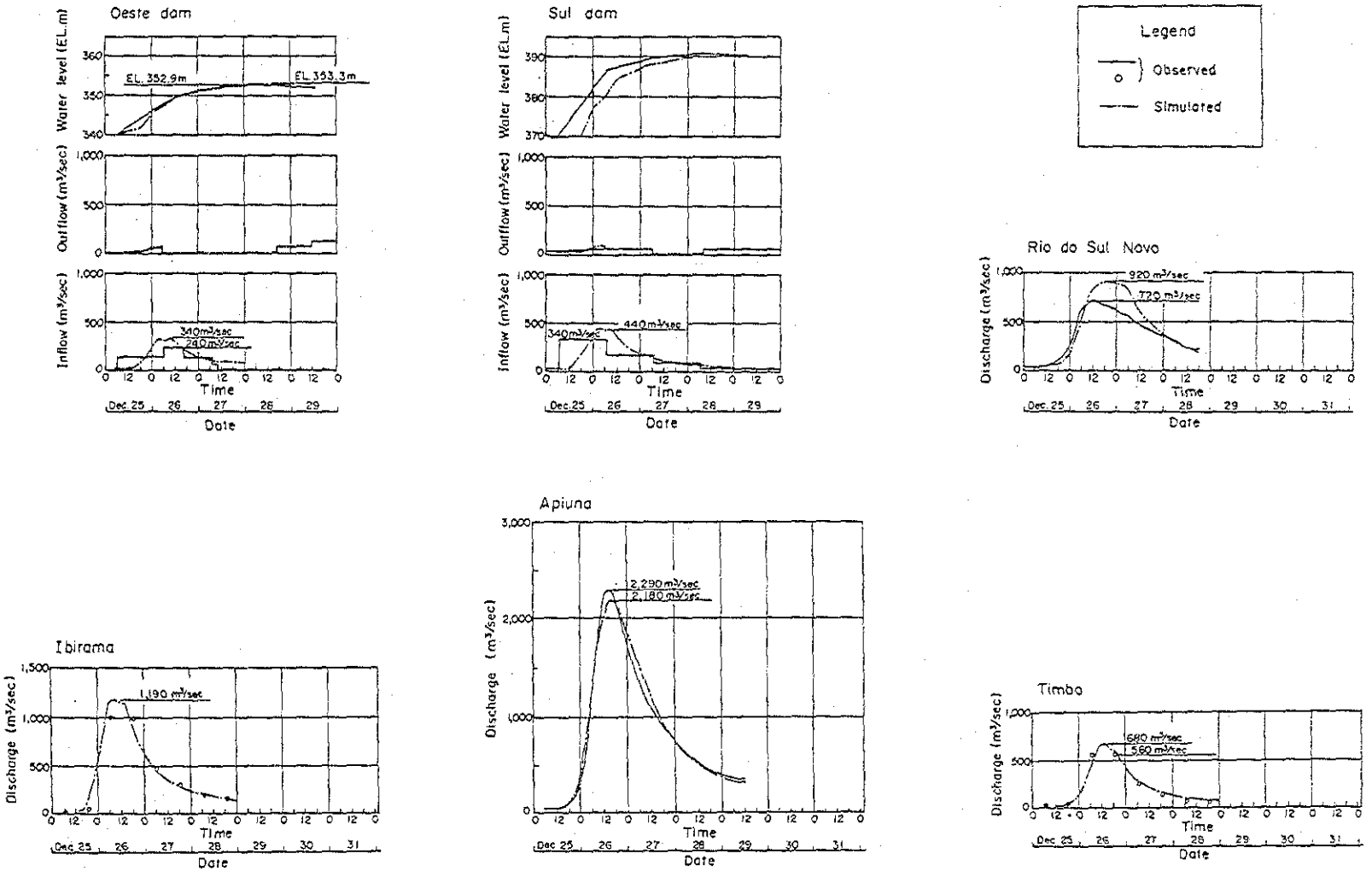


Fig.II.4.12 OBSERVED AND SIMULATED FLOOD HYDROGRAPH (1/8) DEC. 1978

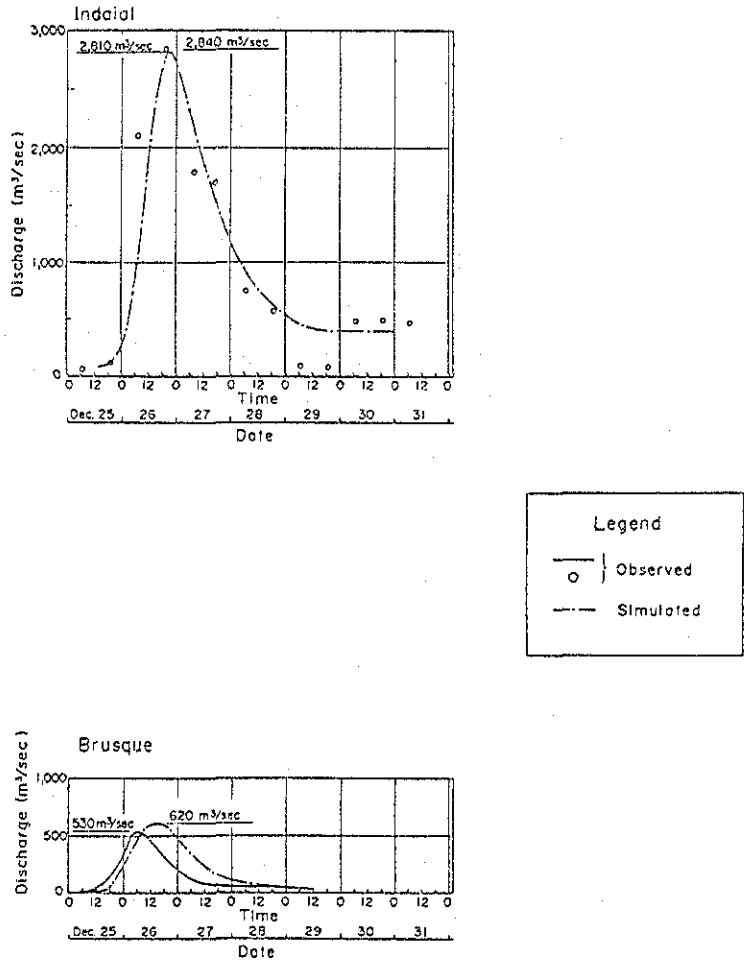


Fig.II.4.12 OBSERVED AND SIMULATED FLOOD HYDROGRAPH (2/8)
DEC. 1978

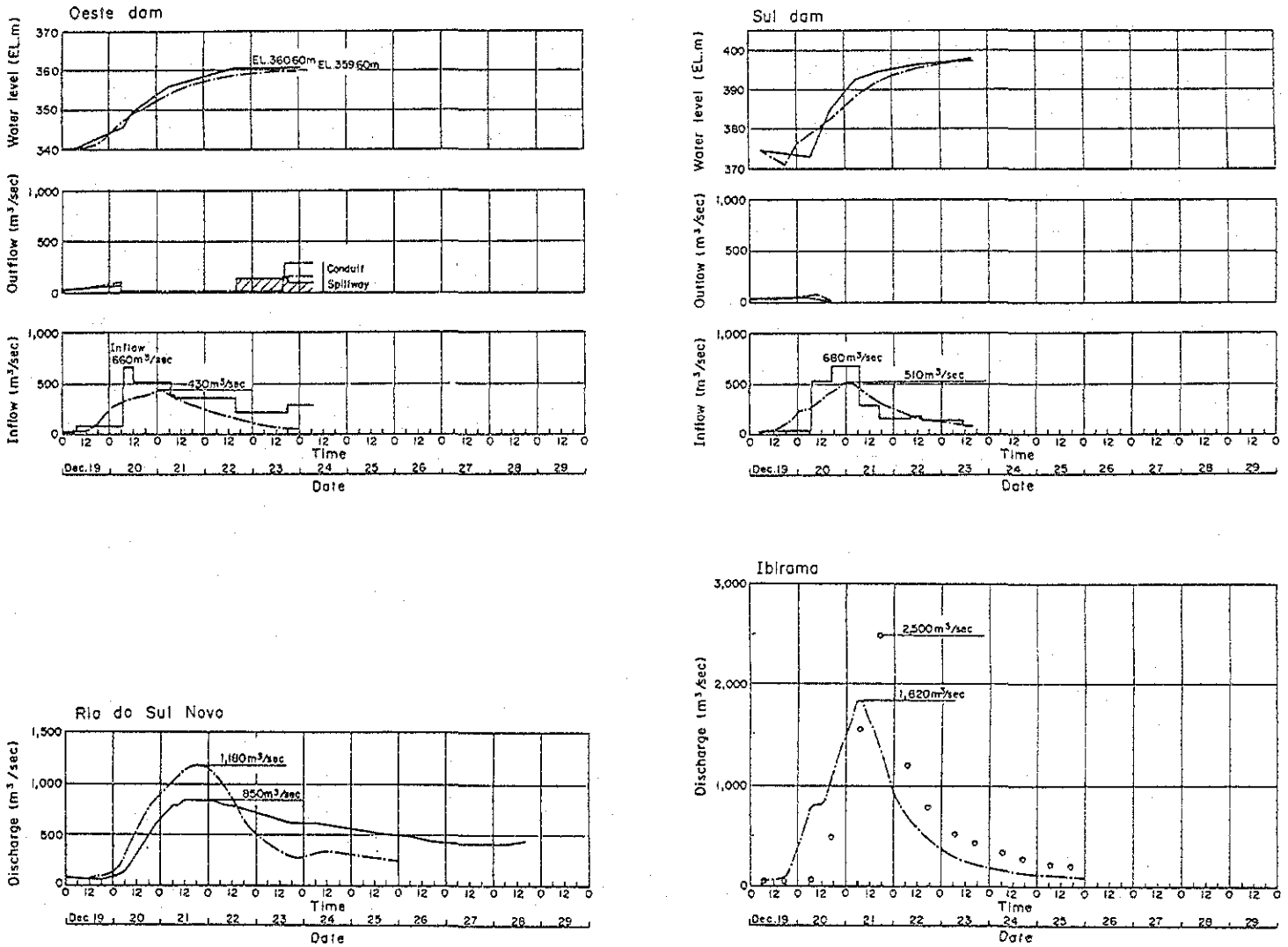


Fig.II.4.12 OBSERVED AND SIMULATED FLOOD HYDROGRAPH (3/8) DEC. 1980

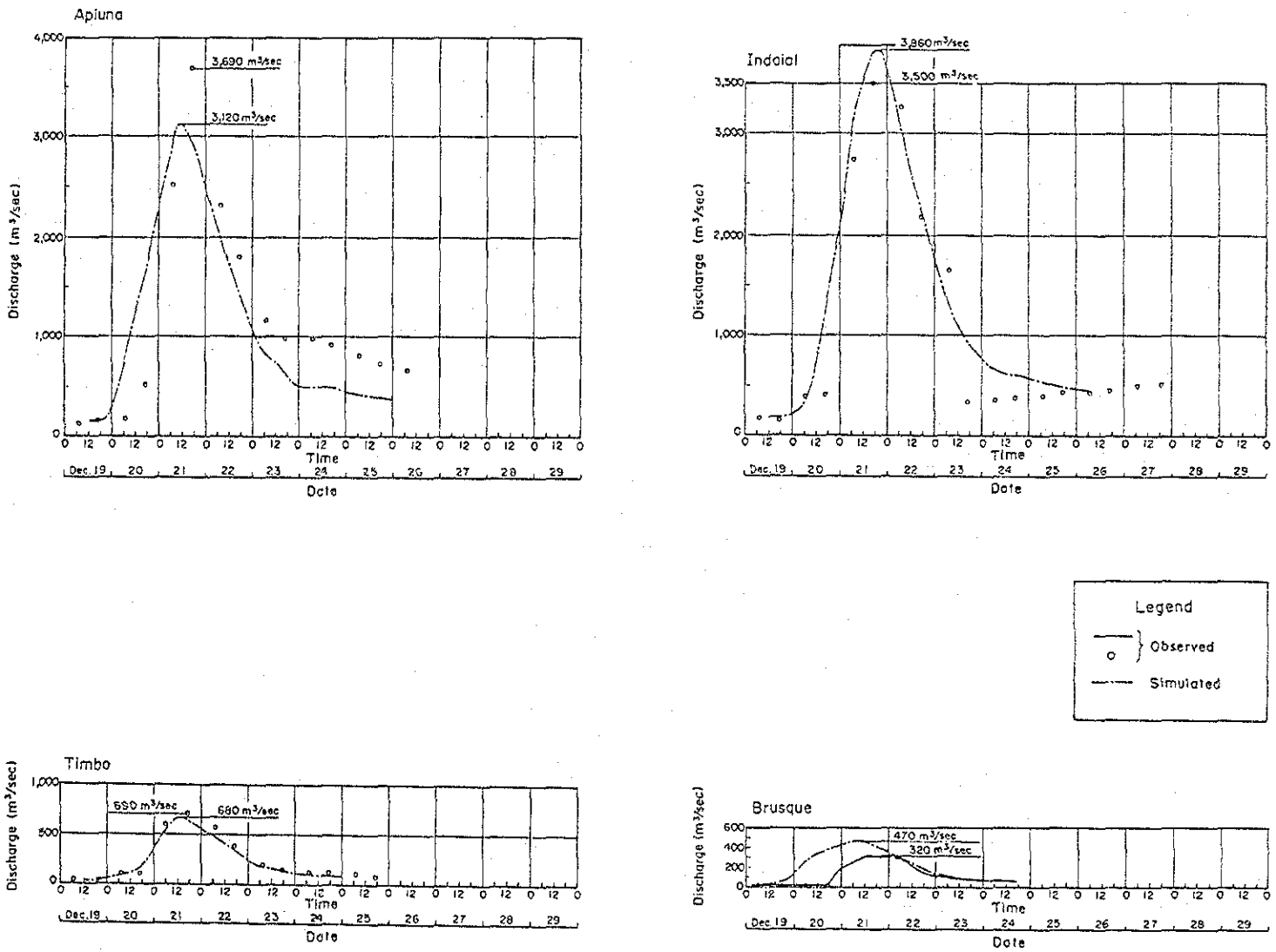
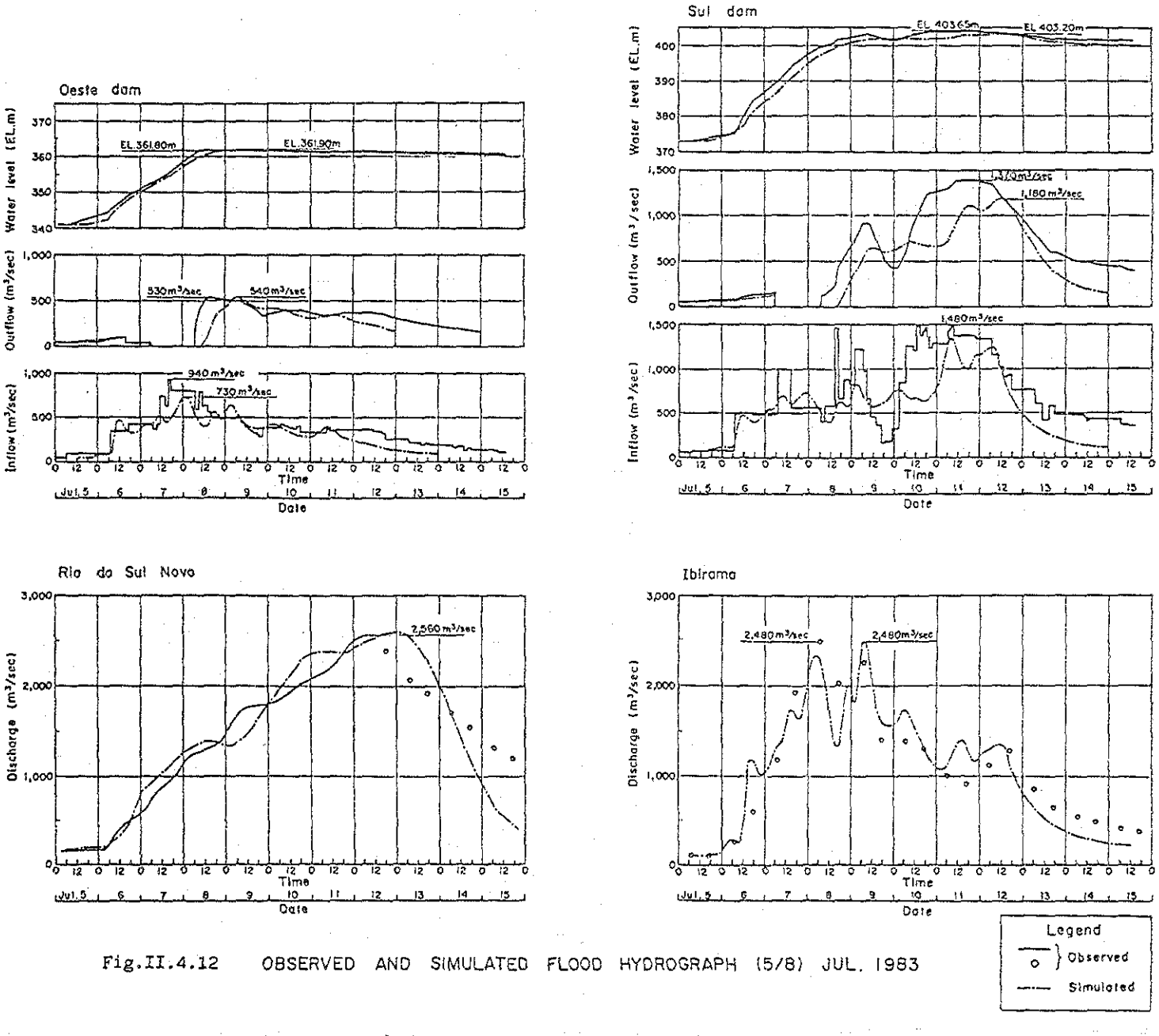


Fig.II.4.12 OBSERVED AND SIMULATED FLOOD HYDROGRAPH (4/8) DEC. 1980



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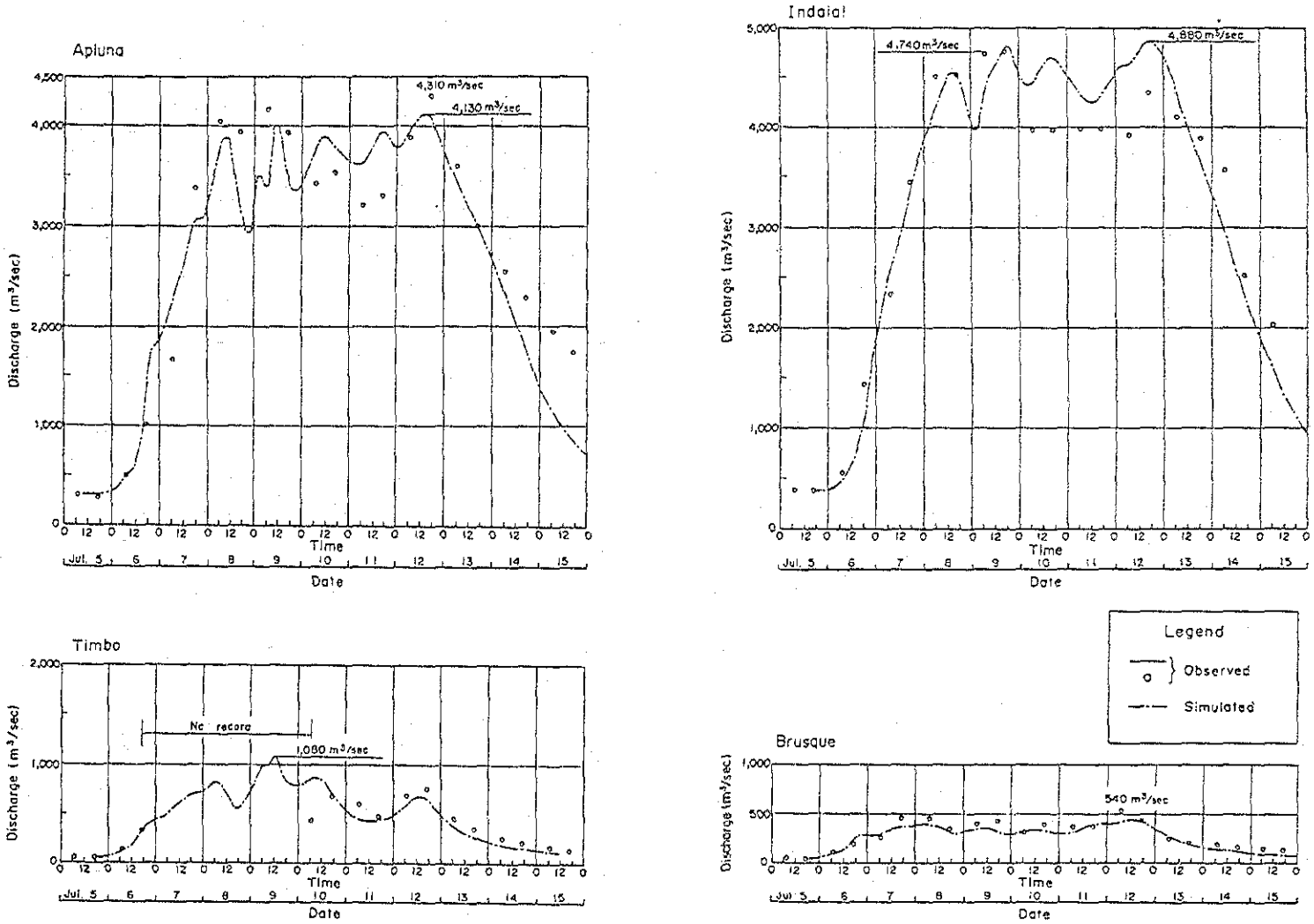


Fig.II.4.12 OBSERVED AND SIMULATED FLOOD HYDROGRAPH (6/8) JUL. 1983

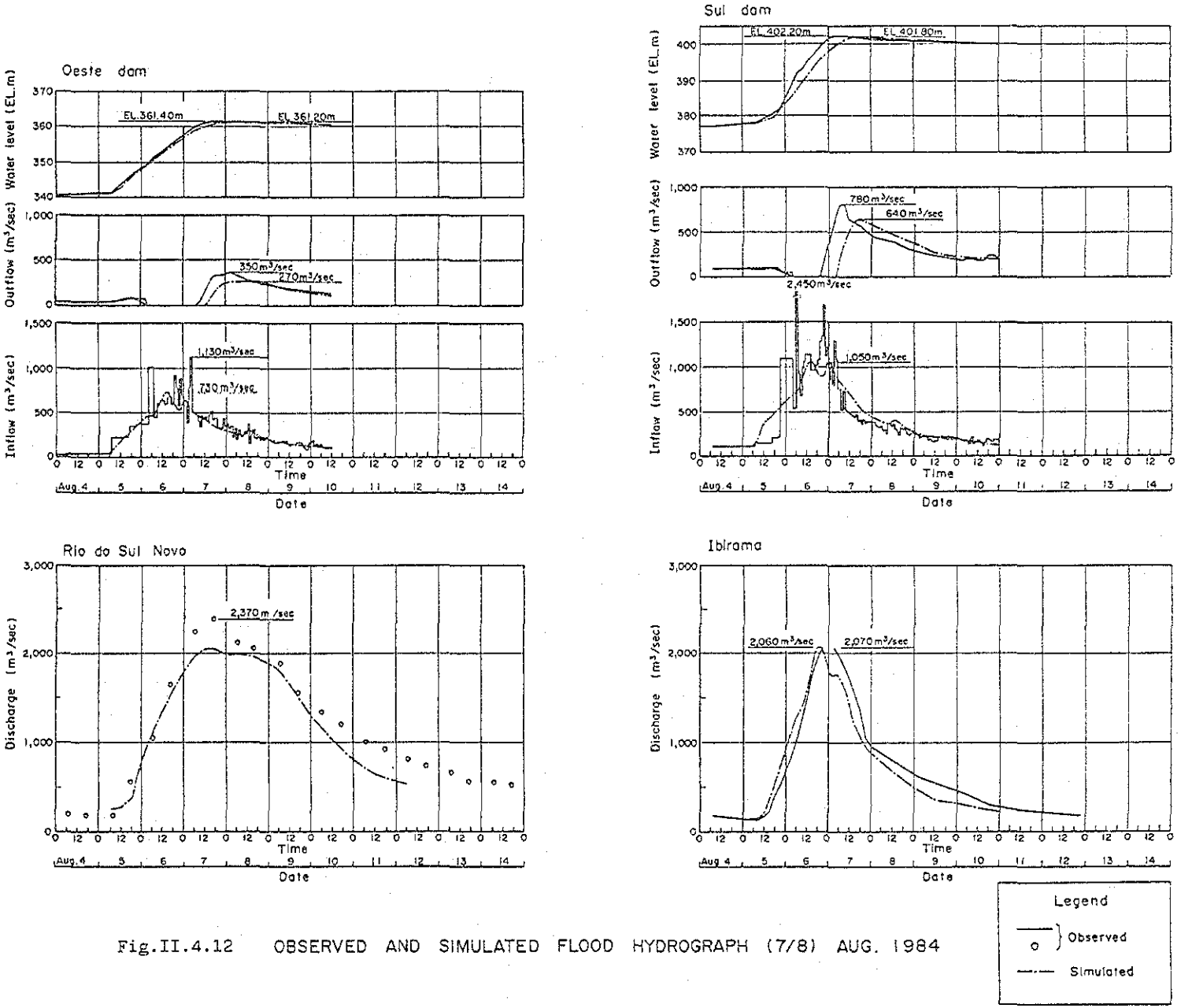


Fig.II.4.12 OBSERVED AND SIMULATED FLOOD HYDROGRAPH (7/8) AUG. 1984

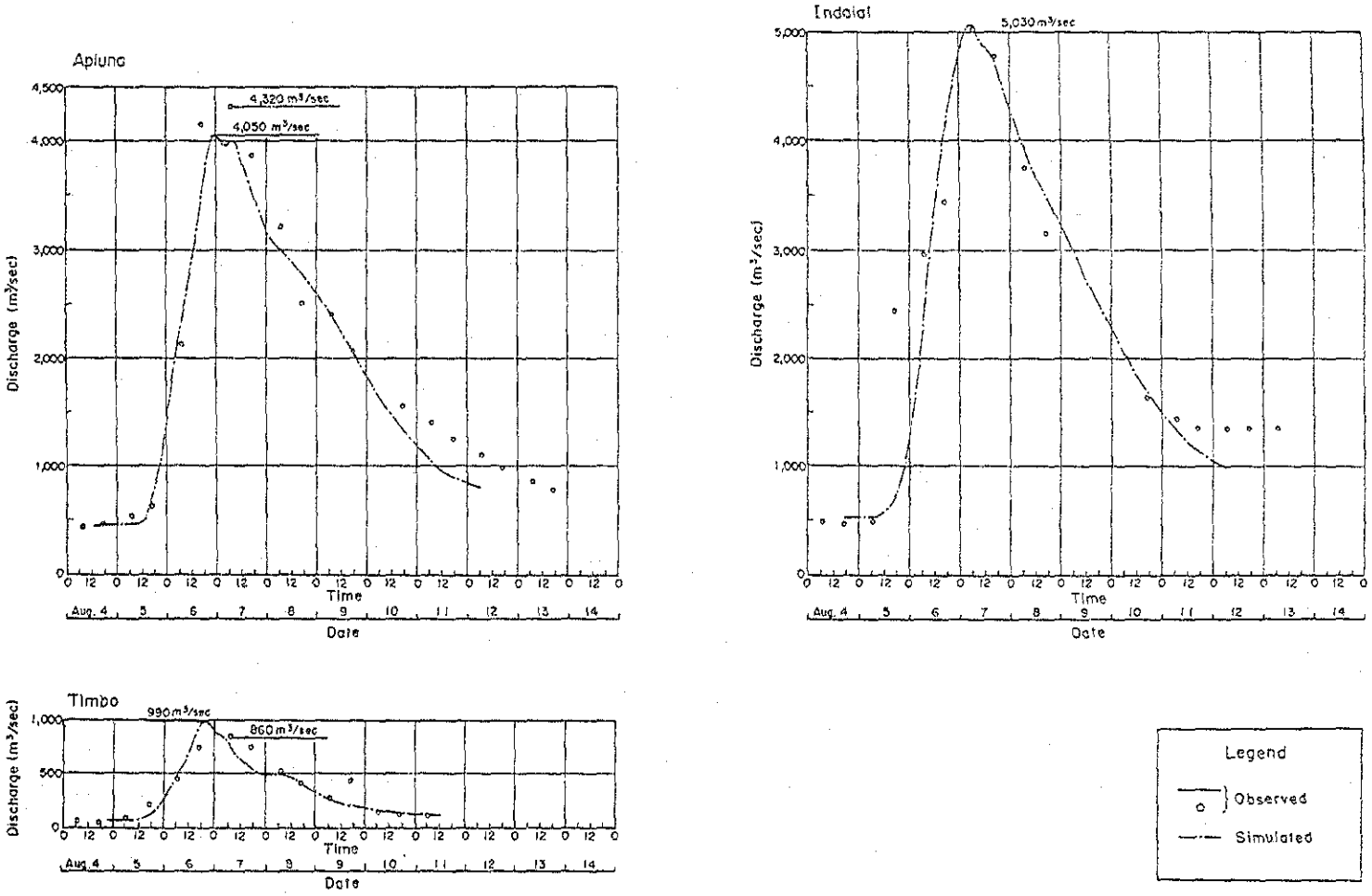
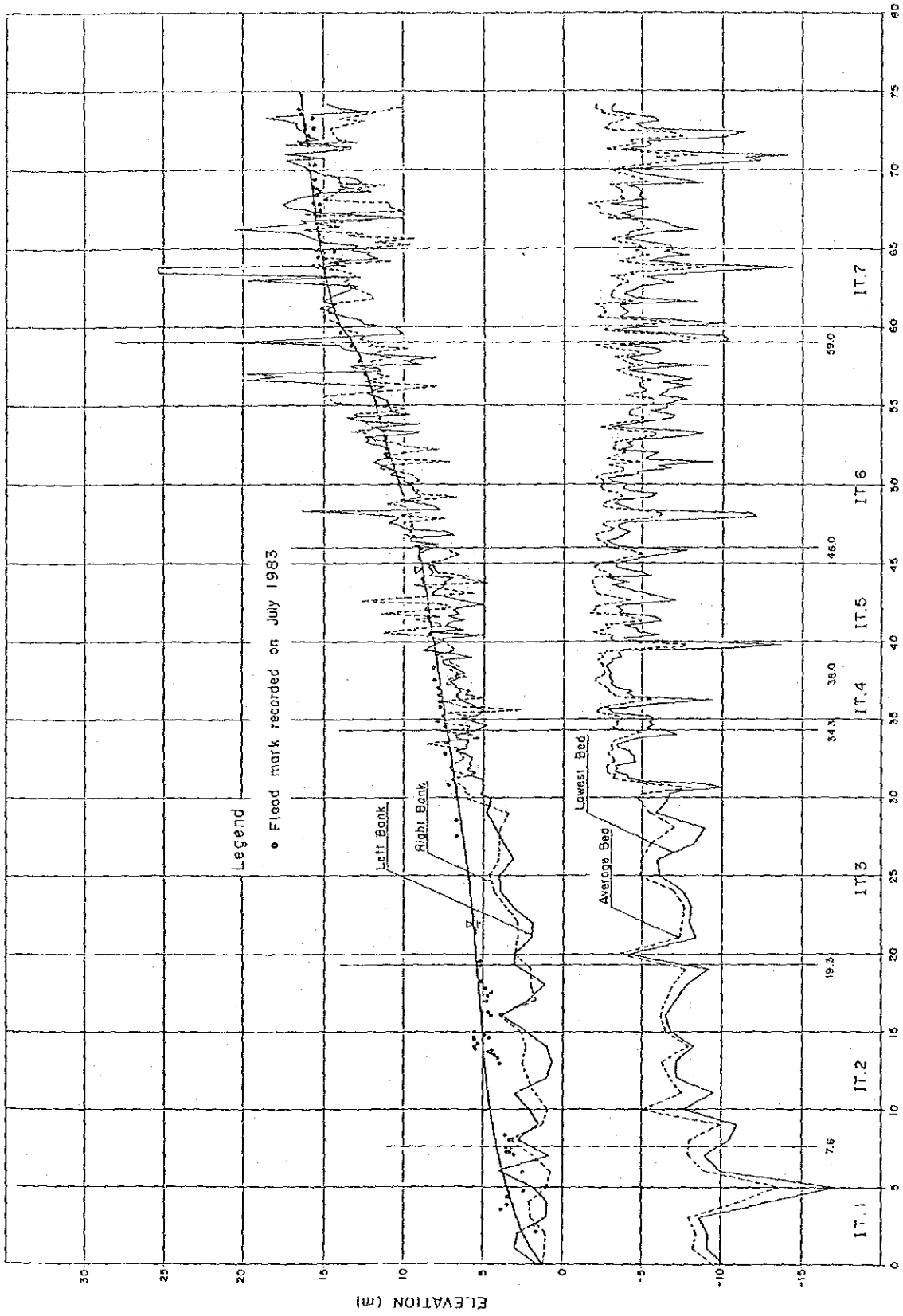


Fig.II.4.12 OBSERVED AND SIMULATED FLOOD HYDROGRAPH (8/8) AUG. 1984



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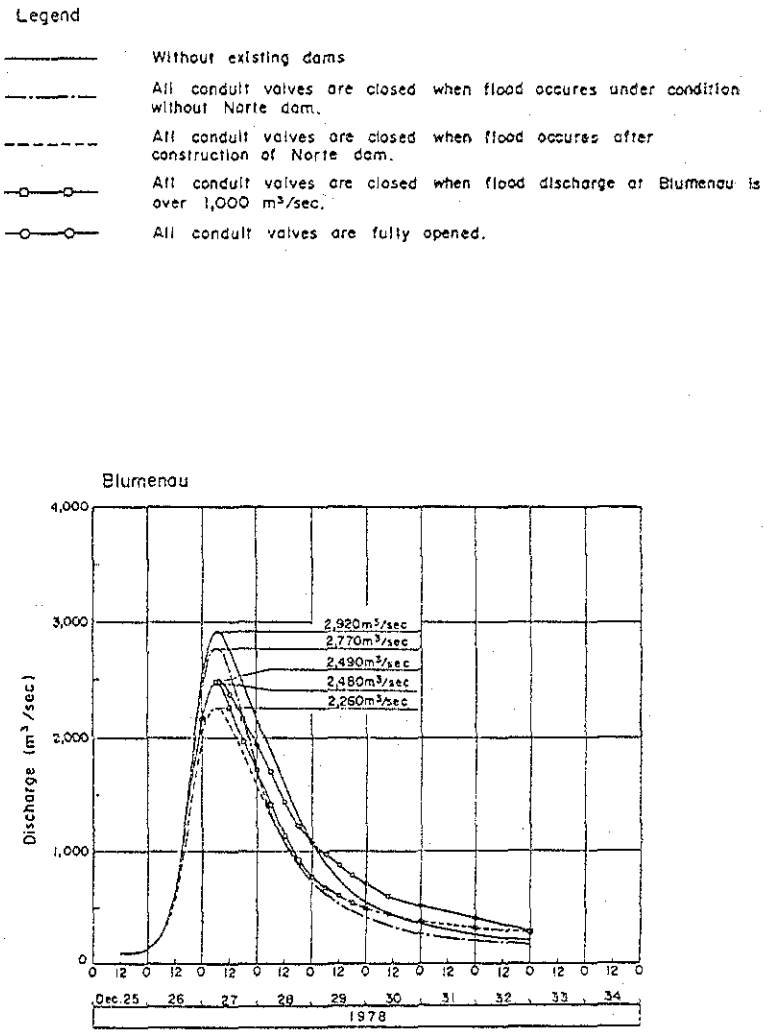


Fig.II.4.14(1/8) RESULTS OF RESERVOIR OPERATION STUDY (FLOOD HYDROGRAPHS ON 1978 FLOOD)

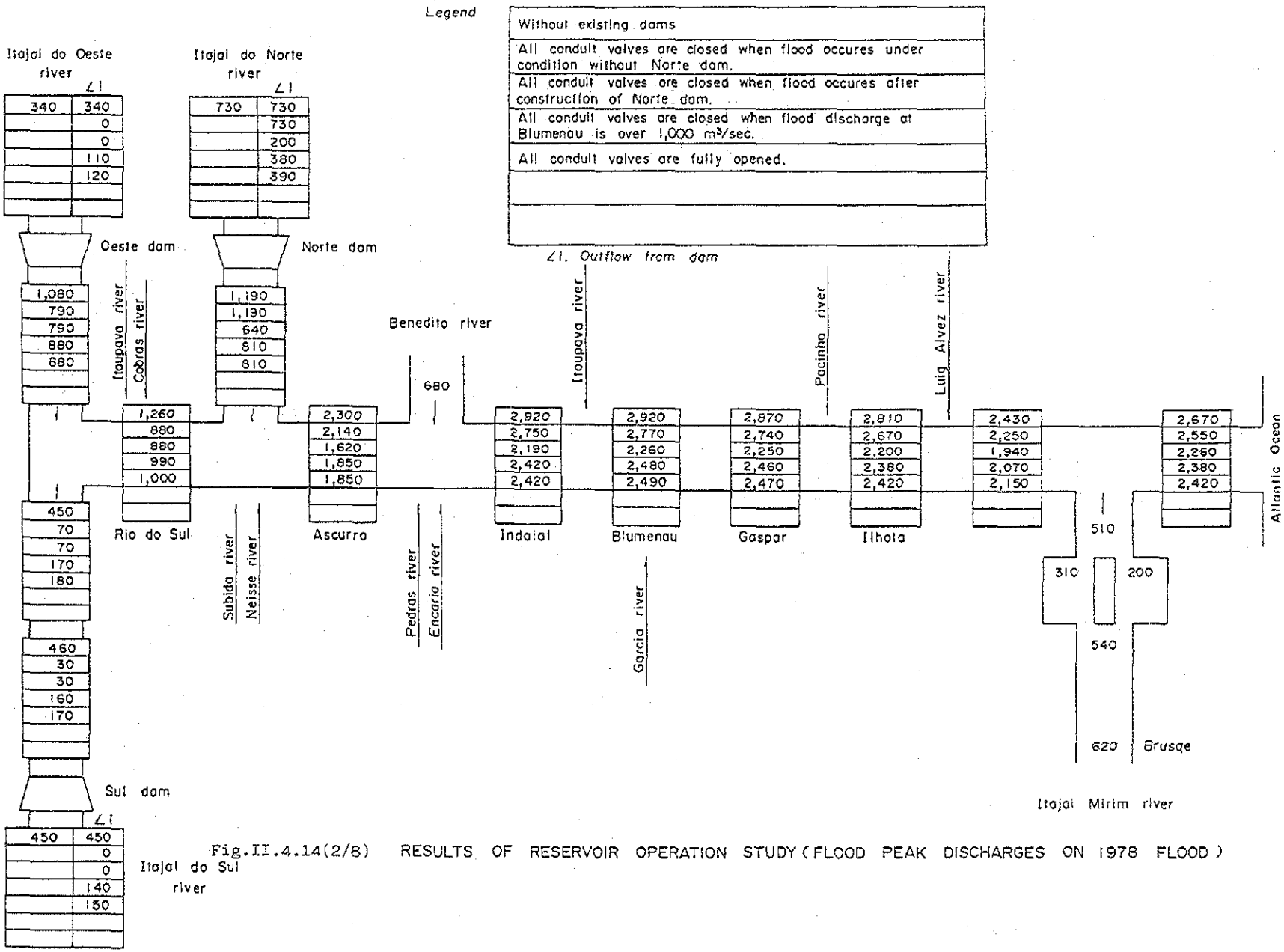
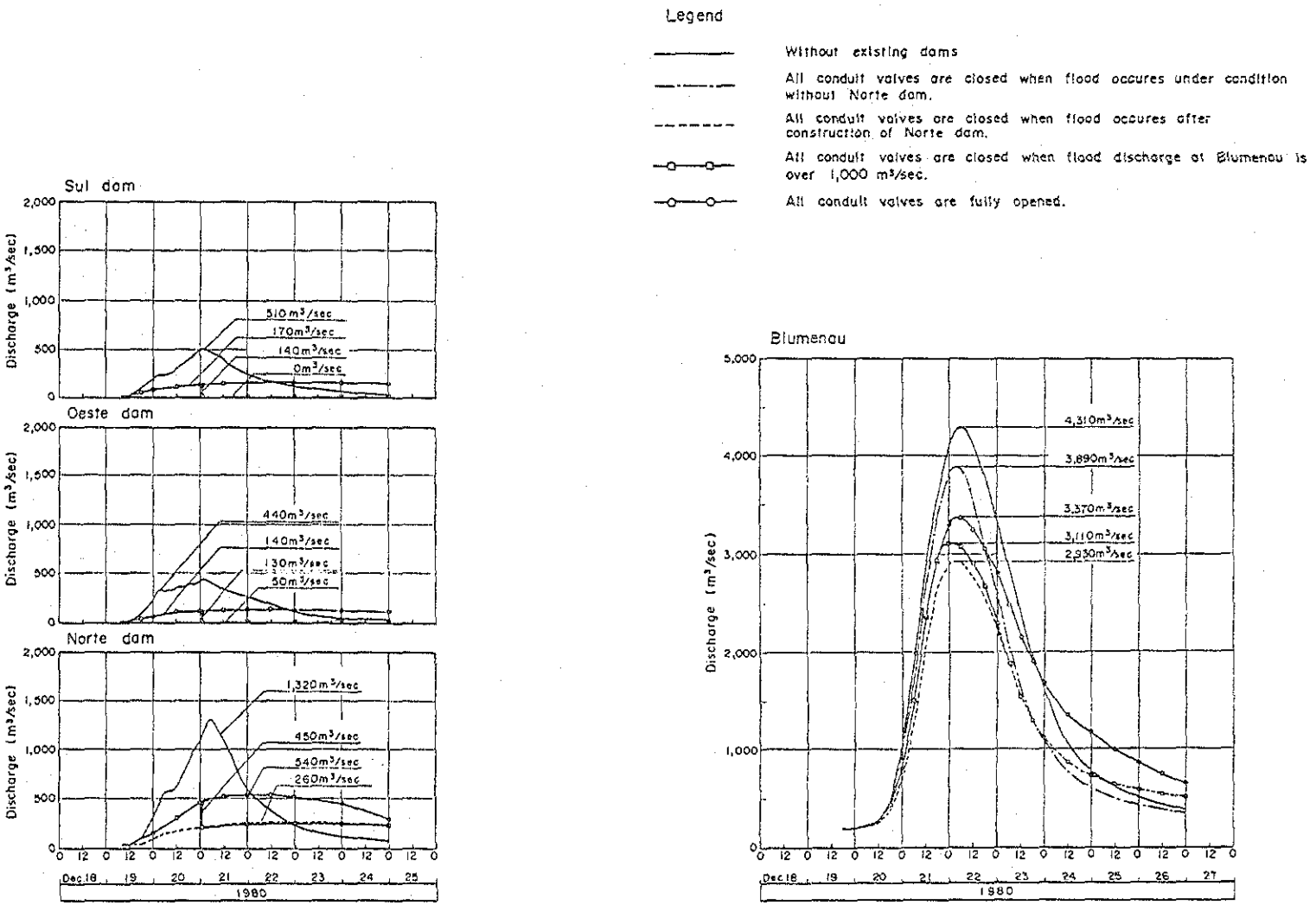


Fig.II.4.14(2/8) RESULTS OF RESERVOIR OPERATION STUDY (FLOOD PEAK DISCHARGES ON 1978 FLOOD)



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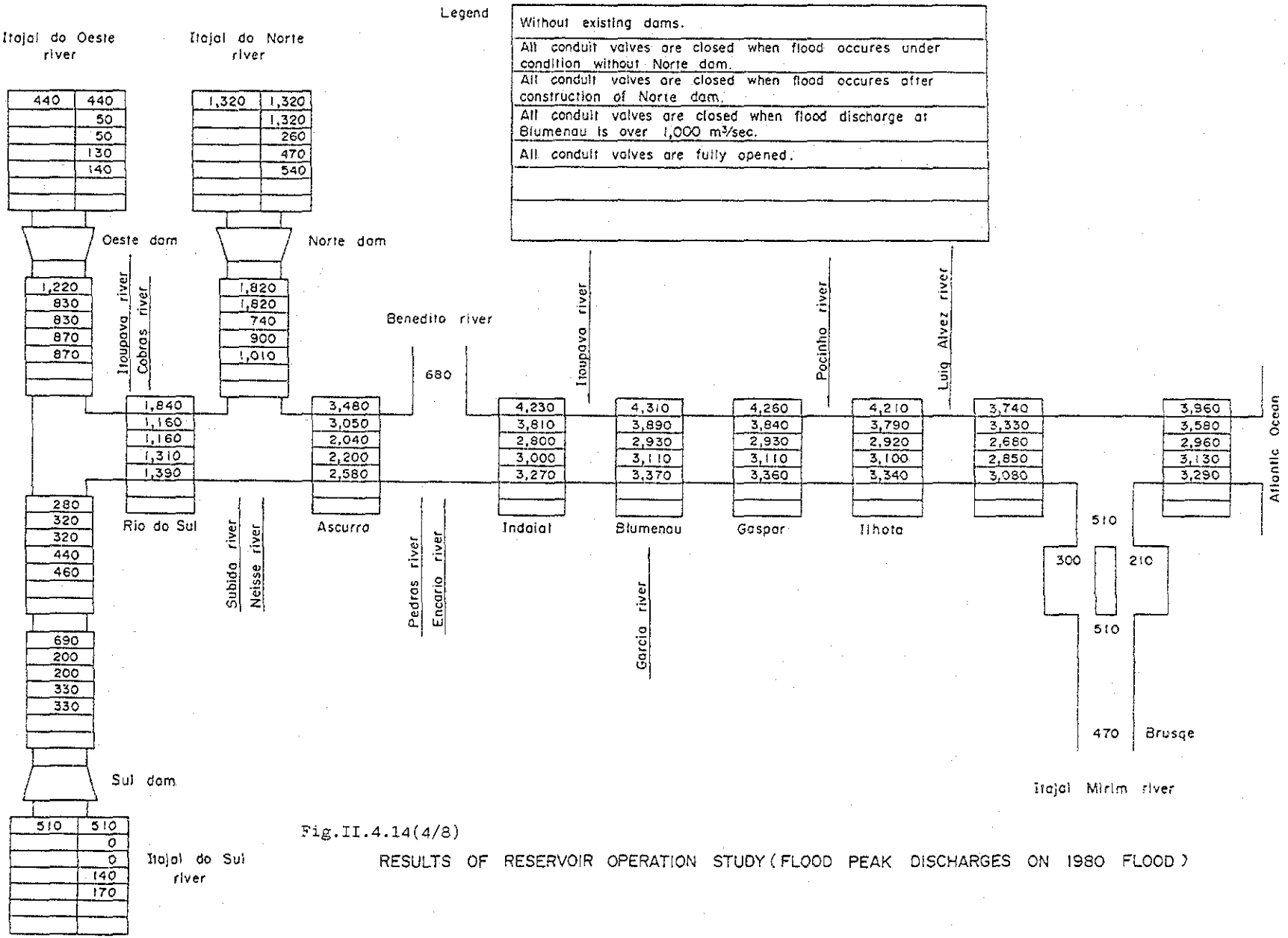

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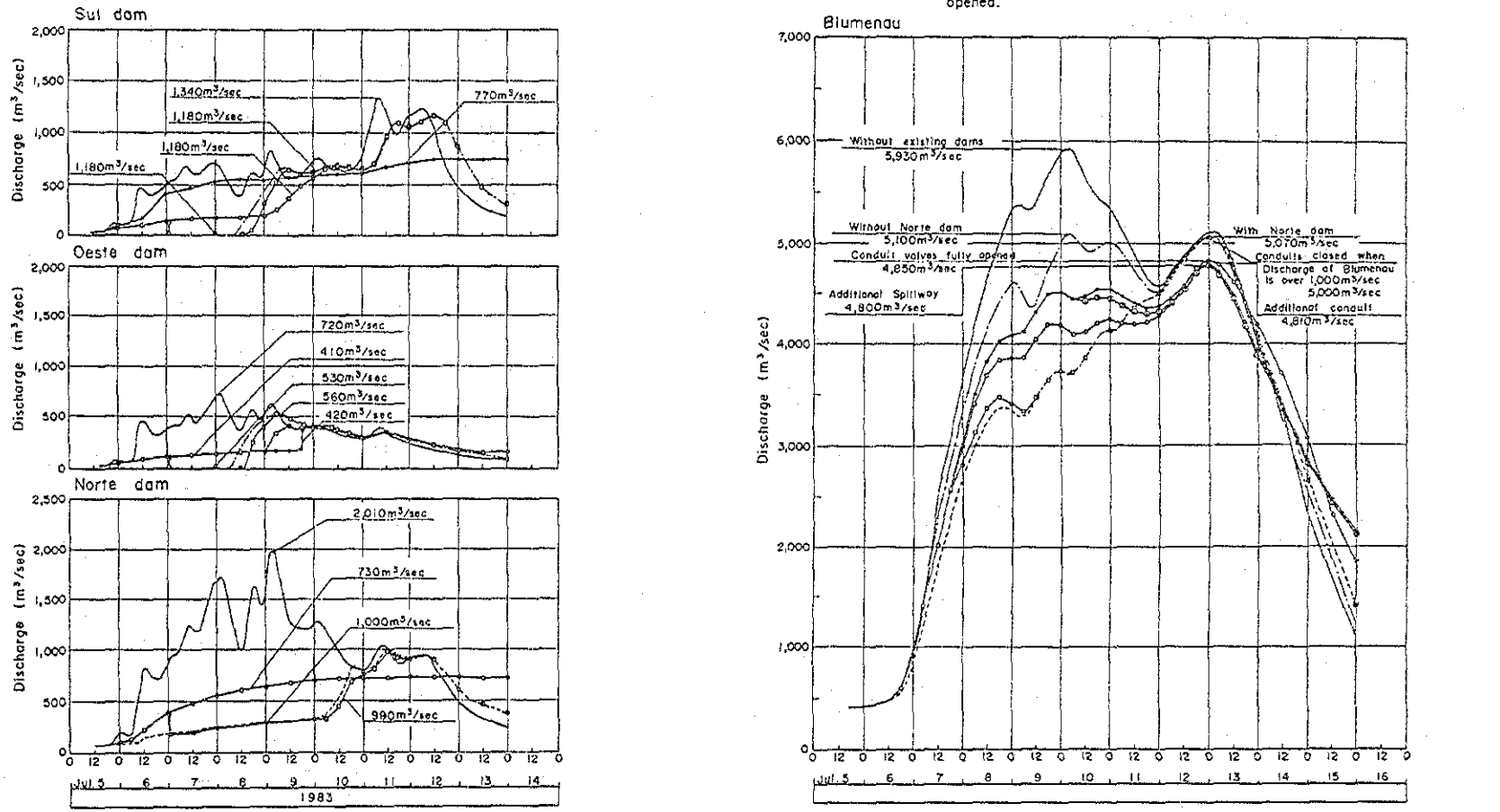

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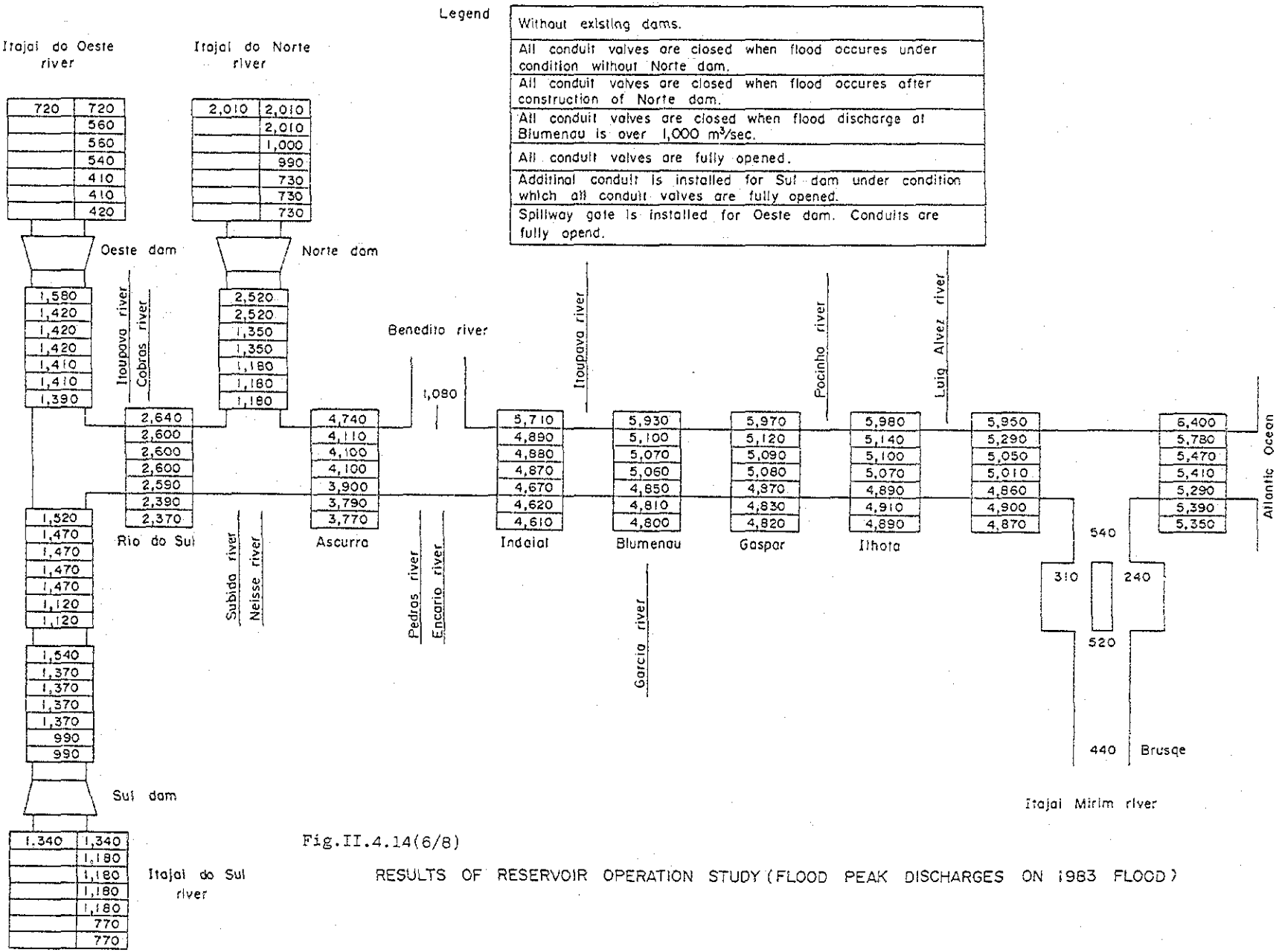

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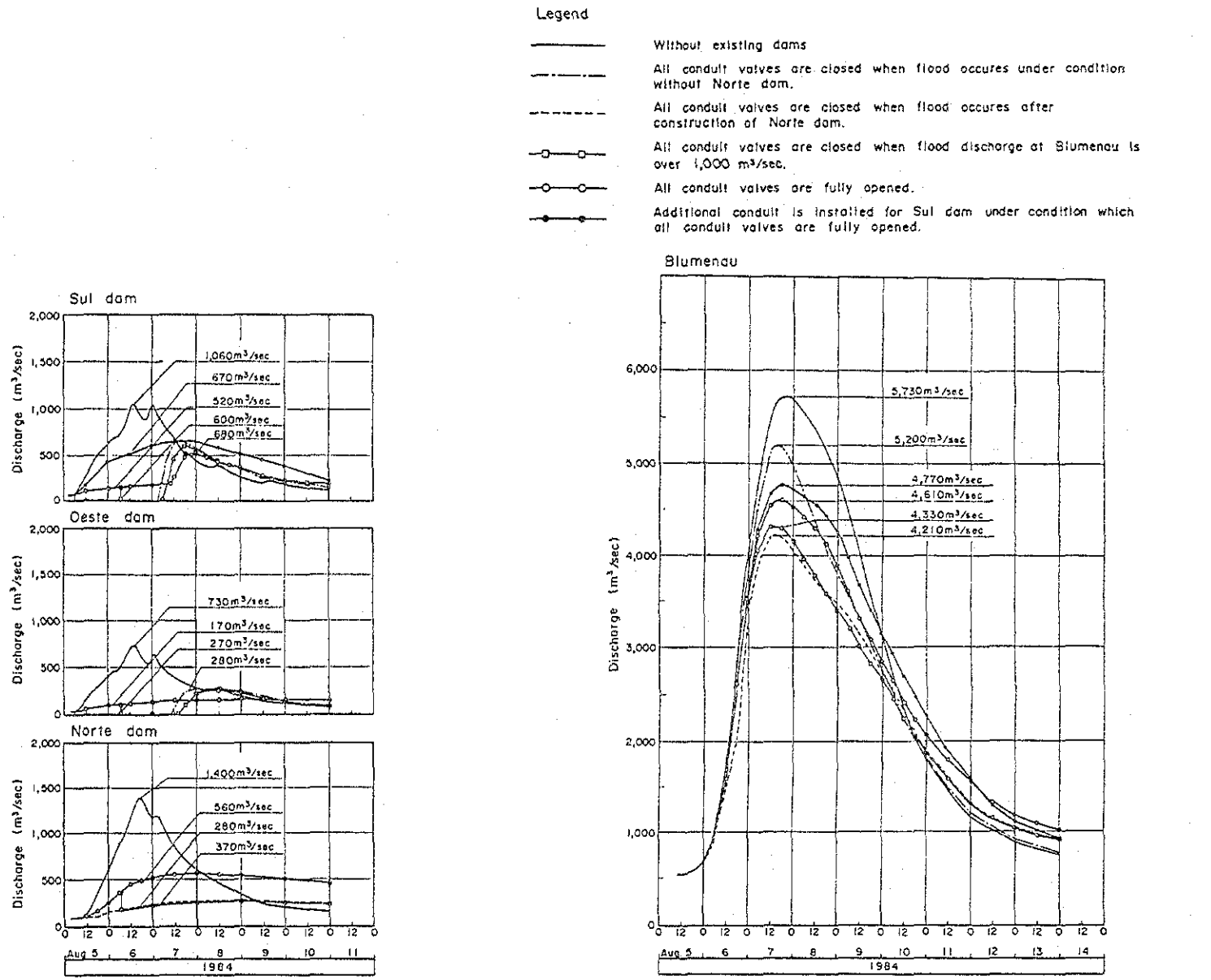
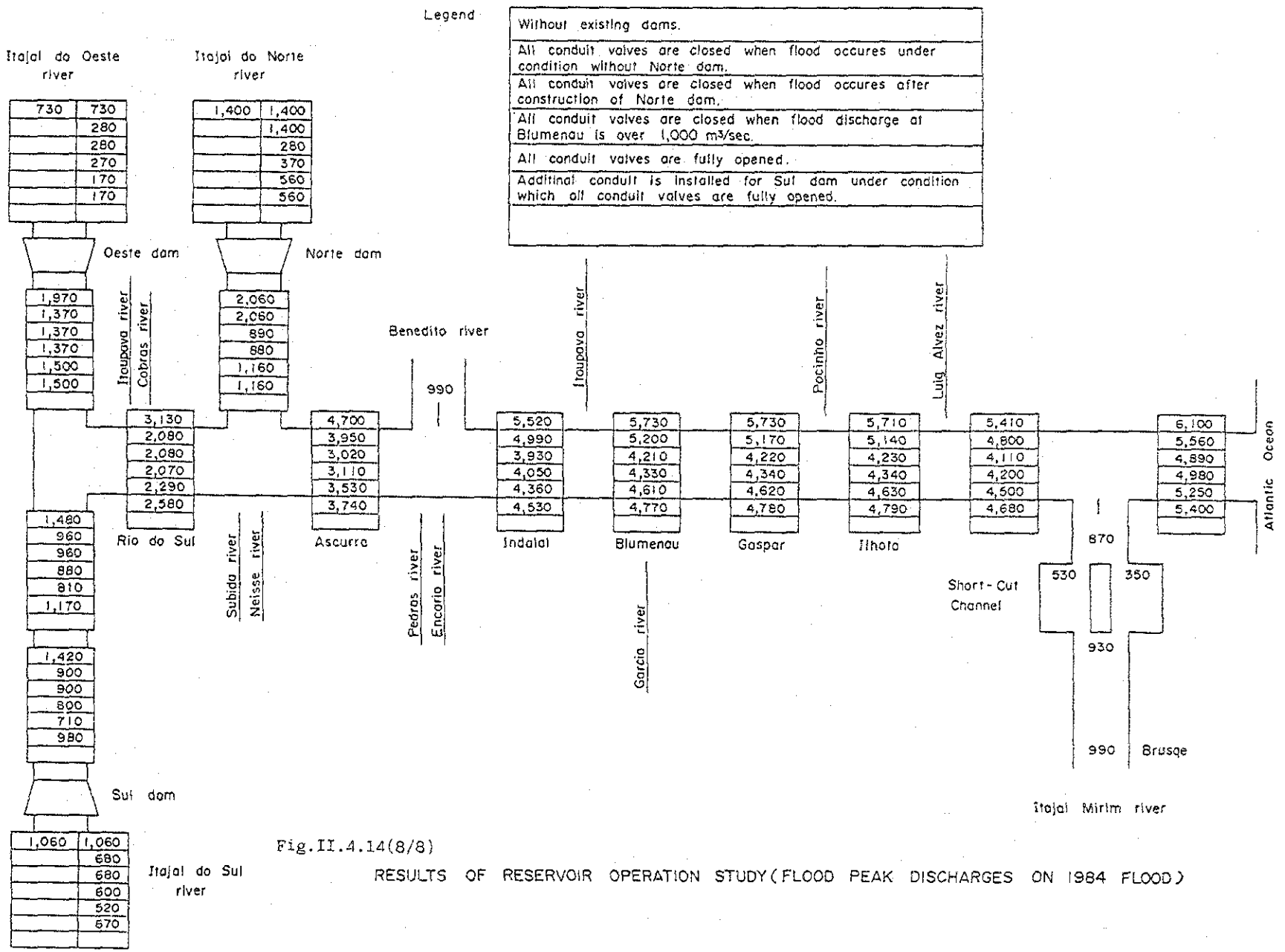


Fig.II.4.14(7/8) RESULTS OF RESERVOIR OPERATION STUDY (FLOOD HYDROGRAPHS ON 1984 FLOOD)



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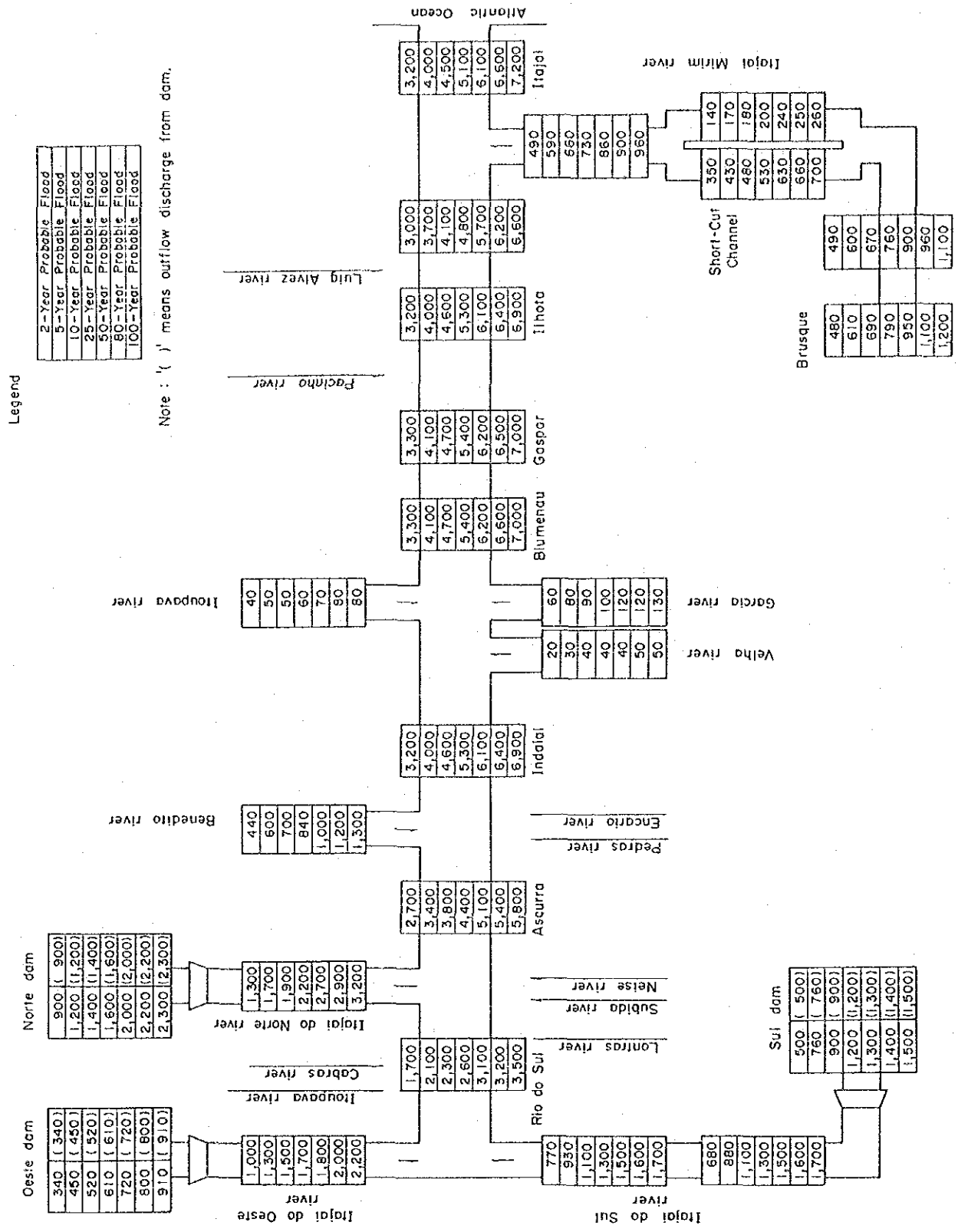
RESULTS OF RESERVOIR OPERATION STUDY(FLOOD PEAK DISCHARGES ON 1984 FLOOD)



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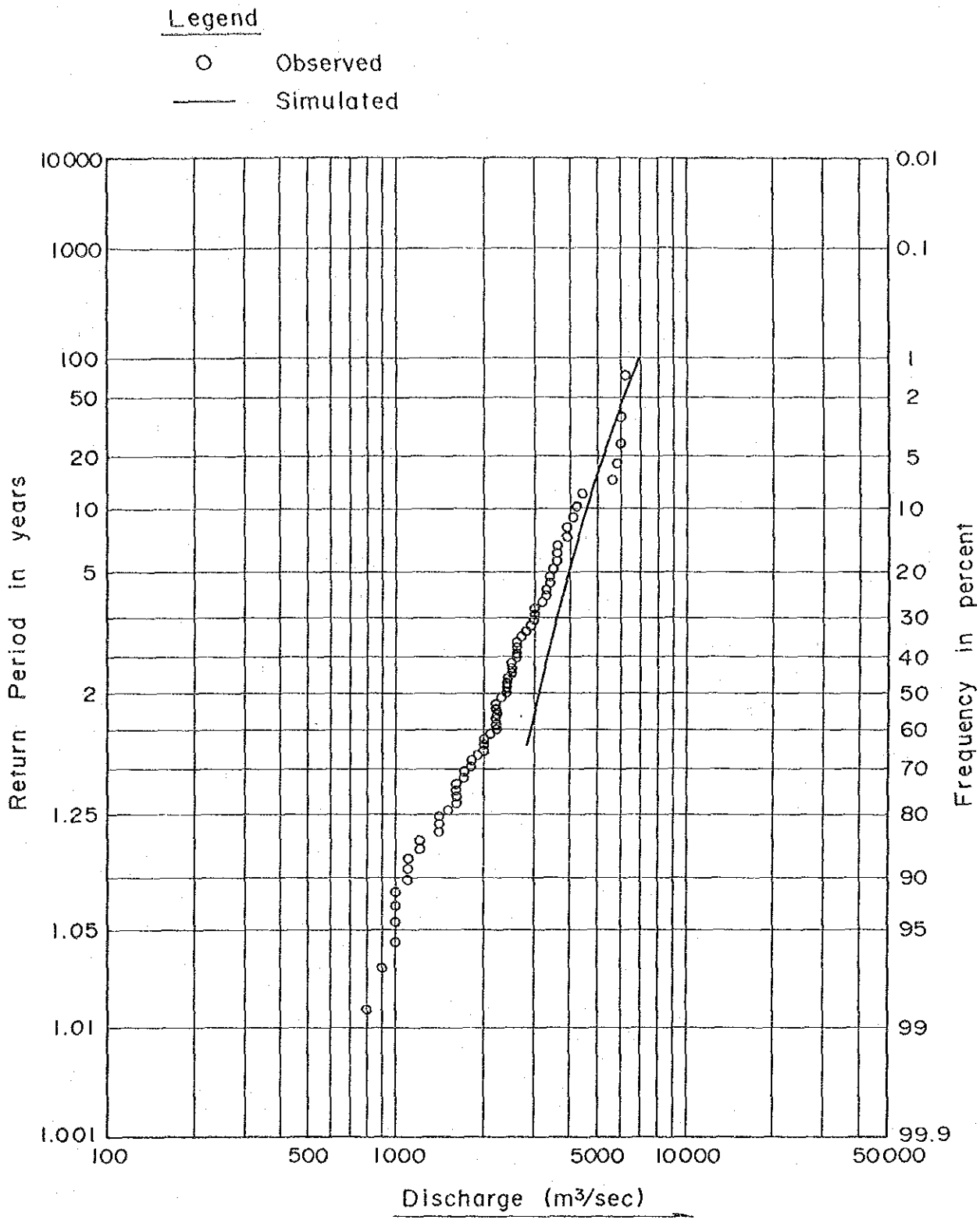

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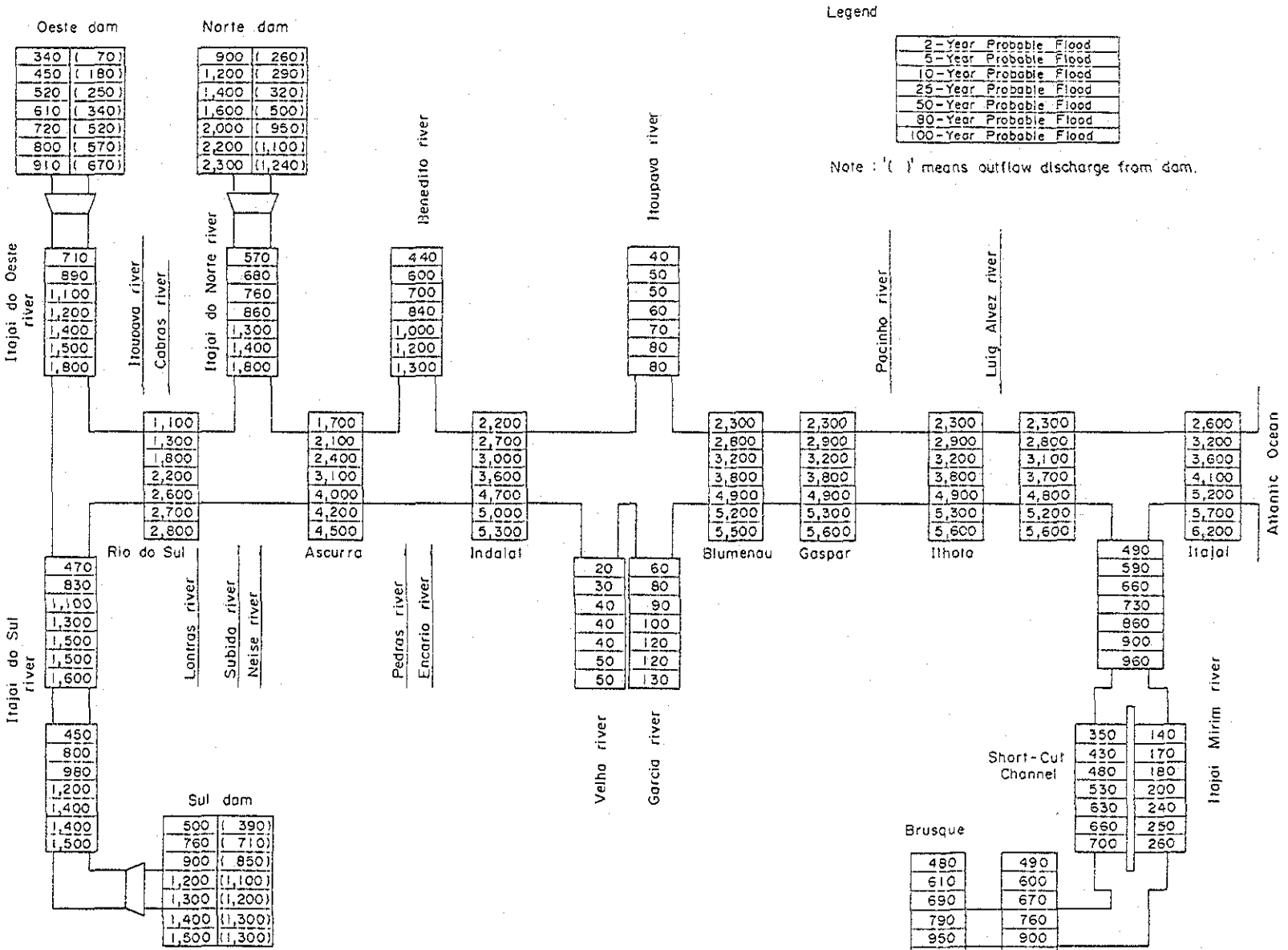

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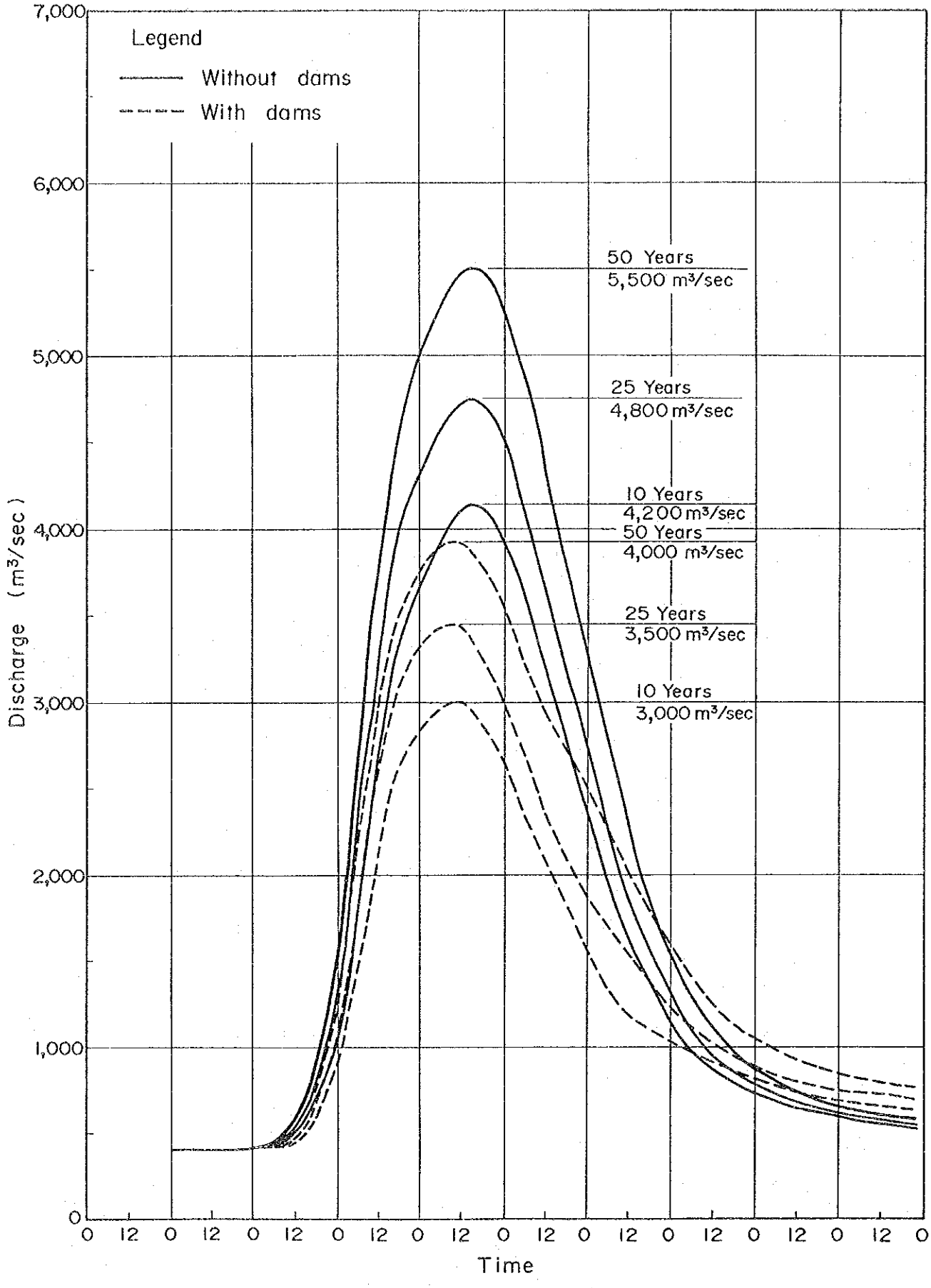
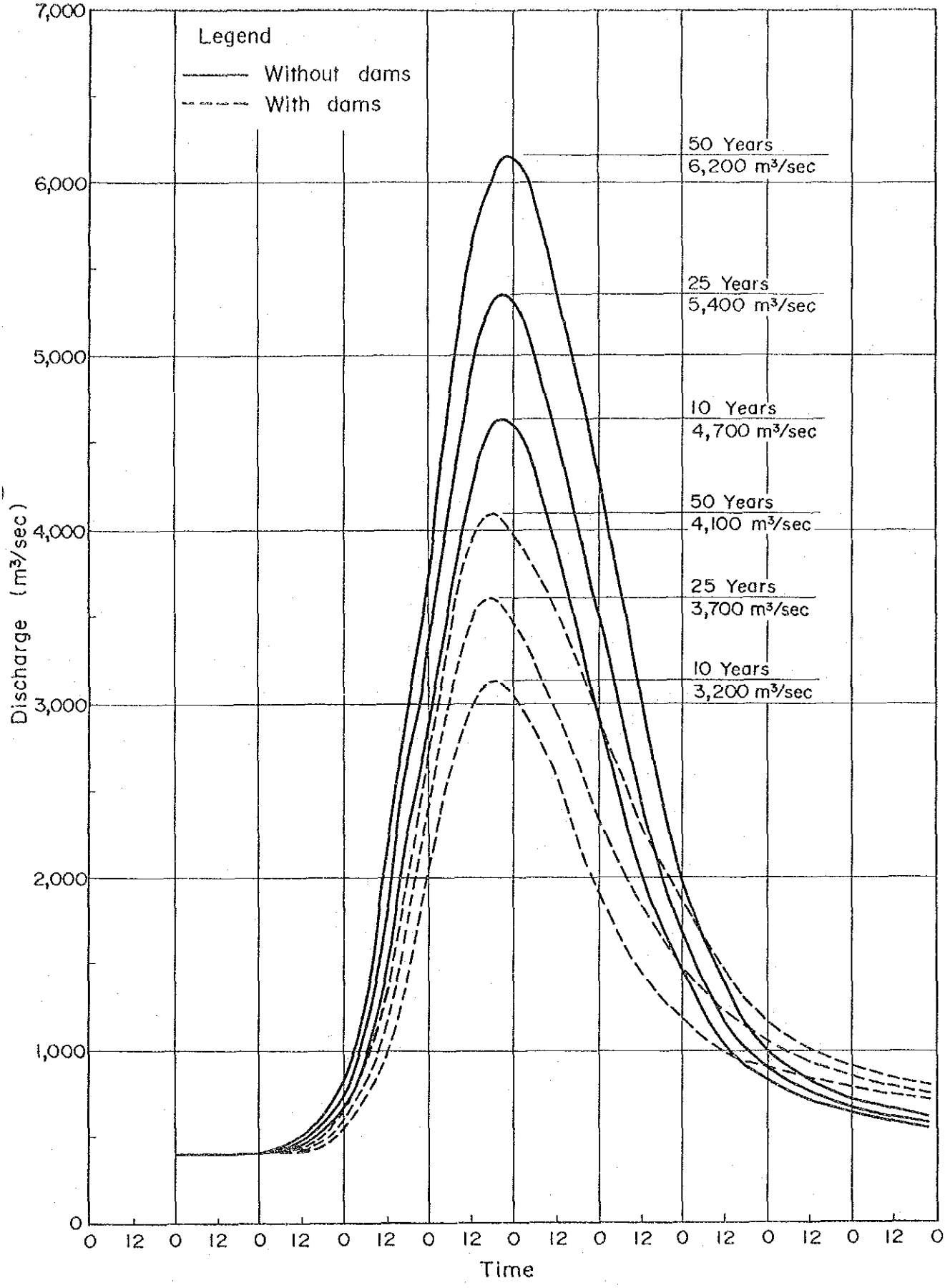


Fig.II.4.18 PROBABLE FLOOD HYDROGRAPHS AT BLUMENAU WITH/WITHOUT EXISTING FLOOD CONTROL DAMS (1/4) BASED ON 1978 RAINFALL PATTERN



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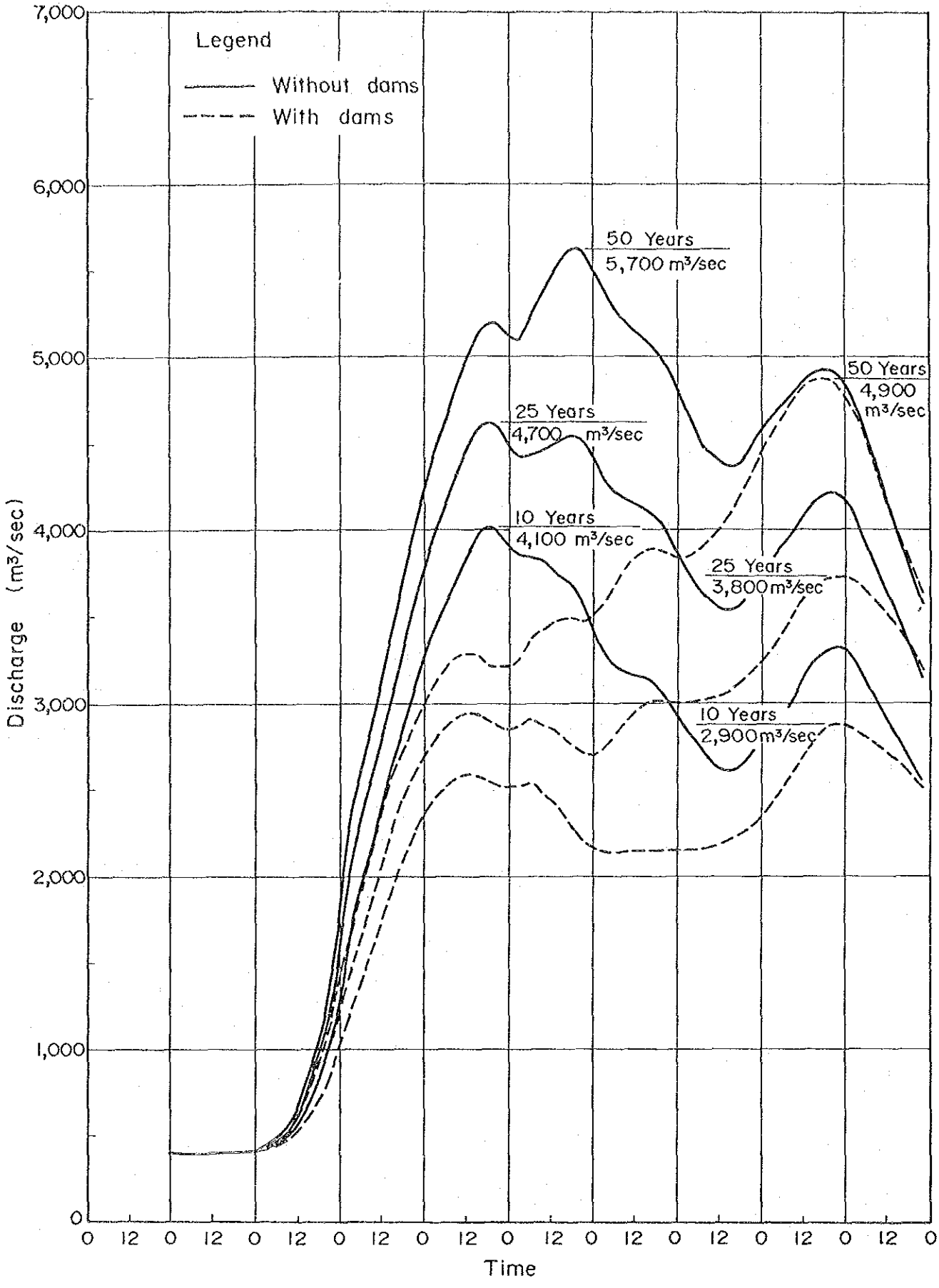

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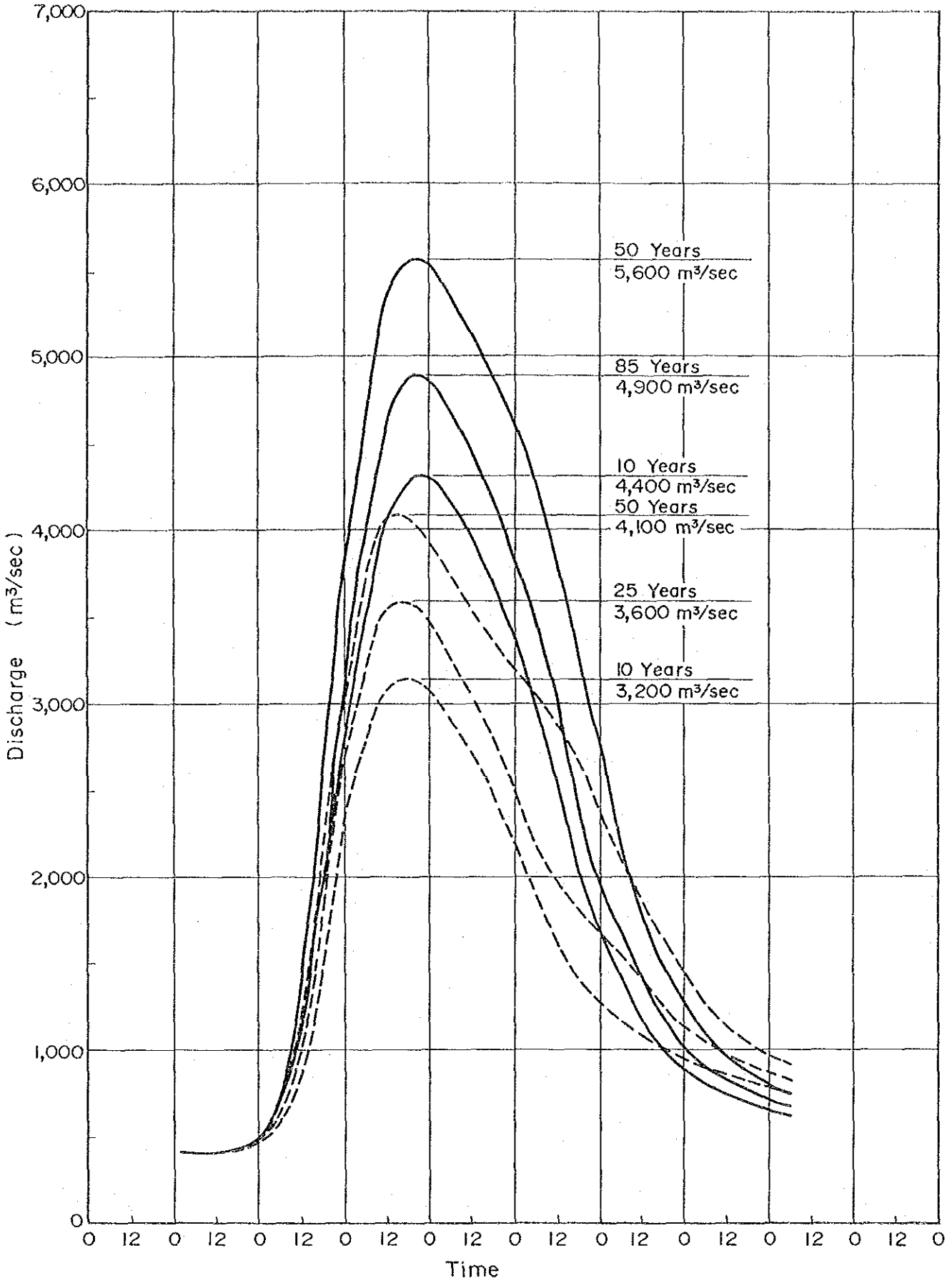

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ANNEX III.

GEOTECHNICAL INVESTIGATION

III. GEOTECHNICAL INVESTIGATION

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LIST OF FIGURES

1. INTRODUCTION

The geotechnical investigation for the study includes (1) investigation of general geological conditions of the Itajai river basin and (2) geotechnical considerations of the geology along the Itajai river.

The investigation of general geological conditions was conducted by the geological maps established by the DNPM and supplementary field checking.

The geotechnical considerations were made by the geological conditions, the geotechnical investigation result for the construction of road, bridges and other structures along BR-470 carried out by DNER, and the supplementary field reconnaissance.

2. GEOLOGY

2.1 Regional Geology

The regional geology of Santa Catarina state consists of the four major groups of the Precambrian, the Palaeozoic, the Mesozoic and the Cenozoic rocks as shown in Fig. III.2.1 .

The Precambrian rocks are distributed along the coast of the Atlantic with about 60 km width. These rocks are divided as follows:

- Archaeozoic complexes of the gneisses and the migmatites consisting of polyphase-banded rocks and blastoporphyritic rocks,

- superior/Archean to inferior/Proterozoic complexes of the Brusque metamorphic complex of mica-schists, metamorphic calcareous rocks, marbles, metamorphic sandstones and metamorphic volcanic rocks, the suite of gneissic granites and the Valsungana intrusive suite of granites, and

- media/superior Proterozoic complexes of the Itajai group of ortho-conglomerates, litho-feldspathic sandstone, basic volcanic rocks, siltstones, rhyolites and silt-sandstones, and the Subida intrusive suite of granites.

The Paleozoic rocks are distributed widely among the Geral mountains and the Mar mountains and sporadically in the other areas. These rocks are sediment accumulated in the Parana tectonic basin. The rocks are sedimentary rocks of glacial, fluvial, coastal or marine deposit origins. The constituent grain sizes vary from clay to sand and some conglomerate is intercalated locally.

The Mesozoic rocks consists of the aeolian sandstones, the basaltic lava flow or dikes and the alkali rocks. The basaltic lava flows and dikes are distributed widely in the most area westside of the Geral mountains. The aeolian sandstones are distributed along the eastern periphery of the basaltic rocks. The alkali rocks are sporadically distributed concentrically in the area situated between about 28o to 28o30' of the south latitude and 50o10' to 50o20' of the west longitude.

The Cenozoic sediment consists of the semiconsolidated Tertiary/diluvial fonglomerate including coarse detritus, the Tertiary/diluvial sediments of terrace deposit and marine deposits, and the alluvial deposits.

The large scale of fonglomerate is found only in the limited area of the upstream reach of the Tres Barras river situated at the north-east edge of the State.

The Tertiary/diluvial deposits are developed widely in the coastal area northern from 27o of the south latitude and stretched along the coast with about 2 to 5 km width towards the south from 28o of the south latitude This sediment is distributed sporadically in the area along the coast between 27o and 28o of the south latitude.

The alluvial deposits are developed widely in the plain area southern from 28o40' of the south latitude and with various scales in the other areas along the rivers.

2.2. Geology in Project Area

2.2.1 General

The Itajai river basin is divided by the Moema mountains (Serra do Moema), the Jaraqua mountains and their feeders at the northern watershed, by the Geral mountains (Serra Geral) and its feeders at the western watershed, and the Tijucas mountains (Serra do Tijucas) and its feeders at the south-eastern watershed as shown in Fig. III.2.2. The main stream crosses the Mar mountains (Serra do Mar) between Lontras and Apiuna, the Pomerode mountains (Serra Pomerode) around Indaial city and the Selke mountains (Serra das Selke) around Blumenau city.

The Itajai river has many tributaries. The main tributaries are, in the order from downstreams, the Itajai Mirim river, the Luis Alves river, the Benedito river, the Itajai do Norte river, the Itajai do Sul and the Itajai do Oeste river.

The geology of Itajai river basin which is illustrated in Fig. III.2.3 consists mainly of the following three groups:

- alluvial deposits of the Cenozoic age distributed widely in the downstream reach of the main stream, the Itajai Mirim river and the Luis Alves river with a maximum depth more than 30 m and narrowly along the upper main stream and the other tributaries with a maximum depth of about 10 m,

- the granulites, migmatites, metamorphic volcanic and sedimentary rock and the intrusive or plutonic rocks of the Precambrian age distributed in the easternside of the Mar mountains, and

- the sedimental rocks of the Palaeozoic age distributed between the Mar and Geral mountains.

2.2.2 Lower Reach

In the right-side area downstream from the easternside of the Mar mountains including the Benedito river and the Luis Alves river basins, the gneisses of Archaeozoic granulite is widely distributed. These rocks are also distributed locally in the right bank around Indaial city.

The anky-metamorphic sandstones of the medium and superior Proterozoic age accompanied with the conglomerate of the same age are distributed in the limited portions of this area along the main stream downstream from Blumenau and around the downstream reach of the Luis Alves river. In this limited area, the anky-metamorphic phyllite and shale from the superior Proterozoic to the Cambrian is distributed locally. The many faults are found in this limited area. Each rock in the gently sloped portion of this area is generally covered with weathered zone of more than 10 m.

In the left side area of the main stream downstream from the eastern of the Mar mountains including the Itajai Mirim river basin, the various Precambrian rocks are distributed complicately.

The micaschist aged from the superior Archaeozoic to the inferior Proterozoic is distributed locally in the Tijuca mountains near the river and in the Itajai mountains near Ilhota and Gaspar, and distributed widely in the same mountains at both sides of the middle-upper reaches of the Itajai Mirim river. This rock layer is occasionally intercalated with meta-calcareous rocks, dolomite and marbles.

The Archaeozoic gneisses are stretched narrowly south-westward from Gaspar to near the Mar mountains and distributed locally around the midpoint between Gaspar and Ilhota and around the midpoint between Ilhota and Itajai.

The anky-metamorphic sandstone is also stretched narrowly along the northern of the gneisses accompanied with the metamorphic conglomerates.

The anky-metamorphic shale and phyllite from the superior Proterozoic to the Cambrian age is distributed widely south-westward from Blumenau to the eastside of the Mar mountains crossing the main stream between the northern Apiuna and Subida.

The anky-metamorphic sandstone of the medium-superior Proterozoic age is distributed locally along the northwestside of the above mentioned shale crossing the main stream between Ascurra and the northern Apiuna.

The granites from the Archaeozoic to the Proterozoic age are distributed widely in the Itajai mountains and the Tijucas mountains around Brusque. The granites of the superior Proterozoic are distributed locally in the Itajai and Tijucas mountains near the above mentioned granite masses and around Subida at the right bank of the main stream.

The metavolcanic-sedimentary sequence is distributed sporadically in the Itajai and Tijucas mountains with a shape of narrow strip from north-east to south-west. In the area along the Itajai Mirim river near to the Mar mountains, however, this sequence is distributed with a width of about 5 km and a length of about 20 km from the same direction as mentioned above. In the other areas than the ones mentioned above, this sequence is distributed with a shape of narrow strip along the southern of the anky-metamorphic sandstone from Gaspar afore-mentioned. Each rock in the gently sloped portion of this area is generally covered with a thick weathered rock layer of more than 10 m depth.

In the area downstream from the eastside of the Mar mountains, the alluvial deposits are developed along the mainstream and the tributaries. The distribution area of these deposits is widened along the main stream downstream from the vicinity of Gaspar and around the confluences with the Luis Alves river and the Itajai Mirim river. According to the geotechnical investigation result for the road project in this area by DNER, the depth of this clayey deposit distributed widely is inferred to be more than 30 m at maximum and this clayey deposit has been found to contain thick layer of organic matter locally, though the riverbed deposit consists mainly of fine to medium sand containing a little coarser particles.

In the areas other than this, the alluvial deposits consist mainly of sandy silt or silty sand intercalated with gravels. The depth of those layers is estimated generally at about 10 m in view that base rocks are occasionally found to crop out in the riverbed in the other areas.

The diluvial deposits are distributed in the right bank of the Itajai river along the coast of the Atlantic.

The palaeozoic sedimentary rocks from the Carboniferous period to the inferior Permian period is distributed in the watershed areas of the Benedito river and its tributary at the eastern slope of the Mar mountains.

2.2.3 Upper Reach

The geology of the upper reach of the Itajai river basin upstream from the Mar mountains consists of the predominant Palaeozoic sedimentary rocks, the Cenozoic alluvial deposits distributed locally along the main stream and tributaries and the Mesozoic basalt lava distributed sporadically at the high altitude portions with minor masses.

This area is divided roughly to four divisions of the Itajai do Norte river basin, the Itajai do Oeste basin, the Itajai do Sul basin and the Itajai Mirim basin. There is no significant geological difference among the main portions of them. In the lower altitude portion of each area, the phyllite and shales of the inferior Permian period is distributed widely. This rock is originated from the glacious marine deposits and accompanied locally with fine sandstones, rhythmite and others. In the higher altitude portion, the inferior/medium Permian sedimentary rocks of fine to medium grains is distributed predominantly. The inferior of these rocks is immatured fine to medium sandstone originated from the fluvial-delta deposits and accompanied locally with coarser grains, shales, micaceous, and very fine sand particles. The medium ones are greenish phyllitic madstone originated from the marine deposits and accompanied with clayey carbonates, superficial silicates and very fine sand grains. The superior ones are fine to very fine sandstones originated from the coastal and fluvial-delta deposits, intercalated with shales, phyllitic carbonates and local bunk of char-coals.

As the altitude increases more in the watershed area of each basin, the age of rocks becomes younger from the medium to the superior Permian period. The rocks are phyllitic shales, siltstones and sandstones originated mainly from the marine deposits and partially from the coastal deposits. The some watersheds of the tributaries of the Itajai Do Oeste river rise in the area where the Mesozoic basalt lava is distributed.

The alluvial deposits are distributed locally in the areas along the main stream between Rio do Sul and Lontras, the Itajai Do Oeste river and its tributaries, and the Itajai Do Sul. Those alluvial deposits are generally of silty sand or sandy silt intercalated with gravel layers. The depth of them is estimated at about 10 m or less generally.

3. GEOTECHNICAL CONSIDERATIONS

3.1 General

For the flood control project, the following structures and construction works are generally contemplated:

- levee embankment and concrete dike,
- dredging and excavation for enlargement of river channel, flood-way and short-cut waterway,
- dam and weir,
- pump station, and
- slope protection works.

The area along the Itajai river and its tributaries, where the above-mentioned structures and works will possibly be considered, is divided into the following 11 districts.taking into account the geological characteristics as shown in Fig.III.2.3.

(1) District A : the area along the Itajai river downstream from Blumenau including the downstream reach of the Luis Alves up to about 5 km upstream from the confluence and the downstream reach of the Itajai Mirim up to about 15 km upstream from the confluence.

(2) District B : the area along the Lagoa do Furado.

(3) District C : the area along the Itajai river between Blumenau and Ibirama.

(4) District D : the area along the Itajai Mirim river between about 15 km and 50 km upstream from the confluence with the Itajai main stream.

(5) District E : upper reach of the Itajai Mirim river.

(6) District F : the Benedito river basin

(7) District G : the area along the Itajai river between Ibirama and Rio do Sul .

(8) District H : the Itajai do Norte basin.

(9) District I : the Itajai do Oeste river basin.

(10) District J : the Itajai do Sul river basin.

(11) District K :the waterhead area of the Itajai Mirim river.

Each of these subdivided districts is studied geotechnically with regards to the foundations and the construction materials of embankment and concrete aggregates for the above-mentioned structures and works to provide the necessary information for the study of the master plan of the Itajai river basin flood control, based upon the afore-mentioned available data, the result of site reconnaissance, the topographical maps and the aerophotographs.

The details of geological consideration in the above districts for possible structures and works are described in the following section.

3.2. Geotechnical Considerations

3.2.1 District A

In this district, the embankment levee and the dredging and excavation to widen the river channel are considered.

The thick alluvial deposits are distributed widely along the river and the Precambrian rocks are distributed in the hills at both banks with considerably thick weathered rock overburden. According to the geotechnical investigation for the realignment of BR-470 road made by the DNER, the alluvial deposit is of more than 30 m thickness at maximum and consist of the clayey soil, the organic matter and the sand. The clayey soil and the organic matter are estimated to have been developed in the back marsh due to the many tributaries and to be distributed widely in view of the topographic condition. The clayey soil layer has generally N-value less than 5 and the high moisture content ranging from 80% to 120%. The organic matter layer contains occasionally peats, its N-value is less than 2 and generally indicates 0, and its moisture content generally ranges from 150% to 400%.

The sand is estimated to be generally underlain below or intercalated in the clayey soil and organic matter layers and the distribution of sand layer in the shallow portion is estimated to be limited in the area at the vicinity of the present and old river course of the main stream. The sand layer of shallow portion is generally so loose that its N-value ranges from 5 to 10 and its grain sizes are classified to fine and medium. The underlain or intercalated sand is generally so dense that its N-value is more than 20.

With regards to the foundation against a levee embankment, these alluvial deposits of the clayey layer and the organic matter layer are evaluated so poor that the critical height of embankment with a general slope of 2-H to 1-V on them is about 2 m and that a serious settlement shall cause by the embankment load. The settlement is roughly estimated at about 40% of the embankment height against the embankment lower than 10 m. Therefore, a several meters height of embankment is obliged to require some special treatment for foundation improvement such as sand-drain or pneumatic pre-consolidation or a several steps of counter-weight with a 2 m lift and a width not less than 10 m and an extra embankment of about 60% of an embankment height against the settlement of foundation sub-soil.

With regards to the cut-slope in dredging to deepen the river channel or excavation to widen the river channel, a slope is required to be not steeper than 2-H to 1-V. In view point from the embankment material, these soil are judged to be unavailable for the main embankment because of their poor workability due to the high moisture content.

The upper sand layer is judged to be generally better than the clayey and/or organic matter layers with regards to the foundation of levee. The critical height of the embankment on this sand layer having more than 10 m thick is estimated to be about 13 m, though the critical height is seriously affected by the thickness of sand layer. The liquefaction which is the most dangerous problem in such loose sand layer can be neglected because no earthquake has been recorded in this region. The settlement of this layer of about 10 m thick due to the levee embankment is estimated to be 10 % of the embankment height at most . With regards to cut-slope in dredging to deepen or excavation to widen the river channel, a slope is

required to be not steeper than 1.5-H to 1-V both in the submerged portion and the portion usually above the water level. From the view point of levee embankment, this sand layer is judged to be unfavorable because of its poor resistibility against erosion due to its poor graduation. This sand material, however, is available for the main levee embankment provided some lining of clayey soil or other adequate materials. For the earth lining material of clayey soil, the decomposed rock mentioned hereafter is judged suitable.

For the embankment material of levee, the decomposed rock is judged to be suitable. The decomposed rock is developed thickly in the many hills distributed sporadically along the both bank of the rivers.

3.2.2 District B

In this district, the floodway will be considered. The construction work of floodway consist of excavation canal and levee embankment.

The geology of this area consists of the same alluvial deposits as mentioned in the foregone sub-section 1) and the Precambrian rocks mostly overburdened with the weathered rock.

The alluvial deposits of the clayey soil layer, the organic matter layer and the sand layer are evaluated samely as those in the district A with regards to the foundation of levee embankment, the cut-slope stability in the channel excavation and the embankment material for levee. The foundation of clayey or organic matter layers will oblige the stepwise-lift embankment with some special foundation treatment such as sand-drains or pneumatic preconsolidation or the counter-weights with a considerable amount of extra embankment to compensate the foundation settlement in the levee construction work. In the excavation of channel, the cut-slope will be 2H to 1V against each of those alluvial deposit layers.

The area where the weathered and fresh rocks are the objectives of the following construction work is estimated at about 3 km stretch. These layers are evaluated favorable for the foundation of levee and the stability of cut-slopes. The weathered rocks are suitable for the levee embankment material and the fresh rocks are also judged to be available for the levee embankment provided with a lining. From the view point of geotechnics only, the cut-slopes will be 0.3H to 1V.

The ratio of the fresh rocks which requires the excavation by blasting is estimated at 20% of the total rock quantity at maximum. The moderately weathered rock which require the excavation by rippering is estimated at about 30% of the total rock amount at maximum. The stretch where the rock is distributed is estimated about 2 km around the road of BR-101.

3.2.3 District C

In this district, along the main stream between Blumenau and Ibirama, the possible works for the flood control plan are considered as follows:

- diversion tunnel and pump station for drainage in Blumenau city,
- dams at the upstream of Ascurra, and the right bank tributaries of the main stream,
- levee embankment along the main stream between Ascurra and Indaial, and

- dredging or enlargement of the river course width along the main stream.

The geology of this district consists of the following layers:

- Precambrian anky-metamorphic sandstone distributed in the left bank of the main stream at Blumenau and in the both banks of the main stream between Ascurra and Apiuna,

- Precambrian metamorphic shales and phyllites distributed widely in the right bank of the main stream between Blumenau and Subida and partially in the left bank around Subida,

- alluvial deposit along the main stream and the tributaries

- Precambrian granites distributed locally in the upstream end of this district around Subida, and

- Precambrian rhyolite or rhyodacite distributed sporadically between the northward Subida and the eastward Apiuna.

The diversion tunnel will be planned in the left bank at Blumenau where the Precambrian sandstone is distributed. This rock is judged to be generally sound and massive favorable for the tunnel excavation. Near at the upstream and downstream ends and the center of the possibly planned tunnel, however, three faults cross the tunnel centerline perpendicularly. Therefore, the some special treatment will be required at the vicinity of these faults.

The pump station for drainage of inner basin will be studied. The pump stations will be situated at the both banks where the comparatively major tributaries are situated. In such areas, the soft alluvial deposits are accumulated thickly. The pile foundation not deeper than 10m will be required for these structures.

The possible dam sites are situated at the area between Ascurra and Apiuna on the main stream (Ascurra Dam), the area on the Neisse river (Neisse Dam) and the area on the Subida river (Subida Dam).

The geology of Ascurra Dam site is of Precambrian metamorphic sandstone. This sandstone is massive and sound and judged to be available for the concrete gravity dam foundation. The concrete aggregates can be produced from the same sandstone distributed abundantly at the vicinity of the dam site. In case that the fill-type dam be planned, the zoned rockfill type with earth core is possible because the impermeable earth core can be borrowed from the decomposed sandstone or shale distributed abundantly nearby, the filter material of sand and gravel mixture can be borrowed from the riverbed deposits. In case that the reservoir water level is planned to higher than about EL.130 m, a saddle dam will be required at the right bank about 1.5 km west-northward. The geology of the saddle dam site is of the sequence of sandstone and shale of the Carboniferous period. This layer is estimated to be not sound. Therefore, the fill-type saddle dam is recommended.

The geology of the Neisse Dam site is of the Precambrian rhyolites or rhyodacites. These rocks are estimated to be massive and sound. Therefore, the concrete gravity dam is estimated to be founded on it. However, the fault is likely run along the river course. For the concrete aggregates of the dam, the same rhyolite or rhyodacites are judged to be available. In case that a fill-type dam be planned, the zoned rockfill-type dam with

earth core is possible, because the impervious earth core material can be borrowed from the decomposed rocks distributed abundantly at the vicinity of the dam site, the rhyolite or rhyodacite nearby can be available for the rock material and the filter material can be borrowed from a mixture of sand and gravel of the riverbed deposits in and along the main stream.

The geology of the Subida Dam site is of metamorphic siltstones. The stratification is developed well and thereby, this rock is judged to be unsuitable for the foundation for a high concrete gravity dam. A zoned rockfill-type dam with earth core is recommended because the earth core material, the filter material and the rock material are collectable within an economical distance.

The river course improvement works of the levee embankment, the dredging and the excavation will be studied in the area along the main stream . The objectives of such works will be mainly the alluvial deposit. The alluvial deposits in this district is estimated to consist of the silty sand or sandy silt intercalated with some gravely layers and its thickness is not deeper than about 10 m. Thereby, several meters height of levee is estimated to be constructed generally without any special treatment for the foundation and these alluvial deposit above the water table can be used for the levee embankment material. For the embankment material, the decomposed or weathered rocks distributed in the gentle slopes of the mountain or hills foot along the river can be available. With regards to the cut-slope in the dredging and the excavation, a slope is estimated to be required not steeper than 2-H to 1-V. However the deep and soft alluvial deposits containing organic matter are possibly distributed locally around the confluences with the major tributaries where the wide alluvial plain is developed along the tributary. In such portions, the foundation treatment or embankment method and the cut-slopes are required to be same as those in the District A .

3.2.4 District D

In this district of the Itajai Mirim river downstream reach, the river course improvement works of levee embankment or excavation of river channel will be studied.

The geology of this district consist of the alluvial deposits along the river course and the Precambrian sedimentary and intrusive rocks generally with thick overburden of weathered zones at the mountain areas on both sides.

The alluvial deposits are estimated to be generally same composition as those in the District C. Some part of the alluvial deposits above the water table and the weathered rocks can be used for the embankment materials.

The cut-slope is generally required to be not steeper than 2-H to 1-V.

The several meters height of embankment can generally be constructed without any special foundation treatments.

3.2.5 District E

In this district of the upper reach of the Itajai Mirim river, the possible works for the flood control plan are considered to be dams.

The geology of this district consists mainly of micashists of Precambrian.

Those rocks are estimated to be unfavorable for the foundation of high concrete gravity dam. In case that the dams is higher than 30 m, a fill-type dam is recommended.

3.2.6 District F

In this area of the Benedito river basin,the possible works for the flood control plan are considered to be the river course improvement work of levee embankment and excavation of river course and the dam construction.

The geology of this area consists of the Precambrian gneisses distributed widely in the basin except the some waterhead areas, the sedimentary rocks of Carboniferous period distributed in some riverhead areas and the alluvial deposits distributed along the lower reaches of the Benedito and Cedros rivers. The gneisses in the lower reach of the Cedros river is estimated to be weathered deeply from the topographic conditions. The alluvial deposits is estimated to be almost same as those in the District C and the District D.

The objectives of the river course improvement works will be mainly the alluvial deposits. The alluvial deposits is estimated to be generally composed of the sandy silt layer with some clayey and the sand and gravel layers intercalated. Therefore it is estimated that the levee embankment of several meters high can generally be constructed without any special foundation treatment and that the cut-slope in the excavation works is required to be not steeper than 2-H to 1-V.

The embankment material can be gotten from the weathered rocks in the hills nearby and the alluvial deposits above the groundwater table.

The dam sites where the topographical conditions are favorable for the flood control plan are rare in this area. It is said generally from the view points of geotechnics, that the gneisses in the flat lower reach are unsuitable for the foundation against a concrete gravity dam because of its deeper weathered zone, but those in the mountainous upstream reach are available for the foundation against the concrete dams.

3.2.7 District G

In this district along the main stream from Ibirama to the vicinity of Rio do Sul, the possible works for the flood control plan are considered to be the river course improvement work of embankment levee and excavation and/or the dam construction.

The geology of this district consists of the sedimentary rocks of the inferior/medium Permian period widely distributed and the alluvial deposits distributed from Lontras to the western of Rio do Sul with a considerable width. The river crosses the Mar mountains between the downstream of Lontras and near Ibirama and in this portion the river forms a gorge. The alluvium deposits in this district is estimated to consist of the silty sand or sandy silt occasionally intermediate with some clay and gravel. With regards to the sedimentary rocks in the gorge, the overburden is estimated to be quite thin because many outcrops of fresh rock are found. These rocks in the other area are generally overburdened with considerably thick weathered zone.

The main objectives of the river improvement works will be mainly the alluvial deposits layer. These alluvial deposits are estimated to be geotechnically almost same as those in the District C. The levee embankment material can be borrowed from the alluvial deposits above the groundwater table and the weathered sedimentary rocks nearby. The embankment upto several meters height can be constructed without any special foundation treatment. The cut-slope in the excavation is required to be not steeper than 2-H to 1-V.

In this district, the dam site favorable for the flood control is rare. However, it is estimated that the concrete gravity dam not higher than 50 m can be founded on the sedimentary rocks in the gorge.

3.2.8 District H

In this district of the Itajai Do Norte river basin, the Norte Dam is under construction for the flood control. The other possible works for the plan are considered to furnish the gates to the Norte Dam to increase the flood control effect of the dam.

The geology consists of the sedimentary rocks of the inferior/medium Permian with a considerably thick overburdens of weathered zone and the very thin alluvial deposits distributed quite locally along the rivers.

At the location where the gates will be constructed, the considerably sound and massive sedimentary rock is distributed and is judged to have a sufficient strength for the foundation of the gates.

3.2.9 District I

In this district of the Itajai do Oeste river basin, the Oeste Dam of concrete gravity type is under operation for the flood control. The other possible works for the flood control plan are considered to raise the dam crest and/or improve the spillout system in order to increase the flood control effect of the dam.

The geology consists of the various sedimentary rocks mainly of the inferior/superior Permian period with considerably thick overburden of the weathered rocks and the alluvial deposits distributed locally along the Itajai do Oeste river and its tributaries. The geology around the Oeste Dam consists of the sound and massive sandstone, the thick decomposed sandstone on the both banks and the alluvial deposits widely distributed in the reservoir area.

From the geotechnical view points, the raise of the dam crest upto about 10m higher than the present height is judged to be possible by the method as mentioned below because it is estimated that the sandstone is sufficiently sound for the foundation of the raised dam and the decomposed sandstone also is sound and impervious for the foundation of the earthfill of about 10 m height. The raise of the dam will be made by a combination of raising the additional concrete dam on the present gravity dam and embankment of the earthfill on both banks. From the topographic conditions, however, the earthfill will be considerably long.

3.2.10 District J

In this district of the Itajai do Sul river basin, the Sul Dam of zoned rockfill with earth center core is under operating for the flood

control. The possible works for the flood control plan are considered to be raising the dam height and/or improvement of the spillout system.

The geology of this district is almost same as that in the District I of the Itajai do Oeste. The geology around the Sul Dam site is somewhat different from that of the Norte Dam site in that the fresh rock at the Sul Dam site is more phyllitic.

The fresh rock of the present foundation of the dam and the weathered rocks are judged to meet the requirements for the foundation of the considerably high dam which is used only for the flood control purpose to impound the water for a while. It is not easy to raise such a dam of a zoned rockfill with center earth core, however, it is judged possible by overlaying a zoned rockfill with an asphalt center core diaphragm from the present earth core on the present dam and embankment of earthfill on both banks though the earthfill will be considerably long.

In order to increase the storage capacity of the dam, the present spillway is required to be modified to a side-overflow type or a bath-tub type which has a long overflow section to be able to discharge safely the water to be spilled out with a shallow overflow depth. This structure shall be founded on the fresh rock same as the main dam foundation.

3.2.11 District K

In this district of the waterhead area of the Itajai Mirim river, the geology consists of the sedimentary rocks of the medium/superior Permian periods.

No works except the slope protection works against erosion is considered.

With regards to the slope protection, this district is mentioned together with the other districts in the next section 3.3.

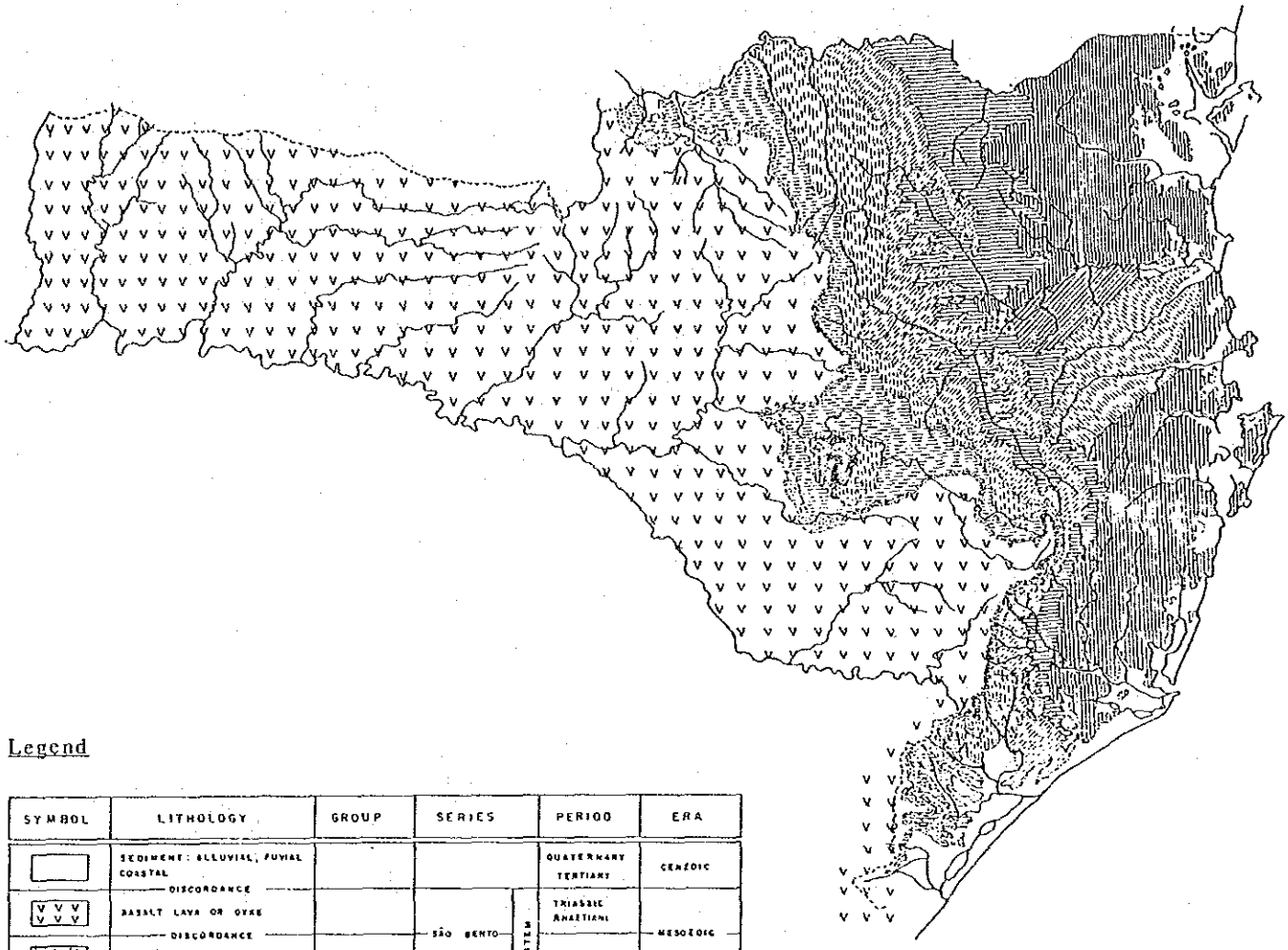
3.3 Erosion and Sedimentation

The superficial erosion is estimated to be considerably active from the fact that the discharging water is always turbid from the upstream stretch to the river mouth.

The particles larger than about fine sand grain are likely to sediment mainly in the downstream stretch lower from Blumenau.

However, the large scale of the landslides or the traces of the slope-wash have not been found in this investigation. Thereby, any slope-protection works are not required to be made at present.

Figures



Legend

SYMBOL	LITHOLOGY	GROUP	SERIES		PERIOD	ERA
	SEDIMENT: ALLUVIAL, FLUVIAL COASTAL				QUATERNARY TERTIARY	CENOZOIC
	DISCORDANCE					
	BASALT LAVA OR DYKE			SÃO BENTO	TRIASSIC RHAETIAN?	MESOZOIC
	DISCORDANCE					
	AEOLIC SANDSTONE				TRIASSIC	
	DISCORDANCE					
	COASTAL SEDIMENTARY ROCKS: SILTSTONE, SHALE, SANDSTONE	RIO DO RASTO		PASSA DOIS	PERMIAN	
	MARINE SEDIMENTARY ROCKS: SHALE, SILTSTONE, SANDSTONE, PHYLLITE	ESTRADA NOVA				
	MARINE SEDIMENTARY ROCKS OF RANAY SILTSTONE	GUATÁ		TUBARÃO	CARBONIFEROUS	PALAEOZOIC
	FLUVIAL SEDIMENTARY ROCKS OF FINE SANDSTONE	ITARARÉ				
	DISCORDANCE					
	ANCHIMETAMORPHIC SANDSTONE, SHALE SILTSTONE; RHYOLITE; VOLCANICS PHYLLITE			ITAJAÍ	CAMBRIAN	
	DISCORDANCE					
	SCHISTS, METAVOLCANIC-SEDIMENT			BRUSQUE	ALGONKIAN	PROTEROZOIC
	DISCORDANCE					
	GNEISSES, MIRMATITES				ARCHAEN	ARCHAEOZOIC
	GRANITE + INTRUSIVE ACID				POST ALGONKIAN	
	RHYOLITE + INTRUSIVE BASIC				POST CAMBRIAN (?) PRE RHAETIC (?)	
	DIABASE + INTRUSIVE BASIC				RHAETIC (?)	

SANTA CATARINA SYSTEM

Fig. III.2.1 REGIONAL GEOLOGICAL MAP OF SANTA CATARINA STATE

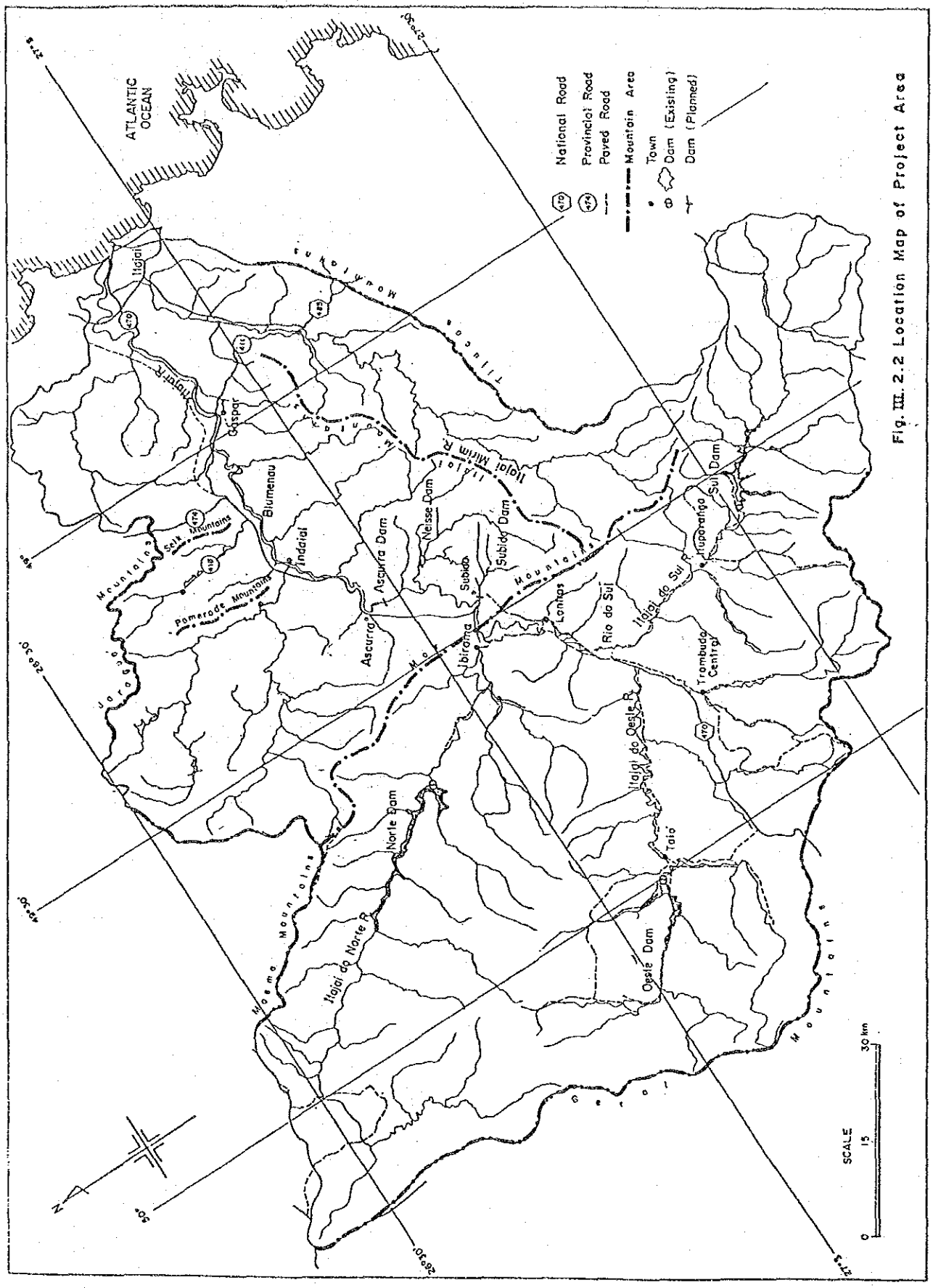


Fig. III. 2.2 Location Map of Project Area

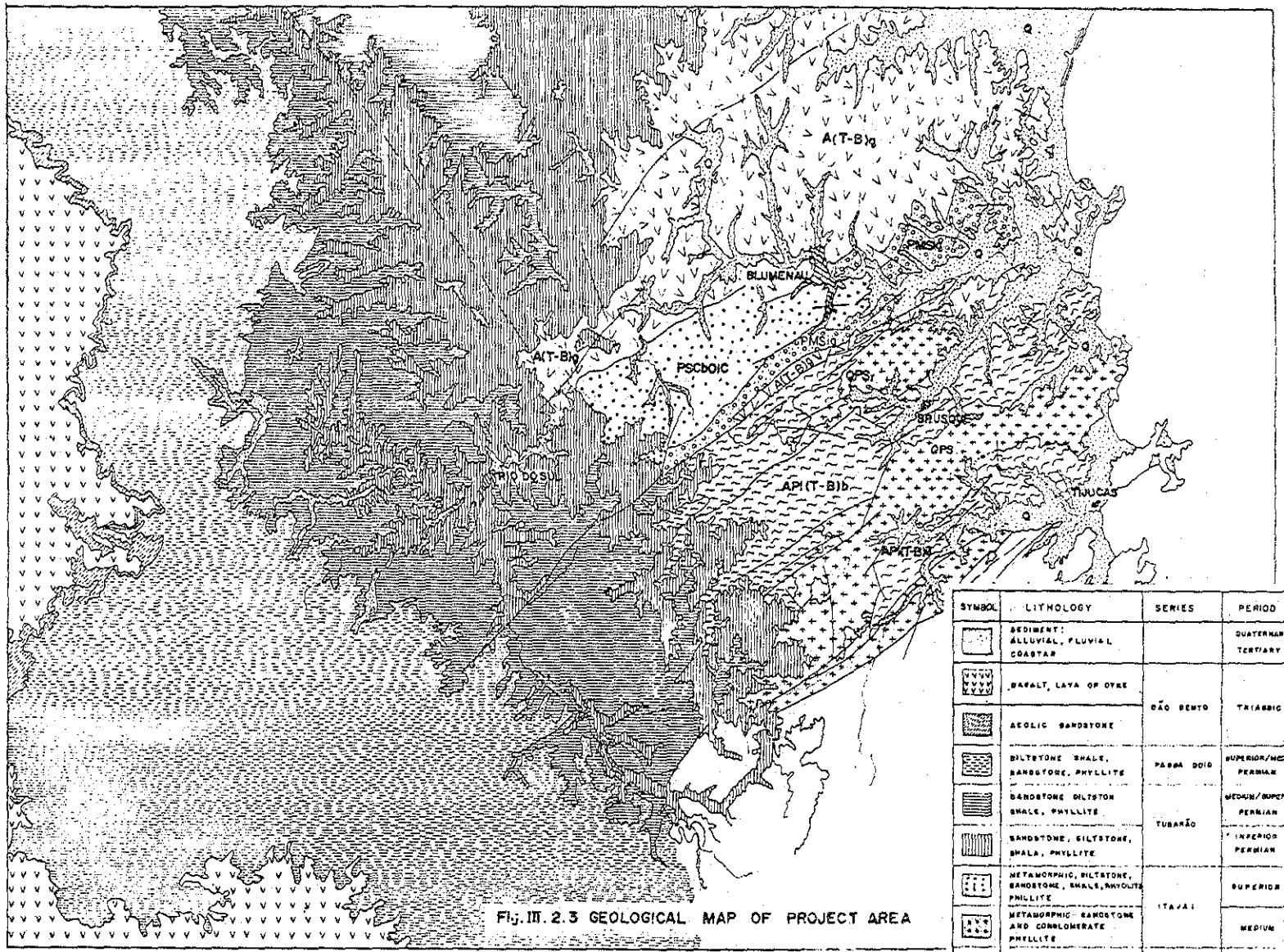


Fig. III. 2.3 GEOLOGICAL MAP OF PROJECT AREA

ANNEX IV. SOCIO-ECONOMY

IV. SOCIO-ECONOMY

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1. INTRODUCTION

The socio-economic study aims at understanding present conditions and projections of socio-economic characteristics such as population and gross regional domestic product (GRDP) in a project site until a target year. These characteristics are indispensable for other sectoral studies, as functioning the basic framework for the proposed project.

Chapter two mentions the present socio-economic conditions in the Itajai river basin comparing with both conditions of the state of Santa Catarina and the whole country. Present conditions are illustrated from the following five aspects: administrative conditions; social conditions; economic conditions; sectoral economic profile regarding industrial situation; and present land use. These items are essential not only to identify the project but also to evaluate the project.

Chapter three describes the future socio-economic conditions, projected on the basis of the national development policies or some dependable assumptions released by international organizations such as United Nations and the World Bank. These projections are vital to evaluate the flood control projects from the point of view of economically enhanced floodplain situation in the future. At the same time, the data are presented to formulate non-structural measures for some floodplain which is not protected by flood control facilities.

This socio-economic study neither covers all aspects of socio-economic conditions of Brazil nor includes any proposal for socio-economic planning. It aims to provide the figures for the use of working out the other relevant sectoral studies. A further study will be needed for more detailed implementation plans in the stage of a feasibility study.

2. PROJECT BACKGROUND

2.1 Administrative Conditions

2.1.1 Administrative division

Brazil, formally called Federative Republic of Brazil in English, covers a national area of 8,511,965 km^2, which amounts to approximately 22.5 times of the Japanese territory. It consists of five grand regions: Norte with an area of 3,581x10^3 km^2; Nordeste, 1,549x10^3 km^2; Sudeste, 925x10^3 km^2; Sul, 578x10^3 km^2; and Centro Oeste, 1,879x10^3 km^2. These regions are divided into states. The states are further divided into mid-regions, mid-region into micro-regions, and micro-regions into municipalities as shown in Fig.IV.2.1.

The administrative entity which has autonomy is the nation, state and municipality among regional divisions mentioned above. Other divisional levels are provided for an expedient on the basis of geographical and socio-economical homogeneity. The federal government, however, sets a national agency covering inter-states on occasion, such as Superintendencia do Desenvolvimento do Nordeste (SUDENE) and Superintendencia do Desenvolvimento da Regiao Sul (SUDESUL). In general, public services such as flood control are executed by a foregoing autonomous entity.

The Itajai river basin is located in the north-eastern part of the state of Santa Catarina. Santa Catarina comprises 4 mid-regions, 16 micro-regions and 199 municipalities. The major part of the basin is covered by the Leste Catarinense mid-region which includes four of five micro-regions, namely: Litoral de Itajai; Colonial de Blumenau; Colonial do Itajai de Norte; and Colonial do Alto Itajai. The other small parts of the basin consist of the following regions: the Sul Catarinense composing one of five micro-regions, the Colonial Serrana Catarinense and, the Oeste Catarinense composing two of five micro-regions, i.e., the Campos de Lages and the Planalto de Canoinhas.

The basin occupies an area of 15,221 km^2 comprising 12,484 km^2 or 80.1% of the Leste Catarinense mid-region, 840 km^2 or 5.5% of the Sul Catarinense and 2,197 km^2 or 14.4% of the Oeste Catarinense. Fig. IV.2.2 shows the composition of the basin in the state.

There are 46 municipalities within the basin, which are broken down as follows: 40 municipalities in the Leste Catarinense mid-region: 1 in the Sul Catarinense; and 5 in the Oeste Catarinense. 40 municipalities in the Leste Catarinense, furthermore, are broken down as follows: 4 municipalities of total 8 in the Litoral de Itajai micro-region; 16 of 16 in the Colonial de Blumenau; 4 of 4 the Colonial do Itajai do Norte; and 16 of 16 the Colonial do Alto Itajai. Fig. IV.2.1 and Fig. IV.2.3 shows the relation among municipalities in the basin. An involved municipality is chosen based on the relation between a watershed of the basin and a municipal boundary. In other words, once some portion of a municipal area is contained by the basin area, the municipality is identified as the municipality involved in the basin. In this context, 9 municipalities of the total have only part of their territories located there.

In this study, the characteristics of the basin would be captured by figures or indices which are figured out by state of Santa Catarina, because of data availability. The basin area, 15,221 km^2, is completely covered by the state and occupies 15.9% of the state area of 95,483 km^2. Although the percentage of the area is comparatively small, the economical and historical background of the basin would characterize the most part of the state.

2.1.2 Institutions concerned

An implementation agency in charge of flood control is Departmento Nacional de Obras e Saneamento (DNOS). Cooperation with agencies concerned, however, is indispensable in order to carry out a flood control project. For example, in the case of the flood control project in Sao Francisco river valley, following agencies were convened to formulate the project as a committee in 1979:

(1) From Ministerio de Interior (MINTER):

- DNOS;
- SUDENE (agency for regional development of Northeastern Brazil); and
- Companhia do Desenvolvimento do Vale do Sao Francisco (CODEVASF-governmental company for development of Sao Francisco Valley)

(2) From Ministerio das Minas e Energia (MME):

- Departamento Nacional de Agua e Energia Eletrica (DNAEE-agency in charge of water matters); and
- Companhia Hidro-Eletrica do Sao Francisco (CHESF-electric power company that has hydroelectric plants along the Sao Francisco river)

(3) From Ministerio dos Transportes (MT):

- Empresa de Portos do Brasil S.A. (PORTOBRAS)

(4) From Ministerio da Agricultura (MA):

- Superintendencia do Desenvolvimento da Pesca (SUDEPE-agency that controls fishing)

(5) Secretaria do Planejamento (SEPLAN-Planning agency of socio-economic development in the country)

(6) State governments concerned

(7) ELETROBRAS (holding company belonging to the Federal Government, that controls most electric power companies in the country)

In order to perform the flood control project in Itajai river basin, cooperation among following agencies would be necessary like the committee mentioned above:

(1) The federal government:

(i) Ministerio de Irrigacao (MI): DNOS;

(ii) Ministerio do Desenvolvimento Urbano e Meio Ambiente (MDUMA): SEMA;

(iii) MINTER: SUDESUL (agency for regional development of Sul region);

(iv) MME: DNAEE; and

(v) Ministerio da Agricultura (MA): Instituto Brasileiro de Desenvolvimento Florestal (IBDF-agency in charge of preservation of forestry and ecological balance)

(2) The state government:

(i) Gabinete do Secretario de Estado Extraordinario para a Reconstrucao de Santa Catarina (agency that promotes to reconstruct facilities and to evacuate victims caused by disasters);

(ii) Coordenacao Estadual de Defesa Civil (CEDEC-organization that alert or declare a state of emergency against flood);

(iii) Conselho Estadual de Recursos Hidricos (CERH-agency that study and analyze water resources); and

(iv) Gabinete de Planejamento Coordenacao Geral (GAPLAN-agency that integrate total development plans in the state).

(3) Municipal government concerned.

DNOS plays a leading role of all projects of utilization and protection of water resources in a hydrographic basin except electric generation and navigation. DNOS, attached the Ministerio da Irrigacao (the Ministry of Irrigation), is composed of a Central Administration in charge of planning and technical supervision, and of 15 Regional Departments which cover the whole Brazilian territory. Itajai river valley is under the control of the 14th (fourteenth) Regional Department of DNOS in Florianopolis, Santa Catarina.

2.2 Social Conditions

2.2.1 Population

According to the 1980 census by the Instituto Brasileiro de Geografia e Estatistica (IBGE), Brazil has a population of 119,002,706. This population increased by about 48.8x106 as compared to the 1960 census shown in Table IV.2.1. During the 60's, the average annual growth rate was recorded at 2.87%. Afterwards, the growth rate slowed down to 2.48% in the 70's.

The population in Santa Catarina was 3,627,933 in 1980. The average growth rate recorded 2.26% during the 70's as shown in Table IV.2.2, which is smaller than that of the country. During the 60's, however, the state recorded the growth rate of 3.02%, which is larger than that of the country. Therefore, immigration into the state might occur rather rapidly during the decade.

The population within the Itajai river basin was estimated at 668,582 in 1980 as shown in Table IV.2.3. Hence, the basin population was counted as follows: (1) urban population is completely counted in principle, in case the town headquarters of a municipality is located inside the basin; and (2) rural population is calculated in proportion to area within the basin, in case some portions of a municipality are included in the basin.

The basin occupied 18.4% of the state population in 1980. This share in 1980 was slightly smaller than that in 1970, 18.8%. Major municipalities with more than 20,000 population were as follows: Blumenau

with 152,518; Itajai, 86,460; Brusque, 41,224; Rio do Sul, 36,240; Indaial, 28,574; Gaspar, 25,606; and Ibirama, 23,522.

The average growth rate in the basin during the decade of the 70's was 2.08%. This rate was smaller than that of the state and the country. As shown in Fig.IV.2.4, people under 14 years old decreased in 1980 drastically, in contrast to the fact that the composition of people over 14 years old was larger than that of the country. This decrease in the number of infant population might be thought that the social phenomenon of nuclear family comes into general and that people can not have many children as in the past. This would expedite to advance the average age of the population. Incidentally, average family size in the basin decreased from 4.90 in 1970 to 4.19 in 1980. This size of 4.19 was smaller than those of Santa Catarina (4.47) and the country (4.40) in 1980.

A population density in the basin of 44 persons per km^2 was somewhat greater than that of the state (38 persons per km^2) in 1980. The greatest value of population density is observed in the municipality of Blumenau of 372 persons per km^2. The densely inhabited municipalities besides Blumenau, with values greater than 100 persons per km2, are as follows as shown in Table IV.2.3: Itajai (284) and Navegantes (170) in the Litoral de Itajai micro-region; Timbo (111) and Brusque (103) in the Colonial de Blumenau micro-region and; Rio do Sul (205) in the Colonial do Alto Itajai micro-region. All these municipalities are characterized by industrial activity, except Navegantes.

The urban population of the basin reached to 426,996 in 1980. This accounted for 63.9% of the total population, which was bigger than that of the state of 59.4% but smaller than that of the country of 67.6%. This means that the urbanization in the basin proceeds faster than the whole state but that the centralization to urban areas is not greater than the whole nation to metropolitan areas such as Sao Paulo and Rio de Janeiro.

2.2.2 Labor force

In 1980, the labor force in the basin registered at 285 thousand. Of this total, 280 thousand or 98.4% was employed. This rate is almost the same as the state of 98.1%. Participation rate, which refers to the rate of the labor force to the total population of 10 years old and over, increased from 44.3% in 1970 to 49.9% in 1980 in the state. This might be mainly caused that the female power began to participate in the labor force.

The agricultural sector, the primary sector, including crop farming livestock breeding, fishery, forestry and rural industry, absorbed 81,744 or 44.7% of the total labor force in 1970 and 72,996 or 25.6% in 1980 within the basin, as shown in Table IV.2.6. The number of workers in this sector went down at the average rate of 1.13% annually. On the other hand, the man powers in this sector in both the state and the nation in 1980 were 418,249 or 30.8% of the total and 12,661,017 or 29.3% respectively, as shown in Table IV.2.5 and IV.2.6. They also decreased at the average annual rate of 0.77% and 0.33%, respectively. Compared with these figures, the labor force in the basin has left much faster than that of other areas during the decade.

The industrial sector, the secondary sector, such as mining, manufacturing, construction and public utilities, employed the largest number of workers accounting for 47,351 or 25.9% of the total basin labor force in 1970 and for 113,318 or 39.8% in 1980. The average annual growth rate of the labor during the decade reached to 9.12%. This is bigger than

that of the country of 7.36%, but it is almost the same as the state of 9.43%. Therefore, the basin has been industrialized at the same speed as the state for the decade of the 70's.

The services' sector, the tertiary sector, such as commerce, transportation and communication, and various kinds of services in the basin absorbed 53,734 in 1970 and 94,040 in 1980 respectively, which accounted for 29.4% of the total labor force in 1970 and 33.0% in 1980. Since the rate of the same years in Santa Catarina were 29.1% and 34.7% respectively, the basin had almost the same experience with regard to services' sector but slightly slower growth than the state.

2.2.3 Cultural conditions

The colonization of southern part of Brazil has been influenced by immigration from Continental Europe. Before colonization, this part was left in natural and almost undeveloped conditions. In 1824, German colonized Sao Leopoldo. Afterwards, Germans and Italians came in succession to settle the south regions. The first settler from Germany to the basin colonized Blumenau in 1851 and succeedingly founded Brusque in 1960. Then some Italian immigrants settled near German villages. Besides Germans and Italians, other Europeans such as Polish and French immigrated into both near the German and Italian settlements and virgin areas. These settlements are now completely intermingled.

Owning to the unique historical background, population distribution by color in the basin is rather different from that of the country. Table IV.2.7 shows its characteristics. White people in the basin count for 96.4% of the total, but they occupied only 54.2% in the nation. Therefore, the original cultures founded by settlers seems to remain still unchanged. In fact, the center areas of the Colonial de Blumenau, including the municipality of Blumenau, still keep the German culture.

With respect to the level of education received by people, Table IV.2.8 shows the academic career of persons ten years old and over as of 1980. According to the table, the people attained the first four years (elementary (old system) or first half of the first grade(new system)) in the basin counts for 265 thousand or 74.2% of the persons who were graduated from some level of schools. This rate is comparatively bigger than the level of the country. However, the rate of higher educated people is smaller than that of the nation and the state.

On the other hand, it is said that 17% of the people five years old and over in the basin had no education or less than 1 year of study. This percentage is slightly smaller than that of the state (20%) and the country (35%) in 1980. Therefore, the basin is characterized as follows: people do not get higher education than the national average, but bottom level of education is lifted up as compared with the national level.

The most dominant religion in Brazil is Catholic. The rests are grouped into various sectors. According to the 1980 census, 89.0% of the national population was Catholic. Protestant ranked second (6.6%). These were followed by other sects of Christianity, oriental religions and Judaism as shown in Table IV.2.9. In the basin, however, religions distribution was different from the national average. Catholic was also dominant religion, but it occupied 80.3% of the total. Percentage of protestants counted for 18.1%. This is because of historical background, that is, because most of people in the basin came from Germany, Italy, and so on, where Protestant is overwhelming for a long time .

2.3 Economic Conditions

2.3.1 Gross Regional Domestic Product

Gross Domestic Product (GDP) in 1984 was about Cr$386,967x10^9 (US$211x10^9) which increased by about 222% as compared with that in the previous year, as shown in Table IV.2.10. Per capita GDP was Cr$2,946x10^3 (US$1,607) which showed an increase by about 214% than that in the previous year. However, real growth rates of GDP and per capita GDP were 4.5% and 2.4% respectively, as shown in Table IV.2.11. Compared with the negative growth rates of last three years, the national economy would be seen to recover gradually.

Gross Regional Domestic Product (GRDP) of the state of Santa Catarina amounts to Cr$14,855x10^9 (US$8.1x10^9) in 1984, which increases by 233% as compared with that in the previous year. GRDP accounts for 3.84% of GDP. Per capita GRDP is Cr$3,768x10^3 (US$2,056) which shows an increase in about 217%. The difference in current prices between the per capita GRDP and GDP aggregates Cr$822x10^3 and the per capita GRDP accounts for 1.23 times of the per capita GDP. For the past few years, the disparity between the two per capita values has gradually been increasing, as shown in Table IV.2.10.

Real growth rates of GRDP and per capita GRDP in 1984 are 4.0% and 2.1%, respectively. Although the regional economy grew a little faster than the national economy between 1977 and 1983, since 1983 the regional economy growth slowed down as compared with the national economy and the difference between the two per capita figures has decreased.

In the 70's in the national economy, a share of Gross Value Added (GVA) of the primary sector went down, because the government aimed at industrialization by means of import replacement industry since the 60's. On the other hand, the secondary sector, manufacturing sub-sector in particular, occupied 37.0% of GDP in 1970 and grew up to 38.9% in 1975 as shown in Table IV.2.3. However, in the 80's, Brazil has experienced serious economic stagnation. Then, the share of the secondary sector went down from 36.0% in 1980 to 35.1% in 1982. The tertiary sector grew up to 55.2% in 1970. Afterwards, financial sub-sector rapidly grew, so the share of the tertiary sector to GDP enlarged to about 60%. Since the government shifted its policy from import replacement to export promotion measure, the leading export products have changed from basic primary goods to industrialized products. Recently, industrialized products occupy near 60% of the total export. The government policy has promoted this economic growth. Yet, since 1982 when the government was confronted with serious financial problem, the national economy has deteriorated drastically, as shown in Table IV.2.14. As a result, this condition has brought about various economic disorders.

During the 70's the state economy has experienced high speed growth, as shown in Table IV.2.15. This was because the secondary sector made a significant increasing contribution to the regional economy. Indeed, the share of the secondary sector was 29.4% in 1970, but in 1980 it grew up to 37.9%, as shown in Table IV.2.13. Manufacturing sub-sector particularly contributed to the growth of GRDP in Santa Catarina. Although the primary sector had a modest rate of growth, its share to GRDP decreased during the 70's. The tertiary sector grew, at almost the same rate as the growth of GRDP. Then, this sector kept almost the same share to the regional economy.

2.3.2 Family income and expenditure

According to the 1980 census, an average monthly income of the country was 4.8 times of the minimum wage. In 1980, the government suggested the minimum wage of Cr$4,419.60 during six months from May to October, so the average income was Cr$19,918 at current prices. In the basin, the average monthly family income was 5.0 times of the minimum wage, i.e. Cr$20,748. The average family income in the basin is slightly higher than the national average. Fig. IV.2.5 shows a distribution of the family income of the country, Santa Catarina and the basin. According to this graph, a deviation of the basin income from the average is quite small as compared with the national distribution. This means that the wages in the basin come into an equalizing tendency earlier than in the whole country.

As for household expenditure, Table IV.2.16 shows its distribution by expenditure group in Florianopolis, the state capital of Santa Catarina. This was investigated in 1981 into 355 families whose income level belonged to 6.5 to 10 times of the minimum wage. Engel's coefficient was 47.4%. Expenditure for housing was 7.7%. Regarding personal property such as household furnishings and equipment, clothing & other wear, and personal effects, 17.0% of the total expenditure was spent for it at that time.

2.3.3 Prices

In the early 70's, inflation in Brazil became calm to less than 20% per annum. Since the end of 70's, however, Brazil has been suffering from serious inflation. It was put on record as follows: 211% in 1983; 239% in 1984; and 235% in 1985 as shows in Table TV.2.17. Also in Santa Catarina, inflation spread over the state. Consumer prices in Florianopolis, the state capital, increased as the same as the inflation in the country as follows: 183% in 1983; 205% in 1984; and 156% in 1985. After declaration of "Plano do Cruzado" on February 28, 1986, price inflation went down and the prices seems to be stable so far. In fact, price inflation rate went down to 0.76% at monthly average between March and July in 1986, in spite of the fact that the monthly average inflation rate between December 1985 and February 1986 was recorded at 14.4%.

2.3.4 Budgetary conditions

The revenue of the federal government accrues from economic activities in the country through taxation system. Since GDP is a result of those activities, the revenue and GDP are closely related with each other. Table IV.2.18 shows relation between the federal revenue and GDP in the country during the latest 15 years. The revenue has accounted for 9.02% of GDP to 10.94% (average 9.90%) since 1970.

In general, flood control facilities are established by the public sectors such as federal government and state government. Therefore, the public investment policy is quite significant to externalize the flood control facilities. The policy is usually reflected in their budget and disbursement.

Table IV.2.19 shows actual disbursement for water related infrastructure and flood control facilities by the federal government from 1980 to 1984. Although the table does not include the disbursement by the state government, the amount spent by the state is too small to install a flood control facility. Incidentally, the state disbursed Cr$35x$10^6$ or 0.004% of the total disbursement in 1984. This amount also accounts for

0.40% of the disbursement for flood control by the federal government, i.e., the 14th regional office of DNOS.

The disbursement for water related infrastructure, including flood and drought control, occupied about 3.0% to 4.6% of the total amount during 1980 to 1984. Once limited it to flood control only, its rate decreased 0.5% to 1.0% of the total disbursement during the same period. Incidentally, the 14th regional office of DNOS spent Cr$8,690x10^6 for flood control in 1984, which accounted for 0.026% of the total national disbursement.

2.4 Sectoral Economic Profile

2.4.1 Agricultural Sector

Agricultural sector is generally divided into five categories; crop production, livestock production, fishery, forestry and rural industry. The total amount of the production in the primary sector in the basin is Cr$13,340x10^6 in 1980 as shown in Table IV.2.20, of which crop production accounts for Cr$8,023x10^6 or 60% of the total and livestock production accounts for Cr$2,917x10^6 or 22%, followed by fishery (Cr$1,077x10^6 or 8%), forestry (Cr$751x10^6 or 6%) and rural industry (Cr$571x10^6 or 4%). The total amount of the basin accounts for 14% of that in the state of Santa Catarina of Cr$96,569x10^6.

(1) Crop production

The main crops cultivated in the basin are rice, maize, cassava, beans, onion, sugar cane and tobacco. Harvested area, unit yield and production of these crops in the basin are shown in Table IV.2.21 for 1980 and Table IV.2.22 for 1984 together with those records in Santa Catarina.

Rice is cultivated with the area of 27,000 ha in 1984 mainly in the flat low land along the river courses. Since most of the rice field in the basin is irrigated by a gravity system and with use of the fertilizer, the unit yield of 4.2 tons per ha is higher than that in Santa Catarina of 3.3 tons per ha. The production of rice in the basin was 114,000 tons in 1984, which shares about 25% of Santa Catarina. Maize is cultivated for feed stuff in the upland through the basin. The harvested area of maize in 1984 was 67,000 ha and the production was 167,000 tons. Cassava is cultivated on the upland through the basin. Its harvested area and production in the basin in 1984 were 22,500 ha and 341,000 tons, respectively. Onion is cultivated mainly in the upland of the Itajai do Sul river basin, one of the main producers of onion in Santa Catarina. The harvested area and production in the basin in 1984 were 8,900 ha and 85,000 tons respectively, and this production contributed to 76% of that of the whole state. Beans are cultivated in the upland of the middle and upper reach of the Itajai river. The harvested area and production in 1984 were 49,000 ha and 44,000 tons, respectively. Sugar cane plantation spreads over the lower reach of the Itajai river with the area of 4,200 ha. Under the proper management including drainage and fertilizer input, their performance with the unit yield of 57 tons per ha in this area is higher than that of 48 tons per ha in the state. The production in the basin was 240,000 tons in 1984. Tobacco field is distributed in the upland of the middle and upper reach of the Itajai river. The harvested area and the production in the basin in 1984 were 35,000 ha and 58,000 tons respectively, which shared 39% for the harvested area and 38% for the production in the state.

The amount of crop production in the basin in 1980, reached Cr$1,065x10^6 for rice, Cr$1,159x10^6 for maize, Cr$1,020x10^6 for cassava, Cr$401x10^6 for beans, Cr$1,553x10^6 for onion, Cr$168x10^6 for sugar cane, Cr$1,907x10^6 for tobacco and Cr$749x10^6 for other crops as shown in Table IV.2.23. Therefore, the crop production in the basin aggregated Cr$8,022x10^6 in total, accounting for 18% of that in the state.

(2) Livestock Production

The important livestock and its products in the basin are cattle, pig, chicken, milk and egg. Their production in the basin and Santa Catarina in 1980 is shown in Table IV.2.24. The numbers of livestock produced in the basin in 1980 were: 58,000 for cattle; 226,000 for pig, 7,575,000 for chicken; 2,000 for horse; 3,000 for sheep; and 1,000 for caprine. Livestock products in the basin in the same year were: 66,000 kl for milk, 11 tons for wool; 7,600x10^3 dozen for egg; and 100 tons for bee products.

The amount of the livestock production and its products in the basin in 1980 attained to Cr$583x10^6 for cattle, Cr$637x10^6 for pig, Cr$753x10^{6}for chicken, Cr$655x10^6 for milk, Cr$202x10^6 for egg and Cr$86x10^6 for others. Therefore, the total amount in the basin was Cr$2,917x10^6, accounting for 7% of that in the state of Cr$39,619x10^6, as shown in Table IV.2.25.

(3) Fishery

There are two big fishing ports at the rivermouth of the Itajai river: Itajai and Navegantes. Fishery activity in the basin is limited to these two ports. Fishing production in the basin in 1980 was: 80,000 tons for fish, 1,300 tons for crustacean and 4,200 tons for mollusk, as shown in Table IV.2.26. This production shared more than 70% of that in the state of 118,000 tons.

The amount of the fishery production in the basin in 1980 is shown in Table IV.2.27. It is Cr$767x10^6 for fish, Cr$199x10^6 for crustacean and Cr$112x10^6 for mollusk. Therefore, the total amount of the fishery production attained to Cr$1,077x10^6, accounting for about 50% of that in the state of Cr$2,143x10^6.

(4) Forestry

Forestry production in both the basin and Santa Catarina in 1980 is shown in Table IV.2.28. Products from natural forest in the basin is 5,219 tons of mate, 1,201x10^3 m^3 of firewood, 307x10^3 m^3 of timber and 253 tons of palm cabbage. Products from reforested area is 6x10^3 m^3 of firewood, 19x10^3 m^3 of timber and 1,679x10^3 units of seedlings. As compared with the state, products from natural forest in the basin is relatively more than those from reforested area.

The amount of the forestry production in the basin in 1980 was Cr$724x10^6 for products from natural forest and Cr$26x10^6 for those from reforested area, as shown in Table IV.2.29, while the amount in the state in the same year was Cr$4,216x10^6 and Cr$2,528x10^6, respectively. Therefore, the forestry production in the basin in 1980 summed up to Cr$751x10^6 in total, accounting for 11% of that in the state.

(5) Rural industry production

The main products of rural industry in the basin are meat, cheese, lard, tobacco, cream, and cassava related. The amount of these products in the basin in 1980 are Cr$162x10^6 for meat, Cr$103x10^6 for cheese and lard respectively, Cr$41x10^6 for tobacco, Cr$37x10^6 for cream and Cr$34x10^6 for cassava related products, as shown in Table IV.2.14. The total amount of rural industry production in the basin in 1980 is Cr$571x10^6 which accounts for 17% of that in the state of Cr$3,312x10^6.

2.4.2 Industrial Sector

The state of Santa Catarina occupies an important position in the national economy. The production of the secondary sector is composed of four sub-sectors, having following distribution in 1980: mining with GVA of Cr$4.5x10^9 or 2.9% of GVA in the secondary sector; manufacturing with Cr$131.3x10^9 or 86.9%; construction with Cr$13.4x10^9 or 9.9%; and public utilities with Cr$2.3x10^9 or 1.5%. Accordingly, manufacturing sub-sector, accounting for 86.9% of the state's industrial product, characterizes the industrial sector in the basin. According to the industrial census in 1980, the major industrial types, occupying about 65% of the value of manufacturing and mining production, are (1) textile; (2) clothing, shoes and woven articles; (3) food products; and (4) lumber. They account for approximately 37%, 18%, 8% and 5% of the value of the basin total receipts, as shown in Table IV.2.31. They also account for approximately 79%, 60%, 12% and 16% of the value of the each total receipts in the state, respectively. The basin accounts for 23.5% of the number of establishments in the state as shown in Table IV.2.32 and 30.6% of the employed persons as shown in Table IV.2.33. Incidentally, the basin accounts for 18.9% of the state population and 15.9% of the state area.

The four major industrial types in the basin mentioned above occupy 6.9%, 5.6%, 0.6% and 2.7% of the value of the national total receipts. The basin on the whole accounts for 1.3% of the number of industrial establishments in the whole country and 1.7% of the employed persons. The basin also has 0.56% of the national population and 0.18% of the national land.

In absolute terms, the manufacturing and mining sub-sectors of the basin have 2,682 establishments, 84,747 employed persons, and total receipts of Cr$116,240x10^6 in 1980. Accordingly, since the state receipts of these sub-sectors was Cr$382x10^9 and GVA of the same sub-sector was Cr$136x10^9 as shown in Table IV.2.13, the gross gain of the sub-sectors accounted for 35.6% of the total receipts. Therefore, GVA of the manufacturing and mining sectors in the basin might be Cr$41,369x10^6, supposing profit rate in the basin was the same as in the state.

The Colonial de Blumenau micro-region is the most important among the entire micro-regions in Santa Catarina. It occupies the first position at the level of the micro-region, in terms of the number of establishments, employed persons and value of receipts. It accounts for 60.0% of the number of establishments in the basin, 70.0% of employed persons and 84.2% of value of receipts, respectively. The most important municipalities in the industrial sector are: Blumenau (67%); Brusque (13%); and Gaspar (8%). Figures above in parentheses are the rates of receipts of each municipality to the Colonial de Blumenau micro-region. The municipality of Blumenau is considered as a prominent district in terms of industrial production.

The main industrial types in the municipality of Blumenau are: textiles (44.1%); clothing, shoes and woven articles (28.3%); and food products (2.7%). Figures in parentheses are the rates of receipts of each industrial type to that of the whole types in Blumenau.

It should be noted that the municipalities of Itajai, Timbo, Indaial, Ilhota, Rio do Sul and Ibirama are also playing an important part in the industrial production. The municipality of Itajai, with production structure oriented toward food products, non-metalic products and paper products, occupies the fourth position in the basin with receipts of 6.2% of the total in 1980. The other municipalities listed above, although with a lower receipt value, represent important economic roles in their respective micro-regions.

In Santa Catarina, coal mining plays the important economic role in mineral extraction. Its production occupies about 80% of the whole country. Although many other mineral resources stand out in the country, the Itajai river basin does not have a remarkable production of mineral resources.

Table IV.2.34 shows assets holdings of manufacturing industry in the basin as of December 31, 1980. An average manufacture in the basin, including mining sub-sector, had Cr$3,409x10^3 of equipment and production facilities, Cr$513x10^3 of installation, Cr$143x10^3 of office furniture, Cr$488x10^3 of transportation facilities and Cr$2,429x10^3 of its site and building, as its tangible fixed assets. At the same time, it stored Cr$4,576x10^3 as an inventory stock such as raw materials and manufactured products.

2.4.3 Services' Sector

The tertiary sector of the state is characterized by a large number of small establishments in general. In 1980, the average annual sales amount of commercial sub-sector in the basin was Cr$65.1x10^9 and that of service sub-sector was Cr$6.2x10^9, as shown in Table IV.2.35. These accounted for 29.2% and 20.9% of the state sales amount, respectively. Total amount of these two sub-sectors accounted for 28.2% of that of the state. The basin also had 20.1% of the number of establishments in the state as shown in Table IV.2.36 and 21.8% of the employed persons as shown in Table IV.2.37.

The total sales amount of commercial sub-sector in the state was Cr$223x10^9 in 1980 and GVA of the commercial sector in the state was Cr$41,636x10^6, as shown in Table IV.2.13. Accordingly, the gross gain of this sub-sector accounted for 18.7% of the total sales amount. Assuming that this rate was applied to the sales amount in the basin, GVA of the sub-sector would be Cr$12,161x10^6. On the other hand, GVA of the services' sector in the basin could not be figured out, because it was impossible to compare the sales amount of this sector with GVA. The services' sector in Table IV.2.35 constitutes "other services" sub-sector in Table IV.2.4, but its sales amount does not include the big portion of sales amount occupied by the independent professionals such as medical doctors and liberal professionals.

The Colonial de Blumenau is the most important in the sector in the basin, both in commercial activity and in services' activity; in the number of establishments, total employed persons and total sales amount. It occupies, in state terms, the first place in the commercial activity and the second place in the services' activity.

From the point of view of the tertiary sector, the main municipalities are Blumenau and Brusque, which account for approximately 85.5% of the total sales amount of the sector in the micro-region. Like other industrial sectors, Blumenau plays the most important role in this sector's activity, with total sales amount of Cr$24,843x10^6 in 1980. This amount occupies about 34.8% of the total sales amount in the basin and 9.8% of the state of Santa Catarina. Blumenau also accounts for 26.3% of the number of establishments in the basin and 36.3% of the employed persons.

The second municipality in importance in the basin is Itajai in Litoral de Itajai micro-region, which participated with Cr$27,365x10^3, 1,537 establishments and 7,317 employed persons in 1980. Of this total sales amount, Cr$26,147x10^3 came from the commercial sector. In particular, wholesale commerce contributed Cr$19,113x10^3 or 61.8% of the commercial sector. The amount of wholesale was much bigger than that in Blumenau of Cr$5,571x10^3. Fuel and lubricant are the principle components, representing the greatest wholesale income.

The third municipality in importance in the basin is Rio do Sul, with Cr$5,371x10^3 in total sales amount, 738 establishments and 3,960 employed persons in 1980. It is the most important in the Colonial do Alto Itajai micro-region, playing a leading role in economic activity for neighboring municipalities of Aurora, Agronomica, Laurentino, Rio do Oeste and Lontras.

Table IV.2.38 shows assets holdings of the tertiary sector in the basin as of December 31, 1980. An average establishment had Cr$413x10^3 of equipment, Cr$71x10^3 of office furniture and Cr$98x10^3 of vehicles. At the same time, it stores Cr$962x10^3 as inventory stock such as merchandise and trading goods.

2.4.4 Infrastructure

(1) Transportation

The Itajai river basin is located between national highways BR-101 and BR-116, the most important interconnecting routes between north and south regions of the country. BR-101 cuts the basin near its river mouth along the seashore line. BR-116 cuts the western neighborhood municipalities from the basin and connects the two southern capital cities, Porto Alegre and Curitiba.

Along the course of the Itajai river, BR-470 connects these two important highways. BR-470 plays an important role as a stem road of connecting major municipalities along the Itajai river. It also connects the basin to western parts of the state over BR-116.

As of 1985, the existing road network in the basin summed up to 14,604 km, which comprised national (205 km), state (926.7 km) and municipal (13,472 km) roads, as shown in Table IV.2.39. Of this total length, paved roads accounted for 610.4 km or 4.2%, broken down as follows: national, 205 km; state, 379 km; and municipal, 26 km. Others are still gravel or earth roads, of which 3,998 km is already improved but is not paved yet. Road density in the basin registered 0.959 km/km^2, which is slightly denser than that in the state average of 0.923 km/km^2.

Santa Catarina had a total of 533,998 registered motor vehicles in 1984. This means 133 vehicles per thousand population, as shown in Table IV.2.40. This figure is more than twice of the national average of 53.0 vehicles per thousand population. Of the total number, car

constitutes the biggest share at 66.8% while buses constitutes 0.6%. Therefore, in the basin, the dominant transportation might mainly rely not on public mass transportation system but on private vehicles.

The railway transportation does not exist anymore in the basin. It used to connect between Trombudo Central and Blumenau. From Blumenau, navigation connected to the maritime part of Itajai through the Itajai river. After completing BR-470 in 1971, it was extinguished. Blumenau used to function as a connecting point between upstream areas of Itajai river and Itajai city.

(2) Water supply

There are existing 44 municipal and industrial water supply systems within 39 municipalities in the basin in 1985, as shown in Table IV.2.41. The rest, 7 municipalities, do not have a piped water supply system,because their urban areas are not located in the basin. Of 44 systems, 39 systems are managed by Companhia Catarinense de Agua e Saneamento (CASAN) and the others, 5 systems in Blumenau, Brusque, Gaspar, Pomerode and Presidente Nereu, are maintained by individual public corporations named as Servico Autonomo Municipal de Agua e Esgoto (SAMAE). There are 439,402 persons covered by water supply systems, which constitutes about 84.2% of total urban population in the basin.

39 of 44 existing water supply systems got water source from surface streams such as rivers and springs in 1985. They took water approximately $3,321 \times 10^3$ m^3 per month on an average. All of them are processing water source through filtration and desinfection. Other 4 systems take source water from wells. According to the record, the typical household connected to the system consumed about 17.8 m^3 per month on an average in 1985.

(3) Electricity

Electricity in the basin is served by Centrais Eletricas de Santa Catarina S.A. (CELESC). The regional electric supply network, including the basin area, is connected to the interconnected system covering three grand-regions of Sudeste, Sul and Centro-Oeste. The basin receives energy through 138 KV transmission lines from J. Lacerda Thermoelectric Plant, and 138 KV, 230 KV and 500 KV lines from Joinville sub-station. All these lines are managed by Centrais Eletricas do Sul do Brasil S.A. (ELETROSUL).

There are three small hydro-electric powerplants in the basin, municipalities Blumenau and Rio dos Cedros. These are maintained by CELESC. CELESC also maintains distribution network to the consumers in the state, including the basin area. Electricity consumption in the basin in 1984 is illustrated in Table IV.2.42. Total consumption in the basin in 1984 was approximately $1,085 \times 10^6$ KWH/annum or 24% of the state consumption. 47% of the total was consumed in the municipality of Blumenau due to significant industries such as textile.

(4) Communication

According to Telecomunicacoes de Santa Catarina S.A. (TELESC), there were 126,210 telephone terminals in the state in 1982. They were broken down as follows: 66% for residential use; 33% for non-residential use; and 1% for public. On the other hand, there were 26,560 terminals in the basin in the same year. Once terminals were

distributed in the same conditions as in the state, 17,530 terminals would be connected to residences. The basin would have 702x10^3 of population, i.e., 167x10^3 households in 1982, so approximately 10% of total families in the basin had a telephone terminal in 1982.

In the Itajai river basin, a flood forecasting and warning system is managed by DNAEE, CEDEC, COMDEC and other organizations concerned. DNAEE originally installed a telemeter system, functioning as transmission of hydrological data from each site to a central station. Other organizations cooperate with each other in order that the system works well as a flood forecasting and warning system. Details of this system are illustrated in the sectoral report of "Flood Control Plan".

There are 18 medium-wave radio stations and 10 frequency modulation (FM) radio stations in the basin. The former are broken down as follows: 7 stations in the Colonial de Blumenau micro-region; 4 in the Colonial do Alto Itajai; 3 in the Litoral do Itajai; and 1 in the Colonial do Itajai do Norte. The latter are distributed as follows: 5 stations in the Colonial de Blumenau; 3 in the Colonial do Alto Itajai; and 2 in the Colonial de Itajai. There are also 2 TV broadcasting stations and 8 TV-transmission stations in the basin.

(5) Social Infrastructure

According to the Department of Education in the state government, there are 519 nursery schools/kindergardens, 1,406 first grade schools (which equal primary schools plus junior high schools), 81 second grade schools (which equal high schools) and 4 colleges/universities in the basin in 1985. Although the number of schools sounds comparatively large, that is because various scales of school are included. For instance, in rural area some schools have only two class rooms because of few pupils.

There are 33 hospitals and 78 clinics in the basin in 1985. 33 hospitals are distributed over 24 towns proper of 46 municipalities. These hospitals prepare 2,528 beds in total, which might be 4.5 beds per 1,000 inhabitants. 78 clinics are scattered over 40 municipalities in the basin.

According to the World Health Organization (WHO), the recommended population is that there should exist 5 hospital's beds per 1,000 inhabitants. Therefore, once the basin area is considered as a whole, a proportion of 4.5 beds per 1,000 inhabitants is somewhat lower than the WHO recommendation. This rate, however, is quite favorable as compared with the national rate of below 1 bed per 1,000 inhabitants.

2.4.5 Housing Conditions

In 1980, these were about 146 thousand houses in the basin. 98.1% of them were in good condition for living, but the rests were rustic and needed to be improved according to the result of the census. The rate of durable houses is higher than the national rate of 88%.

Table IV.2.43 shows the living conditions in houses. In 1980, 41.7% of households in the basin got water through a piped supply system. Although this rate is slightly higher than that of the state, it was still lower than the national coverage of 54.9%. Furthermore, there is no sewerage system in the basin as of August, 1986.

Popular fuel for cooking in the basin was LPG and firewood. This condition is almost the same as the whole country. In the basin and the state, firewood was still the dominant fuel despite the fact that the percentage of firewood went down for the decade. This might be the significant cause to cut down trees on a mountain.

Electrification was actively promoted in the basin, so the rate of electrified households grew from 63.5% in 1970 to 87.2% in 1980. This rate is much higher than the national average of 68.5%. On the other hand, telephone was not widely spread, and still backward compared with the national condition.

Regarding electric appliances, particularly refrigerator and television have come into wide use since 1970. Beside them, car has also spread all over the country. In the basin, more than one-third of households possess their own cars.

2.4.6 Resettlement Experience

DNOS started to condemn the land and houses submerged in the reservoir area of Norte dam, just after the implementation schedule was concreted in 1976. It has had a permanent commission for expropriation of owners from their estates which should be condemned for public welfare. It executed their duties on the basis of the federal law, "Generalidades sobre a Desapropriacao e os dez artigos iniciais (Principles for expropriation and ten articles) do Decreto-Lei 3365 de 21, 6, 1941".

Table IV.2.44 shows the results of compensation for lands and houses which are expropriated to be submerged in the reservoir of Norte dam. There were 221 lots, corresponding to 1,105.6 ha in total, in the reservoir area. DNOS spent them Cr$141,076x10^3 in current prices for compensation. That amount might be equivalent to about Cr$12,121x10^6 in prices of the end of 1985. An average lot had about 5.0 ha of land and was indemnified at Cr$54.9x10^6 in 1985 prices. Therefore, unit cost for compensation was approximately Cr$1.1x10^3/m^2 in 1985 prices. Incidentally, there were 411 lots in a reservoir of Sul dam.

2.5 Present Land Use

2.5.1 General

A land use map of Itajai river basin is not available in any agencies concerned, though some of them are trying to make the one for their projects. Therefore, a land use map was made on the basis of the topographic maps published by IBGE in a scale of 1:50,000, of which cartographic sources were aerial photographs taken in 1966. Furthermore, aerial infrared photographs taken in 1979 in a scale of 1:45,000 were utilized to update the land use information. The land use map was formulated on 2 km x 2 km meshes. The land use was roughly classified into three land use categories : forest area; residential area; and other area including cultivated land. The land use information for some particular areas like newly developed areas was supplemented by site inspection.

According to the land use map, forest areas are mainly limited to the steep mountain range such as Itajai mountains which separates between the Itajai river basin and the Itajai Mirim basin, Moema mountains, the northern basin boundary in Itajai do Norte river basin and Geral mountains, the western-most of the basin. Major cities and towns, i.e., built up areas, are located mainly along Itajai river and are connected to each other with the federal road BR-470. Other area including agricultural land

are spread over the fluvial lowland along the main river courses and in the gently undulating field to undulating hill, especially in Itajai do Sul river and the Itajai do Oeste river basin. Deforestation problem is getting more and more serious in these days because of the excessive cutting of trees in the mountainous area. Incidentally, the land use in the basin shown in Fig. IV.2.6 is roughly enumerated as follows: Forest area with 2,224 meshes or 8,896 km2; built-up area with 74 meshes or 296 km2; and other areas with 1,506 meshes or 6,024 km2.

2.5.2 Present land use

The census of agriculture in 1980 by IBGE shows agricultural land use in the basin. Although it covers 10,878 km2 or 72% of the basin area, it does not give any information of land use except agricultural use. In any case, however, urban areas are included in these other areas. So, urban areas were demarcated on the topographic map on the basis of built-up information on the map. The rest areas are not identified with regard to land use. Table IV.2.45 shows the present land use made through syntheses of aforesaid information in 1980.

Of the total area of 10,878 km2, 9,048 km2 was used for agricultural activities. The rests were not utilized at that time or were not suitable for agricultural production such as river bed or steep slope. Each agricultural activity, i.e., crop land, pasture land and forest land, occupied almost equal area of 3x103 km2. Agricultural land use is summed up as follows:

(Unit: km2 (%))

Micro-Region	Total Area	Residential Area	Crop Land	Pasture Land	Forest Land	Other Area
Litoral de Itajai	668 (100.0	26.9 (4.0)	88.4 (13.2)	123.4 (18.5)	99.1 (14.8)	330.2 (49.5)
Colonial de Blumenau	5,380 (100.0)	92.4 (1.7)	841.8 (15.6)	719.7 (13.4)	1,266.5 (23.5)	2,459.4 (45.8)
Colonial do Itajai do Norte	1,670 (100.0)	6.3 (0.4)	327.7 (19.6)	310.5 (18.6)	347.8 (20.8)	677.7 (40.6)
Colonial do Alto Itajai	4,466 (100.0)	25.9 (0.6)	1,182.8 (26.5)	1,050.3 (23.5)	742.2 (16.6)	1,464.8 (32.8)
Colonial Serrana Catarinense	840 (100.0)	- (0.0)	140.3 (16.7)	231.6 (27.6)	121.3 (14.4)	346.8 (41.3)
Campos de Lages	310 (100.0)	- (0.0)	17.2 (5.5)	164.3 (53.0)	81.0 (26.1)	47.5 (15.4)
Planalto de Canoinhas	1,887 (100.0)	- (0.0)	451.3 (23.9)	330.4 (17.5)	410.2 (21.7)	695.1 (36.9)
Total	15,221 (100.0)	151.5 (1.0)	3,049.5 (20.0)	2,930.2 (19.3)	3,068.0 (20.2)	6,021.8 (39.5)

The most exploited micro-region is Colonial do Alto Itajai, which means that the rate of exploited area such as urban area, crop land and pasture land to the total area is the biggest. The exploited area accounts for 50.6% in that micro-region. In particular, crop land occupies the large area as compared with other micro-region. In this micro region, upland crop production is outstanding in the basin, such as maize, cassava, onion, beans and tobacco. Pasture land also occupies a big area in this micro-region, where stockbreeding is widely spread over the gently undulating field. From the point of exploited area, following municipalities are the most noticeable in this micro-region: Rio do Sul, Rio do Oeste, Petrolandia, Laurentino, Imbuia and Aurora.

Colonial de Blumenau is the most urbanized micro-region in the basin. Although agricultural activity does not occupy a prominent position in the basin economy, lowland crop such as rice is produced in this micro-region, in particular. Sugar cane field also is spread over this lowland area. Lowland field is spread along the downstream of Itajai river and its tributaries. This micro-region still has slightly wide forest area as compared with other micro-regions.

The areas along the middle and lower reaches of the Itajai river are prone to inundation, due to the inadequate capacity of the present river channel. The flood vulnerable area covers the lowlands and the areas along the middle and lower reaches of the Itajai river and the Itajai Mirim river, and the areas along the lower reaches of the Itajai do Sul river, the Itajai do Norte river, the Itajai do Oeste river and the Benedito Novo river. In order to clarify the regional distribution of the land use pattern in the flood vulnerable areas, a detailed study was made by using a systematic mesh map. Table IV.2.46 presents the land use of areas divided into 25 river stretches which are boundaries demarcated by both flood plain characteristics and river conditions. As seen from the table, it is clear that paddy fields and sugar cane area planted in the lower and middle reaches of the rivers, but that other crops and pasture lands are scattered all over the flood vulnerable basin. The land use pattern in flood vulnerable areas is shown in detail in Fig. IV.2.7. The flood vulnerable area encompasses a total area of 289 km^2, which accounts for 1.9% of the area or about 2.8% of crop lands in the basin, and is inhabited by 264x10^3 of residents or 39.3% of the basin population. The population and land use of the flood vulnerable area in 1980 are shown in the table below:

Item	Basin Total	Flood Vulnerable Area	Percentage (%)
Population	670,958	264,000	39.3
Area (ha)			
- Paddy	30,512	2,275	7.5
- Sugar cane	4,123	3,718	90.2
- Other crops	270,316	2,543	0.9
- Pasture	293,022	7,255	2.5
- Residential area	15,150	5,819	38.4
- Other area	908,977	7,308	0.8
Total	1,522,100	28,918	1.9

The flood vulnerable area includes 2,275 ha of paddy fields, which are widely distributed on the areas of the middle and lower reaches of the Itajai river, the Itajai do Oeste river and the Itajai Mirim river. The paddy fields in the flood vulnerable areas accounts for 7.5% of all the

paddy fields in the basin. Since rice production is one of the important crops in the basin and rice is the most vulnerable to flood hazard especially in the early stage of planting, the production of paddy fields from flood damage might be quite important as compared with other crops.

The sugar cane in the flood vulnerable area is cultivated mostly in the lowland of the Itajai river with the area of 3,718 ha, which accounts for 90.2% of the basin total. Therefore, almost of sugar cane production seems to be executed in the flood vulnerable area. The sugar cane itself, however, seems to be comparatively tough to flood damage.

Residential area occupies 8,519 ha in the flood vulnerable area, which accounts for 38.4% of the total residential areas in the basin. This percentage is almost the same as the rate of population in the basin, despite the fact that the flood vulnerable area accounts for only 1.9% of the basin total area. It proves that the flood vulnerable area is more urbanized and thickly inhabited than other upland areas.

2.5.3 Deforestation

Forest generally plays an important role of flood control as well as soil conservation. It retards rainfall to run off from forest area in mountain side and also reduce the amount of surface runoff. Besides it protects soil from water erosion hazard. Because leaves of trees trap the rainfall at first and do not allow that to attack the ground directly. Rainfall, therefore, reaches to the ground slowly and gradually. This retards rainfall to run off and increases the amount of water to permeate into the soils. Soft attack of rain to the ground reduces the water erosion of soils.

Deforestation, however, deteriorate this function of forest. The reasons for forest degradation were enumerated in general as follows:

- Sprawl by urbanization and industrialization;
- Development of farmland;
- Deforestation; and
- Excessive use of agricultural chemicals.

The basin has been abundant in forest resource. In the last 20 years, it is said that forest has degraded at alarming rate in the basin. The high speed economic development has brought about the rapid industrialization and urbanization, and also development of farm lands in the basin. Although these phenomena are still going on in the whole basin, more serious causes for forest degradation in these days would be deforestation, followed by shifting cultivation. Major purposes for deforestation are to produce raw materials for timber, firewood, charcoal, furniture and ship building. As seen in Table IV.2.45, the remaining forest are in mountain area of Itajai mountains and Moema mountains. Cutting for timber seems to occur mainly in these areas nowadays. Felling for firewood and charcoal is done in the whole basin. Because firewood is quite popular as fuel for family cooking, as mentioned in the section 2.4.5, "Housing conditions". Lumber for both furniture and ship building comes from other states or other countries in general. Deforested area for timber production in the basin as of 1980 is roughly estimated at 3,070 ha, based on the timber production data of 307x103 m^3 by IBGE census and the general production of natural forest of 100 m^3/ha by IBDF information.

IBDF is a federal authority and in charge of management of forest resources. It has two important functions: to give permission of deforestation and to promote reforestation; and to keep an ecological balance in forest areas. In Santa Catarina state, there is one state head office in Florianopolis and are sixteen (16) regional offices. Two (2) regional offices are in the basin: Rio do Sul and Itajai. The number of technical staff in the state is only thirteen (13). On the other hand, about 600 of deforestation permits are applied to the state IBDF regional offices near-by annually by timber companies. Although, some officer has to go to the site to check each application, it is very hard to do so for lack of staff. Under such condition, it is said that sometimes there is a big difference between the applied area for cutting and the actual cut area.

At present there are two laws to conserve ecological system of forest: "Codigo Florestal, Lei no. 4771" and "Protecao a Fauna, Lei no. 5197". The former, in particular, defines the areas to be permanently reserved. They are:

(1) along the river or water course with minimum band width is

- 5 m for river of less than 10 m width
- equal to the river width which is between 10 m and 200 m
- 100 m for river of more than 200 m width,

(2) surroundings of lagoon, lake or water reservoir,

(3) spring or well, wherever topographic condition is,

(4) top of hills and mountains and mountain ridge,

(5) whole hill or a part of hill with inclination of more than 45 degree,

(6) rows of trees for fixing dunes or for establishing mangroves,

(7) edge of the table land or plateau,

(8) with altitude of more than 1800 m, natural or artificial grassland, natural forest and campestral vegetation,

(9) forest which is integrated with indigenous species.

However, some part of these areas seems not to be kept well some people concerned.

Recently, some local authorities and institutes were aware of these serious conditions and just started to figure out the ecological balance in forest land and to control the deforestation. For example, the municipality of Brusque, considering one of the causes of 1984 flood damage be excessive cutting of trees, has studied the land use and land slope of the Itajai Mirim river basin in cooperation with Santa Maria University in the state of Rio Grande do Sul, and recommended the ideal land use according to the land slope. Associacao dos Recuperadores Florestais da Bacia do Rio Itajai (ARFRI) was organized to promote reforestation in the basin by major timber companies in 1984. Table IV.2.46 shows the result of forestation so far. As compared with estimated deforested area in the

basin of 3,070 ha as of 1980, reforested area in the same year was only 1,886 ha.

3. BASIN DEVELOPMENT FRAMEWORK

3.1 Basin's Role in the National Economy

3.1.1 Existing development plans

Since March 1985, the new civil government has announced two national economic plans; I. Plano Nacional de Desenvolvimento (I. PND: the First National Plan of Development); and Plano do Cruzado (The Cruzado Plan). I. PND is the first national development plan since the new government started in March 1985. The Cruzado Plan is first in force in February 1986 and the second step of the plan takes effect in July 1986. On the other hand, any regional development plans have not officially been presented by the state government of Santa Catarina or the municipal governments in the Itajai river basin.

I. PND concentrates on the social field. The plan recommends fighting poverty and unemployment as top and immediate priority. To resume employment and economic development and to raise wages, it is necessary to improve the productivity of industry and flexibility of wages and prices, which allow the markets faster adaptation and more absorption of labor. At the same time, the plan aims at recovering the economic growth of at least 6% annually to attain the said social objectives.

As regards domestic industry, the plan insists that the private sector takes the initiative in growing industrial production and that the public sector contributes only to the public services and to the long-term, strategic programs which are not adapted for the private sector. In place of the public sector enterprises which has been developed dependent on the government's credits, the private enterprises are expected to accelerate the national economy in keeping with emerging from poverty and abolishing earning differentials. Thus, the government stimulate the regional decentralization of the industries and support the small and medium industries of native capital. The plan expects that the industrial sector grows at the rate of 7% annually.

The agricultural sector is also expected to grow at the annual growth rate of at least 5%. The government promotes to cultivate new arable lands for internal food and exportation products. In addition to that, the government positively announces the agrarian reform in order to modernize the agricultural structure and to increase the productivity.

The first Cruzado Plan forced in February 1986 is essentially to abolish the indexation in the national economy. "Cruzado" is created as a unit of new currency instead of "Cruzeiro" to abolish/alleviate the main mechanism of automatic adjustment of prices and wages. Moreover, prices and exchange are frozen without time limit. As a result, average inflation rate went down to 0.76% between March and July 1986, in spite of the fact that for three months between December 1985 and February 1986 the monthly inflation rate was 14.4%.

The second Cruzado Plan in July 1986 is basically to increase the saving capacity of the government and to control the overheating of the Brazilian economy. So, the government create the forced saving for the unnecessities of living such as gasoline, new and used cars, and foreign exchange for going abroad. Based on the plan, the government expects the national economy will grow at the real rate of 6 - 7% thereafter up to the end of 1980's, although the prices may inflate at the rate of more or less 15% annually.

3.1.2 Potentials for development in the region

With regard to industrial production, the state of Santa Catarina plays an important role in the national economy, as mentioned in Section 2.4.2. The basin in particular has high degree of industrial accumulation, as compared with other areas. Especially, the manufacturing establishments have been located in the municipalities of Blumenau, Brusque and Gaspar in the Colonial de Blumenau micro-region. This expansionary tendency of industrial accumulation seems to continue in the future as well. This growth is also in accordance with the policy of the national development plan, I. PND. Thus, the municipalities having high degree of location will grow at the expected rate of the regional economy.

The tertiary sector will grow in proportion to the growth of industrial sector in areas of high degree of location. As a result, urbanization in the basin will proceed with economic growth. The Colonial de Blumenau will still stay in the most important position in this sector. Itajai will also play the important part of the commercial activity in both internal trade and foreign trade. And, its importance becomes much more than the before. Furthermore, Rio do Sul will also get an important role in commercial activity for not only neighboring communities in the upper parts of the basin but also western part of the state which is separated by Geral mountains. This marketing structure has been functioning since the national road network was established.

6,231 km^2 or about 40% of the basin area has been exploited for residential area, crop land and pasture land by 1980. Of this total, 3,030 km^2 is utilized for pasture land. This land, however, is not always used for livestock-breeding, and a considerable sum of this area is not utilized and is left as it is. Moreover, it is said that some portion of unidentified area in Table IV.2.45 is in the same condition as pasture land. In other words, although a fairly part of these lands will have to be reforested in order to keep ecological balance and to retard the rainfall to run-off, some part of them could be left for potential crop land. In particular, undulating plateaus in the Colonial do Alto Itajai and the Colonial do Blumenau look to have such a kind of area, so they might have high potentiality for crop production.

Expected economic growth will exceed more than expected population growth in the basin as well as in the country. Industrialization needs more labor force than the before, so the centralization of population will be accelerated into urban areas. Therefore, though urbanization has to be managed with deep care to keep away from urban problems such as environmental pollution, labor force distribution will work out by centralization of labor force and by a rise in labor participation rate because of female workers. On the other hand, the mechanization of agriculture will be promote to set force to remedy lack of labor force in rural area and to get secure of an expected value added in the agricultural sector. In the long run, labor force will be re-distributed in accordance with wealth distribution in the future.

3.2 Socio-economic Projection

3.2.1 Population

Future population in the basin and in Santa Catarina is officially projected by following agencies: IBGE; GAPLAN; and Ministerio de Saude (MS - Ministry of Health). Population projection comes under IBGE's jurisdiction. In 1985 Brazilian statistical yearbook (Reference E022), IBGE presents following two sets of population projection: (a) national

population in total figure up to the year 2025; and (b) municipal population for every municipality in the country in 1985. The methodology for projection is discussed in "Brazil, Estimaciones y Proyecciones de Poblacion 1980-2025: (Reference E112)", which is originally proffered by Latin-American Center of Population. GAPLAN estimates future population by municipality in the state of Santa Catarina up to the year 1990. They uses two methods as follows : (a) a logistic growth curve by Tchebycheff for a total population in the state; and (b) AiBi method for municipal distribution in the state, which is mentioned later. MS also presents future population by municipality in the whole country up to the year 1990, whose purpose is to estimate a demand of medicines in the future. Their methodology is close to that of GAPLAN.

Yet, an official population projection within the basin area for long term is not available. So, basin's population has to be projected in this study. To estimate basin's population up to the year 2020, following assumptions are laid down: (a) the state population would grow in proportion to the national population increases; and (b) the state population is distributed in accordance with the AiBi methodology.

Only IBGE has estimated future population for long term, though it is restricted to the national total population and IBGE has never broken down it to state level yet. Accordingly the future population in the state of Santa Catarina is assumed to occupy 3.0% of the national total hereafter, because the state population in 1960, 1970 and 1980 accounted for 3.02, 3.12% and 3.04% of the national one, respectively.

The AiBi methodology was proposed by Madeira, Goao Lyra and Simoes Cardoso de Silva of Rev. Brasileira de Estatistica in Rio de Janeiro. Basically, the municipal population also grows in proportion as the state population increases. Analytically, the municipal population is expressed as follows:

$$P_i(t) = a_i P_T(t) + b_i$$

where:

$P_i(t)$ - Population of municipality i in the year t;

$P_T(t)$ - Population of the state in the year t ;

a_i - Proportional coefficient of incremental municipal population in relation to the increasing state population; and

b_i - Constant for lineal correction.

According to this hypotheses, the municipal population is estimated after the two figures are determined, which satisfy at the same time corresponding expression of the census years 1970 and 1980.

Namely, for $t = t_0(1970)$; $P_i(t_0) = a_i P_T(t_0) + b_i$

for $t = t_1(1980)$; $Pi(t_1) = a_i P_T(t_1) + b_i$

So, $ai = \Delta P_i / \Delta P_T$

$$bi = [P_i(t_0) + P_i(t_1) - a_i\{P_T(t_0) + P_T(t_1)\}] / 2$$

So that, $\Sigma P_i(t) = \Sigma P_T(t)$

Results, $\Sigma a_i = 1$ and $\Sigma b_i = 0$

The two figures, ai and bi are worked out based on this process. Finally, every municipal population is estimated by the aforesaid equation using these figures.

Table IV.3.1 shows urban and rural population projection in the basin by micro-region up to the year 2020. Despite the fact that 64% of the basin population is in urban areas in 1980, 86% of the basin population will live in urban areas in 2020. Table IV.3.2 shows population projection by municipality up to the year 2020. According to this table, basin population will grow to $1,221 \times 10^3$, or 1.8 times of basin population in 1980 of 668,582. The leading municipality in the basin, Blumenau, grows the most rapidly among municipalities, i.e., from 152,518 in 1980 to 422×10^3 in 2020, or 2.8 times for 40 years.

3.2.2 Gross regional domestic product

As mentioned in the section 3.1.1, available national development plans are I. PND and the Cruzado Plan, both of which are officially effective as medium or short term development policy in the country. The former proposes that the national economy will grow at annual rate of 6% during four years, 1986-1989. At the present time, the latter expects that the national economy will attain the real annual growth of 6-7%.

Yet, any regional development plans are not available, as of August 1986. Accordingly, in order to project GRDP of Santa Catarina in the future, the following conditions are assumed because of data availability:

(1) Projection of GDP in the country for medium term is basically based on the aforesaid national development plans;

(2) Projection of GDP for long term refers to an UN report, that is, "Long term trends in economic development : Report of the Secretary-General, 26 May 1982". According to the medium growth scenario of the report, the petroleum importing economies in Latin America will grow at the annual rate of 5.9% during a decade of the 1980's and 6.0% during a following decade of the 1990's. Although there is no projection after the year 2000, the growth rate for that period is assumed to reduce to two-third of the projection in the previous decade;

(3) Percent share of the state product to the country will grow up to 4% by the year 1990 and will be steady at 4% thereafter. Incidentally, that rate has grown from 2.67% in 1970 to 3.91% in 1984, as shown in Table IV.2.11; and

(4) Industrial structure in the state, including the Itajai river basin, will continue as it is. Therefore, the growth rate of each economic sector will keep the same one as GRDP.

On the basis of these assumptions, GDP and GRDP in Santa Catarina are estimated as shown in Table IV.3.3. GRDP will reach to $Cz\$449 \times 10^9$ in the year 2000 and $Cz\$984 \times 10^9$ in 2020 at 1986 constant prices. Hence, GRDP in 1980 is converted into 1986 prices by implicit deflater (386 between 1980 and 1986) and denomination (Cr$1,000=Cz$1). Based on the foregoing population projection, per capita GRDP will grow from $Cz\$82.6 \times 10^3$ in 2000 and $Cz\$138.9 \times 10^3$ in 2020. These figures correspond to 1.9 times in 2000 as large as per capita GRDP in 1980 of 42.6×10^3 at 1986 constant prices and 2.7 times in 2020 as well.