SUPPORTING REPORT

PART-E

WATER UTILIZATION PLAN

**THE STUDY ON FLOOD CONTROL FOR AMBON AND PASAHARI AREA
IN THE REPUBLIC OF INDONESIA
SUPPORTING REPORT
PART-E**

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1.1 Water Use and Demand

1.1.1 Current Water Use

(1) Domestic Water Use

Water for domestic use in Ambon city is provided by PDAM through both individual household connections and public taps. The main water sources are springs and deep wells connected by a distribution network. No water treatment is currently provided although chlorination is sometimes necessary at water supply reservoirs. Drinking water for areas not served by PDAM is usually taken directly from springs or wells.

PDAM currently serves 20 of Ambon's 50 Desa / Kelurahan, mostly within the Study Area. It is estimated that water supply by PDAM reaches 28% of the city residents. Some industry or commercial facilities have their own source of water and others have metered connections with PDAM. Around 70% of PDAM's water is sold for domestic use. The following Table-E.1.1 shows the number of connections, amount of water sold and the PDAM revenue from the sales of water, by category of consumers in 1995. Figure-E.1.1 shows the monthly water sales from January 1995 to September 1996.

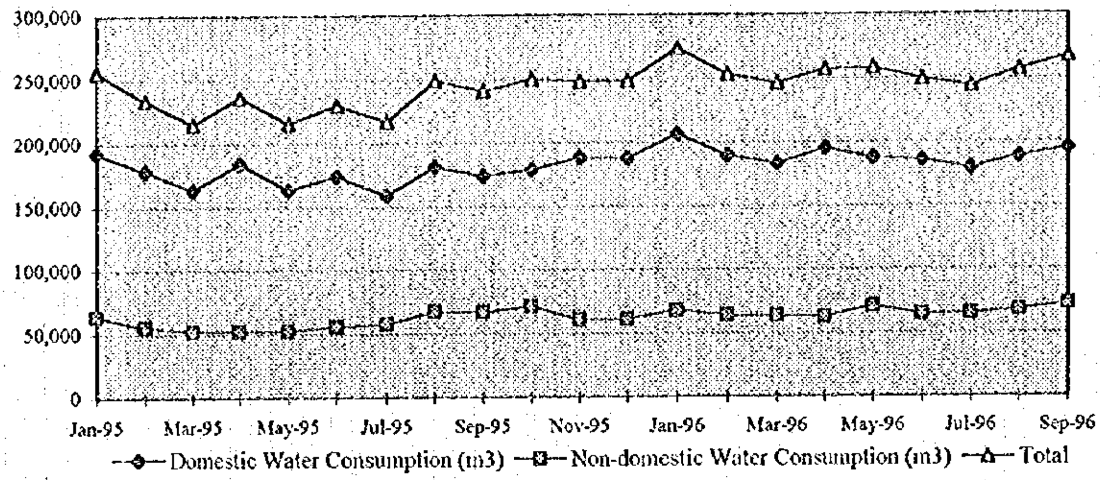
Table-E.1.1 Connection and Sales of Water by PDAM in Ambon City 1995

Item	Number of Connections*	Amount of Water Sold ('000 m3)	Revenue from Water Sales (Rp million)	Unit Price (Rp/m3)
Domestic Water Sales	**8,245**	**2,456**	**1012.2**	**412**
Households	8,117	1,897	929.6	490
Public Taps	128	559	82.6	148
Non-Domestic Water Sales	**926**	**1,077**	**713.6**	**663**
Government	111	544	310.9	572
Commercial	720	214	193.4	904
Industry	6	171	33.5	196
Others	89	148	175.8	1,188
TOTAL	**9,171**	**3,533**	**1725.8**	**488**

*as of Dec. 31, 1995 Source : processed from PDAM monthly report

From the above table, per capita water consumption can be estimated for both household connections and public taps. PDAM assumes that each household has an average of 6.5 occupants which means that approximately 53,000 people obtained water from household connections in 1995. Using the annual total of water sold, the per capita consumption is estimated at 98.5 liters/capita/day (lcd) for consumers supplied by household connections.

It is more difficult to estimate the consumption of the population served by public taps. PDAM assume that each tap supplies 100 people with an average supply of 35 lcd. This estimate appears far too low as the total supplied would be only 164,000 m3/year compared to the actual volume sold in 1995 of 559,000 m3 . However, based on interviews conducted by the JICA Study Team, it was found that the typical charge for use of water from a public tap is Rp 1,500 per household per month. Using this value, the number of households using water from public taps is approximately 4,600, or about 30,000 people assuming 6.5 occupants / household. This figure is equivalent to a per capita consumption of 50 lcd.



Source : processed from PDAM monthly report

Figure-E.1.1 Monthly Water Sales (m³) by PDAM : Jan 95 - Sep 96

(2) River Water Use

Water for other domestic uses such as washing of clothes and personal washing is also taken from springs and wells. Springs are often located within the river water course and it is common to see women and children doing laundry at the sides of the rivers.

The rivers through the city are used extensively by the urban population as a means of garbage disposal. Many toilets are also located in the river courses and consequently the water quality is of a very low standard.

(3) Non-Domestic Water Use

There are no large industrial water users in the Ambon area. However, non-domestic water sales from PDAM still accounted for 30% of the total sales in 1995. 50% of the non-domestic water sales were to government customers, including government offices, schools, hospitals and other public facilities. PDAM also provides water to over 700 commercial customers, mainly shops, businesses, hotels and restaurants in the central city area of Ambon. Other commercial and industrial users have sunk deep wells to meet water supply requirements.

There is very little agricultural water use within the Ambon study area. Small scale agriculture in the upper river basins is rain fed only.

1.1.2 Future Water Demand

Future demand for domestic and non domestic water use has been predicted for the Study Area and for the whole of Ambon City until the Year 2030. The results are summarized in Table-E.1.2 below and given in full in Table-E.1.3. The results are presented graphically in Figure-E.1.2 and explained below.

Table-E.1.2 Summary of Future Water Demand (m^3/day)

Year	1996	2000	2005	2010	2015	2020	2025	2030
Population Projection								
Study Area	160,851	164,670	169,609	174,742	180,078	185,631	191,413	197,437
Ambon Municipality	305,252	326,544	355,261	386,502	420,490	457,469	497,689	541,466
Domestic Water Demand								
Study Area	3,700	5,146	7,208	10,266	12,605	14,850	16,749	18,757
Ambon Total	7,021	10,205	15,099	22,707	29,434	36,598	43,548	51,439
Non Domestic Demand								
Study Area	3,027	4,210	5,898	8,400	10,314	12,150	13,703	15,346
Ambon Total	3,027	4,477	6,774	10,595	14,521	17,587	20,403	23,517
Total Future Demand								
Study Area	6,726	9,356	13,106	18,666	22,919	27,001	30,452	34,103
Ambon Total	10,048	14,681	21,873	33,302	43,955	54,185	63,951	74,956
System Losses								
Study Area	4,484	6,238	7,057	8,000	7,640	9,000	10,151	11,368
Ambon Total	6,698	9,787	11,778	14,272	14,652	18,062	21,317	24,985
Total Water Requirement								
Study Area	11,211	15,594	20,163	26,665	30,559	36,001	40,603	45,470
Ambon Total	16,746	24,468	33,651	47,574	58,607	72,246	85,268	99,942

According to the Water Supply System Development Plan included in the Final Report of the Eastern Island Urban Development Project, the aims of PDAM's regional service plan should be to :

- Meet the National Planning target of supplying water to 80% of the population in the serviced region by the planning target year of 2010.
- Extend water service to developed areas of Ambon not yet served by water supply.
- Improve the water service in the existing serviced area.
- Extend water service to planned development areas in accordance with regional urban development plans.

The prediction of future water demand in this Study is based on the objectives stated in the Water Supply System Development Plan, and makes the following assumptions :

(1) Domestic Water Demand

Population Projection

The projection of population growth for the Study Area and for the whole of Ambon city was described in Supporting Report Part-A.

Water Supply Coverage

Currently, less than 30% of Ambon's population is served by the PDAM water supply network. In accordance with National Planning, it is assumed that water supply coverage will be extended to 80% of the population by the target year of 2015. The PDAM plan aims to achieve 80% coverage by 2010 and assumes that 70% of the population will be served by individual household connections and 10% by public taps. This target is considered to be optimistic and the current prediction assumes 60% served by household connections and 20% by public taps by 2015. After this date, it is assumed that water supply coverage will continue to increase, aiming to serve 100% of the population by 2030 with the reliance on public taps reduced to 10%.

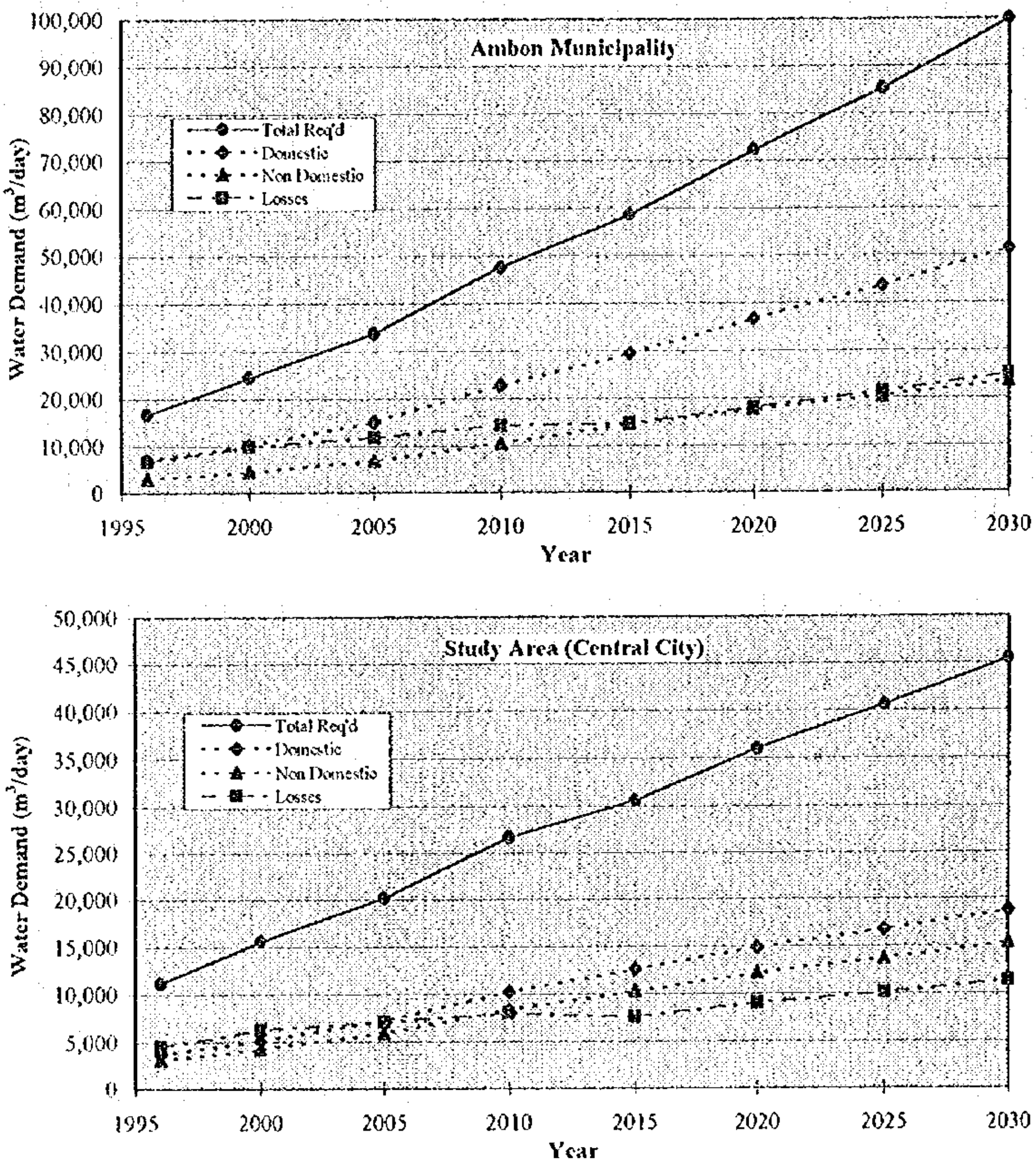


Figure-E.1.2 Future Water Demand Projection

<u>Per Capita Water Consumption</u>

Per capita water consumption is estimated from current PDAM water supply statistics. A value of 100 liters/capita/day (lcd) is assumed for the individual household connections and 50 lcd for the population served by public taps. Although per capita water consumption can be expected to increase with the level of development, it is assumed to remain constant for estimation purposes until such time as the water supply service area is extended to serve most of the population.

Table-E.1.3 Future Water Demand Projection

Year		1996	2000	2005	2010	2015	2020	2025	2030
Population Projection						Target			
Ambon Municipality Total		305,252	326,544	355,261	386,502	420,490	457,469	497,689	541,466
Study Area		160,851	164,670	169,609	174,742	180,078	185,631	191,413	197,437
Other Areas		144,401	161,874	185,652	211,760	240,412	271,838	306,276	341,029
Water Supply Coverage									
Households	%	18.0	25.0	35.0	50.0	60.0	70.0	80.0	90.0
Public Taps	%	10.0	12.5	15.0	17.5	20.0	20.0	15.0	10.0
Not Served	%	72.0	62.5	50.0	32.5	20.0	10.0	5.0	0.0
DOMESTIC DEMAND									
Study Area									
Population Served									
Households		28,953	41,168	59,363	87,371	108,047	129,942	153,130	177,693
Public Taps		16,085	20,584	25,441	30,580	36,016	37,126	28,712	19,744
Not Served		115,813	102,919	84,805	56,791	36,016	18,563	9,571	0
Water Demand	m^3/d								
Households : 100 lcd		2,895	4,117	5,936	8,737	10,805	12,994	15,313	17,769
Public Taps : 50 lcd		801	1,029	1,272	1,529	1,801	1,856	1,436	987
Total Demand	m^3/d	3,700	5,146	7,208	10,266	12,605	14,850	16,749	18,757
Other Areas									
Population Served									
Households		25,992	40,469	64,978	105,880	144,247	190,287	245,021	309,626
Public Taps		14,440	20,234	27,848	37,058	48,082	54,368	45,941	34,403
Not Served		103,969	101,171	92,826	68,822	48,082	27,184	15,314	0
Water Demand	m^3/d								
Households : 100 lcd		2,599	4,047	6,498	10,588	14,425	19,029	24,502	30,963
Public Taps : 50 lcd		722	1,012	1,392	1,853	2,404	2,718	2,297	1,720
Total Demand	m^3/d	3,321	5,059	7,890	12,441	16,829	21,747	26,799	32,683
Total Domestic Demand									
Domestic Demand	m^3/d	7,021	10,205	15,099	22,707	29,434	36,598	43,548	51,439
	l/sec	81	118	175	263	341	424	504	595
NON DOMESTIC DEMAND									
Study Area	%	45	45	45	45	45	45	45	45
Total Demand	m^3/d	3,027	4,210	5,898	8,400	10,314	12,150	13,703	15,346
Other Areas	%	0	5	10	15	20	20	20	20
Total Demand	m^3/d	0	266	877	2,195	4,207	5,437	6,700	8,171
Total Non Domestic Demand									
Non Domestic Demand	m^3/d	3,027	4,477	6,774	10,595	14,521	17,587	20,403	23,517
	l/sec	35	52	78	123	168	204	236	272
TOTAL DEMAND									
Ambon Total	m^3/d	10,048	14,681	21,873	33,302	43,955	54,185	63,951	74,956
	l/sec	116	170	253	385	509	627	740	868
Study Area	m^3/d	6,726	9,356	13,106	18,666	22,919	27,001	30,452	34,103
	l/sec	78	108	152	216	265	313	352	395
SYSTEM LOSSES									
System Losses	%	40	40	35	30	25	25	25	25
Ambon Total	m^3/d	6,698	9,787	11,778	14,272	14,652	18,062	21,317	24,985
Study Area	m^3/d	4,484	6,238	7,057	8,000	7,640	9,000	10,151	11,368
TOTAL WATER REQUIREMENT									
Ambon Total	m^3/d	16,746	24,468	33,651	47,574	58,607	72,246	85,268	99,942
	l/sec	194	283	389	551	678	836	987	1,157
Study Area	m^3/d	11,211	15,594	20,163	26,665	30,559	36,001	40,603	45,470
	l/sec	130	180	233	309	354	417	470	526

(2) Non Domestic Water Demand

Non domestic water demand for government, commercial and industrial users currently accounts for 45% of the total water supplied by PDAM in the central Ambon area. The category of government includes schools, hospitals and other public facilities, in addition to government offices. Commercial users include shops, restaurants, hotels and businesses in the central city. It is assumed that the water demand by such consumers will remain at 45% of the total supplied in the central Study Area.

PDAM does not supply water for non domestic use outside the central city at the present time. However, as population grows in the outer areas of Ambon city, the need for facilities such as shops and schools will develop and so non domestic water demand will grow. The level of this water demand is assumed to increase gradually to reach 20% of the total water demand in these areas by the target year of 2015.

(3) System Losses

Current water losses are estimated by PDAM to account for nearly 40% of the total water volume abstracted from the springs and deep wells serving Ambon. This value for system losses is based on the difference between the measured (estimated) volume of water supplied and the known volume of water sold. Although the PDAM Development Plan gives the reduction of system and production losses a high level of priority, the assumed improvement from 40% at present to only 20% by the year 2000 is considered overly optimistic. For the purposes of this water demand projection, the system losses are assumed to remain at 40% until the year 2000 and thereafter reduce gradually to 25% by the target year of 2015. To achieve even this improvement, significant investment to replace leaking transmission and distribution networks would be required. Further reduction of losses beyond 25% of total volume of water produced is not considered feasible.

(4) Total Water Requirement

As shown in Tables-E.1.2 & 3 and in Figure-E.1.2, the total water requirement for the whole of Ambon municipality will increase from the present production of around 16,700 m^3/day (194 l/s) to over 58,000 m^3/day (670 l/s) in 2015 and to nearly 100,000 m^3/day (1,160 l/s) by 2030. This represents an increase of 350% to 2015 and nearly 600% to 2030 over present production levels. The figures for the current Study Area, corresponding to the central city area where the majority of non-domestic water users are concentrated, are 30,000 m^3/day (350 l/s) in 2015 increasing to over 45,000 m^3/day (520 l/s) by 2030. The percentage increase in required water volume from the current capacity of 11,200 m^3/day (130 l/s) is 270% to 2015 and 400% to 2030.

1.2 Planning Conditions for Water Development

It is proposed to utilize the flood control dams described in the optimum flood control plan (Supporting Report Part-D) as a source of water supply for Ambon central city area. The proposed dams on Ruhu, Batu Gajah and Batu Gantung rivers, namely RH-1, GJ-2 and GT-1, will therefore be utilized as multi-purpose dams and the water utilization plan is outlined below. Water from the dam reservoirs will be used to maintain the river discharge at an acceptable level during the dry season (maintenance discharge) and also to supplement other water sources to meet the future water demand in the Ambon Study area (newly developed discharge). The necessary reservoir volume required to meet the shortfall in future supply has been calculated. It was found that the available discharge from the two dams on Batu Gajah and Batu Gantung rivers will be sufficient to satisfy the future deficit in the medium term (until 2015), assuming that PDAM develop and improve existing water sources as proposed in their Water Supply System Development Plan. The discharge developed by the construction of Dam RH-1 on Ruhu river will satisfy demand in the longer term until beyond 2030.

1.2.1 Compensation Discharge

Compensation discharge is the river discharge necessary to be maintained downstream of a dam in order to ensure the normal function of the river (maintenance discharge) and to provide water to existing water users (water use discharge).

Compensation Discharge = Maintenance Discharge + Water Use Discharge

(1) Maintenance Discharge

The maintenance discharge is the discharge required downstream of a dam to maintain the normal function of the river. This maintenance discharge usually includes the requirements of river transportation, fishing, prevention of salt water intrusion, prevention of estuary sedimentation, maintenance of groundwater levels, preservation of river plants and wildlife, and maintenance or improvement of river water quality. For the five target rivers in Ambon, the problem of river water quality is the most important.

In this water utilization plan, the specific maintenance discharge has been set as 1.0 $m^3/sec/100km^2$ for Ruhu and Batu Gajah rivers, and the maintenance discharge required at each dam site calculated based on the catchment area. For Batu Gantung river, a value of 0.5 $m^3/sec/100km^2$ was used because there is currently no flow in this river during the dry season and therefore such a high level of maintenance discharge is not necessary. The catchment area and maintenance discharge Q_m at the three proposed dam sites and corresponding staff gauges are given in Table-E.1.4.

Table-E.1.4 Maintenance Discharge at Proposed Dam Sites

River & Dam Site	Specific Maint. Discharge $m^3/sec/100km^2$	Dam Site		Reference Point - Staff Gauge			
		C.A. km^2	Qm m^3/sec	C.A. km^2	Qm m^3/sec	Slope	Depth cm *
Ruhu RH-1	1.0	14.49	0.145	14.91	0.149	1/550	15
Batu Gajah GJ-2	1.0	4.27	0.043	4.92	0.049	1/160	8
Batu Gantung GT-1	0.5	4.76	0.024	5.89	0.024	1/160	5

*assuming 1m channel width

(2) Water Use Discharge

There is currently no water abstraction from the rivers in Ambon for consumptive use. This situation is not expected to change and it is not recommended to commence using river water for consumption. Water developed for domestic and other uses in Ambon city should be abstracted directly from the dam reservoir. However, river water is sometimes used for washing and bathing. Table-E.1.4 shows the water depth calculated at an assumed 1m wide channel at each reference point - this depth is thought to be adequate for use for washing and bathing. Therefore, the maintenance discharge descibed above is sufficient for water use discharge downstream of the potential dam sites.

1.2.2 Necessity for City Water Development

(1) Future Water Demand

As described in Section 1.1, total water demand in Ambon municipality is expected to increase from the current level of 16,750 m^3/day to around 58,600 m^3/day by the medium term target year of 2015. In the longer term, total demand will increase to nearly 100,000 m^3/day by the year 2030. In the Study area, corresponding to the central Ambon area, demand is expected to increase from 11,200 m^3/day (130 l/s) to almost 30,600 m^3/day (354 l/s) by the year 2015, and to 45,470 m^3/day (526 l/s) by the year 2030.

(2) Planned Water Resources

The PDAM Water Supply System Development Plan includes plans to develop supplies from springs and boreholes to the east and north of Ambon, including Tulehu spring, deep wells at Poka and Rumah Tiga and abstraction from Wai Lela river. These new water resources will serve the northern and eastern sides of Ambon Bay, including Poka, Rumah Tiga, Paso and Lateri.

In the central Ambon area, according to the PDAM Development Plan, there are plans to sink additional deep wells and to increase production from existing springs and boreholes, as well as to abstract water from a free intake on Air Besar, a tributary in the upper catchment of Ruhu river. The assumed increase in water resources for the central Ambon area, based on the PDAM Development Plan and discussions with PDAM, is shown in Table-E.1.5.

(3) Required Newly Developed Discharge

The timescale of the PDAM Development Plan assumes that the above increases can be achieved by the year 2010. Given that investment is likely to be provided by a Dutch water supply company, this current Study also assumes that the increases shown in Table-E.1.5 can be achieved by 2010. However, the production capacities quoted above have not been verified but are taken from the PDAM report for planning purposes.

Even if production capacity is increased in line with the PDAM plan, the total supply capacity will not be sufficient to meet the increased demand. It can be seen that there will be a shortfall in supply of nearly 9,500 m^3/day (110 l/s) in the central Ambon area by the year 2015 and over 24,000 m^3/day (282 l/s) by the year 2030. In order to satisfy this shortfall, developed water from the proposed multi-purpose dams can be utilized. The following section explains the calculation of the water resources developed by the dams on Ruhu, Batu

Gajah and Batu Gantung rivers.

Table-E.1.5 Assumed Water Resources (Central Ambon Area)

No.	Planned Water Source	Location	Source Capacity (l/s)	Production Capacity (l/s) 1995	2000	2005	2010
A	SPRING SOURCES						
1	Wainitu Spring	Wainitu	80	34	40	50	50
2	Air Keluar Spring	u/s Batu Gantung	13	10	13	13	13
3	Batu Gajah Spring	u/s Batu Gajah	18	13	16	16	18
4	Air Besar Spring	u/s Ruhu	18	18	21	21	23
5	Air Panas / Wainiuw Springs	u/s Ruhu	13	10	6	6	8
6	Wai Pompa Spring #	Halong	40	15	20	24	30
	Sub-Total Springs (l/sec)		182	100	116	130	142
			(m³/d)	8,640	10,020	11,230	12,270
B	DEEP WELL SOURCES						
1	AP / 1	Ambon City	17	17	13	17	17
2	AP / 3	Ambon City			10	10	10
3	AP / 4	Hative Kecil	15	11	10	10	15
4	AP / 4A (Planned 1997)	Hative Kecil			5	5	10
5	AP / 1A	Ambon City		5	5	10	10
6	AP / 1B	Ambon City		5	5	10	10
	Sub-Total Wells (l/sec)		42	38	48	62	72
			(m³/d)	3,280	4,150	5,360	6,220
C	RIVER WATER SOURCES						
1	Air Besar *	u/s Ruhu			30	30	30
	Sub-Total Rivers (l/sec)				30	30	30
			(m³/d)		2,600	2,600	2,600
	TOTAL CAPACITY (l/sec)		214	138	194	222	244
			(m³/d)	11,920	16,770	19,190	21,090

Notes : # Operated by Ambon Municipality (not PDAM)
* Pipeline under construction (PU - Cipta Karya)

1.3 City Water Development Plan

1.3.1 Daily Discharge at Dam Sites

The daily discharge at the proposed dam sites on Ruhu and Batu Gajah rivers was calculated from the flow regime compiled using measured daily water level data. As there are only two years of actual data (October 1994 to September 1996), ten years' daily discharge data was generated by applying the 1995/96 data multiplied by the ratio of total annual rainfall for each year to that in 1995/96. Of the two years' available data, the 1995/96 data was chosen as the more extreme case, in that the daily discharge in the dry season was much lower than that for 1994/95, while the flow in the rainy season was considerably higher. Based on the calculated daily discharge data, the lowest flow condition occurred in 1993, with total rainfall equal to approximately two thirds of the ten year mean value. In the case of Ruhu river, the proposed abstraction by PDAM from Air Besar (a tributary of Ruhu) was deducted from the flow data at the start of the calculation.

A similar method was used for Batu Gantung, although there is no available daily discharge data for Batu Gantung river. The Batu Gajah data was used for the rainy season (May to October), increased in proportion to the larger catchment area. However, during the dry season, the base flow in Batu Gantung was taken as zero based on the data collected since installation of the JICA staff gauge.

The variation in reservoir volume with daily discharge (inflow at dam site) over ten years for the three dams is shown in Figure-E.1.3, assuming maintenance and developed discharge (discharge from dam) as described below. The variation throughout one year is shown for the dry year case (1993 data) in Figure-E.1.4.

1.3.2 Developed Discharge and Required Reservoir Capacity

The developed discharge is the discharge available for water use developed by the construction of a dam and reservoir. Using the assumed 1993 daily discharge data, the necessary reservoir capacity for water development was calculated for a range of values of potential developed discharge for Ruhu, Batu Gajah and Batu Gantung dam sites. The variation of reservoir capacity required with increasing developed discharge is given in Table-E.1.6 and plotted in Figure-E.1.5.

Based on the above, and considering the optimum reservoir size based on hydrological, geological and socio-economic considerations, the developed discharge from each of the three dams was determined as follows :

Ruhu RH-1	16,000 m^3/day	(0.185 m^3/sec)
Batu Gajah GJ-2	8,000 m^3/day	(0.093 m^3/sec)
Batu Gantung GT-1	2,500 m^3/day	(0.029 m^3/sec)

The reservoir volumes necessary to ensure that maintenance discharge of Q_m = 0.145 m^3/sec for Ruhu RH-1, 0.043 m^3/sec for Batu Gajah GJ-2 and 0.024 m^3/sec for Batu Gantung GT-1 is provided downstream, even under the 10 year drought condition, and newly developed discharge as described above can be attained from each dam, are given in Table-E.1.7.

Table-E.1.7 Required Reservoir Volume for City Water Development

River	Developed Discharge (m^3/sec)			Newly Dev. Q	Required Reservoir Volume (m^3)		
	Maint.	Dev.	Total	m^3/day	Maint.	Newly Dev.	Total
Ruhu RH-1	0.185	0.145	0.330	16,000	115,000	949,000	1,064,000
Batu Gajah GJ-2	0.043	0.093	0.136	8,000	20,000	935,000	955,000
Batu Gantung GT-1	0.024	0.029	0.053	2,500	249,000	390,000	639,000

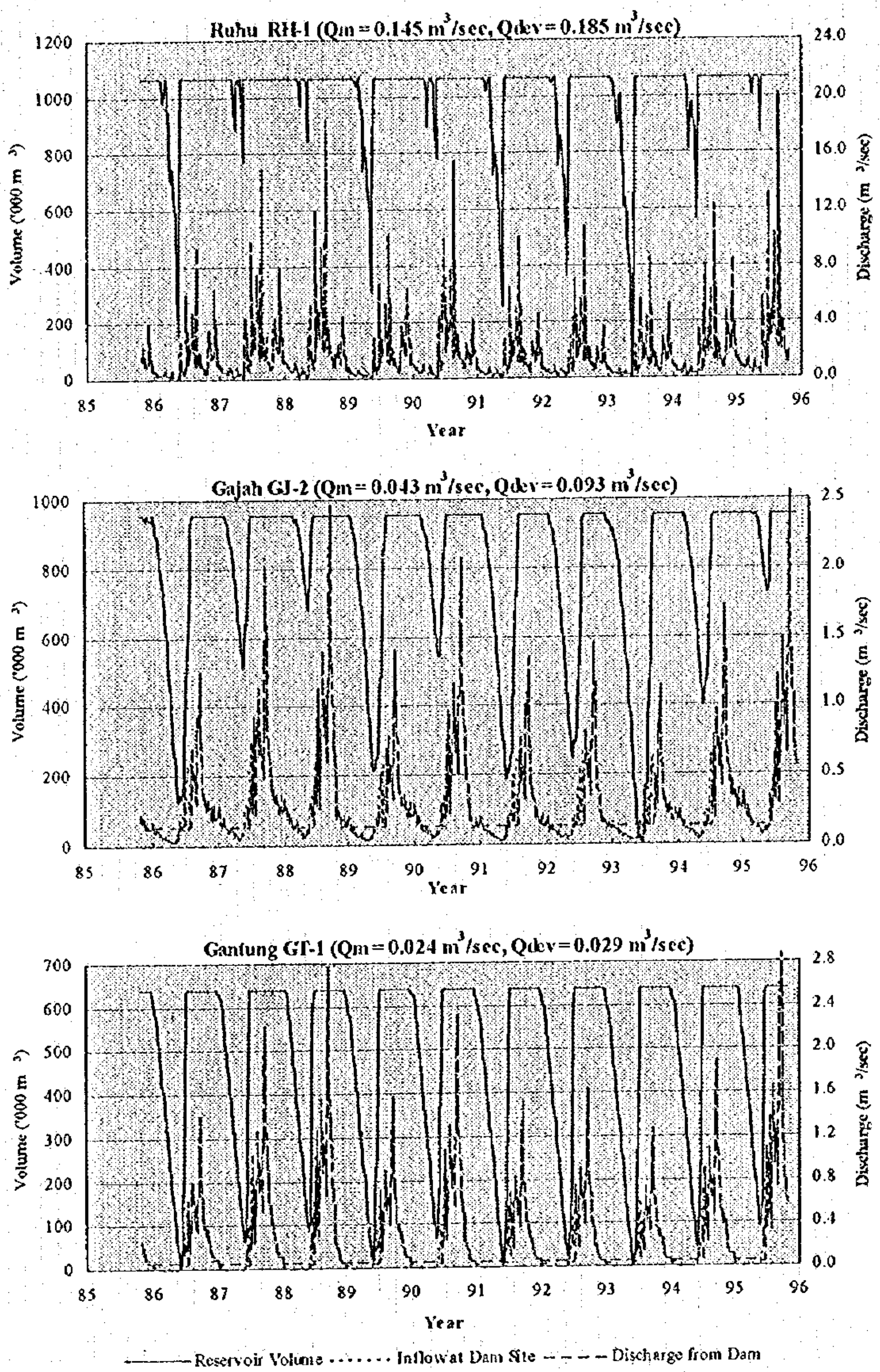


Figure-E.1.3 Variation in Reservoir Volume with Daily Discharge (10 years)

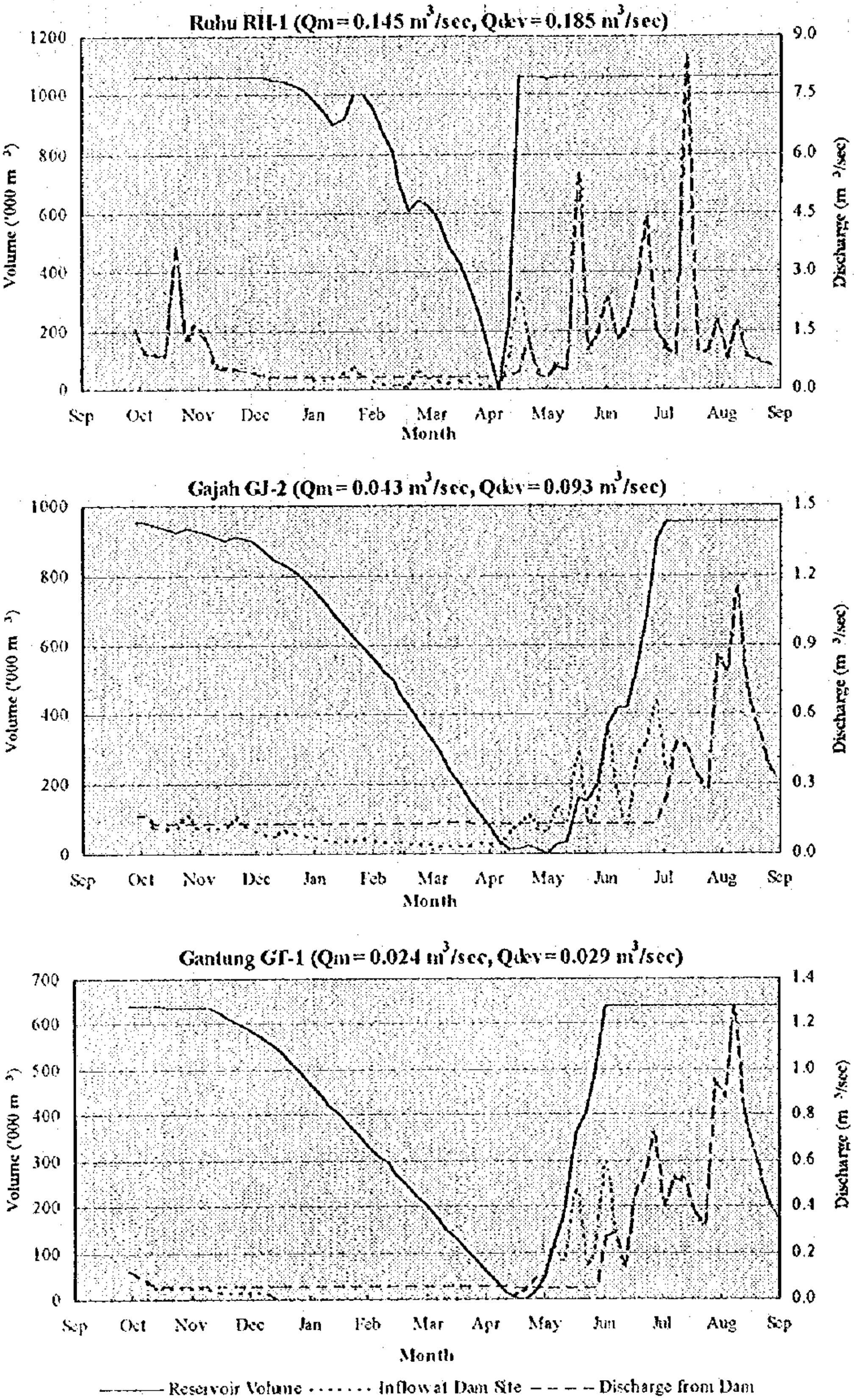


Figure-E.1.4 Variation in Reservoir Volume with Daily Discharge (Dry Year)

Table-E.1.6 Required Reservoir Capacity for Water Utilization

River	Discharge at Dam Site				Reservoir Capacity	Comments
	Maint Qm	Developed Qdev		Total		
	m^3/sec	m^3/day	m^3/sec	m^3/sec	m^3	
RUHU RH-1	0.145	-	-	0.145	115,000	
		2,000	0.023	0.168	154,000	
		4,000	0.046	0.191	206,000	
		6,000	0.069	0.214	312,000	
		8,000	0.093	0.238	455,000	Ruhu RH-1
		10,000	0.116	0.261	592,000	Qm = 0.145 m^3/sec
		12,000	0.139	0.284	729,000	Qdev = 0.185 m^3/sec
		16,000	0.185	0.330	1,064,000	Capacity = 1,064,000 m^3
		20,000	0.231	0.376	1,548,000	
		24,000	0.278	0.423	2,060,000	
		28,000	0.324	0.469	2,562,000	
		32,000	0.37	0.515	3,098,000	
GAJAH GJ-2	0.043	-	-	0.043	20,000	
		1,000	0.012	0.055	77,000	
		2,000	0.023	0.066	152,000	
		3,000	0.035	0.078	254,000	
		4,000	0.046	0.089	353,000	Gajah GJ-2
		5,000	0.058	0.101	484,000	Qm = 0.043 m^3/sec
		6,000	0.069	0.112	611,000	Qdev = 0.093 m^3/sec
		8,000	0.093	0.136	955,000	Capacity = 955,000 m^3
		10,000	0.116	0.159	1,367,000	
		12,000	0.139	0.182	1,824,000	
		14,000	0.162	0.205	2,307,000	
		16,000	0.185	0.228	2,790,000	
GANTUNG GT-1	0.024	-	-	0.024	249,000	
		500	0.006	0.030	324,000	
		1,000	0.012	0.036	404,000	Gantung GT-1
		1,500	0.017	0.041	472,000	Qm = 0.024 m^3/sec
		2,000	0.023	0.047	553,000	Qdev = 0.029 m^3/sec
		2,500	0.029	0.053	639,000	Capacity = 639,000 m^3
		3,000	0.035	0.059	738,000	
		4,000	0.046	0.070	919,000	
		5,000	0.058	0.082	1,119,000	

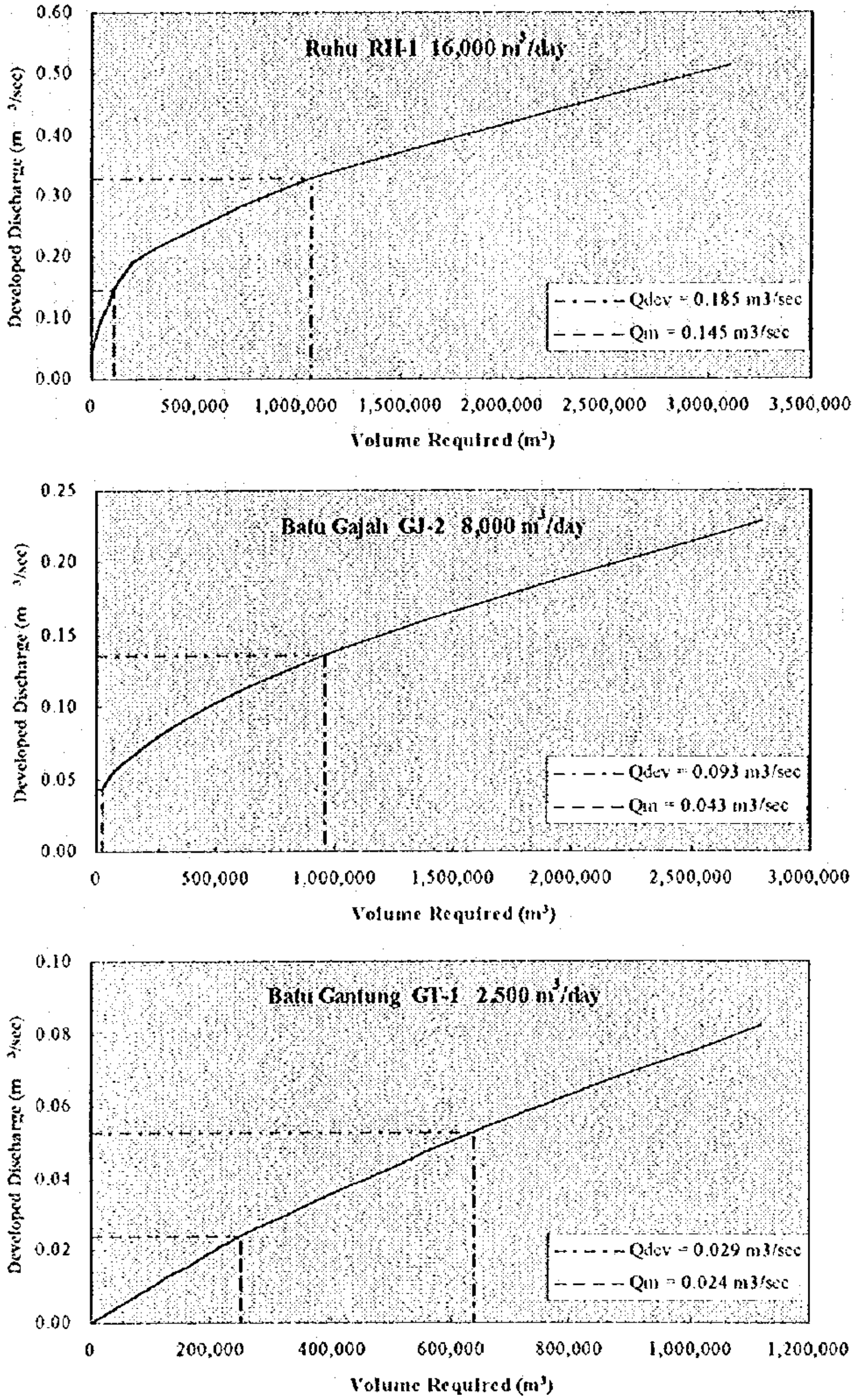


Figure-E.1.5 Variation of Required Reservoir Capacity with Developed Discharge

1.3.3 City Water Development Plan

In order to meet the shortfall between demand and supply in the years up to 2015 and on to 2030, newly developed discharge of 16,000 m^3/day can be provided from Ruhu RH-1, 8,000 m^3/day from Batu Gajah GJ-2 and 2,500 m^3/day from Batu Gantung GT-1. This will be more than sufficient to satisfy the shortfall assuming that PDAM develop other water sources in accordance with the Water Supply Systems Development Plan.

Developed discharge from the proposed multi-purpose dams, constructed in accordance with the revised implementation schedule, has been incorporated in the city water development plan, as shown in the following Table-E.1.8 and Figure-E.1.6.

Table-E.1.8 City Water Development Plan - Ambon Central Area

Year		1996	2000	2005	2010	2015	2020	2025	2030
Future Demand (m^3/day)		11,211	15,594	20,163	26,665	30,559	36,001	40,603	45,470
Springs		8,640	10,020	11,230	12,270	12,270	12,270	12,270	12,270
Wells		3,280	4,150	5,360	6,220	6,220	6,220	6,220	6,220
Rivers :	Air Besar		2,600	2,600	2,600	2,600	2,600	2,600	2,600
	Gajah GJ-2				8,000	8,000	8,000	8,000	8,000
	Gantung GT-1				2,500	2,500	2,500	2,500	2,500
	Ruhu RH-1					16,000	16,000	16,000	16,000
Total Supply (m^3/day)		11,920	16,770	19,190	31,590	47,590	47,590	47,590	47,590

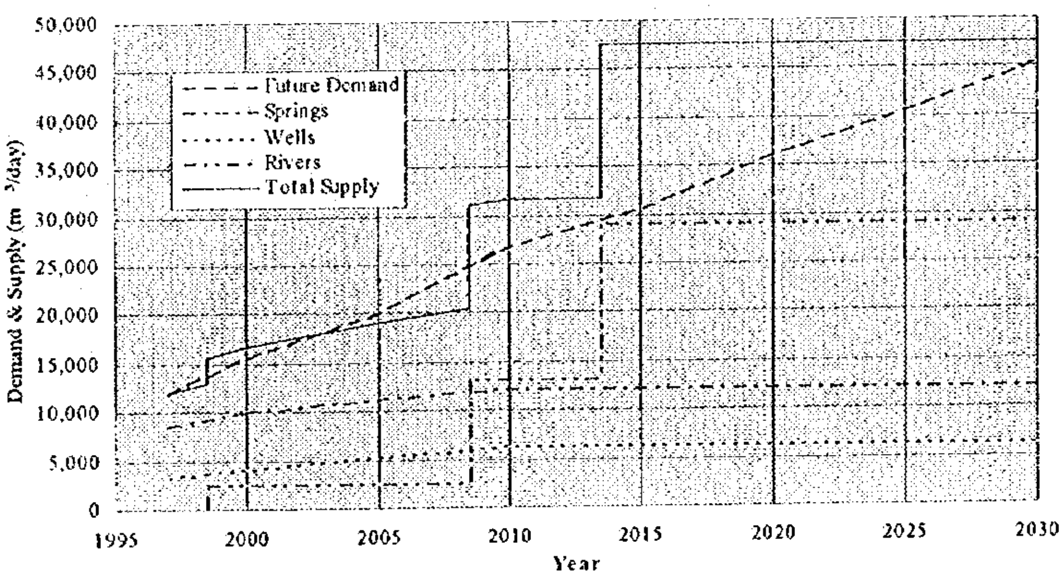


Figure-E.1.6 City Water Development Plan - Ambon Central Area

CHAPTER2 Small Scale Hydropower Generation

2.1 Basic Policy

The purpose of this section is to study small scale hydropower generation plan at Batu Gajah Dam and Batu Gantung Dam. The basic policy of this study is as follows:

- Hydropower generation should depend on Dam Outflow Discharge and Reservoir Water Level.
- Reservoir type should be applied as hydropower generation type.
- Reservoir volume for hydropower generation will be not prepared.
- Normal discharge (maintenance and water-use discharge) provided from dams can be utilized for hydropower generation.

2.2 Basic Condition

2.2.1 Outflow Discharge and Reservoir Water Level in Dam

Using calculation result (10 years: 1986-1995) of water utilization plan, mean annual outflow discharge and reservoir water level of both Batu Gajah Dam and Batu Gantung Dam are shown as follows.

(1) Batu Gajah Dam

The discharge regime of outflow from Batu Gajah Dam is indicated in Table-E.2.1. Figure-E.2.1 indicates the outflow discharge regime and water level regime of Batu Gajah Dam. The median discharge is 0.18 m^3/sec and the low, the drought and the minimum discharge are 0.13 m^3/sec. The minimum is the normal discharge for Batu Gajah Dam.

Table-E.2.1 Outflow Discharge Regime from Batu Gajah Dam

Maximum	High	Median	Low	Drought	Minimum
(1)	(95)	(185)	(275)	(355)	(365)
1.744 m3/s	0.366 m3/s	0.175 m3/s	0.130 m3/s	0.130 m3/s	0.130 m3/s

Note; These values are average from 10 years between 1986-1995.

(2) Batu Gantung Dam

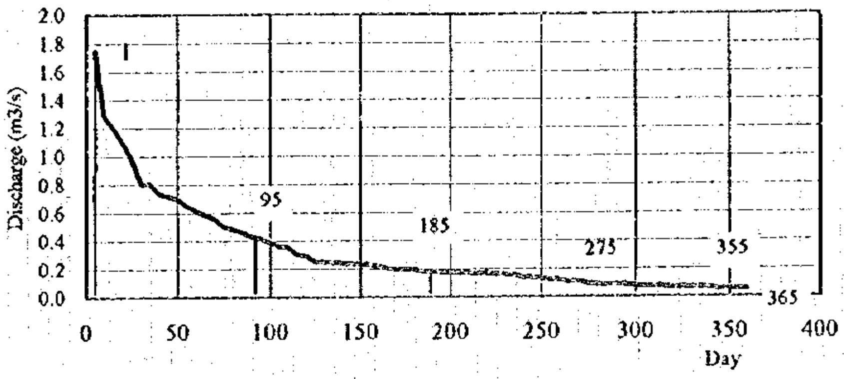
The discharge regime of outflow from Batu Gantung Dam is indicated in Table-E.2.2. Outflow discharge regime of Batu Gantung Dam is about 30 % less, compared with that of Batu Gajah Dam. Figure-E.2.2 indicates the outflow discharge regime and water level regime of Batu Gantung Dam. The median, the low, the drought and the minimum discharge for outflow are about 0.05 m^3/sec. The minimum discharge is the normal discharge for Batu Gantung Dam.

Table Table-E.2.2 Outflow Discharge Regime from Batu Gantung Dam

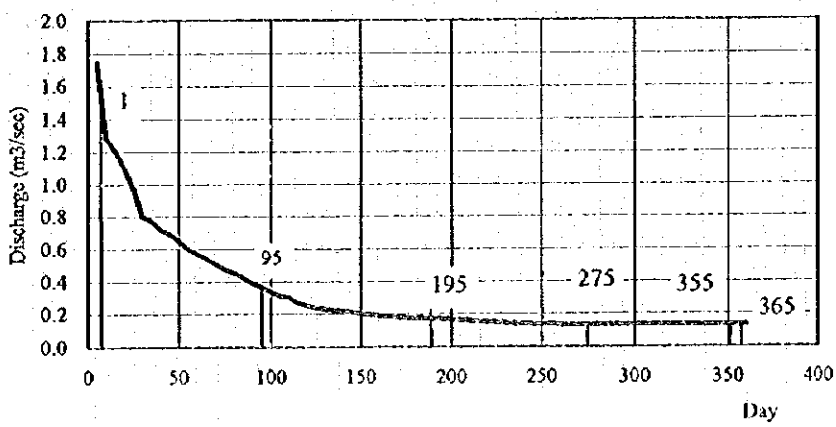
Maximum	High	Median	Low	Drought	Minimum
(1)	(95)	(185)	(275)	(355)	(365)
1.948 m3/s	0.442 m3/s	0.053 m3/s	0.053 m3/s	0.048 m3/s	0.048 m3/s

Note; These values are average from 10 years between 1986-1995.

(1) **Inflow Discharge Regime**



(2) **Outflow Discharge Regime**



(3) **Reservoir Water Level Regime**

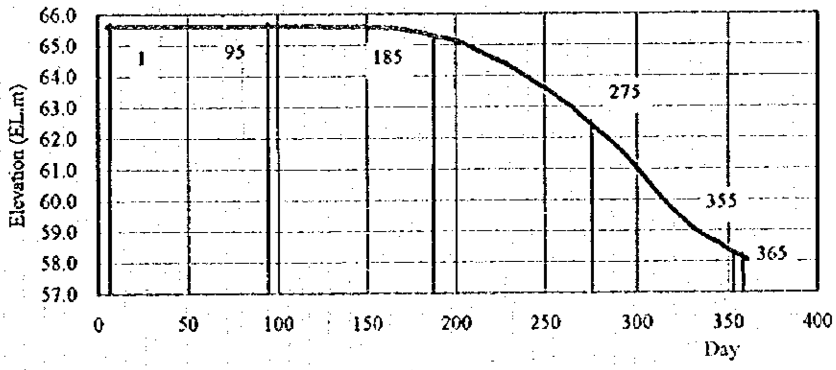
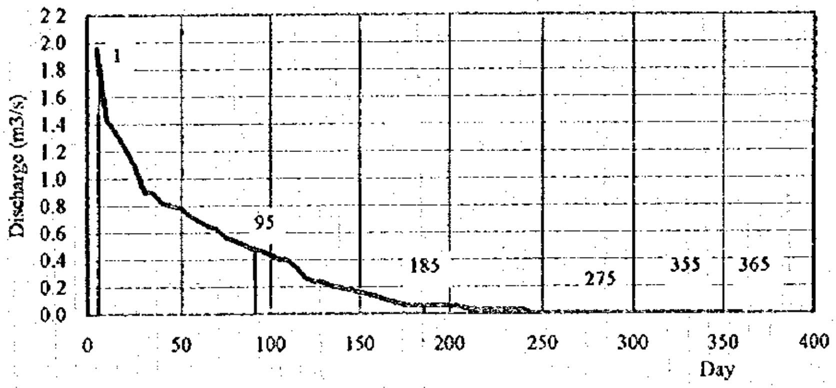
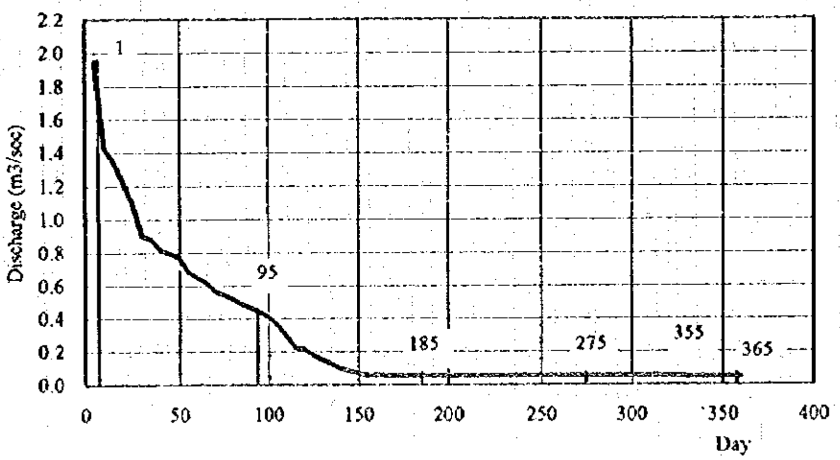


Figure-E.2.1 Discharge Regime and Reservoir Water Level in Batu Gajah Dam

(1) **Inflow Discharge Regime**



(2) **Outflow Discharge Regime**



(3) **Reservoir Water Level Regime**

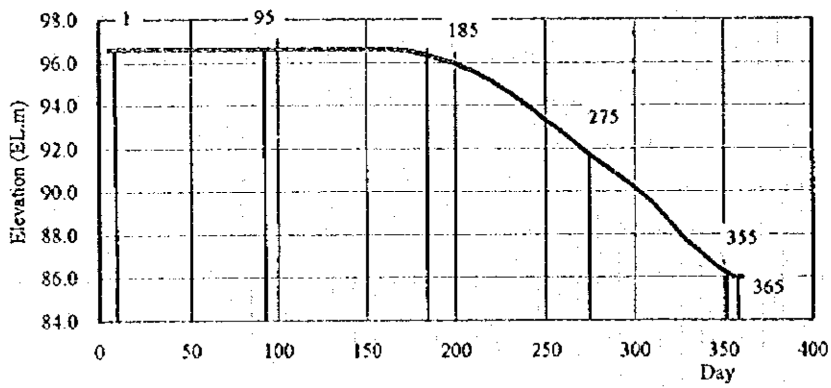


Figure-E.2.2 Discharge Regime and Reservoir Water Level in Batu Gantung Dam

2.2.2 Usual and Maximum Utilization Discharge

In the planning of small scale hydro-power generation, both usual utilization discharge and maximum utilization discharge should be studied. Usual utilization discharge is the discharge which can be used for a whole year and can be set as the normal discharge for both dams (Batu Gajah and Batu Gantung), since both river maintenance discharge and water development discharge are able to be used for hydro-power generation in these dams. Maximum utilization discharge should be set considering water flow regime and hydro-turbine capacity and economic evaluation. Based on the examples of high dams in Japan, it is indicated that the best utilization ratio of intake facility is between 45-75% for hydropower generation. This ratio is defined as annual average utilization ratio of the intake facility scale and can be calculated by the following formula.

(Utilization Ratio of Intake Flow Facility) = [Area DOBCE] / [Area DOBD']
(Utilization Ratio of River Water) = [Area DOBCE] / [Area AOBC]

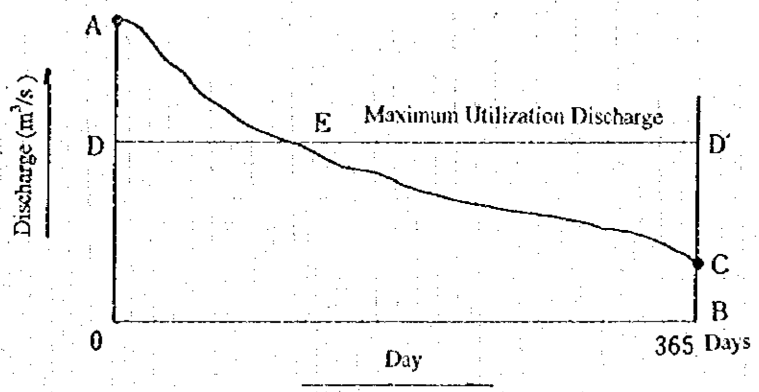


Figure-E.2.3 Relationship between annual discharge regime and maximum utilization discharge

The utilization ratio of intake flow facility and utilization ratio of river water for both dams are calculated as shown in Table-E.2.3. Using these calculation results, the relationship between utilization ratio of intake facility and maximum utilization discharge in each dam as shown in Figure-E.2.4.

Table-E.2.3(1) Calculation of Utilization Rate of Facility and River Water (Batu Gajah Dam)

Day	Outflow average *1	Case1 qmax= 0.150	Case2 qmax= 0.200	Case3 qmax= 0.300	Case4 qmax= 0.400	Case5 qmax= 0.500	Case6 qmax= 0.600	Case7 qmax= 0.700	Case8 qmax= 0.800	Case9 qmax= 0.900	Case10 qmax= 1.000	Note
5	1.744	0.150	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	1.000	Maximum
10	1.285	0.150	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	1.000	
15	1.205	0.150	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	1.000	
20	1.099	0.150	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	1.000	
25	0.970	0.150	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	0.970	
30	0.801	0.150	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.801	0.801	
35	0.773	0.150	0.200	0.300	0.400	0.500	0.600	0.700	0.773	0.773	0.773	
40	0.716	0.150	0.200	0.300	0.400	0.500	0.600	0.700	0.716	0.716	0.716	
45	0.692	0.150	0.200	0.300	0.400	0.500	0.600	0.692	0.692	0.692	0.692	
50	0.652	0.150	0.200	0.300	0.400	0.500	0.600	0.652	0.652	0.652	0.652	
55	0.599	0.150	0.200	0.300	0.400	0.500	0.599	0.599	0.599	0.599	0.599	
60	0.569	0.150	0.200	0.300	0.400	0.500	0.569	0.569	0.569	0.569	0.569	
65	0.540	0.150	0.200	0.300	0.400	0.500	0.540	0.540	0.540	0.540	0.540	
70	0.509	0.150	0.200	0.300	0.400	0.500	0.509	0.509	0.509	0.509	0.509	
75	0.476	0.150	0.200	0.300	0.400	0.476	0.476	0.476	0.476	0.476	0.476	
80	0.453	0.150	0.200	0.300	0.400	0.453	0.453	0.453	0.453	0.453	0.453	
85	0.424	0.150	0.200	0.300	0.400	0.424	0.424	0.424	0.424	0.424	0.424	
90	0.389	0.150	0.200	0.300	0.389	0.389	0.389	0.389	0.389	0.389	0.389	
95	0.366	0.150	0.200	0.300	0.366	0.366	0.366	0.366	0.366	0.366	0.366	high
100	0.337	0.150	0.200	0.300	0.337	0.337	0.337	0.337	0.337	0.337	0.337	
105	0.313	0.150	0.200	0.300	0.313	0.313	0.313	0.313	0.313	0.313	0.313	
110	0.301	0.150	0.200	0.300	0.301	0.301	0.301	0.301	0.301	0.301	0.301	
115	0.269	0.150	0.200	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	
120	0.255	0.150	0.200	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	
125	0.239	0.150	0.200	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	
130	0.230	0.150	0.200	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	
135	0.222	0.150	0.200	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	
140	0.219	0.150	0.200	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	
145	0.211	0.150	0.200	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	
150	0.202	0.150	0.200	0.202	0.202	0.202	0.202	0.202	0.202	0.202	0.202	
155	0.196	0.150	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196	
160	0.190	0.150	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	
165	0.185	0.150	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	
170	0.183	0.150	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	
175	0.178	0.150	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178	
180	0.176	0.150	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	
185	0.175	0.150	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	Median
190	0.172	0.150	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	
195	0.171	0.150	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	
200	0.167	0.150	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	
205	0.165	0.150	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	
210	0.159	0.150	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	
215	0.158	0.150	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	
220	0.152	0.150	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152	
225	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	
230	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	
235	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	
240	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	
245	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	
250	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134	
255	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	
260	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	
265	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	
270	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
275	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	Low
280	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
285	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
290	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
295	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
300	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
305	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
310	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
315	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
320	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
325	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
330	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
335	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
340	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
345	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
350	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
355	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	Drought
360	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	
365	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	Minimum
Total	23.334	10.446	12.272	14.720	16.626	18.180	19.397	20.341	21.030	21.532	22.001	
U.R.F (%)		95.4	84.1	67.2	56.9	49.8	44.3	39.8	36.0	32.8	30.1	
U.R.W (%)		44.8	52.6	63.1	71.3	77.9	83.1	87.2	90.1	92.3	94.3	

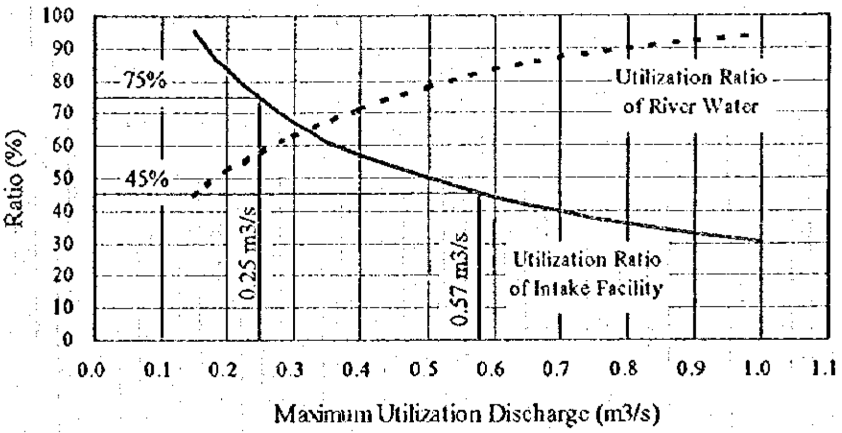
Note: *1.....Average for 10 years (1986-1995)
*2.....U.R.F: Utilization Rate of Facility (%)
*3.....U.R.W: Utilization Rate of Water (%)

Table-E.2.3(2) Calculation of Utilization Rate of Facility and River Water (Batu Gantung Dam)

Day	Outflow average *1	Case1 qmax= 0.050	Case2 qmax= 0.100	Case3 qmax= 0.200	Case4 qmax= 0.300	Case5 qmax= 0.400	Case6 qmax= 0.500	Case7 qmax= 0.600	Case8 qmax= 0.700	Case9 qmax= 0.800	Case10 qmax= 0.900	Note
5	1.948	0.050	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	Maximum
10	1.435	0.050	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	
15	1.347	0.050	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	
20	1.228	0.050	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	
25	1.097	0.050	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	
30	0.902	0.050	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	
35	0.881	0.050	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.881	
40	0.815	0.050	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.815	
45	0.797	0.050	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.797	0.797	
50	0.768	0.050	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.768	0.768	
55	0.685	0.050	0.100	0.200	0.300	0.400	0.500	0.600	0.685	0.685	0.685	
60	0.650	0.050	0.100	0.200	0.300	0.400	0.500	0.600	0.650	0.650	0.650	
65	0.619	0.050	0.100	0.200	0.300	0.400	0.500	0.600	0.619	0.619	0.619	
70	0.564	0.050	0.100	0.200	0.300	0.400	0.500	0.564	0.564	0.564	0.564	
75	0.542	0.050	0.100	0.200	0.300	0.400	0.500	0.542	0.542	0.542	0.542	
80	0.516	0.050	0.100	0.200	0.300	0.400	0.500	0.516	0.516	0.516	0.516	
85	0.488	0.050	0.100	0.200	0.300	0.400	0.488	0.488	0.488	0.488	0.488	
90	0.468	0.050	0.100	0.200	0.300	0.400	0.468	0.468	0.468	0.468	0.468	
95	0.442	0.050	0.100	0.200	0.300	0.400	0.442	0.442	0.442	0.442	0.442	high
100	0.411	0.050	0.100	0.200	0.300	0.400	0.411	0.411	0.411	0.411	0.411	
105	0.364	0.050	0.100	0.200	0.300	0.364	0.364	0.364	0.364	0.364	0.364	
110	0.296	0.050	0.100	0.200	0.296	0.296	0.296	0.296	0.296	0.296	0.296	
115	0.227	0.050	0.100	0.200	0.227	0.227	0.227	0.227	0.227	0.227	0.227	
120	0.215	0.050	0.100	0.200	0.215	0.215	0.215	0.215	0.215	0.215	0.215	
125	0.179	0.050	0.100	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	
130	0.153	0.050	0.100	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153	
135	0.127	0.050	0.100	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	
140	0.100	0.050	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	
145	0.083	0.050	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	
150	0.068	0.050	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	
155	0.057	0.050	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	
160	0.057	0.050	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	
165	0.057	0.050	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	
170	0.056	0.050	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	
175	0.055	0.050	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	
180	0.055	0.050	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	
185	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	Median
190	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
195	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
200	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
205	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
210	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
215	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
220	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
225	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
230	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
235	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
240	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
245	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
250	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
255	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
260	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
265	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
270	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
275	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	Low
280	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
285	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
290	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
295	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
300	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
305	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
310	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
315	0.053	0.050	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	
320	0.052	0.050	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	
325	0.051	0.050	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	
330	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	
335	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	
340	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	
345	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	
350	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	
355	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	Drought
360	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	
365	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	Minimum
Total	20.668	3.636	5.206	7.765	10.003	12.066	13.875	15.298	16.451	17.416	18.112	
U.R.F (%)		99.6	71.3	53.2	45.7	41.3	38.0	34.9	32.2	29.8	27.6	
U.R.W (%)		17.6	25.2	37.6	48.4	58.4	67.1	74.0	79.6	84.3	87.6	

Note: *1.....Average for 10 years (1986-1995)
*2.....U.R.F: Utilization Rate of Facility (%)
*3.....U.R.W: Utilization Rate of Water (%)

Batu Gajah Dam



Batu Gantung Dam

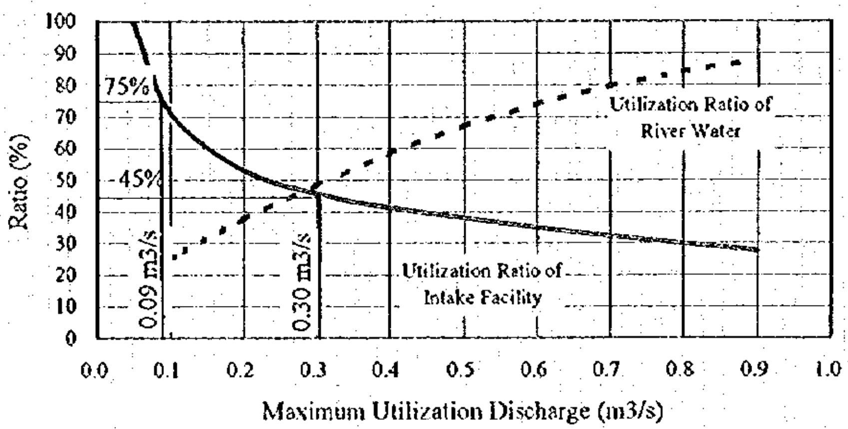


Figure-E.2.4 Relationship between Utilization Ratio of Intake Facility and Maximum Utilization Discharge

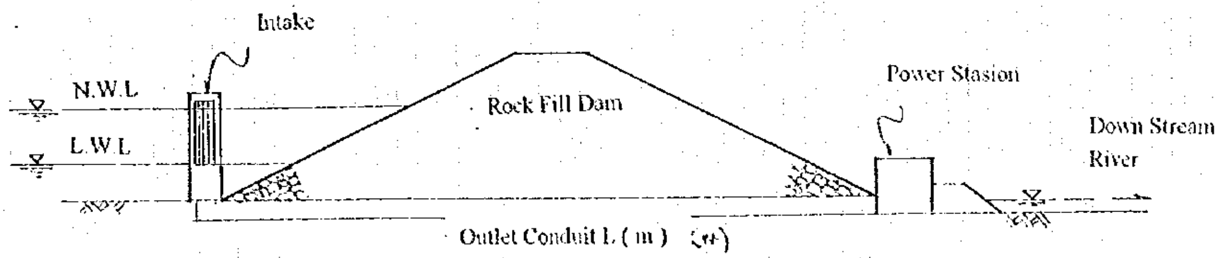
From the above figures, usual utilization discharge and maximum utilization discharge for each dam are given as follows:

Table-E.2.4 Usual and Maximum Utilization Discharge

Dam	Maximum Utilization Discharge		Usual Utilization Discharge
	Ratio of Intake Facility Utilization		Normal Discharge
	45 %	75 %	365th
Batu Gajah	$0.57m^3/s$ (60th)	$0.25m^3/s$ (120th)	$0.13\ m^3/sec$
Batu Gantung	$0.30m^3/s$ (110th)	$0.09m^3/s$ (145th)	$0.048m^3/sec$

2.2.3 Inlet and Outlet Conduit

Figure-E.2.5 indicates the approximate location of inlet and outlet conduits. The discharge velocity of outlet conduit should be generally designed as 2-4 m/sec, so that inner head loss of outlet conduit is reduced. Relationship between design discharge and diameter of outlet conduit is shown in Table-E.2.5 below.



(Note) Batu Gajah Dam: L=290 m
Batu Gantung Dam: L=250 m

Figure-E.2.5 Approximate Location of Hydropower Generation Station

Table-E.2.5 Relationship between Design Discharge and Diameter of Outlet Conduit

Discharge (m^3/sec)	0.1	0.2	0.3	0.4	0.5	0.6
Diameter (m)	0.25	0.35	0.45	0.50	0.55	0.60
Water Velocity (m/sec)	2.0	2.1	1.9	2.0	2.1	2.1

Note; 1) Water Velocity: about 2m/sec (should be generally set at 2-4 m/sec)
2) Roughness Coefficient: 0.012

2.2.4 Hydropower Turbine Type

Suitable type of hydropower turbine should be selected, according to maximum utilization discharge and available water head. Figure-E.2.7 is a diagram prepared for appropriate selection, considering characteristics and manufacturing limits of several kind of hydropower turbines. Basic condition of hydropower in Batu Gajah Dam and Batu Gantung dam is shown in the following table.

Table-E.2.6 Basic Condition for Hydropower Generation Plan

Item	Batu Gajah Dam	Batu Gantung Dam
Reservoir Water Level	EL.65.6 m – 51.6 m	EL.96.7 m – 85.9 m
Down Stream River Level	EL.30.2 m	EL.74.3 m
Total Water Head	35.4 m – 21.4 m	22.4 – 11.6 m
Range of Utilization Discharge (m^3/sec)	0.13 – (0.25 - 0.57)	0.05 – (0.09 - 0.30)
Suitable Type	Crossflow Turbine Type	Not Available

This basic condition should be estimated with the diagram above. It is concluded that Crossflow type turbine is suitable for Batu Gajah Dam (see the below figure). However, no suitable turbine is available for Batu Gantung Dam because both the total water head and discharge is too small in Batu Gantung Dam. It is therefore decided that small scale hydropower generation plan will be studied for Batu Gajah Dam, but not for Batu Gantung Dam.

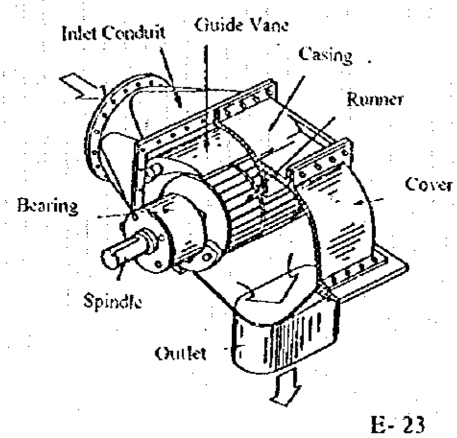


Figure-E.2.6 Crossflow Turbine

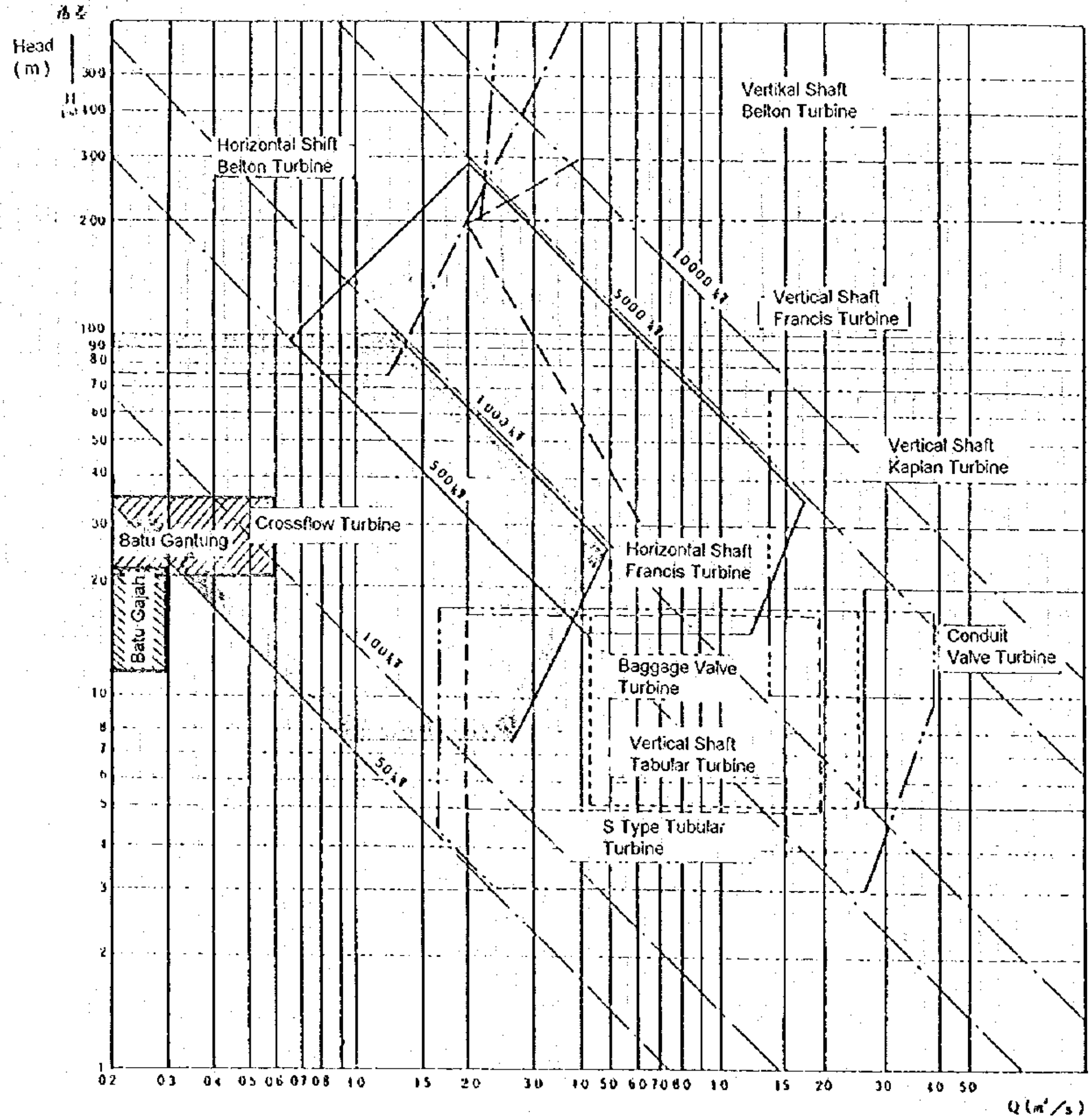


Figure-E.2.7 Suitable Types of Turbine for Total Water Head and Discharge

2.3 Hydropower Production for Batu Gajah Dam

2.3.1 Methodology

Hydropower can be calculated by the following formula.

$$P = 9.8 * Q * H_e * \eta_t * \eta_g$$

P: Hydropower (kW) Q: Utilization Discharge (m^3/sec)

H_e: Effective Head (m)

$$H_e = H_i - H_0 - H_{loss}$$

H_i: Reservoir Water Level, H_0: Down stream river water level

H_{loss}: Head Loss

η_t: Efficiency of hydraulic turbine [Crossflow Type]

η_g: Efficiency of hydropower generator [Synchronous Type]

2.3.2 Hydropower Generator Type

There are two types of Hydropower Generator, namely Synchronous Generator and Induction Generator. Synchronous Generator is more complicated, but it is more flexible and has been used more. Therefore, synchronous generator type should be selected for Batu Gajah Dam.

2.3.3 Study Case

Five study cases of hydropower generation are studied as follows, considering range of maximum utilization discharge.

<Dam Site>	Batu Gajah Dam	[1 Case]
<Calculation Term>	10 years between 1986-1995	[1 Case]
<Normal Utilization Discharge>	0.1 m^3/sec (Drought Discharge)	[1 Case]
<Maximum Utilization Discharge>	0.2, 0.3, 0.4, 0.5, 0.6 m^3/sec	[5 Case]

2.3.4 Calculation Results of Hydropower Production

Calculation results of hydropower production for each case are shown in Table-E.2.8. And these results can be summarized in Table-E.2.7. As the table indicates, maximum hydropower corresponds to maximum utilization discharge, but annual hydropower production does not correspond to maximum utilization discharge and has a peak at 0.5 m^3/s of maximum utilization discharge. The reason for this is that capacity of hydropower station is too large compared to available discharge level and the efficiency of hydropower station is too low, for the case of the maximum utilization discharge of 0.6 m^3/sec.

Table-E.2.7 Calculation Results of Hydropower Production [Batu Gajah Dam]

Case	Utilization Discharge (m^3/sec)		Annual Hydropower Production (MWh) *1	Maximum Hydropower (kW) *1	L5 Hydropower (kW) *1	Utilization Ratio of Intake Facility (%) *1
	Usual	Maximum				
1	0.13	0.2	305	37	33	84
2	0.13	0.3	390	53	40	67
3	0.13	0.4	437	62	43	57
4	0.13	0.5	462	68	43	50
5	0.13	0.6	446	70	38	44

Note; *1...Average values from 10 years between 1986-1995

*2...Calculation Condition; [Turbine] Crossflow Type, [Generator] Synchronous Type

*3... L5 is the average between the hydropower production by minimum discharge and the production by fifth discharge from the minimum.

Table-E.2.8(1) Calculation Results of Hydropower Production
[Batu Gajah Dam: q_{max} = 0.2m³/sec]

(1) Annual Hydropower Production

(Unit: Mwh)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Average
86	29	21	23	21	20	18	16	15	18	31	31	32	276	23
87	32	29	30	24	22	20	20	21	31	32	31	32	325	27
88	32	30	32	27	23	21	21	27	31	32	31	32	339	28
89	30	23	25	21	21	19	17	17	20	32	31	32	289	24
90	32	29	30	25	22	21	20	21	31	32	31	32	326	27
91	30	22	25	21	21	18	16	16	20	32	31	32	285	24
92	31	25	26	22	21	19	17	17	23	32	31	32	295	25
93	27	20	22	21	20	17	14	13	17	28	31	32	264	22
94	32	27	28	22	22	20	19	19	28	32	31	32	311	26
95	32	29	32	28	24	21	21	30	31	32	31	32	344	29
Ave	31	26	27	23	22	19	18	20	25	32	31	32	305	25

(2) Maximum of Hydropower

(Unit: Kw)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	43	37	36	30	28	26	23	21	28	43	43	43	401	33
87	43	43	43	42	30	29	27	30	43	43	43	43	461	38
88	43	43	43	43	31	30	29	43	43	43	43	43	479	40
89	43	43	42	30	29	27	24	23	30	43	43	43	421	35
90	43	43	43	43	30	29	27	30	43	43	43	43	462	39
91	43	42	41	30	29	27	23	22	30	43	43	43	417	35
92	43	43	43	30	29	27	24	24	43	43	43	43	437	36
93	43	30	30	30	28	25	22	18	26	43	43	43	381	32
94	43	43	43	35	30	28	26	27	43	43	43	43	449	37
95	43	43	43	43	39	30	29	43	43	43	43	43	487	41
Max	43	41	41	36	30	28	25	28	37	43	43	43	440	37

(3) L5 Hydropower

(Unit: Kw)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	30	30	30	29	27	23	20	20	23	29	43	43	348	29
87	43	43	33	30	29	27	26	26	43	43	43	43	431	36
88	43	43	39	30	30	29	28	29	43	43	43	43	445	37
89	33	32	30	29	27	25	21	22	26	43	43	43	374	31
90	43	43	34	30	29	28	26	27	43	43	43	43	434	36
91	32	30	30	29	27	24	21	21	25	43	43	43	369	31
92	34	33	30	29	28	25	22	22	26	43	43	43	380	32
93	30	30	30	28	26	22	17	17	21	27	43	43	335	28
94	40	38	30	30	29	26	24	25	30	43	43	43	402	33
95	43	43	41	31	30	29	28	29	43	43	43	43	449	37
Ave	37	37	33	30	28	26	23	24	32	40	43	43	397	33

Table-E.2.8(2) Calculation Results of Hydropower Production [Batu Gajah Dam: $q_{max} = 0.3 m^3/sec$]

(1) Annual Hydropower Production

(Unit: Mwh)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	31	21	24	21	20	18	16	15	18	47	50	51	331	28
87	47	35	35	25	22	20	20	21	47	52	50	52	424	35
88	50	43	42	29	22	21	21	35	50	52	50	52	467	39
89	34	24	26	21	21	18	17	17	20	52	50	51	351	29
90	48	36	36	25	22	20	20	21	47	52	50	52	430	36
91	33	23	25	21	21	18	16	16	20	51	50	51	346	29
92	35	26	26	21	21	19	17	17	26	52	50	52	363	30
93	28	20	22	21	20	17	15	13	17	42	50	49	314	26
94	42	30	30	23	22	20	19	19	37	52	50	52	394	33
95	51	43	44	31	24	21	21	41	50	52	50	52	480	40
Ave	40	30	31	24	21	19	18	22	33	50	50	51	390	35

(2) Maximum Hydropower

(Unit: Kw)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	51	38	37	30	28	26	23	21	28	70	70	70	490	41
87	70	67	65	45	30	29	27	29	70	70	70	70	610	53
88	70	70	70	57	31	30	28	70	70	70	70	70	702	58
89	57	47	45	30	29	27	24	23	30	70	70	70	520	43
90	70	69	67	47	30	29	27	30	70	70	70	70	647	54
91	55	45	44	30	28	26	23	22	29	70	70	70	513	43
92	59	49	47	30	29	27	24	24	68	70	70	70	566	47
93	46	30	30	29	28	25	22	18	25	70	70	70	463	39
94	68	59	57	36	30	28	26	27	70	70	70	70	608	51
95	70	70	70	60	40	30	29	70	70	70	70	70	716	60
Max	61	54	53	39	30	28	25	33	53	70	70	70	587	53

(3) L5 Hydropower

(Unit: Kw)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	30	30	30	28	26	23	20	20	23	29	70	61	391	33
87	49	47	33	30	29	27	26	26	54	70	70	70	530	44
88	61	58	41	30	30	29	28	29	66	70	70	70	580	48
89	34	32	30	29	27	24	22	22	26	70	70	67	451	38
90	51	48	34	30	29	28	26	27	56	70	70	70	538	45
91	32	30	30	29	27	24	21	21	25	66	70	65	440	37
92	35	33	30	29	27	25	22	22	26	70	70	69	459	38
93	30	30	30	28	26	22	18	18	21	27	67	56	372	31
94	42	40	30	30	28	26	24	25	29	70	70	70	484	40
95	64	62	44	31	30	29	28	29	69	70	70	70	595	50
Ave	43	41	33	29	28	26	23	24	40	61	69	67	484	40

Table-E.2.8(3) Calculation Results of Hydropower Production [Batu Gajah Dam: q_{max} = 0.4m³/sec]

(1) Annual Hydropower Production

(Unit: Mwh)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	30	21	23	21	20	17	15	15	18	58	64	59	360	30
87	49	35	34	24	21	20	19	20	58	69	66	69	484	40
88	59	44	43	28	22	21	20	39	61	69	66	69	541	45
89	34	23	25	21	20	18	16	16	20	69	65	63	390	32
90	51	36	36	25	22	20	19	21	58	69	66	69	491	41
91	32	22	24	21	20	18	16	16	19	66	65	62	380	32
92	35	25	25	21	20	18	17	17	26	69	66	64	402	34
93	27	20	22	20	19	17	10	5	16	50	62	56	323	27
94	42	29	29	22	21	19	18	19	42	69	66	67	443	37
95	62	46	46	30	23	21	21	45	62	69	66	69	559	47
Ave	42	30	31	23	21	19	17	21	38	65	65	65	437	40

(2) Maximum Hydropower

(Unit: Kw)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	51	35	35	29	27	25	22	21	27	92	92	92	549	46
87	81	68	66	45	29	28	26	29	92	92	92	92	741	62
88	92	84	81	56	30	29	28	92	92	92	92	92	861	72
89	57	47	45	29	28	26	23	23	29	92	92	92	584	49
90	84	71	68	47	29	28	27	29	92	92	92	92	752	63
91	55	45	43	29	28	26	23	22	29	92	92	92	576	48
92	58	49	47	29	28	26	24	23	69	92	92	92	632	53
93	46	29	29	29	27	25	21	18	25	92	92	92	526	44
94	70	58	56	33	29	27	25	26	92	92	92	92	694	58
95	92	88	86	60	38	29	28	92	92	92	92	92	883	74
Max	69	58	56	39	29	27	25	38	64	92	92	92	680	62

(3) L5 Hydropower

(Unit: Kw)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	29	29	29	28	26	23	19	19	23	28	75	60	389	32
87	49	47	31	29	28	27	25	26	54	92	92	92	593	49
88	60	58	40	29	29	28	27	28	67	92	92	92	643	54
89	32	30	29	28	26	24	21	21	25	92	83	68	480	40
90	51	49	32	29	29	27	25	26	56	92	92	92	601	50
91	31	29	29	28	26	24	21	21	24	67	80	66	445	37
92	32	31	29	28	27	24	22	22	26	92	85	71	491	41
93	29	29	29	27	25	22	0	0	21	26	68	56	333	28
94	41	38	29	29	28	26	24	24	29	92	92	83	535	45
95	64	61	43	30	29	28	27	29	72	92	92	92	661	55
Ave	42	40	32	29	27	25	21	22	40	77	85	77	517	43

Table-E.2.8(4) Calculation Results of Hydropower Production [Batu Gajah Dam: $q_{max} = 0.5m^3/sec$]

(1) Annual Hydropower Production

(Unit: Mwh)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	29	20	23	20	19	14	0	0	12	68	75	63	344	29
87	49	33	34	24	21	19	19	20	66	86	83	83	537	45
88	61	44	42	28	22	20	20	40	72	86	83	86	604	50
89	32	23	24	21	20	18	0	0	19	85	77	68	387	32
90	51	35	35	24	21	20	19	20	67	86	83	84	545	45
91	31	22	24	20	20	18	0	0	19	79	76	67	375	31
92	34	25	25	21	20	18	3	3	25	85	78	71	408	34
93	27	19	21	20	19	9	0	0	9	55	73	59	310	26
94	41	28	29	22	21	19	18	18	44	86	82	78	486	40
95	65	46	45	30	23	21	20	47	73	86	83	86	625	52
Ave	42	30	30	23	21	18	10	15	41	80	79	75	462	43

(2) Maximum Hydropower

(Unit: Kw)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	48	36	35	29	27	25	0	0	27	116	116	116	574	48
87	81	68	66	42	29	28	26	28	116	116	116	116	831	69
88	101	84	81	55	29	29	27	104	116	116	116	116	973	81
89	56	44	42	29	28	26	0	0	29	116	116	116	600	50
90	84	71	68	44	29	28	26	29	116	116	116	116	842	70
91	53	42	40	29	27	25	0	0	28	116	116	116	593	49
92	58	47	44	29	28	26	23	23	69	116	116	116	694	58
93	43	29	29	28	27	24	0	0	24	111	116	116	547	46
94	70	58	55	34	28	27	25	26	116	116	116	116	786	66
95	107	90	87	60	38	29	28	110	116	116	116	116	1011	84
Max	70	57	55	38	29	27	16	32	76	115	116	116	745	68

(3) L5 Hydropower

(Unit: Kw)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	29	29	29	27	25	0	0	0	0	28	74	61	303	25
87	46	43	31	29	28	26	25	25	53	116	115	98	636	53
88	61	57	38	29	29	28	27	28	67	116	116	116	711	59
89	32	30	29	28	26	23	0	0	25	107	83	68	451	38
90	49	46	33	29	28	26	25	26	55	116	116	102	650	54
91	31	29	29	28	26	23	0	0	24	67	80	66	402	33
92	33	32	29	28	26	24	0	0	25	110	86	71	465	39
93	29	29	28	27	25	0	0	0	0	26	68	55	287	24
94	39	37	29	29	27	25	23	24	28	116	102	84	564	47
95	65	62	40	29	29	28	27	28	72	116	116	116	728	61
Ave	41	39	32	28	27	20	13	13	35	92	96	84	520	43

Table-E.2.8(5) Calculation Results of Hydropower Production
[Batu Gajah Dam: $q_{max} = 0.6m^3/sec$]

(1) Annual Hydropower Production

(Unit: Mwh)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	29	19	22	13	0	0	0	0	0	72	87	65	307	26
87	48	33	33	23	20	0	0	4	70	104	98	93	527	44
88	60	43	42	27	20	13	0	36	81	104	101	101	628	52
89	32	22	24	16	0	0	0	0	10	96	89	72	360	30
90	50	34	34	23	20	0	0	7	73	104	99	95	540	45
91	31	21	23	16	0	0	0	0	6	88	88	70	343	29
92	33	24	24	19	0	0	0	0	16	98	90	74	379	32
93	26	18	20	6	0	0	0	0	0	49	85	60	265	22
94	40	28	28	21	10	0	0	0	47	103	94	84	454	38
95	65	45	45	29	22	16	0	46	84	104	101	103	659	55
Ave	41	29	30	19	9	3	0	9	39	92	93	82	446	41

(2) Maximum Hydropower

(Unit: Kw)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	47	35	35	27	0	0	0	0	0	140	140	137	561	47
87	82	67	64	43	27	0	0	27	140	140	140	140	870	73
88	101	84	82	52	28	27	0	105	140	140	140	140	1039	87
89	53	44	43	27	0	0	0	0	27	140	140	140	615	51
90	85	71	67	44	27	0	0	27	140	140	140	140	881	73
91	50	43	42	27	0	0	0	0	27	140	140	140	609	51
92	55	46	45	27	0	0	0	0	68	140	140	140	662	55
93	44	27	27	27	0	0	0	0	0	114	140	128	507	42
94	69	55	52	33	27	0	0	0	140	140	140	140	796	66
95	108	90	87	57	38	27	0	112	140	140	140	140	1079	90
Max	69	56	54	37	15	5	0	27	82	137	140	138	762	70

(3) L5 Hydropower

(Unit: Kw)

Year	10	11	12	1	2	3	4	5	6	7	8	9	Total	Ave
86	28	27	27	0	0	0	0	0	0	27	75	59	242	20
87	46	44	30	27	27	0	0	0	50	140	120	98	582	48
88	58	54	39	27	27	0	0	0	66	140	140	122	673	56
89	31	29	27	0	0	0	0	0	0	108	83	67	346	29
90	47	46	32	27	27	0	0	0	52	140	124	102	597	50
91	29	28	27	0	0	0	0	0	0	66	80	64	294	25
92	33	30	27	27	0	0	0	0	0	113	87	71	387	32
93	27	27	27	0	0	0	0	0	0	0	67	52	201	17
94	40	38	27	27	0	0	0	0	27	131	102	84	477	40
95	63	59	42	28	27	0	0	27	71	140	140	129	727	61
Ave	40	38	31	16	11	0	0	3	27	100	102	85	453	38

2.4 Economic Evaluation

Approximate cost of hydropower station in Batu Gajah Dam are shown in the following Table-E.2.9. From this table, the prime production costs of hydropower station are approximately 300 Rp/kWh and nearly equal to that (285 Rp/kWh) produced by diesel turbine station in Ambon (by PT.PLN in 1997). Therefore, it follows from this that the validity for project of small scale hydropower generation in Batu Gajah Dam must be reasonable in the future when fuel cost may increase, although the hydropower production volume is little.

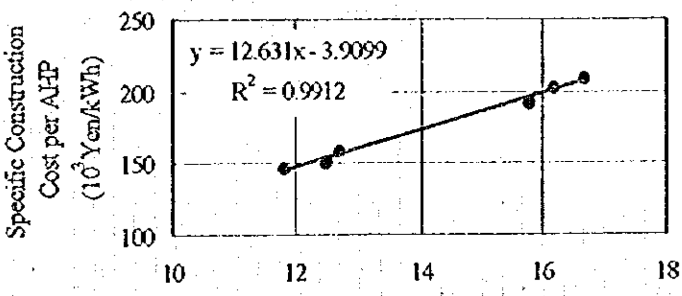
Table-E.2.9 Approximate Cost of Hydropower Station [Batu Gajah Dam]

(Unit; Million Rp)

Item			Unit	Case				
				1	2	3	4	5
Maximum Utilization Discharge			m^3/sec	0.2	0.3	0.4	0.5	0.6
Maximum Hydropower [Pmax]			kW	37	53	62	68	70
Annual Hydropower Production [A.H.P.]			MWh	305	390	437	462	446
(1)Building			Mil.Rp	110	154	165	172	176
(2)Civil Engineering	1)Channel	a. Pipe	Mil.Rp	207	207	207	207	207
		b. Outlet	Mil.Rp	110	110	110	110	110
		c. Other Work	Mil.Rp	3	3	3	3	3
	2)Substructure	a. Substructure	Mil.Rp	22	31	42	59	70
		b. Other Work	Mil.Rp	11	11	11	12	12
	3)Temporary Works		Mil.Rp	7	7	7	8	8
(3)Electric Facility [Turbine, Generator, etc]			Mil.Rp	594	792	924	990	1,034
(4)Power Transmission Line			Mil.Rp	72	72	72	72	72
(5)Construction Running Cost			Mil.Rp	79	97	108	114	118
(6)Total Construction Cost			Mil.Rp	1,215	1,484	1,649	1,747	1,811
Specific Cost 1 (Total Cost) / (Pmax)			Mil.Rp/kW	32.8	28.0	26.6	25.7	25.9
Specific Cost 2 (Total Cost) / (A.H.P.)			Rp/kWh	3,984	3,805	3,774	3,781	4,061
Prime Production Cost			Rp/kWh	316	302	299	300	322

Note: Construction cost is calculated using relationship between several cost items and maximum hydropower, effective water head, etc. This relationship is based on example of hydropower stations in Japan.

The prime production cost is obtained from the following figure that indicates relationship between prime production cost and specific construction cost based on example of hydropower station in Japan.



Note: AHP... Annual Hydro-power Production (kWh)

Figure-E.2.8 Relationship between Prime Production Cost and Specific Construction Cost per Annual Hydropower Production (AHP)

CHAPTER 3 MULTI-PURPOSE DAM PLAN

3.1 Specification of Multi-purpose Dams

The flood control dams in Ruhu, Batu Gajah and Batu Gantung Rivers were proposed in Supporting Report Part-D as part of the optimum flood control plan. After consideration of water utilization for domestic use in Ambon central area, RH-1 Dam, GJ-2 Dam and GT-1 Dam were planned and designed as multi-purpose dams. The specification of these dams are presented in Table-E.3.1. These plans are adopted for the Master Plan involved with water utilization. The reservoir storage allocations are presented graphically in Figure-E.3.1.

Table-E.3.1 Specification of Multi-purpose Dams and Reservoirs

Items		Ruhu River	Batu Gajah River	Batu Gantung River
		RH-1 Dam	GJ-2 Dam	GT-1 Dam
Code of Alternative Flood Control Plan		FCP-RH2	FCP-GJ3	FCP-GT3
Design Scale of River Improvements		1/5	1/10	1/10
Catchment Area (km^2)		14.49	4.37	4.76
Unregulated peak discharge (m^3/sec)	Dam	273	90	99
(30-year return period)	River Mouth	314	123	143
Outflow at peak inflow (m^3/sec)	Dam	114	68	67
Regulated peak discharge	Dam	136	72	73
(m^3/sec)	River Mouth	168	100	110
Cut discharge (m^3/sec)	Dam	159	22	32
	River Mouth	146	23	33
Newly Developed Discharge (m^3/day)		16,000	8,000	2,500
Sediment Capacity (1000 m^3)		580	175	191
Water Utilization Capacity (1000 m^3)		1,064	955	639
: River Maintenance Capacity (1000 m^3)		115	20	249
: New Development Capacity (1000 m^3)		949	935	390
Flood Storage Capacity (1000 m^3)		2,763	380	513
Effective Storage Capacity (1000 m^3)		3,827	1,335	1,152
Total Storage Capacity (1000 m^3)		4,407	1,510	1,343
Low Water Level (EL.m)		46.4	57.2	86.4
Normal Water Level (EL.m)		54.3	71.2	97.5
Surcharge Water Level (EL.m)		63.7	74.6	102.9
Dam Top Elevation (m)		67.7	78.6	106.9
Dam Base Elevation (m)		23.0	38.0	66.0
Freeboard (m)		4.0	4.0	4.0
Dam Height (m)		44.7	40.6	40.9
Dam Crest Length (m)		112.0	200.0	139.0
Dam Foundation Length (m)		10.0	54.0	23.0
Conduit		B3.9m*H3.9m	B8.0m*H3.40	B4.1m*H4.1m
Upstream Slope		1:3.0	1:3.0	1:3.0
Downstream Slope		1:2.5	1:2.5	1:2.5
Dam Top Width (m)		5.0	5.0	5.0
Dam Volume (1000 m^3)		235	404	262
Land Acquisition Area (1000m^2)		515,000	148,000	139,000
Resettlement Household (number)		-	30	-
Construction Cost of Multi Purpose Dam (Rp. Mil)		36,646	49,480	35,306
Total Project Cost (Rp. Mil)		76,491	82,751	60,627
A : Construction Cost (Rp. Mil)		47,339	60,001	43,963
B : Indirect Cost (Rp. Mil)		14,202	18,000	13,189
C : Land Acquisition and Compensation Cost (Rp. Mil)		14,950	4,750	3,475

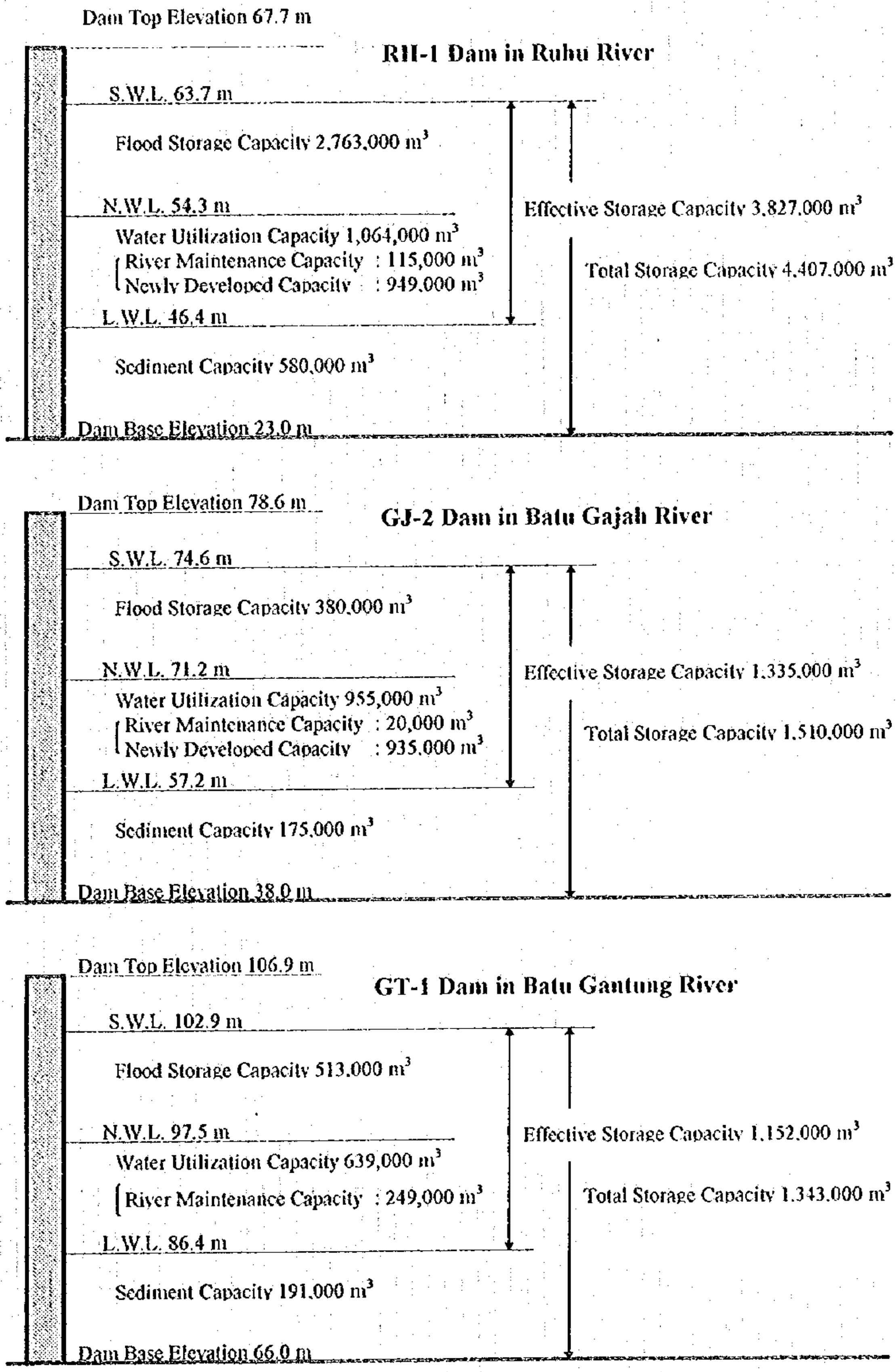


Figure-E.3.1 Reservoir Storage Allocation

3.2 Project Cost of the Optimum Flood Control Plan with Multi-purpose Dam

The estimated project cost of the optimum flood control plan and the plans using multi-purpose dams are shown in Table-E.3.2.

Table-E.3.2 Project Cost of the Optimum Flood Control Plan using Multi-purpose Dams

Unit: Million Rupiah

Alternative	A: Construction Cost A1: River Improvement, A2: Dam, A3: Diversion Channel, A4: Check Dam					B: Indirect Cost	C: Land Acq. & Comp. C1: Land Acquisition C2: Compensation			Total Project Cost
	A1	A2	A3	A4	Total	Total	C1	C2	Total	
<Ruhu River System>										
FCP-RH2: R/I(5) only	9,323	-	-	-	9,323	2,797	675	1,400	2,075	14,195
FCP-RH2: R/I(5)+Dam	9,323	31,344	-	1,370	42,037	12,611	10,950	1,400	12,350	66,998
FCP-RH2: R/I(5)+Dam (Multi-purpose Dam)	9,323	36,646	-	1,370	47,339	14,202	13,550	1,400	14,950	76,491
<Batu Merah River System>										
FCP-BM4: R/I(5)+Div.	9,966	-	29,055	-	39,021	11,706	158	350	508	51,235
<Tomu River System>										
FCP-TM1: R/I(30)	18,753	-	-	1,470	20,223	6,067	0	0	0	26,290
<Batu Gajah River System>										
FCP-GJ3: R/I(10)+Dam	9,091	32,485	-	1,430	43,006	12,902	2,325	700	3,025	58,933
FCP-GJ3: R/I(10)+Dam (Multi-purpose Dam)	9,091	49,480	-	1,430	60,001	18,000	3,700	1,050	4,750	82,751
<Batu Gantung River System>										
FCP-GT3: R/I(10)+Dam	7,327	24,284	-	1,330	32,941	9,882	2,375	0	2,375	45,198
FCP-GT3: R/I(10)+Dam (Multi-purpose Dam)	7,327	35,306	-	1,330	43,963	13,189	3,475	0	3,475	60,627
Flood Control Plan	54,460	88,113	29,055	5,600	177,228	53,168	15,808	2,450	18,258	248,654
Flood Control Plan with Multi-purpose Dam	54,460	121,432	29,055	5,600	210,547	63,164	20,883	2,800	23,683	297,394

3.3 Cost Estimate for Water Treatment Plant

Costs of water treatment plant and pipelines were estimated assuming the following unit costs :

- Unit cost of treatment plant per cubic meter discharge : Rp. 880,000 /m^3
- Unit cost of pipe line per meter : Rp. 160,000 /m

Water treatment plant and pipe line costs are estimated as shown in Table-E.3.3.

Table-E.3.3 Estimated Costs of Water Treatment Facilities

Dam	Developed Disch. (Treated Disch.) (m^3/day)	Pipe Line (m)	Cost of Treatment Facilities (Rp. million)	Cost of Pipe Line (Rp. million)	Total Project Cost (Rp. million)
Ruhu Dam	16,000	800	14,080	128	14,208
Batu Gajah Dam	8,000	2,000	7,040	320	7,360
Batu Gantung Dam	2,500	1,700	2,200	272	2,472
Total	26,500	4,500	23,320	720	24,040