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STATE SECRETARIAT OF PLANNING AND GENERAL COORDINATION, PARANA STATE, THE FEDERATIVE REPUBLIC OF BRAZIL

THE MASTER PLAN STUDY ON

THE UTILIZATION OF WATER RESOURCES IN PARANÁ STATE

IN

THE FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT

SECTORAL REPORT VOLUME B

METEOROLOGY, HYDROLOGY AND SURFACE WATER RESOURCES



December, 1995

Yachiyo Engineering Co., Ltd. Tokyo, Japan

and

Nippon Koei Co., Lid. Tokyo, Japan

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I. EXECUTIVE SUMMARY

2. MAIN REPORT

- I. Strategy for Paraná State
- II. Master Plan for Iguaçu River Basin
- III. Master Plan for Tibagi River Basin

3. SECTORAL REPORT

- A. Socio-economy
- B. Meteorology, Hydrology and Surface Water Resources
- C. Hydrogeology and Groundwater Resources
- D. Domestic and Industrial Water
- E. Agriculture
- F. Hydroelectric Power Generation
- G. Water Utilization Plan
- H. Flood Control
- I. Water Quality and Sewerage
- J. Soil Brosion and Forest
- K. Ecology
- L. Water Environment Management
- M. Institution
- N. Cost Estimate, and Economic and Financial Assessment

4. DATA BOOK

THE MASTER PLAN STUDY ON THE UTILIZATION OF WATER RESOURCES IN PARANA STATE IN THE FEDERATIVE REPUBLIC OF BRAZIL

Sectoral Report Vol. B

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CEHPAR	List of Abbreviation : Center of Hydraulics and Hydrology, Professor Parigot de Souza Centro and Hidraulica e Hodrologia Professor Parigot de Souza
CONAMA	: National Environmental Council Conselho Nacional do Meio Ambiente
COPEL	: Energy Company of the State of Parana Companhia Pananaense de Energia
DEFAM	: Department of Diffusion of Environmental Information Departamento Difusao Informacoes Ambien
DELAM	: Department of Environmental Statistics Departamento Estatistica Ambiental
DIFLA	: Directorate of Inspection and Licensing Diretoria Fiscalização Licenciamento
DNAEE	: National Department of Water and Electric Energy Departamento Nacional de Ágnas e Energia Elétrica
EMATER	Parana State Technical Assistance and Rural Extension Company Empresa Paranaense de Assistência Técnica e Extensão Rural
FAO	: Food and Agriculture Organizationulture Organization Fundo das Nações Unidas para Aliment
ІАР	: Environmental Institute of Parana Instituto Ambiental do Paraná
ЛСА	: Japan International Cooperation Agency Agência de Cooperação Internacional do Japão
SANEPAR	: Sanitation Company of the State of Parana Companhia de Sancamento do Paraná

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CHAPTER 1 METEOROLOGICAL ANALYSIS

1.1 Data Collection

In the Study Area, there are 51 main meteorological stations and 844 rain-gauge stations (as of March, 1995). The Team selected 33 meteorological stations (See Figure-1.1), and additional three rainfall stations by considering their data availability as listed in Table-1.1 and collected data at all selected stations.

According to accuracy and availability of observed data, simulation period adapted for the last 20 years (1974-1993).

1.2 Results of Analysis

1.2.1 General Meteorological Condition

The climate and meteorological conditions of a region are mainly determined by atmospheric circulation that acts on the various scales where the region is inserted. The south of Brazil as a result of localization in the middle latitudes, is subject to the following basic atmospheric actions; (Source : Sugai et al, 1993)

- the Subtropical anticyclone of the South Atlantic
- the Migratory Polar Anticyclone
- the Chaco Center of Low Pressure
- the Amazon Tropical High Pressure
- the Pacific Anticyclone

Along the year, these centers of atmospheric action change position and vary their intensities, and they cause the so called air mass. These air masses have almost uniform physical properties at the same level, such as temperature ,humidity, air pressure and wind, and can be classified as tropical and polar and subclassified as continental and maritime. The influence of air masses in Parana state is characterized as follows;

<From October to March>

A predominance of the Atlantic Tropical air mass of low pressure occurs in the direction of the south of Brazil bringing good dry weather with few clouds.

<From April to September>

An Atlantic Polar air mass occurs more intense in this period, and infiltration occurs north provoking good weather and few clouds, as well as cold nights and droughts.

<Whole Season>

When the tropical air mass goes over the polar one, there are the formation of warm fronts and shorter duration rainfall. When the opposite occurs, there is a formation of cold fronts which provoke instability of great extension and long duration rains, it is called frontal rains.



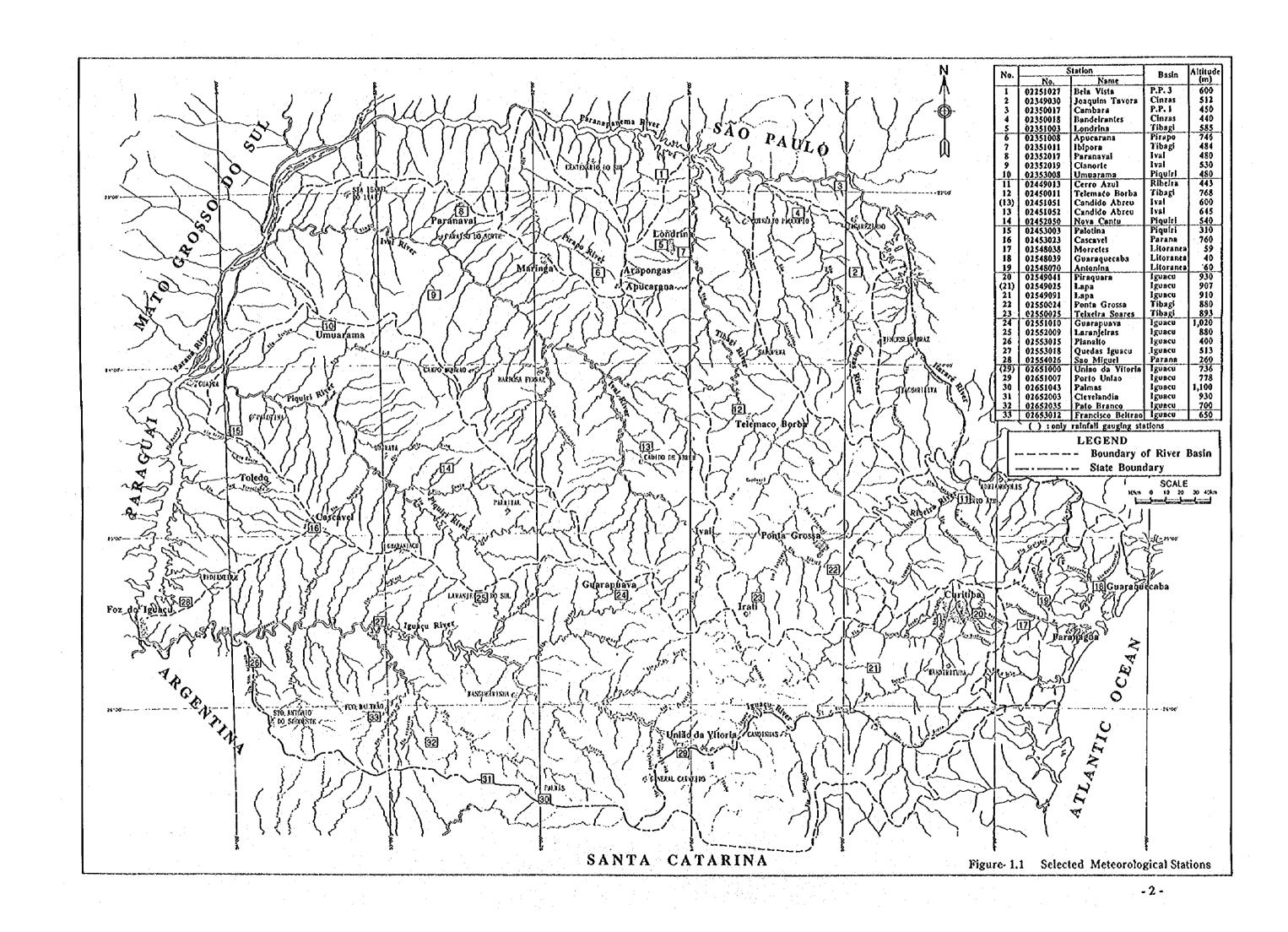


Table-1.1 Meteorological Data Availability

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28 02554026	Sao Miguel	Parana.3	25°26'S	54°22W	260				Sandara Sandara Sandara Sandara	10	100) ₽°.	0 0			
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1.2.2 Rainfall

The rainfall data in Parana has been measured with different agencies and different observation periods by stations. At present, about 900 rain gauge stations are registered.

(1) Monthly Rainfall Distribution

The last 20 years mean monthly rainfall data was summarized as shown in both Table-1.2 and Figure-1.2. The missing monthly rainfall data were determined by applying the correlation equations by station (refer to the section 1.2.9).

Seasonal variations of monthly totals are similar in different parts of the Parana. Fluctuation of monthly rainfall by regions are summarized as follows;

Two different fluctuation pattern exists between Litoranea and Northern region, Southern region. Litoranea and Northern region rainfall pattern only fluctuates once a year on December or January, but at the Southern region has two times a year on both May and October.

(2) Annual Rainfall Distribution

Using the last 20 years annual mean rainfall data as shown in Table-1.2, an Iso-hyetal map was developed as shown in Figure-1.3. In Parana, the following rain characteristics can be observed;

- a) Litoranea at the eastern side of the coast mountains range has the highest annual rainfall volume.
- b) The region including Curitiba at the western side of the coast mountains range has the lowest annual rainfall.
- c) The south-western region has second highest annual rainfall volume because of high altitude between 1100 m and 1200 m, and rainfall volume decrease toward the eastern side.

(3) Long-Term Rainfall Variation

To determine the long term variation of rainfall, 10 typical rainfall stations were selected. And analysis of long period annual rainfall was computed by using 5-years running annual mean and average of 5-years running annual mean rainfall as shown in Figure 1.4.

According to Figure-1.4, rainfall fluctuation cycles of 5-years running annual mean repeat the range from 8 to 12 years in Parana.

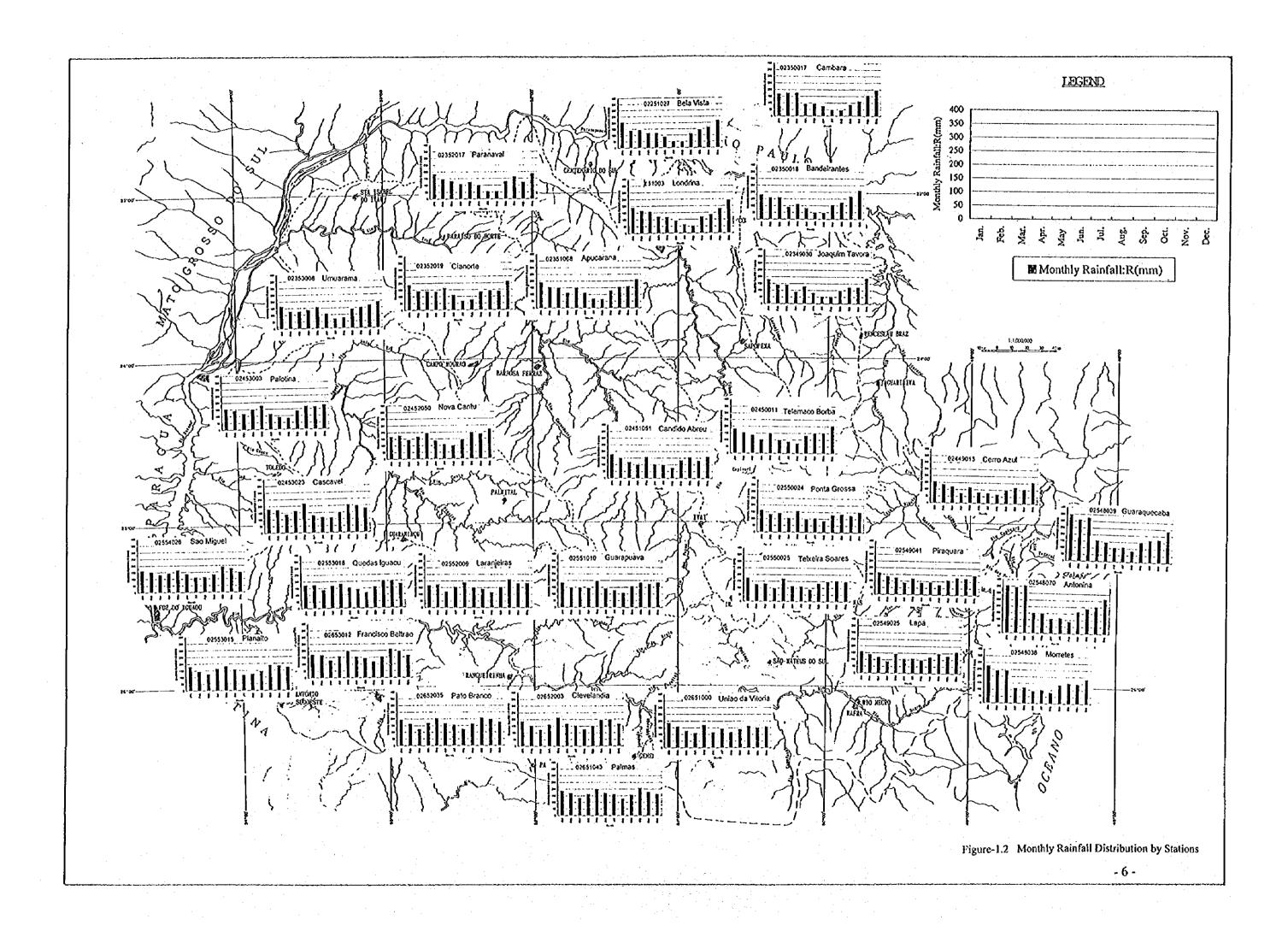
In this Study, meteorological simulation period adapted from 1974 to 1993, there are two fluctuations exist in 1983 and 1990, especially central region and Iguacu basin. It was found that the simulation period adapted last 20 years is sufficient to study of meteorological factor such as rainfall, evaporation and others.

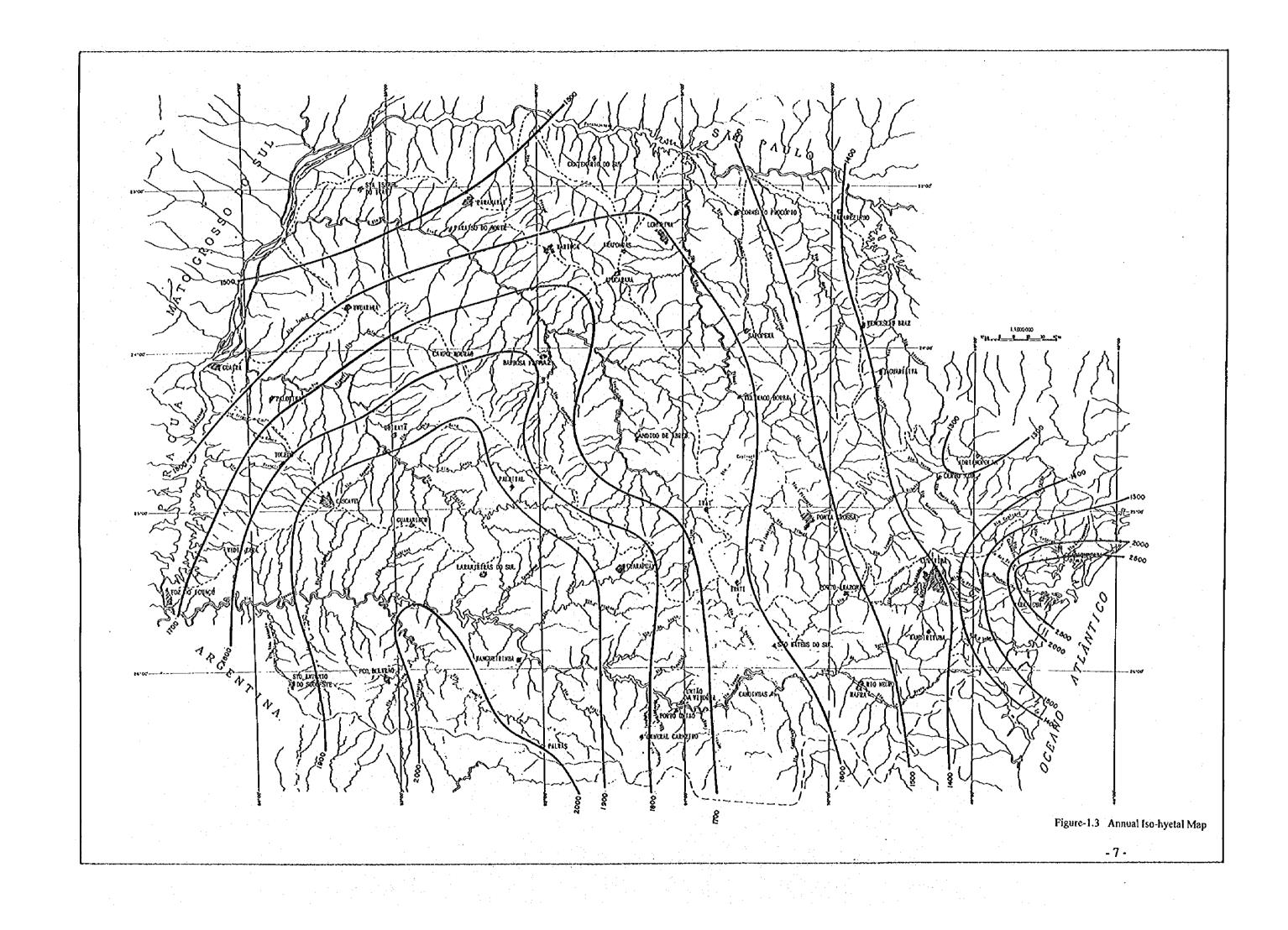
Table-1.2 Annual and Monthly Mean Rainfall (Simulation Period 1974 - 1993, 20 Years)

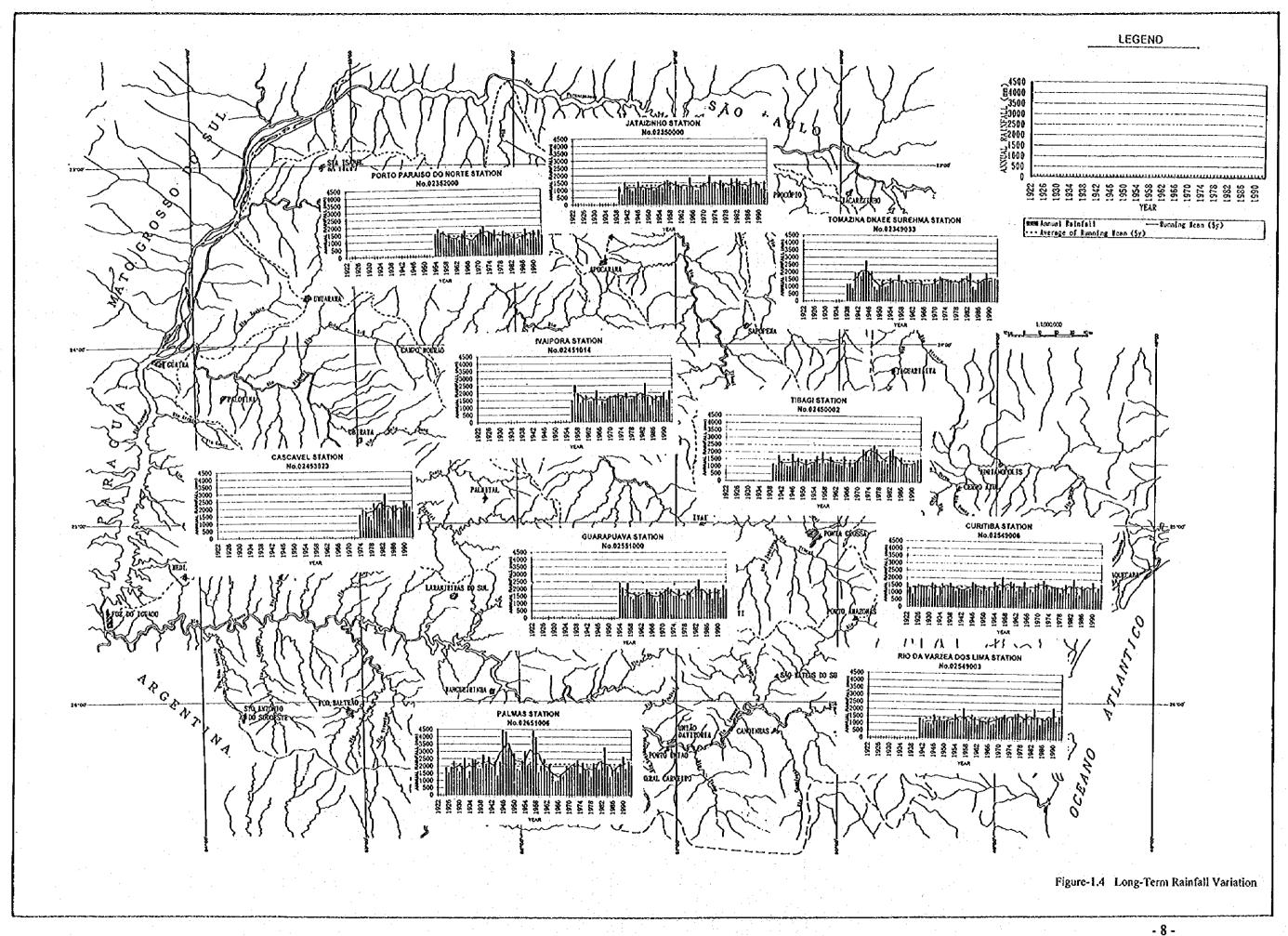
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No. St.No.	Name		Lat.	Long.	Attude								 ,						
1 02251	1 02251027 Bela Vista	P. P. 3	22-57'S 51-12W	MZ1-12	600	206.5	136.6	143.6	116.4	118.3	86.5	51.1	48.1	112.9	145.1	161.9			1544.7
2 02349	2 02349030 Joaquim Tavora	Cinzas	23-30'S 49-52W	49"52W	512	179.3	141.0	141.2	87.5	128.2	80.2	54.5	523	100.2	122.8	122			1400.0
3 02350	3 02350017 Cambara	0 0	22°00'S 50°02'N	50-02W	450	168.4	174.8	175.8	92.6	94.8	75.8	47.0	43.3	84.3	113.4	154.3	•		1419.4
4 02350	4 02350018 Bandeirantes	Cinzas	23°06'S 50°21'W	50'21W	440	179.9	160.1	160.2	90.4	110.9	79,7	49.6	46.3	105.3	122.7	166.3			1482.8
5 02351003	003 Londrina	Tibagi	23*18'S 51*09'W	51*09W	585	189.5	165.5	157.7	120.9	117.8	90.5	62.5	53.1	118.9	136.8	179.1			1634.7
6 02351	6 02351008 Apucarana	Pirapo	23-30'S 51-32W	51+32W	746	190.3	154.6	151.5	112.7	151.0	112.2	69.2	66.2	128.6	153.6	159.1	211.3	138.4	1660.3
7 02351	7 02351011 (Ibipora	Tibagi	23-16'S 51-01'W	51-01W	484	199.9	160.7	155.4	111.6	115.3	90.2	55.8	50.8	117.0	131.2	173.6	·		1587.2
8 02352	8 02352017 Paranavai	ivai	23°05'S 52°26'W	52*26W	480	184.1	145.0	130.2	110.0	123.7	101.4	54.5	54.8	127.2	163.1	120			1501.3
902352	9 02352019 Cianote	is vi	23-40'S 52-35'W	52-35W	530	189.1	142.0	139.5	13% 4	162.7	110.7	66.6	75.8	134.1	143.7	136.8	÷		1646.5
10 02353	10 02353008 Umuarama	Piquíri	23*44'S 53*17W	S3-17W	480	165.0	126.7	125.0	136.0	157.2	108.0	68.5	76.4	141.3	153.3	168.8			1617.4
11 02449	11 02449013 Cemo Azut	Ribeira	S.67.92	MS1-67 S.67.72	643	156.1	135.1	120.01	73.0	116.2	80.8	75.6	66.6	101.01	120.3	105.8			1307.6
12 02450	12 02450011 Telemaco Borba	Tibagi	24-20'S 50-37W	50-37W	768	181.0	155.3	139.1	102.6	150.8	98.5	87.3	74.1	131.7	150.6	151.4			1627.8
(13)02451	13) 02451051 Candido Abreu	N21	24-34'S 51-19W	51-19W	80	178.0	149.9	118.6.	100.1	167.5	102.1	98.8	7.77	131.8	155.9	129.4			1558.9
14 02452	14 02452050 Nova Cantu	Piquin	24-40'S 52-34W	52°34W	8	166.5	178.1	144.2	167.8	195.8	136.1	109.4	99.1	145.1	196.8	185.3		•	1946.2
15 02453	15 02453003 Palotina	Piquiri	24°18'S 53°55'W	53*55W	310	153.1	141.4	117.1	148.4	17.71	114.2	90.3	81.5	135.8	169.4	165.1			1672.3
16 02453	16 02453023 Cascavel			53*26W	760	177.2	173.0	137.1	163.7	218.2	128.9	114,4	109.8	147.8	205.3	197.8			1961.1
17 02548	17 02548038 Mometes	Litoranea		48°49W	20	276.4	242.7	242.8	113.5	118.4	93.5	101.4	82.6	140.2	153.3	1.741			1895.1
18 02548	18 02548039 Gueraquecaba	Litoranea		48-20'W	9	349.0	309.0	326.8	157.1	145.3	107.1	1112	82.0	149.6	166.1	171.9			2311.0
19 02548	19 02548070 Antonina	Litoranea	25-13'S 48-48'W	48-48'W	8	355.5	343.8	355.3	152.1	150.4	110.0	115.6	87.1	165.0	186.9	204.7		•	2490.9
20 02549	20 02549041 Piraquara	lguacu	25*25'S 49*08'W	49°08'W	930	161.3	135.8	125.3	86.4	119.5	88.5	92.8	73.2	109.7	127.2	122.4			1388.3
(Z1) 02549025 Lapa	225 Lapa	louacu	25-47'S 49-43'S	48-43'S	202	159.0	138.0	120.8	86.4	142.5	107.2	109.4	98.3	119.9	146.1	127.7			1513.9
22 02550	22 02550024 Ponta Grossa	10eq	25-13'5	25-13'\$ 50-01'W	880	163.2	133.7	140.3	105.0	157.4	98.1	105.1	85.0	128.4	136.3	126.5			1530.7
23 02550	23 02550025 Teixeira Soares	Tibagi	25-275 50-35W	50°35W	568	174.7	126.0	132.0	0.66	168.3	113.7	1.111	89.9	133.6	147.0	152.5		, ¹	1594.7
24 02551		Iguacu	25-21'S 51-30W	51-30W	020	182.0	147.1	146.8	143.7	196.1	141,4	128.6	107.8	156.4	183.9	174.4			1892.4
25 02552009	009 Laranjeiras	lguacu	25-25'S	52*25W	880	167.1	175.4	120.0	154.8	188.3	150.6	140.4	115.6	152.7	209.6	180.1	•		1936.3
26 02553	26 02553015 Planatto	Iguacu	25-42'S 53-47W	53-47W	Ş	179.8	143.2	123.3	163.8	181.4	157.4	117.2	124.0	144.4	188.3	182.8			1878.7
27 02553	02553018 Quedas Iguacu	iguacu	25.31'S	53-01W	513	172.5	174.7	138.0	168.1	181.4	153.0	142.4	117.0	159.3	204.4	202.8			1990.4
28 02554	28 02554026 Sao Miguel	Parana 3	25-11'S	54-08W	307	162.0	152.6	130.5	143.1	166.4	136.0	111.6	112.8	131.5	189.7	178.2		•	1764,3
(23) 02651	(29) 02651000 [Uniao da Vitoria	Iguacu	26-14'S	51*04W	736	184.9	158.6	125.8	110.8	171.0	116.9	1412	116.3	139.6	162.0	149.6			1738.8
30/02651	30(02651043 [Palmas	lguacu	26*29'S 51*59W	51*59W	1,100	187.2	169.5	131.7	161.8	199.3	171.0	161.2	128.3	122.1	208.6	179.5			2017.1
31 02652	31 02652003 Cievelandia	Iguacu	26"25'S 52"21'W	52*21W	930	186.2	152.4	123.1	162.2	213.8	167.6	154.6	26.3	151.1	195.5	199.1			1998.0
32 02652	32 02652035 Pato Branco	louacu	26"07"S 52"41W	52.41W	700	193.7	163.7	123.9	168.8	204.6	166.2	155.7	123.5	163.7	208.5	197.5			2045.0
33 02653	02653012 Francisco Beltrao	iguacu	26"05'S 53"04'W	53°04W	650	171.6	166.9	127.2	157.8	197.9	154.1	143.1	117.1	153.5	209.7	194.1			1956.8
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Data Source: COPEL

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1.2.3 Temperature

The observation of temperature is normally made by three times a day (9:00, 15:00 and 21:00 hr). Annual mean temperature in Parana has generally range between 16°C and 22°C throughout the year. According to collected data, maximum temperature 41.5°C at Paranavai in the north-west area and minimum temperature -6.8°C both at Palmas and Guarapuava in the south highland area were recorded respectively during the recent 20 years.

The monthly and annual mean temperature were summarized in Table-1.3, and also plotted as an Iso-thermal map (Figure-1.6). The missing monthly mean temperature data were obtained by employing the correlation equation by station. (refer to the section 1.2.9)

The annual mean temperature by the station except for Litoranea area is closely related to its elevation as shown in Figure-1.5. The relation between them can be described as the following equation;

Tm = 24.6 - 0.0077 x EL

where Trin : annual mean air temperature (°C)

EL : elevation (m) correlation coefficient = 0.91

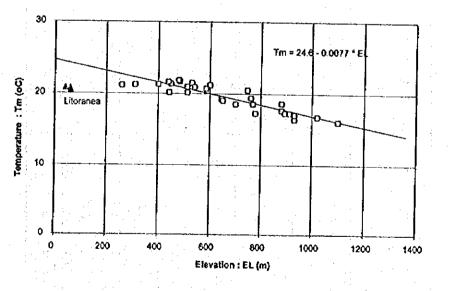


Figure-1.5 Relation between Air Temperature and Elevation

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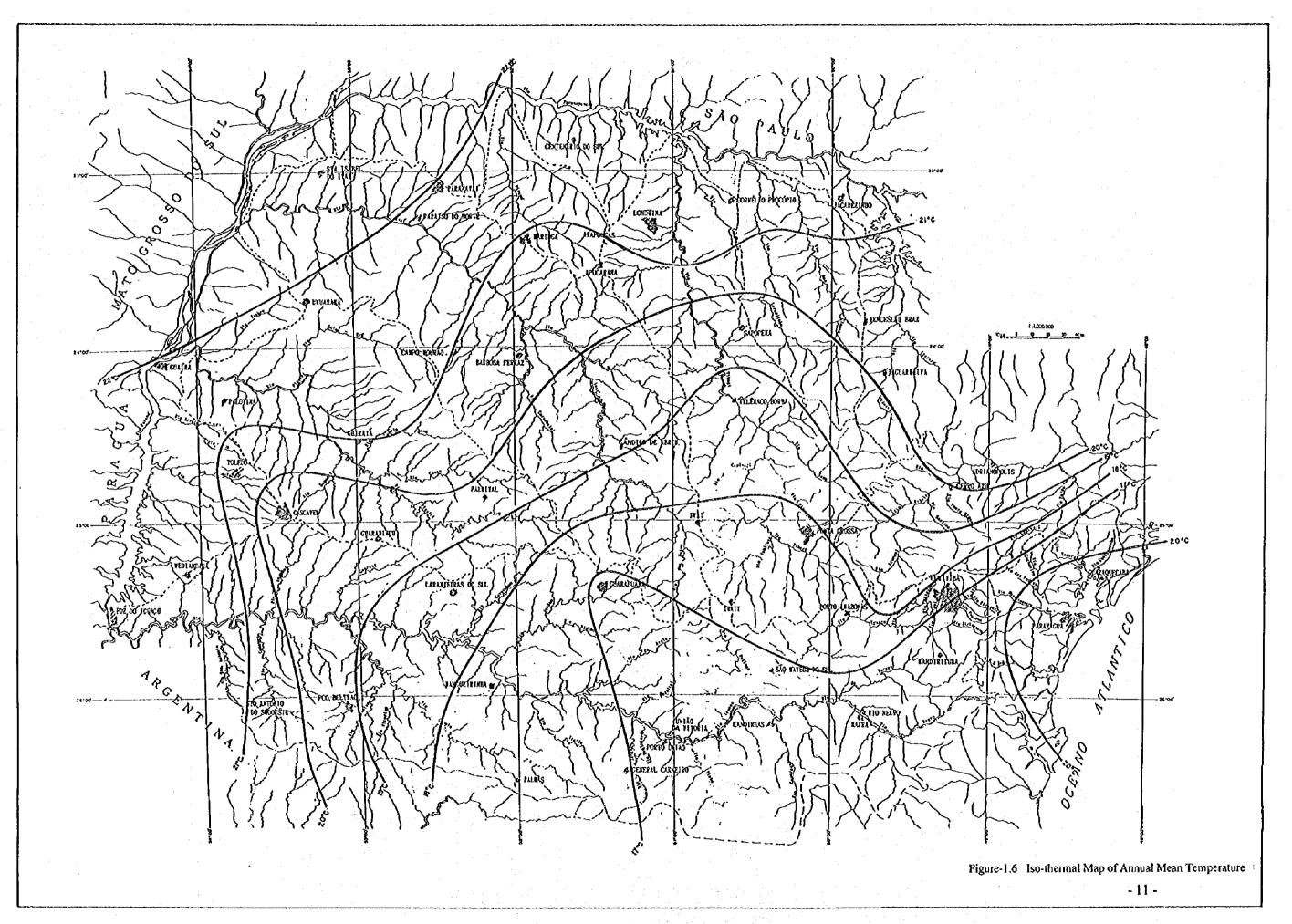
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Sta No. StNo.	Station tho. Name	Basin	Lat Long.	0 n Attr	- 9 	e.	Ž	₹.	Wa	Jun.	Jul.	Aug.	Sep.	В	NOV.	- Dec	Mean
1 02251	1 02251027 Sela Vista	P.P.3	22*57'S 51*12W		600 23.8					4.71	17.5	13.1	19.8	20.02	23.2	23.3	212
2 02349	2 02349030 Joaquim Tavora	Cinzas	23"30'S 49"52W		512 24.4					16.5	16.6	18.2	19.4	21.6	23.0	23.7	20.9
3 02350017	017 Cambara	P.P.1	23°00'S 50°02'W		450 24.4	_			•	17.0	16.9	18.8	202	22.6	23.8	23.9	21.4
4 02350	4 02350018 Bandeirantes	Cinzas	23-06'S 50-21W		440 24.6				•	17.4	17.5	19.3	20.4	27	23.8	24.1	21.6
5 02351(02351003 Londrina	Tibagi	23"18'S 51"09W		585 23.7				•	16.5	16.8	18.3	19.5	21.8	23.0	23.2	20.7
5 02351(5 02351008 Apucarana	Pirapo	V25-15 S.02-62		/46 23.1		ĺ			10.71	17.0	18.6	19.3	21.3	22.2	22.5	20.5
7 02351(7 02351011 Ibipora	Tbagi	23-16'S 51-01W	_	484 24.5				•	17.6	17.7	19,4	20.5	37	8.23	24.0	21.7
8 02352017	017 Paranavai	2	23-06'S 52-26W	` _	480 24.9				• .	17.7	17.9	19.5	20.4	ຶສ	24.1	24.6	21.9
9 02352(9 02352019 Cianofte	Nai	23-40'S 52-35W		530 24.6	:				17.2	17.3	19.0	20.02	สื่	87	242	21.5
10 022534	10 02353008 Umunuma	Piquin	23*44'S SS17'W		480 25.0					17.6	17.7	19.4	20.2	22.6	23.9	24.6	21.8
17 02449	11 02449013 Cerro Azui	Ribeira	V21-95 29-15W		443 24.4					15.3	151	16.5	18.1	20.6	26 26	23.8	20.2
12 02450	12 02450011 Telemaco Borba	igedi	24-20'S 50-37'W		68 22.6		-	. : -		13.9	13.7	15.1	16.7	19.3	20.8	21.9	18.6
3 02451(13 02451052 Candido Abreu	N.	24"38'S 51"15W		645 22.7		,.			14.8	14.9	16.7	17.7	20.3	2.5	22.0	19.3
14 02452(14 02452050 Nova Cantu	Piquin	24-40'S 52"34'W		540 24.5				•	16.4	16.6	18.3	19.4	21.8	23.0	24.0	20.9
15 02453(15 02453003 Palotina	Piquin	24785 53-55W		310 25.2					16.4	15.9	17.5	19.4	233	20	24,8	21.2
16 02453	16 02453023 Cascavel	Parana 3	3 24 56'S 53 26 W		760 23.0					15.0	14.9	16.5	17.8	20.3	216	22.7	19.4
17 02548	17 02548038 Morretes	Litoranea	a [25°30'S]48°49W		59 24.4					16.8	16.4	1.2.1	18.0	202	23	23.6	20.7
8 02548	18 02548039 Guaraquecaba	Litoranea	a 25-18'S 48-20W		40 24.6					16.7	16.3	17.1	18.1	20.4	22.3	23.7	20.7
19 02548	19 02548070 Antonina	Litoranea			60 24.2			•		16.4	16.1	16.7	17.9	20.0	20	3.4	20.4
20 02549	20 02549041 Piraquara	Iguacu	25-25'S 49-08'W		930į 19.9		• .			13.0	12.7	13.6	14.3	16.2	12.9	19.0	16.5
21 02549	21 02549091 Lapa	Iguacu	25.47'S 49"46'S					2		13.6	13.6	14.6	15.3	17.4	1.61	20.0	17.3
22 02550	22 02550024 Ponta Grossa	iCequ	25-13'S 50"01'W		:					13.8	13.8	14.9	15.8	17.9	19.6	20.5	17.71
23 02550	23 02550025 Teixeira Soares	Tibagi	25 27'S 50 35W		893 21.2					13.1	13.0	14.4	15.4	17.8	19.4	20.4	17.4
24 025511	24 02551010 Guarapuava	Iguacu	25 21'S 51 30W	0W 1.020	:		•			12.7	12.6	14.0	15.1	17.4	18.9	19.9	16.3
25 025521	02552009 Laranjeiras	Iguacu	25 25'S 52 25W							14.4	14.6	16.1	17.0	19.3	20.7	21.9	18.7
26 02553	26 02553015 Planatto	Iguacu	25*42'S 53*47'W							16.3	16.6	18.3	2'61	22.0	23.5	25.0	21.3
27 02563	27 02553018 Quedas Iguadu	noen6	25 31 S 53 01 W							15.4	15.5	1.21	15.5	210	22.5	23.8	20.2
28 02554	28 02554026 Sao Miguel	Parana 3			307 25.6					15.8	15.9	17.6	19.2	8	23.7	25.1	21.2
29 02651(29 02651007 Porto Uniao	10mg	26-13'S 51-04W		778 22.0		17			12.2	12.0	13.9	15.0	18.0	19.6	21.3	17.3
30 02651(30 02651043 Paimas	ilguacu	26-29'S 51-59W	-		:				11.8	11.6	13.0	14.1	16.7	18.1	19.5	16.1
31 02652(31 02652003 Clevelandia	guacu	26 25'S 52 21 W			•				12.6	12.7	14.2	15.1	17.6	19.1	20.5	17.1
32 026521	32 02652035 Pato Branco	10macu	26°07'S 52°41W		700 22.5	222	21.4	18.7	15.7	13.9	14.1	15.7	16.8	19.3	2.7	80	18.6
33 02653(33)02653012 Francisco Beltrao	lguacu	26-05'S 53-04'W		650 23.5					13.9	14.1	15.8	17.2	20.0	21.4	0.8 8	19.1
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1.2.4 Evaporation

1) Direct Measurement Data

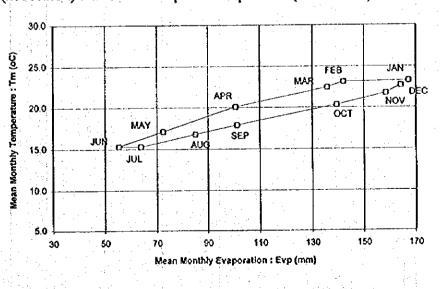
Evaporation pan data after converted by using a pan coefficient (0.6 - 0.8) is useful for estimating the value for lakes or reservoirs. The observation of evaporation pan data is mainly carried out at main meteorological stations in Parana, and is observed by IAPAR (at main meteorological Stations) and DNAEE (at 12 main meteorological stations). But data is not sufficiently available. The Team collected row evaporation pan data at some stations to compare the evaporation data by Penman's equation.

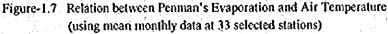
2) Penman's Evaporation

COPEL, IAP and other related agencies are commonly computed an evaporation rate by using Penman's equation. The Team determined the relation between evaporation pan data after converting by using a mean of pan coefficient 0.7 (: Evpan) and evaporation data by Penman's equation (: Evp) at several stations. Using both annual evaporation data, the ratio of Evpan / Evp ranges from 0.7 to 0.9, with a mean of 0.8. The mean value of 0.8 will be employed to estimate the evaporation value for planned dam reservoirs in surface water development study.

The annual mean evaporation results calculated by COPEL using Penman's equation (by Frere, 1979) in the selected 33 stations is summarized as shown in Table-1.4. The missing monthly evaporation data were determined to employ the correlation equation by station. (refer to the section 1.2.9)

One of the factor affecting evaporation is usually known as air temperature. Figure-1.7 shows the relationship between the monthly mean air temperature and the monthly mean evaporation. It obviously indicates that monthly mean evaporation for months having the same monthly mean air temperature of the same month is higher between October and March (hot season) than between April and September (cold season).





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Table-1.4 Annual and Monthly Mean Evaporation by Penman's Equation (Simulation Period 1974 - 1993, 20 years)

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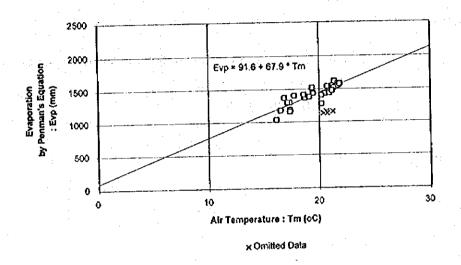
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273705 57704 1323 1124 1050 1124 1050 1124 1050 1124 1050 1124 1050 1124 1050 1724 1051 1255 1724 1051 1255 1050 1055 1050 1055 1050 1050 1055 1050 1050 1754 1051 1125 1055 1050 1055 1050	Zurons Line Line <thline< th=""> Line <thline< th=""> <th< th=""><th>1</th><th>1</th><th></th><th>Long.</th><th>Athtude</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th> </th><th></th><th></th><th></th><th></th><th></th></th<></thline<></thline<>	1	1		Long.	Athtude									 					
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270000 50000 4400 1703 6700 1400 1703 1740 1703 1740 1703 1740 1703 1740 1703 1700 1703	ZUTONS SUNTVN 460 1523 1642 1523 6420 1523 6420 1523 1642 1642 1643 1644 1750 1644 1750 1644 1750 1644 1750 1644 1750 1644 1643 1646		Cinzas	23*30'S	49*52W	512	173,4	152.1	144.6	114.2	80.0	61.5	71.5	66.3				167.7		1505.
Zinos Jorna Holis Holis <th< td=""><td>Zirrys Jona Tol Tol</td><td></td><td>P. P.</td><td>23°00'S</td><td>50°02W</td><td>84</td><td>183.2</td><td>149,7</td><td>148.0</td><td>120.3</td><td>88.2</td><td>70.1</td><td>84.9</td><td>116.1</td><td></td><td></td><td></td><td>166.9</td><td></td><td>1624.</td></th<>	Zirrys Jona Tol		P. P.	23°00'S	50°02W	84	183.2	149,7	148.0	120.3	88.2	70.1	84.9	116.1				166.9		1624.
Theore 272*/15 517*/100 565 767 77.0	Proper Three Three <t< td=""><td></td><td></td><td>23°06'S</td><td>50°21W</td><td>440</td><td>180.6</td><td>155.5</td><td>148.1</td><td>118.4</td><td>84.8</td><td>63.2</td><td>78.6</td><td>108.4</td><td>-</td><td></td><td>•</td><td>172.8</td><td></td><td>1585.</td></t<>			23°06'S	50°21W	440	180.6	155.5	148.1	118.4	84.8	63.2	78.6	108.4	-		•	172.8		1585.
Presex Table Trans Trans <t< td=""><td>Presep Zandes Strates Strates</td><td></td><td></td><td>23 18'S</td><td>51-09W</td><td>585</td><td>175.0</td><td>151.8</td><td>148.1</td><td>118.3</td><td>85.0</td><td>65.8</td><td>76.7</td><td>102.1</td><td>1</td><td></td><td></td><td>:</td><td></td><td>1544.</td></t<>	Presep Zandes Strates			23 18'S	51-09W	585	175.0	151.8	148.1	118.3	85.0	65.8	76.7	102.1	1			:		1544.
Theory 270'56 510'W 464 77.56 750.5 77.86 77.06 77.96 77.06 <th< td=""><td>Theat 27165 7716 10034 1773 10034 1774 7716 10034 1774 7716 1774 7716 1774 7716 1774 7716 1774 7716 1774 7716 1776 7716 7736</td><td></td><td></td><td>S.02.22</td><td>51-32W</td><td>746</td><td>164.1</td><td>139.3</td><td>138.5</td><td>111.5</td><td>78.5</td><td>58.5</td><td>70.0</td><td>92.3</td><td></td><td></td><td></td><td></td><td></td><td>1440.5</td></th<>	Theat 27165 7716 10034 1773 10034 1774 7716 10034 1774 7716 1774 7716 1774 7716 1774 7716 1774 7716 1774 7716 1776 7716 7736			S.02.22	51-32W	746	164.1	139.3	138.5	111.5	78.5	58.5	70.0	92.3						1440.5
New 272405 252 113<	Noil 227057 Noil 227057 Noil 227057 Noil 227057 Noil 727057 770-6 <th< td=""><td></td><td>Tibagi</td><td>23°16'S</td><td>S1*01W</td><td>484</td><td>175.6</td><td>153.5</td><td>48.6</td><td>120.2</td><td>87.3</td><td>67.7</td><td>77.8</td><td>103.4</td><td></td><td></td><td></td><td></td><td></td><td>1556.</td></th<>		Tibagi	23°16'S	S1*01W	484	175.6	153.5	48.6	120.2	87.3	67.7	77.8	103.4						1556.
Duri Zivicolis Struction Str	India 27-405 157-4 175-6 <t< td=""><td></td><td>tvai</td><td>23°06'S </td><td>52°26W</td><td>480</td><td>185.1</td><td>157.0</td><td>156.7</td><td>118.0</td><td>85.0</td><td>68.0</td><td>78.8</td><td>103.3</td><td></td><td></td><td></td><td></td><td></td><td>1587.4</td></t<>		tvai	23°06'S	52°26W	480	185.1	157.0	156.7	118.0	85.0	68.0	78.8	103.3						1587.4
Peruri 22:'455 52''475 440 155/1 113.4	Peruni 22:'415 810 1550 1571 1104 840 653 710 1105 <t< td=""><td></td><td>isvi</td><td>23*40'S</td><td>52°35W</td><td>83</td><td>181.7</td><td>154.6</td><td>154.9</td><td>114.5</td><td>80.8</td><td>53.6</td><td>73.6</td><td>86.5</td><td></td><td>1</td><td></td><td></td><td></td><td>1545.</td></t<>		isvi	23*40'S	52°35W	83	181.7	154.6	154.9	114.5	80.8	53.6	73.6	86.5		1				1545.
Roberta 2xx4xS 5yr3X 4x4A 153.6 105.0 105.6 105.6 105.6 105.6 105.6 105.6 105.6 105.6 105.6 105.6 105.6 105.6 105.6 105.6 105.6 105.6 105.6 105.7 115.4 155.6 105.7 115.4 155.6 105.7 115.4 155.6 105.7 115.4 155.6 105.7 152.7 115.4 155.6 105.7 155.6 105.7 155.6 105.7 155.6 105.7 155.6 105.7 155.6 105.7 155.7 155.7 155.7 155.7 155.7 155.7 155.7 155.6 155.6 155.6 155.7 155.6 155.7 155.7 <	Roema Zarangs Sarangs Sarang		Piquin	23*44S	53-17W	480	185.0	158.9	167.1	119.4	84.9	62.9	74.9	99.2				Ŋ.		1580.
Thee Arrans Sortary S	The Paranes Servers Se	l	Ribeira	24*49'S	49*15W	443	158.7	134.2	130.7	90.6	61.5	51.2	53.7	73.6		х.				1282.(
Nori 247325 511130 656 650 672 1087 1327 1755 1664 1564 1564 1564 1564 1564 1564 1564 1564 1564 1564 1564 1564 1566 1567 1573 1564 1566 1567 1573 1564 1566 1566 1567 1573 1564 1566 1566 1567 1573 1564 1566 1566 1567 1573 1564 1566 1566 1567 1567 1566 1566 1566 1567 1566 <t< td=""><td>Nor 247365 1132 77.9 57.6 65.0 97.1 1032 1732 1733 1386.4 Perium 244305 51730W 500 147.0 143.0 103.8 57.5 65.0 65.7 103.7 173.5 138.4 Perium 24405 5259W 700 147.0 143.0 103.8 57.3 65.7 103.7 173.5 138.4 Perium 224405 537.0W 700 147.3 113.4 84.0 64.1 43.9 57.3 103.7 135.4 133.4 Linemes 257155 5470W 400 143.3 113.4 84.3 64.7 43.9 57.3 103.4 103.2 173.4 103.2 173.5 133.4</td><td>A</td><td>Tibagi</td><td>24-20'5</td><td>- WT502</td><td>768</td><td>167.3</td><td>44.4</td><td>135.9</td><td>101.6</td><td>71.3</td><td>54.7</td><td>64.0</td><td>2</td><td>÷.</td><td></td><td></td><td></td><td></td><td>1385.</td></t<>	Nor 247365 1132 77.9 57.6 65.0 97.1 1032 1732 1733 1386.4 Perium 244305 51730W 500 147.0 143.0 103.8 57.5 65.0 65.7 103.7 173.5 138.4 Perium 24405 5259W 700 147.0 143.0 103.8 57.3 65.7 103.7 173.5 138.4 Perium 224405 537.0W 700 147.3 113.4 84.0 64.1 43.9 57.3 103.7 135.4 133.4 Linemes 257155 5470W 400 143.3 113.4 84.3 64.7 43.9 57.3 103.4 103.2 173.4 103.2 173.5 133.4	A	Tibagi	24-20'5	- WT502	768	167.3	44.4	135.9	101.6	71.3	54.7	64.0	2	÷.					1385.
Preuri 2x*505 5x70 7x6 1x7 120 1x6 1x7 155 156	Preurin 2x*405 5x*30V 560 147.0 143.0 144.6 172.8 173.6 Parama 3 2x*655 5x*30V 300 147.0 130.8 147.0 130.8 147.0 130.8 147.0 130.8 147.6 147.0 130.8 147.0 130.8 147.0 130.8 147.0 130.8 147.0 130.8 147.0 130.8 147.0 130.8 147.0 130.8 147.0 130.8 147.0 130.8 147.0 130.8 147.0 130.8 147.0 150.7 130.0 156.1 44.9 175.6 130.8 130.8 130.8 140.0 150.8 130.8 <td< td=""><td>_</td><td>Nai</td><td>24*38'\$</td><td>51-15W</td><td>SF</td><td>187.0</td><td>159.2</td><td>153.8</td><td>113.2</td><td>77.9</td><td>57.6</td><td>66.0</td><td>87.2</td><td></td><td></td><td></td><td>ч</td><td></td><td>1523.</td></td<>	_	Nai	24*38'\$	51-15W	SF	187.0	159.2	153.8	113.2	77.9	57.6	66.0	87.2				ч		1523.
Prenin 22*155 57:57 113:0 147.0 123:3 113:0 147.0 123:3 113:0 135:4 64:1 44:9 51:8 64:9 75:2 105:2 175:8 175:6 125:0 Premene 22*155 32*457 37:0 147.0 175:5 147.0 175:6 115:4 66:0 75:2 105:2 175:6 125:0 Lucennes 25*155 4470 85:1 15:4 64:0 47:9 55:3 65:7 105:4 115:6 15:4 86:3 105:4 115:6 15:4 86:3 105:4 115:6 15:4 86:3 15:4 86:3 110:3 111:2 <	Premins 22*165 (57:5) (17:2) (12:2)		Piquin	24"40'S	52"34W	250	176.3	147.6	144.0	103.8	74.2	56.4	65.7	87.	. •		1.			1444
Pernena 3 2x*565 5x*765 5x*755 14/10 14/10 10/10 14/10	Perenta 2 5 </td <td></td> <td>Piquiń</td> <td>24-18'5</td> <td>53-55W</td> <td>310</td> <td>147.0</td> <td>129.3</td> <td>119.0</td> <td>85.4</td> <td>64.1</td> <td>48.9</td> <td>51.8</td> <td>64.9</td> <td></td> <td></td> <td></td> <td>÷</td> <td></td> <td>1157.0</td>		Piquiń	24-18'5	53-55W	310	147.0	129.3	119.0	85.4	64.1	48.9	51.8	64.9				÷		1157.0
Liboranea 27:305 49740W 50 147.7 17:27 11:3.0 65.1 45.9 51.6 64.9 75.2 105.2 177.8 133.4 56.6 Liboranea 27:755 4474W 60 144.7 11:16.4 84.3 64.0 64.0 75.1 100.6 134.7 132.8 94.4 Liboranea 27:755 4474W 900 146.1 175.4 111.6 85.3 64.0 64.0 75.1 100.6 134.7 132.3 94.4 Liboranea 27:755 64.00 64.0 64.0 64.0 64.0 75.1 100.6 134.7 132.3 94.4 Liboranea 27:755 64.0 144.0 144.0 <td< td=""><td>Liboranea 27375 487 713 7130 65.1 43.8 75.2 105.2 127.8 133.4 Liboranea 273755 487 60 44.13 715.4 115.4 84.0 65.0 75.1 105.2 127.8 133.4 Liboranea 273755 487 60 141.3 125.4 111.6 85.3 82.7 48.7 75.3 175.4 175.4 173.4 175.4 173.4</td><td></td><td>Parana 3</td><td>24 56'S K</td><td>53-26W</td><td>760</td><td>175.5</td><td>147.6</td><td>144.0</td><td>103.8</td><td>74.2</td><td>56.2</td><td>65.5</td><td>86.7</td><td></td><td></td><td></td><td></td><td></td><td>1440.5</td></td<>	Liboranea 27375 487 713 7130 65.1 43.8 75.2 105.2 127.8 133.4 Liboranea 273755 487 60 44.13 715.4 115.4 84.0 65.0 75.1 105.2 127.8 133.4 Liboranea 273755 487 60 141.3 125.4 111.6 85.3 82.7 48.7 75.3 175.4 175.4 173.4 175.4 173.4		Parana 3	24 56'S K	53-26W	760	175.5	147.6	144.0	103.8	74.2	56.2	65.5	86.7						1440.5
Liboranea 25°155 48°20V 40 142.7 115.6 115.4 64.0 47.9 51.3 62.4 102.6 124.8 134.8	Liboramea 25°155 (45°20W 40 142/7 127.6 115.4 84.0 64.0 47.9 51.3 55.8 74, 102.6 124.8 134.8 11.0 11.0 100 11.0 100 11.0 11.0 11.0		Litoranea		48*49W	28	147.7	129.7	119.0	85.4	8	48,9	51.6	3		1				1158.5
Lucarnea 257-135 4745W 500 141.9 125.8 115.6 64.7 49.4 52.4 65.0 75.1 1003 172.3 172.9 94.5 Lucarnea 257-755 530*65W 900 145.8 111.6 85.3 64.7 48.4 55.1 103.3 173.4 172.9 94.5 Lucarnea 257-755 530*65W 900 145.8 172.4 67.3 51.1 55.1 103.3 173.4 173.2 94.5 R Traagi 257-755 50*07W 860 152.6 133.3 173.4 173.5 96.3 117.2 R Traagi 257-755 50*07W 860 152.6 138.3 172.4 100.8 117.2 R Traagi 257-755 50*07W 860 152.4 100.4 142.7 140.8 117.4 R Traagi 257-755 57*07W 800 160.4 142.7 100.8 117.4 102.4	Lucranea Z5*17S 48*1 48.4 52.4 65.0 75.1 100.3 122.3 132.3	61.	Litoranea		48~20W	4	142.7	127.6	115.4	84.0	64.0	47.9	51.2	63.8						1133.
Iguedu 25*255 45*70W 950 145.1 122.4 111.6 85.3 62.7 48.7 56.4 72.0 84.2 165.6 13.7 103.3 123.4 117.2 Upuedu 25*375 80°0'W 930 145.1 123.4 61.3 77.0 106.6 13.7 105.3 152.4 103.7 Upuedu 25*375 80°0'W 930 143.9 127.1 116.3 70.3 152.4 171.2 105.3 117.2 Second 155.1 143.9 127.1 116.3 87.1 65.7 65.7 65.7 70.3 155.0 117.2 Second 168.1 140.5 132.3 102.4 67.1 55.7 65.3 117.2 Second 168.1 140.5 132.3 102.4 67.1 55.7 65.3 117.2 117.2 Second 159.0 166.1 140.3 122.1 116.5 112.2 116.6 117.2	Iguacu IS727SS 6370W 800 145.1 173.4 111.6 85.3 82.7 44.7 56.4 72.0 64.2 116.6 13.7 150.3 152.4 Rundu 25727SS 6370W 800 153.7 165.3 171.0 170.3 152.4 153.7 150.3 152.4 Rundu 25727S 5070W 800 153.1 116.8 123.1 116.9 122.4 100.8 S Tbagi 25527S 5070W 800 166.1 140.5 132.5 152.4 100.8 S Tbagi 25527S 5070W 803 143.5 172.2 96.5 70.4 55.7 156.4 100.8 S 19uecu 2571'S 510'W 803 166.1 140.2 155.4 100.8 152.4 100.8 S 19uecu 2571'S 510'W 50.3 61.2 55.7 66.3 167.6 152.2 166.8 177.5 166.8 </td <td>•</td> <td>Litoranea</td> <td>25-135</td> <td>48*48'W</td> <td>8</td> <td>141.9</td> <td>125.8</td> <td>115.8</td> <td>6.13</td> <td>8.7</td> <td>49.4</td> <td>52.4</td> <td>65.0</td> <td>· .</td> <td></td> <td>÷.</td> <td></td> <td></td> <td>1134.(</td>	•	Litoranea	25-135	48*48'W	8	141.9	125.8	115.8	6.13	8.7	49.4	52.4	65.0	· .		÷.			1134.(
Guadu Zr*7'S 49*6'S 910 155.8 131.3 150.9 152.4 108.1 1 Thagi Zr*7'S 49*6'S 910 155.8 101.4 76.3 61.9 72.0 92.9 165.8 117.2 159.0 160.8 117.2 5 Thagi Zr*7'S 50*7W 800 162.1 172.3 101.4 76.3 61.9 72.0 92.9 166.8 117.4 160.8 117.4 1 placeu Zr*7'S 50*7W 800 168.1 140.5 136.8 66.5 70.4 55.7 84.7 101.4 176.3 117.4 146.3 117.4 1 placeu Zr*7'S 50*7W 800 168.1 146.2 156.4 61.8 88.7 105.1 156.3 117.4 1 placeu Zr*7'S 50*0YW 400 190.5 144.0 766.8 146.3 177.4 156.3 177.4 156.3 177.4 156.3 177.4 176.5 117.8 127.0 127.0 127.0 126.1 160.8	Guadu Z**/*S state 131.2 150.9 152.4 150.9 152.4 150.9 152.4 150.9 152.4 150.9 152.4 150.9 152.4 150.9 152.4 150.9 152.4 150.9 <t< td=""><td></td><td>Iguacu</td><td>25-25%</td><td>W-80-63</td><td>000</td><td>146.1</td><td>123.4</td><td>111.6</td><td>85.3</td><td>62.7</td><td>48.7</td><td>56.4</td><td>72.9</td><td></td><td></td><td></td><td>4</td><td></td><td>1180.5</td></t<>		Iguacu	25-25%	W-80-63	000	146.1	123.4	111.6	85.3	62.7	48.7	56.4	72.9				4		1180.5
Itbagi 257135 5000TW 860 132.6 133.3 132.3 101.4 76.3 61.9 72.0 92.9 106.6 142.1 159.0 160.4 117.2 Itbagi 257135 50°0TW 860 122.1 16.9 72.0 92.9 106.6 142.1 159.0 160.4 114.4 Iguacu 257275 50°0TW 800 166.1 75.1 55.7 84.8 101.5 153.2 166.8 144.5 Iguacu 257255 55797W 400 190.5 135.0 156.1 140.5 156.1 141.2 166.8 114.4 Iguacu 257425 55797W 400.3 156.1 141.2 166.8 117.4 155.4 117.8 Iguacu 257425 5579 156.1 144.2 140.5 112.4 125.4 117.8 Iguacu 257975 5579 166.1 75.1 56.9 70.4 155.1 127.4 125.4 127.	Theorie 257135 50001W 6800 152.6 138.3 132.3 101.4 76.3 61.9 72.0 92.9 106.6 142.1 158.0 160.4 F Theorie 257175 50°07W 880 162.1 137.5 132.3 105.1 160.6 142.1 158.0 140.8 I Theorie 257275 50°05W 800 164.1 137.5 130.2 62.7 84.6 101.4 130.2 154.4 100.8 Iguacu 257275 50°07W 600 164.1 75.1 56.4 61.8 88.7 155.2 156.2 154.5 166.3 Iguacu 257375 5570Y 1300.5 155.0 144.2 156.4 155.1 157.1 156.2 151.2 Iguacu 257375 5570Y 156.3 152.5 166.1 76.6 35.3 177.4 156.3 157.4 156.3 157.4 156.3 157.4 156.3 151.4 155.3 151.4	÷	Guacu	26*47'S	49*46'S	910	155.8	131.9	124.8	92.4	67.1	53.1	. 62.8	84.2						1303.5
Inbagii 252775 5000000 1443 122/1 116.9 82.6 58.7 46.0 51.2 71.0 87.0 120.4 139.3 144.0 114.6 Iguacu 257255 5000000 166.1 137.5 135.8 70.4 53.3 62.7 84.8 100.4 138.2 154.4 100.8 114.6 Iguacu 257555 52757 84.8 101.4 138.2 155.4 100.8 114.6 100.8 114.6 100.8 114.6 100.8 114.6 100.8 114.6 100.8 114.6 100.8 114.6 100.8 114.6 100.8 114.6 100.8 114.6 100.8 114.6 <td>Tibagii 252/TS 50075W 603 1443 127.1 116.9 82.0 53.7 45.0 51.2 71.0 170.4 130.9 140.8 Iguacu 257215 51770W 1002 164.2 137.5 100.1 70.4 130.3 157.4 150.3 Iguacu 257215 51770W 1002 164.2 137.5 100.1 75.1 55.7 84.8 101.4 130.2 152.2 166.3 155.3</td> <td></td> <td>idequ</td> <td>25-13'5 4</td> <td>50"01"W</td> <td>880</td> <td>152.6</td> <td>138.3</td> <td>132.3</td> <td>101 4</td> <td>76.3</td> <td>61.9</td> <td>72.0</td> <td>92.9</td> <td></td> <td>·* .</td> <td>• •</td> <td></td> <td></td> <td>1405.8</td>	Tibagii 252/TS 50075W 603 1443 127.1 116.9 82.0 53.7 45.0 51.2 71.0 170.4 130.9 140.8 Iguacu 257215 51770W 1002 164.2 137.5 100.1 70.4 130.3 157.4 150.3 Iguacu 257215 51770W 1002 164.2 137.5 100.1 75.1 55.7 84.8 101.4 130.2 152.2 166.3 155.3		idequ	25-13'5 4	50"01"W	880	152.6	138.3	132.3	101 4	76.3	61.9	72.0	92.9		·* .	• •			1405.8
[Guacu 25715 5170W 1,000 164.2 137.5 132.8 38.1 70.8 55.7 66.3 38.7 105.1 140.3 154.4 160.8 114.4 Iguacu 257255 57.7557 55.7 65.3 65.3 62.7 84.8 101.4 138.2 155.2 166.8 114.4 Iguacu 257255 5572575 55.7 65.3 62.7 84.8 101.4 138.2 155.2 166.8 114.4 Iguacu 257355 557757 55.7 65.3 62.7 84.8 101.4 138.2 155.2 196.3 117.8 117.8 117.8 117.8 117.8 117.8 117.8 117.8 117.8 117.8 117.8 117.8 117.8 117.8 117.7 117.8 117.7 117.8	[Guacu 25715 5170W 1000 164.2 137.5 132.8 38.1 70.8 55.7 66.3 88.7 105.1 140.3 153.2 166.8 Iguacu 257255 5770W 400 168.1 140.5 155.5<	2	2	25 ZTS	50-35W	893	148.9	127.1	116.9	82.6	58.7	46.0	512	б Г						1190.
Iguacu 257255 56773 56.3 62.7 56.4 101.4 138.2 153.2 166.8 114.4 Iguacu 257255 5077W 400 190.5 155.5 156.8 117.4 138.2 153.2 166.8 114.4 Iguacu 25747W 400 190.5 155.8 155.5 106.1 75.1 55.4 61.8 89.1 106.8 137.4 136.3 177.4 136.3 117.8 Iguacu 257475 5570W 70.8 49.3 59.1 77.4 136.3 137.9 137.9 137.9 137.9 137.9 137.9 137.9 137.9 137.9 137.9 137.9 137.9 137.9 137.1 132.3 137.1 132.4 132.1 137.1 137.8 132.4 132.1 132.1 132.1 132.1 132.1 132.1 132.1 132.1 132.1 132.1 132.1 132.1 132.1 132.1 132.1 132.1 132.1	Iguacu 257255 52725W 840 163.1 140.5 135.8 155.1 56.4 61.8 101.4 138.2 153.2 165.3 Iguacu 257255 5577W 400 190.5 155.3 152.5 106.1 75.1 56.4 61.8 88.1 106.6 153.3 177.4 196.2 Parana 25715 55701W 770 154.0 144.2 90.2 70.8 60.5 61.8 60.5 153.3 177.4 196.2 177.4 196.3 Parana 25715 55701W 778 154.0 144.2 90.2 70.8 60.5 60.5 60.5 60.5 75.0 74.6 105.0 143.1 Parana 25711% 54706W 778 164.3 164.3 166.3 137.4 132.1 Iguacu 25575 55701W 756.4 150.3 120.7 97.4 83.9 65.0 67.3 65.0 75.7 75.7 75.0			25-21'S	51-30W	1,020	164.2	137.5	132.8	8	70.8	55.7	88.3	88.7						1374.7
Iguacu 25*425 55*425 55*4 61.8 59.1 100.6 133.3 177.4 196.3 127.0 Iguacu 25*15 55*10 71 53.1 55.1 55.4 61.8 59.1 100.6 133.3 177.4 196.3 137.6 Iguacu 25*115 55*01W 513 178.0 141.2 90.2 70.8 40.3 150.3 131.9 177.3 191.4 123.6 Iguacu 25*115 55*01W 71 80.3 141.2 90.3 160.4 132.8 196.3 137.9 177.4 120.7 111.8 Iguacu 25*115 55*01W 77.0 74.6 105.0 149.3 152.1 137.4 122.3 137.4 Iguacu 25*115 55*01W 77.8 160.3 55.0 40.3 45.1 60.5 78.0 177.3 177.3 177.3 177.3 177.3 177.3 177.3 177.3 177.1 132.6 117.7 117.8 122.7 85.4 132.7 137.4 172.7 97.4 Iguacu 25*255 55*1W 75.0 57.1 55.7 75.7 94.1 130.8 164.7 170.7	Iguacu 25*425 55*425 55*4 61.8 38.1 108.8 135.3 177.4 196.3 Iguacu 25*715 55*706W 51.3 175.4 145.2 106.1 75.1 56.4 61.8 38.1 108.6 143.3 177.4 196.3 Iguacu 25*715 55*706W 51.3 176.0 144.9 104.3 72.0 51.4 60.5 149.7 175.3 191.4 Iguacu 25*715 55*706W 710 124.2 104.3 104.3 72.0 51.4 60.5 135.3 137.4 136.3 137.4 Iguacu 25*715 55*706W 7100 124.2 106.3 141.2 90.5 45.1 60.3 65.7 75.7 94.1 130.3 147.7 Iguacu 25*05X5 57*51W 700 178.3 106.4 130.6 49.9 75.7 94.1 130.3 165.1 177.3 Iguacu 25*05X5 57*1W 700 178.3 120.4 139.6 69.0 51.3 56.7 76.7 164.7 177.9 Iguacu 25*05X5 57*1W 700 177.9 94.5 56.7 76.7 76.7 <t< td=""><td></td><td>liguacu</td><td>25 25'S I</td><td>52-25W</td><td>880</td><td>168.1</td><td>140.5</td><td>136.8</td><td><u>96.5</u></td><td>70,4</td><td>53.3</td><td>62.7</td><td>84.8</td><td>1</td><td></td><td>•</td><td></td><td></td><td>1372.7</td></t<>		liguacu	25 25'S I	52-25W	880	168.1	140.5	136.8	<u>96.5</u>	70,4	53.3	62.7	84.8	1		•			1372.7
Parana 3 257115 55701W 513 178.0 144.3 141.2 99.2 59.1 74.6 105.0 142.8 166.2 181.9 117.8 Parana 3 257115 54706W 50.3 155.0 149.3 104.3 72.0 51.4 60.5 78.9 106.2 181.5 117.8 Parana 3 257115 54706W 307 186.5 156.0 149.3 104.3 72.0 51.4 60.5 78.9 106.2 181.6 117.8 Iguecu 25710W 300 156.0 149.3 104.3 72.0 51.4 60.5 78.9 106.8 147.9 97.1 Iguecu 2570W 770 97.4 69.6 40.9 55.7 75.0 177.3 132.4 132.4 Iguecu 2570SS 5156W 1100.3 126.8 130.8 65.0 46.9 55.7 75.7 94.1 130.8 165.7 176.3 Iguecu 2570W 5571W 300 178.6 130.8 156.4 132.6 116.7 177.9 Iguecu 2705SS 5574W 77.7 99.9 140.3 162.6 177.9 116.7 Iguec	Planacu 257115 55701W 513 178.0 144.9 141.2 99.2 70.8 49.3 59.1 74.6 105.0 142.8 186.2 181.6 Paranas 257115 55705W 307 186.5 155.0 149.3 104.3 72.0 51.4 60.5 78.9 190.7 175.3 191.4 Paranas 257115 55705W 307 186.5 156.0 149.3 104.3 72.0 51.4 60.5 78.9 190.7 177.3 191.4 Iguacu 25703 51704W 1700 124.2 170.0 149.3 100.8 135.6 137.9 Iguacu 25703 51704W 73.6 99.8 69.0 51.3 55.7 74.1 130.3 152.9 155.1 Iguacu 2507S 5274W 700 177.9 138.5 94.3 65.0 57.7 75.7 94.1 130.3 152.1 Iguacu 2507S 5274W 700 177.9 95.0 47.3 162.6 177.9 30 19uecu 2507S 557 84.3 55.7 74.1 130.3 162.6 177.9 30 19uecu <td< td=""><td></td><td></td><td>25.42'S It</td><td>53*47W</td><td>\$</td><td>190.5</td><td>155.3</td><td>152.5</td><td>106.1</td><td>75.1</td><td>55.4</td><td>61.8</td><td>89.1</td><td>·.</td><td></td><td></td><td></td><td></td><td>1523.6</td></td<>			25.42'S It	53*47W	\$	190.5	155.3	152.5	106.1	75.1	55.4	61.8	89.1	·.					1523.6
Parana 5 257115 35700 149.7 175.3 191.4 123.4 Parana 5 257115 34700 106.8 149.7 175.3 191.4 123.4 Puecu 267155 51704W 778 150.3 120.7 116.0 79.6 67.1 83.8 166.8 147.9 97.1 Puecu 267055 51704W 1700 124.2 107.3 97.4 60.9 45.1 65.7 78.0 106.6 147.9 97.1 Puecu 267055 51704W 116.0 79.6 40.9 37.9 45.1 62.2 78.0 107.9 125.4 132.1 88.4 Iguacu 267055 5271W 930.0 150.4 139.6 59.3 59.4 65.7 75.7 94.1 130.8 166.7 176.7 Iguacu 267055 5274W 700 176.4 139.6 54.3 56.3 57.7 59.4 162.6 116.7 Iguacu 267055 5274W 650 47.8 56.7 77.7 99.9 140.3 165.6 Iguacu 267055 52704W 650 47.8 56.7 77.7 99.9 140.3 162.6 177.9 Iguacu 267055 55704W 650 47.8	Parana 5 257115 54*06W 307 166.5 165.0 149.3 104.3 72.0 51.4 60.5 78.9 106.8 149.7 175.3 191.4 Fjuecu 257135 51704W 776 150.3 120.7 116.0 79.5 56.9 40.8 48.3 67.1 83.8 116.8 135.1 Iguacu 257035 51704W 776 150.3 120.7 116.0 79.5 55.7 75.0 107.9 125.4 132.1 Iguacu 257035 5170W 67.1 83.8 69.0 51.3 55.7 75.0 164.7 179.3 Iguacu 257075 5271W 700 178.3 150.4 139.6 69.0 51.3 55.7 77.7 99.9 162.6 177.9 Iguacu 257055 52741W 700 177.8 139.6 65.0 47.3 56.7 77.7 99.9 162.6 177.9 Iguacu 257055 52741W 700 177.8 139.6 65.0 47.8 56.7 77.7 99.9 162.6 177.9 Iguacu 257055 52741W 700 177.8 130.5 94.3 56.7 77.7 </td <td>-</td> <td>(</td> <td>25 31 5 1</td> <td>M 10.02</td> <td>513</td> <td>178.0</td> <td>144.9</td> <td>141 2</td> <td>88</td> <td>70.8</td> <td>49.3</td> <td>201</td> <td>74.6</td> <td></td> <td></td> <td>di T</td> <td>÷.</td> <td></td> <td>1413.0</td>	-	(25 31 5 1	M 10.02	513	178.0	144.9	141 2	88	70.8	49.3	201	74.6			di T	÷.		1413.0
Guecu 257135 57704W 778 130.3 120.7 145.6 97.1 Guecu 25704W 770 130.3 156.9 40.8 45.3 67.1 83.8 136.8 147.9 97.1 Guecu 257295 51760 170.3 97.4 69.6 40.3 55.7 56.1 45.3 67.1 83.8 135.4 132.1 86.4 Guecu 257295 51750 170.3 97.4 69.6 40.3 55.7 75.0 107.9 165.1 106.7 Guecu 257255 5271W 9300 166.4 133.6 63.0 51.3 59.4 130.8 165.7 166.7 177.9 165.1 106.7 Guecu 257075 5274W 700 177.9 150.4 133.6 94.3 65.0 47.3 56.7 77.7 99.9 140.3 162.6 177.9 115.6 Juecu 257055 5270W 65.0 47.3 56.7 77.7 99.9 140.3 162.6 177.9 115.6 Juecu 150.5 177.7 99.9 47.3 56.7 77.7 99.9 140.3 162.6 177.9	Guacu 257105 57704W 778 150.3 120.7 116.8 136.8 147.9 Juacu 267295 51158W 1,100 124.2 107.3 125.4 132.1 Juacu 267295 51158W 1,100 124.2 107.3 125.4 132.1 Juacu 267295 51158W 1,000 124.2 107.3 125.4 132.1 Juacu 267295 51158W 130.8 130.8 155.9 46.1 130.3 165.1 Juacu 267255 5271W 930 176.8 139.6 69.0 51.3 55.4 130.3 165.1 Juacu 26775 5241W 730.6 133.5 94.3 130.3 165.6 177.3 Juacu 267075 5271W 93.8 69.0 51.3 55.4 82.3 162.6 177.9 Juacu 270575 5274W 138.5 94.3 65.0 47.3 152.6 177.3 Juacu 270575 5274W 133.6 94.3 133.6 94.3 152.6 177.3 Juacu 270575 5274W 133.6 94.3 65.0 47.8 58.7 77.7 193.9 </td <td></td> <td>3</td> <td>22-115</td> <td>M 202 M</td> <td>102</td> <td>186.5</td> <td>155.0</td> <td>149.3</td> <td>104.3</td> <td>720</td> <td>5.4</td> <td>80.5</td> <td>78.9</td> <td></td> <td></td> <td>: •</td> <td></td> <td></td> <td>1481</td>		3	22-115	M 202 M	102	186.5	155.0	149.3	104.3	720	5.4	80.5	78.9			: •			1481
Iguacu 267295 51156W 1,100 144.2 107.3 97.4 69.6 49.9 37.9 45.1 62.2 78.0 107.9 125.4 132.1 86.4 Iguacu 267255 5271W 930 166.4 133.8 176.3 150.4 132.1 86.4 Iguacu 267075 5274W 700 177.9 150.6 133.6 94.3 165.1 165.1 166.1 Iguacu 267075 5274W 700 177.3 150.6 93.8 66.0 51.3 59.4 82.3 162.6 116.1 Iguacu 287075 5274W 700 178.3 150.6 94.3 65.0 47.8 56.7 77.7 99.9 140.3 162.6 117.9 Iguacu 287055 5274W 650 47.8 56.7 77.7 99.9 140.3 162.6 177.9	Iguacu 267295 51156W 1,100 124.2 107.3 97.4 69.6 49.9 37.9 45.1 62.2 78.0 107.9 152.4 132.1 Iguacu 267075 5271W 930 166.4 133.6 93.8 66.0 47.9 55.7 75.7 94.1 130.8 162.1 Iguacu 267075 5274WW 700 178.3 150.6 133.6 98.8 66.0 51.3 58.4 82.3 102.6 165.1 Iguacu 267075 5274WW 700 177.9 133.6 98.8 66.0 51.3 56.7 77.7 99.9 160.7 Iguacu 287055 5370WW 56.0 47.8 56.7 77.7 99.9 160.3 177.9		iouacu	20-135	51 04 W	18	150.3	120.7	116.0	79.6	56.9	40.8	48.3	67.1		: -			e.	1165.0
Iguadu 25°25'S S2°21'W 330 166.4 135.8 136.8 136.9 66.9 55.7 75.7 94.1 130.8 165.1 108.7 Iguadu 26°07S S2°4'W 700 178.3 130.6 98.8 69.0 51.3 59.4 82.3 165.1 178.5 118.1 Iguadu 26°07S S2°4'W 700 178.3 133.6 98.8 69.0 51.3 59.4 82.3 162.6 118.1 Iguadu 26°07S S2°4'W 700 178.3 133.6 94.3 65.0 47.8 56.7 77.7 99.9 142.3 162.6 115.6 Iguadu 26°05'S S2°05'S S2°05'S2°05'S S2°05'S S2°05'S S2°05'S2°05'S	Iguacu 25'75'S S2'21'W 930 176.4 135.8 128.8 63.9 46.9 55.7 75.7 94.1 130.3 165.1 Iguacu 26''07S S2''4'W 700 178.3 130.4 130.4 130.4 130.3 65.0 51.3 59.4 82.3 102.6 142.3 164.7 178.5 Iguacu 26''05'S S2''0'W 65.0 47.8 56.0 47.8 56.7 77.7 99.9 140.3 165.1 Iguacu 26''05'S S2''0'W 65.0 47.8 56.7 77.7 99.9 140.3 162.6 177.9			26 29'S	51 -59W	8	124.2	107.3	97.4	69,6]	49.9	37.9	45.1	62.2		1.0				1037.0
Iguacu 26°07S 52°4W 700 178.3 150.4 130.6 99.8 69.0 51.3 59.4 82.3 142.3 148.1 116.1 Iguacu 28°07S 55°0WW 650 47.8 99.9 143.1 138.5 94.3 65.0 47.8 117.9 115.6 115.6	[guacu 26'07S 52'41W 730.6 178.3 150.4 139.6 93.8 69.0 51.3 56.4 82.3 142.3 178.5 [guacu 26'07S 55'07S 55'07 148.1 138.6 93.3 65.0 47.8 123.5 142.3 142.3 142.3 142.3 142.1 177.9 [guacu 26'05S 57'07S 56'0 47.8 56'0 47.8 56'7 142.3 142.5 142.5			26°25'S	52"21W	8	166.4	135.8	126.8	8.68	63.9	46.9	55.7	75.7						1303.5
[guace 23°04W] 650 177.9 148.1 138.5 94.3 65.0 47.8 95.7 1 40.3 140.3 146.6 177.9 145.6 147.8 145.6 147.8 145.6 147.9 147.9 145.6 147.9 14	Iguacu 23.05 177.9 94.31 138.5 94.31 177.9 148.1 177.9 148.1 177.9 148.1 177.9 148.1 177.9 148.1 177.9 148.1 <t< td=""><td></td><td>-</td><td>26*07S 4</td><td>52*41W</td><td>8</td><td>178.3</td><td>150.4</td><td>139.6</td><td>98.8</td><td>69.0</td><td>51.3</td><td>59.4</td><td>82.3</td><td></td><td></td><td></td><td></td><td></td><td>5417</td></t<>		-	26*07S 4	52*41W	8	178.3	150.4	139.6	98.8	69.0	51.3	59.4	82.3						5417
		8			N 10.2	650	177.9	148.1	138.5	94.3	65.0	47.8	56.7	77.7		: :	1	e,		1386.7
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一條一時,一時時間還是一樣一樣,也是一個的事件。 化化学学 建建合成化化学 计分子分析 计分子分子 化分子分子 化分子分子 化分子分子 化分子分子 化分子分子 化分子分子 化分子分子			•	-				- 			• .	•••		· ·	: :	1				12
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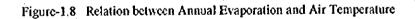
- 13 -

As considering relation between evaporation and air temperature at a certain place, annual mean relation of both parameters can be described as following equation; (Refer to Figure 1.8)

Evp = 91.6 + 67.9 * Tm

where Evp : annual mean evaporation by Penman's equation (mm) Tm : annual mean air temperature (°C) correlation coefficient = 0.87





1.2.5 Potential Evapotranspiration

Evapotranspiration is the evaporation from all water, soil, vegetative, and other surfaces, plus transpiration. COPEL computed the value of potential evapotranspiration by using Penman's equation (by Frere, 1979) which is commonly used in Brazil.

The calculated results were summarized in Table-1.5 and was plotted as an Iso-potential evapotranspiration map (Figure-1.10).

The annual potential evapotranspiration at a certain place except for Litoranea area is related to its elevation, it can be described as following equation; (Refer to Figure-1.9)

where, Evt : annual potential evapotranspiration by Penman's equation (mm) EL : elevation (m)

correlation coefficient = 0.70

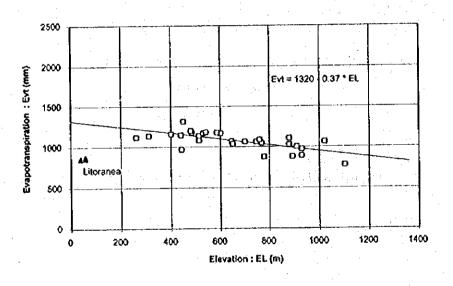


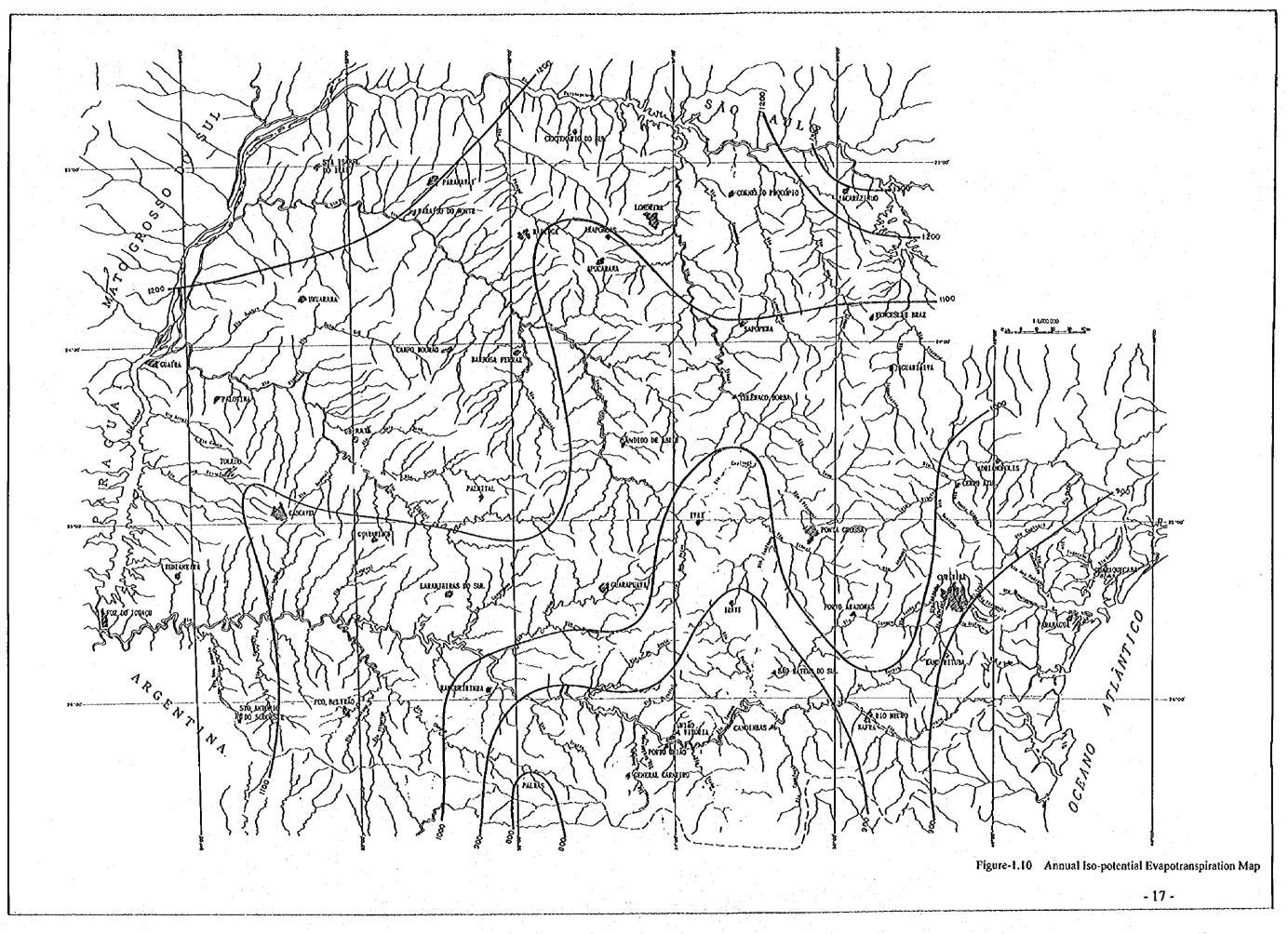
Figure-1.9 Relation between Annual Potential Evapotranspiration and Elevation

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Table-1.5 Annual and Monthly Mean Potential Evapotranspiration (Simulation Period 1974 - 1993, 20 years)

C Tato		د 	Location	ç	E S		Sac.	ð	APPA -	Š	į	c S S S	ŝ	g	₹.	Š	INGEN I	
No. ISt.No. Name	1	Lat.	tong.	Altrude					•			•	•					_
1 02251027 Bela Vista	P.P.3	22*57'S 51*12W	r —	800	133.3	117.0							38.6	120.8	1.42	130.4		Ľ.
2 02349030 Joaquim Tavora	Cinzas	23°30'S 49°52'W	49°52W	512	133.3	117.2			•	•	1		84.7	118.9	133.6	129.9		•
s 02350017 Cambara	P.P.1	23-00'S 50-02'W	50-02W	450	144.7	123.5					-		108.7	141.8	151.7	139.5	•-	•
4 02350018 Bandeirantes	Cinzas	23 06'S 50 21 W	50-21 W	440	135.4	115.0							85.3	118.1	134.0	131.0		•
5 02351003 Londrina	Tibagi	23-18'S 51-09W	51*09W	585	135.2	116.8							91.1	124.2	136.4	132.7		
6 02351008 Apucarana	Decido de la comencia	23-30'S 51-32 W	51-32W	146	124.3	104.8							79.0	113.4	125.5	126.3		ľ
7 02351011 Ibipora	Tibagi	23*16'S S1*01W	S1 01 W	484	135.3	118.3							89.4	123.1	135.2	131.9		·
8 02352017 Paranavai	<u>P</u>	23*05'S 52*26W	52"26W	480	142.9	120.9							87.7	123.3	138.6	138.9	`	
9[02352019 Clanorte	Ivai	23-40'S 52-35'W	52 ⁻³⁵ W	530	139.9	118.7							35.8	120.5	135.5	138.0		•
10 02353008 Umuarama	Piquiri	23-44'S 53-17'W	53-17W	480	142.6	122.0							86.3	120.8	137.7	143.0	•	
11 02449013 Cemo Azul	Ribeita	24-49'S 49"15 W	49°15'W	443	121.5	103.2						ł	65.4	9.66	119.7	120.2		
12 02450011 Telemaco Borba	Tibagi	24-20'S 50-37'W	50°37'W	768	128.1	109.6							7.3	109.1	122.6	125.2		•
13 02451052 Candido Abreu	IEV.	24*38'S 51*15W	W21-15	<u>8</u> 8	132.9	111.9							80.1	117.1	131.4	129.3		·
14 02452050 Nova Cantu	Piquin	24*40°S	24-40'S 52-34W	S 40	146.7	119.9						÷ .	86.6	121.6	135.4	146.4		•
15 02453003 Patotina	Piquin	24*18°S	24-18'S 53-55W	310	142.7	122.3							82.0	114.5	130.9	143.8		
16 02453023 Cascavel	Parana 3	24*56'S 53*26W	53*26W	760	136.9	112.3					л. 1		79.1	110.1	124.4	137.2		
17 02548038 Morretes	Litoranea	25°30'S 48°49'W	48*49W	29	114.1	3.66							56.3	80.1	98.4	106.9		
18 02548039 Guaraquecaba	Litoranea	25-18'S 48-20W	48-20W	40	110.3	98.4							55.8	78.2	80.08	104.1		
19 02548070 Antonina	Litoranea	_	25-13'S 48-48W	8	110.0	97.3							56.6	78.9	95.2	102.9	·.	
20 02549041 Piraquara	lguacu	25-25'S	25"25'S 49"08W	930	112.7	94.8				•			63.5	89.3	103.5	106.5		
21[02549091 [Lapa	Iguacu	25-47'S 49-46'S	49*46'S	910	121.6	101.8							74.9	103.1	118.9	119.7		
22 02550024 Ponta Grossa	Tibagi	25-13'S	25"13'S 50"01'W	880	128.7	108.5							84.5	113.1	127.1	127.9		•
23 02550025 Teixeira Soares	Tibagi	25*27S	25-27'S 50-35W	893	113.3	96.1							64.3	90.4	106.4	107.5		
24 02551010 Cuarapuava	Iguacu	25°21'S	25"21'S 51"30W	1.020	128.3	106.7					•		82.6	109.9	121.5	126.2		•
25 02552009 Laranjeiras	guacu	25-25'S	25-25'S [52-25W]	880	129.0	107.0							76.0	105.1	117.8	128.1		Ĩ
26 02553015 Pranaito	ncen5t	25.42'S	25-42'S 53-47'W	400	147,4	119.7							82.9	117.8	136.9	152.5		ľ
27[02553018 Quedas Iguacu	noenől	25°31'S	25°31'S 53°01W	513	137.5	111.3							7.9.7	109.1	128.1	140.2		
28 02554026 Sao Miguel	Parana 3		25-11'S 54-08'W	307	143.0	118.5							79.9	113.7	134.8	146.9		·
29 02651007 Porto União	Iguacu	26-13'S	26-13'S 51-04W	78	115,4	92.3				•			62.9	89.2	105.5	113.9	_	
30)02651043 Palmas	Iguacu	26-29'S	26-29'S 51-59W	1,100	95.7	82.3	74.2	51.7	35.4	26.1	31.3	45.0	53.0	81.7	96.3	101.7	65.0	779.4
31 02652003 Clevelandia	lguacu	26*25'S	26"25'S 52"21W	026	126.9	103.0							70.1	98.8	116.9	126.3		
32 02652035. Pato Branco	noen6y	26°07'S	52°4 W	8	136.9	115.0							7.0	108.4	126.7	137.3		
23 OPERADED CONCINED DATED	Parison 1	25.00.50	Wans Stew	650	126.4	112.1							72.5	18.1	1242	128.4		



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1.2.6 Wind Speed and Direction

The wind speed and direction are observed by 3 methods in Parana, such as using automatic anemometer recorder, manual observation with anemometer (10 minutes duration) and visual observation. The wind condition in Parana depends on the air mass movement of the whole Brazil.

In January equatorial air mass is moderately humid and has entered from the north. In July the tropical air mass which brings easterly or northeasterly winds to near all area. According to collected data, wind speed is stable at range between 2.0 and 5.0 m/sec throughout the year. The annual mean and monthly wind speed at the each selected stations are summarized in Table-1.6.

-	Statt		Easin		aceli		Jan,	Feb	Mar.	Aø.	May	Na	Jul,	Aug	Sep.	¢a.	Ňov.	Dec.	Mean
	SLNo 07251027	Name Bela Yata	371	Lel. 22'57'5	Long 51°127W	A2840e 800	2.4	2.4	2.4	25	24	24	28	28	31	28	27	24	2
Ì			Cinzas	23°30'S	10-67-4	512	5E 2 6	<u>SE</u> 26	SE 2.8		<u>Ş</u> €	5E 2.4	<u>5E</u> 3 0	\$E	5E 37	5E 34	5E 3 2	5E 29	
2	02349070	Josquin Tavora					ε	· E	E	E	E	3	E 24	E	<u> </u>	- E 35	E 32	E 28	2
3	U2350017	Cambara	P.P.1	23'00 S	50°02'W	450	23 E	2 G E	2.1 E	- 24 SE	20 E	21	E	E	8E	E	E	ε	
7	02350018	S an deir antes	Cnzes	23°06 S	50°21 W	440	28	2 8 SE	2 0 SE	31 SE	26 5E	2 C	3 0 SE	35 5E	4 2 5E	4 C SE	37 SE	3 2 SE	3
5	02351003	Londora	Tead	23'18 5	51'08'N	585	3£ 27	25	2.4	25	23	23	26	27	30	31	30	5 8	2
			-	23°30 S	(1127A)	745	. E	E 42	- E 43	<u>. Е</u>		<u>e</u>		- <u>E</u>	<u>۶</u>	- <u></u>	- E 48	E 43	- 4
1	02351008	Арисельра					E	£	E	٤	22	<u>E</u>	2 5	2 T	<u>٤</u>	E 32	3.	<u> </u>	2
7	02351611	ib por	T ¢ sgr	23'15'5	\$1'0'W	454	2 6 5E	2 4 SE	2 4 5E	2 S SE	SE	Ś	8E	SE	SE	ŠE	\$Ė	SE	5
8	02352017	Perantival	tvai	23.92.8	52"26'W	400	24 54	23 NE	23 NE	23 NE	23 . NE	26 NE	ž te	29 NE	28	27 NE	27 RE	2.6 NE	
	02352019	Cianorta	1val	23'40'S	52°35W	530	2 5		23	2.4	22	2 3	26	27	28	27	26	24 E	2
_	00063408	Umuarama	Piquid	23445	53°17W	680	- 25	2	24	E 25		- E 2 B	<u>٤</u> ١2	E	32	26	<u> </u>	26	2
1							NE	NE	NE	NE	<u>.</u>	NE 1.7	NE 10	NE 19	NE 2.1	NE 2	<u>NE</u>	<u>NE</u>	N
11	02449013	Cene Azul	Ribeira	24'49'5	49°15'W	443	1.B NE	NE	19 NE	LP NE	NE	NE	NE	54	NE	NE	NE	NE	
12	02450011	Telemece Borba	Thing	24*20 5	50'37W	768	20 5E		1.4 5E	18 5E	1.6 5E	1.7 SE	10 5E	18 58	20	21	₹2 15E	22 5E	8
i3	02451052	Cendido Abreu	Mei	24'38'5	\$1°\$\$'%	645	2.1	20	1.0	1.6	20	1.9	21	2 3 5E	24 56	23 SE	23 56	2 2 5E	2
	11/52060	Nova Canto	Pigeiri	24*40 S	52°34 W	540	<u>56</u>		5E	. <u>€</u> 1.₹	5E	5E 1.6	<u>\$E</u> 1 \$	11	20		20	18	1
		And the second second				×	ε	<u>\$</u> E	÷ €	<u>88</u> 22	<u>SE</u>	- E 20	2 2	23	28	E 30	2 E	24	
15	02453003	Palotina	Piquin	24'18'5	53°55*A/	310	NΈ	NE	NE	ΝE	NE	NE	NE	NE	NE	NE	NE	NE	Ň
13	02453023	Cascaval	Parana	2415615	53'28 W	760	3 0 NE		3 D NE	11 NE	33 145	34 14	30 ME	38 NE	38 NE		35 NE	NE	3
17	02548038	Monetes	Lilafana)	25*30'5	49' 49'W	59	1 17	15	13	1.1	1.1	12	12	12 NE	1.4 NE		1 8 NE	- 1.7 NE	
	000 49000	Gualaguecaba	l tomate	25"18'5	48-2014		NE 23		NE 19	<u>NE</u> 17	15	NE 15	<u>NE</u> 11	1.7	2.1	24	25	24	2
		1. S. S.				60	23			5E		<u>86</u> 22	<u>814</u> 23		22		SE 25		
19	02549070	Antonina	Lilorarite	25135	48°48 W		5	5	5	\$	5	5	5	5	S	5	31	5	
20	02543041	Praquera	iquacu.	25.522	49'06 W	830	21		23	24 E		23 N	27	27 N	. 29 E	ε	ε	E	I
27	02549041	Lapa	ligeacu	25*47'\$	49 46 5	910	34	2 9		20	2.0	2 I NE	31 NE		35 E		30		3
11	4365313	EFonte Grosse	i. Téad	25'13'\$	50°01W	880	- 3				33	33	38	36	40	40	1 10	38	
		1.	Ι												<u>NE</u>				
53	0255002	S Febreirn Scarns	Tibəgi		50°35W	1	SE	SE	SE	SE	5E	No.	ŞE	SE	68				
24	025510 1	Guarapuarie	iguacu.	25'21'5	\$1°30W	1,020	20					1 NS	NE	NE	34	<u>ا_</u>	N	ε .	N N
2 5	0255200	aranjekas	Iguecu	25-25-8	57°25Y	860	2	5.2	22	23	24		20	20 E	25		2		
×	0255301	Sisterato	iguacu	25'42 5	53 47%	43				1 31	30	3 6	11	34	34	3.4	3 4	37	1
_	1		- ·		I		NE								NE				
22	0255301	Quedes Ig. Dou	lgubou		53°61W		56	56	58	SE	SE	5E	85	SE	SE	S	50	58	
21	0255402	6 Sao Miguel	Parana	25'11 5	54'08'A	307	2					ε (<u> </u>	E	ſ				
25	0265100	Porte Unite	iguaru	26'13'8	51'01'M	271	1	5 5.1	6 1.0	1 13	1.9						2		
÷	0265104	3 Patrice	Iguacu	26.29.5	51-5914	1,10	<u>54</u>		2	10	3 30	30	21	3 3	31	1 1	3	5 3	1 3
							M												1 1
3	10255200	3 Ciz siandia	guecu		52°21V		M	= N	N	M	NE	N	N	NE	N	N			
3	2 0265203	5 Pate Brance	liguacy	26'07'8	52'41'4	70	i ii					se se	se	54	56	5	S	E N	4 4
3	30255301	2 Francisco Estra	6 iguacu	26*05	53'04'4	65	2	3 2	2 2	9 1 5	1	21							
Ľ		PCO COPEL			J	L	<u>1 N</u>			<u>N</u>	1 24	<u>1 84</u>		بجمسك	L		1		·

Table-1.6Annual and Monthly Mean Wind Speed and Direction(Available Period between 1974 and 1993)

1.2.7 Sunshine Hours

It is generally known that sunshine hours relates to the latitude of observation point. The state of Parana locates between latitude 22°30' and 26°40' and the tropic of Capricorn passes through the north area (Londrina, Maringa city). According to the collected data, mean annual sunshine hours has about 7 hours/day at the regions except for Litoranea area. Litoranea area has about 4 hours sunshine hours almost through the year, because Litoranea area locates to nearby Serra do Mar high mountain range and the fog gathers, especially in the morning. (Refer to Table-1.7)

	Sistio	n	Basin		Locati		Jan	Feb.	Mar	Apr.	May	S.	Jul.	Aug.	Sep.	Oct	Nov.	Dec.	Mean	Annua
10.	St No.	Name	1	Lat	Long.	Altitude								1.1					- 1 - E	
1	02251027	Bela Vista	P.P.3	22.278	51"12'W	ŝ	6.9	7.0	6.9	7.4	6.9	6.7	7.5	7.4	6,4	7.2	7.7	66		2,57
2	02349030	Joaquim Tavora	Çinzas	23*30'S	49152W	512	6.B	6.7	8.9	7.1	63		6.9	7.1	82	7.3	7.7	6.3	58	2,47
3	02350017	Cambara	P.P.1	23100 S	50°02°W	450	7.0	69	6.9	7.4	6 9	6.6	7.5	7.5	8.4	7.2			7.0	2,55
- 4	02350018	Bandeirantes	Cirizas	23°06'S	50°21W	- 440	7.1	6.9	7.0	7.3	. 6.6	66	7.3	7.3	63		7.7	6.7	7.0	2,56
	02351003		Tibagi	23"18"S	51 09W	585				7.4	6 .8		- 7.À	7.3	6.3	74	7.6		7.0	2,56
6	02351008	Apucarana	Pirapo	23'30'S	51'32W	745	7.0	6.8	7.4	75	68	7.5	1.7	7.5	6.6	7.3	7.3	6.6	7.1	2,59
- 7	02351011	ibipora	Tibegi	23'16'5	51°01W	- 484	6.6	6.9	8.9	7.4	6.9	6.6	7.5	7.3	6.3	73	7.5	6.5	7.0	2,56
8	02352017	Paranaval	Ivai	23'05'5	52 26 W	480	7.4	7.2	7,4	7.5	6.6	86	7.4	7.2	62	. 7.5	7.9	7.0	7.2	2,61
9	02352019	Cianorte	Ival .	23.40.8	52°35W	530	7.2	7.1	7.4	7.3	65	6.6	7.3	7.0	.6.1	7.3	1.7	7.1	. 7.0	2,57
10	02353008	Umuarama	Piquid	23*44'S	53°17W	480	7.4	7.4	7.4	7.4	67		7.1	68	6.1	7.2	7.9			2,59
11	02449013	Cerro Azul	Ribeira	24 49 5	49 15W	443	5.6	55	52	4.9	. 4.2	3.7	4.2	4.4	4.2	5.1	5.7	5.4	4.8	1,73
12	02450011	Telemaco Borba	Tépoji	24'20'5	50°37'W	768	8.5	65	6.3	63	6.0	5.7	6.4	8.4	5.6	6.5	6.7	62	63	2,28
13	02451052	Candido Abreu	ivai	24'38'5	51 15W	645	8.5	7.3	6.6	7.2	6.9	5.8	6.7	6.8	5.8	- 7.0	8.0	. 7.6	6.9	2,53
14	02452050	Nova Cantu	Piquiri	24'40'5	52°34W	540	7.4	7.0	7.0	6.8	8.4	8.0	6.6	8.7	6.2	. 6.9	7.2	7.1	6.8	2,47
15	02453003	Paloina	Piquif	24'18'S	53*55W	. 310	7.7	7.5	7.4	7.1	6.4	60	6.7	6.5	6.0	7.0	7.6			2,53
16	02453023	Cascavel	Parana 3	24'56'S	53 26 W	760	7.3	7.1	7.1	8.7	8.3	8.1	6.7	65	5.9	6.7	7.3	7.3	5.8	2.45
17	02548038	Morretes	Litoranea	25*30\$	48'49'W	59	4.9	5.1	4.7	4.3	4.6	4.5	4.2	3.E	3.1	3.7	4.5	₹.5	4.3	1,58
18	02548039	Guaraquecaba	Litoraries	25'18'S	48°20'w	: 40	4.6	4.8	4.5	4.3	4.5	4.4	4.2	3.8	3.1	3.5	4.5	- 4,4	. 4.2	
19	02548070	Antonina	Litoranea	25'13'S	48'49'W	60	4.7	4.6	4.5	4,4	4.7	4.6	4.3	4.0	3.2	3.6	. 4.5	4.4	4.3	1,56
20	02549041	Piraquara	iquacu	25-25-5	49°08'W	930	5.6	. 5.6	5.1	4.9	50	5.1	5.6	53	4.5	5.1	5.6	5.1	52	
21	02549091	Lapa	Guacu	25*47\$	49 46 \$	910	55	6.4	52	57,	5.4	4.9	. 5,6	5.5	4.5	53	6.6	6.3	5.6	2,03
22	02550024	Ponta Grossa	Tibagt	25135	50101W	880	5.B	6 0	5.9	59	5.9	58	6.3	62	\$.5	6.1	6.3	5.6	8.0	2,17
23	02550025	Tebairs Soares	TibediT	25-275	50°35W)	693	5 B	. 59	5.4	5.1	5.0	5.1	53	5.5	5.0	56	6.1	. 5 2	5.4	1,97
24	02551010	Guarapuava	lguecu	25-21-5	51 30W	1,020	6.5	6.4	. 6.5	63	60	5.7	6.4	8.6	59	66	66	86	6.3	2,31
25	02552009	Laranjeres	lguacu	25-25'5	52 25 W	880	6 B	6.7	88	8.7	63	80	66	65	5.9	8.7	89	6.7	5.6	2,39
	02553015		locecu	25'42 \$	53'47 W	400	6.B	67	6.8	8.7	83	80	8.6	65	59	8.7	69	8.7	3.8	2,39
27	02553018	Ouedas louacu	lguacu	25'31'S	53'01W	513	7.3	6.9	7.0	6.4	59	5.4	6.1	6.3	5.9	66	7.4	7.5	8.6	2,40
		Sao Miguel	Parana 3			307	7.9	7.6	7.2	8.0	5.7	52	59	6.1	5.9	7.1	. 7.8	82	6.7	2,44
		Porto Uniao	iguacu	26-13 5	51 04 W	778	6.5	7.5	6.8	7.4	6.5	5.9	63	62	5.7	6.7	7.4	7.3	8.7	2,45
	02651043		Jousicu		51 59 W	1,100	6.9	85	85	53	5.7	57	5.8	62	5.7	5.8		69	6.3	
		Clevelandia	liguocu	26-25-5	52'21W	930	7.4	69	71	8.4	6.1	5.8	6.3	62	60	69	7.5	7.4	66	2,42
32	02652035	Pato Branco	louncu		52'41W	700	7.8	72	7.5	8.4	- 6.1	5.6	62	6.4	6.3	8.9	7.5	7.6	3.8	2,49
22	02662012	Francisco Behrao	IQUECU	261055	53°04W	650	7.3	7.1	7.2	63	6.0	5.4	6.1	6.1	6.1	6.9	7.5	7.5	86	

Table-1.7 Annual and Monthly Daily Mean Sunshine Hours (Available Period between 1974 and 1993)

Data Source : COPEL



1.2.8 Relative Humidity

Relative humidity in Parana is almost constant, range between 70 and 80 % throughout the year. Monthly relative humidity by the selected stations is summarized in Table-1.8.

The annual mean relative humidity is closely related to air temperature, it can be described as the following equation; (Also see Figure 1.11)

RH = 111.5 - 1.9 * Tm

where, RH : annual mean relative humidity (%) Tm : annual mean air temperature (°C) correlation coefficient = 0.81

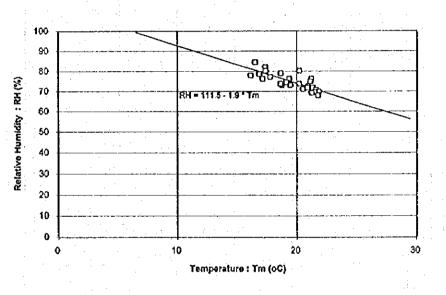


Figure-1.11 Relation between Relative Humidity and Air Temperature

Table-1.8 Annual and Monthly Mean Relati (Available Period between 1974 and 1
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do sete	-	a. 16							~		_		_						_	~		-	~		~	~	~	~	č	~		7	~	5	
													•											1		·					78.0				
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È		. 1			Ċ															•					1	÷	,				74.1				
Ś		65.9	68.8	64.6	6.49	66.0	67.0	64.0	66.0	65.2	65.0	76.3	75.1	73.0	67.3	71.5	68.8	85.5	85.1	84.9	84.3	80.8	75.4	1.8	76.0	101	66.0	69.69	69.5	74.6	74.9	72.6	69.5	69.9	
ġ,					÷				۰.					•						•											74.9			•	
		61.8	67.5	64.5	62.7	65.1	62.1	62.6	62.2	63.2	61.3	80.9	78.4	73.3	629	75.0	69'0	86.8	87.8	86.9	81.9	80.6	74.6	77.5	74.8	6 29	65.5	70.1	73.2]	80.4	75.3	72.8	70.3	72.1	
		66.5	7.7	71.0	68.1	70.5	66.8	67.6	66.4	67.4	64.7	64.3	81.1	79.0	70.4	78.8	72.9	86.6	87.7	87.4	82.1	83.3	76.4	80.4	78.9	71.9	68.6	73.0	78.1	85.0	78.1	75.6	73.5	75.9	
- unr		23.0	76.8	75.6	73.8	15.9	72.6	73.4	20	74.1	71.2	85.7	84.4	82.6	75.6	81.5	E 11 3	86.2	88.1	87.1	84.7	85.0	79.2	83.6	81,3	76.1	74.7	79.5	81.6	85.0	81.7	79.1	777	79.8	
λε _M	ļ	73.5	71.3	76.4	74.6	757	73.3	72.3	74.6	73.2	71.2	85.58	84.3	81.0	76.0	80.2	76.5	36.5	88.4	87.4	86.5	84.8	80.0	8.38	82.3	76.8	73.8	78.7	81.6	83.8	82.9	. 2.62	78.9	79.9	
Å.		7.7	74.3	74.1	72.8	73.8	73.3	70.8	72.9	7.2	69.7	82.8	81.3	80.4	75.3	76.7	74.7	87.3	87.4	87.6	87.5	85.0	79.8	83.5	81.6	76.5	72.6	77.5	79.8	82.2	82.6	79.3	78.3	77.6	
.'IBW		73.5	74.8	75.5	73.9	75.3	75.3	72.8	7.57	21.9	70.8	81.2	80.4	79.4	75.0	76.9	75.6	87.2	86.6	87.0	86.5	85.2	80.1	83.3	81	76.3	2.1.5	1	75,5	83.8	79.3	1 64	75.0	76.6	
Çê L		74.9	74.3	7.0	74.8	76.0	76.8	74.0	74.4	74.6	72.0	5.67	79.1	75.8	76.1	78.8	77.8	85.3	85.1	85.6	85.4	81.2	79.3	81.6	80.9	1.0	72.2	76.8	76.2	79.7	79.9	80.0	7.77	7	
Jan.	-	75.9	74.2	76.7	757	76.1	76.7	75.0	73.4	73.8	71.5	78.1	76.8	77.8	23.9	78.6	75.6	84.5	83.5	84.3	85.0	828	77.5	80.1	79.1	74.5	69.2	74.0	74.0	79.8	76.5	76.7	73.8	73.5	
	Attrude	800	512	450	440	585	746	484	480	8	480	443	768	6455	Ş	310	760	59	4	8	830	910	880	663	1.020	880	400	513	202	778	N 1100 7	630	200	650	
Locato	- Guon	51*12W	49*52W	50°02'W	50-21W	V-00-13	51-32W	51-01W	52°26W	52*35W	53-17W	49*15W	50°37W	51-15W	52-34W	53°55W	V.92.59	48*49W	48"20W	48*48'W	W80-67	49*46'S	W.10.09	50~35W	51-30W	52~25W	W12.63	53°01W	54"08W	51"04W	26-29'S 51-59W	62*21W	52*41W	53°04W	
	l Lat.	22-57'S 51 -12W	23-30'S 49-52W	23-00'S 50-02'M	23*06'S 50*21'W	23-18'S 51-09W	123-30'S 51-32'W	23-16'S 51-01'W	23*05'S 52*26W	23*40'S 52*35'N	23*44'S 53*17V	24-49'S (49-15W	24-20'S 50-37'N	24*38'S	24-40'S 52-34'N	24-18'S 53-55W	24-56'S 53-26 V		25-18'S 48-20W		25"25"S 49"08"	25 47'S 48 46'S	25*13'S	25°27'S	25-215	25 25'S	25*425	25*315	25-11'S	26-13'S	26-29'S	26-25'5	26°07'S	26°05'S	
Basın		P.P.3	Cinzas	P.P.1	Cinzas	Theor.	Pirabo	Tibaci	i P	Vai	Piquiri	Ribeira	Tibagi	N.	Piquin	Piouin	Parana 3	Litoranca	Litoranea	Litoranea	lauacu			Tbagi	Iguacu		Iguacu		Parana 3	lguacu		rpenőj		iguacu.	
							g			octe			Borba		_		ļ	retes	araquecaba	onina	RUBIC		a Grossa	xeira Soares	arapuava	anjeiras	nalto	edas Iguacu	o Miguel	to Uniao	mas	welandia	0 Branco	ncisco Beltrao	COPEL
ŝ	No. St.No. Name	1 02251027 Bela Vista	2 02349030 Joaquim Tavora	3 02250017 Cambara	4 02350018 Bandeirantee	5 02351003 (Londrina	6 02351008 Apucarar	7 02351011 [bioora	8 02352017 Paranava	9 02352019 Cianorte	10 02353008 Umuarama	11 02449013 Cemo AZU	202450011 Telemaco Borba	3 02451052 Candido Abreu	14 02452050 Nova Camu	15 02453003 Palotina	16 02453023 Cascavel	17 02548038 Morretes	18 02548039 Guaraquecaba	19 02548070 Antonina	20 02549041 Piraquara	21 02549091 1 208	22 02550024 Ponta Grosse	23 02550025 Texteira Soare	24 02551010 Guarapuava	25 02552009 Laranjeiras	26 02553015 Planalto	27 02553018 Quedas Iguacu	28 02554026 Sao Miguel	29 02651007 Porto Uniac	30 C2651043 Paimas	31 02652003 Clevelandia	32 02652035 Pato Branco	33 02653012 Francisco Beltrao	Data Source : COPE
	o' No	F	~	10	4	· •0	ľ	~ ~		0	5	Ē	2	1	4	2	⁹	1	82	\$	8	Ň	8	8	2	8	8	2	8	8	8	5	8	8	ļ

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1.2.9 Correlation Analysis

The missing data of the following meteorological items were determined to employ correlation equation by station. The simulation period were adapted for the last 20 years (1974-1993). The employed correlation equations were summarized as shown in Table-1.9 - Table-1.11.

- Monthly Rainfall
- Monthly Temperature
 - Monthly Evaporation

Table-1.9

Correlation Equations for Monthly Rainfall

No.	X Station	Y Station	Y=a+b	XX	X = ə'+ b'	x Y	Correla	
NO.	A Galda		а	b	a	<u>b'</u>	Coeffic	and spin rates.
3-4	02350017 Cambara	02350018 Bandeirantes	15.40	0.93	-16.63	1.08	-1	0.8
5-7	02351003 Londrina	02351011 Ibipora	12.89	0.68	-14.64	. 1,14	<u> </u>	0.9
_	02352017 Paranaval	02351008 Apucarana	30.32	0.87	-34 94	1.15	-	0.8
		02351011 Ibipora	28.48	0.77	-36.87	1.29		0.7
_		02451052 Candido Abreu	33.64	0.85	-39.39	1.17		0.7
	02451052 Candido Abreu	02351008 Apucarana	27.12	0.73	-36.92	1.36		0.7
	02451052 Candido Abreu	02351011 Ibipora	33.64	0.66	-51,12	1.52		0.6
		02452050 Nova Cantu	59.97	0.81	-73.69	1.23		0.7
	02452050 Nova Cantu	02453023 Cascavel	22.08	0.86	-25.69	1.16		0.7
	02453003 Palotina	02453023 Cascavel	43.36	0.66	50.61	1.17		0.
-	02548038 Morretes	02548039 Guaraquecaba	13.74	1.13	-12.20	0.89		0.8
	02548070 Antonina	02548038 Morreles	17.76	0.68	26.11	1.47		0.
_	02549041 Piraquara	02449013 Cerro Azul	19.51	0.78	-25.16	1.29		0
	202549091 Lapa	02550024 Ponta Grossa	28.79	0.85	-34.05	1.18		0.
	02550024 Ponta Grossa	02550025 Teixeira Soares	21.02	0.87	-24.10	1.15		0.3
,	502551010 Guarapuava	02552009 Laranjeiras	22.49	0.88	-25.56	1.14		0.1
	7 02553015 Pianalto	02553018 Quedas Iguacu	28.59	0.88	-32.65	1.14		0.
	8 02553018 Quedas Iguacu	02554026 Sao Miguel	21.82	0.75	-28.96	1.33		0.
	102651043 Palmas	02652003 Clevelandia	9.49	0.94	-10.11	1.07	· ·	0.
• • . • .	2 02652003 Clevelandia	02652035 Pato Branco	13.30	0.94	-14.10	1.06		0.

No.	X Station	Y Station	Y=a+	bxX	X = a'+ i	YXY	Correlation
			а	b	8'	b'	Coefficient
3.4	02350017 Cambara	02350018 Bandelrantes	1.07	0.96	-1.11	1.04	0.9
5.7	02351003 Londrina	02351011 ibipora	1.56	0.97	-1.61	1.03	1.0
8-6	02352017 Paranaval	02351008 Apucarana	1.79	0.85	-2.09	1.17	0.9
9-10	02352019 Cianorte	02353008 Umuarama	0.29	1.00	-0.29	1.00	1.0
11-12	02449013 Cerro Azul	02450011 Telemaco Borba	-0.79	0.95	0.84	1.06	0.9
13-6	02451052 Candido Abreu	02351008 Apucarana	5,35	0.78	-6.81	1.27	0.9
14-15	02452050 Nova Cantu	02453003 Palotina	-2.61	1.14	2 29	0.83	0.9
15-16	02453003 Palotina	02453023 Cascavel	0.83	63.0	-0.95	1.14	0.9
17-18	02548038 Morretes	02548039 Guaraquecaba	-0.37	1.02	0.36	0.98	1.0
19-20	02548070 Antonina	02549041 Piraquara	-1.51	0.88	1.71	1.13	0.9
21-22	02549091 Lapa	02550024 Ponta Grossa	-1.09	1.07	1,01	0.93	0.9
22-23	02550024 Ponta Grossa	02550025 Teixeira Soares	-1 38	1.06	1.31	0.95	0.9
22.24	02550024 Ponta Grossa	02551010 Guarapuava	-1.36	1.03	1,32	0.97	0.9
25-27	02552009 Laranjeiras	02553018 Quedas Iguacu	-0.31	1.10	0.28	0.91	0.9
28-27	02553015 Planalto	02553018 Quedas Iguacu	-0.74	0.98	0.75	1.02	0.9
27-28	02553018 Quedas Iguacu	02554026 Sao Miguel	-1 21	1.11	1.10	0.90	0.9
29-31	02651007 Porto Uniao	02652003 Clevelandia	2 25	0.86	-2.62	1.17	0.9
30-31	02651043 Palmas	02652003 Clevelandia	1.31	0.98	-1.34	1.02	0.9
32-33	02652035 Pato Branco	02653012 Francisco Beltrao	-1.39	1.10	1.26	0.91	1.0

Table-1.10 Correlation Equations for Monthly Temperature

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Table-1.11

Correlation Equations for Monthly Evaporation

							والجماعية وتوسوه وموسات	
No.	X	Station	Y Station	Y≍a	+bxX	X = a'	+ b' + Y	Correlation
				a	b i	a' .	6 6	Coefficient
1-6	02251027	Bela Vista	02351008 Apucarana	-4.17	0.96	4.33	1.04	0.90
2-3	02349030	Joaquim	02350017 Cambara	21.42	0.93	-22.96	1.07	0.95
3-4	02350017	Cambara	02350018 Bandeirantes	-5.25	0.98	5.35	1.02	0.96
5-7	02351003	Londrina	02351011 Ibipora	4.29	0.97	-4.41	1.03	0.95
6.7	02351008	Apucarana	02351011 Ibipora	27.28	0.85	-31.98	1,17	0.88
8-9	02352017	Paranavai	02352019 Cianorte	-5.85	1.02	5.75	0.98	0.9
9-10	02352019	Cianorte	02353008 Umuarama	4.24	0.99	-4.28	1,01	0.9
10-11	02353008	Umuarama	02449013 Cerro Azul	13.53	0.99	-13,73	1.01	0.98
12-13	02450011	Telemaco Borba	02451052 Candido Abreu	-4.51	1.14	3.96	0.68	0.91
13-5	02451052	Candido Abreu	02351003 Londrina	21.74	0.85	-25,68	1.18	0.9
	02452050	Nova Cantu	02453003 Palotina	4.72	0.77	-6.16	1.31	0.9
15-16	02453003	Palotina	02453023 Cascavel	9,94	1.14	-8.72	0.88	0.9
	02548038	Morretes	02548039 Guaraquecaba	2.04	0.96	-2.14	1.05	0.9
17-19	02546038	Morretes	02548070 Antonina	4.47	0.93	-4.79	1.07	0.9
17-20	02548038	Morretes	02549041 Piraquara	14.25	0.86	-16.54	1.16	0.9
17-21	02548038	Morretes	02549091 Lapa	4.47	1.02	-4.38	0.98	0.9
20-21	02549041	Piraguara	02549091 Lapa	-3.87	1.09	3.54	0.91	0.9
21.22	02549091	Lapa	02550024 Ponta Grossa	10.22	0.98	-10.39	1.02	0.9
22-23	02550024	Ponta Grossa	02550025 Teixeira Soares	-17.08	0.99	17.22	1.01	0.9
23-24	02550025	Teixeira Soares	02551010 Guarapuava	13,39	1.02	-13.12	0.99	. 0.9
25-27	02552009	Laranleiras	02553018 Quedas Iguacu	-5.19	1.09	4,78	0.92	0.9
	02553015	Planaito	02553018 Quedas Iguacu	4.10		-4.54	1.11	0.9
	02553018	Quedas Iguacu	02554026 Sao Miguel	-3.56	1.07	3.32	0.93	0.9
	02651007	Porlo Uniso	02652003 Clevelandia	2.92	1.09	-2.67	0.91	0.9
	02651043	Paimas	02653012 Francisco Beltrao	41.30	0.85	-48.31	1.17	0.7
	02652003	Clevelandia	02652035 Pato Branco	12.68		-12.94	1.02	0.9
	02652035 02653012	Pato Branco Francisco Beltrao	02653012 Francisco Beltrao 02553018 Quedas Iguacu	-3.06 6.76		3.05 -6.96	1.00	0,9 0,9
22.56	02003012	Legucisco pelitgo	02000010 000008 190800	0.70	0.81	-0.90	1.03	0.3

CHAPTER 2 HYDROLOGICAL ANALYSIS

2.1 Review of Hydrological Measurement Data

2.1.1 Present Discharge Measurement

There are 217 hydrological stations (as of March, 1995) operated by mainly DNAEE, COPEL, IAP, of which 69 stations are provided with automatic level recorder. The actual field works such as discharge measurement, water quality sampling and sediment sampling by each hydrological station are carried out by 11 observation teams of IAP. The frequency of field measurements is either once a month or once in two months, and at times when the floods occur.

2.1.2 Confirmation of Discharge Measurement

The Study Team visited several operating hydrological stations accompanied with an observation team from IAP to confirm the accuracy of field measurement in terms of instrumental and methodological. The comments are described as follows;

< Instrument >

IAP has been using enough number of sounding current meters, the instrument is well maintained as annual calibration.

< Methodology >

The methodology is enough skilled in executing the discharge measurement and sampling by two observers.

2.1.3 Review of Discharge Rating Curve

To convert the observed data of water level to discharge, the discharge rating curve is essential. The discharge rating curve generally prepared from relation between water level and discharge as determined by the discharge measurements. It is usually expressed as the following equations;

1) Second-degree curve

 $Q = a x (H + b)^2$ where, a, b : constant

2) n-degree curve

 $Q = a x (H + b)^{n}$ where, a, b, n : constant, n = 1.5 - 2.5

The established discharge rating tables and curves in Parana are determined by manual plotting method. To confirm that the established discharge rating curves in Parana are exact curve with flow measurement data, the Team employed the second-degree curve determined by the least square method. Figure-2.1 shows both discharge rating curves at some selected station, and there are not much different between two curves.

Therefore, the discharge rating curves /or tables established by Counterparts were employed to determined discharge by selected station in this Study.

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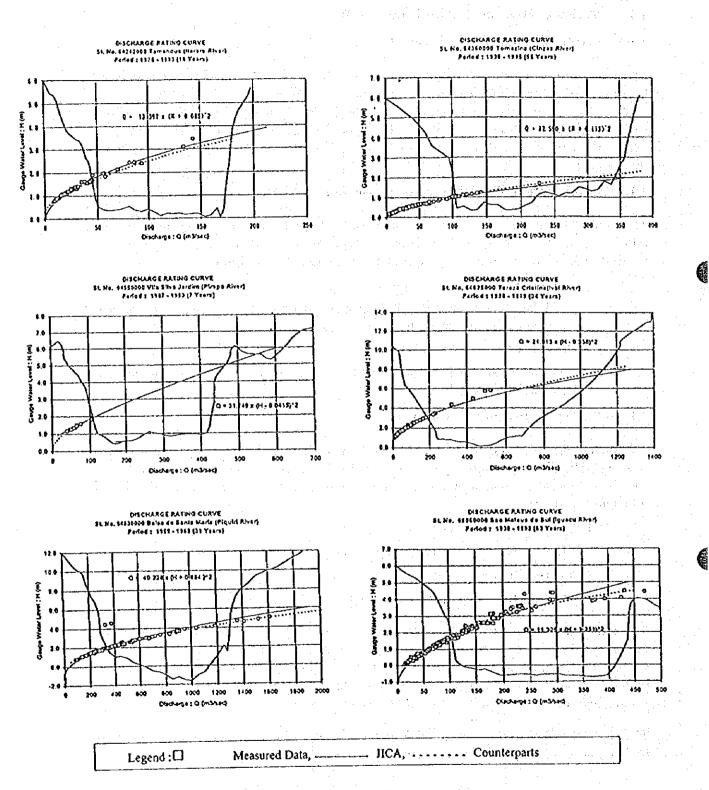


Figure-2.1 Discharge Rating Curves

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2.1.4 Hydrological Database

At present, the following three database systems are used by the different public agencies in Parana;

MSDHD (DNAEE)
 SISTEMA DAD (COPEL)
 CADASTRO-PLU-FLU (IAP)

The database system developed in this Study are composed of the following components and described in Figure-2.2. The database prepared by JICA Study Team is covered all registered stations except for the closed stations in Parana State.

- 1) Filling System
 - H-Q Table by Station
 - Cross Section Data by Station
 - Flow Measurement Data by Station
 - Daily River Water Level
- 2) Analyzing System
 - Discharge Rating Curve by using Manning's Formula
 - Discharge Rating Curve by using Least Square Method
 - Daily Discharge
 - Monthly Discharge
 - Correlation Analysis between Stations
 - Flow Regime Table and Graph

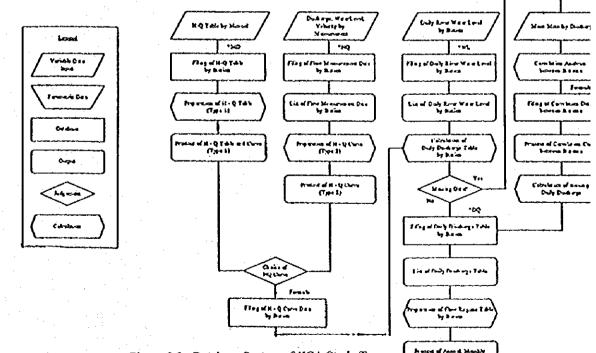


Figure-2.2 Database System of JICA Study Team

2.2 Runoff Analysis

2.2.1 Discharge Reference Point

To clarify the flow characteristics of each river basin, 31 hydrological stations were selected as discharge reference points by considering the following conditions; (See Figure 2.3)

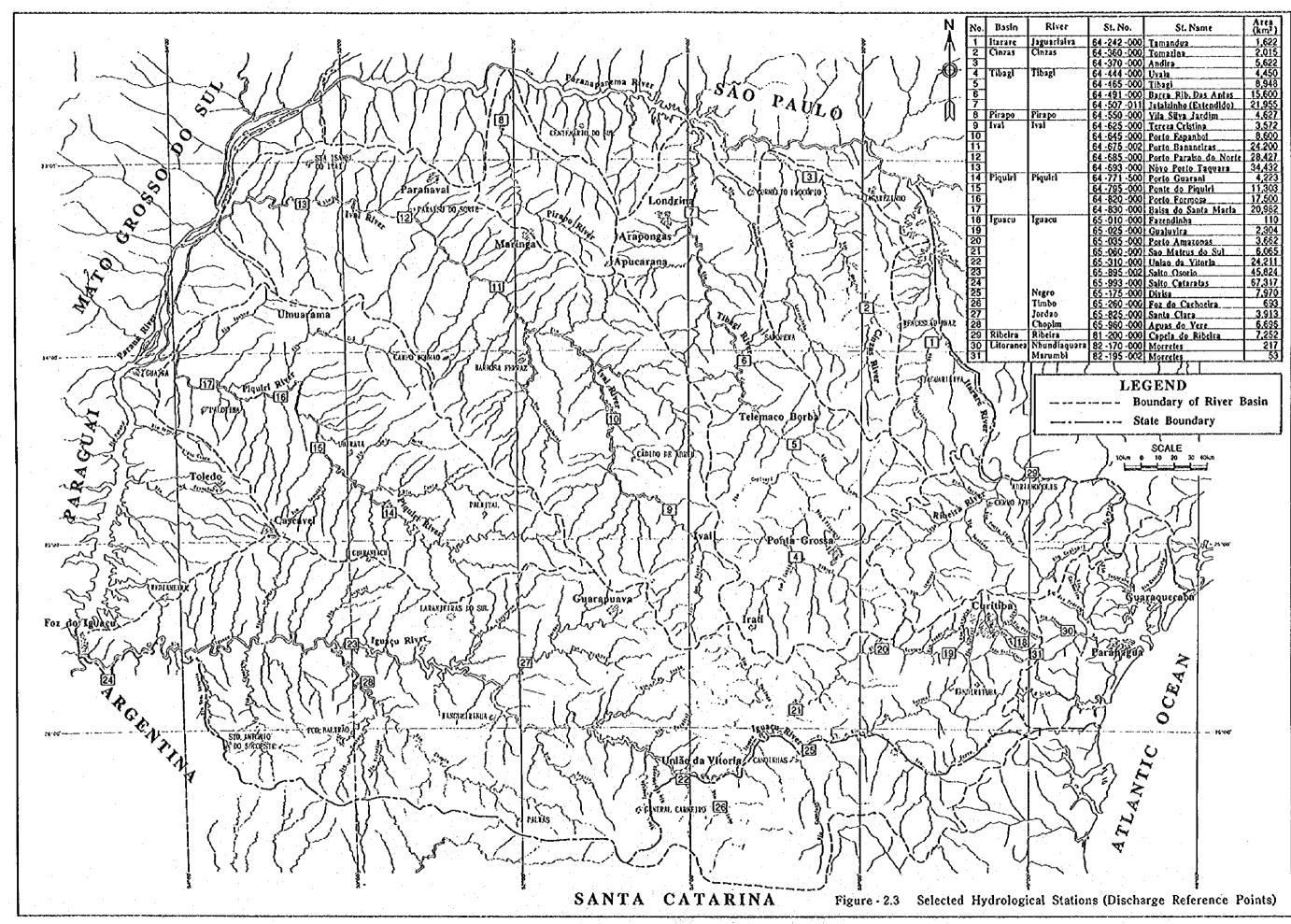
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- data availability
- balance of catchment area
- accuracy of existing data

Considering the discharge measurement data availability and other collected data as shown in Table-2.1, the simulation period was applied to the last 20 years (1974 to 1993).

2.2.2 Discharge Correlation Analysis

In case that the missing or not-available discharge data were found at each selected station, the correlation equations as shown in Table-2.2 was employed. The simulation period was adapted for the last 20 years (1974 - 1993).



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Table-2.1 Hydrological Data Availability at Each Selected Stations

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Table-2.2 Monthly Specific Discharge Correlation Results

Unit (m³/sec/100 km²)

NO.	River	X Station	Y Station	Y=a+	bxX I	X = a + b	'XY I	Correlation
ю.	N.Yei	70000		8	δ	<u>a'</u>	b'	Coefficient
-2	litarara Ciazat	64242000, 1622 km2	64360000, 2015 km2	0.00037	0.84951	-0.00044	1.17701	0.9521
-2	11/21/21/2-011/203	Tamandua (Itarare)	Tomazina (Cinzas)					1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1
-3	Cianas Cianas	64360000, 2015 km2	64370000, 5622 km2	-0.00292	1.01074	0.00289	0.98938	0.9601
3	C111285-C111285	Tomazina (Cinzas)	Andira (Cinzas)					
1.5	Tibagi-Tibagi	64444000, 4450 km2	64465000, 8948 km2	0.00157	0.92193	-0.00170	1.08468	0.9737
1-5	Tioagi-Tioagi	Uyala (Tibagi)	Tibagi (Tibagi)					
5-8	Tibaqi-Tibaqi	64465000, 8948 km2	64491000, 15600 km2	0.00131	0.90742	-0.00144	1.10203	0.9889
-8	Tioagi-Tioagi	Tibagi (Tibagi)	Barra Rib. das Antás (Tibagi)	0.00101			1.2	
÷7	Tibagi-Tibagi	64491000, 15600 km2	64507011, 21955 km2	0.00030	0.98994	-0.00031	1.01016	0.9855
rl	rioagi-rioagi	Barra Rib, das Antas (Tibagi)	Jataizinho (Tibagi)	0,0000				
1-8		64507011, 21955 km2	64550000, 4627 km2	0.00796	0.38490	-0.02068	2.59805	0.7383
-8	Tibagi-Pirapo	· · · ·	Vila Silva Jardim (Pirapo)		0.00100	0.01000		
		Jalaizinho (Tibagi) 64625000, 3572 km2	64645000, 8600 km2	0.00366	0,85109	-0.00426	1.16132	0.9782
9-10	ival-ival		Porto Espanhol (Ival)	0.00000	0.00100		1.101.02	
	Į	Tereza Cristina (Ival)	64675002, 24200 km2	0.00363	0.73018	-0.00497	1.36952	0.9613
10-11	Ivai-Ival	64645000, 8600 km2	Porto Bananeiras (Ivai)		0.10010	-0.00101	100002	
	L	Porto Espanhol (Ivai)	64685000, 28427 km2	0.00086	0.95612	-0.00090	1.04589	0,9890
11-12	Ival-Ival	64675002, 24200 km2		0.00000	0.00012	-0.00050	1.04505	0.0000
	ļ	Porto Bananeiras (Ivai)	Porto Paraiso do Norte (Ivai)	0.00206	0.88949	-0.00232	1.12424	0.9271
12-13	lval-lvai	64685000, 28247 km2	64693000, 34437 km2	0.00200	0.00349	-0.00232	1.12424	0.5211
	l	Porto Paraiso do Norte (Ivai)	Novo Porto Taquara (Ivai)	0.00115	1.04025	-0.00110	0.96130	0.9742
4-15	Piquiri-Piquiri	64771500, 4223 km2	64795000, 11303 km2	0.00115	1,04025	-0.00110	0.90130	0.3142
	L	Porto Guarani (Piquin)	Ponte do Piquiri (Piquiri)	0.00540	0 70040	-0.00782	1.42430	0.9812
15-16	Piquin-Piquin	64795000, 11303 km2	64820000, 17500 km2	0.00549	0.70210	-0.00762	1.42430	0.9012
	<u> </u>	Ponte do Piquiri (Piquiri)	Porto Formosa (Piquin)		0.84994	-0.00239	1.17655	0.9765
16-17	Piquin-Piquin	64820000, 17500 km2	64830000, 20982 km2	0.00203	0.84994	-0.00239	1.1/055	0.4103
	<u></u>	Porto Formosa (Piquiri)	Balsa do Santa Maria (Piquin)				4 07000	0.8258
18-19	Iguacu-Iguacu	65010000, 110 km2	65025000, 2304 km2	-0.00119	0.92679	0.00128	1.07899	0.8236
		Fazendinha (Iguacu)	Guajuvira (Iguacu)					0.0300
19-20	iguacu-iguacu	65025000, 2304 km2	65035000, 3662 km2	-0,00011	0.93787	0.00012	1.06625	0.8760
		Guajuvira (Iguacu)	Porto Amazonas (Iguacu)			l	6 05 1 60	0.9453
20-21	liguacu-lguacu	65035000, 3662 km2	65060000, 6065 km2	0.00044	0.94833	-0.00047	1.05448	0.9453
	<u> </u>	Porto Amazonas (Iguacu)	Sao Mateus do Sul (Iguacu)					
21-22	iguacu-iguacu	65060000, 6065 km2	65310000, 24211 km2	0.06073	1.11026	-0.00065	0.90069	0.9293
	j	Sao Mateus do Sul (Iguadu)	Uniao da Vitoria (Iguacu)					
23-24	Iguacu-Iguacu	65895002, 45824 km2	65993000, 67317 km2	0.00359	0.80064	-0.00449	1.24900	0.9630
	1	Salto Osorio (Iguacu)	Salto Cataratas (Iguacu)					
21-25	Iguacu-Negro	65060000, 6065 km2	65175000, 7970 km2	0.00394	0.86862	-0.00453	1.15125	0.8618
	·	Sao Mateus do Sul (Iguacu)	Divisa (Negro, Iguacu)					
22-25	Iguacu-Negro	65310000, 24211 km2	65175000, 7970 km2	0.00390	0,76368	-0.00511	1,30946	0.8877
		Uniao da Vitoria (Iguacu)	Divisa (Negro, Iguacu)					
26-22	Timbo-Iguacu	65260000, 693 km2	65310000, 24211 km2	0.00362	0.61317	-0.00590	1.63088	0.8470
		Foz do Cachoeira (Timbo)	Unlao da Viloria (Iguacu)					
27-28	Jordao-Chopin	65825000, 3913 km2	65960000, 6696 km2	-0.00313	1.18238	0.00265	0.84575	0.8916
		Santa Clara (Jordao, Iguacu)	Aguas do Vere (Chopim, Iguacu)					
23-28	Iguacu-Chopin	65895002, 45824 km2	65960000, 6696 km2	0.00499	1.09337	-0.00457	0.91460	0.8149
	1	Salto Osorio (Iguacu)	Aguas do Vere (Chopim, Iguacu)		1			
31-1	Ribeira-Itarare	81200000, 7252 km2	64242000, 1622 km2	-0.00542	1,50814	0.00359	0.66307	0.8513
		Capeta do Ribeira (Ribeira)	Tamandua (Itarare)	<u> </u>			1. 	<u>1995 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997</u>
32-33	Litoranea	82170000, 217 km2	82195002, 53 km2	-0.00205	1.55160	0.00132	0.64450	0.8459
	1	Morretes	Morretes	1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1		1. A.	

2.2.3 River Flow Simulation

Based on the river flow data for the last 20 years period (1974-1993), daily discharge at each discharge reference point were determined, and the missing daily discharge were determined by monthly discharge correlation analysis among the stations.

The flow regime shows the annual condition using the calculated daily discharge at a certain hydrological station and shall be indicated by the daily discharge and number of exceeded days. The annual flow regime of each selected stations in the Study area shows as follows;

- High Discharge (95th daily discharge from the greatest)
- Normal Discharge (185th daily discharge from the greatest)
- Low Discharge (275th daily discharge from the greatest)
- Drought Discharge (355th daily discharge from the greatest)

The flow regime is commonly used to find the fluctuation in the daily discharge, and utilized for determining the potential water characteristics in Japan.

The flow regime computed by station was adapted for 20 years period (1974-1993), and mean value of the 95th, 185th, 275th and 355th daily discharge for the last 20 years period were calculated. The results of mean flow regime for the last 20 years period are summarized in Table-2.3, and Figure-2.4 shows flow regime curves at the typical selected hydrological stations.

Basin	River	No	SL No.	StName	Area	Dail	/ Discharge	(m3/sec)	
			1997 - A.		(km2)	95 day	185 day	275 day	355 day
Itarare	Jaguarialva	T I	64-242-000	Tamandua	1,622	33.86	23.56	18.13	13.0
Cinzas	Cinzas	2	64-360-000	Tomazina	2,015	38,19	25.11	18.09	12.2
		3	64-370-000	Andira	5,622	88.26	50,03	34,18	22.3
Tibagi	Tibagi	4	64-444-000		4,450	116.02	64.61	40.56	24.8
1.1		- 5	64-465-000	Tibagi	8,948	229.39	132 92	87.08	51.6
1997 - N. 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 19	1.1.19	6	64-491-000	Barra Rib das Antas	15,600	381.96	230 94	153 34	95 2
1.00	1 1 1	7	64-507-011	Jata zinno (Extendido)	21,955	502.08	312.46	211.73	128.7
Prapo .	Pirapo	-8	64-550-000	Vila Silva Jardim	4,627	79.54	61.38	49.43	37.7
lvai	Ivai	9	64-525-000	Tereza Cristina	3,572	80 26	38 23	21 57	10.9
		10	64-645-000	Porto Espanhol	8,600	220 04	115.48	67.89	37.2
1.0		11	64-675-002	Porto Bananeiras	24,200	561.65	311.55	199.13	120.5
·		12	64-685-000	Porto Paraiso do Norte	28,427	650.69	381.95	262.71	173.5
		13	64-693-000	Novo Porto Taquara	34,432	777.78	491.69	355 97	246 3
Piquin	Piquiri	11	64-771-500	Porto Guarani	4,223	120.83	60.39	33.58	16.6
•	1	15	64 795-000	Ponte do Piquiri	11,303	345.65	186.73	111.87	652
	1.1	16	64-820-000	Porto Formosa	17,500	498.85	315.78	219.41	143.2
		17	64-830-000	Balse do Santa Maria	20,982	551.77	368.49	262.97	172.2
guacu	Iguaou	18	65-010-000	Fazendinha	110	3.13	1.86	1.29	08
•	1	19	65-025-000	Guaiuvra	2,304	58 29	35.78	22.03	12.5
1		20	65-035-000	Porto Amazonas	3,662	84.96	49.48	30.73	17.1
· · · · ·		21	65-060-000	Sao Maleus do Sul	6,065	136.44	78.47	50.85	30.3
		22	65-310-000	Unizo da Viloria	24,211	656.67	365.42	232.03	131.3
		23	65-895-002	Sallo Osorio	45,624	1310.22	829.86	532.17	262.6
		24	65-993-000	Salto Calaratas	67,317	1690.20	1126 20	792.05	436.7
	Negro	25	65-175-000	Divisa	7,970	195 67	112 64	76 21	49 5
. `	Timbo	26		Foz do Cachoeira	693	22.90	12.47	7.92	4.5
	Jordao	27	65-825-000		3,913	125.17	77.18	49.67	28.1
1.0	Chopim			Aguas do Vera	6,696	224.80	131.11	78.13	40.1
Ribeira	Roeira	29		Capela do Ribeira	7,252	.130 63	101.75	86 87	728
Liloranea	Nhundiaquara	30			217	14.43	8.04	4.86	2.5
	Marumbi		82-195-002		53	5.02	211	1.61	0.7

Table-2.3 Flow Regime (mean values for the last 20 years period (1974 - 1993))

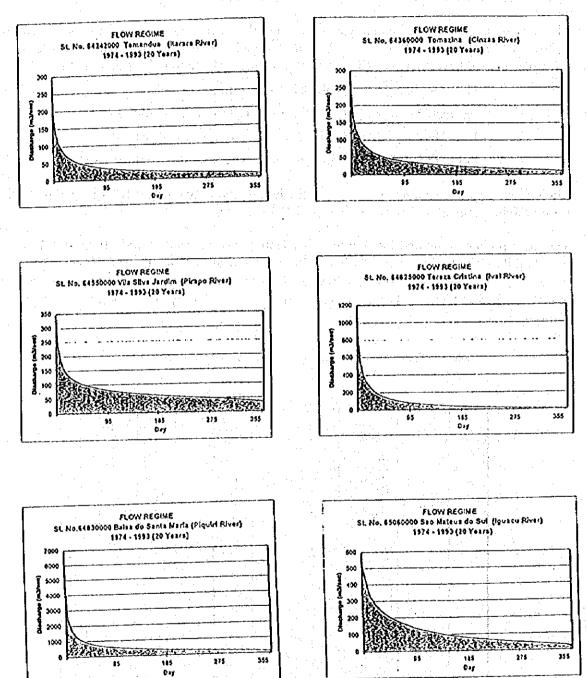


Figure-2.4 Flow Regime (Typical Selected Stations)

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2.2.4 Characteristics of River Flow

(1) Monthly Discharge

Using the last 20 years period (1974-1993), the average monthly flow patterns at each discharge reference points were given as Table-2.4.

(2) Monthly Specific Discharge

Based on the monthly mean discharge at each station, monthly mean specific discharge were determined as shown in Table-2.5, and Figure-2.5 shows distribution of monthly mean specific discharge by discharge reference point. Based on Figure-2.5, characteristics of monthly specific discharge are summarized as follows;

<Upper Iguacu>

Monthly specific discharge at the region including Curitiba at the western side of the coast mountain range, Ribeira river basin and Negro river basin ranges from 1.3 to 2.9 m^3 /sec/100km², with a mean of 2.0 m^3 /sec/100km². The monthly fluctuation is not clearly existed as compared with other regions.

<North Eastern Region>

Monthly specific discharge at the region including Itarare, Cinzas, Tibagi and Pirapo river basins ranges from 1.1 to 2.7 $m^3/sec/100km^2$, with a mean of 1.9 $m^3/sec/100km^2$. The runoff peak exists twice a year from December to February and from May to July.

<Central, Western and Middle and Lower Iguacu Region>

Monthly specific discharge at the region including Ivai, Piquiri, Middle Iguacu and Lower Iguacu river basins ranges from 1.2 to 4.3 m^3 /sec/100km², with a mean of 2.5 m^3 /sec/100km². This region has a biggest value in Parana, and especially fluctuation pattern is clearly occurred from May to July.

<Litoranea Region>

The region of coast area has highest value in Parana ranges from 2.6 to 12.3 m^3 /sec/100km², with a mean of 7.0 m^3 /sec/100km², and fluctuation of peak runoft occurs on between October and March with different from the patterns of other regions.

 Table-2.4 Mean Monthly Flow Pattern

					r					_				Unit:m3%	sec
¥0.	SL No.	SI.Name	Jan.	Feb.	Mar.	Арг.	May	Jun.	Jul.	Aug.	Sep.	Col.	Nev.	Dec,	Anguat Mean
	\$4-242-000	Tamandua	45 PD	40 58	34.81	25.35	33.18	37.30	28.05	23.01	27.51	28 32	27.10	38.24	1
7	64-360-000	Tomazine	52 65	45 59	37.09	27.11	38.47	40.43	32.06	25.53	30.78	31.13	31.06	1.1	1
3	64-370-000	Andra	138 23	102.41	97.54	64 30	65.64	99 06	64.07	\$1 05	69.25	70.43	73 24		
	64 464 000		82.08	75 00	65 94	54.03	PS.10	120 68	110.16	88 71	95.95	114.38	₽2 59	1.77	1
5	£4-465-000	Tibagi	182.43	163 47	140.72	\$11.55	198.58	238.47	213.79	163 61	191.69	215 13	180.77	180 37	181.55
	64 491-000	Bana Rib das Antas	327 14	302 20	257 61	201 20	336 32	394.13	338.93	263 82	311.56	346 62	305 30		
,	64-507-011	Jalaizinho (Extendido)	489 63	430 B4	379.40	290 27	457.11	528.12	435.63	335.14	401.53	43 03	400.88	462.21	421.10
		Vila Säva Jardim	\$1.47	82.42	79.47	87.93	75 25	78.50	82.64	58 52	58 54	65.78	65.71	81.31	72.25
,		Tereza Cristina	77.04	62 83	52.83	48 32	121,13	108 02	95 06	63.40	98.47	101.19	71.07	73.75	
10		Porto Espanhol	190 83	174.14	145 26	121.24	278 26	246 07	224.57	162 56	225 66	242.70	181 35	199.60	198 98
11		Porto Bananeiras	543 58	489 96	390 28	335 08	631.71	609 57	479.40	301.75	517.65	\$74.15	469 63	552.41	497.93
12	1	Porto Paraiso do Norte	853 64	565.38	478 50	1.1.1.1	733.08	698 59	585.57	448 66	595.05	659.30	539 50	852 59	583.10
13		Novo Porfo Taquara	785 56	726.99	\$77.55	514 64	868 26	758.70	852.80	523 91	821.86	790 66	651.50	783.11	704.30
34		Porto Guarani	97 35	100 22	82.69	75.04	187.44	141.84	124 49	93.75	120.84	134.39	119 29	137.58	114.58
15		Ponte do Piquíri	300 91	278 30	195 98	220.90	508 62	406.74	336.73	267 26	336.48	357.57	330 28	409.71	331.96
,,,		Porto Formesa	430.10	409 95	312.43	333.41	649.41	540.12	463.67	876 25	455 80	506.74	468.36	541.19	
,,		Baba do Santa Mada	472.57	450.43	387.95	365 61	655 76	601.71	516 69	432 25	498 95	577.35	532.07	597.53	508 07
1.0	65-010-000		3 19	3 07	2.61	2.15	2 68	2 35	2.49	2 02	2.57	2 84	2 52	2.54	2 59
19	65-025-000		48.82	47.67	44.90	34.92	45 38	48.06	52.10	47.28	47.26	54 58	42 03	45.42	45.30
20		Porto Amazonas	68 69	68.41	64.51	48 35	75.15	76.47	61 53	64 65	72.41	77.8B	61 26	67.35	68 72
21		Sag Mateos do Sul	112 93	102 22	\$3.53	74.29	113.58	133 35	125.44	111.09	114.97	133.59	102.18	108.29	130.54
22		Uniao de Viloria	467.10	452 99	413 22	325 20	499.24	648 35	624.43	545.11	527.63	622.39	502 15	489 66	509.62
23	65 895-002		834 50	788 66	745.53	652 79	1432.93	1436.19	1562 36	1074.55	1164.26	1274.95	1301.89	1104.30	1112 08
24		Sallo Celaratas	1221 31	1159.48	1103 50	1020.03	1850 84	1950 93	2007.48	1485.45	1643.48	1773 19	1748 53	1518.51	1540 89
25	65-175-000		158 59	145.85	135.47	105 44	147.24	\$76 70	175 68	176 82	155 32	184.76	148.95	158 27	155 93
26		Faz do Cachoeira	15 69	17.05	14.66	11 33	21.35	21,15	25 22	21.16	19.88	24.34	19.51	19 71	19597
27	65-625-000		\$2.67	85 28	71.61	72 10	155.48	134.79	141.32	94.51	114.08	135 21	121 26	115 84	111.15
2.0		Aguas do Vere	141.30	132 04	111.42	128 25	287 06	283 57	309,19	181.74	210.62	235 87	243.34	171.52	203 58
20		Capela do Ribeira	140.07	138.04	128 81	102.45	134,17	139.15	125 97	106 62	124 07	122.74	118 50	126 97	1.00
-+-			17.01	130.01	15 19	11.73	10 39	6 81	7 24	5.74	10 87	13.39	13 93	120.97	125 50
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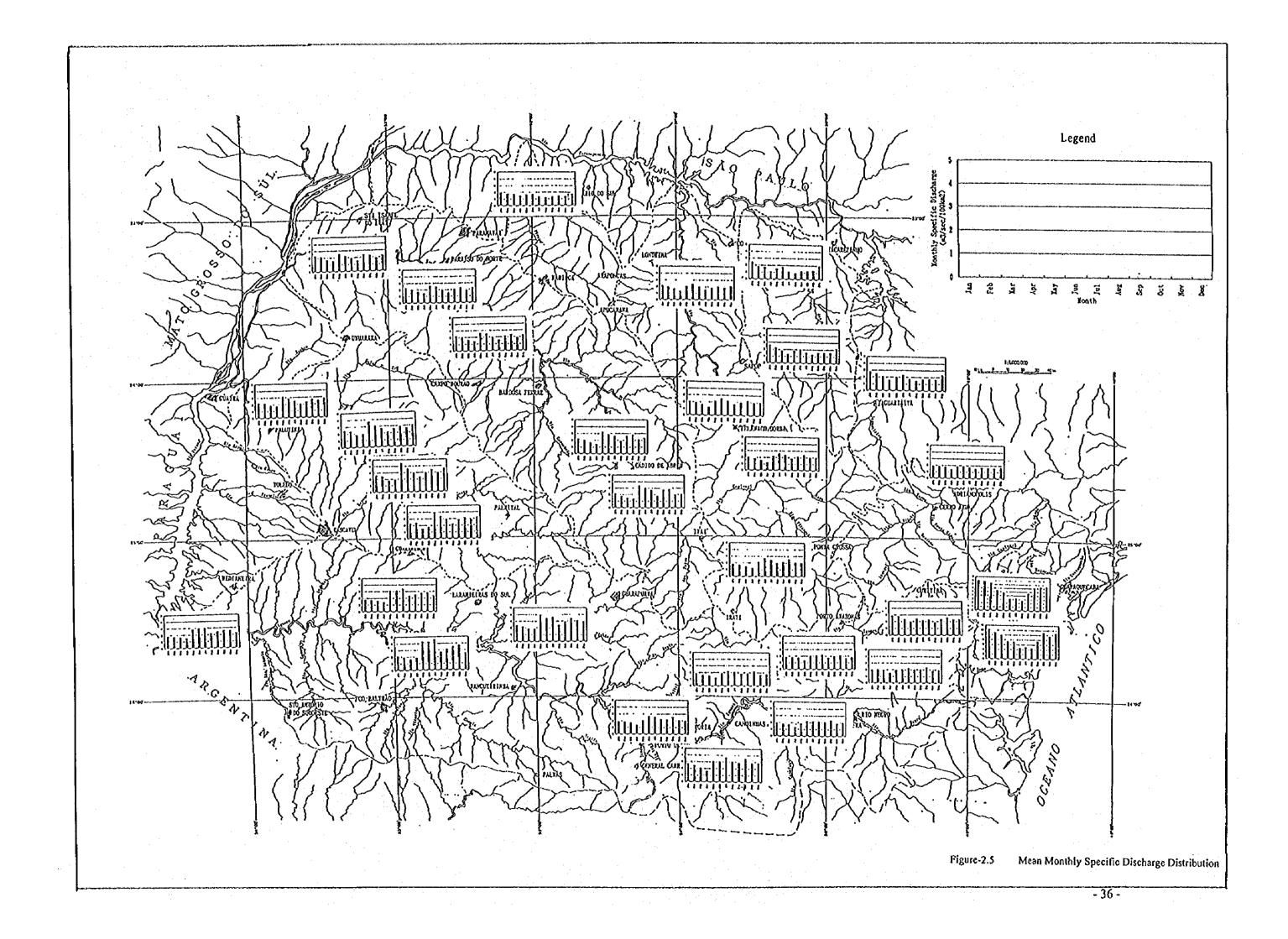
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1	64 242 000	Tamandus.	1,622	2 835	2 502	2.146	1.563	2 046	2 305	1 728	1.458	1.696	1.745	1.871	2 358	2 005
2	64-360-000	Tomazina	2,015	2 813	2 263	1 841	1 346	1.810	2 007	\$ 591	1 267	1.527	1 \$45	1.541	2.181	1.794
3	64-370-000	Andira	5,622	2.459	1.822	1 735	1.144	1.547	1.762	1.140	6 905	1.232	1.254	1.303	1.951	1.524
4	64-414-000	Uvala	4,450	1.841	1.685	1.482	1 214	2.161	2.712	2 4 7 5	1 993	2.158	2 570	2 641	2 006	2 032
5	64-485-000	Tibagi	8,943	2 039	1.827	1.573	1 247	2.219	2 643	2 389	1 020	2.142	2.404	2.020	2 018	2 029
6	64-491-000	Barra Rib das Antas	15,600	2 097	1 937	1 651	1 290	2.156	2 526	2,160	1 691	1.997	2 222	1.957	1 893	1 973
7	64-507-011	Jataizinho (Extendido)	21,955	2 230	1.953	1.726	1.322	2 082	2.405	1.684	1 527	1.829	2.018	1.828	2.105	1 \$18
8	64-550-000	Via Silva Jardim	4,627	1 977	1.781	1.717	1.468	1.626	1.895	1.354	1,221	1 287	1.413	1,420	- 1.75?	1.562
•	64-625-000	Tereza Cristica	3,572	2 157	1.759	1,480	1,353	\$ 391	3.024	2 661	1.775	2 757	2 833	1 990	2.065	2 270
\$0	64 645-000	Porto Espenhoi	8,600	2 2 1 9	2 025	1 831	3.410	\$ 236	2 881	2 8 1 1	1.891	2 826	2 822	2.109	2.323	2314
11	64-875-002	Porto Sananeiras	24,200	2 245	2 025	1.613	1.385	2 8 10	2.519	1 981	1.577	2.139	2 373	1.941	2 283	2 058
12	64-585-000	Porto Paraiso do Norte	28,427	2.297	1.\$89	1.884	1.424	2 579	2.458	1.990	1.578	2 104	2 319	1.898	2 294	2 051
13	84-893-000	Nevo Porto Taquara	\$4,432	2 281	2.111	1.672	1.495	2 516	2.198	1 8 96	1.522	2 387	2 296	1 892	2 274	2 645
14	64 771-500	Porto Guarani	4,223	2.305	2.373	1,485	1,777	3.965	3 359	2 948	2 220	2.862	3.182	2 825	3 258	2,713
15	64-795-006	Ponte do Piquirl	11,503	2 662	2,462	1.734	1,954	4 500	3.599	2 979	2 320	2.977	3.429	1.002	3 625	2 937
18	64-820-000	Porto Formosa	17,500	2.458	2 343	1.785	1.905	3.711	3 (086	2 650	2 150	2 603	2 8 96	2 665	\$ 093	2 6 1 2
17	64-830-000	Balse do Sente Maria	26,982	2 252	2 194	1 649	1.742	3.125	2.863	2.493	2.060	2 368	2.752	2 538	2 849	2.421
18	85-010-000	Fazendinha	\$10	2.904	z 790	2 373	1.955	2.435	2.139	2 262	1.634	2.337	2 581	2 289	2 305	5 3 20
19	65-025-000	Gualuvin	2,304	2 032	2 069	1 952	1.518	1 970	2.066	2 261	2 052	2 051	2 369	1 824	1.971	2 0 13
20	65-035-000	Porto Amazonas	3,862	- 1.876	1 613	1.762	1 320	2 052	2 068	2 2 26	1.766	1.977	2.127	1.673	1 839	1.177
21	65-060-000	Sao Mateus do Sul	8,065	1.863	1.685	1 542	1.225	\$.873	2 199	2 (85	1.832	1 896	2 203	1 685	1.785	1.823
22	65-310-000	Unieo de Véoria	24,21)	1.929	1.871	1.707	1 343	2 062	2 870	2 579	2.251	2.179	2.571	2 074	2 023	2.105
23	65-895-002	Sallo Osorio	45,824	1.822	1.721	1 627	1,425	3.127	3.139	3.453	2 345	2 541	2 762	2 841	2.410	2.427
24	65-993-000	Salto Cataratas	67,317	1 814	1 722	1.639	1.515	2.018	2 052	2 982	2 207	2.641	2 834	2 597	2 253	2 298
25	65-175-000	Divisa	7,970	1.965	1.827	1,700	1.323	1.847	2 217	2 264	2.143	2 076	2 3 18	1.869	1.956	1.956
26	85-260-000	Foz do Cechoeira	693	2.697	2.450	2.115	1.632	3.081	3 052	3 640	3 054	2 869	3 512	2 815	2 644	2 836
27	65-825-000	Santa Clara	3,913	2 368	2.179	1.830	1 843	3 973	3 445	3.611	2.405	2 815	3.455	3.099	2 960	2 8 40
28	65-960-000	Aguas do Vere	0.626	2.111	1.972	1.684	1 885	4.287	4 235	4 6 18	2.714	3.145	3 587	3 724	2.562	3 040
29	81-200-000	Capela do Ribeira	7,252	1 937	1.876	\$.778	1.413	1.850	1.919	1,737	1,490	1.751	1.692	1.508	1.751	1231
30	82-170-000	Morreles	217	8 025	7.868	7.460	5.406	4.789	3.140	3 337	284	6 838	8.173	8.419	6 519	5.535
31	82-195-002	Marretes	53	12 359	10 686	8 891	7.313	7.149	4 85 1	5 064	4 807	7.467	11.058	9.465	10 710	8 393

Table-2.5 Mean Monthly Specific Discharge

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Probable Discharge Analysis 2.2.5

Using annual maximum daily discharge data by each discharge reference point, probable discharge by discharge reference point were computed using plotting position method.

The simulation period were adapted available period by the selected station in order to determine an general tendency of peak flood discharge in this section.

(1) Plotting Position Method (Source: Ministry of Construction in Japan)

Probability papers can be used for a brief estimation of the probability or random hydrological quantities. Typical methods for giving the plotting position of samples are widely known as Weibull (1939) (or Tomas plot, 1948) and Hazen (1930) plotting position methods.

Weibull plot can give the expected value of plotting position of order statistics, when samples are regarded as a set of order statistics. On the other hand, Hazen plot corresponds to the median of each interval of each sample value represented by a histogram and is a simple method. Weibull plot is rational for empirically presuming the distribution and gives a slightly larger hydrological quantity compared to Hazen plot at the upper tail of distribution for the same probability of exceedance or non-exceedance, which means at the safe side in planning point of view. Thus, the use of Weibull plot is very reasonable when making simplified estimations based on probability paper.

 $P(xj) = \frac{J}{N+1}$ or $F(xi) = \frac{i}{N+1}$(Equation 2.1) Weibull Plot

Hazen Plot

 $P(xj) = \frac{2j-1}{2N}$ or $F(xi) = \frac{2i-1}{2N}$(Equation 2.2)

where, P(xj): probability of exceedance of a certain value of a hydrological quantity x

> F(xi): probability of non-exceedance of a certain value of a hydrological quantity xi

i : order of xi from the greatest value of sample

i : order of xi from the lowest value of sample

N: size of samples

Using annual maximum daily discharge data by each discharge reference point, probable discharge by discharge reference point were computed using both Weibull (1939) (or Tomas plot, 1948) and Hazen (1930) plotting position methods.

(2) Distribution Function Formula (Source: Ministry of Construction in Japan)

Shape of frequency distribution of hydrological quantities varies depending on the kind of hydrological elements and method of drawing samples and thus precautions should be taken. In this study, two distribution types were applied as follows;

Logarithmic Normal Type Distribution 1)

Although hydrological quantities can be approximated to normal distribution as they are. or by means of logarithmic conversion or the conversion of square root or cubit root, the logarithmic normal distribution is often used since a widely applicable method of analysis has been established for the logarithmic normal distribution. Basic formula for logarithmic normal distribution is shown as below,

 $u = a^{t}\log \frac{x+b}{xo+b}$ or $\xi = a \cdot \log \frac{x+b}{xo+b}$

 $\log(x + b) = \log(xo + b) + \frac{1}{a'} \cdot u = \log(xo + b) + \frac{1}{a} \cdot \xi$(Equation 2.4) $a, a' > 0, x_0 > -b, -b < x < \infty$

 $u \& \xi$: values converted from x, standard normal variables

F(x): probability of non-exceedance of x

P(x): probability of exceedance of x

xo, a, a', b : constant values

$$a^{\prime} = a \cdot \sqrt{2} \cdot , u = \xi \cdot \sqrt{2} ,$$

Constant values in the functions are normally estimated based on samples and they can be estimated by Iwai's method, moment method, least square method and others.

<Least Square Method>

This method computed a regression line to fit the plotted data.

<Iwai's Method>

This method considers that the technique of normal distribution and empirical distribution for estimating three parameters xo, a' and b in logarithmic normal distribution given by (Equation 2.3) and (Equation 2.4).

Estimation of b :

When a sample size (number of years of data) for hydrological quantity x is N, a median value xg (first approximate value of xo) should first determined.

 $b = \frac{1}{m} \sum_{s=1}^{m} bs$ 2.5)

where, $bs = \frac{xl xs - xg^2}{2xg - (xl + xs)}$, (l = N - s - 1)

with $m \approx N/10$, bs should be calculated for s=1,2,...m and then b should be determined. bs should be determined based on the s-th value xs, 1-th values or (N-s+1)-th values x1 and xg.

$$xg: \log xg = \frac{1}{N} \sum_{i=1}^{N} \log xi$$

xg is a median value (first approximate value of xo)

Estimation of xo and 1/a'

$$\log (xo + b) = \frac{1}{N} \sum_{i=1}^{N} \log (xi + b) \dots (Equation 2.6)$$

$$\frac{1}{a^{i}} = \sqrt{V} = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} \{\log (xi + b) - \log (xo + b)\}^{2}} \dots (Equation 2.7)$$

$$= \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} \{\log (xi + b)\}^{2} - \frac{N}{N-1} \{\log (xo + b)\}^{2}} \dots (Equation 2.7)$$

The procedure for estimating constants shown above and (Equation 2.4) is normally applied for examining the maximum-value-side of distribution but can also be applied to the minimum-value-side as long as the value of b is carefully handled. That is, if the minimum value of x as characteristics of hydrological quantity to be applied has to be zero or larger, then b = 0 or b < 0. Therfore, if b >0 in (Equation 2.5) to (Equation 2.7), the remaining constants xo and 1/a' should be determined using b = 0. If b = 0, the distribution curve shows a straight line on logarithmic normal probability paper. For this purpose, if the sample distribution shows a curve and the adaptability of distribution applied is not good, it is desired to apply the logarithmic normal distribution with the upper side bounded, that is suitable for the minimum-value-side of distribution.

<Estimating Constants by Moment Method (Ishihara and Takase's Method)>

This method can determined the constant values based on the moment.

Estimation of 1/a'

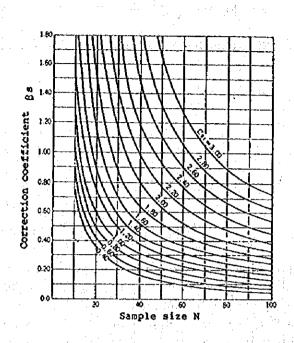
 $\frac{1}{a'} = \frac{\log e}{\sqrt{2}} \cdot \frac{1}{k} = 0.30709 \cdot \frac{1}{k}$ (Equation 2.8)

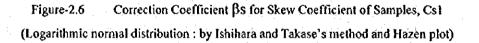
1/k should be determined by the following procedure: First, find the skew coefficient of samples, Csl

$$CsI = \frac{\sum_{i=1}^{N} (xi - \bar{x})^{3}}{(N - 1)\sigma x^{3}} = \sqrt{\frac{N - 1}{N} \cdot \frac{\bar{x}^{3} - 3(\bar{x}^{2}) \cdot \bar{x} + 2(\bar{x})^{3}}{\{\bar{x}^{2} - (\bar{x})^{2}\}^{\frac{3}{2}}} \dots (Equation 2.9)$$

$$\bar{x} = \frac{1}{N} \sum_{i=1}^{N} xi, \bar{x}^{2} = \frac{1}{N} \sum_{i=1}^{N} xi^{2}, \bar{x}^{3} = \frac{1}{N} \sum_{i=1}^{N} xi^{3}$$

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$$Cs = \frac{e^{9/4k^{2}} - 3e^{5/4k^{2}} + 2e^{3/4k^{2}}}{(e^{1/k^{2}} - e^{1/2k^{2}})^{3/2}}$$

$$\therefore \frac{1}{k} = \left[2\ln\left\{\sqrt[3]{1 + \frac{1}{2}Cs^{2} + \frac{1}{2}Cs\sqrt{4 + Cs^{2}}} + \sqrt[3]{1 + \frac{1}{2}Cs^{2} - \frac{1}{2}Cs\sqrt{4 + Cs^{2}}} - 1\right\}\right]^{1/2}$$

.....(Equation 2.11)
Estimation of h. xo

b =
$$\frac{1}{\sqrt{\lambda^2 - 1}} \sigma x - mx \equiv A_3 \sigma x - mx$$

xo - $mx - \frac{\lambda - 1}{\lambda(\lambda^2 - 1)} \sigma x \equiv mx - B_3 \sigma x$ (Equation 2.12)
xo + b = $\frac{\lambda}{\lambda\sqrt{\lambda^2 - 1}} \sigma x \equiv C_3 \sigma x$
where, $\lambda = \exp\left(\frac{1}{4k^2}\right)$
 $mx \equiv \overline{x} = \frac{1}{N} \sum_{i=1}^{N} x_i, \quad \sigma x \equiv \sqrt{Vx} = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} (x_i - \overline{x})^2}$

Method of solution by moments stated above is based on the empirical correration method utilizing sample distribution (based on Hazen plot) in (Equation 2.10). The results of this method can approximate relatively well the theoretical solutions of distribution functions.

2) Extreme Value Distribution (Type I)

This distribution is derived as the distribution of the maximum values of data in a group taken from a population having exponential type distribution, and the data of maximum values of hydrological quantities of each year can be suited to this distribution in many cases. This distribution shows a straight line on the extreme value probability paper. Basic formula for extreme value distribution is shown as below;

$$P(x) = 1 - exp(-e^{-y})$$

$$y = a(x - xo) \text{ or } x = xo + \frac{1}{a}y$$

$$a, xo > 0, -\infty < x < \infty$$
(Equation 2.13)
(Equation 2.14)

where, x : random hydrological quantity (annual maximum value)

y : standard extreme variable transformation of x

P(x): probability of exceedance

xo, a : constant values

Constant values xo, and a in the above formulae are normally estimated based on samples, and various methods of estimation are available such as Gumbel's method (moment method), Kimball's method.

<Estimating Constants by Gumbel's Method>

$$\frac{1}{a} = \frac{Sx}{Sy}$$

$$xo = \overline{x} - \frac{1}{a}\overline{y}$$
.....(Equation 2.15)
where, $\overline{x} = \frac{1}{N}\sum_{i=1}^{N} xi$ $S_x = \sqrt{\frac{1}{N}\sum_{i=1}^{N} (xi - \overline{x})^2} = \sqrt{\frac{1}{N}\sum_{i=1}^{N} xi^2 - (\overline{x})^2}$

.....(Equation 2.16)

For y, (Equation 2.13) can be rewritten as shown below with respect to sample No. i = 1, 2, ..., N.

Using Weibull plotting method,

yi =
$$-\ln\{-\ln(1 - P(x))\} = -\ln(-\ln\frac{i}{N+1})$$
(Equation 2.17)

Then, y and S_y should be determined from the following formula;

$$\overline{y} = \frac{1}{N} \sum_{i=1}^{N} y_i$$
, $Sy = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (y_i - \overline{y})^2} = \sqrt{\frac{1}{N} \sum_{i=1}^{N} y_i^2 - \overline{y}^2}$(Equation 2.18)

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y and Sy are determined only by N and also can be obtained from the table proposed by Gumbel. In the above method of solution, the plotting position samples is utilized together with the Weibull plot as shown in (Equation 2.17).

(2) Results of Probable Discharge Analysis

The results of probable discharge calculation were applied the above methods, and Table-2.6 shows only results of Gumbel's method and Figure-2.6 shows results of four methods such as least square method, moment method, Iwai method and Gumbel's method at typical discharge reference points in this Study.



Summary of Probable Discharge at Typical Discharge Reference Points Table-2.6 (Gumbel's Method)

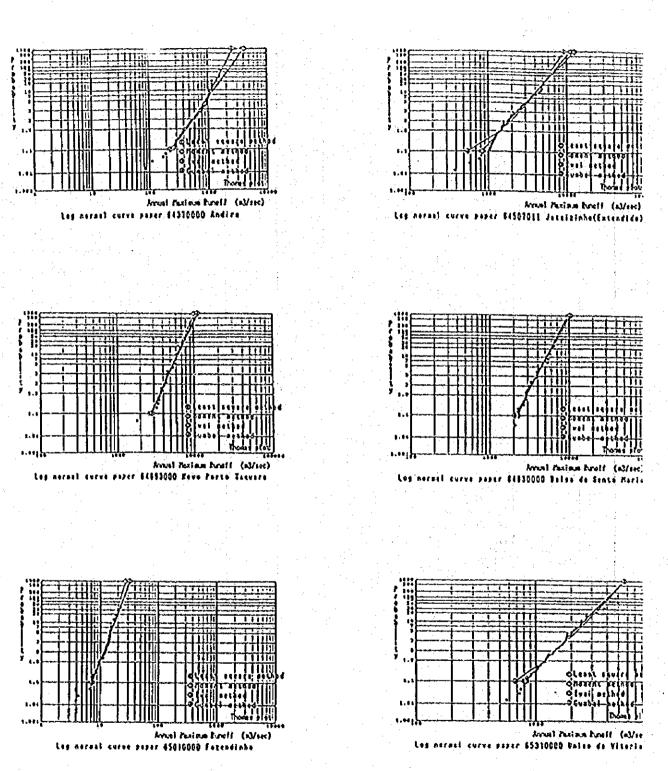
		, r			T		·				Unit : (m3	3/sec)
Basin	River	No.	St. No.	StName	Period	Catchment		Prol	able)	rear		1
						Area (km²)	2	5	10	30	50	10
Itarare	Jaguariaiva	1	64-242-000	Tamandua	1976-1993	1,622	243.7	485.7	646.0	888.1	998.6	1,14
Cinzas	Cinzas	2	64-360-000	Tomazina	1931-1993	2,015	231.5	379.4	477.3	625.2	6928	71
		3	64-370-000	Andira	1931-1993	5,622	588.0	917.0	1,134.8	1,464.0	1,614.2	1,8
ficagi	Tibagi	4	64-444-000	Uvaia	1974-1993	4,450	328.8	500.6	614.4	786.4	864.8	9
		5	64-465-000	Tibagi	1931-1993	8,948	652.7	1,056.6	1,317.4	1 711.5	1,891.5	2,1
		6	64-491-000	1) Barra Rib das Antas	1941-1993	15,600	1,222.8	1,878.8	2,313.1	2,969.3	3,268.9	3,6
		7	64-507-011	Jataizinho (Extendido)	1931-1993	21,955	1,921.4	3,172.5	4,000.9	5 252.7	5,824.1	6,5
Pirapo	Pirapo	8	64-550-000	Vila Silva Jardim	1967-1993	4,627	310.8	437.4	521.2	647.8	705.6	7
Ivai	lvai	9	64-625-000	Tereza Cristina	1957-1992	3,572	979.7	1,445.0	1,753.0	2,218.5	2,431.0	2,7
		10	64-645-000	Porto Espanhol	1965-1993	8,600	1,716.7	2,495.0	3,010.2	3,788.8	4,144.2	4,6
۰.		11	64-675-002	Porto Bananeiras	1974-1993	24,200	3,552.7	4,681.0	5,428.1	6,556.9	7,072 2	7,70
		12	64-685-000	Porto Paraiso do Norte	1953-1993	28,427	3,610.7	4,820.4	5,621.3	6,831.4	7,383.9	8,1
	· .	13	64-693-000	Novo Porto Taguara	1974-1993	34,432	4,120.6	5,324 2	6,121.1	7,325 2	7,874.8	8,6
Piquiti	Piquiri	14	64-771-500	Porto Guarani	1976-1993	4,223	1,513 2	1,996.4	2,316.4	2,799.8	3,020.5	3,3
		15	64-795-000	*2) Ponte do Piquín	1970-1993	11,303	3,493.3	4,938.2	5,894.9	7,340.5	8,000.4	8,8
		16	64-820-000	Porto Formosa	1966-1993	17,500	3,061.4	4,470.4	5,403.3	6,812.9	7,456.4	8,3
1		17	64-830-000	•2) Balsa do Santa Maria	1969-1993	20,982	3,331.3	4,519.1	5,305.5	6,493.8	7,035.2	7,7
lquácu	Iguacu	18	65-010-000	Fazendinha	1955-1993	110	11.2	14.8	17.1	20.7	22.3	
Ĩ.		19	65-025-000	Guajuvira	1976-1993	2,304	200.2	375.4	491.4	666.7	746 7	8
- 12 - 14		20	65-035-000	Porto Amazonas	1935-1993	3,662	291.1	452.1	558.7	719.7	793.2	8
1.1.1		21	65-060-000	Sao Mateus do Sul	1930-1993	6,065	380.9	587.5	724.3	930.9	1,025.3	1,1
		22	65-310-000	Uniao da Vitoria	1930-1993	24,211	1,460.4	2,182.1	2,659.9	3,381.9	3,711.5	_4,1
		23	65-895-002	Salto Osorio	1940-1993	45,824	4,289.7	7,989.2	10,438.6	14,139.6	15,829.2	18,1
		24	55-593-000	Salto Cataratas	1926-1993	67,317	8,065.4	14,095.9	18,088.6	24,121.8	26,876.0	30,5
	Negro	25	65-175-000	Divisa	1964-1993	7,970	491.9	644.8	746.0	899.0	968.8	1,0
·	Timbo	26	65-260-000	Foz do Cachoeira	1974-1993	693	124.0	219.3	283.1	378.9	422 6	4
	Jordao	27	65-825-000	Sanla Clara	1949-1993	3,913	615.0	1,092,3	1,408.3	1,885.8	2,103.8	2,3
	Chopim	28	65-960-000	Aguas do Vere	1956-1993	6,696	1,394.6	2,343.6	2,971.8		4,354.6	4,9
Ribeira	Ribeira	29	81-200-000	Capela do Ribeira	1936-1993	7,252	655.9	993.0	1,216.2	1,553.5	1,707.4	1,9
	Nhundiaguara	30	82-170-000	Morretes	1938-1993	217	111.5	153.0	180.4	221.9	240 8	2
	Marumbi	31	82-195-002	Morretes	1975-1993		55.1	78.2	93,4	116.5	127.0	- 1

Note : 1

1) The data period from 1947 to 1973 are not available
 2): These results are not accurate enough, because of the data source

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Figure-2.7 Results of Probable Discharge at Typical Discharge Reference Points (Weibull Plotting Position Method

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