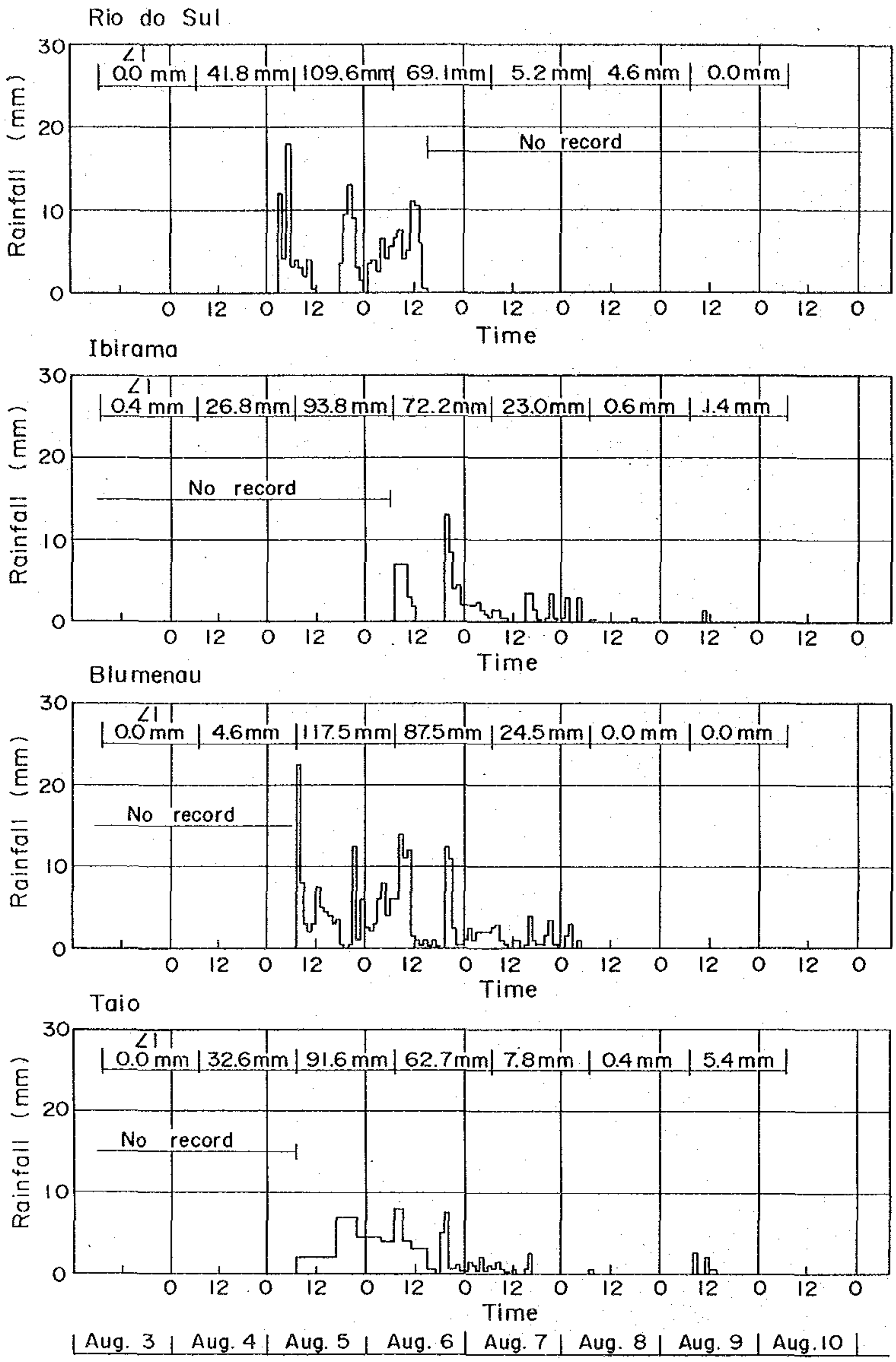


Fig. I.3.8 RECORDED HOURLY RAINFALL DISTRIBUTION OF RAIN STORM IN 1984 (2/2)

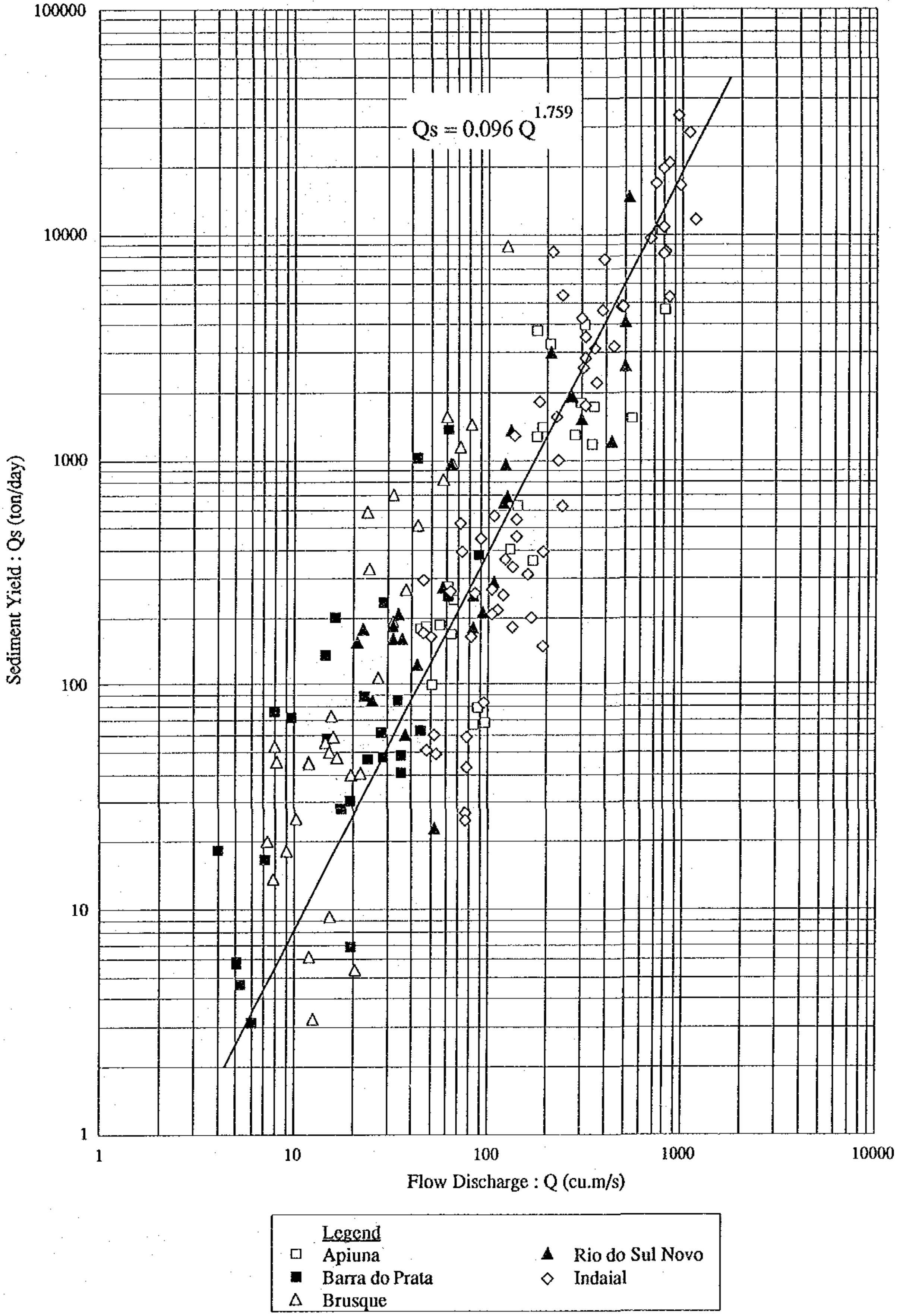


Fig. I.3.9 RELATION BETWEEN SEDIMENT AND FLOW DISCHARGES IN THE ITAJAI RIVER BASIN

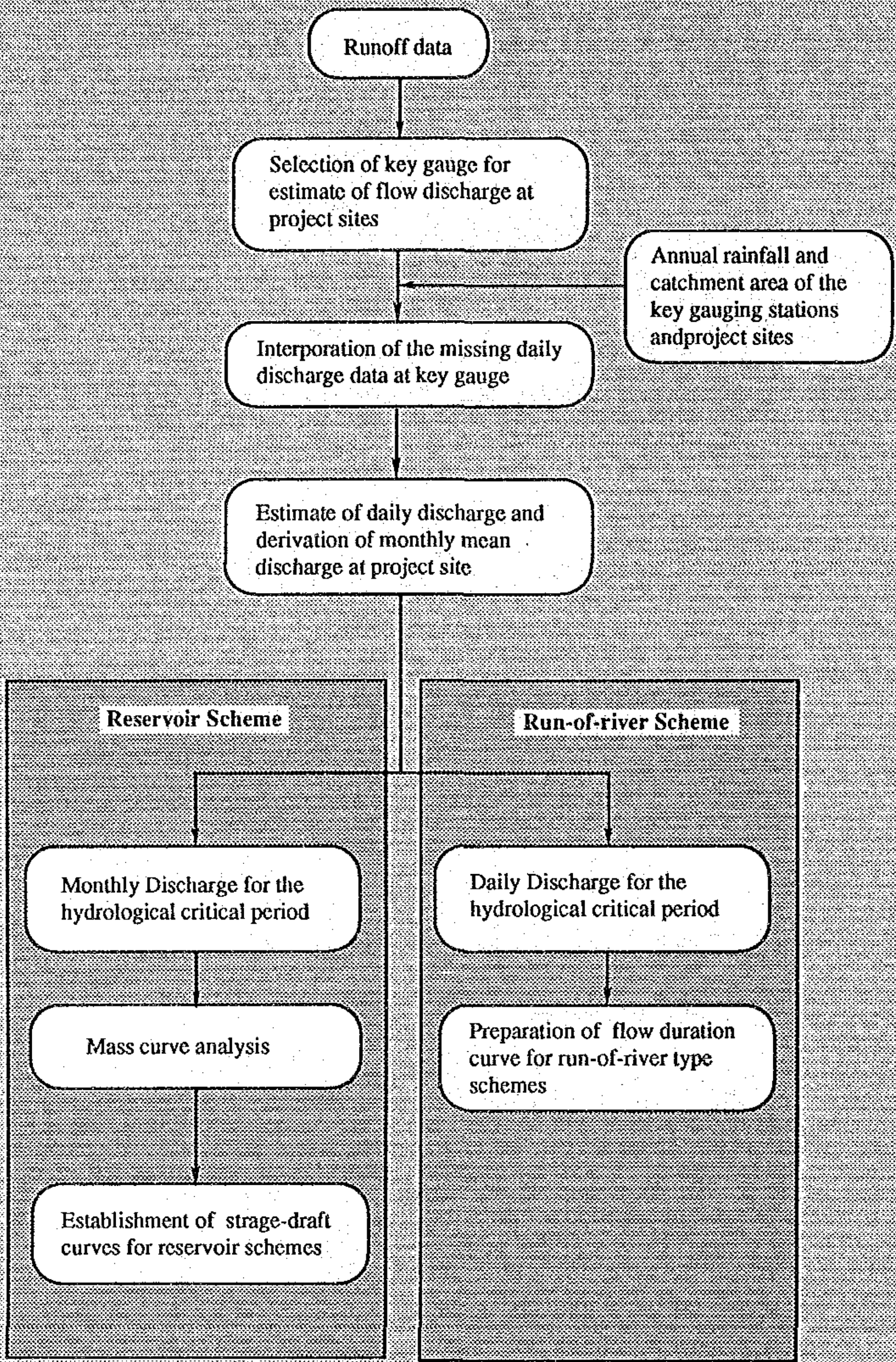
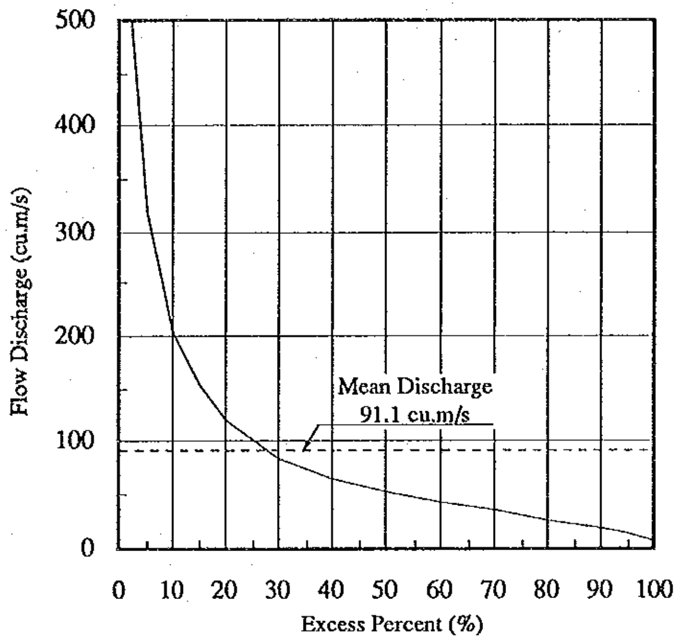
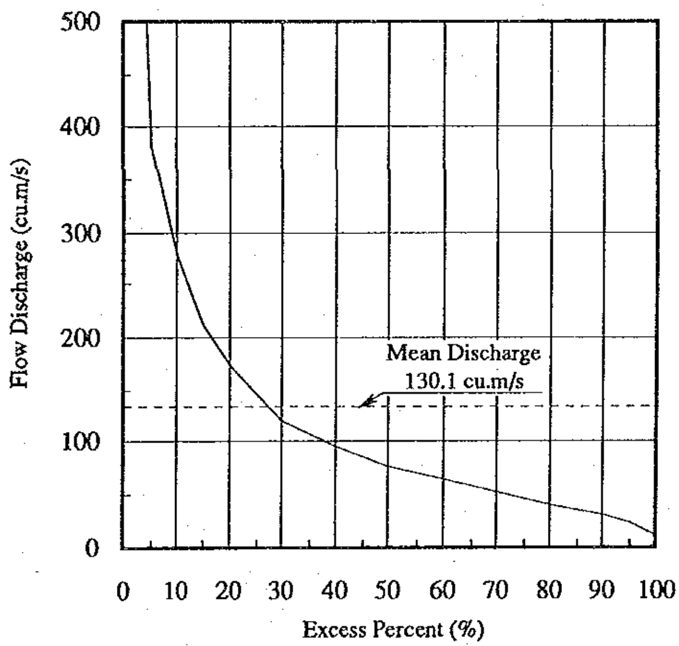


Fig. I.4.1 GENERAL WORK FLOW DIAGRAM OF LOW FLOW ANALYSIS



Excess Percent (%)	Flow Discharge (cu.m/s)
1	562.0
5	318.0
10	204.0
15	155.0
20	121.0
30	83.9
40	64.6
50	53.1
60	44.4
70	35.7
80	27.4
90	18.9
95	15.0
100	7.3

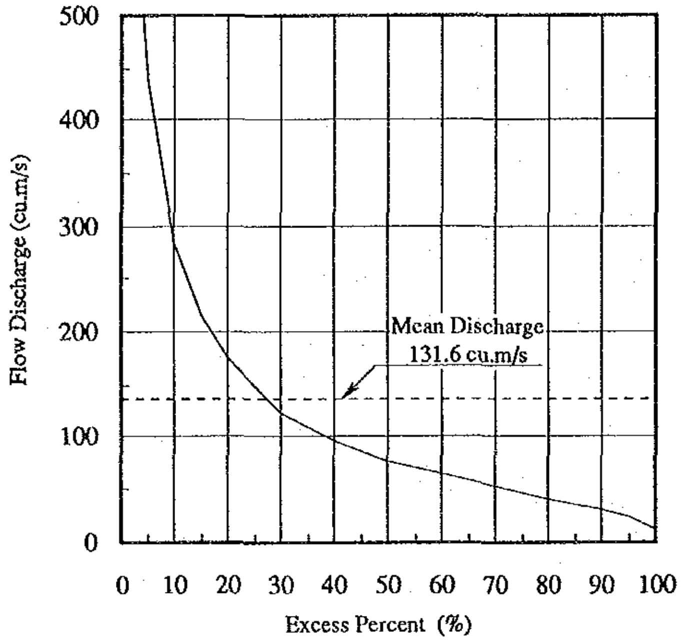
Scheme No. 1 and 2 : Salto Pilao (1) and (2)



Excess Percent (%)	Flow Discharge (cu.m/s)
1	797.0
5	381.0
10	281.0
15	212.0
20	173.0
30	121.0
40	96.3
50	76.5
60	65.3
70	53.5
80	40.9
90	30.1
95	23.8
100	11.2

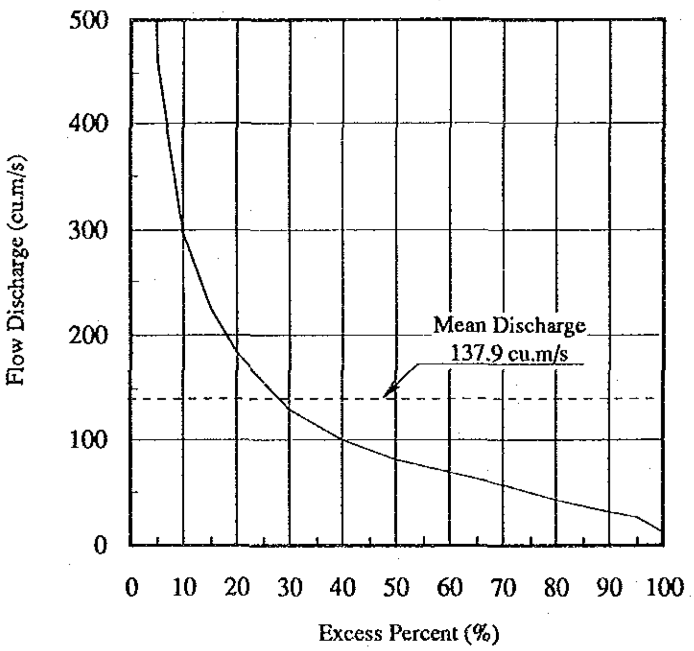
Scheme No.3 : Ibirama

Fig .I.4.2 FLOW DURATION CURVES FOR RUN-OF-RIVER SCHEMES (1/4)



Excess Percent (%)	Flow Discharge (cu.m/s)
1	806.0
5	436.0
10	284.0
15	215.0
20	175.0
30	123.0
40	97.4
50	77.4
60	66.0
70	54.1
80	41.4
90	30.5
95	24.1
100	11.4

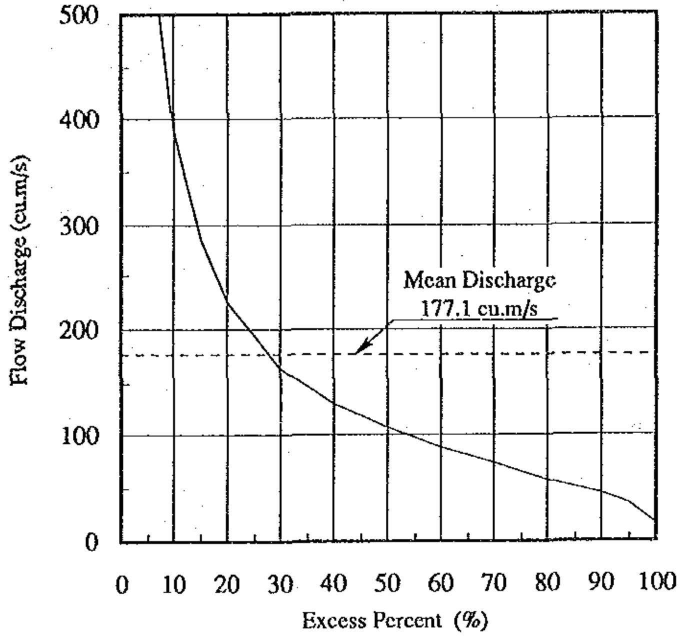
Scheme No. 4 : Subida



Excess Percent (%)	Flow Discharge (cu.m/s)
1	844.0
5	458.0
10	298.0
15	225.0
20	184.0
30	129.0
40	102.0
50	81.1
60	69.2
70	56.7
80	43.3
90	31.9
95	25.3
100	11.9

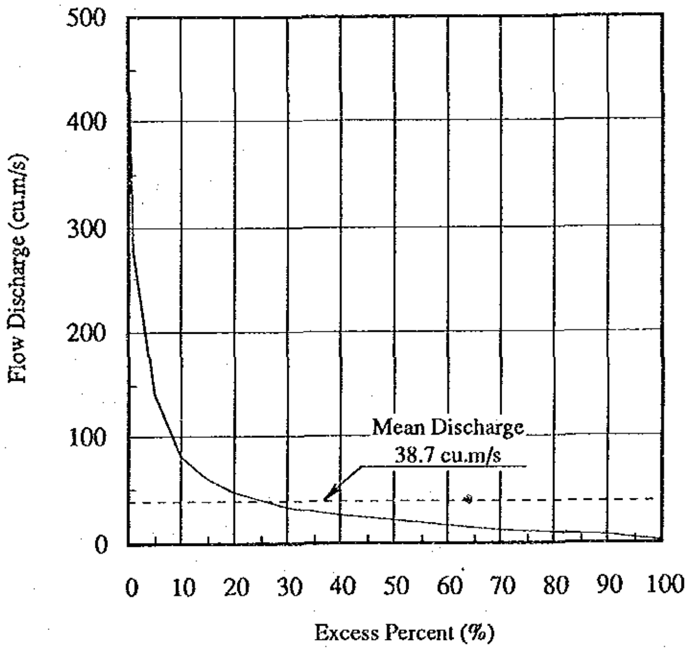
Scheme No.5 : Ascurra

Fig .I.4.2 FLOW DURATION CURVES FOR RUN-OF-RIVER SCHEMES (2/4)



Excess Percent (%)	Flow Discharge (cu.m/s)
1	1049.0
5	590.0
10	388.0
15	284.0
20	226.0
30	165.0
40	129.0
50	109.0
60	88.0
70	74.0
80	58.8
90	44.9
95	36.0
100	17.0

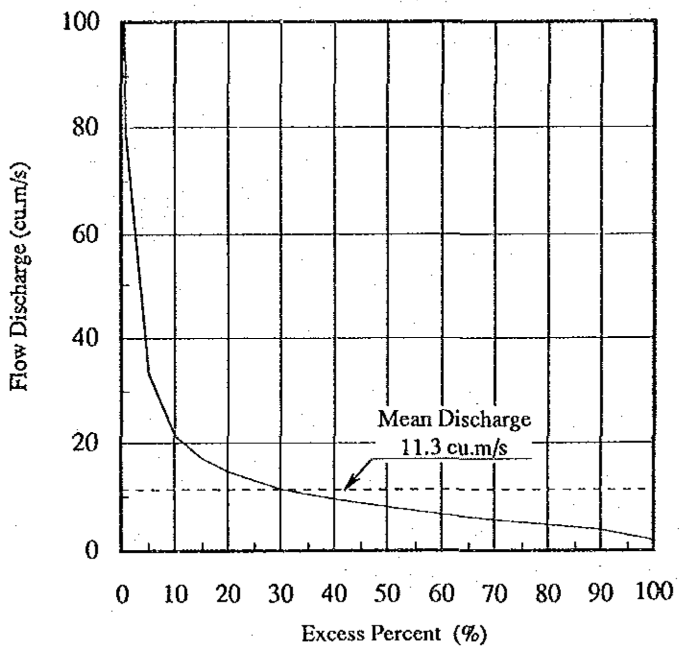
Scheme No. 6 : Indaial



Excess Percent (%)	Flow Discharge (cu.m/s)
1	280.3
5	145.0
10	82.8
15	60.6
20	48.2
30	33.2
40	25.4
50	20.8
60	17.0
70	13.1
80	10.6
90	7.5
95	5.7
100	1.2

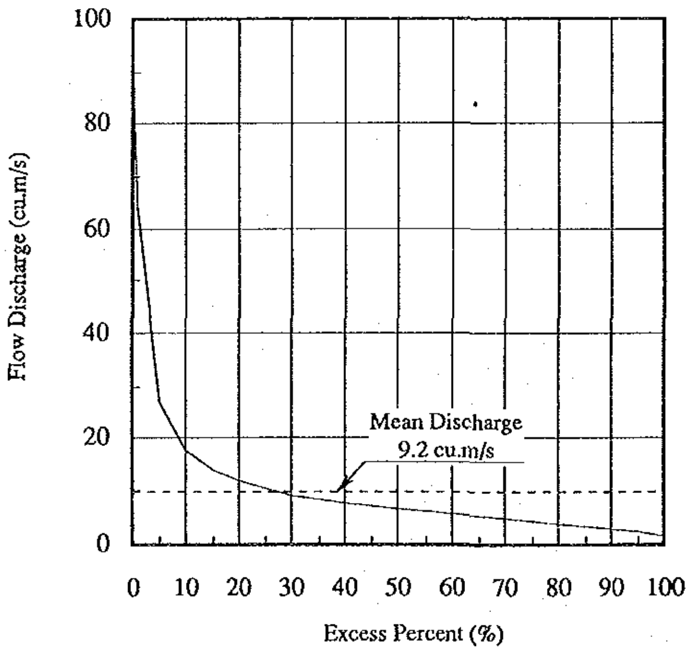
Scheme No.7 : Dalbergia

Fig .I.4.2 FLOW DURATION CURVES FOR RUN-OF-RIVER SCHEMES (3/4)



Excess Percent (%)	Flow Discharge (cu.m/s)
1	75.5
5	31.7
10	20.6
15	16.5
20	14.0
30	10.8
40	9.1
50	7.6
60	6.6
70	5.6
80	4.6
90	3.4
95	2.8
100	1.9

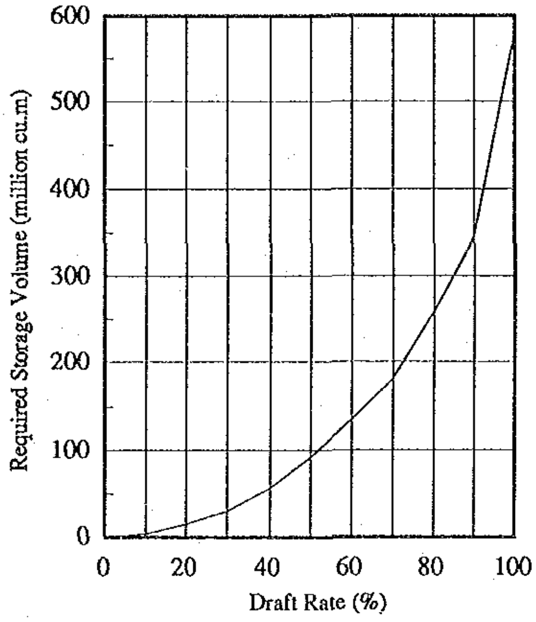
Scheme No. 11 : Benedito Novo



Excess Percent (%)	Flow Discharge (cu.m/s)
1	61.2
5	25.7
10	16.7
15	13.4
20	11.4
30	8.8
40	7.4
50	6.2
60	5.3
70	4.6
80	3.7
90	2.8
95	2.3
100	1.5

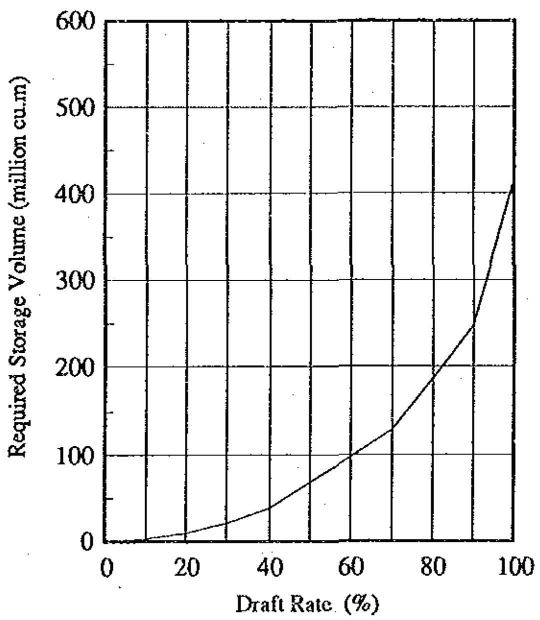
Scheme No.12 : Alto Benedito Novo

Fig .I.4.2 FLOW DURATION CURVES FOR RUN-OF-RIVER SCHEMES (4/4)



Draft Rate (%)	Required Storage Volume (mil.cu.m)
10	2.4
20	13.6
30	28.4
40	53.8
50	91.2
60	132.9
70	179.6
80	258.9
90	344.0
100	579.0
Mean Discharge	18.0cu.m/s

Scheme No. 8 : Barra da Pratinha

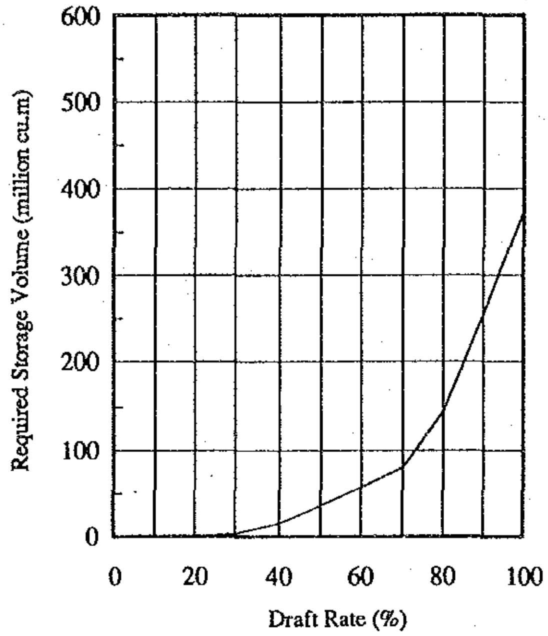


Draft Rate (%)	Required Storage Volume (mil.cu.m)
10	1.7
20	9.8
30	20.4
40	38.7
50	65.5
60	95.5
70	129.0
80	186.0
90	247.1
100	416.0
Mean Discharge	12.9cu.m/s

Note; Draft rate means the ratio of firm discharge to mean discharge in critical period.

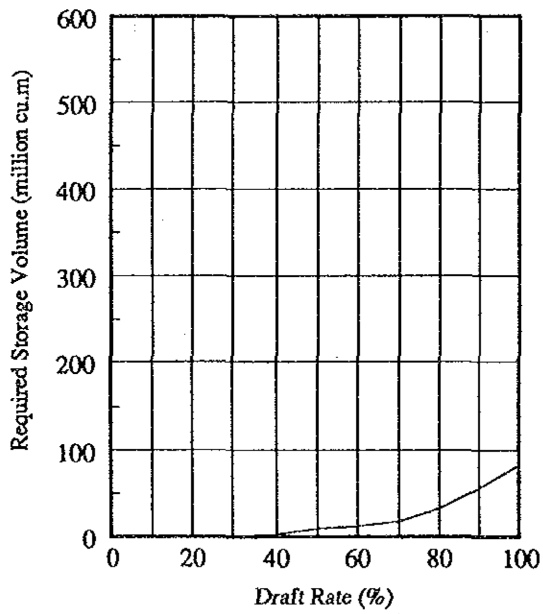
Scheme No. 9 : Barra das Pombas

Fig .I.4.3 STORAGE-DRAFT CURVES FOR RESERVOIR SCHEMES (1/4)



Draft Rate (%)	Required Storage Volume (mil.cu.m)
10	0.0
20	0.0
30	3.5
40	13.8
50	33.3
60	52.8
70	76.1
80	138.5
90	246.0
100	363.0
Mean Discharge	15.1 cu.m/s

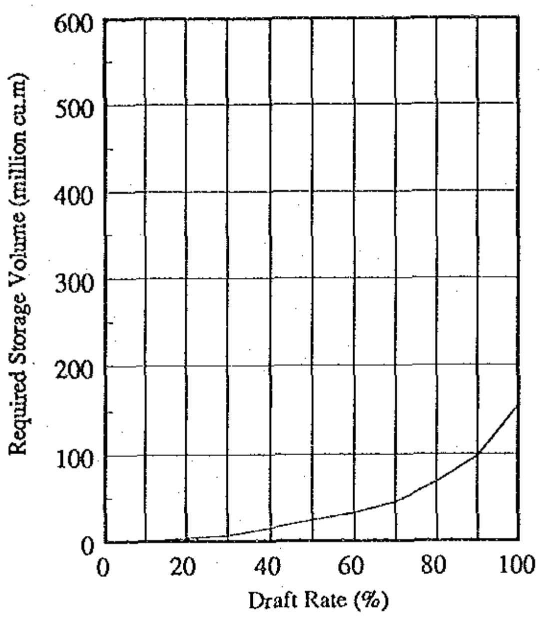
Scheme No. 10 : Timbó



Draft Rate (%)	Required Storage Volume (mil.cu.m)
10	0.0
20	0.0
30	0.8
40	3.0
50	7.2
60	11.4
70	16.4
80	29.8
90	53.0
100	78.2
Mean Discharge	3.2cu.m/s

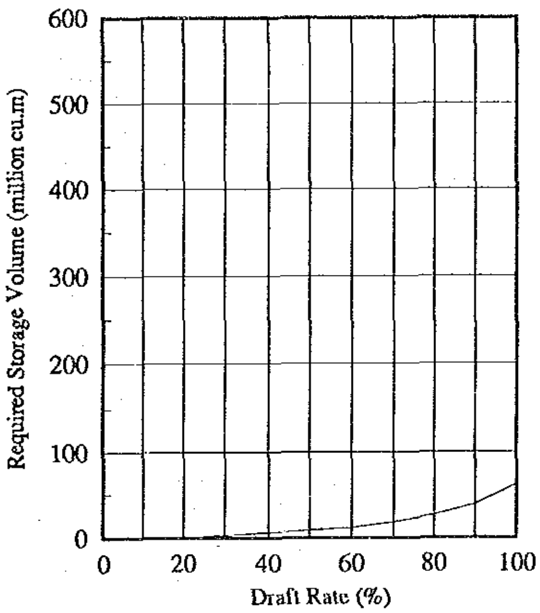
Scheme No. 13 : Doutor Pedrinho

Fig .I.4.3 STORAGE-DRAFT CURVES FOR RESERVOIR SCHEMES (2/4)



Draft Rate (%)	Required Storage Volume (mil.cu.m)
10	0.0
20	1.6
30	6.4
40	13.8
50	22.6
60	31.4
70	42.1
80	67.1
90	95.1
100	155.2
Mean Discharge	5.7cu.m/s

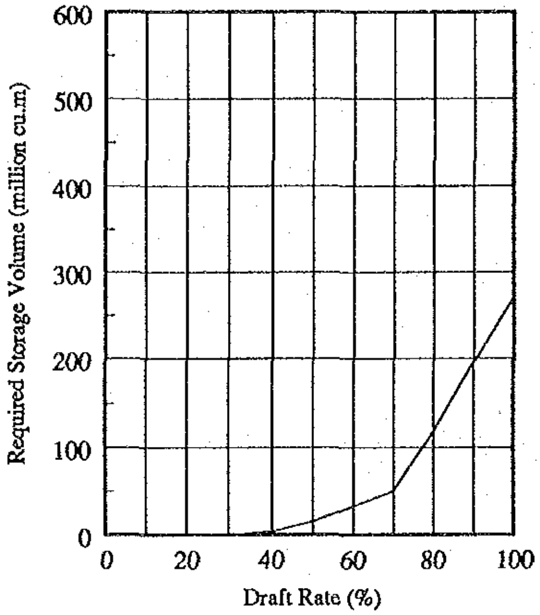
Scheme No. 14 : Trombudo Central (1)



Draft Rate (%)	Required Storage Volume (mil.cu.m)
10	0.0
20	0.6
30	2.5
40	5.5
50	9.0
60	12.5
70	16.7
80	26.6
90	37.7
100	61.6
Mean Discharge	2.2cu.m/s

Scheme No. 15 : Trombudo Central (2)

Fig .I.4.3 STORAGE-DRAFT CURVES FOR RESERVOIR SCHEMES (3/4)



Draft Rate(%)	Required Storage Volume (mil.cu.m)
10	0.0
20	0.0
30	0.0
40	2.5
50	15.7
60	31.3
70	49.5
80	116.2
90	194.3
100	272.4
Mean Discharge	10.0cu.m/s

Scheme No. 16 : Botuvera

Fig .I.4.3 STORAGE-DRAFT CURVES FOR RESERVOIR SCHEMES (4/4)

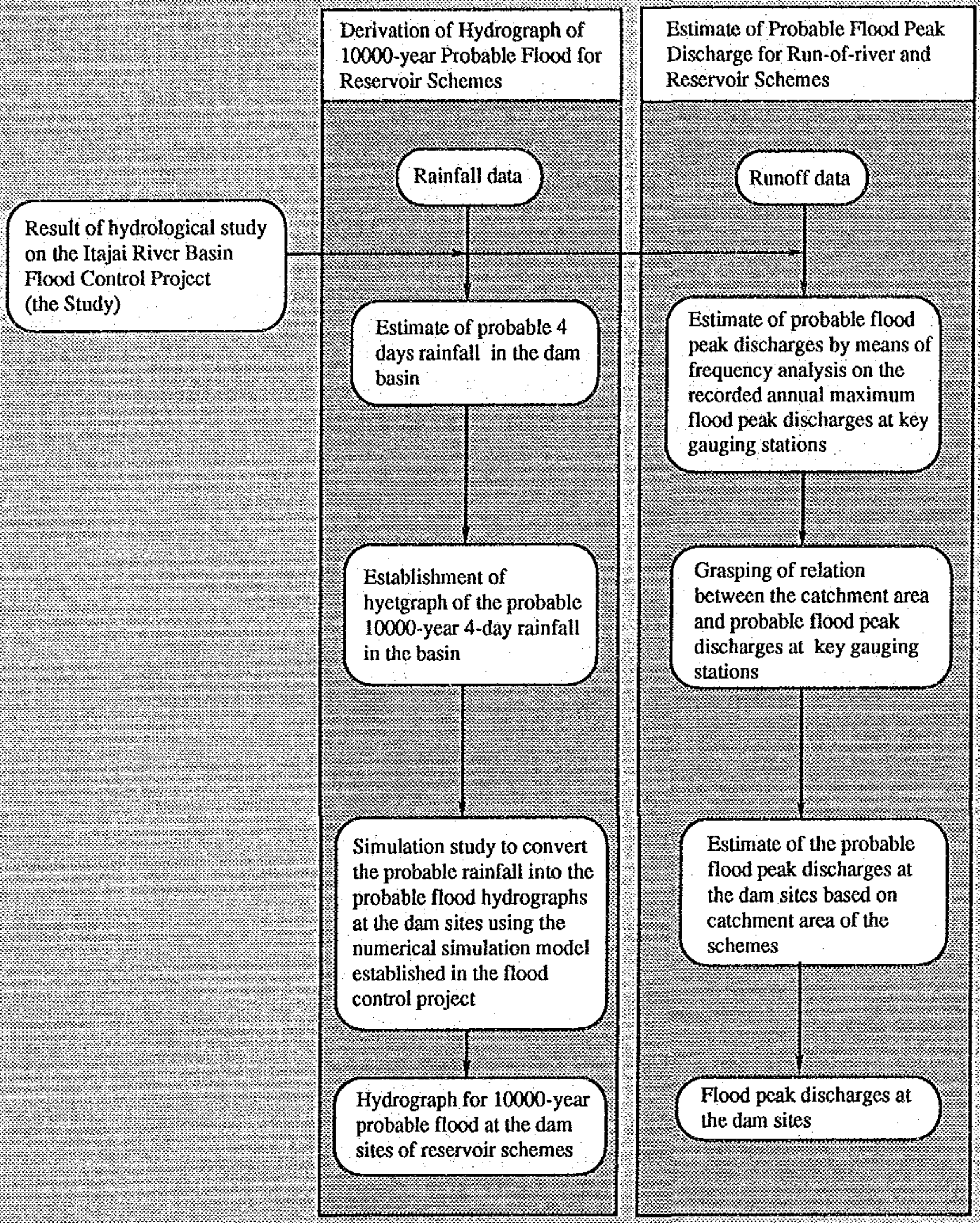


Fig. I.5.1 GENERAL WORK FLOW DIAGRAM OF FLOOD RUNOFF ANALYSIS

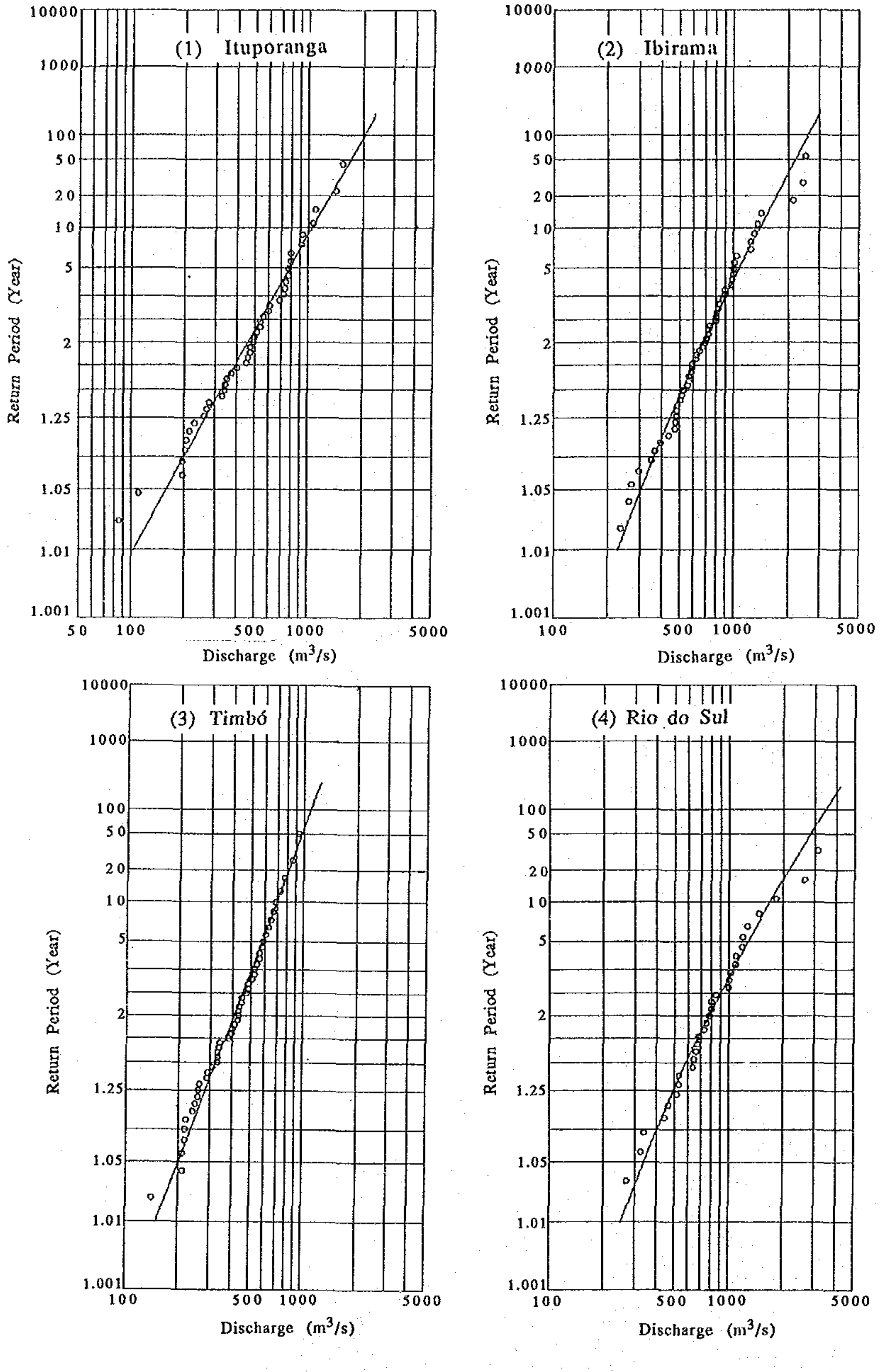
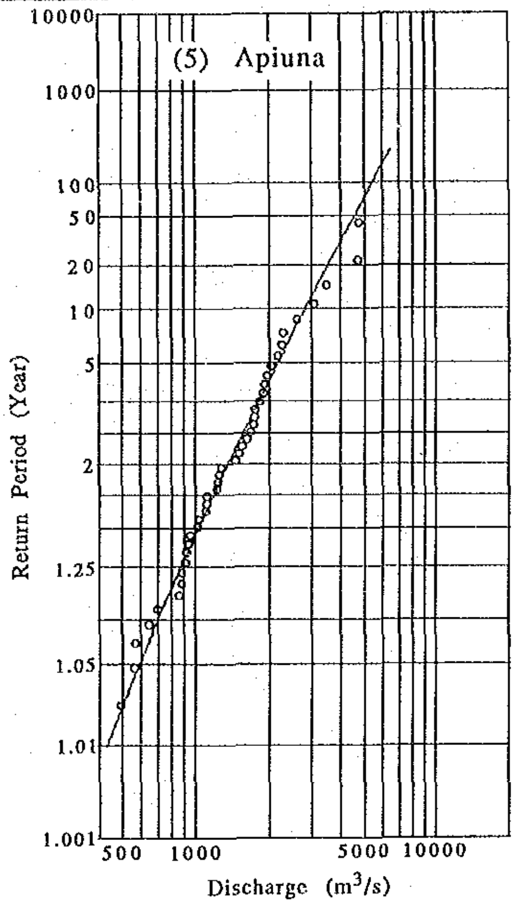
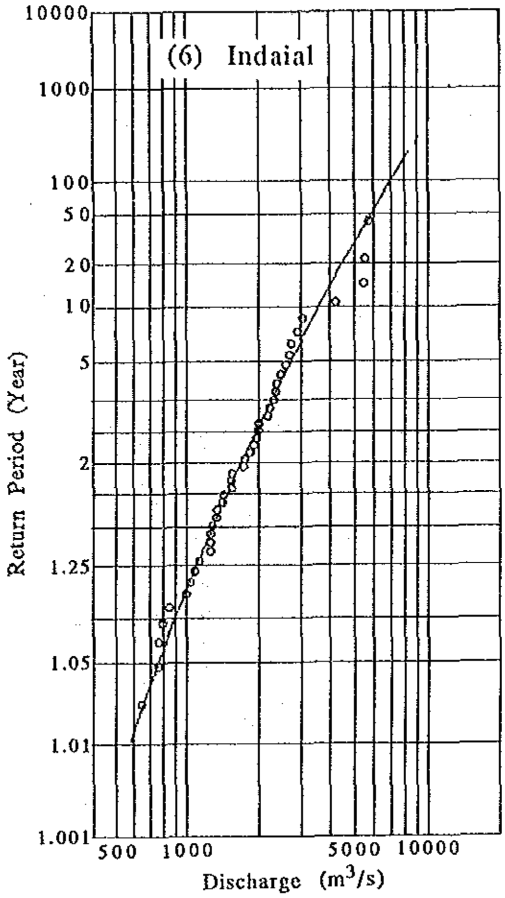


Fig. I.5.2 FREQUENCY CURVE OF ANNUAL MAXIMUM FLOOD PEAK DISCHARGES IN THE ITAJAI RIVER BASIN (1/2)





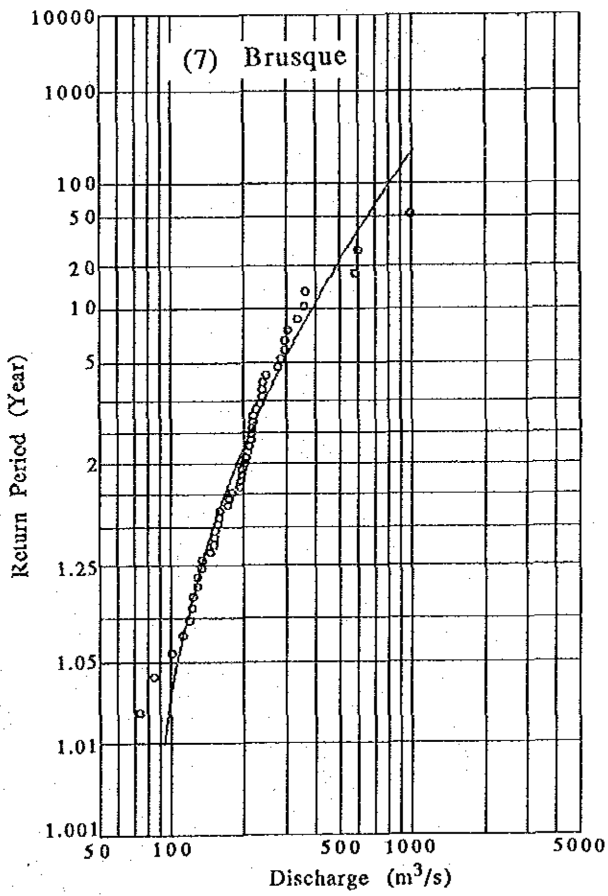


Fig. I.5.2 FREQUENCY CURVE OF ANNUAL MAXIMUM FLOOD PEAK DISCHARGES IN THE ITAJAI RIVER BASIN (2/2)

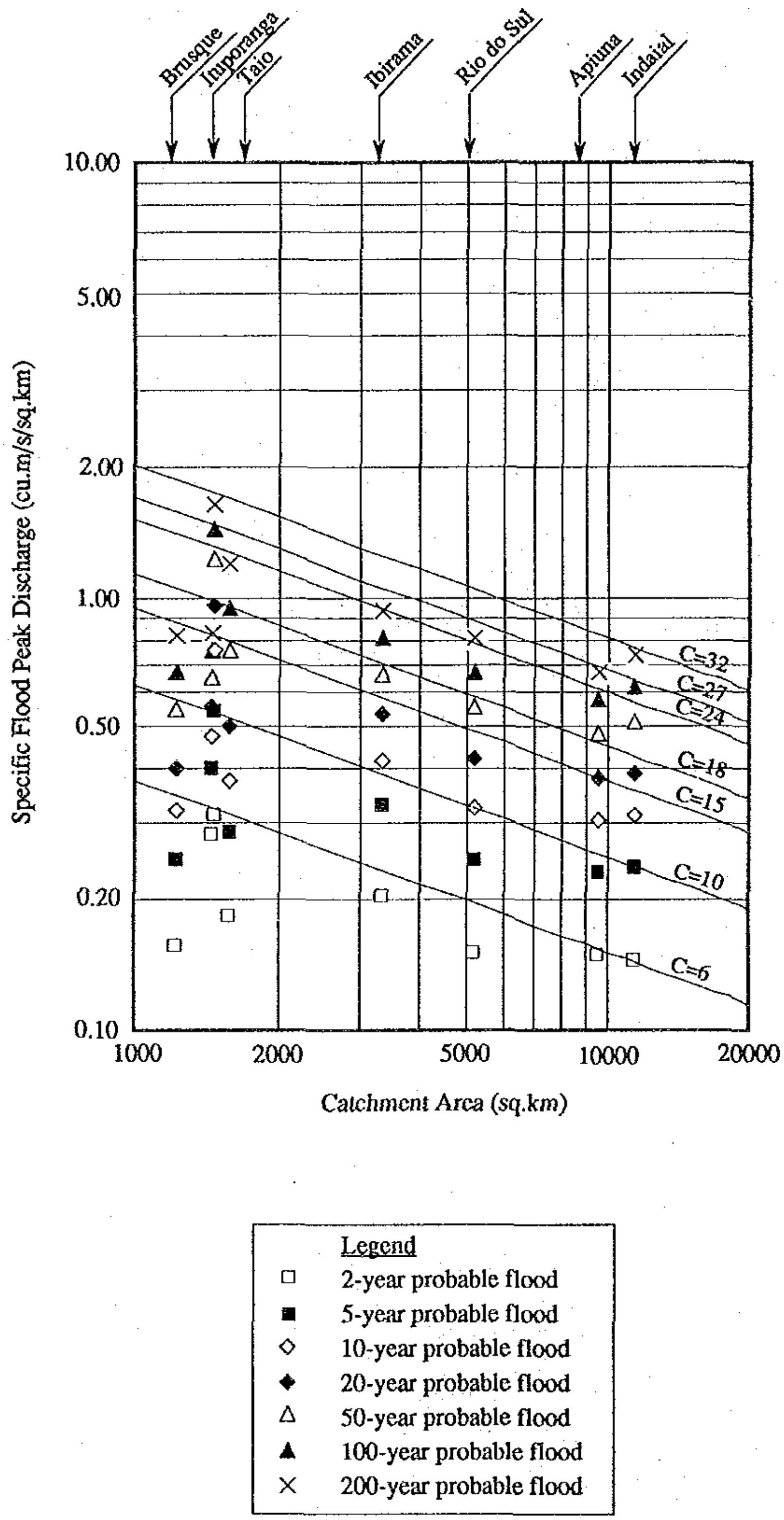
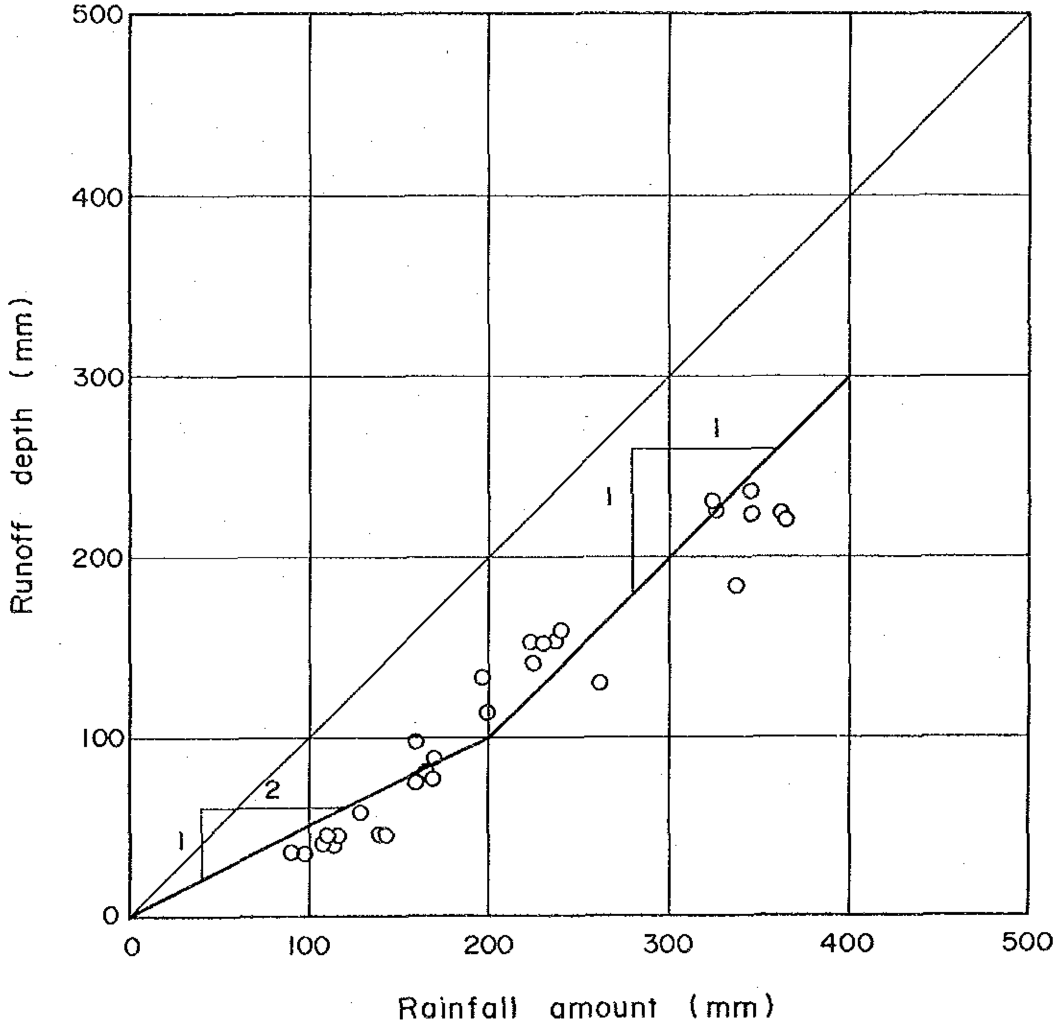
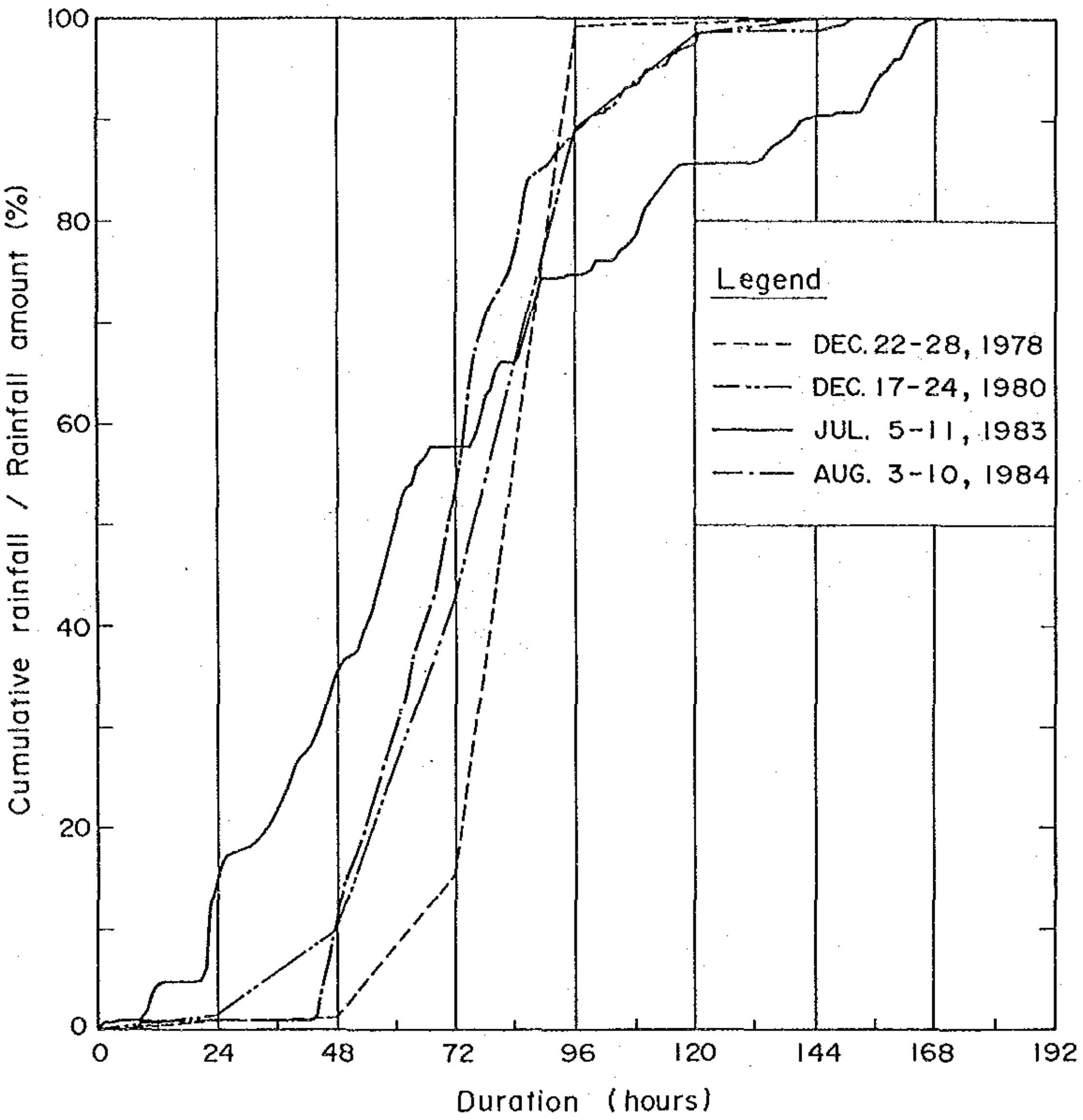


Fig. I.5.3 RELATION BETWEEN SPECIFIC FLOOD PEAK DISCHARGE AND CATCHMENT AREA



Source : Itajai River Basin Flood Control Project

Fig. I.5.4 RELATION BETWEEN FLOOD RUNOFF DEPTH AND TOTAL RAINFALL IN RAIN STORMS



Source : Itajai River Basin Flood Control Project

Fig. I.5.5 RELATION BETWEEN BASIN MEAN RAINFALL AND ITS DURATION DURING RAIN STORM

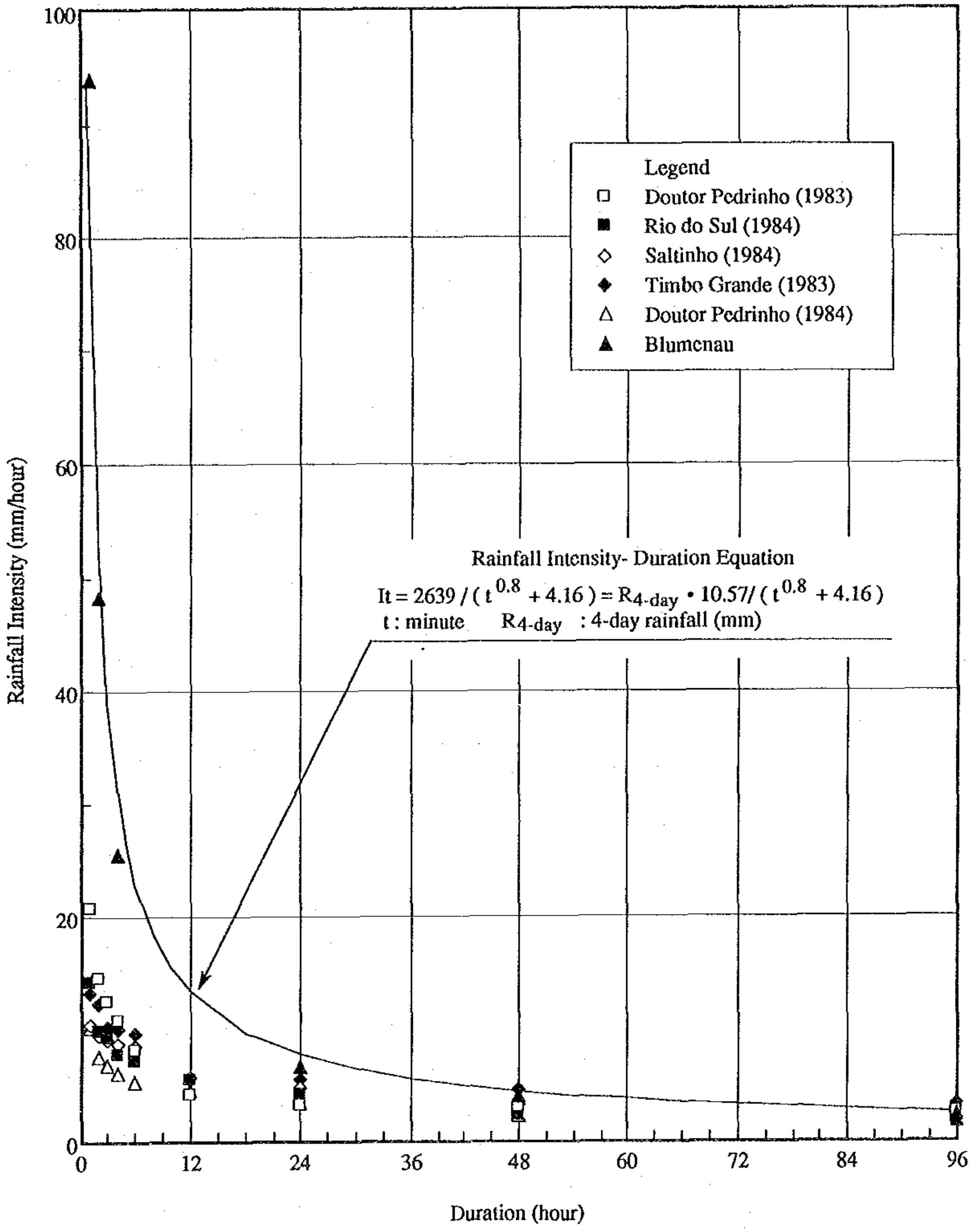


Fig. I.5.6 RELATION BETWEEN RAINFALL DURATION AND INTENSITY DURING RAIN STORM

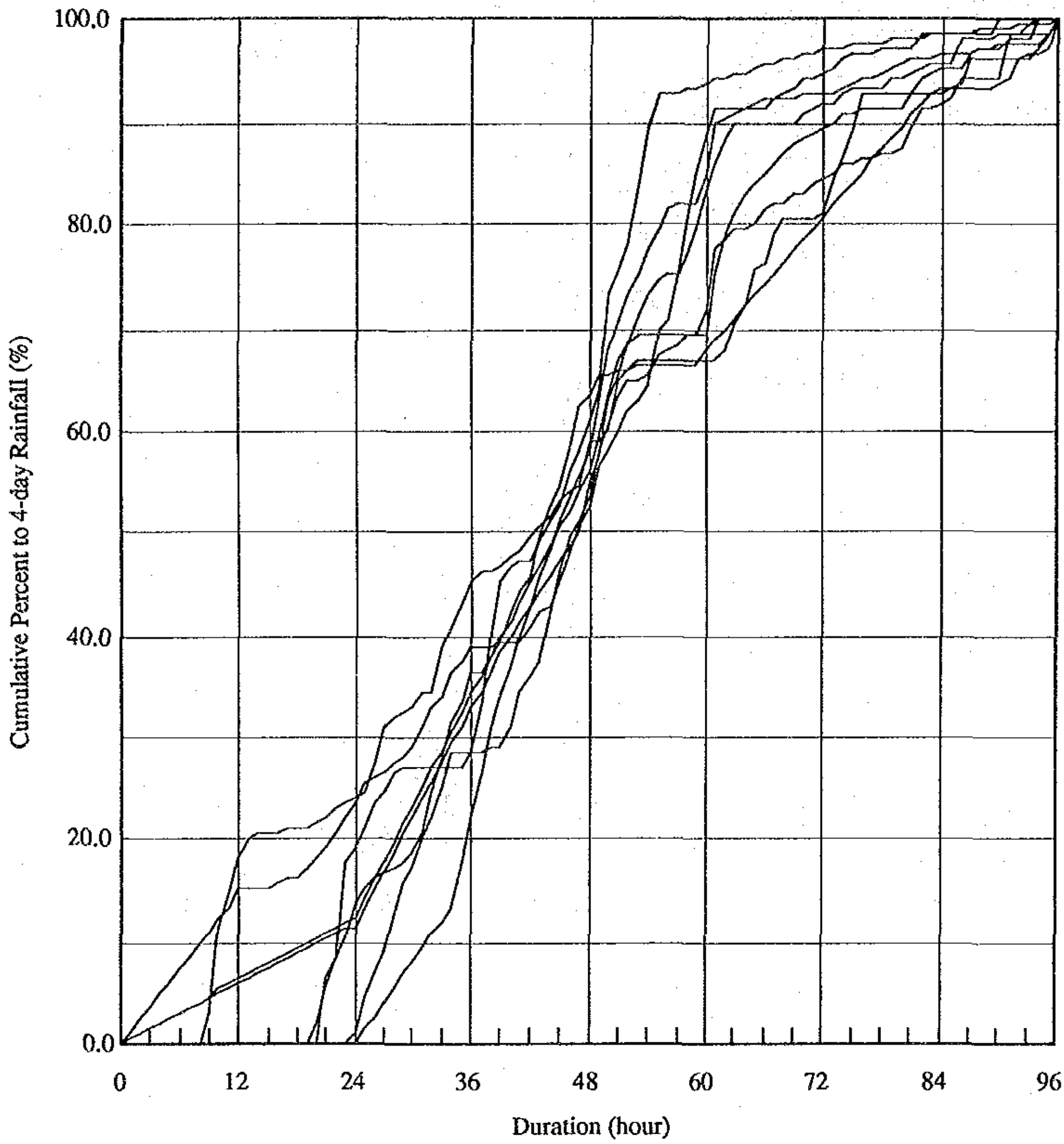


Fig.I.5.7 RELATION BETWEEN RAINFALL AND ITS DURATION FOR 4 DAYS DURING RAIN STORM

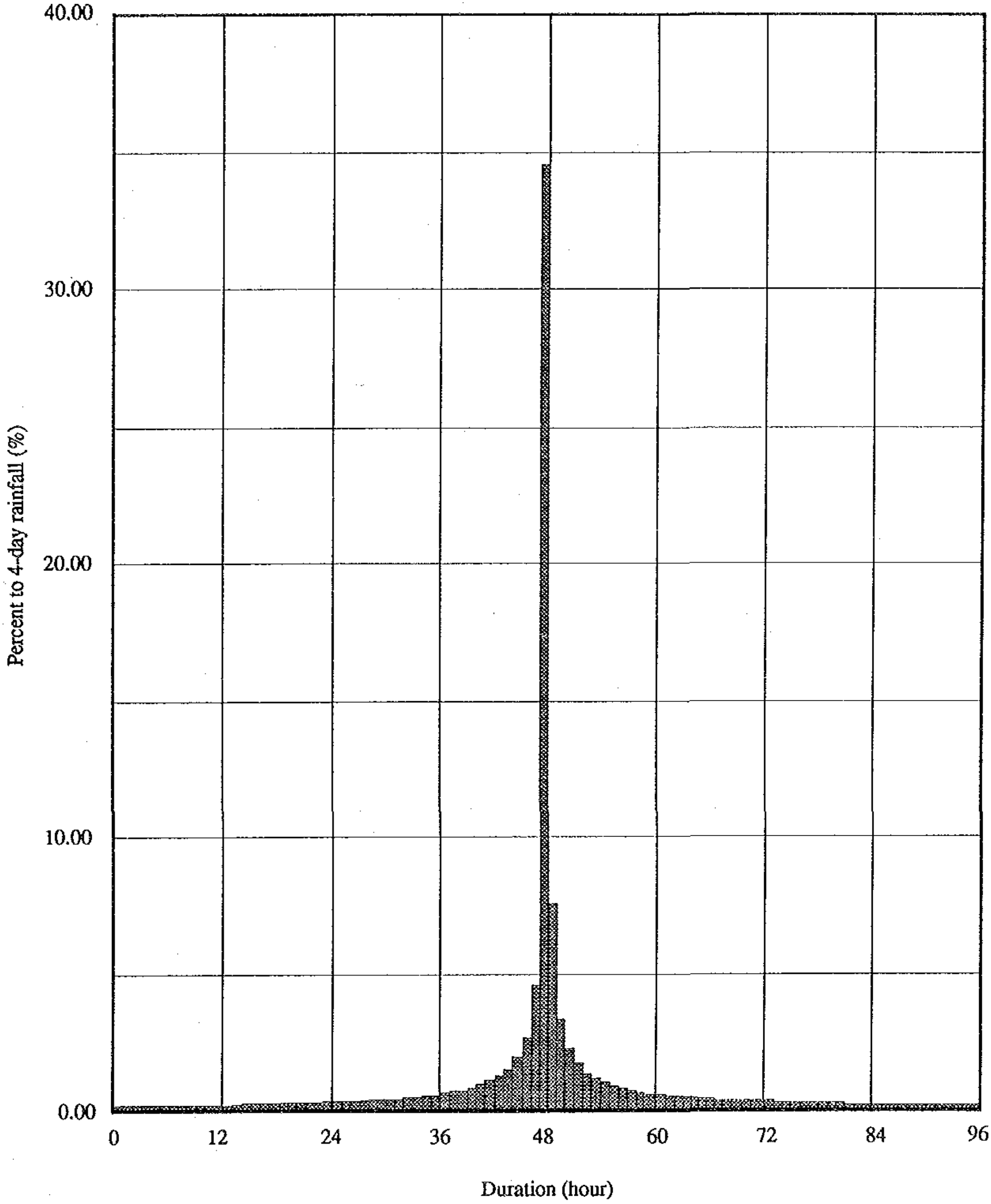


Fig.I.5.8 TYPICAL HYETGRAPH OF RAIN STORM

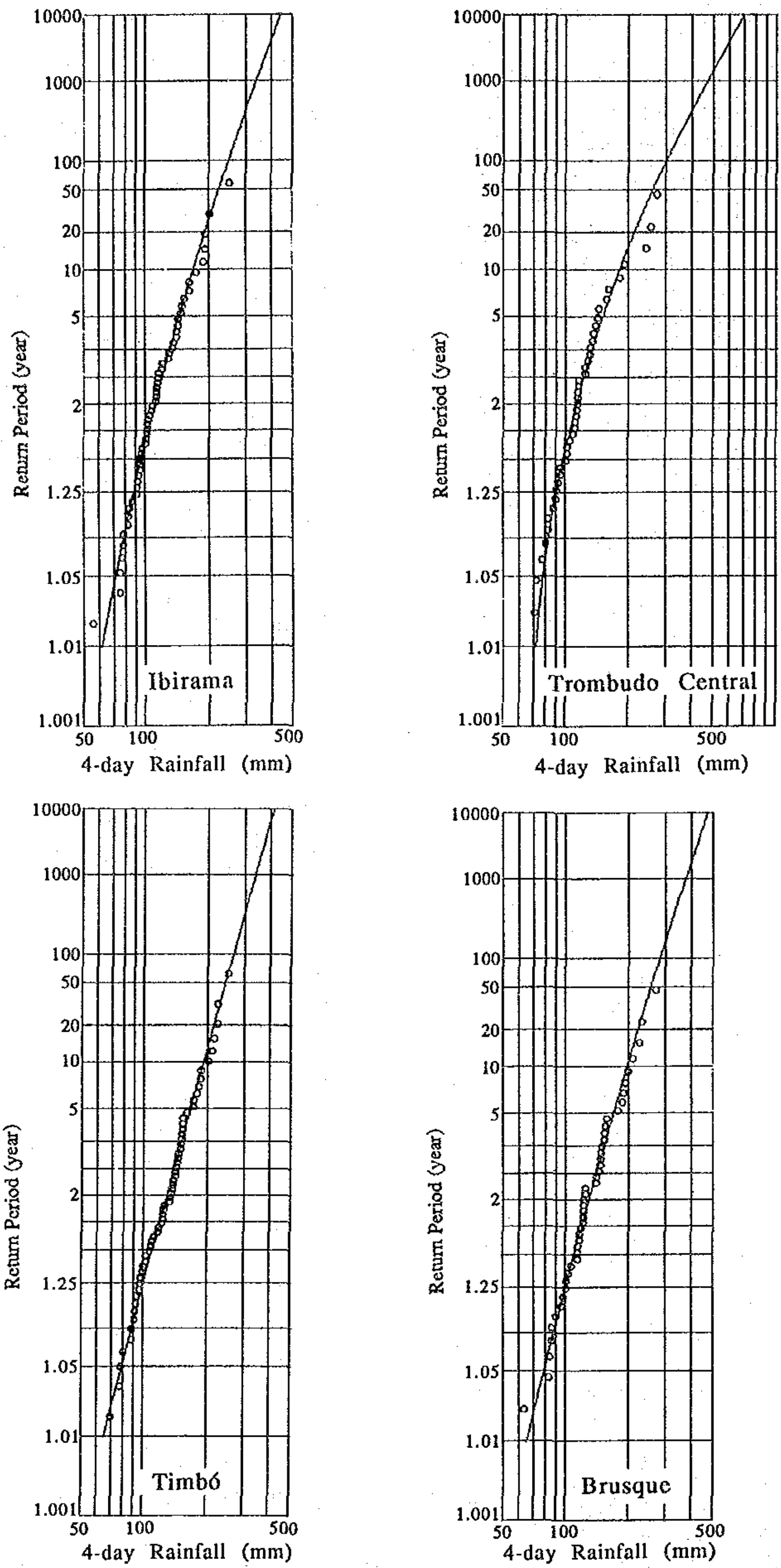


Fig. I.5.9 FREQUENCY CURVES FOR ANNUAL MAXIMUM RAINFALLS AT IBIRAMA, TROMBUDO CENTRAL, TIMBO AND BRUSQUE

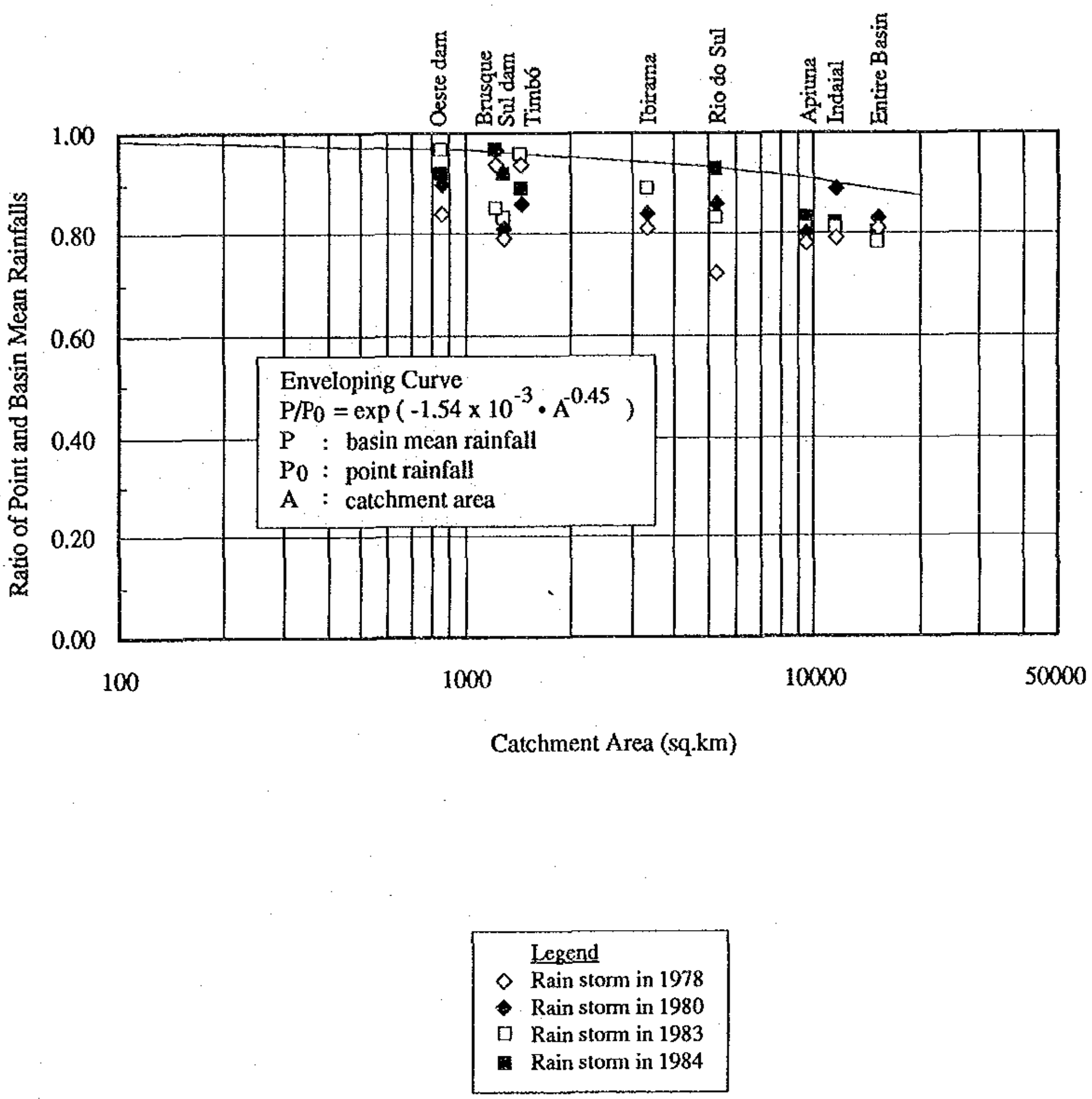
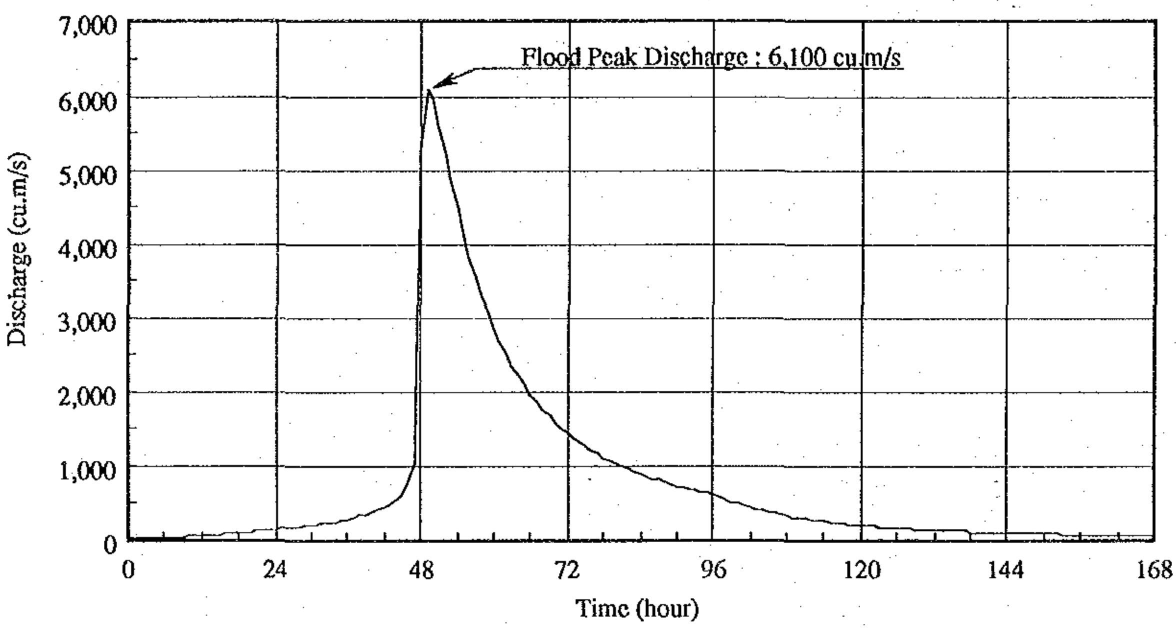
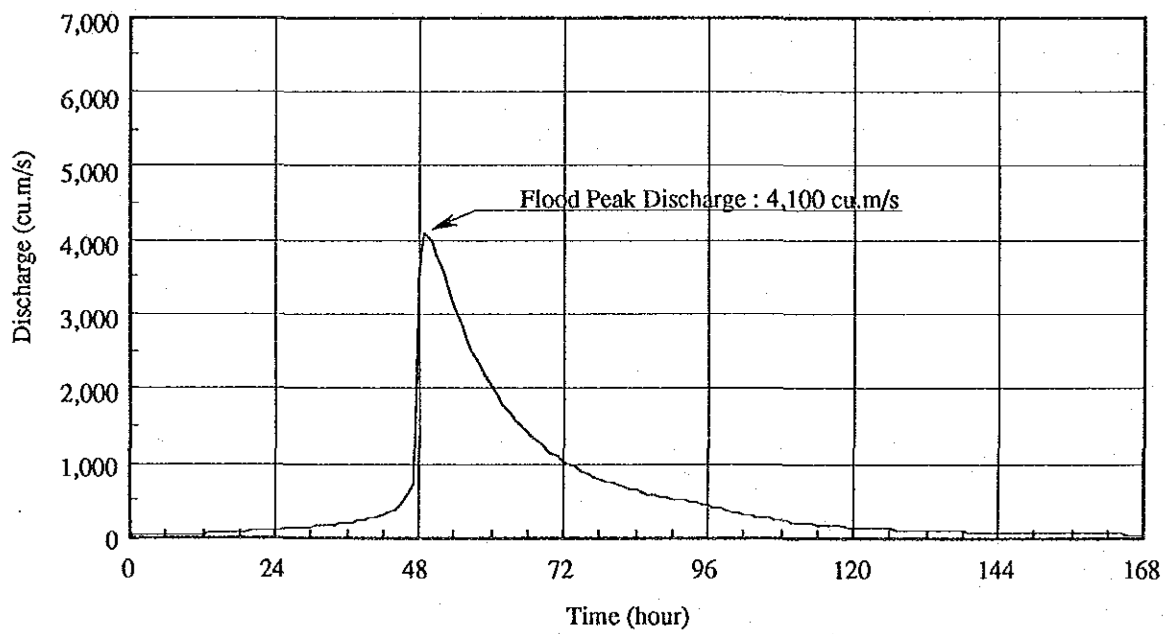


Fig.I.5.10 REALTION BETWEEN POINT AND BASIN MEAN RAINFALLS

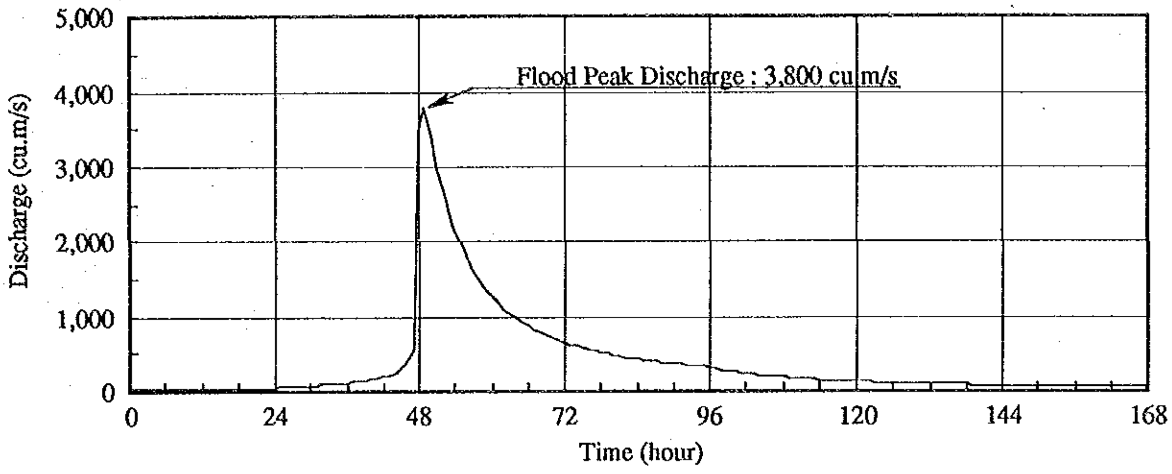


Scheme No.8 : Barra da Pratinha

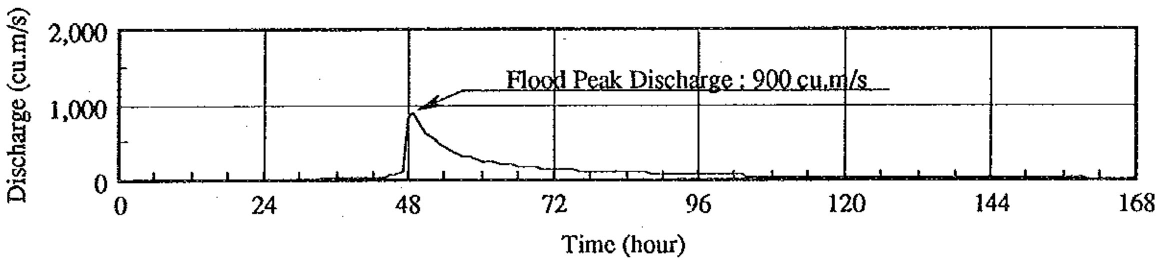


Scheme No.9 : Barra das Pombas

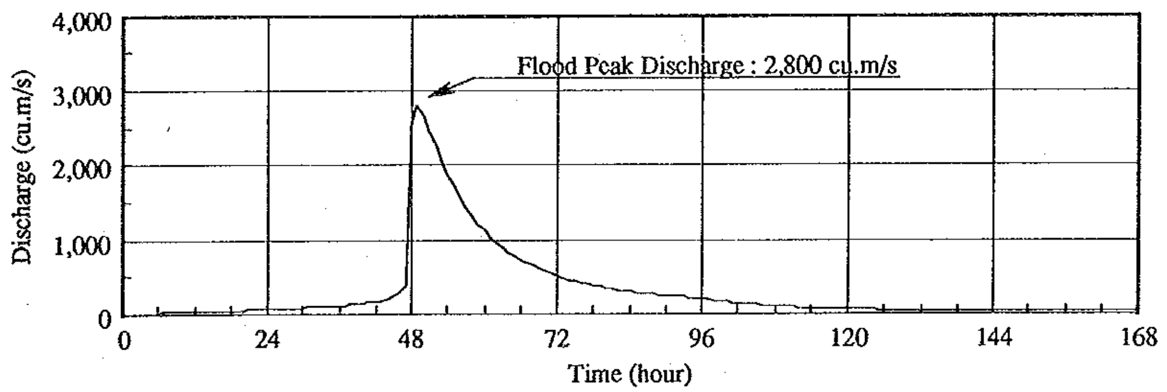
Fig.I.5.11 10000-YEAR PROBABLE FLOOD HYDROGRAPHS (1/3)



Scheme No. 10 : Timbó

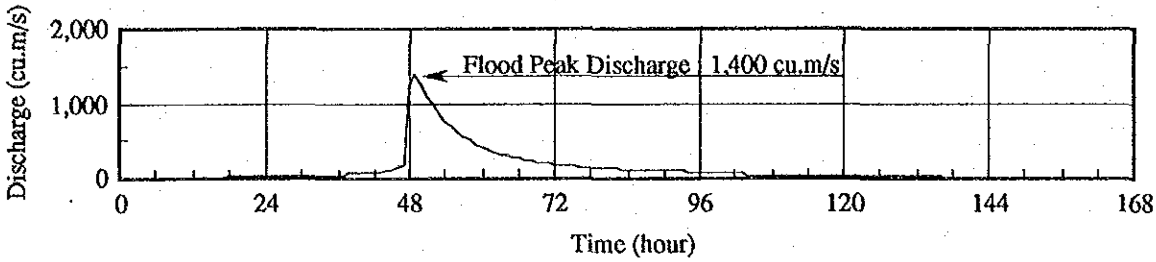


Scheme No. 13 : Doutor Pedrinho

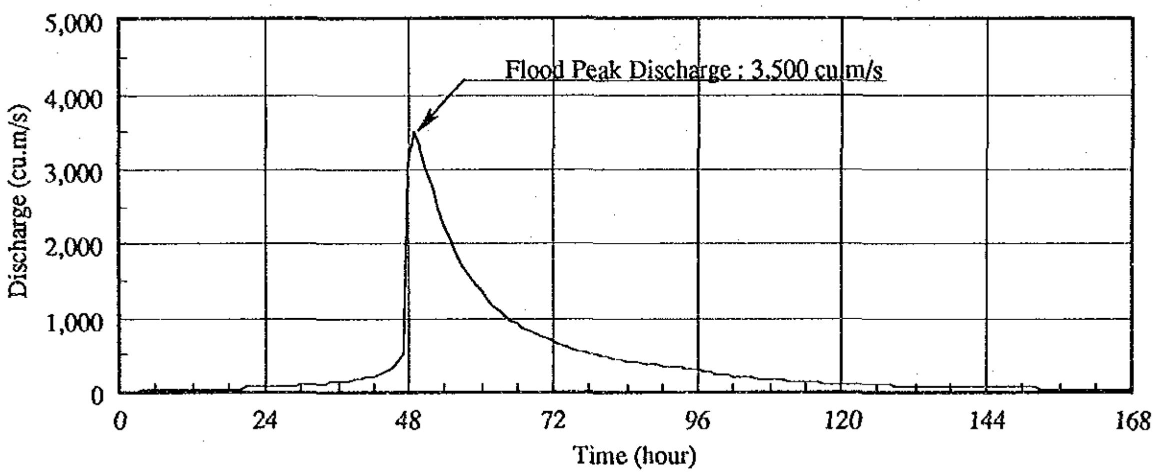


Scheme No. 14 : Trombudo Central (1)

Fig.I.5.11 10000-YEAR PROBABLE FLOOD HYDROGRAPHS (2/3)



Scheme No. 15 : Trombudo Central (2)



Scheme No.16 : Botuvera

Fig.I.5.11 10000-YEAR PROBABLE FLOOD HYDROGRAPHS (3/3)

ANNEX II

GEOLOGICAL INVESTIGATION

ANNEX II. GEOLOGICAL INVESTIGATION

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURE

1. INTRODUCTION

Sixteen hydropower potential sites have been identified based on the map study. For these sites, geological investigation to make clear the geological characteristics necessary for preliminary planning was carried out by means of surface inspection without exploratory borings and also of geological map study. The investigation concentrated on intake dam, waterway, powerhouse and construction material sites.

2. GENERAL TOPOGRAPHY AND GEOLOGY OF THE ITAJAI RIVER BASIN

2.1 Outline of the Basin

The Itajai river originates in the central mountain region of Santa Catarina state, flows eastward and into the Atlantic Ocean. The total river length of the Itajai is 250 km. Six tributaries join the Itajai main stream. They are the Benedito river, Itajai do Norte river, Itajai do Oeste river, Trombudo river, Itajai do Sul and Itajai Mirim river. The area of the entire river basin is about 15,220 km^2.

2.2 General Topography

The topography in this region is represented by shield and table mountain which are typical geomorphology in the stable continent. It was formed by a long term erosion without movement of crust and gentle plateau is extensively distributed. River flows generally in a wide and open U-shaped valley.

The shape of the river section varies in relation to geology. In the upper reaches where sedimentary rock exists, the river channel is deeply eroded. In the middle reaches area where granite and gneiss exist, it seems that erosion of river proceeds strongly horizontally rather than vertically and consequently wide U-shape valleys are formed.

The gradient of the river is gentle as a whole. However steep gradients exist in the middle reaches. In this area sedimentary rock contacts with granite and gneiss. It was assumed that the steep gradient portions were formed as a result of relatively greater erosion in the sedimentary rocks than that in the granite and gneiss.

2.3 General Geology

The geological composition of the Itajai river basin consists of Precambrian (Archeozoic), Precambrian (Protezoic), Carboniferous, Cretaceous Jurassic and Quaternary in chronological order, as listed in Table II.2.1 in which the names of layers and lithology in each geological age are presented.

Precambrian (Archeozoic) layers named as Santa Catarina Complex and Taboleiro Complex widely spread in the southern part of the basin. The distribution area of these layers shows large belt with 50 km in width and 200 km in length. The lithology of these layers is Gneiss and Granite.

Precambrian (Protezoic) layers named as Brusque Metamorphic Complex, Gaspar Formation, Campo Alegre formation and Subida Intrusive Bodies distribute in the middle reach of the basin forming the ranges of gentle hills. The lithology of these layers is composed of phyllite, sandstone, mudstone and associated with gneiss, granite, intrusive rhyolite.

Carboniferous layer named as Rio do Sul formation extensively appears in the middle to upper reaches of the basin. The lithology of this layer is composed of sandstone alternated with mudstone and shale, where a typical table mountain is extending.

Cretaceous, Jurassic layer named as Serra Geral Formation which is the characteristic in the South America Continent spreads and extends ranging from source area of the basin to inland of continent. The distribution of this layer was estimated to cover more than 25,000 km^2. The lithology is basalt and has a very wide plateau. This basalt partially intrudes into the Carboniferous layer. It is called diabase in this region. The quaternary layer (Alluvial and colluvial sediment) is found as river deposit, coastal deposit and talus deposit. According to the geological map of Santa Catarina state, zoning structure is found in series from the Precambrian layer to the Cretacious layer. Extensive horizontal structure of Carboniferous layer without folding and fault is worthy of special description.

3. GEOLOGY OF IDENTIFIED HYDROPOWER POTENTIAL SITES

3.1 General

The preliminary geological investigation for the identified 16 hydropower potential sites was carried out by means of surface inspection and geological maps. The geological characteristics of major structure sites and construction material sites were investigated for the respective identified sites to carry out the geological assessment necessary for preliminary planning. The location of the identified 16 sites is given in Fig. II.3.1.

3.2 Scheme No. 1, Salto Pilao (1)

3.2.1 Layout of facilities

This scheme is run-of-river type. An intake dam would be located at about 15 km downstream of Rio do Sul. A 7 km long pressure tunnel would be aligned in the right bank and powerhouse is located at just upstream of Subida.

3.2.2 Damsite and reservoir

A concrete intake dam about 20 m high and 275 m wide with gated spillway is planned. The conceivable reservoir area is about 4.65 km^2. The damsite is located at a wide valley with gentle hills and its geology consists of granite which crops out sporadically at the river side. The foundation rock of the damsite is granite which is hard and massive.

It is presumed that the required excavation depth is about 2 m in the river bed and right bank, and about 5 m in the left bank. Judging from the massiveness of granite of out crop, no fractured zone is expected to exist. Since the bank slope is gentle (about 15 degree in gradient) landslides do not take place. Considering the hardness and massiveness of the granite, foundation treatment will not be necessary. Since gentle hills extends widely in the reservoir area, landslides and water leakage will not take place.

3.2.3 Waterway

A pressure tunnel with about 7 km long and 5.2 m in diameter is aligned in the hilly mountain in the right bank. A state road is located along this waterway route. The waterway route is aligned along gentle hills and crosses many tributaries. The general geology of the route is granite, which is possibly hard and massive as a whole. 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. It is presumed that tunnel excavation is possible with partial steel support. Excavated material will be used for concrete aggregate. Consolidation grouting will be necessary in places.

3.2.4 Powerhouse, tailrace and substation

The powerhouse, tailrace and substation would be located at just upstream of Subida, which can be accessible through the existing state road. These structure sites are situated on a gentle skirt part of a mountain. The base rock consists of granite and it is covered with talus deposit.

It is assumed that foundation rock consists of granite, and thickness of excavation (talus deposit and weathered rock) is about 10 m. Since the excavated material consists of clay and big boulders, it will not be used for concrete aggregate.

A small band of fractured zone crosses the site. Judging from the gradients (15 to 20 degree) landslides seldom take place.

3.2.5 Construction materials

The proposed quarry site is located at about 1 km in 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 far from the damsite, geological composition is coarse and medium sand of granite. Coarse aggregate area cannot be found near the site.

Considering these conditions above-mentioned, it is proposed to produce fine and coarse aggregate by crushing rock material at the quarry site.

3.3 Scheme No. 2, Salto Pilao (2)

3.3.1 Layout of facilities

This scheme is an alternative for scheme No. 1. Intake dam would be sited as in scheme No. 1. About 5 km long pressure tunnel is aligned in the hilly mountain of left bank, and powerhouse is located at 3 km south of Ibirama.

3.3.2 Damsite and reservoir

The geological situation of this structure site is the same as that for the scheme No. 1.

3.3.3 Waterway

A pressure tunnel with 4.9 km long and 4.6 m in diameter would be aligned through the mountain on the left bank. A federal road is located near this waterway route. Several tributaries cross the route. The tunnel route consists of mainly granite and partially sandstone up to the powerhouse site.

Both granite and sandstone are expected to be hard from observation of outcrops. It is assumed that small fractured bands may exist in some places. Rock cover is probably enough as a whole.

It is presumed that tunnel excavation will be possible with steel supports in several parts. Fresh excavated rock will be used for the concrete aggregate. Consolidation grouting will be needed for local fractured zone.

3.3.4 Powerhouse, tailrace and substation

These facility sites are situated at 3 km south of Ibirama. These areas consists of narrow ridges and no flat spaces exist. The foundation rock at the structure sites consists of sandstone which out crops near the powerhouse site in a weathered condition. 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.

Since the composition of the excavated material is weathered sandstone, it can not be used for concrete aggregate. Small bands of fractured zones will exist across the site. It was judged that landslides seldom occur.

3.3.5 Construction materials

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.

3.4 Scheme No. 3, Ibirama

3.4.1 Layout of facilities

This scheme is run-of-river type. An intake dam would be located at about 4 km downstream of Ibirama. About 10 km long pressure tunnel is aligned in the mountain area of left bank and powerhouse is selected at about 1 km upstream of Apiuna.

3.4.2 Damsite and reservoir

About 20 m high and 280 m wide concrete intake dam with gated spillway is planned. Conceivable reservoir area is about 0.75 km^2. Federal road is located along the left bank of the damsite. Around this site wide U-shape valley opens with cliff in the right bank and foundation rock consists of sandstone which crops out in the river side. It is hard and massive and available for concrete dam. It is presumed that the required excavation depth is about 2 m in the river bed and right bank, and about 5 m in the left bank. Judging from massiveness of sandstone of outcrop, it is unlikely that fractured zones exist. As sandstone outcrops along the bank slope, landslides seldom take place. Since the sandstone at this site is regarded as hard and massive, foundation treatment will not be needed. Landslide and water leakage in the reservoir will not take place in view of continuous outcrop of sandstone.

3.4.3 Waterway

A pressure tunnel with 9.7 km long and 5.3 m in diameter would be aligned through mountain range on the left bank. A village road will intersect the middle of the route. A large table mountain with steep side slope rises up and four tributaries cross the tunnel route. The tunnel route consists of rhyolite and sandstone, respectively in the upstream and downstream of the route. Both rhyolite and sandstone seem to be hard. It is presumed that small band of fractured zone exists crossing the route and small amount of water comes out below tributary position. It seems that tunnel excavation is possible with steel supports in several portions. Fresh excavated material will be used for concrete aggregate. Consolidation grouting will not be needed except weak parts at the fractured zone.

3.4.4 Powerhouse, tailrace and substation

These structure sites are situated at 1 km upstream of Apiuna where a round ridge appears and wide and flat terrace exists near the river. These sites consist of sandstone. It is presumed that the necessary depth of excavation (terrace deposit and weathered sandstone) will be 10 m. Since the composition of the excavated material will be fine soil, it will not be used for concrete aggregate. Small bands of fractured zone will exist in some places. It is judged that landslides seldom take place.

3.4.5 Construction materials

The proposed quarry site is located at about 2 km upstream of damsite where access is possible through an existing town road. It consists of table mountain with steep side slopes. This quarry site consists of hard granite and surface soil is about 5 m in depth. The available volume is presumed to be about 300,000 m^3. The fine aggregate area will be obtained at the same site as that stated in scheme No. 1. Coarse aggregate will be produced at the quarry site.

3.5 Scheme No. 4, Subida

3.5.1 Layout of facilities

This scheme is run-of-river type. An intake dam is located at about 7 km upstream of Apiuna. About 5 km long pressure tunnel is aligned in mountain area in the left bank and powerhouse is planned at about 1 km upstream of Apiuna.

3.5.2 Damsite and reservoir

About 20 m high and 165 m wide concrete intake dam with gated spillway is planned. Conceivable reservoir area is about 0.6 km^2. The damsite consists of U-shape valley with gorge and its foundation rock comprises rhyolite which is hard and massive. It is presumed that necessary excavation depth is about 2 m in river bed, 5 m in both banks respectively, but excavation material cannot be used for concrete aggregate due to its heavily weathering. Judging from the massiveness of rhyolite outcrops, fractured zones are unlikely to exist, and landslides do not take place. Foundation treatment will not be needed in consideration of hardness of rhyolite. Since reservoir area is relatively small, geological problems will not take place.

3.5.3 Waterway

A pressure tunnel with 5.3 km long and 5.3 m in diameter is aligned in the mountain of left bank. A huge mountain dome rises up in the upstream part and undulated mountain ridge exists in the downstream part of the route. The tunnel route consists of hard rhyolite and sandstone in the upstream and downstream parts respectively.

It seems that small band of fractured zone exists partially in the section of sandstone and small amount of water comes out below tributary. It is presumed that tunnel excavation is possible with steel support locally in the section of sandstone. Fresh excavated material will be used for concrete aggregate. Consolidation grouting will not be needed except local weak position such as fractured zone.

3.5.4 Powerhouse, tailrace and substation

The location of structure sites is the same as that for scheme No. 3.

3.5.5 Construction materials

The proposed quarry site is located at about 0.5 km from the right bank of the damsite. It comprises large mountain which is intruded and risen up with a cliff. The rock material 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 at the quarry site.

3.6 Scheme No.5, Ascurra

3.6.1 Layout of facilities

This scheme is run-of-river type. An intake dam would be located at 4 km upstream of Ascurra. About 5.3 km long pressure tunnel is aligned in the right bank and powerhouse is located at about 5 km downstream of Ascurra.

3.6.2 Damsite and reservoir

About 20 m high and 200 m wide concrete intake dam with gated spillway is planned. Conceivable reservoir area is about 8 km^2. The foundation rock consists of hard rhyolite. It is presumed that 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. Since bank slope is gentle and surface soil is thin (about 15 degree in gradient and 2 m in thickness) landslide does not take place. Foundation treatment will not be necessary from the viewpoint of hardness and massiveness of rhyolite. Gentle hilly mountains extends widely with outcrops of rhyolite in the reservoir area. Landslides and water leakage will not occur.

3.6.3 Waterway

A pressure tunnel with 5.3 m long and 6.1 m in diameter would be aligned on the right bank. A state road is provided along the route. The tunnel route is composed of hard rhyolite in the upstream part of the route and moderately hard sandstone in its downstream. Judging from cracky condition of sandstone of outcrop, fractured zones will exist in some places in the section of sandstone. Tunnel excavation is possible with supports in weak parts. Among the excavated material, fresh rhyolite will be used for concrete aggregate. Consolidation grouting will be necessary in the cracky position of sandstone.

3.6.4 Powerhouse, tailrace and substation

These structure sites 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, but excavated material cannot be used for concrete aggregate due to its heavy weathering. Judging from the cracky condition of the sandstone of outcrops, a fractured zone may possibly cross the site. Since slope of the ridge is gentle, (15 to 20 degree in gradient), landslides scarcely take place.

3.6.5 Construction materials

The proposed quarry site is located in the mountainous area about 1 km 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.

3.7 Scheme No. 6, Indaial

3.7.1 Layout of facilities

This scheme is run-of-river type. An intake dam would be located about 1 km downstream of Indaial. A 2.3 km long open channel would be aligned on the right bank and the powerhouse would be located about 3 km downstream of Indaial.

3.7.2 Damsite and reservoir

A 17 m high 160 m wide concrete intake dam with gated spillway is planned. The conceivable reservoir area is about 0.90 km^2. There are federal and state roads on the left and right banks respectively. The damsite consists of granite, terrace and talus deposit. It is presumed that the excavation depth will be about 2 m in the river bed and about 5 m in both river banks, but the excavated material will not be used for concrete aggregate. It is presumed that the existence of fractured zones is rare. Since the bank slope is nearly flat, landslides do not take place. Foundation treatment will not be necessary because the granite is hard and massive. Gentle hills occur in the reservoir area. Thus,no geological defects have been found.

3.7.3 Waterway

An open channel with trapezoid section and 2.3 km in length would be aligned along the right bank in parallel with the state road. There are gentle slope of talus with several small tributaries along the route. The waterway route consists of mainly thick overlying talus deposit. It is presumed that the foundation rock is granite, the required excavation depth (talus deposit and weathered granite) is 10 to 15 m, but excavated material cannot be used for concrete aggregate due to heavy weathering. It seems that small fractured zone exists in the position of tributary and slope sliding is probably caused by excavation of talus deposit.

3.7.4 Powerhouse, tailrace and substation

Those structure 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. It is presumed that foundation rock is granite and the required excavation depth to remove talus deposit and weathered granite is about 15 m. Since excavation material may comprise clayey soil, it cannot be used for concrete aggregate. It seems that small fractured zone exists across the site and landslide scarcely takes place judging from nearly flat slope of the structure sites (10 degree in gradient).

3.7.5 Construction materials

The proposed quarry site is located at about 10 km in the southern part of 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 300,000m^3.

Location of fine aggregate is the same site as proposed for scheme No. 1 and coarse aggregate will be produced in the quarry site.

3.8 Scheme No. 7, Dalbergia

3.8.1 Layout of facilities

This scheme is run-of-river type. An intake dam would be located at about 10 km upstream of Ibirama. About 9 km long pressure tunnel is aligned in the right bank and powerhouse is located at about 3 km downstream of Ibirama.

3.8.2 Damsite and reservoir

About 20 m high and 220 m wide concrete intake dam with gated spillway is planned. Conceivable reservoir area is estimated at about 1.1 km^2. Town road passes in the left bank in parallel with the river. The damsite is located at a U-shaped valley and its foundation rock is hard and massive gneiss. It is presumed that the required excavation depth is about 2 m in the river bed and right bank and about 5 m in the left bank. It will be possible to use the excavated material in the river bed for concrete aggregate.

Judging from massiveness of gneiss of outcrop, fractured zone scarcely exist. Since bank slope is gentle (15 degree in gradient), landslides will not take place. Foundation treatment will not be needed in consideration of hardness of gneiss. Since gentle hills with outcrops of gneiss extends in the reservoir area, no geological defect was found.

3.8.3 Waterway

A pressure tunnel with 9 km long and 3.6 m in diameter is aligned in the right bank. The tunnel route passes nearly flat hill and crosses many tributaries. It consists of mainly hard gneiss and locally hard granite which probably appears near the end position of route. It is presumed that the fractured zone appears beneath the tributary. Tunnel excavation is possible with steel supports in some weak sections and the excavated material will be used for concrete aggregate. Consolidation grouting will not be needed except in some weak places such as the fractured zone.

3.8.4 Powerhouse, tailrace and substation

These structure sites are situated at about 3 km downstream of Ibirama, where round ridge exists in the waterway side and flat terrace opens near the river side. It is presumed that foundation rock of the sites consists of granite and thickness of the required excavation is about 10 m. Since composition of the excavated material is clayey soil, it will not be used for concrete aggregate. There is possibility of existence of small fractured zone crossing the site. While, judging from slope gradient (10 to 15 degree) landslides will not take place.

3.8.5 Construction materials

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. It is presumed that depth of surface soil is about 5 m and available volume is 300,000 m^3. Coarse and fine aggregates will be produced at the quarry site.

3.9 Scheme No. 8, Barra da Pratinha

3.9.1 Layout of facilities

This scheme is reservoir type. An intake dam would be located at about 90 km upstream of Ibirama and powerhouse is aligned at immediate downstream of the dam.

3.9.2 Damsite and reservoir

About 80 m high, 650 m wide rock fill dam is planned. Conceivable reservoir area is estimated at about 6.2 km^2. The damsite is located at U-shape valley with gorge and it consists of sandstone which out crops in the river side. Foundation rock is sandstone which is hard and massive. It is presumed that 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. Among the excavation material, weathered sandstone in the bank slope will be used for earth material. Since sandstone is hard and tight, foundation treatment will not be needed. Sandstone continuously out crops in the reservoir area, consequently no geological defects are found.

3.9.3 Powerhouse, tailrace and substation

Since these sites are located just downstream of the dam body, geological conditions are the same as for the damsite.

3.9.4 Construction materials

The required materials are rock, filter, impervious material for fill dam and concrete aggregate. Since natural filter material cannot be found near the site, it is proposed to produce it at the quarry site.

The proposed quarry site is located at about 1 km from the damsite. The quarry site consists of fairly hard sandstone. It is presumed that 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. It is presumed that 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.

3.10 Scheme No. 9, Barra das Pombas

3.10.1 Layout of facilities

This scheme is reservoir type. An intake dam would be located about 110 km upstream of Ibirama, and powerhouse is aligned immediately downstream of the dam.

3.10.2 Damsite and reservoir

About 90 m high and 650 m wide rock fill dam is planned. Conceivable reservoir area was estimated at about 22 km^2. The damsite is located at U-shape valley and it consists of hard sandstone alternated with mudstone which outcrops at bank slope in a weathered condition. It is presumed that 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. Since surface soil and weathered zone are relatively thin, problem of landslide will not be serious. Foundation treatment will be needed for the fractured zone. It is presumed that landslides and water leakage are unlikely to take place in the reservoir area considering the thin surface soil and weathered zone.

3.10.3 Powerhouse, tailrace and substation

Since these sites are located just downstream of the dam body, the geological conditions are the is same as for the damsite.

3.10.4 Construction materials

The required materials are rock, filter, impervious material for fill dam and concrete aggregate. Since natural filter material cannot be found near the site, it is proposed to produce it at the quarry site.

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 which out crops on the mountain side. This sandstone appears moderately hard in quality. It is presumed that depth of overburden surface soil and weathered sandstone is about 10 m and depth of the fresh sandstone is limited to about 20 m. Although it is possible to obtain the rock material necessary for dam embankment, excavation of a very large area will be needed at the quarry sites.

For the required impervious material, weathered zone sandstone in the quarry site will be used. It is presumed that the thickness of the material is about 8 m and that 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.

3.11 Scheme No. 10, Timbo

3.11.1 Layout of facilities

This scheme is a reservoir type. An intake dam would be located at about 8 km upstream of Timbo and powerhouse is aligned at just downstream of the dam.

3.11.2 Damsite and reservoir

About 55 m high and 500 m wide rock fill dam is planned. The conceivable reservoir area was estimated at about 1 km^2. The damsite has gentle bank slopes and a flat river bed. It consists of hard and tight gneiss which out crops on the right bank. It is presumed that 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. Among the excavated material, weathered gneiss will be used for impervious material for dam. Foundation treatment will not be necessary because gneiss is hard and tight. Since gentle hill widely spreads in the reservoir area, no geological defects are found.

3.11.3 Powerhouse, tailrace and substation

Since these sites are located at just downstream position of the dam body, the geological conditions will be the same as for the damsite.

3.11.4 *Construction materials*

The required materials are rock, filter, impervious material for fill dam and concrete aggregate. Since natural filter material cannot be found near the site, it is proposed to produce them at the quarry site. 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. It is presumed that 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 which are good impervious material. It is presumed that the thickness of material is about 10 m and that 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 crushing.

3.12 Scheme No. 11, Benedito Novo

3.12.1 Layout of facilities

This scheme is run-of-river type. An intake dam would be located at about 4 km upstream of Benedito Novo. About 2.5 km long pressure tunnel is aligned in the right bank and powerhouse is located at 2 km upstream of Benedito Novo.

3.12.2 Damsite and reservoir

About 20 m high and 160 m wide concrete intake dam with gated spillway is planned. Conceivable reservoir area was estimated at about 0.2 km^2. The damsite is located at a U-shape valley and it consists of hard and tight granite which sporadically crops out in reservoir area. It is presumed that the required excavation depth is about 2 m in river bed, 5 m in both river banks, but excavated material cannot be used for concrete aggregate due to its heavy weathering.

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 because granite is hard and tight. Reservoir area is relatively small. No geological problems will occur.

3.12.3 Waterway

A pressure tunnel with 1.9 km long and 2.8 m in diameter is aligned through mountain ridge at right bank. The tunnel route is composed of table mountain with oval shaped ridge, and it consists of hard and massive granite and diorite which crop out in the slope of road near the route. It is presumed that fractured zone scarcely exists except heavily weathered part in the upstream tunnel route. Fresh excavated material from the tunnel will be used for concrete aggregate. Consolidation grouting will be executed only in weak places.

3.12.4 Powerhouse, tailrace and substation

These sites are situated at about 2 km upstream of Benedito Novo, where there is a round shaped ridge at the waterway side and a low river terrace on the river side. The sites consist of terrace deposits and granite. It is presumed that the thickness of excavation (terrace deposit and weathered granite) is about 10 m but excavated material will not be used for concrete aggregate due to its heavy weathering. So far as the observation of the condition of granite in outcrop, fractured zone scarcely exists, and landslide seldom takes place in view of slope gradient (about 15 degree).

3.12.5 Construction materials

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 which appears hard and good. It is presumed that 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.

3.13 Scheme No. 12, Alto Benedito Novo

3.13.1 Layout of facilities

This scheme is run-of-river type. An intake dam would be located at about 4 km upstream of Alto Benedito Novo. About 1.5 km long pressure tunnel is aligned in the left bank and powerhouse is located at about 1 km upstream of Alto Benedito Novo.

3.13.2 Damsite and reservoir

About 20 m high and 90 m wide concrete intake dam with gated spillway is planned. Conceivable reservoir area is about 0.2 km^2. The damsite is located at U-shape valley and rapid gorge and it consists of hard and tight granite which crops out in the river side. It is presumed that the required excavation depth is about 2 m and 5 m, respectively in the river bed and river banks. Excavated material comprising the weathered granite will not be used for concrete aggregate. Judging from 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 in view of tightness of granite. Since the reservoir area is small, no geological problems are expected.

3.13.3 Waterway

A pressure tunnel 1.5 km long and 2.9 m in diameter is proposed on the left bank of the river where an existing state road crosses at the middle of the route. A gentle mountain ridge with the shape of a horse shoe extends along the waterway route and it consists of granite. 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. It is presumed that water springs are few and rock cover will be enough, moreover tunnel excavation is possible with steel supports in the fractured zone. Fresh excavated material will be used for concrete aggregate. Consolidation grouting will not be needed except in parts of the fractured zone.

3.13.4 Powerhouse, tailrace and substation

These 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. Foundation rock is regarded as granite. It is remarkable that weathering progresses and granite is decomposed so deeply. It is presumed that a landslide would occur at the weathered granite site unless more than 20 m thick excavation at the back of the powerhouse or prevention work against a landslide is performed for construction of the powerhouse.

3.13.5 Construction materials

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.

3.14 Scheme No. 13, Doutor Pedrinho

3.14.1 Layout of facilities

This scheme is reservoir type. An intake dam would be located at about 20 km upstream of Alto Benedito Novo and powerhouse is aligned at just downstream of dam.

3.14.2 Damsite and reservoir

About 55 m high and 500 m wide rock fill dam is planned. Conceivable reservoir area is about 2.0 km^2. The damsite is located at 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 which out crops in the reservoir area. Since it appears moderately hard and partly cracky, it will be possible to utilize for rock fill dam. It is presumed that the required excavation depth is 10 to 15 m, and the excavated material will be used for impervious material. Since cracky zone appears in the contact position between sandstone and mudstone, fractured zone will appear. Landslide are unlikely to take place because the bank slope is gentle (about 15 degree in gradient) and surface soil is relatively thin (about 2m in thick). Consolidation grouting will be required in the part of fractured zone. Although surface soil is relatively thin in the reservoir area, slope is relatively steep. Consequently there is a possibility of slope failure to some extent.

3.14.3 Powerhouse, tailrace and substation

Since these sites are located at just downstream position of dam body, geological condition is the same as that for the damsite.

3.14.4 Construction materials

The required materials are rock, filter, impervious material for fill dam and concrete aggregate. Since natural filter material cannot be found near the site, it is proposed to produce it at quarry site. 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 which out crops in the top position of mountain. It is presumed that depth of surface soil is about 5 m and available volume is 5 million m^3. The proposed borrow pit site is located at about 0.5 km upstream bank slope of left bank around damsite, where gentle slope of talus deposit spreads. Geological type of the material is talus deposit, weathered sandstone and mudstone.

It is presumed that 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.

3.15 Scheme No. 14, Trombudo Central (1)

3.15.1 Layout of facilities

This scheme is reservoir type. An intake dam would be located at about 4 km south of Trombudo Central and powerhouse is aligned at just downstream of the dam.

3.15.2 Damsite and reservoir

About 40 m high and 350 m wide rock fill dam is planned. Conceivable reservoir area is about 12 km^2. The damsite comprises wide river channel with gentle bank slopes and it consists of slightly soft river deposit and sandstone, shale alternation which out crops at right bank of the river. It is presumed that the required excavation depth is more than 10 m and excavated material will be used for impervious material. 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 degree in gradient) at the dam site. Consolidation grouting will be necessary for foundation treatment in the fractured zone. Considering wide distribution of relatively thick talus deposit in the reservoir area, there is a possibility of slope sliding to some extent.

3.15.3 Powerhouse, tailrace and substation

Since these sites are located at just downstream position of dam body, geological condition is the same as that for the damsite.

3.15.4 Construction materials

The required materials are rock, filter, impervious material for fill dam and concrete aggregate. Since natural filter material cannot be found near the site, it is proposed to produce it at quarry site. Since suitable quarry site does not exist near the damsite, the proposed quarry site was selected at about 30 km east of the damsite. The site is flat hill and it consists of intrusive basalt. This basalt is hard and regarded as a good material. It is presumed that 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). This weathered sandstone and shale are regarded as a good quality for impervious one. It is presumed that thickness of material is about 10 m and available volume is 500,000 m^3. Fine and coarse aggregates will be obtained by crushing the rock materials at the quarry site.

3.16 Scheme No. 15, Trombudo Central (2)

3.16.1 Layout of facilities

This scheme is reservoir type. An intake dam would be located at about 4 km west of Trombudo Central and powerhouse is aligned at just downstream of the dam.

3.16.2 Damsite and reservoir

About 45 m high and 600 m wide rock fill dam is planned. Conceivable reservoir area is about 10 km^2. Since horizontal distance between this damsite and the site of scheme No. 14 is only 4 km, geological and topographical conditions at this site are very similar to those of scheme No. 14.

3.16.3 Powerhouse, tailrace and substation

These sites are located at just downstream position of the dam body. The geological conditions for these structural sites are also similar to those of scheme No. 14.

3.16.4 Construction materials

The proposed quarry site is the same as that for scheme No. 14. The proposed borrow pit site was selected 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.

3.17 Scheme No. 16, Botuvera

3.17.1 Layout of facilities

This scheme is reservoir type. An intake dam would be located at about 15 km upstream of Botuvera and powerhouse is aligned at just downstream of the dam.

3.17.2 Damsite and reservoir

About 70 m high and 270 m wide rock fill dam is planned. Conceivable reservoir is about 3 km^2. The damsite is located at deep U-shape valley and it consists of hard phyllite which is observed in the slope of existing road. It is presumed that the required excavation depth is about 2 m in river bed, 5 m in river banks and the excavated material will be used for impervious material. 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). Consolidation grouting for foundation treatment will be needed for the fractured zone. The ridge of left bank appears relatively thin for the reservoir, consequently some water leakage may take place.

3.17.3 Powerhouse, tailrace and substation

Those sites are located at just downstream position of dam body, geological conditions are the same as that for the damsite.

3.17.4 Construction materials

Utilization of existing quarry site is proposed. It 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 which are regarded as good for rock material. It is presumed that 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 which is regarded as a sufficiently impervious material. It is presumed that thickness of useful zone of weathered phyllite is about 5 m and available volume is 500,000 m^3. Since natural filter material cannot be found near the site, it is proposed to produce at quarry site. Fine and coarse aggregates will be also produced by crushing the rock material at the quarry site.

4. GEOLOGICAL ASSESSMENT

4.1 General

General assessment of the 16 schemes identified was studied based on the results of field inspection. Evaluation of each identified scheme site is summarized in Table II.4.1. The standard of geological assessment shown in Table II.4.2 was applied to evaluate the degree of geological characteristics of each site. Evaluation was made by 4 gradings, i.e., (A) Excellent, (B) Good, (C) Acceptable (average) and (D) Poor.

4.2 Evaluation of Each Identified Scheme Site

(1) Scheme No. 1, Salto Pilao (1)

It is judged that the geological conditions are good as a whole. There is a problem of the thickness of the rock zone for the tunnel near its inlet.

(2) Scheme No. 2, Salto Pilao (2)

The geological conditions for all structuie sites are good as a whole except for the powerhouse site. Since there is not enough space for construction of the powerhouse, large scale excavation will be needed.

(3) Scheme No. 3, Ibirama

The geological conditions for all structure sites are good as a whole, especially for the powerhouse site where a large flat space is available.

(4) Scheme No. 4, Subida

All structure sites have good geological conditions. The dam and powerhouse sites in particular are excellent. Furthermore the relatively narrow U-shaped valley with a gorge is suitable for dam construction. The powerhouse site is the same as that for scheme No. 3.

(5) Scheme No. 5, Ascurra

The geological conditions for the structure sites, except for the powerhouse site, are good. It is presumed that a fractured zone exists and that the excavation depth will increase to some extent at the powerhouse site.

(6) Scheme No. 6, Indaial

The geological conditions for the structure sites are good and acceptable except for the waterway and powerhouse sites. Since the route of the open channel is located in a talus deposit area, deep excavation will be needed. Excavation for the powerhouse will also be costly because the powerhouse site consists of talus deposit which will have to be removed.

(7) Scheme No. 7, Dalbergia

The geological conditions for the structure sites are good as a whole. The damsite in particular has good geological conditions since hard granite outcrops on the river side and consequently excavation can be reduced.

(8) Scheme No. 8, Barra da Pratinha

The geological conditions for the structure sites are good as a whole. However, since filter material is not available near the damsite, it will have to be produced at the quarry site.

(9) Scheme No. 9, Barra das Pombas

The geological conditions for the structure sites are mostly good. However, a large amount of excavation work will be needed at the quarry site to obtain the rock material because fresh sandstone is limited and extends over a wide area.

(10) Scheme No. 10, Timbo

The geological conditions for the structural sites are good as a whole except for construction material site. Filter material for the dam embankment will have to be produced by crushing the rock material at the quarry site.

(11) Scheme No. 11, Benedito Novo

The geological conditions for the structure sites are good as a whole. But it seems that there may be a fractured zone at the heavily weathered part in the upstream tunnel route.

(12) Scheme No. 12, Alto Benedito Novo

The geological conditions for the structure sites except for the powerhouse site are good. It is presumed that a landslide may occur in the weathered zone at the powerhouse site, unless more than 20 m of excavation is carried out in the back of the powerhouse or preventive work against landslide is undertaken for construction of the powerhouse.

(13) Scheme No. 13, Doutor Pedrinho

The geological conditions for the structure sites are not good as a whole. Since the damsite and powerhouse site consist of sandstone alternated with mudstone, excavation of more than 10 m in depth will be needed. No suitable quarry site is available in the vicinity of the dam sites. Moreover, since no natural filter material is available, it will have to be produced at the quarry site.

(14) Scheme No. 14, Trombudo Central (1)

The geological conditions for the structure sites are not good as a whole. Since the damsite and powerhouse site consist of slightly soft river deposits and sandstone shale alternation, excavation of more than 10 m in depth will be needed. Besides the proposed quarry site is located very far from the damsite.

(15) Scheme No. 15, Trombudo Central (2)

The geological conditions for the structure sites are almost similar to those for the scheme No. 14.

(16) Scheme No. 16, Botuvera

The geological conditions of the structure sites are acceptable as a whole. Since the damsite and powerhouse site consist of phyllite which has jointing cracks, it is presumed that fractured zones will exist in some places. Filter material will have to be produced by crushing the rock material. The proposed quarry site is located rather far from the damsite and it would seem that impervious material is not sufficient in quantity.

TABLES

Table II.2.1 SIMPLIFIED STRATIGRAPHY IN THE ITAJAI BASIN

Geological Age	Name of Layer	Lithology (Rock Type)
Quaternary	Alluvial and Colluvial sediment	Clay, Sand, Gravel
Cretaceous Jurassic	Serra Geral Formation	Basalt, Diabase (Intrusive Basalt)
Carboniferous	Rio do Sul formation	Sandstone, Mudstone, Shale
Precambrian (Protezoic)	Subida Intrusive Bodies	Granite, Diorite
	Campo Aleare formation	Sandstone, Mudstone Associated with Intrusive Rhyolite
	Gaspar Formation	Sandstone
	Brusque Metamorphic Complex	Phyllite, Schist Associated with Gneiss Granite
Precambrian (Archeozoic)	Taboleiro Complex	Gneiss, Granite
	Santa Catarina Complex	Gneiss, Granite

Table II.4.1 GEOLOGICAL ASSESSMENT

No.	Name of Scheme	Name of River	*1 Type	*2 Lithology	*3 Assessment				
					Dam Site	Waterway	Powerhouse	Reservoir	Material
1	Salto Pilao (1)	Itajai	1	Gr, Ss	A/B	B/C	B	A/B	B
2	Salto Pilao (2)	Itajai	1	Gr, Ss	A/B	B/C	C	A/B	B
3	Ibirama	Itajai	1	Ry, Ss	A/B	B/C	A	A/B	B
4	Subida	Itajai	1	Ry, Ss	A	A/B	A	A	B
5	Ascurra	Itajai	1	Ry, Ss	A/B	B/C	C	A/B	B
6	Indaial	Itajai	1	Gr	B	C/D	C/D	B	C
7	Dalbergia	Itajai do Norte	1	Gs, Gr	A	B	B	A	B
8	Barra da Pratinha	Itajai do Norte	2	Ss	A	-	B	A	B/C
9	Barra das Pombas	Itajai do Norte	2	Ss, Md	B	-	B	B	C/D
10	Timbo	Benedito	2	Gs	A/B	-	B	A/B	B/C
11	Benedito Novo	Benedito	1	Gr, Di	A/B	B/C	B	A/B	B
12	Alto Benedito Novo	Benedito	1	Gr, Di	A/B	B/C	C/D	A/B	B
13	Doutor Pedrinho	Benedito	2	Ss, Md	C	-	C	B/C	C/D
14	Trombudo Central (1)	Trombudo	2	Ss, Sh	C	-	C	C	C/D
15	Trombudo Central (2)	Trombudo	2	Ss, Sh	C	-	C	C	C/D
16	Botuvera	Itajai Mirim	2	Ph	C	-	C	C	C

*1 Type 1: Run-of river Type 2: Reservoir

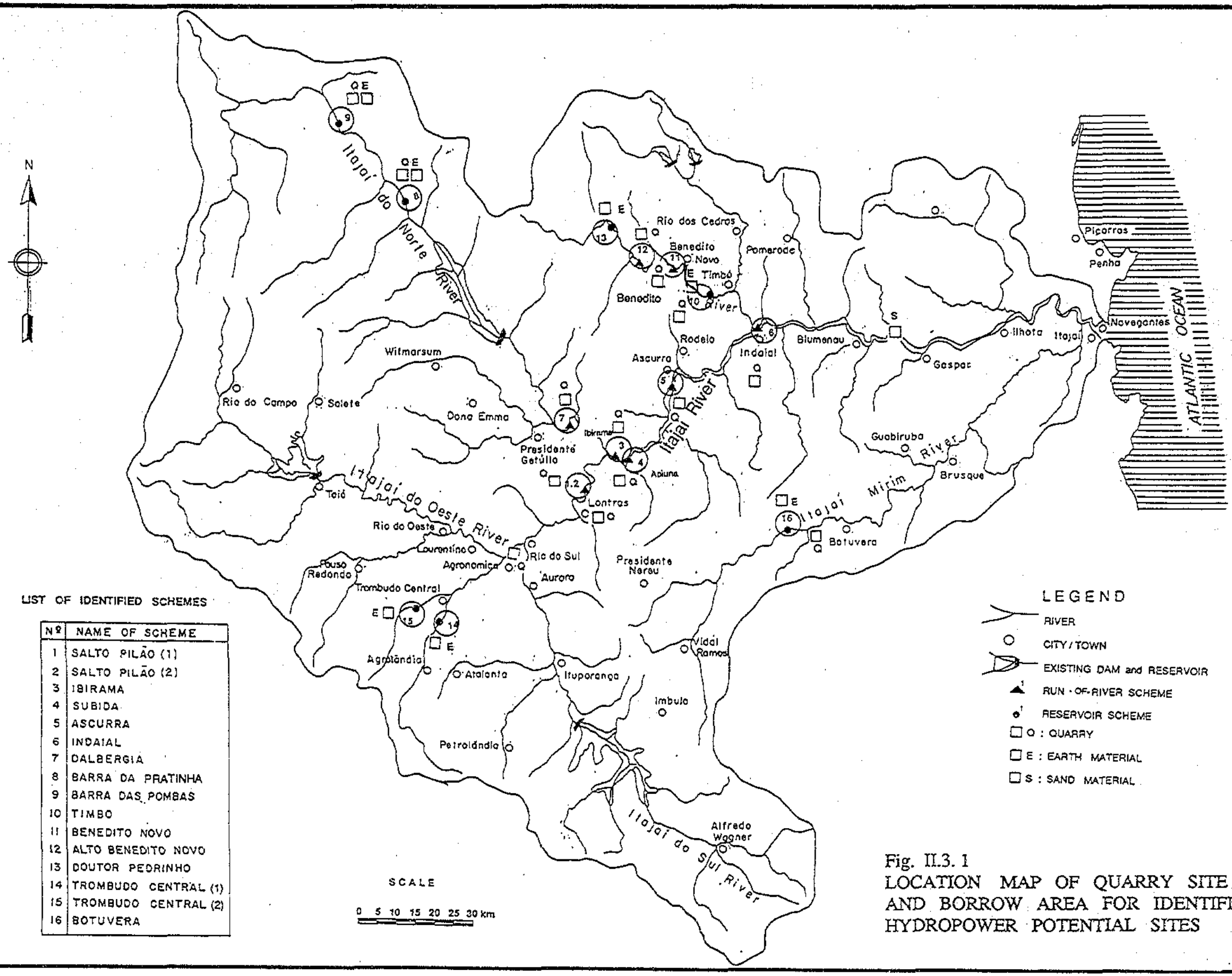
*2 Lithology; Gr: Granite Ss: Sandstone Ry: Rhyolite
Gs: Gneiss Md: Mudstone Di: Diorite
Sh: Shale Ph: Phyllite

*3 A: Excellent B: Good C: Acceptable D: Poor

Table II.4.2 STANDARD OF GEOLOGICAL ASSESSMENT

Grade of Assessment	Damsite	Waterway/ Penstock Tunnel	Powerhouse	Reservoir	Construction Materials	
					Location	Quality
(A) Excellent	A site with thin weathered zone and no fractured zone, where it is possible to construct a concrete dam.	Hard rock without any problem, which presents problem for tunnel excavation and support is not required.	A site with thin overburden and hard rock, which is suitable for constructing powerhouse.	A reservoir where no geological problem exists.	Distance is less than 5km.	Hard and massive rock.
(B) Good	A site with hard rock and some fractured zone, where it is possible to construct a concrete dam.	Hard, fairly hard rock, which presents no problem for tunnel excavation but partial support and lining are required.	A site with some overburden and relatively hard rock, where it is possible to construct a powerhouse.	A reservoir where a little geological problem exists. Small water leak and small scale slope failure may take place.	Distance is between 5km and 10km.	Hard rock, slightly weathered, and rarely cracked.
(C) Acceptable	A site with slightly hard and fractured zone, where it is possible to construct a rock fill dam.	Hard and fairly hard rock with some problems such as fractured zone. Supporting and lining are required.	A site with relatively thick overburden. But no large defect exist.	A reservoir where some water leak or slope slide appears but it will be within allowable limits.	Very far distance (10km and 20km)	Hard rock and fairly hard rock, but relatively many cracks are found.
(D) Poor	A site with poor geological conditions, which is not recommendable for constructing dam.	Soft rock and many weak zones appear. Support and lining are required.	A site with large scale geological defects such as landslides, which is not recommendable for constructing a powerhouse.	A reservoir which is not recommendable due to geological defects such as much water leakage or large scale landslide.	Distance is more than 20 km.	Soft and cracky rock which is not recommendable for rock material.

FIGURE



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

Fig. II.3. 1
LOCATION MAP OF QUARRY SITE AND BORROW AREA FOR IDENTIFIED HYDROPOWER POTENTIAL SITES

ANNEX III

SOCIO-ECONOMY

ANNEX III. SOCIO-ECONOMY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

1. INTRODUCTION

The socio-economic study aims to understand the present and prospective socio-economic characteristics of the state of Santa Catarina. These characteristics are indispensable for other sectoral studies for setting up the basic framework of the power development plan.

Chapter two provides an overview of economic conditions in Brazil including present conditions of electric power supply and consumption. Chapter three describes socio-economic conditions in Santa Catarina in comparison with the nation or national averages so as to clarify the regional potential and correlations within the country. Chapter four reviews power supply and consumption in Santa Catarina and its problems and needs for power development. Chapter five discusses the acceptability of the marginal cost of electricity which has been specified by ELETROBRAS and is applied to examination of the economic viability of the electric power development plan.

2. OVERVIEW OF ECONOMIC CONDITIONS IN BRAZIL

2.1 Economic Conditions in Brazil

The Brazilian economy expanded remarkably during the 1970s as shown in Table III.2.1. During this period the annual growth rate of GDP was as high as about 5 to 14% and achieved 8.6% on an average. However, it decreased to an average of about 2% per annum during the 1980s with a minus growth rate in 1981, 1983 and 1988 due to the worldwide economic recession.

A sectoral breakdown of the economy is presented in Table III.2.2 which shows the average growth rate of GDP in the 1970s and 1980s. This table shows that the average growth rate for agriculture, industry and service sectors shifted downwards from 8.2, 10.9 and 8.8% in the 1970s to -0.7, 1.8 and 4.2% respectively in the 1980s. The subsectors of agriculture, manufacturing, commerce and transportation shifted down significantly, while the mining, public utility and banking subsectors remained almost the same. This table also shows the distribution of GDP by sector for the last 18 years. The shifting down of the GDP may be seen in agriculture, and upward in industry and the service sector.

The economy in Brazil is still in a condition of stagnation but some recovery is becoming apparent in GDP per capita. Table III.2.1 shows that the GDP per capita for the latest year is regaining the last peak level of Cr$102 thousand in 1980. There is also the indication of some recovering of the economy in the trade balance as may be seen in the following;

(Unit: Million US$)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
Trade Balance	-2,823	1,202	770	6,470	13,089	12,486	8,304	11,172	19,096
Export FOB	20,132	23,293	20,165	21,899	27,005	25,639	22,348	26,224	33,784
Import FOB	22,955	22,091	19,395	15,429	13,916	13,153	14,044	15,052	14,688

2.2 Electric Power Supply and Consumption

Generation and supply of electric energy in Brazil have been administrated by the *Ministry of Infrastructure (MIE). In order to orient and implement a nationwide policy for the* power field, MIE employs two entities, namely, DNAEE and ELETROBRAS.

DNAEE is responsible for issuance of concessions for utilization of river water and dealing in power between producers, suppliers and users. On the other hand, ELETROBRAS is responsible for planning, financing and coordination of expansion and operation of the Brazilian power system. ELETROBRAS has also a federal holding company for four regional subsidiaries ; ELETRONORTE, CHEESF, FURNAS and ELETROSUL, which own and operate power generation systems and inter-regional transmission lines in the northern, northeastern, central west/southern and southern regions. Furthermore, within each region there are state utilities, usually supervised by the state government, which are responsible for some of the power generation as well as local transmission and distribution.

Power consumption by category of consumer for whole Brazil for 1980-1989 period is given in Table III.2.3. This table shows that the electric power consumption has been growing at as much as 6.6% per annum from 114,305 GWh in 1980 to 202,516 GWh in 1989, and fastest for residential use. The power consumption by consumers is 53% for industry, 21% for residents and 26% for others. The prospective power consumption is forecast to be a little slower but to expand steadily at a growth rate of 5.8% per annum over the next decade.

The power supply by type of source for whole Brazil for 1980-1989 is shown in Table III.2.4. This table shows that hydropower provides more than 90% of the generation capacity, while nuclear power plant initiated in 1985 provides only about 1%. To meet the increase in power consumption, power supply has been expanded at a rate of 6.5% per annum.

3. STATE OF SANTA CATARINA

3.1 Geographic Condition

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 state has an area of 95,483 km^2 or 1.12% of the national total as shown in Table III.3.1 and contains a coastal plain below 200m in attitude, coastal mountain ranges of attitude between 200 - 800m and western highland of attitude over 800m, in the ratios of 14 %, 42% and 44% respectively. The mountains and highland are generally not so steep and rather flat on top so that they have been well developed for primary industry with a high efficiency of land use, namely 77.8% of the total area as shown in Table III.3.9.

Most of the rivers and tributaries from the western highland flow to west and south into Rio Uruguai, others flow to the north into the Rio Iguacu, and others flow east into the Atlantic Ocean.

The predominant climate is humid semi-tropical with the temperature ranging between 13 and 25°C. The highlands have severe winters with temperature sometimes below freezing and snowfalls, while the coastal plains are rather temperate and variable in their temperatures due to the cold current along the Atlantic seaboard.

3.2 Administration

The administration of the state of Santa Catarina has been divided into 22 microregions which are further divided into 217 municipalities as shown in Table III.3.1.

The state government is located in Florianopolis, and is composed of 14 secretarias, 3 procuradorias and 8 special offices attached to the governor's cabinet as shown in Fig. III.3.1. Amongst these, the following secretaries are closely related to this project study;

(1) Secretaria de Estado de Coordenacao Geral Planejamento (SEPLAN); The Secretaria and his staff are responsible for general coordination and planning of policy and basic strategy in the state administration.

(2) Secretaria de Tecnologia, das Minas e Energia (CTME); This secretary is in charge of administration of science, technology, mines and energy affairs. Under the supervision of CTME, CELESC operates electric power generation and supply in the state area.

(3) SEDUMA-Secretaria de Desenvolvimento Urbano e Meio Ambiente; This secretary is in charge of urban development and environmental affairs.

3.3 Population

The state of Santa Catarina has a population of 4.6 millions or 2.97% of the national total, 155 millions in 1990 as shown in Table III.3.1. The national census in the 1960s, 1970s and 1990s as given in Table III.3.2 shows that population increased at an annual growth rate of 3.2% in the 1960s, 2.26% in the 1970s and 3.29% in the 1980s. 8 major municipalities as shown in Table III.3.1, hold more than 100,000 inhabitants and are situated on the coastal plains, particularly in the northern and central regions.

According to an estimation in July 1989 by the General Coordination and Planning Office (SEPLAN) of the state government, the population in Santa Catarina is projected to increase to about 5.3 million in 2000 and 6.2 million in 2010 as follows;

	1995	2000	2005	2010
Population (10^3 person)	4,795	5,246	5,689	6,176
Annual growth rate: (%)	1.80	1.80	1.65	1.65

3.4 Labor Force and Employment

The latest census in Brazil and Santa Catarina given in Table II.3.2 shows that the state of Santa Catarina marked a higher growth in labor force and gainful workers than the national average. This table also shows that of the 2,716 thousand population 10 years old and over in 1980, around a half or 1,356 thousand was regarded as labor force. Of the total labor force, 98.1% or 1,331 thousand was employed in primary, secondary and tertiary industries in the proportions of 30.8%, 31.6% an 35.7% respectively as shown in Table III.3.3. Since then, even in the slow economic growth in the 1980s, employment has expanded at a rate of 2.52% per annum, including an annual average growth of zero% in agriculture, 3.75% in manufacturing and 3.95% in service sectors.

As the result, the total employment has increased by more than 100% during the last 20 years and the distribution by sector was estimated at 41% in service, 35.6% in manufacturing and 23.4% in agriculture as shown in Table III.3.3.

3.5 Economy

The economy of the state of Santa Catarina has grown more rapidly and with much higher productivity than the national average and contributies to the national economy more than its proportional weight in population and land area.

Table III.3.4 shows the GDP in Brazil and GRDP in Santa Catarina for the 1970-1988 period. This table shows that Santa Catarina in the 1970s had a much higher net GRDP growth rate at 11.8% than the GDP growth rate of 8.6% in Brazil and achieved more than the mean level of GDP per capita since the end of that decade. Despite of minus growth in the state economy in 1983 and 1988, the annual average growth rate for 1980-1988 period was 4.1% against that of 2% in Brazil.

GRDP for the primary, secondary and tertiary sectors in Santa Catarina for 1983-1989 period is given in Table III.3.5. This table shows that the proportions for the primary and secondary sectors expanded but that for the tertiary sector declined, though the ranking of share in each sector was unchanged throughout that period.

The growth rate of GRDP for 1987-1989 period in Santa Catarina is shown in Table III.3.6. It is clarified in this table that the primary sector has had the highest annual growth rate among the three sectors and the annual growth rate for all subsectors in the primary sector was higher than that of the annual average for subsectors. The data showing a comparison between the national average and the regional average for production in subsectors of the primary sector are not available except for agriculture and fishery. Table III.3.7 shows a comparison of national and regional averages of production in agriculture and fishery. It shows that primary products such as apples, garlic, tobacco, onions, wheat, corn, soya beans, honey and fish are highly ranked in the national production.

The annual average growth rate for the secondary sector was estimated at 2.14% in Table III.3.6, which is smaller than the annual average for the three sectors. Among subsectors of the secondary sector, manufacturing has been a mainstay in regional economy holding top share with one third of GRDP. According to the comparison of manufacturing in Santa Catarina with the national total in 1980 and 1985 as shown in Table III.3.8, there are 10 extraordinary industries which have a higher share than that of regional average of 3.8% in 1985. These are non-metallic products, machinery, timber, furniture, paper, plastic products, textiles, clothing, food products and tobacco. These industries also contribute greatly to the Gross Value Added (GVA) in Santa Catarina and are mainly located in the northern and central coastal plains with exception of some food processing, ceramics and plastic industries.

The annual average growth rate for the tertiary sector is as small as 0.81% due to the negative growth in 1987 and 1988 by commercial subsector as shown in Table III.3.6. The growth rate of this subsector except in transport/communications and real estate is smaller than that of the annual average for the three sectors, but the tertiary sector itself shares about 43% of GRDP.

3.6 Land Use

No data are available on land use in the state of Santa Catarina except for land use for the primary sector in 1985 as shown in Table III.3.9. This table shows that the acreage of land used for the primary sector was 68,259 km^2 which is about 71.5% of the state area, and consists of about 26% of pasture land, 23% for agricultural land, 20% for forest and 3% of unused area. The majority of the land has been used for pasture, natural forest and seasonal agriculture. It is presumed that the remaining area, 27,224 km^2 comprises urban area, unused area unsuitable area for cultivation and other uses.

3.7 Infrastructure

(1) Transportation

Transportation infrastructure in the state of Santa Catarina is summarized in Table III.3.10.

Santa Catarina had a federal, state and municipal road network of 60,878 km in total length in 1988. Lengthwise, the share of road length in Santa Catarina to that in Brazil is 4.1% which is larger than that of land area (1.12%) and population (2.97%). However, the pavement ratio is only 7.9% which is less than the national average of 8.9%. A 44,000 km long municipal road construction extension project is projected.

There are three major sea ports in the state : Imbituba, San Francisco do Sul and Itajai. Of these, San Francisco do Sul is the most active as the main gateway to the northern industrial area of the state with an average share of 63.4% . Recession of the growth rate of cargo handling at Imbituba port may be affected by a dull mining market. The share of sea ports in Santa Catarina in terms of cargo handled to those in Brazil is around 4%.

The one international airport in the state, Hercilio Luz airport in Florianopolis plays an important role especially for time saving in person trips and mail. The annual average increase rate of passenger for 1985-1987 period in this airport has been about 22%.

(2) Communications

Telephone activities in Santa Catarina are described in Table III.3.11. Installation of telephone sets in Santa Catarina has grown at an annual average rate of 8.2% for the past 3 years in contrast with the national average of 5.1%. In view of the present situation with 13 inhabitants per telephone set and the overwhelming use for long distance calls, there must be a space for further expansion of the system.

4. PROBLEMS AND NEEDS FOR ELECTRIC POWER DEVELOPMENT

4.1 Electric Power Supply and Consumption in Santa Catarina

CELESC is a Santa Catarina owned company responsible for supply of electric power for the state. CELESC has its own transmission line and distribution system which is linked with the south/southeast power transmission system. CELESC has a power facilities with an installed capacity of 74.3 MW which consists of 12 hydropower plants. The majority of these power plants are located in the mountainous area on the tributaries of the major rivers.

Table III.4.1 shows the relationship between power generation and consumption for 1980-1989 in Santa Catarina. This table shows that CELESC generated only about 6% of the energy required for the power demand and 7060 GWh of energy handled was supplied to industry, residential, commercial and rural uses. In all about 75% of consumers are industrial and residential. Table III.4.1 also shows the annual growth rate of power generation and power consumption. The 1980/89 data shows that self power generation by CELESC declined and purchased energy increased, while, power consumption increased at the annual growth rate of 8.3%. The increase in the growth rate is conspicuous for public service, rural and residential uses.

4.2 Power Energy Demand

Table III.4.1 shows that total energy handled by CELESC has doubled since 1980 and that its annual growth rate has been 8%.

CELESC has forecasted power energy demand by type of consumer up to 2001 based on the method specified by ELETROBRAS. The forecasted power energy demand from 1990 to 2001 is as follows:

(Unit: GWh)

Consumer	1990	1995	2000	2001
Residential	1482	2081	2736	2877
Industrial	3380	4309	5500	5745
Commercial	641	825	1030	1074
Rural	602	812	1022	1064
Public light	223	269	314	323
Government	122	153	190	199
Public service	105	139	182	190
Self consumption	8	9	10	11
Total	6563	8597	10984	11483

It is assumed in this forecast that the annual growth rate of power consumption is about 5.2% and distribution of power consumption for each consumer is the same as that for 1989.

4.3 Problems and Needs for Electric Power Development

CELESC has small scale hydropower plants in the tributary area and generates the power energy of only about 6% of the power demand. The remaining power energy has been supplied by interconnection of the power systems of the south and southeastern regions. The electric power tariff in this interconnected system has been determined by ELETROBRAS. CELESC disbursed more than 50% of its budget for purchasing of energy from the interconnected power supply system.

Table III.4.1 shows that self power generation by CELESC is gradually decreasing and purchased energy is increasing as the power demand increases year by year. CELESC is concerned the decrease in share of self power generation and intends to reduce disbursement on purchased energy by up to 20% by developing own hydropower projects.

Hydropower development planning has so far been concentrated on the rapid river stretch downstream of Rio do Sul in the Itajai river basin. The study in 1966 result was reviewed in 1974 and 1977. However, this plan has not been realized for the following reasons;

(i) The right to construct power plant and generation of power supply was granted to all power companies by decree through DNAEE at the time of the study in 1966. Since regional company (ELETROSUL) was not established at that time, the planning of hydropower development was promoted by CELESC. In 1968, ELETROSUL was established. Since then, the right to construct power plant has rested with ELETROSUL and CELESC has only had the right to distribute energy.

(ii) Even so, CELESC has had difficulty in obtaining funds to improve the existing transmission and distribution systems.

In order to increase the share of self power generation by CELESC, it is therefore necessary to look for cheaper sources of power supply than the specified power tariff. Study of several small scale hydropower schemes in the tributary areas, including the hydropower potential survey in the Itajai river basin, are being carried out within the state by CELESC. Among them, the Itajai river basin has the largest power market areas in the state. Thus, if the hydropower schemes studied in the Itajai river basin are economically feasible, development of these schemes will be essential to attain CELESC's objective.

5. MARGINAL COST OF ELECTRICITY

ELETROBRAS has employed the theory of Marginal Cost of Expansion to project evaluation and pricing since 1984. This theory is based on the comparison of energy output and the monetary inputs for facilities and operation in accordance with the conceivable power demand.

The formula calculation of CME is as follows;

$$CME = \frac{CATE \times 10^3}{8.76\ (ICEQ - EN)} + \frac{(CGTE + CDFE + COME\ ) \times 10^3}{8.76\ ICEQ}$$

Where;

	CME	:	Marginal cost of expansion (US$/MWh)
	CATE	:	Compound annual investment for construction of hydraulic/thermal power projects (10^6 US$/year)
	ICEQ	:	Compound annual output (guaranteed energy) to be generated by all power projects (MW/year)
	EN	:	Compound annual output (guaranteed energy) to be generated by nuclear power projects (MW/year)
	CGTE	:	Compound annual average of fuel cost for all thermal plants (10^6 US$/year)
	CDFE	:	Compound annual average cost for compensation of presumed energy deficit (10^6 US$/year)
	COME	:	Compound annual operation and maintenance cost of all power projects, except fuel cost for thermal power projects (10^6 US$/year)

CME for interconnected south and southeastern system in 1989 was calculated in the following procedures :

(i) The power demand for the next ten year period was forecast by ELETROBRAS as follows;

(Unit;MW/year)

Year	1989	'90	'91	'92	'93	'94	'95	'96	'97	'98
South	3,318	3,567	3,828	4,112	4,408	4,734	5,147	5,471	5,806	6,156
Southeast	15,247	16,089	17,014	18,005	18,989	19,798	20,950	21,999	23,072	24,126
Total	18,565	19,656	20,842	22,117	23,397	24,712	26,097	27,470	28,878	30,282

(ii) To meet this power demand, large scale promising hydro and thermal power schemes and nuclear power plant were planned as listed in Table III.5.1.

(iii) The power energy to be generated by these schemes was calculated as given in Tables III.5.2 and III.5.3 assuming that the power energy is generated from 6th to 10th year.

(iv) Annualization of the capital investments for these projects except for the nuclear power plants was calculated in Table III.5.4. The annualized capital was based on the NPV (net present value) of each project plant at 10% per annum discount rate for the project life of 50 years for hydropower plant, and 30 years for thermal power plant respectively.

(v) The fuel cost required for generation of the power output at each thermal power plant was calculated as shown in Table III.5.5 using the unit cost of coal and oil as shown in Table III.5.6.

(vi) It was assumed that if a power deficit occurs due to a delay of project construction or water deficit due to hydrological conditions, such a deficit will be compensated by existing thermal power plants. In this case the implicit cost of US$300/MWh was introduced considering the high actual cost of operation of existing thermal power plants with inferior efficiency.

(vii) The operation and maintenance cost for all facilities except for the fuel cost for the thermal plants were calculated as shown in Table III.5.7.

Consequently, CME was calculated at about 36 US$/MWh as follows;

$$\text{CME} = \frac{963.45 \times 10^3}{8.76\,(4195.60-753.27)} + \frac{(85.78 + 28.18 + 20.98\,) \times 10^3}{8.76 \times 4195.60}$$

$$= \frac{279.88 + 32.162}{8.76} = 35.62 \text{ US\$/Mwh}$$

CME for the next five year periods was calculated by applying the same procedures as the foregoing. The calculated CME is as follows;

5 YEARS PERIOD	CME	
1991 - 1995	34	US$/MWh
1996 - 2000	36	"
2001 - 2005	43	"
2006 - 2010	53	"
2011 onward	64	"

The series of procedure for marginal cost calculation were reviewed in detail. The result of review is as follows;

(1) The concept of this CME is principally based on the annual energy to be generated by the promising large scale projects including the majority of hydropower schemes and several thermal power schemes, and their investment cost. These schemes are those selected from among the inventory study. Since it is conceivable that the combination of these selected schemes is the most promising power supply source in the interconnected system and there are no more economical alternative schemes than those of the adopted combination, the value obtained from CATE and ICEQ is considered to be reasonable.

(2) The implicit cost to estimate the cost for the presumed power deficit is introduced on the assumption that the power for the presumed deficit is supplied by the existing thermal plants, and relatively high costs are applied to the estimation. Considering the present power supply facilities including thermal plants with inferior efficiency for power generation and high operation cost have been operated, it is necessary to recognize the introduction of this high implicit cost.

In view of the above-mentioned comments, it was concluded that application of the concept of CME to the economic evaluation of the hydropower development schemes is acceptable.

TABLES

Table III.2.1 GDP, BRAZIL, AT CURRENT AND 1980 CONSTANT PRICE IN 1970 - 1988, WITH PER CAPITA AND GROWTH RATE

Year	GDP at current price		GDP at 1980 constant price		GDP per capita at 1980 constant price		Implicit index number
	Amount	Growth rate	Amount	Growth rate	Amount	Growth rate	(*1)
	(Cr$ 10^6)	(% per annum)	(Cr$ 10^6)	(% per annum)	(Cr$ 10^3)	(% per annum)	
1970	194		5,419		56.35		
1971	258	33.0	6,037	11.4	61.46	8.7	19.4
1972	347	34.5	6,758	11.9	67.16	9.3	20.1
1973	512	47.6	7,700	13.9	74.72	11.3	29.5
1974	745	45.5	8,336	8.3	79.00	5.7	34.4
1975	1,050	40.9	8,763	5.1	81.11	2.7	34.1
1976	1,635	55.7	9,654	10.2	87.29	7.6	41.3
1977	2,496	52.7	10,130	4.9	89.48	2.5	45.5
1978	3,618	45.0	10,629	4.9	91.74	2.5	38.1
1979	5,964	64.8	11,348	6.8	95.72	4.3	54.4
1980	12,400	107.9	12,400	9.3	102.24	6.8	90.3
1981	24,662	98.9	11,853	- 4.4	95.01	- 6.6	108.1
1982	51,029	106.9	11,929	0.6	94.01	- 1.6	105.6
1983	118,736	132.7	11,516	- 3.5	88.74	- 5.6	141.0
1984	393,745	231.6	12,104	5.1	91.24	2.8	215.5
1985	1,413,772	259.1	13,114	8.3	96.74	6.0	231.4
1986	3,708,196	162.3	14,109	7.6	101.87	5.3	143.8
1987	11,884,734	220.5	14,618	3.6	103.34	1.4	209.3
1988	92,993,145	682.5	14,578	- 0.3	100.93	- 2.3	684.6
70/80				8.6		6.1	
80/88				2.0		- 0.2	
70/88				5.7		3.3	

Note : *1 - Implicit index number represents the growth rate of current/constant price ratio in comparison with previous year.

Soureces : SEPLAN, IBGE & SEPLAN/SC (SE-01, SE-02 and SE-05)

Table III.2.2 GDP, BRAZIL, AT 1980 CONSTANT PRICES, BY INDUSTRIAL SECTORS IN 1970 - 1988, WITH GROWTH RATE AND SECTORAL DISTRIBUTION

GDP, BRAZIL, AT 1980 CONSTANT PRICES — Unit: Thousand Cr$

Year	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988
GDP-const	4865271	8339619	12079107	11779900	11889737	11707984	12377960	13473831	13442728	15095821	15120538
Agricult.	561898	896441	1232100	1118960	919734	1057139	1152339	1222271	1251438	1166502	1162302
Industry	1743673	3366693	4902241	4602672	4794307	4427776	4880494	5215634	5359878	5820816	5672966
Min.	37930	68350	125617	150538	164622	264860	473282	478679	399275	293818	294905
Manufa.	1335118	2613963	3746089	3445781	3595432	3284270	3515118	3735008	3754313	3995050	3859218
Constru.	262797	518762	812737	810772	798057	652939	635481	726543	910008	1108031	1075676
P.Uty.	107828	165618	217798	195581	236196	225707	256613	275404	296282	423917	443167
Service	2559700	4076485	5944766	6058268	6175696	6223069	6345127	7035926	6831412	8108503	8285270
Commerc	798145	1213657	1328305	1216158	1215576	1143506	1188652	1256369	1276833	1273212	1237944
Transport	179894	270773	461692	465838	489093	460627	468440	490482	495214	498468	515415
Communic	29802	65721	110751	120905	125256	122066	119834	125899	110048	131560	145401
Banking	293141	545926	955622	1179412	1164280	1327757	1297592	1484561	1021467	1986561	1991727
Govern.	449194	625669	780920	760988	832651	750822	670584	890474	1011591	1091951	1114554
R. Estate	451903	558195	825659	885448	891104	999560	1071239	1121289	1182305	1333145	1329475
Others	357621	796544	1481817	1429519	1457736	1418731	1528786	1666852	1733954	1793606	1950754

Note: Figures represent gross amounts before adjustment of intermediate financial expenses, indirect taxes and subsidies.

DISTRIBUTION BY INDUSTRIAL SECTORS (%)

Year	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988
GDP-const	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Agricult.	11.55	10.75	10.20	9.50	7.74	9.03	9.31	9.07	9.31	7.73	7.69
Industry	35.84	40.37	40.58	39.07	40.32	37.82	39.43	38.71	39.87	38.56	37.52
Min.	0.78	0.82	1.04	1.28	1.38	2.26	3.82	3.55	2.97	1.95	1.95
Manufa.	27.44	31.34	31.01	29.25	30.24	28.05	28.40	27.72	27.93	26.46	25.52
Constru.	5.40	6.22	6.73	6.88	6.71	5.58	5.13	5.39	6.77	7.34	7.11
P.Uty.	2.22	1.99	1.80	1.66	1.99	1.93	2.07	2.04	2.20	2.81	2.93
Service	52.61	48.88	49.22	51.43	51.94	53.15	51.26	52.22	50.82	53.71	54.79
Commerc	16.40	14.55	11.00	10.32	10.22	9.77	9.60	9.32	9.50	8.43	8.19
Transport	3.70	3.25	3.82	3.95	4.11	3.93	3.78	3.64	3.68	3.30	3.41
Communic	0.61	0.79	0.92	1.03	1.05	1.04	0.97	0.93	0.82	0.87	0.96
Banking	6.03	6.55	7.91	10.01	9.79	11.34	10.48	11.02	7.60	13.16	13.17
Govern.	9.23	7.50	6.47	6.46	7.00	6.41	5.42	6.61	7.53	7.23	7.37
R. Estate	9.29	6.69	6.84	7.52	7.49	8.54	8.65	8.32	8.80	8.83	8.79
Others	7.35	9.55	12.27	12.14	12.26	12.12	12.35	12.37	12.90	11.88	12.90

GROWTH RATE (Previous year = 100)

Year	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	Avarage % p.a. 1970/80	1980/88
GDP/constant price		171.41	144.84	97.52	100.93	98.47	105.72	108.85	99.77	112.30	100.16	9.5	2.8
Agriculture		159.54	137.44	90.82	82.20	114.94	109.01	106.07	102.39	93.21	99.64	8.2	-0.7
Industry		193.08	145.61	93.89	104.16	92.35	110.22	106.87	102.77	108.60	97.46	10.9	1.8
Mining		180.20	183.78	119.84	109.36	160.89	178.69	101.14	83.41	73.59	100.37	12.7	11.3
Manufacturing		195.79	143.31	91.98	104.34	91.35	107.03	106.26	100.52	106.41	96.60	10.9	0.4
Construction		197.40	156.67	99.76	98.43	81.82	97.33	114.33	125.25	121.76	97.08	12.0	3.6
Pubic Utility		153.59	131.51	89.80	120.77	95.56	113.89	107.32	107.58	143.08	104.54	7.3	9.3
Service		159.26	145.83	101.91	101.94	100.77	101.96	110.89	97.09	118.69	102.18	8.8	4.2
Commerce		152.06	109.45	91.56	99.95	94.07	103.95	105.70	101.63	99.72	97.23	5.2	-0.9
Transportation		150.52	170.51	100.90	104.99	94.18	101.70	104.71	100.96	100.66	103.40	9.9	1.4
Communication		220.53	168.52	109.17	103.60	97.45	98.17	105.06	87.41	119.55	110.52	14.0	3.5
Banking		186.23	175.05	123.42	98.72	114.04	97.73	114.41	68.81	194.48	100.26	12.5	9.6
Government		139.29	124.81	97.45	109.42	90.17	89.31	132.79	113.60	107.94	102.07	5.7	4.5
Real Estate		123.52	147.92	107.24	100.64	112.17	107.17	104.67	105.44	112.76	99.72	6.2	6.1
Others		222.73	186.03	96.47	101.97	97.32	107.76	109.03	104.03	103.44	108.76	15.3	3.5

Sources: SEPLAN & IBGE (SE-01, SE-02, SE-20 and SE-21)

Table III.2.3 ELECTRIC ENERGY CONSUMPTION AND PROJECTION IN BRAZIL

(Unit: GWh) (Unit: %)

Year	Industry	Resident	Others	Total	Industry	Resident	Others	Total
Historical consumption:					Distribution:			
1980	61673	23247	29385	114305	53.95	20.34	25.71	100.00
1981	61419	25078	31743	118240	51.94	21.21	26.85	100.00
1982	64125	27095	33960	125180	51.23	21.64	27.13	100.00
1983	67505	29771	36469	133745	50.47	22.26	27.27	100.00
1984	78810	30975	38839	148624	53.03	20.84	26.13	100.00
1985	89712	32698	41406	163816	54.76	19.96	25.28	100.00
1986	97376	35814	43875	177213	55.03	20.21	24.76	100.00
1987	97376	38404	46296	182076	53.48	21.09	25.43	100.00
1988	103699	40564	48612	192875	53.76	21.03	25.20	100.00
1989	107903	43626	50987	202516	53.28	21.54	25.18	100.00
Average : 1980-1989					53.09	21.01	25.89	100.00
Projection:								
1990	108769	44665	53350	206784	52.60	20.60	25.80	100.00
1995	148589	59436	72332	280357	53.00	21.20	25.80	100.00
2000	191599	77951	94707	364257	52.60	21.40	26.00	100.00
Growth rate: (previous year = 100)								
1981	99.59	107.88	108.02	103.44				
1982	104.41	108.04	106.98	105.87				
1983	105.27	109.88	107.39	106.84				
1984	116.75	104.04	106.50	111.12				
1985	113.83	105.56	106.61	110.22				
1986	108.71	109.53	105.96	108.18				
1987	99.85	107.23	105.52	102.74				
1988	106.49	105.62	105.00	105.93				
1989	104.05	107.55	104.89	105.00				
1990	100.80	102.38	104.63	102.11				
1995	136.61	133.07	135.58	135.58				
2000	128.95	131.15	130.93	129.93				
Growth rate: annual average (%)								
80/89	6.4	7.2	6.3	6.6				
90/95	6.4	5.9	6.3	6.3				
95/00	5.2	5.6	5.5	5.4				
90/00	5.8	5.7	5.9	5.8				

Sources: ELETROBRAS, IBGE (SE-01 and SE-31)

Table III.2.4 INSTALLED GENERATING CAPACITY AND PROJECTION IN BRAZIL

(Unit: MW) (Unit: %)

Year	Hydraulic	Thermal :	(Oil)	(Coal)	(Diesel)	(Nuclear)	(Other)	Total		Hydraulic	Thermal	Total
	Historical capacity :									Annual growth :		
1980	27081	3484	1876	748	859		1	30565				
1981	30596	3655	1992	748	915			34251		13.0	4.9	12.1
1982	32542	3687	1992	748	947			36292		6.4	0.9	5.8
1983	33556	3641	1972	730	937		2	37197		3.1	-1.2	2.7
1984	35001	3626	1966	730	922		8	38627		4.3	-0.4	3.8
1985	37503	4365	1966	730	1004	657	8	41868		7.1	20.4	8.4
1986	39262	4502	1972	890	967	657	16	43764		4.7	3.1	4.5
1987	42843	4567	1835	1040	1019	657	16	47410		9.1	1.4	8.3
1988	45783	4682	1842	1040	1107	657	36	50465		6.9	2.5	6.4
1989	49219	4664	1844	1040	1001	657	22	53883		7.5	-0.4	6.8
	Projection :											
1990	50485	4667						55152		2.6	0.1	2.4
1991	53343	4667						58010		5.7	0.0	5.2
1992	54728	5102						59830		2.6	9.3	3.1
1993	55976	5927						61903		2.3	16.2	3.5
1994	57240	5927						63167		2.3	0.0	2.0
	Average distribution : (%)											
80/89	90.03	9.97	4.80	2.05	2.38	0.70	0.04	100.00		Annual average growth :		
									1980/89	6.9	3.3	6.5
									1990/94	3.2	6.2	3.5

Sources: ELETRBRAS, IBGE (SE-01 and SE-31)

Table III.3.1 ESTIMATED POPULATION IN BRASIL AND SANTA CATARINA - 1990

	Municipality	Area sq. km	Population	Density Persons/sq. km	Percentage Distribution Area	Percentage Distribution Population	Percentage Distribution Urban/Rural	Major Municipality Population > 100,000	
BRASIL	4,425	8,511,996	155,162,917	18.28	(100.00)	(100.00)			
SANTA CATARINA	217	95,483	4,601,500	48.19	(1.12) 100.00	(2.97) 100.00	68/32		
- Microregion -									
1 Grande Florianopolis	13	4,665	504,349	108.11	4.89	10.96	80/20	Florianopolis Sao Jose	242,861 120,744
2 Foz do Rio Itajai	10	1,531	246,274	160.85	1.61	5.35	80/20	Itajai	119,356
3 Medio Vale do Itajai	11	3,260	372,525	102.90	3.79	8.10	78/22	Blumenau	220,741
4 Alto Vale do Itajai	19	5,409	195,818	36.20	5.66	4.26	44/56		
5 Nordeste do Estado de SC	5	2,760	403,347	146.14	2.89	8.76	92/08	Joinville	358,094
6 Planalto Norte	4	5,191	95,908	18.47	5.44	2.08	45/55		
7 Alto Rio do Peixe	11	8,468	203,802	24.06	8.87	4.43	59/41		
8 Meio Oeste Catarinense	14	7,241	161,860	22.32	7.58	3.51	44/56		
9 Oeste de Santa Catarina	19	6,117	388,306	63.47	6.41	8.44	36/64	Chapeco	119,716
10 Extremo Oeste de SC	13	4,272	241,290	56.48	4.47	5.24	28/72		
11 Serrana	13	16,204	291,684	18.00	16.97	6.34	62/38	Lages	159,775
12 Vale do Rio Tubarao	11	2,751	170,490	61.97	2.88	3.71	60/40		
13 Sul do Estado de SC	8	2,128	261,724	122.99	2.23	5.69	71/29	Criciuma	134,116
14 Alto Uruguai Catarinense	12	3,167	146,928	46.39	3.32	3.19	26/74		
15 Extremo Sul de SC	10	2,936	136,544	46.50	3.07	2.97	41/59		
16 Vales Tijucas e Itajai Mirim	8	2,073	115,407	55.67	2.17	2.51	67/33		
17 Alto Irani	9	4,810	141,033	29.32	5.04	3.06	35/65		
18 Vale Canoinhas	5	4,260	128,071	30.06	4.46	2.78	55/45		
19 Vale Itapocu	6	2,226	125,073	56.18	2.33	2.72	57/43		
20 Laguna	6	1,672	124,088	74.21	1.75	2.70	54/46		
21 Rio Itajai do Sul	7	2,477	55,652	22.46	2.59	1.21	21/79		
22 Alto Rio Negro	3	1,505	91,507	60.80	1.58	1.99	80/20		

Sources : IBGE, SEPLAN/SC (SE-01 and SE-14)

Table III.3.2 POPULATION BY SEX, URBAN/RURAL RESIDENT AND LABOR FORCE IN BRASIL AND SANTA CATARINA

Item	Number of Persons			Percentage Distribution (%)			Average Annual Growth Rate (%)		
	1960	1970	1980	1960	1970	1980	'60 - 70	'70 - 80	'60 - 80
BRASIL									
1. Population	70,191,370	93,139,037	119,002,706	100.0	100.0	100.0	2.87	2.48	2.67
2. Male	35,059,546	46,331,343	59,123,361	49.9	49.7	49.7	2.83	2.47	2.65
3. Female	35,131,824	46,807,694	59,879,345	50.1	50.3	50.3	2.91	2.59	2.70
4. Urban	31,303,034	52,084,984	80,436,409	44.6	55.9	67.6	-	4.44	-
5. Rural	38,767,423	41,054,053	38,566,297	55.2	44.1	32.4	-	-0.62	-
6. 10 Year & over	48,740,564	65,683,745	87,677,224	69.4	70.5	73.6	3.03	2.93	2.98
7. Labor Force	-	29,557,224	43,235,712	-	31.7	36.3	-	3.88	-
8. Labor Participation Rate (%)	-	45.0	49.3	-	-	-	-	-	-
9. Gainful Workers	22,750,028	29,060,714	42,271,156	32.4	31.7	36.3	2.65	3.88	3.26
10. Employment Rate (%)	-	98.3	97.8	-	-	-	-	-	-
11. Unemployment	-	496,510	964,186	-	0.5	0.8		6.86	-
12. Unemployment Rate (%)	-	1.7	2.2	-	-	-	-	-	-
SANTA CATARINA									
1. Population	2,118,116	2,901,734	3,327,933	100.0	100.0	100.0	3.20	2.26	2.73
2. Male	1,074,254	1,462,702	1,830,199	50.7	50.4	50.4	3.13	2.27	2.70
3. Female	1,043,862	1,439,032	1,797,734	49.3	49.6	49.6	3.26	2.25	2.76
4. Urban	673,981	1,246,043	2,154,238	31.8	42.9	59.4	6.34	5.63	5.98
5. Rural	1,444,135	1,655,691	1,473,695	68.2	57.1	40.6	1.38	-1.15	0.10
6. 10 Year & over	1,334,483	1,990,306	2,715,519	63.0	68.6	74.9	4.08	3.16	3.62
7. Labor Force	-	82,229	1,356,186	-	30.4	37.4	-	4.39	-
8. Labor Participation Rate (%)	-	44.3	49.9	-	-	-	-	-	-
9. Gainful Workers	641,195	867,529	1,330,802	30.3	23.9	37.4	3.24	4.39	3.82
10. Employment Rate (%)	-	98.3	98.1	-	-	-	-	-	-
11. Unemployment	-	14,700	25,384	-	0.5	0.7	-	5.61	-
12. Unemployment Rate (%)	-	1.7	1.9	-	-	-	-	-	-

Source : IBGE (SE-12)

Table III.3.3 NUMBER OF POPULATION 10 YEARS OLD AND OVER BY INDUSTRIAL GROUP IN SANTA CATARINA

Industrial Group	Number of Persons				Percentage Distribution (%)				Average Annual Growth Rate (%)			
	1970	1980	1985 *	1990 *	1970	1980	1985	1990	70 - 80	80 - 85	85 - 90	80 - 90
Agriculture	451,697	418,249	410,000	407,000	51.2	30.8	26.7	23.4	-0.77	-0.01	-0.00	-0.00
Industry	174,020	428,392	525,000	619,000	19.7	31.6	34.3	35.6	9.43	4.15	3.35	3.75
- Manufacturing	-	319,323	-	-	-	23.5	-	-	-	-	-	-
- Construction	-	80,799	-	-	-	6.0	-	-	-	-	-	-
- Others	-	28,270	-	-	-	2.1	-	-	-	-	-	-
Services	256,512	484,161	598,000	713,000	29.1	35.7	39.0	41.0	6.55	4.31	3.58	3.95
- Commerce	48,742	110,004	-	-	5.5	8.1	-	-	8.48	-	-	-
- Transportation & Comunication	31,286	50,377	-	-	3.5	3.7	-	-	4.88	-	-	-
- Other Services	176,484	323,780	-	-	20.0	23.9	-	-	6.26	-	-	-
Not specified	-	25,384	-	-	-	1.9	-	-	-	-	-	-
Total	882,229	1,356,186	1,533,000	1,739,000	100.0	100.0	100.0	100.0	4.39	2.48	2.55	2.52

* : Estimate

Sources : IBGE, SEPLAN/SC (SE-012 and SE-015)

Table.III.3.4 GDP/BRAZIL AND GRDP/SANTA CATARINA AT 1980 CONSTANT PRICE IN 1970 - 1988, WITH PER CAPITA AND GROWTH RATES

Year	GDP, Brazil at 1980 constant prices		GDP per capita, Brazil at 1980 constant prices		GRDP, Santa Catarina at 1980 constant prices		Contribution to GDP, Brazil	GRDP per capita, S.C. at 1980 constant prices		Difference from GDP per capita
	Amount	Growth rate	Amount	Growth rate	Amount	Growth rate		Amount	Growth rate	
	(Cr$ 10^6)	(% per annum)	(Cr$ 10^3)	(% per annum)	(Cr$ 10^6)	(% per annum)	(%)	(Cr$ 10^3)	(% per annum)	(Cr$ 10^3)
1970	5,419		56.53		131		2.4	45.05		- 11.48
1971	6,037	11.4	61.46	8.7	149	14.3	2.5	49.67	10.3	- 11.79
1972	6,758	11.9	67.16	9.3	168	12.4	2.5	55.32	11.4	- 11.84
1973	7,700	13.9	74.72	11.3	184	9.6	2.4	59.29	7.2	- 15.43
1974	8,336	8.3	79.00	5.7	210	14.3	2.5	66.27	11.8	- 12.73
1975	8,763	5.1	81.11	2.7	234	11.3	2.7	72.13	8.8	- 8.98
1976	9,654	10.2	87.29	7.6	267	13.9	2.8	80.33	11.4	- 6.96
1977	10,130	4.9	89.48	2.5	286	7.4	2.8	84.35	5.0	- 5.13
1978	10,629	4.9	91.74	2.5	307	7.2	2.9	88.41	4.8	- 3.33
1979	11,348	6.8	95.72	4.3	347	13.1	3.1	97.74	10.6	2.02
1980	12,400	9.3	102.24	6.8	400	15.4	3.2	110.29	12.8	8.05
1981	11,853	- 4.4	95.01	- 6.6	410	2.5	3.5	110.21	- 0.1	14.67
1982	11,929	0.6	94.01	- 1.6	438	6.9	3.7	115.43	4.7	21.42
1983	11,516	- 3.5	88.74	- 5.6	422	- 3.6	3.7	109.13	- 5.5	20.39
1984	12,104	5.1	91.24	2.8	439	3.9	3.6	111.32	2.0	20.08
1985	13,114	8.3	96.74	6.0	487	11.0	3.7	121.39	9.0	24.65
1986	14,109	7.6	101.87	5.3	533	9.3	3.8	130.47	7.5	28.60
1987	14,618	3.6	103.34	1.4	556	4.4	3.8	133.97	2.7	30.63
1988	14,578	- 0.3	100.93	- 2.3	550	- 1.1	3.8	130.48	- 2.6	29.55
70/80		8.6		6.1		11.8			9.4	
80/88		2.0		- 0.2		4.1			2.1	
70/88		5.7		3.3		8.3			6.1	

Soureces : IBGE, SEPLAN & SEPLAN/SC (SE-01, SE-02, SE-20 and SE-21)

Table III.3.5 GRDP, SANTA CATARINA IN 1983 - 1989 AT CURRENT PRICES BY INDUSTRIAL SECTOR

(Unit: Cz$ 10^6)

Year	1983		1984		1985		1986		1987		1988		1989	
	GRDP	Share (%)												
Primary industry	665	14.46	2,215	14.92	8,588	16.00	21,197	14.91	81,028	16.81	640,058	17.11	9,535,304	17.26
Secondary industry	1,598	35.84	5,310	35.76	20,322	37.86	55,460	39.01	196,472	40.76	1,473,518	39.39	21,904,682	39.65
Tertiary industry	2,216	49.70	7,323	49.32	24,766	46.14	65,512	46.08	204,522	42.43	1,627,267	43.50	23,805,114	43.09
Total GRDP at Market Price	4,458	100.00	14,849	100.00	53,675	100.00	142,170	100.00	482,021	100.00	3,740,843	100.00	55,245,101	100.00

Sources : SEPLAN/SC (SE-07, SE-20 and SE-21)

Table III.3.6 GROWTH & DISTRIBUTION OF GROSS REGIONAL DOMESTIC PRODUCT, SANTA CATARINA IN 1987 - 1989 AT 1980 CONSTANT PRICES BY INDUSTRIAL SECTOR

Sectors	Annual growth rate of sectoral GRDP, S.C. (previous year = 100)			Annual average (%)	Sectoral distribution of GRDP, S.C. (%)		
(Year)	1987	1988	1989	1986/1989	1987	1988	1989
Primary industry	114.95	100.58	104.89	6.64	16.81	17.11	17.26
Agriculture	119.12	95.15	110.32	7.73	6.82	6.59	8.43
Forestry	102.82	107.97	106.39	5.70	0.75	0.82	1.06
Cattle	113.91	102.54	98.43	4.76	8.90	9.27	7.09
Fishery	84.35	127.24	101.02	2.73	0.33	0.43	0.68
Secondary industry	106.55	95.52	104.69	2.14	40.76	39.39	39.65
Mining	88.63	117.46	76.14	-7.45	1.20	1.43	1.05
Manufacturing	106.96	93.81	105.39	1.88	35.33	33.61	34.15
Construction	107.91	100.74	106.05	4.86	3.61	3.69	3.77
Public util	109.81	105.69	106.16	7.20	0.62	0.67	0.67
Tertiary industry	98.10	101.33	103.05	0.81	42.43	43.50	43.09
Commerce	84.00	85.30	103.66	-9.44	9.57	8.33	8.30
Finance	104.32	100.02	101.34	1.88	8.94	9.13	8.89
Transport/Communication	112.85	106.61	103.98	7.75	7.61	8.23	8.23
Government	100.97	101.92	101.49	1.46	3.51	3.65	3.57
Real estate	109.01	105.68	105.95	6.87	2.77	2.99	3.05
Others	90.87	109.12	102.96	0.69	10.02	11.16	11.04
Total:	104.38	98.91	104.01	2.40	100.00	100.00	100.00

Sources : SEPLAN/SC (SE-07, SE-20 and SE-21)