5.4 Water Demand Projection by Sector and by Region

5.4.1 Demand Distribution of Municipalities Located in the Basin Boundary

(1) Urban Areas (Domestic and Industrial Water)

There are some urban areas which straddle boundaries of several basins such as Cascavel and others. Water demand for these urban areas are to belong to Iguaçu river basin.

(2) Rural Areas (Domestic and Agricultural Water)

Water demand for rural areas which straddle boundaries of several basins are distributed from municipality unit to Iguaçu river basin in accordance with the following equation:

$$D_P = D_M \times \frac{A_P}{A_M}$$

where:

D_P; rural water demand of Iguaçu river basin
D_M; rural water demand of municipality
A_P; area of municipality in Iguaçu river basin
A_M; area of municipality

5.4.2 Water Demand Projection in Iguaçu River Basin

The water demand projection by sector and by region in Iguaçu river basin was calculated for both base and alternative cases as shown in Table-5.13.

5.5 Environmental Sanitation Program for Curitiba Metropolitan Region (PROSAM)

PROSAM is an environmental sanitation project for Curitiba Metropolitan region including water supply, flood control and urban drainage, sewerage system, environment conservation etc. It includes construction of Irai dam for water supply of 2.0 m^3/sec, drainage channel excavation with a length of 15 km along left bank of the Iguaçu River, development river park, sewer pipe line with a length of 1,300 km, 8 sewerage treatment plants, solid waste disposal, bridges, and environmental education, etc. The total project cost amounts to US$ 233 x 10^6, 52% of which is to be financed by the World Bank. The project is scheduled to be implemented from 1992 to 1997. However, the progress rate as of June 1995 is estimated less than 20%.

Table-5.15 (1) Water Demand by Sector and by Region in Iguaçu River Basin [m^3/day]

MRH	No.	Name	Type	Zone	1993				2005				2015			
					Urban		Rural		Urban		Rural		Urban		Rural	
					Domestic	Industrial	Domestic	Agricultural	Domestic	Industrial	Domestic	Agricultural	Domestic	Industrial	Domestic	Agricultural
MRH 268	1	Alm. Tamandare	A		6,560	1,640	180	110	15,850	2,550	180	120	29,700	3,520	180	140
MRH 268	2	Araucaria	A		5,930	68,000	540	410	13,300	62,800	530	500	24,270	66,610	540	620
MRH 268	3	Balsa Nova	A		260	3,090	370	160	570	4,750	370	210	1,020	6,510	330	250
MRH 268	5	Campina Grande do Sul	A		1,520	660	70	80	5,210	1,600	60	100	10,750	2,440	60	130
MRH 268	6	Campo Largo	A		5,580	6,530	310	150	9,370	12,140	280	180	14,980	15,380	250	210
MRH 268	7	Colombo	A		12,080	4,400	350	90	27,120	7,270	320	100	49,530	9,860	310	120
MRH 268	8	Contenda	A		490	80	290	170	780	130	290	200	1,210	190	300	230
MRH 268	9	Curitiba	A		193,990	141,020	0	30	278,370	231,160	0	40	377,770	303,270	0	50
MRH 268	10	Fazenda Rio Grande	A		2,650	260	240	220	9,920	440	280	270	20,850	640	260	330
MRH 268	12	Mandirituba	A		470	90	660	890	870	150	710	1,140	1,470	210	640	1,360
MRH 268	13	Pinhais	A		7,500	3,870	270	20	13,330	9,250	340	20	22,000	13,210	300	30
MRH 268	14	Piraquara	A		2,050	230	900	40	3,330	560	1,010	40	5,190	800	920	50
MRH 268	15	Quatro Barras	A		910	1,670	70	90	2,360	2,020	60	110	4,520	2,510	50	130
MRH 268	17	Sao Jose dos Pinhais	A		12,260	12,550	860	370	27,340	27,550	820	440	49,800	38,510	750	510
MRH 268	268	Critiba Metropolitan Area	A		252,250	244,090	5,110	2,830	407,720	362,370	5,250	3,470	613,060	463,660	4,890	4,160
MRH 288	274	Cascavel	A		20,430	8,700	550	1,010	40,040	8,230	380	1,230	60,660	8,600	260	1,450
MRH 288	282	Foz do Iguacu	A		28,610	1,190	170	200	63,710	1,510	50	230	103,070	1,580	20	270
MRH 290	352	Guarapuava	A		12,330	5,870	1,550	2,530	20,070	8,810	1,790	3,110	28,790	12,930	1,890	3,700
MRH 288	294	Medianeira	B		2,570	740	460	910	5,090	1,120	290	1,100	7,220	1,170	190	1,270
MRH 289	324	Dois Vizinhos	B		2,150	2,680	720	1,470	4,210	5,920	420	1,850	6,610	8,500	240	2,170
MRH 289	327	Francisco Beltrao	B		5,570	4,330	1,050	1,980	10,630	6,830	810	2,450	17,590	9,810	520	2,920
MRH 289	333	Pato Branco	B		5,040	740	640	1,190	8,190	1,980	550	1,500	11,820	2,840	410	1,780
MRH 291	367	Palmas	B		2,730	2,060	690	2,580	4,600	2,590	500	3,170	7,230	2,660	300	3,800
MRH 291	371	Uniao da Vitoria	B		4,200	2,960	260	470	5,350	4,540	250	580	6,630	4,230	230	680
MRH 271	30	Quitandinha	C	a	210	30	860	550	310	50	970	670	410	70	1,030	810
MRH 272	32	Campo do Tenente	C	a	240	20	230	170	510	10	260	210	850	10	280	250
MRH 272	35	Porto Amazonas	C	a	260	50	60	70	370	120	80	90	500	180	80	110
MRH 272	36	Rio Negro	C	a	2,170	6,420	430	350	3,140	9,160	460	440	4,340	12,610	470	520
MRH 275	47	Sao Joao do Triunfo	C	a	270	30	670	100	530	10	720	120	800	10	710	140
MRH 275	48	Sao Mateus do Sul	C	a	1,730	1,740	1,230	370	2,750	2,310	1,350	440	4,000	3,360	1,370	520
MRH 276	51	Mallet	C	a	620	250	430	510	1,180	470	390	640	1,860	650	330	750
MRH 276	53	Reboucas	C	a	590	70	530	220	910	100	570	270	1,310	110	580	320
MRH 288	273	Capitao Leonidas Marques	C	a	490	30	420	570	790	40	170	710	950	40	80	840
MRH 289	318	Boa Esperanca do Iguacu	C	a	50	0	220	310	110	0	150	380	170	0	90	450
MRH 289	319	Bom Sucesso do Sul	C	a	100	0	200	590	160	10	190	720	230	10	160	870
MRH 289	328	Itapejara do Oeste	C	a	400	120	340	850	550	190	250	1,060	730	280	150	1,250
MRH 289	330	Marmeleiro	C	a	620	80	650	550	1,180	210	700	670	1,840	300	680	770
MRH 289	338	Realeza	C	a	920	90	510	390	1,080	200	310	470	1,240	290	190	540
MRH 289	342	Santa Izabel do Oeste	C	a	460	20	520	510	540	40	340	630	620	50	160	730
MRH 289	346	Saudade do Iguacu	C	a	190	70	190	360	270	110	170	450	370	160	130	540
MRH 289	347	Sulina	C	a	90	270	280	350	100	450	170	420	100	650	110	500
MRH 290	357	Quedas do Iguacu	C	a	1,720	1,450	1,040	540	2,500	2,250	910	650	3,180	3,300	830	750
MRH 290	358	Rio Bonito Iguacu	C	a	70	460	320	90	90	520	280	100	100	760	250	110
MRH 290	360	Virmond	C	a	60	40	200	90	80	60	170	100	90	90	160	110
MRH 291	361	Bituruna	C	a	620	650	500	3,810	1,110	1,190	450	4,700	1,700	1,180	390	5,700
MRH 291	368	Paula Freitas	C	a	170	20	220	200	420	20	180	260	720	20	140	300

Table-5.13 (2) Water Demand by Sector and by Region in Iguaçu River Basin [m³/day]

MRH	No.	Name	Type	Zone	1993				2005				2015			
					Urban		Rural		Urban		Rural		Urban		Rural	
					Domestic	Industrial	Domestic	Agricultural	Domestic	Industrial	Domestic	Agricultural	Domestic	Industrial	Domestic	Agricultural
MRH 291	370	Porto Vitoria	C	a	200	20	130	80	270	100	130	100	350	60	120	110
MRH 271	28	Agudos do Sul	C	b	60	10	380	360	70	20	440	440	70	30	470	530
MRH 271	29	Pien	C	b	130	250	450	320	320	330	510	390	500	460	550	460
MRH 276	54	Rio Azul	C	b	340	120	660	540	480	190	760	650	650	280	800	790
MRH 288	269	Boa Vista da Aparecida	C	b	270	20	490	250	390	20	470	290	430	20	420	340
MRH 288	275	Catanduvas	C	b	430	20	400	420	870	30	280	500	1,260	30	200	590
MRH 288	285	Ibema	C	b	340	250	160	280	790	300	150	340	1,220	310	140	410
MRH 288	305	Santa Lucia	C	b	160	10	190	260	250	0	100	320	300	10	50	370
MRH 288	313	Tres Barras Parana	C	b	340	30	700	550	550	30	460	660	670	30	310	760
MRH 289	316	Ampere	C	b	600	390	470	1,180	800	600	320	1,490	1,020	860	150	1,760
MRH 289	320	Capanema	C	b	780	60	750	750	880	110	450	930	980	160	160	1,090
MRH 289	321	Chopinzinho	C	b	840	130	780	1,480	1,170	300	550	1,840	1,540	430	300	2,170
MRH 289	322	Coronel Vivida	C	b	1,250	250	860	820	1,710	570	660	990	2,210	820	430	1,160
MRH 289	323	Cruzeiro do Iguacu	C	b	200	200	220	800	410	650	140	1,020	650	940	90	1,220
MRH 289	325	Eneas Marques	C	b	140	10	410	360	190	10	320	450	240	20	210	500
MRH 289	329	Mariopolis	C	b	290	60	240	280	390	120	210	330	510	180	180	390
MRH 289	331	Nova Esperanca do Sudoeste	C	b	70	0	330	490	100	0	330	590	130	10	300	690
MRH 289	334	Perola do Oeste	C	b	320	20	590	320	390	40	380	390	470	60	160	440
MRH 289	335	Pinhal Sao Bento	C	b	50	0	150	160	80	0	110	200	100	0	60	240
MRH 289	336	Planalto	C	b	410	20	720	470	500	40	470	560	610	60	200	640
MRH 289	337	Pranchita	C	b	270	20	390	490	450	70	240	600	650	100	90	710
MRH 289	339	Renascenca	C	b	210	110	370	720	240	220	360	880	270	320	310	1,050
MRH 289	340	Salgado Filho	C	b	180	10	650	630	260	30	550	770	350	40	410	880
MRH 289	341	Salto do Lontra	C	b	480	20	600	1,580	760	30	380	1,980	1,070	50	150	2,370
MRH 289	343	Santo Antonio Sudoeste	C	b	860	80	590	940	1,170	160	380	1,160	1,530	220	160	1,390
MRH 289	344	Sao Joao	C	b	490	30	580	1,230	710	50	380	1,540	960	70	170	1,820
MRH 289	345	Sao Jorge do Oeste	C	b	370	30	430	580	400	60	280	730	420	80	130	870
MRH 289	348	Vere	C	b	280	20	500	710	450	50	360	880	640	70	200	1,050
MRH 289	349	Vitorino	C	b	260	30	260	620	370	60	210	770	490	90	150	910
MRH 290	351	Cantagalo	C	b	710	110	590	210	2,330	200	700	240	6,300	290	740	280
MRH 290	356	Pinhao	C	b	1,060	750	1,690	780	1,010	710	2,010	940	900	1,050	2,130	1,060
MRH 291	362	Clevelandia	C	b	1,390	870	330	1,650	1,750	1,030	330	2,020	2,140	660	310	2,430
MRH 291	363	Cruz Machado	C	b	270	200	1,000	980	410	840	1,090	1,180	580	900	1,110	1,360
MRH 291	364	General Carneiro	C	b	700	580	360	320	1,530	940	320	380	2,570	920	270	450
MRH 291	365	Honorio Serpa	C	b	80	20	500	120	200	10	570	130	340	10	610	160
MRH 291	366	Mangueirinha	C	b	500	1,290	970	360	1,180	1,210	1,080	420	2,030	1,260	1,120	490
MRH 291	369	Paulo Frontin	C	b	170	30	350	540	310	40	410	660	470	40	440	790
MRH 271	31	Tijucas do Sul	C	c	110	120	410	180	150	220	490	220	200	340	520	270
MRH 272	33	Lapa	C	c	2,110	840	1,460	680	3,230	870	1,490	830	4,640	1,050	1,440	970
MRH 275	46	Antonio Olinto	C	c	70	20	510	150	150	30	550	180	240	30	560	200
MRH 288	276	Ceu Azul	C	c	490	870	200	460	910	1,310	200	550	1,260	1,360	200	620
MRH 288	284	Guaraniacu	C	c	680	30	430	630	1,330	40	320	760	1,880	40	240	830
MRH 288	290	Lindoeste	C	c	70	10	380	480	70	10	240	570	50	10	160	660
MRH 288	293	Matelandia	C	c	730	130	310	700	1,340	210	150	830	1,820	220	80	970
MRH 288	306	Santa Tereza do Oeste	C	c	290	20	100	210	550	30	60	250	760	40	40	290
MRH 288	307	Santa Terezinha Itaipu	C	c	1,040	90	90	140	2,300	80	60	160	3,480	90	40	180
MRH 288	309	Sao Miguel do Iguacu	C	c	880	350	300	480	1,800	340	150	570	2,610	360	80	660
MRH 289	317	Barracao	C	c	480	20	640	320	890	40	400	380	1,360	50	160	450
MRH 289	326	Flor da Serra do Sul	C	c	30	0	340	1,120	40	10	330	1,380	60	10	290	1,650
MRH 289	337	Nova Prata do Iguacu	C	c	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table-5.13 (3) Water Demand by Sector and by Region in Iguaçu River Basin [m^3/day]

MRH	No.	Name	Type	Zone	1993				2005				2015			
					Urban		Rural		Urban		Rural		Urban		Rural	
					Domestic	Industrial	Domestic	Agricultural	Domestic	Industrial	Domestic	Agricultural	Domestic	Industrial	Domestic	Agricultural
MRH 290	350	Candoi	C	c	190	230	1,220	700	300	240	1,500	820	400	360	1,580	930
MRH 290	353	Inacio Martins	C	c	270	330	810	720	370	380	1,080	890	450	560	1,140	1,060
MRH 290	354	Laranjeiras do Sul	C	c	2,100	310	710	470	2,520	400	520	580	2,720	590	410	670
MRH 290	355	Nova Laranjeiras	C	c	30	50	380	210	40	70	330	250	40	100	300	280
MRH 272	34	Palmeira			0	0	190	140	0	0	210	150	0	0	220	180
MRH 276	50	Irati			0	0	520	200	0	0	440	250	0	0	350	280
		Total			373,410	294,780	49,970	58,010	628,920	434,920	45,210	71,050	946,980	556,340	39,090	83,890

CHAPTER 6 WATER RESOURCES DEVELOPMENT

6.1 Surface Water Potential

6.1.1 Zoning for Surface Water Potential

In order to compare required water supply with surface water potential, Iguaçu river basin was divided into 22 blocks as shown in Figure-6.1.

Discharge reference point was determined downstream of each block. Each reference point is the same as the point of water quality study. Surface water potential was calculated at each discharge reference point.

6.1.2 Surface Water Potential

Surface water potential was calculated by deducting maintenance discharge (50%$Q_{10,7}$) from the low water flow ($Q_{10,7}$) at each reference point. Low water flow was applied as follows:

(1) Curitiba metropolitan area ------ HG64 (CEHPAR,1990)

(2) catchment area < 5,000km² ----- HG52 (CEHPAR,1982)

(3) catchment area ≥ 5,000km² ----- MINIMUM DISCHARGE VALUES FOR THE STATIONS STUDIED BY JICA IN PARANÁ STATE (COPEL,1995)

The result are shown in Table-6.1.

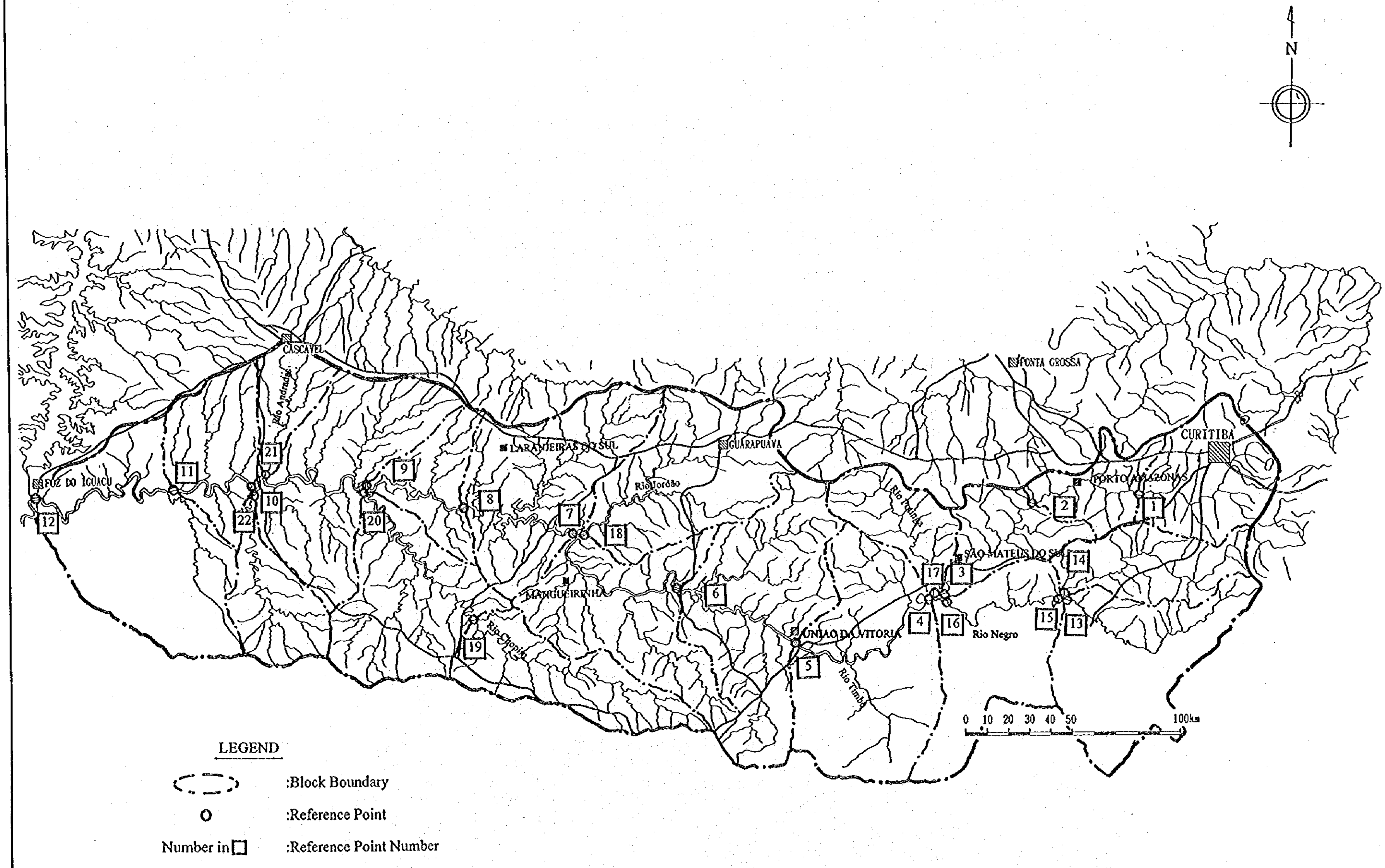


Figure-6.1 Iguaçu River Basin Division

Table-6.1 Surface Water Potential and Quality

Reference Point	River Name	Location	Catchment Area (km2)	Surface Water Quality in 1993 BOD(mg/l)	Surface Water Potential (m3/sec)	Required Water Supply (m3/sec) * 1993		
						1993 Urban	2005 Urban	2015 Urban
1	Rio Iguacu	Guajuvira (downstream Curitiba metropolitan Area)	2,830	13.7	3.27	8.04 -4.77 0.41	11.12 -7.85 0.29	15.01 -11.74 0.22
2	Rio Iguacu	south of Porto Amazonas	4,219	1.37	4.18	8.31 -4.13 0.50	11.53 -7.35 0.36	15.56 -11.38 0.27
3	Rio Iguacu	upstream confluence of Rio Negro	5,992	0.39	6.88	8.40 -1.52 0.82	11.65 -4.77 0.59	15.72 -8.84 0.44
4	Rio Iguacu	downstream confluence of Rio Potinga	18,465	0.30	20.57	8.78 11.79 2.34	12.12 8.45 1.70	16.33 4.24 1.26
5	Rio Iguacu	upstream Uniao da Vitoria	24,414	0.06	33.31	8.94 24.37 3.73	12.32 20.99 2.70	16.54 16.77 2.01
6	Rio Iguacu	Foz do Areia Dam	30,031	0.00	42.72	9.13 33.59 4.68	12.56 30.16 3.40	16.84 25.88 2.54
7	Rio Iguacu	downstream confluence of Rio Jordao	38,722	0.00	57.69	9.61 48.08 6.00	13.20 44.49 4.37	17.66 40.03 3.27
8	Rio Iguacu	Salto Santiago Dam	43,421	0.00	65.75	9.82 55.93 6.70	13.44 52.29 4.89	17.99 47.76 3.65
9	Rio Iguacu	downstream confluence of Rio Chopim	52,244	0.00	80.29	10.84 69.45 7.41	14.80 65.49 5.43	19.74 60.55 4.07
10	Rio Iguacu	downstream confluence of Rio Capanema	60,245	0.18	92.20	11.77 80.43 7.83	16.04 76.16 5.75	21.32 70.88 4.32
11	Rio Iguacu	route 163	62,656	0.05	95.46	11.87 83.59 8.04	16.16 79.30 5.91	21.46 74.00 4.45
12	Rio Iguacu	river mouth (Foz do Iguacu)	68,700	0.10	102.76	12.71 90.05 8.08	17.58 85.18 5.85	23.48 79.28 4.38
13	Rio Negro	upstream confluence of Rio da Varzea (include Rio Negro)	4,472	0.18	5.63	0.17 5.46 33.12	0.22 5.41 25.59	0.29 5.35 19.41
14	Rio da Varzea	river mouth	2,289	0.85	2.88	0.13 2.75 22.15	0.15 2.73 19.20	0.19 2.69 15.16
15	Rio Negro	downstream confluence of Rio da Varzea	6,761	0.41	8.50	0.30 8.20 28.33	0.37 8.13 22.97	0.48 8.02 17.71
16	Rio Negro	river mouth	10,639	0.07	12.65	0.31 12.34 40.81	0.38 12.27 33.29	0.49 12.16 25.82
17	Rio Potinga	river mouth	1,834	2.61	1.05	0.08 0.97 13.13	0.10 0.95 10.50	0.12 0.93 8.75
18	Rio Jordao	river mouth (include Guarapuava)	4,446	0.00	6.10	0.44 5.66 13.86	0.58 5.52 10.52	0.76 5.34 8.03
19	Rio Chopim	Sao Luiz (include Palmas)	3,005	0.87	4.35	0.19 4.16 22.89	0.24 4.11 18.13	0.29 4.06 15.00
20	Rio Chopim	river mouth (include Pato Branco, Francisco Beltrao and Dois Vizinhos)	7,076	0.00	8.16	0.93 7.23 8.77	1.25 6.91 6.53	1.62 6.54 5.04
21	Rio Andrade	river mouth (include Cascavel)	1,267	11.4	1.21	0.56 0.65 2.16	0.81 0.40 1.49	1.10 0.11 1.10
22	Rio Capanema	river mouth	1,974	2.38	2.21	0.11 2.10 20.09	0.13 2.08 17.00	0.14 2.07 15.79

*Remark

first line
 Required Water Supply (calculated in section 6.3)
second line
 Surface Water Potential - Required Water Supply
third line
 Possible Development Water / Required Water Supply

6.2 Groundwater Potential

6.2.1 Definition of Boundary of Area for Groundwater Study

The major municipal urban areas located in the Iguaçu river basin straddles over the boundary of other river basins. Therefore, the Iguaçu river basin for the study of the groundwater resources is composed of such areas as Iguaçu river basin, Karst basin on the right bank of Ribeira river, a part of the left bank of Piquiri river, and a part of Paraná III river basin including a part of the neighboring groundwater basins related to the major urban demand centers

6.2.2 Assessment of Groundwater Potential in Iguaçu River Basin

The Iguaçu River Basin is composed of the following aquifers in order of older age:

Karst, Crystalline Rocks (including Granitic Rocks), Furnas Formation, Upper-Middle Paleozoic, Upper Paleozoic, Botucatu Formation, Serra Geral Formation north, Serra Geral Formation south, Guabirotuba Formation.

The specific mean discharge which is defined as the specific mean of the annual minimum of average discharge of continuous 7 days (mQ_7) is used for the key data for the assessment of groundwater potential in this study. The result of the assessment of aquifers in the Iguaçu River Basin is shown in Table-6.2. Assessment of Furnas Formation and Guabirotuba Formation are not able to be done by limitation of the data conditions.

Table-6.2 Spatial Groundwater Potential of Iguaçu River Basin Estimated by Water Circulation

[1] Aquifer	[2] Location in River Basin	[3] Study Area	[4] Spatial mQ7	[5] Permissive Yield		[6] Required Recharge	[7] Total Permissive Yield	[8] Productivity of Borehole
		km^2	$x\ 10^{-3}$ m^3/km^2	%	$x\ 10^{-3}m^3$ $/s/km^2$	$km^2/s/m^3$	m^3/s	$x10^{-3}\ m^3/s$
Karst	mainly Ribeira nad Upper Iguaçu	3,500	8.29	30	2.49	400	8.750	44.40
Cristalline Rocks	Upper Iguaçu	4,500	6.37	10	0.64	1600	2.880	5.56
Furnas Formation	Upper Iguaçu	350	-	15	-	-	-	11.10
Middle-Upper Paleozoic	Upper Iguaçu	3,900	4.69	10	0.47	2,100	1.830	2.78
Upper Paleozoic	Upper to Middle Iguaçu	3,100	4.90	10	0.49	2,000	1.520	2.78
Botucatu Formation	Middle to Lower Iguaçu	32,000	-	-	-	-	-	124.00
Serra Geral Formation north	Lower Iguaçu	1,900	5.32	20	1.10	610	3.120	19.20
Serra Geral Formation south	Middle to Lower Iguaçu	32,000	5.26	15	0.79	1,300	11.900	3.33
Guabirotuba Formation	Upper Iguaçu	920	3.53	20	0.76	1,300	0.699	3.33

Note
[4]: Spatial and specific mQ_7
[6]: Required Rechargeing Area by $1m^3/s$ of groundwater yield
[7]: Total Permissive Yield of Aquifer in Study Area

The characteristics of each aquifer are described as follows:

(1) Karst

Groundwater potential of Karst is evaluated to be high. The Karst area included in the Iguaçu River basin has a drainage area of about 3,500 km^2, and about 8.75m^3/s can be developed within the permissible yield. This groundwater resource is appropriate for large scale development since its borehole productivity (borehole yield) is extremely large as 44 l/s/borehole.

The water quality of this aquifer is adequate for drinking water such as mineral water for Curitiba City, but not adequate for hydro-thermal and steam resources of industrial water resources because of its chemical characteristics.

(2) Botucatu Formation

The permissible yield of Botucatu Formation can not be estimated in this study, and it is difficult to apply the concept of permissible yield to this formation at present. It's permissible yield can be technically estimated by use of the drawdown data of groundwater table, but the drawdown data are not available. The specific mean discharge also cannot be applied to this formation because of the nature of its geologic structure.

However, the amount of its groundwater is assessed to be very large based on its extraordinarily large borehole productivity (124 l/s; in average of 9 boreholes) and storage volume. It's storage volume is assessed to be more than 20 times larger than that of Karst and a little less than 10 times of that of Serra Geral Formation.

This aquifer forms layering, and its water temperature becomes 40-70 °C at the depth of deeper than 800 m. This groundwater resource, therefore, is assessed to have high potential of industrial water use with appropriate control of pH and Na by mixing with other fresh water resources in consideration of confined water pressure, pH level and content of natrium.

(3) Serra Geral Formation north

This aquifer is broadly distributed from near Cascavel to the north, but the study area within the Iguaçu River basin is limited to the area of 1,900 km^2 near Cascavel. Though the spatial permissive yield and mean productivity of borehole of this formation is less than a half of those of Karst, its potential is relatively large and is assessed to be an adequate groundwater resource for medium scale development.

The water quality of this aquifer is appropriate for both domestic and industrial water supply.

(4) Serra Geral Formation south

The aquifer of Serra Geral Formation is broadly distributed with a basin area of 32,000 km^2 in the area middle reach to downstream of the Iguaçu River Basin. The groundwater resource of this aquifer is assessed to be appropriate for small to medium scale development based on its spatial permissive yield and productivity.

(5) Guabirotuba Formation

This aquifer is distributed in Curitiba metropolitan area (CMA) with a basin area of 900 km^2, and its groundwater resource is widely used for the domestic and industrial water in CMA. Monitoring of groundwater of this formation is required with high maneuverability because it is distributed in the urban area. It will be required to measure promptly chemical contents in response to necessity not limiting to the standard observation items for drinking water because there is a possibility of contamination of groundwater.

The total permissive yield of the whole aquifer is estimated to be about 0.7 m^3/s (average of CMA). Various kind of adverse effects on the use of wells will be expected in the central urban area of Curitiba city in the near future because present groundwater use for industries is estimated to be very high in this area.

(6) Furnas Formation

The aquifer of Furnas Formation is assessed to be appropriate for small scale development based on its productivity of borehole.

(7) Other Aquifers

Groundwater development of other aquifers not aforementioned is assessed to be infeasible except for the rural areas facing shortage or lack of other fresh water sources because of its low permissive yield and productivity.

6.3 Required Water Supply Amount

6.3.1 Water Demand and Sources

Water demands are estimated for urban domestic water, rural domestic water, industrial water and agricultural water. Water source which is appropriate for each water demand seems to be basically as shown in Table-6.3, from the view point of developed amount, technology, realization, etc.

Table-6.3 Water Demand and Source

Water Demands	Region	Main Water Sources	Sub Water Sources
Domestic	Urban	Surface Water	Groundwater
	Rural	Groundwater	Surface Water
Industrial	Urban	Surface Water	Groundwater
Agricultural	Rural	Surface Water	Groundwater

Water source of urban domestic water and industrial water will be established by considering the characteristics of the region, surface water potential, groundwater potential, etc.

6.3.2 Water Losses

Required water supply amount is calculated by adding various losses to each water demand. Percentage of total water loss which includes losses for intake, conveyance, treatment, distribution of water, etc., is assumed as shown in Table-6.4 taking into consideration present loss percentage, future improvement and type of water development.

Table-6.4 Percentage of Water Losses

Purpose of Water Use	Region	1993(%)	2005(%)	2015(%)
Domestic	Urban	40	30	25
	Rural	15	10	10
Industry	Urban	15	10	10
Agriculture	Rural	20	20	20

6.3.3 Classification and Zoning of Region

The urban areas were classified into the following categories by considering characteristics of each area:

(1) Type-A: Large urban areas

The large urban areas were defined that their population will be more than approximately 100,000 in 2015.

(2) Type-B: Medium urban areas

The medium urban areas were defined that their population will be more than approximately 50,000 in 2015.

(3) Type-C: Other urban areas

The other urban areas were classified into the following zoning by considering topographic conditions:

1) Zone-a: Urban areas located nearby main streams

These areas located nearby main stream or downstream of tributaries, therefore problems of the shortage of intake rate and water quality are few.

2) Zone-b: Urban areas located upstream of second or third tributaries

Although there are problems of possible water development volume and intake method, water quality problems are quite few.

3) Zone-c: Urban areas located at top or ridge of mountains

These areas require to intake the water from the downstream of urban town, and water volume, water quality and intake method have many problems.

A hundred and one municipalities belong to Iguaçu river basin, out of which 17 urban areas were classified into Type-A and other 6 urban areas were classified into Type-B. 76 belong to Type-C and 2 municipalities belong to only rural areas.

Type-C urban areas were classified into 3 zones by considering topographic conditions. Urban classification and zoning of Type-C urban areas are shown in Table-6.5.

6.3.4 Required Water Supply

Assuming water loss percentage as shown in Table-6.4, based on water demand estimated in the Section-5.4, required water supply by sector and by region was calculated for both base and alternative cases as shown in Table-6.6.

Table-6.5 Classification and Zoning of Urban Areas in Iguaçu River Basin

No.	Municipality Name	Type	Zone	MRH
1-14	Curitiba Metropolitan Area	14 municipalities of MRH 268		
1	-Alm. Tamandare	A		MRH 268
2	-Araucaria	A		MRH 268
3	-Balsa Nova	A		MRH 268
4	- Campina Grande do Sul	A		MRH 268
5	-Campo Largo	A		MRH 268
6	-Colombo	A		MRH 268
7	-Contenda	A		MRH 268
8	-Curitiba	A		MRH 268
9	-Fazenda Rio Grande	A		MRH 268
10	-Mandirituba	A		MRH 268
11	-Pinhais	A		MRH 268
12	-Piraquara	A		MRH 268
13	-Quatro Barras	A		MRH 268
14	-Sao Jose dos Pinhais	A		MRH 268
15	Cascavel	A		MRH 288
16	Foz do Iguacu	A		MRH 288
17	Guarapuava	A		MRH 290
18	Medianeira	B		MRH 288
19	Dois Vizinhos	B		MRH 289
20	Francisco Beltrao	B		MRH 289
21	Pato Branco	B		MRH 289
22	Palmas	B		MRH 291
23	Uniao da Vitoria	B		MRH 291
24	Quitandinha	C	a	MRH 271
25	Campo do Tenente	C	a	MRH 272
26	Porto Amazonas	C	a	MRH 272
27	Rio Negro	C	a	MRH 272
28	Sao Joao do Triunfo	C	a	MRH 275
29	Sao Mateus do Sul	C	a	MRH 275
30	Mallet	C	a	MRH 276
31	Reboucas	C	a	MRH 276
32	Capitao Leonidas Marques	C	a	MRH 288
33	Boa Esperanca do Iguacu	C	a	MRH 289
34	Bom Sucesso do Sul	C	a	MRH 289
35	Itapejara do Oeste	C	a	MRH 289
36	Marmeleiro	C	a	MRH 289
37	Realeza	C	a	MRH 289
38	Santa Izabel do Oeste	C	a	MRH 289
39	Saudade do Iguacu	C	a	MRH 289
40	Sulina	C	a	MRH 289
41	Quedas do Iguacu	C	a	MRH 290
42	Rio Bonito Iguacu	C	a	MRH 290
43	Virmond	C	a	MRH 290
44	Bituruna	C	a	MRH 291
45	Paula Freitas	C	a	MRH 291
46	Porto Vitoria	C	a	MRH 291
47	Agudos do Sul	C	b	MRH 271
48	Pien	C	b	MRH 271
49	Rio Azul	C	b	MRH 276
50	Boa Vista da Aparecida	C	b	MRH 288
51	Catanduvas	C	b	MRH 288
52	Ibema	C	b	MRH 288
53	Santa Lucia	C	b	MRH 288
54	Tres Barras Parana	C	b	MRH 288
55	Ampere	C	b	MRH 289
56	Capanema	C	b	MRH 289
57	Chopinzinho	C	b	MRH 289
58	Coronel Vivida	C	b	MRH 289
59	Cruzeiro do Iguacu	C	b	MRH 289
60	Eneas Marques	C	b	MRH 289
61	Mariopolis	C	b	MRH 289
62	Nova Esperanca do Sudoeste	C	b	MRH 289
63	Perola do Oeste	C	b	MRH 289
64	Pinhal Sao Bento	C	b	MRH 289
65	Planalto	C	b	MRH 289
66	Pranchita	C	b	MRH 289
67	Renascenca	C	b	MRH 289
68	Salgado Filho	C	b	MRH 289
69	Salto do Lontra	C	b	MRH 289
70	Santo Antonio Sudoeste	C	b	MRH 289
71	Sao Joao	C	b	MRH 289
72	Sao Jorge do Oeste	C	b	MRH 289
73	Vere	C	b	MRH 289
74	Vitorino	C	b	MRH 289
75	Cantagalo	C	b	MRH 290
76	Pinhao	C	b	MRH 290
77	Clevelandia	C	b	MRH 291
78	Cruz Machado	C	b	MRH 291
79	General Carneiro	C	b	MRH 291
80	Honorio Serpa	C	b	MRH 291
81	Mangueirinha	C	b	MRH 291
82	Paulo Frontin	C	b	MRH 291
83	Tijucas do Sul	C	c	MRH 271
84	Lapa	C	c	MRH 272
85	Antonio Olinto	C	c	MRH 275
86	Ceu Azul	C	c	MRH 288
87	Guaraniacu	C	c	MRH 288
88	Lindoeste	C	c	MRH 288
89	Matelandia	C	c	MRH 288
90	Santa Tereza do Oeste	C	c	MRH 288
91	Santa Terezinha Itaipu	C	c	MRH 288
92	Sao Miguel do Iguacu	C	c	MRH 288
93	Barracao	C	c	MRH 289
94	Flor da Serra do Sul	C	c	MRH 289
95	Nova Prata do Iguacu	C	c	MRH 289
96	Candoi	C	c	MRH 290
97	Inacio Martins	C	c	MRH 290
98	Laranjeiras do Sul	C	c	MRH 290
99	Nova Laranjeiras	C	c	MRH 290
100	Palmeira	*		MRH 272
101	Irati	*		MRH 276

* : Urban area is not included in Iguacu river basin. Only rural area spreaded in the basin.

Table-6.6 Required Water Supply by Sector and by Region in Iguaçu River Basin [Base Case]

[m3/sec]

Municipality Name	Type	Zone	1993 Urban Domestic	1993 Urban Industrial	1993 Urban Total	2005 Urban Domestic	2005 Urban Industrial	2005 Urban Total	2015 Urban Domestic	2015 Urban Industrial	2015 Urban Total	2005-1993 Urban Domestic	2005-1993 Urban Industrial	2005-1993 Urban Total	2015-1993 Urban Domestic	2015-1993 Urban Industrial	2015-1993 Urban Total
Critiba Metropolitan Area	A		4.866	3.324	8.190	6.740	4.661	11.401	9.463	5.962	15.425	1.874	1.337	3.211	4.597	2.638	7.235
Cascavel	A		0.394	0.118	0.512	0.662	0.106	0.768	0.936	0.111	1.047	0.268	0.000	0.268	0.542	0.000	0.542
Foz do Iguacu	A		0.552	0.016	0.568	1.053	0.019	1.072	1.591	0.020	1.611	0.501	0.003	0.504	1.039	0.004	1.043
Guarapuava	A		0.238	0.080	0.318	0.332	0.113	0.445	0.444	0.166	0.610	0.094	0.033	0.127	0.206	0.086	0.292
Medianeira	B		0.050	0.010	0.060	0.084	0.014	0.098	0.111	0.015	0.126	0.034	0.004	0.038	0.061	0.005	0.066
Dois Vizinhos	B		0.041	0.036	0.077	0.070	0.076	0.146	0.102	0.109	0.211	0.029	0.040	0.069	0.061	0.073	0.134
Francisco Beltrao	B		0.107	0.059	0.166	0.176	0.088	0.264	0.271	0.126	0.397	0.069	0.029	0.098	0.164	0.067	0.231
Pato Branco	B		0.097	0.010	0.107	0.135	0.025	0.160	0.182	0.037	0.219	0.038	0.015	0.053	0.085	0.027	0.112
Palmas	B		0.053	0.028	0.081	0.076	0.033	0.109	0.112	0.034	0.146	0.023	0.005	0.028	0.059	0.006	0.065
Uniao da Vitoria	B		0.081	0.040	0.121	0.088	0.058	0.146	0.102	0.054	0.156	0.007	0.018	0.025	0.021	0.014	0.035
Total of Type-C/Zone-a	C	a	0.236	0.161	0.397	0.312	0.228	0.540	0.409	0.310	0.719	0.076	0.067	0.143	0.173	0.149	0.322
Total of Type-C/Zone-b	C	b	0.296	0.077	0.373	0.392	0.117	0.509	0.545	0.141	0.686	0.099	0.043	0.142	0.256	0.070	0.326
Total of Type-C/Zone-c	C	c	0.193	0.045	0.238	0.272	0.056	0.328	0.349	0.069	0.418	0.079	0.012	0.091	0.156	0.024	0.180
Total			7.204	4.004	11.208	10.392	5.594	15.986	14.617	7.154	21.771	3.191	1.606	4.797	7.420	3.163	10.583

(2) Required Water Supply of Urban Area by Sector and by Region in Iguacu River Basin [Alternative Case]

[m3/sec]

Municipality Name	Type	Zone	1993 Urban Domestic	1993 Urban Industrial	1993 Urban Total	2005 Urban Domestic	2005 Urban Industrial	2005 Urban Total	2015 Urban Domestic	2015 Urban Industrial	2015 Urban Total	2005-1993 Urban Domestic	2005-1993 Urban Industrial	2005-1993 Urban Total	2015-1993 Urban Domestic	2015-1993 Urban Industrial	2015-1993 Urban Total
Curitiba Metropolitan Area	A		4.866	3.324	8.190	6.072	4.197	10.269	8.026	5.059	13.085	1.206	0.873	2.079	3.160	1.735	4.895
Cascavel	A		0.394	0.118	0.512	0.746	0.164	0.910	1.120	0.225	1.345	0.352	0.046	0.398	0.726	0.107	0.833
Foz do Iguacu	A		0.552	0.016	0.568	1.188	0.103	1.291	1.873	0.187	2.060	0.636	0.087	0.723	1.321	0.171	1.492

(3) Required Water Supply of Rural Area by Sector and by Region in Iguacu River Basin

[m3/sec]

Municipality Name	Type	Zone	1993 Rural Domestic	1993 Rural Agricult.	2005 Rural Domestic	2005 Rural Agricult.	2015 Rural Domestic	2015 Rural Agricult.	2005-1993 Rural Domestic	2005-1993 Rural Agricult.	2015-1993 Rural Domestic	2015-1993 Rural Agricult.
Total of Type-A	A		0.099	0.094	0.098	0.116	0.090	0.140	0.004	0.022	0.003	0.046
Total of Type-B	B		0.052	0.124	0.035	0.154	0.024	0.182	0.000	0.030	0.000	0.058
Total of Type-C/Zone-a	C	a	0.141	0.165	0.118	0.204	0.109	0.250	0.000	0.039	0.003	0.085
Total of Type-C/Zone-b	C	b	0.261	0.327	0.217	0.403	0.177	0.470	0.008	0.076	0.012	0.143
Total of Type-C/Zone-c	C	c	0.121	0.121	0.104	0.144	0.097	0.170	0.005	0.023	0.008	0.049
Total			0.674	0.831	0.572	1.021	0.497	1.212	0.017	0.190	0.026	0.381

6.4 Water Development in Curitiba Metropolitan Area

The large urban areas included in Curitiba Metropolitan Area are as shown below:

1) Curitiba
2) Almirante Tamandare
3) Colombo
4) Piraquara
5) Sao Jose dos Pinhais
6) Araucaria
7) Campo Largo
8) Pinhais
9) Fazenda Rio Grande
10) Quatro Barras
11) Campina Grande do Sul
12) Balsa Nova
13) Contenda
14) Mandirituba

6.4.1 Water Requirement

Water requirement for urban area is mainly composed of urban domestic water and industrial water. Required water supply in Curitiba Metropolitan Area is shown in Table-6.7.

Table-6.7 Required Water Supply in Curitiba Metropolitan Area (m^3/s)

Case	Required Water	Year		
		1993	2005	2015
Base Case	Required Water Supply	8.190	11.401	15.425
	Water to be newly developed		3.211	7.235

6.4.2 Process of Water Resources Development Study

As studied in the Section-6.1, there is no room for direct intake from river due to shortage of natural discharge in the upstream of Iguaçu river until confluence of Negro river. Therefore, development of new water resources has to depend on the combination of surface water by dam-reservoir and groundwater.

Process of water resources development in Curitiba Metropolitan Area was as shown below:

(1) Water supply in Curitiba Metropolitan Areas was studied for surface water development by dams. Water development in proposed 10 dams, planned by SANEPAR around Curitiba at the upstream of Iguaçu river was studied.

(2) Water supply in Curitiba Metropolitan Area was studied for groundwater development by wells.

(3) The Combination of dams and wells was optimized for the water supply.

6.4.3 Surface Water Development by Dam

The water development calculation was made based on the following conditions.

a) Assuming the daily discharge at proposed dam sites are inflow to the reservoir, daily water balance in the reservoir is simulated for 20 years.

b) Maintenance discharge from the reservoir and downstream of intake point is assumed to be 50% of $Q_{10,7}$ and the daily discharge is to be more than the maintenance discharge.

c) i) When inflow is less than the sum of proposed development water and maintenance discharge, deference is supplied from reservoir water.

ii) When inflow is more than the sum of proposed development water and maintenance discharge, excess of inflow is recharged to the reservoir. If the reservoir is full at that time, excess water is discharge to the downstream of dam.

d) Evaporation from reservoir is also counted by applying average monthly evaporation data for 20 years at Piraquara observation station.

e) Seepage or infiltration from reservoir is neglected.

f) The maximum period of recovery is about 5 years.

The proposed 10 dams planned by SANEPAR are shown in Table-6.8 and Figure-6.2.

Table-6.8 Proposed 10 dams planned by SANEPAR

Name of Dam (River)	Dam Site				Intake Point				Treat-ment Station	Supply Reser-voir
	Catch-ment Area (km²)	$q_{10,7}$ [m³/s/100km²]	$Q_{10,7}$ 50% [m³/s]	Correc-tion Coeffi-cient	Catch-ment Area (km²)	$q_{10,7}$ [m³/s/100km²]	$Q_{10,7}$ 50% [m³/s]	Correc-tion Coeffi-Cient		
1 Irai	112.6	0.355	0.200	0.781	226.6	0.408	0.460	1.807	ETA Irai	Cajura
2 Piraquara 2	58.0	0.397	0.115	0.450						
3 pequeno	62.3	0.465	0.145	0.566	110.0	0.465	0.255	1.000	ETA Iguaçu	
4 Alto Miringuava	71.9	0.417	0.150	0.586	97.1	0.402	0.195	0.768	ETA BARRO PRETO	Xaxim
5 Cotia Despique	154.7	0.271	0.210	0.820	same as dam site				ETA COCHOENE	
6 Alto Mauricio	36.0	0.277	0.050	0.195	ditto					Ceasa
7 Das Oncas (Mandirituba)	29.0	0.276	0.040	0.156	ditto					
8 Faxinal	63.3	0.269	0.085	0.333	ditto					Araucaria
9 Das Onces (Coutenda)	75.6	0.265	0.100	0.392	ditto					
10 Piunduva	25.4	0.276	0.035	0.137	ditto					

[Note] : daily discharge at each dam site is calculated by multiplying daily discharge at Fazendinha station by correction coefficient.

Correction Coeffivient : α =C.A/110.0 x $q_{10,7}$/0.465

110.0 : C.A. of Fazendinha

$q_{10,7}$ value was calculated by HG64

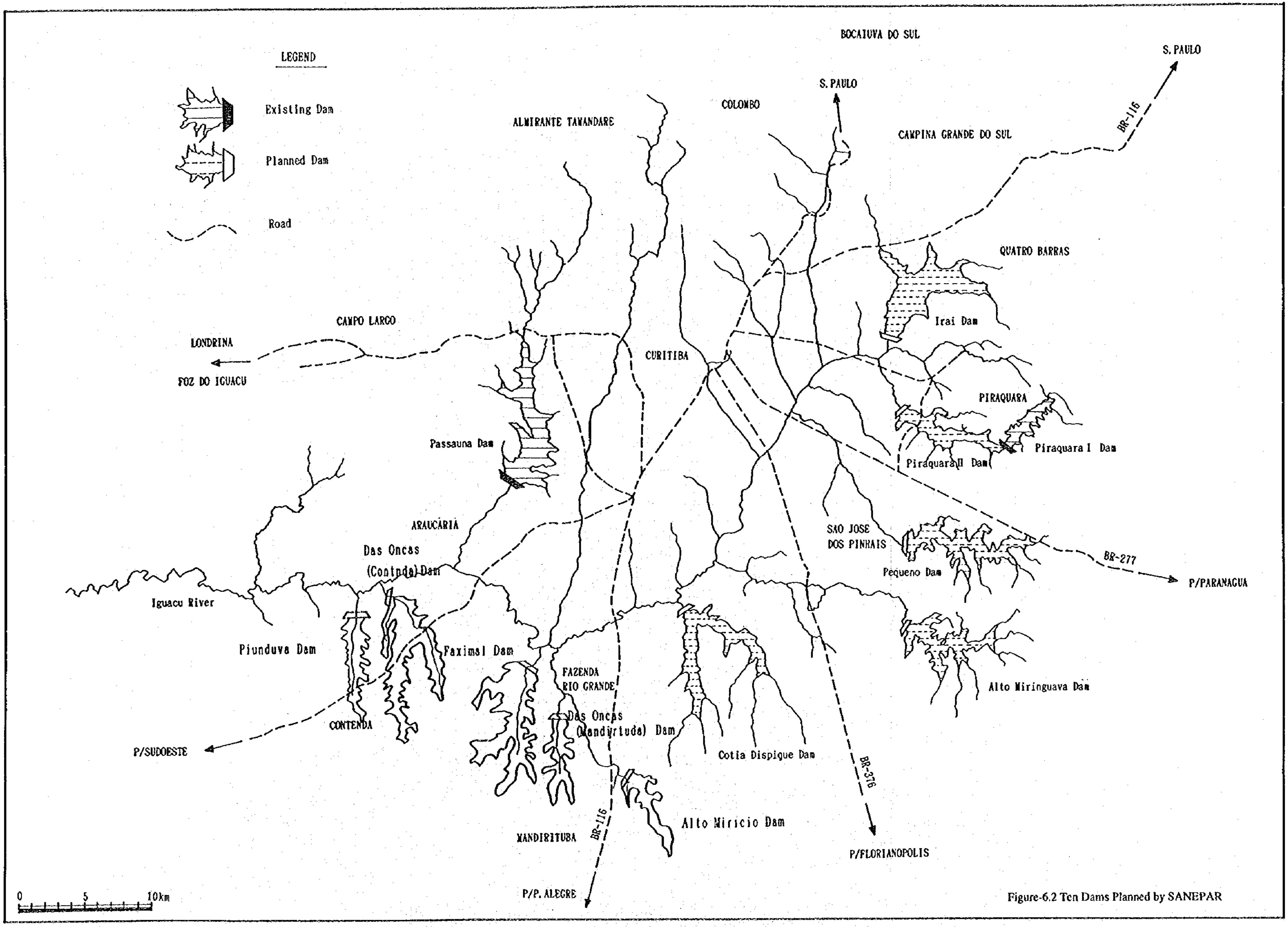


Figure-6.2 Ten Dams Planned by SANEPAR

Several cases of proposed water development volume range from 0.10 m³/sec to 1.40 m³/sec were assumed at each proposed dam. Simulation of daily water balance in reservoir was carried out for 20 years. The result of simulation are shown in Table-6.9.

For example, judging from required recovery period of reservoir capacity, an appropriate water development volume by Pequeno dam(No.3) seems to be 0.8m³/sec.

The water development volume by dams around Curitiba is as shown in Table-6.9.

Table-6.9 DevelopedWater and Required Reservoir Capacity by Planned Dam

Name of Dam		Develop-ment Water (m³/sec)	Reservoir Capacity (x 10⁶m³)	Period of Recovery (Year)
1	Irai	1.30	47.9	2.0
		1.40	52.4	5.5
		1.50	57.9	9.0
		1.60	63.6	-
2	Piraquara II	0.70	15.3	4.5
		0.75	21.9	5.5
		0.80	36.7	10.0
		0.85	47.7	-
3	Pequeno	0.60	15.5	2.0
		0.70	20.1	4.0
		0.80	25.4	5.5
		0.90	33.0	-
		1.00	48.2	-
4	Alto Miringuava	0.40	5.2	2.0
		0.50	14.4	3.0
		0.60	19.4	5.5
		0.70	27.6	-
		0.80	46.4	-
5	Cotia Despique	1.00	27.6	3.0
		1.10	32.9	4.5
		1.20	38.9	5.5
		1.30	47.2	-
		1.40		-
6	Alto Mauricio	0.15	3.0	1.5
		0.20	5.3	2.0
		0.25	7.8	5.0
		0.30	11.6	-
		0.36		-
7	Das Onças (Mandirituba)	0.10	1.7	1.5
		0.15	3.5	2.0
		0.20	5.8	4.5
		0.25	9.7	-
		0.30		-
8	Faxinal	0.30	5.2	1.5
		0.40	9.8	2.0
		0.50	14.9	5.5
		0.60	25.0	-
		0.70		-
9	Das Onças (Contenda)	0.40	7.2	2.0
		0.50	11.8	2.5
		0.60	16.8	5.0
		0.70	25.3	-
		0.80		-
10	Piunduva	0.10	1.8	1.5
		0.15	4.0	2.0
		0.20	6.7	5.5
		0.25		
		0.30		
Total		6.50	210.0	

[Note] "-": It means that capacity is not recovery.

Several cases of proposed water development volume range from 0.10 m³/sec to 1.40 m³/sec were assumed at each proposed dam. Simulation of daily water balance in reservoir was carried out for 20 years. The result of simulation are shown in Table-6.9.

For example, judging from required recovery period of reservoir capacity, an appropriate water development volume by Pequeno dam(No.3) seems to be 0.8m³/sec.

The water development volume by dams around Curitiba is as shown in Table-6.9.

Table-6.9 DevelopedWater and Required Reservoir Capacity by Planned Dam

Name of Dam		Develop-ment Water (m³/sec)	Reservoir Capacity (x 10⁶m³)	Period of Recovery (Year)
1	Irai	1.30	47.9	2.0
		1.40	52.4	5.5
		1.50	57.9	9.0
		1.60	63.6	-
2	Piraquara II	0.70	15.3	4.5
		0.75	21.9	5.5
		0.80	36.7	10.0
		0.85	47.7	-
3	Pequeno	0.60	15.5	2.0
		0.70	20.1	4.0
		0.80	25.4	5.5
		0.90	33.0	-
		1.00	48.2	-
4	Alto Miringuava	0.40	5.2	2.0
		0.50	14.4	3.0
		0.60	19.4	5.5
		0.70	27.6	-
		0.80	46.4	-
5	Cotia Despique	1.00	27.6	3.0
		1.10	32.9	4.5
		1.20	38.9	5.5
		1.30	47.2	-
		1.40		-
6	Alto Mauricio	0.15	3.0	1.5
		0.20	5.3	2.0
		0.25	7.8	5.0
		0.30	11.6	-
		0.36		-
7	Das Onças (Mandirituba)	0.10	1.7	1.5
		0.15	3.5	2.0
		0.20	5.8	4.5
		0.25	9.7	-
		0.30		-
8	Faxinal	0.30	5.2	1.5
		0.40	9.8	2.0
		0.50	14.9	5.5
		0.60	25.0	-
		0.70		-
9	Das Onças (Contenda)	0.40	7.2	2.0
		0.50	11.8	2.5
		0.60	16.8	5.0
		0.70	25.3	-
		0.80		-
10	Piunduva	0.10	1.8	1.5
		0.15	4.0	2.0
		0.20	6.7	5.5
		0.25		
		0.30		
Total		6.50	210.0	

[Note] "-": It means that capacity is not recovery.

6.4.4 Groundwater Development by Wells

The aquifers in and around the Curitiba Metropolitan Area are Crystalline Rock, Guabirotuba Formation and Karst. The aquifer being targeted for groundwater development is the Karst aquifer, which is the most productive of the three.

The Karst aquifer is located some 10 to 50 km to the north of Curitiba, its influence area is 400 $km^2/m^3/s$ and its permissive yield per well is 0.044 m^3/s/well.

The survey for the groundwater development of the Karst aquifer was carried out over four stages using the development of approximately 1 m^3/s as one unit. The four stages have been numbered 1 to 4 in order starting from the easiest one to develop. Table-6.10 and Figure-6.3 provide production data and indicate the locations of the wells in the aquifer respectively.

Table-6.10 Productivity of Karst aquifer

No.	Number of Productive Borcheles	Productivity (m^3/s)	Stage	Number of Productive Borcheles	Productivity (m^3/s)	Influence Area (km^2)
1	9	0.40				
2	5	0.20				
3	5	0.20	1	29	1.20	480
4	3	0.10				
5	7	0.30				
6	6	0.25				
7	6	0.25	2	24	1.00	400
8	6	0.25				
9	6	0.25				
10	6	0.25				
11	6	0.25	3	24	1.00	400
12	6	0.25				
13	6	0.25				
14	6	0.25				
15	6	0.25	4	24	1.00	400
16	6	0.25				
17	6	0.25				
Total				101	4.20	1680

(Note) borehile depth is 60 m
permissive yield is 0.044m^3/s
infruence area is 400 $km^2/m^3/s$

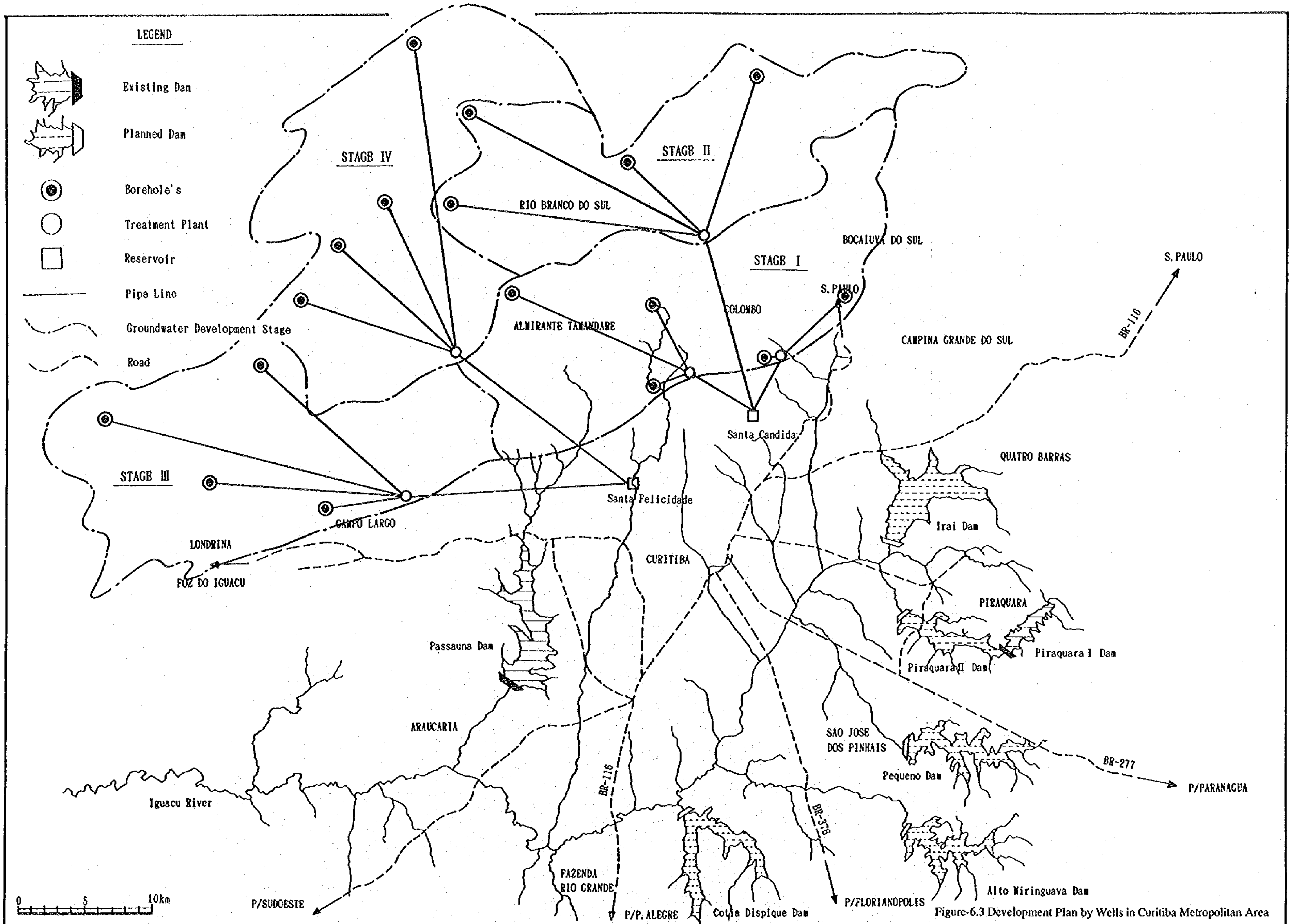


Figure-6.3 Development Plan by Wells in Curitiba Metropolitan Area

6.4.5 Optimization of the Water Supply System

As was mentioned earlier, whereas the required water supply in the Curitiba Metropolitan Area is 7.235 m^3/s, the maximum available amount that can be developed from the ten dams is just 6.50 m^3/s, meaning that it will be difficult to meet the demand through surface water alone. Moreover, as the amounts of water developed from the groundwater of the Karst aquifer increase, the feeding of water over long distances will lead to an increase in the unit water costs (rates) of development. For these reasons, it is necessary to ensure the water supply in the Curitiba Metropolitan Area through a combination of both surface water development by dams and groundwater development by the Karst aquifer.

The features of surface water development by dam in contrast to groundwater development are as described in Table 6.11.

Table-6.11 Comparison of Surface Water Development by Dam and Groundwater Development

Item	Surface Water Development by Dam	Groundwater Development
① Stable water intake (certainty of available water)	As the development plan has been formulated based on the results of statistically processing materials relating to water, which have been collected over a long period, and performing simulations using actual daily flow rates, the degree of certainty regarding the design water intake is high.	The monitoring of groundwater has been implemented in recent times, however, compared to the data on surface water, that relating to groundwater is lacking in terms of the length of period and size of area. Moreover, it cannot be said that a full understanding has been gained of the potentially available groundwater quantities and of the effects of development on surrounding ground and surface water quantities. It is therefore less certain that the design water intake can be secured, compared to the case of surface water development.
② Water quality	In order to preserve the quality of the water in the dam reservoirs, development and improvement of the sewerage systems in upstream towns and the taking of measures to counter eutrophication in the reservoirs will be necessary.	As the Karst aquifer contains hard water, careful thought will need to be given to its specific uses in the case where it is used as industrial water.
③ Construction period	As large-scale works will be necessary, the construction period will be relatively long.	The boring of wells will not take such a long time, however, the laying of pipe lines will be slightly more time consuming than the construction of dams.
④ Environmental impact	As reservoirs will be constructed artificially, it will be necessary to formulate a detailed plan upon first understanding the effects on ecological systems, the surrounding residents and water quality, etc.	Little direct effect on the surface environment can be expected, however, planning will have to take into consideration ground subsidence and the effects on other wells. As groundwater also acts as a source of surface water, it will also be necessary to amply consider the effects the development will have on the flows of downstream rivers.
⑤ Development cost	In the case of dam development, the cost will vary depending on the topographical conditions of the dam sites and the flow conditions of the rivers. Similarly, in the case of groundwater development, cost will vary depending on the distances between the development sites and supply areas, and also on the topographical conditions in the surrounding areas. It is therefore difficult to make sweeping statements about which form of development is the cheaper.	

Regarding the optimal combination of surface water development by dams and groundwater development in order to fulfill the water requirement of Curitiba Metropolitan Area, setting will be done upon conducting the following examinations based on the characteristics described in Table 6.11.

(1) Development costs will be calculated for each stage of both the dam development and the groundwater development, and the cheapest combination in the case where both are combined will be adopted.

(2) The order of priority of the development will be decided in consideration of the required construction periods and the exploitable water quantities, etc.

The costs involved in the development of each dam and wells in each stage are as indicated in Table-6.11. The relationship between development costs when dam development and groundwater development are combined in order to develop the required water supply of 7.235 m^3/s is as shown in Figure-6.4.

Table-6.12 Development Cost

Water Source	Supply Reservoir / Well Field Zone	Name of Dam / Number of Wells	Develpment Volume (m^3/s)	Cost (10^6US$)	Unit Cost (10^6US$/$m^3/s$)
Surface Water	Cajura	Irai	1.400	49.3	35.2
		Piraquara 2	0.750	22.0	29.3
		Pequeno	0.800	28.6	35.8
	Xaxim	Alto Mirinquava	0.600	35.3	58.8
		Cotia Despique	1.200	43.8	36.5
	Ceasa	Alto Mauricio	0.250	20.0	80.0
		Das Oncas (Mandirituba)	0.200	25.4	127.0
	Araucaria	Faxinal	0.500	25.5	51.0
		Dos Oncas (Contenda)	0.600	23.1	38.5
		Piunoluva	0.200	17.4	87.0
Groundwater	Stage 1	29	1.290	40.3	31.2
	Stage 2	24	1.066	51.3	48.1
	Stage 3	24	1.066	53.7	50.4
	Stage 4	24	1.066	54.9	51.5

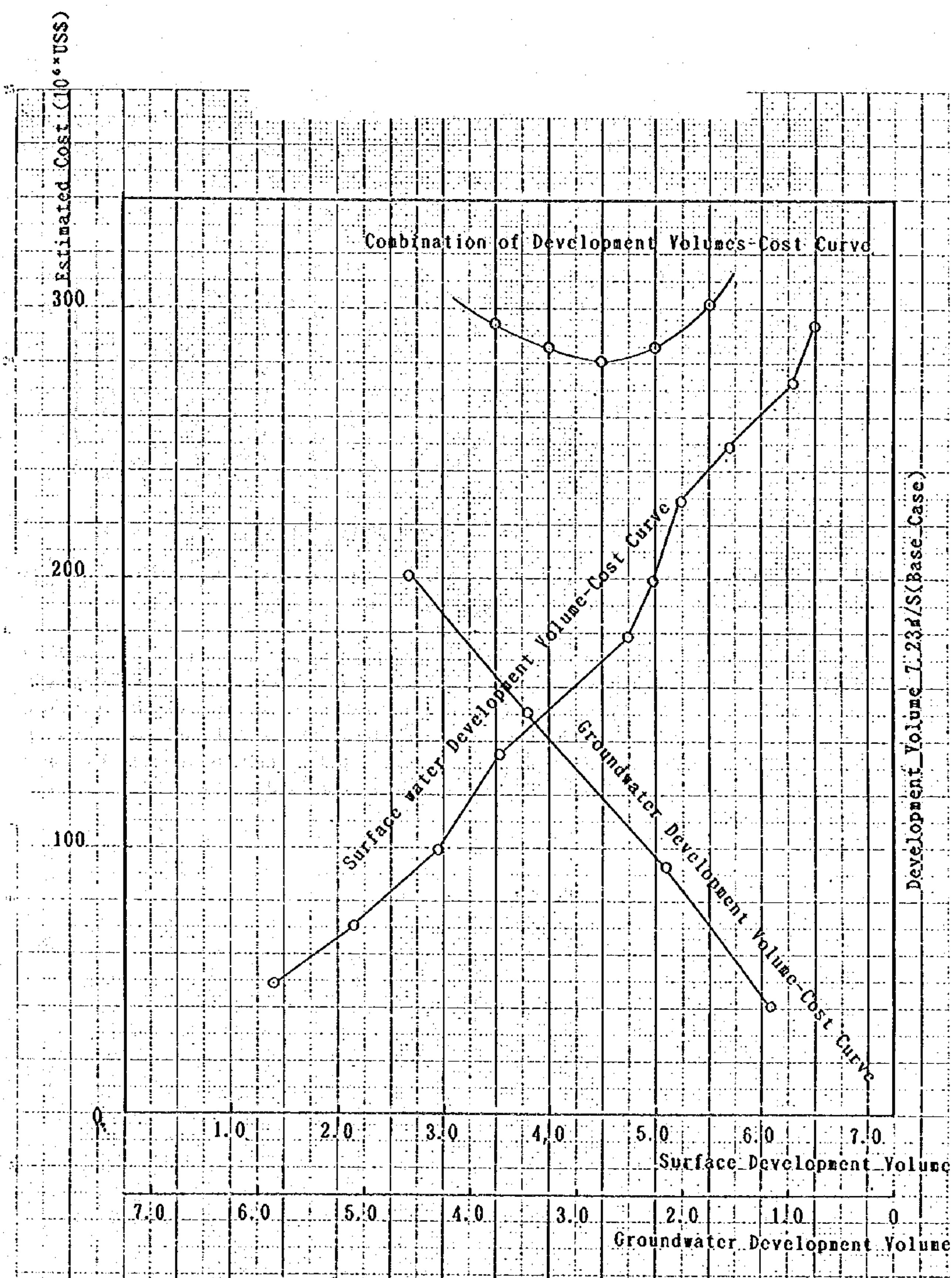


Figure-6.4 Relation between Development Volume and Cost

Based on Table-6.12 and Figure-6.4, the optimum use of dams and groundwater in terms of development cost is shown in Table-6.13. The water supply system in Curitiba metropolitan area is shown in Figure-6.5.

Table-6.13 Optimization of Water Supply

Name of Water Resource	Constructions	Development Volume (m^3/s)	Cost (10^6US$)
Irai Dam	dam, pipeline (Ø 1,200 x 15,000 m)	1.400	49.3
Piraquara II Dam	dam, pipeline (do.)	0.750	22.0
Pequeno Dam	dam, pipelin (Ø 800 x 8,000 m)	0.800	28.6
Alto Miringuava Dam	dam, pipeline (Ø 900 x 23,500 m)	0.600	35.3
Cotio Despique	dam, pipeline (Ø 900 x 17,000 m)	1.200	43.8
wells (stage 1)	29 wells, pipeline	1.290	40.3
wells (stage 2)	27 wells, pipeline	1.195	57.5
Total		7.235	276.8

6.4.6 Implementation Schedule of Water Development

The development schedule in the case of the combination of dam development and groundwater development shown in Table-6.13 is as illustrated below.

Dam construction will take a relatively long time until completion, however, once completed it will be possible to obtain large amounts of water. The development of groundwater will take less time compared to dam. As 5 dams will be constructed over 20 years, one dam will be built every 4 years. Groundwater development will be implemented in the period during dam construction in order to supplement the water supply. Figure-6.6 gives a detailed representation of the implementation schedule of the development.

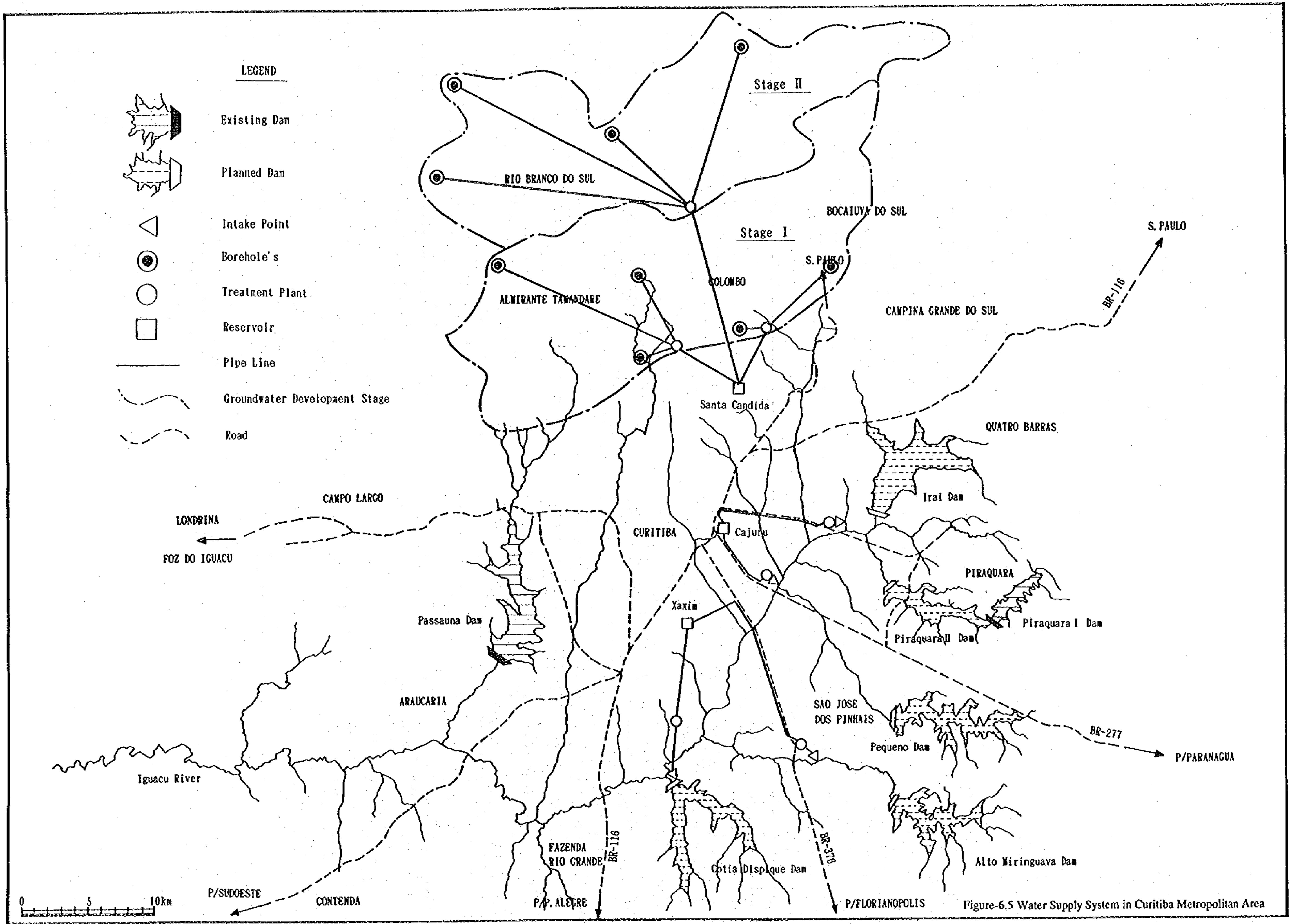
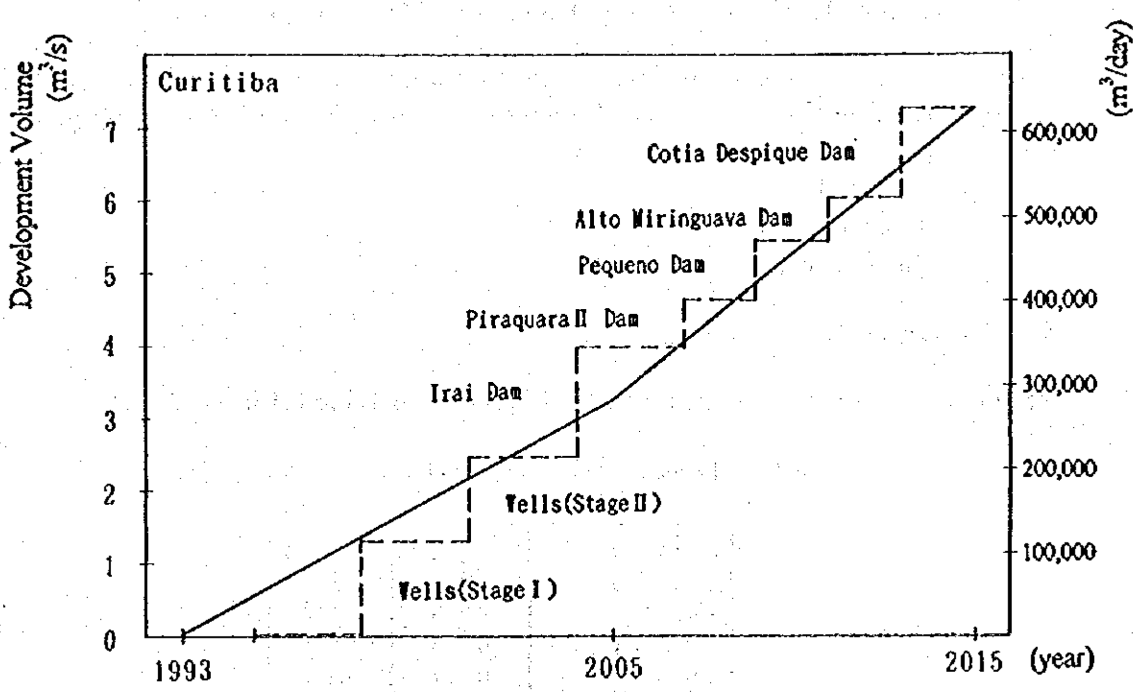


Figure-6.5 Water Supply System in Curitiba Metropolitan Area



Wells (StageI)	110.6			
Wells (StageII)	157.9			
Irai Dam		135.4		
Pirequara II Dam			60.4	
Pequeno Dam			78.5	
Alto Miringuava Dam			96.9	
Cotia Despique Dam				120.3
Total : 760.0 million us$	215.9 [28%]	218.2 [29%]	211.4 [28%]	114.5 [15%]

Figure-6.6 Implementation Schedule of Critiba Metropolitan Area

6.5 Water Development in Large Urban Areas (Type-A)

The urban areas were defined that their population will be more than approximately 100,000 in 2015. The following urban areas belong to Type-A as large urban areas in Iguaçu river basin except for Curitiba Metropolitan Area.

- Cascavel
- Foz do Iguaçu
- Guarapuava

6.5.1 Water Requirement

Required water supply in large urban areas is shown in Table-6.14.

Table-6.14 Required Water Supply in Large Urban Areas (m^3/s)

Municipality	Year	
	2005	2015
Cascavel	0.268	0.542
Foz do Iguaçu	0.504	1.043
Guarapuava	0.127	0.292

[Note] Water requirement for urban area is mainly composed of urban domestic water and industrial water.

6.5.2 Process of Water Resources Development Study

The process of water resources development in large urban areas is as shown below.

(1) In cities where main rivers are nearby and direct intake is easy, water supply shall be secured through surface water development.

(2) In cases where development by means of direct intake is difficult, careful consideration shall be given to the ease of development to the development capacity and the development cost, etc. for both surface water and groundwater.

(3) Regarding the development of surface water, more detailed examination shall be made on the promising alternatives stated in the Strategy (Main Report I) upon consideration of the local survey results and the state of existing facilities.

(4) Examination shall be given to the case where the whole water supply is provided by groundwater development.

(5) Based upon the examination results of (3) and (4), the optimal development plan shall be formulated upon first giving careful consideration to the conditions stated in (2).

6.5.3 Water Resources Development Policies

Based upon consideration of the topographical conditions in Type-A cities and the surface water and groundwater conditions in the target areas, the water resources development policies as shown in Table-6.15 were decided upon.

Table-6.15 Water Resources Development Policies for Large Urban Areas

City	Topographical Condition	State of Water Resources		Water Resource Development
		Surface Water	Groundwater	
Cascavel	Cascavel is situated in the mountains within the basins of the Iguaçu, Piquiri and Paranâ3.	As the water resources are the rivers that flow down from the mountains, the water intake points must be placed downstream in order to expand their catchment area, meaning that the pipe lines will become very long. As the catchment area is small, the construction of a dam will be necessary.	The town is surrounded by the Serra Geral Formation north aquifer and below that the Botucatu Formation aquifer, and the productivity levels in both of these are high.	As the city has a large water requirement and the development of surface water is not easy, the development plan shall be formulated upon first examining the potential of both surface water development and groundwater development.
Foz de Iquacu	This city is situated at the mouth of the Iguaçu river next to the reservoir of the Itaipu Dam.	The city currently obtains its water from the reservoir of Itaipu Dam. Compared to the water quantity of Paraná river, the necessary water requirement is very small.	Same as above (however, change north to south)	Development will involve improving the intake facilities from Itaipu Dam and the pipe line facilities for taking water from Paraná river.
Guarapuava	This city is situated in the upper reaches of the Jardao river, which is a right tributary of the Iguaçu river. It is situated 20-30 km from the mountain tops.	A river with a catchment area of 700 km^2 runs nearby the city and direct intake development is feasible.	The Serra Geral Formation south aquifer is located around the town, however, the productivity of the existing wells is low.	In view of the fact that direct intake development is easy and the groundwater productivity is low, the development will be performed on the surface water resources.

6.5.4 Water Supply System in Large Urban Areas

The water supply systems that should be promoted in large urban areas are as shown in Table-6.16 below.

Table6-.16 Water Supply System Recommended in Large Urban Area

City	Water Supply System	Constructions	Catchment Area or Well Number	Development Volume (m^3/s)	Cost (10^6US$)
Cascavel	direct intake from Sao Jose river	pumps, pipeline (Ø 300 x 13,000 m x 2)	145.0km²	0.300	14.2
	wells (Serra Geral F. aquifer)	wells, pipeline (Ø 400 x 11,000 m)	9 boreholes	0.180	
	and (Botucatu F. aquifer)	wells, pipeline (Ø 300 x 8,000 m)	1 boreholes	0.120	24.7
Foz do Iguaçu	direct intake from Paraná river	pumps, pipeline (Ø 500 x 1,900 m x 3)	-	1.043	11.1
Guarapuava	direct intake from Bananas river	pumps, pipeline (Ø 300 x 4,800 m x 2)	704.0km²	0.292	9.1

The intake points and pipe lines for each city are as illustrated in Figure-6.7 - 6.9.

6.5.5 Implementation Schedule of Water Development

The implementation schedules for each city are as shown in Figure-6.10.

No. S-C1			Scale : 1 / 50,000
(Location) X =257	Y =7224		
Basin	River	Municipality	Others
Iguacu	Rio Sao Jose	Cascavel	

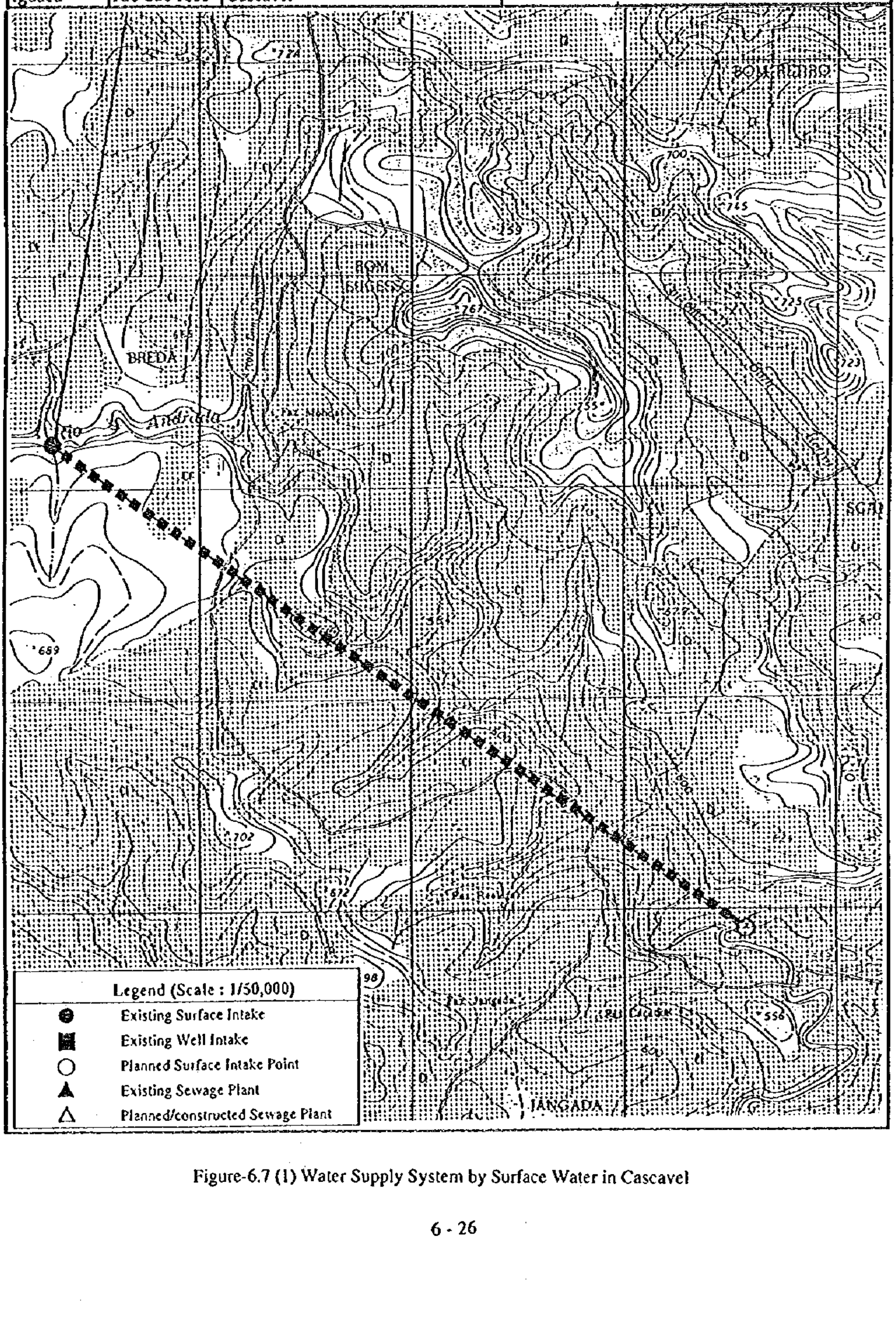


Figure-6.7 (1) Water Supply System by Surface Water in Cascavel

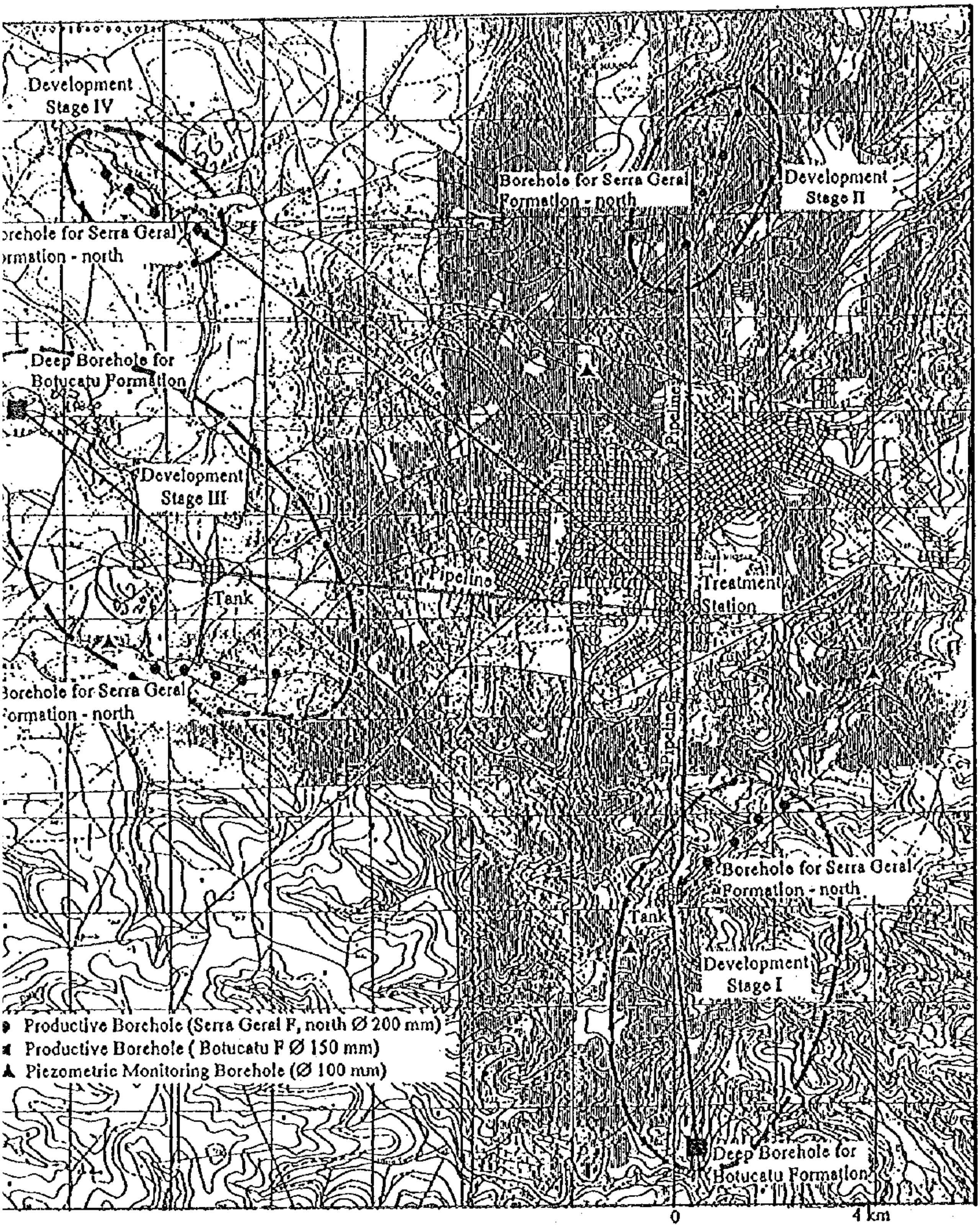


Figure-6.7 (2) Water Supply System by Groundwater in Cascavel (using stage I and II)

No. S-FII			Scale : 1 / 50,000
(Location) X =746	Y =7185		
Basin	River	Municipality	Others
Iguacu	Itaipu Reser.	Foz do Iguacu	

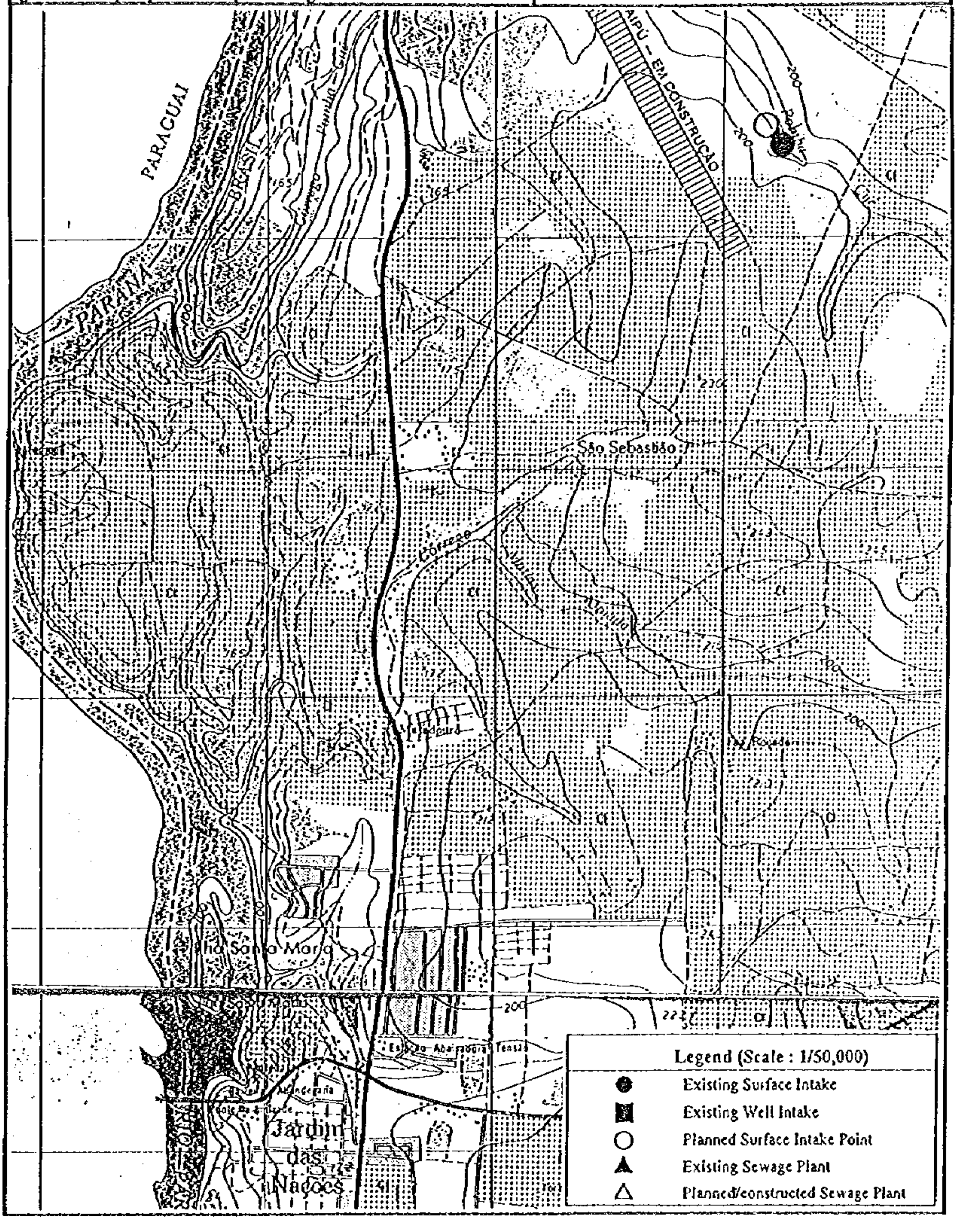


Figure-6.8 Water Supply System in Foz do Iguaçu

No. S-G1			Scale : 1 / 50,000
(Location)	X =454	Y =7186	
Basin Iguacu	River Rio Bananas	Municipality Guarapuava	Others

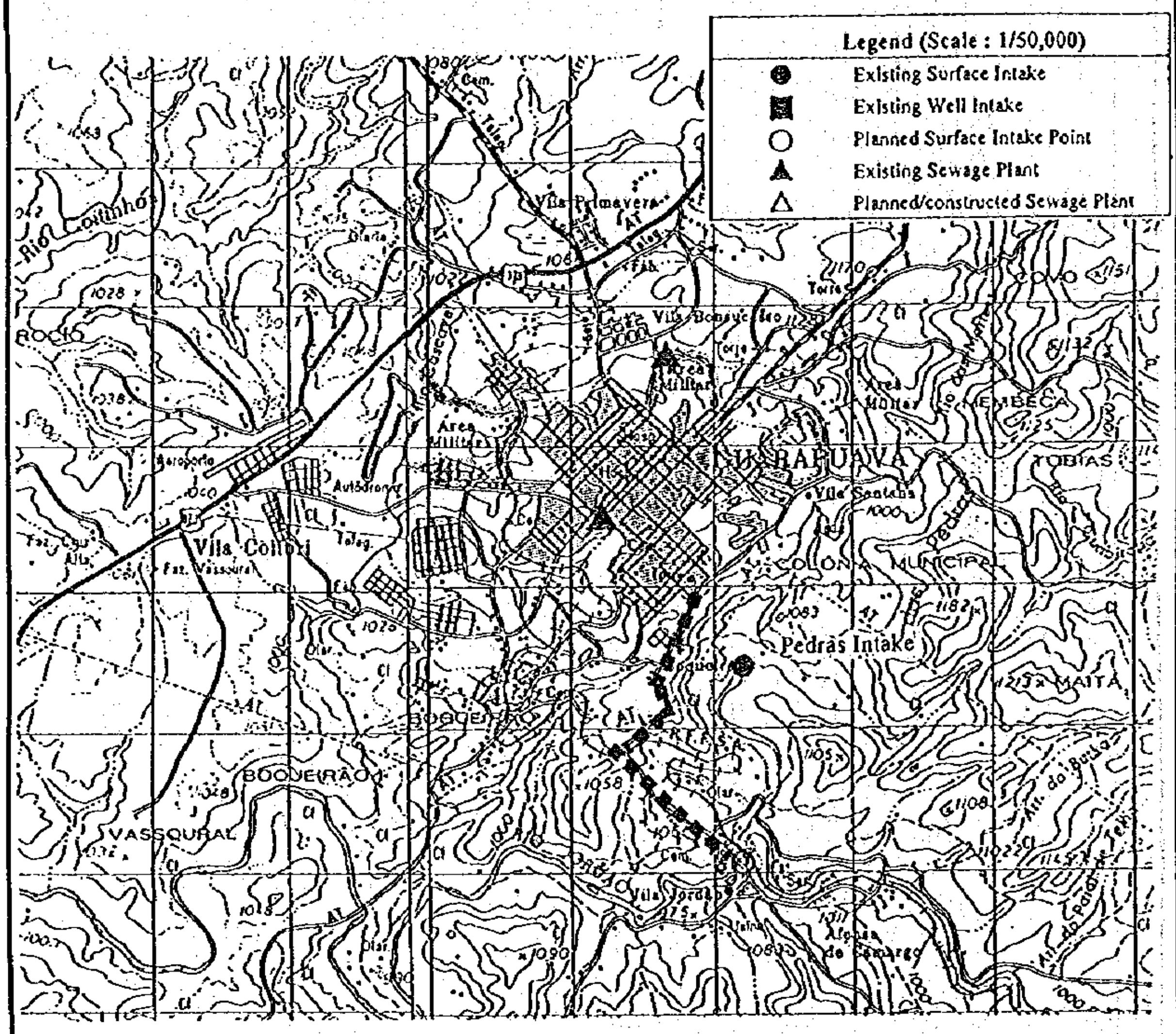


Figure-6.9 Water Supply System in Guarapuava

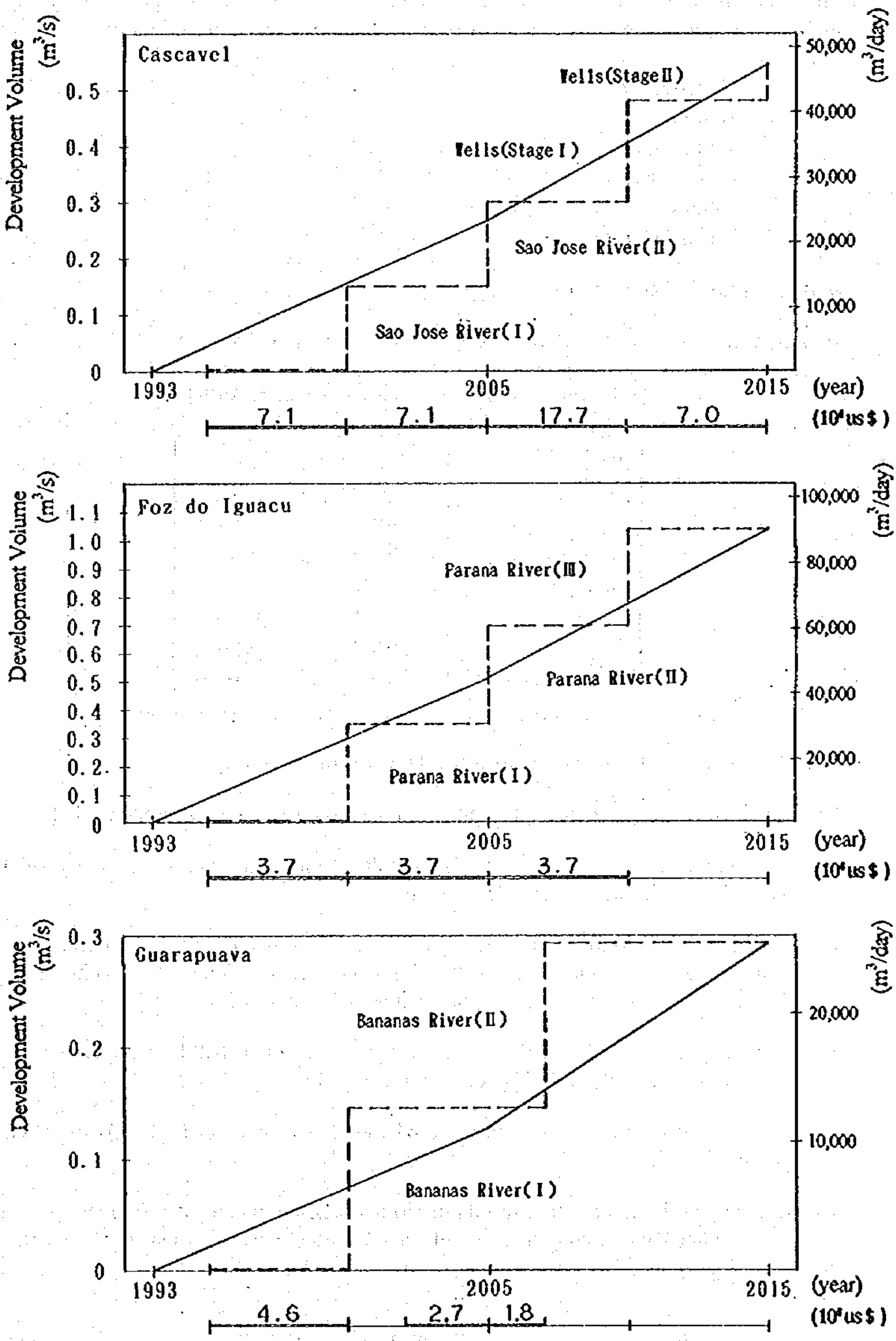


Figure-6.10 Implementation Schedule of Large Urban Area

6.6 Water Development in Medium Urban Areas (Type-B)

The urban areas were defined that their population will be more than approximately 50,000 in 2015. The following urban areas belong to Type-B as medium urban areas in Iguaçu river basin.

- Francisco Beltrao
- Pato Branco
- Medianeira
- Dois Vizinhos
- Palmas
- Uniao da Vitoria

6.6.1 Water Requirement

Required water supply in medium urban areas was shown in Table-6.17.

Table-6.17 Required Water Supply in Medium Urban Areas (m^3/s)

Municipality	Year	
	2005	2015
Francisco Bertrao	0.098	0.231
Pato Brauco	0.053	0.112
Mediuneira	0.038	0.066
Dois Vizinhos	0.061	0.164
Palmas	0.028	0.065
Uniao da Vitoria	0.025	0.035

[Note] Water requirement for urban area is mainly composed of urban domestic water and industrial water.

6.6.2 Process of Water Resources Development Study

The process of water resources development in medium urban areas is as shown below.

(1) In cities where main rivers are nearby and direct intake is easy, water supply shall be secured through surface water development.

(2) In cases where development by means of direct intake is difficult, careful consideration shall be given to the ease of development, the development capacity and the development cost, etc. for both surface water and groundwater.

(3) Regarding the development of surface water, examination shall be made based on the topographical conditions and water resource materials.

(4) Examination shall be given to the case where the whole water supply is provided by groundwater development.

(5) Based upon the examination results of (3) and (4), the optimal development plan shall be formulated upon first giving careful consideration to the conditions stated in (2).

6.6.3 Water Resources Development Policies

Based upon consideration of the topographical conditions in Type-B cities and the surface water and groundwater conditions in the target area, the water resources development policies as shown in Table-6.18 were decided upon.

Table-6.18 Water Resources Development Policies for Medium Urban Areas

City	Topographical Condition	State of Water Resources		Water Resources Development
		Surface Water	Groundwater	
Francisco Beltrao	This city is situated in the mid-stream of a tributary to the Iguaçu river and 30-40 km downstream from the mountain tops.	A river with a catchment area of 400 km² runs nearby the city and direct intake development is feasible.	The Serra Geral Formation south aquifer is located around the town, however, the productivity of the existing wells is low.	In view of the fact that direct intake development is easy, the development will be performed on the surface water resources.
Pato Branco	This city is situated in the upper reaches (near the mountain tops) of a tributary to the Iguaçu river.	Development through the direct intake of water from the river running nearby the town is feasible.	The Serra Geral Formation south aquifer is located around the town, and the productivity of the existing wells is high.	As the development of both surface water and groundwater is easy, the development plan will be formulated upon first examining both possibilities.
Medianeira	This city is situated on the ridge that separates the Iguaçu river and the Paraná river.	As the city is situated on a ridge, it is difficult to obtain large amounts of water from just one intake point, so intake will need to be performed at a number of locations.	Same as above	The water supply plan that combines both surface water development and groundwater development will be formulated.
Dois Vizinhos	This city is situated in the mid-stream of a tributary to the Iguaçu river. The catchment area of the nearby river is small at less than 100 km².	The water demand cannot be satisfied solely through the intake of water from the city's surrounding small rivers. If water was taken from Chopim river, the demand for water would be satisfied, however, the pipe line length would be 210 km.	Same as above	If taking water from Chopim river is effective, the water supply can be secured through development of surface water alone, however, if this turns out to be unrealistic a supply plan that combines both surface water development and groundwater development
Palmas	This city is situated in the upper reaches (near the mountain tops) of a tributary to the Iguaçu river.	Development through the direct intake of water from the river running nearby the city is feasible.	Same as above	As the direct intake development of surface water is easy, the river running nearby the city will be developed as the water supply source.
Uniao da Vitoria	This city is situated in the mid-stream of the mainstream Iguaçu river.	The direct intake of water from the Iguaçu river mainstream is possible.	The Upper Paleozoic aquifer is located around the town, however, the productivity of existing wells is low and the permissive yield is small.	As the direct intake of surface water is easy and the nearby aquifer is not suited to groundwater development, surface water will be developed as the water supply source.

6.6.4 Water Supply System in Medium Urban Areas

Water supply systems proposed for medium urban areas are shown in Table-6.19.

Table-6.19 Proposed Water Supply System for Medium Urban Areas

City	Water Supply System	Constructions	Catchment Area or Well Number	Development Volume (m^3/s)	Cost (10^6US$)
Franccisco Beltrao	direct intake from Marrecas river	pumps, pipeline (Ø 300 x 700 m x 2)	437.0km²	0.231	4.7
Pato Branco	direct intake from Chopim river	pump, pipeline (Ø 300 x 12,500 m)	2817.0km²	0.112	9.1
	(Alternative) Wells (Botucatu F.aquifer)	wells, pipeline (Ø 300 x 6,000 m)	1 borehole	0.124	(8.1)
Medianeira	Wells(Botucatu F.aquifer)	well, pipeline (Ø 300 x 4,000 m)	1 borehole	0.124	4.3
Dois Vizinhos	direct intake from Chopim river	pump, pipeline (Ø 300 x 7,500 m)	4050.0km²	0.134	9.1
	(Alternative) Wells (Serra Geral F.aquifer) and (Botucatu F.aquifer)	wells, pipeline (Ø 300 x 6,000 m)	3 boleholes 1 boleholes	0.012 0.124	(10.3)
Palmas	direct intake from Caldeiras river	pump, pipeline (Ø 200 x 3,400 m)	83.7km²	0.065	4.9
Uniao da Vitoria	direct intake from Iguaçu river	pump, pipeline (Ø 200 x 200 m)	24.414km²	0.035	3.7

6.6.5 Implementation Schedule of Water Development

Implementation schedule of water development is shown in Figure-6.11 (1)-(2).

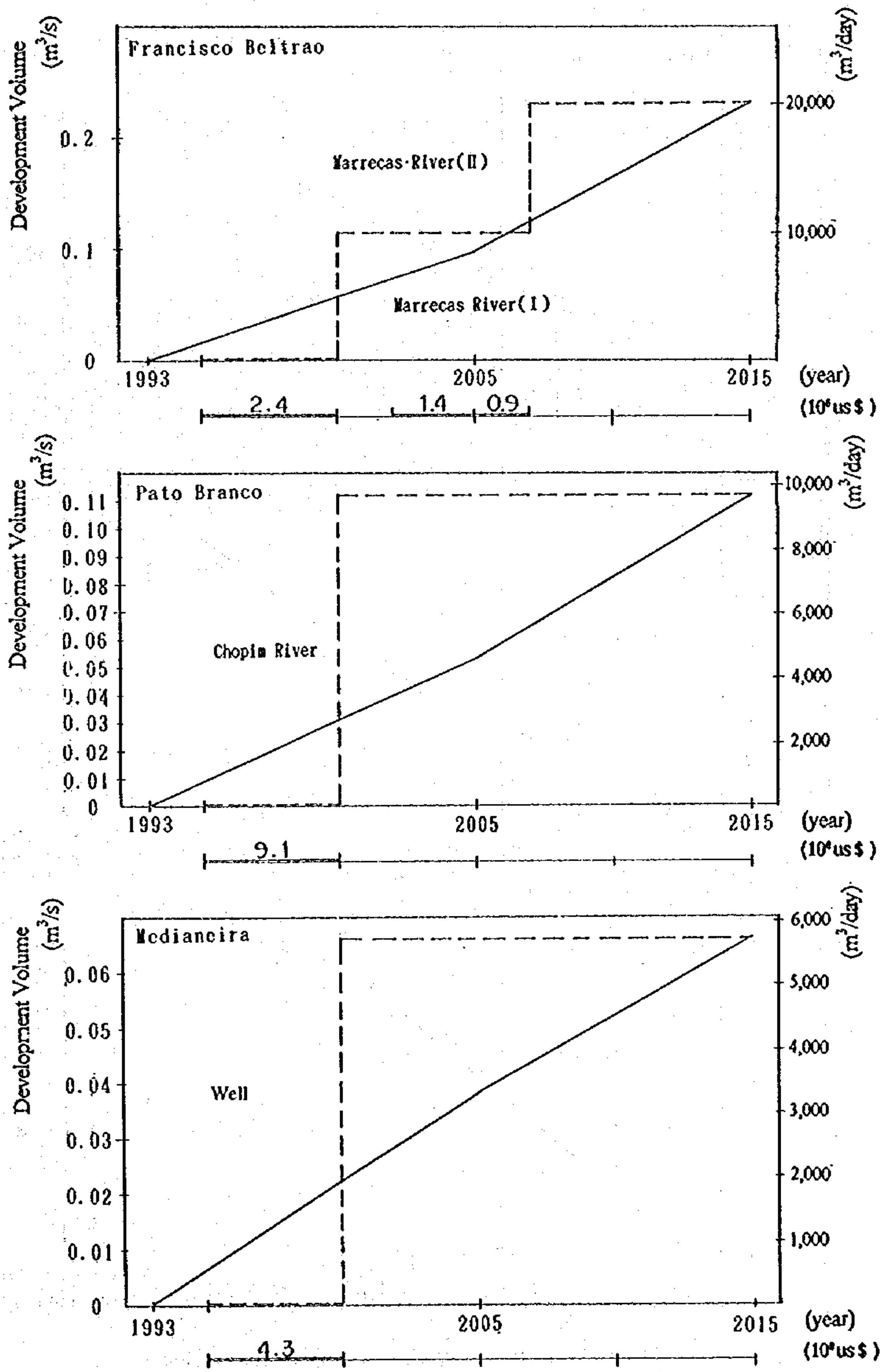


Figure-6.11 (1) Implementation Schedule of Medium Urban Areas

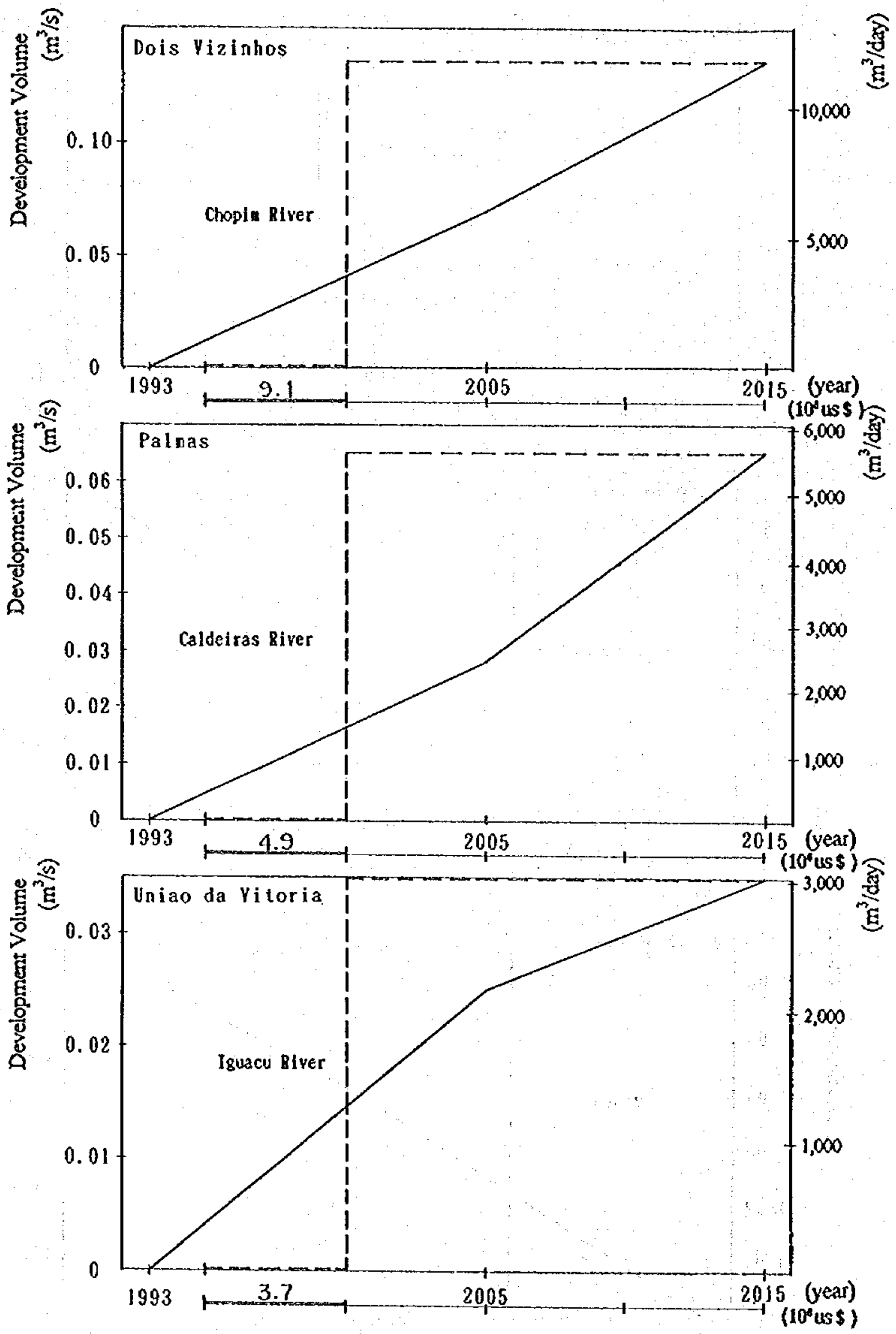


Figure-6.11 (2) Implementation Schedule of Medium Urban Areas

6.7 Water Development in Other Urban Areas (Type-C)

Water development study of other urban areas was done for zone-a, zone-b and zone-c.

6.7.1 Water Requirement

Required water supply in other urban areas was shown in Table-6.20.

Table-6.20 Required Water Supply in Other Urban Areas (m^3/s)

Zone	Year	
	2005	2015
Zone-a	0.143	0.322
Zone-b	0.142	0.326
Zone-c	0.091	0.180

[Note] Water requirement for urban area is mainly composed of urban domestic water and industrial water.

6.7.2 Process of Water Resources Development Study

Process of water resources development in other urban areas was as shown below:

(1) Determination of water resource for each zone evaluating surface water potential and groundwater potential.

(2) Identification of the relationship between the water requirement and its development cost based on the cost estimation of several municipalities selected from each zone.

(3) Cost estimation of all municipalities applying the above relationship to the water requirement of each municipalities.

6.7.3 Water Resources Development Policies

The water resources development policies for Type-C cities, based upon consideration of the topographical conditions and surface water and groundwater conditions in each zone, are as indicated in Table-6.21.

Table-6.21 Water Resources Development Policies for Other Urban Areas

<table>
<tr><th rowspan="2">City</th><th rowspan="2">Topographical Condition</th><th colspan="2">State of WaterResources</th><th rowspan="2">Water Resources Development Policies</th></tr>
<tr><th>Surface Water</th><th>Groundwater</th></tr>
<tr><td>Zone-a</td><td>These areas are situated nearby mainstream or downstream of tributaries.</td><td>As these areas are located nearby rivers with ample catchment areas, direct intake development is easy to achieve.</td><td rowspan="3">Of the aquifers located within the Iquacu River basin, those suited to groundwater development are the Karst, Farnas Formation, Guabirotuba Formation, Botucatu Formation and the Serra Geral Formation north and south aquifers. Of these, the first three are located in the Curitiba metropolitan area. Regarding the supply of groundwater to Type-C cities, the Botucatu Formation and Serra Geral Formation aquifers are situated in usable locations. The former of these possesses greater productivity potential, however, deep drilling would be necessary. As the Type-C cities do not have such a high water requirement, development of the latter (Serra Geral Formation) aquifer is more appropriate.</td><td>As the direct intake development of surface water is easy, the nearby rivers will be developed as water supply sources.</td></tr>
<tr><td>Zone-b</td><td>These areas are situated near the second or third tributaries</td><td>The catchment areas of the nearby rivers are too small for performing the direct intake of water. The development of surface water would be possible if the intake points are placed further downstream, although the pipe line lengths would become long.</td><td>For those cities, which are located on the Serra Geral Formation south aquifer and where the required water supply can be met by one well (0.003 m^3/s or less), groundwater will be developed in order to provide the water supply. For those cities requiring a bigger water supply or which are not located on the said aquifer, direct intake development of surface water will be implemented.</td></tr>
<tr><td>Zone-c</td><td>These areas are situated on top of ridges of mountains.</td><td>Surface water resources are not sufficient to provide the required water in those cities with a large water demand.</td><td>For those cities which are located on the Serra Geral Formation south aquifer and where the required water supply can be met by three wells (0.010 m^3/s or less), groundwater will be developed in order to provide the water supply. For those cities requiring a bigger water supply, or which are not located on the said aquifer, direct intake development of surface water will be implemented to meet the supply requirement.</td></tr>
</table>

6.7.4 Water Supply System in Other Urban Areas

Water supply system in other urban areas are shown in Table-6.22 by each zone.

Table-6.22 Water supply System in Other Urban Areas

Zone	Number of Municipalities	Water Supply System	Development Volume Surface Water (m^3/s)	Development Volume Groundwater (m^3/s)	Cost (10^6US$)
C-a	23	direct intake from river	0.322	-	9.7
C-b	22	direct intake from river	0.298	-	42.5
	16	wells	-	0.028	14.8
C-c	9	direct intake from river	0.157	-	28.4
	8	wells	-	0.023	7.5
Total			0.777	0.051	102.9

6.7.5 Implementation Schedule of Water Development

Implementation schedule of water development is shown in Figure-6.12.

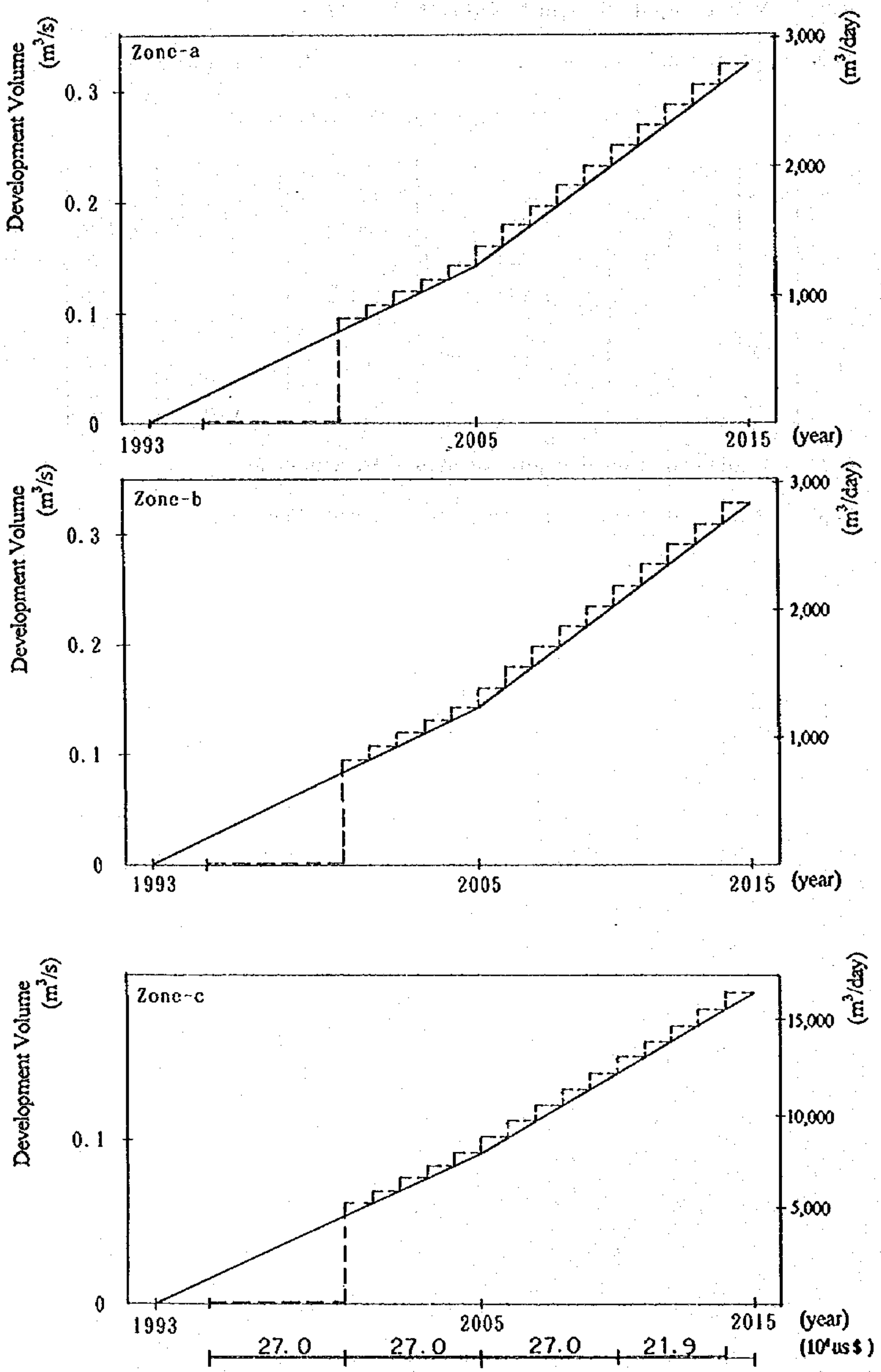


Figure-6.12 Implementation Schedule of Other Urban Area

6.8 Water Development for Rural Domestic Water

In rural areas, it is difficult to supply the water requirement by surface water systematically, because demand of domestic water is scattered due to topographic condition. Therefore, supply for domestic water will be done by groundwater development.

The demand of domestic water in rural areas tends to decrease from the point of view of the whole Iguaçu river basin. Although there is an increase in some municipalities if the demand is examined with municipality wise, the volume of demand is very little. The maximum volume to be newly development is about 0.004m^3/s.

As a result, the development of rural domestic water will not be necessary and only improvement or maintenance of existing wells is enough to satisfy the future water demand.

6.9 Water Development for Agricultural Water

Supply method of agricultural water at rural areas is generally a pipeline method with a direct intake using a pipeline and headworks.

According to hearing and field reconnaissance, an average of intake volume was less than 0.001 m^3/s, and average length of pipeline was 3 km.

The total water requirement for agricultural sector is 0.381 m^3/s. The total cost of its development was estimated applying the cost of unit water development determined during the cost estimation for large and medium urban areas and thus the total cost is US$4.6 million.

6.10 Total Cost for Water Development

The total cost for water development covering from intake to water-service installation was summarized in Table-6.23.

Table-6.23 Total Cost for Water Development

Development Volume (m^3/s)		Cost (10^{6}us$)
(1) Domestic and Industrial Water Development (Urban Area)		
1)Curitiba Metropolitan Area	7.235 (2.638)	760.0
2) Large Urban Areas	1.877 (0.090)	59.1
3) Medium Urban Areas	0.643 (0.192)	35.8
4) Other Urban Areas	0.828 (0.243)	102.9
Sub-total	10.583 (3.163)	957.8
(2) Agricultural Water Development (Rural Area)		
	0.381	4.6
Total	10.964 (3.163)	962.4

Note: ( )shows industrial water

The implementation schedule of water supply project is shown in Table-6.24.

Table-6.24 Implementation Schedule of Water Supply Project for Iguaçu River Basin

Area	Project	Water Resource	Development Volume (m3/s)	Project Cost (million us$)	Construction Schedule 96–00	Construction Schedule 01–05	Construction Schedule 06–10	Construction Schedule 11–15
<Curitiba Metropolitan Area>								
		Wells (StageI)	111,000	110.6				
		Wells (StageII)	103,000	157.9				
		Irai Dam	121,000	135.4				
		Piraquara II Dam	65,000	60.4				
		Pequeno Dam	69,000	78.5				
		Alto Miringuava Dam	52,000	96.9				
		Cotia Despique Dam	104,000	120.3				
	(5 year Progress Rate)		625,000	760.0	215.9 [29%]	207.2 [27%]	222.4 [29%]	114.5 [15%]
<Large Urban Area>								
	Cascavel	Sao Jose River (I)	13,000	7.1				
		Sao Jose River (II)	13,000	7.1				
		Wells (StageI)	16,000	17.7				
		Wells (StageII)	10,000	7.0				
	Foz do Iguacu	Parana River (I)	30,000	3.7				
		Parana River (II)	30,000	3.7				
		Parana River (III)	30,000	3.7				
	Guarapuava	Bananas River (I)	13,000	4.6				
		Bananas River (II)	12,000	4.5				
	(5 year Progress Rate)		167,000	59.1	15.4 [26%]	13.5 [23%]	23.2 [39%]	7.0 [12%]
<Medium Urban Area>								
	Francisco Beltrao	Marrecas River (I)	10,000	2.4				
		Marrecas River (II)	10,000	2.3				
	Pato Branco	Chopim River	10,000	9.1				
	Medianeira	Wells (Stage II)	11,000	4.3				
	Dois Vizinhos	Chopim River	12,000	9.1				
	Palmas	Caldeiras River	6,000	4.9				
	Uniao da Vitoria	Iguacu River	3,000	3.7				
	(5 year Progress Rate)		62,000	35.8	33.5 [94%]	1.4 [4%]	0.9 [2%]	0 [0%]
<Other Urban Area>		Surfacewater & Wells						
	(5 year Progress Rate)		72,000	102.9	27.0 [26%]	27.0 [26%]	27.0 [26%]	21.9 [22%]
<Agricultural Water>		Surfacewater						
	(5 year Progress Rate)		33,000	4.6	1.1 [24%]	1.2 [26%]	1.1 [24%]	1.2 [26%]
Total			959,000	962.4	292.9 [31%]	250.3 [26%]	274.6 [28%]	141.6 [15%]

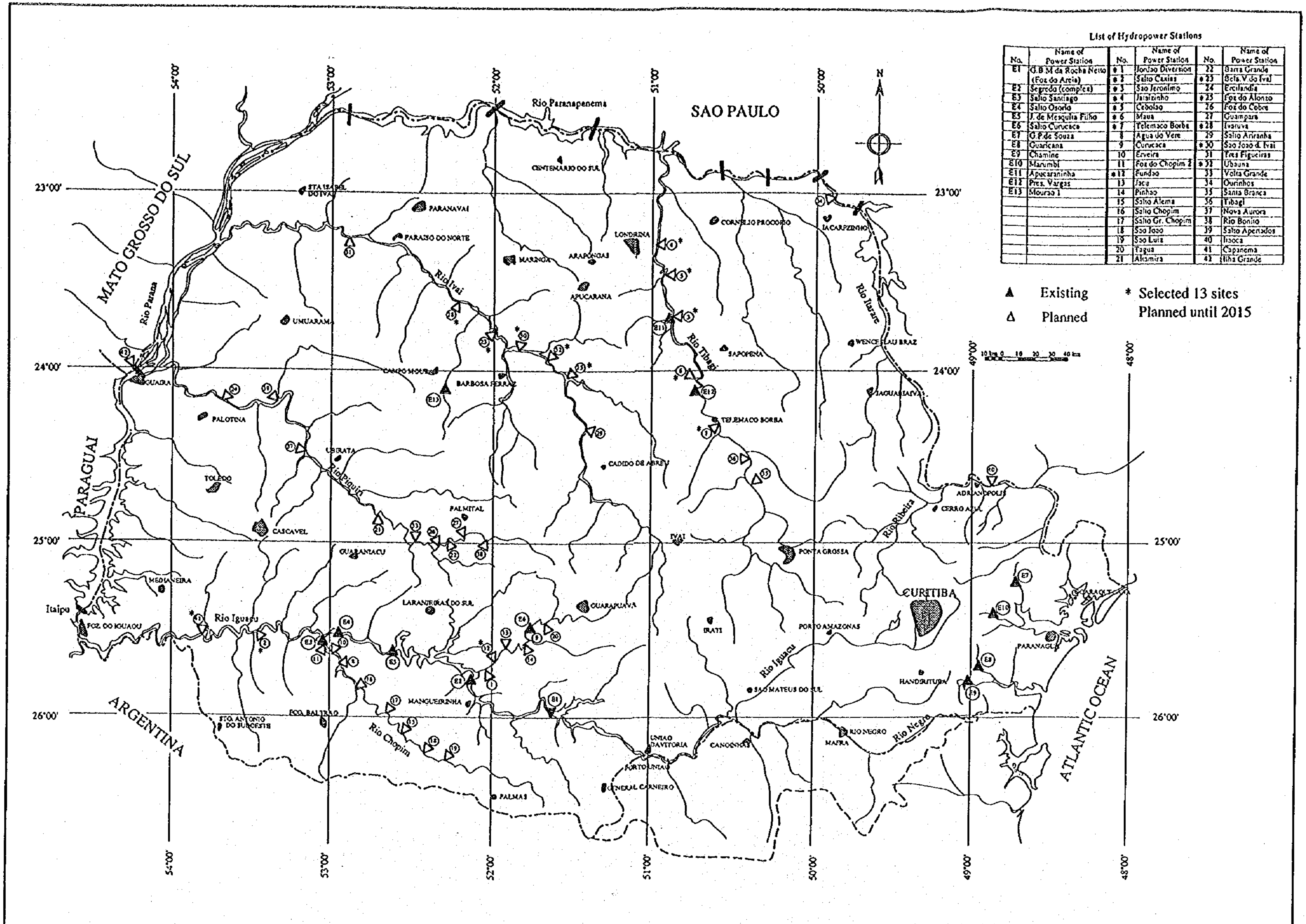
6.11 Hydropower Development

The hydropower development in the Iguaçu river basin is planned as shown in Table-6.25 and in Figure-6.13.

Table-6.25 Planned Hydropower Stations in Iguaçu River Basin

No.	Name of Power Station	Basin	River System	Intalled Capacity MW	Firm Energy Gwh	Planned Start-up Year
1	Jordao Diversion	Iguaçu	Jordao	6.5	526*	Mar. 96
2	Salto Caxias	Iguaçu	Iguaçu	1,240	4,853	Dec. 98
	Total (up to 2005)			1,247	5,379	
12	Fundao	Iguaçu	Jordao	154	640	2005-09
	Total (2005 to 2015)	Iguaçu		154	640	
Grand Total		Iguaçu		1,400	6,019	

Remarks: * denotes increment of energy in the existing Segredo plant and Jordao small plant.



List of Hydropower Stations

No.	Name of Power Station	No.	Name of Power Station	No.	Name of Power Station
E1	G.B.M da Rocha Netto (Foz do Areia)	* 1	Jordao Diversion	22	Barra Grande
		* 2	Salto Caxias	* 23	Bela V. do Ivai
E2	Segredo (complex)	* 3	Sao Jeronimo	24	Ercilandia
E3	Salto Santiago	* 4	Jataizinho	* 25	Foz do Alonzo
E4	Salto Osorio	* 5	Cebolao	26	Foz do Cobre
E5	J. de Mesquita Filho	* 6	Maua	27	Guampara
E6	Salto Curucaca	* 7	Telemaco Borba	* 28	Ivaruva
E7	G.P.de Souza	8	Agua do Vere	29	Salto Ariranha
E8	Guaricana	9	Curucaca	* 30	Sao Joao d. Ivai
E9	Chamine	10	Erveira	31	Tres Figueiras
E10	Marumbi	11	Foz do Chopim 2	* 32	Ubauna
E11	Apucaraninha	* 12	Fundao	33	Volta Grande
E12	Pres. Vargas	13	Jacu	34	Ourinhos
E13	Mourao 1	14	Pinhao	35	Santa Branca
		15	Salto Alema	36	Tibagi
		16	Salto Chopim	37	Nova Aurora
		17	Salto Gr. Chopim	38	Rio Bonito
		18	Sao Joao	39	Salto Apertados
		19	Sao Luiz	40	Itaoca
		20	Tagua	41	Capanema
		21	Altamira	42	Ilha Grande

Source : COPEL

Figure-6.13 Existing and Inventoried Hydropower Stations in Paraná State