No. 05

INSTITUTO GEOGRAFICO DE ENERGIA ELECTRICA

REPUBLIC OF COLOMBIA

FEASIBILITY REPORT

ON

ALTERNATIVE HYDROELECTRIC POWER PROJECTS

APPENDIX

OCTOBER 1978

INTER-AMERICAN DEVELOPMENT BANK

REPUBLIC OF COLOMBIA

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INSTITUTO COLOMBIANO DE ENERGIA ELECTRICA

REPUBLIC OF COLOMBIA

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JULUMITO HYDRO-ELECTRIC POWER PROJECT

APPENDIX

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APPENDIX

APPENDIX

APPENDIX– I

ADDITIONAL INVESTIGATIONS REQUIRED FOR DETAIL DESIGN

CONTENTS

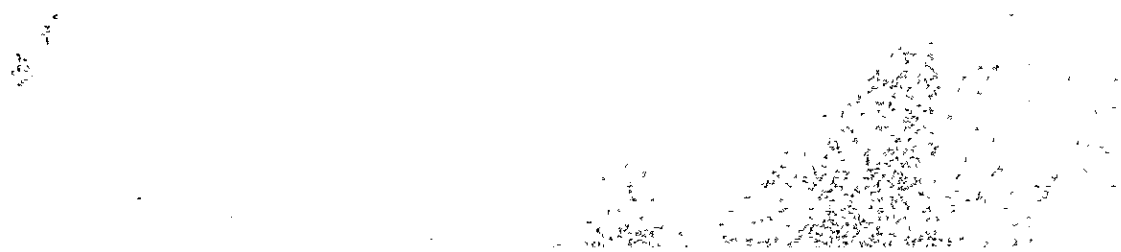


FIGURE LIST

APPENDIX I ADDITIONAL INVESTIGATIONS REQUIRED FOR DETAIL DESIGN

The particulars of the various investigations required to be completed by the time detail designing, as recommended in Chapter 2 will be described in this appendix.

I.1 Topographical Surveying

The scope of topographical surveying is shown in Fig. 1-1

I.2 Hydrological and Meteorological Investigations

I.2.1 Hydrological Investigations

(1) The run-off observation data of Julumito Gauging Station on the Rio Cauca, Malvasa and Palace Gauging Stations on the Rio Palace, and Pte. Carretera Gauging Station on the Rio Sate should be collected and arranged continuously for the future.

(2) Hourly flood discharge at the above gauging stations should be observed and arranged.

(3) In addition to the above, run-off at the gauging stations provided on the mainstream and tributaries of the Rio Cauca near the project catchment area should be gathered and arranged for as long a period as possible.

I.2.2. Meteorological Investigations

(1) Precipitation Data

(a) Observation data on daily precipitations at the meteorological observation stations of Popayan, Purace, Coconuco and Florida in the project area should be collected and arranged continuously for the future.

(b) A meteorological observation station should be provided in the Rio Palace intake catchment area and daily precipitation should be observed and arranged.

(c) Hourly precipitations during heavy precipitations should be observed and arranged at the above observation stations.

(d) In addition to the above, precipitation observation records at the meteorological observation stations provided on the mainstream and tributaries of the Rio Cauca near the project catchment area should be gathered and arranged for as long a period as possible.

(2) Temperature, Humidity and Evaporation

Observation data on daily temperature, humidity and evaporation at Popayan Meteorological Observation Station should be gathered and arranged for as long a period as possible.

I.3 Geological Investigations

ICEL and the Survey Team carried out various field investigations (geological investigation works, dam embankment materials tests and preparation of topographical maps) from May 1979, and these investigations have been completed.

Upon analyses of the results of these investigations, the Survey Team considers it desirable for a small amount of additional supplementary investigations (additional tests on dam foundation, dam embankment materials, etc.) to be conducted.

These additional supplementary investigations would consist of the items described below.

I.3.1 Julumito Dam Site

A. In-situ Loading Tests

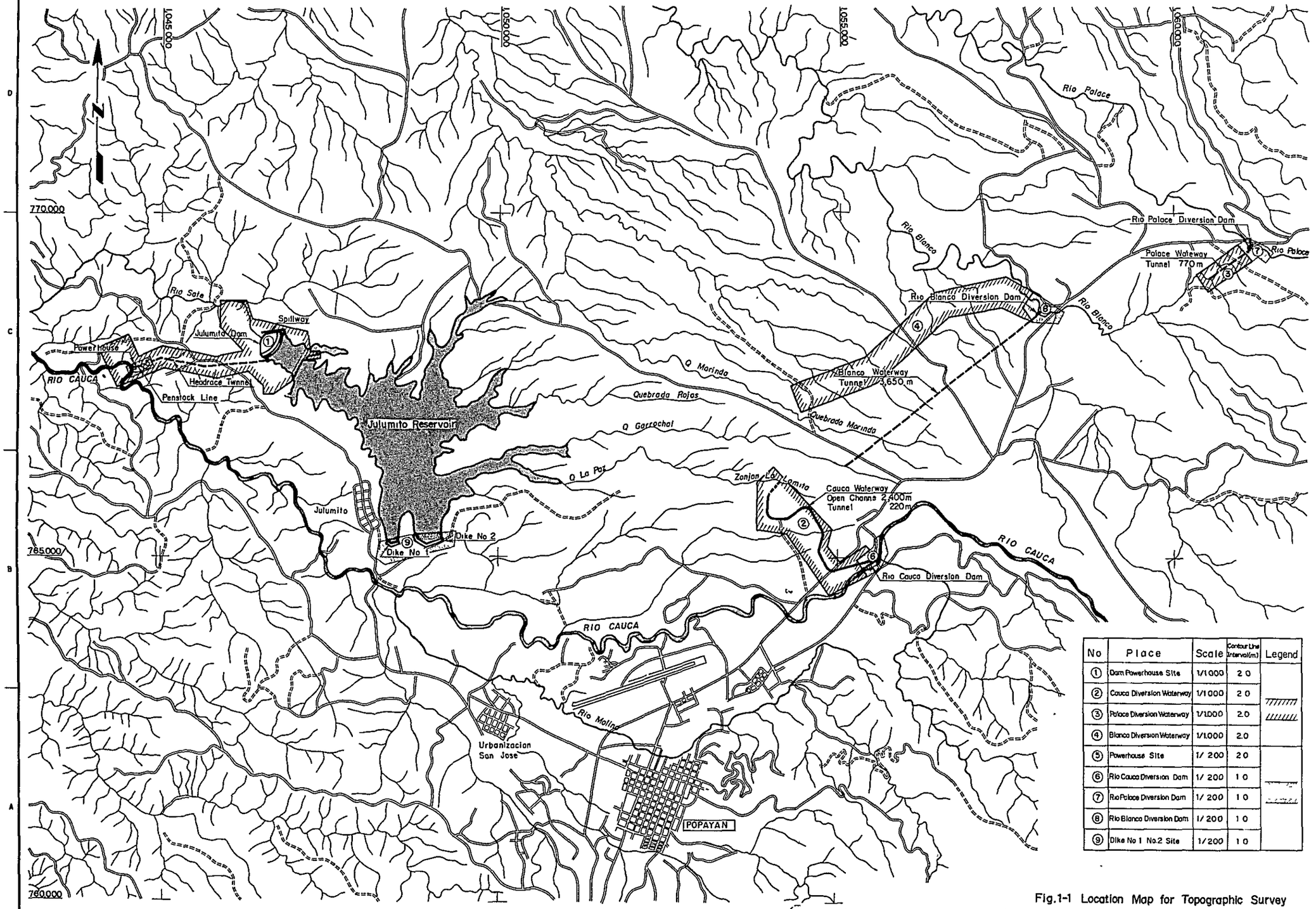
The purpose of these tests would be to estimate the bearing capacities of the volcanic ash layer and the weathered andesitic lava. The tests would be performed utilizing trenches, test adits and test pits, with load-settlement curves prepared, and coefficients of deformation, static moduli of elasticity and yielding loads calculated.

The locations of the tests would be as indicated in the following table.

Test Points for In-situ Loading Tests

Test Adit or Pit	Test Point	Number of Test Points
	(Distance in meters from portal)	
Test Adit A-1	5, 10 and 15 m	3
A-2	do	3
A-3	do	3
A-4	do	3
	(Depth in meters from top)	
Test Pit DTP-101	3, 5 and 7 m	3
DTP-102	do	3

With regard to test adits, some are collapsed at portals, and in conducting the tests, cleaning and reexcavation of loading planes will be required.



No	Place	Scale	Contour Line Interval(m)	Legend
①	Dam Powerhouse Site	1/1000	2 0	
②	Cauca Diversion Waterway	1/1000	2 0	
③	Palace Diversion Waterway	1/1000	2.0	
④	Blanco Diversion Waterway	1/1000	2.0	
⑤	Powerhouse Site	1/ 200	2 0	
⑥	Rio Cauca Diversion Dam	1/ 200	1 0	
⑦	Rio Palace Diversion Dam	1/ 200	1 0	
⑧	Rio Blanco Diversion Dam	1/ 200	1 0	
⑨	Dike No 1 No.2 Site	1/200	1 0	

Fig.1-1 Location Map for Topographic Survey

SHEET NO. OF

B. Tests with Undisturbed Samples

(1) Permeability Tests

(2) Direct shearing Tests ... Samples of size about 30 cm × 30 cm × 25 cm are to be collected, and tests performed consolidated, undrained. Deformation-stress curves during consolidation and shearing are to be prepared, and C and Φ calculated. Calculations of C and Φ are to be made using samples more than 4 and varying vertical load.

(3) CBR Tests ... The correlations with single shear tests, triaxial compression tests and consolidation tests are to be determined for use as one type of data for evaluation of the dam foundation.

(4) Triaxial Compression Test ... Samples are to be collected by thin-wall sampler and consolidated-undrained and consolidated-drained tests are to be performed.

(5) Consolidation Tests

Accompanying the abovementioned tests performed to examine the permeability, consolidation settlement and shear strength of the foundation, the tests of the following should be carried.

(6) Natural Water Content

(7) Field Density

(8) Dry Density

(9) Specific Gravity of Soil Particles

(10) Gradation Analysis ... Analyses are to be made especially of grain sizes smaller than 0.074 mm to clarify the content of silt and clay.

(11) Consistency ... Samples as close as possible to natural water content are to be used. Testing using material dried in an oven and adding water is to be avoided. In tests of liquid limit, samples are to be thoroughly remolded.

(12) In-situ (or with undisturbed samples) calculations of degrees of saturation and void ratios.

C. Grout Tests

On examination of the results of permeability tests on the volcanic ash layer and weathered residual soil, there is a point (critical pressure) where flow suddenly increases at 3 - 5 kg/cm^2 and lugeon values show 25 - 50. In order to grout effectively for these strata and achieve water cut-off, it is necessary to study the method of grouting to be adopted. At this site, grouting pattern of 3 rows or 5 rows is to be adopted and the grouting

is to be executed from the outer row to the inner row in order, and coefficients of permeability are to be calculated for the respective rows and the correlations with quantities grouted are to be investigated.

Regarding the packer to be used when injecting grout milk, since the geological condition is soft, it is desirable for an air packer type having enough sealing length, and moreover, readily capable of adjusting to variations of hole diameter to be adopted.

I.3.2 Dikes No. 1 and No. 2 Sites

A. Test Pits and Soil Tests

Two test pits each of 1.5 m x 1.5 m and 7 m deep are to be excavated at the No. 1 and No. 2 sites, respectively, for a total of 4 pits. Undisturbed samples are to be collected from 3 m, 5 m and 7 m, and direct shearing tests, triaxial compression tests and consolidation tests are to be performed, natural water contents, field densities, specific gravity of soil grain, gradation analysis and consistencies are to be measured, and in-situ degrees of saturation calculated.

I.3.3 Rio Palace Diversion Dam and Palace Diversion Waterway

A. Boring

At the Rio Palace Diversion Dam site, it is desirable for two boreholes each 20 m in length to be drilled to confirm the thicknesses of the river-bed sand-gravel and the weathered zone at the left bank.

For the tunnel route, it is desirable for one borehole of length of 60 m to be drilled at a place where the earth cover will be thin.

I.3.4 Rio Blanco Diversion Dam and Blanco Diversion Waterway

A. Boring

The vicinity of Rio Blanco Diversion Dam consists of river-bed sand-gravel and flood-plain deposits in the form of low terraces and the conditions cannot be said to be favorable for a dam foundation. It is desirable for three boreholes each 20 m in length to be drilled to confirm the geological condition of the dam foundation.

Regarding Blanco Diversion Waterway, it is desirable for boreholes each of 60 m length to be drilled at two locations along the tunnel portion.

I.4 Dam Embankment Materials

I.4.1 Quarry Site

According to the results from Borehole QDH-1 drilled at the right-bank side of the

Rio Cauca approximately 500 m downstream of the powerhouse site, the thickness of the volcanic ash layer is relatively small with the thickness of 26.0 m, but the underlying andesite has been subjected to strong weathering action and hard andesite cannot be obtained until reaching a depth of 54 m. Consequently, although it is possible to use this location as a quarry site to an extent, it is desirable to have a separate site investigated as an alternative.

As the next stage of investigation, it is desirable for a borehole of length of 100 m to be drilled at the alternative site at the left bank of the Rio Cauca opposite to the powerhouse, to obtain a concept of the geological condition and to examine the feasibility as a quarry site.

I.4.2 Borrow Area

In the latest investigations, various tests were performed mainly for the case of using the volcanic ash layer as core material, and an outlook on the feasibility of this was gained. It was found that the material is excellent in water cut-off properties, but there are some problems involved because of high water content.

Consequently, it will be desirable for the following tests to be additionally carried out.

A. Test by Deep Test Pit

A test pit of depth of about 15 m is to be excavated, samples collected from every 1 m of depth and a series of physical property tests performed to investigate the variations in influence of weathering and physical properties according to depth.

B. Tests With Blended Materials

In order to eliminate the drawback of using the volcanic ash alone as core material, it is desirable to blend volcanic ash and weathered andesite at a suitable ratio, and for compacted permeability tests, triaxial compression tests, etc. to be performed.

As a location where weathered andesite will be available, a site at the right bank of the Rio Cauca approximately 500 m downstream from the powerhouse site is conceivable.

APPENDIX – II

ACTUAL POWER DEMAND OF CEDELCA AND CEDENAR

CONTENTS

II-1 Performance at Generating End

Year	CEDELCA Maximum demand (MW)	CEDELCA Generated energy (GWh)	CEDELCA Energy growth rate (%)	CEDELCA Load Factor (%)	CEDENAR Maximum demand (MW)	CEDENAR Generated energy (GWh)	CEDENAR Energy growth rate (%)	CEDENAR Load Factor (%)	Total Maximum demand (MW)	Total Generated energy (GWh)	Total Energy growth rate (%)	Total Load Factor (%)	
1966	8.2	41.9	11.4	58.3	9.3	48.4	21.0	59.4	17.5	90.3	16.2	58.9	
1967	8.4	44.6	6.3	60.6	9.3	47.5	-1.8	58.3	17.7	92.1	2.3	59.4	
1968	8.9	47.6	6.5	61.1	9.4	47.7	0.2	57.9	18.3	95.1	3.3	59.3	-CEDELCA power system was interconnected with CEDENAR system in 1968
1969	11.4	51.2	7.3	51.3	20.0	61.7	29.3	35.2	31.4	105.9	11.3	38.5	-Rio Mayo P.S. was put in service in September, 1969
1970	12.3	61.8	20.8	57.4	18.8	85.7	39.0	52.0	29.2	147.5	39.3	57.7	
1971	13.1	66.7	7.8	58.1	19.4	103.6	20.9	61.0	32.5	170.3	15.5	59.8	
1972	13.9	70.3	5.4	57.7	26.8	133.1	28.5	56.7	40.7	203.4	19.4	57.0	-CEDELCA and CEDENAR power systems were interconnected with the central power system in 1973
		(69.8)		(53.5)		(130.1)		(53.4)		(199.9)		(53.4)	
1973	14.9	82.8	17.8	63.4	27.8	133.3	0.2	54.7	42.7	216.1	6.2	57.8	
		(82.6)		(63.7)		(144.8)		(52.8)		(227.4)		(56.3)	
1974	14.8	120.8	45.9	93.1	31.3	147.7	10.8	53.9	46.1	268.5	24.2	66.5	
		(102.0)		(61.3)		(162.7)		(53.2)		(264.7)		(56.1)	
1975	19.0	164.7	36.3	98.9	34.9	164.9	11.6	53.9	53.9	329.6	22.7	69.8	-Florida No.2 P.S. was put in service in November, 1975
		(111.3)		(55.2)		(182.5)		(48.5)		(293.8)		(50.9)	
1976	23.0	129.8	-21.2	64.4	42.9	184.0	11.6	48.9	65.9	313.8	-4.8	54.3	
		(120.6)		(53.4)		(182.7		(43.6)		(303.3)		(47.0)	
1977	25.8	126.3	-2.7	55.8	47.8	184.9	0.5	44.2	73.6	311.2	-0.1	48.3	-Ipiales substation was interconnected with Catambuco substation through 115 kV transmission line in December, 1975
Annual growth rate(%)													
'66 - '71	9.8	9.7	-	-	15.8	16.4	-	-	13.2	13.5	-	-	
		(10.4)				(9.9)				(10.1)			Figures in parenthesis indicate the value except for the energy sold to other electric power companies
'71 - '77	11.9	11.2	-	-	16.2	10.1	-	-	14.6	10.6	-	-	

	CEDELCA									CEDENAR									Total	
	(A)						(B)	(C)	(D)							(E)	(F)	(G)	(H)	(I)
Year	Generated energy (GWh)	Residentials (GWh)	Commercials (GWh)	Industrial (GWh)	Officials (GWh)	Street lighting (GWh)	Others (GWh)	Subtotal (GWh)	Loss factor (%)	Generated energy (GWh)	Residentials (GWh)	Commercials (GWh)	Industrial (GWh)	Officials (GWh)	Street lighting (GWh)	Others (GWh)	Subtotal (GWh)	Loss factor (%)	Energy demand (GWh)	Loss factor (%)
1966	41.9	21.4	3.5	3.0	2.8	1.5	-	32.2	23.2	48.4	27.2	-	4.5	1.1	2.7	-	35.5	26.7	67.7	25.0
1967	44.6	22.3	3.5	3.1	3.0	1.5	-	33.4	25.1	47.5	27.4	-	4.3	1.1	2.6	-	35.4	25.5	68.8	25.3
1968	47.6	22.5	3.4	3.4	2.9	1.5	-	33.7	29.2	47.7	27.5	1.1	3.8	1.3	2.4	-	36.1	24.3	69.8	26.6
1969	51.2	24.1	3.7	2.9	3.0	1.5	-	35.2	31.3	61.7	29.2	6.5	5.6	1.8	2.4	-	45.5	26.3	80.7	23.8
1970	61.8	28.6	4.4	3.1	3.6	2.5	-	42.2	31.7	85.7	43.3	9.4	9.2	3.2	2.8	-	67.9	20.8	110.1	25.4
1971	66.7	32.5	4.6	2.9	4.4	3.5	-	47.9	28.2	103.6	53.4	11.1	9.3	5.4	3.0	-	82.2	20.7	130.1	23.6
1972	70.3	34.3	5.0	3.0	4.6	3.6	-	50.5	28.2	133.1	57.7	10.7	9.4	5.6	3.4	-	86.8	34.8	137.3	32.5
1973	(69.8) 82.8	39.0	5.8	2.6	5.2	3.5	13.0	(56.1) 69.1	16.5	(130.1) 133.3	64.2	11.2	10.1	6.2	3.6	3.2	(95.3) 98.5	26.1	(152.4) 167.6	22.4
1974	(82.6) 120.8	44.9	6.5	2.8	6.3	3.8	38.2	(64.3) 102.5	15.1	(144.8) 147.7	68.4	11.9	9.8	6.2	3.8	2.9	(100.1) 103.0	30.3	(164.4) 205.5	23.5
1975	(102.0) 164.7	50.6	6.5	2.5	6.7	4.4	62.7	(70.7) 133.4	19.0	(162.7) 164.9	79.1	12.8	9.3	6.3	4.1	2.2	(111.6) 113.8	31.0	(182.3) 247.2	25.0
1976	(111.3) 129.8	57.6	6.8	3.4	5.9	4.4	18.5	(78.1) 96.6	25.6	(182.5) 184.0	89.3	12.6	9.2	6.6	5.3	1.5	(123.0) 124.5	32.3	(201.1) 221.1	29.5
1977	(120.6) 126.3	60.2	7.0	3.9	8.3	6.8	5.7	(86.2) 91.9	27.2	(182.7) 184.9	92.3	11.1	8.9	6.6	6.3	2.2	(125.2) 127.4	31.1	(211.4) 219.3	29.5
Annual growth rate(%)																				
'66 - '71	9.7	8.7	5.6	-0.1	9.5	18.5	-	8.3	-	16.4	14.4	-	15.6	37.5	2.1	-	18.3	-	14.0	-
'71 - '77	(10.4) 11.2	10.8	7.2	5.1	11.2	11.7	-	(10.3) 11.5	-	(9.9) 10.2	9.5	0.0	-0.1	3.4	13.2	-	(7.3) 7.7	-	(8.4) 9.1	-

Note: (1) (B) & (E): Energy sold to other electric power companies

(2) (D) & (G): $\frac{(A) - (C)}{(A)} \times 100$

(3) Figures in parenthesis indicate the value except for the energy sold to other electric power companies

II-3 General Information (1970-1977): CEDELCA

NUMERO DE SUSCRIPTORES FACTURADOS

Año	Residencial	Comercial	Industrial	Oficial	Alumbrado Publico	Otras Empresas	Varios	Total
1970	18874	1243	99	434	14	-	1	20665
1971	19775	1361	104	481	16	-	21	21758
1972	20615	1497	106	509	18	-	8	22753
1973	22159	1665	105	562	22	1	10	24524
1974	24008	1719	125	586	27	1	26	26492
1975	26699	1737	129	658	27	1	20	29271
1976	28403	1660	145	692	28	1	45	30974
1977	29309	1528	164	703	34	-	84	31822
Crec.%	6.49	2.99	7.48	7.13	13.51	-	88.32	6.36

MWh VENDIDOS

Año	Residencial	Comercial	Industrial	Oficial	Alumbrado Publico	Otras Empresas	Varios	Total
1970	28620	4224	3056	5069	1085	-	131	42185
1971	32529	4596	2916	4449	3527	-	52	48064
1972	34294	4991	2967	4646	3618	-	114	50630
1973	39012	5777	2572	5246	3524	12961	39	69131
1974	44868	6484	2808	6308	3842	38108	49	102467
1975	50703	6491	2545	6676	4409	62660	18	135502
1976	57597	6848	3441	5949	4109	37865	457	116266
1977	60231	7018	3914	8338	6771	5500	240	92012
Crec.%	11.22	7.52	3.60	7.37	29.90	-19.29	9.03	11.79

VALOR DE LA ENERGIA VENDIDA (MILES DE PESOS)

Año	Residencial	Comercial	Industrial	Oficial	Alumbrado Publico	Otras Empresas	Varios	Total
1970	4505	671	454	745	89	-	20	6484
1971	5559	813	490	861	367	-	22	8112
1972	7021	1109	552	1050	400	-	39	10171
1973	9544	1658	523	1210	406	1919	31	15291
1974	12619	2157	681	1400	445	5640	27	22969
1975	17896	2895	1264	2111	599	14013	45	38823
1976	25553	3937	2097	2846	721	3613	408	39175
1977	40242	5604	2969	4312	2411	1091	167	56796
Crec.%	36.73	35.42	30.77	28.51	60.21	-13.17	35.42	36.35

II-4 General Information (1970-1977): CEDENAR

NUMERO DE SUSCRIPTORES FACTURADOS

Año	Residencial	Comercial	Industrial	Oficial	Alumbrado Publico	Otras Empresas	Varios	Total
1970	26653	2711	423	347	25	1	-	30160
1971	28281	2840	475	407	27	1	-	32031
1972	33060	2803	502	462	20	1	-	36848
1973	32236	2855	546	474	30	1	-	36142
1974	34296	3191	580	431	32	1	-	38531
1975	40402	3019	596	479	38	1	-	44535
1976	44384	3069	590	499	58	1	-	48601
1977	48438	2869	524	515	54	2	-	52402
Crec.%	8.91	0.81	3.11	5.80	11.63	10.41	-	8.21

MWh VENDIDOS

Año	Residencial	Comercial	Industrial	Oficial	Alumbrado Publico	Otras Empresas	Varios	Total
1970	43469	9290	9100	6100	2869	11160	-	81988
1971	53373	11050	9256	5425	3245	16473	-	98822
1972	57746	10711	9390	5593	3390	16885	-	103715
1973	64179	11209	10065	6238	3638	3210	-	98539
1974	68387	11905	9755	6201	3818	2934	-	103000
1975	79075	12788	9192	6249	4141	2185	-	113630
1976	89600	12631	9167	6640	5258	1519	-	124815
1977	92310	11100	8888	6599	6289	2213	-	127399
Crec.%	11.36	2.58	-0.34	1.13	11.86	-20.64	-	6.50

VALOR DE LA ENERGIA VENDIDA (MILES DE PESOS)

Año	Residencial	Comercial	Industrial	Oficial	Alumbrado Publico	Otras Empresas	Varios	Total
1970	6364	1422	1271	458	241	1173	-	10929
1971	9837	2752	1805	1028	342	1903	-	17667
1972	12352	2870	2090	1104	384	1872	-	20672
1973	14750	3126	2314	1332	445	362	--	22329
1974	17468	4095	2554	1440	606	313	-	26476
1975	26420	6286	4689	2306	1290	240	-	41231
1976	38699	7679	6103	3233	2103	303	-	58120
1977	56189	10025	7245	4310	3931	780	-	82480
Crec.%	36.50	32.18	28.23	37.75	49.01	-5.66	-	33.47

II-5 Population

Unit: Thousand persons

	Cauca	Nariño	(A) Sub-total	(B) Entire Country	(A)/(B) x 100
1964	607.2	705.6	1,312.8	17,484.5	7.5
1965	623.3	729.2	1,352.5	18,107.8	7.5
1966	636.2	748.2	1,384.4	18,611.4	7.5
1967	643.4	767.7	1,411.1	19,129.1	7.4
1968	662.9	787.7	1,450.6	19,661.1	7.4
1969	676.7	808.3	1,485.0	20,207.9	7.4
1970	690.7	829.3	1,520.0	20,770.0	7.3
1971	705.0	850.9	1,555.9	21,347.7	7.3
1972	719.6	873.1	1,592.7	21,941.5	7.3
1973	734.6	895.9	1,630.5	22,551.8	7.2
1974	749.8	919.3	1,669.1	23,179.1	7.2
1975	765.3	943.2	1,708.5	23,823.7	7.2
1976	781.2	967.8	1,749.0	24,486.4	7.2
1977	797.4	993.1	1,790.5	25,167.5	7.1
1978	813.9	1,018.9	1,832.8	25,867.5	7.1
1979	830.8	1,072.8	1,903.6	26,586.9	7.1
1980	848.0	1,100.7	1,948.7	27,326.5	7.1
1981	865.6	1,129.3	1,994.9	28,086.5	7.1
Increase(%)					
'64 - '73	2.1	2.7	2.4	2.9	-
'73 - '81	2.1	2.9	2.6	2.8	-

APPENDIX III

OUTLINE OF ECONOMY OF REPUBLIC OF COLOMBIA

TABLE LIST

APPENDIX III OUTLINE OF ECONOMY OF REPUBLIC OF COLOMBIA

The economy of Colombia has developed relatively smoothly with bearing fruit of aggressive economic policies such as the economic development plans formulated from around the late 1960s and establishment of export goals. However, the major industry supporting the colombian economy is depend on still agriculture, i.e. coffee. The proportion of coffee to the total agricultural production was 62% in 1977, while the proportion of coffee to the total exports was also 62% aided by favorable prices. The economy depending on coffee (coffee production is second in the world next to Brazil) is affected by meteorological conditions and international market prices, and therefore, the Colombian Government has promoted industrial diversification and industrialization policies for a long time. Namely, import reducing industries have been promoted, while efforts have been made to nurture export industries, and emphasis has also been placed on growth of the chemical and heavy industries sector. In particular, capital has been concentrated in the petrochemicals, steel, shipbuilding and automobile sectors. Meanwhile, in the private sector, investment has been conspicuously concentrated in existing manufacturing industries, i.e. textiles, cement, foodstuffs and hides.

The results have already appeared prominently in the gross domestic product with the contribution of the manufacturing sector of GDP in 1975 being 4.0% over the 17.3% of 1960, while that in 1977 being 1.4% over. (The ratio of the manufacturing sector in 1977 relatively declined due to the sudden rise in coffee prices.) In the agricultural sector, the contribution shrank from 34.1% in 1960 to 25.8% in 1977. (If there had not been the sudden rise in coffee prices this ratio would have been even lower.) The trend of GDP after 1970 is shown in Table III-1, and the ratios of each department in GDP is shown in Table III-2.

Table III-1 Trend in Gross Domestic Product

Year	GDP 10^6 Col.$	Real Economic Growth Rate (%)
1971	40,605	5.5
1972	43,307	6.7
1973	46,602	7.2
1974	49,632	6.5
1975	52,604	5.3
1976	56,812	8.0
1977	59,653	5.0

Note: Price in 1958 = 100

Source: Banco de la República

Table III-2 Composition of Gross Domestic Product

	1960	1970	1975	1977
Agriculture	34.1	28.6	29.2	25.8
Mining	3.9	2.1	1.3	1.1
Manufacturing	17.3	17.5	21.3	18.7
Construction	3.6	5.5	5.1	4.2
Electricity, Gas, Water Supply	0.9	1.5	1.2	1.8
Transportation & Communication	6.6	7.4	6.1	8.8
Foreign Trade	15.7	17.3	18.1	-
Administration, Defense	5.5	6.9	6.8	-
Others	12.4	13.2	10.9	-
Total	100.0	100.0	100.0	100.0

In the colombian economy of 1977, the favorable export price of coffee continued from the previous year to be the motive force of growth, and whereas the manufacturing industries centering around textiles and foodstuffs grew, since production of the principal grains of rice, maize and wheat was unfavorable, the real growth rate (GDP) became 5.0% and was lower than the 8.0% of 1976.

As stated in 10.2.8, the greatest problem of the economy in Colombia is inflations, and the rate of rise in the consumer price index in 1977 was 22.2%, and although lower than the 27.2% of the previous year, the Government target of 10% could not be achieved.

Because the international prices of coffee changed to a high level, the foreign currency reserves reached US$1,829 million at the end of 1977 and is showing a trend of further increase and attained US$2,107 million in June 1978.

As described above, the economy of Colombia in 1977, supported by the favorable condition of coffee exports, has moved ahead smoothly, and in 1978 the production of coffee recorded the highest in history. It is estimated that the agricultural production increased greatly with the trend of economical expansion and that the growth rate (GDP) had been 6.8 to 8.4%

APPENDIX – Ⅳ

CALCULATION OF PRESENT VALUE

CONTENTS

APPENDIX IV CALCULATION OF PRESENT VALUE

IV.1 Present Value of Constant Annual Cost

With constant annual cost disbursement at the median of the year as A, and discount rate as i, the present value of disbursement A in the n-th year will be the following:

$$\frac{A}{(1+\frac{i}{2})(1+i)^{n-1}}$$

If the annual inflation rate is taken to be e, the above present value will be the following:

$$\frac{A(1+\frac{e}{2})(1+e)^{n-1}}{(1+\frac{i}{2})(1+i)^{n-1}}$$

Therefore, in case of considering this inflation rate, the total amount S_e converted to present value of the annual disbursement A over a period of n years is expressed by the following equation:

1st Year 2nd Year 3rd Year n-th Year

$$S_e = \frac{A(1+\frac{e}{2})}{(1+\frac{i}{2})} + \frac{A(1+\frac{e}{2})(1+e)}{(1+\frac{i}{2})(1+i)} + \frac{A(1+\frac{e}{2})(1+e)^2}{(1+\frac{i}{2})(1+i)^2} + \frac{A(1+\frac{e}{2})(1+e)^{n-1}}{(1+\frac{i}{2})(1+i)^{n-1}}$$

$$= \frac{A(1+\frac{e}{2})}{(1+\frac{i}{2})} \times \frac{(1+i)[(1+i)^n - (1+e)^n]}{(1+i)^n \times (i-e)} \quad \cdots\cdots\cdots \text{ in case of } i \neq e$$

$$S_e = nA \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{ in case of } i = e$$

IV.2 Present Values of Construction Cost and Equipment Replacement Cost

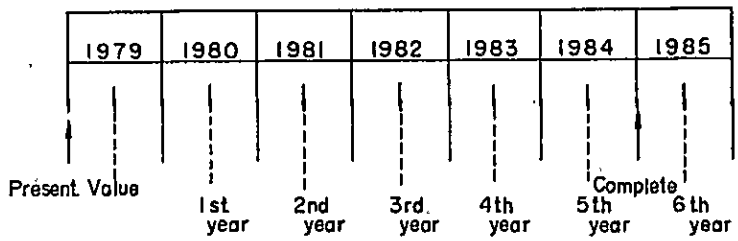
With the price in the middle of the year as A, and the inflation rate as e, the annual median price A_n in the n-th year will be the following:

$$A_n = A(1+e)^n$$

If the discount rate is i, the present value A' of the above price at the beginning of the year will be the following:

$$A' = \frac{A(1+e)^n}{(1+i)^n(1+\frac{i}{2})}$$

IV.3 Calculation of Present Value in Case of Discount Rate 12%



IV.3.1 Alternative Thermal Power Station

(1) Construction Cost (10^3US$)

Foreign Currency Portion (e = 7%, i = 12%)

1981: $1,744(1 + 0.07)^2/(1 + 0.12)^2(1 + 0.06) = 1,502$

1982: $7,546(1 + 0.07)^3/(1 + 0.12)^3(1 + 0.06) = 6,207$

1983: $9,606(1 + 0.07)^4/(1 + 0.12)^4(1 + 0.06) = 7,548$

1984: $8,546(1 + 0.07)^5/(1 + 0.12)^5(1 + 0.06) = 6,420$

21,677

Domestic Currency Portion (e = 10%, i = 12%)

1981: $1,741(1 + 0.1)^2/(1 + 0.12)^2(1 + 0.06) = 1,585$

1982: $4,677(1 + 0.1)^3/(1 + 0.12)^3(1 + 0.06) = 4,180$

1983: $5,612(1 + 0.1)^4/(1 + 0.12)^4(1 + 0.06) = 4,924$

1984: $6,677(1 + 0.1)^5/(1 + 0.12)^5(1 + 0.06) = 5,759$

16,448

Total $21,677 + 16,488 = 38,115$

(2) Operation and Maintenance Cost (10^3US$)

The prices in the middle of 1985 are as follows:

Foreign currency portion:

$A = A'(1 + e)^6 = 1,108(1 + 0.07)^6 = 1,663$

Local currency portion:

$A = A'(1 + e)^6 = 962(1 + 0.10)^6 = 1,705$

Foreign Currency Portion (e = 7%)

$$S_e = \frac{1,663(1 + 0.035)}{(1 + 0.06)(1 + 0.12)^6} \times \frac{(1 + 0.12)[(1 + 0.12)^{50} - (1 + 0.07)^{50}]}{(1 + 0.12)^{50}(0.12 - 0.07)}$$

$$= 822.6 \times \frac{290.68}{14.45} = 16,548$$

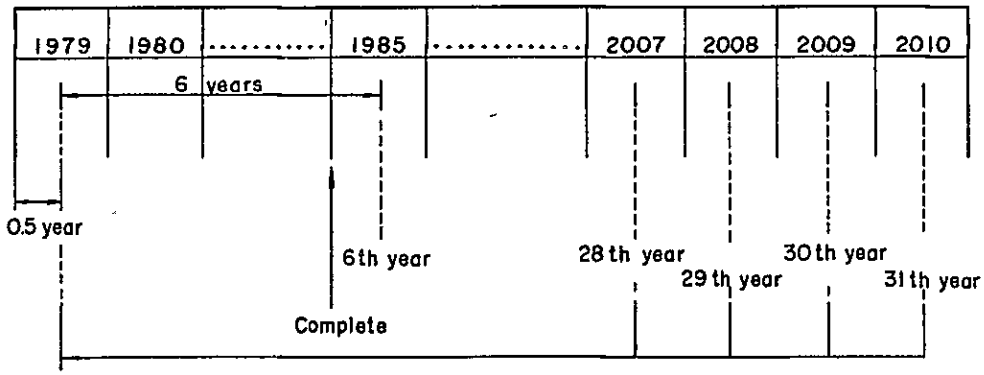
Local Currency Portion (e = 10%)

$$S_e = \frac{1,705\ (1 + 0.05)}{(1 + 0.06)(1 + 0.12)^6} \times \frac{(1 + 0.12)[(1 + 0.12)^{50} - (1 + 0.10)^{50}]}{(1 + 0.12)^{50}\ (0.12 - 0.10)}$$

$$= 855.6 \times \frac{192.2}{5.78} = 28,451$$

Total 16,548 + 28,451 = 44,999

(3) Equipment Replacement Cost (10^3US$)



Disbursements by Year

	Foreign Currency	Local Currency	Total
2007	1,195	1,993	3,188
2008	6,037	3,742	9,779
2009	7,684	4,490	12,174
2010	7,038	4,742	11,780
Total	21,954	14,967	36,921

Foreign Currency Portion (e = 7%)

2007: $1,195(1 + 0.07)^{28}/(1 + 0.12)^{28}(1 + 0.06) = 314$

2008: $6,037(1 + 0.07)^{29}/(1 + 0.12)^{29}(1 + 0.06) = 1,515$

2009: $7,684(1 + 0.07)^{30}/(1 + 0.12)^{30}(1 + 0.06) = 1,842$

2010: $7,038(1 + 0.07)^{31}/(1 + 0.12)^{31}(1 + 0.06) = 1,612$

5,283

Local Currency Portion (e = 10%)

2007: $1,993(1 + 0.10)^{28}/(1 + 0.12)^{28}(1 + 0.06) = 1,135$

2008: $3,742(1 + 0.10)^{29}/(1 + 0.12)^{29}(1 + 0.06) = 2,093$

2009: $4,490(1 + 0.10)^{30}/(1 + 0.12)^{30}(1 + 0.06) = 2,467$

2010: $4,742(1 + 0.10)^{31}/(1 + 0.12)^{31}(1 + 0.06) = 2,559$

8,254

Total 5,283 + 8,254 = 13,537

(4) Calculation of Fuel Cost (10^3US$)

$$S_e = \frac{2,232(1+0.035)}{(1+0.06)(1+0.12)^6} \times \frac{(1+0.12)[(1+0.12)^{50} - (1+0.07)^{50}]}{(1+0.12)^{50}\,(0.12-0.07)}$$

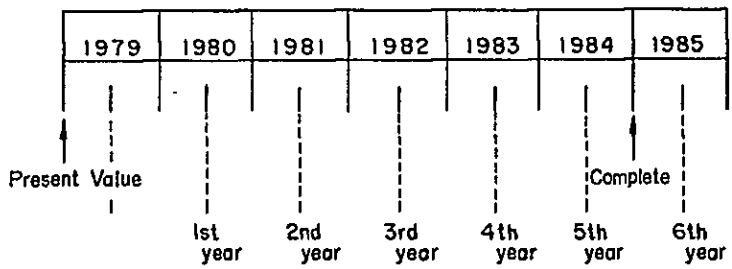
$$= 1,104 \times \frac{290.68}{14.45} = 22,208$$

Provided that the fuel cost in 1979 is US$1,487 x 10^3

$$A = A'(1+0.07)^6 = 1,487(1+0.07)^6 = 2,232$$

Total (1) + (2) + (3) + (4) = 38,125 + 44,999 + 13,537 + 22,208 = 118,869

IV.3.2 Julumito Hydro-electric Power Station



(1) Construction Cost (10^3US$)

Foreign Currency Portion (e = 7%, i = 12%)

1979:	0	
1980:	$571(1+0.07)/(1+0.12)(1+0.06)$	= 515
1981:	$149(1+0.07)^2/(1+0.12)^2(1+0.06)$	= 128
1982:	$10,587(1+0.07)^3/(1+0.12)^3(1+0.06)$	= 8,708
1983:	$18,695(1+0.07)^4/(1+0.12)^4(1+0.06)$	= 14,690
1984:	$10,559(1+0.07)^5/(1+0.12)^5(1+0.06)$	= 7,932
		31,973

Local Currency Portion (e = 10%, i = 12%)

1979:	$139/(1+0.06)$	= 131
1980:	0	
1981:	$1,554/(1+0.1)^2(1+0.12)^2(1+0.06)$	= 1,415
1982:	$9,192/(1+0.1)^3(1+0.12)^3(1+0.06)$	= 8,215
1983:	$9,709/(1+0.1)^4(1+0.12)^4(1+0.06)$	= 8,519
1984:	$5,975/(1+0.1)^5(1+0.12)^5(1+0.06)$	= 5,154
		23,434

Total 31,973 + 23,434 = 55,407

(2) Operation and Maintenance Cost (10^3US$)

The cost in the middle of 1985 will be the following:

Foreign currency portion:

$$A = A'(1 + e)^6 = 347\ (1 + 0.07)^6 = 521$$

Local currency portion:

$$A = A'(1 + e)^6 = 389\ (1 + 0.10)^6 = 689$$

Foreign Currency Portion (e = 7%)

$$S_e = \frac{521(1 + 0.035)}{(1 + 0.06)(1 + 0.12)^6} \times \frac{(1 + 0.12)[(1 + 0.12)^{50} - (1 + 0.07)^{50}]}{(1 + 0.12)^{50}\ (0.12 - 0.07)}$$

$$= 257.7 \times \frac{290.68}{14.45} = 5,184$$

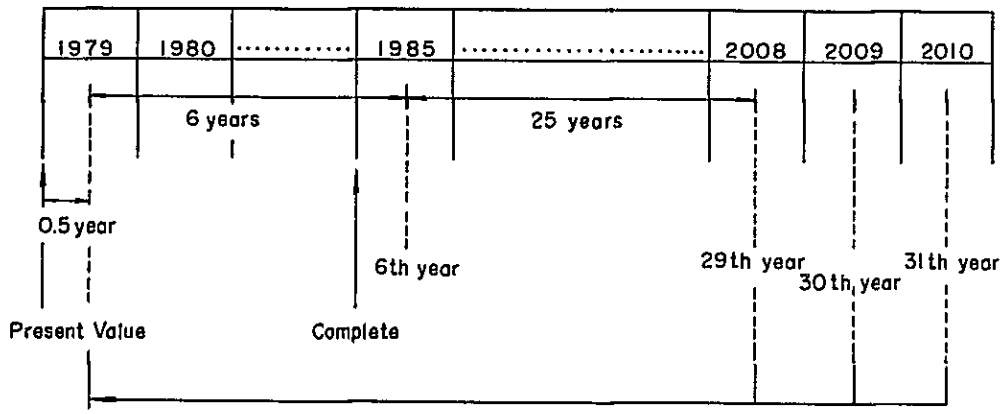
Local Currency Portion (e = 10%)

$$S_e = \frac{689(1 + 0.05)}{(1 + 0.06)(1 + 0.12)^6} \times \frac{(1 + 0.12)[(1 + 0.12)^{50} - (1 + 0.1)^{50}]}{(1 + 0.12)^{50}(0.12 - 0.1)}$$

$$= 345.7 \times \frac{192.2}{5.78} = 11,495$$

Total $5,184 + 11,495 = 16,679$

(3) Equipment Replacement Cost (10^3US$)



Disbursements by Year

	Foreign Currency	Domestic Currency	Total
2008	1,018	42	1,060
2009	7,875	380	8,255
2010	4,259	779	5,038
Total	13,152	1,201	14,353

Foreign Currency Portion (e = 7%)

2008: $1{,}018(1 + 0.07)^{29}/(1 + 0.12)^{29}(1 + 0.06) = 255$

2009: $7{,}875(1 + 0.07)^{30}/(1 + 0.12)^{30}(1 + 0.06) = 1{,}888$

2010: $4{,}259(1 + 0.07)^{31}/(1 + 0.12)^{31}(1 + 0.06) = 975$

3,118

Local Currency Portion (e = 10%)

2008: $42(1 + 0.1)^{29}/(1 + 0.12)^{29}(1 + 0.06) = 23$

2009: $380(1 + 0.1)^{30}/(1 + 0.12)^{30}(1 + 0.06) = 209$

2010: $779(1 + 0.1)^{31}/(1 + 0.12)^{31}(1 + 0.06) = 420$

652

Total $3{,}118 + 652 = 3{,}770$

Total (1) + (2) + (3) = 55,407 + 16,679 + 3,770 = 75,856