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THE STUDY
ON
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POWER [illegible]
PROJECT

VOLUME I

EXECUTIVE SUMMARY

OCTOBER 1993

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY
ON
ITAJAI RIVER BASIN HYDROELECTRIC POWER POTENTIAL INVENTORY PROJECT

VOLUME I

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LIST OF VOLUMES

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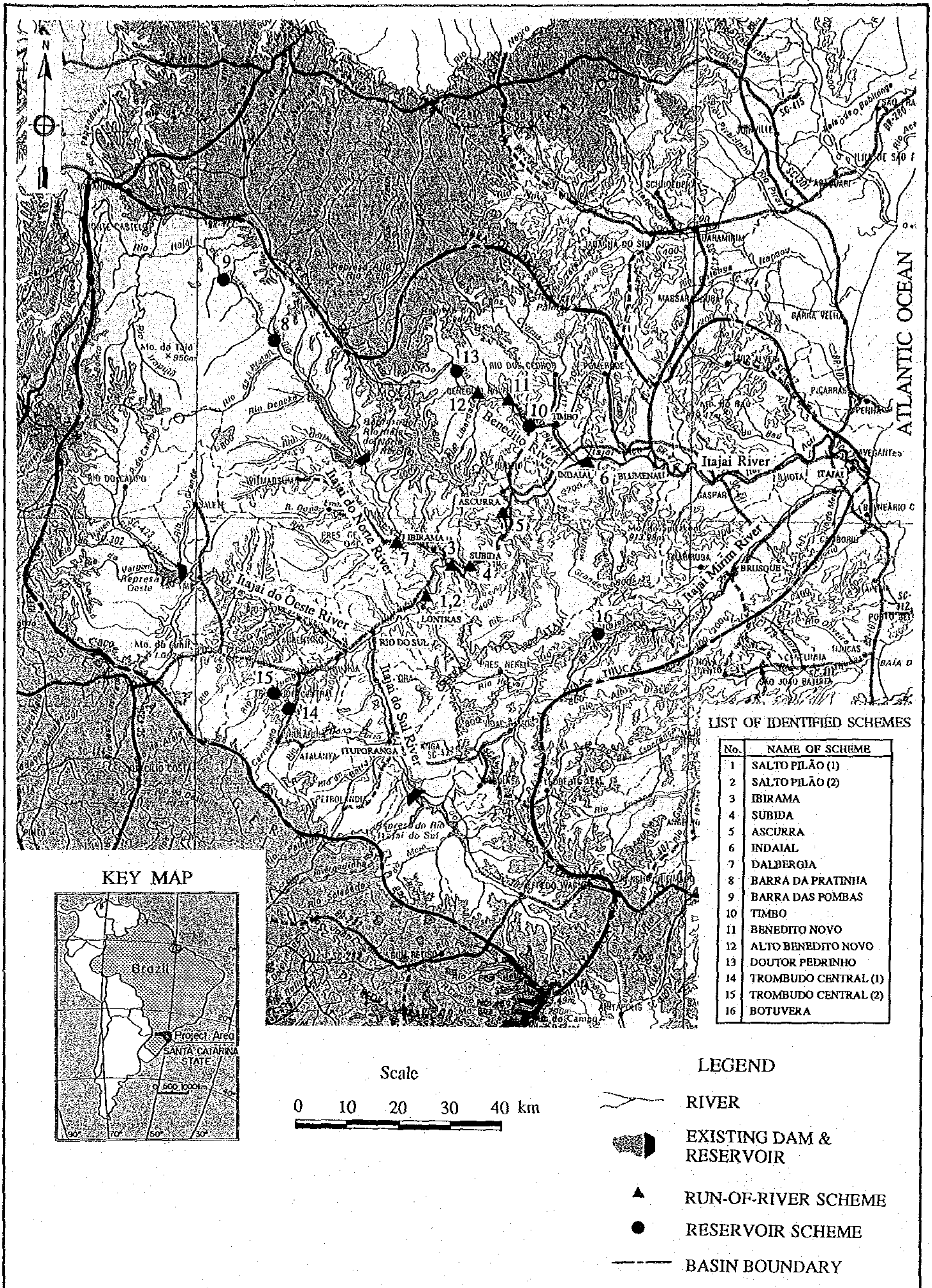
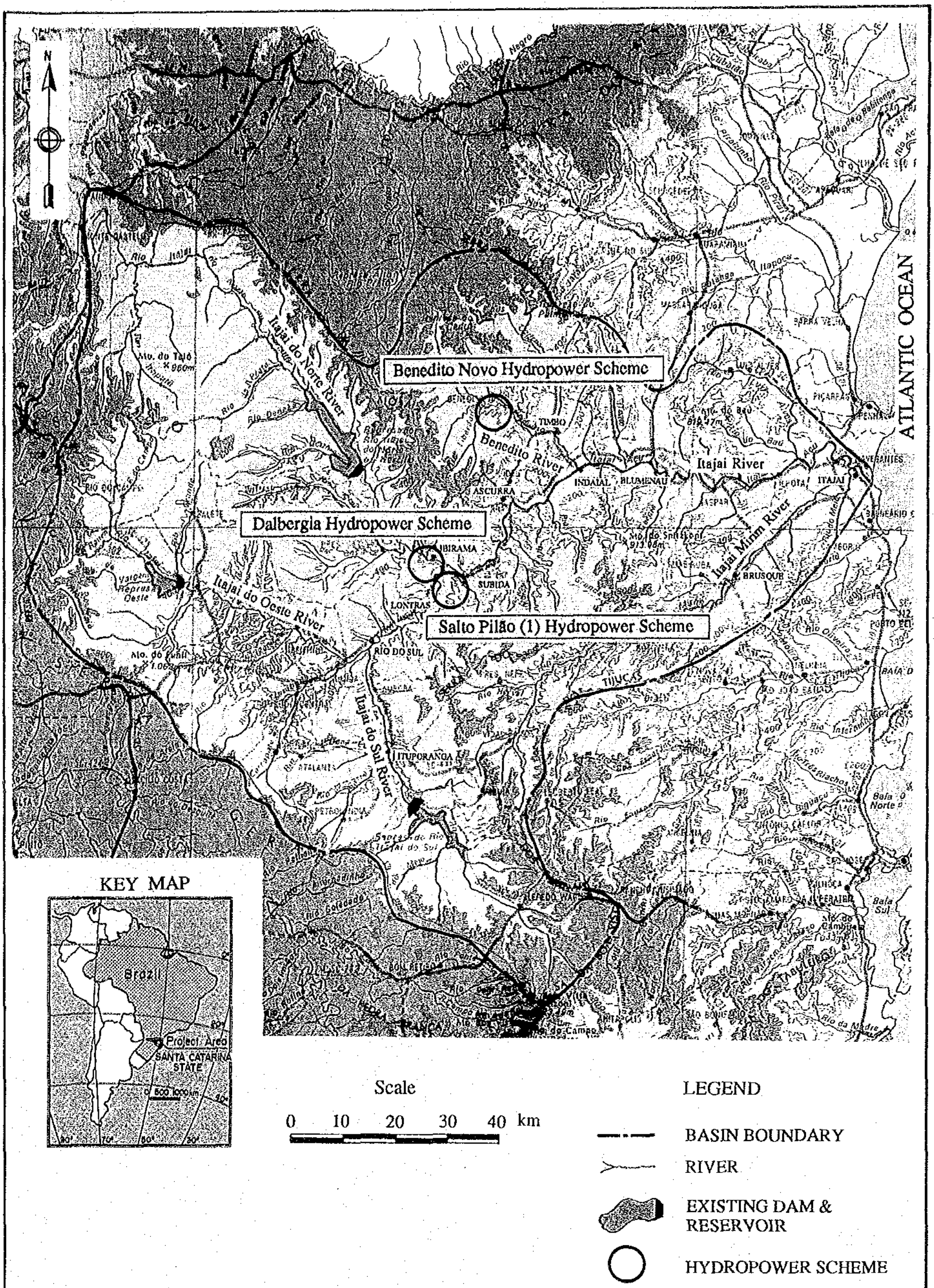


LIST OF IDENTIFIED SCHEMES

No.	NAME OF SCHEME
1	SALTO PILÃO (1)
2	SALTO PILÃO (2)
3	IBIRAMA
4	SUBIDA
5	ASCURRA
6	INDAIAL
7	DALBERGIA
8	BARRA DA PRATINHA
9	BARRA DAS POMBAS
10	TIMBO
11	BENEDITO NOVO
12	ALTO BENEDITO NOVO
13	DOUTOR PEDRINHO
14	TROMBUDO CENTRAL (1)
15	TROMBUDO CENTRAL (2)
16	BOTUVERA

LOCATION MAP OF 16 IDENTIFIED HYDROPOWER SCHEMES



LOCATION MAP OF SELECTED 3 HYDROPOWER SCHEMES

ABBREVIATIONS

(1) Organizations and Agencies

JICA	:	Japan International Cooperation Agency
ACARESC	:	Associação de Crédito e Assistência Rural de Santa Catarina
CASAN	:	Companhia Catarinense de Águas e Saneamento
CEDEC	:	Coordenação Estadual de Defesa Civil
CELESC	:	Centrais Elétricas de Santa Catarina S.A.
CEPA	:	Instituto de Planejamento e Economia Agrícola de Santa Catarina
CIDASC	:	Companhia Integrada de Desenvolvimento Agrícola de Santa Catarina
DNAEE	:	Departamento Nacional de Águas e Energia Elétrica
DNER	:	Departamento Nacional de Estradas de Rodagem
DER	:	Departamento de Estradas de Rodagem
DNOS	:	Departamento Nacional de Obras de Saneamento
ELETROBRAS	:	Centrais Elétricas Brasileiras S.A.
ELETROSUL	:	Centrais Elétricas do Sul do Brasil S.A.
EMATER	:	Empresa de Assistência Técnica e Extenção Rural
EMBRAPA	:	Empresa Brasileira de Pesquisa Agropecuária
EMPASC	:	Empresa de Pesquisa Agropecuária de Santa Catarina
FATMA	:	Fundação de Amparo à Tecnologia e Meio Ambiente
FGV	:	Fundação Getúlio Vargas
GAPLAN	:	Gabínete de Planejamento e Coordenação Geral
GCPS	:	Grupo Coordenador do Planejamento dos Sistemas Elétricos
IBDF	:	Instituto Brasileiro de Desenvolvimento Florestal
IBGE	:	Instituto Brasileiro de Geografia e Estatística
IBRD	:	International Bank for Reconstruction and Development
ITAG	:	Instituto Técnico de Administração e Gerência
MA	:	Ministério da Agricultura
MDUMA	:	Ministério do Desenvolvimento Urbano e Meio Ambiente
PORTOBRAS	:	Empresa Brasileira de Portos
SAMAE	:	Serviço Autônomo Municipal de Água e Esgoto
SUDEPE	:	Superintendência do Desenvolvimento da Pesca
ITAIPU BINATIONAL	:	Entity for hydropower development of Rio Parana, which was established based on the treaty between Brazil and Paraguay

(2) **Abbreviations of Measurement**

Length

mm	:	millimeter
cm	:	centimeter
m	:	meter
km	:	kilometer

Area

cm^2	:	square centimeter
m^2	:	square meter
ha	:	hectare
km^2	:	square kilometer

Volume

cm^3	:	cubic centimeter
l	:	liter
m^3	:	cubic meter
MCM	:	million cubic meter

Weight

g	:	gram
kg	:	kilogram
ton	:	metric ton

Electricity

Hz	:	Hertz
kV	:	Kilovolt
MVA	:	Megavolt Ampere
kVA	:	Kilovolt Ampere
MW	:	Megawatt
kW	:	Kilowatt
GWh	:	Gigawatt hour
MWh	:	Megawatt hour
kWh	:	Kilowatt hour
V	:	Volt
W	:	Watt

Time

s or sec	:	second
min	:	minute
h or hr	:	hour
d	:	day
y or yr	:	year

Others

%	:	percent
℃	:	degree centigrade
10^3	:	thousand
10^6	:	million
10^9	:	billion

Derived Measure

m^3/s	:	cubic meter per second

Money

Cr$	:	Cruzeiro
US$	:	US dollar
¥	:	Japanese Yen

(3) **Exchange Rate**

Official rate as of end of June 1990 : US$1 = Cr$61.05 = ¥ 150

Official rate as of end of May 1991 : US$1 = Cr$285.5 = ¥ 140

(4) **Others**

		Socio-economic Technical Terms
GDP	:	Gross Domestic Product
GRDP	:	Gross Regional Domestic Product
GVA	:	Gross Value Added
VA	:	Value Added
PV	:	Production Value

SUMMARY

Project Background and Objectives and Scope of Study

1. The state of Santa Catarina with an area of 95,483 km^2 is located in the southern part of the Federative Republic of Brazil. The state has a population of 4.6 million which corresponds to 2.97% of the national total in 1990. Manufacturing industry in the state has been a mainstay of the regional economy with the top share of one-third of GRDP, and non-metallic products, machinery, timber, furniture, paper, plastic products, textiles, clothing, food products and tobacco industries are predominating. Owing to the activity in this sector, electric energy consumption increased from 2,676 GWh in 1979 to 6,456 GWh in 1989 or at the average growth rate of 9.2%. The industrial sector consumed more than 50% of the power energy in the state of Santa Catarina. In the Itajai river basin with an area of 15,220 km^2, there are major industrial centers such as Blumenau, Itajai, Brusque, Indaial, Gaspar, Ibirama, etc. The power energy consumption by the industrial sector in these municipalities occupies about 20% of that of the state and it is forecast to further increase in future stage. To cope with the increase in power demand in the Itajai river basin, CELESC, which takes care of all the power demand in the state, intends to develop hydroelectric power projects in the Itajai river basin. CELESC recently obtained the concession for a hydroelectric power inventory study of the basin. Accordingly, the Federal Government of Brazil requested a technical assistance of the Government of Japan for the implementation of this study. In response to this request, JICA dispatched a preliminary study team to Brazil in December 1989, and CELESC and JICA agreed to carry out the study on hydropower potential in the Itajai river basin.

2. The objective of the study is to prepare an inventory of the hydroelectric potential for its orderly development in the Itajai river basin. The study is divided into two stages: the first stage is to prepare a provisional inventory of the hydroelectric power potential and to select the projects to be further elaborated in the next stage; the second stage is to undertake pre-feasibility studies of the projects selected in the previous stage.

3. The Study was carried out during 17 months from the middle of June 1990 to the middle of October 1991, comprising 7 months for the first stage and 10 months for the second stage. Result of the study was compiled in the final report which comprises five volumes. Vol. I is the executive summary which summarizes the results of the studies in the first and second stages. Vol. II is the main report on the first stage and presents the summarized results of hydroelectric power potential inventory in the Itajai river basin and selection of projects for pre-feasibility study in the next stage. Vol. III is the main report on the second stage and presents the summarized results of pre-feasibility study on Salto Pilao (1), Dalbergia and

Benedito Novo hydropower schemes. Vol. IV is the supporting report on the first stage and deals with the various sectorial studies, namely, hydrological study, geological investigation, socio-economic studies, electric power supply and power demand studies, environmental studies and studies on hydroelectric power potential inventory. Vol. V is the supporting report on the second stage and deals with sectorial studies for the selected three schemes, namely, topographic survey, geological investigation, studies on hydroelectric power schemes and environmental impact studies.

The Itajai river basin

(1) Location and river system

4. The Itajai river basin with a catchment area of 15,220 km^2 is located in the northern part of the state of Santa Catarina, and extends about 150 km from north to south and 155 km from east to west. The basin area occupies about 16 % of the total area of the state. The basin faces the Iguacu river basin in the north and west, the Uruguai river on the south and the Atlantic Ocean at the Itajai city in the east. Upstream stretch of the Itajai river is named as the Itajai do Sul river which originates in the southern mountain area with an altitude of 1,850 m. The Itajai do Sul joins the Itajai do Oeste river, which flows down from the western part of the basin, near the Rio do Sul city. After joining the Itajai do Oeste river, the Itajai do Sul changes its name to the Itajai river. The Itajai river joins the Itajai do Norte river near Subida. After flowing down of about 50 km northeastward, it joins the Benedito river near Indaial city. The Itajai river flows down eastward and near Itajai city it joins the Itajai Mirim river, and finally it debouches into the Atlantic Ocean.

(2) Meteoro-hydrology

5. The annual mean temperature in the Itajai river basin is 19.7°C in Itajai and 20.1°C in Blumenau in the downstream area and 18.4°C in Ituporanga in the mountainous area. The minimum daily mean temperature is 13.2°C in Ituporanga in June and the maximum is 25.5°C in Taió in January. The annual rainfall in the basin ranges from 1,300 mm to 1,500 mm in the center of the basin and from 1,600 mm to 1,800 mm in the northern and southern parts of the basin. The basin mean annual rainfall is 1,500 mm to 1,600 mm. The basin mean annual evaporation is around 800 mm, which corresponds to the evaporation rate of 2.2 mm/day. The annual mean relative humidity is 85.7 % in Itajai and 77 % in Indaial, which are maximum and minimum in the basin, respectively. The monthly mean discharge in the Itajai river and its tributaries is 30.0 m^3/sec at Ituporanga, 54.3 m^3/sec at Ibirama, 103 m^3/sec at Río do Sul, 220 m^3/sec at Indaial and 25.1 m^3/sec at Brusque. The runoff coefficient ranges from 0.38 to 0.4.

(3) Geology

6. Main geological layer in the project areas consist of Santa Catarina complex, Gaspar formation, Campo formation and Subida Intrusive Bodies of precambrian era in geological time which are associated locally with Rio do Sul and/or Itaraje formation of carboniferous time.

Santa Catarina complex which widely distributes in the middle to lower reaches of the Itajai river (Blumenau to Ibirama and Benedito Novo) is lithologically composed of gneiss and granite. Gaspar formation which distributes from Blumenau to Ibirama is composed of slate, sandstone and hornfels. Campo formation which outcrops in the form of mountain dome around Ibirama is composed of rhyolite. Subida Intrusive bodies which spread in the vicinity of Ibirama and Dalbergia are composed of granite and gneiss. Rio do Sul or Itaraje formation which is found in the local area around the Rio do Sul is composed of shale.

(4) Soil and vegetation

7. The soil in the Itajai river basin is classified into 8 types, namely, Low Humic Distric Gleysol (HGPD), Red-yellow Ferralic Podsols (PVa), Red-yellow Latosolic Podsols (PVLa), Eutric Lithosols (Re), Ferralic Cambisols (Ca), Distric Cambisols (Cd), Humic Ferralic Cambisols (CHa) and Ferralic White Cambisols (CBHa). HGPD type occurs on lowland along the Itajai river. PVa type soil extends over the low area in the southern part of the Itajai city. Ca and Cd type soils widely spread in the mountainous area. The other types of soil have limited distribution. The low land and hilly area along the Itajai river are well utilized for agriculture and pasture, while the hilly and highland in the middle and upstream reaches are covered with primary and secondary forest. The majority of the forest up to an altitude of about EL 600 m consists of secondary forest and afforestation. This type of forest occupies a major part of the forest in the basin area. As the altitude of the mountainous area increases, natural vegetation increases, but its acreage is limited. This natural vegetation consists of sub-tropical ever green hard woods.

(5) Land use

8. Census of agriculture in 1980 by IBGE shows that about 60 % of the basin area is utilized for agriculture such as crop land, pasture and forest. The forest area extends mainly in the mountainous areas between Itajai river and Itajai Mirim river, and Benedito river and Itajai do Oeste river. The crop area and pasture land are situated in the low lands along the Itajai, Itajai do Oeste and Itajai do Sul rivers. The rests accounting for about 40 % are urban areas,

areas not utilized, areas unsuitable for agricultural activity or area of which land use is not identified.

(6) Socio-economy

9. Brazil has a land area of 8,511,965 km^2 which is about 22.5 times that of Japan. The population in Brazil was estimated at about 136 million in 1985. GDP per capita in 1989 was estimated at US$ 1,919. The state of Santa Catarina is located in the southern part of Brazil with a long triangular shape between the states of Parana and Rio Grande do Sul, facing to the Atlantic Ocean in the east and Argentina in the west. The population in the Itajai river basin was estimated at about 669,000 in 1980, which corresponds to about 18.5 % of the state population. The annual growth rate of population in the basin in the 1970's was 2.08 % which is lower than that of 2.26 % in the state and 2.48 % in the country. The municipalities with more than 20,000 inhabitants are Blumenau, Itajai, Brusque, Rio do Sul, Indaial, Gaspar, Ibirama and Timbó. The future population in the basin is forecast at 822 thousand in 1990, 963 thousand in 2000 and 1,226 thousand in 2020, assuming average rate of 1.8 % for 1980 - 2000 period and 1.2 % for 2000 - 2020 period.

10. The primary sector in industrial structures in the basin consists of such subsectors as agriculture, forestry, cattle, fishery and rural industry. The total amount of the production in the primary sector in the basin in 1980 was Cr$ 13,340 million comprising Cr$ 8,023 million or 60 % of the total for crop production, Cr$ 2,917 million or 22 % for livestock production, Cr$ 1,077 million or 8 % for fishery, Cr$ 751 million or 6 % for forestry and Cr$ 571 million or 4 % for rural industry. Main crops cultivated in the basin are rice, maize, cassava, beans, onion, sugarcane and tobacco. Among them, production of onion in the basin shares about 76 % of that of the state.

The secondary sector plays an important role for the basin and also for the state. The total amount of the production in the secondary sector in the basin was Cr$ 116.5 billion in 1980. Major industrial types occupying about 65 % of manufacturing and mining production are (1) textile, (2) clothing, shoes and woven articles, (3) food products and lumber. They account for 37 %, 18 % and 5 % respectively of the value in the basin.

The tertiary sector in the basin is characterized by a large number of small establishments. The annual sales amount of this sector in the basin in 1980 was Cr$ 71.3 billion comprising Cr$ 65.1 billion or 91 % of the total for commercial subsectors and Cr$ 6.2 billion or 9 % for service subsector. Among the major municipalities in the basin, Blumenau occupies first place in the commercial activity and second place in the service activity in the state. The second and third municipalities in terms of sales amount in the basin are Itajai and Rio do Sul respectively.

Electric Power Supply and Demand

11. The supply of electric power in Brazil has been regulated by the Ministry of Infrastructure which organizes two entities, namely, DNAEE and ELETROBRAS. DNAEE is responsible for framing the electric power policy, approving the implementation program of power construction and determining the electric power tariff for controlling the Brazilian power industry. ELETROBRAS is responsible for planning, financing and coordinating the expansion and operation of the Brazilian power system. It controls four regional utilities; ELETRONORTE in the northern region, CHESF in the northeastern region, FURNAS in the center west/southeastern region and ELETROSUL in the southern region. ELETROBRAS also has partnership in the state utilities and hold 50 % of the stock of ITAIPU Binational. Four subsidiary companies have their own power transmission network. They are also interconnected with two major power systems, namely, north/northeast and south/southeast power supply systems. State governments have their own electric power enterprises and have the right to develop power generating plants within their territories with DNAEE's approval. CELESC is a Santa Catarina state government owned utility established in 1956 and is responsible for supplying electric power for the state.

12. A power market survey was carried out to collect and review the basic data necessary for forecasting of power demand. The data involved not only for CELESC but also for the south/southeast system, which is interconnected with CELESC. The situation of power supply in Brazil, south/southeast system and CELESC at the end of 1989 is summarized as follows;

(i) The total installed capacity of generating plants of the power supply system in whole Brazil was 53,883 MW and their annual energy production was 232,705 GWh. Hydropower accounted for 91% and 96% respectively of those totals.

(ii) The total installed capacity of generating plants of the south/southeast power system was 41,034 MW.

(iii) The maximum peak demand in the power supply system of CELESC was 1,228 MW in capacity and 7,061 GWh in energy. CELESC had its own power plant with a total installed capacity of 74 3 MW and generated only 386 GWh of energy. The remaining 6,675 GWh or 95% were purchased from ELECTROSUL, ITAIPU Binational and others. The ratios of energy sales to the respective consumers categories in CELESC were 21%: residential, 54%: industrial, 9%: commercial, 9%: rural and 7%: public and others.

13. In a recent 10 years, energy consumption in CELESC increased from 2,676 GWh to 6,456 GWh at an average annual growth rate of 9.2%, which was higher than that of 0.6% of GDP and 3.3% of GRDP. The maximum demand in CELESC also increased from 564.7 MW to 1,228.4 MW at an average annual growth rate of 8.1%. The typical daily load curves of CELESC in 1989 showed a pattern of night peak time with a daily load factor of 74% to 83% on week days. Annual load factors for 1970-1983 period have been calculated to be between 53% and 62%. After 1983, it increased up to 66% at an average annual rate of about 1%.

14. The electric power tariff system for power supply to the consumers and for the power trading between the concessionaires was revised on March 15 and June 7, 1990, respectively to recover the relative decline of tariff due to inflation. Although the tariff has been increased, the average tariff still seems to be cheaper than that in other countries in the Middle and South America.

15. Power demand forecast for each region in Brazil was made by ELETROBRAS in the National Electric Energy Plan for 1987/2010 (Plan 2010) and this forecast was revised by GCPS in the 10-year Expansion Plan (1990-1999). CELESC also made its demand forecast for the state of Santa Catarina in July 1990. The results of the latest forecast seem to be reasonable and are as follows:

(i) Energy and power demand in the south/southeast power system will increase at the average growth rates of 5.1% and 4.4% respectively and they will increase to 258,636 GWh and 41,940 MW by 2000 respectively.

(ii) Energy and power demand in CELESC power system will increase at the average rates of 4.9% and 4.2% respectively to 11,994 GWh and 1,938 MW by 2000 respectively.

16. Based on the power demand forecast, a expansion program for the south/southeast power system up to 2000 including CELESC's system was made and reviewed by GCPS. The result of this review shows that the demand and supply are in balance with a reasonable reserve of power.

17. CELESC has no intention to construct a thermal power plant at present because of its high construction cost. Study of a thermal power plant as an alternative to the Itajai hydropower plants was made by comparison of their energy cost. As the result of comparison, it was concluded that hydropower is more economical than the coal fired power plant.

Master Plan Study in First Stage

(1) Map study

18. Identification of hydropower potential sites (herein called "map study") was carried out based on the topographic maps at a scale of 1:50,000 with a contour interval of 20 m, and at a scale of 1:10,000 and 10 m contour interval and referring the longitudinal profile of river stretches. Two types of development, namely, run-of-river type and reservoir type were contemplated in this study. For the run-of-river type development, run-of-river scheme with single intake, run-of-river scheme with inter-basin water transfer intake (s), and run-of-river scheme with regulating pondage are contemplated. For the reservoir type development, single dam scheme, dam + waterway scheme, reservoir scheme with saddle dam (s), and reservoir scheme with inter-basin water transformer intake (s) are conceivable. Among these, a regulation pond scheme for run-of-river type development and a single dam scheme for reservoir type development were selected.

19. A map study to identify the hydropower potential sites was carried out based on the foregoing topographic maps under prerequisite condition to avoid submergence of large town and city by development. As a result of the map study for whole Itajai river basin, a total of 16 hydropower potential sites have been identified as listed in Table 1. These include 9 run-of-river type schemes and 7 reservoir type schemes. The location of the identified schemes is shown in Fig. 1.

(2) Geological assessment

20. For the sixteen identified hydropower potential sites, geological investigation to assess the geological characteristics necessary for preliminary planning was carried out by means of surface inspection without exploratory borings and by geological map study. The investigations in each site concentrated on the proposed intake dam, waterway, powerhouse and construction material sites.

21. Geological assessment of the respective hydropower potential sites was carried out by providing criteria for assessment and an index to evaluate the degree of the geological characteristics. The degree of the geological assessment for the respective sites evaluated by these criteria and index is listed in Table 2. General feature of the geological situations for the identified schemes is as follows;

(i) Scheme No. 1, Salto Pilão (1); the damsite is located at a wide valley with gentle hills and its geology consists of hard granite. The required excavation depth is about 2 m in the river bed and right bank, and about 5 m in the left bank. Considering the hardness and massiveness of the granite, foundation treatment will not be necessary. A pressure tunnel is aligned along hard granite in the hilly mountain in the right bank. It is presumed that fractured zones with some water spring exists below tributary position. It is noticeable for the tunnel route that the rock cover is presumably thin in the upstream part of the route. The proposed powerhouse, tailrace and substation would be located on a gentle skirt part of a mountain in the right bank of the Itajai river. The base rock consists of granite and it is covered with talus deposit. Thickness of excavation (talus deposit and weathered rock) is about 10 m. The proposed quarry site is located at about 1 km upstream from the right bank of the damsite. The site is nearly flat hill and consists of granite with hard rock and good in quality. It is presumed that surface soil depth is about 5 m and about 300,000 m^3 of rock material is available. The fine aggregate is available at river side near Blumenau city at about 70 km from the damsite. It will be necessary to produce fine and coarse aggregate by crushing rock material at the quarry site.

(ii) Scheme No. 2, Salto Pilão (2); the geological situation of the damsite is the same as that for the scheme No. 1. A pressure tunnel is aligned along hard granite and partially sandstone in the mountain on the left bank. It is assumed that small fractured bands may exist in some places. The proposed powerhouse, tailrace and substation are located at sandstone layer in the left bank of the Itajai river. It is presumed that the required depth of excavation (weathered sandstone) will be about 5 m. Since there is not enough space for construction of a powerhouse, large scale excavation will be needed. Although it is conceivable to construct an underground type powerhouse, it is not economical since fresh sandstone exists at about 5 m below the weathered sandstone but it has a cracky characteristics and consequently much cost will be needed for treatment of rock excavation. The proposed quarry site is located at about 5 km upstream in the left bank from the damsite. It consists of hard granite. It is presumed that since sufficient rock material is available, fine and coarse aggregates are produced by crushing this rock material.

(iii) Scheme No. 3, Ibirama; the damsite is located at U-shape valley with cliff in the right bank and gentle slope in the left bank. The foundation rock consists of hard sandstone. The excavation depth is about 2 m in the river bed and right bank, and about 5 m in the left bank. Foundation treatment will not be needed. Landslide and water leakage in the reservoir will not take place. A pressure tunnel is aligned through mountain range on the left bank. The tunnel route consists of rhyolite and sandstone, respectively in the upstream and downstream of the route. It is presumed that small band of fractured zone exists. The proposed powerhouse, tailrace and substation are located at wide and flat terrace which consist of sandstone. The necessary depth of excavation (terrace deposit and weathered sandstone) will be 10 m. The proposed quarry site is located at about 2 km upstream of damsite. It consists of table mountain which consists of hard granite and surface soil of about 5 m in depth. The available volume is presumed to be about 300,000 m^3. Fine aggregate will be obtained at the same site as that stated in scheme No. 1. Coarse aggregate will be produced at the quarry site.

(iv) Scheme No. 4, Subida; the damsite consists of U-shape valley with gorge and its foundation rock comprises rhyolite which is hard and massive. Necessary excavation depth is about 2 m in river bed, 5 m in both banks respectively. Judging from the massiveness of rhyolite outcrops, fractured zones are unlikely to exist, and landslides do not take place. A pressure tunnel is aligned along hard rhyolite and sandstone in the upstream and downstream in the mountain of the left bank. It seems that small band of fractured zone exists. The location of the powerhouse, tailrace and substation is the same as that for scheme No. 3. The proposed quarry site is located at about 0.5 km from the right bank of the damsite. It comprises large mountain which consists of very hard and massive rhyolite with very thin surface soil. The assumed available volume is more than 5 million m^3. Fine and coarse aggregates will be produced by crushing the rock materials at the quarry site.

(v) Scheme No. 5, Ascurra; the damsite is located at a relatively narrow river valley with steep slope in both banks. The foundation rock consists of hard rhyolite. The required excavation is about 2 m in the river bed and about 5 m on both banks. Judging from the massiveness of the rhyolite of outcrop, fractured zone scarcely exists. A pressure tunnel is aligned along hard rhyolite in the upstream part of the route and moderately hard sandstone in its downstream in the right bank of the Itajai river. Judging from cracky condition of sandstone of outcrop, fractured zones will exist in some places in the section of sandstone. The proposed powerhouse, tailrace and substation are situated at the river side on a flat terrace, about 5 km downstream of Ascurra. The foundation rock of the powerhouse site consists of sandstone. It is presumed that the required thickness of excavation (terrace deposit and weathered sandstone) is about 15 m. It was judged that a fractured zone may possibly cross the site. The proposed quarry site is located in the mountainous area at about 1 km upstream from the right bank of the damsite where a steep round ridge extends with an oval shape. The quarry site consists of hard rhyolite and the presumed thickness of surface soil is about 10 m and the available volume is 300,000 m^3. Coarse and fine aggregates will be produced by crushing the rock material at the quarry site.

(vi) Scheme No. 6, Indaial; the damsite is located at relatively narrow river valley with steep slope in both banks. The damsite consists of granite, terrace and talus deposit. The excavation depth will be about 2 m in the river bed and about 5 m in both river banks. Since the bank slope is nearly flat, landslides do not take place. Foundation treatment will not be needed. An open channel with trapezoid section and 2.3 km in length is aligned along the right bank in parallel with the state road. The waterway routes will be aligned mainly on thick overlying talus deposit. The required excavation depth (talus deposit and weathered granite) is 10 to 15 m. The proposed powerhouse, tailrace and substation sites are situated at about 3 km downstream of Indaial where gentle talus deposit extends toward river and steep slope is formed in river side. The foundation rock is granite and the required excavation depth to remove talus deposit and weathered granite is about 15 m. It seems that small fractured zone exists. The proposed quarry site is located at about 10 km in the southern part of the damsite. The quarry site is hilly mountain which comprises hard granite. It is presumed that depth of surface soil is about 10 m and available volume is 300,000 m^3. Location of fine aggregate is the same site as proposed for scheme No.1 and coarse aggregate will be produced at the quarry site.

(vii) Scheme No. 7, Dalbergia; the damsite is located at a U-shaped valley and its foundation rock is hard and massive gneiss. The required excavation depth is about 2 m in the river bed and right bank and about 5 m in the left bank. Since bank slope is gentle (15 degree in gradient), landslides will not take place. A pressure tunnel is aligned along mainly hard gneiss and locally hard granite in the right bank. It is presumed that the fractured zone appears beneath the tributary. The proposed powerhouse, tailrace and substation sites are situated at about 3 km downstream of Ibirama, where round ridge exists in the waterway site and flat terrace opens near the river side. The foundation rock of the sites consists of granite and thickness of the required excavation is about 10 m. There is possibility of existence of small fractured zone crossing the site. The proposed quarry site is located at about 0.5 km from the right bank of damsite. The quarry site comprises gentle hill spread in wide range and its material consists of gneiss which crops out in the hill side. Depth of surface soil is about 5 m and available volume is 300,000 m^3. Coarse and fine aggregates will be produced by crushing the rock materials at the quarry site.

(viii) Scheme No. 8, Barra da Pratinha; the damsite is located at U-shape valley with gorge and it consists of hard sandstone which out crops in the river side. The required excavation depth is about 2 m in river bed and about 5 m in both banks. Fracture zones are unlikely to exist in view of the massiveness of the sandstone in out crops. Since surface soil is thin (less than 5 m thick) landslide do not take place. Since proposed powerhouse, tailrace and substation sites are located just downstream of the dam body, geological conditions are the same as those for the damsite. The proposed quarry site is located at about 1 km from the damsite. The quarry site consists of fairly hard sandstone. Depth of surface soil is about 10 m and available volume is 5 million m^3. The proposed borrow pit site is located at about 1 km from the left bank of damsite. The material of the site consists of talus deposit and weathered sandstone. Thickness of the earth material (talus deposit and weathered sandstone) is about 10 m, and available volume is 300,000 m^3. Fine and coarse aggregates will have to be produced by crushing the rock material at the quarry site.

(ix) Scheme No. 9, Barra das Pombas; the damsite is located at a U-shape valley and it consists of hard sandstone alternated with mudstone. The required excavation depth will be about 5 m and excavated material will be used for the impervious zone. Judging from the jointing cracks between sandstone and mudstone, fractured zone probably exists in some places. Foundation treatment will be needed for the fractured zone. Landslides and water leakage are unlikely to take place in the reservoir area considering the thin surface soil and weathered zone. The proposed quarry sites are selected on mountain top areas on both banks, about 2 km far from the damsite. The quarry sites are located at table mountain and it consists of sandstone fresh rock. Depth of overburden surface soil and weathered sandstone is about 10 m and depth of fresh sandstone is limited to about 20 m. For the required impervious material, weathered zone sandstone in the quarry site will be used. Thickness of the material is about 8 m and the available volume is about 500,000 m^3. Fine and coarse aggregate will be produced by crushing the rock material at the quarry site.

(x) Scheme No. 10, Timbó; the damsite has gentle bank slopes and a flat river bed. It consists of hard and tight gneiss. The required excavation depth is about 2 m in river bed and 10 m in both river banks. Judging from tightness of gneiss outcrops, fractured zones are unlikely to exist. Since the bank slope is gentle (about 15 degree in gradient) land slide do not occur. The proposed quarry site is located at about 2 km north of the damsite. It comprises mountain ridge elongated in the shape of long boot, and consists of hard and massive gneiss. Depth of surface soil is about 10 m, and available volume is 5 million m^3. The proposed borrow pit site is located at about 0.5 km from the left bank of the damsite. It consists of talus deposit and weathered gneiss. Thickness of material is about 10 m and the available volume is 300,000 m^3. It is proposed to utilize the rock material at the quarry site for fine and coarse aggregates after its crushing.

(xi) Scheme No. 11, Benedito Novo; the damsite is located at a U-shape valley and it consists of hard and tight granite which sporadically crops out in reservoir area. The required excavation depth is about 2 m in river bed, 5 m in both river banks. Judging from tightness of granite, fractured zone scarcely exists. Since surface soil is relatively thin, possibility of landslide is rare. Foundation treatment will not be needed. A pressure tunnel is aligned along hard and massive granite and diorite in the mountain ridge at right bank. It is presumed that fractured zone scarcely exists except heavily weathered part in the upstream tunnel route. The proposed powerhouse, tailrace and substation sites are situated at about 2 km upstream of Benedito Novo, where there is a round shaped ridge as the waterway side and a low river terrace on the river side. The sites consist of terrace deposits and granite. Thickness of excavation (terrace deposit and weathered granite) is about 10 m. Fractured zone scarcely exists, and landslide seldom takes place in view of slope gradient. The proposed quarry site is located at about 1 km south of Benedito Novo. The quarry site is composed of gentle hilly mountain and it consists of diorite. The depth of surface soil is about 10 m and that the available volume is 500,000 m^3. It is proposed that fine and coarse aggregates will be produced by crushing the rock material at the quarry site.

(xii) Scheme No. 12, Alto Benedito Novo; the damsite is located at U-shape valley and rapid gorge and it consists of hard and tight granite. The required excavation depth is about 2 m and 5 m, respectively in the river bed and river banks. Judging from the tightness of granite in outcrop, fractured zone scarcely exists. Since surface soil is very thin, landslide does not take place. Foundation treatment will not be needed. A pressure tunnel is aligned along granite in the left bank of the river. This granite is on the whole hard and massive except the beside the power house where the weathering is deep in places with a fractured zone. The proposed powerhouse, tailrace and substation sites are located at about 1 km upstream of Alto Benedito Novo. These sites consist of granite which out crops in a heavily weathered condition. It is presumed that a landslide would occur at the weathered granite site. The required excavation depth is about 20 m. Same quarry site as stated for the scheme No. 11 is proposed. The transportation distance is about 4 km. It is proposed that fine and coarse aggregates are produced by crushing the rock material at the quarry site.

(xiii) Scheme No. 13, Doutor Pedrinho; the damsite is located at a deep U-shape valley with flat river bed and it consists of river deposit, talus deposit and base rock (sandstone, mudstone alternation). Foundation rock is sandstone alternated with mudstone. The required excavation depth is 10 to 15 m. Since cracky zone appears in the contact position between sandstone and mudstone, fractured zone will appear. Landslide are unlikely to take place. The proposed quarry site is located at about 20 km downstream of damsite. The quarry site is composed of wide table mountain and it consists of hard sandstone. Depth of surface soil is about 5 m and available volume is 15 million m^3. The proposed borrow pit site is located at about 0.5 km upstream of the left bank slope around the damsite, where gentle slope of talus deposit spreads. Its thickness is about 10 m and available volume is about 500,000 m^3. Fine and coarse aggregates will be obtained by crushing the rock materials in the quarry site.

(xiv) Scheme No. 14, Trombudo Central (1); the damsite is located at a wide river channel with gentle bank slopes and it consists of slightly soft river deposit and sandstone, shale alternation. The required excavation depth is more than 10 m. Since there are cracky part in shale, fractured zone will exist to some extent. It seems that landslide scarcely takes place judging from gentle bank slope (about 15 degrees in gradient) at the dam site. The proposed quarry site is located at about 30 km east of the damsite. The site is flat hill and it consists of intrusive basalt. Depth of surface soil is about 5 m and available volume is 3 million m^3. The proposed borrow pit site is located at the hill top of about 0.5 km from the damsite which is accessible through existing state road. The borrow pit site consists of weathered rock (sandstone, shale alternation). Thickness of material is about 10 m and available volume is 500,000 m^3. Fine and coarse aggregate will be obtained by crushing the rock materials at the quarry site.

(xv) Scheme No. 15, Trombudo Central (2); the geological and topographical conditions of this damsite are almost the same as those of Trombudo Central (1) scheme, since horizontal distance between this damsite and the site of scheme No. 14 is only 4 km. The proposed quarry site is the same as that for scheme No. 14. The proposed borrow pit site is located at the right bank slope about 0.5 km from the damsite. The borrow pit consists of weathered rock and it is proposed to utilize it for dam embankment.

(xvi) Scheme No. 16, Botuvera; the damsite is located at a deep U-shape valley and it consists of hard phyllite. The required excavation depth is about 2 m in river bed, 5 m in river banks. Since phyllite has jointing cracks, fractured zone will exist in some places. It seems that landslide scarcely takes place because surface soil is very thin (less than 5 m in thickness). The proposed quarry site is located at about 10 km downstream from the damsite. The quarry site is formed by rugged mountain ridge and it consists of phyllite and slate. Depth of surface soil is about 5 m and available volume is 5 million m^3. The proposed borrow pit site is located at 0.5 km downstream of the damsite in the left bank. The borrow pit site is formed by gentle slope with rectangle shape and it consists of weathered phyllite. Thickness of useful zone of weathered phyllite is about 5 m and available volume is 500,000 m^3. Fine and coarse aggregates will be also produced by crushing the rock material at the quarry site.

(3) Environmental assessment

22. In order to identify the impact and to evaluate significance of environmental aspects for 16 identified hydropower potential sites, as well as to clarify the environmental items for which further study is needed in the second stage, Initial Environmental Examination (IEE) was

performed at this stage by means of check lists comprising items for natural and social environmental impacts due to project realization.

23. The items of examination of the impact on the environment are land, river environment, vegetation, wildlife in the natural environment, and population, industries, traffic, landscape and historical and archaeological assets of the social environment. The evaluation of impact on the respective items was performed by providing the criteria for evaluation and an index to evaluate the degree of the impact. The extent of the impact for the respective items evaluated by these criteria and index is listed in Table 3. The overall evaluation for the various schemes is as follows;

(i) Salto Pilão (1) and (2) schemes; these schemes are run-of-river type and there are no serious environmental problems.

(ii) Ibirama and Subida schemes; since a national road is provided along the left bank of the damsites, relocation of road is needed due to dam constructions. It will exert on effect on regional economy and bring about inconvenience for land transportation. Except for this effect, there are no environmental effect.

(iii) Ascurra scheme; although this scheme is run-of-river type, a relatively large scale reservoir area will be needed. Since there are houses, forests and farm lands in this area, problem of relocation of houses and effect on forestry are conceivable. Besides relocation of road is needed. The effects on land transportation are pointed out.

(iv) Indaial scheme; this scheme is located near Indaial city and national and state roads are provided along both left and right banks of the damsite. The impact on traffic is pointed out.

(v) Dalbergia scheme; this scheme is run-of-river type and there are no serious environmental problems.

(vi) Barra da Pratinha scheme; since a dam of about 80 m high is planned, and there are large forest area and existing road in the submerged area, the impacts on vegetation and traffic are pointed out.

(vii) Barra das Pombas scheme; since a large scale reservoir will be created in the mountainous area, and there are forest area, farm land and existing road in the submerged area, the impact on vegetation, agriculture, traffic and wildlife is pointed out.

(viii) Timbó scheme; this scheme is reservoir type but the reservoir area is relatively small due to the relatively steep river bed slope. However, since a national road is provided along the left bank of the damsite, the effect on traffic is pointed out.

(ix) Benedito Novo and Alto Benedito Novo schemes; these schemes are run-of-river type and there are no serious environmental problems.

(x) Doutor Pedrinho scheme; this scheme is reservoir type but its submerged area is relatively small due to the steep river bed slope. However, there will be a impact on traffic due to submergence of the existing road along the valley.

(xi) Trombudo Central (1) and (2) schemes; these schemes are reservoir type and are located near the urban area. There are houses, existing roads and farm lands in the submerged area. Consequently there will be impact on removal of house, traffic and agriculture and problem of eutrophication in the reservoir are pointed out.

(xii) Botuvera scheme; this scheme is reservoir type and is located at the mountainous area. The submerged area is covered with forest area, and the existing road is provided along the valley in the submerged area. Thus, there are impact on vegetation, wildlife and traffic.

(4) Design standard set out by ELETROBRAS

24. For each hydropower site identified by the map study, power and energy were calculated based on the criteria specified by ELETROBRAS. ELETROBRAS established the criteria as follows;

(i) For the inventory study, the firm energy in the basin will be approximated to the average energy generated during hydrologically critical period in the interconnected system of the southern region and the southeastern region.

(ii) The hydrologically critical period in the interconnected system is defined as the period from April 1949 to November 1956 based on the hydrological conditions in two regions.

(iii) The guaranteed energy is defined as the mean energy generated by the plant during the critical period of the 1,000-year synthetic flow plus a proportional part of the power deficit in the system, and it is defined as 90% of the firm energy.

(iv) The secondary energy is defined as the energy producible in excess of the firm energy and it is usually calculated as the difference between the long term average energy and the firm energy.

(v) The economic viability of a hydropower project of interconnected system is analyzed by comparing the "unit cost of guaranteed energy" of the project with the "marginal cost of expanded energy". The unit cost of guaranteed energy is obtained by the following expression:

$$CUEG = \frac{CIA - 8{,}760 \cdot CRES \cdot ES - 1{,}000 \cdot CMP \cdot PG}{8{,}760 \cdot EG}$$

where :

CUEG	;	Unit cost of guaranteed energy in US$/MWh
CIA	;	Annual equivalent cost in US$; corresponds to the total investment cost multiplied by capital recovery factor for a useful life of 50 years at 10 % per annum (0.1009)
CRES	;	Reference cost of secondary energy; in US$/MWh; is considered to be the fuel cost of 10 US$/MWh which is estimated as the cost of weighted mean of fuel for coal, gas, oil and nuclear
ES	;	Secondary energy, in MW
CMP	;	Marginal cost of peak, in US$/MW
PG	;	Guaranteed peak of power plant, in MW
EG	;	Guaranteed energy, in MW on an average

The marginal cost of expanded energy of system, which actually represents a composition of unit cost of guaranteed energy, is presented for every five years as follows;

Five - Year Period	Marginal Cost of Expanded Energy (US$/MWh)
1991 - 1995	34
1996 - 2000	36
2001 - 2005	43
2006 - 2010	53
2011 onward	64

(5) Plan formulation

25. The hydropower development was studied by varying the development scale for the respective identified hydropower site. For run-of-river type development, the study was made by varying the ratio of average turbine flow to maximum plant discharge. For reservoir type development, alternative studies were made by varying the active storage capacity and reservoir full supply level. To proceed with power output calculation for each scheme, plant discharge,

operating level, operating head, power output and energy were calculated by applying simplified criteria.

26. In order to evaluate the identified 16 schemes through first screening, basic dimensions of major structures of the schemes were determined based on the empirical design criteria. Based on the result of this basic design, preliminary costs were estimated using the unit prices at price level of June 1990 for similar projects which were implemented or are being implemented by CELESC.

27. Based on the result of the power output calculation and preliminary cost estimate for the identified hydropower potential sites, an inventory of hydropower potential of 16 schemes including alternative plans by varying the development scale for the run-of-river scheme and changing reservoir development scale for the reservoir type was prepared. To determine the optimum scale of the hydropower development for respective identified schemes, the unit cost of the guaranteed energy was calculated as an evaluation index. Based on the evaluation index, the optimum development scale for each of the identified schemes was selected from among several alternative plans. The features of the 16 schemes at the optimum scale thus determined are as follows;

No.	Name of Scheme	Type	Installed Capacity (kW)	Annual Energy Ef (GWh)	Guaranteed Energy Eg (GWh)	Secondary Energy Es (GWh)	Total Construction Cost (Mil. US$)	Unit Cost of Guaranteed Energy (US$/MWh)
1.	Salto Pilão (1)	ROR	117,800	721.3	649.1	69.5	114.6	16.7
2.	Salto Pilão (2)	ROR	67,100	470.0	423.0	31.2	80.7	18.5
3.	Ibirama	ROR	24,600	172.1	154.9	32.4	121.4	77.0
4.	Subida	ROR	9,200	64.1	57.7	12.1	74.7	128.5
5.	Ascurra	ROR	5,600	34.2	30.8	8.5	75.2	243.7
6.	Indaial	ROR	10,500	73.4	66.0	11.5	57.1	85.5
7.	Dalbergia	ROR	15,900	97.5	87.7	14.2	58.5	65.7
8.	Barra da Pratinha	RES	9,500	41.6	37.4	20.8	161.4	429.6
9.	Barra das Pombas	RES	14,100	61.7	55.5	11.2	179.3	323.8
10.	Timbó	RES	3,800	16.7	15.0	8.3	62.3	413.8
11.	Benedito Novo	ROR	12,500	65.7	59.1	11.7	26.1	42.5
12.	Alto Benedito Novo	ROR	12,900	56.7	51.0	10.5	36.0	69.2
13.	Doutor Pedrinho	RES	1,400	6.2	5.6	2.0	67.8	1,222.0
14.	Trombudo Central (1)	RES	2,100	9.1	8.1	1.6	44.7	551.2
15.	Trombudo Central (2)	RES	1,100	4.6	4.2	0.5	53.9	1,299.7
16.	Botuvera	RES	6,000	26.1	23.5	10.8	73.9	313.1

Remark :
ROR ; Run-of-river type scheme
RES ; Reservoir type scheme

The total power potential in terms of the installed capacity in the Itajai river basin was estimated at about 238 MW.

28. The first screening was carried out by comparing the unit cost of guaranteed energy and the marginal cost of the expanded energy of the system. The marginal cost estimated for every five years ranges from US$34/MWh in 1991-1995 period to US$64/MWh in 2011 onward. Taking into account these values, schemes of which the unit cost of guaranteed energy was larger than US$ 70/MWh were eliminated. The schemes which passed this first screening evaluated by the above criterion are five which are all run-of-river types. The name of the schemes and their features are as follows;

Name of Scheme	Installed capacity (MW)	Annual energy (GWh)	Guaranteed energy (GWh)
Salto Pilão (1)	117.8	721.3	649.1
Salto Pilão (2)	67.1	470	423
Dalbergia	15.9	97.5	87.7
Benedito Novo	12.5	65.7	59.1
Alto Benedito Novo	12.9	56.7	51

29. In order to select the hydropower schemes to be taken up for the pre-feasibility study in the following stage, second screening was performed for five schemes which passed the first screening. To obtain the cost information necessary for the second screening, general layout of five hydropower schemes was prepared based on the topographic maps at a scale of 1:50,000. The work quantity of the major components of the power facilities was estimated based on the prepared layout plan. The cost required for the second screening evaluation was estimated by multiplying the obtained work quantities by the unit costs used in the first screening. The second screening evaluation was performed in the same manner as that applied to the first screening evaluation. The power output and energy for the five schemes were recalculated based on the loss calculation for the fixed dimension of the power facilities. Based on the power output calculation and cost estimate, the unit cost of the guaranteed energy for the five schemes was also recalculated. Main features of the five schemes thus determined are as follows;

Name of scheme	Installed capacity (MW)	Annual energy (GWh)	Guaranteed energy (GWh)	Const cost (Mil US$)	Unit cost of guaranteed energy (US$/MWh)
Salto Pilão (1)	118.7	757.7	682	122.6	17.2
Salto Pilão (2)	67.8	490	441	87.2	19.9
Dalbergia	15.9	109.5	98.6	65.2	65.6
Benedito Novo	12.8	69.8	62.9	26.4	40.6
Alto Benedito Novo	13.2	59.4	53.4	38.2	70.1

30. For these five schemes, a technical review was made to judge the appropriateness for actual implementations. Main items of the technical review were geology in particular for technical aspect, constraints to construction work such as access facilities and other pre-

construction work requirement, sociological and environmental problems and other constraints to project implementation. It was judged from the result of the technical review that there would be no notable technical and environmental problems in implementing these schemes.

Of the five schemes selected, Salto Pilão (2) scheme is an alternative for Salto Pilão (1) scheme and both schemes are mutually exclusive. Of the two schemes, Salto Pilão (1) is superior to Salto Pilão (2) from the viewpoint of economic viability and scale of the installed capacity. The unit cost of the guaranteed energy for Alto Benedito Novo scheme will exceed the marginal cost of the expanded energy from 2011 onward. The unit cost of the guaranteed energy for Dalbergia scheme will exceed slightly the marginal cost from 2011 onward but annual energy to be generated by Dalbergia scheme is about 1.8 times that for Alto Benedito Novo scheme. The unit cost of the guaranteed energy for Benedito Novo scheme is smaller than the marginal cost of the expanded energy for 2001-2005 period. Considering all the above, it was decided to select three schemes, i.e, Salto Pilão (1), Dalbergia and Benedito Novo schemes for pre-feasibility study to be carried out in the next stage. The selected schemes has all been evaluated that their environmental impact would be relatively small.

Pre-feasibility Study in Second Stage

(1) Principle and criteria for study

31. The share of hydropower plants to the total power installation in south/southeast power supply system was 93 % in 1989. Run-of-river type power plants in this system are mainly operated for base power supply together with nuclear and coal fired power plants and reservoir type hydropower plants are operated for peak power supply. The relationship curves between the demand forecast and power supply by power expansion program of this power supply system show that the rate of reserve for energy is smaller than that for power. It implies that the power system requires the development of power plants for energy supply, namely base power supply. In these circumstances, it is considered that the hydro power plants to generate a cheaper electric energy and to supply base power to the CELESC power system together with the existing CELESC's hydropower plants should be planned in the Itajai river basin.

32. The selected 3 hydropower schemes are all run-of-river type by utilizing fully the head available in the rapid river stretch. In the master plan stage, the most appropriate damsite and powerhouse site were selected based on the topographic maps at a scale of 1:50,000 with a contour interval of 20 m and at a scale of 1:10,000 with a contour interval of 10 m only for river stretch. According to the topographic maps at a scale of 1:10,000 with a contour interval of 5 m, which were prepared in the second stage, several alternative dam axes are conceivable

though the powerhouse site is topographically limited. Then the study on the hydropower schemes was carried out by two steps; namely, selection of dam axis and optimization study and pre-feasibility grade design for the project components.

33. The development ratio is defined as the ratio of average turbine discharge to maximum plant discharge. Various scales of the power facilities were compared based on this development ratio in the first stage, and the hydropower schemes with facilities to supply the cheapest electric power energy were selected. The development ratio thus determined were 0.7 for Salto Pilão (1) scheme, 0.7 for Dalbergia scheme and 0.6 for Benedito Novo scheme. An optimization study on project components in this study was carried out assuming the same development ratio as determined in the first stage. The relation among the average turbine discharge, maximum plant discharge and the development ratio is summarized as follows;

Name of scheme	Average turbine discharge (m3/s)	Maximum plant discharge (m3/s)	Development ratio
Salto Pilão (1)	50.3	71.9	0.7
Dalbergia	19.3	27.6	0.7
Benedito Novo	8.4	13.9	0.6

(2) Plan formulation and pre-feasibility design

34. In addition to the dam axis proposed in the master plan study in the first stage, two dam axes were contemplated in this study. The locations of these dam axes for three schemes are shown in Figs. 2, 3 and 4. Geological features of major facilities for 3 hydropower schemes, which were clarified based on the geological investigation in the second stage, are summarized in Table 4. The comparative study to select the most suitable dam axis was made from two aspects, namely, technical and economic aspects and environmental aspect. According to the result of the environmental impact study, number of houses and area of land for the cases of the respective dam axes, which will be affected by the project, are as shown in Table 5. Summary of the environmental impact study is presented in item (6). The result of the environmental impact study clarifies that majority of the resort complex which is located in the left side of the Itajai river immediately upstream of the dam axis-A for Salto Pilão (1) scheme will be submerged if the dam axis-A or B is selected. For the Benedito Novo scheme, an intake structure for the existing hydropower plant with a capacity of 1.1 MW is located at the left side near the dam axis-A. Then it is pointed out that compensation of that power station is needed whichever the dam axis is selected. As a result of the economic comparison based on the construction cost estimated on the basis of the plan and design considering the geological characteristics and assessed power energy and also of the result of the environmental impact

study, dam axis-C for the Salto Pilão (1) scheme, dam axis-B for the Dalbergia scheme and dam axis-C for the Benedito Novo scheme were selected.

35. Based on the selected dam axis and related waterway, optimization study and pre-feasibility design of the project components were carried out. Since the damsite of 3 schemes are located at narrow river channels with relatively hard rocks in their foundations, concrete gravity type dam was adopted. The optimum scale of the headrace tunnel and penstock was determined by means of economic comparison and allowable flow velocity from the viewpoint of operation and maintenance. The detailed scale of other facilities was decided based on hydraulic and structural calculation. Principal features of the scheme thus determined are given in the followings. General layout of three schemes is shown in Figs.5, 6 and 7 for Salto Pilão (1) scheme, Figs.8, 9 and 10 for Dalbergia scheme and Figs. 11, 12 and 13 for Benedito Novo scheme.

I. SALTO PILÃO (1) HYDROPOWER SCHEME

(1) Concept for development

Purpose of power generation;	To supply base power to CELESC power system
Type of development;	Run-of-river type with regulating pondage

(2) Access to the project site; Through BR-470 highway and state road which branches from BR-470 highway near Lontras town

(3) Geological conditions at the structure sites

Damsite;	Foundation rock consists of hard granite. There are cracks in the river bed.
Headrace tunnel route;	Tunnel route consists of hard granite. There are 110 m long fault zones.
Surge tank site;	It consists of hard rhyolite. There are no technical problems.
Penstock route;	It consists of hard rhyolite. There are no technical problems.
Powerhouse site;	There is hard rhyolite in 12 m below the ground surface. There are no technical problems.

(4)	Hydrology	
	Catchment area;	5,602 km^2
	Average annual rainfall;	1,530 mm
	Average annual runoff;	109.9 m^3/sec
(5)	Dam and reservoir	
	Full Supply Level (FSL);	319 m
	Minimum Operation Level (MOL);	317 m
	Reservoir area at FSL;	0.40 km^2
	Daily regulation capacity;	620,000 m^3
	Type of dam;	Concrete gravity type
	Crest elevation;	320.5 m
	Maximum dam height;	20.5 m
	Crest length;	260 m
(6)	Spillway	
	Type of spillway;	Overflow type with gates
	Design flood discharge;	5,700 m^3/sec
	Crest elevation;	306.1 m
	Overflow length;	66 m
(7)	Headrace tunnel	
	Type;	Concrete lined circular tunnel
	Length of tunnel;	6,305 m
	Diameter of tunnel;	5.2 m
(8)	Surge tank	
	Type of surge tank;	Simple type
	Diameter of surge tank;	20 m
	Height of surge tank;	55.04 m
(9)	Penstock line	
	Type of penstock line;	Underground inclined pressure shaft, steel lined
	Diameter of penstock line;	5.2 m ~ 2.7 m
	Number of penstock line;	1 lane
	Length of penstock line;	505 m

(10) Power station

Type of power house;	Open-air type
Dimensions of power house;	34.0 m wide x 50.0 m long x 33.2 m high

(11) Power and energy

Maximum plant discharge;	71.9 m^3/sec
Tailwater level;	110.50 m
Rated head;	191.9 m
Installed capacity;	113.6 MW
Guaranteed energy;	654.2 GWh

(12) Generating facilities

Type of generator;	Vertical shaft, semi-umbrella
Number of unit;	2 units
Rated output;	56.8 MW

(13) Transmission line

138 kV line to existing transmission line;	7 km

II. DALBERGIA HYDROPOWER SCHEME

(1) Concept for development

Purpose of power generation;	To supply base power to CELESC power system
Type of development;	Run-of-river type with regulating pondage

(2) Access to the project site; Through BR-470 highway and SC-421 state road which branches from BR-470 highway at confluence of the Itajai river and Itajai do Norte river

(3) Geological conditions at the structure sites

Damsite;	Foundation rock consists of hard gneiss. There are cracks in the river bed.
Headrace tunnel route;	Tunnel route consists of hard gneiss. There are 110 m long fault zones.
Surge tank site;	It consists of hard gneiss. There are no technical problems.

Penstock route;	It consists of hard gneiss. There are no technical problems.
Powerhouse site;	There is hard gneiss in 11 m below the ground surface. There are no technical problems.

(4) Hydrology

Catchment area;	3,203 km^2
Average annual rainfall;	1,510 mm
Average annual runoff;	52.7 m^3/sec

(5) Dam and reservoir

Full Supply Level (FSL);	227 m
Minimum Operation Level (MOL);	226.2 m
Reservoir area at FSL;	0.37 km^2
Daily regulation capacity;	240,000 m^3
Type of dam;	Concrete gravity type
Crest elevation;	228.5 m
Maximum dam height;	22.5 m
Crest length;	392 m

(6) Spillway

Type of spillway;	Overflow type with gates
Design flood discharge;	4,100 m^3/sec
Crest elevation;	218.5 m
Overflow length;	87.5 m

(7) Headrace tunnel

Type;	Concrete lined circular tunnel
Length of tunnel;	8,720 m
Diameter of tunnel;	3.6 m

(8) Surge tank

Type of surge tank;	Simple type
Diameter of surge tank;	14.0 m
Height of surge tank;	60.91 m

(9) Penstock line

Type of penstock line;	Underground inclined pressure shaft, steel lined
Diameter of penstock line;	3.6 m ~ 1.7 m
Number of penstock line;	1 lane
Length of penstock line;	524 m

(10) Power station

Type of power house;	Open-air type
Dimensions of power house;	23.6 m wide x 35.0 m long x 30.4 m high

(11) Power and energy

Maximum plant discharge;	27.6 m^3/sec
Tailwater level;	133.50 m
Rated head;	74.1 m
Installed capacity;	16.8 MW
Guaranteed energy;	105.3 GWh

(12) Generating facilities

Type of generator;	Vertical shaft, suspension type
Number of unit;	2 units
Rated output;	8.4 MW

(13) Transmission line

23 kV line to Ibirama substation;	2 km

III. BENEDITO NOVO HYDROPOWER SCHEME

(1) Concept for development

Purpose of power generation;	To supply base power to CELESC power system
Type of development;	Run-of-river type with regulating pondage

(2) Access to the project site;	Through BR-470 highway and state road which branches from BR-470 highway at confluence of the Itajai river and Benedito river

(3) Geological conditions at the structure sites

Damsite;	Foundation rock consists of hard gneiss. There are fault cracks zones in the left side.
Headrace tunnel route;	Tunnel route consists of hard gneiss. There are 280 m long fault zones.
Surge tank site;	It consists of hard gneiss. There are no technical problems.
Penstock route;	It consists of hard gneiss. There are no technical problems.
Powerhouse site;	There is hard gneiss in 5 m below the ground surface. There are no technical problems.

(4) Hydrology

Catchment area;	586 km^2
Average annual rainfall;	1,620 mm
Average annual runoff;	14.5 m^3/sec

(5) Dam and reservoir

Full Supply Level (FSL);	277 m
Minimum Operation Level (MOL);	270 m
Reservoir area at FSL;	0.029 km^2
Daily regulation capacity;	160,000 m^3
Type of dam;	Concrete gravity type
Crest elevation;	278.5 m
Maximum dam height;	24.5 m
Crest length;	130 m

(6) Spillway

Type of spillway;	Overflow type with gates
Design flood discharge;	1,500 m^3/sec
Crest elevation;	236.9 m
Overflow length;	34 m

(7) Headrace tunnel

Type;	Concrete lined circular tunnel
Length of tunnel;	1,815 m

Diameter of tunnel;	2.8 m

(8) Surge tank

Type of surge tank;	Simple type
Diameter of surge tank;	10 m
Height of surge tank;	31.31 m

(9) Penstock line

Type of penstock line;	Underground inclined pressure shaft, steel lined
Diameter of penstock line;	2.8 m ~ 1.2 m
Number of penstock line;	1 lane
Length of penstock line;	455 m

(10) Power station

Type of power house;	Open-air type
Dimensions of power house;	21.1 m wide x 30.8 m long x 21.6 m high

(11) Power and energy

Maximum plant discharge;	13.9 m^3/sec
Tailwater level;	154.20 m
Rated head;	115 m
Installed capacity;	13.2 MW
Guaranteed energy;	65.4 GWh

(12) Generating facilities

Type of generator;	Vertical shaft, suspension type
Number of unit;	2 units
Rated output;	6.6 MW

(13) Transmission line

69 kV line to Timbó substation;	17 km

(3) Construction plan and cost estimate

36. Implementation schedule of the projects including feasibility study, detailed design and construction works was prepared. It is scheduled to execute the construction works during

4 years for the Salto Pilão (1), 3.5 years for the Dalbergia and 3 years for the Benedito Novo as shown in Figs.14 , 15 and 16 respectively.

37. Based on the works quantities estimated on the basis of the foregoing features of the schemes and analyzed unit costs of major work items, the construction cost was estimated at price level of May, 1991 as follows;

(Unit: thousand US$)

	Name of scheme		
	Salto Pilão (1)	Dalbergia	Benedito Novo
- Direct cost	143,506	80,880	41,593
- Compensation cost	171	183	2,003
- Administration cost	7,175	4,044	2,080
- Engineering service cost	4,100	3,760	3,480
- Physical contingency	23,243	13,330	7,373
Total	178,195	102,197	56,529

Based on the construction time schedule, the construction fund to be disbursed in each construction year was estimated as follows, assuming that the project works are executed by contractor or supplier who will be selected through international competitive tendering and 20% of the construction cost is disbursed as an advance payment.

(Unit: thousand US$)

Construction year	Name of scheme		
	Salto Pilão (1)	Dalbergia	Benedito Novo
1st	55,398	30,202	17,392
2nd	19,900	23,035	16,076
3rd	54,231	35,807	23,061
4th	48,666	13,152	-
Total	178,195	102,197	56,529

(4) Project evaluation

38. The economic evaluation of the hydropower schemes was made by means of the comparison of unit cost of the guaranteed energy and marginal cost of the expanded energy of the system, which has been specified by ELETROBRAS. In addition, Economic Internal Rate of Return (EIRR) was assessed assuming several marginal costs of the expanded energy of the

system. The marginal cost of the expanded energy of the system applied in the evaluation was officially revised in May 1991 as shown bellow;

Five-Year Period	Marginal Cost of Expanded Energy (US$/MWh)
1991 - 1995	45
1996 - 2000	48
2001 - 2005	58
2006 - 2010	71
2011 onward	86

Result of the assessed unit cost of the guaranteed energy for three schemes is as follows;

Name of scheme	Installed capacity (MW)	Guaranteed energy (GWh)	Secondary energy (GWh)	Construction cost (Mill US$)	Unit cost of guaranteed energy (US$/MWh)
Salto Pilão (1)	113.6	654.2	63.0	178.2	26.5
Dalbergia	16.8	105.3	12.2	102.2	96.7
Benedito Novo	13.2	65.4	11.4	56.5	85.4

It shows that the Salto Pilão (1) hydropower scheme is remarkably superior to other two schemes from the viewpoints of economic viability and scale of the installed capacity. The marginal cost of the expanded energy in the system for 1996-2000 period is set at US$ 48/MWh. It implies from the comparison of this figure and US$ 26.5/MWh of the unit cost of the guaranteed energy that the Salto Pilão (1) scheme is worth developing at the earliest stage as possible. The unit cost of the guaranteed energy for the Benedito Novo hydropower scheme is about US$ 85.4/MWh, which is close to US$ 86/MWh of the marginal cost of the expanded energy for 2011 onward. It means that the Benedito Novo hydropower scheme is worth developing but its development will have to be postponed until the stage when the scheme becomes viable as the regional economy is upheaved. While, the Dalbergia hydropower scheme is judged to be infeasible at this stage since the assessed unit cost of the guaranteed energy is far beyond the specified marginal cost.

EIRR estimated assuming several marginal costs is as follows;

Name of scheme	EIRR (%) Marginal cost (US$ / MWh) 45	48	58
Salto Pilão (1)	13.3	14.1	16.5
Dalbergia	3.4	3.7	4.8
Benedito Novo	4.0	4.4	5.6

39. Overall evaluation of the schemes was made based on four aspects, namely, economic feasibility, timing of implementation, degree of contribution to social and economic development in the region and environmental impacts. From the viewpoint of economic feasibility and timing of implementation, Salto Pilão (1) scheme is superior to other two schemes and worth developing at the earliest stage. For degree of contribution to social and economic development in the region, two aspects, i. e., stable power supply to the consumer and creation of job opportunity and activation of regional economy were contemplated. For environmental impact due to project implementation, extent of number of household and acreage of land to be affected by construction of project facilities was considered. The result of the evaluation for these four aspects shows that the Salto Pilão (1) scheme is the most promising project among the three hydropower scheme. It is therefore recommended that this hydropower scheme be selected for feasibility study to be carried out in the following stage.

(5) Program for feasibility study in the following stage

40. The program for feasibility study on Salto Pilão (1) hydropower scheme in the following stage comprises field works and feasibility study and design. The field works consist of topographic survey, environmental and compensation surveys and geological investigation. The feasibility study and design comprise hydrological study, socio-economy study, power study, plan formulation, structural design, cost estimate and project evaluation. Details of this program are stated in Chapter 10 in the main report in Vol. III. It is scheduled to carry out the field works and feasibility study and design during 10 months.

(6) Summary of environmental impact study

41. Salto Pilão (1) scheme

(1) Natural environment

(i) Landscape

a. Present condition; the project area is located along the Itajai river in the middle part of the Itajai river basin. Vicinity of the damsite is composed of hills whose relative height is 30 to 100 m. River bed slope is generally steep forming small scale rapid and it becomes more steeper up to the proposed powerhouse site. There is aesthetic value of landscape but it has not been utilized for the tourist purpose.

b. Impact; a small pond is formed in the upstream of the damsite, and velocity of river flow in the downstream of the damsite is reduced. Landscape may vary due to the development of the quarry site.

c. Measure; it is desirable to arrange the mountain area after its utilization as the quarry site. Evaluation of indirect impact and its measure is stated in the items concerned.

(ii) Vegetation

a. Present condition; mountain slope has been utilized as pasture. There are secondary forests along the river channel.

b. Impact; since the secondary forest distributes in several parts, it is hardly to utilize it for production. Besides, such small portion of forest is not economically viable from the forestry point of view. Impact to the vegetation due to its reduction by submergence is very small.

c. Measure; no measure is needed.

(iii) Wildlife

a. Present condition; some important bird species are found in the area. They are Jacuacu (Penelope obscura) and Araponga (Procnias nudicollis). The former is listed as a threatened species to extinction by the government of Brazil and the latter as an endangered species. In addition to the above two species, ten species are living. Two types of fish, one is living in rapid stream and the other in still water are found. Besides fish migrating in the river is also found. They are consumed by the local residents. It is believed that very few of the major predators typical to the Latin America rainforest, such as Jaguar (Panthera onca) and Puma (Felis concolor) are still in the mountain ranges of the region. However, during the field survey, there was no evidence of predators at the time of this study. Neither the herbivorous animals on which the carnivorous animals prey are found.

b. Impact; if the forest area is lost due to impounding of reservoir, the living place for important bird species will be affected and it is feared to exterminate them. Some fishes, especially those adapted to the still water will increase in the reservoir area. On the contrary, the fish living in the rapid stream may be reduced. There are no effect to the predator living in the mountain area.

c. Measure; in order to minimize the effect to the bird species living in the forests along riverine areas, it is desirable to minimize the area of forest to be submerged. Unless the schemes with the dam axis-A or B is superior to the scheme with the dam axis-C from the viewpoint of economic viability or other environmental aspects, the dam axis-C should be selected. Besides, fish breeding by increasing the population of fish adapted to still water should be planned. But for its implementation, special consideration of adverse effects such as eutrophication and reduction of the existing fish due to fish migration should be taken. Further study and observation on ecological structure will be needed.

(iv) Water resources

a. Present conditions; most of the rural households obtain water from the shallow wells developed individually. In the area where a community is formed, community water supply systems are developed. A few isolated households obtain water from the streams nearby. Water treatment system is considered to be substandard. Water quality for most of the houses in the area is substandard and spread of water-born diseases among the families nearby the project area is very common. There are about 9,707 ha of farm land in the upstream of the damsite and 16 m^3/sec of river water is utilized during December to March in the next year.

b. Impact; creation of reservoir will generally bring about deposition of sediment in the reservoir, eutrophication and lowering of river bed in the downstream stretch. The reservoir in the scheme is not so large as to vary the duration of the river flow, but the river discharge in the stretch between damsite and tailrace will be reduced due to intaking of a part of river discharge for power generation. The river discharge in the downstream of the tailrace varies depending on the daily regulation of the reservoir. Groundwater levels along the reservoir areas may rise if the dam axis-A or -B is selected. The rising level of groundwater may benefit a large number of local residents living along the reservoir area because shallow well development should be enhanced in the area where there is no groundwater and it was not tapped in the past. The dam axis-C will affect no part of the residential area around the reservoir area. However, the rising level of groundwater may in the long term affect the soil moisture conditions in the farm land along the reservoir area, and advantage and disadvantage due to the rise of groundwater may take place.

c. Measure; since sediment load in the river is a very few and there is no sediment deposit in upstream and downstream from the damsite, sediment deposit in the reservoir and lowering of river bed in the downstream will be solved by proper operation of gates provided in the dam. Eutrophication problem will be also solved by proper operation of gates. It was judged from the present riverine condition that there are no effect to the river stretch between the damsite and tailrace though the river discharge is reduced. If some disadvantage take place in future stage it can be solved by gate operation. On this occasion a part of river water to be used for power generation will be lost. An artificial variation of river water level in the downstream from the tailrace will be solved by warning for water release. Regarding rise of groundwater near the reservoir area, its utilization and measure should be planned based on the investigation after impounding of the reservoir. As stated in item for public health, contamination of water quality due to use of agricultural chemicals and industrial waste water may take place. Unless such water contamination due to drainage from cities in the upstream area is properly controlled, eutrophication problem cannot be avoided. Overall management of river environment including observation of water quality will be needed.

(v) Mineral resources

a. Present conditions; there is no resource of which extraction could be economically viable.

b. Impact; there is no impact.

c. Measure; no measure is needed.

(2) Social environment

(i) Population

a. Present condition; two large population centers are located in the upstream from the damsite; Lontras (population is 7,623 in 1989) at several km upstream of the damsite and Rio do Sul (population is 44,108 in 1989) at about 15 km upstream of the damsite.

b. Impact; more than 87 household in Lontras area will be submerged if the dam axis-A or -B is selected. For the dam axis-C, 9 households will be submerged.

c. Measure; compensation is needed. In order to avoid resettlement problem due to implementation of the project as far as possible, the dam axis-C should be selected.

(ii) Land use and economic activities

a. Present conditions; along the river stretch, forest area, residential area, farm land in plain area and pasture and upland area in hill area are located. Wood from the forest is a major source of fuel. Major cities are Lontras and Rio do Sul and industry is developing in both cities. There are about 807 property holders and agricultural land is 10,595 ha. Livestock rearing is common in the area and two to three cattle are kept every one ha of land. Cattle and sheep are major livestock and milk is major source of income for rural residents. Major industries in the secondary sector in Lontras consist of furniture making, transportation of non-metallic products, textile, and shoe manufacturing. There is a resort complex in the left bank at immediately upstream of the dam axis-A.

b. Impact; due to creation of reservoir a part of cities, pasture, farm land and resort complex will be lost. Besides, land use in other area due to resettlement will be affected. For the dam axis-A or -B, 259 and 288 ha of land respectively will be lost, majority of the resort complex will be submerged and alignment of new road will be needed. For the dam axis-C, the area to be submerged is 33 ha and resort complex is not included. Alignment of new road is not needed. In case of the dam axis-A or -B, water level will be increased by about 1 to 2 m higher than the present water level due to impounding of the reservoir, though the impounded water level is confined within the river channel. Deforestation due to construction work of the project may destroy fuel wood for local residents.

c. Measure; the dam axis-C which results in the minimum submerged area should be selected. More detailed land use survey will be needed.

(iii) Public health

a. Present conditions; it appears that the water-born diseases such as diarrhea are common among the local residents. It has been reported that fish in the upstream area are killed. No clear substantiation has been made to date. However, it is believed that killing fish are caused by excessive use of agricultural chemicals. Also, though the scale is small, industrial waste discharge, which is relatively uncontrolled in the area, is also believed to be one of the factors for killing fish.

b. Impact; there are no impact.

c. Measure; overall management of water environment including observation of water quality is needed.

(iv) National parks and wildlife sanctuaries

a. Present conditions; there is no evidence of national parks and wildlife sanctuaries to be directly or indirectly affected by the project.

b. Impact; there is no impact.

c. Measure; no measure is needed.

(v) Historical and archaeological sites

a. Present conditions; there are no historical and archaeological sites significant for academic value as well as for tourism.

b. Impact; there is no impact.

c. Measure; no measure is needed.

42. Dalbergia scheme

(1) Natural environment

(i) Landscape

a. Present condition; the project area is located along the Itajai do Norte river in the middle part of the Itajai river basin. Vicinity of the damsite is formed by hilly areas with relative height of 80 to 100 m. There was no evidence and no opinion among the local people that the area is of significant aesthetic value to their life and for the nation as a whole.

b. Impact; quarry site, disposal area and areas for construction of powerhouse, access road and other ancillary facilities of the project will be situated in wide areas.

c. Measure; although the proposed quarry site and spoil banks are scattering wide areas of waste lands, consideration should be given to avoid disturbance to natural landscape in the planning.

(ii) Vegetation

a. Present condition; the vegetation around the damsite is a mixture of riparian forest, which is presumably the secondary natural forest, limited patches of grassland, and agricultural land including pasture

b. Impact; since the secondary forest distributes in several parts, it is hardly to utilize it for production. Besides, such small portion of forest is not economically viable from the forestry point of view. Impact to the vegetation, due to its reduction by submergence is very small.

c. Measure; no measure is needed.

(iii) Wildlife

a. Present conditions; there is a large number of bird species identified in the project area. All of them are common species in Southern Brazil. Endangered species such as Pato-mergulhador (Mergus octocetaceus) and Soco-boi-escuro (Tigrisoma fasciatum) are expected to exist in the area. However, none of them have been identified at the time of the study. There are two types of fish in this area: one adapted to rapid streams; the other adapted to still water. They are consumed by the local residents. No large mammals are found in the project area.

b. Impact; no bird species and their habitat are adversely affected by the project. Fish, especially those adapted to still water, will increase in the reservoir area. On the other hand, the fish population adapted to rapid streams will decrease to some extent.

c. Measure; fish breeding by increasing the population of fish adapted to still water should be planned. But for its implementation, special consideration of adverse effects such as eutrophication and reduction of the existing fish due to fish migration should be taken. Further study and observation on ecological structure will be needed.

(iv) Water resources

a. Present condition; most of the rural households obtain water from the shallow wells developed individually. In the area where a community is formed, village and town water supply systems are developed. A few isolated households obtain water from the streams nearby. Water treatment system is considered to be substandard. The quality of water being used by most of the houses is substandard and spread of water-born diseases among the families living near the project area is very common. There is no demand for agriculture.

b. Impact; creation of reservoir will generally bring about deposition of sediment in the reservoir, eutrophication and lowering of river bed in the downstream stretch. The reservoir in this scheme is not so large as to vary the duration of the river flow, but the river discharge in the stretch between damsite and tailrace will be reduced due to intaking of a part of river discharge for power generation. The river discharge in the downstream of the tailrace varies depending on the daily regulation of the reservoir. Groundwater levels along the reservoir areas may rise. The rising level of groundwater may benefit a large number of local residents living along the reservoir area. The rising level of groundwater may in the long term affect the soil moisture conditions in the farm land along the reservoir area and advantage and disadvantage due to the rise of groundwater may take place.

c. Measure; since sediment load in the river is very few and there is no sediment deposit in upstream and downstream from the damsite, sediment deposit in the reservoir and lowering of river bed in the downstream will be solved by proper operation of gates provided in the dam. Eutrophication problem will be also solved by proper operation of gates. It was judged from the present riverine condition that there are no effect to the river stretch between the damsite and tailrace though the river discharge is reduced. If some disadvantage take place in future stage it can be solved by gate operation. On this occasion a part of river water to be used for power generation will be lost. An artificial variation of river water level in the downstream from the tailrace will be solved by warning for water release. Regarding rise of groundwater near the reservoir area, its utilization and measure should be planned based on the investigation after impounding of the reservoir. As stated in item for public health, contamination of water quality due to use of agricultural chemicals and industrial waste water may take place. Unless such water contamination due to drainage from cities in the upstream area is properly controlled, eutrophication problem cannot be avoided. Overall management of river environment including observation of water quality will be needed.

(v) Mineral resources

a. Present condition; there are no mineral resources of which extraction is economically viable.

b. Impact; there is no impact.

c. Measure; no measure is needed.

(2) Social environment

(i) Population

a. Present condition; the largest center directly affected by the Dalbergia scheme is Dalbergia, a few km upstream of the damsite and Ibirama at 7 km downstream of the damsite. The size of population in Dalbergia cannot be clearly established because the census data include Ibirama. The total population of Ibirama increased to 25,814 in 1989 from 21,000 in 1970. During this period, remarkable shift from rural population to urban population took place.

b. Impact; for the dam axis-A or B, 17 households are submerged. For the dam axis-C, 20 households are subject to submerge.

c. Measure; resettlement for the submerged area is needed, though the impact of this problem is almost the same whichever the dam axis is selected.

(ii) Land use and economic activities

a. Present condition; although the plain area along the river is very small, it is used as small scale farming and reforested area. The sloped area is covered with forest, which is a major important source of fuel wood for local residents. Livestock rearing is common in the area. Major industries in the secondary sector in Dalbergia are timber and textile industries.

b. Impact; due to impounding of reservoir, small scale reforested area and undeveloped grassland will be submerged. The submerged area is in the order of 19 to 25 ha. Land use in other area will be affected due to relocation and resettlement. Deforestation due to construction works of the project may destroy fuel wood for local residents.

c. Measure; influence to land use and economic activities by the project can be solved by ordinary compensation and resettlement. More detailed land use survey is needed.

(iii) Public health

a. Present condition; it has been reported that fish population in the upstream area has decreased. No clear substantiation has been made to date. However, it is believed that killing fish are caused by excessive use of agricultural chemicals. Industrial waste discharge, which is relatively uncontrolled in the area, is also believed to be one of the factors for killing fish.

b. Impact; there is no impact.

c. Measure; overall management for river environment including observation of water quality is needed.

(iv) National parks and wildlife sanctuaries

a. Present condition; there is no evidence of national parks and wildlife sanctuaries to be directly or indirectly affected by the project.

b. Impact; there is no impact.

c. Measure; no measure is needed.

(v) Historical and archaeological sites

a. Present condition; stone arrow heads were found near the damsite in the past. But no other historical and anthropological sites were recorded in the project area.

b. Impact; impact is unknown.

c. Measure; archaeological investigation should be conducted.

43. Benedito Novo scheme

(1) Natural environment

(i) Landscape

a. Present condition; the project area is located along the Benedito river in the middle part of the Itajai river basin. Vicinity of the damsite is formed by hilly and mountainous areas with relative height of 80 to 200 m. Both river banks of the damsite are very steep slope. There are a series of water fall with a few meters high. There was no evidence and no opinion among the local people that the damsite and the reservoir area are of significant aesthetic value to their life style and for the nation as a whole.

b. Impact; quarry site, disposal area and areas for construction of power house, access for construction site, and other ancillary facilities of the project are situated in wide areas.

c. Measure; although the proposed quarry site and spoil banks are scattering wide areas of waste lands, consideration should be given to avoid disturbance to natural landscape in the planning.

(ii) Vegetation

a. Present condition; the small plain area along the river is utilized as small scale pasture and agricultural land for family consumption. Secondary forest covers the mountain slope.

b. Impact; since the secondary forest distributes in several parts, it is hardly to utilize it for production. Besides, such small portion of forest is not economically viable from the forestry point of view. Impact to the vegetation due to the reduction by submergence is very small.

c. Measure; no measure is needed.

(iii) Wildlife

a. Present condition; many birds species are identified in the area. There are two types of fish in this area: one adapted to rapid streams; the other adapted to still water. Both types of fish are consumed by the local residents. There was no evidence of carnivore.

b. Impact; it was judged that there will be no impact to bird species and their habitat. Fish, especially those adapted to still water may increase in the reservoir area to some extent. On the other hand, the fish population adapted to rapid streams will decrease to some extent.

c. Measure; fish breeding by increasing the population of fish adopted to still water should be planned. Bur for its implementation, special consideration of adverse effects such as eutrophication and reduction of the existing fish due to fish migration should be taken. Further study and observation on ecological structure will be needed.

(iv) Water resources

a. Present conditions; most of the rural households obtain water from the shallow wells developed individually. Although there is a town near the project site, Alto Benedito Novo, there is no water treatment system of which standard is comparable to that of a large city. A few isolated households obtain water from the streams nearby. The quality of water being used by most of the houses in the area is substandard. There is no water demand for agriculture.

b. Impact; creation of reservoir will generally bring about deposition of sediment in the reservoir, eutrophication and lowering of river bed in the downstream stretch. The reservoir in this scheme is not so large as to vary the duration of the river flow, but the river discharge in the stretch between damsite and tailrace will be reduced due to intaking of a part of river discharge for power generation. According to the hydrological calculations for this scheme, the river discharge in the downstream of the tailrace varies depending on the daily regulation of the reservoir. Groundwater levels along the reservoir areas may rise if the dam axis-A or -B is selected. The rising level of groundwater may benefit a large number of local residents living along the reservoir area.

c. Measure; since sediment load in the river is very few and there is no sediment deposit in upstream and downstream from the damsite, sediment deposit in the reservoir and lowering of river bed in the downstream will be solved by proper operation of gates provided in the dam. Eutrophication problem will be also solved by proper operation of gates. It was judged from the present riverine condition that there will be no effect to the river stretch between the damsite and tailrace though the river discharge is reduced. If some disadvantage take place in future stage it can be solved by gate operation. On this occasion a part of river water to be used for power generation will be lost. An artificial variation of river water level in the downstream from the tailrace will be solved by warning for water release. Regarding rise of groundwater near the reservoir area, its utilization and measure should be planned based on the investigation after impounding of the reservoir. As stated in item for public health, contamination of water quality due to use of agricultural chemicals and industrial waste water may take place. Unless such water contamination due to drainage from cities in the upstream area is properly controlled, eutrophication problem cannot be avoided. Overall management of river environment including observation of water quality will be needed.

(v) Mineral resources

a. Present conditions; there is no resource of which extraction is economically viable.

b. Impact; there is no impact.

c. Measure; no measure is needed.

(2) Social environment

(i) Population

a. Present condition; the largest population centers near the project area are Alto Benedito Novo immediately upstream of the damsite and Benedito Novo at the downstream of powerhouse site. The size of the population in Alto Benedito Novo cannot be explicitly established because the census data for Benedito Novo is combined with that of Alto Benedito Novo. The population in Benedito Novo in 1989 was 12,000. Of the total population, shift of rural population to urban population took place.

b. Impact; due to impounding of the reservoir, 112 houscholds for the dam axis-A, 28 households for the dam axis-B and 23 households for the dam axis-C will be submerged.

c. Measure; resettlement is needed. The problems arising from the settlement are almost the same for 3 cases.

(ii) Land use and economic activities

a. Present condition; the plain area along the river is very small and it is utilized as small scale farm land for family consumption use and reforested area. Sloped area is covered with forest, which is an important source of fuel wood for local residents. Livestock rearing is common in the area. The major industries in the secondary sector in Benedito Novo/Alto Benedito Novo consist of timber, furniture, transportation of non-metallic products and food processing. Due to the recent trend in conservation of natural forest, the present timber industry has been facing severe demand for the reduction of its scale of production. There are two hydro-electric power stations in the project river stretch. One is the power station with an installed capacity of 1.12 MW which is owned by the local community and the other is the power station with installed capacity of 0.15 MW which is owned by a private company.

b. Impact; due to the impounding of the reservoir, 31 ha of land for the dam axis-A, 17 ha for the dam axis-B and 3 ha for the dam axis-C will be submerged. The land use in other area is affected due to relocation and resettlement. Besides, deforestation owing to the construction works of the project may destroy fuel wood for local residents. One of the two existing power stations will be affected by the project. Santa Maria Electric Cooperative power station is located at 400 m downstream of the dam axis-C. The installed capacity of this power station is 1.12 MW at present and it is scheduled to increase to 3.12 MW by the end of this year. Whichever the dam axis is selected, a sufficient supply of river water for power generation of the Santa Maria Cooperation power station would become impossible since majority of river water is used for Benedito Novo hydropower scheme. Privately owned power station is located at 1,000 m downstream of the dam axis-C. The installed capacity of this power station is 0.15 MW. Operation of the power station would not be affected since power energy can be generated by river maintenance flow.

c. Measure; influence to land use and economic activities by the project can be solved by ordinary compensation and resettlement. More detailed land use survey is needed. Compensation for Santa Maria power station will be needed, but compensation for its power generation will not be needed because power tariff of this power station is very high compared with the tariff specified by ELETROBRAS and consequently CELESC intends to supply electric power to this region instead of power supply by Santa Maria power station in future stage. For the privately owned power station, agreement for reliable water release should be concluded.

(iii) Public health

a. Present condition; it appears that the water-born diseases such as diarrhea are common among the local residents. Unlike Salto Pilão scheme, there has been no report that the fish population in the upstream area was killed by agricultural chemicals and industrial waste.

b. Impact; there is no impact.

c. Measure; overall management of river environment including observation of water quality is needed.

(iv) Existing national parks and wildlife sanctuaries

a. Present condition; there are no designated conservation areas such as national parks and wildlife sanctuaries to be affected by the implementation of the project.

b. Impact; there is no impact.

c. Measure; no measure is needed.

(v) Historical and archaeological sites

a. Present condition; there are no historical and archaeological sites significant for academic value or for tourism.

b. Impact; there is no impact.

c. Measure; no measure is needed.