Table V. 4. 28 THE NUMBER AND ANNUAL INCREASE RATE OF INDUSTRIAL ESTABLISHMENT PER 25HA BY RIVER STRETCH

River Stretch	Urban 1986	Urban 2000	Urban 2020	Rural 1986	Rural 2000	Rural 2020
IT 1	2.3 (1.8)	3.0 (0.0)	3.1	0.00 (-)	0.00 (-)	0.00
IT 2	2.4 (1.8)	3.2 (0.0)	3.3	0.04 (1.6)	0.05 (0.9)	0.06
IT 3	2.5 (-1.6)	2.0 (-)	2.0	0.02 (-)	0.02 (-3.4)	0.01
IT 4	2.5 (-1.6)	2.0 (-)	2.0	0.02 (-)	0.02 (-3.4)	0.01
IT 5	7.1 (1.9)	9.3 (0.0)	9.3	0.04 (1.6)	0.05 (1.7)	0.07
IT 6	7.1 (1.9)	9.3 (0.0)	9.3	0.04 (1.6)	0.05 (1.7)	0.07
IT 7	5.3 (0.0)	5.3 (0.0)	5.3	0.10 (1.9)	0.13 (1.0)	0.16
IT 8	4.7 (0.2)	4.8 (0.1)	4.9	0.06 (1.1)	0.07 (1.3)	0.09
IT 9	4.7 (0.2)	4.8 (0.1)	4.9	0.01 (-)	0.01 (-)	0.01
IT 10	0.0 (-)	0.0 (-)	0.0	0.02 (-)	0.02 (-)	0.02
IT 11	3.9 (4.1)	6.8 (2.9)	12.1	0.03 (3.7)	0.05 (3.0)	0.09
IT 12	3.6 (·	3.5 (·	3.4	0.01 (-)	0.01 (-)	0.01
IT 13	3.2 (·	3.2 (-)	3.2	0.03 (-)	0.03 (-)	0.03
			2.5			
IS 1	2.4 (0.2)	2.5 (0.0)	2.6	0.07 (-)	0.07 (-)	0.07
IS 2	0.0 (-)	0.0 (-)	0.0	0.00 (-)	0.00 (-)	0.00
IS 3	2.7 (-1.5)	2.2 (-1.9)	1.5	0.02 (-)	0.02 (-3.4)	0.01
IN 1	3.9 (-2.1)	2.9 (-2.4)	1.8	0.00 (-)	0.00 (-)	0.00
IO 1	2.2 (-)	2.2 (0.2)	2.3	0.04 (-)	0.04 (-)	0.04
IO 2	2.4 (0.6)	2.6 (-)	2.6	0.04 (-)	0.04 (-)	0.04
BN 1	8.2 (0.9)	9.3 (0.9)	11.1	0.01 (-)	0.01 (-)	0.01
IM 1	2.7 (1.9)	3.6 (0.0)	3.6	0.08 (1.6)	0.10 (1.3)	0.13
IM 2	2.7 (1.9)	3.6 (0.0)	3.6	0.08 (1.6)	0.10 (1.3)	0.13
IM 3	0.0 (-)	0.0 (-)	0.0	0.00 (-)	0.00 (-)	0.00
IM 4	0.0 (-)	0.0 (-)	0.0	0.01 (-)	0.01 (5.6)	0.03
IM 5	6.9 (2.5)	9.7 (0.5)	10.7	0.05 (3.4)	0.08 (1.6)	0.11

Note: Parentheses indicates an annual increase rate of buildings.

Table V. 4. 29 THE NUMBER AND ANNUAL INCREASE RATE OF BUILDINGS IN COMMERCIAL SECTOR PER 25HA BY RIVER STRETCH

River Stretch	Urban			Rural		
	1986	2000	2020	1986	2000	2020
IT 1	9.5 (2.7)	13.6 (0.9)	16.4	0.00 (-)	0.00 (-)	0.00
IT 2	10.4 (2.7)	15.0 (0.9)	17.9	0.06 (-1.3)	0.05 (-)	0.05
IT 3	4.8 (0.1)	4.9 (-)	4.8	0.03 (-2.8)	0.02 (-)	0.02
IT 4	4.8 (0.1)	4.9 (-)	4.8	0.03 (-2.8)	0.02 (-)	0.02
IT 5	8.8 (3.5)	14.3 (0.3)	15.3	0.05 (-)	0.05 (-1.1)	0.04
IT 6	8.8 (3.5)	14.3 (0.3)	15.3	0.05 (-)	0.05 (-1.1)	0.04
IT 7	15.6 (0.0)	15.6 (0.0)	15.6	0.03 (-2.8)	0.02 (-)	0.02
IT 8	7.7 (2.8)	11.4 (1.6)	15.8	0.03 (-2.8)	0.02 (-)	0.02
IT 9	7.7 (2.8)	11.4 (1.6)	15.8	0.02 (-)	0.02 (-3.4)	0.01
IT 10	0.0 (-)	0.0 (-)	0.0	0.03 (-2.8)	0.02 (-3.4)	0.01
IT 11	2.1 (3.3)	3.3 (1.8)	4.7	0.01 (-)	0.01 (-)	0.01
IT 12	5.6 (2.8)	8.2 (1.5)	11.1	0.01 (-)	0.01 (-)	0.01
IT 13	9.9 (2.6)	14.1 (0.6)	15.9	0.02 (-4.8)	0.01 (-)	0.01
IS 1	8.6 (2.3)	12.1 (0.5)	13.5	0.03 (-2.8)	0.02 (-)	0.02
IS 2	1.9 (1.1)	2.2 (-)	2.2	0.02 (-)	0.02 (-)	0.02
IS 3	7.9 (2.5)	11.2 (1.7)	15.7	0.00 (-)	0.00 (-)	0.00
IN 1	8.0 (2.7)	11.6 (0.8)	13.6	0.00 (-)	0.00 (-)	0.00
IO 1	5.1 (2.4)	7.1 (0.5)	7.9	0.02 (-)	0.02 (-)	0.02
IO 2	2.9 (0.2)	3.0 (-)	3.0	0.02 (-)	0.02 (-3.4)	0.01
BN 1	8.8 (3.3)	13.8 (1.0)	16.8	0.02 (-)	0.02 (-3.4)	0.01
IM 1	12.4 (2.7)	17.9 (0.7)	20.9	0.05 (-)	0.05 (-)	0.05
IM 2	12.4 (2.7)	17.9 (0.7)	20.9	0.05 (-)	0.05 (-)	0.05
IM 3	0.0 (-)	0.0 (-)	0.0	0.00 (-)	0.00 (-)	0.00
IM 4	0.0 (-)	0.0 (-)	0.0	0.05 (-)	0.05 (-)	0.05
IM 5	10.1 (1.7)	12.8 (0.7)	14.8	0.01 (-)	0.01 (3.5)	0.02

Note: Parentheses indicates an annual increase rate of buildings.

Table V.4.30 THE LIVESTOCK VALUE IN 1986 BY RIVER STRETCH

Unit : million Cz$

River Stretch	Municipality	Live stock value per 25ha
IT 3	Ilhota	0.02
IT 4	Ilhota	0.02
IT 5	Gaspar	0.10
IT 6	Gaspar	0.10
IT 7	Blumenau	0.08
IT 8	Blumenau	0.08
IT 9	Indaial	0.04
IT 10	Indaial, Rodeio	0.08
IT 11	Ascurra	0.06
IT 12	Indaial, Lontras	0.07
IT 13	Lontras, Rio do Sul	0.12
IS 1	Rio do Sul, Aurora	0.14
IS 2	Aurora, Ituporanga	0.09
IN 1	Ibirama	0.05
IO 1	Rio do Sul, Agronomica	0.10
IO 2	Agronomica, T. Central	0.09
BN 1	Indaial, Timbo	0.08
IM 1	Itajai	0.06
IM 2	Itajai	0.06
IM 3	Itajai	0.06
IM 4	Itajai, Brusque	0.04
IM 5	Brusque	0.03

Note: Livestock value by river stretch is estimated by the weighed average based on livestock value by municipality shown in Table V.4.19 and the number of E meshes shown in Table V.4.1.

Future livestock value is assumed to increase in proportion to the growth rate of GRDP share by primary sector.

1986-2000 3.7%p.a.
After 2000 2.6% p.a.

Table V.4.31 FLOOD DAMAGE RATE

Building and Indoor movables

Item	Below Floor Level	0-0.5m	0.5-0.9m	1.0-1.99m	2.0-2.99m	Over 3.0m
1.Building	0.03	0.053	0.072	0.109	0.152	0.22
2.House hold effects	0.00	0.086	0.191	0.331	0.499	0.69
3.Properties	0.00	0.154	0.295	0.339	0.509	0.597

Note: *1 Sloop less than 1/1000

Agriculutural Crops

Depth	Duration (days)	Paddy	Average of Damage Rate(Upland Crop)	Sugarcane
Less than 0.5m deep	1-2	0.21	0.27	0.00
	3-4	0.30	0.42	0.00
	5-6	0.36	0.54	0.00
	7-	0.50	0.67	0.03
0.5-1.0m	1-2	0.24	0.35	0.00
	3-4	0.44	0.48	0.00
	5-6	0.50	0.67	0.03
	7-	0.71	0.74	0.06
More than 1.0m	1-2	0.37	0.57	0.00
	3-4	0.54	0.67	0.03
	5-6	0.64	0.81	0.06
	7-	0.74	0.91	0.09

Source: Criteria for the Engineering of River and Sabo Project , Ministry of Construction, Japan

Table V.4.32 ANNUAL MEAN FLOOD DAMAGE

(Unit : Thousand Cz$)

Stretch	1978-PATTERN		1980-PATTERN		1983-PATTERN		1984-PATTERN	
	1986	2020	1986	2020	1986	2020	1986	2020
IT 1	25,695	60,955	19,290	45,760	18,882	44,798	26,924	63,871
2	34,772	82,574	34,142	81,079	34,513	81,962	42,694	101,390
3	27	44	27	44	26	42	32	50
4	595	957	684	1,099	465	746	684	1,099
5	7	12	10	18	12	23	10	18
6	1,783	4,525	1,996	5,059	5,637	14,186	1,996	5,059
7	100,460	171,338	126,557	215,745	96,432	164,264	131,175	223,601
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	5	10	8	14	20	35	8	14
11	450	1,325	557	1,609	2,851	8,351	792	2,302
12	5	9	8	15	19	33	8	15
13	12,260	27,159	20,312	44,879	79,553	175,555	57,516	126,636
IS 1	8,631	19,153	10,936	24,238	20,246	45,061	23,314	51,827
2	31	53	31	52	41	70	32	54
3	153	317	0	0	6,479	13,389	286	591
IN 1	0	0	0	0	0	0	0	0
IO 1	6,214	13,207	8,971	18,963	18,752	39,787	18,372	39,064
2	43	74	54	96	38	67	122	211
BN 1	0	0	0	0	50	110	0	0
IM 1	27,413	65,562	13,280	31,689	15,672	37,568	32,129	76,827
2	6,903	16,574	3,431	8,243	4,744	11,396	7,261	17,430
3	230	369	176	281	67	108	322	519
4	298	492	173	287	13	24	455	751
5	7,662	17,578	1,676	3,784	4	8	22,162	50,596

Table V.4.33 POTENTIAL DIRECT FLOOD DAMAGE CAUSED by 50-YEAR SCALE OF 1983 TYPE OF FLOOD IN 1986

Unit : Thousand cz$

River	Crop Damage			Damage to Building & Property				
Stretch	Paddy	Sugarcane	Other Crop	Urban	Rural	Livestock	Infrastructure	Total
IT 1	0	0	0	150,330	0	0	43,596	193,926
IT2	0	0	0	162,634	376	0	47,273	210,283
IT3	0	0	0	0	140	124	77	341
IT4	0	0	0	7,401	67	36	2,176	9,680
IT5	56	0	0	0	61	60	51	228
IT6	135	0	0	142,416	112	660	41,564	184,887
IT7	0	0	0	1,324,342	148	24	384,109	1,708,623
IT8	0	0	0	0	0	0	0	0
IT9	0	0	0	0	0	0	0	0
IT10	0	0	0	0	87	304	113	504
IT11	191	0	0	51,748	67	48	15,096	67,150
IT12	3	0	0	0	0	259	76	338
IT13	67	0	0	443,507	117	2,052	129,265	575,008
IS1	0	0	0	60,101	93	392	17,570	78,156
IS2	0	0	0	0	0	180	52	232
IS3	0	0	0	29,150	0	0	8,453	37,603
IN1	0	0	0	0	0	0	0	0
IO1	0	0	0	58,702	142	250	17,137	76,231
IO2	115	0	0	217	71	90	143	636
BN1	0	0	0	320	0	0	65	385
IM1	19	0	0	188,444	233	402	54,838	243,936
IM2	13	0	0	67,770	1	0	19,658	87,442
IM3	211	0	0	0	0	0	61	272
IM4	97	0	0	0	40	80	63	280
IM5	0	0	0	0	63	0	18	81
Total	907	0	0	2,687,082	1,818	4,961	781,454	3,476,222

Table V.4.34 INUNDATED URBAN AREA AND AFFECTED POPULATION CAUSED BY 50-YEAR SCALE OF 1983 TYPE OF FLOOD

unit: ha

River Stretch	Below floor level	0.0-0.5m	0.5-0.99m	1.0-1.99m	2.0-2.99m	over 3.00m	Total
IT1	103	175	130	83	0	0	491(213)
IT2	0	13	45	183	25	0	266(253)
IM1	43	83	268	43	0	0	437(311)
IM2	50	55	100	0	0	0	205(100)
IT7	2	10	20	110	210	298	650(638)

Note: Parentheses indicates inundated area excluding "Below floor level" and "0.0-0.5m". Based on these figures, inundation population in Blumenau is estimated to be 57,600 and those in Itajai plus Navegantes is projected to be 45,400 in 1986. Inundation population means people who have to abandon houses due to inundation.

Table V.4.35 FLOOD DAMAGE TO INDUSTRIAL ESTABLISHMENT BY 50-YEAR SCALE OF 1983 TYPE OF FLOOD

unit:million Cz$

River Stretch	Below floor level	0.0-0.5m	0.5-0.99m	1.0-1.99m	2.0-2.99m	over 3.0m	Total
IT1	0.3	10.9	15.3	13.3	0.0	0.0	39.5
IT2	0.0	0.9	5.9	32.5	5.7	0.0	45.0
IM1	0.1	6.3	38.4	8.4	0.0	0.0	53.2
IM2	0.1	4.2	14.3	0.0	0.0	0.0	18.6
						Sub-total	156.6
IT7	0.0	1.5	5.5	41.0	100.0	169.3	317.0

Figures

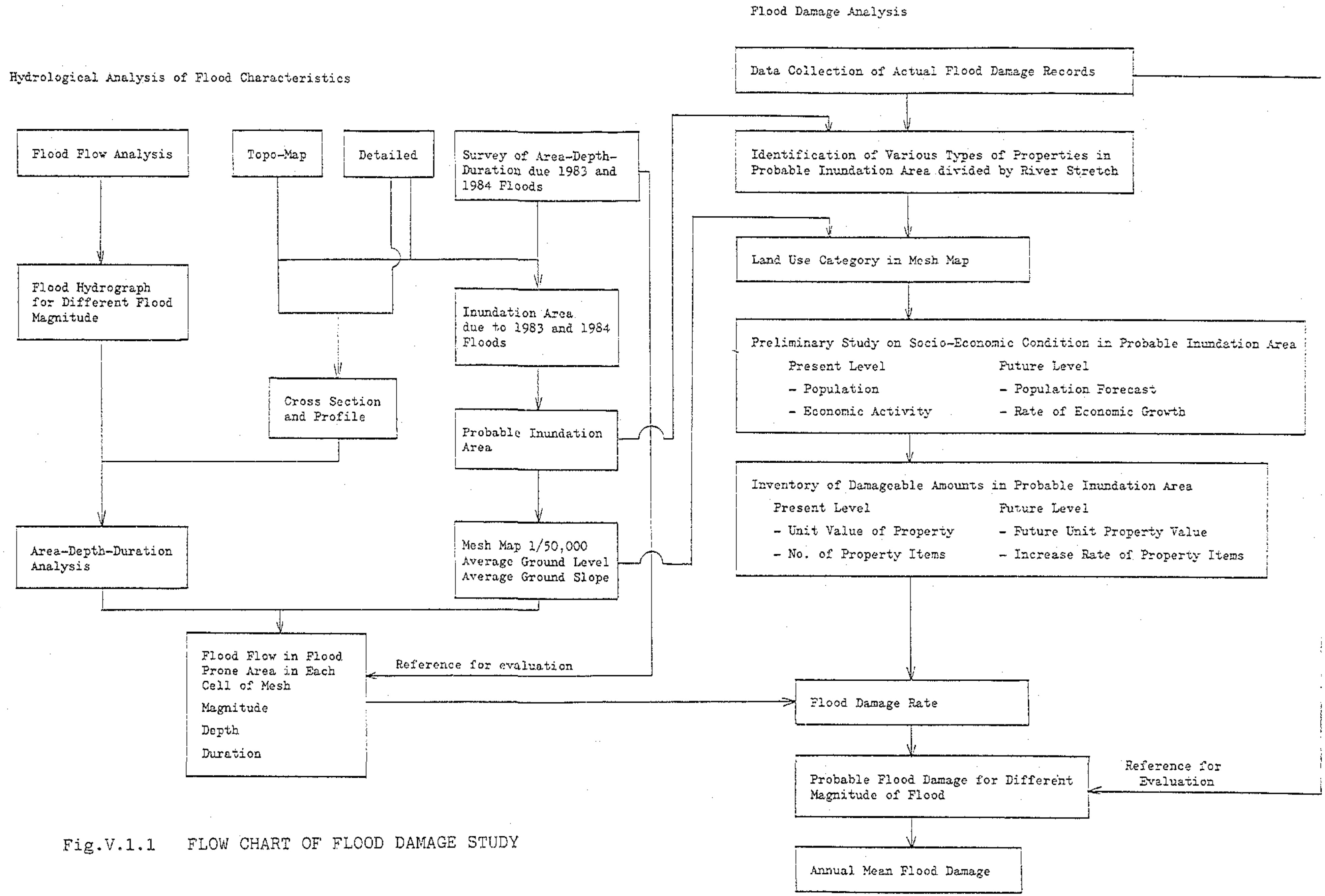


Fig.V.1.1 FLOW CHART OF FLOOD DAMAGE STUDY

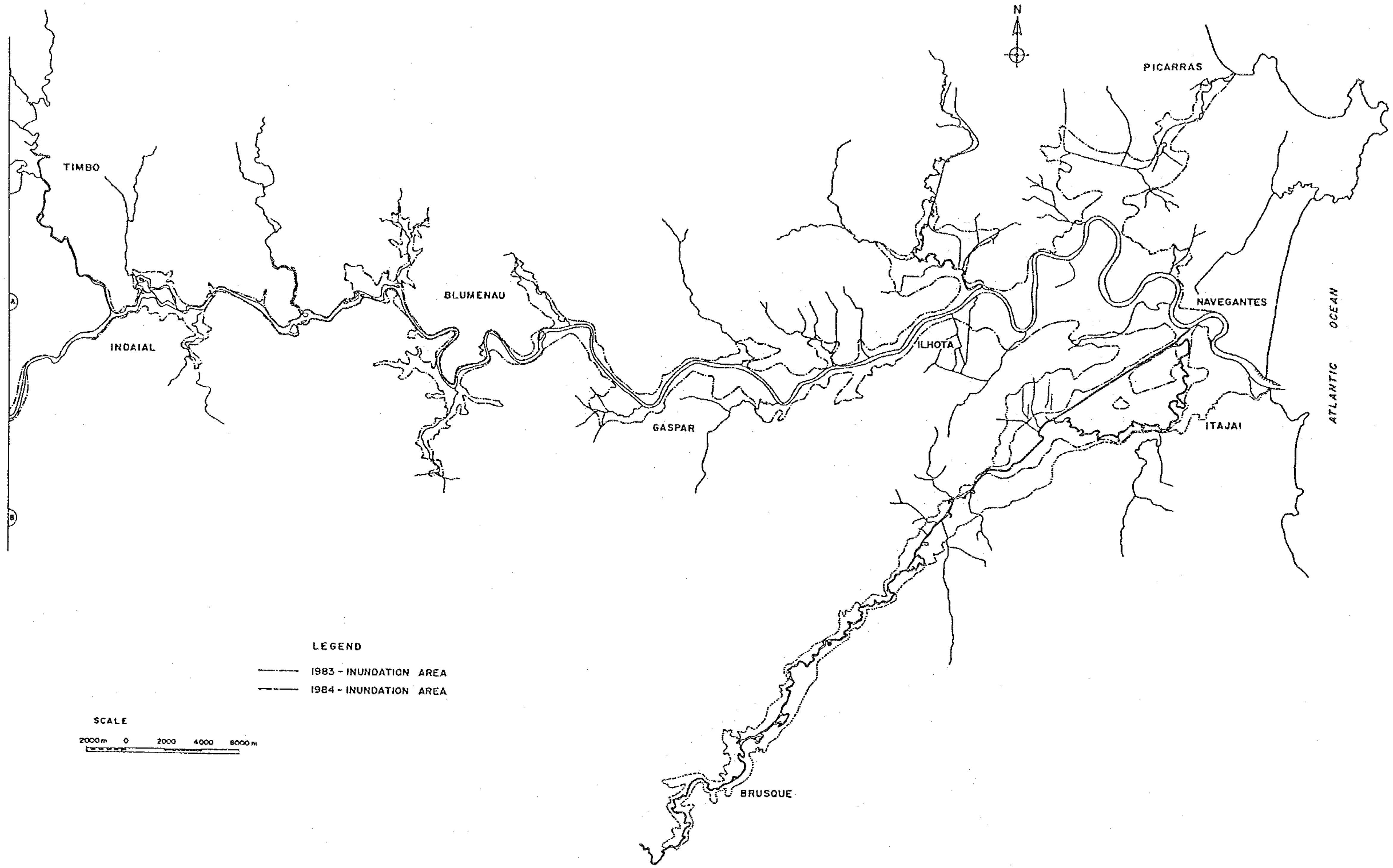


Fig. V.2.1 (1/2) – INUNDATION AREA OF 1983 AND 1984 FLOODS

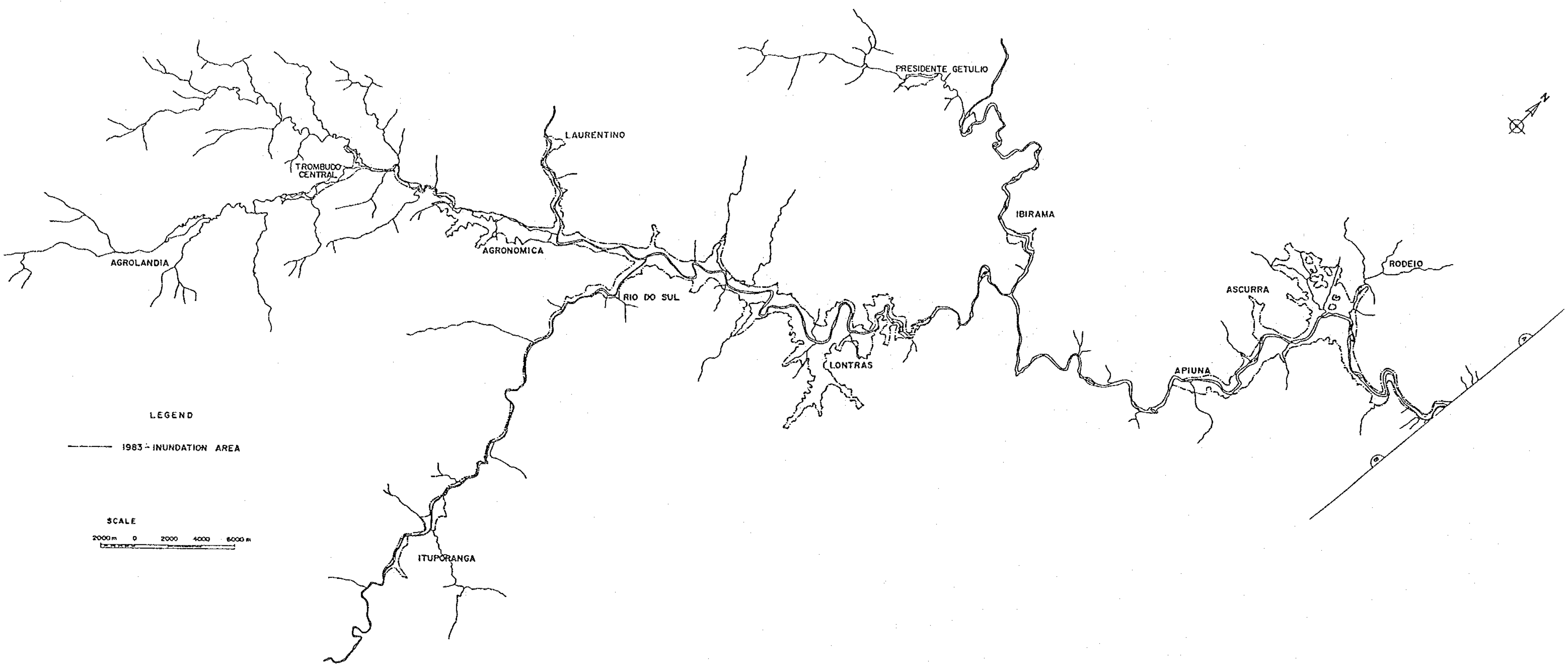
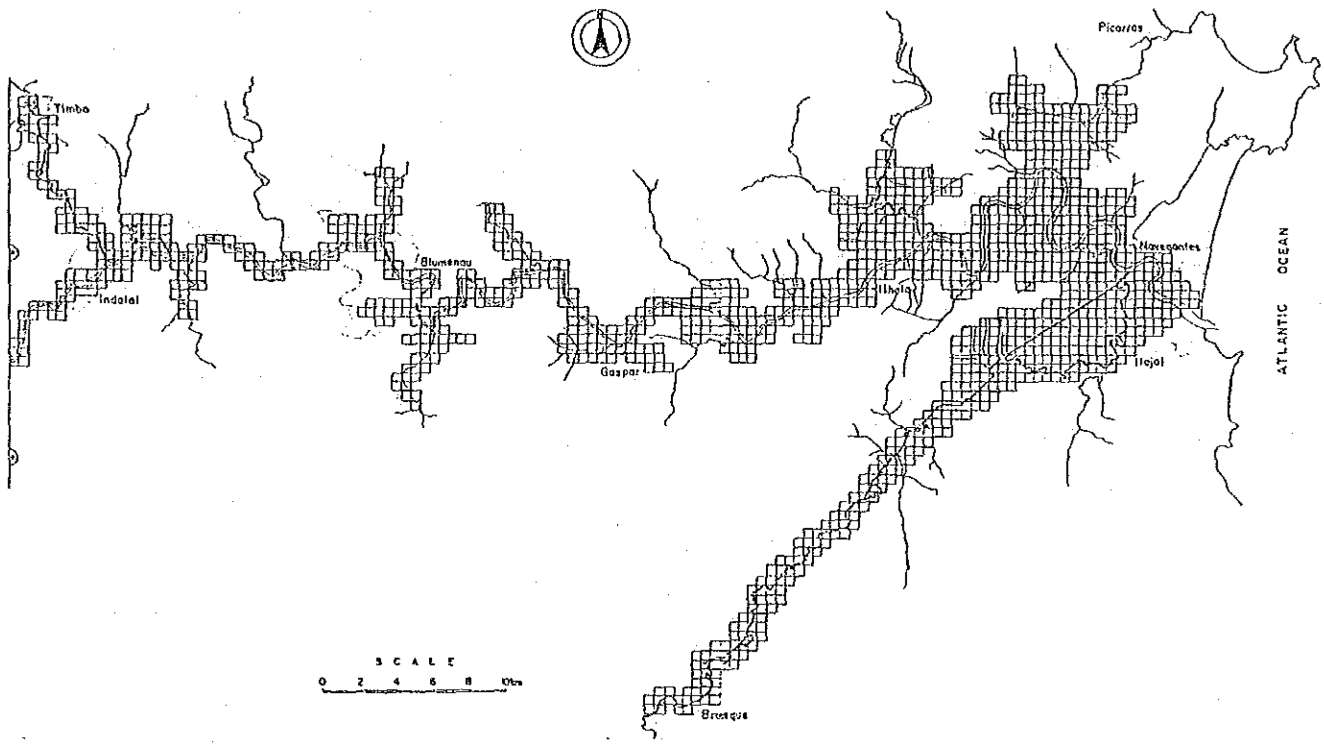


Fig. V.2.1 (2/2) - INUNDATION AREA OF 1983 AND 1984 FLOODS



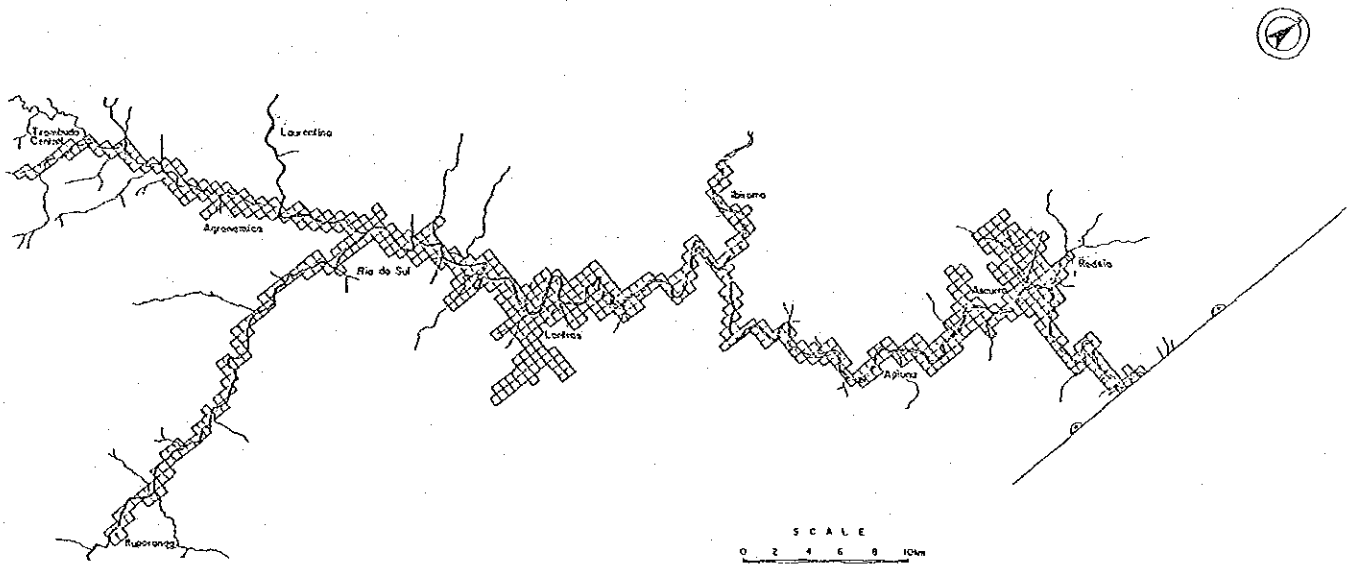


Fig.V.3.1 PROBABLE INUNDATION AREA IN THE ITAJAI RIVER BASIN

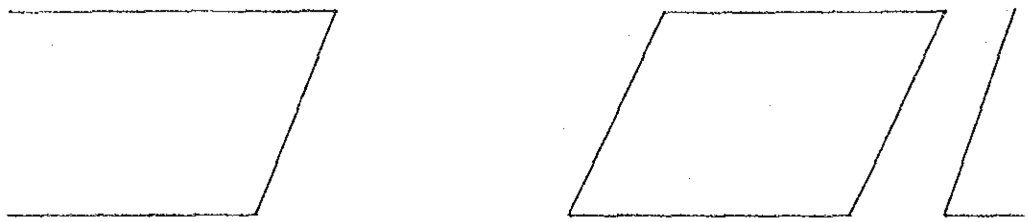
Fig. V.4.1 DAMAGEABLE VALUE OF IRRIGATED PADDY

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(A) Cropping calender												
(B) Planted area (%)	100	100	75	25						25	75	100
(C) Accumulated cost (%)	65	75	85	98						20	40	55
(D) Flood frequency	1.9	11.5	3.9	1.9	7.7	7.7	3.9	19.3	11.5	11.5	11.5	7.7

	1986	2000
(E) Yield (ton/ha)	4.1	5.0
(F) Price (Cz#/ton)	2,050	2,387
(G) Production cost (Cz#/ha)	6,129	7,470
(H) Net income (Cz#/ha)	2,276	4,465
(I) Damageable cost (Cz#/ha)	4,024	4,900
(J) Damageable value (Cz#/ha)	1,670	2,640

Remarks: $(J) = \sum_{JAN}^{DEC} (B \times C \times D \times I + B \times D \times H)$

Fig. V.4.2 DAMAGEABLE VALUE OF MAIZE

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(A) Cropping calender													
(B) Planted area (%)	1st								50	100	100	50	
	2nd	100	100	100	50								50
(C) Accumulated cost (%)		50	60	80	90				30	50	70	90	30
(D) Flood frequency		1.9	11.5	3.9	1.9	7.7	7.7	3.9	19.3	11.5	11.5	11.5	7.7

	1986	2000
(E) Yield (ton/ha)	2.6	4.0
(F) Price (Cz#/ton)	1,734	1,886
(G) Production cost (Cz#/ha)	1,782	2,740
(H) Net income (Cz#/ha)	2,726	4,804
(I) Damageable cost (Cz#/ha)	1,382	2,125
(J) Damageable value (Cz#/ha)	2,130	3,650

Remarks: $(J) = \sum_{JAN}^{DEC} (B \times C \times D \times I + B \times D \times H)$

Fig. V.4.3 DAMAGEABLE VALUE OF SUGARCANE

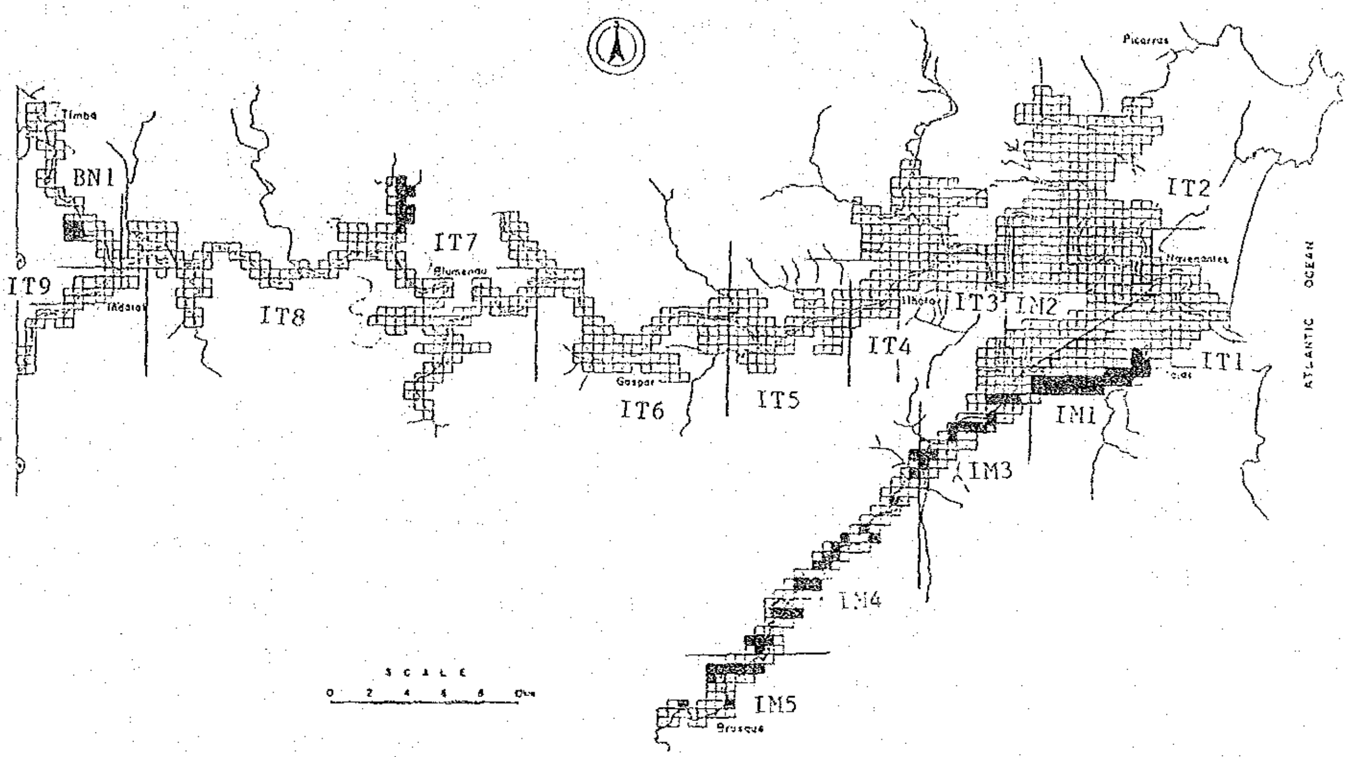
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(A) Cropping calender												
Plantation												
Harvesting												
(B) Planted area (%)	55	65	75	85	89	81	69	61	59	56	54	51
(C) Accumulated cost (%)	29	38	47	55	62	70	73	83	103	111	118	124
(D) Flood frequency	1.9	11.5	3.9	1.9	7.7	7.7	3.9	19.3	11.5	11.5	11.5	7.7

	1986	2000
(E) Yield (ton/ha) /1	12.0	20.0
(F) Price (Cz#/ton)	997	3,200
(G) Production cost (Cz#/ha)	9,365	15,610
(H) Net income (Cz#/ha)	2,600	48,390
(I) Damageable cost (Cz#/ha)	8,720	14,530
(J) Damageable value (Cz#/ha)	6,200	38,530

Remarks: $(J) = \sum_{JAN}^{DEC} (B \times C \times D \times I + B \times D \times H)$

/1 The redendment rate from sugarcane to sugar is around 20%.

Yield of sugarcane is 60 ton/ha and would be 100 ton/ha in 1986 and 200 respectively.



Legend

More than 2.0 m
1.0 m - 2.0 m
0.0 m - 1.0 m
No inundation

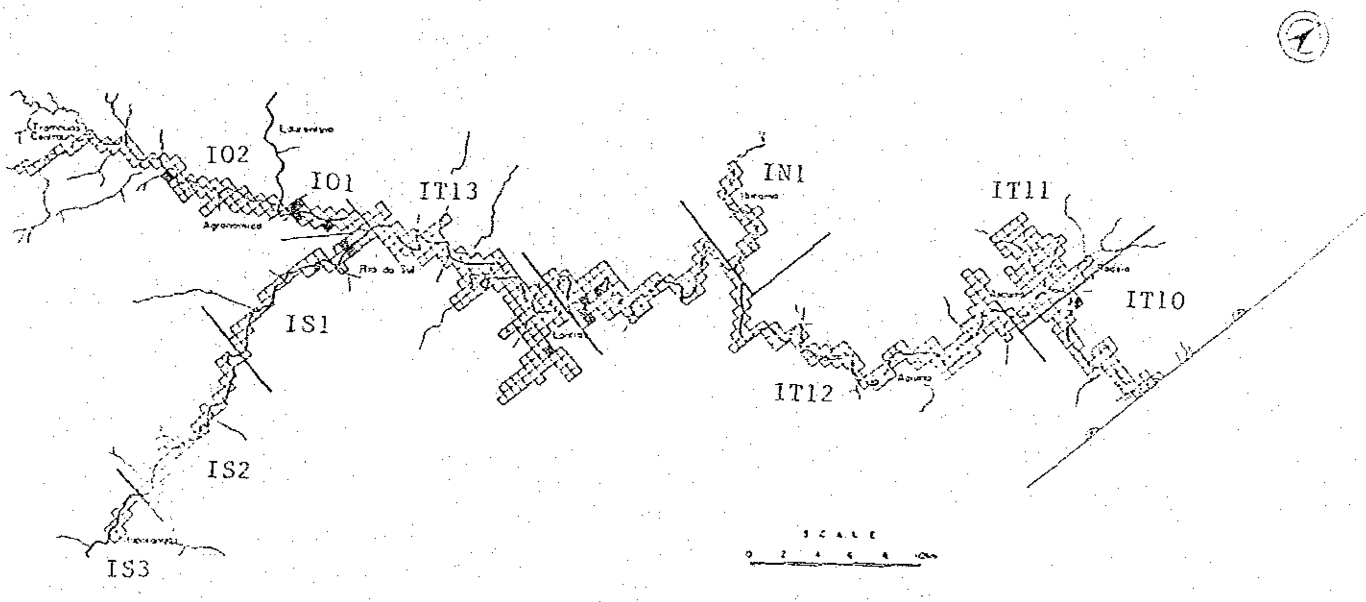
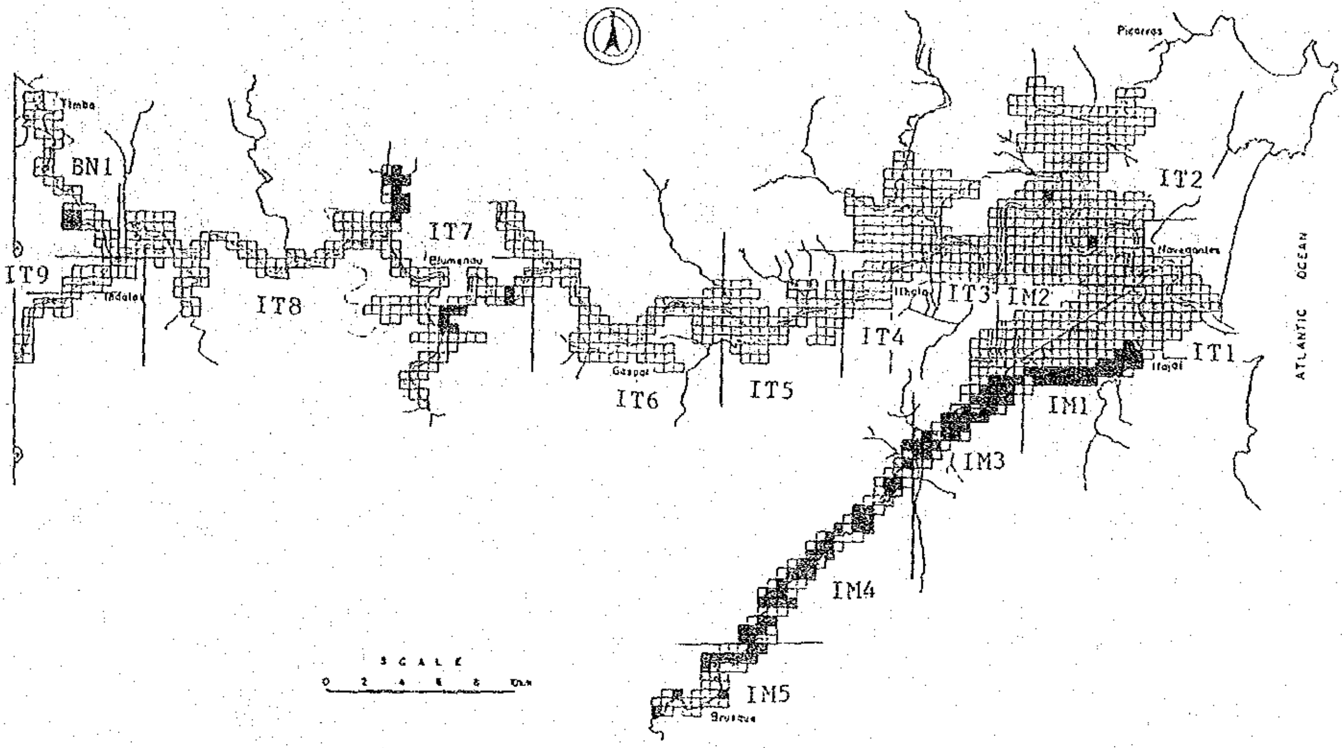


Fig.V.5.1 INUNDATION AREA DUE TO PROBABLE FLOOD (1/3)

10 Year



Legend

- More than 2.0 m
- 1.0 m - 2.0 m
- 0.0 m - 1.0 m
- No inundation

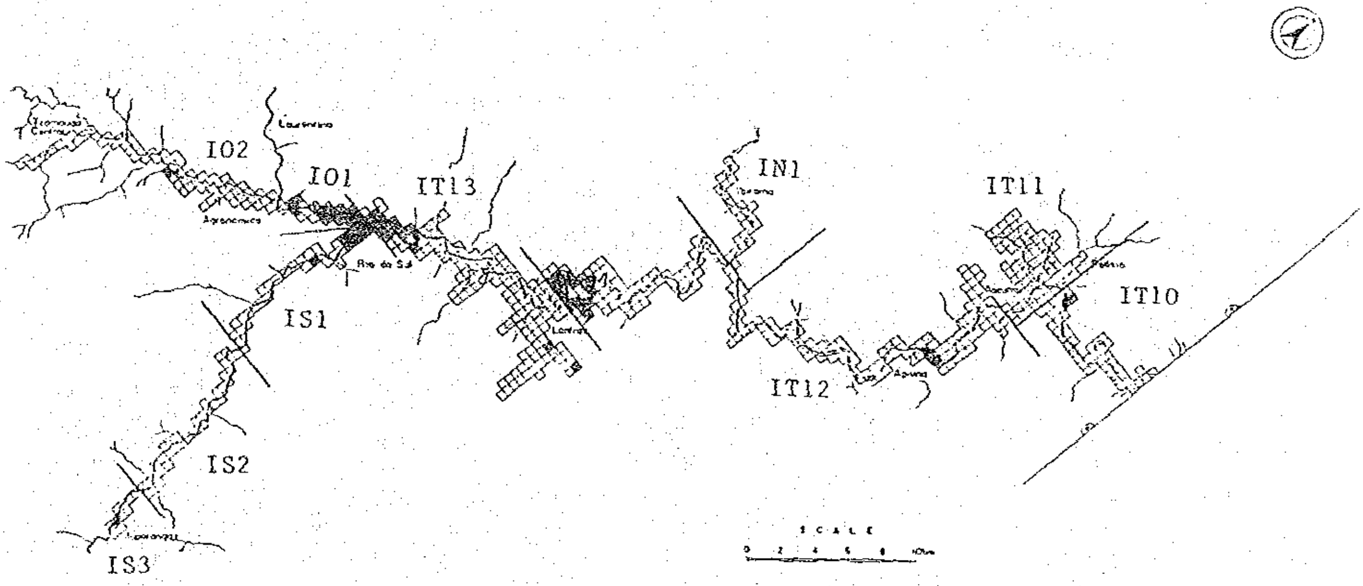


Fig.V.5.1 INUNDATION AREA DUE TO PROBABLE FLOOD (2/3)

25 Year

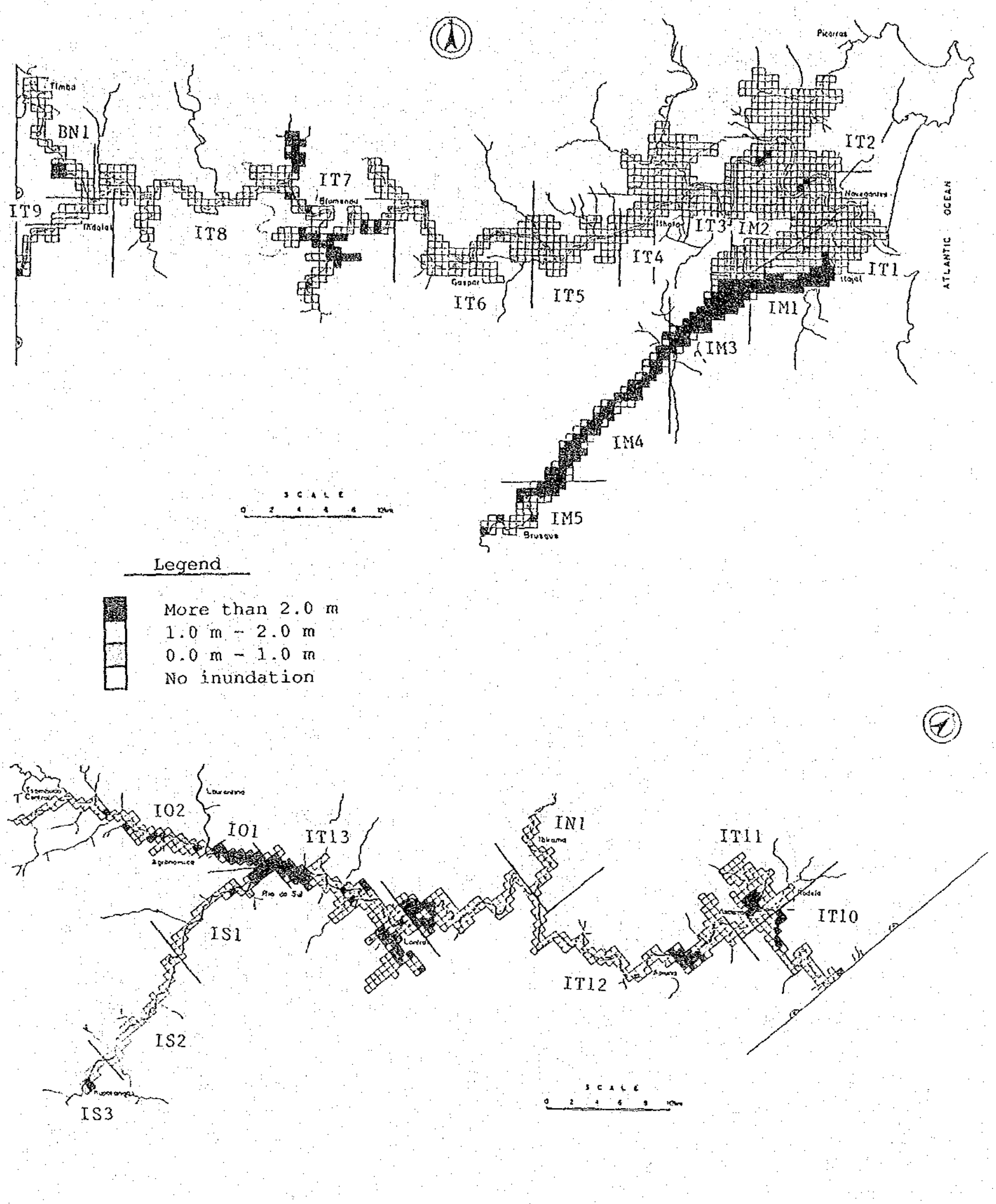


Fig.V.5.1 INUNDATION AREA DUE TO PROBABLE FLOOD (3/3)

50 Year

ANNEX VI. FLOOD CONTROL PLAN

VI. FLOOD CONTROL PLAN

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1. INTRODUCTION

The Itajai river basin with a catchment area of 15,220 km^2 locates in the center of Santa Catarina State in the southern part of Brazil.

The basin is situated between 26°20' to 27°50' of south latitude and 48°40' to 50°20' of west longitude and extends to about 150 km from the north to south and 155 km from east to west. The eastern part of the basin faces the Atlantic Ocean at Itajai city.

The Itajai river is originated from the mountain range with altitude of 1,800 m in the southmost of the basin and flows to northward changing its name to Itajai do Sul and joins with Itajai do Oeste river at Rio do Sul city and Itajai do Norte river at Ibirama city. Afterward, the Itajai river changes its direction to eastward, passes through Blumenau city, the largest city in the basin, collecting several tributaries, joins with Itajai Mirim river at Itajai city and finally debouches to the Atlantic Ocean. Total length of the Itajai river is 250 km which is the middle class of the river in this country. General plan of the Itajai river basin is shown in Fig. VI.1.1.

The basin belongs to subtropical zone except coastal zone. There are no clear divisions between dry and wet seasons. The period from June to August corresponds to winter and the period from December to March is summer. There are spring and autumn between these periods. The annual mean temperature is about 21°C having 25.3°C of the maximum temperature in January and 17°C of the minimum temperature in July and August. The annual mean rainfall is 1,400 mm ranging from 1,000 mm to 1,600 mm. It tends to occur much rainfall in the northern part and less rainfall in the southern part of the basin. The average relative humidity in the basin is 80%. The annual mean discharge in the Itajai river at Indaial gauge is 286 m^3/sec.

The geology of the basin consists mainly of alluvial deposits, Precambrian rocks and Palaeozoic sedimentary rocks.

The alluvial deposits distributed in the lower and flat area downstream from Blumenau city consist mainly of sand, clay and organic matter, and forms generally the very soft ground. The alluvial deposits in the other areas consist generally of sand and silt with some gravel and from comparatively compact ground though it is loose in a general view sense.

The Precambrian rocks consist of the Archaeozoic granulite of gneisses and migmatites of schists and the Proterozoic metamorphic rocks of sandstone, shale, siltstone and phyllites and the intrusive rocks of granites and rhyolites. They are distributed in the area south-eastern from the Mar mountains running along the center of the basin approximately from north-northeast to the south-southwest. The Palaeozoic rocks comprising of sandstone, siltstone, shales and phyllites and distributed in the upper reaches westside of the Mar mountains.

The population of the basin on the basis of the statistics in 1980 was 671 thousand which is about 18% of the total population of Santa Catarina State. Among them about 64% concentrates in major cities along the Itajai river and remaining lives in the rural areas. Major cities in the basin are Itajai having the population of 85 thousand, Gaspar with the population of 26 thousand, Blumenau with the population of 155 thousand, Indaial with the population of 29 thousand, Ibirama with the population of 24 thousand, Rio do Sul with the population of 41 thousand and Brusque with population of 41 thousand. Major economic activity in the basin comprises agriculture, industry and stockbreeding.

Gross Regional Domestic Product (GRDP) of Santa Catarina amounted to Cr$400 billion at current prices, which accounted for 3.59% of Gross Domestic Product (GDP) of the country. The per capita GRDP was Cr$110 thousand, which was 1.23 times of the per capita GDP. Gross Value Added (GVA) of each economic sector was as follows: the primary sector with GVA of Cr$64 billion or 16.0% of GRDP; the secondary sector (industrial sector) with Cr$151 billion or 37.9%; Itajai river basin has the same industrial structure as Santa Catarina State as stated in the followings.

The primary sector produced a total amount of Cr$13.3 billion in the basin in 1980. The major agricultural activity were crop farming, accounting for 60% of the total production, and stockbreeding with 22%, following fishery, forestry and rural industry. The major crops are rice, maize, cassava, beans, onion, sugar cane and tobacco. They were chiefly farmed in the following areas: rice, being farmed in flat lowlands along rivers; maize, cassava and beans in hilly lands scattered in the whole basin: tobacco in hilly and mountainous lands in upstream areas of rivers. The stockbreeding, mainly producing cattle, pig, chicken, milk and egg, are broadly distributed all over the basin.

The manufacturing sub-sector, accounting for 87% of GVA in the secondary sector in 1980, characterized the industrial sector. The major manufacturing types in the basin, having about 65% of the value of manufacturing production (Cr$116 billion), were textile Cr$42.7 billion (37%); clothing, shoes and woven articles Cr$20.7 billion (18%); food products Cr$8.7 billion (8%), and timber Cr$5.2 billion (5%). The most important cities in terms of manufacturing production were Blumenau (67%), Brusque (13%) and Gaspar (8%). Therefore, Blumenau is considered as a prominent district with respect to industrial production.

The commercial and service's sub-sectors play leading roles in the tertiary sector, being characterized by a large number of small establishments. Although the establishments are scattered in the whole basin, their major activity regarding sales amount was executed in the following cities: Blumenau, accounting for 25% of a total amount of commercial activity (Cr$65.1 billion) and 42% of service's activity (Cr$6.2 billion); Itajai, 31% and 17%, and Rio do Sul, 6% and 6%, respectively.

Out of the total basin land area of 15.221 km^2, the agricultural land occupied the largest area of 9,048 km^2 or 59.5% in 1980. It was broken down as follows: crop land, 3,050 km^2 or 20.0% of the total area; pasture land, 2,930 km^2 or 19.39%, forest land, 3,068 km^2 or 20.2%. The residential areas occupied 151 km^2 or 1.0% of the total area. The rests, accounting for 6,022 km^2 or 39.5%, were areas not utilized, areas unsuitable for agricultural activity, or areas of which land use was not identified.

The Itajai river basin has a long history of flooding. Among them, the floods in 1983 and 1984 caused serious flood damage in the basin. In 1983 flood took place large scale inundation in the riparian areas along the Itajai main stream, while 1984's flood caused the inundation in the areas along the Itajai Mirim river. Total inundation area caused by two floods was about 270 km^2 which is about 2% of the basin area. The inundation mainly extended over vast area downstream from Blumenau city and Ascurra and Rio do Sul areas in the upstream reaches. Especially, more than 80% of the Blumenau city inundated at flood time in July 1983. The duration of inundation lasted about one week on an average, especially inundation period in several places in the downstream of the Itajai river reached to 2 weeks.

In order to cope with such repeating inundation, Oeste dam having flood control space of 110 million m^3 and covering catchment area of 1,042 km^2 and Sul dam having flood control space of 98 million m^3 and catchment area of 1,273 km^2 were constructed in 1972 and 1975 respectively. Besides, Norte dam having flood control space of 263 million m^3 and catchment area of 2,318 km^2 is being constructed in the tributary of the Itajai river. Furthermore river improvement works by widening of the river channel is under construction in Blumenau-Gaspar stretch in the Itajai river, and upstream stretch from Itajai city in the Itajai Mirim river.

Even after the construction of the foregoing flood control dams, major cities along middle and lower stretches of the Itajai river still have suffered from inundation.

In this Appendix VI, the following items are presented:

(1) Present river conditions

(2) Basic concept for flood control in the basin

(3) Formulation of provisional plan

(4) Formulation of mid-term plan

(5) Formulation of long-term plan

(6) Program of flood control projects

(7) Recommendation for non-structural measures

(8) Selection of flood protective stretch for feasibility study

2. PRESENT RIVER CONDITION

2.1 River Feature

The Itajai river is characterized by its irregular river bed slope as illustrated in Fig.VI.2.1. It will be widely classified into three stretches, namely, upstream stretch with gentle river slope in the upstream of Lontras city, middle stretch with remarkable steep river slopes between downstream of Lontras city and Subida, and rather steep river slope between Subida and upstream of Blumenau city, and lower stretch with remarkably gentle river slope between Blumenau city and river mouth. The river feature in the respective stretches in presented hereinafter.

(1) Upstream river stretch

About 70 km long river stretch in Itajai do Sul with altitude of EL 320 to EL 360 from downstream of the existing Sul dam to about 5 km downstream of Lontras, has a slope with 1 to 2000. The Itajai do Sul river flows down to almost northward meanders slightly and joins with Itajai do Oeste river at the center of Rio do Sul city. Existing Oeste dam is located in Itajai do Oeste river at about 78 km upstream of the Itajai confluence. The river slope of Itajai do Oeste is also gentle slope of 1:4000. The river width of the Itajai do Sul and Itajai do Oeste rivers in the upstream from Rio do Sul city is about 100 m and its river depth is 10 m.

The Itajai do Sul river changes its name to Itajai river after joining with Itajai do Norte river. The river width in Itajai near Rio do Sul city is about 100 to 120 m and its depth is about 10 m.

(2) Middle river stretch

The Itajai river with gentle slope in the upper stretch suddenly changes its river slope from near Salto Pilao town and flows down rapidly to Subida with altitude of EL 110 m meandering sharply and passing through U-shape valley in mountainous zone. The river slope in this stretch is about 1:60 and river length is about 16 km. In this river stretch, Itajai do Norte river with river slope of 1 to 50 joins from left side at about 5 km upstream of Subida. Norte dam is being constructed in Itajai do Norte river at about 46 km upstream of the Itajai confluence. River slope in Itajai do Norte river between the Norte dam and 20 km upstream from the Itajai confluence is about 1:2200.

The Itajai river flows down through U-shape valley and debouches to flat plain area at about 5 km downstream of Subida. It flows down to northeasternward to Indaial city. The river slope between Subida and Indaial city is about 1:700 and river length is about 49 km.

River width in this stretch varies from 120 m to 280 m. Benedito river, a tributary of the Itajai river, joins from left side in the center of Indaial city.

The Itajai river changes its direction to eastward from Indaial city and flows down to upstream of Blumenau city with altitude of EL 10 m. The river length in this stretch is about 15 km and its slope is about 1 : 400. The river width changes widely from about 180 m to 350 m and outcrop of the rock is found along the river course.

(3) Lower river stretch

River slope of the Itajai becomes gentle at just upstream of Blumenau city. The Blumenau city is situated along V-shape meandered Itajai river stretch and houses densely develop up to both river banks. The river width is about 140 m and its depth is about 20 m.

The Itajai river flows down to eastward meandering gently and passing Gaspar and Ilhota cities, and after joining with Itajai Mirim river flowing from right side near Itajai city, it finally debouches to Atlantic Ocean near Itajai city. The river slope between upstream of Blumenau city and river mouth is 1:10,000 to 1:15,000. River width in this stretch is 200 to 300 m on an average and its depth is about 15 to 20 m at Gaspar city, 17 m at Ilhota city and 10 m in the upstream stretch of Itajai city respectively.

The Itajai Mirim river, which originates from mountain zone in the southern part of the basin, flows down to northeastward passing through Botuvera town and Brusque city. Remarkably meandered river stretch between Brusque and Itajai cities was improved straightly by means of short cutting 15 years ago. The Itajai Mirim river divides into two stretches at the southwestern part of the Itajai city, namely, one is largely meandered existing river channel and other is short cut channel connected with the meandered river channel straightly. Immediately after joining these two channels, the Itajai Mirim debouches to Itajai river at the north part of the Itajai city. The river slope of the Itajai is about 1:10,000. River width of the Itajai Mirim in Brusque-Itajai stretch is about 50 m and its depth is 4 to 8 m.

River width and river depth and flow capacity in the main stream of the Itajai river and its major tributaries in their confluences with the Itajai river are given in Figs.VI.2.2, VI.2.3 and VI.2.4 respectively. Present bankfull flow capacity in major river stretches is summarized as follows:

River stretch	Flow capacity (m^3/sec)
Ilhota - Blumenau	2,000 to 4,000
Downstream from Ilhota	800 to 1,500
Blumenau city	3,000
Ilhota - Blumenau	2,000 to 4,000
Downstream from Ilhota	800 to 1,500
Indaial city	6,000
Ascurra town	3,000 to 4,500
Rio do Sul city	1,000
Lowermost of Itajai Mirim	400 to 500

2.2 Past Large Flood and Its Rainfall Characteristics

In the Itajai river basin, large floods occurred on July 5-15th, 1983 and August 5-9, 1984.

In July 1983, the rain started from the night on July 5th and continued for 7 days up to July 12th in the entire Itajai river basin. The recorded maximum hourly rainfall is 22 mm hour at Dr. Pedorinho in the Benedito river basin and the basin mean rainfall amount in 1, 4, and 7 days are estimated to be 65 mm, 216 mm and 324 mm respectively. Flood peak discharges at the major water level gauging stations are 1,500 m^3/sec at the Sul dam, 1,000 m^3/sec at the Oeste dam, 2,000 m^3/sec at Rio do Sul, 2,500 m^3/sec at Ibirama, 4,400 m^3/sec at Apiuna, 4,800 m^3/sec at Indaial and 540 m^3/sec at Brusque, and are continued for around 1 week by the rainfall with a long duration time.

In August 1984, the rain started from the morning on Aug. 5th to Aug. 8th and the maximum hourly rainfall recorded at Blumenau city was 25 mm. The basin mean rainfall in 1 and 3 days are 110 mm and 216 mm respectively and the heavy rainfall of around 150 mm/day occurred in the Itajai Mirim basin. Since rainfall pattern in 1984 is more intensive than rain storm in 1983, the shape of flood hydrological is sharp and flood peak discharge is larger than in 1983. Flood peaks at major sites are 2,500 m^3/sec at the Sul dam, 1,200 m^3/sec at the Oeste dam, 1,860 m^3/sec at Rio do Sul, 400 m^3/sec at Ibirama, 4,400 m^3/sec at Apiuna, 860 m^3/sec at Timbo and 5,100 m^3/sec at Indaial.

2.3 Existing Records of Past Large Scale of Floods

(1) General

The occurrence of floods of large scale has been common natural phenomenon in the Itajai river valley, by virtue not only of the meteorological conditions with intense rains of long duration, but also the morphological conditions of the basin with its bottom surrounded by hilly land.

The recent large scale of floods occurred in 1983 and 1984 caused the great trouble to the inhabitants and various kinds of properties of the Itajai basin of which major cities such as Blumenau and Itajai suffered heavily from tremendous amount of flood damages. The scale of floods occurred in 1983 and 1984 in terms of flood damages in Santa Catarina can be assessed by the indication that the sum of flood damages caused by 1983 flood (715 billion Cr$) was about 16% of GRDP of Santa Catarina, whereas the same ratio was about 2% in case of the flood in 1984.

Inundation area along the Itajai river and its tributaries due to the flood in 1983 and 1984 crossed over territory of 20 municipalities. Due to rainfall intensity and pattern, inundation area along the Itajai Mirim river was characterized by the flood in 1983, while inundation area along the Itajai river was bigger in 1983 than the flood in 1984. The characteristic of inundation area due to both floods can be explained in such a way that inundation area in the Itajai river basin was largely caused by overflow of river waters from tributaries of the Itajai river.

(2) Area-depth-duration

Inundation area along the Itajai river was bigger in 1983 than in 1984, while inundation area along the Itajai Mirim river was bigger in 1984 than in 1983. The extent of area under inundation along the Itajai river due to the flood in 1983 and along the Itajai Mirim river due to the flood in 1984 was about 270 km^2 which is about 2% of catchment area (15,220 km^2) of the Itajai river basin.

There are many places where local engineering firm (HIDROTERRA S.A.) conducted to measure water depth in inundation area along the Itajai river caused by the flood in 1983 and along the Itajai Mirim river due to the flood in 1984. Moreover, water depth of some place where the existing records cannot cover was checked by a reconnaissance survey. It was clarified from the available records and interview survey that water depth reached to more than 1 m at many measuring points in both floods, in particular, water depth at some parts of city area in Blumenau and Rio do Sul was more than 2 m.

The result of interview survey to ask local people about duration of inundation shows that the duration was comparatively long, and average days of inundation were about 7 days in cases of 1983 and 1984 downstream of Itajai river.

(3) Actual flood damages

Although data on detailed categories of flood damage collected from municipal governments and relating authorities are not complete, the number of inundation population and houses in the Itajai river basin was 141,700 and 31,700 respectively in the flood in 1983. This inundation population corresponds to about 64% of that in Santa Catarina.

Flood damages stated in the existing records are classified into crop damage, building damage inclusive indoor movables, and damage to public sector such as infrastructure and public building. Damage amount incurred in Blumenau was outstanding compared with other municipalities. It can be conceivable that municipalities where lots of population was affected by inundation tended to suffer from more damage amounts.

2.4 Existing Flood Control Facilities

2.4.1 General

The riparian areas along the Itajai river and its tributaries have been suffered from inundation due to medium and large magnitudes of flood. However substantial flood control measure has not been materialized in era of 1950. In August 1957, large magnitude of flood took place in the Itajai river and large extent of the riparian areas has suffered from inundation. In order to cope with the repeating inundation, flood control dam plans were worked out and among them, Sul and Oeste dams were constructed in 1975 and 1972 respectively and besides Norte dam is being constructed. However even after the construction of the Sul and Oeste dams, major cities along the middle and lower stretches of the Itajai river still have suffered from inundation at the flood time of 1983 and 1984. In order to supplement flood control effect by the foregoing dams, river improvement plan in Itajai and Itajai Mirim rivers has been worked out and among them, several plans have been materialized.

This chapter presents the flood control effect in the past by the existing dams and present situation of the river improvement works and plan which are promoted by DNOS.

2.4.2 Existing dams and their flood control effect

The Sul, Oeste and Norte dams have been designed as the flood control use and flood release facilities consisting of gated outlet conduits in the dam bottom and non-gated spillway are provided. Feature of the existing flood control dam/reservoir is summarized in Table VI.2.1.

Investigation of the dams including operation condition, possibility of installation of the spillway gates and additional outlet facility and checking of accuracy of reservoir area - water level - storage volume relationship were carried out. Consequently, it was judged that;

(1) It will be technically possible to install the spillway gates on the existing dams,

(2) It will be also technically possible to install the additional outlet facilities only for Sul dam because Oeste dam consists of concrete gravity dam and there are no space to provide the outlet facility, and for Norte dam, its embankment work already being carried out, and

(3) Reservoir area - water level - storage volume for three dams estimated in the design stage is considered to be reasonable since the difference of the relationship estimated in the design stage and that checked in this time is only within 5 %.

Present operation method for outlet facilities is as follows.

(1) All the conduit valves are principally closed when heavy rainfall is observed at dam site.

(2) All the conduit valves are principally closed when reservoir water level is over 10 m in depth from the river bed.

The effect of the flood peak reduction by the existing Sul and Oeste dams was examined by simulation study, and it was clarified that flood peak at the Blumenau and Itajai was reduced by 830 m^3/sec and 660 m^3/sec for the flood in 1983 and 530 m^3/sec and 610 m^3/sec for the flood in 1984 respectively.

In order to find out the suitable flood control method for three dams, study on the flood control effect was made for the following four methods;

(1) Flood control by means of present operation method.

(2) Flood control by means of revision of the present operation rule, namely, flood control by operation method in case that the existing outlet conduits are fully opened.

(3) Flood control by means of modification of existing outlet facility for the Sul dam, namely, flood control by operation method in case that an additional outlet facility is provided for the Sul dam and all of the outlet conduits are fully opened.

(4) Flood control by means of modification of non-gated spillway, namely, flood control by operation method in case that the spillway gates for three dams are installed and flood is released through fully opened outlet conduit and gated spillway.

The flood control effect by these four methods was examined using the flood discharge data in 1978, 1980, 1983 and 1984. Details of the examination are presented in the Supporting Report "Hydrology". It was clarified from the examination that ;

(1) By an application of the revised and/or modified operation method, more effective flood peak reduction can be made comparing with the case of the present operation method in case of 1983's flood which has a long duration of flood peak.

(2) On the contrary, in case of the floods in 1978, 1980 and 1984 which have a short flood duration period, the flood peak discharges in the downstream stretch in case of the application of the revised and/or modified operation method increase comparing with the case of the present operations method.

Since occurrence of large scale of flood with a long duration of flood peak such as the flood in 1983 is very rare case and consequently probable 4-day continuous rainfall is applied to the estimation of the design flood as explained in the following chapter, present operation method was selected as the most effective flood control method by the existing dams.

2.4.3 River improvement works and plans

(1) General

Since the occurrence of large magnitude of flood in 1983, river improvement plan in the Itajai river basin was aggressively promoted by DNOS and a part of them is being implemented. In order to incorporate and synchronize the present river improvement plan with the master planning in this time, present situation of the river improvement work and plan were investigated.

DNOS is implementing the river improvement work and plan in Blumenau-Gaspar stretch, and Rio do Sul - Lontras stretch in the Itajai river, and in a part of Itajai Mirim river at present. Details of their work and plan are presented hereinafter.

(2) River improvement work in Blumenau - Gaspar stretch

It is intended by this river improvement plan to lower flood water level by 3.5 m at the upstream end of the project river stretch by means of mainly widening of the existing river channel and river dredging to arrange the river width. Major features of the river improvement plan are as follows:

(i) Project river stretch; 22 km from about 6 km downstream of Gaspar city to Blumenau city.

(ii) Design flood; 6,000 m^3/sec (assumed peak flood discharge at Blumenau in July, 1983).

(iii) Design river channel; river channel with 220 m in width by widening the existing river channel by about 150 m.

(iv) Total excavation volume; 27.5 million m^3.

(v) Expected working period; 18 months by June 1986.

The river improvement work was commenced from January 1985 by contract system. The work is now promoted in parallel with the detailed design works and the river stretch where the detailed design and compensation of lands and houses were completed is partly being improved using 3 units of dredger and 3 units of dragline. The river improvement works were completed at three sections of 46 km, 55.6 km and 56.6 km stretches respectively. The excavated earth volume by February 1986 is about 1.3 million m^3 in total.

It is planned to divide the whole project river stretch into 10 sections and to complete within 18 months by June 1986. However, the progress of the work is largely delayed due to financing problem.

(3) River improvement plan in Rio do Sul - Lontras stretch

It is planned by this river improvement plan to lower the flood water level by about 3.3 m by means of widening of the existing river channel and construction of two portions of short cut channel. Major features of the river improvement plan are as follows:

(i) Project river stretch; 17.4 km from junction of Oeste river to existing Lontras bridge downstream of Rio do Sul city.

(ii) Design flood; 2,800 m3/sec (assumed peak flood discharge at July 1983).

(iii) Design river channel; 90 m of river width in 2.4 km long stretch in upstream and 110 m of river width in its downstream stretch.

(iv) Construction of short cut channel; 2 portions

(v) Total excavation volume; 7.2 million m^3, including 6.9 million m^3 of earth excavation and 240,000 m^3 of rock excavation.

(vi) Construction cost; US$14.9 million.

A part of the river improvement work was commenced from 1985 using draglines. Since flood water level has been raised by narrow span of the existing Lontras bridge, it was extended by 1985.

(4) River improvement plan in Itajai Mirim

Serious flood damage caused in the riparian area along the Itajai Mirim river due to large scale of flood in March 1961. Since then, river improvement including the widening of the existing river channel, construction of short cut channels in many stretches and river dredging to arrange the river width was commenced up to Brusque city and completed by 1972. However since large scale inundation took place due to the flood in August 1984, extention work of the river channel was commenced at the short cut channel portion near Itajai city and also at the existing river channel at Brusque city. Excavated volume during the period from January 1985 to February 1986 is about 460,000 m^3. However, definite plan regarding design flood, design river channel and so on is not yet established.

2.5 Existing Flood Forecasting and Warning System in the Basin

After the flood in 1983, DNAEE implemented a flood forecasting and warning system in the Itajai river basin and started its preliminary operation in August of 1984.

The system operates with data supplied by a radio system composed of five rainfall and water level gauging stations which are located at Taio, Ituporanga, Ibirama, Apiuna and Blumenau. The stations, in addition to permitting the sensing of water levels and rainfall levels, also have a voice and observer channel. These locations are shown in Fig.VI.2.5.

The warning system has central operating station (CEOPS) in Blumenau and Curitiba, equipped for the control and processing and dissemination of data and information.

The stations can be interrogated both from Curitiba (CEOPS) and from Brasilia (DNAEE) by telephone.

The data processed in Curitiba (CEOPS) are transmitted by telex to state coordination of civil defense (CEDEC) in Florianopolis, in which the necessity of warning is judged.

CEDEC has the criteria of the attention, warning and critical water level for each city above mentioned, and transmits the results of judgement for warning to Blumenau (CEOPS).

The announcement of warning to the public is held by COMDEC, which is subordinate to CEDEC and organized by each municipal unit, and emergency measures are taken also by COMDEC.

The warning and critical water levels of each city are as follows.

Location	Water Level		
	Attention(m)	Warning(m)	Critical(m)
Taio	4.00	6.00	7.00
Ituporanga	2.50	3.00	4.00
Rio do Sul	4.00	6.00	7.00
Ibirama	3.00	3.50	4.30
Indaial	3.50	4.30	5.20
Blumenau	5.00	6.00	8.50

Water level indicates the height measured at each water level gauge.

Fig.VI.2.6 shows the schematic functioning of the warning system for the first stage.

Prediction of flood water level is made for Rio do Sul, Indaial and Blumenau by means of the data supplied by the radio system mentioned above, eventually supplemented with information from the existing Sul and Oeste dams. The water levels and rainfall at the stations of Taio and Ituporanga, as well as eventual information on the flows from Oeste and Sul dams, will permit estimation of the levels at Rio do Sul. The same information, supplemented with the water levels and rainfall at Apiuna and Ibirama will permit evaluation of the levels at Indaial and Blumenau.

2.6 Existing River Structures and Related Structures

(1) River structures

A revetment is provided only at the river bank along the Blumenau and Brusque cities. They are 1.2 km long concrete type revetment in the right bank of the Blumenau stretch and about 200 m long gabion type revetment at Ireneu Bornhausen bridge in Brusque city in the Itajai Mirim river. At the left river bank of the Itajai river mouth, stone pitch groyne with an interval of 130 m is installed for the river length of 1.3 km. Any levee is not provided for all of the Itajai river and its tributaries.

(2) Related structure

The related structures such as bridge, pumping stations for municipal and industrial water supply, hydro electric power station, ferry port and harbour have been located in the Itajai river and its tributaries.

More than 100 nos of concrete bridges cross over the Itajai river and its tributaries. Majority of them are roadway bridges connecting the national road and local road. For most of the bridges, water supply pipe is attached and no aqueduct is provided. Majority of substructure of these bridges is constructed by concrete pile foundation. Although it is not clear about the scouring phenomena at flood time in 1983 and 1984, a serious scouring at the bridge foundation site is not found at present. Location of the bridge site and their features are shown in Fig.VI.2.7 and Tables VI.2.2 and VI.2.3

There are three hydro electric power stations in the Itajai river basin. One of them is located at 10 km upstream of Blumenau city and others are situated in the upstream of the Benedito river respectively. Their installed capacity is small scale such as 6300 kw for the power station at the upstream of Blumenau and 7400 kw and 17600 kw for the power stations in Benedito river. Their features are given in Tables VI.2.2 and VI.2.3.

Many drainage pipes with small size diameter have been installed along the river near city area.

There are two ferry sites in the Itajai river near its river mouth. Besides, a harbour is located at the river mouth of the Itajai. This harbour is utilized as shipping port for agricultural products and timber and as a fishing port. In addition, there are many small and large scale shipyards in the Itajai river near the harbour.

3. BASIC CONCEPT FOR FLOOD CONTROL IN THE BASIN

3.1 General

An inundation takes place over vast areas along the Itajai main stream and its tributaries. It is deemed impractical, from the viewpoints of economic effectiveness and budgetary fund, to realize perfect flood control works for the entire stretches of such large river system. Therefore, it should be contemplated to mitigate flood damage to a practical extent by considering structural measures and non-structural measures.

The structural measures will be adopted in due consideration of their economic effectiveness, safety of livelihood of the riparian people and social urgent requirement.

In application of the structural measures, higher target level of protection as possible would be desirable to be adopted for safety of facility and long term stability and livelihood of the reparian people concerned. However, much amount of the construction cost and long construction period will be needed for materialization of the higher target level plan. In order to realize the flood control plan as earlier as possible and to meet with social urgent requirement, stage wise flood control plan was contemplated.

Non-structural measures will be considered as possible means of supplementing the structural measures. In areas where no effective structural measures will be applied, mitigation of flood damage by means of non-structural measures will be considered. Recommendation for non-structural measures will be made considering the foregoing situations.

A feasibility study to be carried out in the following stage will be made for the structural measures.

3.2 Conceivable Structural Measures

The following structural measures were contemplated for blood control planning for the Itajai river basin in view of the river channel profiles, inundation conditions and basin topography;

- Widening of River channel
- Dredging (excavation)
- Levee construction and/or filling of excavated material from river channel
- Floodway
- Flood retardation basin
- Flood control dams

The respective structural measures are presented below.

(1) River improvement including widening of existing river channel, dredging, levee construction and/or filling of excavated material from river channel.

Existing river channel of the Itajai and its tributaries are single cross section without levee. For this river stretch, river improvement plan by combining the widening of existing river channel, dredging, levee construction and/or filling of excavated material from river channel will be adopted in due consideration of river characteristics, hydraulic situation of river channel and topography of the river stretch.

(2) Floodway

The flow capacity in the Itajai river in its endmost stretch is too small to discharge the flood coming from the catchment area of 15,220 km2. The flood flow exceeding the flow capacity of the river channel overflows from the existing river channel and inundates along both banks every flood time. In order to mitigate these inundations, a floodway connecting with sharp bend portion of the downstream of the Itajai river and Atlantic Ocean near Picarras city has been proposed.

(3) Flood retardation basin

Habitual inundation area downstream of Ilhota city is conceivable to be utilized as a flood retardation basin. It is, however, not recommendable to utilize it as the flood retardation basin due to the following reasons:

(i) The habitual inundation takes place in low land areas and they are utilized as cultivation area of sugar cane pasture, etc. and

(ii) All of these areas belong to private owned lands and consequently it is rather difficult to control the cultivation activity by governmental law, and it is impractical to purchase these areas to use them as the flood retardation area.

Due to these reasons, the plan of the flood retardation basin as the flood control facility was deleted.

(4) Flood control dams

The effective operation method by the existing Sul, Oeste and Norte dams to reduce the flood peak in the downstream flood prone areas was studied, and it was clarified that the operation method by means of closing of the outlet facility when heavy rainfall occurred at the damsite is the most effective for flood peak reduction in the downstream river stretches. The effect to flood peak, these reduction for the case of floods in 1983 and 1984 was examined under the condition that these floods are regulated by adopting the proposed operation method to the existing three dams. It was clarified that the regulated flood peak discharge is about 5100 m^3/sec for 1983's flood and 4400 m^3/sec for 1984's flood and they are still large values comparing with the present flow capacity of the river channel.

The conceivable flood control dam schemes to protect flood prone areas in the basin are as follows:

(i) Ascurra dam : Middle of the Itajai river. Catchment area is 9,581 km^2.

(ii) Trombudo dams (A) and (B) : Upstream of Trombudo river. Catchment area is 300 km^2 for the dam (A) and 116 km^2 for the dam (B).

(iii) Benedito dam : Upstream of Benedito river. Catchment area is 730 km^2.

(iv) Mirim dam : Upstream of Itajai Mirim river. Catchment area is 640 km^2.

DNAEE proposed alternative scheme for Ascurra dam by combining Salto Pilao, Subida and Neisse dams. However, since the reservoir efficiency (construction cost/effective storage) is inferior to the Ascurra dam, these alternative schemes were deleted.

3.3 Flood Control Method by Structural Measures

Since much flood damage takes place in major cities along the Itajai river and its tributaries, it was contemplated to protect the river stretches along these cities from flood by means of the combination of the foregoing structural measures.

3.3.1 Flood control for Blumenau city

Among flood prone river stretches, the river stretch along the Blumenau city is a bottleneck in view of the flood control planning because houses and buildings approach up to the both river banks along V-shaped meandering river course and it is practically impossible to increase the flow capacity by widening of the existing river channel or by constructing of high levee. Besides it is considered to be difficult to obtain an agreement of the inhabitant for construction of high levee because it disturbs scenery of the Blumenau city.

In due consideration of the foregoing situation, it is considered to protect the Blumenau city from flood by the following steps;

(1) It is contemplated to increase the flow capacity of the river channel along the Blumenau city by steepening hydraulic gradient of the flood water level and by minimizing rise of the flood water level as far as possible. To achieve the above purpose, it is duly necessary to lower the flood water level at the downstream end of the Blumenau river stretch and it will be made by means of widening of the river channel between the downstream end of the Blumenau river stretch and downstream of the Gaspar city and also about 6.5 km long river stretch in the upstream of the Blumenau river stretch. Among these methods, the river improvement in the up and downstream of the Gaspar city accords with that being performed by DNOS at present.

(2) As the following step to increase the flow capacity of the Blumenau river stretch, it is contemplated;

(i) To widen the left river bank along the Blumenau city as far as possible.

(ii) To reduce roughness coefficient of the river channel along the Blumenau city by arranging the river bank slope and providing river bank slope protection.

(iii) To provide concrete parapet wall for the right river bank along the Blumenau city for about 600 m long stretch in the upstream from the confluence with a tributary, Garsia river, which is locally low elevation. In view of scenery of the Blumenau city, height of the concrete parapet should be limited less than 1.5 to 2 m.

The flow capacity of the river channel along the Blumenau city by means of the above methods is calculated at around 5000 m^3/sec which corresponds to 50-year probable flood.

(3) To protect major cities downstream from the Blumenau city from flood, flood control method by combination of river improvement and proposed Ascurra dam is conceivable.

(4) The Blumenau city is inundated not only by the flood from the Itajai river but also by the flood flow from tributaries flowing into the city areas. To cope with back swamp problem due to flood from the tributaries, drainage plan for this back swamp should be taken into account for the planning.

In order to lower the flood water level at the Blumenau river stretch, about 1.4 km long flood diversion tunnel plan by connecting with the upstream and downstream ends of V-shaped meandering river stretch was studied. It was estimated that difference of water level between inlet and outlet of the tunnel for about 2,400 m^3/sec of the present discharge capacity of river channel is only about 0.8 m and hydraulic gradient is 1/2,000 to 1/2,500. The estimated discharge capacity of the tunnel in case of one lane with a diameter of 12 m is only about 200 m^3/sec. Since the design flood in case of the provisional plan is 3,400 m^3/sec, five lanes of tunnel with diameter of 12 m is needed to discharge 1,000 m^3/sec of the flood discharge. However, construction cost of the tunnel work in this plan is too costly and long construction period is needed. Due to these reasons, this flood diversion plan was deleted from planning.

3.3.2 Flood control for Itajai city

Many houses and harbor facilities approach up to both river banks along the Itajai city and it is practically impossible to widen the river channel and to construct high levee. When flood water level is raised to increase the flow capacity of the river channel, drainage from Itajai Mirim river which joins with Itajai river at its endmost stretch becomes impossible. Therefore, it is necessary to work out the flood control plan which does not rise the flood water level. The conceivable flood control method for the Itajai city is as follows;

(1) The bankfull flow capacity in the endmost Itajai river is so small as being 1,000 m^3/sec. To discharge safely the flood in the Itajai Mirim river to Atlantic Ocean through the Itajai river channel, it is necessary to shut out the flood from the Itajai river and to flow down to Atlantic Ocean through the proposed floodway to be provided connecting with the Itajai river in the upstream of the Itajai city and Atlantic Ocean near Picarras city.

(2) Flood discharge in the Itajai Mirim river debouches to the Itajai river through the existing meandering river channel and short cut channel at the endmost river stretch. At the flood time in July 1983, a part of the Itajai city was inundated by flood coming through the existing meandering river channel. In order to protect the Itajai city area from flood from the Itajai Mirim river, flow capacity of the existing short cut channel should be increased by widening of its river channel and levee should be provided along the meandering river channel and widened short cut channel.

3.3.3 Flood control for other cities

Conceivable flood control method for Gaspar, Ilhota, Ascurra, Rio do Sul, Ituporanga and Brusque cities is as follows;

(1) It is practically impossible to widen the river channel and to construct high levee in the river stretch along the Gaspar city because many houses approach up to the river banks. To protect the Gaspar city from flood, the flood discharge more than the flow capacity of the river channel along the Gaspar city should be flown down through a proposed flood diversion channel to be provided connecting with the upstream and downstream ends of V-shaped meandering Gaspar river stretch.

(2) Since there are many outcrop of rocks on river bed along Rio do Sul, Ascurra and Ituporanga cities, river improvement plan by means of widening of the river channel will be adopted and supplementally, levee and/or filling of exavated material from river channel will be provided for the river bank which is locally low elevation.

(3) To protect major cities downstream from Rio do Sul city from flood, flood control method by combination of river improvement and proposed Trombudo dams is conceivable.

(4) It is necessary to work out the flood control plan which does not rise the flood water level in the Blumenau and Itajai river stretches. Then river improvement plan by means of widening of the river channel will be applied to the Ilhota river stretch and supplementally levee and/or filling of excavated material from river channel will be provided for the river bank which is locally low elevation.

(5) For flood control for Brusque city in the Itajai Mirim river, two methods are conceivable. One is the river improvement by means of widening of the river channel. Other is the combination plan of river improvement and the proposed Mirim dam.

3.4 Flow Chart for Formulation of Flood Control Plan

It is contemplated to formulate the flood control plan in the Itajai river basin by the following procedures:

(1) Establishment of flood control level

(2) Selection of protective river stretches

(3) Formulation of flood control plan by means of river improvement including river channel improvement and floodway in consideration of flood peak reduction by the existing dams and combination of river improvement and new dam.

(4) Formulation of flood control projects.

(5) Recommendation for non-structural measures.

(6) Selection of flood protection area for feasibility study.

The plan formulation diagram of flood control in the Itajai river basin is shown in Fig. VI.3.1.

3.5 Establishment of Flood Control Level

In due consideration of the flood control method by structural measures, it was contemplated to work out the flood control plan in the Itajai river basin based on the following three flood control levels;

(1) Long term plan

In application of the structural measures, higher target level of protection as possible would be desirable to be adopted for safety of facility and long term stability and livelihood of the riparian people. From these viewpoints, a long term plan was assumed to be introduced for target plan for future phase of flood control, and 50-year probable flood was applied as the design flood due to the reason that if the river improvement work to cope with 50-year probable flood is finished, flood peak discharge with the same scale as that in July 1983 can be safely flown down through the river channel along the Blumenau city.

(2) Mid-term plan

In order to realize the long-term plan, much construction cost and long term construction period are needed. To attain the final target plan of flood protection as earlier as possible, stage wise flood control plan was contemplated and mid-term plan was assumed to be introduced. A 25-year probable flood was taken as the design flood due to the following reasons;

(i) After the river improvement plan to cope with 25-year probable flood is completed, the second largest flood in 1984 can be safely discharged.

(ii) The mid-term plan can complete the work schedule corresponding to almost half of the work quantities for the long-term plan.

(3) Provisional plan

In order to realize the flood control plan as earlier stage as possible and to meet with the urgent social requirement, short term provisional plan was assumed to be introduced and 10-year probable flood was selected as the design flood due to the following reasons;

(i) The present flow capacity of the river channel along Blumenau - Gaspar stretch and Ascurra stretch corresponds to 5-year probable flood.

(ii) The quantities of major works for river improvement against 10-year probable flood are not so increased comparing with those for 5-year probable flood.

(iii) Compensation problems including lands and houses and relocation of public road for river improvement against 10-year probable flood is almost the same as these for 5-year probable flood.

3.6 Selection of Criteria for Protective River Stretch

3.6.1 General

It is contemplated to select the objective areas for flood control by structural measures by means of damage potential indicated by amount of flood damage and inundation population. Selection criteria for protective river stretch is presented as follows.

3.6.2 Division of flood analysis area by river stretch

In order to carry out the study on flood analysis and selection of the flood protection priority areas, Itajai main stream and its tributaries are divided by stretches as follows:

Itajai river

IT1 From the river mouth to the confluence of the Itajai Mirim river

IT2 From the confluence of the Itajai Mirim river to the proposed floodway site

IT3 From the proposed floodway site to 1.5 km downstream of Ilhota city

IT4 From 1.5 km downstream of Ilhota city to 2 km upstream of the Ilhota city

IT5 From 2 km upstream of Ilhota city to 3 km downstream of Gaspar city

IT6 From 3 km downstream of Gaspar city to the confluence of the Belchior river

IT7 From the confluence of the Belchior river to 6.5 km upstream of Blumenau city

IT8 From 6.5 km upstream of Blumenau city to 5 km downstream of Indaial city

IT9 From 5 km downstream of Indaial city to 3 km upstream of the confluence of the Benedito river

IT10 From 3 km upstream of the confluence of the Benedito river to the confluence of the Sao Pedro river

IT11 From the confluence of the Sao Pedro river to 5 km upstream of Ascurra city

IT12 From 5 km upstream of Ascurra city to 3 km downstream of Lontras city

IT13 From 3 km downstream of Lontras city to the confluence of the Itajai do Oeste river

Itajai Mirim river

IM1 From the confluence of the Itajai river to the existing diversion site

IM2 Existing diversion channel

IM3 From the existing diversion site to 9.2 km upstream of confluence with diversion channel

IM4 From 9.2 km upstream of confluence with diversion channel to 4 km downstream of the Brusque city

IM5 From 4 km downstream of Brusque city to 5 km upstream of the Brusque city

Benedito river

BN1 From the confluence of the Itajai river to the confluence of the Cedros river

Itajai do Norte river

IN1 From the confluence of the Itajai river to 7.5 km upstream from the confluence

Itajai do Oeste river

IO1 From the confluence of the Itajai river to confluence with Oeste and Trombudo rivers

IO2 From the confluence of Oeste and Trombudo river and 15 km upstream from the confluence.

Itajai do Sul river

IS1 From the confluence of the Itajai river to the Aurora city

IS2 From the Aurora city to 2 km downstream of the Ituporanga city

IS3 From 2 km downstream of the Ituporanga city to 1.5 km upstream of the city.

The river stretches thus divided are shown in Fig. VI.3.2.

3.6.3 Selection criteria for priority protective areas

In order to know the degree or level of importance for flood prone areas along the respective divided river stretches, preliminary selection of the priority protection areas was made under the following criteria:

Proposed structure	Area/place to be protected	Selection criteria
River improvement	River stretch	Priorities given by damage potential of each stretch (damage cost and inundation population per km and per km^2)

Increase in the population and flood damage potential due to future land use is considered for this preliminary selection. Result of the preliminary selection of the priority protection area is given in Table VI.3.1. This table shows that the river stretches classified as Level-1 are the most important protective areas and next priority is given to a stretch of Level-2, then Level-3.

Based on the criteria for protective priority areas classified by three levels: Levels-1, 2 and 3 as stated in the foregoing, some alternative plans for protective stretches are counterplotted in the following chapter.

3.7 Condition for Estimation of Construction Cost and Benefit

The following criteria were applied for economic evaluation;

(1) Construction cost

Cost in 1986 basis. It is assumed that 85% of the construction cost is foreign currency.

(2) Economic cost

85% of the estimated financial cost

(3) Flood control benefit

Benefit accrued from reduction of flood damage

(4) Construction period

River improvement ; construction period is estimated based on the annual earth work of about 0.5 to 0.6 million m^3.

(5) Discount rate; 8% per annum

3.8 Non-Structural Measures

Non-structural measures will be considered as a possible means of supplementing the structural measures. In the areas where effective structural measures are not applied, mitigation of flood damage by means of non-structural measures will be considered and recommendation for the following non-structural measures will be made;

(1) Flood plain management

(2) Structural change to houses and restriction of new house building

(3) Restriction of land use along river course

(4) Flood forecasting and warning system

(5) Land conservation and reforestation

4. FORMULATION OF PROVISIONAL PLAN

4.1 General

The provisional plan was formulated by means of river improvement method comprising river improvement including the widening and dredging of the existing river channel and partial levee construction, floodway at the endmost Itajai river and taking into account, the flood control effect by the existing Sul, Oeste and Norte dams.

The river improvement plan was studied under the following procedures:

(1) Selection of protective river stretch

(2) River improvement structural plan

(3) Economic evaluation for river improvement plan

4.2 Selection of Protective River Stretches

4.2.1 General

The flow capacity in the river stretch along the Blumenau and Itajai cities is too small to discharge the flood from the upstream river basin, and if the flood control work in the upstream reaches from the Blumenau city is exclusively materialized, flood peak discharge in the downstream stretch will increase remarkably and consequently, huge amount of the cost for flood control work to cope with each increased flood peak will be obliged to be disbursed. To avoid such situation, selection of the protective stretch was studied under the following procedures:

(1) Selection of the protective river stretch in the downstream from Indaial.

(2) Selection of the protective river stretch in the upstream from Indaial.

Selection of the river stretch to be protected by the structural measures was studied based on the concept that first priority should be given to the areas with higher flood damage as shown in Table VI.3.1 Selection of protective river stretch in the upstream of Indaial was studied under the concept that the influence to the flood control plan in the downstream due to flood control in the upstream from Indaial should be minimized. Details of the study are presented below.

4.2.2 Selection of protective river stretch in the downstream from Indaial

Based on the result of preliminary selection of the priority protection area as shown in Table VI.3.1, the river stretches along the Blumenau, Gaspar, Ilhota, Itajai and Brusque cities are selected as the improvement stretch and other stretches are left as unprotected stretch. This scheme is herein called as Alternative 1.

Flood discharge distribution for 10-year probable floods for Alternative 1 is given in Fig.VI.4.1.

4.2.3 Selection of protective river stretch in the upstream from Indaial

In addition to the protective stretch in Alternative 1, in the downstream from Indaial, the river stretch along Rio do Sul city are selected as the improvement stretch and other stretches were left as unprotected stretch. This scheme is defined as Alternative 2. Alternatives 3 and 4 are also proposed, which protect Ascurra and Ituporanga stretches respectively in addition to the respective stretches in Alternative 2.

Flood discharge distribution for 10-year probable floods for Alternatives is shown in Fig.VI.4.1. This figure shows that the flood peak discharge in the downstream stretch is increased due to the river improvement work for Rio do Sul stretch and its increased discharge is 100 m^3/sec. The flood water level corresponding to the additional increased flood discharge of 100 m^3/sec is only around 0.10 at the Blumenau and Itajai river stretches. Since it is considered that the increase in the river improvement cost due to this increase of the flood water level is negligible small, Alternative 4 was selected for planning of river improvement for provisional plan.

4.3 River Improvement Structural Plan

4.3.1 General

Planning and designing of the river improvement structural plan were carried out based on the flood control method by structural measures as stated in paragraph 3.2. Details of the planning and designing for the respective stretches are as follows;

4.3.2 River improvement structural plan

(1) Blumenau river stretch

To protect the Blumenau city from flood, the following measures were planned;

(i) River improvement in 18 km long stretch between the downstream end of the Blumenau city and downstream of the Gaspar city, and also 6.5 km long stretch in the upstream of the Blumenau city.

(ii) Widening of the river channel in the several left river bank portions in the Blumenau stretch as shown in Fig.VI.4.2.

(iii) Arrangement of the river bank slope of the Blumenau stretch and protection work for the arranged bank slope to reduce roughness coefficient of the river channel.

(iv) Construction of about 1.5 m high and 600 m long concrete parapet wall along the right river bank upstream from the confluence with Garsia river. To avoid defilement of the appearance of the street in the Blumenau city, the concrete parapet wall as illustrated in Fig.VI.4.3 is proposed.

The river improvement plan by means of widening of the river channel and dredging to arrange the river channel was applied to the Blumenau - Gaspar stretch and about 6.5 km long stretch upstream of the Blumenau city, and supplementally levee and/or filling of the excavated materials from river channel was planned for the river bank which is locally low elevation. Criteria of the river improvement plan are as follows;

(i) Side slope of the excavated river channel is 1:2.

(ii) Filling of the excavated materials from river channel is adopted to the river bank side where no house is located and elevation is locally low.

(iii) Levee is provided to the river bank side where the houses are located and elevation is locally low. Location of the levee in river bank is decided considering the river cross section which is able to flow down 50-year probable flood. The clearance between toe of the levee and edge of the excavated river slope is 5 m. Height of levee is decided based on the water level corresponding to 50-tear probable flood. Freeboard of the levee is 0.5 m.

(iv) Side slope of the levee is 1:2 on both sides and crest width of the levee is 4 m.

The Blumenau city has been inundated not only by the flood from the Itajai river but also by the flood from tributaries, Garcia, Velha and Itoupava. To cope with the inundation due to flood from these tributaries, three methods are conceivable. One is to provide the levees along the inundated river stretch to protect both banks area from flood coming from Itajai main stream. Height of the levee will be the same as that at the confluence part with the Itajai main stream. Second one is to close the confluence portion by gated weir and to discharge the flood from the tributary after the flood water level of the Itajai river is lowered. Third one is to provide the pumping station at the confluence portion with main stream to drain forcibly the flood water during flood peak time. It is presumed that high flood water level lasts during a long time in the Itajai main stream, while the duration time of flood water level in the tributary, which is higher than that of the Itajai main stream, is remarkably short. This means that flood control method by the gated weir is not effective to mitigate the back swamp area. Thus, the method to construct the levee along the inundated river stretch and to provide the pumping station was applied in this plan though perfect drain by the pump may be impossible because the catchment area of the tributary is so large as being of about 150 km^2.

(2) Gaspar river stretch

The following measures were planned to protect the Gaspar city;

(i) River dredging to increase the flow capacity of river stretch along the Gaspar city.

(ii) Construction of the flood diversion channel to discharge the flood exceeding the flow capacity of the improved river stretch along the Gaspar city. The flood diversion channel will be provided by connecting with the upstream and downstream ends of V-shaped meandering Gaspar river stretch.

Criteria for the river improvement plan are the same as those for the Blumenau river stretch.

(3) Itajai river stretch

The bankful discharge capacity in the downstream of the Itajai river stretch is so small as being about 1,000 m^3/sec. In order to protect the Itajai city from flood from Itajai main stream and Itajai Mirim river, a floodway to discharge the flood exceeding the discharge capacity in the Itajai river stretch was contemplated for the route connecting with the Itajai river at about 11 km upstream of the Itajai city and Atlantic Ocean near Picarras city in the northward.

Several alternatives to divert the flood into the proposed floodway were contemplated. They are;

(i) Alternative-1 which is natural diversion method without any flood diversion structures in the Itajai river and floodway sides.

(ii) Alternative-2 which is the flood diversion method by provioding a closure dam with outlet facilities in the Itajai river side.

(iii) Alternative-3 which is the flood diversion method by providing gated overflow weir in the Itajai river side, and

(iv) Alternative-4 which is the flood diversion method by providing the gated weir at the floodway side and gated overflow weir at the Itajai river side.

General plan of these four alternative plans is shown in Fig.VI.4.4. The flood diversion method for these alternative plan was studied as follows. In this case, 50-year probable flood was adopted to study the plan for final stage.

(i) For Alternative-1;

This plan intends to flow down the design flood discharge to the Itajai river by natural flood diversion method without gate operation. Since the design flood from the Itajai Mirim river is 860 m^3/sec, the flood discharge which can be flown down to the Itajai river is 140 m^3/sec. Consequently, the flood discharge to be flown down through the floodway is estimated at around 5,000 m^3/sec. Width of the floodway in this case becomes so widely as being about 870 m and consequently the construction cost becomes too costly due to a large amount of earth works. While the flood discharge flowing down to the Itajai river varies depending on the magnitude of flood from the Itajai Mirim river, and ratio of the flood discharge to the Itajai river and floodway varies when the variation of river bed takes place near the inlet portion of the floodway. Besides, it is impossible to flow down the flood discharge corresponding to the allowable discharge in the downstream of the Itajai river by this natural flood diversion method.

(ii) Alternative-2;

This plan intends to protect the Itajai city from flood by diverting majority of flood to the floodway without complicate gate operation. Width of the floodway in this plan is 280 m. It is possible in this plan to flow down the discharge of 100 to 150 m^3/sec through the outlet facility but diversion of more larger flood discharge to the Itajai river is impossible. Due to this flood diversion method, this plan has a demerit that the existing Itajai river channel between the closure dam and Itajai Mirim confluence is not effectively utilized.

(iii) Alternative-3;

This plan intends to flow down as much flood discharge as possible to the Itajai river by effectively utilizing the existing Itajai river channel. Width of floodway in this plan is decided at 270 m under the condition that 140 m^3/sec of the flood flows down to the Itajai river at the water level corresponding to the elevation of river bank at the closure damsite. Width of the gated overflow weir is set at 86 m based on the water level corresponding to 4,100 m^3/sec to be diverted to the floodway under the condition that 1,000 m^3/sec of flood flows down to the Itajai river. It is possible in this plan to regulate the flood discharge ranging from 140 m^3/sec to 1,000 m^3/sec flowing down to the Itajai river by operating the gates on the closure dam at itajai river side. Since several numbers of gate are installed in this plan, the construction cost will be rather increased and besides complicate gate operation will be needed.

(iv) Alternative-4;

This plan also intends to flow down as much flood discharge as possible to the Itajai river by effectively utilizing the existing Itajai river channel. Width of the floodway in this plan is about 270 m. It is possible in this plan to regulate completely the flood discharge flowing down to the Itajai river by joint operation of the gates at the floodway and Itajai river sides even when any magnitude of flood flows from upstream of the Itajai river. However, due to the provision of the gates at the floodway and Itajai river sides, much construction cost will be needed and besides, complicate compound gate operation will have to be required.

Among these alternative plans, Alternative-3 seems to be the most suitable method in this planning stage considering flood diversion method to effectively utilize the limited flow capacity of the river stretch along the Itajai city and to minimize the frequency of use of the floodway and obtaining of social agreement for this plan from inhabitant in Picarras city, though technical justification for this plan by means of model test, study on hydrological matters and so on. Thus, Alternative-3 is recommended to be adopted to this study.

The proposed floodway was planned as a compound section providing levee on both sides. In the floodway, design flood is discharged through the excavated low water channel without rising the flood water level and levee with height enough for free board is provided on both banks. Detailed criteria for the floodway are as follows:

(i) The width of the low water channel is 180 m for discharging the design flood. The distance between the levees is 290 m including allowance of 55 m between the foot of the levee and top of the low water channel. This allowance will be useful as a room in case of increase in flood peak discharge in future stage.

(ii) Depth of the low water channel is the same as that of the existing river channel at junction portion of the proposed floodway and Itajai river.

(iii) Side slope of the low water channel is 1:2.

(iv) Side slope of the levee is 1:2 and crest of the levee is 4 m.

A jetty was planned to be provided at the outlet of the floodway to avoid the flowing the sedimented water into seaside of the Picarras city. The jetty consisting of the stone piling with 100 m in total length was planned to be provided in the both sides.

The closure dam in the Itajai river at just downstream of the confluence with the floodway was planned to divert the flood from the Itajai river to the floodway. In this case, two alternative closure dams are conceivable. One is the closure dam consisting of earth filling with outlet facility to discharge the maintenance flow to the downstream of the Itajai river. Other is the closure dam with channel to pass small scale ship. It is considered that river maintenance flow will have to be discharged for cleaning of the river water and other purposes, but navigation is not always necessary for the Itajai river considering the socio-economic conditions of the basin. Due to this reason, the closure dam with outlet facility having the capacity of 15 m^3/sec during the dry season as illustrated in Fig.VI.4.5 was applied to this plan. This outlet facility also has a function to flow down 100 to 150 m^3/sec of discharge at flood time, which is the allowable discharge in the endmost Itajai river in consideration of flood from Itajai Mirim river.

About 3.8 km long river improvement by means of widening of the existing short cut channel in the Itajai Mirim river at its endmost stretch and levee construction along the meandering river channel and widened short cut channel. The improved river width in the short cut channel is about 70 m on an average.

(4) Ascurra, Rio do Sul, Ituporanga and Brusque river stretches

The river improvement plan by means of widening of the river channel and dredging to arrange the river channel was applied to the protective stretches along Ascurra, Rio do Sul, Ituporanga and Brusque cities, and supplementally levee and/or filling of excavated material from river channel was planned to be provided for the river bank which is locally low elevation. Criteria for the river improvement plan is the same as that for the Blumenau - Gaspar stretch.

(5) Ilhota river stretch

The river improvement plan by means of the same method as stated in the above was applied to the Ilhota stretch. However, river bed locally rises in the stretch between the confluence with a tributary, Luis Alves and about 5 km downstream of the Gaspar city. In order to keep the design flood water level in the Ilhota stretch, river dredging in about 8 km long stretch upstream from Luis Alves confluence is to be carried out even if this river stretch is designated as unprotected river stretch.

Fig.VI.4.6 shows the longitudinal profile of the design river bed and design flood water level. General plan of river channel alignment is shown in Figs.VI.4.7 through VI.4.14. Standard cross sections for protective stretches are given in Fig.VI.4.15.

4.4 Economic Evaluation for Provisional Flood Control Plan

The construction cost for river improvement plan for the selected protective stretches was estimated as shown in Tables VI.4.1 based on the unit prices in similar projects near project site, estimated work quantities and foregoing estimation condition.

Annual flood control benefit which accrues from the reduction of the flood damage was estimated based on the result of the flood damage study.

Table VI.4.2 shows the result of the economic evaluation. This table shows that the economic internal rate of return (EIRR) for the river improvement plans except for Ilhota and Ascurra stretches is almost more than 8% and the highest one is the Blumenau-Gaspar stretch, but EIRR for the river improvement plan for Ilhota and Ascurra stretches is remarkably small.

5. FORMULATION OF MID-TERM PLAN

5.1 General

The mid-term plan was formulated by means of river improvement method in consideration of the flood control effect by the existing dams. The procedure of the planning is the same as that for the provisional plan.

5.2 Flood Discharge Distribution

Study on selection of protective river stretch in the downstream and upstream from Indaial was made in the same manner as stated in paragraph 4.2 Fig. VI.5.1 shows the flood discharge distributions in case that the Blumenau - Gaspar, Ilhota, Itajai and Brusque stretches are protected and these for the cases that respective Rio do Sul, Ascurra and Ituporanga stretches are protected exclusively. This figure shows that the flood discharge in the downstream river stretch increased due to river improvement work in Rio do Sul stretch is about 100 m^3/sec. The flood water level corresponding to this increase flood discharge is only 0.1 m. Since it is considered that this increased water level is negligible small, Alternative 4 was selected for flood control plan.

5.3 River Improvement Structural Plan

(1) Blumenau river stretch

To further increase the flow capacity in the river stretch along the Blumenau city, the following measures were planned to proceed with the river improvement by means of widening of river channel in Blumenau - Gaspar stretch and also for 6.5 km long stretch upstream from the Blumenau city.

(2) Gaspar river stretch

The flood diversion channel which was constructed in the provisional plan stage was planned to be widened to discharge the increased designed flood flow.

(3) Itajai river stretch

The river channel in the floodway and the existing short cut channel in the Itajai Mirim river was planned to be widened.

(4) Ituporanga, Rio do Sul, Ascurra, Ilhota and Brusque river stretches

The river improvement by means of widening of the river channel was planned to the river stretches along the Ituporanga, Ascurra, Rio do Sul, Ilhota and Brusque cities.

Fig. VI.4.6 shows the longitudinal profile of the design river bed and design flood water level. General plan of river channel alignment is shown in Figs.VI.4.7 through VI.4.14. Standard cross sections for protective stretches are given in Fig.VI.4.15.

5.4 Economic Evaluation for Mid-Term Flood Control Plan

Based on the foregoing river improvement structural plan, the construction cost for the river improvement works necessary to discharge the design flood for the mid-term plan was estimated as shown in Tables VI.4.1.

The result of the economic evaluation for the mid-term plan is shown in Table VI.4.2. This table shows that EIRR for the river improvement plan except for Ilhota and Ascurra stretches is higher than 8% and net benefit for the river improvement plan for Blumenau-Gaspar stretch is the highest among the selected protective stretches. When the increase in the flood damage potential in the future is taken into account, EIRR for the river improvement plan for Ascurra stretch is 7.1%.

6. FORMULATION OF LONG TERM PLAN

6.1 General

The long term flood control plan was studied for both cases of river improvement plan and combination plan of the river improvement and flood control dam. Four dams have contemplated for flood control in the Itajai river basin. They are Ascurra, Benedito, Trombudo and Mirim dams as shown in Fig. VI.6.1.

The proposed Ascurra dam with a catchment area of about 9,400 km^2 located in the Itajai main stream at about 3 km upstream from Ascurra city seems to be effective for flood control mainly for the river stretch downstream from the Blumenau city.

The proposed Benedito dam with a catchment area of 726 km^2 located in the Benedito river at about 8 km upstream from the Timbo city is limited its dam height less than 40 m because Benedito Novo city is located in the upstream of the damsite. The maximum effective storage capacity is only about 12 million m^3. This storage volume corresponds to 17 mm in rainfall amount. While, total amount for 4-day continuous rainfall in the catchment area of the proposed Benedito dam for the long term plan is estimated at around 270 mm. Since the rainfall amount corresponding to the total storage capacity of the proposed Benedito dam is only 6 % of the total amount of 4-day continuous rainfall, this dam scheme was deleted from the flood control planning.

The proposed Trombudo dams with a catchment area of 300 km^2 for dam (A) and 116 km^2 for dam (B) located in the Trombudo river at about 28 km upstream from the confluence with Itajai do Sul seems to be effective for flood control to the river stretch down stream from Rio do Sul city.

The proposed Mirim dam with a catchment area of 640 km^2 located in the Itajai Mirim river at about 30 km upstream from the Brusque city seems to be effective for flood control for the Brusque city and endmost Itajai Mirim stretch along the Itajai city.

Taking into account the foregoing expected flood control effect by the proposed dams, formulation of the long-term plan by means of the combination plan of river improvement and flood control dam was made by dividing into flood control for river stretch along the Itajai main stream and flood control for river stretch along the Itajai Mirim river.

6.2 Flood Control by River Improvement Plan

6.2.1 Flood discharge distribution

The influence to the downstream stretch due to the river improvement in the upstream stretch was investigated. Fig. VI.6.2 shows the flood discharge distribution for 50-year probable flood for Alternatives 1 to 4. This figure shows that the flood discharge in the downstream river stretch increased due to the river improvement in Rio do Sul stretch is 100 m^3/sec. The flood water level corresponding to this increased flood discharge is only 0.1 m. Since it is considered that this increased water level is negligible small, Alternative 4 was selected for flood control plan.

6.2.2 River improvement structural plan

To discharge the design flood as shown in the flood discharge distribution, the following measures were planned for the respective protective stretches;

(1) Widening of the river channel to discharge the design flood for Blumenau - Gaspar stretch, 6.5 km long river stretch upstream from Blumenau city, Rio do Sul - Lontras stretch, Ascurra stretch, Ituporanga stretch, Ilhota stretch, and Brusque stretch.

(2) Widening of the flood diversion channel at the Gaspar stretch, floodway and existing short cut channel in the Itajai Mirim river.

Fig. VI.4.6 shows the longitudinal profile of the design river bed and design flood water level. General plan of river channel alignment is shown in Figs.VI.4.7 through VI.4.14. Standard cross sections for protective stretches are given in Fig. VI.4.15.

6.2.3 Economic evaluation for river improvement plan

The construction cost required for the long term plan by means of the river improvement plan is given in Tables VI.4.1.

The result of the economic evaluation is shown in Table VI.4.2. This table shows that EIRR for river improvement plan for Ituporanga and Rio do Sul-Lontras stretches slightly decreases comparing with that for mid-term plan but it is still higher than around 8% while EIRR for river improvement plan for Ilhota and Ascurra stretches is negligible small. When the increase in the flood damage potential in the future is taken into account, EIRR for the river improvement plan for Ascurra stretches is 8.3%.

6.3 Flood Control by Combination Plan of River Improvement and Flood Control Dam

6.3.1 Flood control for river stretch along Itajai main stream

As stated in the foregoing, two alternative flood control methods by combination of river improvement and flood control dam were contemplated for river stretch along the Itajai main stream. Alternative 1 is the flood control method by combination of river improvement and proposed Ascurra dam. Alternative 2 is the flood control method by combination of river improvement and proposed Trombudo dams.

Fig. VI.6.3 shows the flood discharge distribution for Alternative 1 under the condition that the flood peak discharge larger than 25-year probable flood at the Blumenau stretch is regulated by the Ascurra dam. Fig. VI.6.4 shows the flood discharge distribution for Alternative 2 under the condition that all of the flood from the upstream of the proposed Trombudo dams is stored in the reservoirs.

The respond Ascurra dam was planned as concrete gravity dam due to the following reasons;

(1) Geological condition of the damsite is sound for construction of concrete gravity dam.

(2) Cost for spillway facility will increase remarkably for the case of fill type dam.

(3) Provision of the required number of outlet facilities in the dam bottom is impossible for the case of fill type dam.

For construction of the Ascurra dam, it is unavoidable to submerge about 10 km long national road and Apiuna town because they are located at around EL 85 m and to avoid their submergence, dam height has to be limited up to 15 m and its gross capacity is only 80 million m3. Thus it was planned in dam scheme to relocate them.

While, the Trombudo dams (A) and (B) were planned as earth fill dam in consideration of the topographic and geological conditions.

Table VI.6.1 shows the cost comparison for Alternatives 1 and 2 and only river improvement plan. It is clarified that only river improvement plan is the most economical for flood control in the stretch along the Itajai main stream. Thus, the combination plan of the river improvement and flood control dam for the river stretch along the Itajai river was deleted from the study.

6.3.2 Flood control for river stretch along Itajai Mirim

To protect the Brusque city and endmost Itajai Mirim stretch along the Itajai city, flood control method by combination of river improvement and proposed Mirim dam was studied.

Fig. VI.6.3 show the flood discharge distribution for this method under the condition that the flood discharge larger than 25-year probable flood at the Brusque stretch is regulated by the Mirim dam. The proposed Mirim dam was planned as a rock fill dam considering the topographic and geological conditions.

Table VI.6.1 show the comparison of the cost for the combination plan of river improvement and Mirim dam and for only river improvement plan. It clarified that only the river improvement plan is more economical than the combination plan. Thus, flood control by combination of river improvement and Mirim dam was deleted from the study.

7. IMPLEMENTATION PROGRAM OF FLOOD CONTROL PROJECTS

7.1 Formulation of Flood Control Projects

The flood control plans worthly of implementation were contemplated in Sections 4 to 6 within the frameworks of long-term, mid-term and provisional plans. The promising flood control projects are summarized below;

Promising Project	Provisional plan	Mid-term plan	Long-term plan
Design Flood	10-year	25-year	50-year
River Improvement			
- Blumenau-Gaspar stretch	24.5 km (E)	24.5 km (E)	24.5 km (E)
- Floodway and down-stream of Itajai Mirim	14.5 km	14.5 km (E)	14.5 km (E)
- Rio do Sul-Lontras and, Ituporanga stretches	17.4 km (E)	17.4 km (E)	17.4 km (E)
- Brusque stretch	9.0 km (E)	9.0 km (E)	9.0 km (E)
- Ilhota stretch	-	-	3.7 km (E)
- Ascurra stretch	-	-	4.0 km (E)

Note; E means enlargement of channel

Among three stages of the plan, first priority for implementation should be given to the provisional plan since it plays an important role for raising safety factor for flood control in an early stage.

7.2 Outline of the Proposed Flood Control Projects

The followings show the outline and purpose of the proposed flood control projects;

(1) Provisional plan stage

The river improvement in this stage comprises the following work items;

(i) Blumenau - Gaspar stretch (24.5 km)

The river channel in 18 km long stretch between the downstream of the Blumenau stretch and downstream of the Gaspar stretch is widened to lower the flood water level in the Blumenau and Gaspar stretches. The river channel in 6.5 km long stretch in the upstream of the Blumenau stretch is widened. Levee and/or filling of excavated material from river channel is provided only at the river bank with locally low evaluation. About 1.3 km long and 80 m wide flood diversion channel is constructed detouring the Gaspar city. Several left river bank portions in the Blumenau stretch are widened. The river bank slope in the Blumenau stretch is arranged and surface slope protection work comprising revetment and sod facing is executed to reduce the roughness coefficient. About 1.5 m high and 600 m long concrete parapet is provided in the right river bank along the Blumenau city. To protect the lowland along the inundated river stretch in the tributaries flowing into the Blumenau city, levee is provided and pumping station is provided at the confluence portions of the main stream.

(ii) Floodway and downstream of Itajai Mirim

Floodway scheme

About 10.7 km long and 180 m wide floodway will be constructed to Atlantic Ocean near Picarras city and jetty consisting of stone piling will be provided at the outlet of the floodway to prevent the flowing the sedimented river water into the coastal area in the Picarras city. To divert all of the flood from the Itajai river, a closure dam comprising earth filling and riprap at the outside slope will be constructed in the Itajai river at just downstream of the confluence with the floodway.

Downstream of Itajai Mirim (3.8 km)

About 3.8 km long existing short cut channel in the Itajai Mirim river will be widened and levee will be provided for the widened short cut channel and existing meandering river stretch along the Itajai city.

(iii) Rio do Sul - Lontras stretch and Ituporanga stretch (17.4 km)

The river channel will be widened and supplementally levee and/or filling of excavated material from river channel will be provided for the river bank with locally low elevation.

(iv) Brusque stretch (9 km)

The river channel will be widened and supplementally levee and/or filling of excavated material from river channel will be provided for the river bank with locally low elevation.

(2) Mid-term plan stage

The river channel in Blumenau-Gaspar stretch, river stretch upstream of the Blumenau stretch, flood diversion channel in Gaspar stretch, Rio do Sul - Lontras stretch, Ituporanga stretch, Brusque stretch, short cut channel in Itajai Mirim river and floodway is further widened.

(3) Long-term plan

The river improvement in the long-term plan stage is as follows;

(i) River channel in Ituporanga stretch, Rio do Sul - Lontras stretch, Ascurra stretch, Blumenau - Gaspar stretch, flood diversion channel in Gaspar stretch, Brusque stretch, existing short cut channel in the Itajai Mirim river and floodway is further widened.

(ii) Ilhota stretch (3.7 km)

The river channel is widened and supplementally levee and/or filling of excavated material from river channel is provided for the river bank with locally low elevation. To lower the flood water level in this stretch, river dredging is executed to excavate locally rised river bed in about 8 km long stretch upstream from the confluence with a tributary, Luis Alves river.

(iii) Ascurra stretch (4 km)

The river channel is widened and supplementally levee and/or filling of excavated material from river channel is provided for the river bank with locally low elevation.

7.3 Implementation Program

Taking into account the result of economic evaluation, degree of social urgent requirement and extent of compensations of lands and houses, implementation schedule of the flood control projects was worked out as shown in Fig. VI.7.1. Sequence of the river improvement work by stage is schematically shown in Fig. VI.7.2.

7.4 Cost Estimate of Flood Control Projects

The construction cost necessary for each stage was estimated. The estimated cost was summarized as follows;

	Total (10^6 Cz$)
Provisional plan stage	
River improvement	
- Blumenau-Gaspar stretch	507
- Floodway and downstream of Itajai Mirim	737
- Rio do Sul-Lontras and Ituporanga stretches	879
- Brusque stretch	105
Sub-total	2,222
Mid-term plan stage	
River improvement	
- Blumenau-Gaspar stretch	261
- Floodway and downstream of Itajai Mirim	119
- Rio do Sul-Lontras and Ituporanga stretches	378
- Brusque stretch	13
Sub-total	771
Long-term plan stage	
River improvement	
- Blumenau-Gaspar stretch	391
- Floodway and downstream of Itajai Mirim	197
- Rio do Sul-Lontras and Ituporanga stretches	283
- Brusque stretch	22
- Ilhota stretch	237
- Ascurra stretch	95
Sub-total	1,225
Grand total	4,218

Note; Cost is estimated on 1986 basis.

8. RECOMMENDATION FOR NON-STRUCTURAL MEASURES

8.1 General

Non-structural measures were contemplated as possible mean of supplementing the structural measures. In area where effective structural measures were not applied, mitigation of flood damage by means of non-structural measures were also contemplated. In this section, recommendation for non-structural measures were made for the followings;

(1) Flood plain management

(2) Structural change to houses and restriction of new house building

(3) Restriction of land use along river course

(4) Flood forecasting and warning system

(5) Land conservation and reforestation

The recommendation of non-structural measures was studied assuring the situation after the provisional plan was completed.

8.2 Recommendation for Non-structural Measures

8.2.1 Flood plain management

The flat lands in the flood vulnerable area along the Itajai and its tributaries are occupied mainly by agricultural land. It is predicted that the flat plain in the flood vulnerable area will be utilized as the agricultural land as it is even in the future stage though the crop productivity will be gradually increased.

This measure intends to minimize the agricultural flood damage by regulating the agricultural activity in the areas where the structural measures are not applied. General procedure for application of this measure is as follows;

(1) to select flood prone areas where the structural measures are not applied;

(2) to select some areas in the flood prone areas, where the agricultural production has been damaged by flood and/or will be affected in the future;

(3) to designate flood prone zones with the ranks in consideration of intensity of flood such as the depth and the frequency of inundation; and

(4) to set forth regulations for agricultural activities in the designated flood prone areas.

In general, the flood plain management has the advantage of reducing or preventing following troublesome problems:

- reducing habitual flood damages on agricultural production;

- preventing new development which could result in potential losses and damages;

- reducing public costs for emergency operation, relief, evacuation and restoration.

Agricultural production has damaged by flood in some cultivation areas along the river stretches. The crops which have been seriously damaged by flood is paddy and upland crop. In the pasture land, livestock has been affected by flood more seriously than paddy but it will be diminished by introducing a flood forecasting and warning system.

The river stretches with cultivation area of paddy and upland crops were selected from the river stretches in which the structural measures are not applied. They are listed as follows;

Symbol	River stretch
IT5	Upstream of Ilhota city
IO2	" of Rio do Sul city
IM1	" of Itajai city
IM2	"
IM3	"
IM4	"

In order to examine the suitability of land use for paddy and upland crops in the flood prone areas along these river stretches, inundation area in each stretch was estimated assuming that 2-year and 5-year probable floods take place after the river improvement work to cope with the provisional plan is finished. The estimated inundation area was divided into the following two area divisions;

Division - 1; Water depth is 0 to 0.5 m for 2-year probable flood and 0 to 1.0 m for 5-year probable flood.

Division - 2; Water depth is more than 0.5 m for 2-year probable flood and more than 1.0 m for 5-year probable flood.

Zoning map of each stretch is illustrated in Fig. VI.8.1. Based on this zoning map and land use map in the basin area, it is recommended that ;

(1) Present agricultural lands in area division - 1 are mainly utilized for upland crop, sugarcane and pasture land. In order to decrease flood damages on agricultural production, a counter-measure for the cultivation of upland crop is necessary, which is the most vulnerable among agricultural production mentioned above. Accordingly, it is recommendable that the cultivation of vegetable, vulnerable product, be converted to grain crops such as maize and wheat.

(2) Present agricultural lands in area division - 2 are mainly utilized for paddy production. This is because these lands are located in flat areas along the Itajai river and its tributaries depending on their abundant water resources and because paddy is relatively tough for flood as compared with other crops. Although area division - 2 has higher potential of vulnerability on flood than area division - 1, extensive land use alteration of paddy cultivation will be practically difficult, considering the reasons mentioned above. Thus, it is recommended to establish official relief measures to relieve flood victims.

8.2.2 Structural change to houses and restriction of new house building

These measures intend to mitigate flood damage in flood prone area by applying structural change to houses such as making high floor, diking around houses and/or elevating ground by land filling and lay restricting new house buildup in the flood prone area.

The measure by means of structural change to houses will be effective for the areas specified as follows;

- Area with relatively few resident which sparsely built up.

- Area with relatively shallow inundation depth

The measure by restricting new house building will be applied to the areas with relatively deeper inundation depth and high frequent inundation.

The river stretches with the areas as specified in the above were selected from among the river stretches in which structural measures are not applied. They are listed as follows;

Symbol	River stretch
IT3	Upstream of Itajai city
IT4	Ilhota city
IT5	Upstream of Ilhota city
IT12	" Ascurra city
IO2	" Rio do Sul city
IM1	" Itajai city
IM2	" "
IM3	" "
IM4	" "

The area division to apply structural change to houses and restriction of new house building were determined as follows;

(1) Inundation area in each stretch was estimated assuming that 2-year and 5-year probable floods take place after the river improvement world to cope with the provisional plan is finished.

(2) The estimated inundation area was divided into the following two area divisions;

Division - 1; Water depth is 0 to 0.5 m for 2-year probable flood and 0 to 1.0 m for 5-year probable flood.

Division - 2; Water depth is more than 0.5 m for 2-year probable flood and more than 1.0 m for 5-year probable flood.

Fig.VI.8.1 shows two area divisions for each stretch classified in accordance with the foregoing criteria. It is recommended from the view point of the inundation depth that;

(1) Structural change to houses is applied to the area division - 1.

(2) Restriction of new house building is adopted to the area division - 2 and in case that existing houses are located in the area division - 2, structural change to house is to be applied.

8.2.3 Restriction of land use along river course

This measure intends to prevent disaster for houses and inhabitant due to side erosion of river bank and falling down of river bank slope by restricting the construction of houses and buildings along the river course.

According to the information obtained in the survey, land use of river bank in the stretch between the Itajai river mouth and Blumenau is controlled by navy and land use in 33 m wide from the edge of river bank is restricted. While the land use in above 15 m wide from the edge of river bank is restricted in the river stretch upstream of Blumenau.

These regulations are considered to be fairly effective in view operation and maintenance of the river channel if the land use in the river bank is strictly controlled by these regulations, however actually, many houses are being built up to river bank at present.

The disaster due to side erosion of river bank and falling down of river bank slope does not take place in the Itajai main stretch in the past but the disaster took place in the tributaries flowing into the Blumenau city.

It is anticipated to increase the houses along the river course in future stage. To prevent the disaster for houses and inhabitant along the river banks, it is recommended to reinforce restriction by foregoing existing regulations, especially for the following stretches;

- Ituporanga stretch
- Confluence portion of Itajai do Oeste and Itajai do Sul rivers
- Blumenau stretch
- Gaspar stretch
- Ilhota stretch
- Endmost stretch of Itajai mirim river
- Tributaries flowing into blumenau city.

8.2.4 Flood forecasting and warning system

This measure intends to reduce the flood damage in the areas protected by the structural measures if flood warning is given in advance in case that flood larger than the design flood occurs. This measure will be also effective to mitigate the flood damage to casualty and livestock in the areas where are effective structural measures by giving the flood warning in advance.

After occurrence of flood in July, 1983, DNAEE planned and implemented a flood forecasting and warning system in the Itajai river basin. This system operates with the date supplied by radio system composed of rainfall and water level gauging stations at Taio, Ituporanga, Ibirama, Apiuna, and

Blumenau. The preliminary operation of the system was started in August 1984 but flood forecasting and warning effect by this system is still unknown because of no occurrence of large scale flood since its operation stage. DNAEE has planned to install five additional telemetering stations at Rio do Sul, Indaial, Itajai, Botuvera and Brusque at the final stage.

In order to work out the flood forecasting and warning system in the basin consistent with the flood control plan in this study, improvement of the following matters is requested to the existing system;

(1) This system plans to operate by using the data to be supplied by telemetering system. But actually it was changed to radio system due to financing problem. To proceed with prompt forecasting and warning for the flood, it should be improved to the telemetering system though propagation test to confirm the capability of the telemetering method in the mountainous areas is needed.

(2) The large scale flood in the downstream is caused mainly by the rainfall in the mountainous areas in the upstream river basin. However, the planned system has no telemetering station for such mountainous areas especially in the upstream areas of the Norte, Sul and Benedito river basins.

(3) The inundation in the Blumenau city is caused not only by the flood from the Itajai river but also by back swamp due to inundation by tributaries. Since the flood from the tributary has a sharp rising and recessing characteristics and very short arrival time from occurrence of rainfall, earlier forecasting of flood from the tributary areas is required.

In due consideration of these problems, it is recommended to install the telemetering stations as shown in Table VI.8.1 to the existing system in addition to five stations proposed by DNAEE. Location of the proposed telemetric station is given in Fig.VI.8.2.

8.2.5 Land conservation and reforestation

(1) General

Forest generally plays an important role for flood control as well as soil conservation. It is, however, presumed that deforestation is progressing in the mountain area in the Itajai river basin. IBGE census in 1980 states that the estimated deforested area in the basin is about 3100 ha while the reforested area is only 1900 ha.

It is considered that inundation may take place by increasing runoff coefficient due to large scale deforestation and deforestation in steep slope zone causes land slide. It was intended in this study to minimize the disaster due to deforestation by investigating the relationship between progress of the deforestation and occurrence of disaster. However since the data showing the location and acreage of the annual deforestation are not available at all, recommendation for land conservation and forestation was made for the followings;

(i) Reinforcement of forest conservation

(ii) Promotion of forestation in non-utilized area of hilly and mountainous areas and deforested area

(2) Reinforcement of forest conservation

The result of land use survey and field reconnaissance clarifies that gentle undulating to undulating areas in the Norte river basin have been deforested and now the deforestation is progressing in the mountainous areas such as Serra da Maenua in the left bank of the Norte river and Serra do Itajai located between the Itajai and Itajai Mirim rivers. Several places in these areas consist of steep slope zone and consequently deforestation in that place is prohibited by the law but the deforestation is still progressing. Besides, since the geological condition of Serra do Itajai is very fragile against land sliding, permanent reservation of the forest in this area is needed.

In view of these situations, it is recommended to reinforce restriction of deforestation to restrain progress of the deforestation by IBDF which is a federal authority and is in charge of management of forest resources. For this purpose, IBDF is firstly requested to investigate the present situation of the deforestation in the basin areas including topography, geology, vegetation, etc. Since the staff of IBDF is insufficient to proceed with the reinforcement of the deforestation control, it is recommended to cooperate with other organization and agency such as municipality and university.

(3) Promotion of reforestation in non-utilized area of hilly and mountainous areas and deforested area

IBDF is now giving an incentive to promote reforestation by tax reduction. It is reported that 450,000 ha of deforested area has been reforested in Santa Catarina state for the last 20 years. ACARESC has an reforestation program for small farmers. However, deforested area in the basin seems to exceed reforested area in 1980.

According to the IBGE Census in 1980, 61,000 ha of non-utilized land remains in the basin. Although the location of such land cannot be defined so far, reforestation to these areas and to the deforested areas should be promoted. To make this measure more smoothly, it is necessary to inform the importance of forest function to flood for inhabitant. A campaign for enlightenment to reforestation should be promoted.

9. SELECTION OF FLOOD PROTECTIVE STRETCH FOR FEASIBILITY STUDY

The protective river stretch and flood control facility to be selected for the feasibility study were decided taking into account the following factors;

- High economic effectiveness
- Degree of social urgent requirement
- Influence to downstream reach due to realization of flood control project
- Extent of compensation for lands, houses, public facilities, etc.
- Degree of difficulty for execution works

Among the proposed flood control projects, the river improvement project including Blumenau - Gaspar stretch and river stretch upstream of the Blumenau stretch was selected for the feasibility study due to the following reasons;

(1) Among the proposed flood control projects, the river improvement project in these stretches has the highest economic viability.

(2) Among population in the flood prone areas for whole Itajai river basin, about 36% concentrates in these areas and consequently urgent social requirement to realize the flood control project is strongly requested.

(3) Even if the river improvement work in these stretches is realized, flood discharge to the downstream stretch is not increased.

(4) The river improvement work in the Blumenau - Gaspar stretch is partly executed by DNOS and a part of the compensation problem was already solved. Especially, it is considered that there are no problem for compensation for lands and houses to early realize the provisional plan.

(5) Major works in this river improvement project comprise widening of the existing river channel and river dredging to arrange the river channel and these works can be easily executed using common construction equipment.

The river improvement project involves the following works;

(1) Widening of the existing river channel and levee construction for the river banks with locally low elevation.

(2) Construction of concrete parapet in the Blumenau stretch.

(3) Drainage work for tributary to minimize back swamp problem.

Tables

Table VI. 2. 1. FEATURES OF SUL, OESTE AND NORTE DAMS

Item	Unit	Sul	Oeste	Norte
1. Reservoir				
Name of river		Itajai do Sul	Itajai do Oeste	Itajai do Norte
Location (from river mouth)	km	330	263	193
Catchment area	km2	1,290	860	2,318
Flood control space	Million cm.	97.5	83	357
Flood water level	El.m	399	360	302.5
2. Dam				
Type		Rockfill	Gravity type concrete	Rockfill
Crest elevation	El.m	410	363	309.5
Crest length	m	367.5	311	365.0
Height	m	43.5	25	65
Dam volume	Thousand cm.	678	85	2,200
Dam slope (upstream, downstream)		1:2.5, 1:2.0	1:0.03, 1:0.7	1:2.5, 1:2.0
3. Spillway				
Type		Non-gated overflow	Non-gated overflow	Non-gated overflow
Crest length	m	65.0	98	300
4. Outlet valves				
Type		Gated conduit	Gated conduit	Non-gated conduit
Scale		1.5m x 3m x5 lanes	1.5m x 7 lanes	1.5m x 5 lanes
Type				Gated conduit
Scale				2.6m x 2.6m x 2 lanes
5. Completed time		Nov. 1975	Mar. 1972	To be completed on Dec. 1987

Table VI.2.2 NUMBER OF EXISTING RIVER STRUCTURES AND RELATED STRUCTURES IN THE ITAJAI RIVER BASIN

River	Investigated River Strech	Road Bridge			Pumping Station		Hydroelectric Power Station	Weir or Dam
		National	State	Municipal	CASAN	SAMAE		
Itajai river	River-mouth to the confluence of Itajai do Norte and Sul river (182.0 km)	7	3	9	4	2	1	1
Itajai Mirim river	Confluence with Itajai main stream to SAMAE's weir (38.7 km)	2	1	15	1	1	-	1
Benedito river	Confluence to CASAN's pumping station (10.5 km)	1	-	1	1	-	-	-
Itajai do Norte river	Confluence to DALBERGIA BRIDGE (21.3 km)	1	3	-	-	-	-	-
Itajai do Oeste river	Confluence to LAURENTINO BRIDGE (12.0 km)	1	3	2	-	-	-	-
Itajai do Sul river	Confluence to ITUPORANGA (28.5 km)	1	5	4	2	-	1	1
Trombudo river	Confluence to AGROLANDIA BRIDGE (35.9 km)	-	6	4	-	-	-	-
Braco do Trombudo river	Confluence to QUILOMETRO CINCO (8.8 km)	-	2	1	-	-	-	-
Garcia river	Confluence to MARIO SCHMIDT STREET (6.3km)	-	-	7	-	-	-	1
Velha river	Confluence to RUDOLFO RUEDIGER BRIDGE (3.7 km)	-	-	7	-	-	-	-
Itoupava do Norte river	Confluence to RUDIBERTO KRUEGER STREET (12.0 km)	-	-	7	-	-	-	-
Fortaleza river	Confluence to FISKE STREET (4.5 km)	-	-	7	-	-	-	-
Total		13	23	64	8	3	2	4

Source: DNER, DER, RFFSA, CASAN, SAMAE, CELESC and municipal government office.

Table VI.2.3 EXISTING RIVER STRUCTURES AND RELATED STRUCTURES IN THE ITAJAI RIVER BASIN (1/3)

Road Bridge

/1 NO.	Name	Location: Distance from River-mouth/ Confluence (km)	/2 Admini- strative Office	Features: Length (m)	Features: Width (m)	Features: Lowest Elevation of Girder (m)	Remarks
Itajai river							
1	BR 101	17.9	DNER	474.5	8.0	8.6	RC
2	HERCILIO DEEKE	51.7		154.7	9.8	10.4	-do-
3	JOSE DA SILVA	64.4		185.6	16.1	15.0	-do-
4	PONTE EM ARCO	66.6	RFFSA	180.2	13.3	19.8	-do- (old railway)
5	ADOLFO KONDER	68.1		124.8	10.8	13.2	RC
6	PONTE FERROVIARIA	68.8	RFFSA	200.0	7.8	17.8	Steel (old railway)
7	IRINEU BORNHAUSEN	74.2		161.5	10.9	13.0	RC
8	PONTE DO SALTO	77.2		177.2	7.2	26.3	Steel
9	EMILIO BAUMGARTEN	93.5		161.0	6.4	-	RC
10	VICTOR KONDER	93.8		324.2	12.0	98.4	-do-
11	SAO PEDRO	0.3	DNER	70.0	8.3	-	Sao Pedro river, RC
12	SAO PAULO	0.2	-do-	54.0	8.3	-	Sao Paulo river, RC
13	SC 470 (ASCURRA)	115.5	-do-	130.0	9.3	-	RC
14	SC 470 (SUBIDA)	140.5	-do-	200.0	9.4	-	-do-
15	SUBIDA	141.3	DER	112.0	6.0	-	-do-
16	LONTRAS	165.3	-do-	190.0	10.2	334.6	-do-
17	AV. IVO SILVEIRA	180.3	-do-	130.0	10.5	378.8	-do-
18		182.1	-do-	134.0	2.0	-	Wooden, footpath
19		182.8		133.0	3.1	-	-do-
Itajai Mirim river							
1'	VELHA (old bridge)	0.2		115.8	6.0	4.0	RC
	MARCOS KONDER	0.2		90.0	13.2	2.4	-do-
2'	TANCREDO NEVES	1.5		78.0	11.9	4.3	-do-
3'	BR 101	3.8	DNER	74.0	5.0	6.2	-do-
4'	NOVA BRASILIA	1.0		52.0	5.0	-	-do-
5'	JOAO DA SILVA	3.0		46.0	13.0	2.0	-do-
6'	ADOLFO KONDER	4.5		129.0	13.3	1.8	-do-
7'	WERNER	9.0		44.6	6.0	3.0	-do-
8'	BR 101	11.0	DNER	70.3	10.2	3.8	-do-
9'	TATU	14.4		14.0	3.5	2.1	Wooden
10'	LARANJEIRAS	15.0	DER	56.0	5.0	9.0	RC
11'	CAMPECHE	17.8		76.9	2.7	-	Wooden
12'	TRABALHADORES	23.3		84.1	2.6	-	-do-
13'	RENAUX	27.4		60.0	0.8	20.8	Wooden, Footpath
14'	SANTOS DUMONT	31.3		65.0	2.5	17.6	Wooden
15'	BENJAMIN CONSTANT	33.9		57.0		19.7	-do-
16'	MARIO OLINGER	34.8		59.6		21.0	RC
17'	ARTHUR SCHLOESSER	36.4		64.4		17.8	-do-
18'	IRINEU BORNHAUSEN	36.6		57.5		19.2	-do-
Benedito river							
1'	CARLOS SCHROEDER	0.1		87.6	9.3	-	RC
2'	SC 470	1.4	DNER	82.0	8.5	-	-do-
Itajai do Norte river							
1'	SC 470	0.2	DNER	225.5	9.5	-	RC
2'	IBIRAMA	3.9	DER	100.7	9.5	-	-do-
3'	PONTO CHIC	5.4	-do-	136.5	11.2	-	-do-
4'	DALBERGIA	21.3	-do-	80.0	8.3	-	-do-
Itajai do Oeste river							
1'	VALDEMAR BORNHAUSEN	0.3	DER	91.2	10.0	382.0	RC
2'		4.2		90.0	3.0	-	Wooden
3'		5.2		101.5	2.3	-	Wooden, footpath
4'	SC 470	6.2	DNER	120.0	9.5	-	RC
5'		11.7	DER	75.0	9.2	-	-do-
6'	LAURENTINO	12.0	-do-	70.2	9.5	-	-do-
Itajai do Sul river							
1'	AV. BARAO DO RIO BRAN	0.1	DER	151.8	10.8	339.4	RC
2'	FERROVIARIA	0.6	RFFSA	144.6	6.8	341.3	RC (old railway)
3'		1.1		152.7	6.9	-	Wooden
4'		1.4		103.0	2.9	-	-do-
5'	STROZ	6.2		48.0	4.2	-	-do-
6'	AURORA	13.1	DER	80.2	10.5	-	RC
7'	SANTA TEREZA	21.8	-do-	53.2	4.0	-	Wooden
8'	ACESSO A ATLANTA	26.4	-do-	100.8	10.2	-	RC
9'	PENSIL	26.9		61.2	2.9	-	Wooden, footpath
10'	ACESSO A PETROLANDIA	28.0	DER	61.5	8.2	-	RC

Source : DNER, RFFSA, DER, and municipal office
Note : /1 ; Numbers in this table corresponds to those in Fig.VI.2.6.
: /2 ; Administrative offices except DER, RFFSA and DNER are regional ones.
: 1) ; Blank column of the name of bridge shows that bridge is not named.
: 2) ; - denotes that dimension is not clear.

Table VI.2.3 EXISTING RIVER STRUCTURES AND RELATED STRUCTURES IN THE ITAJAI RIVER BASIN (2/3)

Road bridge

/1 NO.	Name	Location: Distance from River-mouth/ Confluence(km)	/2 Administrative Office	Feature: Length (m)	Feature: Width (m)	Feature: Lowest Elevation of Girder (m)	Remarks
Trombudo river							
1'	BARRA DO TROMBUDO	0.4	DER	58.0	9.4	-	RC
2'	ACESSO A AGRONOMICA	2.9	-do-	40.0	9.4	-	-do-
3'	ACESSO A MOSQUITINHO	3.8	-do-	40.0	9.4	-	-do-
4'	MOSQUITO	9.1	-do-	20.0	5.0	-	-do-
5'	BRACATINGA	14.8		26.8	4.9	-	Wooden
6'	TROMBUDO CENTRAL	17.8		29.8	6.6		RC
7'		17.9		37.5	10.5	-	-do-
8'		19.0		26.5	9.3	-	-do-
9'	PALHOCINHA	24.2	DER	20.0	5.4	-	-do-
10'	AGROLANDIA	35.9	-do-	98.9	9.2	-	-do-
Braco do Trombudo							
1'	TROMBUDO CENTRAL	0.2	DER	21.0	9.6	-	RC
2'	VILA TEODORA	5.6		15.0	4.2	-	Wooden
3'	QUILOMETRO CINCO	8.8	DER	18.0	5.0	-	RC
Picarras river							
1'	IRINEU BORNHAUSEN	0.4	DER	56.5	10.5	3.7	RC
Lagoa do Furado river							
1'	FURADO	0.5		29.3	4.9	2.5	RC
2'	BR 101	2.6	DNER	30.0	8.0	3.7	-do-
Garcia river							
	DESEMBARGADOR PEDRO SILVA	0.2		48.9	14.3	-	RC
	PONTE DA RUA VII	0.8		52.0	19.0	-	-do-
	PONTE DA RUA MANAUS	1.6		33.7	1.0	-	Wooden, footpath
	PONTE DA RUA MOACIR PINHEIRO	4.0		37.4	1.0	-	-do-
	PONTE DA RUA ZENDRON	5.3		42.0	-	16.0	RC
	ARMANDO DA SILVA	5.7		33.0	-	18.0	-do-
	PONTE DA RUA MARIO SCHMIDT	6.3		32.0	-	14.8	-do-
Velha river							
	PONTE DA RUA PERIMETRAL	0.2		65.0	-	15.0	RC
	PONTE DA RUA SAO PAULO	0.4		45.0	15.0	-	-do-
	PONTE DA PARAIBA	0.9		42.0	6.0	-	-do-
	PONTE DA RUA VII	2.3		30.2	18.2	-	-do-
	PONTE DA RUA MARIANA BRONNEMANN	2.9		21.0	-	10.8	-do-
	ALBERTO BUSNARTO	3.0		17.5	-	10.8	-do-
	RUDOLFO RUEDIGER	3.7		18.0	-	12.5	-do-
Itoupava do Norte river							
		0.2		23.2	-	-	Wooden, footpath
	PONTE DA RUA 2 DE SETEMBRO	0.3		107.3	8.5	-	RC
	BR - 470	2.3		60.0	13.0	-	-do-
	PONTE DA RUA GUILHERME SEMERFF	4.9		20.5	10.3	-	-do-
	PONTE DA RUA CARLOS PAGEL	9.4		8.5	5.3	-	-do-
	PONTE DA RUA FELIPE JENSEN	11.5		8.5	5.3	-	-do-
	PONTE DA RUA RUDIBERTO KRUEGER	12.0		23.0	9.3	-	-do-
Fortaleza river							
	PONTE DA RUA RODOLFO REDUNZ	2.0		5.7	-	-	Wooden
	PONTE DA RUA FRANCISCO VAHLDIECK (1)	2.1		4.9	-	-	-do-
	PONTE DA RUA JULIO MICHEL	2.3		7.0	11.4	-	RC
	PONTE DA RUA FRANCISCO VAHLDIECK (2)	2.8		8.4	10.8	-	-do-
	PONTE DA RUA JOHANN MAUL	4.1		3.9	-	-	Wooden
	PONTE DA RUA PISKE	4.5		3.9	-	-	-do-

Source : DNER, RFFSA, DER and municipal office.

Note : /1 ; Numbers in this table correspond to those in Fig. VI.2.6.

/2 ; Administrative offices except DNER, RFFSA and DER are regional ones.

1) ; Blank column of the name of bridge shows that bridge is not named.

2) ; - denotes that dimension is not clear.

Table VI.2.3 EXISTING RIVER STRUCTURES AND RELATED STRUCTURES IN THE ITAJAI RIVER BASIN (3/3)

Weir or Dam

/1 NO.	Name	Purpose	Location: Distance from River-mouth /Confluence (km)	Admini-strative Office	Features: Length (m)	Features: Height (m)	Features: Crest Elevation (m)	Remarks
Itajai river								
1	SALTO WEISBACH	Hydroelectric power, Municipal water supply	78.0	CELESC and SAMAE	400.0	3.5	18.3	Intake discharge for Municipal water supply 450 l/s
Itajai Mirim river								
2		Municipal water supply	38.7	SAMAE	35.0	3.5	-	
Garcia river								
3	ARTEX	Industrial water supply	6.9		32.5	1.9	17.3	Enterprise
Sao Pedro river								
4		Municipal water supply	1.0	CASAN	24.0	1.8	-	Intake discharge 15 l/s
Sollim river								
5		-do-	1.0	-do-	37.0	5.0	-	
Itajai do Sul river								
6	AGUAS NEGRAS	Hydroelectric power and water supply	25.6		150.0	1.5	-	Enterprise
Tifa Sercilio river								
		-do-	15.0	CASAN	20.0	3.0	-	
Cedros river								
	PINHAL	Hydroelectric power	49.0	CELESC	150.0	15.0	-	Reservoir
	CEDROS	-do-	42.0	-do-	91.0	17.0	-	Intake
Palmeiras river								
	RIO BONITO	-do-	51.0	-do-	118.0	19.0	-	Reservoir
	PALMEIRAS	-do-	40.0	-do-	53.0	10.0	-	Intake

Pumping Station for Municipal Water Supply

/1 NO.	Location: Distance from River-mouth/ Confluence (km)	Left/Right Bank	Administrative Office	Features: Nos. of Pump		Features: Intake Discharge (l/s)	Remarks
Itajai river							
1	36.0	R	CASAN	2		5.0	
2	52.0	L	SAMAE	2		60.0	
3	67.8	R	-do-	3		133.0	
4	94.0	L	CASAN	2	/2	36.0/139.0	/3
5	126.0	R	-do-	2		8.0	
6	166.0	R	-do-	2	/2	8.0	
Itajai Mirim river							
1'	4.5	L	CASAN	3		550.0	
2'	38.7	L	SAMAE	3		140.0	Weir
Benedito river							
	10.5	L	CASAN	2		39.4	
Itajai do Sul river							
1'	1.0	R	CASAN	2		140.0	
2'	25.6	R		1		14.0	Enterprise
3'	28.5	R	CASAN	2		19.0	
Canhanduba river							
1'	0.5	R	CASAN	2		100.0	
Krauel river							
1'	3.0	R	-do-	3		19.0	

Hydroelectric power station

/1 NO.	Name	Location: Distance from River-mouth/ Confluence (km)	Admini-strative Office	Turbine Discharge (m3/s): Max	Turbine Discharge (m3/s): Normal	Effective Head (m)	Output (kW): Max	Output (kW): Normal	Remarks
Itajai river									
1	SALTO WEISBACH	78	CELESC	89.0	-	-	6,300	-	
Itajai do Sul river									
	AGUAS NEGRAS	25		-	-	1.5	320	-	Enterprise
Cedros river									
	CEDROS	42		4.1	-	214	7,400	-	
Palmeiras river									
	PALMEIRAS	40	-do-	7.1	-	285	17,600	-	

Source : CELESC, SAMAE and CASAN
Note :
/1 : Numbers in this table correspond to those in Fig. VI.2.6.
/2 : One pump is reserve.
/3 : Planned figure
1) : Blank column of the name of weir shows that weir is not named.
2) : - denotes that value is not clear.

Table VI.3.1 SELECTION OF PROTECTIVE AREA

Municipality	River Stretch	Flood Prone Area (km2)	Affected Popu-lation	Annual Mean Damage thousand Cz$	Popu-lation per km2	Potential Flood Damage per km2 thousand Cz$	Damage-ability level
Itajai	IT1+2	53.1	106,000	259,520	2,000	4,890	1
Navegantes	IM1+2						
Ilhota	IT3	25.1	0	50	0	2	3
Ilhota	IT4	4.4	800	1,100	180	250	2
Gaspar	IT5	10.1	10	18	1	2	3
Gaspar/Blumenau	IT6+IT7	27.4	105,870	228,660	3,860	8,350	1
Indaial	IT8	0.0	0	0	0	0	3
Indaial	IT9	0.0	0	0	0	0	3
Indaial/Rodeio	IT10	5.7	10	35	2	6	3
Ascurra	IT11	9.4	3,800	8,350	400	890	2
Apiuna/Lontras	IT12	4.3	0	33	0	8	3
Lontras/ Rio do Sul	IT13	24.8	36,400	267,169	1,470	10,770	1
Aurora	IS1						
Agronomica	IO1						
Aurora	IS2	1.5	0	70	0	45	3
Ituporanga	IS3	2.2	4,800	13,390	2,180	6,090	2
T.Central	IO2	4.0	100	210	25	50	3
Timbo	BN1	1.5	100	110	65	70	3
Itajai	IM3	12.1	0	520	0	40	3
Itajai/Brusque	IM4	11.5	10	750	1	65	3
Brusque	IM5	6.0	18,640	50,600	3,110	8,430	1
Ibirama	IN1	0.0	0	0	0	0	3
Total		203.1	276,540	830,585			

Note : (1) Flooding area means estimated inundated area at 100-year scale flood.

(2) Affected population means estimated number of population affected by 100-year scale flood.

(3) Criteria of levelling damageability by stretch

	Population per km2	Damage per km2
Level 1	1,000 over	1,000 over
Level 2	100-1,000	100-1,000
Level 3	below 100	below 100

(4) Simulation of affected population and annual mean flood damage in river stretch of IN-1 is based on the condition that Norte dam is constructed

Table VI.4.1 CONSTRUCTION COST FOR RIVER IMPROVEMENT (1/13)

Work Item	Unit	Unit Cost (Cz$)	Stretch : IT-1 Long-Term Plan 5) Quantity (x1000)	Stretch : IT-1 Long-Term Plan 5) Amount (Mil. Cz$)	Stretch : IT-2 Long-Term Plan 5) Quantity (x1000)	Stretch : IT-2 Long-Term Plan 5) Amount (Mil. Cz$)	Stretch : IM-1 Long-Term Plan 5) Quantity (x1000)	Stretch : IM-1 Long-Term Plan 5) Amount (Mil. Cz$)
Channel Improvement								
1. Main Civil Works								
Preparatory Works 1)				0.00		0.12		0.74
Excavation								
Dredger	CU.M	16.9		0.00		0.00		0.00
Common	CU.M	19.4		0.00		0.00		0.00
Dragline	CU.M	8.5		0.00		0.00		0.00
Rock	CU.M	900.0		0.00		0.00		0.00
Embankment	CU.M	30.1	-	-	52.0	1.57	80	2.41
Concrete Wall	CU.M	1650.0		0.00		0.00		0.00
Revetment	SQ.M	57.5		0.00		0.00		0.00
Gabion	CU.M	473.8		0.00		0.00		0.00
Sod Facing	SQ.M	10.1	6.0	0.06	20.0	0.20	55	0.56
Road	L.S							
Bridge	L.S						(2 nos.)	7.60
Sub-Total				0.06		1.89		11.31
Miscellaneous 2)				0.00		0.09		0.57
Total				0.06		1.98		11.88
2. Compensation								
Farm Land	SQ.M	10.0	3.4	0.03	120.3	1.20	14	0.14
Residential Land	SQ.M	30.0		0.00		0.00		0.00
Building	SQ.M	900.0		0.00		0.00	8.6	7.74
Total				0.03		1.20		7.88
3. Engineering and Administration 3)				0.01		0.25		1.58
4. Contingency 4)				0.01		0.34		2.13
Grand Total				0.11		3.77		23.47

Notes;
1) 7% of Main Civil Works excluding Preparatry Works and Miscellaneous.
2) 5% of Main Civil Works excluding Miscellaneous.
3) 8% of (1.+2.)
4) 10% of (1.+2.+3.)
5) For these stretches, the works for Long-Term Plan is to be taken from the stage of Provisional Plan as the difference of required quantities is negligibly small among the Provisional, Mid-Term and Long-Term Plans.

Table VI.4.1 CONSTRUCTION COST FOR RIVER IMPROVEMENT (2/13)

Stretch : Floodway

Work Item	Unit	Unit Cost (Cz$)	Provisional Plan 3,300 m3/s		Mid-Term Plan 4,000 m3/s		Long-Term Plan 5,100 m3/s	
			Quantity (x1000)	Amount (Mil. Cz $)	Quantity (x1000)	Amount (Mil. Cz$)	Quantity (x1000)	Amount (Mil. Cz$)
Channel Improvement								
1. Main Civil Works								
Preparatory Works 1)				32.61		38.70		48.64
(1) Floodway								
Excavation								
Dredger	CU.M	16.9	740.00	12.51	930.00	15.72	1,250.00	21.13
Common	CU.M	19.4	14,600.00	283.24	18,100.00	351.14	23,800.00	461.72
Dragline	CU.M	8.5	-	-	-	-	-	-
Rock	CU.M	113.4	350.00	39.69	490.00	55.57	720.00	81.65
Embankment , earth	CU.M	30.1	278.00	8.37	278.00	8.37	278.00	8.37
, rock	CU.M	129.9	17.00	2.21	17.00	2.21	17.00	2.21
Sod Facing	SQ.M	10.1	210.00	2.12	210.00	2.12	210.00	2.12
Road	L.S.		(0.8 km)	2.00	(0.8 km)	2.00	(0.8 km)	2.00
Bridge	L.S.		(3 Nos.)	54.00	(3 Nos.)	54.00	(3 Nos.)	54.00
(2) Gated overflow weir								
Embankment , earth	CU.M	30.1	42.80	1.29	42.80	1.29	42.80	1.29
, rock	CU.M	129.9	93.00	12.08	93.00	12.08	93.00	12.08
Earth lining	CU.M	17.0	9.60	0.16	9.60	0.16	9.60	0.16
Sod Facing	SQ.M	10.1	0.40	0.00	0.40	0.00	0.40	0.00
Concrete	CU.M	1,650.0	14.40	23.76	14.40	23.76	14.40	23.76
Gabion	CU.M	473.8	0.03	0.01	0.03	0.01	0.03	0.01
Gate	L.S			13.90		13.90		13.90
Pile	L.S			10.50		10.50		10.50
Sheet pile	L.S			0.20		0.20		0.20
Sub-Total				498.45		591.53		743.54
Miscellaneous 2)				24.92		29.58		37.18
Total				523.37		621.11		780.72
2. Compensation								
Farm Land	SQ.M	10.0	3,100.00	31.00	3,100.00	31.00	3,100.00	31.00
Residential Land	SQ.M	30.0	200.00	6.00	200.00	6.00	200.00	6.00
Building	SQ.M	900.0	13.90	12.51	13.90	12.51	13.90	12.51
Total				49.51		49.51		49.51
3. Engineering and Administration 3)				45.83		53.65		66.42
4. Contingency 4)				61.87		72.43		89.67
Grand Total				$\boxed{680.58}$		$\boxed{796.70}$		$\boxed{986.32}$

Notes;
1) 7% of Main Civil Works excluding Preparatry Works and Miscellaneous.
2) 5% of Main Civil Works excluding Miscellaneous.
3) 8% of (1.+2.)
4) 10% of (1.+2.+3.)

Table VI.4.1 CONSTRUCTION COST FOR RIVER IMPROVEMENT (3/13)

Stretch : IT-4

Work Item	Unit	Unit Cost (Cz$)	Provisional Plan 3,400 m3/s Quantity (x1000)	Provisional Plan 3,400 m3/s Amount (Mil. Cz$)	Mid-Term Plan 4,000 m3/s Quantity (x1000)	Mid-Term Plan 4,000 m3/s Amount (Mil. Cz$)	Long-Term Plan 5,100 m3/s Quantity (x1000)	Long-Term Plan 5,100 m3/s Amount (Mil. Cz$)
Channel Improvement								
1. Main Civil Works								
Preparatory Works 1)				6.69		8.43		11.98
Excavation								
Dredger	CU.M	16.9	4190	70.81	4903	82.86	6390	107.99
Common	CU.M	19.4	740	14.36	1379	26.75	2700	52.38
Dragline	CU.M	8.5		0.00		0.00		0.00
Rock	CU.M	900.0		0.00		0.00		0.00
Embankment	CU.M	30.1	40	1.20	40	1.20	40	1.20
Concrete Wall	CU.M	1650.0		0.00		0.00		0.00
Revetment	SQ.M	57.5		0.00		0.00		0.00
Gabion	CU.M	473.8		0.00		0.00		0.00
Sod Facing	SQ.M	10.1	60.0	0.61	94.0	0.95	100.0	1.01
Road	L.S		(4.2 km)	8.60	(4.2 km)	8.60	(4.2 km)	8.60
			including BR-470 0.4 km		including BR-470 0.4 km		including BR-470 0.4 km	
Bridge	L.S							
Sub-Total				102.27		128.79		183.16
Miscellaneous 2)				5.11		6.44		9.16
Total				107.38		135.23		192.32
2. Compensation								
Farm Land	SQ.M	10.0	613	6.13	613	6.13	613	6.13
Residential Land	SQ.M	30.0		0.00		0.00		0.00
Building	SQ.M	900.0	0.6	0.54	0.6	0.54	0.6	0.54
Total				6.67		6.67		6.67
3. Engineering and Administration 3)				9.12		11.35		15.92
4. Contingency 4)				12.32		15.33		21.49
Grand Total				135.49		168.58		236.40

Notes;
1) 7% of Main Civil Works excluding Preparatry Works and Miscellaneous.
2) 5% of Main Civil Works excluding Miscellaneous.
3) 8% of (1.+2.)
4) 10% of (1.+2.+3.)

Table VI.4.1 CONSTRUCTION COST FOR RIVER IMPROVEMENT (4/13)

Stretch : IT-6

Work Item	Unit	Unit Cost (Cz$)	Provisional Plan 3,400 m3/s		Mid-Term Plan 4,000 m3/s		Long-Term Plan 5,100 m3/s	
			Quantity (x1000)	Amount (Mil. Cz$)	Quantity (x1000)	Amount (Mil. Cz$)	Quantity (x1000)	Amount (Mil. Cz$)
Channel Improvement								
1. Main Civil Works								
Preparatory Works 1)				8.54		15.69		26.45
Excavation								
Dredger	CU.M	16.9	2690	45.46	4490	75.88	7050	119.15
Common	CU.M	19.4	2480	48.11	6130	118.92	11820	229.31
Dragline	CU.M	8.5		0.00		0.00		0.00
Rock	CU.M	900.0		0.00		0.00		0.00
Embankment	CU.M	30.1	110.0	3.31	110.0	3.31	110.0	3.31
Concrete Wall	CU.M	1650.0		0.00		0.00		0.00
Revetment	SQ.M	57.5	1.2	0.07	1.2	0.07	1.2	0.07
Gabion	CU.M	473.8		0.00		0.00		0.00
Sod Facing	SQ.M	10.1	231	2.33	321	3.24	333	3.36
Road	L.S	(6.3 km inc. BR470	2.0 km)	13.72	(6.3 km)	13.72	(6.3 km)	13.72
Bridge	L.S		(1 no.)	9.00	(1 no.)	9.00	(1 no.)	9.00
Sub-Total				130.55		239.84		404.37
Miscellaneous 2)				6.53		11.99		20.22
Total				137.07		251.83		424.59
2. Compensation								
Farm Land	SQ.M	10.0	1010	10.10	1010	10.10	1010	10.10
Residential Land	SQ.M	30.0	148.0	4.44	148.0	4.44	148.0	4.44
Building	SQ.M	900.0	21.3	19.17	21.3	19.17	21.3	19.17
Total				33.71		33.71		33.71
3. Engineering and Administration 3)				13.66		22.84		36.66
4. Contingency 4)				18.44		30.84		49.50
Grand Total				202.89		339.22		544.46

Notes;
1) 7% of Main Civil Works excluding Preparatry Works and Miscellaneous.
2) 5% of Main Civil Works excluding Miscellaneous.
3) 8% of (1.+2.)
4) 10% of (1.+2.+3.)

Table VI.4.1 CONSTRUCTION COST FOR RIVER IMPROVEMENT (5/13)

Stretch : IT-7

Work Item	Unit	Unit Cost (Cz$)	Provisional Plan 3,400 m3/s		Mid-Term Plan 4,000 m3/s		Long-Term Plan 5,100 m3/s	
			Quantity (x1000)	Amount (Mil. Cz$)	Quantity (x1000)	Amount (Mil. Cz$)	Quantity (x1000)	Amount (Mil. Cz$)
Channel Improvement								
1. Main Civil Works								
Preparatory Works 1)				10.41		16.93		26.67
Excavation								
Dredger	CU.M	16.9	1984	33.53	3014	50.94	5834	98.59
Common	CU.M	19.4	1991	38.63	5740	111.36	10321	200.23
Dragline	CU.M	8.5		0.00		0.00		0.00
Rock	CU.M	900.0		0.00		0.00		0.00
Embankment	CU.M	30.1	1089	32.78	1089	32.78	1089	32.78
Concrete Wall	CU.M	1650.0	1.1	1.82	1.1	1.82	1.1	1.82
Revetment	SQ.M	57.5	9.0	0.52	9.0	0.52	9.0	0.52
Gabion	CU.M	473.8		0.00		0.00		0.00
Land Clearing	SQ.M	35.0	221	7.74	221	7.74	221	7.74
Sod Facing	SQ.M	10.1	550	5.56	640	6.46	660	6.67
Road	L.S		(1.5 km)	3.80	(1.5 km)	3.80	(1.5 km)	3.80
Bridge	L.S			24.30		26.50		28.80
Sub-Total				159.09		258.85		407.62
Miscellaneous 2)				7.95		12.94		20.38
Total				167.04		271.79		428.00
2. Compensation								
Farm Land	SQ.M	10.0	390	3.90	390	3.90	390	3.90
Residential Land	SQ.M	40.0	570.0	22.80	570.0	22.80	570.0	22.80
Building	SQ.M	900.0	63.5	57.15	63.5	57.15	63.5	57.15
Total				83.85		83.85		83.85
3. Engineering and Administration 3)				20.07		28.45		40.95
4. Contingency 4)				27.10		38.41		55.28
Grand Total				298.06		422.50		608.08

Notes;
1) 7% of Main Civil Works excluding Preparatry Works and Miscellaneous.
2) 5% of Main Civil Works excluding Miscellaneous.
3) 8% of (1.+2.)
4) 10% of (1.+2.+3.)

Table VI.4.1 CONSTRUCTION COST FOR RIVER IMPROVEMENT (6/13)

Stretch : IT-11

Work Item	Unit	Unit Cost (Cz$)	Provisional Plan 2,500 m3/s Quantity (x1000)	Provisional Plan Amount (Mil. Cz$)	Mid-Term Plan 3,300 m3/s Quantity (x1000)	Mid-Term Plan Amount (Mil. Cz$)	Long-Term Plan 4,200 m3/s Quantity (x1000)	Long-Term Plan Amount (Mil. Cz$)
Channel Improvement								
1. Main Civil Works								
Preparatory Works 1)				0.47		2.80		4.72
Excavation								
Dredger	CU.M	16.9	80	1.35	250	4.23	410	6.93
Common	CU.M	19.4	100	1.94	650	12.61	1580	30.65
Dragline	CU.M	8.5		0.00		0.00		0.00
Rock	CU.M	900.0	3.5	3.15	13	11.70	20	18.00
Embankment	CU.M	30.1	-	-	-	-	-	-
Concrete Wall	CU.M	1650.0		0.00		0.00		0.00
Revetment	SQ.M	57.5	0.5	0.03	0.5	0.03	0.5	0.03
Gabion	CU.M	473.8		0.00		0.00		0.00
Sod Facing	SQ.M	10.1	20	0.20	90	0.91	130	1.31
Road	L.S							
Bridge	L.S				(1 no.)	10.50	(1 no.)	10.50
Sub-Total				7.14		42.78		72.14
Miscellaneous 2)				0.36		2.14		3.61
Total				7.50		44.92		75.75
2. Compensation								
Farm Land	SQ.M	10.0	365	3.65	365	3.65	365	3.65
Residential Land	SQ.M	30.0	0.6	0.02	0.6	0.02	0.6	0.02
Building	SQ.M	900.0	0.3	0.27	0.3	0.27	0.3	0.27
Total				3.94		3.94		3.94
3. Engineering and Administration 3)				0.92		3.91		6.38
4. Contingency 4)				1.24		5.28		8.61
Grand Total				13.60		58.05		94.68

Notes;
1) 7% of Main Civil Works excluding Preparatry Works and Miscellaneous.
2) 5% of Main Civil Works excluding Miscellaneous.
3) 8% of (1.+2.)
4) 10% of (1.+2.+3.)

Table VI.4.1 CONSTRUCTION COST FOR RIVER IMPROVEMENT (7/13)

Stretch : IT-13

Work Item	Unit	Unit Cost (Cz$)	Provisional Plan 1,800 m3/s Quantity (x1000)	Provisional Plan Amount (Mil. Cz$)	Mid-Term Plan 2,300 m3/s Quantity (x1000)	Mid-Term Plan Amount (Mil. Cz$)	Long-Term Plan 2,600 m3/s Quantity (x1000)	Long-Term Plan Amount (Mil. Cz$)
Channel Improvement								
1. Main Civil Works								
Preparatory Works 1)				30.67		48.12		59.91
Excavation								
Dredger	CU.M	16.9	2920	49.35	4170	70.47	4900	82.81
Common	CU.M	19.4	7000	135.80	10380	201.37	12500	242.50
Dragline	CU.M	8.5		0.00		0.00		0.00
Rock	CU.M	900.0	240	216.00	410	369.00	530	477.00
Embankment	CU.M	30.1	-	-	-	-	-	-
Concrete Wall	CU.M	1650.0		0.00		0.00		0.00
Revetment	SQ.M	57.5	8.5	0.49	8.5	0.49	8.5	0.49
Gabion	CU.M	473.8		0.00		0.00		0.00
Sod Facing	SQ.M	10.1	200	2.02	210	2.12	210	2.12
Road	L.S						(1 km)	2.00
Bridge	L.S		(6 nos.)	34.50	(6 nos.)	44.00	(6 nos.)	49.00
Sub-Total				468.83		735.57		915.83
Miscellaneous 2)				23.44		36.78		45.79
Total				492.27		772.35		961.62
2. Compensation								
Farm Land	SQ.M	10.0	1450	14.50	1450	14.50	1450	14.50
Residential Land	SQ.M	30.0	700.0	21.00	700.0	21.00	700.0	21.00
Building	SQ.M	900.0	48.0	43.20	48.0	43.20	48.0	43.20
Total				78.70		78.70		78.70
3. Engineering and Administration 3)				45.68		68.08		83.23
4. Contingency 4)				61.67		91.91		112.36
Grand Total				678.32		1011.04		1235.91

Notes;
1) 7% of Main Civil Works excluding Preparatry Works and Miscellaneous.
2) 5% of Main Civil Works excluding Miscellaneous.
3) 8% of (1.+2.)
4) 10% of (1.+2.+3.)

Table VI.4.1 CONSTRUCTION COST FOR RIVER IMPROVEMENT (8/13)

Stretch : IO-1

Work Item	Unit	Unit Cost (Cz$)	Provisional Plan 1,100 m3/s		Mid-Term Plan 1,200 m3/s		Long-Term Plan 1,400 m3/s	
			Quantity (x1000)	Amount (Mil. Cz$)	Quantity (x1000)	Amount (Mil. Cz$)	Quantity (x1000)	Amount (Mil. Cz$)
Channel Improvement								
1. Main Civil Works								
Preparatory Works 1)				4.50		5.32		6.96
Excavation								
Dredger	CU.M	16.9	582	9.84	700	11.83	950	16.06
Common	CU.M	19.4	736	14.28	940	18.24	1350	26.19
Dragline	CU.M	8.5		0.00		0.00		0.00
Rock	CU.M	900.0	31	27.90	37.5	33.75	50	45.00
Embankment	CU.M	30.1		0.00		0.00		0.00
Concrete Wall	CU.M	1650.0		0.00		0.00		0.00
Revetment	SQ.M	57.5	3.4	0.20	3.4	0.20	3.4	0.20
Gabion	CU.M	473.8		0.00		0.00		0.00
Sod Facing	SQ.M	10.1	73	0.74	73.3	0.74	73.7	0.74
Road	L.S		(0.35 km)	0.70	(0.35 km)	0.70	(0.35 km)	0.70
Bridge	L.S		(2 nos.)	10.60	(2 nos.)	10.60	(2 nos.)	10.60
Sub-Total				68.76		81.38		106.45
Miscellaneous 2)				3.44		4.07		5.32
Total				72.20		85.45		111.77
2. Compensation								
Farm Land	SQ.M	10.0	158	1.58	158	1.58	158	1.58
Residential Land	SQ.M	30.0	152.0	4.56	152.0	4.56	152.0	4.56
Building	SQ.M	900.0	18.0	16.20	18.0	16.20	18.0	16.20
Total				22.34		22.34		22.34
3. Engineering and Administration 3)				7.56		8.62		10.73
4. Contingency 4)				10.21		11.64		14.48
Grand Total				112.31		128.05		159.32

Notes;
1) 7% of Main Civil Works excluding Preparatry Works and Miscellaneous.
2) 5% of Main Civil Works excluding Miscellaneous.
3) 8% of (1.+2.)
4) 10% of (1.+2.+3.)

Table VI.4.1 CONSTRUCTION COST FOR RIVER IMPROVEMENT (9/13)

Stretch : IS-1

Work Item	Unit	Unit Cost (Cz$)	Provisional Plan 1,100 m3/s Quantity (x1000)	Provisional Plan 1,100 m3/s Amount (Mil. Cz$)	Mid-Term Plan 1,300 m3/s Quantity (x1000)	Mid-Term Plan 1,300 m3/s Amount (Mil. Cz$)	Long-Term Plan 1,500 m3/s Quantity (x1000)	Long-Term Plan 1,500 m3/s Amount (Mil. Cz$)
Channel Improvement								
1. Main Civil Works								
Preparatory Works 1)				1.76		2.62		3.38
Excavation								
Dredger	CU.M	16.9	195	3.30	278	4.70	364	6.15
Common	CU.M	19.4	590	11.45	931	18.06	1220	23.67
Dragline	CU.M	8.5		0.00		0.00		0.00
Rock	CU.M	900.0	10.3	9.27	15.0	13.50	19.2	17.28
Embankment	CU.M	30.1		0.00		0.00		0.00
Concrete Wall	CU.M	1650.0		0.00		0.00		0.00
Revetment	SQ.M	57.5	0.9	0.05	0.9	0.05	0.9	0.05
Gabion	CU.M	473.8		0.00		0.00		0.00
Sod Facing	SQ.M	10.1	64	0.65	68	0.69	69	0.70
Road	L.S							
Bridge	L.S		(1 no.)	0.45	(1 no.)	0.45	(1 no.)	0.45
Sub-Total				26.93		40.07		51.68
Miscellaneous 2)				1.35		2.00		2.58
Total				28.28		42.07		54.26
2. Compensation								
Farm Land	SQ.M	10.0	88	0.88	88	0.88	88	0.88
Residential Land	SQ.M	30.0	132.0	3.96	132.0	3.96	132.0	3.96
Building	SQ.M	900.0	12.5	11.25	12.5	11.25	12.5	11.25
Total				16.09		16.09		16.09
3. Engineering and Administration 3)				3.55		4.65		5.63
4. Contingency 4)				4.79		6.28		7.60
Grand Total				52.71		69.09		83.58

Notes;
1) 7% of Main Civil Works excluding Preparatry Works and Miscellaneous.
2) 5% of Main Civil Works excluding Miscellaneous.
3) 8% of (1.+2.)
4) 10% of (1.+2.+3.)

Table VI.4.1 CONSTRUCTION COST FOR RIVER IMPROVEMENT (10/13)

Stretch : IS-3

Work Item	Unit	Unit Cost (Cz$)	Provisional Plan 980 m3/s Quantity (x1000)	Provisional Plan Amount (Mil. Cz$)	Mid-Term Plan 1,200 m3/s Quantity (x1000)	Mid-Term Plan Amount (Mil. Cz$)	Long-Term Plan 1,400 m3/s Quantity (x1000)	Long-Term Plan Amount (Mil. Cz$)
Channel Improvement								
1. Main Civil Works								
Preparatory Works 1)				1.63		2.31		2.95
Excavation								
Dredger	CU.M	16.9		0.00		0.00		0.00
Common	CU.M	19.4	170	3.30	390	7.57	590	11.45
Dragline	CU.M	8.5	96	0.82	185	1.57	280	2.38
Rock	CU.M	900.0	5	4.50	10	9.00	15	13.50
Embankment	CU.M	30.1	4.4	0.13	4.4	0.13	4.4	0.13
Concrete Wall	CU.M	1650.0		0.00		0.00		0.00
Revetment	SQ.M	57.5	2.0	0.12	2.0	0.12	2.0	0.12
Gabion	CU.M	473.8		0.00		0.00		0.00
Sod Facing	SQ.M	10.1	24	0.24	43	0.43	43	0.43
Road	L.S		(1.5 km)	4.13	(1.5 km)	4.13	(1.5 km)	4.13
Bridge	L.S		(3 nos.)	10.00	(3 nos.)	10.00	(3 nos.)	10.00
Sub-Total				24.87		35.26		45.09
Miscellaneous 2)				1.24		1.76		2.25
Total				26.11		37.02		47.34
2. Compensation								
Farm Land	SQ.M	10.0	195	1.95	195	1.95	195	1.95
Residential Land	SQ.M	30.0		0.00		0.00		0.00
Building	SQ.M	900.0	1.3	1.17	1.3	1.17	1.3	1.17
Total				3.12		3.12		3.12
3. Engineering and Administration 3)				2.34		3.21		4.04
4. Contingency 4)				3.16		4.34		5.45
Grand Total				34.73		47.69		59.95

Notes;
1) 7% of Main Civil Works excluding Preparatry Works and Miscellaneous.
2) 5% of Main Civil Works excluding Miscellaneous.
3) 8% of (1.+2.)
4) 10% of (1.+2.+3.)

Table VI.4.1 CONSTRUCTION COST FOR RIVER IMPROVEMENT (11/13)

Stretch : IM2-A (0-0.8 km)

Work Item	Unit	Unit Cost (Cz$)	Provisional Plan 660 m3/s		Mid-Term Plan 730 m3/s		Long-Term Plan 860 m3/s	
			Quantity (x1000)	Amount (Mil. Cz$)	Quantity (x1000)	Amount (Mil. Cz$)	Quantity (x1000)	Amount (Mil. Cz$)
Channel Improvement								
1. Main Civil Works								
Preparatory Works 1)				0.51		0.53		0.58
Excavation								
Dredger	CU.M	16.9	45	0.76	60	1.01	90	1.52
Common	CU.M	19.4	10	0.19	13	0.25	21	0.41
Dragline	CU.M	8.5		0.00		0.00		0.00
Rock	CU.M	900.0		0.00		0.00		0.00
Embankment	CU.M	30.1	7.5	0.23	7.5	0.23	7.5	0.23
Concrete Wall	CU.M	1650.0		0.00		0.00		0.00
Revetment	SQ.M	57.5		0.00	0.35	0.02	0.35	0.02
Gabion	CU.M	473.8		0.00		0.00		0.00
Sod Facing	SQ.M	10.1	5.0	0.05	7.0	0.07	7.0	0.07
Road	L.S							
Bridge	L.S		(1 no.)	6.00	(1 no.)	6.00	(1 no.)	6.00
Sub-Total				7.74		8.11		8.83
Miscellaneous 2)				0.39		0.41		0.44
Total				8.13		8.52		9.27
2. Compensation								
Farm Land	SQ.M	10.0		0.00		0.00		0.00
Residential Land	SQ.M	30.0	35.0	1.05	35.0	1.05	35.0	1.05
Building	SQ.M	900.0	4.0	3.60	4.0	3.60	4.0	3.60
Total				4.65		4.65		4.65
3. Engineering and Administration 3)				1.02		1.05		1.11
4. Contingency 4)				1.38		1.42		1.50
Grand Total				15.18		15.64		16.53

Notes;
1) 7% of Main Civil Works excluding Preparatry Works and Miscellaneous.
2) 5% of Main Civil Works excluding Miscellaneous.
3) 8% of (1.+2.)
4) 10% of (1.+2.+3.)

Table VI.4.1 CONSTRUCTION COST FOR RIVER IMPROVEMENT (12/13)

Stretch : IM2-B (0.8-3.8 km)

Work Item	Unit	Unit Cost (Cz$)	Provisional Plan 480 m3/s		Mid-Term Plan 530 m3/s		Long-Term Plan 630 m3/s	
			Quantity (x1000)	Amount (Mil. Cz$)	Quantity (x1000)	Amount (Mil. Cz$)	Quantity (x1000)	Amount (Mil. Cz$)
Channel Improvement								
1. Main Civil Works								
Preparatory Works 1)				0.21		0.31		0.61
Excavation								
Dredger	CU.M	16.9	100	1.69	135	2.28	200	3.38
Common	CU.M	19.4	60	1.16	100	1.94	200	3.88
Dragline	CU.M	8.5		0.00		0.00		0.00
Rock	CU.M	900.0		0.00		0.00		0.00
Embankment	CU.M	30.1	-	-	-	-	-	-
Concrete Wall	CU.M	1650.0		0.00		0.00		0.00
Revetment	SQ.M	57.5		0.00		0.00		0.00
Gabion	CU.M	473.8		0.00		0.00		0.00
Sod Facing	SQ.M	10.1	18	0.18	20	0.20	24	0.24
Road	L.S							
Bridge	L.S						(1 no.)	1.20
Sub-Total				3.24		4.73		9.31
Miscellaneous 2)				0.16		0.24		0.47
Total				3.40		4.97		9.78
2. Compensation								
Farm Land	SQ.M	10.0	95	0.95	95	0.95	95	0.95
Residential Land	SQ.M	30.0	30.0	0.90	30.0	0.90	30.0	0.90
Building	SQ.M	900.0	6.7	6.03	6.7	6.03	6.7	6.03
Total				7.88		7.88		7.88
3. Engineering and Administration 3)				0.90		1.03		1.41
4. Contingency 4)				1.22		1.39		1.91
Grand Total				13.40		15.27		20.98

Notes;
1) 7% of Main Civil Works excluding Preparatry Works and Miscellaneous.
2) 5% of Main Civil Works excluding Miscellaneous.
3) 8% of (1.+2.)
4) 10% of (1.+2.+3.)

Table VI.4.1 CONSTRUCTION COST FOR RIVER IMPROVEMENT (13/13)

Stretch : IM-5

Work Item	Unit	Unit Cost (Cz$)	Provisional Plan 690 m3/s Quantity (x1000)	Provisional Plan 690 m3/s Amount (Mil. Cz$)	Mid-Term Plan 790 m3/s Quantity (x1000)	Mid-Term Plan 790 m3/s Amount (Mil. Cz$)	Long-Term Plan 950 m3/s Quantity (x1000)	Long-Term Plan 950 m3/s Amount (Mil. Cz$)
Channel Improvement								
1. Main Civil Works								
Preparatory Works 1)				3.94		4.63		5.81
Excavation								
Dredger	CU.M	16.9		0.00		0.00		0.00
Common	CU.M	19.4	1800	34.92	2260	43.84	3040	58.98
Dragline	CU.M	8.5	460	3.91	560	4.76	750	6.38
Rock	CU.M	900.0		0.00		0.00		0.00
Embankment	CU.M	30.1	1.0	0.03	1.0	0.03	1.0	0.03
Concrete Wall	CU.M	1650.0		0.00		0.00		0.00
Revetment	SQ.M	57.5	7.5	0.43	7.5	0.43	7.5	0.43
Gabion	CU.M	473.8		0.00		0.00		0.00
Sod Facing	SQ.M	10.1	150	1.52	155	1.57	160	1.62
Road	L.S							
Bridge	L.S		(3 nos.)	15.50	(3 nos.)	15.50	(3 nos.)	15.50
Sub-Total				60.25		70.76		88.75
Miscellaneous 2)				3.01		3.54		4.44
Total				63.26		74.30		93.19
2. Compensation								
Farm Land	SQ.M	10.0	700	7.00	700	7.00	700	7.00
Residential Land	SQ.M	30.0	150.0	4.50	150.0	4.50	150.0	4.50
Building	SQ.M	900.0	15.0	13.50	15.0	13.50	15.0	13.50
Total				25.00		25.00		25.00
3. Engineering and Administration 3)				7.06		7.94		9.46
4. Contingency 4)				9.53		10.72		12.77
Grand Total				104.85		117.96		140.42

Notes;
1) 7% of Main Civil Works excluding Preparatry Works and Miscellaneous.
2) 5% of Main Civil Works excluding Miscellaneous.
3) 8% of (1.+2.)
4) 10% of (1.+2.+3.)

Table VI.4.2 RESULT OF ECONOMIC EVALUATION

(Unit:Million Cz$)

Stretch	Symbol	Design Scale (year)	Economic Construction Cost /1	Present Worth /2 Benefit	Present Worth /2 Cost	B-C	EIRR (%)
Itajai	IT1+2	10	580.7	514.8	444.1	70.7	9.2
	IM1+2	25	682.3	655.0	506.6	148.4	10.2
		50	853.3	720.5	596.9	123.6	9.6
Ilhota	IT4	10	110.8	4.5	92.2	-87.7	(-)
		25	139.3	8.4	111.7	-103.3	(-)
		50	197.7	9.9	146.4	-136.5	(-)
Blumenau	IT6+7	10	368.2	501.3	305.4	195.9	12.7
Gaspar		25	592.8	708.1	434.0	274.1	12.6
		50	929.3	783.0	559.6	223.4	11.3
Ascurra	IT11	10	8.3	0.0	8.0	-8.0	(-)
		25	46.5	29.2	34.2	-5.0	(6.8)
		50	78.1	56.6	53.2	3.4	(8.5)
Rio do Sul	IT13	10	660.2	586.0	553.9	32.1	8.5
	IS1	25	974.4	818.6	763.7	54.9	8.6
	IO1	50	1,207.4	907.2	839.7	67.5	8.3
Ituporanga	IS3	10	27.5	33.6	25.7	7.9	10.8
		25	38.7	49.6	35.5	14.1	11.7
		50	49.2	55.3	43.3	12.0	10.6
Brusque	IM5	10	75.2	70.1	68.2	1.9	8.2
		25	86.5	132.2	76.3	55.9	13.7
		50	105.8	161.9	88.8	73.1	14.3

Note: /1 Economic construction cost
Economic cost of main civil works is 85 % of financial cost.
Economic cost of compensation is evaluated by production foregone of crops or buildings.
Engineering/administration service is evaluated by financial cost.

/2 Discount rate 8%

/3 Parentheses indicates economic evaluation at future level.

Table VI.6.1 COST COMPARISON OF STRUCTURAL MEASURES FOR LONG-TERM PLAN

(Unit; Million Cz$)

Stretch	Itajai river			Itajai Mirim river	
	AL-1	AL-2	R/I	Mirim dam +R/I	R/I
IT 1	-	-	-	0.1	0.1
IT 2	-	-	-	4.0	4.0
Floodway	785	950	987	-	-
IT 4	169	230	237	-	-
IT 6	339	530	545	-	-
IT 7	423	575	608	-	-
IT 11	58	86	95	-	-
IT 13	1,236	1,160	1,236	-	-
				-	-
IO 1	159	128	159	-	-
IS 1	84	84	84	-	-
IS 3	60	60	60	-	-
IM 1	-	-	-	24	24
IM 2	-	-	-	31	38
IM 5	-	-	-	118	141
Ascurra dam	1,271	-	-	-	-
Trombudo					
(A) dam	-	334	-	-	-
(B) dam	-	214	-	-	-
Mirim dam	-	-	-	313	-
Total	4,584	4,351	4,011	490	207

Notes;

AL-1: Alternative 1 (Ascurra dam + River Improvement)
AL-2: Alternative 2 (Trombudo (A), (B) dam + River Improvement)
R/I : River Improvement

Table VI.8.1 ADDITIONAL TELEMETERIC STATIONS

Location	Main Protection Area
1.Lomba Alta	Sul dam and its downstream
2.Sul dam	Rio do Sul
3.Rio do campo	Oeste dam and its downstream
4.Oeste dam	Rio do Sul
5.Barra do Prata	Norte dam
6.Norte dam	Ibirama, and its downstream
7.Dr. Pedolinho	Timbo, its downstresm
8.Garcia	Blumenau
9.Porto Escalvado	Picarras

Figures

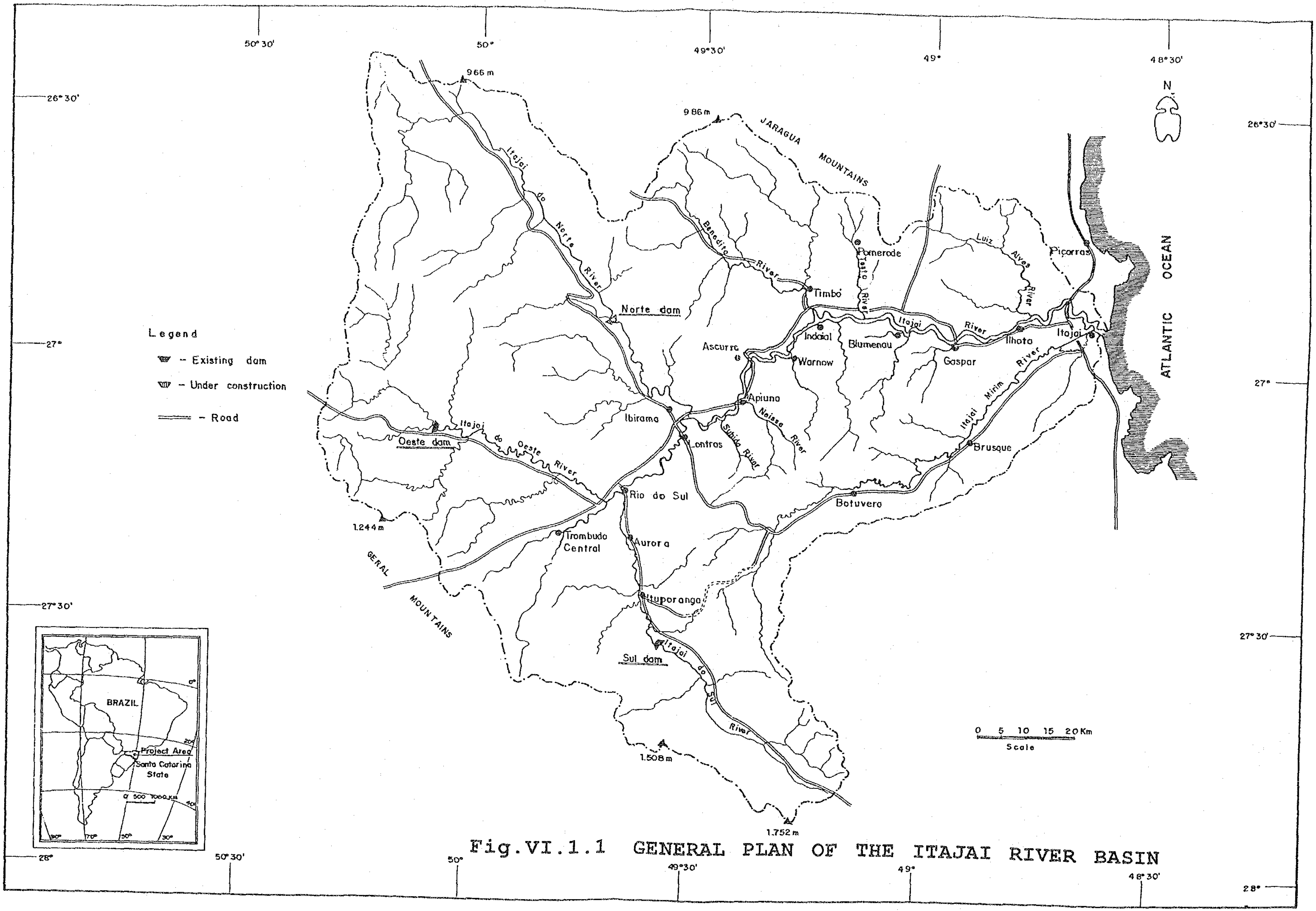

Fig.VI.1.1 GENERAL PLAN OF THE ITAJAI RIVER BASIN

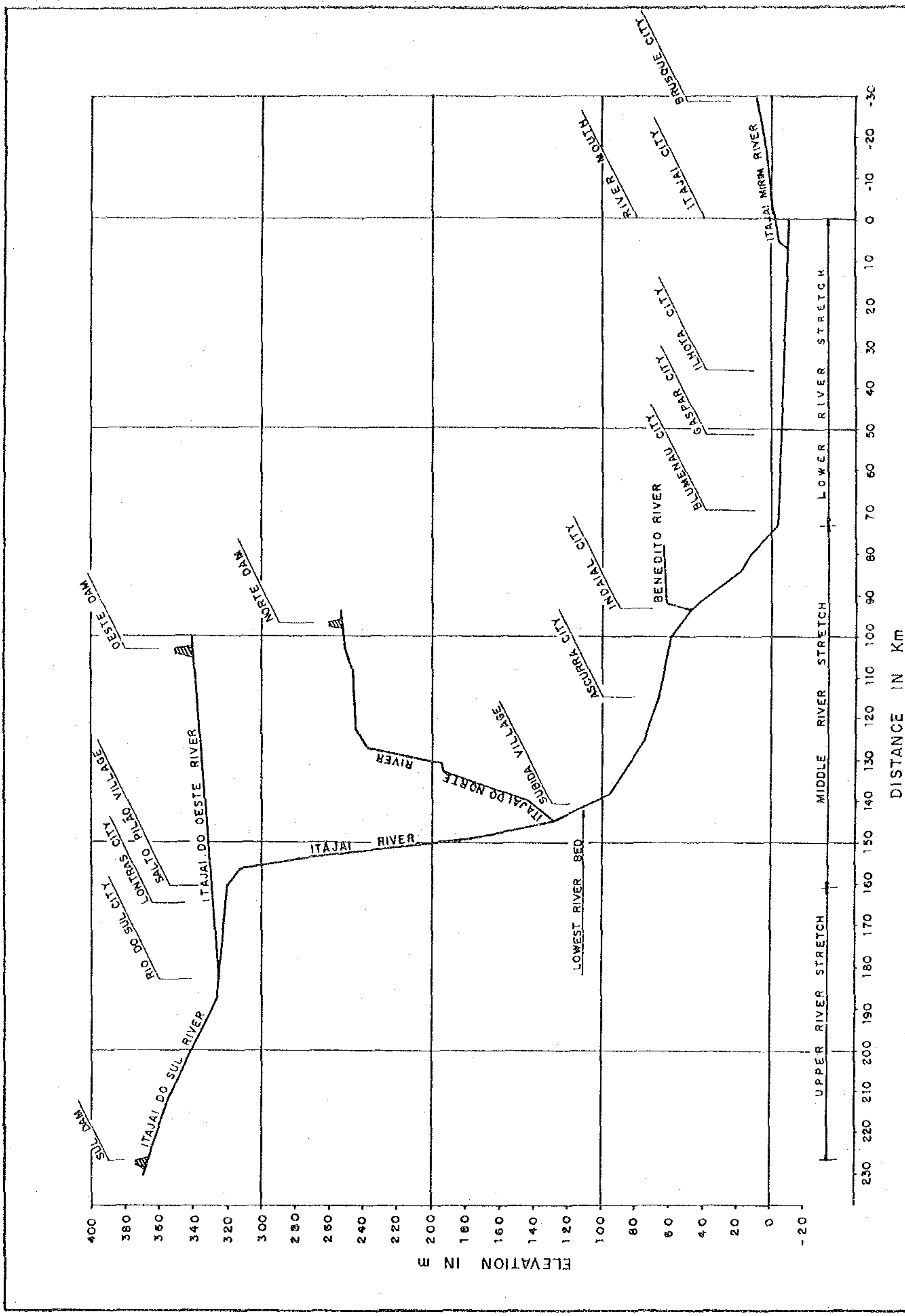

Fig.VI.2.1 LONGITUDINAL PROFILE OF ITAJAI RIVER AND ITS TRIBUTARIES