ANNEX III. HYDROLOGICAL STUDY

III. HYDROLOGICAL STUDY

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1. INTRODUCTION

The hydrological study on the master planning for entire Itajai river basin flood control was concentrated mainly for estimation of probable flood discharge for flood control planning. In the Feasibility study for Blumenau-Gaspar river stretch, the following investigation and studies are carried out;

(1) Additional data collection including rainfall and water level observation for the tributaries, namely, the Garcia, Velha and Itoupava rivers for grasping hydrological relation between main Itajai river and tributaries in order to make drainage plan in Blumenau city area.

(2) Review of the flood discharge distribution through meteo-hydrological data collection, analyses on these data and examination of the flow capacity of river course in the main Itajai river and tributaries based on the result of river cross-sectional survey executed by JICA TEAM in this stage.

(3) Flood runoff analysis for drainage system plan in the Blumenau city along the Itajai river and tributaries flowing into the Itajai river through Blumenau city, which are Garcia, Velha and Itoupava rivers.

The detail of the above studies and analyses is stated in the following sections.

2. METEO-HYDROLOGICAL DATA

Meteo-hydrological data in and around the Blumenau-Gaspar river stretch up to the end of 1986 were collected at DNAEE and other institution concerned. As for the data in 1987, the data collected by DNOS in the basin are only available for this study. The list of meteo-hydrological stations and their data is shown in Table III.2.1 and their location is illustrated in Fig.III.2.1.

2.1 Rainfall

There exists six rainfall gauging stations in and around Blumenau-Gaspar river stretch which were installed by DNAEE and INMET. Among the preceding stations, three gauges had been abandoned and others, Blumenau (No. 02649007), Garcia (No. 02649009) and Itoupava Central (No. 02649010), are being operated.

Daily rainfall data are available at the above six stations for their observation periods and hourly rainfall data are observed only at Blumenau rainfall gauging station (No.02649007) by an automatic recorder since July 1984. This station has been installed for the purpose of flood forecasting and warning system by DNAEE. Besides, hourly rainfall records at Blumenau (No.02649020) by INMET are available from 1930 to 1968. However, the hourly records for rain storm on July 1983 was not observed. Therefore, the hourly data at the rainfall gauging stations in the neighboring basin as shown in Table III.2.1 were incorporated to the study in addition to the data mentioned above. Besides, the two hourly rainfall observatories are installed by DNOS in the Garcia river basin for grasping the characteristics of rainfall in the tributary area for making drainage planning in Blumenau city. They are Nova Russia and Garcia stations as illustrated in Fig. III.2.1.

2.2 Water Level

Water level observation in the main Itajai river and its tributaries, Garcia and Itoupava rivers were carried out at five stations by DNAEE as shown in Table III.2.1. As for the Velha river, the observation was never executed. The observation at four stations except Blumenau was stopped since 1960.

The automatic recorder is equipped at the Blumenau water level gauging station and water level hydrograph is recorded since July 1984.

To supplement water level data in the tributaries and to grasp the relation between the main Itajai river and tributaries for the urban drainage planning in Blumenau city, three water level staff gauges are installed by DNOS under the observation regulation of three times a day normally and every hour in case that rainfall is observed at the gauge site.

3. REVIEW OF FLOOD ANALYSIS IN MASTER PLAN STAGE

3.1 Flow Capacity of Blumenau-Gaspar river stretch

The flow capacity under the present condition in Blumenau-Gaspar river stretch in main stream of Itajai river was examined in master plan stage by mean of non-uniform flow calculation based on the river-cross section with an interval of 1 km.

In this study, the flow capacity which is one of the important factor of river system model in flood analysis was reviewed by non-uniform calculation using the river-cross section surveyed by an average interval of 300 m in 1987.

In the non-uniform flow calculation, the following assumptions are applied;

(1) Initial water level is set at 1.1 m at the river mouth of Itajai river which is mean monthly highest tide water level from 1983 to 1985.

(2) Effective river width in each cross-section is assumed as a width between both river banks except river cross-section at 56.5 km, 60 km and 76.5 km at which the flowing water is remained as dead water storage in wide river width partially comparing with the up/downstream river width. At these sections, those dead water space was omitted and effective river width was obtained by connecting up and downstream river width straightly.

(3) Roughness coefficient in the river course is set at 0.035 taking into account the present flow condition.

Flow capacity derived from the above assumption by non-uniform flow calculation is illustrated in Fig. III.3.1. As seen in the figure, the flow capacity under the present condition at Blumenau and Gaspar cities are derived at around 3,000 m3/sec and 3,000-4,000 m3/sec, respectively. Comparing with the flow capacity in this stretch with that estimated in the master plan stage, it is judged that the value of flow capacity is almost same and that the change of river characteristics which affect to the river channel model is not found out in the result.

3.2 Flood Discharge Distribution

In the master plan stage, the design flood discharge distribution in the entire Itajai river basin for the provisional plan which corresponds to 10-year probable flood was worked out using the actual flood hydrographs and hourly/daily rainfall records on December 1978, December 1980, July 1983 and August 1984. In the above floods, floods in 1983 and 1984, which caused the large amount of flood damage in the entire basin.

According to the result of the collected additional data in the feasibility study stage, the annual maximum water levels at Blumenau in 1985, 1986 and 1987 are recorded at 5.30 EL.m on Feb. 15th , 6.56 EL.m on Nov. 6th and 7.22 El.m on May 21st, and flood peak discharges are estimated at 800 m3/sec, 1,000 m3/sec and 1,200 m3/sec, respectively.

In this stage, topographic survey was carried out for grasping the detailed river characteristics along the Blumenau-Gaspar river stretch and tributaries. According to the result of flow capacity examination, the river characteristics are not different from result in the master plan study.

In consideration of the study this time, the flood discharge distribution worked out in the master plan stage is applied to the feasibility study in Blumenau-Gaspar river stretch.

4. FLOOD ANALYSIS IN THE BLUMENAU CITY AREA ALONG BLUMENAU-GASPAR RIVER STRETCH AND TRIBUTARIES

4.1 Hydrological Condition in the Tributaries

The Garcia, Velha and Itoupava rivers have a catchment area of 157 km^2, 56 km^2 and 93 km^2, and their river length are around 35 km, 18 km and 16 km respectively.

Table III.4.1 shows the monthly rainfall at Blumenau for a period from 1944 to 1986. This table shows that annual rainfall amount ranges from 900 mm in 1968 to 2,600 mm in 1983 and its mean value is about 1,600 mm. Variation of monthly rainfalls are from 90 mm between April and August to 200 mm in February. Monthly amount of 542 mm in July 1983 in which the large scale flood occurred is the largest value among the recorded data.

Table III.4.2 indicates the monthly mean discharge for a period from 1935 to 1966 at Garcia water level gauging station in the Garcia river. Annual mean discharge in this table is calculated at 3.4 m^3/sec. Based on the ratio of the catchment area at river mouth and that of 127 km^2 at Garcia water level gauging station, annual mean discharges at the river mouth of each tributary are derived as follows.

Name of river	Annual mean discharge (m^3/sec)
Garcia river	4.2
Velha river	1.5
Itoupava river	2.5

As for the flood records such as flood hydrograph which is used for the study on relation between occurrence times of flood peak in the main Itajai river and tributaries, there was no data in the tributary areas. In this study, water level observation at three stations in the tributaries started from March 1st, 1987 was applied to grasp the above hydrological relation for making drainage plan in Blumenau city. The maximum water level and discharge estimated by uniform flow calculation from March to end of June at the preceding stations are summarized as follows.

Name of station	Zero of Gage (El.m)	Max. Gage Height (m)	Max. Discharge (m^3/sec)	Occurrence Date
Garcia	17.269	1.50	37.7	May 14
Velha	14.623	1.60	29.3	May 20
Itoupava	11.976	1.94	19.3	June 13

Since no large scale flood takes place in the tributary area and in the main Itajai river as mentioned in section 3.2, the procedures and methods for flood analysis as stated in the following sections are adopted taking into account the availability of hydrological data.

4.2 General Procedure and Methods

Flood analysis aims at determining a design flood peak discharge and its volume for drainage structure such as a pump, regulating pond and other related structures incorporated in the drainage plan in Blumenau city. To meet these requirements, the following analyses are required;

(1) Estimation of probable 4-day rainfall in Blumenau city area of which rainfall amount is distributed to actual hourly rainfall pattern at Blumenau and is converted to flood discharge hydrograph by mathematical model for mass curve analysis for examination of relation between pump capacity and regulating pond for the proposed drainage network.

(2) Establishment of probable rainfall intensity-duration curve to work out probable flood peak discharges from drainage districts for design of drainage pipes or canals connecting to the existing drainage network.

(3) Runoff coefficient study taking into account the land use condition at present and in future in order to evaluate the influence of urbanization and development of Blumenau city area.

(4) Runoff calculation by the rational formula method incorporating the above study results. Rational formula method is widely used for drainage system plan in Japan in case that there is no data sufficient to establish the runoff model in city area.

General plan of drainage districts which is divided taking into account the existing drainage network in Blumenau city is illustrated in Fig.III.4.1. The proposed drainage facilities such as a pumping station, regulating pond and connecting water way by this study is also shown in this figure.

4.3 Probable 4-Day Rainfall

As a basin mean probable 4-day rainfall for each divided drainage district, point probable 4-day rainfall is adopted on the basis of daily rainfall records at Blumenau (No.02649007) for 40 years from 1944 to 1985, since the area of objective drainage districts are less than 5 km^2 as shown in Fig.III.4.1 and area reduction of point rainfall is considered to be negligibly small.

Table III.4.3 indicates the annual maximum 4-day rainfall series at Blumenau and its frequency curve by means of third type distribution method by Pearson is illustrated in Fig.III.4.2. Probable 4-day rainfalls are summarized as below.

Return period (year)	Probable rainfall (mm)
2	124
5	163
10	188
25	219
50	242

4.4 Probable Rainfall Intensity-Duration Analysis

In the objective area, DNOS studied on the probable rainfall intensity duration curve by statistical method which estimates the probable rainfall using the annual maximum rainfall series in some duration times at Blumenau (No.02649020) from 1930 to 1956, and result of study was published in " Chuvas Intensas no Brasil" in December 1957.

According to the above study, the relation between the probable rainfall and its duration is expressed by the following formula;

$$P = K (A t + B \log (1 + C t))$$

$$K = T^D \qquad D = a+b/T^c$$

Where, P ; Probable rainfall amount in mm for a given duration time,

t ; Duration in hour,

T ; Return period in year and

A, B, C,D, a, b and c ; Constants.

Among the constants above, A, B, C and c for Blumenau are given as 0.2, 24, 20 and 0.25 respectively based on the results of study. Constants of a and b are given in Table III.4.4 against the duration times. Probable rainfall intensity-duration curve are shown in Fig.III.4.3. According to the above intensity-duration curves, probable rainfall intensities against the duration of 15, 30 and 60 minutes with 10-year probability, which covers the concentration time of flood in drainage districts, are summarized as follows.

Return period (year)	Probable rainfall intensity (mm/hour)				
	Duration time (minutes)				
	15	30	60	120	240
2	84	57	37	23	14
5	98	68	45	28	17
10	109	76	51	32	19
25	126	88	59	37	23
50	135	96	66	42	26

To update/examine the probable rainfall intensity-duration curve studied by DNOS, probable rainfall intensity-duration analysis is carried out by adding the rainfall records by an automatic recorder at Blumenau after 1956.

Annual maximum rainfall series with duration times of 15, 30, 60, 120 and 240 minutes based on the above records are listed up in Table III.4.5. As seen in the table, the maximum rainfall among the annual maximum series occurred in 1965 and this heavy rainfall is considered to affect the rainfall intensity-duration curve by DNOS. Frequency curves by means of Pearson III type distribution are illustrated in Fig.III.4.4. Based on the estimated probable rainfall against the preceding duration times, probable rainfall intensity-duration curves are examined for return periods of 2, 5, 10, 25 and 50 years. In the examination, the following formula is applied;

$$I = a / (t^{n} + b)$$

where, I ; Rainfall intensity in mm/hour,

t ; Duration time in minutes and

a, b, n ; Constants.

The constants in the above formula are worked out by the following procedure;

(1) Assumption of n-value between 0.5 and 1.0

(2) Calculation of a and b by least square method

(3) Calculation of standard deviation

(4) Selection of combination of constants which gives the least standard deviation repeating the calculation from (1) to (3).

Probable rainfall intensity duration curves against return period of 2, 5, 10, 25 and 50 years are given as follows;

$I_{2\text{-year}} = 3,467/(t+28)$

$I_{5\text{-year}} = 4,842/(t+33)$

$I_{10\text{-year}} = 5,859/(t+34)$

$I_{25\text{-year}} = 7,090/(t+34)$

$I_{50\text{-year}} = 8,133/(t+33)$

where, I ; Rainfall intensity in mm/hour and

t ; Duration time in minutes.

From the above, probable rainfall intensities against the selected duration times are listed in the following table;

Return period (year)	Probable rainfall intensity (mm/hour)				
	Duration time (minutes)				
	15	30	60	120	240
2	81	60	39	23	13
5	101	77	52	32	18
10	120	92	62	38	21
25	145	111	75	46	26
50	169	129	87	53	30

4.5 Runoff Coefficient

there are no records on the runoff coefficient in Blumenau city area. Therefore, the results of the study on runoff coefficient by land use classification such as a city area, farm land, pasture, no-use land and forest area are applied to this study. Land use condition in Blumenau city area is divided into city area, farm land, pasture, no-use land and forest area, and their runoff coefficients classification by land use category in Japan are introduced as follows;

- City area ; 0.9 ,
- Farm, pasture and no-use lands ; 0.6 and
- Forest area ; 0.7.

Runoff coefficients in the drainage districts are calculated by means of weighted average method against area of the preceding land use classification in drainage districts taking into account the present land use classification based on the topographic map of 1/10,000 and future land use map planned by the Blumenau municipality in 1985 to evaluate the influence of urbanization and development in Blumenau city area. Runoff coefficients in drainage districts at present and in future are listed in Table III.4.6. As seen in the table, increase of runoff coefficient in drainage area due to urbanization of city area is estimated at around 10 %.

4.6 Flood Runoff from Drainage Area

4.6.1 Rational formula

Rational formula for flood hydrograph and flood peak discharge estimation is expressed as follows;

$$Q_p = f \times r \times A / 3.6$$

where, Q_p ; Flood peak discharge in m^3/sec,

f ; Runoff coefficient,

A ; Drainage area in km^2 and

r ; Rainfall intensity for a duration time corresponding to the concentration time of drainage district in mm/hour.

Concentration time is usually divided into the following two portions;

(1) Time of entry which means flowing time of rain water into a main canal or drainage pipe.

(2) Time of flow which means passing time of flood flow in main canal or drainage pipe.

In estimation of the time of entry, Carvey's formula is applied to drainage district in city area. As for the drainage district which has drainage area more than 2 km^2 and in which forest area is widely distributed, the average value of Kraven, Ruziha and emperical formula developed by Public Works Research Institution, Ministry of Construction in Japan is applied as a time of entry since hydrological condition between city area and forest area is considered to be different.

In estimation of time of flow, Manning formula is adopted for canal drainage system, and assumption of flood flow velocity of 1.0 m/sec is applied to drainage pipe system since the slope of the existing drainage pipes is unknown and average velocity of flood flow in drainage pipe is usually designed at around 1.0 m/sec in Japan for urban drainage network planning.

Concentration time in a drainage district is calculated by total time of (1) and (2). The formulas mentioned above are introduced as follows;

Carvey's formula

$$T = 1.441 \left(n\ l / s^{0.5} \right)^{0.467}$$

Kraven's formula

$T = l / v$

v = 3.5 m/sec	H/l > 1/100
v = 3.0 m/sec	1/100 > H/l > 1/200
v = 2.1 m/sec	H/l < 1/200

Ruziha's formula

$T = l / v$

$v = 20 \times (H/l)^{0.6}$

Empirical formula by Public Works Research Institution

$$T = 60 \times 0.00167 \times \left(l / I^{0.5} \right)^{0.7}$$

Manning's formula

$T = l / v$

$v = R^{(2/3)}\ I^{(1/2)} / n$

Where, T ; Lag-time in minutes,

v ; flow velocity

n ; Roughness coefficient,

l ; Distance in meter,

s ; Ground slope

H ; Difference of elevation between inlet and outlet of a main canal or main drainage pipe

R ; Hydraulic mean depth in meter, and

I ; River bed slope.

4.6.2 Flood runoff for pumping drainage network with regulating pond

To decide a capacity of pump and regulating pond incorporated in urban drainage system plan, probable flood hydrograph and its flood volume are simulated by the rational formula using the probable 4-day rainfall with 10-year return period at Blumenau and the actual rainfall pattern on July 1983 and August 1984, taking into account the availability of hourly rainfall records during large scale flood. It is assumed that water level in the main Itajai river is set at design high water level since there is lack of hourly rainfall and hydrograph records for grasping the relation between flood water level in the main Itajai river and occurrence of rain storm in Blumenau-Gaspar river stretch.

As a actual rainfall pattern, the record at Blumenau (No.02649007) in August 1984 and at Doutor Pedrinho (No.02649017) in July 1983 are adopted since the hourly rainfall data on July 1983 is available only at Doutor Pedorinho and Timbo Grande in the entire basin and the former is the nearest station from the Blumenau city area.

The concept of the preceding two actual rainfall patterns are summarized as follows;

Name of station	Rainfall Pattern	Rainfall amount (mm)	
		4 days	7 days
Doutor Pedorinho	July 1983	279.2	380.0
Blumenau	August 1984	234.1	234.1

The above rainfall distribution records are enlarged to 10-year probable 4-day rainfall and input to rainfall-runoff model so as to convert to probable flood discharge hydrograph in drainage district. Enlarging factors for these patterns are calculated to be 0.663 against 1983 pattern and 0.790 against 1984 pattern from 10-year probable 4-day rainfall of 188 mm. Based on the simulated 10-year probable flood hydrograph by the above method, the relation between required regulating volume and pump capacity is examined by mass curve analysis assuming some different pump capacities. This relation applied to design of a capacity of pump and regulating pond in drainage network planning.

Fig.III.4.5 shows the relation of required pond volume and pump capacity in the proposed drainage network as illustrated in Fig.III.4.1. Figs.III.4.6 and III.4.7 show 10-year probable rainfall distribution, simulated flood hydrograph based on the preceding rainfall distribution, and its mass curve for the regulating pond against G-1, G-2 and G-4 drainage districts based on 1983 and 1984 rainfall patterns respectively. In these figures, accumulated drainage volume by pump capacity of 7.8 m^3/sec which is selected by the maximum pond volume of 367 thousand m^3 based on the topographic/land use conditions in the regulating pond is indicated for example of simulation study and mass curve analysis.

4.6.3 Probable flood peak discharges from the drainage district

Probable flood peak discharges from drainage districts are estimated by incorporating the rational formula, runoff coefficient based on future land use map and probable rainfall intensity for a duration time corresponding to a concentration time of drainage district as listed in Table III.4.7. Probable flood peak discharges with the selected return periods are shown in Table III.4.8.

5. RECOMMENDATION FOR FUTURE HYDROLOGICAL NETWORK

In order to rise the accuracy of hydrological study in next stage, the execution of the following hydrological observation is recommended to DNOS and other institution concerned;

(1) To supplement the existing hydrological observation network in the upstream basin from Blumenau city and to study on its flooding conditions, the installation of additional automatic water level and rain gauges in Itajai do Oeste, Itajai do Sul, Itajai do Norte and Benedito river basins and their observation are recommended.

(2) In addition to the above, water level observation at Gaspar city, Ilhota city, road bridge of BR-101 and river mouth of Itajai river is recommended to clarify the hydraulic condition in the downstream river stretches and to rise the accuracy of design flood water level in Blumenau-Gaspar river stretch. Besides, in order to clarify the affect to the water level at Blumenau due to a floodway proposed for flood control plan for Itajai city, observation for tidal water level and its flow direction at the outlet site of the floodway is recommended. In this case, it is desirable to continue the observation during at least one year.

(3) To clarify the relation between water levels in the main Itajai river and tributaries flowing into Itajai river through Blumenau city, it is recommended to continue the hydrological observation at water level and rainfall gauging stations newly installed by DNOS in feasibility study stage. Especially, it is desirable to modify the water level gauges in Garcia and Velha rivers to an automatic recorder from existing ordinary staff gauge to cope with the occurrence of flood in night time, steep shape of flood hydrograph and short duration of flood peak discharge.

Locations of the additional recommendable hydrological observatories in the upstream basin from Blumenau and new water level and rainfall gauging stations installed in feasibility study are illustrated in Fig.III.5.1.

Tables

Table III.2.1 LIST OF HYDROLOGICAL GAUGING STATION IN AND AROUND BLUMENAU-GASPAR RIVER STRETCH

(1) Daily rainfall

NO.	No. of Station	Name of Station	Observation Period	Institution
1.	02648000	Gaspar	1935 - 1966	DNAEE
2.	02649000	Passo Manso	1935 - 1967	DNAEE
3.	02649007	Blumenau	1944 - 1985	DNAEE
4.	02649009	Garcia	1941 - 1985	DNAEE
5.	02649010	Itoupava Central	1941 - 1985	DNAEE
6.	02649020	Blumanau	1948 - 1969	INMET
New gauge in the tributaries' basin by DNOS				
Garcia river basin				
7.		Nova Russia	March 1987 - Present	DNOS
8.		Artex	April 1987 - Present	DNOS

(2) Hourly rainfall

NO.	No. of Station	Name of Station	Observation Period	Institution
1.	02648005	Indaial	1971 - 1982	DNAEE
2.	02649017	Doutor Pedrinho	1981 - 1985	DNAEE
3.	02649007	Blumenau	1984 - 1986	DNAEE
4.	02649020	Blumanau	1935 - 1937 1943 1952 - 1968	INMET

(3) Discharge record

NO.	No. of Station	Name of Station	Observation Period	Institution
1.	83700000	Passo Manso	1940 - 1967	DNAEE
2.	83820000	Garcia	1934 - 1967	DNAEE
3.	83760000	Itoupapava	1929 - 1938	DNAEE
4.	83840000	Gaspar	1927 - 1966	DNAEE
5.	83800002	Blumanau	1939 - 1985	DNAEE
New gauge in the tributaries' basin by DNOS				
6.		Garcia river	March 1987 - Present	DNOS
7.		Itoupava river	April 1987 - Present	DNOS
8.		Velha river	March 1987 - Present	DNOS

Table III.4.1 MONTHLY RAINFALL AT BLUMENAU

Unit : mm

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	JUl.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1944	-	-	-	72	41	44	32	132	39	51	188	83	-
1945	175	351	44	134	32	72	100	36	111	114	43	141	1,353
1946	219	295	212	63	108	207	122	160	43	252	53	96	1,830
1947	141	162	165	21	143	75	115	120	163	175	84	153	1,517
1948	187	290	147	57	255	2	126	152	77	121	49	30	1,493
1949	94	122	271	159	27	113	10	113	78	85	123	106	1,301
1950	247	98	264	75	68	45	24	84	118	191	44	147	1,405
1951	210	250	81	48	23	35	55	0	64	243	81	140	1,230
1952	117	138	151	48	34	138	48	31	133	208	78	199	1,323
1953	144	89	183	82	143	4	74	58	71	231	74	137	1,290
1954	184	173	135	239	188	98	130	29	107	235	38	98	1,654
1955	102	190	111	117	138	91	152	68	99	31	70	121	1,290
1956	153	123	93	122	147	92	53	41	122	120	19	181	1,266
1957	110	107	109	169	117	124	227	239	283	94	172	189	1,940
1958	180	258	243	106	70	97	63	77	154	180	108	309	1,845
1959	310	183	140	203	64	40	28	100	199	95	108	97	1,567
1960	315	294	239	76	82	38	26	230	85	115	256	128	1,884
1961	76	250	151	98	99	100	42	20	316	193	282	182	1,809
1962	121	106	254	47	91	45	93	22	160	156	80	99	1,274
1963	236	249	215	33	8	34	30	51	209	233	222	111	1,631
1964	81	75	233	105	67	111	93	46	101	150	52	126	1,240
1965	209	187	156	184	198	60	143	117	83	49	143	241	1,770
1966	237	305	121	151	56	109	26	71	86	190	55	212	1,619
1967	182	307	109	40	30	95	144	49	130	80	201	148	1,515
1968	113	86	71	43	26	49	59	76	110	153	37	96	919
1969	126	281	151	198	92	174	84	77	67	126	172	162	1,710
1970	176	343	113	55	36	226	92	71	103	100	33	213	1,561
1971	151	261	190	167	81	120	90	47	113	126	96	58	1,500
1972	203	204	170	37	17	110	100	222	120	105	119	274	1,681
1973	388	85	92	99	99	149	144	257	160	94	88	125	1,780
1974	174	112	462	58	17	86	135	39	92	95	76	69	1,415
1975	179	171	94	66	71	75	57	209	195	214	219	140	1,690
1976	207	175	165	66	225	139	173	110	71	142	99	162	1,734
1977	230	175	220	88	16	39	75	184	202	214	191	144	1,778
1978	215	165	124	2	36	109	66	54	96	115	128	240	1,350
1979	58	66	44	184	167	71	50	62	145	250	130	80	1,307
1980	110	145	105	60	40	70	200	135	170	155	62	227	1,479
1981	118	119	148	51	39	28	131	33	64	142	66	131	1,070
1982	85	307	176	69	113	132	71	86	23	195	244	149	1,650
1983	272	155	190	116	264	168	542	82	208	91	138	308	2,534
1984	195	167	197	155	83	131	88	274	118	86	176	75	1,745
1985	48	263	182	201	38	34	92	7	128	126	101	97	1,317
1986	168	210	117	180	84	29	47	87	130	140	106	211	1,509
Mean	173	193	163	101	88	89	99	97	124	146	114	150	1,542

Table III.4.2 MONTHLY MEAN DISCHARGE AT GARCIA

Unit : cms

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	JUl.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1935	3.3	4.0	3.8	2.8	2.2	2.6	2.1	2.8	4.0	8.5	3.7	3.2	3.6
1936	4.8	3.5	3.3	3.3	3.0	4.0	2.8	7.3	7.0	5.9	4.1	4.1	4.4
1937	3.5	6.3	8.6	6.7	6.7	3.3	2.7	3.3	2.6	4.9	5.4	3.8	4.8
1938	4.5	5.3	3.8	4.0	3.9	3.8	3.4	2.7	2.7	2.6	2.5	2.6	3.5
1939	4.3	4.2	3.8	3.6	3.1	3.0	2.5	2.1	4.2	5.6	11.2	5.5	4.4
1940	6.0	4.9	3.1	2.7	3.1	1.9	3.2	3.6	2.3	3.7	4.1	3.2	3.5
1941	3.0	3.2	2.5	1.9	2.7	2.3	1.5	1.6	1.4	1.5	2.5	2.4	2.2
1942	1.7	4.2	3.3	2.9	2.6	2.7	2.1	1.7	1.5	1.4	1.3	2.0	2.3
1943	1.2	1.4	2.1	1.3	1.3	2.2	2.1	4.3	3.1	5.9	3.1	1.9	2.5
1944	3.7	4.2	5.7	3.4	1.9	1.6	1.2	1.5	1.3	1.2	2.1	1.4	2.4
1945	1.5	4.0	2.8	2.7	1.4	1.3	1.7	1.0	2.6	3.7	1.6	2.8	2.3
1946	3.7	8.1	6.0	4.9	2.7	3.8	4.4	4.1	2.7	5.8	3.6	2.7	4.4
1947	2.9	5.1	5.9	2.7	2.7	2.0	2.9	3.3	3.5	8.7	4.9	6.0	4.2
1948	5.0	7.5	7.2	3.9	7.0	3.0	2.8	4.2	2.2	2.2	2.0	1.3	4.0
1949	1.6	1.8	5.3	5.4	2.8	4.1	2.4	2.7	3.0	2.8	3.7	3.0	3.2
1950	5.5	6.6	8.3	4.4	3.2	2.8	2.1	2.5	2.7	4.5	2.5	2.8	4.0
1951	3.8	6.5	4.2	2.8	1.9	1.6	1.6	0.9	1.0	4.8	2.0	3.2	2.9
1952	3.7	3.3	3.3	2.0	1.9	2.3	1.8	1.4	2.4	3.8	2.9	2.2	2.6
1953	2.5	2.0	2.2	1.4	1.6	1.0	1.2	1.0	1.2	2.9	3.0	2.2	1.9
1954	3.7	3.7	5.1	7.5	4.9	4.0	4.3	2.5	2.8	9.0	3.3	1.9	4.4
1955	1.6	1.8	2.0	1.8	3.2	2.2	4.1	2.0	3.3	1.6	1.9	1.8	2.3
1956	3.2	3.9	2.3	2.1	3.6	2.3	1.9	1.7	3.5	4.8	3.4	3.8	3.0
1957	3.2	4.4	2.8	3.1	5.5	3.4	6.6	10.8	12.3	5.3	9.2	5.3	6.0
1958	4.8	3.8	6.3	4.0	2.7	3.2	2.3	2.3	4.0	4.1	3.7	4.5	3.8
1959	5.4	5.2	4.0	4.4	2.9	2.0	1.5	2.0	3.9	2.9	2.1	2.4	3.2
1960	5.6	9.2	7.7	3.0	2.3	1.8	1.5	4.1	2.3	2.4	5.9	4.2	4.2
1961	3.0	4.2	3.5	2.9	2.6	2.1	1.8	1.3	4.6	5.4	8.0	5.0	3.7
1962	3.5	3.9	4.1	2.0	1.9	1.6	2.1	1.4	2.4	2.5	2.7	2.7	2.6
1963	3.4	7.6	4.3	2.7	2.0	1.6	1.5	1.4	3.3	4.1	5.9	4.7	3.5
1964	3.0	3.1	3.4	2.7	3.6	2.6	2.5	2.7	2.6	3.8	2.2	3.3	3.0
1965	3.0	2.7	2.8	3.1	4.0	3.1	2.8	2.9	3.7	2.5	2.9	4.6	3.2
1966	4.0	6.9	4.5	4.8	2.4	3.1	2.2	2.4	2.6	4.0	3.7	4.3	3.7
Mean	3.6	4.6	4.3	3.3	3.0	2.6	2.5	2.8	3.2	4.2	3.8	3.3	3.4

Table III.4.3 ANNUAL MAXIMUM 4-DAY RAINFALL SERIES AT BLUMENAU

NO.	Year	Date		4-day Rainfall
		Month	Day	(mm)
1	1944	Nov.	24 - 27	112.2
2	1945	Feb.	17 - 20	116.0
3	1946	Aug.	27 - 29	116.9
4	1947	Jan.	12 - 15	71.8
5	1948	May	16 - 19	170.5
6	1949	Mar.	26 - 29	129.2
7	1950	Sep.	21 - 23	78.7
8	1951	Jan.	19 - 21	104.4
9	1952	Mar.	17 - 20	101.1
10	1953	Oct.	28 - 31	89.3
11	1954	Mar.	31 - Apr. 3	201.0
12	1955	May	17 - 20	122.9
13	1956	May	5 - 8	68.4
14	1957	Aug.	16 - 19	114.0
15	1958	Dec.	17 - 21	162.2
16	1959	Apr.	4 - 6	115.1
17	1960	Jan.	31 - Feb. 3	219.0
18	1961	Oct.	31 - Nov. 3	224.2
19	1962	Mar.	1 - 4	132.8
20	1963	Sep.	26 - 29	137.2
21	1964	Mar.	1 - 3	83.8
22	1965	Apr.	7 - 10	135.0
23	1966	Feb.	9 - 12	150.3
24	1967	Feb.	11 - 14	111.7
25	1968	Oct.	27 - 30	86.5
26	1969	Feb.	27 - Mar.2	142.9
27	1970	Feb.	2 - 5	162.4
28	1971	Apr.	20 - 23	80.9
29	1972	Aug.	25 - 28	152.2
30	1973	Aug.	26 - 29	139.8
31	1974	Mar.	9 - 12	170.4
32	1975	Sep.	30 - Oct. 3	151.3
33	1976	Jul.	26 - 29	107.5
34	1977	Feb.	3 - 6	117.6
35	1978	Dec.	26 - 26	144.0
36	1981	Mar.	27 - 29	140.8
37	1982	Feb.	2 - 5	135.8
38	1983	Jul.	6 - 9	215.4
39	1984	Aug.	5 - 7	156.6
40	1985	Apr.	5 - 7	127.4
41	1986	Oct.	8 - 11	104.8

Table III.4.4 CONSTANTS IN PROBABLE RAINFALL INTENSITY-DURATION CURVE PUBLISHED BY DNOS

Duration Time (hour)	Constants	
	a	b
5 /60	0.108	-0.080
15 /60	0.122	0.080
30 /60	0.138	0.080
1	0.156	0.080
2	0.166	0.080
4	0.174	0.080
8	0.176	0.080
14	0.174	0.080
24	0.170	0.080
48	0.166	0.080
72	0.160	0.080
96	0.156	0.080
144	0.152	0.080

Note : The above a and b are constants in the following formula published by DNOS.

$$P = K (A t + B \log (1 + C t))$$

$$K = T^{D} \qquad D = a + b/T^{C}$$

Where, P ; Probable rainfall amount (mm) for a duration,

t ; Durayion in hour,

T ; Return period in year and

A, B, C, D, a, b and c ; Constants.

Table III.4.5 ANNUAL MAXIMUM RAINFALLS AT BLUMENAU (02649020)

Unit : mm

Year	Duration Time (minutes)									
	Date	15	Date	30	Date	60	Date	120	Date	240
1935	Jan.13	22.0	Jan.13	30.0	Jan.13	30.5	Oct. 3	33.0	Oct. 3	49.8
1936	Apr. 9	20.0	Jan.22	36.0	Jan.22	46.5	Apr.12	51.7	Apr.12	52.6
1937	Mar.31	25.5	Mar.31	41.0	Mar.31	41.0	Mar. 6	63.2	Mar. 6	69.2
1943	Feb.22	20.0	Feb.22	25.4	Feb.22	25.5	Feb.22	27.5	Feb.22	31.1
1952	Dec.30	20.3	Dec.26	32.0	dec.26	33.5	Dec.26	34.2	Dec.30	47.7
1953	Feb.24	20.0	Feb.24	29.0	Feb.24	30.0	May.31	32.0	Sep.16	47.2
1954	Jan.13	25.8	Jan.13	30.0	Jan.13	36.5	Apr. 1	45.5	Mar. 1	64.0
1955	Feb.28	24.0	Feb.17	30.0	Feb.17	43.1	Feb.17	52.6	Feb.17	57.6
1956	May. 8	30.0	May. 8	33.5	May. 8	36.2	May. 8	40.7	May. 8	41.8
1957	Mar.20	20.0	Mar.20	27.0	Mar.20	32.8	Mar.20	36.2	Mar.20	39.7
1958	Dec.18	25.0	Dec.18	46.0	Dec.18	68.0	Dec.18	80.8	Dec.18	83.7
1959	Jan.23	20.0	Apr. 6	29.5	Jan.23	50.0	Jan.23	63.6	Jan.23	65.4
1960	Jan.18	20.0	Mar. 3	27.7	Dec.25	38.3	Feb. 3	50.0	Feb. 3	71.5
1961	Nov.27	19.5	Nov.27	28.0	Nov.27	28.5	Mar.21	35.6	Feb.18	48.0
1962	Mar. 7	16.0	Mar. 7	24.3	Mar. 2	30.0	Mar. 2	44.4	Mar. 2	74.5
1963	Mar.23	20.0	Mar.23	32.6	Mar.23	37.0	Mar.23	57.0	Mar.23	68.8
1964	Mar.24	14.6	Mar.15	18.0	Mar.15	20.9	Mar.15	26.4	Mar.15	27.0
1965	Mar. 2	40.0	Mar. 2	80.0	Mar. 2	94.0	Mar. 2	96.6	Mar. 2	96.6
1966	Feb.12	28.0	Feb.12	38.8	Feb.12	42.0	Feb.12	83.7	Feb.12	102.0
1967	Dec. 3	19.0	Dec. 3	30.0	Dec. 3	36.0	Dec. 3	42.0	Dec. 3	52.4
1968	Feb.13	17.0	Feb.13	31.5	Feb.13	34.1	Feb.13	34.1	Feb.13	34.1
1984	Aug. 5	9.0	Aug. 5	14.0	Aug. 5	27.4	Aug. 5	32.5	Aug. 5	36.2

Table III.4.6 RUNOFF COEFFICIENT IN DRAINAGE DISTRICT

Name of Drainage District	Catchment Area (km2)	Present Land Condition				Future Land Use Condition			
		City Area (km2)	Farm, Pasture and No-use lands (km2)	Forest Area (km2)	Runoff Coefficient	City Area (km2)	Farm, Pasture and No-use lands (km2)	Forest Area (km2)	Runoff Coefficient
G-1	3.94	0.50	0.07	3.37	0.72	1.04	-	2.90	0.75
G-2	2.50	0.32	0.18	2.00	0.72	1.33	-	1.17	0.81
G-3	1.13	0.31	0.14	0.68	0.74	0.67	-	0.46	0.82
G-4	5.17	1.07	0.04	4.06	0.74	1.67	-	3.50	0.76
V-1	0.43	0.30	0.01	0.12	0.84	0.38	-	0.05	0.88
V-2	0.62	0.38	0.16	0.08	0.80	0.62	-	-	0.90
V-3	0.67	0.29	0.08	0.30	0.77	0.56	-	0.11	0.87
V-4	0.68	0.44	0.03	0.21	0.83	0.49	-	0.19	0.84
V-5	0.59	0.36	0.07	0.16	0.81	0.59	-	-	0.90
V-6	1.17	0.59	0.13	0.45	0.79	1.17	-	-	0.90
V-7	2.34	0.73	0.13	1.48	0.76	1.88	-	0.46	0.86
I-1	0.51	0.23	0.24	0.04	0.74	0.53	-	-	0.90
I-2	1.93	0.15	0.91	0.87	0.67	1.66	-	0.27	0.87

Note : Area by land use category is based on the topographic map of 1/10,000 in 1987 for the present condition and based on the future land use map planned by municipal government of Blumenau for the future land use condition.

Table III.4.7 CONCENTRATION TIME IN DRAINAGE DISTRICTS

Name of Drainage District	Catchment Area (km2)	River Length (km)		Slope		Time of Entry (min.)				Time of Flow (min.)	Concentration Time (min.)
		L1	L2	i1	i2	Kraven	Ruziha	P.W.	Mean		
Itoupava river											
I-1	0.51	0.5	0.7	1 /50	1 /200	-	-	-	11	12	22
I-2	1.93	2.7	-	1 /80	-	13	31	117	54	-	54
Velha river											
V-1	0.43	0.6	0.4	1 /10	1 /200	-	-	-	8	7	15
V-2	0.62	0.7	0.4	1 /10	1 /400	-	-	-	8	7	15
V-3	0.67	0.5	0.8	1 /10	1 /300	-	-	-	7	13	21
V-4	0.68	0.6	0.8	1 /40	1 /200	-	-	-	11	13	24
V-5	0.59	0.5	1.0	1 /10	1 /400	-	-	-	7	17	24
V-6	1.17	0.8	0.7	1 /20	1 /300	-	-	-	11	12	22
V-7	2.34	2.0	2.0	1 /15	1 /200	10	39	53	34	15	49
Garcia river											
G-1	3.94	1.5	1.7	1 /15	1 /170	7	29	43	27	32	58
G-2-1	0.32	0.3	0.6	1 /10	1 /400	-	-	-	6	10	16
G-2-2	2.18	1.4	1.6	1 /15	1 /70	-	-	-	13	27	40
G-3	1.13	1.6	1.1	1 /10	1 /40	-	-	-	12	18	31
G-4	5.17	2.8	2.8	1 /20	1 /160	13	65	74	51	47	98

Remark : P.W. means estimation methods developed by Public Works Reserch Institution, Ministry of Construction in Japan.

Note : L1, L2, i1 and i2 is as follows;
The longest river length from main canal or pipe
River length of main canal or pipe
River bed slope of the longest river from main canal or pipe
Ground slope of main canal or pipe

Table III.4.8 PROBABLE FLOOD PEAK DISCHARGES FROM DRAINAGE DISTRICTS

Name of Drainage District	Catchment Area (km2)	Concentration Time (min.)	Rainfall Intensity (mm/hr)			Probable Flood Discharge (cms)		
			2	5	10 /2	2	5	10 /2
Itoupava river								
I-1	0.51	22	69	88	105	9 (17.3) /1	11 (22.0)	13 (26.2)
I-2	1.93	54	42	56	67	20 (10.2)	26 (13.5)	31 (16.1)
Velha river								
V-1	0.43	15	81	101	120	9 (20.2)	11 (25.2)	13 (29.9)
V-2	0.62	15	81	101	120	12 (20.2)	16 (25.2)	19 (29.9)
V-3	0.67	21	71	90	107	11 (17.1)	15 (21.7)	17 (25.7)
V-4	0.68	24	67	85	101	11 (15.6)	13 (19.8)	16 (23.6)
V-5	0.59	24	67	85	101	10 (16.7)	13 (21.2)	15 (25.3)
V-6	1.17	22	69	88	105	20 (17.3)	26 (22.0)	31 (26.2)
V-7	2.34	49	45	59	71	25 (10.8)	33 (14.1)	39 (16.9)
Garcia river								
G-1	3.94	58	40	53	64	33 (8.4)	44 (11.1)	52 (13.3)
G-2-1	0.32	16	79	99	117	6 (17.7)	7 (22.2)	8 (26.4)
G-2-2	2.18	40	51	66	79	25 (11.5)	33 (14.9)	39 (17.8)
G-3	1.13	31	59	76	90	15 (13.4)	19 (17.2)	23 (20.5)
G-4	5.17	98	28	37	44	30 (5.8)	40 (7.8)	48 (9.4)

Note : /1 Spesific discharge in cms/sq.km.
/2 Return period in year.

Figures

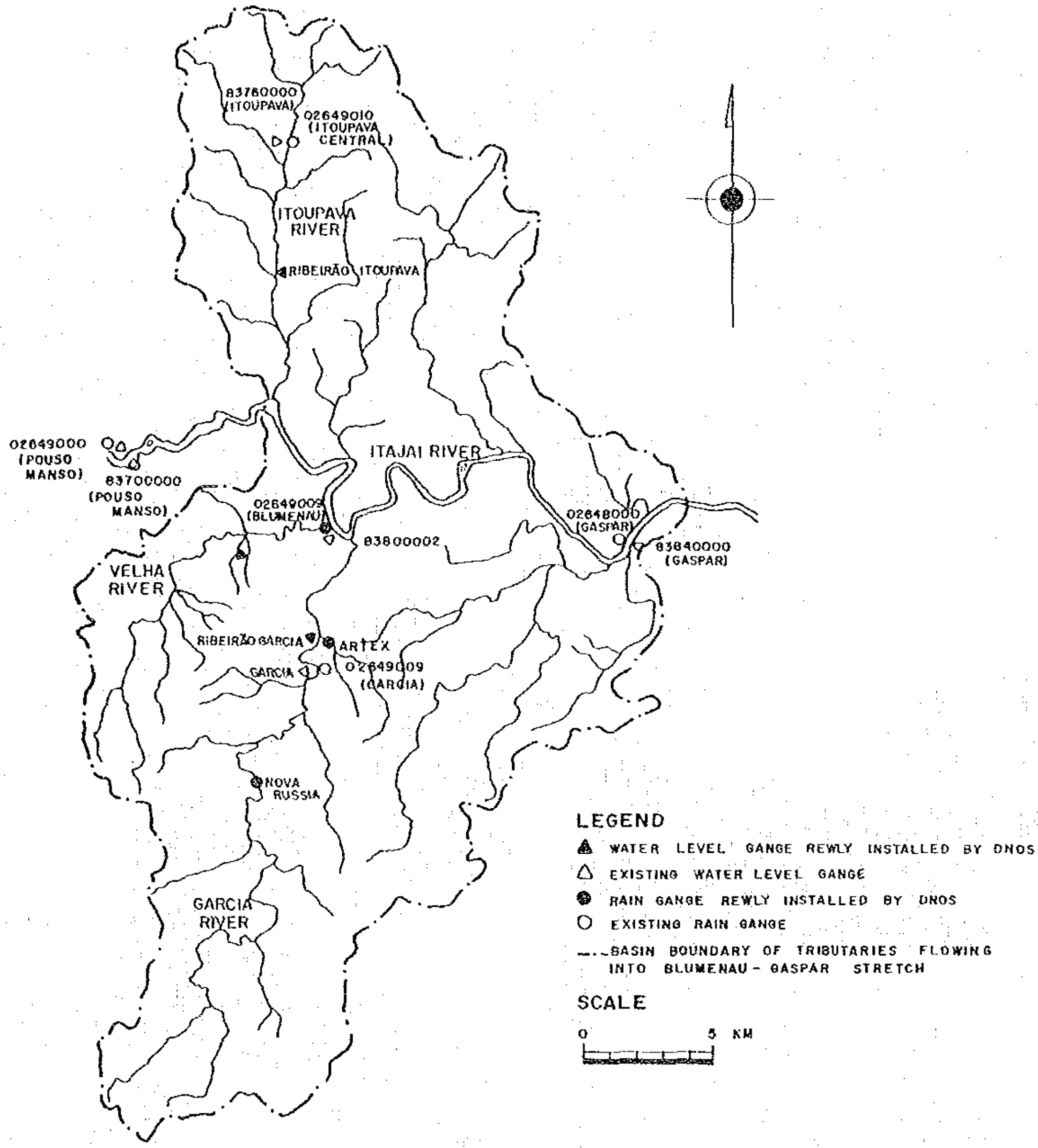


Fig. III.2.1 **LOCATION MAP OF METEO-HYDROLOGICAL GAUGING STATION IN / AROUND BLUMENAU GASPAR STRETCH**

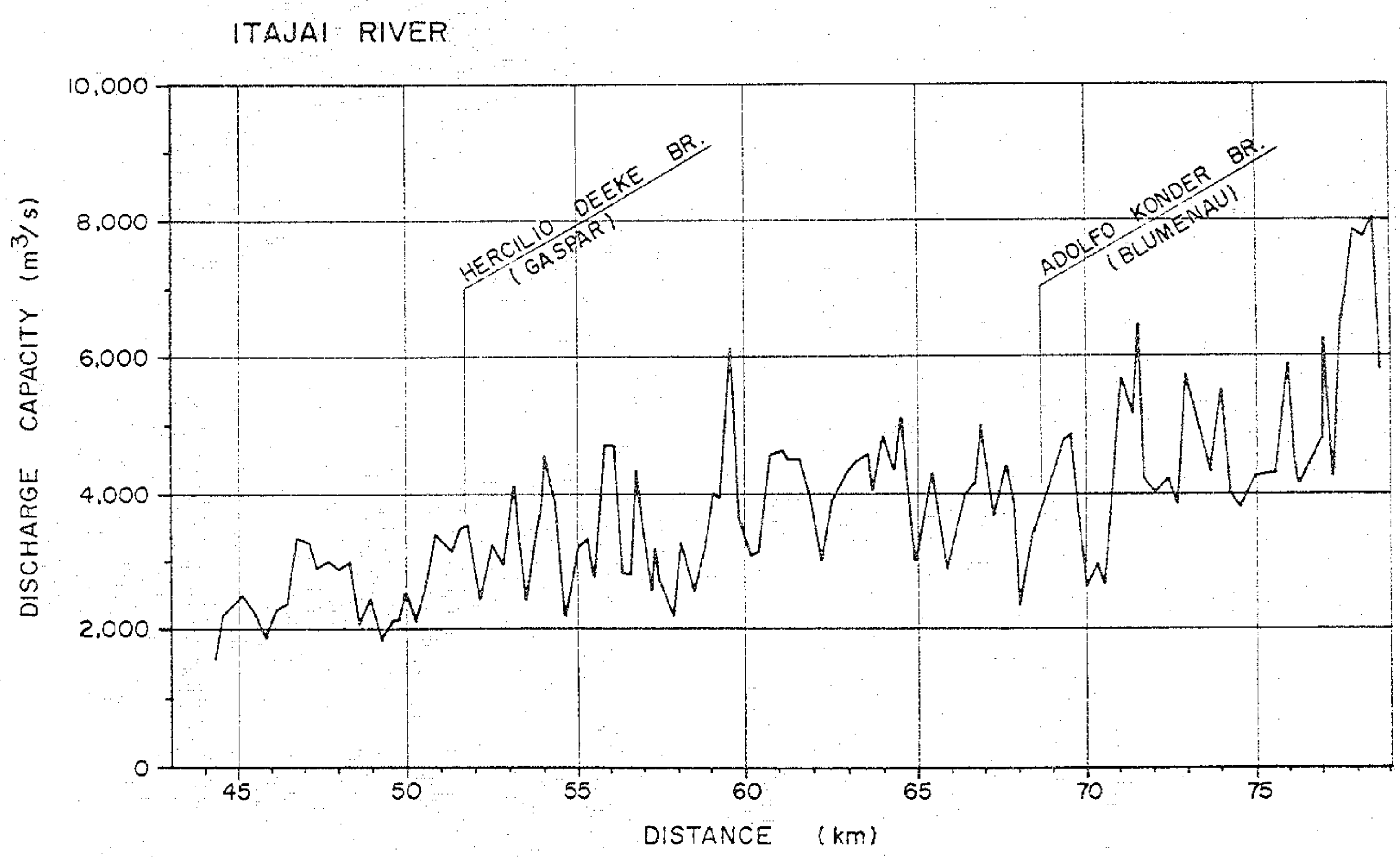
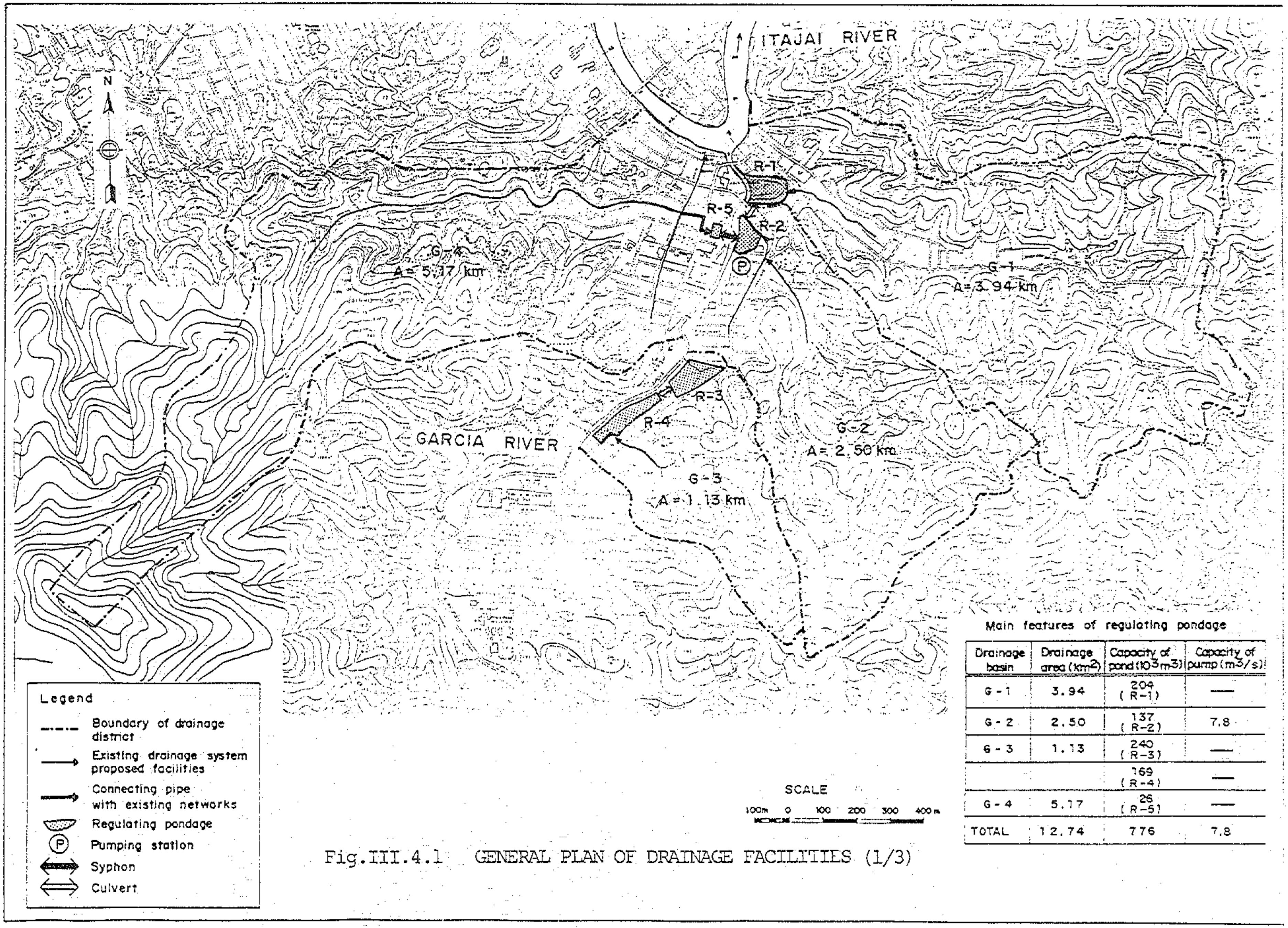


Fig. III.3.1 BANKFUL DISCHARGE CAPACITY OF BLUMENAU - GASPAR STRETCH



Main features of regulating pondage

Drainage basin	Drainage area (km^2)	Capacity of pond ($10^3 m^3$)	Capacity of pump (m^3/s)
G-1	3.94	204 (R-1)	—
G-2	2.50	137 (R-2)	7.8
G-3	1.13	240 (R-3)	—
		169 (R-4)	—
G-4	5.17	26 (R-5)	—
TOTAL	12.74	776	7.8

Fig.III.4.1 GENERAL PLAN OF DRAINAGE FACILITIES (1/3)

Drainage basin	Drainage area (Km²)	Capacity of pond ($10^3 m^3$)	Capacity of pump (m^3/s)
V-1	0.43	—	—
V-2	0.62	101 (R-7)	—
V-3	0.67	57 (R-9)	1.0
V-4	0.68	—	—
V-5	0.59	50 (R-6)	0.7
V-6	1.17	57 (R-8)	0.7
V-7	2.34	15 (R-10)	4.0
Total	6.50	280	6.4

SCALE
100m 0 100 200 300 400 m

Legend
- Boundary of drainage district
- Existing drainage system

Proposed facilities;
- Connecting pipe with existing networks
- Regulating pondage
- (P) Pumping station
- Syphon
- ( ) Connecting pipe number

Fig.III.4.1 GENERAL PLAN OF DRAINAGE FACILITIES (2/3)

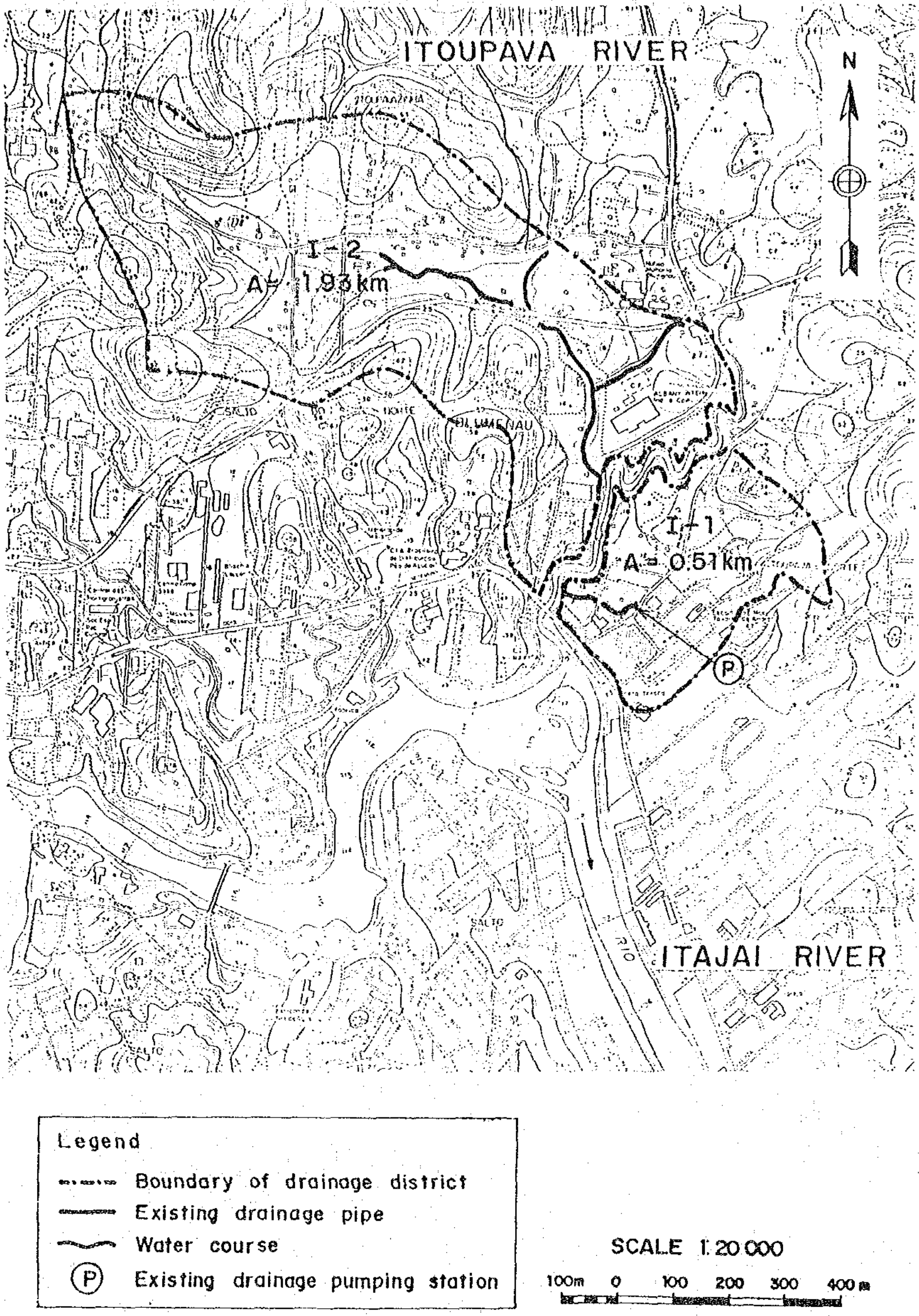


Fig.III.4.1 GENERAL PLAN OF DRAINAGE FACILITIES (3/3)

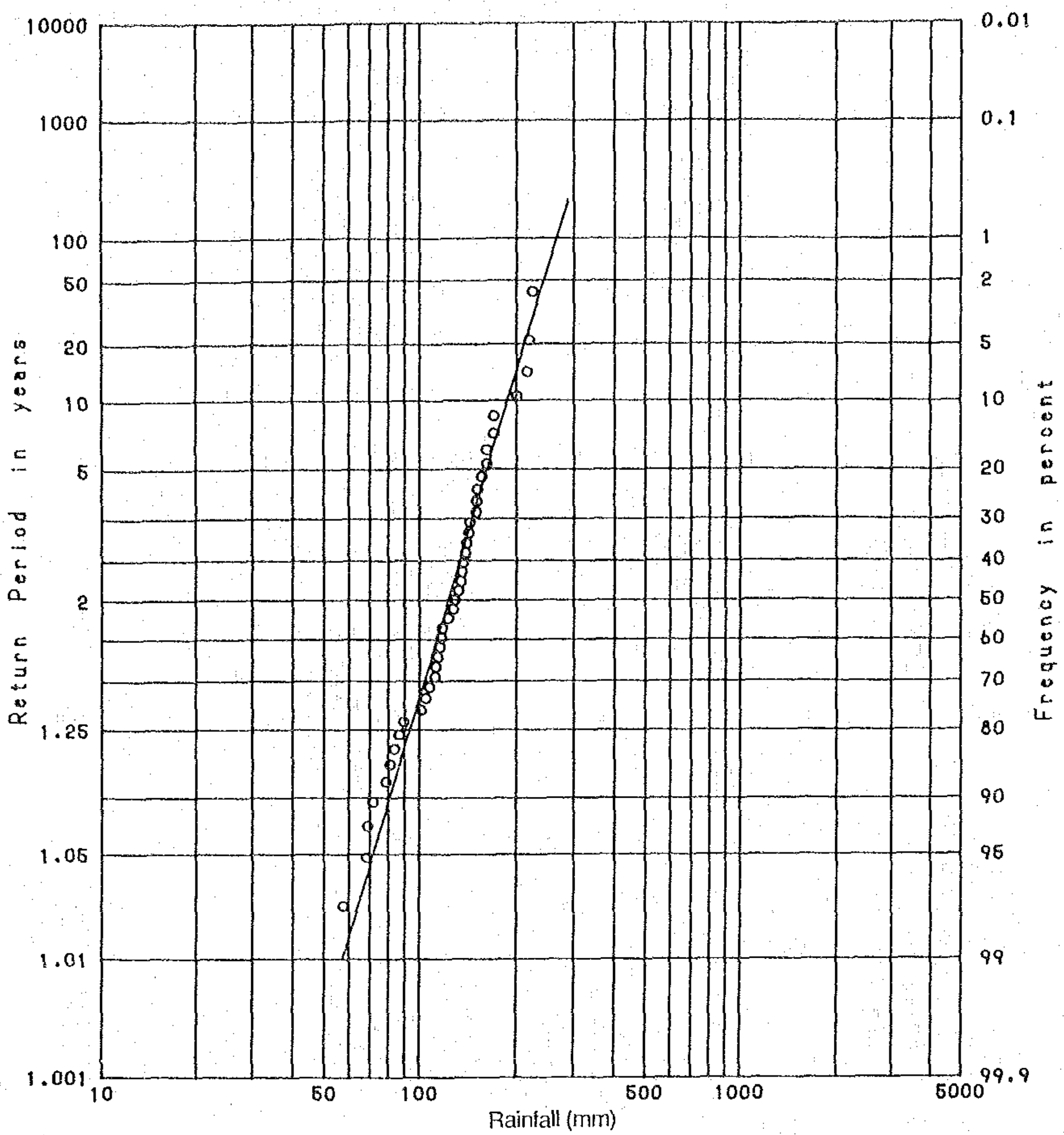
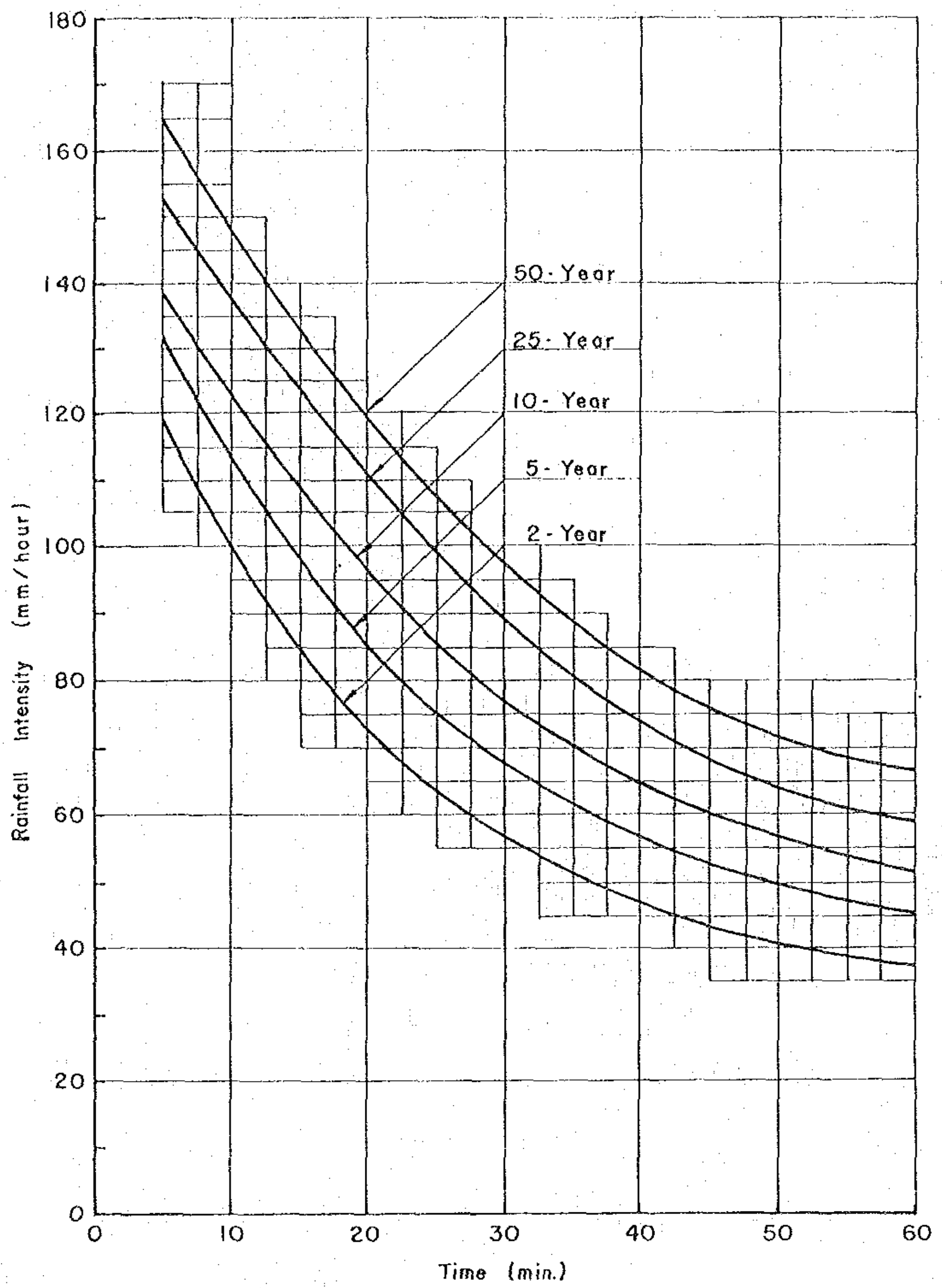
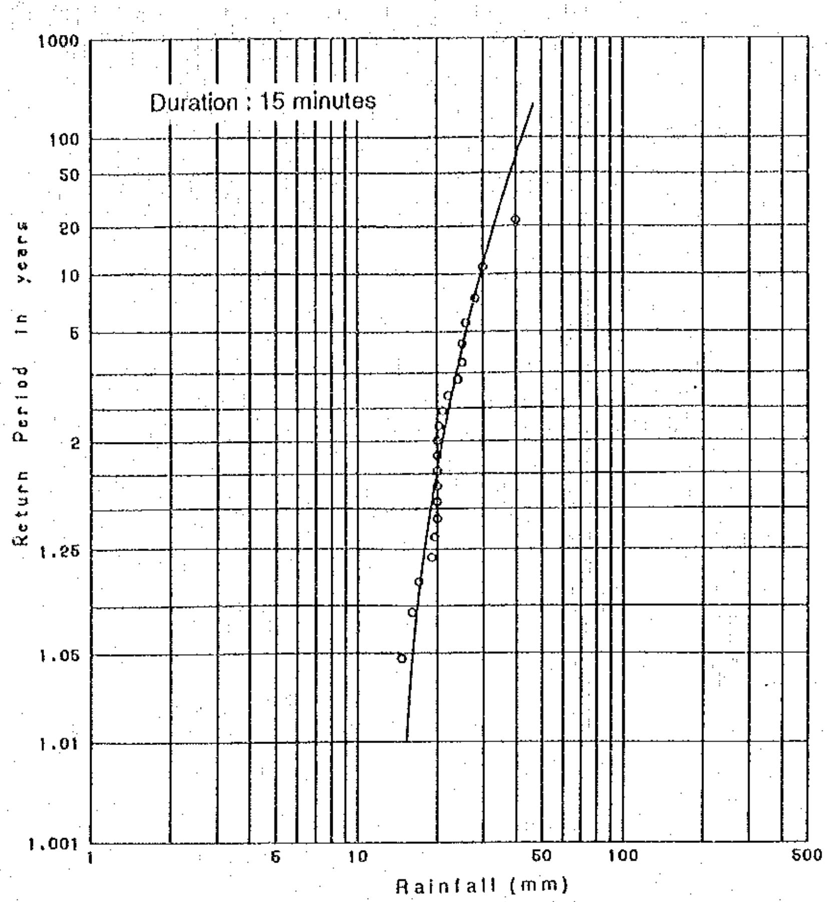


Fig.III.4.2 ANNUAL MAXIMUM 4-DAY RAINFALL AND ITS FREQUENCY CURVE AT BLUMENAU



Source: Chuvas Intensas no Brasil

Fig. III. 4.3 PROBABLE RAINFALL INTENSITY - DURANTION CURVE PUBLISHED BY DNOS



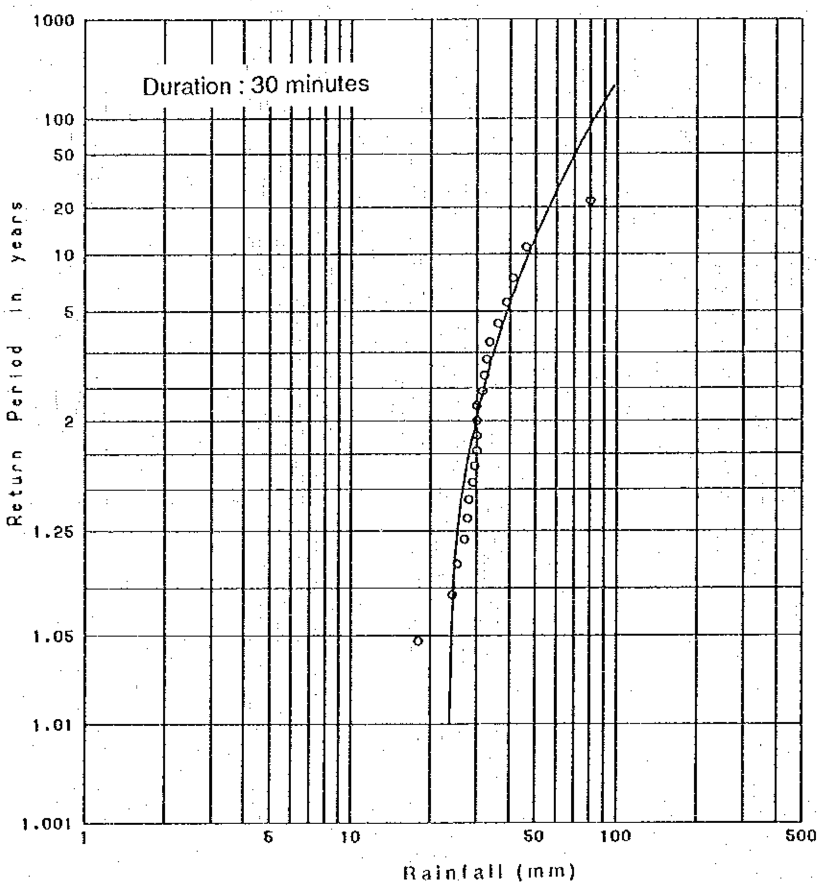
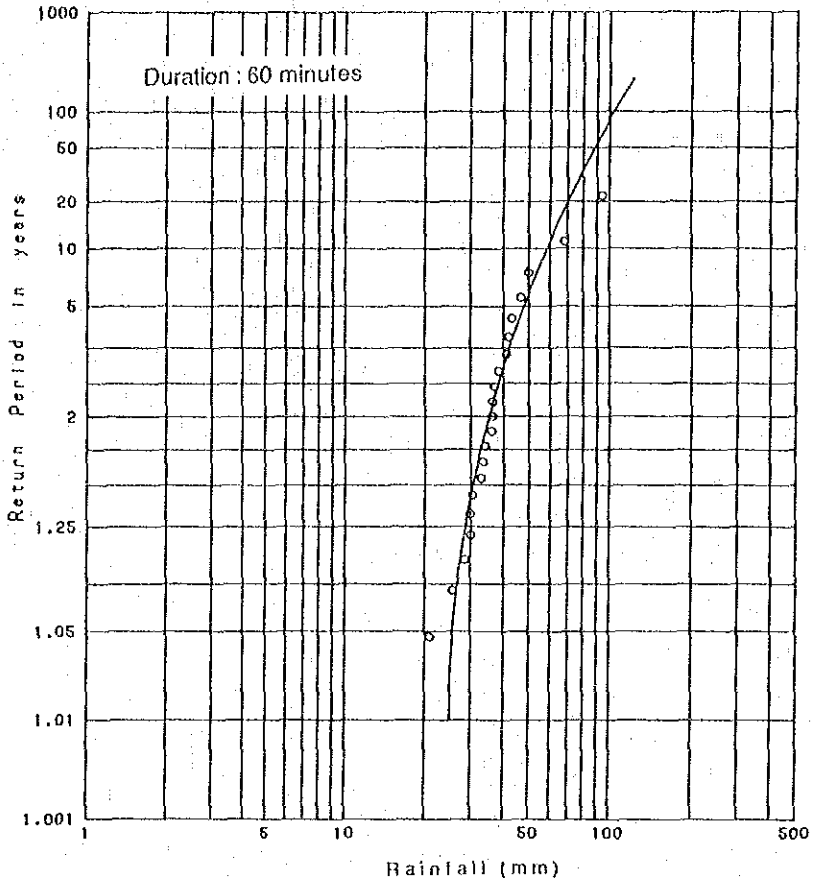


Fig.III.4.4 ANNUAL MAXIMUM HOURLY RAINFALL SERIES AND THEIR FREQUENCY CURVE AT BLUMENAU (1/3)



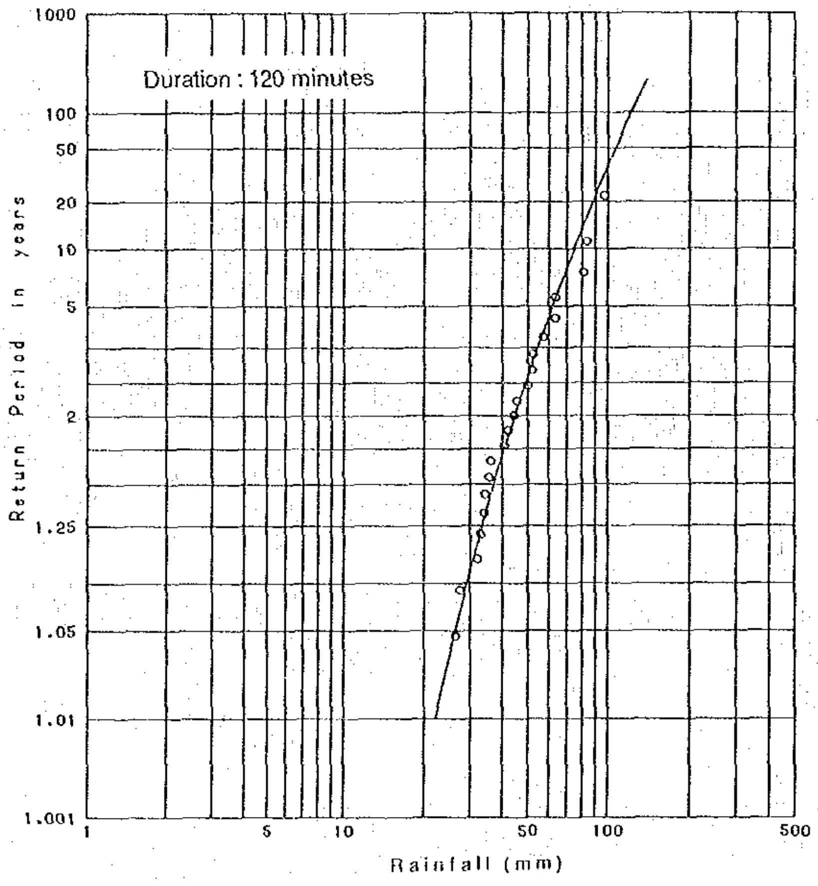


Fig.III.4.4 ANNUAL MAXIMUM HOURLY RAINFALL SERIES AND THEIR FREQUENCY CURVE AT BLUMENAU (2/3)

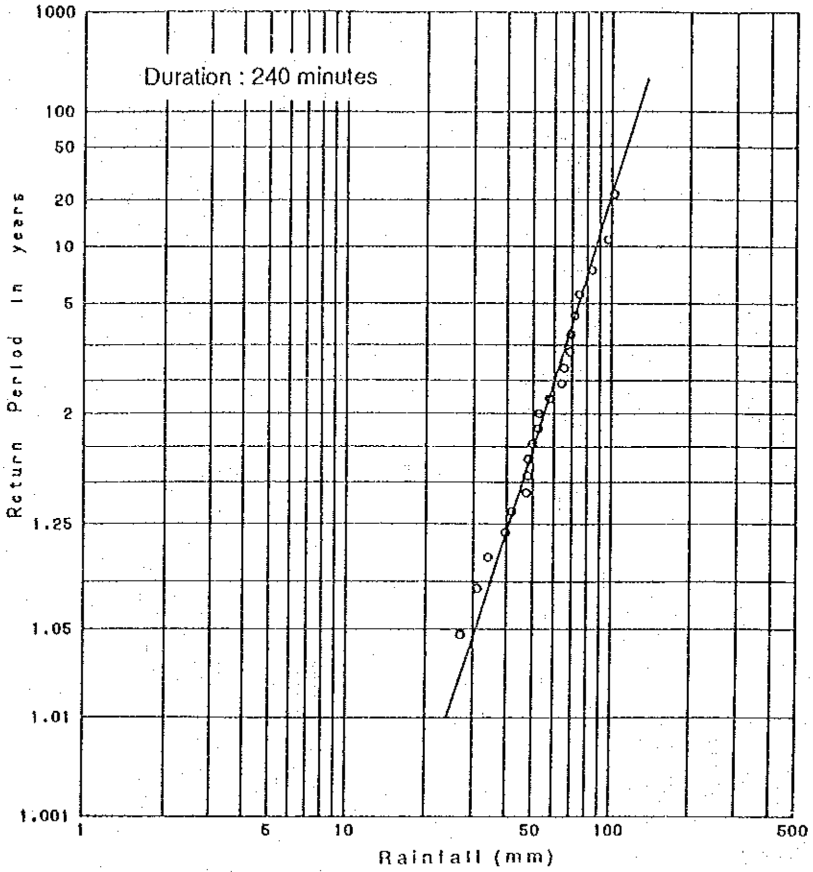
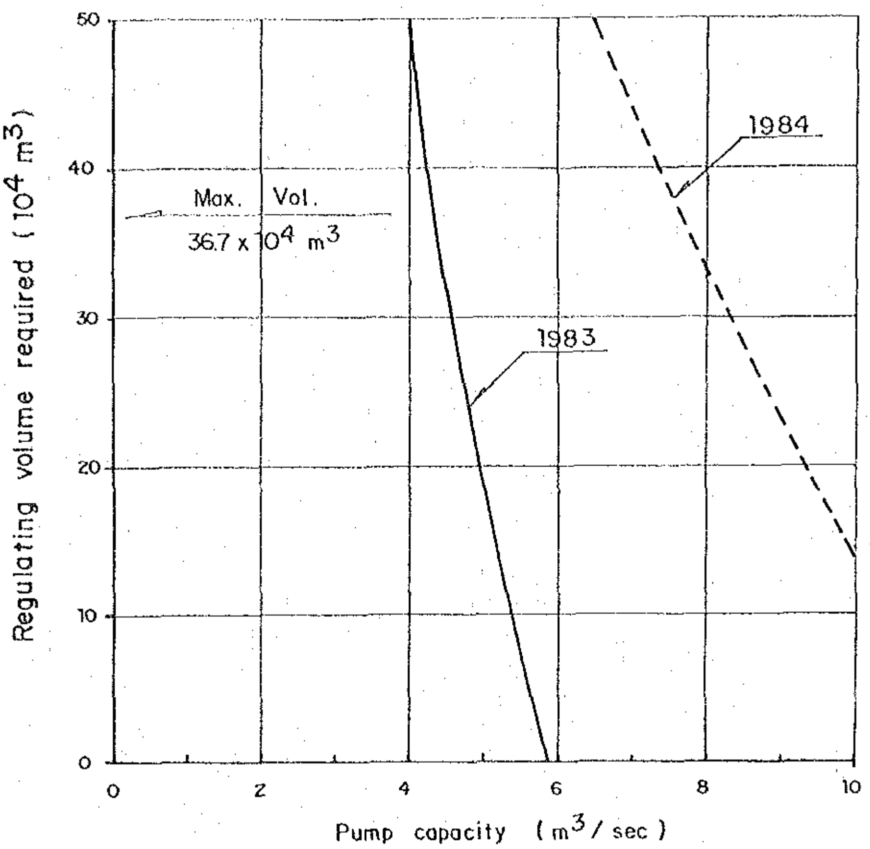


Fig.III.4.4 ANNUAL MAXIMUM HOURLY RAINFALL SERIES AND THEIR FREQUENCY CURVE AT BLUMENAU (3/3)

Regulating pondage for G-1, G-2 and G-4 drainage districts



Regulating pondage for G-3 drainage district

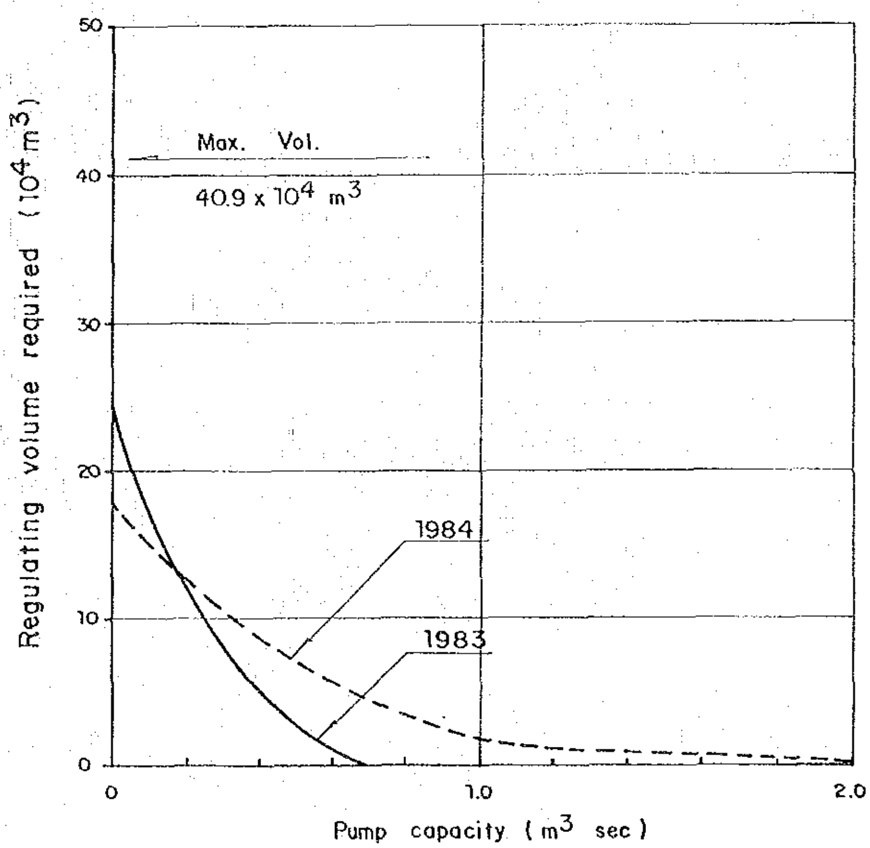
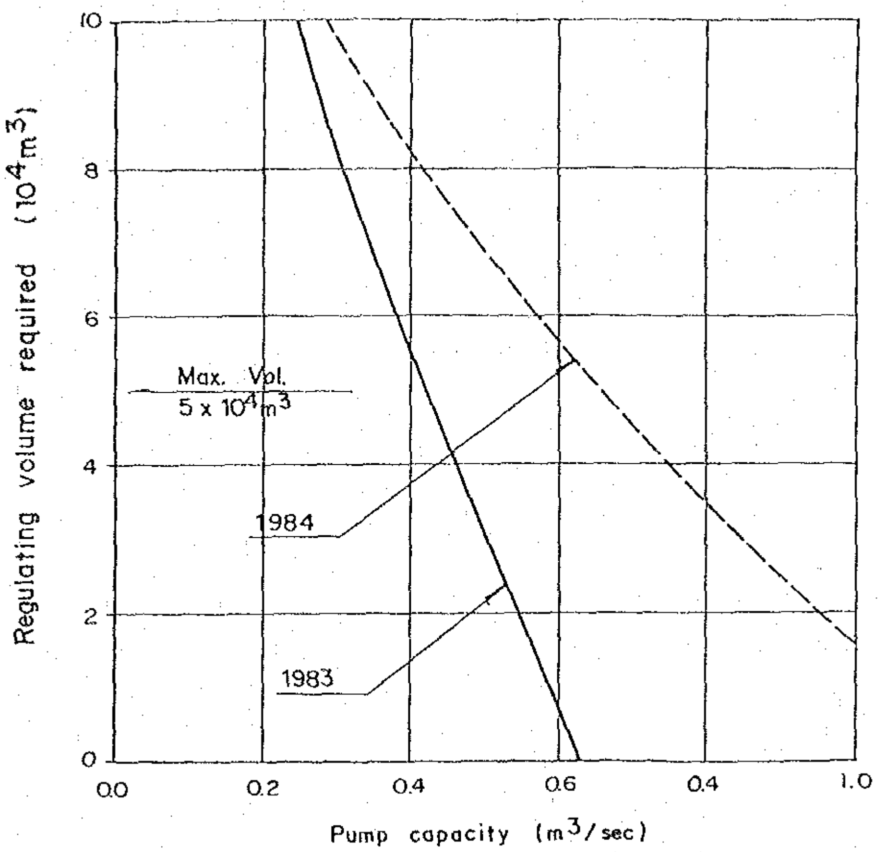


Fig.III.4.5 RELATION BETWEEN PUMP CAPACITY AND REGULATING VOLUME OF POND (1/3)

Regulating pondage for V-1 and V-5 drainage districts



Regulating pondage for V-2 and V-6 drainage districts

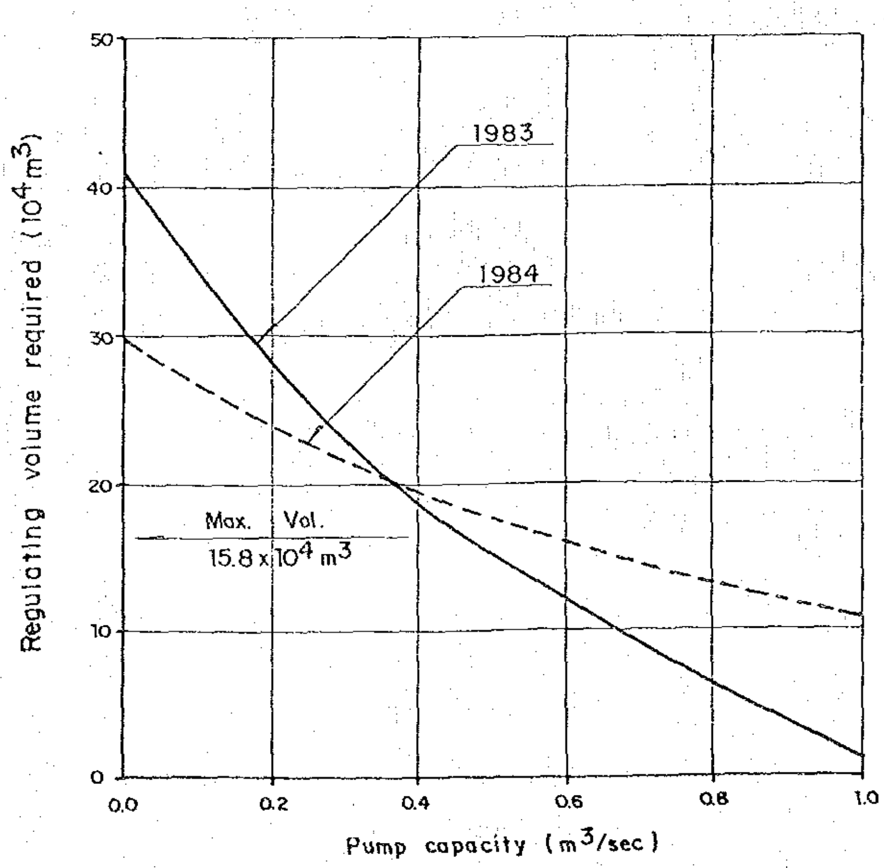


Fig.III.4.5 RELATION BETWEEN PUMP CAPACITY AND REGULATING VOLUME OF POND (2/3)

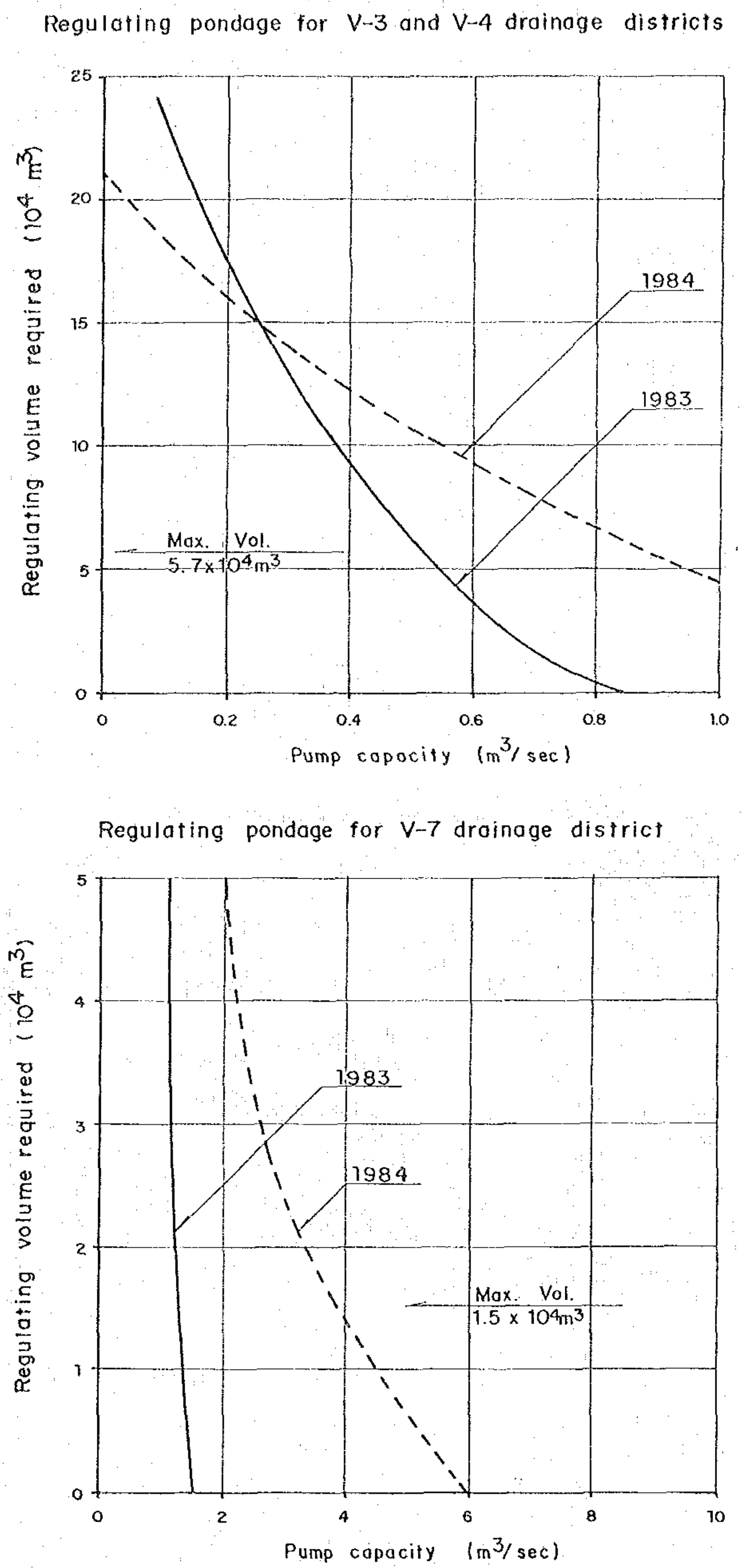


Fig.III.4.5 RELATION BETWEEN PUMP CAPACITY AND REGULATING VOLUME OF POND (3/3)

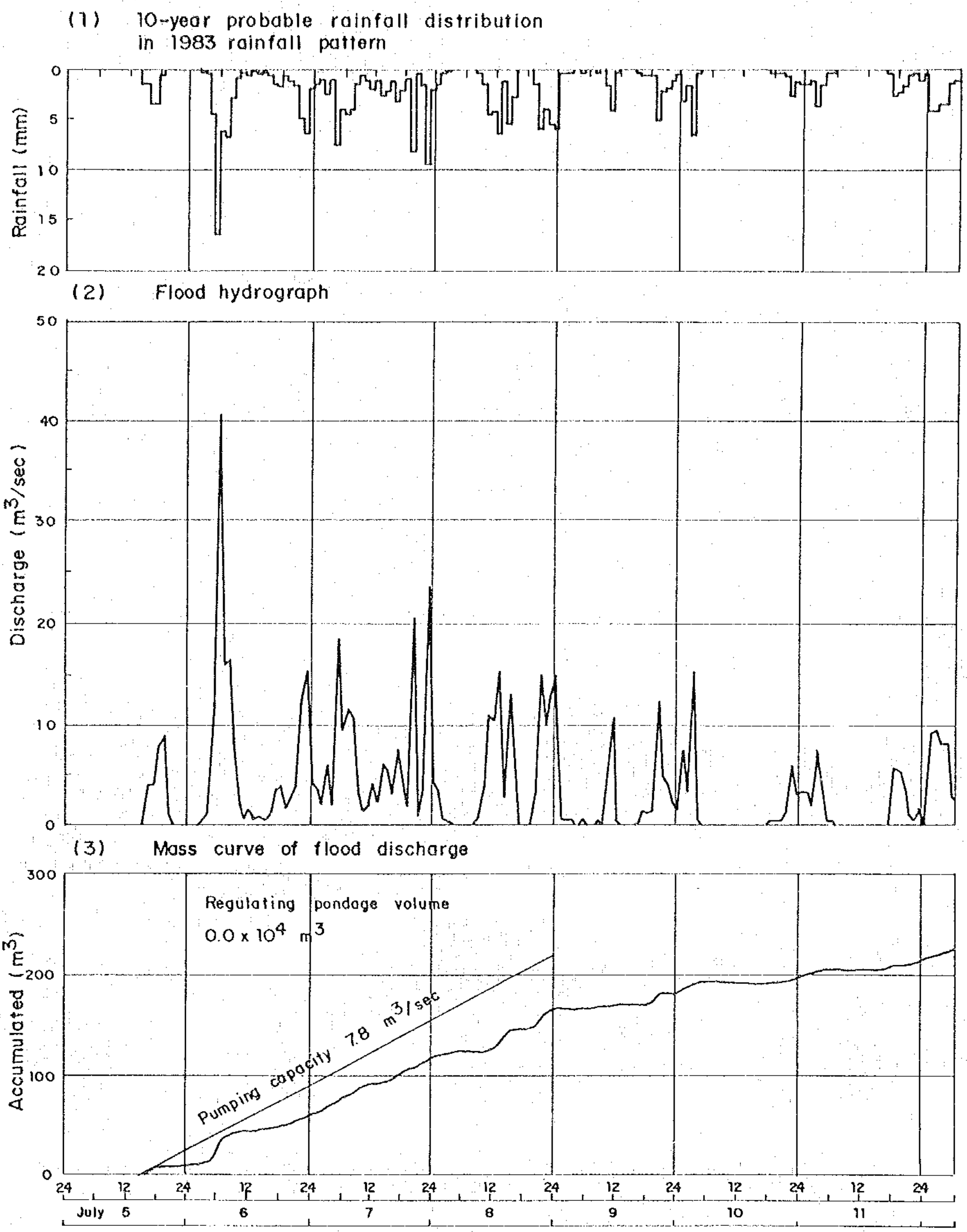


Fig. III.4.6 MASS CURVE ANALYSIS ON RELATION BETWEEN PUMP CAPACITY AND REGULATING PONDAGE VOLUME FOR G-1, G-2 AND G-4 DRAINAGE DISTRICTS BASED ON 1983 RAINFALL PATTERN

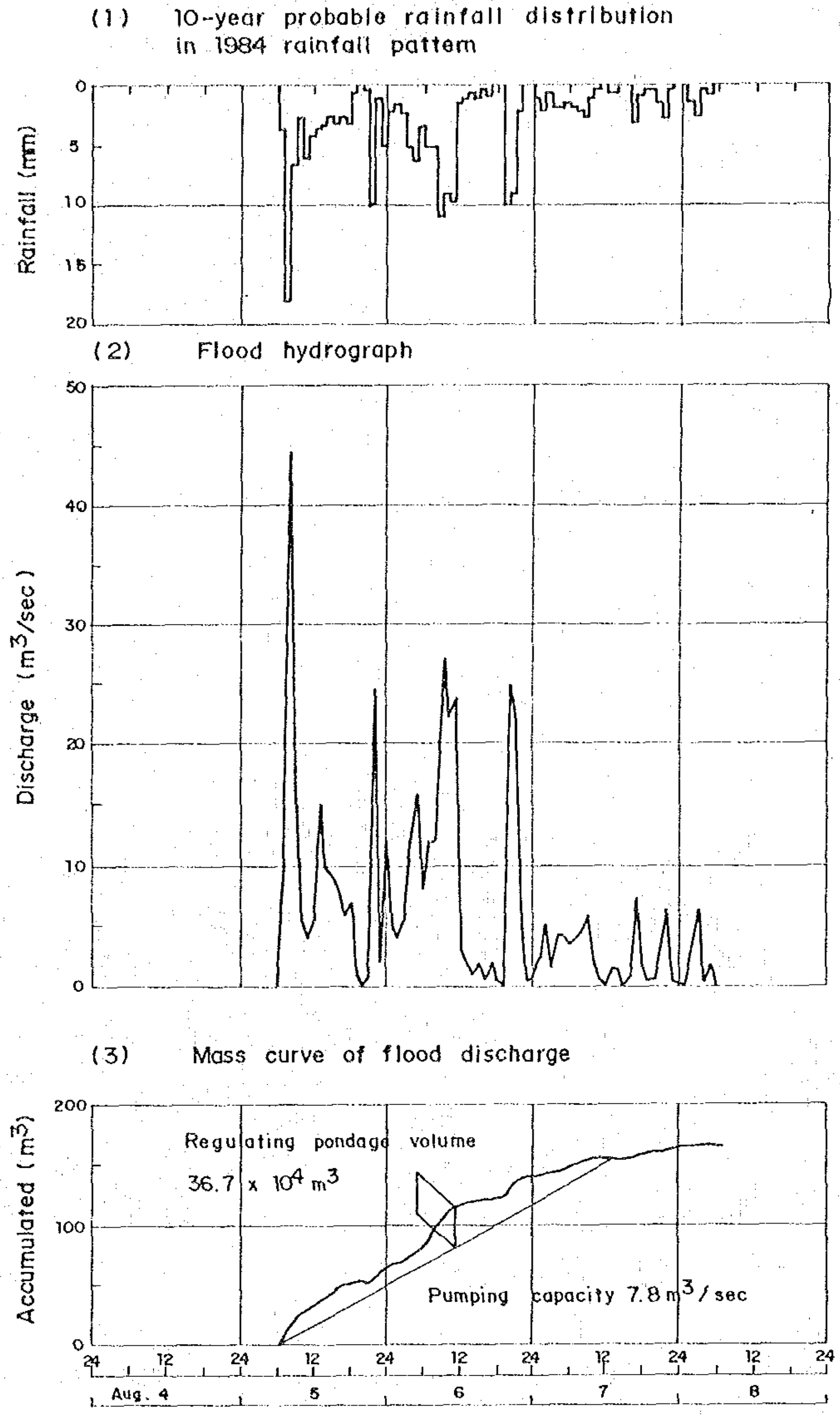


Fig. III.4.7 MASS CURVE ANALYSIS ON RELATION BETWEEN PUMP CAPACITY AND REGULATING PONDAGE VOLUME FOR G-1, G-2 AND G-4 DRAINAGE DISTRICTS BASED ON 1984 RAINFALL PATTERN

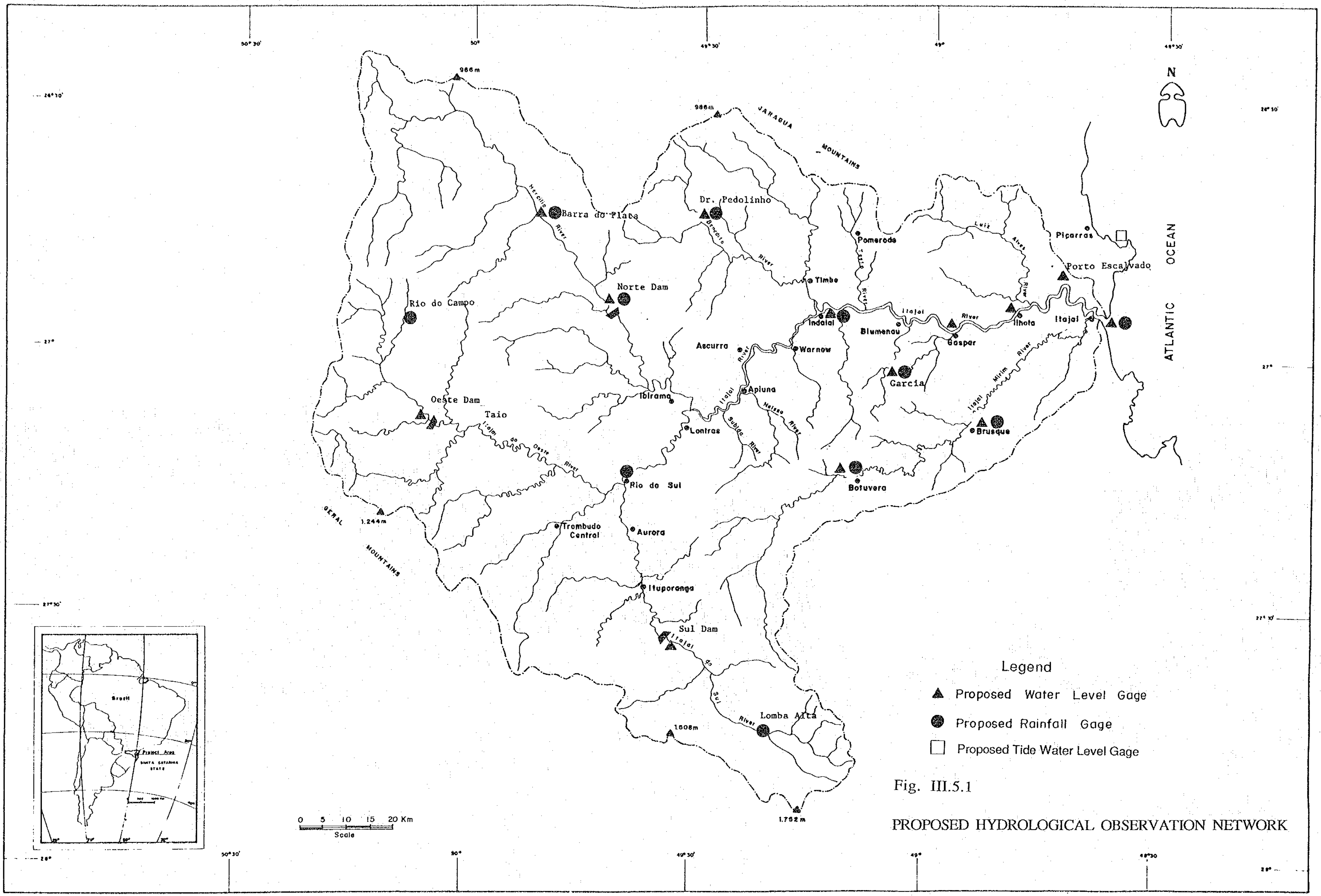


Fig. III.5.1

PROPOSED HYDROLOGICAL OBSERVATION NETWORK

ANNEX IV. SOCIO-ECONOMY

IV. SOCIO-ECONOMY

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1. INTRODUCTION

The socio-economic study in this feasibility study presents the socio-economic structure in the project area in order to identify the project planning conditions and to evaluate the project itself. The project area is characterized from the three aspects: social conditions; economic conditions, and land use. The characteristics of the area is studied for both the present and future conditions.

The socio-economic conditions in the project area might be characterized by figures and/or indices of the following spatial clusters in this feasibility study because of data availability:

- study area: it comprises the municipalities of Blumenau and Gaspar;
- study area within the Itajai river basin: it consists of the two municipalities excluding a portion of outside of the basin, i.e., a part of Blumenau municipality (refer to Fig IV.2.1); and
- project area: it covers the whole probable inundation areas within Blumenau-Gaspar stretch.

The study is made up of three chapters. Chapter two mentions the present social and economic conditions of the project area comparing with the basin's conditions. Chapter three presents the situation of land use in the project area. Finally, Chapter four describes the future conditions mentioned in primary chapters. The projection is formulated on the basis of the national development policies, some dependable assumptions, and the same methodology used in the master plan.

2. SOCIO-ECONOMIC CONDITIONS

2.1 Social Conditions

The project area lies across the two municipalities of Blumenau and Gaspar. It covers the municipal area of approximately 69 km^2, comprising 29 km^2 of Blumenau municipality and 40 km^2 of Gaspar municipality. One part of the area in Blumenau lies in an urban area, although the other part in Gaspar spread over both urban and rural areas.

The study area consisting of two municipalities occupies 867 km^2, i.e., 531 km^2 of Blumenau and 336 km^2 of Gaspar. Both municipalities are divided into urban areas and rural areas, as shown in Fig.IV.2.1 and Table IV.2.1. An urban area is further divided into "a bairro (city ward)". Blumenau has 30 bairros and Gaspar 11 bairros. Bairros do not have any autonomous administration. They have existed only in customary communities. Therefore, bairros in Gaspar in particular are not demarcated accurately each other, though those in Blumenau are delineated a little clearly as compared with Gaspar.

The study area within the Itajai river basin is smaller than the study area mentioned above, which is connected to the master plan study. The reason is that the municipality of Blumenau is physically divided into 2 parts by the watershed of the Moema mountain range. Although most of Blumenau exists in the Itajai basin, some parts of rural areas and bairro Vila Itoupava, a part of urban areas, are located outside of the Itajai basin. Of the total area of Blumenau, 410 km^2 is included in the basin, so the study area within the basin comes into 746 km^2.

Both municipalities are located in Colonial de Blumenau micro-region. They, however, do not have any political or administrative relations. Though they have an independent autonomous administration and their organizational scale is different each other, their administrative structure is quite similar, as shown in Fig.IV.2.2. In addition to general line departments, some advisory committees and some extra-governmental organizations such as SAMAE (public corporation of municipal water supply) and FURB (municipal university of Blumenau) are set up under jurisdiction of a mayor. COMDEC (Comissao Municipal de Defesa Civil), under direct control of the mayor, works immediately in the case of emergency such as flood disaster. In the case of huge disaster such as 1983 and 1984 floods, COMDECs are controlled by CEDEC (Coordenacao Estadual de Defesa Civil : civil defense of the state). In this way, the coordination between two municipalities must be conducted by the state government.

According to the 1980 census by IBGE, the study area had a population of 182,864. The population increased by 101,180 as compared to 1960 census shown in Table IV.2.2. During the 60's, the average annual growth rate was recorded at 3.8%. In the 70's, however, it was accelerated to 4.4%, which was bigger than the basin's growth rate of 2.08%. The population in the project area in 1980 was estimated at 65,500. This corresponded to about 36% of that of the study area, despite the fact that the project area occupied only 8% of the study area.

Population density in the study area was 211 persons/km^2 in 1980, which is much greater than that of the basin of 4.4 persons/km^2. In the project area, its density recorded 949 persons/km^2, as shown in Table

IV.2.1. This is because most of the area lies in urban areas of both municipalities.

The urban population of the study area reached to 159,726 in 1980, which accounted for 87.3% of the total population. That of the project area was 63,235 in the same year. It accounted for about 97% of the urban population of 65,500 and also for about 40% of urban population of the study area. This means that the project area is quite urbanized. Urban population in Blumenau has continuously increased at 6.1% of average annual growth rate during 60's and at 5.4% during 70's. In Gaspar, urban population increased at extremely high speed of 11.9% annually during 70's, although its absolute number of increment was comparatively small. The urban population in Gaspar might be influenced by the urban agglomeration of Blumenau.

The number of gainful workers registered at 84,130 in 1980 as shown in Table IV.2.3. Of this total, 46,843 or 55% worked in the industrial sector. Manufacturing sub-sector especially absorbed the largest number of 40,566, which accounted for 48.2% of the total. The number in the industrial sector has grown at 9.0% annually during the 70's. The tertiary sector had 33,590 in 1980, the second big share among three sectors, accounting for 39.9% of the total. It has grown at 6.3% annually during the 70's. On the other hand, the primary sector occupied only 2,357 or 2.8% of the total in 1980. It has decreased at the rate of 4.8% annually during the same period. Accordingly, it is said that the study area has industrialized at a quite high speed during the 70's.

2.2 Economic Conditions

2.2.1 Economic profile

The study area is identified as an industrialized district not only in the basin but also in the state. Corresponding to the industrialization since the 70's, commercial and services industry in the study area has also played an important role as the marketing base in the basin. To the contrary, the primary sector has correspondingly declined in the study area. The total product, however, has actually increased at quite high growth rate. Accordingly, the living standard of inhabitants would be improved in proportion to the economic growth.

(1) Primary sector

The primary sector is generally divided into five sub-sectors : crop production, livestock production, fishery, forestry and rural industry. Since the study area has not had any inland fishponds as well as not bordered upon the seashore, the fishery sub-sector does not exist there. The total production of the four sub-sectors amounted to Cr$ 467 million in 1980 at current prices, as shown in Table IV.2.4, accounting for only 3.5% of the basin's total.

The main crops cultivated in the study area are rice, cassava, sugar-cane and maize in order of production value, as shown in Table IV.2.5. Rice is cultivated with the area of 2,300 ha in 1980 mainly in the flat low land along the river courses. The production was 8,600 tons, which shared about 8.2% of the basin. The rice production amounted to Cr$ 81 million at current prices, accounting for 7.6% of the basin. The production of other main crops such as cassava, sugar-cane and maize aggregated 13,800 tons, 18,800 tons and 2,200 tons, respectively. The amount of their production reached

Cr$ 64 million, Cr$ 29 million and Cr$ 24 million, respectively. Although sugar-cane is cultivated in rural area of the study area, the harvested areas are located outside of the project area. On the other hand, rice fields spread over the project area along the Itajai river and its tributaries.

The important livestock and its products in the study area are milk, egg and pig in order of production value, as shown in Table IV.2.6. The amount of milk production attained to Cr$ 136 million, accounting for 20.8% of the basin's production.

The forestry production in the study area shared the comparatively important role in the basin. Firewood was produced from natural forest to 176 thousand m^3 and from reforested area to one thousand m^3, respectively as shown in Table IV.2.7. It amounted to Cr$ 28 million and Cr$ 0.7 million accounting for 14.8% and 37.6% of the basin, respectively. Timber from reforested area recorded the high share of 16.6% as shown in the table.

The main products of rural industry in the study were custard, cheese and cassava-related in order of production value, as shown in Table IV.2.8. They accounted for 29.7%, 13.0% and 8.9%, respectively. Although production of spirit sugar cane, butter and rice-related occupied a big share in the basin, its amount is small as compared with other agricultural products.

(2) Secondary sector

The secondary sector is usually divided into four sub-sectors. In the study area, the manufacturing sub-sector is the most descriptive and representative industry not only in the secondary sector but in the whole industrial structure, as mentioned above. According to the industrial census in 1980, the manufacturing and mining sub-sector recorded 684 establishments, 38,067 employees and a production value of Cr$ 69,246 million at current prices, accounting for 25.3%, 44.9% and 59.4% of the basin's production respectively, as shown in Table IV.2.9 to 11.

The main industrial types in the study area are (1) textile and (2) clothing, shoes and woven articles on the basis of production value. They account for 46.0% and 27.3% of the total production of the manufacturing and mining sub-sectors in the study area, respectively. In terms of employees, they absorb 42.7% and 23.3%, respectively. With regard to the number of establishments, however, they occupy only 11.5% and 9.5%, respectively. Accordingly, the production value per an establishment of these types achieves the sizeable amounts of Cr$ 505.5 million and Cr$ 248.5 million respectively, as shown in Table IV.2.12, which succeeds the chemistry type. The number of employee per an establishment comes into the great figures of 258.2 and 116.8 respectively, which gets the top-notch position in the study area.

In terms of production value, the following industrial types succeed the two types mentioned above in the study area : chemistry (4.7%); food products (4.4%); and metallurgy (3.5%); and paper (2.2%). Figures in parentheses are the rates of production value of each industrial type to that of the whole types in the study area. The chemistry accomplishes the big amount of production value per an establishment but it does not so much contribute to employment in the study area, because its number of employee occupies 229 or 0.6% of the total employees. However,the chemistry may contribute to regional economy, because labor productivity and management efficiency of the chemistry achieved the best result among all industrial types, as shown in Table IV.2.12. The paper production gets the medium position with regard to management efficiency and contributes to employment commensurate to the share of production value in the study area.

The production of the manufacturing and mining sub-sectors has grown at the average annual real growth rate of 37.9% during the first 5 years in the 70's and at 16.3% during the second 5 years. During the second five years, the economic growth moderated as compared with that during the first five years, but it was still high. The remarkable industrial types with regard to economic growth during the decade were (1) clothing, shoes and woven articles; (2) textile; (3) chemistry; (4) electric and communication products; (5) plastic product; (6) machinery; (7) mining; and (8) paper. Clothing, shoes an woven articles grew at extremely high rate during the first five years. During the same period, types of chemistry, machinery, electric and communication products, and plastic products grew at higher rate than the average growth rate in the study area.

(3) Tertiary sector

The tertiary sector is characterized as a large number of medium and small establishments in general. In 1980, the annual sales amount of commercial sub-sector in the study area was Cr$ 22,443 million and that of service's sub-sector was Cr$ 25,682 million at current prices, as shown in Table IV.2.15. Since the number of establishment of these two sub-sectors registered 1,195 and 2,840 as shown in Table IV.2.13, sales amount per establishment was Cr$ 18.8 million and Cr$ 9.0 million, respectively. An average production value of manufacturing and mining sub-sectors was Cr$ 101.2 million, so that of the tertiary sector is recognized to be much smaller than that of the industrial sector. Since the number of employee of the two sub-sectors registered 8,665 and 15,761, sales amount per an employee was Cr$ 2.6 million and Cr$ 1.6 million, respectively.

The service's sub-sector occupied 52% of the basin's sales amount in 1980. The study area is the most concentrated town in the basin in terms of service's industry. The commercial sub-sector accounted for 34.4%, which rate was smaller than the service's. This was because the sales amount of wholesale sector was comparatively small. In the basin, in terms of sales amount of wholesale, Itajai municipality is ahead of Blumenau. Itajai , having a harbor and being located along the national freeway of BR-101, plays an important part as a base of merchandize distribution in the sul grand-region as well as in the basin. From this point of view, the wholesale in Blumenau would cover the basin and its surroundings.

The sales amount of these sub-sectors has grown up at 37.7% annually during the first half of the decade in the 70's and down at -3.1% during the second half. Although the growth rate during the decade was 15.5%, it was lower than that of the industrial sector of 26.6%.

2.2.2 Gross regional domestic product

The record of GRDP (gross regional domestic product) in the study area is not available. Therefore, GRDP is estimated on the basis of the production value of each economic sector mentioned in the previous section and the following assumptions:

(1) In the primary sector, since the total production value in the study area is available, GVA (gross value added) is estimated by the coefficient of GVA to production value, which is assumed to be equal to the coefficient of the state of 66.7%;

(2) In the secondary sector, since GVA of the manufacturing and mining sub-sectors is available in the industrial census report, GVA of the sector is estimated by the coefficient of GVA of the sub-sector to the total GVA of the secondary sector, which is assumed to equal the coefficient of the state of 115% in 1980, 117% in 1975; and 129% in 1970; and

(3) In the tertiary sector, since only the sales amount of the commercial and service's sub-sectors is available in the industrial census report, the GVA of the sector is estimated through the following two steps:

(i) GVA of the commercial and service's sub-sectors is estimated based on the coefficient of GVA of the commercial sub-sector because of data availability;

(ii) GVA of the tertiary sector is estimated by the coefficient of the two sub-sectors to the total GVA of the tertiary sector, which is assumed to equal the coefficient of the state of 337% in 1980, 308% in 1975 and 328% in 1970.

GRDP in the study area is shown in Table IV.2.16. The primary sector has declined at quite high speed as compared with that of the state. The secondary sector recorded at quite high growth rate of 12.2% annually in the first five years in 70's and of 20.4% in the second five years. The tertiary sector got the more remarkable annual growth rate of 25.0% in the first five years but declined at 4.4% in the second five years. As a result, the secondary sector had an extremely big share of 74.1% in 1980, in spite of the fact that it share went down to 44.3% in 1975 from 51.0% in 1970. Although the tertiary sector recorded also rapid growth and got share of 51.6% in 1975, it paced down and decreased its share to 25.2% in 1980. The primary sector continuously lost its percentage share from 11.4% in 1970 to 0.7% in 1980.

These drastic changes of industrial structure in the study area might make people fall into rapid alteration of living circumstance. It might stir up some urban problems such as housing shortage, lack of infrastructure and environmental pollution. These items are discussed in the following chapter "Present land use".

Per capita GRDP in the study area was Cr$ 261 thousand at current prices in 1980, as shown in Table IV.2.16. It was about 2.4 times larger than both per capita GDP and GRDP of the state of Cr$ 110 thousand. In 1970, though the disparity was not so big, i.e., almost 1.7 times of the state and 1.5 times of the country. This was because the economic growth in the study area was achieved higher than those in the state and in the country. From the point of view of living standard, people in the study area might improve their living style and might enjoy a higher cultural life than before.

2.3 Infrastructure

(1) Road

As of 1986, the existing paved road network in the study area sums up to 149 km, which comprised national road (27 km), state road (88 km) and municipal road (34 km). The federal road is BR-470, which lies across the study area from east to west along the Itajai river. The state installed following four lines in the study area: SC-411 connecting Gaspar to Brusque; SC-418, Blumenau to Pomerode; SC-470, Blumenau-Ilhota; and SC-474, Blumenau-Massaranduba.

(2) Water supply

The municipal water in the two municipalities is supplied by each public corporation, SAMAE (Service Autonomo Municipal de Agua e Esgoto). 186 thousand people are covered by them, which accounts for 82% of the total population in the study area. Each SAMAE gets source water from the Itajai river and supplies municipal water after treatment. They have no sewage system in their territory yet.

(3) Electricity

Electricity in the study area is served by CELESC (Centrais Eletricas de Santa Catarina S.A.). CELESC does not generate so much electricity by itself and mainly receives high-voltage primary electricity through transmission lines of ELETROSUL (Centrais Eletricas do Sul do Brasil S.A.). After transforming to low-voltage, CELESC supplies electricity to demanders, covering almost 100% of them. CELESC has a mini hydro-electric power plant on the Itajai river in the study area. The plant is used only to supplement the shortage during peak demand hours, so the driving efficiency is said to be less than 10% for a year.

(4) Communication

According to TELESC (Telecomunicacoes de Santa Catarina S.A.), there were about 17,600 telephone terminals in the study area in 1986. Of the total number of terminals, 70% is installed in residences. Therefore, telephone terminal is popularized at the rate of one terminal for 20 persons. Since a family size is 4.3 persons, almost 20% of the total family has a telephone terminal.

There are 6 medium-wave radio stations and 4 frequency modulation (FM) radio stations in the study area. In addition, there are also a TV broadcasting station and three TV-transmission stations.

(5) Social infrastructure

According to the department of education of both city halls, there are 98 nursery schools/kindergardens, 108 first grade schools, 13 second grade schools and 1 university in the study area. There are 15 clinics and 5 hospitals in the study area in 1986. The hospitals prepare 905 beds in total. Since that equals about 4.0 beds per 1,000 inhabitants, this ratio is smaller than the average ratio in the basin of 4.5 beds.

(6) Housing

In 1980, there were about 41 thousand houses in the study area. 99.3% of them were in good condition for living, according to population census. The rests, 0.7%, were rustic and needed to be improved. The rate of durable houses is higher than the basin's rate of 98.1%.

With regard to electric appliances in the study area, refrigerator, television and radio were installed approximately by 90% of the total families in 1980. Beside them, about 44% of the families possesses their own cars.

3. PRESENT LAND USE

3.1 Present conditions

3.1.1 Urban area

The study area of 867 km^2 is divided into urban area of 174 km^2 or 20% of the total area and rural area of 696 km^2 or 80%. The project area of 69 km^2 is divided into urban area of 42 km^2 or 60% of the total area and rural area of 27 km^2 or 40% as well. In this way, most of the project area is occupied by urban area, so its character is identified as an urban characteristic.

In both municipalities of Blumenau and Gaspar, urban areas are demarcated on a legislative basis, i.e., a municipal law. The municipality of Blumenau legislated the law on August 9, 1974 as the municipal law No.2021 and Gaspar, on March 7, 1974 as the municipal law No. 480. According to the law of Gaspar, the urban area is identified as follows: (1) a central area of the municipality and its surroundings where buildings are lined continuously; (2) a rural cluster where buildings are lined continuously; and (3) an area where industrial establishments and social infrastructures are located with a water supply system. On the basis of this law, urban areas might be demarcated as shown in Fig.IV.2.1.

The urban area of Blumenau is divided into 30 bairros, including "Centro". Although the urban area of Gaspar would be divided into 11 bairros also including "Centro", its demarcation is quite vague and furthermore its delineation map is not available. Thus, in order to identify the characteristics of Gaspar's urban area, a bairro boundary map is formulated based on the following references: (1) a sketch map drawn by a municipal architect; and (2) a sketch map and statistical data of the industrial and commercial association of Gaspar. As a result, the bairro boundary was demarcated as Fig.IV.2.1.

3.1.2 Built-up area

During the 70's the society in the study area especially in Blumenau has attained a remarkable economic growth as mentioned in the previous chapter. A lot of industrial establishments as well as residences were settled in the study area during that time. Accordingly, the green-space and not utilized area were developed for their sites. Those areas have been developed so quickly that the settlement of urban infrastructure could not catch up with the urbanization.

In addition to lack of urban infrastructure, the following urban problems become visible in the study area, especially in built-up areas such as residential, industrial and commercial areas, in Blumenau in particular:

(1) Land erosion: Some people develop a steep slope land for residential use, because of lack of plain land. Consequently, in case of heavy rain, they occasionally suffer from a landslide.

(2) Submergence: Some people build their residences in low land or riverside. They are always exposed to many dangers such as flood inundation, in case of heavy rain.

(3) Sprawl: Some people, who can not get a living space in the central area and its surroundings, construct their residences in suburbs along streets. This ribbon development brings about inconvenience and inefficiency for urban services.

(4) Congestion: As a city grows, a central area undertakes many urban functions such as business center, information center and amusement center. Lack of necessary public space such as plaza and parking lot brings about inconvenience and inefficiency, as well.

In the study area, these problems are already conceived and some countermeasures are taken into consideration, i.e., the construction of a building is prohibited in the following conditions: (1) on a slope more than 30° and on a top of a mountain in difficulties for reforestation, (2) on a lower land than 12 m above the sea level and on a riverside within 33 m from the river boundary; and (3) a building having more than 7 stories.

Built-up areas in the study area has been developed with those urban problems so far. The built-up area, however, has absorbed and will absorb the demand of living space and production space as follows.

(1) Residential area

In the study area, the urban area has grown up at extremely high speed in order to absorb increasing population. Residential area has expanded through the following stages since the first settlement:

(i) The central zone ("Centro") and its surroundings have been developed in the early stage. In Centro, highrised apartments are established recently. Some superior residences lie upon the high lands of surroundings in the right bank side of the Itajai river.

(ii) Along the Garcia river, on the lower Velha river and in the low land of Bairo Ponta Aguda, medium and somewhat lower class houses are established in the secondary stage. They are located within 5 km - zone from the center of Centro (refer to Fig.IV.2.1).

(iii) In the third stage, new houses and residential lots are being settled in suburbs over 5 km-zone such as along the middle reach of the Velha river, in the high land of Ponta Aguda, along Itoupava river and in both Bairros Vorstadt and Bela Vista along SC-470. Bairro Bela Vista is in a territory of the municipality of Gaspar. Both Blumenau and Gaspar are being conglomerated with each other as conurbation.

(iv) As the industrial facilities are settled along the Itoupava river on the outskirts of the center area of Blumenau, new residential areas are developed along SC-474. In Gaspar, a few large scale factories are established along SC-470. Lots of houses are also built as ribbon development along SC-470 beside those factories.

(2) Industrial area

In urban area of Blumenau, there are some famous large-scale manufacturing industries in medium and high lands along the Garcia river and the Velha river. A lot of medium and small scale factories are located along the Itajai river in both Bairros Itoupava Seca and Itoupava Norte. New settlements of manufacturing industry are constructed in northern part along the Itoupava river and SC-474. In Gaspar, large scale industries are quite a few. They are located along the Itajai river and SC-470. Medium and small scale manufacturing industries lie scattered in urban areas such as Bairro Rua Itajai, Bairro Sete de Setembro and Bairro Bela Vista.

(3) Commercial area

In Blumenau, there are many department stores, shops, restaurants, hotels and banks along both Quinze de Novembro street and Pres. Castelo Branco avenue (Beira Rio) in Centro. Most of the buildings are highrised. In surroundings of the core, many commercial and services' stores are scattered but not so highrised as the central area. Shopping centers are lined up along streets in residential areas in suburbs. In Gaspar, there is a shopping center along SC - 470 in Centro and its surroundings. In Bairro Bela Vista, a shopping center is being formed.

3.1.3 Rural area

In Blumenau, there are no rural areas in the probable inundation area. Rural activity, however, is carried on in perimeter zone of the urban area, though its production amount seems to be quite little. Gasper produces more agricultural products than Blumenau. Some rural areas in the probable inundation area lie along the Itajai river. In low lands in probable inundation areas, paddy fields expand along the Itajai river and its tributaries. Pasture lands also expand in low land areas. Sugar-cane, however, is cultivated in the back of the low land.

3.2 Present Land Use

The land use map of urban area in Blumenau was formulated by the municipal government in 1985, which is prepared to amend the aforesaid municipal law concerned with an urban policy because the law is too old to catch up with urbanization. This map is instructive to illustrate conditions of present land use and movement of urbanization in Blumenau. On the other hand, the land use map of Gaspar is not available. Therefore, the land use map was made on the basis of the topographic maps formulated by JICA in a scale of 1:10,000 and the aerial photographs taken in this year by JICA, in addition to a site inspection. Thus, the land use of 174.3 km^2 in the urban area of the study area is classified as follows: residential use with an area of 8,627 ha or 50% of the total urban area; industrial use, 1,038 ha or 6%; commercial use, 941 ha or 5%; green space, 6,270 ha or 36%; and not utilized area, 554 ha or 3%. Present land use of rural area in the probable inundation area in Gaspar are classified by the same procedure as urban areas mentioned above.

The land use map in the probable inundation area was formulated on 200 m x 200 m on the basis of the aforesaid land use information. The land use was primarily classified into four categories: built-up area; agricultural area; green space; and not utilized area. Secondarily, built-up area and agricultural area are divided into three sub-categories respectively: residential area, industrial area, commercial area in built-up area; and paddy field, crop land and pasture land in agricultural area. Green space, such as forest, bush, open space for recreation, exists not only in rural areas but also in urban areas. Parks and plazas in urban areas present some green space for inhabitants. Not utilized area means river channel, areas being not used at present and so on.

Of the total area of 69 km^2 in the probable inundation area, 42 km^2 or 60% is occupied by urban areas and 27 km^2 or 40% by rural areas. Present land use in the area is classified as shown in Table IV.3.2. It is divided into 14 blocks, which are formulated along the Itajai river and its tributaries. The total lands in the probable inundation area are used as follows: residential use with an area of 2,508 ha or 36.5% of the total area; industrial use, 369 ha or 5.4%; commercial use, 599 ha or 8.7%; paddy field, 950 ha or 13.8%; crop land, 362 ha or 5.3%; pasture land, 485 ha or 7.1%; green space, 993 ha or 14.5%; and not utilized area, 594 ha or 8.7%.

4. REGIONAL FRAMEWORK

4.1 Socio-economic Projection

4.1.1 Population

An official population projection is not available except national total population estimated by IBGE, as mentioned in the master plan study. Therefore, the future population of the study area is projected on the basis of the following assumptions:

(1) The methodology of projection is the same as the one adopted in the master plan study, that is, (a) at first, the state population grows in proportion to national population increase and (b) the municipal population is estimated based on the AiBi methodology:

(2) The definition of urban area will be kept in the same as legislated by municipal laws in 1972. The urban population is principally absorbed in urban areas demarcated by the laws.

(3) Bairro Vila Itoupava occupies the same percentage (0.9%) of urban population of Blumenau in the future as it did in 1980. Accordingly, the urban population within the Itajai river basin in municipality of Blumenau accounts for 99.1% of the total urban population. Rural population within the Itajai river basin in the municipality of Blumenau also accounts for 67.6%.

Table IV.4.1 shows population projection in the study area up to the year 2020. According to the table, a population in the study area in 2020 grows to 484 thousand, or 2.6 times of the population in 1980 of 182,864. A population in the study area within the basin in 2020 grows to 478 thousand, or 2.7 times of the population of 178.124 in 1980 as well. The population of 478 thousand is divided into two municipal population as follows: 422 thousand or 88.4% in Blumenau and 55 thousand or 11.6% in Gaspar. The urban population in the study area within the basin in 2020 accounts for 96% of the total population, although the urban population accounted for 89% in 1980. As a result, the total population and the urban population in the study area within the basin grows at 2.5% and 2.7% of average annual growth rate from 1980 to 2020, respectively. On the contrary, the rural population decreased at the average annual rate of 0.3% for the same period of 40 years.

4.1.2 Economic growth

In the study area, any regional development plans are not available. Economic projection in the study is not available, as well. Therefore, GRDP projection is done on the basis of the following assumptions:

(1) Percent share of the product in the study area to state's product would be steady at 12% because the percent shares in 1970, 1975 and 1980 were 10.7%, 12.7% and 11.9% respectively, as shown in Table IV.2.16.

(2) Agricultural production would keep constant after 1980, although it had dropped down drastically during the decade of 70's as shown in Table IV.2.16. Though rural population gradually decreases year by year, the productivity of agricultural production would be improved as time passed.

(3) Industrial sector would grow at the same pace as the regional economic growth of the study area, because the industrial sector is the major industry in the study area and its GVA occupies 74% of GRDP in 1980, as shown in Table IV.2.16.

(4) To attain the expected growth in the study area, the rest of the product is produced by the services' sector.

GRDP in the study area and GVA of each economic sector are estimated as shown in Table IV.4.2. GRDP will reach Cr$189 billion in the year 2000 and Cz$413 billion in 2020 at 1987 constant prices. Hence, GRDP in 1980 is converted into 1987 prices by implicit deflator (1,352 between 1980 and 1987) and denomination (Cr$1,000 = Cz$1). Per capita GRDP in the study area, which is calculated by GRDP and the aforesaid population projection, will grow from Cz$352 thousand in 1980 to Cz$553 thousand in 2000 and to Cz$835 thousand in 2020. These figures correspond to 1.6 times in 2000 as large as per capita GRDP in 1980 of Cz$352 thousand at 1987 constant prices and 2.4 times in 2020. This growth of per capita seems to be somewhat moderate as compared with the growth of the entire state. This is because population grows faster than the economic production. As a result, the difference between per capita GRDPs reduces from 2.4 times in 1980 which is the ratio of the per capita GRDP of the Study area (Cz$352 thousand) to the one of the state area (Cz$149 thousand), to 2.0 times (Cz$835 thousand to Cz$486 thousand) in 2020.

4.2 Land Use Plan

4.2.1 Urbanization and zoning

During two decades of the 60's and the 70's, the study area has been urbanized so quickly that settlement of infrastructure for urban services could not catch up with the urbanization. Urban population in the study area grew at average annual rate of 6.0% for 60's and at 5.8% during 70's. This extreme population growth seems to calm down since 1980, but it is estimated to proceed at more than 4% for this decade. Urbanization, therefore, still proceeds in almost the same pace as before.

Both municipalities of Blumenau and Gaspar are preparing to make a guideline for sound urbanization as a counter-measure for urban sprawl. The municipality of Gasper considers some bulk regulations such as coverage and floor-area ratio for each bairro in accordance with a state of urbanization. The municipality of Blumenau prepares the land use plan as a guideline for new settlers in urban areas of Blumenau. The plan is expected to affect them to develop urban areas for safe, convenient, comfortable and functional urban activities. The government is trying to make the land use plan into a municipal law in order that the plan is compulsory for all settlers.

The land use plan of Blumenau presents a zoning system in the urban area. It proposes to classify the urban area into the following zoning categories:

(1) Residential Zone : this zone is classified into four levels such as special residential zone, residential zone 1, 2 and 3. Residential zone 3 is prepared for new settlers as a developing new residential area. Recently, new residential lots are settled along the middle reach of the Velha river and lower reach of the Itoupava river, and in the upper part of Bairro Ponta Aguda.

(2) Industrial zone : this zone is classified into three categories. Zone 1 is a new industrial zone which is expected to expand along the Itoupava river (or SC-474) and BR-470. New manufacturing industries are constructed in this zone. In Zone 2, small and medium scale industries are located along Itajai river especially in Bairros of Itoupava Seca and Itoupava Norte, and along the middle reach of the Velha river. In Zone 3, large scale industries are established. Most of these factories are located in hilly parts and device a means of self-defense to inundation after 1983 flood.

(3) Commercial and service zone : the commercial zone is set in the center of Blumenau city. The daily service zones are located along the main roads in almost all bairros. The service zone is classified into three levels in accordance with time of settlement. Then, Service zone 3 is a latest shopping center, which is located in developing areas.

(4) Others : other zones are classified into two categories, such as preserved zone for forest and special zone for recreation.

4.2.2 Expansion of built-up area

Population and regional economy in the study area within the Itajai river basin is expected to increase at comparatively high speed, although the pace is much lower than before, as shown in the next table.

	Average annual growth Rate (%)		
	1970-1980	1980-2000	2000-2020
Urban population	5.8	3.5	1.9
Regional economy	13.1	5.5	4.0

Accordingly, the urban population in 2020 becomes about 2.9 times of urban population in 1980 and regional economy 6.4 times. In order to support this growth, the urban area would have to be improved so much by the year 2020. Blumenau, in particular, has no vast plains in its territory, so existing urban area should be improved to utilize its limited land at high degree. Even if the high improvement is brought about , the urbanization could not help expanding to the hinterland of the existing urban area. To estimate newly developed areas absorbing expanded urban activity, the following assumptions are set up.

(1) Urban areas are improved to utilize limited lands by means of urban renewal such as redevelopment and land readjustment as follows:

(i) In 3 km-zone, a gross density which is the number of inhabitants per a gross area increases up to 60 persons/ha;

(ii) In 5 km-zone, a net density which is the number of inhabitants per a residential area increases to 38 persons/ha, the same density as the density of 3 km-zone as of 1986; and

(iii) Outside of 5 km-zone, a net density increases to 31 persons/ha, the same density of 5 km-zone in 1986.

(2) A preserved areas such as forest area is not invaded up to 2020, because of the policy.

(3) Industrial areas such as industrial zone and commercial zone to urban area keep the same percentage as it is illustrated in the land use plan, because the land use is reflection of socio-economic and productive activities. Thus, a rate of residential area to build up area is 80% and a rate of residential area to urban area is 60%. Those rates are the same as those as of 1986.

On the aforesaid assumptions, the future population will be absorbed in urban areas as shown in Table IV.4.3. Of the total urban population of 460 thousand in 2020, 413 thousand or 90% will be absorbed in the existing urban areas. 41 thousand have to be absorbed in newly developed residential areas outside of the existing urban areas. The new residential area would amount to 1.5 thousand ha. As a result, built-up areas would increase from 10.5 thousand ha in 1986 to 12.5 thousand ha in 2020, so its increment becomes 2.0 thousand ha. The newly developed areas will be settled in the hinterlands of the existing urban areas over 5 km from the center of Blumenau. They would spread along the Itoupava river (or SC-474) and along BR-470 in hilly parts in Blumenau as the municipal government intends. They are completely free from flood disaster because they are located in hilly parts of the study area. In Gasper, however, residential area sprawl so quickly that it is quite difficult for the municipal government to guide the development soundly. Since both municipalities of Blumenau and Gasper form conurbation each other, they might have serious urban problems in the case that they do not cooperate each other to cope with rapid agglomeration. If so, urban area might sprawl more than estimated area mentioned above. Incentive leadership for new settlers is indispensable in order to utilize a limited land effectively.

Tables

Table IV.2.1 OUTLINE OF THE PROJECT AREA : 1980

	Blumenau			Gasper			Total		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
1. The Study Area									
Area (km^2)	156	375	531	18	318	336	174	696	867
Population	146,001	11,257	157,258	13,725	11,881	25,606	159,726	23,138	182,864
Density (Persons/km^2)	936	30	296	763	37	76	934	33	211
2. The Study Area within the Itajai River Basin									
Area (km^2)	149	261	410	18	318	336	167	579	746
Population	144,683 /1	7,835 /1	152,518	13,725	11,881	25,606	158,408	19,716	178,124
Density (Persons/km^2)	971	30	372	763	37	76	949	34	239
3. The Project Area									
Area (km^2)	29	0	29	13	27	40	42	27	69
Population	52,354	0	52,354	10,881	2,265	13,146	63,235	2,265	65,500
Density (Persons/km^2)	1,805	-	1,805	837	84	329	1,506	84	949

Note : /1 Population is adjusted because bairro Vila Itoupava is outside of the basin.
Source : E024

Table IV.2.2 POPULATION GROWTH IN THE STUDY AREA

Item	Population			Percentage Distribution (%)			Average annual Growth Rate (%)	
	1960	1970	1980	1960	1970	1980	'60 - '70	'70 - '80
1. Population	81,684	118,692	182,864	100.0	100.0	100.0	3.8	4.4
Blumenau	66,778	100,275	157,258	81.8	84.5	86.0	4.1	4.6
Gaspar	14,906	18,417	25,606	18.2	15.5	14.0	2.1	3.4
2. Male	40,750	58,391	89,983	49.9	49.2	49.2	3.7	4.4
Blumenau	33,179	49,186	76,995	40.6	41.4	42.1	4.0	4.6
Gaspar	7,571	9,205	12,988	9.3	7.8	7.1	2.0	3.5
3. Female	40,934	60,301	92,881	50.1	50.8	50.8	3.9	4.4
Blumenau	33,599	51,089	80,263	41.1	43.0	44.9	4.3	4.6
Gaspar	7,335	9,212	12,618	9.0	7.8	6.9	2.3	3.2
4. Urban	50,786	90,972	159,726	62.1	76.6	87.3	6.0	5.8
Blumenau	47,740	86,519	146,001	58.4	72.9	79.8	6.1	5.4
Gaspar	3,046	4,453	13,725	3.7	3.8	7.5	3.9	11.9
5. Rural	30,893	27,720	23,138	37.8	23.4	12.7	-1.0	-1.7
Blumenau	19,038	13,756	11,257	23.3	11.6	6.2	-3.1	-1.9
Gaspar	11,860	13,964	11,881	14.5	11.8	6.5	1.6	-1.5
6. Economically Active (10 year old and over)	-	86,603	139,361	-	73.0	76.2	-	4.9

Table IV.2.3 NUMBER OF GAINFUL WORKERS BY INDUSTRIAL GROUP IN THE STUDY AREA

Industrial Group	Number of Persons		Persentage Distribution (%)		Average Annual Growth Rate in 1980 (%)	Percentage Share to the basin in 1980 (%)
	1970	1980	1970	1980		
Agriculture	3,901	2,357	9.3	2.8	-4.8	3.2
Industry	19,840	46,843	47.2	55.7	9.0	41.3
- Manufacturing	-	40,559	-	48.2	-	42.4
- Construction	-	5,353	-	6.4	-	36.1
- Others	-	931	-	1.1	-	34.1
Services	18,319	33,590	43.5	39.9	6.3	35.7
- Commerce	4,495	8,890	10.7	10.5	7.1	37.0
- Transportation & Communcation	1,610	3,250	3.8	3.9	7.3	33.7
- Other service	12,214	21,450	29.0	25.5	5.8	35.5
Not Specified	-	1,340	-	1.6	-	29.5
Total	42,026	84,130	100.0	100.0	7.2	29.5

Source : E026 and E034

Table IV.2.4 VALUE OF PRODUCTION IN PRIMARY SECTOR IN THE STUDY AREA

Item	Value (Cr$10³)	Percentage Distribution (%)	Share to the Basin (%)
Crops	204,402	43.8	2.5
Livestock	178,057	38.1	6.1
Fishery	0	0.0	0.0
Forestry	48,575	10.4	6.5
Rural Industry	35,725	7.7	6.3
Total	466,758	100.0	3.5

Table IV.2.5 CROP PRODUCTION IN THE STUDY AREA : 1980

Item	Production Amount				Value	
	Harvested Area (ha)	Unit Yield (tons/ha)	Amount (tons)	Share to the Basin(%)	Value (Cr$10³)	Share to the Basin(%)
Rice	2,326	3.7	8,639	8.2	80,684	7.6
Maize	1,227	1.8	2,213	1.0	24,692	2.1
Cassava	1,044	13.2	13,878	3.7	63,760	6.2
Beans	142	0.6	80	0.4	3,608	0.9
Onion	-	-	-	-	12	0.0
Sugar-cane	823	22.8	18,775	7.1	29,114	17.3
Tabacco	36	1.3	48	0.1	2,083	0.1
Others	7	4.4	31	-	449	0.1
Total	-	-	43,573	-	204,402	2.5

Source : E053 and E065

Table IV.2.6 LIVESTOCK PRODUCTION IN THE STUDY AREA : 1980

Item	Production Amount			Value	
	unit	Amount	Share to the Basin(%)	Value (Cr$10³)	Share the Basin(%)
Cattle	heads	752	1.3	3,320	0.6
Pig	heads	4,392	1.9	13,853	2.2
Chicken	heads	28,447	0.4	2,829/1	0.4
Milk	kl	13,110	19.8	136,407	20.8
Egg	10³dozen	605	7.9	15,834	7.8
Others	-	-	-	5,814	6.7
Total	-	-	-	178,057	6.1

Note : /1 This value is estimated on the bases of the production share.
Source : E052

Table IV.2.7 FORESTRY PRODUCTION IN THE STUDY AREA : 1980

Item	Production Amount			Value	
	Unit	Production	Share the Basin (%)	Value (Cr$103)	Share to the Basin (%)
1. Natural Production					
Firewood	10³m³	176	14.7	27,935	14.8
Timber	10³m³	14	4.6	18,450	4.2
Cabbage Palm	tons	22	8.7	728	8.0
2. Forested Production					
Firewood	10³m³	1	16.7	695	37.6
Timber	10³m³	2	40.0	1,126	16.6
Timber for paper	10³m³	0	0.0	96	0.8
Seedings	10³m³	0	0.0	45	0.8
Total	-	-	-	48,575	6.5

Source : E052

Table IV.2.8 RURAL INDUSTRY PRODUCTION IN THE STUDY AREA : 1980

Item	Value (Cr$10³)	Share to the Basin (%)
Sugar	81	3.2
Spirit sugar cane	1,553	37.0
Syrup	996	3.8
Custard	11,104	29.7
Butter	2,064	14.6
Cheese	9,220	8.9
Cassava-related	4,429	13.0
Grape-related	0	0.0
Rice	530	25.7
Tabacco	5	0.0
Coffee	7	0.5
Corn-meal	17	1.7
Lard	2,128	2.0
Meat	2,177	1.3
sausage	517	2.2
Bacon	897	7.3
Total	35,725	6.3

Source : E052

Table IV.2.9 NUMBER OF MANUFACTURING ESTABLISHMENTS IN THE STUDY AREA

Industrial Type	Number of Establishments			Average Anuual Growth Rate (%)		Perscentage Distribution in 1980 (%)	Share to the Basin in 1980 (%)
	1970	1975	1980	'70 - '75	'75 - '80		
Mining	10	14	17	7.0	4.0	2.5	23.9
Non-metal Products	72	73	76	0.3	0.8	11.1	21.0
Metallurgy	41	34	60	-3.6	12.0	8.8	36.8
Machinery	14	29	50	15.7	11.5	7.3	50.0
Electric & Communication Products	5	11	17	17.1	9.1	2.5	51.5
Vehicle	10	11	11	1.9	0.0	1.6	19.3
Timber	63	66	94	0.9	7.3	13.7	13.7
Furniture	55	43	54	-4.7	4.7	7.9	23.3
Paper	7	8	11	2.7	6.6	1.6	61.6
Rubber	3	5	4	10.8	-4.3	0.6	66.7
Leather	6	3	3	-12.9	0.0	0.4	30.0
Chemistry	8	6	6	-5.5	0.0	0.9	19.5
Medicine	0	0	0	0.0	0.0	0.0	0.0
Soap, Perfume	3	2	3	-7.7	8.4	0.4	33.3
Plastic Products	4	8	15	14.9	13.4	2.2	88.2
Texitile	44	50	63	2.6	4.7	9.2	33.7
Clothing	16	37	76	18.3	15.5	11.1	38.1
Food Products	69	61	65	-2.3	1.3	9.5	17.2
Beverage	23	17	12	-5.8	-6.6	1.8	75.0
Tobacco	3	3	2	0.0	-7.7	0.3	22.2
Printing	18	18	19	0.0	1.1	2.8	33.3
Other Manufacturing	18	19	26	1.1	6.5	3.8	47.3
Total	492	518	684	1.0	5.7	100.0	25.3

Source : E028,E031 and E071

Table IV.2.10 NUMBER OF EMPLOYEES BY MANUFACTURING ESTABLISHMENTS IN THE STUDY AREA

Industrial Type	Number of Employees			Average Anuual Growth Rate (%)		Perscentage Distribution in 1980 (%)	Share to the Basin in 1980 (%)
	1970	1975	1980	'70 - '75	'75 - '80		
Mining	44	77	108	11.8	7.0	0.3	45.6
Non-metal Products	868	1,413	1,756	10.2	4.6	4.6	32.0
Metallurgy	1,020	1,702	2,329	10.8	6.5	6.2	57.4
Machinery	140	1,061	1,646	49.9	9.2	4.3	44.4
Electric & Communication Products	42	147	480	28.5	26.7	1.3	47.0
Vehicle	166	398	302	19.1	-5.3	0.8	23.9
Timber	576	771	1,177	6.0	8.8	3.0	9.9
Furniture	366	405	478	2.0	3.4	1.3	29.6
Paper	298	926	919	25.5	-0.1	2.4	65.9
Rubber	26	47	50	12.6	1.2	0.1	100.0
Leather	74	55	19	-5.7	-19.1	0.1	54.3
Chemistry	94	30	229	-20.3	50.2	0.6	100.0
Medicine	0	0	0	0.0	0.0	0.0	0.0
Soap, Perfume	18	-	-	-	-	-	-
Plastic Products	120	229	420	13.8	12.9	1.1	74.3
Texitile	10,547	8,161	16,266	-4.9	14.8	42.7	67.3
Clothing	223	9,154	8,875	110.2	-0.5	23.3	69.9
Food Products	899	1,075	1,313	3.6	4.1	3.4	23.8
Beverage	83	127	251	8.9	14.6	0.7	77.0
Tobacco	472	1,152	-	19.5	-	-	-
Printing	201	330	407	10.4	4.3	1.1	66.0
Other Manufacturing	1,258	533	1,032	-15.7	14.1	2.7	55.7
Total	17,535	27,7893	38,067	9.6	6.5	100.0	44.9

Source : E028, E031 and E071

Table IV.2.11 PRODUCTION OF MANUFACTURING ESTANBLISHMENTS IN THE STUDY AREA

Industrial Type	Productioin Value (Cr$10⁶ at market prices)			Average Annual Real Growth Rate(%)		Perscentage Distribution in 1980 (%)	Share to the Basin in 1980 (%)
	1970	1975	1980	'70 - '75	'75 - '80		
Mining	0	3	108	27.0	35.2	0.2	55.1
Non-metal Products	10	73	955	12.5	12.5	1.4	27.1
Metallurgy	23	209	2,452	30.0	14.9	3.5	64.4
Machinery	3	99	1,211	68.3	10.2	1.7	34.9
Electric & Communication Products	1	24	592	61.8	25.0	0.9	47.1
Vehicle	3	40	482	40.8	11.9	0.7	43.8
Timber	9	39	524	-4.0	3.3	0.7	10.0
Furniture	4	25	1,510	12.2	1.9	2.2	64.6
Paper	11	62	11	19.1	25.4	1.6	61.1
Rubber	1	4	55	13.5	20.6	0.1	100.0
Leather	2	5	14	-7.6	26.6	0.0	93.3
Chemistry	2	112	3,280	99.1	27.1	4.7	99.2
Medicine	0	0	0	0.0	0.0	0.0	0.0
Soap, Perfume	0	-	-	-	-	-	-
Plastic Products	1	24	463	55.9	19.6	1.7	68.3
Texitile	237	1,853	31,846	35.8	19.1	46.0	75.6
Clothing	3	1,547	18,883	179.1	8.5	27.3	87.6
Food Pruducts	42	222	3,036	2.5	21.7	4.4	33.5
Beverage	3	12	275	-0.3	35.9	0.4	96.5
Tabacco	33	376	-	-1.3	-	-	-
Printing	3	21	295	23.6	14.4	0.4	80.6
Other Manufacturing	26	153	3,062	20.9	15.7	4.4	89.4
Total	417	4,903	69,246	37.9	16.3	100.0	59.4

Note : /1 Production Values are converted by implicit deflator.
Source : E028, E031 and E071

Table IV.2.12 MANAGEMENT INDICES OF MANUFACURING ESTABLISHMENTS IN THE STUDY AREA

Industrial Type	Production per Establishment Establishment (Cr$10⁶/est)	Employees per Establishment (employees/est.)	Productivity of Labor (Cr$10⁶/emp.)	Value Added (VA) (Cr$10⁶)	Coefficient of Value Added (VA/Production Value)	Production of Value Added: Per Labor (Cr$10⁶/emp.)	Production of Value Added: Per Establishement (Cr$10⁶/est.)
Mining	6.3	6.3	1.00	32	0.30	0.30	1.88
Non-metal Products	12.6	23.2	0.54	686	0.72	0.39	9.03
Metallurgy	40.9	38.8	1.05	1,508	0.62	0.65	25.13
Machinery	24.2	32.9	0.74	715	0.59	0.43	14.30
Electric & Communication Products	34.8	28.2	1.23	326	0.55	0.68	19.18
Vehicle	43.8	27.5	1.60	102	0.21	0.34	9.27
Timber	5.6	12.5	0.45	356	0.68	0.30	3.79
Furniture	3.8	8.9	0.42	122	0.60	0.26	2.26
Paper	137.3	83.5	1.64	603	0.40	0.66	54.82
Rubber	13.8	12.5	1.10	24	0.44	0.48	6.00
Leather	4.7	6.3	0.74	9	0.64	0.47	3.00
Chemistry	546.7	38.2	14.32	1,204	0.37	5.26	200.67
Medicine	-	-	-	-	-	-	-
Soap, Perfume	-	-	-	-	-	-	-
Plastic Products	30.9	28.0	1.10	302	0.65	0.72	20.13
Texitile	505.5	258.2	1.95	10,332	0.32	0.64	164.00
Clothing	248.5	116.8	2.12	110,376	0.60	1.28	149.68
Food Pruducts	46.7	20.2	2.31	789	0.26	0.60	12.14
Beverage	22.9	20.9	1.10	104	0.38	0.41	8.67
Tobacco	-	-	-	-	-	-	-
Printing	15.5	21.4	0.72	180	0.61	0.44	9.47
Other Manufacturing	117.7	39.7	2.97	1,946	0.63	1.89	74.85
Total	101.2	55.7	1.82	30,716	0.44	0.81	44.91

Source : E028, E031 and E071

Table IV.2.13 NUMBER OF COMMERCIAL AND SERVICES' ESTABLISHMENTS IN THE STUDY AREA

Industrial Type	Number of Establishments			Average Anuual Growth Rate (%)		Perscentage Distribution in 1980 (%)	Share to the Basin in 1980 (%)
	1970	1975	1980	'70 - '75	'75 - '80		
Commerce							
Retail Store	838	843	1,093	0.1	5.3	91.5	28.1
Wholesale	85	102	102	3.7	0.0	8.5	33.6
Sub-total	923	945	1,195	0.5	4.8	100.0	28.5
Services							
Eating and Lodging	190	243	468	5.0	14.0	28.4	25.1
Maintenance and Fixing	212	287	485	6.2	11.1	29.5	28.5
Personal Care	319	100	154	-20.6	9.0	9.4	28.8
Broadcasting	16	12	18	-5.5	8.4	1.1	42.9
Eastate Agent	-	-	55	-	-	3.3	50.5
Other service	71	169	465	18.9	22.4	28.3	51.7
Sub-total	808	811	1,645	0.1	15.2	100,.0	31.9
Total	1,731	1,756	2,840	0.3	10.1	-	30.4

Source : E029, E030, E032, E072, and E073

Table IV.2.14 NUMBER OF EMPLOYEES BY COMMERCIAL AND SERVICES' ESTABLISHMENTS IN THE STUDY AREA

Industrial Type	Number of Employees			verage Anuual Growth Rate (%)		Perscentage Distribution in 1980 (%)	Share to the Basin in 1980 (%)
	1970	1975	1980	'70 - '75	'75 - '80		
Commerce							
Retail price	3,277	4,807	7,360	8.0	8.9	84.9	42.3
Wholesale	826	1,694	1,305	15.4	-5.0	15.1	39.3
Sub-total	4,103	6,501	8,665	9.6	5.9	100.0	38.1
Services							
Eating and Lodging	645	1,078	2,218	10.8	14.6	30.0	39.8
Maintenance and Fixing	818	928	1,504	2.6	10.1	21.2	34.5
Personal Care	414	141	315	-19.3	17.4	4.4	46.0
Broadcasting	216	224	216	0.7	-0.6	3.0	69.0
Eastate Agent	-	-	215	-	-	3.0	46.4
Other service	322	882	2,718	22.3	25.2	38.3	47.4
Sub-total	2,415	3,253	7,096	6.1	16.9	100.0	41.1
Total	6,518	9,754	15,761	8.4	10.1	-	39.4

Source : E029, E030, E032 E033, E072 and E073

Table IV.2.15 SALES AMOUNT OF COMMERCIAL AND SERVICES' ESTABLISHMENTS IN THE STUDY AREA

Industrial Type	Sales Amount(Cr$ 10^6 at market prices)			Average Anuual Growth Rate (%) ∠1		Percentage Distribution in 1980 (%)	Share to the Basin in 1980 (%)
	1970	1975	1980	'70 - '75	'75 - '80		
Commerce							
Retail price	199	1,089	16,832	21.5	13.5	75.0	48.0
Wholesale	123	2,369	5,611	56.3	-21.9	25.0	20.0
Sub-total	322	3,458	22,443	39.1	-4.5	100.0	34.4
Services							
Eating and Lodging	9	49	870	12.2	20.1	26.9	49.9
Maintenance and Fixing	9	39	504	7.6	13.0	15.6	38.4
Personal Care	2	4	98	-31.6	30.0	3.0	51.3
Broadcasting	3	26	119	24.0	-7.7	3.7	75.3
Eastate Agent	-	-	129	-	-	4.0	39.7
Other service	5	61	1,519	32.0	28.8	46.8	63.0
Sub-total	28	178	3,239	16.1	20.8	100.0	52.0
Total	350	3,636	25,682	37.7	-3.1	-	36.0

Note : ∠1 Sales amount are converted by implicit deflator.
Source : E029,E030, E032, E033, E072 and E073

Table IV.2.16 GROSS REGIONAL BOMESTIC PRODUCT BY INDUSTRIAL ORIGIN AT CURRENT PRICES

Item	Gross Regional Domestic Product (Cr$10[6])			Percentage Distribution (%)			Average Annual Real Growth Rate/1 (%)	
	1970	1975	1980	1970	1975	1980	'70 - '75	'75 - '80
1. GDRP in Santa Caterina								
Agriculture	1,176	6,793	64,028	22.5	21.6	16.0	9.9	6.7
Industry	1,536	10,745	151,485	29.4	34.1	37.9	15.0	12.2
Services	2,519	13,970	184,592	48.1	44.3	46.1	11.5	12.2
Total	5,231	31,508	400,105	100.0	100.0	100.0	12.3	11.3
Per Capita GRDP (Cr$)	1,803	9,711	110,286	-	-	-	9.4%('70 - '80)	
2. Estimated GRDP in Study Area /2								
Agriculture	64	163	131	11.4	4.1	0.7	-6.6	22.4
Industry	285	1,766	35,323	51.0	44.3	74.1	12.2	20.4
Services	210	2,030	12,031	37.6	51.6	25.2	25.0	-4.4
Total	559	3,989	47,665	100.0	100.0	100.0	16.0	9.5
Per Capita GRDP (Cr$)	3,057	-	260,658	-	-	-	-	-
3. Share of the Studya Area to S.C.								
(%)	10.7	12.7	11.9	-	-	-	-	-

Note : /1 Real Values are calculated by implicit deflator.
/2 GVA of each sector is estimated on the basis of both municipal production value and coefficient of value added.
Source : E008

Table IV.3.1 PRESENT LAND USE IN URBAN AREAS IN THE STUDY AREA

No.	Bairro	Bairro Area (ha)	Land Use (ha)					Population in 1986*1	Density*2 (Persons/ha)		Number of Establishment	
			Residesntial	Industrial	Commercial	Green Space	Not Utilized		Gross	Net	Manufac-turing	Commercial & Services
	Blumenau											
1	Centro	90	29	6	50	0	5	4,220	47	146	73	1,545
2	Jardim Blumenau	30	12	0	18	0	0	927	31	77	12	52
3	Bom Retiro	250	34	31	6	179	0	1,858	7	55	7	40
4	Petropolis	50	30	0	1	19	0	1,715	34	57	5	27
5	Da Velha	2,190	830	50	130	1,180	0	24,833	11	30	187	785
6	Victor Konder	40	21	7	12	0	0	1,830	46	87	25	132
7	Vila Nova	180	111	12	57	0	0	7,396	41	67	66	273
8	Do Asilo	670	377	38	43	210	2	15,972	24	42	90	272
9	Do Salto	220	136	16	37	0	31	3,665	17	27	16	73
10	Itoupava Seca	190	110	38	35	0	7	4,013	21	36	70	282
11	Boa Vista	140	88	0	2	32	28	2,561	18	29	3	18
12	Itoupava Norte	730	518	12	156	10	34	13,407	18	26	68	417
13	Ponta Aguda	670	370	0	68	161	71	9,244	14	25	47	259
14	Vorstadt	390	190	0	62	97	41	5,312	514	28	54	179
15	Riberao Fresco	200	78	0	16	105	0	2,451	12	31	21	76
16	Do Garcia	680	357	20	66	237	0	16,593	24	46	93	460
17	Da Gloria	390	89	2	35	264	0	8,345	21	94	19	124
18	Progresso	940	243	35	24	638	0	10,089	11	42	50	150
19	Vila Formosa	290	48	0	5	234	0	1,187	4	25	4	25
20	Fortaleza	880	667	56	0	157	0	13,636	15	20	45	206
21	Salto do Norte	580	210	116	23	177	54	6,093	11	29	47	157
22	Weissbach	400	165	0	42	160	33	1,894	5	11	12	27
23	Passo Manso	650	328	91	0	162	69	2,620	4	8	18	65
24	Badenfurt	410	191	120	0	66	33	2,116	5	11	16	77
25	Testo Salto	640	548	76	0	16	0	2,225	3	4	16	60
26	Itoupavazinha	1,050	349	79	79	543	0	3,516	3	10	77	48

(To be continued)

(Continuation)

No.	Bairro	Bairro Area (ha)	Land Use (ha)					Population in 1986/1	Density/2 (Persons/ha)		Number of Establishment	
			Residesntial	Industrial	Commercial	Green Space	Not Utilized		Gross	Net	Manufac-turing	Commercial & Services
27	Itoupava Central	1,640	1,088	120	0	432	0	7,042	4	6	48	171
28	Vila Itoupava	700	331	0	0	369	0	1,647	12	5	13	83
29	Fidelis	50	50	0	0	0	0	321	6	6	5	13
30	Valparaiso	260	120	0	0	140	0	5,697	22	47	17	76
	Total	15,600	7,718	925	970	5,588	399	182,425	12	24	1,168	6,172
	Gaspar											
1	Centro	60	26	2	9	20	3	767	13	30	10	76
2	Nova Esperanca	20	12	2	3	3	0	471	124	39	11	23
3	Gasparinho	60	42	2	4	12	0	941	16	22	9	24
4	Gaspar Grande	60	38	4	8	8	2	772	13	20	19	60
5	Coloninha	140	86	6	5	30	13	1,106	8	13	7	28
6	Margem Gequerda	340	172	5	8	112	43	2,963	9	17	7	45
7	Rua Itajai	310	156	21	9	78	46	1,894	6	12	11	23
8	Sete de Setembro	170	105	10	8	47	0	2,285	13	22	13	33
9	Santa Terezinha	150	109	8	7	26	0	1,979	13	18	9	35
10	Finguera	180	97	7	6	58	12	1,529	8	16	9	29
11	Bela Vista	340	247	10	12	35	36	4,201	12	17	11	73
	Total	1,830	1,090	77	79	429	155	18,908	10	17	116	449
	Grand Total	17,430	8,808	1,002	1,049	6,017	554	201,333	12	23	1,284	6,621

Note : /1 Population in Blumenau is estimated by the municipal government.
Population in Gaspar is estimated by the same procedure as the master plan study.
/2 Gross density is population per urban area (h) and net density is poplation per residential area (ha).
/3 Green space in Gaspar includes some crop lands.

Source : E012

Table IV.3.2 PRESENT LAND USE IN THE PROBABLE INUNDATION AREA BY BLOCK

(Unit : ha)

Block	Total	Built-up Area			Agricultural Area			Green Space	Not Utilized Area
		Residential	Industrial	Commercial	Paddy	Crop	Pasture		
IT	2,360	1,099	96	313	36	0	0	222	594
SA	132	90	27	8	0	0	0	7	0
IO	468	240	203	13	0	0	0	12	0
FO	236	190	0	19	0	0	0	27	0
VE	392	185	13	134	0	0	0	60	0
GA	440	280	26	98	0	0	0	36	0
BE	280	8	0	0	179	5	0	88	0
CS	100	8	0	0	0	48	0	44	0
U1	36	1	0	0	0	0	8	27	0
U2	44	5	0	0	0	0	0	39	0
GG	964	200	4	14	336	81	95	234	0
DS	308	83	0	0	133	0	75	17	0
AR	348	44	0	0	266	5	0	33	0
PG	752	75	0	0	0	223	307	147	0
Total	6,860	2,508	369	599	950	362	485	993	594
Percentage Distribution (%)	100.0	36.5	5.4	8.7	13.8	5.3	7.1	14.5	8.7

Table IV.4.1 PROJECTED POPULATION IN THE STUDY AREA

Item	1985	1990	1995	2000	2005	2010	2015	2020
I. The Study Area								
Population	222,543	263,862	302,764	340,841	378,160	414,776	450,482	484,471
-Blumenau	193,027	230,269	265,333	299,653	333,290	366,293	398,476	429,111
-Gaspar	29,516	33,593	37,431	41,188	44,870	48,483	52,006	55,360
II. The Study Area within the Itajai River Basin								
1. Population	217,516	258,501	297,115	334,911	371,956	408,303	443,751	477,500
-Blumenau	188,000	224,908	259,684	293,723	327,086	359,820	391,745	422,140
-Gaspar	29,516	33,593	37,431	41,188	44,870	48,483	52,006	55,360
2. Urban	198,286	239,513	278,442	316,523	353,829	390,416	426,097	460,099
-Blumenau	180,240	217,149	251,989	286,095	319,526	352,328	384,323	414,804
-Gaspar	18,046	22,364	26,453	30,428	34,303	38,088	41,773	45,295
3. Rural	19,230	18,988	18,673	18,388	18,123	17,887	17,655	17,401
-Blumenau	7,760	7,759	7,695	7,628	7,560	7,492	7,422	7,336
-Gsaspar	11,470	11,229	10,978	10,760	10,563	10,395	10,233	10,065

Table IV.4.2 PROJECTED GROSS REGIONAL DOMESTIC PRODUCT IN THE STUDY AREA

GRDP / Economic Sector	1980 /1	1990	2000	2010	2020
Projected GRDP (at 1987 Constant Prices)					
GRDP in Stanta Catarina ($Cz\$10^6$)	540,751	877,326	1,571,158	2,325,698	3,442,601
-Per capita GRDP ($Cz\&10^3$)	149	193	289	370	486
GRDP in the Study Area ($Cz\$10^6$)	64,420	105,279	188,539	279,084	413,112
-Primary Setor	420	420	420	420	420
-Secondary Sesctor	47,740	78,019	139,720	206,820	306,144
-Tertiary Sector	16,260	26,840	48,399	71,844	106,548
-Per capita GRDP ($Cz\$10^3$)	352	399	553	673	835
Average Annual Growth Rate (%)					
GRDP in Santa Catarina	-	5.0	6.0	4.0	4.0
-Per capita GRDP	-	2.6	4.1	2.5	2.8
GRDP in the Study Area	-	5.0	6.0	4.0	4.0
-Primary Sector	-	0.0	0.0	0.0	0.0
-Secondary Sector	-	5.0	6.0	4.0	4.0
-Tertiary Sector	-	5.1	6.1	4.0	4.0
-Per capita GRDP	-	1.3	3.3	2.0	2.2

Note: /1 Values is converted by an implicit deflator and a price index. Implicit deflator is presented by GAPLAN and Price index by IBGE.

Table IV.4.3 EXPANSION PROJECTION OF URBAN AREA

Item	3 Km Zone	5 Km Zone	10 Km Zone	15 Km Zone	Total
Present Land Use					
Population	47,898	84,954	44,204	22,630	199,686
Urban Area (ha)	2,830	5,100	4,280	4,520	16,730
Built-up Area (ha)	1,630	3,360	3,053	2,485	10,528
Residential Area (ha)	1,257	2,733	2,390	2,097	8,477
Gross Density /2 (Persons/ha)	17	17	10	5	12
Net Density /3 (Persons/ha)	38	31	18	11	24
Projected Land Use					
projected Urban Population (in 2020)	-	-	-	-	477,500
Density Projection (Persons/ha)	60/2	38/3	31/3	31/3	-
Adaptable Population	169,800	103,854	74,090	65,007	412,751
Protruded Population	-	-	64,749		64,749
Requisite Residential Area (ha)	1,257	2,733	6,576		10,566
Reguisite Built-up Area (ha)	1,630	3,360	8,085		13,075
Requisite Urban Area (ha)	2,830	5,100	12,271		20,200
Increment of Residential Area (ha)	-	-	-		2,089
Increment of Built-up Area	-	-	-		2,547
Increment of Urban Area	-	-	-		3,470

Note : /1 Each zone is estimated as following bairros are included:

- 3 Km-zone : Centro, Jardim Blumenau, Bom Retiro, Petropolis, Victor Konder, Boa Vista, Ponta Aguda, Vorstadt, Riberao Fresco, Do Garcia and Vila Formosa in Blumenau.
- 5 Km-zone : Da Velha, Vila Nova, Do Asilo, Itoupava Seca, Itoupava Norte, Fortaleza and Valparaiso in Blumenau.
- 10 Km-zone : Do Salto, Da Gloria, Prgresso, Salto do Norte, Salto Weissbach, Passo Manso, Badenfult and Fidelis Vista in Gaspar.
- 15 Km-zone : Itoupavazinha and Itoupava Central in Blumenau; and Centro. Nova Esperanca, Gasparinho, Gaspar Grande, Margem Esquerda. Rua Itajai, Sete de Setembro and Santa Terezinha in Gaspar.

/2 Population per urban area

/3 Population per residential area

Figures

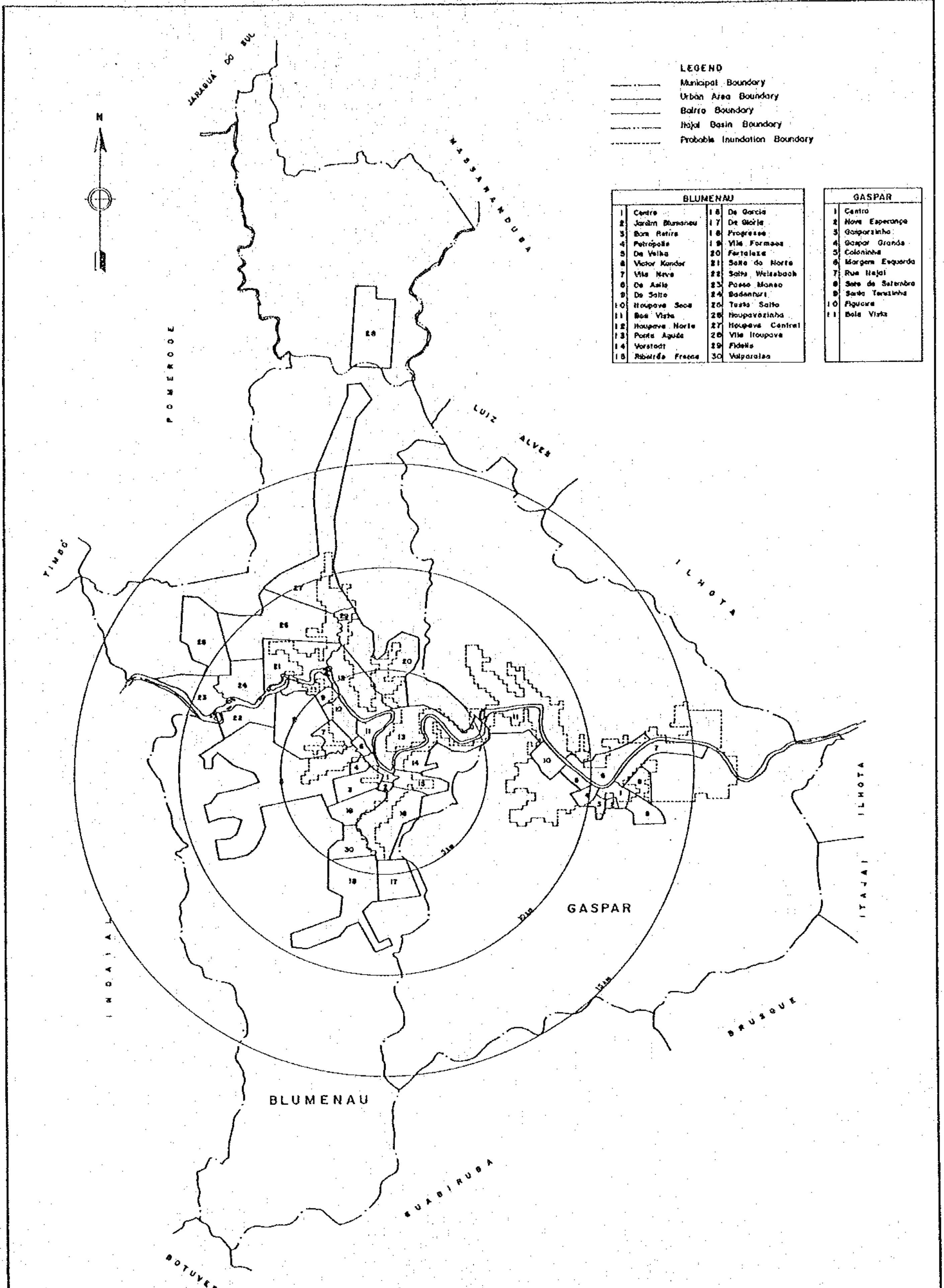

Fig. IV.2.1 ADMINISTRATIVE DISTRICT IN THE STUDY AREA

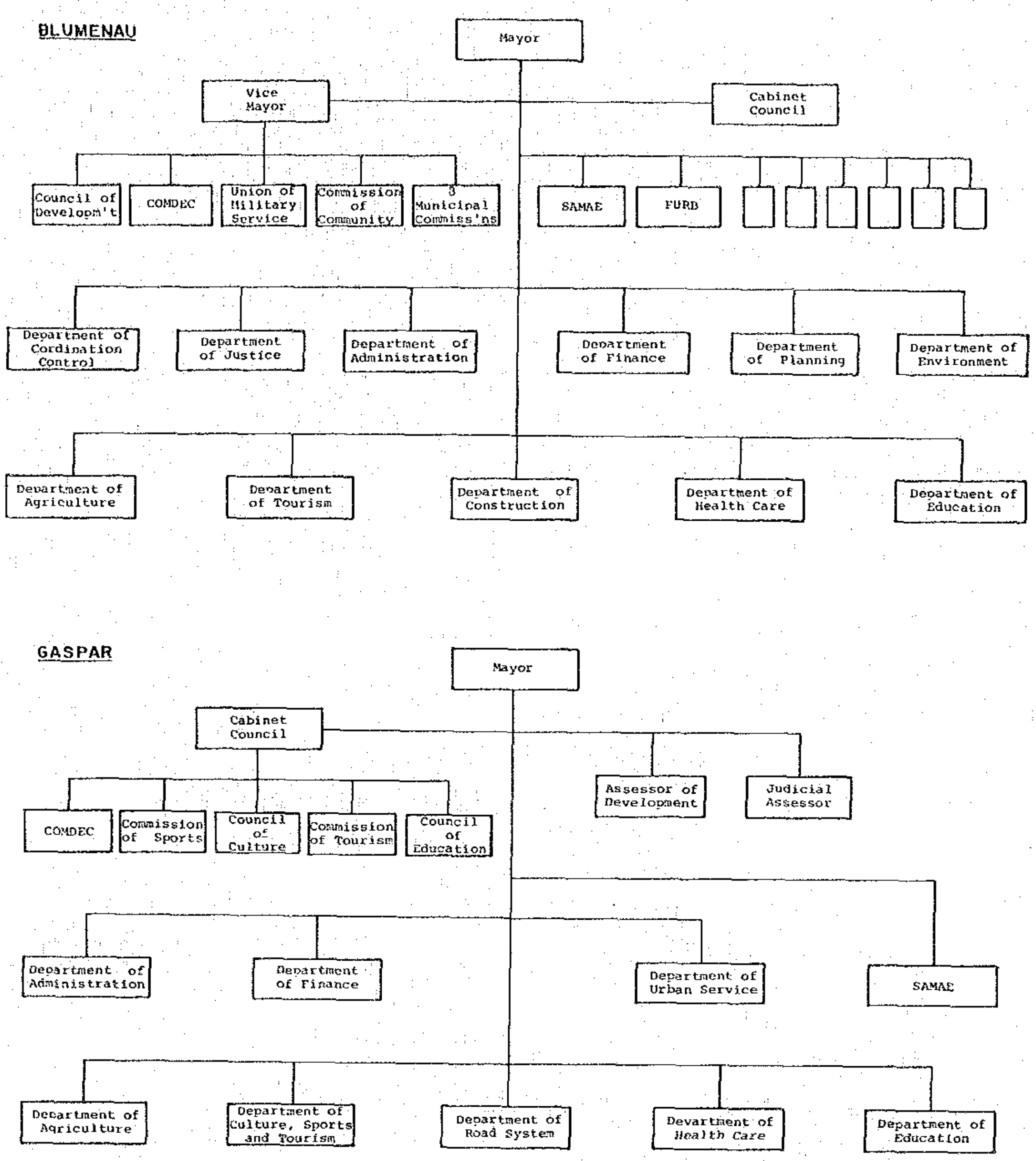

Fig. IV.2.2 ORGANIZATION CHART OF MUNICIPALITIES CONCERNED

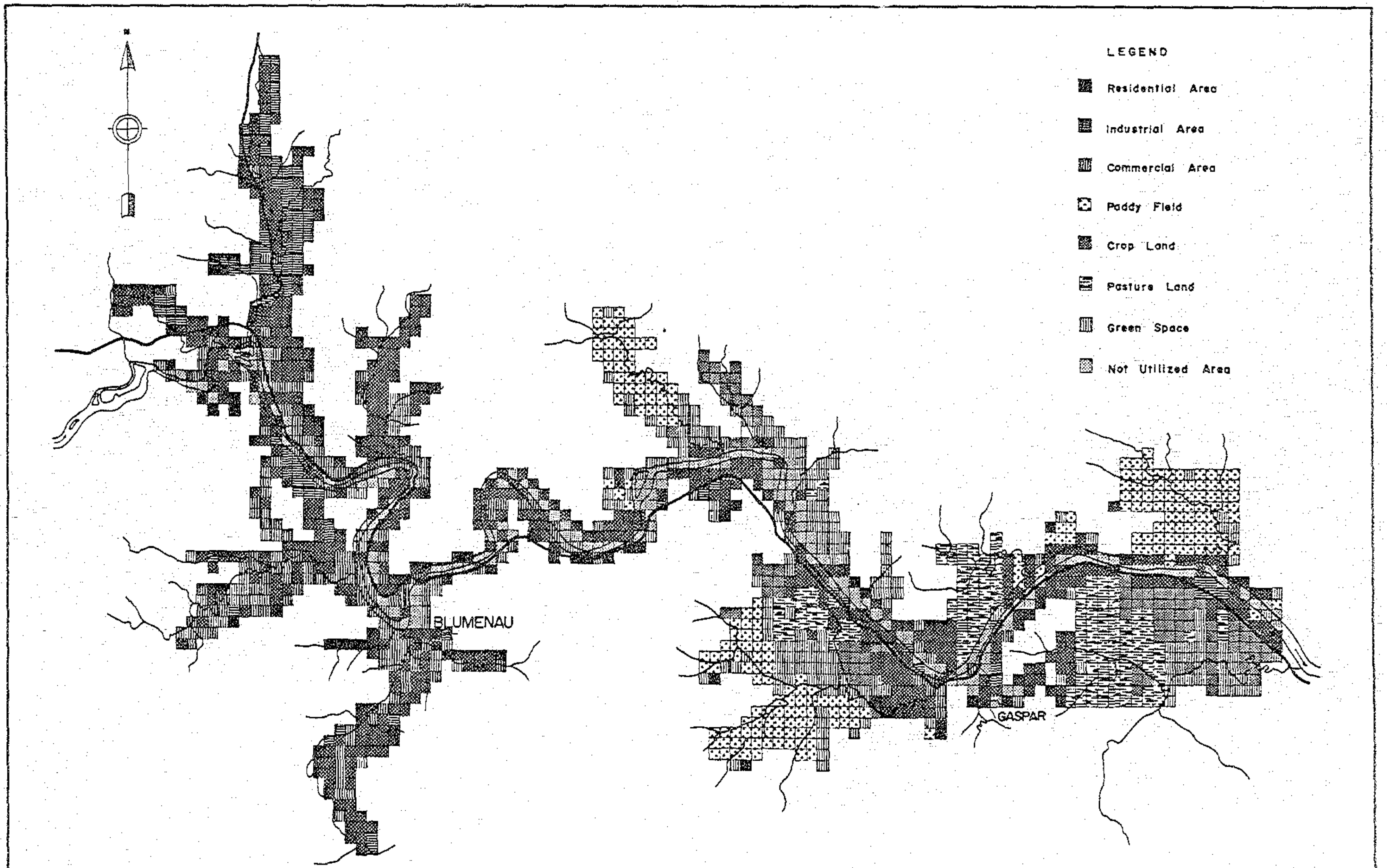

Fig. IV.3.1 PRESENT LAND USE IN THE PROBABLE INUNDATION AREA