$ 5.25	$ -	$ -	$ 17.43	$ 54.90
Drill Rig with Compressor	$ 8.43	$ 3.49	$ 13.75	$ 3.39	$ -	$ -	$ 9.91	$ 38.97
Generator 275kW	$ 3.46	$ 0.79	$ 17.24	$ 3.64	$ -	$ -	$ 2.31	$ 27.44
Generator 455kW	$ 6.23	$ 1.43	$ 29.25	$ 6.18	$ -	$ -	$ 4.16	$ 47.25
Hydraulic Excavator 6cy bucket CAT 375-L	$ 26.71	$ 18.49	$ 18.22	$ 3.85	$ -	$ -	$ 37.22	$ 104.49
Front End Loader CAT 953 Crawler - 1.7cm	$ 16.43	$ 3.71	$ 5.62	$ 1.88	$ -	$ -	$ 24.75	$ 52.39
Front End Loader CAT 939-C Crawler - 1.15cm	$ 10.61	$ 2.39	$ 4.18	$ 1.40	$ -	$ -	$ 15.98	$ 34.56
Front End Loader CAT 980-G Wheel - 4.6cm	$ 24.55	$ 8.32	$ 12.77	$ 3.37	$ 7.72	$ 0.96	$ 19.09	$ 76.78
Front End Loader CAT 990-SeriesII Wheel - 9.2cm	$ 59.28	$ 20.34	$ 26.61	$ 7.02	$ 9.73	$ 1.21	$ 46.21	$ 170.40
Roller, Double-drum, self Propelled	$ 13.24	$ 2.99	$ 6.71	$ 1.89	$ -	$ -	$ 15.72	$ 40.55
Staking Conveyor	$ 2.42	$ 0.57	$ 0.61	$ 0.24	$ 0.20	$ 0.02	$ 1.66	$ 5.72
Conveyor	$ 3.55	$ 0.85	$ 1.64	$ 0.65	$ 0.37	$ 0.05	$ 2.43	$ 9.54
Crushing Plant (Secondary)	$ 12.10	$ 6.53	$ 12.90	$ 5.11	$ 0.61	$ 0.08	$ 14.17	$ 51.50
Screening Plant	$ 11.71	$ 2.72	$ 3.28	$ 1.30	$ 0.40	$ 0.05	$ 9.15	$ 28.61
Crushing Plant (Primary)	$ 10.11	$ 5.41	$ 7.66	$ 1.89	$ 0.56	$ 0.07	$ 6.34	$ 32.04
Dozer/Ripper D8	$ 14.57	$ 8.47	$ 14.16	$ 3.49	$ -	$ -	$ 17.33	$ 58.02
Dozer/Ripper D6	$ 11.53	$ 4.58	$ 7.66	$ 2.43	$ -	$ -	$ 17.64	$ 43.84
Water Truck	$ 9.11	$ 2.87	$ 13.13	$ 3.23	$ 1.06	$ 0.13	$ 6.37	$ 35.90
Flatbed Trailer, 48 ft long	$ 1.39	$ 0.36	$ -	$ -	$ 0.52	$ 0.06	$ 0.69	$ 3.02
Bottom Dum Truck	$ 18.92	$ 5.39	$ 11.93	$ 3.34	$ 7.49	$ 0.93	$ 13.11	$ 61.11
Lowboy 50 ton	$ 4.45	$ 0.50	$ 1.63	$ 0.09	$ 0.48	$ 0.06	$ 0.99	$ 8.20
3/4 Ton Pickup F250 4X4	$ 1.73	$ 0.41	$ 2.92	$ 0.72	$ 0.38	$ 0.05	$ 1.31	$ 7.52
Transit Mixer	$ 4.74	$ 1.13	$ 5.87	$ 1.84	$ 0.35	$ 0.04	$ 3.39	$ 17.36
Tractor trailer	$ 6.60	$ 2.27	$ 13.92	$ 3.43	$ 1.91	$ 0.24	$ 4.64	$ 33.01
Truck, off-highway; rear dump 58 ton	$ 19.48	$ 14.34	$ 15.09	$ 4.51	$ 11.56	$ 1.44	$ 12.24	$ 78.66
Truck, off-highway; rear dump 25 ton	$ 8.55	$ 6.23	$ 6.04	$ 1.80	$ 6.48	$ 0.81	$ 5.36	$ 35.27
Compressor & Vibrators	$ 4.60	$ 3.35	$ 3.25	$ 0.97	$ 3.48	$ 0.43	$ 2.87	$ 18.95

Commun Equipment

Equipment Description	Hourly Operating Rate	Standby Hourly Rate
50 ton Crawler Mounted Crane	$50.31	$19.43
Forklift truck	$25.22	$6.96
50 ton Lowboy	$8.20	$2.96
Flatbed trailer	$3.20	$1.06
Fuel Bowser	$6.69	$2.36
Tractor trailer	$33.01	$5.57
Utility Trialer	$1.13	$0.42
75 mm submersible pump	$1.07	$0.27
100 mm diaphragm pump	$1.96	$0.50
150 mm submersible pump	$7.92	$1.23
3/4 Pickup Truck	$7.52	$1.28
Welding set	$5.53	$0.68
	$151.76	$42.72

Assume 70% standby and 30% operating on the basis of 40 hr per week

Cost of Commun Equipment	$13,075	42 mth		**$549,145**
Operating Crew				
Crew Leader	$10.00	1	$10.00	
Drivers	$6.20	3	$18.60	
Mechanics	$6.60	3	$19.80	
Electrician	$6.60	1	$6.60	
Welder	$7.90	1	$7.90	
Equipment Operator	$7.90	1	$7.90	
			$70.80	

Assume 40 hr per week for 42 months

Cost of Operating Crew	$12,272	42 mth	**$515,424**

Other Costs

Mobilization of Equipment

40-ft container from US port including Shipping, US port handling, Panama Port Handling			**$4,500**
Trucking Container to construction Site			
Loading	2 hr		
Travel 65 km to site	2 hr		
Unload	2 hr		
Return	2 hr		
Transportation Cost	27.53	8 hr	**$220.24**
Loading/Unloading	69.21	4 hr	**$276.84**
	Estimated cost per container		**$5,000**
Assume same cost for demobilization			
Estimated Numbert of containers	40		**$400,000**

Power

Generators 275kW	$40,000	3 each	$120,000
Generators 545 kW	$86,000	1 each	$86,000
Housing	$8,000	4 each	$32,000
Transmission	$16,500	16 km	$264,000
Operating Cost at $0.08/kWh	$0.08	13,264,000 kWh	$1,061,120
			$1,563,120

Unit Rate Computation for Common Excavation

Description	Hourly Rates Labor	Equip.	Quantity	Amount
Dozer/Ripper D8	$ 7.90	$ 58.02	1	$ 65.92
Hyd Excavator 4.6 cm bucket	$ 7.90	$ 104.49	1	$ 112.39
Dozer D6	$ 7.90	$ 43.84	1	$ 51.74
Loader 9.2 cm bucket	$ 7.90	$ 170.40	1	$ 178.30
58-ton Rear Dump Truck	$ 6.20	$ 78.66	4	$ 339.44
Crew Leader	$ 10.00		1	$ 10.00
Unskilled Labor	$ 5.50		4	$ 22.00
			Total	$ 779.79

Production Rate	320 cm/hr	Rate	$ 2.44
		Indirect Cost 30%	$ 0.73
		Total Rate	$ 3.17

Unit Rate Computation for Structural Rock Excavation

Description	Hourly Rates Labor	Equip.	Quantity	Amount
Dozer/Ripper D6	$ 7.90	$ 43.84	1	$ 51.74
Drill Rig	$ 7.90	$ 38.97	1	$ 46.87
Compressor & 4 hand drills	$ 22.00	$ 17.51	2	$ 79.02
Loader 1.7 cm bucket	$ 7.90	$ 52.39	1	$ 60.29
25-ton Rear Dump Truck	$ 6.20	$ 35.27	2	$ 82.94
Crew Leader	$ 10.00		1	$ 10.00
Unskilled Labor	$ 5.50		4	$ 22.00
			Subtotal	$ 352.86

Production Rate	40	cm/hr	Rate	$ 8.82
Explosives	1.00	kg/cm @	$ 1.50	$ 1.50
Misc consummable (10%)				$ 0.88
			Subtotal	$ 11.20
			Indirect Cost 30%	$ 3.36
			Total Rate	$ 14.56

Unit Rate Computation
for
Bulk Rock Excavation

Description	Hourly Rates Labor	Hourly Rates Equip.	Quantity	Amount
Dozer/Ripper D8	$ 7.90	$ 58.02	1	$ 65.92
Drill Rig	$ 7.90	$ 38.97	2	$ 93.74
Compressor & 4 hand drills	$ 22.00	$ 17.51	2	$ 79.02
Loader 4.6 cm bucket	$ 7.90	$ 76.78	1	$ 84.68
25-ton Rear Dump Truck	$ 6.20	$ 35.27	4	$ 165.88
Crew Leader	$ 10.00		1	$ 10.00
Unskilled Labor	$ 5.50		4	$ 22.00
			Subtotal	$ 521.24

Production Rate	100	cm/hr	Rate	$ 5.21
Explosives	0.65	kg/cm @	$ 1.50	$ 0.98
Misc consummable (10%)				$ 0.52
			Subtotal	$ 6.71
			Indirect Cost 30%	$ 2.01
			Total Rate	$ 8.72

Unit Rate Computation
for
Operate Quarry

Description	Hourly Rates Labor	Hourly Rates Equip.	Quantity	Amount
Dozer/Ripper D6	$ 7.90	$ 43.84	1	$ 51.74
Drill Rig incl. Compressor	$ 7.90	$ 38.97	2	$ 93.74
Compressor & 4 hand drills	$ 22.00	$ 17.51	2	$ 79.02
Crushing and Screening Plant	$ 7.90	$ 60.55	1	$ 68.45
Secondary Crushing Plant		$ 51.50	1	$ 51.50
Conveyor		$ 5.72	2	$ 11.44
Front End Loader CAT 939-C Crawler - 1.15cm	$ 7.90	$ 34.56	1	$ 42.46
25-ton Rear Dump Truck	$ 6.20	$ 35.27	2	$ 82.94
Crew Leader	$ 10.00		1	$ 10.00
Unskilled Labor	$ 5.50		10	$ 55.00
			Subtotal	$ 546.29

Production Rate	80 cm/hr		Rate	$ 6.83
Explosives	0.80 kg/cm @	$ 1.50		$ 1.20
Misc consummable (10%)				$ 0.68
			Subtotal	$ 8.71
			Indirect Cost 30%	$ 2.61
			Total Rate	$ 11.32

Unit Rate Computation for Concrete Mix & Transport

Description	Hourly Rates Labor	Hourly Rates Equip.	Quantity	Amount
Batching Plant 75 cm/hr	$ 7.90	$ 52.11	1	$ 60.01
Cement Silo & loading		$ 9.50	1	$ 9.50
Standby Generator		$ 5.00	1	$ 5.00
Transit Mixer	$ 6.20	$ 17.36	8	$ 188.48
Dumper 2cm		$ 5.00	4	$ 20.00
Water Storage & Cooling Plant	$ 7.90	$ 45.00	1	$ 52.90
25-ton Rear Dump Truck	$ 6.20	$ 35.27	2	$ 82.94
Expatriate	$ 60.00		1	$ 60.00
Crew Leader	$ 10.00		3	$ 30.00
Unskilled Labor	$ 5.50		10	$ 55.00
			Subtotal	$ 563.83

Production Rate	40 cm/hr	Rate	$ 14.10
Cement	0.36 T/cm @	$ 120.00	$ 43.20
Additive	0.5 gal/cm	$ 15.00	$ 7.50
Aggregates	1 cm/cm @	$ 8.71	$ 8.71
		Subtotal	$ 73.51
		Indirect Cost 30%	$ 22.05
		Total Rate	$ 95.56

Unit Rate Computation for Concrete Placement

Description	Hourly Rates Labor	Hourly Rates Equip.	Quantity	Amount
50-ton Crane	$ 7.90	$ 50.31	1	$ 58.21
80-ton Crane	$ 7.90	$ 84.89	1	$ 92.79
Tower Crane	$ 7.90	$ 54.90	1	$ 62.80
Concrete Pump	$ 7.90	$ 16.96	2	$ 49.72
Compressor & Vibrators	$ 6.20	$ 18.95	2	$ 87.50
Expatriate	$ 60.00		1	$ 60.00
Crew Leader	$ 10.00		3	$ 30.00
Unskilled Labor	$ 5.50		10	$ 55.00
Miscellaneous			15%	$ 74.40
			Subtotal	$ 570.42

Production Rate	40 cm/hr	Rate	$ 14.26
Concrete			$ 73.51
		Subtotal	$ 87.77
		Indirect Cost 30%	$ 26.33
		Total Rate	$ 114.10

Unit Rate Computation for Steel Reinforcement

Description	Hourly Rates Labor	Equip.	Quantity	Amount
Unload, Sort and Pile				
Crew Leader	$ 10.00		1	$ 10.00
15-ton Yard Crane	$ 7.90	$ 22.74	1	$ 30.64
Unskilled Labor	$ 5.50		4	$ 22.00
			Subtotal	$ 62.64
Production Rate	9 T/hr		Rate	$ 6.96
Cut, Bend and Place				
Crew Leader	$ 10.00		1	$ 10.00
15-ton Yard Crane	$ 7.90	$ 22.74	1	$ 30.64
Unskilled Labor	$ 6.60		30	$ 198.00
			Subtotal	$ 238.64
Production Rate	1 T/hr		Rate	$ 238.64
Reinforcement Steel	1 T/T @		$ 760.00	$ 760.00
Miscellaneous			5%	$ 38.00
			Subtotal	$ 1,043.60
			Indirect Cost 30%	$ 313.08
			Subtotal	$ 1,356.68

Unit Rate Computation for Formwork

Description	Hourly Rates Labor	Hourly Rates Equip.	Quantity	Amount
Fabrication				
Crew Leader	$ 10.00		1	$ 10.00
Skilled Labor	$ 6.60		3	$ 19.80
Unskilled Labor	$ 5.50		2	$ 11.00
			Subtotal	$ 40.80
Material				
Production Rate		2 sm/hr	Rate	$ 19.90
Wood & Plywood		1.15 sm/sm @	$ 20.00	$ 23.00
Miscellaneous			10%	$ 2.30
			Subtotal	$ 45.20
Reuse		5		$ 9.04
Cleanup & Erection				
Crew Leader	$ 10.00		1	$ 10.00
Unskilled Labor	$ 5.50		3	$ 16.50
			Subtotal	$ 26.50
			Indirect Cost 30%	$ 10.66
			Total Rate	$ 46.20

Unit Rate Computation
for
RCC

Description	Hourly Rates Labor	Hourly Rates Equip.	Quantity	Amount	Labor
Pugmill	$ 7.90	$ 63.50	2	$ 142.80	$ 15.80
Conveyors		$ 31.30	10	$ 313.00	$ -
Cement Silo & loading		$ 9.50	5	$ 47.50	$ -
Bottom Dump Truck	$ 6.20	$ 61.11	8	$ 538.48	$ 49.60
Dozer D8	$ 7.90	$ 58.02	8	$ 527.36	$ 63.20
Roller, Double-drum, self Propelled	$ 7.90	$ 40.55	8	$ 387.60	$ 63.20
Loader 1.7 cm bucket	$ 7.90	$ 52.39	5	$ 301.45	$ 39.50
Transit Mixer	$ 6.20	$ 17.36	4	$ 94.24	$ 24.80
Water Storage & Cooling Plant	$ 7.90	$ 53.90	2	$ 123.60	$ 15.80
Loader 9.2 cm bucket	$ 7.90	$ 170.40	2	$ 356.60	$ 24.80
25-ton Rear Dump Truck	$ 6.20	$ 35.27	8	$ 331.76	$ 120.00
Mobile lighting Set 4 x 1000 W		$ 5.75	8	$ 46.00	
Water Truck	$ 6.20	$ 35.90	4	$ 168.40	$ 40.00
Expatriate	$ 60.00		2	$ 120.00	$ 110.00
Crew Leader	$ 10.00		4	$ 40.00	$ 85.01
Unskilled Labor	$ 5.50		20	$ 110.00	$ 651.71
Miscellaneous			15%	$ 547.32	
			Subtotal	$ 4,196.11	

Production Rate	250 cm/hr	Rate	$	16.78
Cement	0.1 T/cm @	$ 110.00	$	11.00
Miscellaneous		10%	$	1.10
Aggregates	1 cm/cm @	$ 8.71	$	8.71
		Subtotal	$	37.60
		Indirect Cost 30%	$	11.28
		Total Rate	$	48.87

PANAMA CANAL RIO INDIO HYDROELECTRIC SCHEME
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment
Feature: Low Level Outlet Tunnel
Length: 640 meters (intake portal to outlet portal)
Diameter: 4.00 meters (D-shaped Section)
Does not include construction adits Basic Drill/Blast Project # 15593

SUMMARY

The following summary is prepared from the detailed analysis that follows

	Total
Total Tunnel Excavation Price	**$2,066,700**
Total Tunnel Concrete Lining Price	**$512,200**
Total at January 1999 Level	**$2,578,900**

Method of Excavation	Analysis Drill and Blast Method				Totals
Type of Support Requirements	Type I	Type II	Type III	Type IV	
Finished Diameter	4.00	4.00	4.00	4.00	4.00
ID area	14.28	14.28	14.28	14.28	
Finished Tunnel radius	2.00	2.00	2.00	2.00	2.00
Excavated Tunnel radius	2.32	2.32	2.32	2.32	
Excavated tunnel diameter	4.64	4.64	4.64	4.64	
Excavated area	19.22	19.22	19.22	19.22	
Tunnel Length for analysis	64	256	192	128	640
Excavation Volume/m	19.2	19.2	19.2	19.2	19.2
Excavation Pay Volume	1,200	4,900	3,700	2,500	12,300
Concrete Lining Thickness, m	0.32	0.32	0.32	0.32	
Overbreak assumed, m	0.10	0.10	0.15	0.15	
Shotcrete Lining Thickness, m	0.0	0.0	0.05	0.05	
Shotcrete Area, Sqm	0	1,900	2,300	1,500	5,700
Excavated Volume for lining/m (inc inv	20.9	20.9	21.8	21.8	21.3
Tunnel Length, m	64	256	192	128	640
Total Excavated Volume, Cu.m.	1,300	5,400	4,200	2,800	13,700
Loose Volume, Cu.m., Mucking	2,080	8,640	6,720	4,480	21,920
Invert concrete volume	45	178	134	89	445
Concrete Lining Volume	380	1,519	1,307	871	4,076
Pay Concrete Volume	424	1,697	1,440	960	4,522
2 M #8 Rockbolts	0	600	900	100	1,600
Steel Sets, kg				59,200	59,200
Production, days for one Heading	9	51	48	64	173
Excavation Manhours, Local	4,172	22,528	21,120	28,160	75,980
Excavation Manhours, Foreign	0	0	0	0	0
Labor Cost - Excavation, Local	34,900	188,300	176,500	235,300	635,000
Labor Cost - Excavation, Foreign	0	0	0	0	0
Tunnel Concrete Lining Cost, Local	36,934	147,736	125,585	83,757	394,012
Tunnel Concrete Lining Cost,Foreign	0	0	0	0	0
Equipment Cost, Local	27,530	148,662	139,370	185,827	501,389
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	17,128	116,385	122,524	197,381	453,417
Material Cost, Foreign	0	0	0	0	0
Tunnel Excavation Cost, Local Total	79,558	453,346	438,394	618,508	1,589,807
Tunnel Excavation Cost, Foreign Tota	$0	$0	$0	$0	$0
Concrete Lining Cost, Total	**36,934**	**147,736**	**125,585**	**83,757**	**394,012**
Tunnel Excavation Cost	**79,558**	**453,346**	**438,394**	**618,508**	**1,589,807**
With Contractors OH&P of 30%	30%	30%	30%	30%	
Tunnel Excavation Price	**$103,400**	**$589,400**	**$569,900**	**$804,100**	**$2,066,800**
Tunnel Lining Price	**$48,014**	**$192,056**	**$163,261**	**$108,884**	**$512,215**
Tunnel Price					**$2,579,015**
Concrete Lining Price, Local	48,014	192,056	163,261	108,884	512,215
Concrete Lining Price, Foreign	0	0	0	0	0
Tunnel Excavation Price, Local	103,425	589,350	569,912	804,061	2,066,748
Tunnel Excavation Price, Foreign	0	0	0	0	0
					Avg. Price
Price/CuM, excavation only/CuM	$86.17	$120.29	$154.03	$321.64	$168.03
Price/CuM, Concrete Lining/CuM	$113.18	$113.18	$113.35	$113.39	$113.28

PANAMA CANAL RIO INDIO HYDROELECTRIC SCHEME
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment
Feature: Low Level Outlet Tunnel
Length: 640 meters (intake portal to outlet portal)
Diameter: 4.00 meters (D-shaped Section)
Does not include construction adits Basic Drill/Blast Project # 15593

GEOLOGY

Rock type as interpreted from site visits and geol mapping suggests four types of supports for the following lengths

Tunneling Condition	Segment 1
Roca Buena - Designation Type I	[illegible]
Roca Regular - Designation Type II	40%
Roca Mala - Designation Type III	30%
Roca Muy Mala - Designation Type IV	20%
	100%

Type I - Roca Buena best rock conditions, minimal overbreak, generally self-supporting or requiring minimal support with shotcrete and spot bolting; full face excavation with normal advance

Type II - Roca Regular, good to fair rock conditions, moderate overbreak with rockbolt support and shotcrete; normal advance possible with proper bolting and shotcreting

Type III - Roca Mala, poor rock conditions, weathered or weak rock, loosely jointed, possible water inflows; Full face excavation with slower short advance and large overbreaks. Requires prompt support with pattern rockbolting and shotcrete

Type IV - Roca Muy Mala/Pesima, very poor rock conditions, full of fault and shear zones, mod to highly weathered, potential squeezing conditions in gouge; water inflows; possibly top heading and benching; prompt support within the open face with steel ribs and lagging, backpacking and shotcete with fabric; grouting may be necessary to control water; spiling possible in worst conditions.

Type V - Not mentioned above but worse than type IV and with high waterflows. Specific areas are not identified for above tunnels at this time

Condition/Rock Type	Q Values	Rock Mass Rating (RMR)
I	> 7	>60
II	7 > Q >1	60>RMR>40
III	1 > Q >.4	40>RMR>35
IV	.4> Q	35 > RMR

Blastability	Good	Medium
SPR =	0.38	0.47
	Basalt/Sandstones	

PANAMA CANAL RIO INDIO HYDROELECTRIC SCHEME
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature	Low Level Outlet Tunnel	
Length	640 meters (intake portal to outlet portal)	
Diameter	4.00 meters (D-shaped Section)	
Does not include construction adits	Basic Drill/Blast	Project # 15593

SUPPORT

Shotcrete Thickness	5	cm Layers	Fiber or wire reinf
Rockbolts	25	mm X 2 meter long w/epoxy	
Steel Ribs	6" X 12"	I section @ .5 to 1.5 spacing	
Lagging	5	cm corrugated	
Dry Pack	0.5	in. from Tunnel Muck	

All tunnel analysis is based on assumed/interpreted geology from initial site visits and mapping.
No results from any investigations are incl

Length of Segment	640	Meters	
Finished Diameter	4.00	Meters	
Horse Shoe Section			
Concrete Lining Thickness	0.32	Meters	0.15 m invert slab
Length of tunnel for each type			
Type I	64	Meters	
Type II	256	Meters	
Type III	192	Meters	
Type IV	128	Meters	

Shotcrete with wire(or fibrous), 5 cm la	0	SqM, Type I	None
	1,900	SqM, Type II	Crown only
	2,300	SqM, Type III	Crown and Ribs
	1,500	SqM, Type IV	Crown and Ribs
Total Shotcrete	5,700	SqM	

Rockbolts, 25 mm X 2 M Long	0	EA, Type I	Bolts/@ 7.5 M Spacing
As per typical Harza	600	EA, Type II	Bolts/@ 2 M Spacing
	900	EA, Type III	Bolts/@ 1.5 M Spacing
	100	EA, Type IV	Bolts/@ 5 M Spacing
Total Rockbolts	1,600	EA	
Steel ribs, 6" X 12" X 45 KG/M	59,200	KG, Type IV	

PANAMA CANAL RIO INDIO HYDROELECTRIC SCHEME
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment

Feature: Low Level Outlet Tunnel
Length 640 meters (Intake portal to outlet portal)
Diameter 4.00 meters (D-shaped Section)
Does not include construction adits — Basic Drill/Blast — Project # 15593

TUNNEL EXCAVATION

Tunnel Crew	Local $$/HR Production	Local $$/HR Production	Foreign $$/HR Foreign
Walker	$12.50	$12.50	
Foreman	$10.00	$10.00	
Jumbo Drill Foreman	$10.00	$0.00	
Miners	$6.60	$52.80	
Blaster	$6.20	$6.20	
Compressor Operator	$6.20	$6.20	
Mucker Operator	$7.90	$7.90	
Truck Drivers	$6.20	$12.40	
Dozer Operator	$7.90	$0.00	
HVAC Electrician/Mechanics	$6.20	$3.10	
Oilers	$6.20	$3.10	
Rockbolters	$6.60	$13.20	
Shotcreters	$6.60	$13.20	
Pump Operators	$6.20	$6.20	
Mechanics	$6.60	$3.30	
Electricians	$6.20	$3.10	
22 Total Crew, $$/Hr		$153.20	$0.00
Total Labor Cost, Local		$634,900	
Total Labor Cost, Foreign		$0	

ROUNDS	Type I	Type II	Type III	Type IV	
Meters/Round	3.0	3.0	2.0	1.0	
Vol/Round	57.7	57.7	38.4	19.2	
Holes/SqM	2.5	2.3	2.2	2.0	
Length of Holes (total, cum.)	111	113	76	39	
Drill Holes, Meters/Hr	10	10	10	[illegible]	
No. of drills	4	4	4	[illegible]	
Total Drilling/Hr	40	40	40	40	
Drilling Time	2.8	2.8	1.9	1.0	
Move in	0.3	0.3	0.3	0.3	
Total drilling Time	3.1	3.1	2.2	1.3	
Blasting					
Kg/CuM	2.0	1.8	1.7	1.5	
Kg/Round	115	104	65	29	
Load Time @ 80 Kg/Hr	1.4	1.3	0.8	0.4	
Add for blasting & Ventilating	1.0	1.0	1.0	1.0	
Total Blast time	2.4	2.3	1.8	1.4	
Excavation Supports					
Scaling	0.3	0.3	0.3	0.5	
Place supports	0.2	0.5	1.0	3.0	
Total Support Time	0.5	0.8	1.3	3.5	
Muck					
Move in	0.5	0.5	0.5	0.5	
Mucking at 25 CM/hr	2.3	2.3	1.5	0.8	
Total Muck Cycle	2.8	2.8	2.0	1.3	
Total Cycle Hours	8.8	9.0	7.3	7.4	
No of Rds with of 2 X 10 Hr Shifts+ 4	2.7	2.7	3.3	3.2	
Advance/Day	8.2	8.0	6.5	3.2	
Realistic rds/day	2.3	2.0	2.0	2.0	
Realistic advance/day	6.8	5.0	4.0	2.0	
Total number of Days for one Crew	9	51	48	64	173
Total explosives required	2,500	8,900	6,300	3,700	
Detonators	875	4,005	4,725	2,960	
Drill Bits & Steel	2,358	9,603	7,275	4,962	

PANAMA CANAL RIO INDIO HYDROELECTRIC SCHEME

Panama

Feasibility Level Cost for Tunneling

Unit Cost Estimate for Typical Tunnel Alignment

Feature Low Level Outlet Tunnel

Length 640 meters (intake portal to outlet portal)

Diameter 4.00 meters (D-shaped Section)

Does not include construction adits — Basic Drill/Blast — Project # 15593

Plant & Equipment	L. Cost/Hr	F. Cost/Hr
1 4 Drill Jumbo	$55.00	$0.00
1 4 CuM Mucker	$31.25	$0.00
2 Trucks, 5 CuM	$24.46	$0.00
1 Shotcrete Pump	$45.20	$0.00
Dozer		
2 Compressors, Electrical	$10.13	$0.00
1 Dewatering Equipment	$7.53	$0.00
2 100 HP Fans	$6.04	$0.00
1 Drifters	$0.61	$0.00
1 Flatbeds	$13.35	$0.00
Equipment Cost per hour	$193.57	$0.00
Utilization Factor	75%	60%
Actual Cost/Hr	$145.18	$0.00

	Type I	Type II	Type III	Type IV
Equipment & Plant, Local	$27,530	$148,662	$139,370	$185,827
Equipment & Plant, Foreign	$0	$0	$0	$0

Materials		
Explosives	$1.50	$$/KG
Detonators	$2.50	$$/EA
Bits & Steel	$2.50	$$/LM
Spiling	$150.00	$$/EA
Shotcrete Cement	$110.00	$$/TON
Shotcrete Aggregate	$5.00	$$/TON
Steel Fibers	$1.20	$$/KG
Wiremesh	$1.00	$$/KG
Timber	$0.35	$$/BF
Rockbolts	$15.00	$$/EA
Steel Sets	$2.00	$$/KG
Vent air line	$40.00	$$/LM
Utility lines	$30.00	$$/LM
ST&S	5.00%	

	Type I	Type II	Type III	Type IV	Total
Explosives	$3,750	$13,350	$9,450	$5,550	$32,100
Detonators	$2,188	$10,013	$11,813	$7,400	$31,413
Bits & Steel	$5,895	$24,007	$18,187	$12,404	$60,493
Spiling	$0	$0	$0	$15,000	$15,000
Shotcrete Cement	$0	$6,270	$7,590	$4,950	$18,810
Shotcrete Aggregate	$0	$1,568	$1,898	$1,238	$4,703
Steel Fibers	$0	$6,156	$7,452	$4,860	$18,468
Wiremesh	$0	$4,560	$5,520	$3,600	$13,680
Timber	$0	$0	$840	$1,120	$1,960
Rockbolts	$0	$27,000	$40,500	$4,500	$72,000
Steel Sets	$0	$0	$0	$118,400	$118,400
Vent air line	$2,560	$10,240	$7,680	$5,120	$25,600
Utility lines	$1,920	$7,680	$5,760	$3,840	$19,200
ST&S	$816	$5,542	$5,834	$9,399	$21,591
Total Materials for tunnel work	$17,128	$116,385	$122,524	$197,381	$453,417
Materials, Local	$0	$0	$0	$0	
Materials, Foreign	$0	$0	$0	$0	

Tunnel Excavation Cost/CuM, Local	$129.25		
Tunnel Excavation Cost/CuM, Foreign	$0.00	Dec 2000 Cost	Days
		$79,558	173

PANAMA CANAL RIO INDIO HYDROELECTRIC SCHEME
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment
Feature: Low Level Outlet Tunnel
Length: 640 meters (Intake portal to outlet portal)
Diameter: 4.00 meters (D-shaped Section)
Does not include construction adits — Basic Drill/Blast — Project # 15593

TUNNEL INVERT CONCRETE LINING					Total CuM
Quantity	45	178	134	89	445
Average placing Rate (cu m/day)	200	200	200	200	
Number of work days	0	1	1	0	2

Concrete Lining Crew

		Local	Local Total	Foreign
1	Walker	$12.50	$12.50	
1	Foreman	$10.00	$10.00	
0	Form Foreman	$10.00	$0.00	
4	Miners	$6.60	$26.40	
1	Carpenters	$6.60	$6.60	
1	Compressor Operator	$6.20	$6.20	
1	Mucker Operator	$7.90	$7.90	
2	Concrete Truck Operators	$6.20	$12.40	
0	HVAC Electrician/Mechanics	$6.20	$0.00	
1	Pump Operators	$6.20	$6.20	
0	Mechanics	$6.60	$0.00	
0	Electricians	$6.20	$0.00	
12	Total Crew, $$/Hr		$88.20	$0.00
	Total Labor Cost, Local (10 hr day)		$1,964	
	Total Labor Cost, foreign		0	

	Plant & Equipment	Local	Foreign
1	Johnson Type Low Profile + Ice Plant	$52.00	$0.00
2	Concrete Haulers	$25.00	$0.00
1	Lot Pumping Equipment	$48.95	$0.00
1	Lot fans	$13.83	$0.00
		$139.78	$0.00
	Utility Factor	75.00%	65.00%
	Actual Cost/Hr	$104.84	$0.00
	Equipment Cost/Day	$2,096.70	$0.00

MATERIALS				
Cement @ 30% of Volume	134	Tons @	$110.00	14,700
Aggregate & Sand (see Quarryco.xls)	980	Tons @	$10.00	9,800
Admixtures	223	Gals @	$15.00	3,341
				27,840

Concrete Costs by Sections	Type I	Type II	Type III	Type IV	
Labor Cost - Concrete, Local @ 10 hrs	200	800	600	400	2,000
Labor Cost - Concrete, Foreign @ 10 h	0	0	0	0	0
Equipment Cost, Local	467	1,868	1,401	934	4,670
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	2,784	11,136	8,352	5,568	27,840
Material Cost, Foreign	0	0	0	0	0
					34,500
TOTAL CONCRETE COST	$3,500	$13,800	$10,400	$6,900	$34,600
Tunnel concrete Lining Cost, Local	$3,451	$13,804	$10,353	$6,902	$34,510
Tunnel concrete Lining Cost, Foreign	$0	$0	$0	$0	$0
$$/CuM	$78.57	$77.45	$77.83	$77.45	
Local Cost/CuM	$77.47				
Foreign Cost/CuM	$0.00				

PANAMA CANAL RIO INDIO HYDROELECTRIC SCHEME
Panama
Feasibility Level Cost for Tunneling
Unit Cost Estimate for Typical Tunnel Alignment
Feature: Low Level Outlet Tunnel
Length 640 meters (Intake portal to outlet portal)
Diameter 4.00 meters (D-shaped Section)
Does not include construction adits   Basic Drill/Blast   Project # 15593

TUNNEL CONCRETE LINING

					Total
Length	64	256	192	128	640
Quantity	380	1,519	1,307	871	4,076

Use Prefabricated Steel Forms on Dolly
Each set 20 M Long and a 24 hour concrete placing will be used with 8 hours for placing forms and reinforcing (if any), 8 hours of concrete placing and 8 hours to cure, clean and move

Average placing Rate (cu. M / day)	150	150	150	150	
No. of Steel Sets	0	0	0	0	0
Number of 10 hour work days	3	10	9	6	27

Concrete Lining Crew

		Local	Local Total	Foreign	
1	Walker	$12.50	$12.50	$0.00	0
1	Foreman	$10.00	$10.00		
0	Form Foreman	$10.00	$0.00		
8	Miners	$6.60	$52.80		
8	Carpenters	$6.60	$52.80		
1	Compressor Operator	$6.20	$6.20		
1	Mucker Operator	$7.90	$7.90		
2	Flat Bed Operators	$6.20	$12.40		
1	HVAC Electrician/Mechanics	$6.20	$3.10		
1	Pump Operators	$6.20	$6.20		
1	Mechanics	$6.60	$3.30		
1	Electricians	$6.20	$3.10		
25	Total Crew, $$/Hr		$170.30	$0.00	
	Total Labor Cost, Local		$46,281		
	Total Labor Cost, foreign		0		

	Plant & Equipment	Local	Foreign
1	Johnson Type Low Profile + Ice Plant	$52.00	$0.00
2	Concrete Haulers	$25.00	$0.00
1	Lot Pumping Equipment	$45.00	$0.00
1	Lot fans	$4.53	$0.00
		$126.53	$0.00
	Utility Factor	75.00%	65.00%
	Actual Cost/Hr	$94.90	$0.00
	Equipment Cost/Day	$1,897.95	$0.00

MATERIALS

Cement	1,223	Tons @	$110.00	134,521	
Aggregate & Sand (see Quarryco.xls)	8,968	Tons @	$10.00	89,681	
Admixtures	2,038	Gals @	$15.00	30,573	
Steel Forms	0	KG @	$1.50	0	
Timber for Bulkheads	278	SqM @	$25.00	6,949	37,522
				261,723	

Concrete Costs by Sections	Type I	Type II	Type III	Type IV	
Labor Cost - Concrete, Local	4,300	17,200	14,800	9,900	46,200
Labor Cost - Concrete, Foreign	0	0	0	0	0
Equipment Cost, Local	4,804	19,217	16,534	11,023	51,579
Equipment Cost, Foreign	0	0	0	0	0
Material Cost, Local	24,379	97,514	83,898	55,932	261,723
Material Cost, Foreign	0	0	0	0	0
					359,500
TOTAL CONCRETE COST	$33,500	$133,900	$115,200	$76,900	$359,502
Tunnel concrete Lining Cost, Local	$33,483	$133,932	$115,232	$76,855	$359,502
Tunnel concrete Lining Cost, Foreign	$0	$0	$0	$0	$0
$$/CuM	$78.96	$78.90	$79.98	$80.08	
Local Cost/CuM	$79.50				
Foreign Cost/CuM	$0.00				