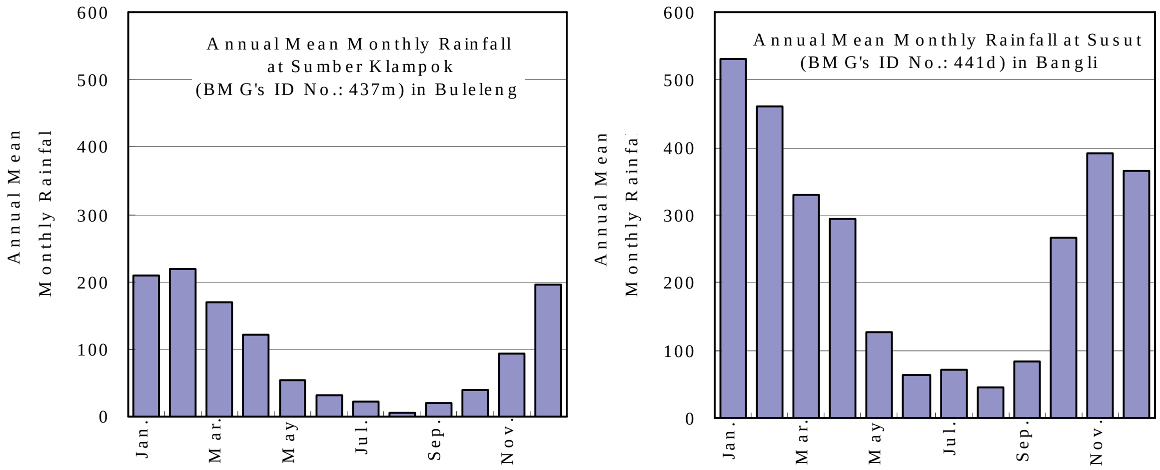
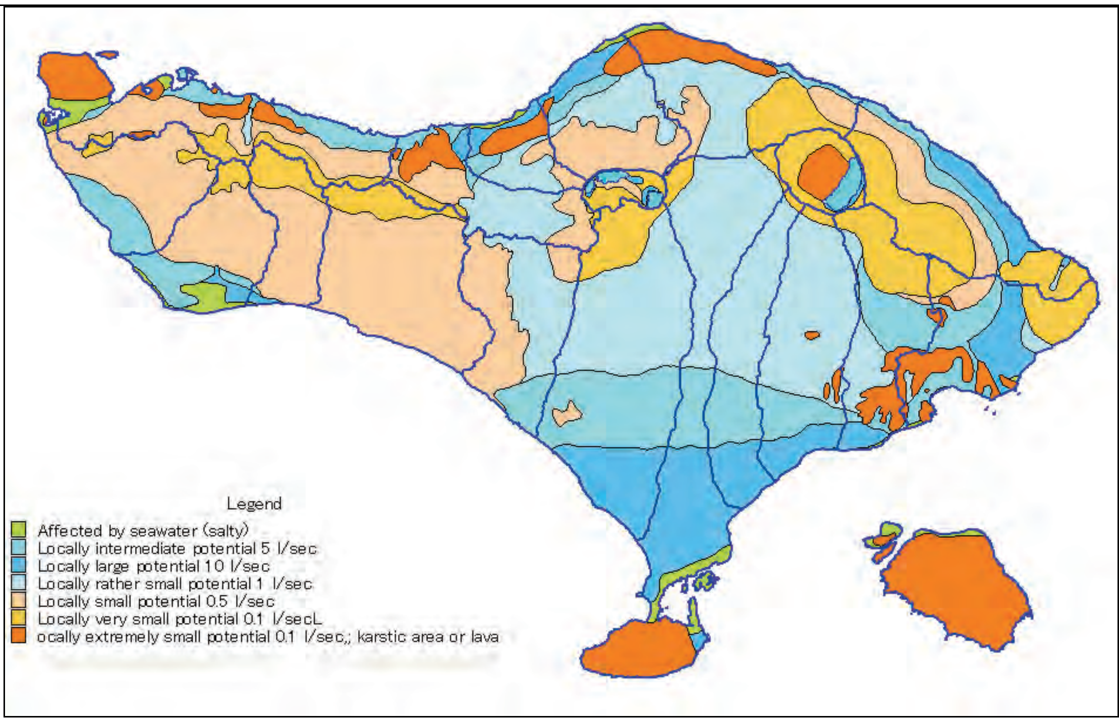


(Coastal Area) (Mountainous Area)

Figure-2.5 Monthly Rainfall Patterns

2.5 Hydro-geological Condition

Bali is the island covered by volcanic sediments except the west end of the island, which is Mount Prapatagung-Gilimanuk Area, and the south end of the island, which is Bukit Peninsula or Bualu Area, where limestone and calcareous stratums occur. The island of Nusa Penida is also formed by limestone. Hydrogeological feautures of formations are summarized below. .



Source:Reconnaissance Hydrogeological Map of Bali published by the Geological Survey of Indonesia in 1972.

Figure-2.6 Reconnaissance Hydrogeological Map (1972)

Generally, alluvium and young volcanic sediments are highly permeable, and Lower Quaternary and tertiary sediments have wide-ranging permeability due to the formation.

The number of wells drilled up to 90 meters or less is almost 50% of the wells and about 80% of the wells were drilled up to 120 meters or less.

The wells drilled to 50 meters were only 8%, as shown below. Relatively deeper wells have been constructed in the western part, and the northwestern part, Gerokgak area, though the depths of wells drilled in the southern area vary widely

The yield of springs ranges from less than one litter to several hundreds litters per second. According to the result, there are 9 springs yielding 500 liter/sec or more, and 67 springs yield from 100 to less than 500 lit./sec. Over 100lit/sec wells are located in mountainous area.

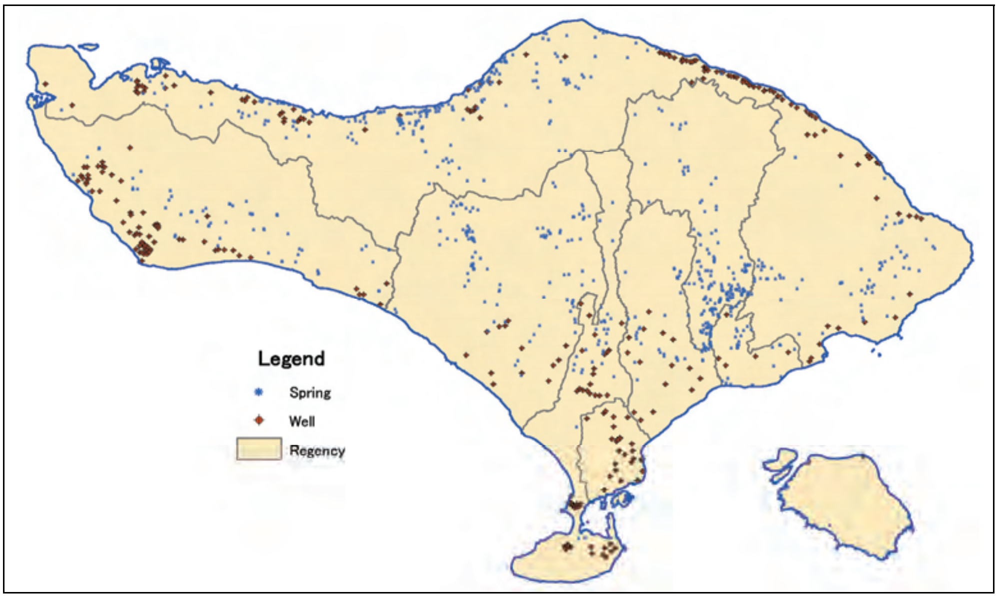


Figure-2.7 Location of Well and Springs

2.6 Natural Environment and Water Quality

The natural environment of Bali had been long modified since ancient times due to human activities, principally due to rice farming (paddy cultivation), which is understandable as being a highly populated small fertile island. The significant coastal natural resources having much tourism importance as well include golden (white) sand beaches concentrated in southern coasts of Bali (Sanur, Kuta, Jimbaran and Nusa Dua), and coral reefs concentrated principally in southern coastal waters of Sanur and Nusa Dua as well as the small islands of Nusa Lembongan (and Nusa Ceningan) and also the eastern (Amed and Tulamben areas) and western (Menjangan Island) coastal waters of the mainland Island. The other most significant coastal natural resource of the Island includes its mangrove forestation principally concentrated in the southeastern coast of the Island along the Benoa Bay that is also declared as a protected coastal forest area (Ngurah Rai Great Forest Park) ranging to 1,200 km^2, equivalent to 1/4 area of Bali Island.

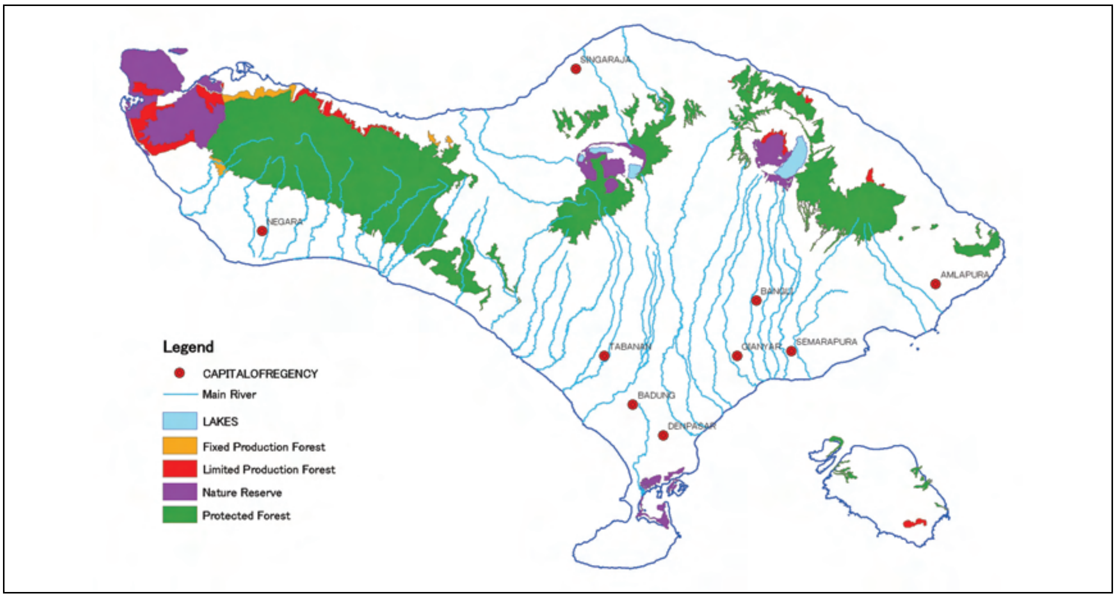


Figure-2.8 Map of Protected Areas in Bali

For water quality, conforming to the Article 14 of the new basic environmental law (No. 23/1997) that stipulates the formulation of environmental quality standards, the Government Regulation No.82/2001 (PP82/2001) was published as also noted above under Item (1).

Based on all available data and also the recent measurement results of this JICA study as well as site inspection, the water quality of Badung and Mati Rivers passing through the highly developed Denpasar and Kuta area in South Bali is evaluated as the worst polluted rivers in the whole province, which is also visually discernable.

The water quality of all 5 major lakes and dam of Bali Island was investigated in overall, of which the 3 scenic lakes in the central mountainous region, namely, Beratan, Buyan and Tamblingan are regarded as pristine and have the best water quality for a lake. Also the quality of Batur Lake is good though its natural dissolved solid content is rather high.

In overall, the quality of groundwater of South Bali area in the Central Denpasar and further south at Kuta and Nusa Dua is regarded as not suited as potable water sources since their dissolved solids content is high, in addition to the high salinity due to seawater intrusion in case of Kuta and Nusa Dua areas located adjacent to the coast. Moreover the coastal groundwater in Penida Islands of Nusa Penida and Nusa Lembongan is also saline due to seawater intrusion. The groundwater in the other mainland area of Bali Island is regarded as good and suited for unrestricted beneficial use including as source of potable water use.

2.7 Agriculture and Irrigation

According to Table-2.3, more than 5,000 ha paddy field has been converted to housing area. The area of about 870ha of paddy field has been decreasing for the year from 1997 to 2003.

Table-2.3 Transition of Paddy Area

No.	Regencies, City	1997 (ha)	1999 (ha)	2001 (ha)	2003 (ha)	Increasing Rate (%/year)
01	Jembrana	8,135	7,889	7,685	7,013	-2.44
02	Tabanan	23,836	23,414	23,154	22,639	-0.86
03	Badung	11,578	10,816	10,619	10,334	-1.88
04	Gianyar	15,323	15,203	14,966	14,937	-0.42
05	Klungkung	4,049	4,016	3,985	3,932	-0.49
06	Bangli	2,887	2,888	2,888	2,888	0.01
07	Karangasem	7,308	7,099	7,059	7,034	-0.63
08	Buleleng	11,420	11,581	11,472	11,011	-0.61
71	Denpasar	3,314	3,165	3,031	2,856	-2.45
Total		87,850	86,071	84,859	82,644	-1.01

Sources: Bali in Figures 2003, BPS Statistics

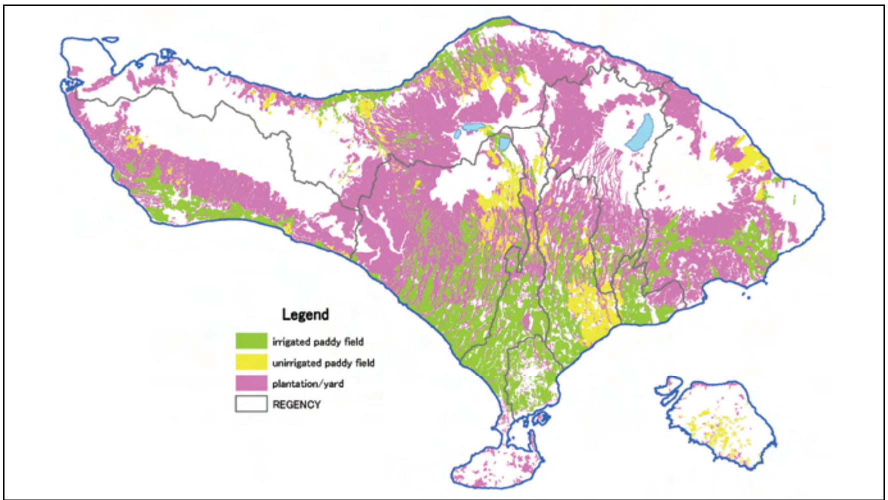


Figure-2.9 Agriculture Area in Bali

2.8 Electricity Infrastructures and Supply Potential

At present, there are four main electricity sources in Bali, such as *Jawa-Madura-Bali* (*JAMALI*) Interconnection System, Diesel Electricity Generator Plant (*Pusat Listrik Tenaga Diesel/PLTD*) in Gilimanuk, Gass Electricity Generator Plant (*Pusat Listrik Tenaga Gas/PLTG*) in Gilimanuk, and a *PLTG* in Pesanggrahan. Present potential power generated by those sources and peak load demand in Bali is shown in Table-2.4

Table-2.4 Present Electricity Sources and Supply Potential in Bali

Kinds of Power	Electric Energy	Supply Capacity
I. Bali		516 MW
1. Bali	452 MW	316MW
1) PLTD Gilimanuk(Diesel)	50 MW	
2) PLTG Gilimanuk(Gas)	100 MW	
3) PLTD Pesanggrahan	78 MW	
4) PLTG Pesanggrahan	128 MW	
5) PLTG Pemaron	96 MW	
2. From Java	—	200 MW
II. Peak Load	—	450 MW

CHAPTER 3 WATER DEMAND AND POTENTIAL

3.1 Future Socio-Economic Framework

The Bali Provincial Government made up “Spatial Plan of Bali Province” in 1996, which was revised as “Revised Spatial Plan of Bali Province 2003 – 2010” for super-ordinate plan of PROPEDA.

(1) Population

The Revised Spatial Plan envisages the future population in Bali Province on the basis of three scenarios as shown in Table-3.1.

Table-3.1 Future Population (Scenarios)

Scenario	Growth Rate		Population in Bali		Sarbagi(Metropolitan) Area		
	-2010	-2025	(thousand)	(%)	Rate (%)	(thousand)	(%)
High	1.26%	1.26%	4,304	104.0	2.19 2.71 1.97 1.47	Metro：2,183 Denoasar：1,038 Badung：580 Gianyar：565	106.3 107.5 106.2 104.4
Middle-A	1.18%	1.18%	4,220	101.9	2.06 2.56 1.97 1.37	Metro：2,118 Denpasar：1,002 BAdung：563 Gianyar：553	103.2 103.7 103.1 102.2
Middle-B	1.18%	1.05%	4,139	100.0	1.74 2.41 1.85 1.28	Metro：2,053 Denpasar：966 Badung：546 Gianyar:541	100.0 100.0 100.0 100.0
Low	1.05%	1.05%	4,086	98.7	1.75 2.14 1.69 1.21	Metro：1,960 Denpasar：903 Badung：526 Gianyar：531	95.5 93.5 96.3 98.2

The population projection is framed by applying two steps that are: Trend Projection and Development Projection.

<Trend Projection>

- Until 2010, the middle scenario 1.18% of the Revised Spatial Plan is considered to be more realistic according to the information from Bali Provincial Government.
- From 2011, the low scenario 1.05% of the Spatial Revised Plan is applied.

Taking into account this trend, scenario of Middle-B shall be adopted for the future population. Thus, the population of the development projection is applied as presented in Table-3.2

Table-3.2 Population Projection

Unit: 1000 persons

Regency/City	Census	Trend Projection			Development Projection
	2000	2005	2010	2025	2025
Jembrana	232	238	244	263	263
Tabanan	376	388	400	436	436
Badung	346	379	425	547	540
Gianyar	393	419	451	541	541
Klungkung	155	157	159	164	164
Bangli	194	202	210	235	235
Karangasem	361	367	375	396	396
Buleleng	558	565	571	591	613
Denpasar	532	600	704	966	951
Total	3,147	3,315	3,539	4,139	4,139

Note: The actual growth rate of 1990 – 2000 was reflected in projection of the respective Kabupaten.
Source: Study Team

<Development Projection>

According to the suggestion of the Revised Spatial Plan for the industrial development at Celukan Bawang in Buleleng, inter-regency migration of workers is taken into consideration by a half of food/beverage and textile industries in Badung and Denpasar are assumed to be shifted to Celukan Bawang in Buleleng during the period of years 2010-2025.

(2) Economic Growth of Manufacturing Industry Sector

The Revised Spatial Plan envisages the industry sector economic growth as follows: 1) 5.49% for years 2003 – 2005, and 2) 8.44% for years 2006 – 2010. The growth rate of 5.5% during 2004 to 2005 is applied. The growth rate of 7% is applied from 2006 to 2025, which is the average rate between 5.5% and 8.4% envisaged by the Revised Spatial Plan.

(3) Output of Manufacturing Industry

Industrial output is used for industrial water demand projection. The output until the target year 2025 is projected as presented in Table-3.3**.**

Table-3.3 Projection of Industrial Output

Unit: billion Rp.

Kabupaten	Actual	Trend Projection			Development Projection
	2003	2004	2010	2025	2025
Jembrana	297	313	463	1,270	1,270
Tabanan	137	144	213	585	585
Badung	293	309	458	1,256	715
Gianyar	155	164	242	664	664
Klungkung	22	23	34	93	93
Bangli	5	5	7	20	20
Karangasem	62	66	97	267	267
Buleleng	10	10	15	42	1,559
Denpasar	538	568	838	2,302	1,326
Total	1,519	1,602	2,367	6,499	6,499

Source: Study Team

(4) Necessary Number of Hotel Rooms

Water demand for tourism is to be projected based on necessary number of hotel rooms that is estimated by assuming the number of tourist, number of guest at hotel, number of guest at room, and length of stay at hotel. Thus, necessary number of hotel rooms until 2025 is estimated as shown in Table-3.4.

Table-3.4 Projected Necessary Hotel Rooms

Classification of Hotel	2004	2010	2025
Classified hotel	9,300	12,200	24,100
Non-classified hotel and other accommodations	5,400	7,100	14,000
Total	14,700	19,300	38,100

Source: Study Team

3.2 Water Demand Projection for Domestic and Non-domestic Water

3.2.1 Conditions for Demand Projection

(1) Domestic Water Demand

<Public Water Supply>

The future unit consumption rate of domestic water use through public water supply system should be decided considering the change of life style.Unit consumption rate of each PDAM service area is decided based on the current rate and future life style of users. However, the rates for Denpasar and Badung (PTTB service areas) are set as 220 lit/head/day and 210 lit/head/day respectively, minimizing the increase (10 lit/head/day for 20 years) of the rate through campaigns for save water.

<Non-Public Water Supply>

Regarding the domestic water obtained by non-public water supply system, unit rates are decided based on the questionnaire survey for 9 regencies/city conducted by the Study Team. The current unit consumption rate is 60 lit/head/day. This rate will be constant in future.

Table-3.5 Base Data for Domestic Water Demand Projection

Water Supply Enterprises	Public Supply									Non-Public W. Supply
	Unit Consumption (liter/person/day)			Service Coverage Ratio (%)			Unaccounted Water Rate (%)			Consump. (ltr/p/day)
	2004	2010	2025	2004	2010	2025	2004	2010	2025	2004
Denpasar	210	220	220	45	55	70	25	20	20	60
Badung	170	180	210	35	45	70				
PT.TB	200	210	210	65	70	80				
Gianyar	130	140	160	45	55	70				
Jembrana	110	120	150	30	35	50				
Tabanan				40	50	70				
Klungkung				50	55	70				
Bangli				20	30	50				
Karangasem										
Buleleng										

Source: JICA Study Team

(2) Non-domestic Water Demand

<Commercial/Public/Institutional Water>

Bali Water Supply Master Plan conducted by SMEC International PTY LTD in 2000 estimated commercial/public/institutional water consumption by applying the ratio of 20% to domestic water consumption. Similarly, the same ratio was set up in this study as shown in Table-3.6

<Manufacturing Industry Water>

The survey on major industry of Bali Province such as food/beverage, textile and wood industries was conducted by the Study Team. According to the data collected, the unit water consumption of manufacturing industry was estimated at 10 m^3/day/annual output of billion Rp. as shown in Table-3.6. In this study, the ratio is estimated currently at 20 % and 40 % in 2025.

<Tourism Water>

The survey on hotels of Bali Province was conducted by the Study Team. According to the data collected, the unit water consumption of star hotel and non-star hotels was estimated respectively at 3.3m^3/room/day and 1.5m^3/room/day. So, current service coverage ratio of this category is not high, which is estimated at around 20 %. Thus, service coverage ratio was assumed 70 % in 2025.

<Unaccounted Water>

Considering current ratio of 23%, unaccounted water ration shall be set as 20% from year of 2010.

Table-3.6 Base Data for Non-domestic Water Demand Projection

Category	Calculation Condition for Water Consumption		Service Coverage Ratio (%)		
	Entity	Calculation Condition	2004	2010	2025
Commercial/Public/Institutional	PT.TB	30% of Domestic Water	100	100	100
	PDAM Denpasar and Tabanan	20% of Domestic Water			
	Other 7 PDAMs	10% of Domestic Water			
Industrial	Manufacturing	10 m^3/output in billion Rp.	20	25	40
Tourism	Star hotel	3.3 m^3/room/day	20	40	70
	Non-star hotel	1.5 m^3/room/day	100	100	100
Unaccounted Water	Same as rate of domestic water (%)		23	20	20

Source: JICA Study Team

3.2.2 Water Supply Requirement of Bali Province

By applying all factors, overall water supply requirement of Bali Province is projected and summarized inTable-3.7.

Table-3.7 Water Supply Requirement by Regency of Bali Province

(Unit: lit/s)

Regency//City Year	Public Water Supply			Non-Public Water Supply			Total		
	Domestic	Non-Domestic	Total	Domestic	Non-Domestic	Total	Domestic	Non-Domestic	Total
Jembrana									
- 2005	125	26	152	113	31	144	239	57	296
- 2010	148	35	184	109	40	149	258	75	333
- 2025	285	109	395	91	88	179	376	197	573
Tabanan									
- 2005	276	69	345	156	19	174	432	88	519
- 2010	347	89	436	138	23	160	485	112	597
- 2025	663	195	858	90	45	135	753	240	993
Badun (Total)									
- 2005	470	248	718	145	251	396	615	499	1,114
- 2010	625	378	1,003	138	257	396	763	635	1,398
- 2025	1,189	1,000	2,189	264	99	363	1,288	1,264	2,552
Badung-PDAM									
- 2005	237	37	273	118	29	147	355	66	421
- 2010	343	55	398	111	35	146	454	90	544
- 2025	721	130	851	74	38	111	794	167	962
Badung-PTTB									
- 2005	233	211	444	27	222	249	260	433	693
- 2010	281	323	604	27	223	250	309	545	854
- 2025	468	870	1,338	25	226	252	494	1,096	1,590
Gianyar									
- 2005	397	64	461	155	23	178	552	87	639
- 2010	503	83	586	140	28	168	643	111	754
- 2025	876	182	1,058	112	53	164	988	235	1,223
Kulungkung									
- 2005	136	15	151	53	3	56	189	18	207
- 2010	151	18	169	49	4	53	201	21	222
- 2025	249	33	282	34	7	41	282	40	323
Bangli									
- 2005	74	10	83	110	0	110	183	10	193
- 2010	109	14	123	101	1	102	211	14	225
- 2025	255	31	287	81	1	82	336	33	369
Karangasem									
- 2005	136	30	166	198	10	208	334	39	374
- 2010	195	41	236	181	11	192	376	52	428
- 2025	430	97	526	136	21	158	566	118	684
Blereng									
- 2005	211	34	245	304	6	309	515	39	554
- 2010	297	46	344	275	6	281	573	52	625
- 2025	665	194	859	211	113	324	876	306	1,182
Denpasar									
- 2005	929	251	1,180	227	99	326	1,157	350	1,507
- 2010	1,232	345	1,577	218	115	333	1,450	460	1,910
- 2025	2,119	686	2,805	197	134	330	2,316	820	3,136
Bali - Total									
- 2005	2,754	747	3,501	1,460	441	1,901	4,215	1,188	5,402
- 2010	3,608	1,048	4,657	1,350	485	1,834	4,958	1,533	6,491
- 2025	6,731	2,527	9,259	1,050	726	1,776	7,782	3,253	11,035
SARBAGITA									
- 2005	1,796	563	2,359	527	373	900	2,324	936	3,260
- 2010	2,360	806	3,166	496	400	897	2,856	1,206	4,062
- 2025	4,184	1,868	6,052	573	286	857	4,592	2,319	6,911

3.3 Water Potential

(1) Surface Water Potential

For the ungauged basins which are not covered by the SGSs, the runoff data at the fourteen (11) key SGSs are transposed to runoff of the ungauged basins in proportion to their catchment area and basin average rainfall.

Based on the annual average runoff in each of the major river basins, the surface water potentials of the rivers are estimated by Sub-basin. As shown in Table-3.8, the total surface water potential in the Study Area is derived to be 6,055mil.m^3/year(192.0m^3/sec) or 1,079mm/year. The runoff ratio against average rainfall for the whole Bali Province is derived to be about 54 % (1,079/2,003mm = 0.54).

Table-3.8 Estimated Total Surface Water Potentials in Bali Island

Sub-Basin	Area	Annual Rainfall		Annual Runoff		
	(km^2)	(mm)	(m^3/s)	(mm)	(Million m^3)	(m^3/s)
Total	5,632.86	2,003	356.493	1,079	6,055.3	192.012

Based on river discharge, surface water potential for each Regency was estimated as shown in Table-3.9. There are three calculation cases for those are: case A; Natural discharge, case B; Natural discharge for more than 10km^2 and case C; 95% discharge.

Table-3.9 Surface Runoff Potential in Bali (Regency,City)

Item	Rainfall	Area	Discharge(m^3/s)	Annual Runoff (m^3/s)		
	(mm)	(km^2)		Case A	Case B	Case C
Jembrana	1,980	841.80	52.700	25.994	23.015	5.753
Tabanan	2,479	839.33	65.788	40.018	35.696	8.924
BAdung	2,195	418.52	29.046	17.178	14.085	3.521
Denaoasar	2,080	123.98	8.154	5.144	4.021	1.005
Gianyar	2,276	368.00	26.482	16.373	15.550	3.888
Klunglung	1,935	105.38	6.447	4.258	4.125	1.031
Bangli	2,024	520.81	33.329	16.562	14.342	3.586
Karangasem	1,804	839.54	47.887	25.696	18.807	4.701
Buleleng	1,841	1,365.88	79.507	37.364	27.296	6.824
Penida island	1,079	209.62	7.151	3.425	0.507	0.127
Total	2,003	5,632.86	356.493	192.012	157.445	39.360

Case A：Based on Natural Discharge (Refer to Figure-3.2)
Case B：Natural Discharge for more than 10 km^2
Case C：95% Discharge

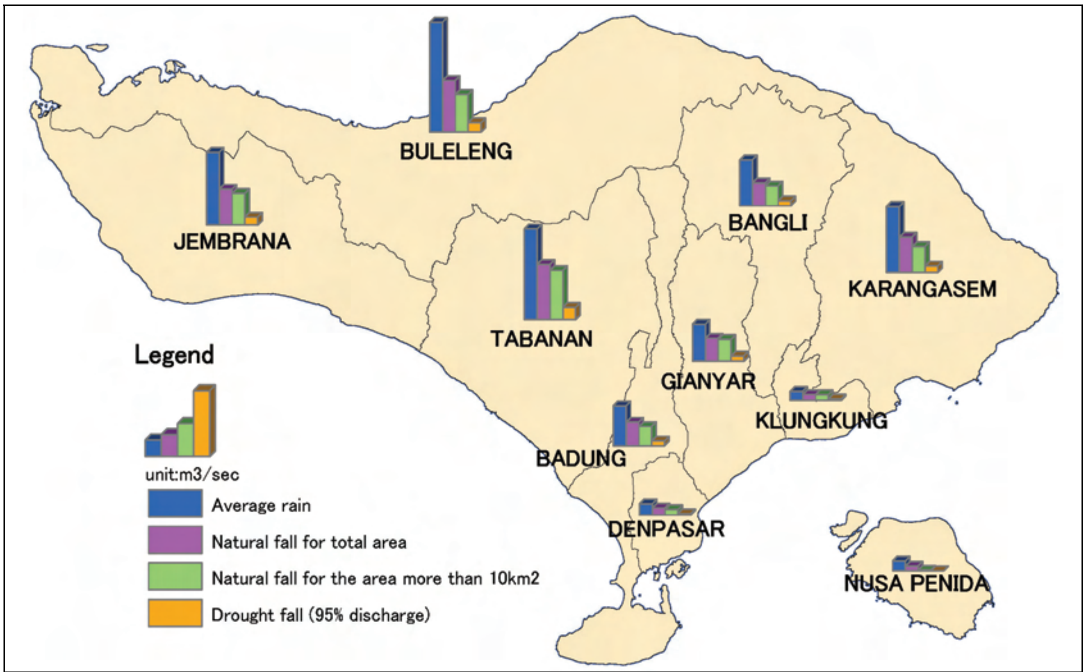
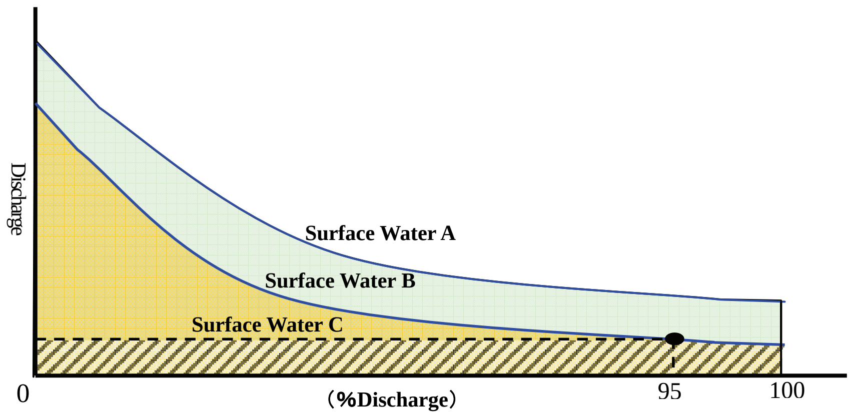


Figure-3.1 Surface Water Potential in Bali



A： Natural Flow in All Catchments Area (Total Runoff=Surface Water A)
B： Natural Flow in more than 10 km^2 of Catchments Area
(Total Runoff=Surface Water A only in Catchments Area of 10km^2)
C： Natural Flow in more than 10 km2 of Catchments Area ranging from 0 % to 95% discharge and remains discharge to 100% discharge. (Total Runoff from 0%to 95%discharge + remains to 100%discharge)

Figure-3.2 Calculation Case for Surface Water A to C

(2) Surface Water Development by Reservoir

There exist five (5) dam reservoirs in Bali Island. Of these, Telaga Tunjung dam in Tabanan Regency is under construction.

(3) Lake Water Potential

There exist four (4) closed lakes in Bali Island. These four (4) caldera lakes have no outlet to the rivers except having the spillway at Beratan Lake. It is said that water of these caldera lakes infiltrates and pours out into the neighboring river basins as springs. With these values, the annual infiltration amounts in the four (4) closed lakes are calculated as shown in Table-3.10.

Table-3.10 Preliminarily Estimate of Infiltration from Caldera Lake

No.	Lake Name	Average Rainfall (mm/year)	Rainfall Volume (10^6 m^3/year)	Rainfall Loss (10^6 m^3/year)	Infiltration Amount	
					(mm/year)	(m^3/sec)
1.	Danau Batur	1,809	184.9	78.1	106.8	3.4
2.	Danau Beratan	2,741	36.2	10.7	25.4	0.8
3.	Danau Buyan	2,994	72.8	18.9	53.8	1.7
4.	Danau Tamblingan	2,958	33.4	8.5	25.0	0.8
Total		-	327.2	116.2	211.0	6.7

(4) Spring Water Potential

Survey result for spring water potential was estimated as follows:

Table-3.11 Springs Water Potential

Regency/City	Yield		Abstracted Volume				
			Irrigation	PDAM	Others	Total	
	(lit./sec)	(mil./year)	(lit./sec)	(lit./sec)	(lit./sec)	(lit./sec)	(mil./year)
Jembrana	118.9	3.7	3.0	0.0	0.2	3.2	0.1
Tabanan	4148.6	130.8	832.5	1022.0	7.5	1862.0	58.7
Badung	1335.2	42.1	406.8	15.0	55.6	477.4	15.1
Denpasar	-	0.0	-	-	-	0.0	0.0
Gianyar	3051.9	96.2	80.0	393.0	1339.0	1812.0	57.1
Klungkung	263.1	8.3	0.0	78.8	56.6	135.4	4.3
Bangli	3393.4	107.0	517.0	131.3	43.4	691.7	21.8
Karangasem	9955.9	314.0	2357.7	183.2	1992.1	4533.0	143.0
Buleleng	6172.6	194.7	147.2	408.1	2378.8	2934.1	92.5
Nusa Penida	524.9	16.6	0.0	20.0	0.0	20.0	0.6
Total	28,964.5	913.4	4,344.2	2,251.4	5,873.2	**12,468.8**	**393.2**

(5) Groundwater Development Potential

Groundwater development potential is considered to be the total groundwater flow from which the pumped volume of deep wells is deducted. The calculation of groundwater flow analysis does not count subsurface flows affected by dug wells and springs. For the estimation of deep wells groundwater potential, groundwater flow approach and recharge coefficient method (IUIDP Method) are executed.

Table-3.12 Groundwater Potential in Bali

Items / Regency,City	Potential (lit/s)		Existing Groundwater (lit/s)				Remains Potential (lit/s)
	Flow Method	Recharge method	Irrigation	Water Supply	others	Total	
Jembrana	3,612	1,126	357	139	85	581	545
Tabanan	850	2,489	10	5	84	99	2,390
Badung	3,035	1,075	31	236	279	546	529
Denpasar		292	0	350	297	647	-355
Gianyar	4,972	1,246	0	360	82	442	804
Klungkung		181	0	5	29	34	147
Bangli		1,551	0	0	9	9	1,542
Karangasem	2,096	2,090	113	69	24	206	1,884
Buleleng	5,676	2,093	305	82	24	411	1,682
Nusa Penida	0	289	0	5	0	5	284
Toatal	20,241	12,432	816	1,251	913	2,980	9,452

Note) Development in Nusa Penida shall be recommended.

(6) Hydrological Water Balance

<Annual Variation>

Based on the hydrological analysis, monthly average rainfall and monthly average potential evapotranspiration were estimated for the whole Bali Province, and are shown in Table-3.13.

Table-3.13 Monthly Average Rainfall and Potential Evapotranspiration

Month	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Rainfall	360	347	257	172	68	55	42	23	40	140	220	278	2,003
Potential Evapotranspiration	101	98	115	117	120	108	115	126	127	127	109	104	1,367
Surplus	259	249	142	55	-52	-53	-73	-103	-87	13	111	174	636

< Hydrological Water Balance in Bali Province>

Hydrological water balance is basically explained by the equation of "[Basin Storage] = [Inflow] – [Outflow]", and using the elements of hydrological cycle, it can be expressed as the following equation:

$$\Delta S = P - \left[Et + R + G \right]$$

Where, P: Rainfall
Et: Evapotranspiration
R: River runoff
G: Groundwater recharge
ΔS: Change of basin water storage

Regarding change of basin storage as zero for long term hydrological balance, annual hydrological balance in Bali Province were preliminary assessed herein.

The above assessment results are summarized in Table-3.14.

Table-3.14 Hydrological Water Balance in Bali Province/Island

Case	Hydrological Elements	Depth in mm	Volume (10^6 m^3/y)	Volume (m^3/s)	Ratio for Rainfall
Natural Flow	Rainfall	2,003	11,283	357.8	100.0 %
	Evapotranspiration	795	4,480	142.1	39.7 %
	Surface Runoff	1,075	6,055	192.0	53.7 %
	Ground Water	133	748	23.7	6.6 %
Current Discharge	Rainfall	2,003	11,283	357.8	100.0 %
	Evapotranspiration	888	5,005	158.7	44.4 %
	Surface Runoff	999	5,624	178.4	49.8 %
	Ground Water	116	654	20.7	5.8 %

Total Area: 5,632.86 km^2

3.4 Water Balance between Water Demand and Potential

According to the balance between water resources potential and water demand in Bali Province shown in Table-3.15. Surface water A to C shown in Table-3.15 is the calculation case explained below.

The following water balance could be found in the present and future in Bali:

- Looking at annual water balance between potential and demand in year at mean discharge, water potential in Bali could be considered to be more than enough in total; especially surface water potential seems to be very large.
- Picking up the balance at Denpasar City, however, potential and demand becomes almost balancing in 2015 and becomes short in 2025 of the target year.
- Water demand in 2025 of Badung and Gianyar Regency also show the large portion.
- On the other hand, water demand of Jembrana, Karangasem and Bangli show the little portion with less than about 30% for the water resources and it will continue until 2025.

Table-3.15 Water Balance between Water Demand and Potential

Items	DEN	BAD	GIA	TAB	KLU	JEM	BUL	BAN	KAR	Total
Potential A Note)	5,436	19,588	20,671	46,656	8,896	27,239	45,630	21,506	37,742	233,409
Potential B	4,313	16,495	19,848	42,334	5,890	24,260	35,562	19,286	30,853	198,842
Potential C	1,297	5,931	8,186	15,562	2,416	6,998	15,090	8,530	16,747	80,757
- Surface Water A	5,144	17,178	16,373	40,018	7,638	25,994	37,364	16,562	25,696	192,012
- Surface Water B	4,021	14,085	15,550	35,696	4,632	23,015	27,296	14,342	18,807	157,445
- Surface Water C	1,005	3,521	3,888	8,924	1,158	5,753	6,824	3,586	4,701	39,360
- Spring Water	0	1,335	3,052	4,149	788	119	6,173	3,393	9,956	28,965
- Ground Water	292	1,075	1,246	2,489	470	1,126	2,093	1,551	2,090	12,432
Existing Water Use	2,953	10,045	9,037	15,418	1,999	2,810	8,679	2,037	2,986	55,964
- Irrigation	1,260	7,650	6,768	12,034	1,400	2,062	6,780	1,398	2,033	41,385
- Public Water Supply	1,180	718	461	345	151	152	245	83	166	3,501
- Non-public W. Supply	326	396	178	174	56	144	309	110	208	1,901
Future Demands(PWS)	2,805	2,189	1,058	858	282	395	859	287	526	9,259
Current(PWS)	1,115	946	562	544	234	139	394	120	224	4,278
- Rivers	800	650	0	81	130	0	0	0	73	1,734
- Springs	0	50	214	458	94	0	312	120	82	1,360
- Wells	315	246	348	5	10	139	82	0	69	1,204
Balance(PWS)	1,690	1,243	550	314	48	256	465	167	302	5,015
Remains Potential A	2,670	10,824	13,264	34,103	7,289	24,881	38,296	19,915	35,335	186,622
Remains Potential B	1,547	7,731	12,441	29,781	4,283	21,902	28,228	17,695	28,446	152,055
Remains Potential C	-1,469	-2,833	779	3,009	809	4,640	7,756	6,939	14,340	33,970
Ratio A	0.6	7.7	23.1	107.6	150.9	96.2	81.4	118.3	116.0	36.2
Ratio B	-0.1	5.2	21.6	93.8	88.2	84.6	59.7	105.0	93.2	29.3
Ratio C	-1.9	-3.3	0.4	8.6	15.9	17.1	15.7	40.6	46.5	5.8

Note) Potential =Surface Water (A,B,C))＋Springs＋Ground water
Surface water potential
A: Natural Flow, B: Natural Flow only for more than 10km^2 C: 95% discharge
Ratio：(Remains Potential – Balance)/Balance
Ratio of less than 0.0 shows a shortage of potential, whereas more than 0.0 shows a large potential.

CHAPTER 4 MASTER PLAN FOR WATER RESOURCES DEVELOPMENT AND MANAGEMENT

4.1 Frame Work of Water Resources Development and Management

(1) Purpose of Establishment

The Law No.7/2004 on Water Resources was approved by DPR in February 2004 and signed by the President in March 2004. The Water Sector Adjustment Loan (WATSAL) by the World Bank provided backgrounds to the law. A statement of GOI issued prior to the commencement of WATSAL in 1999 referred to such concepts as the introduction of a comprehensive water use rights framework both for surface water and groundwater and the reinforcement of the principle of beneficiary contribution toward the government costs of public water supply and irrigation services. During the course of some three years of debate on the draft law, the emphasis on the economic principle was moderated and the law that was finally adopted stresses, among others, 1) the protection of traditional communities and weaker economic groups and 2) the water use rights without license for basic daily needs and small-scale irrigation systems. Also, the law takes account of the new administration structure under regional autonomy for setting out water resources management arrangements.

In accordance with this Law of Water Resources, the Master Plan for Water Resources Development and Management in Bali shall be established.

(2) General Strategy for Water Master Plan

Under the philosophy of the New Water Resources Law, The general strategy for the Water Master Plan of Bali Province is set up below.

- **<u>Basement of Water Master Plan</u>**
  Keeping the New Water Resources Law, and respecting Bali-peculiar spiritual culture, the Master Plan for Water resources Development and Management in Bali Province should be formulated as to meet an international standard.

- **<u>Basic Concept</u>**
  Water resources development and management should be based on the concept of "one island (basin), one plan, and one management".

- **<u>Respect of SUBAK</u>**
  Bali has been historically having its own traditional, cultural and religious commitment, which is embodied in SUBAK. SUBAK should be respected in water resources development and management.

- **<u>Community Participation</u>**
  In formulating the Master Plan, efforts for community participation should be made through stakeholders' meetings.

- **<u>Water Development & Allocation</u>**
  To seek water sources, water users have to find water sources first at their regency and their river basin and second at other regency or other river basin. According to the water balance between future demand and water potential, Denpasar and Badung have no more water potential within the areas. Thus, conveyance of water developed in other river basins or other regencies is inevitable.

4.2 Water Resources Development Plan

4.2.1 Alternatives for Water Resources Development

(1) Options of Water Sources and Development Policies

The options of water sources to be developed in Bali are as follows:

- The options of water sources are river water, spring water, groundwater and natural lake water. The lake water is not a target of water source to develop.
- Although the river water is used mostly for irrigation, it will be promising water source to

develop after confirmation of its surplus potential.

- The methods to develop river water are 1) Direct Intake from River Flow, and 2) Storage of Flood Water in Reservoir. The former is suitable for small and medium scale projects and the latter is suitable for large scale projects.
- Due to the hydrologic and hydro-geologic characteristics of the volcanic island of Bali, there are many perennial springs. Many of these springs are used in Bali. Springs not to be used will be the target to develop, but will be relatively small or medium scale. As the water quality of spring is good enough for drinking water, springs will be promising water sources to develop in small or medium scale.

4.2.2 Water Supply Plan

(1) Current Issues of Water Supply

<Water Sources>

The water sources of PDAMs consist of wells, springs and river water. Amount discharge for water sources was estimated as about 4.5m^3/s in Bali. Of these, about 3.0m^3/s was used for water supply.

<Water Tariff>

Most of PDAMs apply a metered system of billing rate, and have kept the water tariff at the same rate for a long time. The water tariff ranges from Rp. 500 to 800.

<Operation and Maintenance>

A number of Staff worked in PDAM and PT.TB is 1,600 staffs. Only PDAM Bleleng resulted in surplus due to continuous low operation cost.

Every PDAM have owed long-term debt mostly to Central Government. Financial data of PT.TB was not available. However, revenue of water sales of PT.TB could be estimated, by analyzing data of PT.TB, to reach Rp.40billion in 2005, of which more than 60 % might be generated by water sales to industry category including hotels.

(2) Strategies for Water Supply Plan

For the reinforcement of water supply facilities, the following strategies should be studied.

<u>Requirement for Water Sources</u>

The following conditions of water sources should be taken into account to select water sources for domestic and non-domestic water supply system:

- **<u>User's Territory and User's Basin</u>:** When each water supply company seeks new water sources to meet new water demand, he has to find them first in his territory (Regency) and his river basin. Other territory and other basin are the second option.
- **<u>Location of Water Sources</u>:** Water sources at upstream or higher elevation are preferable for applying a gravity water distribution system. And the nearest location to water consumption areas is better to convey water.
- **<u>Water Quality of Water Sources</u>:** Water quality should meet the water quality standards in Indonesia for domestic and non-domestic water supply.
- **<u>Number of Water Sources</u>:** From the economical viewpoint, some limited water sources are better than many water sources because of reducing operation and maintenance cost.
- **<u>Location of Water Sources:</u>** Water sources at upstream or higher elevation are preferable for applying a gravity water distribution system. And the nearest location to water consumption areas is better to convey water.

<u>Minimum Water Cost</u>

To develop new capacity for water supply, water cost per cubic meter shall be minimizes considering Development Cost for Water Sources and Operation and Maintenance Cost.

<u>Staged Implementation</u>

To implement the improvement of water supply capacity, a step-by-step construction to meet time-to-time water demand is preferable.

Maintenance of Facilities

The average unaccounted water rate at present in Bali is 23 %, which is still low level. To keep this rate in low level is equivalent to water saving and new water sources development. Moreover, proper replacement of pumps and motors saves their running costs.

<Water Sources for Future Water Supply>

Table-4.1 shows the percentage of the current water sources for public water supply system by regency/city.

Table-4.1 Water Sources by Regencies

Regencies	River	Spring	Well	Explanation
Junbrana	-	-	100%	All the water sources are deep wells
Tabanan	15%	84%	1%	Main water sources are springs
Badung	67%	8%	25%	3 water sources are used. Main sources are rivers
Gianyar	-	38%	62%	Springs and wells are water sources. Wells are used more.
Kulungkung	55%	40%	5%	Main sources are rivers and springs
Bangli	-	100%	-	All the water sources are springs.
Karangasem	33%	37%	30%	3 water sources are used evenly.
Buleleng	-	79%	21%	Springs and wells are water sources. Springs are used more.
Denpasar	72%	-	28%	Rivers and wells are water sources. Rivers are used more.
Total	40%	32%	28%	3 water sources are used. Large scale water sources are rivers.

- Integrated Public Water Supply System for **Denpasar Metropolitan Area:** To meet a large amount of demand, development of river flow is inevitable. Promising rivers are Ayung, Penet, Petanu Rivers and so on in the territory, and Unda River outside of the territory. Development of other sources (spring and deep well) is necessary. Deep well development in Denpasar is not recommendable due to the problem of sea water intrusions.
- **Tabanan:** Hoo River development is undertaken through Teragatunjung Dam. Spring development is recommendable.
- **Klungkung:** Future water source is spring for both territories in Bali Island and Nusa Penida. In Nusa Penida, springs have enough capacity. Although distributed users are remote from springs, piped distribution system is recommendable.
- **Jembrana:** To meet current demand, development of deep wells is necessary, Benel Dam planed by local government will supply domestic water for future demand.
- **Buleleng:** Future water sources are springs and deep wells.
- **Bangli:** Future water source is springs. Water distribution to new users in remote areas is carefully examined.
- **Karangasem:** Future water sources are springs and deep wells. Water distribution to new users in remote areas is carefully examined.

(3) Water Supply Plan for Southern Bali Area

As the southern Bali area (one city and 4 regencies: Denpasar, Badung, Gianyar, Tabanan and Kulungkung: SARBAGITAKU) has concluded the agreement on the cooperation of water supply in the area, the water supply plan for the southern Bali area is examined and prepared.

Current Water Supply Capacity and Demand

Due to the total water demand and remaining water potential, the southern Bali area is divided into 2 areas, namely 1) Denpasar & Surrounding Area (SARBAGI) and 2) Other Area (TAKU). According to this classification, the water supply capacity and water demand for the southern Bali area are shown in Table-4.2.

Table-4.2 Water Supply Capacity and Water Demand in Southern Bali Area

Area	Water Supply Company	Items	2005	2010	2015	2020	2025
(A) Metropolitan Area (SARBAGI)	(1) Denpasar PDAM	Demand (lit/s)	1,180	1,577	1,986	2,396	2,805 (2,650)
		Capacity (lit/s)	1,115				
		Balance (lit/s)	-65	-462	-871	-1,281	-1,690
	(2) Badung PDAM	Demand (lit/s)	273	399	549	700	851 (813)
		Capacity (lit/s)	296				
		Balance (lit/s)	23	-108	-253	-404	-555
	(3) Badung PTTB	Demand (lit/s)	444	604	849	1,094	1,338 (1,099)
		Capacity (lit/s)	650				
		Balance (lit/s)	206	46	-199	-444	-688
	(4) Gianyar PDAM	Demand (lit/s)	461	586	744	901	1,058 (1,008)
		Capacity (lit/s)	562				
		Balance (lit/s)	101	-24	-182	-339	-496
	Total [1+2+3+4]	Demand (lit/s)	2,358	3,166	4,128	5,091	6,052 (5,571)
		Capacity (lit/s)		808	962	963	961
		Balance (lit/s)	2,623				
		Demand (lit/s)	265	-548	-1,505	-2,468	-3,429 (-2,948)
(B) Other Area (TAKU)	(5) Tabanan PDAM	Capacity (lit/s)	345	436	577	718	858
		Balance (lit/s)	544				
		Demand (lit/s)	201	108	-33	-174	-314
	(7) Kulungkung PDAM	Capacity (lit/s)	151	169	206	245	282
		Balance (lit/s)	235				
		Demand (lit/s)	84	66	29	-10	-47
	Total [5+6]	Capacity (lit/s)	496	605	783	963	1,140
		Balance (lit/s)		109	178	180	141
		Demand (lit/s)	775				
		Capacity (lit/s)	279	170	-8	-188	-365
Total (A+B)	Total [1+2+3;+4+5+6]	Balance (lit/s)	2,854	3,771	4,911	6,054	7,192
		Demand (lit/s)		917	1,140	1,143	1,138
		Capacity (lit/s)	3,398				
		Balance (lit/s)	544	-373	-1,513	-2,656	3,794

Note: ( ) shows lowest projection based on the condition for population with 1.05% (minimum value of Spatial Plan), for manufacturing with 3.5%(half of initial Master plan) and for tourism with 2.1%(average value of 1999-2004 excluding 2003)

Alternative Water Sources

<Surface Water>

Surface water development has two methods: 1) direct intake from river and 2) storage rainy season discharge at reservoir. In both cases, it is necessary to arrange water right with downstream users.

Table-4.3 Alternative Plans of Surface Water Development for SARBAGITAKU Area

River	Catchment Area	Development Method	Development Scale	Explanation
Ayung	301.92 km^2	Storage	1,800 lit/s	■ Storage method can develop a large volume of water ■ In the case that the intake points are upstream or midstream reaches, it is necessary to arrange the water right with existing users.
		Direct Intake	200 lit/s	
Penut	190.36 km^2	Direct Intake	300 lit/s	
Empas	107.08 km^2	Direct Intake	200 lit/s	
Hoo	170.61 km^2	Direct Intake	300 lit/s	
Balian	154.74 km^2	Direct Intake	900 lit/s	
Oos	119.95 km^2	Direct Intake	100 lit/s	
Petanu	96.89 km^2	Direct Intake	300 lit/s	
Sangsang	84.12 km^2	Direct Intake	100 lit/s	
Unda	232.19 km^2	Direct Intake	500 lit/s	

<Spring and Groundwater>

Spring water and Groundwater are access-friendly water resources with relatively good water quality and could be easily developed near the consumer area. However, development volumes of spring and groundwater are limited and not suitable for large scale development.

Table-4.4 Spring/Groundwater Use and Potential (SARBAGITAKU Area)

Items / Regency	Spring (lit/s)			Groundwater (lit/s)		
	Potential	Current Use	Remaining	Potential	Current Use	Remaining
Tabanan	4,149	1,862	2,287	2,489	99	2,390
Badung	1,335	478	857	1,075	546	529
Denpasar	0	0	0	292	647	-355
Gianyar	3,052	1,812	1,240	1,246	442	804
Kulungkung	263	135	128	181	34	147
Penida	525	20	505	288	5	284
Total	9,324	4,306	5,018	5,571	1,773	3,799

<Water Source Options by Consumed Scale>

According to the consumed water volume, SARBAGITAKU area divided into two groups of area: 1) Large-Scale Consumed Area and 2) Medium & Small Scale Consumed Area.

Table-4.5 Water Source Options for Water Supply (SARBAGITAKU Area)

Area	Consumer	Zone	Supplier	Options of Water Source
Denpasar & Surrounding Area (SARBAGI)	Large Scale	Denpasar	DEN-PDAM	Surface Water: Ayung River (Storage, Direct Intake)
		Northern Kuta / Badung	BAD-PDAM	Surface Water: Punet River (Direct Intake)
		Central Kuta / Badung	BAD-PTTB	Surface Water: Putanu and Unda Rivers (Direct Intake)
		Southern Kuta / Badung		
		Southern Part of Gianyar	GIA-PDAM	Surface Water: Putanu and Unda Rivers (Direct Intake) + Groundwater
	Medium Small	Northern Part of Gianyar	GIA-PDAM	Spring + Groundwater
		Northern Part of Badung	BAD-PDAM	Spring + Groundwater
Other Area (TAKU)	Medium Small	Tabanan	TAB-PDAM	Surface Water: Hoo River (Storage and Direct Intake) + Spring + Groundwater
		Kulungkung	KLU-PDAM	Spring

<Zero Option of Water Supply>

The new Water Law, 2004 stipulates that “The state guarantee the right of every person in obtaining drinking water to fulfill a healthy, clean and productive life.” If the Bali Provincial Government (or PDAM, water supply company) does not undertake this water supply project, which would systematically address the rapid increase in water demand in the coming 20 years, the following situations are considered to ensue.

- Water supply projects aims at the enhancement of the health status and living standard of people. If a water supply project satisfying the demand is not implemented, it is expected that people would seek the use of other contaminated or deteriorated water resources. This would result in deterioration of hygienic condition and increase in waterborne infectious diseases.

- Water supply projects are obliged to involve periodical renewal and improvement of facilities, as well as expansion of facilities. If there is no supply of water that can be drunk safely and is delivered stably, people are expected to depend on alternative water resources other than supplied water. In such case, water charges would not be collected as they should, and water supply authorities would be unable to pay the costs of periodical renewal and expansion of facilities.

- If the demand for alternative water resources is not satisfied by the expansion of supply capacity, a situation would result where a decrease of water pressure and restriction of water supply take place routinely. In Denpasar City, water supply restriction is enforced every afternoon, and local people are coping with this situation by storing water in tanks and pails. Frequency of such situation would have a social impact on the daily living of the inhabitants.

- The project area contains 60 deep wells that are used as the sources of potable and industrial water. If water supply is not augmented by the implementation of this project, people are expected to accelerate the development of easily accessible groundwater sources including shallow wells and deep wells

- SARBAGI (Bali Provincial Metropolitan Areas) is located in the coastal alluvial plain comprising intercalating Quaternary clay layer. Because of this, groundwater extraction exceeding its potential would lead to extensive groundwater depletion, as well as land subsidence due to consolidation of clay layer. Inflow of saline water is also anticipated, since the electric conductivity of water in 4 shallow wells (depth 3-25m) near the coastline has reached 800-2,100 μS/cm.

As explained above, the Zero Option (no implementation of the water supply project) is not a viable alternative, because it would cause adverse effects on people's health, the local community, and the water environment in the vicinities.

<Alternatives of Integrated Water Supply System>

The current demand of the Denpasar Metropolitan Area through public water supply system is 2,358 lit/s. This demand is estimated to increase to 6,052 lit/s (about 2.6 times of the current demand) in the target year of 2025. To meet the increased demand, the Study Team proposes the following new water supply systems for the Metropolitan Area.

- **For northern parts of the area (Northern parts of Badung and Gianyar regencies):**
  To meet small or medium scale demands in the different areas, springs and deep wells in the territory will be developed to minimize the water conveyance distance from water sources to the service area according to the potential of each area
- **For southern parts of the area (Denpasar and Southern parts of Badung and Gianyar regencies):**
  To meet large scale demand in the intensive areas, river flows in the territory first and outside the territory secondly will be developed to economize construction cost and to minimize the impacts to natural & social environments. This integrated water supply system is composed of three (3) sub-systems namely Western System, Central System and Eastern System.

The integrated water supply system for Metropolitan Area is examined and alternative plans of each sub-system are shown in Table-4.6 and Figure-4.1 to Figure-4.5.

Table-4.6 Alternatives of Integrated Water Supply System for Metropolitan Area

System and Alternatives	Intake Point	Water Treatment Plant	Water Conveyance	Remarks
Western System	➢ Capacity: 300lit/s ➢ Service Area: Mainly middle parts of Badung regency ➢ Water Source: Penet River located on the boundary between Badung and Tabanan regencies ➢ Terminal Point of Main Water Conveyance Line: KEROBOKAN			
W1	Middle reach of Penet river	Kapal	Pump intake and gravity conveyance	◆ Some existing intakes for irrigation and water supply in downstream.
W2	Mouth of Penet river	Mungu	Pump intake and gravity conveyance	◆ No intake in downstream
Central System	➢ Capacity: 1,800lit/s ➢ Service Area: Denpasar and southern parts of Badung regency ➢ Water Source (1): With dam in Ayung river ➢ Water Source (2): Without Dam, a) Surface water, b) Groundwater, c) Surface water + Groundwater ➢ Terminal Point of Main Water Conveyance Line: Existing IPA-Ayung			
C1 (With Dam)	Downstream near dam site	Downstream near dam site	Gravity intake and gravity conveyance	◆ Some existing intakes for irrigation and water supply in downstream
C2 (With Dam)	Middle reach of Ayung river	Near existing IPA-Ayung	Pump intake and no conveyance	◆ Some existing intakes for irrigation and water supply in downstream
C3 (Without Dam)	Surface Water	Near existing IPA-Ayung	Pump intake and pump conveyance	◆ Intake points: River mouths of 6 rivers
C4 (Without Dam)	Groundwater	Near existing IPA-Ayung	Well production and pump conveyance	◆ Well: 180 deep wells
C5 (Without Dam)	Surface Water + Groundwater	Near existing IPA-Ayung	Pump intake / well production and pump conveyance	◆ Intake points: River mouths of 5 rivers ◆ Well: 90 deep wells
C6 (With Small Dam)	Middle reach of Ayung river	Near existing IPA-Ayung	Well production and pump conveyance	◆ Small size of dam ◆ Well: 90 deep wells
Eastern System	➢ Capacity: 800lit/s ➢ Service Area: Southern parts of Badung regency and southern parts of Gianyar regency ➢ Water Source: Petanu river and Unda river ➢ Terminal Point of Main Water Conveyance Line: Existing IPA/Badung Estuary			
E1	Middle reach of Unda river (Telagawaja)	Middle reach of Unda river (Telagawaja)	Gravity intake and gravity conveyance	◆ Some existing intakes for irrigation and water supply in downstream ◆ Water Conveyance: Via Ubud
E2	Middle reach of Unda river (Telagawaja)	Middle reach of Unda river (Telagawaja)	Gravity intake and gravity conveyance	◆ Some existing intakes for irrigation and water supply in downstream ◆ Water Conveyance: Via Sunrise Road
E3	Mouth of Unda river	Mouth of Unda river	Pump intake and pump conveyance	◆ Water Conveyance: Via Sunrise Road
E4	Mouth of Petanu river + Mouth of Unda river	Mouth of Petanu river + Mouth of Unda river	Pump intake and pump conveyance	◆ Water Conveyance: Via Sunrise Road ◆ Stage installation of intake point
E5	River mouth of Petanu river + Middle reach of Unda river	Mouth of Petanu river + Middle reach of Unda river	Combination of (1) Pump intake and pump conveyance + (2) Gravity intake and gravity conveyance	◆ Water Conveyance: Via Sunrise Road ◆ Stage installation of intake point

Central System→ With Dam

System	Alternatives	Explanation
Western System	W1	◆ Intake and Water Treatment: Middle reach of Penet River (Kapal) ◆ Water Conveyance: To Kerobokan by Gravity
	W2	◆ Intake and Water Treatment: Downstream reach of Penet River (Mungu) ◆ Water Conveyance: To Kerobokan by Pump
Central System	C1	◆ Intake: Downstream of Dam ◆ Water Conveyance: To the existing IPA Ayung by Gravity ◆ Water Treatment: Beside the existing IPA Ayung
	C2	◆ Intake and Water Treatment: Beside the existing IPA Ayung
Eastern System	E1	◆ Intake and Water Treatment: Middle reach of Unda River (Teragawaja) ◆ Water Conveyance: To Kuta byGravity (via Ubud)
	E2	◆ Intake and Water Treatment: Middle reach of Unda River (Teragawaja) ◆ Water Conveyance: To Kuta by Gravity (via Sunrise Road)
	E3	◆ Intake and Water Treatment: River mouth of Unda River ◆ Water Conveyance: To Kuta by Pump (via Sunrise Road)
	E4	◆ Intake and Water Treatment: (1)River mouth of Petanu River, (2)River mouth of Unda River ◆ Water Conveyance: To Kuta by Pump (via Sunrise Road)
	E5	◆ Intake and Water Treatment: (1)River mouth of Petanu River, (2)Middle reach of Unda River (Teragawaja) ◆ Water Conveyance: (1)To Kuta by Pump (via Sunrise Road), (2) To Kuta by Gravity

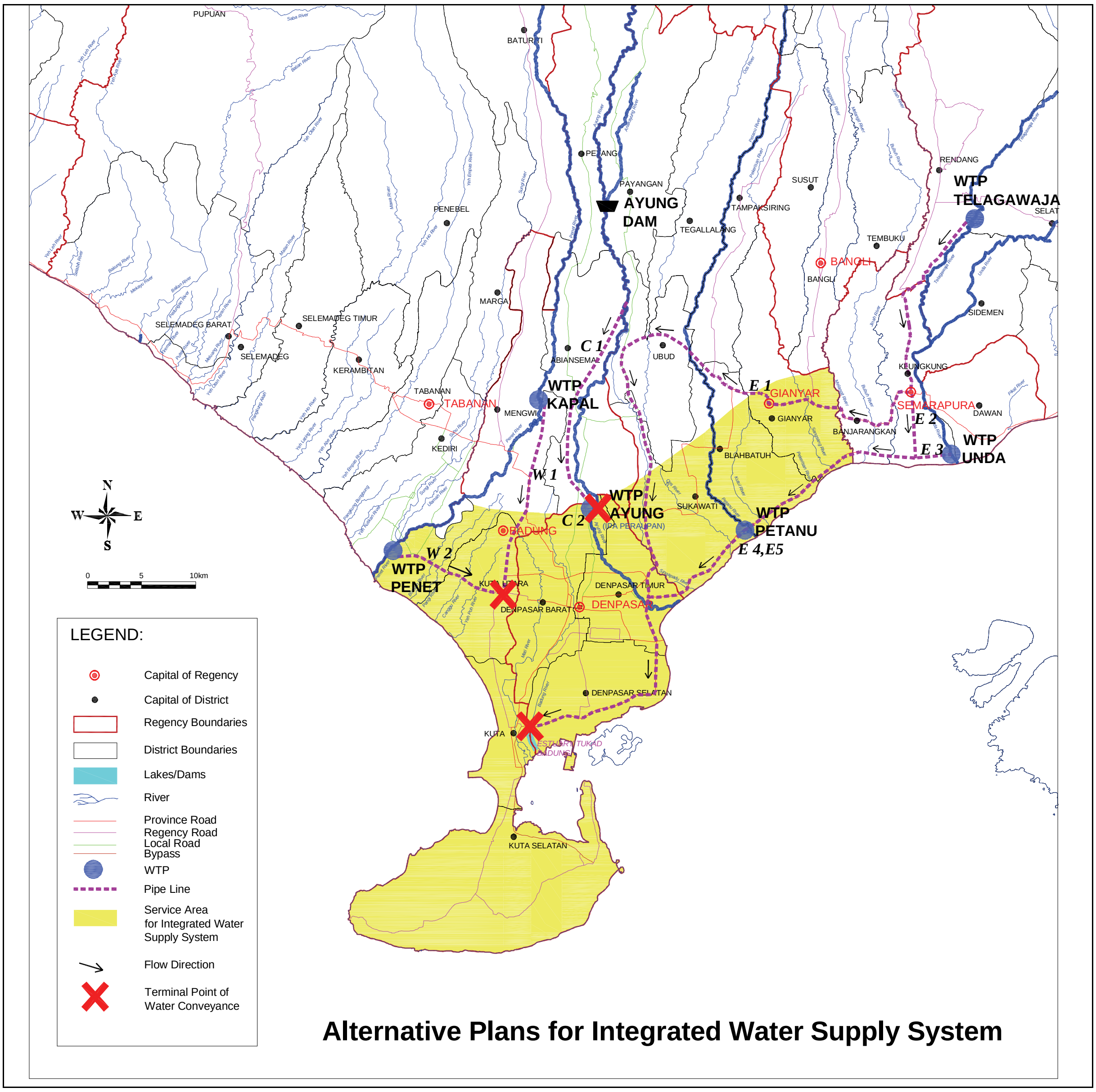


Figure-4.1 Alternatives for Water Supply for SARBAGI (With Ayung Dam)

Central System→ Without Dam

System	Alternatives	Explanation
Central System	C3	Water Source: Surface Water at River Mouths, Developmentt River and Volume: Balian R.→ 900lit/s, Hoo R. → 300lit/s, Empas R. → 200lit/s, Ayung R. → 200lit/s, Oos → 100lit/s, Sangsang R. → 100lit/s, Total Volume: 1,800lit/s
	C4	Water Source: Groundwater, Development Area: Tabanan, Total Volume: 1,800lit/s (180 Wells)
	C5	Water Source: Surface Water at River Mouths and Groundwater, <Surface Water> Hoo R. → 300lit/s, Empas R. → 200lit/s, Ayung R. → 200lit/s, Oos → 100lit/s, Sangsang R. → 100lit/s, Volume: 900lit/s, <Groundwater> Volume: 900lit/s (90 Wells)

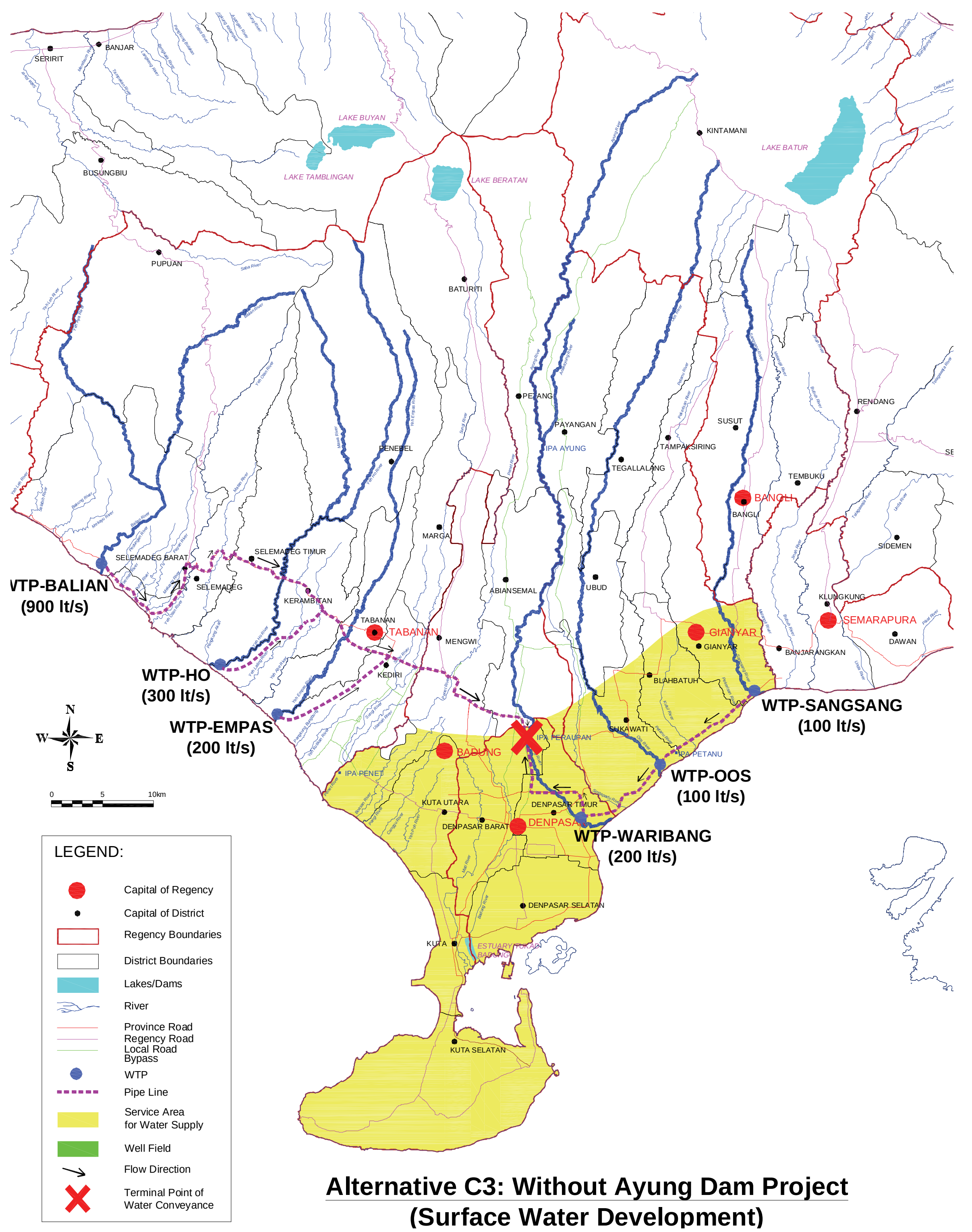


Figure-4.2 Alternative Plans without Ayung Dam (Surface Water Development)