Feasibility Design for the Ríos Coclé del Norte and Caño Sucio Water Supply Projects

Coclé del Norte - Caño Sucio - Río Indio Project

Diseño de Factibilidad para los Proyectos de Abastecimiento de Agua en los Ríos Coclé del Norte y Caño Sucio

Proyecto Coclé del Norte - Caño Sucio - Río Indio

Volumen 2

Montgomery Watson Harza

Diciembre del 2003

Contrato No. 110994

Resumen Ejecutivo

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

THE PANAMA CANAL

ENGINEERING SERVICES

Work Order No. 5
The Ríos Coclé del Norte and Caño Sucio Water Supply Projects

Volume 2

Feasibility Study Of The
Río Coclé del Norte Reservoir Acting in Full Regulation
With The
Río Caño Sucio and Río Indio Reservoirs

DECEMBER 2003

MWH
In association with
TAMS Consultants, Inc.
Ingenieria Avanzada, S.A.
Tecnilab, S.A.

EXECUTIVE SUMMARY

INTRODUCTION

The ACP is undertaking a canal capacity study, which includes the evaluation of additional sources of water to augment Canal capacity. The transit of ships through the Panama Canal is dependent upon the availability of the fresh water stored in Madden and Gatun reservoirs. Water availability is limited and, even at present traffic levels, is not sufficient to meet traffic demand during prolonged dry periods. Therefore, new sources of water must be identified, defined, and evaluated.

The US Army Corps of Engineers (USACE) performed a reconnaissance study for the Panama Canal Commission to identify and evaluate potential water supply projects. A reservoir on the Río Coclé del Norte, operating between elevations 90 m and 100 m and in conjunction with reservoirs on the Río Caño Sucio and Río Indio, was recommended as a feasible alternative for further consideration to develop a long-term water supply plan.

The Autoridad del Canal de Panama (ACP), formerly the Panama Canal Commission, has authorized Montgomery Watson Harza, formerly Harza Engineering Company, to perform an engineering feasibility study of this project under Contract CC-3-536, Work Order 005, dated June 19, 2000.

OBJECTIVE OF THE STUDY

The original objective of this study was to determine the technical and economic feasibility of the project. An assessment of the environmental feasibility was to have been performed separately under the direction of the ACP.

During the course of the study, it was decided by the ACP that water resources development in the Río Coclé del Norte basin would only occur in conjunction with a plan to add new locks to the Panama Canal System. Under this assumption, the demand for and benefits from developing the Río Coclé del Norte Project could not be assessed at this time. Therefore, a determination of economic feasibility was not possible. The objective of the study was changed to an assessment of technical feasibility.

HYDROLOGY AND RIVER HYDRAULICS

Studies were performed to confirm the long-term streamflow sequences at the Río Coclé del Norte and Río Caño Sucio damsites, to estimate the spillway design floods at each site, and to estimate the impact of reservoir sedimentation.

A long-term flow sequence (1948-1999) at the Río Coclé del Norte damsite was generated by adding the data from El Torno and Batatilla, adjusted for drainage area and rainfall. The flows at El Torno and Batatilla were completed using correlations with El Chorro, Los Canones and Boca de Uracillo. The mean annual flow at the Río Coclé del Norte damsite is estimated to be 107.5 m^3/s and the monthly distribution of flow is shown below

MONTHLY MEAN STREAMFLOW AT THE RÍO COCLÉ DEL NORTE DAMSITE (m^3/s)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
89.5	52.1	37.7	53.5	91.8	108.8	107.7	125.3	139.2	162.7	173.0	149.2	107.5

There are no flow data available for the Río Caño Sucio. The long-term flow sequence was generated using the monthly flows of the Río Indio at Boca de Uracillo and a drainage area ratio (about 0.304) between the two locations.

The mean annual flow at the damsite is estimated to be 7.5 m^3/s and the monthly distribution of flow is shown below:

MONTHLY MEAN STREAMFLOW AT THE RÍO CAÑO SUCIO DAMSITE (m^3/s)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
4.8	2.4	1.6	1.8	4.6	7.8	8.0	9.5	10.9	14.4	14.3	10.3	7.5

The probable maximum floods (PMF), based on probable maximum precipitation (PMP) were adopted as the spillway design flood for both dams. PMP estimates of 714 mm and 679 mm were adopted for the Río Coclé del Norte and Río Caño Sucio basins respectively based on information presented in the National Weather Service publication of PMP dated 1978. Using the HEC-1 computer model and allowing for a based flow estimated from an analysis of major historic floods, the PMF for each dam was estimated as follows:

Dam	Peak Inflow (m^3/s)	Flood Volume (MCM)
Río Coclé del Norte	10,550	1,005 (5-day)
Río Caño Sucio	1,690	80 (3-day)

The impact of sediment deposition on storage in the reservoir was evaluated using data from the Río Coclé del Norte basin, Lake Madden and other sources. After 100 years, it is expected that sediment deposition will reduce the live storage of the Río Coclé del Norte reservoir by about 1 percent and, therefore, presents no problem. The impact of the project on the Río Caño Sucio and Río Indio reservoirs cannot be estimated without modeling. The transfer of large volumes of water from the Río Coclé del Norte to these reservoirs will impact sediment deposition. In the Caño Sucio Reservoir, an allowance will be included for continuous dredging. No allowance has been included for the Indio Reservoir.

GEOLOGIC CONDITIONS

The geologic conditions were established on the basis of geologic mapping, geomorphological analysis, photogeologic studies, a moderate subsurface investigation program, and construction materials investigations.

Río Coclé del Norte Damsite

Bedrock at the dam site is found to consist mostly of porphyritic basalt and, less commonly of basic agglomerate. Rock float and large boulder talus indicate the presence of *in situ* bedrock at relatively shallow depths, but severe weathering is evident. Basalt float was observed all the way up the left abutment to above El. 100 m. Rock outcrop was observed at river level on the left side, at several other locations on the left abutment and is widespread on the right side.

Both abutments are heavily vegetated and are almost entirely covered with talus, colluvial, and residual soils. Small, scattered rock outcrops can be observed throughout the site area on both abutments, especially in gullies. Most of the dam site area is characterized by a moderately deep weathered profile with locally thick soil cover typical of the sub-tropical climate.

Based upon experience with geological investigations and construction in the Canal Area, it is likely that several small faults and shear zones could exist at the dam site. From regional geologic mapping and photogeologic studies, the presence of major faults, however, is not expected. Some photogeologic linears, shown on Exhibit 2-5, have been interpreted in the dam site area but these are not thought to be caused by significant faulting.

In general, the basaltic foundation bedrock at the site should provide a suitable foundation for all types of structures being considered.

Río Caño Sucio Damsite

The Río Caño Sucio dam site is located at the upstream end of an approximately 250-m long waterfalls section. The main drop at the falls is about 7 m high, but several smaller falls and cataracts are located downstream over a horizontal distance of about 200 m.

Bedrock units in the Río Caño Sucio project area consist of Tertiary sedimentary rocks. A medium to coarse-grained sandstone occurs at the proposed dam site, cropping out at the waterfalls and in the riverbed. Abutments at the damsite are covered by residual soils and weathered sandstone float. In outcrop, the sandstone is locally strong, moderately hard, and erosionally resistant, as evidenced by the formation of the waterfalls. The shape of the river valley and absence of rock exposure above the valley floor suggest that the slopes forming either side of the river valley consist of residual overburden to some depth.

In general, the foundation bedrock at the site is not expected to present any significant constraints on project development that cannot be taken care of with appropriate conventional design details and construction practices. In regard to other geological aspects, there do not appear to be any strongly adverse conditions or fatal flaws at the site that would seriously hinder or prevent development or make it too costly to construct Río Caño Sucio Dam.

Water Transfer Facilities

The water transfer facilities will consist of a combination of canals and tunnels. Existing geologic maps of the region show bedrock in the region as belonging to 'undifferentiated Tertiary volcanics'. In fact, no regional geologic mapping has yet been carried out in this area.

The first part of the water transfer facilities, from the Río Coclé drainage to the Río Caño Sucio drainage, will require excavation through the saddle area at Quebrada Encantada. The excavation will be through varied sedimentary rock units belonging to the upper Cañazas Formation and lower Caimito Formation, ranging from marls, limestones, siltstones, coarse-grained sandstones, to conglomerates. Based on the presence of abundant basalt float in the area, igneous units could also occur in the area, possibly local dikes, sills, or isolated lava flows.

The bulk of the proposed canal alignment through the Río Caño Sucio Reservoir would encounter various soil or overburden units rather than rock formations. The nature and origin of these are unknown at this time.

It is probable that excavation of the 2,550-m long tunnel from the Río Caño Sucio Reservoir to the Río Indio drainage will encounter a wide range of rock types and tunneling conditions. Rock types could include sandstone and softer epiclastics of the Caimito Formation as well as hard, strong lavas (andesites, dacites, and basalts) and agglomerates. Because of the relatively low cover, various degrees of weathering of the rock formations should be expected over much of the tunnel length.

Construction Materials

The types of required construction materials for the project are:

- Materials for cofferdams;
- Concrete aggregates;
- Filters and drains;
- Rock fill for the dam, backfill materials and other structural fills, and;
- Rock for riprap and slope protection.

For the Río Caño Sucio project, most of the facilities are comprised of concrete or roller compacted concrete and, therefore, the required construction material is concrete aggregate. All coarse and fine aggregate for concrete needs to be manufactured from quarried igneous rock materials, *i.e.* basalt or andesite. Quarry sites for obtaining this material were identified 5-6 km southeast of the damsite at Cerro Miguel and Cerro Loma Alta.

At the Río Coclé del Norte site, the diversion cofferdams will consist of temporary dikes designed to divert the river, in combination with channel excavation. Currently, it is assumed that these could be constructed from locally available random fill obtained from the immediate area of the dam site.

The majority of the rockfill and all aggregates (including coarse and fine aggregates for concrete, filters, drains, and riprap) for the Río Coclé del Norte Project need to be manufactured from quarried sources. Coarse and fine aggregates for concrete will be processed from quarried igneous rock materials, i.e. basalt or andesite. Aggregates for filters and drains will be obtained by processing of the same quarry sources as exploited for concrete aggregates. The area one to three kilometers to the east of the damsite consists of high hills that could be stripped and opened as quarries.

Materials for backfill will come from the required excavations, including use of tunnel excavation spoil. A portion of the rockfill for the dam also could be obtained from required excavation, provided that it is not too decomposed.

It is anticipated that some mixing with imported sands and silts will be necessary.

DESCRIPTION OF THE PROJECT

Implementation of a project to result in the impoundment of the Río Coclé del Norte Reservoir that will operate in full regulation with the Río Caño Sucio and Río Indio Reservoirs will require the construction of:

- A dam on the Río Coclé del Norte,
- A dam on the Río Caño Sucio,
- A combination of canal and tunnel to transfer water from the Río Coclé del Norte Reservoir through the Río Caño Sucio Reservoir to the Río Indio Reservoir, and
- A second tunnel between the Río Indio Reservoir and Lake Gatun.

In addition, it has been determined that a power plant at the base of the Río Coclé del Norte dam is feasible. Commercial agriculture associated with the development of the project is not warranted at this time. A general plan of the project is shown on Exhibit 1.

Río Coclé del Norte Dam and Reservoir

The major elements that comprise the storage facility on the Río Coclé del Norte include:

- A 113-m high concrete-face rockfill dam with its crest at El. 101 and top-of-structure at El. 103,
- A 50-m wide spillway in the right abutment with a capacity at full surcharge of 250 m^3/s,
- An 8-m diameter, D-shaped tunnel in the left abutment sized to pass the 50-year flood and provide for drawdown in the case of emergency,
- A 75 MW powerplant at the base of the dam, incorporating a minimum release facility.

The dam will impound a reservoir with a gross storage capacity of about 14,440 MCM and operate between El. 100, the full supply level, and El. 90. Live storage between El. 100 and El. 90 will be about 3,840 MCM. The reservoir area at the full supply level is 414 square kilometers.

Of the total project yield of 3,570 MCM/year, the yield resulting from the addition of the Río Coclé del Norte reservoir is 3,380 MCM/year or 44.5 lockages/day. The 75 MW powerplant will contain three equal-sized units and generate an average of 410 GWh/year ranging from 538 GWh/year in the initial years of operation to 76 GWh/year at the end of its economic life.

A general site plan of the Río Coclé del Norte Project, showing the location of the dam and appurtenant works is shown on Exhibit 2.

Río Caño Sucio Dam and Reservoir

The major elements that comprise the storage facility on the Río Caño Sucio include:

- A 22-m high roller compacted concrete (RCC) dam at the waterfall site with its crest at El. 103 and top-of-structure at El. 105,
- A 25-m wide spillway over the face of the dam with a capacity at full surcharge of 430 m^3/s
- A diversion conduit to pass the 50-year dry-season flood
- A minimum release facility

The dam will impound a reservoir with a gross storage capacity of about 73 MCM and operate between El. 100, the full supply level, and El. 90. Live storage between El. 100 and El. 90 will be 68.5 MCM. The reservoir area at the full supply level is 12.4 square kilometers. The system yield allocated to the project is estimated to be 190 MCM/year or 2.5 lockages/day.

A general site plan of the development, showing the arrangement of the dam and its appurtenant works is shown on Exhibit 3.

Water Transfer Facilities to Río Indio Reservoir

To transfer water from the Río Coclé del Norte reservoir to the Río Indio basin, it is necessary to construct:

- An 6,500-m long west branch of canal through the divide between the Río de U and the Río Limon to the Río Caño Sucio
- A 8,650-m long canal east branch along the Río Caño Sucio and Río Cerro Miguel to the headrace of a tunnel to the Río Indio basin, and
- A 2,550-m long, 5.5-m diameter tunnel.

The dimensions of the facilities are controlled by the requirement to pass about 160 m3/s when the Río Coclé del Norte reservoir is at its minimum level (El. 90). A plan showing the canal and tunnel alignment is presented on Exhibit 4.

Second Tunnel from Río Indio Reservoir to Lake Gatun

According to the present concept, the Río Indio Project will have been constructed about 20 to 30 years prior to any Río Coclé del Norte Project configuration. As described in the Río Indio Water Supply Project Report (2), a 4.5-m diameter tunnel is required to convey

Río Indio water to Lake Gatun. With the connection of the Río Coclé del Norte Project to the system, a second tunnel, 8250-m long with a diameter of 6.5 m, will be required. The tunnel will be aligned parallel and next to the presumed existing tunnel. A plan of the alignment is shown on Exhibit 5.

COST OF THE PROJECT

The estimated cost of the Project has been developed on the basis of the present feasibility design and construction schedule, plus a compensation and mitigation cost estimated by the ACP. The construction cost estimates represent the prevailing rates and prices in January 2003 and are based on the assumption that an international contractor will construct the water supply and hydropower facilities without restriction on sources of supplies and equipment. The unit prices have been estimated at feasibility level.

A summary of the project cost is shown below.

Item	Estimated Cost
Mitigation and Compensation Costs	**$238,000,000**
Access Roads and Construction Camp	$16,490,000
Río Coclé del Norte Storage Facilities	$190,710,000
Río Caño Sucio Storage Facilities	$6,500,000
Water Transfer Facilities	$79,750,000
Second Río Indio-Lake Gatun Tunnel	$85,520,000
Reservoir Clearing	$42,110,000
Subtotal Direct Cost	**$421,080,000**
Contingency	$77,120,000
Direct Cost	**$498,200,000**
Engineering and Administration	$74,800,000
Construction Cost (Jan 2003 price level)	**$573,000,000**
TOTAL COST	**$811,000,000**

The annual operating costs include the costs of operation and maintenance (O&M), for the various features, the cost of replacing short-life equipment, administration by the Owner, and insurance. In addition, an annual cost associated with watershed management, implementation of the environmental mitigation plan and the relocation activities is included. The annual operation and maintenance costs are summarized below:

Item	Annual Cost
O&M	$2,600,000
Replacement	$150,000
Admin and General Expenses	$700,000
Insurance	$575,000
Resettlement Administration	$150,000
Watershed Management	$150,000
Mitigation Plan Implementation	$100,000
Total (rounded)	**$4,425,000**

PROJECT IMPLEMENTATION

The durations of the construction of each component are estimated at 2.5 years for the access roads, 2 years for the Río Caño Sucio Project, 6 years for the Río Coclé del Norte Project, 3 years for the Water Transfer Facilities, and 3 years for the second Tunnel from Río Indio Reservoir to Lake Gatun. Overall the construction, including the filling of the reservoirs to levels sufficient for the project to be operational, will require nearly 8 years, with full operation achieved in under 12 years.

It is estimated that full implementation of the Project could be achieved within 17 years, with additional water being supplied within 13 years. However, the Reconnaissance Report (1) water demand schedule shows the project will not be required until about 2032, assuming that the Río Indio Water Supply Project is in operation. Therefore, the project can be initiated as late as 2019 to meet that demand schedule. If the project is selected, environmental studies, funding, design, contractor selection, can all be accommodated within this overall implementation schedule. The implementation schedule is shown on Exhibit 5.

CONCLUSIONS AND RECOMMENDATIONS

Without the information required to perform and economic and financial evaluations (for reasons given in Section 1.3.2), it is not possible to make a recommendation concerning the implementation of the project. The economic cost of water is higher than what might normally be expected for a commercial supply and approaches what might be expected for an M&I supply. However, the current benefits accruing to water supply from the Panama Canal operation also are high and may continue at this level. Therefore, development of the project cannot be ruled out, but the recommendations, at this time, can relate only to the relative attractiveness of the possible alternative developments in the basin.

Conclusions

As a result of the studies described in this report and its appendices, it is concluded that:

- The Project is technically feasible.
- The dam sites selected in the Reconnaissance Report are suitable sites for the development of the water resources of the Río Coclé del Norte and Río Caño Sucio Basins.
- A concrete-faced rockfill dam at the Río Coclé del Norte site and an RCC dam at the Río Caño Sucio sites are the most appropriate types of dam for the sites based on the available information, estimates of cost, and preferences of the ACP.
- It is our considered opinion that there are no geologic or geotechnical problems associated with the sites that cannot be accommodated using conventional solutions although the lack of subsurface investigations has increased the potential for inaccuracies in the estimate of cost.
- The yield of the Panama Canal system will increase by about 3,570 MCM/yr (about 47 L/d) with the addition of the Project.
- For the rates of growth of demand considered, the full yield of the Project is not used within 50-years and, therefore, the project is too large.
- There is no way to significantly lower both the yield and the cost of the Project (Lowering the yield will not significantly lower the cost because the minimum supply level must stay at El. 90 so that the Río Coclé del Norte Reservoir can act in full regulation with the Río Caño Sucio Reservoir. Lowering the cost can be accomplished by lowering the Coclé del Norte dam, but that would preclude operation with the Río Caño Sucio Reservoir).
- The addition of a 75 MW hydropower plant at Río Coclé del Norte dam is economically attractive.
- The inclusion of a commercial agricultural endeavor is technically feasible, but is not economically viable at this time and development should not be initiated at this time.
- Construction of the project is estimated to cost about $573 million in 2003 dollars. An addition $238 million have been allowed for compensation and mitigation for a total cost of $811 million.
- The economic cost does not compare favorably with any of the other Western Watershed Projects studied to date.

Recommendations

As a result of these conclusions, development of the Río Coclé del Norte Reservoir at a full supply level of El. 100 and acting in full regulation with the Río Caño Sucio and Río Indio Reservoirs is not recommended.

TABLE OF SIGNIFICANT DATA

Project Setting		
The project is located in three adjoining watersheds identified as the "Western Watersheds". All three projects drain into the Atlantic Ocean and are located from 30km to 80 km to the west of Colon.		
Hydrology		
Río Coclé del Norte		
Average Annual Precipitation	2,800	mm
Average Annual Streamflow	107.5	m^3/s
Río Caño Sucio		
Average Annual Precipitation	3,500	mm
Average Annual Streamflow	7.5	m^3/s
Río Coclé del Norte Storage Facilities		
Reservoir		
Drainage Area	1,594	km^2
Normal Maximum Water Level	El. 100	msl
Volume (rounded)	14,440	MCM
Surface Area	414	km^2
Minimum Pool Level	El. 90	msl
Volume	10,600	MCM
Surface Area	347	km^2
Live Storage	3,840	MCM
Dam		
Type of Dam	Concrete-face rockfill	
Crest Length	1,020	m
Parapet/Crest Elevation	103/101	m
Minimum Foundation Elevation	-10	m
Maximum Height	113	m
Upstream and Downstream Slope	1.4H:1.0V	
Fill Volume	6,090,000	m^3
Upstream and Downstream Slope	1.4H:1.0V	
Spillway		
Type of Spillway	Ungated ogee	
Spillway Crest Elevation	100	m
Crest width (clear)	50	m
Excavation Volume	221,000	m^3
Concrete volume	2,300	m^3

TABLE OF SIGNIFICANT DATA, cont.

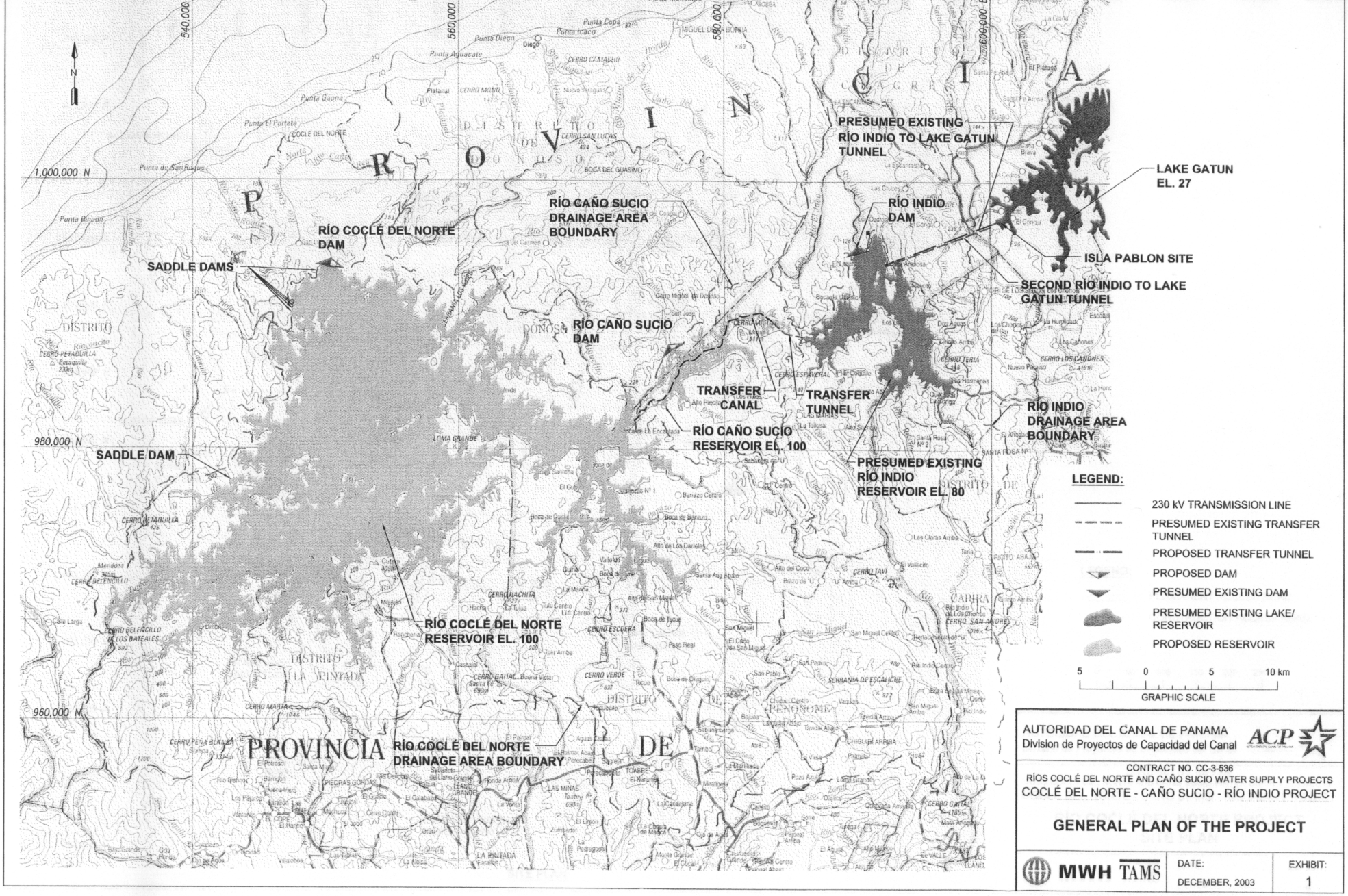
Río Coclé del Norte Storage Facilities, cont.		
Spillway, cont.		
Spillway Design Flood		
Peak Inflow	10,550	m^3/s
5-day Volume	1,005	MCM
Peak Outflow	250	m^3/s
Surcharged Reservoir Level	El. 101.8	msl
Diversion During Construction		
Section Shape	modified horseshoe; vertical sides; horizontal invert	
Diameter	8.0	m
Length	550	m
Diversion Flood	3,860	m^3/s
Discharge Capacity	636	m^3/s
Upstream Cofferdam Height (maximum)	29.5	m
Downstream Cofferdam Height (maximum)	8	m
Cofferdam Fill Volume	614,000	m^3
Minimum Release Facility		
Type	Bypass in hydropower plant	
Capacity	10.7	m^3/s
Río Caño Sucio Storage Facilities		
Reservoir		
Drainage Area	111	km^2
Normal Maximum Water Level	El. 100	msl
Volume	74	MCM
Surface Area	12.4	km^2
Minimum Pool Level	El. 90	msl
Volume	5	MCM
Surface Area	2.5	km^2
Live Storage	69	MCM
Sediment (Dead) Storage	8	MCM
Dam		
Type of Dam	RCC	
Crest Length	220	m
Crest Elevation	El. 105	msl
Minimum Foundation Elevation	83	m
Maximum Height	22	m
Upstream and Downstream Slope	Vertical and 0.75H:1V	
RCC Volume	27,900	m^3

TABLE OF SIGNIFICANT DATA, cont.

Río Caño Sucio Storage Facilities, cont.		
Spillway		
Type of Spillway	Ungated ogee	
Spillway Crest Elevation	El. 100	msl
Spillway Width	25	m
Spillway Design Flood (initial operation)		
Peak Inflow	1,690	m^3/s
3-day Volume	78	MCM
Peak Outflow	393	m^3/s
Surcharged Reservoir Level	El. 103.6	msl
Diversion During Construction		
Type	Box culvert	
Dimensions	2.0 x 2.0	m
Length	48	m
Diversion Flood	90	m^3/s
Discharge Capacity	47	m^3/s
Upstream Cofferdam Height (hydraulic)	4.5	m
Downstream Cofferdam Height (hydraulic)	None required	
Cofferdam fill Volume	1,210	m^3
Minimum Release Facility		
Type	Steel pipeline in diversion conduit	
Capacity	0.75	m^3/s
Water Transfer Facilities		
Coclé del Norte to Río Indio Canal		
Length	15,150	m
Base width	5.0	m
Side slopes	2H:1V	
Coclé del Norte to Río Indio Tunnel		
Length of tunnel	2,550	m
Diameter	5.5	m
Shape	Modified horseshoe	
Capacity at Maximum Pool	220	m^3/s
Capacity at Minimum Pool	180	m^3/s
Río Indio to Lake Gatun Tunnel		
Length	8,250	m
Diameter	6.5	m
Shape	Modified horseshoe	

TABLE OF SIGNIFICANT DATA, cont.

Power Facilities		
Power and Energy		
Installed Capacity	75	MW
Firm Capacity	75	MW
Average Annual Energy Production	410	GWh/year
Peak Annual Energy Production	538	GWh/year
Minimum Annual Energy Production	76	GWh/year
Unit Information		
Number of Units and Capacity	3-25	MW
Design Head	95	m
Discharge	30	m^3/s
Rotational Speed	360	rpm
Generator Rating	27,800	kVA
Generator Frequency	60	Hz
Power Factor	0.9	
Physical Data		
Powerplant Type	Surface	
Power Tunnel Length	260	m
Power Tunnel Diameter	5.0	m
Estimated Project Cost		
Construction Cost (January 2003)	$573,000,000	
Mitigation and Compensation Cost	$238,000,000	
Total Project Cost	$811,000,000	
Annual Cost	$4,425,000	
Estimated Project Schedule		
Implementation Period (Operational)	12.5	years
Implementation Period (Full Operation)	16.5	years
Construction Period (Operational)	8	years
Construction Period (Full Operation)	12	years
Estimated Project Yield		
Volumetric Reliability	99.6	%
System Yield w/ Norte/Sucio/Indio Project	107.3 L/d	8,150 MCM
Yield allocated to the Norte/Sucio Project	**47.0 L/d**	**3,570 MCM**
Yield allocated to Río Caño Sucio Reservoir	**2.5 L/d**	**190 MCM**
Yield allocated to Río Coclé del Norte Reservoir	**44.5 L/d**	**3,380 MCM**



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

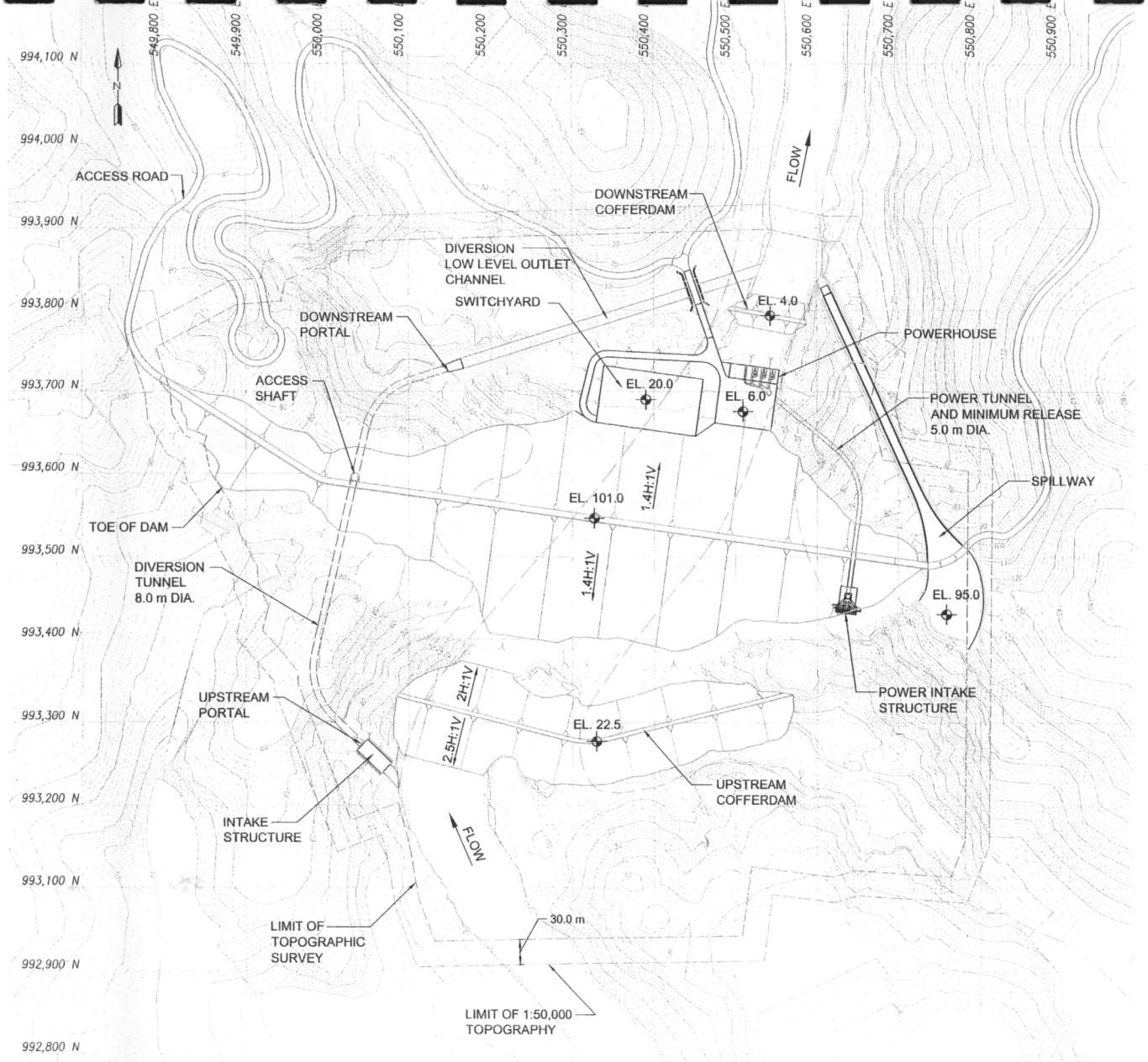
ACP

CONTRACT NO. CC-3-536
RÍOS COCLÉ DEL NORTE AND CAÑO SUCIO WATER SUPPLY PROJECTS
COCLÉ DEL NORTE - CAÑO SUCIO - RÍO INDIO PROJECT

GENERAL PLAN OF THE PROJECT

MWH TAMS

DATE:	EXHIBIT:
DECEMBER, 2003	1



SITE PLAN

LEGEND:

PERMANENT ACCESS ROAD

CONSTRUCTION ACCESS ROAD

0 50 100 150 200 250 m

GRAPHIC SCALE

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

ACP

CONTRACT NO. CC-3-536

RÍOS COCLÉ DEL NORTE AND CAÑO SUCIO WATER SUPPLY PROJECTS

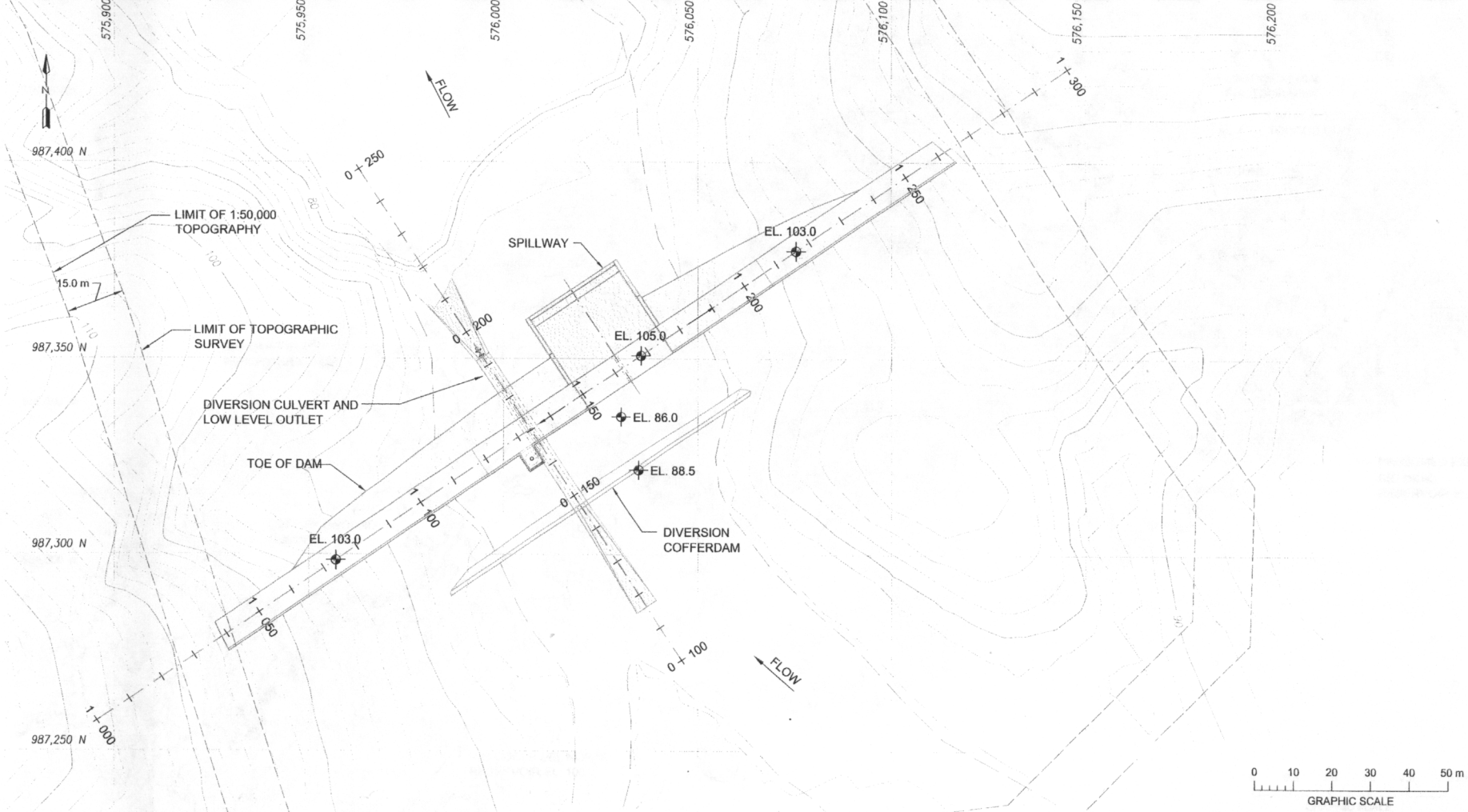
COCLÉ DEL NORTE - CAÑO SUCIO - RÍO INDIO PROJECT

RÍO COCLÉ DEL NORTE PROJECT
SITE PLAN

MWH TAMS

DATE: DECEMBER, 2003

EXHIBIT: 2



SITE PLAN

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

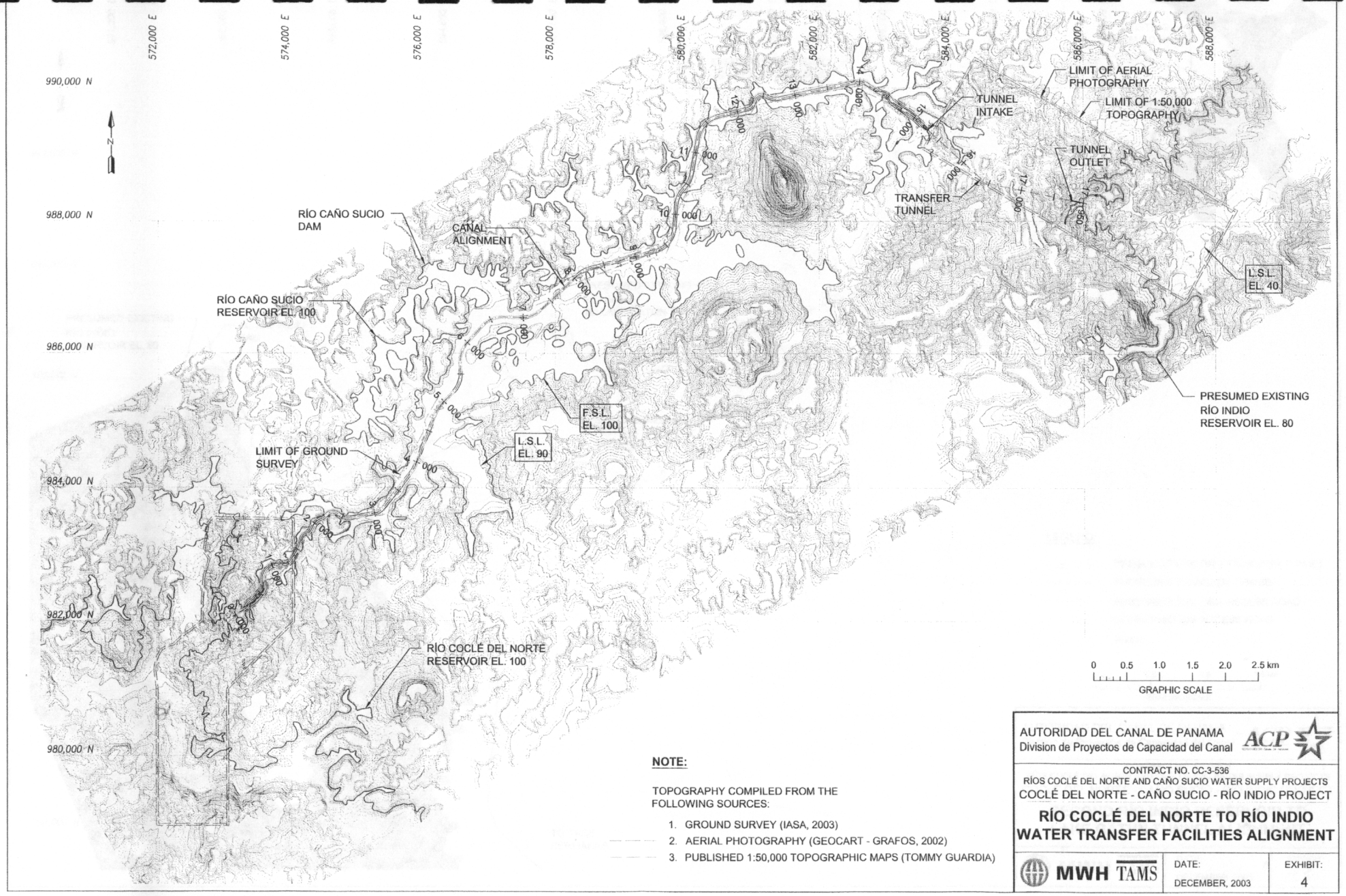
ACP

CONTRACT NO. CC-3-536
RÍOS COCLÉ DEL NORTE AND CAÑO SUCIO WATER SUPPLY PROJECTS
COCLÉ DEL NORTE - CAÑO SUCIO - RÍO INDIO PROJECT

RÍO CAÑO SUCIO PROJECT
SITE PLAN

MWH TAMS

DATE:	EXHIBIT:
DECEMBER, 2003	3



NOTE:

TOPOGRAPHY COMPILED FROM THE FOLLOWING SOURCES:

1. GROUND SURVEY (IASA, 2003)
2. AERIAL PHOTOGRAPHY (GEOCART - GRAFOS, 2002)
3. PUBLISHED 1:50,000 TOPOGRAPHIC MAPS (TOMMY GUARDIA)

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

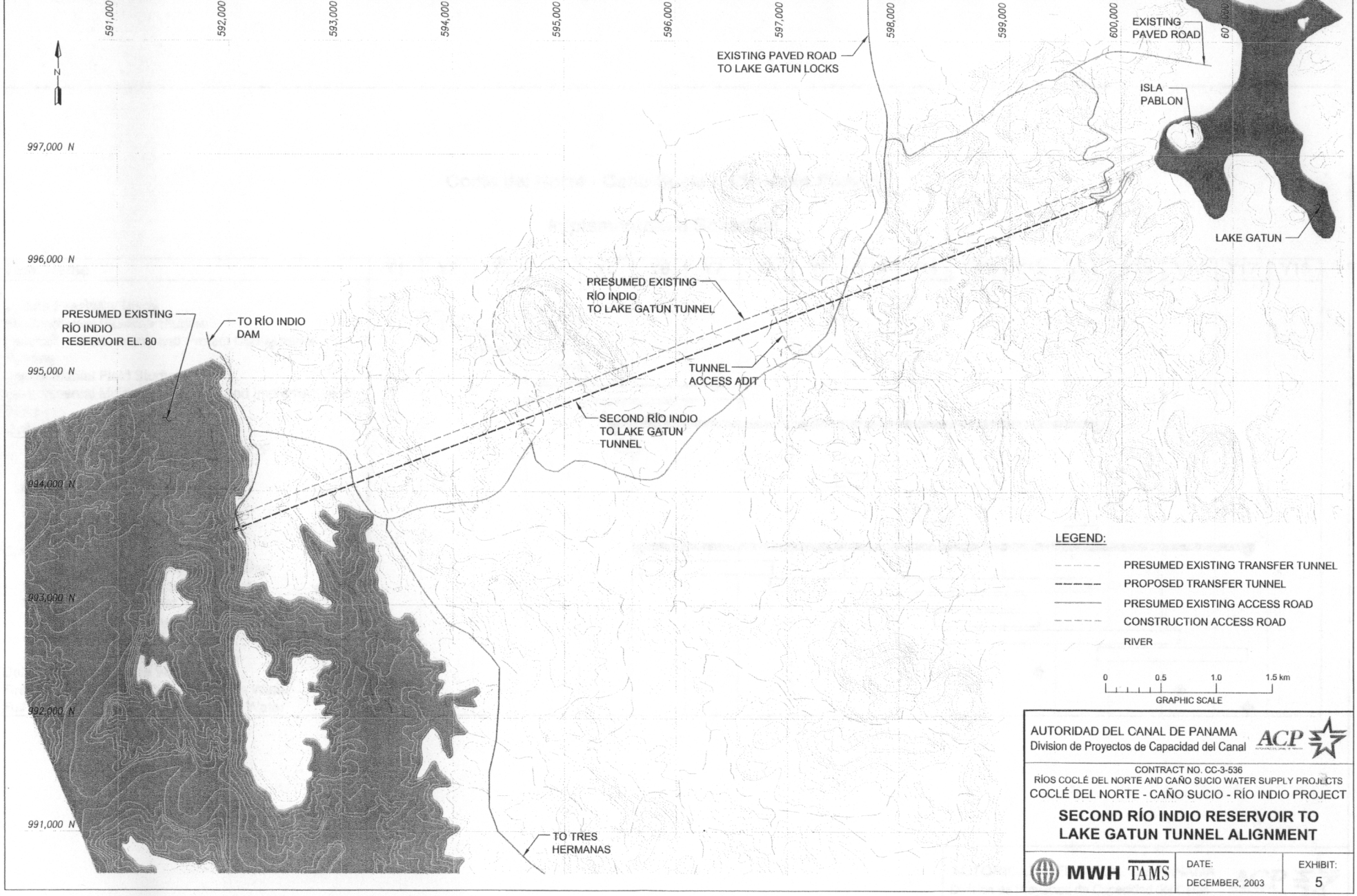
CONTRACT NO. CC-3-536
RÍOS COCLÉ DEL NORTE AND CAÑO SUCIO WATER SUPPLY PROJECTS
COCLÉ DEL NORTE - CAÑO SUCIO - RÍO INDIO PROJECT

RÍO COCLÉ DEL NORTE TO RÍO INDIO WATER TRANSFER FACILITIES ALIGNMENT

MWH TAMS

DATE: DECEMBER, 2003

EXHIBIT: 4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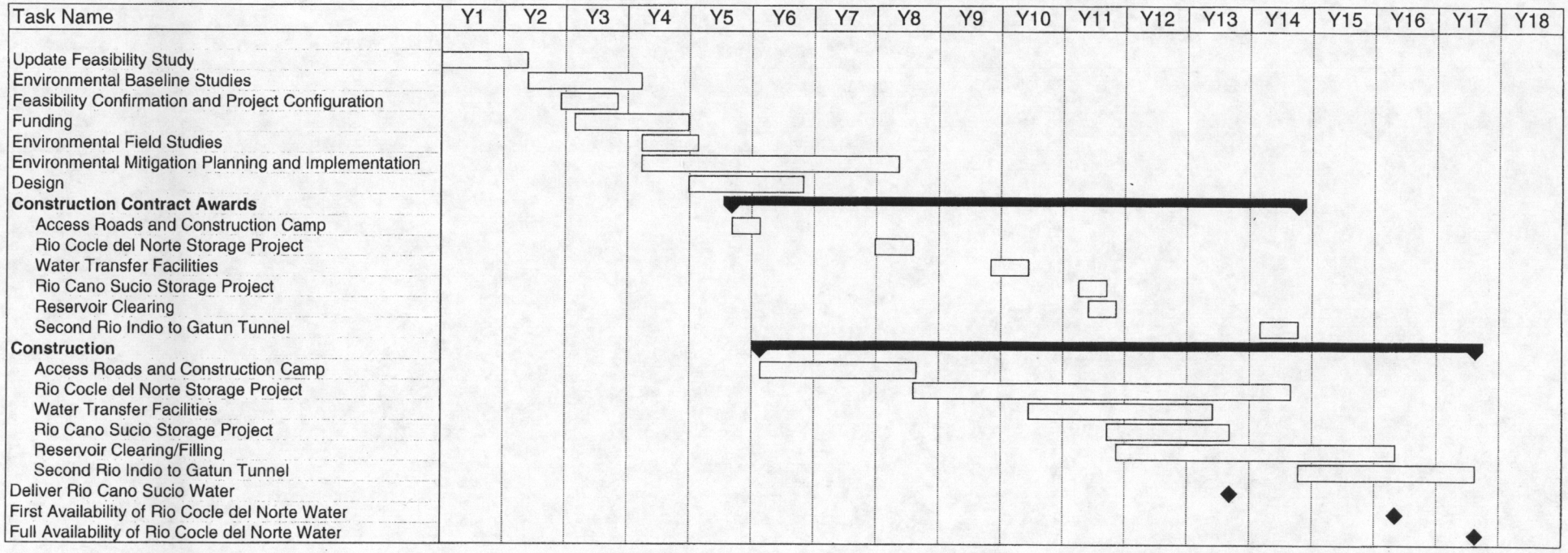
EXISTING PAVED ROAD TO LAKE GATUN LOCKS
EXISTING PAVED ROAD
ISLA PABLON
LAKE GATUN
PRESUMED EXISTING RÍO INDIO TO LAKE GATUN TUNNEL
PRESUMED EXISTING RÍO INDIO RESERVOIR EL. 80
TO RÍO INDIO DAM
TUNNEL ACCESS ADIT
SECOND RÍO INDIO TO LAKE GATUN TUNNEL
TO TRES HERMANAS
LEGEND:
PRESUMED EXISTING TRANSFER TUNNEL
PROPOSED TRANSFER TUNNEL
PRESUMED EXISTING ACCESS ROAD
CONSTRUCTION ACCESS ROAD
RIVER
0
0.5
1.0
1.5 km
GRAPHIC SCALE
AUTORIDAD DEL CANAL DE PANAMA
Division de Proyectos de Capacidad del Canal
ACP
CONTRACT NO. CC-3-536
RÍOS COCLÉ DEL NORTE AND CAÑO SUCIO WATER SUPPLY PROJECTS
COCLÉ DEL NORTE - CAÑO SUCIO - RÍO INDIO PROJECT
SECOND RÍO INDIO RESERVOIR TO LAKE GATUN TUNNEL ALIGNMENT
MWH TAMS
DATE:
DECEMBER, 2003
EXHIBIT:
5

Cocle del Norte - Cano Sucio - Rio Indio Project

Implementation Schedule



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

CONTRACT NO. CC-3-536
RÍOS COCLÉ DEL NORTE AND CAÑO SUCIO WATER SUPPLY PROJECTS
COCLÉ DEL NORTE - CAÑO SUCIO - RÍO INDIO PROJECT

IMPLEMENTATION SCHEDULE

MWH TAMS

DATE: DECEMBER, 2003

EXHIBIT: 6