(c) **Electro-mechanical Equipment and Transmission Line**

Cost of electro-mechanical equipment, transmission tower, and cable are paid in foreign currency. Cost of domestic transportation and equipment assembly/installation is paid in local currency.

(d) **Engineering and Administrative Cost**

Regarding the engineering and administrative cost, 89% is paid in local currency and 11% in foreign currency.

(e) **Compensation**

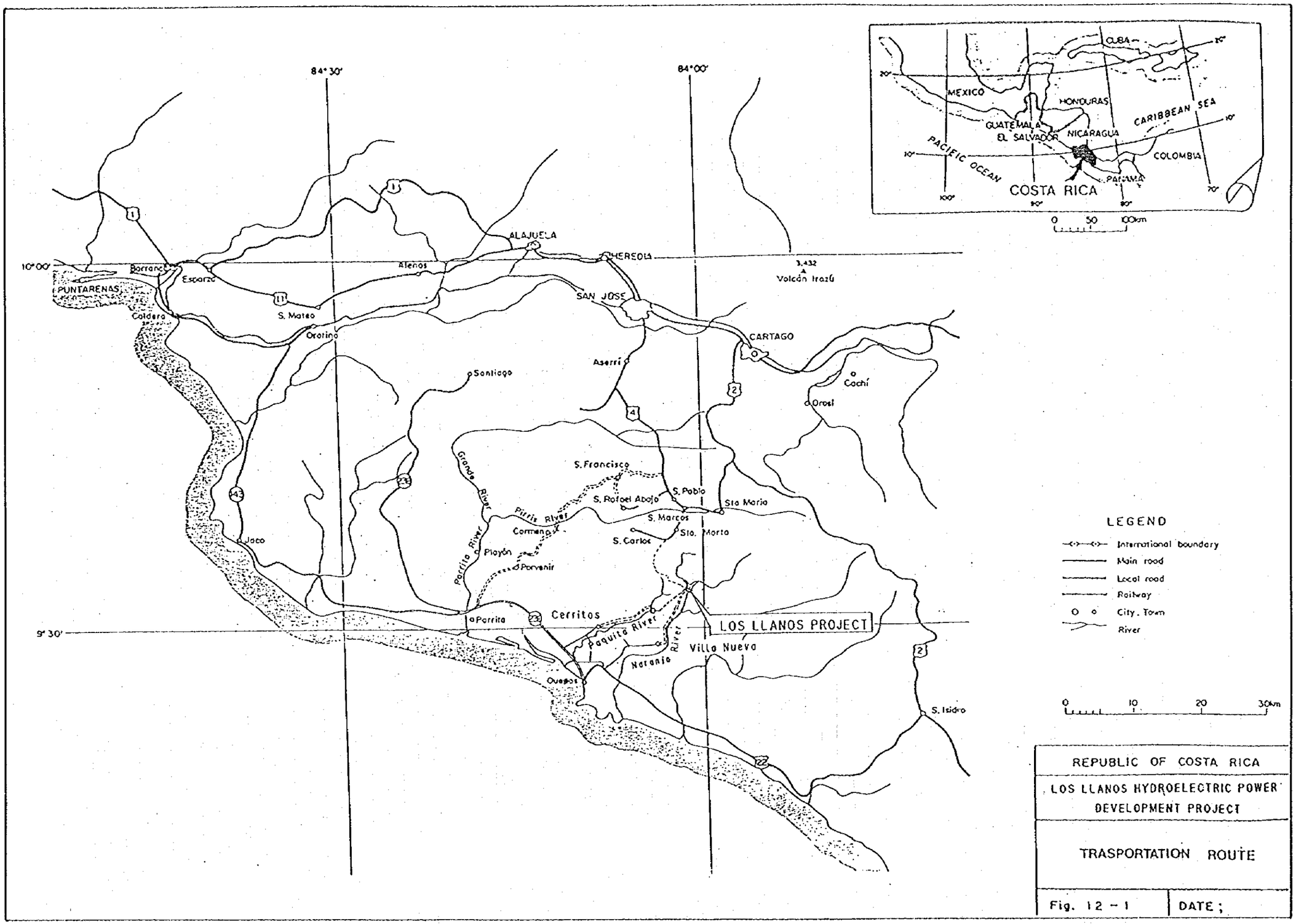
Compensation is paid in local currency.

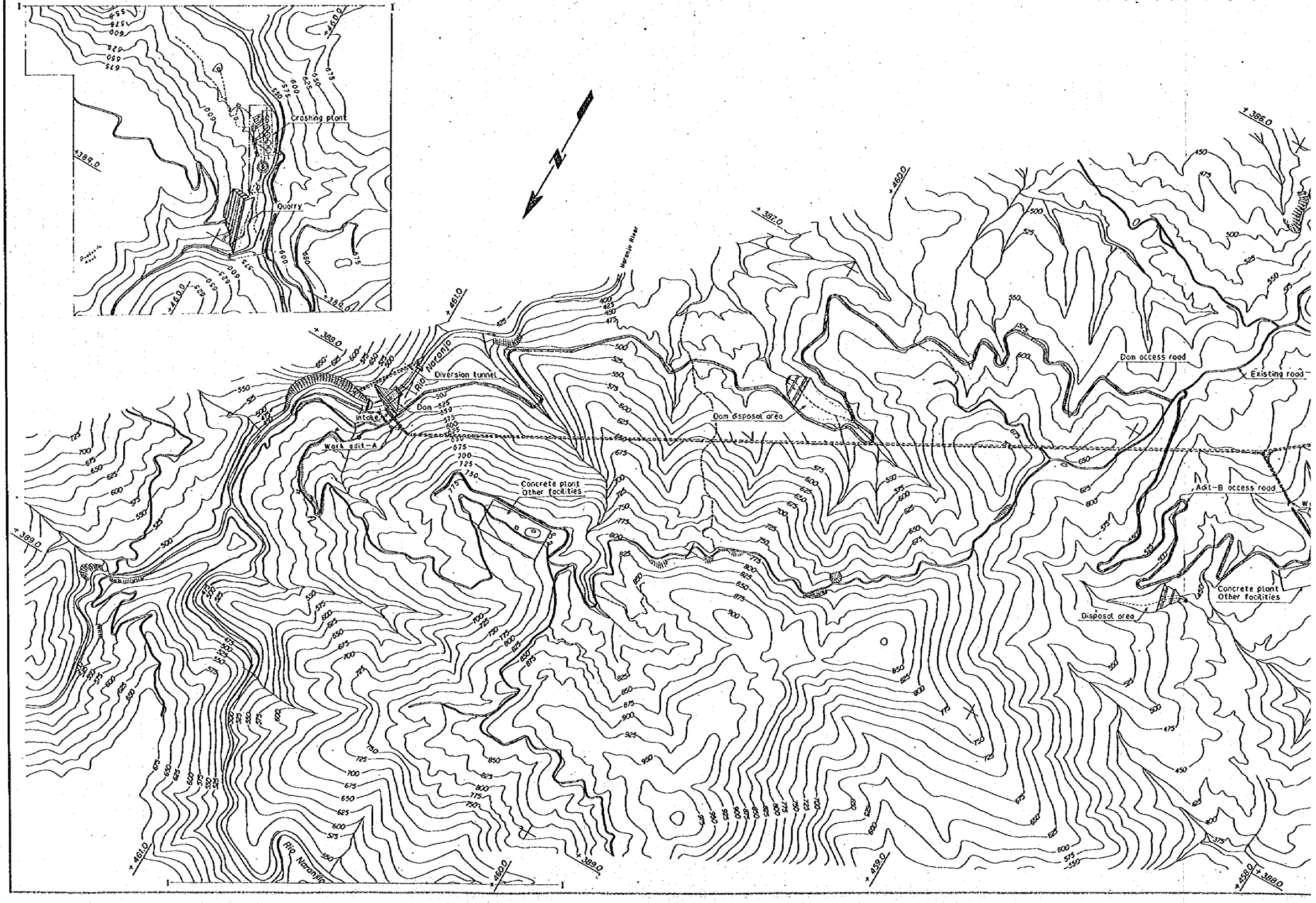
(f) **Interest during Construction**

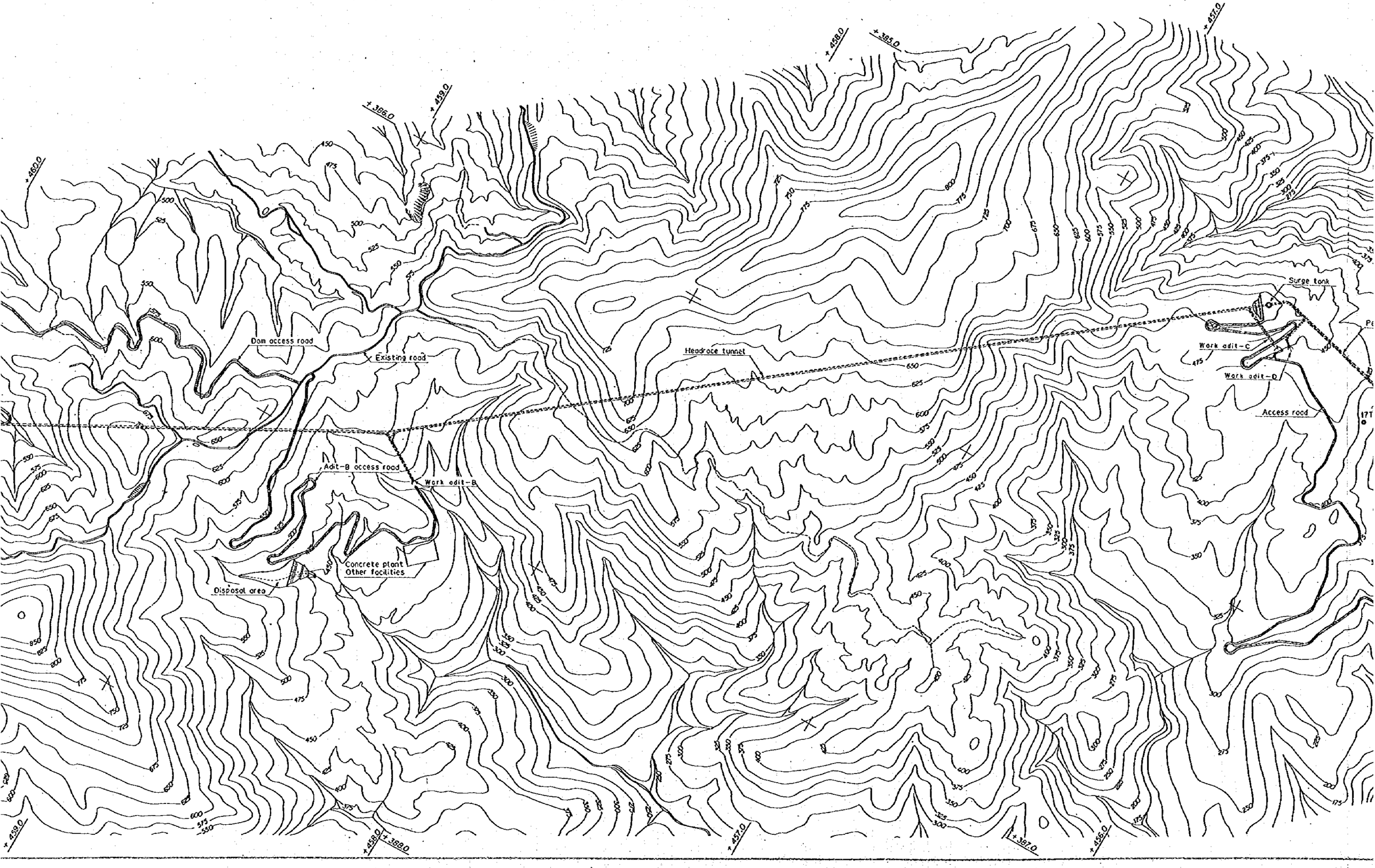
Interest during construction is appropriated only for the foreign currency since the local currency portion is free of interest.

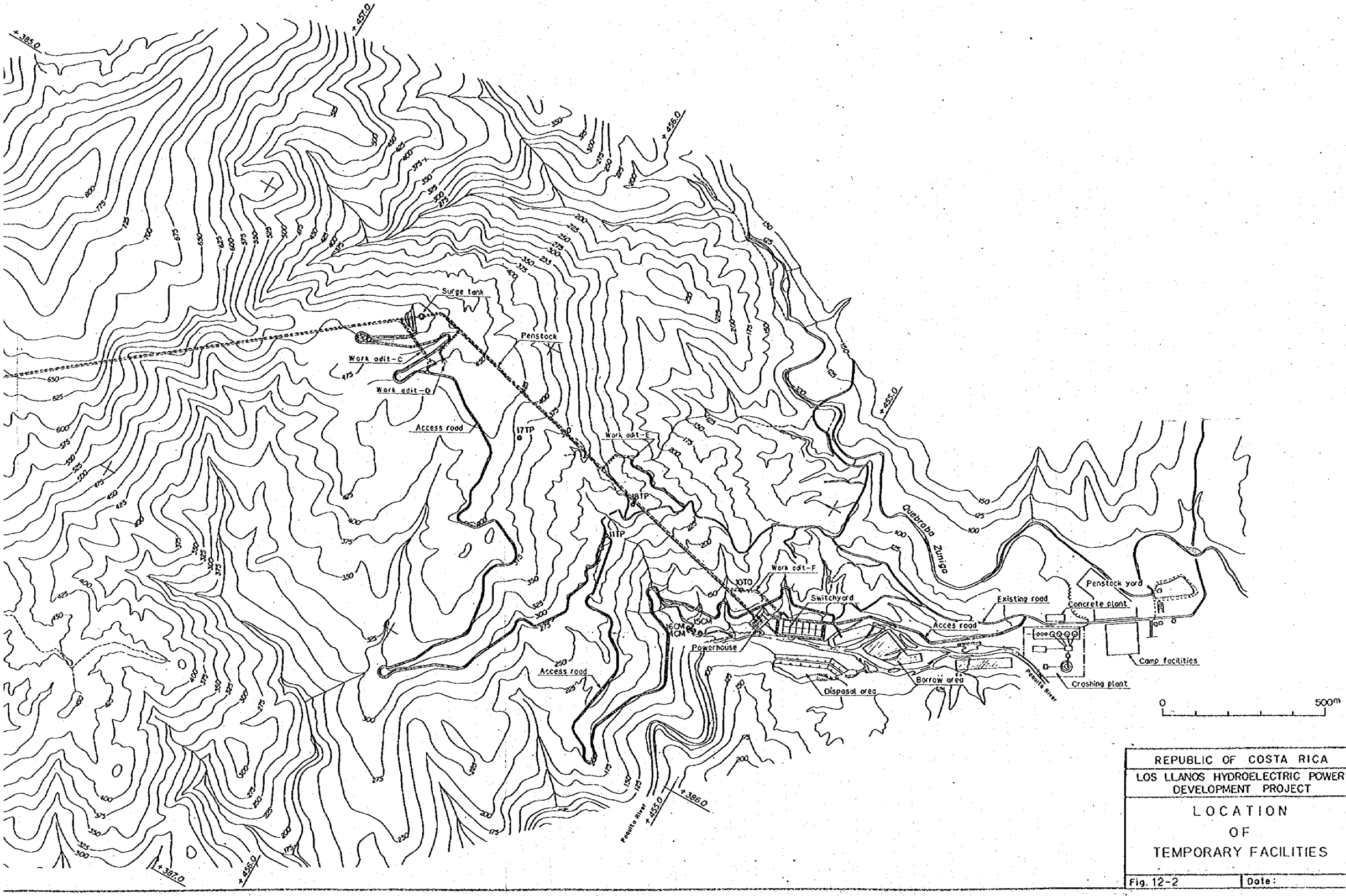
12.2.2 Construction Cost

Construction cost in local and foreign currency, and the construction cost in each year are described in Table 12-5 and Table 12-6 respectively.


84°30'
84°00'
10°00'
9°30'
ALAJUELA
HEREDIA
3,432
Volcán Irazú
Barranca
Esparza
Atenas
PUNTARENAS
Caldera
S. Mateo
Orotina
SAN JOSE
CARTAGO
Aserrí
Santiago
Cochí
Orosi
S. Francisco
S. Rafael Abajo
S. Pablo
Sta María
S. Marcos
Sto. Morta
S. Carlos
Pirrís River
Grande River
Parrita River
Comercio
Ploytón
Porvenir
Jaco
Parrita
Cerritos
Paquita River
Naranjo River
Villa Nueva
LOS LLANOS PROJECT
Quepos
S. Isidro
MEXICO
HONDURAS
GUATEMALA
EL SALVADOR
NICARAGUA
CUBA
CARIBBEAN SEA
COLOMBIA
PANAMA
PACIFIC OCEAN
COSTA RICA
0 50 100km
LEGEND
International boundary
Main road
Local road
Railway
City, Town
River
0 10 20 30km
REPUBLIC OF COSTA RICA
LOS LLANOS HYDROELECTRIC POWER DEVELOPMENT PROJECT
TRASPORTATION ROUTE
Fig. 12 - 1
DATE ;


Crushing plant
Quarry
Río Naranjo
Diversion tunnel
Dam
Intake
Work adit-A
Concrete plant
Other facilities
Dam disposal area
Dam access road
Existing road
Adit-B access road
Concrete plant
Other facilities
Disposal area
Río Naranjito
+388.0
+389.0
+461.0
+387.0
+460.0
+386.0
+459.0
+458.0


Dam access road
Existing road
Headrace tunnel
Surge tank
Work adit-C
Work adit-D
Access road
Adit-B access road
Work adit-B
Concrete plant
Other facilities
Disposal area
+460.0
+459.0
+458.0
+457.0
+456.0
+455.0
+386.0
+388.0
+387.0



REPUBLIC OF COSTA RICA	
LOS LLANOS HYDROELECTRIC POWER DEVELOPMENT PROJECT	
LOCATION OF TEMPORARY FACILITIES	
Fig. 12-2	Date:

Fig. 12-3 Construction Schedule

Item	Quantity	−1 st	1 st	2 nd	3 rd	4 th	Remarks
		2 4 6 8 10 12	2 4 6 8 10 12	2 4 6 8 10 12	2 4 6 8 10 12	2 4 6 8 10 12	
Preparatory works and Camp Facilities							
Road Construction	Dam 6.0 Km. Power plant 0.9 Km Headrace tunnel 7.2 Km		Comencement of Construction	Diverting River		Comencement of Filling Reservoir	
Care of River Diversion Tunnel	D = 6.0 m, L = 225 m		Ex. Conc.			Plug	
Coffer-dam	Upstream h = 20.5 m, Conc. 3,430 m3						Comencement of Power Operation
	Downstream h = 11.5 m, Conc. 1,200 m3						
Dam	Excavation 58,030 m3						
Height 62.4m	Concrete 89,200 m3						
Crest length 114.0m	Drilling & Grouting 3,100 m						
Power Intake	Excavation 9,250 m3						
	Concrete 1,000 m3						
Headrace Tunnel	D = 3.1 m L = 5,540 m (Maximum length 2,770 m)		Adit Ex.	Ex.	Conc.	Plug Consol.	
Surge Tank	Shaft D = 8.0 m, h = 57.3 m		Open Ex.	Glory Ex. Shaft	Conc. Shaft		
	Shaft Ex. 3,640 m3, Conc. 1,100 m3						
Penstock	Horizontal tunnel ΣL=1,090 m		Ex.	Conc.			
Embedded type D=3.1 ~2.2m*1 line	Inclined tunnel ΣL= 508 m		Ex.	Conc.			
D=1.25m * 2 lines	After branch ΣL=26 m * 2		Ex.	Conc.			
Power-house & Switchyard	Excavation 69,500 m3		Ex.				
Outdoor type	Concrete 13,000 m3			Conc. Architecture			
Tailrace	Excavation 1,410 m3						
	Concrete 2,210 m3						
Hydraulic Equipment	Spillway Gate 10m * 12.5m * 2						
	Outlet Gate & Coduit						
	Intake Gate 4m * 4m * 1						
	Draft Gate 2m * 4m * 2						
	Penstock D=3.1 ~1.25 m, L=1,560 m						
Electromechanical Equipment	No. 1 Unit						Test
	No. 2 Unit						Test
Switchyard							Test
Transmission Line		Land acquisition					Test
Telecomunication							Test

Power Station
Adit-F
Adit-E
Adit-D
Surge tank
ISLA DAMAS
Isla Damas
Quepos
Punta Quepos
Punta Catedral
ISLAS GEMELAS
ISLA OLOCUITA
PARQUE NACI
Naranjito
Villanueva
Paso Indios
Llamaron
Concepcion

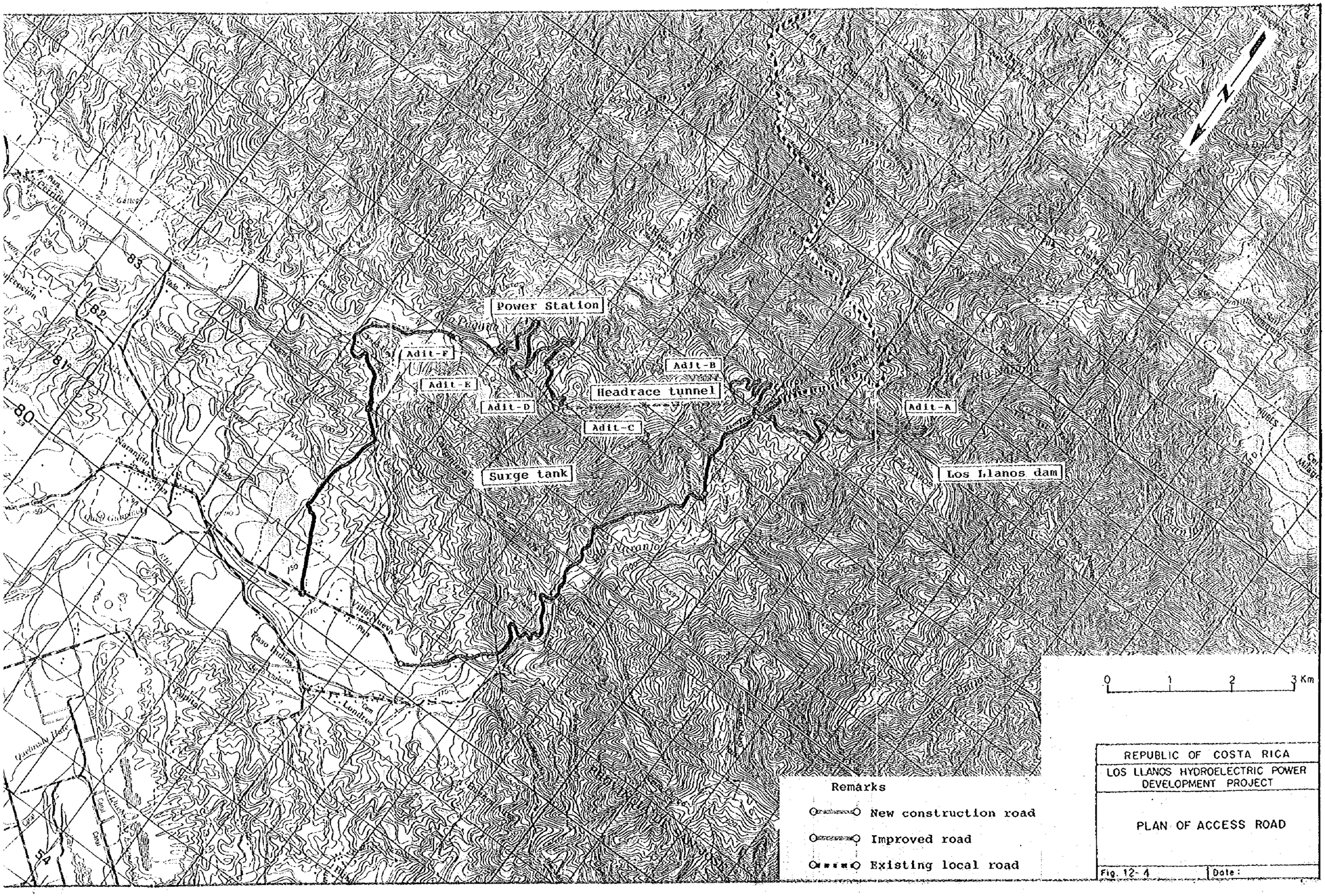

Power Station
Adit-F
Adit-E
Adit-D
Adit-C
Adit-B
Adit-A
Headrace tunnel
Surge tank
Los Llanos dam
Remarks
New construction road
Improved road
Existing local road
0 1 2 3 Km
REPUBLIC OF COSTA RICA
LOS LLANOS HYDROELECTRIC POWER DEVELOPMENT PROJECT
PLAN OF ACCESS ROAD
Fig. 12-4
Date :

Table 12-1 Principal Civil Works

Items	Description	Civil Works	
Care of River			
Diversion Tunnel	D=6.0 m, L=225 m	Tunnel Ex. Lining conc.	8,800 m3 2,200 m3
Cofferdam	Upsteam H=20.5 m Downstream H=11.5 m	Concrete Concrete	3,400 m3 1,200 m3
Dam	Concrete gravity dam H=62.4 m, L=114.0 m	Excavation Concrete	58,100 m3 89,200 m3
Power Intake	Inclined type Qmax. =27 m3/sec	Excavation Concrete	9,250 m3 1,000 m3
Headrace Tunnel	Pressure tunnel Qmax. =27 m3/sec D=3.1 m, L=5540 m	Tunnel Ex. Lining conc.	69,200 m3 24,600 m3
Surge Tank	Restric Oriffice type Shaft D=8.0 m	Shaft Ex. Lining conc.	3,700 m3 1,100 m3
Penstock	Embedded type D=3.1～2.2 m L=1540*1 Line D=1.25 m L= 26*2 Lines	Tunnel Ex. Lining conc.	19,500 m3 10,900 m3
Powerhouse	Outdoor type W=21 m*L=39 m*H28.5 m	Excavation Concrete	60,200 m3 6,800 m3
Tailrace	Open channel W=20 m, L=43 m	Excavation Concrete	1,400 m3 2,200 m3
Switchyard	Out door type 40 m*120 m	Excavation Concrete	9,300 m3 6,200 m3

Table 12-2 Principal Machinery

1. Equipment for Dam Construction

Name	Specification	Power (ps)	Weight (ton)	Number
Excavation works				
Bull dozer	20～30 ton class	160～290	20～40	4
Wheel loader	Bucket 2 m3	155	12.4	4
Dump truck	20～30 ton class	290～430	20～30	8
Crawler drill	Drifter 180 kg Air consump. 17m3/min		5.1	2
Leg drill	Jack 40 kg class Air consump. 3 m3/min		0.04	8
Compressor	Discharge 21 m3/min	195	4.1	2
Water pump	Discharge 0.5 m3/min	3.7 KW	0.2	2
Concrete works				
1) Quarry				
Bull dozer	30 ton class	290	40	2
Wheel loader	Bucket 2 m3	155	12.4	4
Dump truck	30 ton class	430	27	3
Crawler drill	Drifter 180 kg Air consump. 17m3/min			
Compressor	Discharge 9 m3/min	75 KW	2.6	1
Water pump	Discharge 0.5 m3/min	3.7 KW	0.2	1

Name	Specification	Power (ps)	Weight (ton)	Number
2) Crashing plant (50～130 ton/hr)				
Joe crasher	Entrance 100x120 cm	130 KW	90	1
Corn crasher	Mantle 130 cm	95 KW	29	2
Rod mill	Drum 210x360 cm	190	55	1
Vib. feeder		5	3	3
Apron feeder	150x400 cm	8	21	1
Belt-conveyer, others				1
Water pump	Q-4 m3/min, h=30 m	37	0.75	3
3) Batching plant (60～100 m3/hr)				
Mixer	Autmation, Forced mixing type 1.5 m 60 m3/hr	82 KW	63.4	1
Cement silo	500 ton	0.75KW	38	2
Water pump	Q-4 m3/sec, h=30 m	37 KW	0.75	2
4) Transportation (60 m3/hr)				
Truck mixer	3.0 m3	220	7.4	5
Incline	3.0 m3			1
5) Placing (60 m3/hr)				
Diesel car	6 ton class	78	6	2
Dolly	Capa. 3 m3	--	4.5	2
Cable crane	One tower swing Capa. 13.5 ton	514 KW	303	1
	Fixed type Capa. 3 ton	67 KW	33	1

Name	Specification	Power (ps)	Weight (ton)	Number
Bucket	Capa. 3 m3	--	--	2
Vibrator	LS			
Water pump	Capa. 2 m3/min	110KW	1	2
6) Cooling works Cooling plant	Refrigerating plant Capa. 200 JRT	180 KW	5.4	1
7) Grouting works Boring machine	Capa. 27 m/min	5 KW	0.3	2
Grout pump	Capa. 30-70 lt/min	3.7 KW	0.2	2
Grout mixer	Mixer 200 liter	2	0.2	2

2. Equipment for Headrace Tunnel (For half section of the tunnel between Adit B and Adit-C)

Name	Specification	Power (ps)	Weight (ton)	Number
Excavation Works				
(1) Drilling works				
Drill jambo, 2 booms, Rail type				
Air driving	Drifter 90 kg	49.3	7.0	1
Compressor	Stationary type 22 m3/hr	125 KW	--	1
(2) Mucking works				
Tractor loader, Rail type Air driving	Bucket 0.35m3	18.0	8.5	1
Train loader	Capa. 15 m3 Gauge 762 or 914mm	18 ps/or 24 KW	16.8	1
Cherry picker				1
(3) Transportation works (Inside of the tunnel)				
Battry car	10 ton car	54.4 KW	12.4	2
Torlley	Capa. 4.5 m3	--	3.2	5
Chiplar				1
(4) Supporting works				
Shotcrete	Capa. 4 m3/hr	30.0	0.6	1
Concrete plant (NATM)	Portable type Capa. 10 m3/hr	20.4 KW	7.5	1
(5) Transportation works (Outside of the tunnel)				
Dump truck	Capa. 11 ton	240.00	11.00	2
(6) Disporsal area				
Bull dozer	Capa. 20 ton	160.00	16.20	1

Name	Specification	Power (ps)	Weight (ton)	Number
Lining concrete works				
Concrete plant	Capa. 10 m3/hr Tilting mixer	7.5 KW	7.4	1
Cement silo	Capa. 50 ton	0.75 KW	6.2	1
Concrete pump	Capa. 10 m3/hr	22 KW	1.4	1
Agitator car	Capa. 3 m3/hr	11 KW	4.0	1
Crashing plant	Capa. 120m3/hr	Common use		1
Consolidation grouting works (Around Tunne).				
Drilling	Boring machine	10.0	0.44	1
Grout pump				1
Grout mixer				1
Mortar injection works (Gap between lining conc. and rock)				
Grout pump	0.8-1.2 m3/hr	25.0	3.1	1
Grout mixer	---			1

Table 12-3 Labor Cost

Unit:U S $

Name	Unit Price
Forman	4.39
Miner	2.26
Heavy Machine Operator (A)	2.34
Light Machine Operator (B)	2.00
Crane Operator	2.35
Mechanic	2.26
Steel Fixer	2.26
Plumber	2.26
Electrician	2.26
Carpenter	2.35
Driller	2.26
Ditto, Assist	2.00
Groutman	2.26
Labor	1.90

Table 12-4 Material Unit Price

Unit: U S $

Name	Specification	Unit	Home Producton	Importation
Cement	Portland	ton	77.0	
	Extra fine		95.0	
Flyash				52.0
Admixure	AE agent	Kg		6.0
	Water reducing	Kg		4.0
	Accelerator	Kg		2.0
Shape Steel	Angle	ton		940.0
	H-beem	ton		610.0
Pipe	Carbone S. pipe	ton		1,150.0
	Seam welded pipe	ton		
Rolled Steel	6≦t ≦20 mm	ton		1,470.0
	20≦t ≦38 mm	ton		1,500.0
	38≦t ≦50 mm	ton		1,530.0
Steel Bar	Round bar (D=13 ～44 mm)	ton		1,065.0
	Deformed bar (D=13 ～44 mm)	ton		950.0
Rock-bolt	Deformed bar (D22×L3000 mm)	pc		19.5
	Deformed bar (D25×L3000 mm)	pc		24.0
	Deformed bar (D25×L5000 mm)	pc		29.3

Name	Specification	Unit	Home Producton	Importa-tion
Rail	20 Kg class	ton		1,080.0
	30 Kg class	ton		1,150.0
Welded Metal	3.2 ×100 ×100	m2		1.7
	4.0 ×100 ×100	m2		2.4
Fuel and Oil	Gasoline	lt	0.37	
	Light oil	lt	0.30	
	Lubrication	lt	3.08	
	Grease	Kg		
Blasting	Dynamite	Kg		1.9
	ANFO	Kg		0.43
	Elec. Detonation	pc		1.41
	Elec. Leads	m		
	Detonating	m		
Aggregate	Sand	m3	10.0	
	Gravel	m3	20.0	
Bit and Rod Genaral	Bit (D=30 ~44 mm)	pc		74.0
	Rod 22 mm ×2 m	pc		97.8
Rock-bolt	Bit (D=36 ~38 mm) (Metal crawn)	pc pc		124.7
	Rod 3 m (D=33.5 ~50 mm)	pc		133.0
B. Machine	Bit (D=36 ~66 mm) (Metal crawn)	pc		33.5
	Rod 3 m (D=33.5 ~50 mm)	pc		132.3

Name	Specification	Unit	Home Producton	Importa-tion
Wood	Boad	m3	120.0	
	Balk	m3		
	Planking	m3		
Metal forms Flat type	150 ×1800 mm	pc		17.2
	300 ×1800 mm	pc		23.7
Water Stop Vinyl chloride	7 mm×300 mm	m		16.0
	9 mm×300 mm	m		18.7

Table 12-5 Estimated Construction Cost

As of Jan. 1995
US$ = 168 Colones
Unit:10^3 US$

Items	Description	Total	Foreign Currency	Local Currency
1. Civil Works		63,522.9	34,620.3	28,902.6
	Care of River	1,929.4	908.8	1,020.6
	Dam	11,999.5	5,675.5	6,324.0
	Water way	31,558.6	17,696.9	13,861.7
	Power intake	409.3	239.8	169.6
	Headrace tunnel	23,435.5	13,198.9	10,236.6
	Surge tank	961.9	580.1	381.8
	Penstock	6,318.2	3,466.5	2,851.7
	Tailrace	433.8	211.6	222.1
	Powerhouse, Switchyard	5,172.1	3,000.5	2,171.6
	Powerhouse	1,962.9	1,174.7	788.2
	Control building	1,413.7	795.1	618.6
	Switchyard	1,795.5	1,030.7	764.8
	Disposal Area	1,998.7	1,213.4	785.2
	Preparatory Works	10,864.6	6,125.1	4,739.5
	Access road	6,381.1	3,336.4	3,044.7
	Camp facility	3,159.5	1,709.7	1,449.8
	Power supply	1,324.0	1,079.1	244.9
2. Hydraulic Equipment		8,970.1	7,426.1	1,543.9
	Gate & Valve	3,042.3	2,591.4	450.9
	Penstock & S.Liner	5,784.5	4,748.7	1,035.8
	Bridge	143.3	86.0	57.2

Items	Description	Total	Foreign Currency	Local Currency
3.	Electromechanical Equipment	27,261.3	24,208.1	3,053.2
	Turbine	8,687.5	7,714.5	973.0
	Generator	7,472.5	6,635.6	836.9
	Transformer	1,100.0	976.8	123.2
	Crane etc	3,531.3	3,135.8	395.5
	Control equip.	2,650.0	2,353.2	296.8
	Switchyard	2,800.0	2,486.4	313.6
	Communication equip.	1,020.0	905.8	114.2
4.	Transmission Line	4,208.0	3,182.0	1,026.0
5.	Total Direct Cost (1+2+3+4)	103,962.3	69,436.6	34,525.8
6	Project Control (Direct cost x 18.5 %)	19,233.0	2,115.6	17,117.4
7.	Compensation	673.2	0.0	673.2
	House, Relocation LS	361.9	0.0	361.9
	Land, Power Plant LS	90.0	0.0	90.0
	Land, Transmission LS	10.4	0.0	10.4
	Compensation under T.L	210.9	0.0	210.9

Items	Description	Total	Foreign Currency	Local Currency
8. Contingency		13,473.7	7,145.4	6,328.3
	Civil works x 15 %	9,528.4	5,193.0	4,335.4
	Hydraulic equipment x 5 %	448.5	371.3	77.2
	Electromecanical equipment x 5 %	1,363.1	1,210.4	152.7
	Transmission Line x 5 %	210.4	159.1	51.3
	Project conrolling x 10 %	1,923.3	211.6	1,711.7
9. Total Indirect Cost		33,379.9	9,261.1	24,118.9
10. Total Construction Cost (Total direct cost + Total indirect cost)		137,342.3	78,697.6	58,644.6
11. Interest During Construction		14,420.6	14,420.6	0.0
12. TOTAL PROJECT COST (Investment Cost)		151,762.9	93,118.2	58,644.6

Table 12-6 Fund Requirement in Each Year

As of Jan. 1995
US$ = 168 Colones
Unit:10^3 US$

F.C; Foreign currency, L.C; Local currency, T: Total

Item		-1st year	1st year	2nd year	3rd year	4th year	Total	Remarks
1. Civil Works								
Care of River	F.C		738.8	123.5	0.0	46.5	908.8	Coffer dam and
	L.C		776.8	159.2	0.0	84.7	1,020.6	Diversion tunnel
	T		1,515.5	282.7	0.0	131.2	1,929.4	
Dam	F.C		121.3	2,254.2	2,895.3	404.7	5,675.5	Dam, Spillway and
	L.C		56.3	2,363.1	3,417.6	487.0	6,324.0	Outlet works
	T		177.6	4,617.4	6,312.9	891.6	11,999.5	
Waterway	F.C		7,123.2	6,772.9	3,364.3	436.5	17,696.9	Intake, Headrace
	L.C		4,873.8	5,613.7	3,130.6	243.7	13,861.8	tunnel, Surge
	T		11,997.0	12,386.5	6,494.9	680.2	31,558.6	tank & Penstock
Powerhouse & Switchyard	F.C		956.2	1,481.5	562.8	0.0	3,000.5	
	L.C		621.3	1,105.1	445.2	0.0	2,171.6	
	T		1,577.5	2,586.7	1,008.0	0.0	5,172.1	
Disposal Area	F.C		709.2	504.2	0.0	0.0	1,213.4	Dam, Waterway and
	L.C		456.4	328.9	0.0	0.0	785.2	Powerhouse
	T		1,165.6	833.1	0.0	0.0	1,998.7	
Preparatory Works	F.C	5,615.8	127.3	127.3	127.3	127.3	6,125.1	Access rord,
	L.C	4,230.1	127.3	127.3	127.3	127.3	4,739.5	Camp facilities,
	T	9,845.8	254.7	254.7	254.7	254.7	10,864.6	T.L for Const.
Civil Works Total	F.C	5,615.8	9,776.0	11,263.7	6,949.8	1,015.0	34,620.3	
	L.C	4,230.1	6,911.8	9,697.3	7,120.7	942.8	28,902.7	
	T	9,845.8	16,687.8	20,961.1	14,070.5	1,957.8	63,522.9	
2. Hydraulic Equipment	F.C	0.0	0.0	5,123.9	654.0	1,648.2	7,426.1	Gates & Penstock
	L.C	0.0	0.0	1,099.4	111.3	333.2	1,543.9	
	T	0.0	0.0	6,223.4	765.3	1,981.4	8,970.1	

Item		-1st year	1st year	2nd year	3rd year	4th year	Total	Remarks
3. Electromechanical Equipment	F.C	0.0	4,149.0	692.7	16,346.3	3,020.0	24,208.0	
	L.C	0.0	0.0	0.0	1,647.7	1,405.6	3,053.3	
	T	0.0	4,149.0	692.7	17,994.0	4,425.6	27,261.3	
4. Transmission Line	F.C	0.0	637.0	1,959.0	391.0	195.0	3,132.0	
	L.C	0.0	205.0	0.0	547.0	274.0	1,026.0	
	T	0.0	842.0	1,959.0	938.0	469.0	4,208.0	
5. Total Direct Cost (1+2+3+4)	F.C	5,615.8	14,562.0	19,039.4	24,341.1	5,878.2	69,436.4	
	L.C	4,230.1	7,116.8	10,796.8	9,426.7	2,955.6	34,525.9	
	T	9,845.8	21,678.8	29,836.1	33,767.8	8,833.8	103,962.3	
6. Project Control (T.D.C x 18 %)	F.C	200.4	441.2	607.2	687.2	179.8	2,115.6	
	L.C	1,621.1	3,569.4	4,912.5	5,559.9	1,454.5	17,117.4	
	T	1,821.5	4,010.6	5,519.7	6,247.0	1,634.2	19,233.0	
7. Compensation	F.C	673.2	0.0	0.0	0.0	0.0	673.2	
	L.C	0.0	0.0	0.0	0.0	0.0	0.0	
	T	673.2	0.0	0.0	0.0	0.0	673.2	
8. Contingency								
Civil	F.C	842.4	1,466.4	1,689.6	1,042.5	152.3	5,193.0	
	L.C	634.5	1,036.8	1,454.6	1,068.1	141.4	4,335.4	
	T	1,476.9	2,503.2	3,144.2	2,110.6	293.7	9,528.4	
Hydraulic Equipment	F.C	0.0	0.0	256.2	32.7	82.4	371.3	
	L.C	0.0	0.0	55.0	5.6	16.7	77.2	
	T	0.0	0.0	311.2	38.3	99.1	448.5	
Electromecha. Equipment	F.C	0.0	207.5	34.6	817.3	151.0	1,210.4	
	L.C	0.0	0.0	0.0	82.4	70.3	152.7	
	T	0.0	207.5	34.6	899.7	221.3	1,363.1	
Transmission Line	F.C	0.0	31.9	98.0	19.6	9.8	159.1	
	L.C	0.0	10.3	0.0	27.4	13.7	51.3	
	T	0.0	42.1	98.0	46.9	23.5	210.4	
Project Controlling	F.C	20.0	44.1	60.7	68.7	18.0	211.6	
	L.C	162.1	356.9	491.3	556.0	145.4	1,711.7	
	T	182.1	401.1	552.0	624.7	163.4	1,923.3	
Total Contingency	F.C	862.4	1,749.8	2,139.1	1,980.8	413.4	7,145.4	
	L.C	796.6	1,404.0	2,000.8	1,739.4	387.5	6,328.3	
	T	1,659.0	3,153.8	4,139.9	3,720.1	800.9	13,473.7	

Item		-1st year	1st year	2nd year	3rd year	4th year	Total	Remarks
9. Total Indirect Cost (6+7+8)	F.C	1,062.8	2,191.0	2,746.2	2,667.9	593.2	9,261.0	
	L.C	3,090.9	4,973.4	6,913.3	7,299.3	1,842.0	24,118.9	
	T	4,153.7	7,164.4	9,659.6	9,967.2	2,435.1	33,379.9	
10. Total Construction Cost (5+9)	F.C	6,678.5	16,753.0	21,785.6	27,009.0	6,471.4	78,697.5	
	L.C	7,321.0	12,090.2	17,710.1	16,726.0	4,797.5	58,644.8	
	T	13,999.5	28,843.2	39,495.7	43,735.0	11,268.9	137,342.3	
11. Interest During Construction (R=8.5 %)	F.C	283.8	1,279.7	2,917.6	4,991.3	4,948.2	14,420.6	
	L.C	0.0	0.0	0.0	0.0	0.0	0.0	
	T	283.8	1,279.7	2,917.6	4,991.3	4,948.2	14,420.6	
12. Ground Total (Investment Cost)	F.C	6,962.4	18,032.6	24,703.2	32,000.4	11,419.6	93,118.1	
	L.C	7,321.0	12,090.2	17,710.1	16,726.0	4,797.5	58,644.8	
	T	14,283.3	30,122.8	42,413.2	48,726.3	16,217.1	151,762.9	

Remarks: Figures in total and ground total do not necessarily correspond to the respective sum because factions have been rounded off in the course of calculation.

Chapter 13 Environment

Chapter 13 Environment

CHAPTER 13 ENVIRONMENT

Contents

List of Figures

List of Tables

CHAPTER 13 ENVIRONMENT

13.1.1 Location

The location of area for the project is indicated in Figure 13-1. The project area is located upstream of the Naranjo and Paquita Rivers, both of which originate south of San Jose, capital of Costa Rica, and flow southward to the Pacific Ocean. As administrative district, while the project area is in Aquirre County, downstream of the Naranjo River belongs to Puntarenas County.

Downstream areas of the both rivers consists of gently-sloping plains with small agricultural villages scattered. Near the river mouths is Quepos City, the largest city in the area.

13.1.2 Basins including the Project Area

Details of the basins including the project area are shown in Figure 13-2. The area is in a mountain region and away from human communities.

Middle and lower reaches of the Naranjo River are a plain with gentle slope scattered with small farming villages. The situation of the Paquita River is similar to the Naranjo River basin.

13.1.3 Outline of Facilities for the Project

The main scheme of the project is to construct a hydroelectric power station of run of river type with a capacity of 85 MW located at the Paquita River. From a small reservoir with a capacity of 653,000m^3 to be constructed at Los Llanos site, right downstream of confluence of the Naranjo River and Naranjito River, water for electric power generation of 273m^3/sec. is to be supplied to the powerhouse by utilizing a head of 389.7m.

13.2 Environmental Characteristics of Project Area

13.2.1 Protection of the Natural Environment

(1) Environment Evaluation Guide

The following items are related to policy, and so on concerning the environmental impact evaluation related to the development of Costa Rica and environmental protection.

a) **Guia para la evaluacion de impacto ambiental**

These are guidelines for implementing an environmental evaluation related to energy projects of the Ministry of Industry, Energy, and Mines.

The following items must be taken into consideration.

- Environmental impact due to the planned project and related action
- Unavoidable environmental impact
- Alternative proposal including cancellation of the plan
- Short-term local utilization and long-term ongoing utilization, or change in productivity
- Project implementation and disappearance of resources

Methods of environmental impact evaluation are classified as follows.

<Obtaining a grasp of the present situation>

- Describing the present situation of the environment
- Determining the project factors
- Determining the factors that are effected by the project

<Estimation of Impact>

- Obtaining a grasp of important changes in the environment
- Qualitative estimation of important special and time-related changes

<Impact evaluation>

- Benefits resulting from the implementation of the project
- Comparison with the benefits resulting from the implementation of alternative proposals
- Recommendations

The following items are included in the impact evaluation items.

- Quality of the atmosphere
- Water quality
- Ecology
- Topology and scenery
- Society

Form of possession and utilization of land, changes due to the project, impact on population, relocation, change in productivity, employment

- Biological resources, sanitation, scenery
- Environmental protection measures adopted during the implementation of the project
- Environmental standards, treatment and disposal of waste
- Method and cost of reducing environmental impact

b) **Guia basica para la elaboration de los estudios de impacto ambiental para la actividad minera**

This guide was enacted in 1982 as ordinance No.6797 by the Ministry of Industry, Energy, and Mines, as a guide for performing environmental impact evaluations for mine development.

The following items are mandated by the impact evaluation manual.

<Description of plan>

<Present condition of the environment>

<Environmental impacts likely to occur during the implementation of the project>
- Physical and biological impacts on the environment
- Impact on the social environment

<Impact of the plan on the environment>
- Physical and biological environment
- Impact due to the plan

<Analysis and impact alleviation measures>

<Comparison with cost benefit analysis>

<Environmental impact evaluation and certificate of examination of actions for which an environmental impact evaluation was guaranteed>

c) **Guia para la elaboracion de estudios de impacto ambiental para proyectos de salinas en refugios de vida silvestre y humedales**

The contents of the guide for evaluating the environmental impact resulting from the development of salt farms are as follows.

<Description of the plan>

<Information related to the regional environment>
- Physical environment
- Biological environment
- Social environment

<Impact on the environment, pollution and loss>

<Suitable policy for preventing a negative impact on the environment, and related schedule>

<Declaration of implementation of environmental protection measures>

d) **Guia basica para la elaboracion de estudios de impacto ambiental para proyectos de aprovechamiento de recursos naturals renovables**

The contents of the guide for evaluating the environmental impact resulting from the implementation of development projects for restructuring natural resources are as follows.

e) **Guia basica para la elaboracion de estudios de impacto ambiental para proyectos de cuacultura en refugios de vida silvestre y humedales**

The contents of the guide for evaluating the environmental impact resulting from the implementation of forest and swampland cultivation projects are as follows.

<Description of the plan>

<Information concerning the regional environment>
- Physical
- Biological

• Social

<Impact on the physical, biological and social environment, evaluation of the results of analysis, and necessary counter measures>

<Schedule and cost of implementing countermeasures for reducing negative impacts>

<Documents that indicate the policy for restoring the environment>

(2) **Waste Treatment (De las obligaciones y restrucciones relativas a la recoleccion y eliminacion de residuous solidos)**

(3) **Prevention of Environmental Pollution (De las deberes y restricciones a que quedan sujetas las personas para evitar la contaminacion del ambiente)**

(4) **Prevention of Air Pollution (Programa de control de contaminacion del aire)**

(5) **Noise and Vibration Standards (Reglamento para el control de ruidos y vibraciones)**
The noise standard for a workplace is 85 dB.

(6) **Regulations Pertaining to the Ecology (Codigo ecologico)**

a) **Archeological cultural assets**
- Protection agreements pertaining to archeological cultural assets and art
- Protection agreements pertaining to culture and nature
- National archeological cultural assets
- Recommendations pertaining to the protection of endangered public or private cultural assets

b) **Natural heritage**
- Protection agreements pertaining to fauna and flora and the natural beauty in Central and South America
- Agreements prohibiting the trading of fauna and flora
- Agreements pertaining to nationally important swamplands related to the habitat of waterfowl, etc.
- Establishment of national park business
- Laws for the protection of wildlife

c) **Basin area**

- Ocean protection agreements pertaining to the Caribbean Sea region, etc., around Central and South America.
- Cooperation for the prevention of oil spills in the Caribbean Sea region, etc.
- Agreements to prevent pollution resulting from dumping of garbage and other waste matter into the ocean
- Method of offshore fishing and related preservation agreements
- Agreements related to territorial waters and adjacent territories
- Marine and coastal law regulations

This law was enacted in 1977 as ordinance No.6043.
It consists of rules for marine and coastal development and also includes river basin management action. It also covers basin area lowlands. In other words, it is a law which mandates that coastal projects take into account the effect on the environment.

d) **Forests**

- Forestry law regulations

This law covers not only forest preservation zones and protected zones, but rather the entire basin area. It applies mainly to preservation and protected zones, and also management zones consisting of primeval forests and secondary forests.
In these regions, forestry and agriculture and also self-sustaining alternative industries are carried out by means of the participation of the inhabitants.
All of these activities are presented to the people of the farming society, and from this viewpoint the water power development project can benefit the regional society.
A law for the protection of the mangroves was enacted in 1992 as part of the provisions related to the protection of forests. This law covers all mangroves adjacent to the seashore and also mangroves in danger of extinction at the river mouth in the public zone.

e) **Plant and animal quarantine**

f) **Health**

g) **Environmental administration**

- Agreements pertaining to the environment and development in Central America

- Reorganizing the Ministry of Industry, Energy, and Mines as the Ministry of Natural Resources, Energy and Mines
- Territorial water

(7) Land and Colonization Law Regulations

The land and colonization law was enacted in 1961 as ordinance No.2825 to formally regulate the process of land development. It is an extremely valuable tool for controlling land possession rights and resolving land-related disputes.
The intent of this law is quite clear in relation to maintenance and management of natural resources.
The important parts of this law are clause 4 of article 1, and articles 7, 68, 87, 133, 136 and 153.

(8) Water Management Law Regulations

The water management law was enacted in 1942 as ordinance No.276. It is an extremely useful tool for the development of water power development, and covers water conveyance, irrigation, and individual water rights. The most important sections of this law are section 8 which indicates the right of possession of the state to water power energy, and section 9 which defines forest preservation measures to prevent reduction of natural water.

(9) Nature Protection Zones and National Parks

In the north east region upstream from Londres on the Naranjo River is the Los Santos forest protected zone which contains 49.53% of the area of the Naranjo River basin. On the east side of this region is the Nara Mount protection zone which contains 6.87% of the basin area.
In the coastal zone lying between the Naranjo River and Paquita River is a 682 ha national park.

a) Los Santos forest protected zone

An 62,000 ha area was designated as a protected zone in October 1975 under ordinance No.5389-A, and re-designated in April 1994 under ordinance 23260-MIRENEN.

Forest protection is defined by article 35. A detailed outline of forest protection and national park protection given by Thelen and Dalfelt (1979) is set out below.

The nation has vast areas that are covered by forests in zones suitable for the production of timber, water, feed, wild animals and recreational activities. These forests are places where people live and carry outhuman activities. Protection of the forests in this area ensure both development of water power and a supply of fresh water to San Jose. This zone is located in Perez District of San Jose Prefecture, and lies at an altitude of between 500 and 3491 m. The most representative part of the protected zone consists of rain forests on hills, rain forests on lowmountains, and rain forests in mountain districts. Part of the protected zone also consists of subalpine high-rain paramo (barren plains). Natural vegetation in the management zone has changed due to expansion of farming and cattle pastures. This protected zone consists of 13,731 ha of productive forest, 34,666 ha of protected forest, and 13,603 ha used for other purposes (Figure 13-3).

b) **Cerro Nara protected zone**

This zone, which has an area of 2,280 ha, was designated as a protected zone in December 1984 by ordinance No.6875 for the purpose of protecting the water retention function of the forest. It belongs to Aguirre District of Puntarenas Prefecture and Oata District of San Jose Prefecture, and is adjacent to the South West side of the Los Santos forest protected zone. Some 80% of this zone is primeval forest. According to the forest law, the purposes of managing this zone are soil preservation, water regulation, and protection of the environment and the water system. This zone is important from the viewpoint of water retention performance. According to Thelen and Dalfelt (1979), this zone is defined as a hydrological resources production zone.

The main purpose of this zone is production of water, and the second purpose is preservation of the diversity of animal species.

The spring which supplies drinking water to Narajito in Aguirre District is in this zone.

Also, this zone has an important surface drainage network for the Brujo River and the Naranjo River (ICE 1994).

Both the Los Santos forest protected zone and the Cerro Nara protected zone are adjacent to the boundary of the planned site, and are completely unaffected by reduction of water resulting from the implementation of the plan.

c) **Manuel Antonio National Park**

On the right bank of the mouth of the Naranjo River downstream of Londres is the Manual Antonio National Park.

This national park was established in 1978 under ordinance No.7901-A. This park belongs to Puntarenas Prefecture. It embraces a land area of 682 ha and a sea area of 55,000 ha, and consists of tropical wet forest (Figure 13-4).

This park already has a management plan, and is efficiently managed by the National Park Service of the Ministry of Natural Resources, Energy and Mines.

d) **Fila Chonta proposed protected zone**

The area of the proposed protected zone is between 30,000 and 40,000 ha (Mattey and Salazar 1994). It is an extremely important underground water percolation site.

A similar protected site is Cerro Nara.

e) **Estero Boca Vieja and Estero Negro mangrove systems**

These two mangrove systems are located at the mouths of the Naranjo River and Paquita River, respectively. They were taken into account and defined by the wildlife conservation law No.7317. Under the forest law, on the other land, mangrove systems must be managed according to a technically designed management plan. The Estero Negro mangrove system is a belt which runs along the lagoon in the south east direction from the mouth of the Naranjo River (Figure 13-5).

13.2.2. Characteristics of Topography and Geology

1) Topography

a) Outline

Naranjo river originates from the area near the south west east of Central Highland, flows down in the south west direction and flows into Pacific Ocean. The altitude of river origin basin is about 2500 m, but this is a very rapid river flowing the altitude difference of about 200m in the mountainous area of about 25 km up to the north east of Londres.

The dam spot is planned at the spot of about 500 m above the sea level which is rather downstream side of block having this type of rapid river slope, and both the banks are surrounded by the cliffs.

This river, after flowing down this type of rapid upper and middle areas, flows the alluvial low land along the Pacific Ocean, the river slope becomes slow, and there is only the altitude difference of 200 m in about 15 km up to the river mouth. In this way, the upper and middle areas of this river show the sharp topography, but no large scale land slide and land slip are not recognized in this area.

Paquita river originates from the area close to the south west end of Central Highland, flows down in the south west direction and flows into the Pacific Ocean. The altitude of river origin area is about 1000 m but the altitude difference is about 900 m between about 10km from the river origin area, and thereafter the river slope is gentle toward the alluvial plain. The power generation spot is in the middle area between the sharp zone and the gentle zone, which is small but has the topography rich in irregular ups and downs. No large scale land slide and collapsed land are recognized in this area.

b) Precious topography

No precious topographical features are recognized in the project spot.

(2) Geology

a) Outline

At the dam spot, the conglomerate and coarse rocks are distributed geologically out of the accumulated rocks from Jurassic period to the Palaeogene. The pudding stone structuring the conglomerate is gigantic round pudding stones in many cases, and the single layer thickness range from several meter to several tens of meter, but their boundary is not clear. The running direction of layer face is north/west-

south/east direction and approximately constant in the north/east direction inclination, but the organic topography attributable to the layer face is not clear.

As the surface accumulated substance, the weathered layer of conglomerate distributing thick in a partial gentle slope land is featuristec, shows the featuristic onion-like weathering, but in the other area, the weathered soil and cliff accumulated substance and river bed accumulated substance are not developed.

Therefore, the exposures of basic rocks are many, and specially in the vicinity of dam spot, the fresh and hard conglomerates partially overhang and form a shart cliff, Further, no large scale dislocation is recognized.

In the raceway route, the conglomerate or coarse-fine sand stones are distributed out of the accumulated locks from Jurassic period to Paleogene. Partially a slight unconformity is recognized but generally the north/west-south each direction running and the north east inclination continues almost over the entire area of route.

No large scale dislocation and crush zones are recognized, In addition, no organization topography attributable to the geology structure can be recognized. As the surface layer accumulated substance, the weathered layer developing thick on the partial area, especially on the top of ridge is featuristic. On the other hand, the cliff accumulated substance and the river bed accumulated substance are not developed so much.

In the Paquita River basin at the power station spot, the conglomerate or coarse-fine particle sandy rocks are distributed much out of the sedimentary rocks from Jarassic period to Palaengeno. On the other hand, with the vicinity of power generation station planned spot as its boundary, the fine particle sedimentary rocks involving the calcium sedimented substances are dispersed on the west side. It can be observed partially that the lime rocks are involved as the allochthonous rock body in the peat rocks. The peat rocks includes the location indicating the slaking characteristics but the fresh area includes also the location showing the relatively massive state ??rotoh??. No large scale of dislocation can be recognized.

The location showing the dislocation crush belt zone where the weathering or degradation can be recognized partially in the boundary between both the parties, but which can be considered to be the slightly inclined unconfonnity.

As the surface layer sedimented substance, the strong weathering layer at the location indicating the irregular and complex topography is featuristic and also the cliff sedimented substances are recognized at some locations but they are not of large scale. The sedimented substances applicable to the upper and lower two stage terrace are recognized to the terrace sedimented substance along Paquita

River, and along the present river bed, the river bed sedimented substance consisting of unsolidified conglomerate layer is developing.

b) **Precious topography**

No precious topography are not recognized at the project spot.

13.2.3 Hydrological Characteristics

(1) **Surface Water**

The hydrological environment of the rivers concerned in this survey is indicated below.

a) **The Areas of River Basin**

The areas of the Naranjo River and Paquita River basins are shown below.

Basin	Naranjo River	Paquita River
Upper Basin	149.47	31.87
Mid-Stream Basin	68.73	35.98
Lower Basin	50.63	33.92
Basin Total	268.83	101.77
Total	327.90	

b) **Weather**

The rainfall pattern on the Pacific Ocean side features a well-defined dry season between December and April, a wet season between May and November, and a short dry season, called a "small summer", between July and August.

The climate of the Naranjo River basin, the height above sea level of which varies from 0 to 2,900 m, varies quite distinctly over an extremely short distance.

According to the Koppen classification, the Naranjo River basin exhibits two distinct types of climate.

The climate over an altitude of between 1,500 and 2,900 is called a "rainy moderate climate" (CW'a). The average temperature during the coldest month varies between -3°C and -18°C, and the temperature during the hottest month is at least 20°C.

On the other hand, the part of the basin at an altitude of between 0 and 1,500 m is known for its short dry season. In other words, it has a rainy tropical climate (Amw) which is suitable for growing tropical forests.
During the driest month, the rainfall is no more than 60mm. The temperature during the coldest month is at least 18°C.

The rainfall varies between 2,400 mm on the north eastern side where the altitude is highest, to 8,000 mm in the central zone near the Los Llanos dam site (Figure 13-6). The rainfall decreases in the downstream direction, and is 4,000 mm in the coastal zone.

The rainfall in this region varies greatly between the dry season and the wet season. During the dry season from December to March, the rainfall is between 100 and 200 mm, while during the wet season, particularly September and October, the average monthly rainfall is between 900 and 1000 mm. During the wet season, rain falls as a result of the combination of the trade winds from the Pacific Ocean side and the mountain slopes that form the basin (orographic region).
On the other hand, torrential rain that causes flooding in the basin is caused by hurricanes from the Atlantic Ocean side (non-orographic region). Table 13-1 shows the average monthly rainfall at three points in the Naranjo river basin. Table 13-2 shows monthly rainfall data for the past 22 years at Baltolo.

e) **Flow rate**

The source of the Naranjo River is the Gemelas spring of Quebrade Gemelas on the 2,800 m Palanana mountain. Many springs which do not have names flow into the Naranjo River before it joins with the Naranjito River. The only village between the source of the Naranjo River and the point where it joins with the Naranjito River is Naranjo. From here, the river flows into a deep canyon.

The source of the Brujo River, which is another mainstream, is located in the Bayoneta Range at a height of 2700 m above sea level. This river flows along the northern boundary of the Nara Mount protected area roughly parallel to the Naranjo River before converging with the Naranjo River.

The source of the Naranjito River, which is a mainstream, starts in La Laguna, which is 2,160 m above sea level, and Dota Rang. It flows near the villages of Bajo Reyes and Naranjillo, then converges with the Naranjo River.

The average annual flow rate calculated from flow rate observation data taken over a period of 22 years at the measurement point in Londres, which is at the middle reaches of the Naranjo River, is 28 m^3/sec.
The maximum average flow rate (average for October over a period of 23 years) is 56 m^3/sec., and the minimum monthly average flow rate is 5.7 m^3/sec. (Table 13-3).

By performing correlation with the flow rate at this point, the flow rate at the Los Llanos dam site was estimated to be 15 m^3/sec., and the maximum and minimum monthly average flow volumes were estimated to be 27 m^3/second and 4.3 m^3/sec., respectively (Table 13-4(a)).
The flow rate measured 1994-1995 at Los Lanos, Lordres and Brujo river are shown in Table 13-4(b).

d) **Suspended sediment and drage sediment**

According to an estimate made by ICE, the average annual amount of suspended sediment at Londres is 151,000tons. Also, the average annual amount of draged sediment was estimated to be 49,000 tons using the Meyer-Peter equation, and 35,000 tons using the Einstein-Brown equation respectively.

The reported (ICE 1994) values for Naranjo River suspended and draged sediment at Londres are as follows.

Total annual suspended sediment	151,000 ton/year
Draged sediment	42,000 ton/year
Total	193,000 ton/year

e) **Water quality**

The water quality of the Naranjo, Brujo and Paquita rivers is as shown in Table 13-5 ~ 13-7 .

・ Naranjo River

According to data for the past two years, the BOD is a maximum of 2.2 mg/l, phosphates a maximum of 0.59 mg/l, and nitrates 0.99 mg/l, and the average figures are 1 mg/l, 0.2 mg/l, and 0.5 mg/l, respectively. Although the BOD is low, there is a tendency for high phosphate and nitrate values to appear at certain times.

According to measured values obtained at Londres between February and March, which is the dry season, the BOD was between 0.8 and 1.7 mg/l, which indicates that the river is clean. The values for phosphates was between 0.06 and 0.07 mg/l, for ammonia salts between 0.003 and 0.018 mg/l, for nitrites between 0.002 and 0.008 mg/l, and for nitrates 0.001 mg/l max. It can thus be seen that while the phosphate content is somewhat high, the nitrogen content is extremely low. At Los Llanos as well, the BOD was low, being between 0.5 and 1.2 mg/l, however the figure for ammonia salts was somewhat high, lying between 0.007 and 0.063 mg/l. However, other nitrogen values were low, and phosphates were also low, indicating a tendency toward oligotrophication.

- **Brujo River**

The BOD of the Brujo River is between 0.59 and 1.9 mg/l, and the phosphate and nitrogen contents are also low.

- **Paquita River**

According to data obtained in September near the mouth of the river, the BOD is 0.7 mg/l, phosphates 0.4 mg/l, nitrates 0.02 mg/l, and DO 7.8 mg/l.

The BOD measured during the dry season between February and March was between 0.2 and 1.9 mg/l, and phosphates were 0.09 mg/l. Both phosphates and, nitrates seem to be high during the wet season.

However, this water quality is basically the same as that of the Naranjo River. The data obtained between April and July is as follows.

The BOD in April is clean at 0.4mg/l, but the TIN is in the higher trend at 0.08mg/l as compared with the other periods. This inclination appears not only in Paguita river but also in Naranjo river.

(2) Hydrogeological Characteristics

According to OFIPLAN (1979), it is considered that there is a plentiful supply of underground water in the Naranjo River basin. Underground water is utilized as the source of service water by means of several wells, however it been reported that in the vicinity of the Naranjo River the water level drops in the dry season.

Table 13-8 shows the results of a survey of the water level in the wells distributed in the downstream region of the Naranjo River (Figure 13-7).

During February and March, the water level is low in the vicinity of the water intake (W-5) and also in the vicinity of the Quebrada Estero Negro (W-6) and also in the vicinity of Estero Negro by the sea (W-1), and conversely the water level is high at the cultivated land at the south of the palm plantation (W-4), Delicias at the south east of the plantation (W-3), and the sand bar on the sea side of Estero Negro (W-2).

Groundwater levels varied little (0.3 m) at W-1 and W-2 near the seacoast, but rose about 1 m at W-3, 4 and 6 and fell some 1 m at W-5 near the intake. Water surface in almost all the wells was at approximately 2 m from the top of wells, indicating that water levels were close to the ground surface, even in the dry season.

13.2.4 Soil Characteristics and Usage Condition

Soil map for the project area and its periphery indicates that the area consists of mainly Entisoles (E), Inceptisoles (I) and Ultisoles (U). The soil at the reservoir and Banu (?) area, directly related to the project, is E11 of Lithic Ustorthent. The soil is distributed in steep areas, whose topsoil is characterized by erosion susceptibility as it consists of fine particles with deep thickness and drains very well.

In Palm plantation and near mouth of the Naranjo River exists the soil classified as I173 and E16, belonging to Fluvaquentic Ustropept and Typic Ustifluvent, respectively. They involve fine particles and have good permeability.

13.2.5 Aquatic Organisms

(1) Rivers

According to observations made at the dam site on the Naranjo River (ICE 1994), there are four kinds of fish including Mugilidae and Poecilidae (Table 13-2). Also, a survey of fish in the Naranjo River and Paquita River performed during the dry season indicates that there are a total of 18 kinds of fish, including two kinds of Gambusia affinis, three kinds of Eleotris oxycephala, one kind of Gobius, one kind of Haemulidae, three kinds of Cichlidae, four kinds of Characidae, one kind of Striped mullet, two kinds of Lutjanus vitta, and one kind of Centropomidae (Appendix 13). A total of four kinds of fish in the Striped mullet,

Lutijanidae and Centropomidae family, were found at the mouth of the Naranjo River and Estero Negro.

Pocilliopsis turrubatrensis, which belongs to the Poecillidae family, was not found in the lower reaches of the Paquita River.

(2) Brackish water area and coast

Contour line of depth in the front of the Manual Antonio National Park and the mouth of the Naranjo River roughly follow the coast line, however the vicinity of Mogote Island in front of the mouth of the Naranjo River is shallow and the 10 m depth line is roughly 2 km offshore (Figure 13-8.). The sediments at the mouth of the Naranjo River (CCT 1984) consists of sand and clay, and is dark brown.
The sediments in the vicinity of Mogote Island consists of sand, shells and clay, and is gray. The sediments in front of Puerto beach consists of sand and shells, and is gray. It is no different to the west side (Figure 13-9.).

According to a survey of the current in this water area (CCT 1984), there is a westward current in front of the mouth of the Naranjo River, however at flood tide there is also a current that flows toward the river mouth (Figure 13-10).
According to a biological survey carried out by CCT (1982) in the Manuel Antonio National Park, the area is inhabited by the following life.

The fish that inhabit shallow waters include Goubis, Aspasma, Chromis notatus, Snake eel, Engraulic, Paraprist poma trilineafum, and Striped mullet. Mollusca include Sea hare, Holothuria, Placophora, Mytilus, Conus, Littorihacea, Cerithium nodulosum, Cypraeacea, Oliva, Neritacea, and Batillaria. Anthropods include Balanus, Paguridae, Alpheus, Pachygrasus crassipes, Petrolisthes, Palinurus, Squilla, Palaemon nipponensis, Ocypoda stimpsoni, and Panaeidae. Echinodermata include Echinometra, Diadema, and etc. (Appendix.).

(3) Marine Life

A sand beach of about 10 km extends from the Naranjo River to the Savegre River. There are few houses and tourists hardly ever come here. This sand beach is said to be the spawning ground for the sea turtle.

Three kinds of sea turtle migrate to this beach, and it has been reported that in the spawning season between 3 and 50 sea turtles come up onto the beach. A turtle hatchery is provided at one corner near the mouth of the Naranjo River (Figure 13-11).

This area has been ranked second on a 4-step scale, as a migration and spawning ground, based on research carried out at Costa Rica University in 1990 (Table 13-10).
According to information concerning turtle spawning grounds (Figure 13-10), three kinds of turtles, Olive Ridley, Leatherback and Hawksbill, migrate to this spawning ground.

Fundevi (1944) issued the following report concerning large marine animals.

In the range of the Naranjo River and Paquita River, the most general kind of marine animal is the Humpback whale (Nwgaptera ovaenglia, Balaenopteridae). In January, the Bottle nose dolphin (Tursipos truncatus, Delfinidae) appears, as shown in Appendix 10. Both of these animals come close to the shore. Reptiles that appear are the
sea snake(Pelamis platurus, Elapidae) and the above-mentioned three kinds of sea turtles. Sea turtles come up on to the land at most of the Pacific Ocean beaches, however there are several particularly popular spawning places among these beaches. In this area, between 10 and 15 sea turtles have been sighted on each of the Savegre and Matapalo beaches in one night. The kinds of sea turtles in this area are the Hawksbill (Eretmochelys imbricata), Olive Ridley (Lepidochelys olivacea) and Leatherback (Dermochelys coriacea).

According to a local field survey carried out by Fundevi in the Naranjo River and Paquita River areas, the spawning season is from June to November. Appendix 10 shows the animals that migrate to this area. In addition to sea turtles, dolphins, whales and other animals have also been sighted.

13.2.6 Terrestrial Animals and Plants

According to the outlines of life zones in Costa Rica, there are many transition zones at the borders of the life zones in conformity with natural conditions. It is said that 13,021 species of plants live in these zones.

Alien species have been positively introduced into Costa Rica, and their number exceeds 30 species even when limited to main timber plants, such as Cipres, Pino, and Casuarina. The number is estimated to exceed 200 species if all included. Those tree species which are said to be endangered in Costa Rica are listed in Table 13-11.

The basins of the Rivers Naranjo and Paquita are generally divided into the following four environment zones from upstream to downstream (as shown in Figure 13-11), and the project site and its surrounding areas are composed of characteristic climate zones, respectively.

- **Premontane wet forest (bmh-P V)**

This zone is appropriate for soil exploitation thanks to an affluent, but not excessive, amount of rainfall and is especially suited for exploitation of perennial crop and pasture. Trees are generally 30 to 40m tall and are composed of two or three strata of evergreen trees. A few broad leaf trees are found in the dry season. The amount of Periphytons may be classified from medium to affluent.
This zone covers Londres and its downstream areas.

- **Tropical wet forest (bmh-t)**

This zone involves a problem of soil erosion caused by excessive rainfall. However, it indicates high levels of biomass productivity and forest activities, and there are grown dense, tall Ceiba (Ceiba pentandre) and other forest trees. The amount of periphytons is affluent. This zone covers from Londres to the dam site and includes a part of Quepos.

- **Premontane rain forest (bp-p)**

The environment of this zone involves excessive rainfall and high temperature which restrict sustainable agriculture and pasturing. Few people live there for this reason. The plant in this zone is evergreen, and the amount of periphytons is affluent. The zone is characteristic of high biological diversity and density.
Trees are 30 to 40m high and are composed of three strata. The dam site is located in this zone.

- **Lower montane moist forest(bh-MB)**

This zone is suited for activities to utilize soil for gardening purposes, and many people live there. The hill area east of Londres belongs to this zone.

(1) Plant Species

Regarding the distribution of vegetation around the project site, there are a vast spread of crop land in the coastal area, except for the Manuel Antonio National Park, but no natural forest are found as the Landsat satellite images have indicated. The most conspicuous among the forests in this area is the mangrove in the Estero Negro in the coastal area.

However, no mangrove species are found in the Nefroforestal Lagoon where terrestrial grasses and bush flourish.

On the other hand, a part of the mountainous area of the project site has been developed, and grasslands are scattered on mountain sides. These areas have been exploited as pasture lands for domesticated animals and also as crop lands.

The project spot is occupied by Premontane Rain Forest (bp-P) and Tropical Wet Forest (bmh-t) as shown in Figure, and are structured of the species shown in Table 13-12 and 13-13.

a) **Reservoir**

The dam site is located at a valley covered with tropical forests, but there are no forests at the right bank downstream the dam site. The area is utilized as crop land. The left bank forms a forest which reaches into a protection zone. Rocks are exposed at both banks of the place where the main body of the dam is to be constructed and the flora is relatively poor. Trees flourish at the area to be covered with the reservoir, but some logged areas are found along the valley slopes of the right bank.

The area in the location which becomes the reservoir is 11.5ha, and according to the result of surveying the volume of trees with the blocks being determined, 16 species of tree can be recognized, and the timber volume reaches 279.8m^3 in 11.5ha. Table lists up the names of existing tree, but out of them Batocarpus costariencis (Ojoche macho) is the precious species positioned at A-rank. The market price of these tibers is estimated to be 1,073,000 colones.

b) **Dam site**

The survey has found a total of 24 families and 30 species(Table 13-15), including Moraceae, Paeoniaceae, Lauraceae, Myrtaceae, Piperaceae, and Burseraceae (ICE,1994).

Among them, Platymiscium belonging to the Papilionaceae family is protected as endangered species.

There is the junction between Naranjo river and Brujo river at about 4 km from just below the downstream side of Dam spot. In the project, the water volume in this block is planned to be decreased. The local climate (atmospheric temperature and

humidity) by altitude at the spot just below the dam spot is as shown in Figure 13-14. The humidity doesn't fall down at 3 spots different in altitude even during the period when flow rate of the river decreases in dry season, and the relationship between the reduction in flow rate of river and the local climate change is not found out.

c) **Power plant site**

At the power plant site have been found a total of 29 families and 107 species such as Piperaceae, Moraceae, Leguminosae, Araceae, Solanaceae, Myrtaceae, Rubiaceae, Lauraceae, and Euphorbiaceae(Table 13-16).

No plants belonging to these species have been identified as endangered.

d) **The river mouth of the Naranjo**

- **Mangrove forest at the mouth of the River Naranjo**

Fundevi reported (1994) that Rhizophora racemosa and Avicennia germinans are distributed along the main waterway and a low salinity area, respectively, and that both Rhizophora racemosa and Rhizophora harrisonia grow where sediments are disturbed while Rhizophora mangle grows where they settle.

It is also reported that at the rear side of the belts of R. racemosa and R. harrisonia is found a zone mixed with A. germinans and that the succeeding belt is extremely narrow and is composed of A. germinans.

It is further reported that a belt of Acrostichua aureum mixed with A. germinans follows the above belts and that there are a few types of belts with lower salt resistance.

As a result of the reconnaissance made in February 1995 of the area from the mouth of the River Naranjo to the interior of Estero Negro where mangrove grows, the following six species were found .

Salado	Avicennia gerainans or A. nitida
Guateador	Rhizophora harrisonii
Caballero	Rhizophora mangle
Pinuela	Pellicicra rhizophorae
Biajagua	Heliconia latisphata
Manslavejuro	Acrostichum aureum

The distribution of these species is shown in Figure 13-15 and in the observation at Estero Negro were found no substantial differences in the species compositions between the entrance and the secluded points of the water way. According to the situation indicating a vertical distribution structure, Pinuela was found in some places where Guateador was expected to be found.

Except the fact that Bijagua was found only near the river mouth, it is understood that terrestrial undulations had generated both horizontal and vertical distributions as observed above.

Along the River Naranjo, mangrove is distributed on both banks from the river mouth to 500m upstream. It also observed the transition from the mangrove into ordinary land species which had occurred at a very short distance. At the far end of the water way at the Estero Negro was formed the land on which Monocots and Ferns were growing well.

At the western water side of the Channel Cacao which connects to the Estero Negro were found mangroves partially covering the zone from the entrance about 200m ahead.

The salinity of the water at the point where the Estero Negro and this waterway connect to each other was 4 mg/l, but the scope as shown in Figure 13-16 was a tidal area. This figure also indicates the distribution of the water of the waterway at the connecting point of the Palm Plantation and the mangrove area.

Both banks of the water following the Palm Plantation are plain and are cultivated to grow paddy.

- **Mangrove in the Manuel Antonio National Park**

According to Fundevi (1994), the number of the mangrove species in the National Park was six: Rhizophora mangle L., Avicennia gumminans L., Laguncularia racemosa, Pellicicra rhizophorae Triana & Planch, Acrosticum aureum, and Boodleopsis verticillate Dawson.

- **Mangrove environment**

The INCU' report (1993) on mangrove along the Pacific coast in Costa Rica indicates the below-mentioned order of importance of the species in the mangrove

area at the Estero Damas and Estero Palo Seco (Quepos: 9°28"N and 84°13"W) which are slightly apart from the west of the project site.

R.racemosa>P.rhizophorae>Agerminans>R.mangle>L.racemosa

When referring to the environment of this area where mangrove grows, the salinity of the soil ranges from 26 to 30%, and the concentration of organic substances ranges from 12.9 to 13.4%. The salinity of the water is reported to change from one to 30.

Water quality measured at the mangrove area at Quepos and the mouth of the River Savegre was as shown in Figure 13-17,Table 13-17.

The water salinity ranged from 32 to 32.65 when measured at high waters at the mangrove in Quepos, thereby hardly indicating substantial differences between the entrance and the secluded end of the mangrove area. There are at least two small brooks flowing into the mangrove area, but they indicated an extremely small amount of water, since the survey was conducted in the dry season. The species comprising the mangrove area were Caballero, Pinuela, Salado, Mariquita, Manslevejuro, and Phryganocidia phollosporna which were scattered in the area in a form of communities.

This area dries up at low waters, and trees grow on flat portions, clearly higher than the level of water routes but immersed about 30 cm at high waters.

The species comprising the mangrove at the mouth of the River Savegre included Gateador, Salado, and etc. The salinity ranged from 1 to 32.79 at the surface layer, from 11.8 to 32.85 at 0.5m deep, and from 23.8 to 32.47 at 1m deep when measured in February which falls under the dry season. (Table 13-18)

The water quality at the mouths of the Estero Negro and the Naranjo is shown in Figure 13-18 and Appendix 11. The survey results are detailed as follows.

• **February**

Tidal differences between high and low waters range from about 2.5m to 3m. As the scope of salinity variation is shown below, there were definite differences in the horizontal distribution of salinity depending on tidal conditions. The salinity at the whole Estero Negro was reduced at the low waters when the water depth was also reduced.

The same is applicable to the mouth of the River Naranjo, but according to the data of February 27, a mass of water with relatively high salinity was left at some parts of the lower layer at both areas.

A mass of water with relatively low salinity remained at the surface of the mouth of the River Naranjo at high waters, while the Estero Negro indicated a uniform value of salinity since marine water enters almost all the parts of the river.

Tide	Depth (m)		Estero Negro	Naranjo
Low	0	(a)	2.3 to 27.5	2.2 to 13.7
		(b)	3.3 to 17.6	0.9 to 2
	0.5	(a)	2.3 to 29.5	26.7 to 32.4
		(b)	4 to 8.2	0.9
	1	(a)	27.9 to 31.2	29.7
		(b)	4.1	0.9
High	0	(a)	30.2 to 33	2.7 to 20.5
		(c)	29.8 to 32.7	2.1 to 15.3
	0.5	(a)	32.2 to 33	32.2 to 32.5
		(c)	31 to 32.7	31.7 to 32.4
	1	(a)	32.3 to 33	32.8
		(c)	31 to 32.7	31.7 to 32.4
	2	(a)	32.6 to 33	33.0
		(c)	31.2 to 32.7	-

*The data (a), (b), and (c) were obtained on February 27, March 1, and February 28, 1995, respectively.

* Data obtained at N-5 are not included in this table.

• **March**

The salinity in this month was as shown below.

Tide	Depth(m)	Estero Negro	Naranjo
Low	0	32.3 to 33.8	31.9 to 33.4
(rising)	0.5	32.8 to 34.3	31.9 to 34.2
	1	32.9 to 34.2	31.92
High	0	28.9 to 32.8	2.2 to 4.5
	0.5	30.6 to 32.8	30.4 to 32.7
	1	31.5 to 32.8	32.1 to 32.8
		32.1 to 32.8	32.7 to 32.8

According to the survey of the salinity while the tide is rising from the low waters, the value of salinity ranges around 33 at the Estero Negro, with values less than 33 measured at the entrance and the secluded area of the waterway (Figure. 13-19).

Similar patterns were found at high waters, though the values of salinity were slightly lower. The salinity was low at the mouths of the Estero Negro and the Naranjo.

• **April**

The salinity in this month was as shown below.

Tide	Depth	Estero negro	Naranjo
Low	0	0.0 to 2.5	0.0
	0.5	0.0 to 2.5	0.0
	1	0.o to 2.5	0.7
High	0	1.2 to 11.0	0.7 to 1.0
	0.5	4.8 to 11.1	1.2 to 3.7
	1	4.5 to 14.7	1.2 to 10.0
	2	5.1 to 25.8	20.0 to 28.5

The situation changed drastically from February and March, where no salinity exceeding 30 was observed and surface concentration was below 11 even at high tide.

The following table shows the relationship between flow rate at Londres and precipitation at Naranjillo in the 2 week period before and after April 26, when flow rate was considerably high with some precipitation at the measurement of the above salinity.

	April											May			
	19	20	21	22	23	24	25	26*	27	28	29	30	1	2	3
Flow rate (m^3/sec.)	13.3	15.3	16.1	18.7	20.3	18.7	16.9	18.8	20.0	20.0	20.9	20.0	17.6	17.7	20.2
precipitation (mm)	27.3	19.0	22.2	18.1	46.0	32.7	17.5	27.9	8.8	29.7	68.6	17.3	10.6	61.1	75.0

* The above salinity was observed.

As the flow rate at Londres in April from 1971 to 1993 was 4.70 m^3/sec at minimum, 8.51 m^3/sec on the average and 15.32 m^3/sec at maximum, shown in Table 13-4(a), 18.8 m^3/sec, observed on April 26, was greater than the maximum. This suggests that the salinity observation date was already in the rainy season, not in the dry season.

It is not evident, however, whether the Naranjo River has always such low salinity at the flow rate similar to the one observed on April 26, since salinity at a shrimp farm taking water from Estero Negro was controlled between 10 and 25 even at the peak of rainy seasons. Continuous observation for salinity in various conditions are desired.

e) **Plants in the Manuel Antonio National Park**

CCT (1982) reported that 84 families and 348 species of plants grew in the National Park (Appendix 12). Among them, endangered species are listed below.

Adiantaceae	2 species
Cyatheaceae	5 species
Dannstaedtiaceae	1 species
Schizaeaceae	1 species
Graminae	2 species
Orchidaceae	18 species
Palmae	1 species
Rhizophoraceae	3 species
Gymnospermae	2 species
Verbernaceae	2 species
Total	37 species

Those species which grow in brackish-water environment, form mangrove, and are protected include Avicennia uninda, Avicennia racemosa, Rhizophora mangle L., R. harrisil, and Cassipourea pondantha Stand.

(2) Animals

According to a report (Appendix 13) on endangered animals in Costa Rica, there are 11 species of Aves, 1 species of Amphibia, 7 species of Reptilia, and 16 species of Mammaria. Those whose numbers are decreasing include the families of Accipitridas and Falconidas and one species of Ara ambigua of Aves, one species of Iguana iguana of Reptilia, and 9 species of Mammaria including Dasypodidae.

The report of ICE (1994) which surveyed the dam site found the following species of animals.

They observed 9 species of Mammaria (Table 13-19) which included the endangered species of Alouatta palliera (monkey), Nasua narica (raccoon), Aquoti paca (paca), and Eira barbara (weasel).

They also reported 13 species of Aves, which included an endangered species of Aratingasp. (Parrot). For Reptilia, 10 species were observed, including two endangered species of Iguana (Table 13-20). Also 11 species of insects were observed (Table 13-21).

Fundevi made a report (1994) that the following animals were observed in an area between the Rivers Naranjo and the Paquita, including a coastal zone.

	Family	Species
Aves		
Pelecaniformes	4	4
Ciconiformes	3	6
Anseriformes	1	1
Falconiformes	3	7
Gruiformes	1	3
Charadriiformes	3	7
Columbiformes	1	5
Cuculiformes	1	1
Caprimulgiformes	1	2
Apodiformes	1	1
Coraciformes	1	3
Piciformes	3	3
Passeriformes	10	24

	Family	Species
Mammalia		
Carnivora	1	1
Primates	1	1
Amphibia		
Anura	2	3
Squamata	3	4

The species of these animals are as listed in Appendix 14 while those which are considered as endangered are listed in Appendix 15 which includes 8 species of Aves, 2 of Mammalia, and one of Reptilia (Green iguana).

Appendix 16 indicates those animals which are or have been endangered in this district according to past records. Among them, those animals which are related with water include the following species.

Amphibia
- Oedipina carablanca (Salamander)
- Eleutheradactylus (Mountain toad)
- Agalychnis callidryas (Gaudy leaf frog)
- Centrolenella spinosa (Grass frog)
- Centrolenella vireovittata (Grass frog)
- Atelocusvarius (Harlequin frog)
- Dendrobates granuliferus (Poison frog)
- Phyllobates vittatus (Poison frog)

Reptilia
- Anole
- Green iguana
- Rainbow boa
- Boa musarana
- Bicoloted mica
- Eyelash viper
- Cayman
- Crocodile

Monkeys, crocodiles, and a few species of birds were watched in the mangrove forest during the reconnaissance of the river mouth. Fundevi reported (1994) that the following birds had been observed there.

Aves

Vireo pallens, Vireonidae (Mangrove vireo)
Amazilia boucardi, Trochilidae (Mangrove humming bird)
Dentroica erithachoridus, Parulidae (Yellow mangrove warbler)
Casmerodius albus, Ardeidae (Great egret)
Egretta caerulea, Ardeidae (Little blue heron)
Euroocimus albus, Threskiornithidae (White ibis)
Cochlearius cochlearius, Ardeidae (Boat-billed heron)
Nyctanessa violacae, Ardeidae (Yellow-crowned night heron)

The Vegra Lagoon which is located near the River Naranjo in the Manuel Antonion National Park is protected from influences by the water of the river thanks to the difference in height between this location and the river.

About 2000 heads of monkey, Saimiri Oersteoi Citrinellus,regarded as vulnerable, are said to live in the Park, but there is another information that only 500 live there and the balance live outsides the Park .

13.2.7 Locations with High Landscape Value and Recreation Zone

The project spot is in the mountainous area, and the dam and the reservoir spots are inside the deep valley. The woodland paths runs in the vicinity of this spot, but the roads for the purpose of inhabitants' traffic, and the traffic volume is extremely low. The landscape around the dam and reservoir is the usual mountainous landscape.
The power generation spot is in the similar way and is located at the location which can not be seen from the roads.

The recreation spots in the vicinity of project site are the water bathing, fishing and river raft travel in the Londres of middle stream which is at the downstream side of dam spot. Manuel Antonio National Park is a recreation spot in the sea coast zone.

13.2.8 Noise and Vibration

No particular sources of noises and vibration exist in the dam site and the power plant site.

13.2.9 Population

The population of Costa Rica as of 1990 was about 3 million. The population distribution in the area related to the Los Llanos project is described below.

The Naranjo and Paquita rivers that are the object of the project are located in two administrative regions, Puntarenas Province and San Jose Province. The counties within these provinces that are directly related to the project are Tarrazu, which contains the San Carlos, Lorenzo and San Marcos areas, and Dota, which contains the Quepos, Savegra and Naranjito areas (Figure 13-20)

Looking at the population data for 1984 and 1990, it can be seen that the population in each county increased by about 10% during this interval. The percentage of the population in farming areas was 88% in San Marcos, 100% in San Lorenzo, 100% in San Carlos, 48% in Quepos, 100% in Savegra and 100% in Naranjito.

Province	County	District	Population	Area (km^2)	Density ($/km^2$)
San Jose	Tarrazu	San Marcos	5,381	42.07	127.9
			6,097		144.9
			7,232		172.0
		San Lorenzo	2,391	191.12	12.5
			2,990		15.6
			3,114		16.3
		San Carlos	1,073		
			1,434		23.4
			1,510		24.6
Puntarenas	Aguirre	Quepos	9,093	222.89	40.8
			12,279		55.1
			13,929		62.5
		Savegre	2,466	216.24	11.4
			3,113		14.4
			3,200		14.8
		Naranjito	1,760	104.64	16.8
			2,076		19.8
			2,136		20.4

* Upper column in the population is the data on 1984, middle is the data is on 1990, lower one is the data on 1994.

District	Name	Number	Remarks
San Lorenzo	Naranjo	10(?)	2 Families always reside here and 4 families moves according to the seasons.
	San Joaquin	60	Temporal population increase during the coffee harvest season.
	Napoles	Napoles	
	Santa Celilia	22	Temporal population increase during the coffee harvest season.
	Naranjillo	120	No population change.
	Esquipulas	50	No population change.
Naranjito	Villannueva	300	No population change.
	Paso Real	100	Population in the trend in the slight increase.
	Londres	1,500	Population in the trend in the decrease.
	Naranjito	600-500	Population in the trend of increase.
Quepos	Cerritos	200	Population in the trend of slight increase.

The total population of the main villages and hamlets in the Naranjo River basin is about 28,000. This is equivalent to about 1% of the population of Costa Rica.

There are 23 settlements in the basin area. Of these, the present population of the main villages and hamlets is as shown in the above table (based on field surveys). The total population of the six hamlets of San Lorenzo that were the object of the survey is about 400. In Naranjito, the total population obtained as a result of carrying out a field survey exceeded the figure of 2,076 obtained during the national census. This result indicates that the population is concentrated in Londres Each of the towns Villa Nnueva, Londres and Naranjito has a good bus service, and many people commute to the central city of Quepos on the coast. Coffee is grown in the upper reaches of the Naranjo River, and the population varies around harvest time.

13.2.10 Industry and Economy

(1) Situation concerning the development of industry and the economy

a) Upper reaches of the Naranjo River

There is a coffee industry in the upper reaches of the Naranjillo and Naranjo rivers, and most of the land under cultivation is sloping land of at least 45°. The coffee industry was started by settlers from Los Santos.

Presently, coffee is produced by milos brought in by the settlers, and is a potential source of contamination of the river water in the future.

On the left bank of the Naranjo River is a protected forest. Unfortunately, it appears likely that the forest may be reduced by settlers in the future. Future development in this area is the coffee industry, the raising of livestock for personal use and also for making a livelihood, and the growing of foreign species of trees.

b) Middle reaches of the Naranjo River

At present, economic activities and employment in this area are low. On the slopes on the left bank of the Naranjo River are forests which blend well with the natural scenery. On the right bank are plantations of annatto trees, while in the vicinity of the Gracias A Dios gorge are unimproved ranches.

c) Lower reaches of the Naranjo River

This is one of the areas of high population density. Industries here include palm plantations, tourism and fishing. These industries tend to spread outward toward Savegree beach.

d) Upper reaches of the Paquita River

The main industry here is the coffee plantations introduced by settlers from Valle de los Santos.

A significant contribution has been made to the development of the area by the laying of a road from the vicinity of Santa Juana to San Joaquin and El Rodeo.

This road has a steep gradient and the roadbed is unstable, and is a cause of erosion.

e) **Middle reaches of the Paquita River**

The main industries in this area are large scale livestock (cattle) raising and rice growing.

f) **Lower reaches of the Paquita River**

In this area, the palm industry, rice growing and teak cultivation are thriving, however the area is highly urbanized. Also, the area around and above the middle reaches of the Naranjo River has a thriving tourist industry, and is located strategically between Quepos City and the Manuel Antonio National Park.

(2) Structure of industry in the area that contains the planned site

The structure of industry in the area where the planned area is contained is as shown in Table 13-22. The primary industry is the agriculture which occupies 60% or about twice the national value of Costa Rica, and then comes the tertiary industry including the sight seeing industry

The commercial industry covers Coopesantos in Trrazu county and ICE in Aguiree county. According to the social economic evaluation of Aguirre and Parrita counties (SIS:Table 13-23), the population density and the land development force are at the upper rank but, the social economy index, the land development situation, the organization level of inhabitants and the maintenance of social foundation, etc. are in the extremely low situation. The SIS values of Quepos, Savegre, Naranjito and Parrita are respectively 5, 13, 9.13, 8063 and 8.00, and Savegre, Naranjito and Parrita districts are positioned at the poorest districts because the minimum value is 10 (Table 13-24). The population concentration is conspicuous in Quepos city, but in the middle degree and is not rich.

In these areas, desired are the maintenance of agricultural foundation and the additional maintenance of local economic development including the sight seeing development and natural rotation.

(3) Agricultural Production in the Project Area

Table 13.25 indicates past trend in agricultural production in Aguirre County. The County produces palm, achiote, vanilla, pepper, cacao, rice, maize, kidney bean, papaya and pine, among which palm and rice are main products. The production of these products tends to increase recently and reached 14,132 million colones in 1994.

Cultivated area downstream of the project area is 8,686 ha including the Paquita River basin. The area for the products other than the main ones are 5 ha for achiote, 2 ha for vanilla, 2 ha for pepper, 10 ha for cacao, 5 ha for papaya, 11 ha for banana and 1 ha for pine. Products including achiote and pepper are cultivated in a mountain region (Table 13.26).

(4) Main industries in hamlets

The results of a field survey concerning industries, water for drinking and other daily needs, and utilization of the river, in the hamlets along the Naranjo River, are shown in Table 13-27.

The hamlets in which coffee is the main industry are San Joequin, Santa Celilia, Napoles and Naranjillo. Stock raising is carried out in Naranjillo, and both stock raising and agriculture are carried out in Paso Real, Londres and Naranjio. The hamlets where agriculture is the main industry are Esquipulas and Villa Nueva.

In Londres and Esquipulas, the river is used for rafting but not for commercial fishing. In the lower reaches of the river, palm growing and shrimp farming are carried out.

The palm industry is carried out in an area that spans the Naranjo River and Paquita River. Fresh water is necessary for growing palms, and for this purpose small water channels criss-cross the plantation area. The turn over from palm growing is shown in the following table.

Owner	Fruit(MT)	Ha	Output by Ha
Jan 94-Nov 94			
• Palma Tica	102,430	7,455	13.7
• Independent Producers	41,244	2,704	15.3
Total	143,674(A)	10,159(B)	14.1(A/B)
1995(Estimated)			
• Palma Tica	124,044	7,614	16.3
• Independent Producers	50,847	2,704	18.8
Total	174,891(A)	10,318(B)	17.0(A/B)

(by Fundevi:1994)

The local produce and turnover in the hamlets along the river near the planned site has no difference in kind from one hamlet to another.

The center of the tourist industry is the Manuel Antonio National Park, and there are many hotels along the road joining the park to Quepos City. However, there are no hotels at the mouth of the Naranjo River on the eastern side of the park, or along the banks of the river.

13.2.11 Income and Unemployment

According to the urbanization percentage and employment percentage in the area including the project site, the labor possible population percentage is also increasing together with the population increase in Trrazu county. The employment population is increasing out of the labor possible population, 96% of all the labor possible population has the occupation and the unemployment percentage is only at 4%.

The contents of occupation of employment are such that the salary workers occupy the most or 53% or more than half, then 32% for the individual enterpriser, and the employers are only at 2%.

In Aguirre county, at total population decreased slightly in 1984, but the labor possible population is increasing. However, the labor possible population is about 50% and remains unchanged. Out of them, the employment population is about 90%, and the unemployment is about 10% which is comparatively higher than Tarrazu county.

The contents of occupation are such that the salary workers are about 73%, then the individual enterpriser at about 18% and the employers at 3%, thus the percentage of salary workers is high (Table 13-28).

Summarizing these matters, it can be said that the primary industry such as agriculture is the main occupation in these areas, and the workers employed by partial employers occupy the most population.

According to the hearing survey at agricultural office in Aguirre county in Londres, here are many people who work away from home in this area, and are in poor state with he average monthly income is 15,000 colones/family.

Savegre district and Naranjito district are said to be the poorest district in Costa Rica, the farm village district in Parrita county is also in the similar situation, and the social economic situation in these districts is said to be critical.

The society and economy in Aguirre county and Parrita county are subjected by the development of such primary industry as banana cultivation, palm cultivation, extensive livestock, rice cultivation, timber production etc. in the past, and 80% of agriculture farmers live in the forestry of the district to be protected, and are maintaining the self sufficient economy. On the other hand, almost all of the lands in plain field are occupied by a small number of owners, and the areas which are not utilized are considerable. The fishery is one of important economic activities in the objective area, but its technical level is low and it is said that the administrative support is less and the borrowing from financial agencies is difficult.

13.2.12 Land Utilization

(1) Current Land Utilization

According to the Costa Rica land utilization drawing (Figure 13-21 Instituto Geografico Nacional Depart Amento de Geografia), a large part of the area downstream of Londres in the Naranjo River basin, and downstream of Ceritos in the Paquita River basin is occupied by pastures and Africa palm plantations. Between these plantations are farms that grow seasonal crops and also forests. Near the sea are extensive mangrove forests. A long the banks of both rivers are cultivated land, rice fields, ranches, pastures and sparse forests. These areas are virtually flat.

The upper reaches of these rivers consist of forests. According to an on-site survey, there are pastures and fields, made by cutting down forests, which are located irregularly below the peaks and also on the slopes of the hills. Part of the forest on the downstream side of the dam site has already been cut down for agricultural development, and also part of the forest in the vicinity of the power station site has been cut down in preparation for raising livestock.

The situation in the upstream and downstream parts of the basin area is shown below. Figure 13-22 to 13-23 shows an image obtained by Landsat.

a) **Upper reaches of the Naranjo River**

Coffee growing is widely carried out in this area. On the western slopes, narrow roads are clustered together, while on the hill tops there are roads running between crop farms and grazing lands that have all but been denuded of trees.

The main type of farming is coffee(Coffee arabiga) growing amidst cypress (Cupresus sp.), jaul (Alnus juralensis), poro (Poro poro), and other kinds of trees related to citric acid. Stock raising is done on land surrounded by natural forests or planted cypress forests. In this area, there is a change in the land utilization situation. In other words, the land is gradually changing from pasture land to coffee plantation land.

Near San Lorenzo, coffee plantations are the main industry, while in San Martin, the land is used for both ranches and coffee plantations. However, the land is steep and unstable. There are also small corn (Zea maiz) beans (Phaseoulus vulgaris) and sugar (Sachacarum officinarum) plantations in this area.

The canyon located at the north of the Naranjo River in the direction of Milagro Hill is covered with dense forest. The existence of this forest signifies that natural water is stored here, thus ensuring a stable supply of water to the Naranjo River.
On the east side of the Naranjo River is the Los Santos forest protected district where the best environment is maintained. This forest supplies important water to the Naranjo River.

b) **Middle and lower reaches of the Naranjo River**

The land in the middle reaches is extensively used. Land application includes stock raising and cultivation of achoite. There are also small scale plantations of citrics, poppy and pepper. In the lower reaches, the land is used for single crop rice growing and large scale palm cultivation.

c) **Upper reaches of the Paquita River**

In the upper reaches, the way in which the land is used is rapidly changing. In some parts, there are unimproved ranches and landslides, and the land has been abandoned. Like the west side of the upper reaches of the Naranjo River, the land in this area is covered with small forests. Also, there are many heaps of sand and soil resulting from frequent washing away by rain. This has affected the middles reaches, where the village of La Gallega is situated, and also the lower reaches. This sand and soil is used for rice growing and palm cultivation.

d) **Middle and lower reaches of the Paquita River**

Mangroves and riverbank vegetation grow on the right bank at the mouth of the Paquita River. The mangroves called Rizofora mangle have a high resistance to salinity. Also, a muddy environment is created. The left bank at the mouth of the river has a thick layer of accumulated soil, and there is no vegetation on it. However, there is sand and tree trunks scattered about, so it is clear that the Paquita River has enough power to drag objects and material when it flows into the sea. There are rice paddies in the middle reaches and palm plantation in the lower reaches of the River. Downstream of Cerritos, on the right bank of the river mouth there exists a palm plantation and on the opposite side there is a teak (Tectona grandis) forest.

Near La Gallega village, the right bank of the River is eroded by the river flow.

(2) Change in Land Use (1987 to 1992)

Figure 13-23 depicts the changes of palm forest and grassland occurred in the last 5 years based on the Landsat images. Palm forest in Savegre and Parrita districts have seen considerable changes and there have been an increase in palm forest along the Naranjo River at the area extending south from TOMA district. Inspection of this area in 1955 found many palm trees still in the growth stage judging from their low height at the north side of the highway.

Grassland have changed in a wide area, especially drastically changed in the upper reaches of the Naranjo River and the middle reaches and mountain region of the upper reaches of the Paquita River.

(3) Future Land Use

Fundevi (1994) reported future land use as follows:

Land use for agricultural production in Costa Rica is in a stable dynamics. The area for crop production in 1960 was 9 percent of the national territory, 10 percent in 1980 and 10.32 percent in 1990. The area used for pastures has been increasing, as seen in 19 percent in 1960 and 31 percent in 1980. Forest areas has been decreasing from 56 percent in 1960 to 32 percent in 1990, which is related to the increase in pastures for livestock industry.

The situation described above for the country may be applied to Naranjo and Paquita River basin.

There is no comprehensive law pertaining land utilization which regulates planning and management for land and water resources. Only available legislation is the one pertaining natural resources or ecosystems. Concerning land use planning, the Executive Decree No.18564-MAG on November 6, 1988 created the Soil Conservation Service and a Land Use Capacity Determination Methodology was officialized in 1991. All these are considered as technical instruments for planning and management for areas with no specified use.

All these legal instruments could facilitate use of the natural resources base of the basin, if considered in a systematic way in the planning process for the basin.

13.2.13 Public Facilities and Services

(1) Degree of Fulfillment of Social Needs

A report on social infrastructure for Aguirre and Parrita Counties indicates that public health and nutrition conditions is middle and fulfillment of education and housing needs is not satisfactory, degree of fulfillment of comprehensive basic needs being middle (Table 13-29). However, there is a huge gap in the degree of fulfillment of basic needs between two Counties, Aguirre being 65 percent, but Parrita being 39 percent. Although the degree is judged middle for Aguirre County, its housing, education, public health and nutrition are not satisfactory and further many population migrates from rural area to urban one and both unemployment and semi-unemployment ratios are high; the reason for middle ranking for this County lies in the development of tourism in Manuel Antonio National Park and existence of comparatively well-developed commerce and service in Quepos City.

In Aguirre County, there is a paved road connecting to another state, only one in Costa Rica, as an infrastructure for rural area. In Aguirre and Parrita Counties, there are roads of 913 km in length in use, of which 63 percent is made with dirt, 37 percent gravel and 1 percent paved.

(2) Traffic

There are two principal roads in the project area as indicated in Figure 13-1 and 13-24; one is a route passing the central part of the country, originating at San Jose, going through San