CHAPTER 1 FLOOD CONTROL FOR AMBON AREA

1.1 General Condition of Ambon Area

1.1.1 Socio-economy

(1) Current Population

According to the census in October 1990, the population of Ambon City was 275,888. The recent census conducted by the Statistics Office of Ambon City shows that the population in June 1996 was 304,334. If these figures are used, the average annual increase in population in Ambon City is 1.7%. The population of Ambon City increased 4.5% per year from 1971 to 1980 and 2.9% per year from 1980 to 1990.

Table-1.1 Population Growth in Ambon City, 1961-1996

Year	1961	1971	1980	Oct. 1990	Jun. 1996	Dec. 1996*
Population	99,142	139,704	207,702	275,888	304,334	305,252
Population Growth Rate per year	-	3.5 %	4.5 %	2.9 %	1.7 %	1.7 %

Source: Ambon City Statistics (* Estimation by JICA Study Team)

The Study Area includes 20 Desa/Kelurahan, which are expected to be more or less influenced by the project. The Central City Area includes 17 Desa/Kelurahan and the Upstream Area includes 3 Desa/Kelurahan. The population of the Study Area is about 160,000 : 149,000 in Central City and 11,000 in the upstream area. The population density in the Central City, excluding Batu Merah, is 105 persons/ha, while it is only 1.1 person/ha in the upstream area.

(2) Current Economic Conditions

Ambon City is the capital and the trade center of Maluku Province, accounting for 11% of the total provincial population and 25% of the provincial Gross Domestic Product (GDP) in 1994. The annual growth rates of regional GDP for Maluku Province and Ambon City from 1983 to 1994 were 7.6% and 7.5% in real terms, respectively.

Average income per capita in Maluku Province and Ambon City is around Rp. 1.1 million. Since each household has five to six family members, average household income is estimated to be around Rp. 5 million to 7 million. Ambon residents work mostly in governmental and non-governmental services, retail, hotel/restaurant and transportation; around 80% of all workers fall into these sectors.

(3) Population Projection

As stated above, the study team estimated current population increase at 1.7% per year in Ambon City and applies the same rate, 1.7%, as future annual population increase rate in Ambon City. Table-1.2 shows the projected future population in Ambon City.

Table-1.2 Population Projection in Ambon City

Year	1990	1996	2000	2005	2010	2015	2020	2025	2030
Population	275,888	305,252	326,544	355,261	386,502	420,490	457,469	497,698	541,466

The future population increase in the Central City is estimated to be 0.5% per year, which will only be attained by vertical development of land. The population increase in the upstream area is estimated to be the same as that of Ambon City, namely 1.7 %. Table-1.3 shows the future population in the Central City and Upstream Area and Figure-1.1 shows the projected population growth in Ambon City and the Study Area.

Table-1.3 Population Projection in the Study Area

Year	1996	2000	2005	2010	2015	2020	2025	2030
Central City	149.205	152.212	156.055	159.996	164.036	168.178	172.425	176.779
Upstream Area	11.646	12.458	13.554	14.746	16.043	17.453	18.988	20.658
Study Area	160.851	164.670	169.609	174.742	180.078	185.631	191.413	197.437

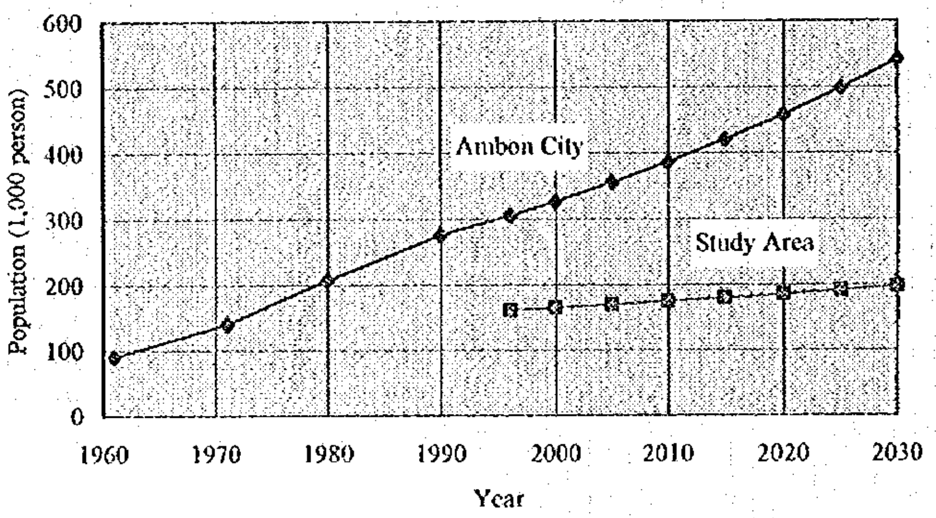


Figure-1.1 Population Projection in Ambon City and the Study Area

(4) GDP Projection

The growth rate of Ambon City's GDP per capita averaged 4.4% per year from 1983 to 1994. However, due to statistical errors rather than business cycles, the observed GDP per capita fluctuated significantly. Table-1.4 shows the annual growth rate of the City's GDP per capita. The growth rate of Ambon City's GDP per capita was 4.4% per year in 1983-1994, 5.5% in 1983-1988, 3.4% in 1988-1994, and 5.7% in 1990-94.

Table-1.4 Annual Growth Rate of Ambon City per capita GDP

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Growth Rate(%)	2.3	0.7	3.0	1.1	22.0	-7.0	5.3	1.2	4.0	13.1	5.0

Source : Ambon City Statistics Office

Based on the trend over the last ten years, the study team applied a rate of 4.5% to determine future annual increase in per capita GDP in Ambon City. As a result, the real GDP increase becomes 6.3% per year since the population increase is forecast at 1.7% per year.

1.1.2 Physical Geography

(1) Regional Topography and Geology

Ambon Island located in the northern reaches of the Banda Sea in Maluku Province of eastern Indonesia. Banda Sea is surrounded by the Sunda arc and Banda arc. The Banda arc is comprised of an outer arc (non-volcanic) which connects the islands of Sumba, Timor, Tanimbar, Seram and Buru from west to east and an inner arc (volcanic) that connects the islands of Flores, Alor, Wetar, Banda and Ambon.

On the whole, Ambon Island comprises a part of the inner arc and the majority of its basement rock is made up of volcanic rocks from the neogene tertiary period. This indicates that Ambon Island is an area that gave rise to complex geological structures.

(2) Topography in the Study Area

The island of Ambon comprises the north island (Semenanjung Hitu) and the south island (Semenanjung Lai Timor) situated on either side of Ambon Bay which is a tectonic valley. Although the two islands were originally separate, a sand bar formed at the northern tip (near the village of Paso) of the south island thus connecting the two into a land tied island.

The five target rivers start their flow in the backbone range and flow northwestward down the steep mountain side, towards Ambon Bay via hilly plateaus and alluvial lowlands. The reaches of the rivers can be generally categorized into mountainous region, hilly plateau and alluvial lowland.

(3) Geology in the Study Area

The geological composition can be summarized as shown in Table-1.5. The oldest rocks in this area are the Kanikeh Formation Ultrabasic, intruding of the late Mesozoic age, occurred in the southern part of the island. Ambon granite, intruding of the tertiary age, is exposed in the upper reaches of the target rivers. The rocks near the foot of the mountain are greatly altered by superficial weathering. In the plateaus, Quaternary coral limestone covers the above mentioned basement rocks.

The alluvial lowlands which comprise the lower reaches of the rivers are mainly covered with alluvial fan deposits (cobbles, pebbles, sand) at the mouth of the valleys and alluvium (pebbles, sand, clay etc.) near the river mouth.

Table-1.5 Geological Composition of Ambon Island

Period	Formation	Rocks
Quaternary	Alluvial Deposits	Cobble, Pebble, Sand, Silt, Clay
	Coral Limestone	Coral Limestone
Tertiary	Ambon Volcanic Rocks (Ambonite)	Andesite, Dacite, Volcanic Breccia, Tuff Breccia, Tuff
	Ambon Granite	Biotite Granite Biotite Cordierite
Cretaceous-Jurassic	Ultrabasic Rocks	Harzburgite, Dunite, Serpentinite, Gabbro
Jurassic-Triassic	Kanikeh Formation	Sandstone, Shale, Siltstone, Conglomerate, Limestone

(4) Current Land Use in the Study Area

The catchment area of the five rivers can be divided into two areas by their land use characteristics, namely Upstream Area and Central City Area. The Upstream Area is mostly covered with bushes and grass although cropping trees and small cultivated farmland are also observed. The Central City Area covers most of the urban area in Ambon City.

Although 92% of the land is classified as residential area in the Central City Area for statistical purposes, the residential area also includes un-populated hillsides, where grass and bushes predominate because the steep land does not allow for construction of houses.

According to the "Current Land Use" map prepared by BPN (National Land Agency), residential areas are found along the Ambon Bay and the five rivers. Although there are small forest areas in the upstream of Batu Merah, Batu Gajah and Batu Gantung rivers, mixed garden and grass and bush areas predominate most of the upstream area of the five rivers.

(5) Future Land Use

<u>Ambon City</u>
According to the "Future Land Development" map prepared by BPN, 40% of the total study area is designated as forest reserve. However, since there are currently no substantive restrictions on land use, some new settlements are already established in this area. Human settlement on the hillside should be restricted in order to prevent further soil erosion of the mountain.

<u>Study Area</u>
Considering that Ambon City is the biggest trade center in Maluku Province and that there is not enough land in the Central City for future industrial growth, land in the Central City will continue to be used primarily for housing and commercial activities. The city population will continue to spread mainly outside of the Central City, along the Ambon Bay.

1.1.3 Hydrology and Flood Damage

(1) Climate

The climate in Indonesia can generally be described as marine tropical with high temperatures and much rain. Temperature variation is small and there is a rainy season from October to March and a dry season from April to September. The division of the rainy season and dry season is usually clear in the west region from Sumatra to Bali and in Irian Jaya, but the rainy season is shorter in much of the east region except for Irian Jaya.

In the study area of Ambon, the rainy season is from May to September and the trend is exactly the opposite of the west region from Sumatra to Bali. The average temperature and humidity are as high as 26.1 °C and 83 % respectively, indicating a hot and humid climate. Figure-1.2 characterizes the seasonal fluctuation of weather.

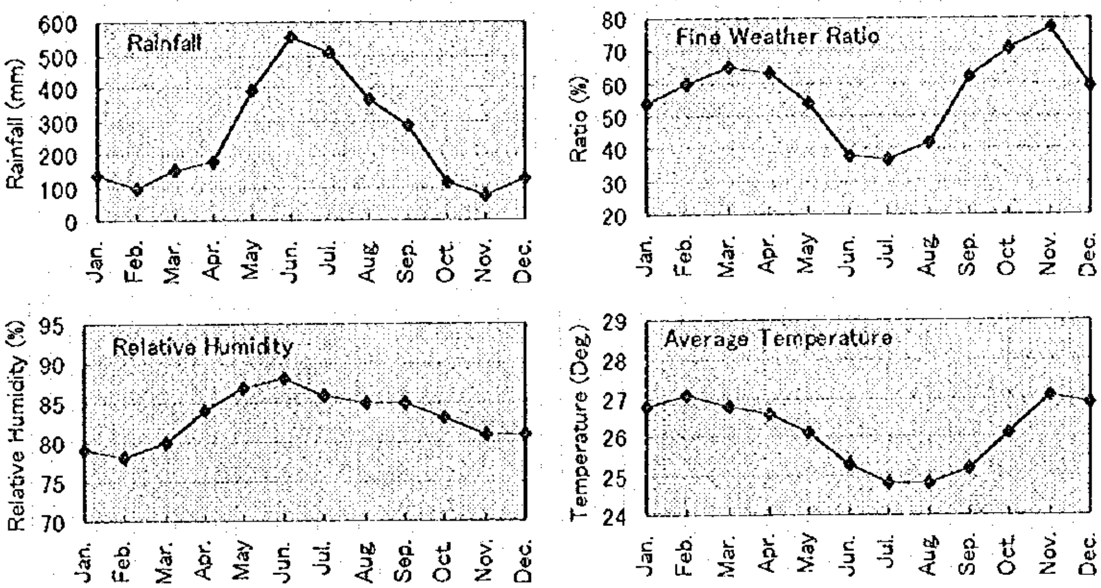


Figure-1.2 Seasonal Fluctuation of Weather at Pattimura Ambon Station

(2) River Systems

The Study area includes the basins of the five rivers named Ruhu River, Batu Merah River, Tomu River, Batu Gajah River and Batu Gantung River, from the north. The catchment areas and main river lengths are shown in Table-1.6 and the river systems and basin boundaries are illustrated in Figure-1.3.

Table-1.6 Catchment Area and Length of Study Rivers

River Name	Catchment Area (km^2)	Length of Main Course (km)
Ruhu River	16.84	12.7
Batu Merah River	7.03	7.3
Tomu River	5.64	7.0
Batu Gajah River	5.97	6.7
Batu Gantung River	6.87	5.7

The longitudinal profiles of these five rivers are shown in Figure-1.4 and are summarized as follows :

- Ruhu River, the most northerly of the target rivers and whose downstream and river mouth is away from the other rivers, has the largest basin and the most gentle river slope of the five rivers.
- Batu Merah River, Tomu River and Batu Gajah River, which are located in the center of the central city area, have similar features of basin area and slope. However, Batu Merah River has a slightly more gentle slope than the other two rivers.
- Batu Gantung River, which is located to the south of the target rivers, has the steepest slope of the five rivers.

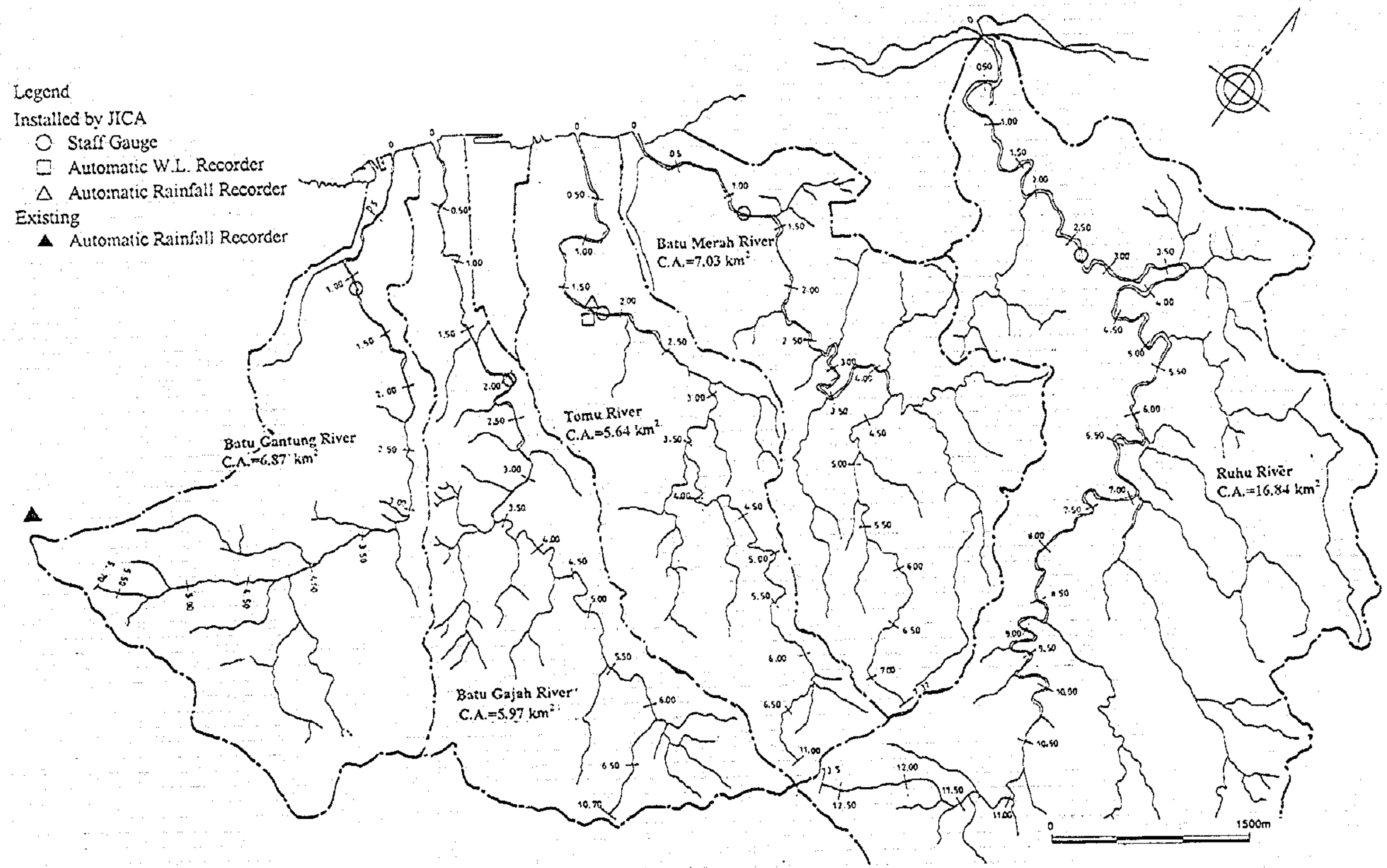


Figure-1.3 River Systems of the Target Rivers

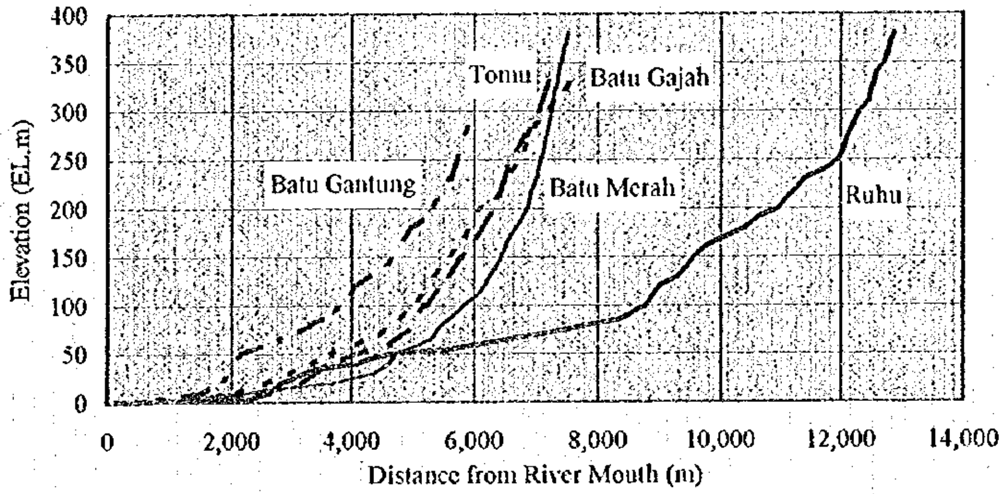


Figure-1.4 Longitudinal Features of the Five Target Rivers

(3) Hydrology

(a) Observation Stations

The following hydrometric observation stations were installed in the Ambon area by the Study Team :

- Automatic rainfall recorder (ARR) : 1 in Tomu River
- Automatic water level recorder (AWLR) : 1 in Tomu River Basin
- Staff gauges : 5 in Ambon (1 on each river)

The locations of the observation stations installed by the Study Team in the Ambon area are shown in Figure-1.3 and the stations are listed in Table-1.7. The catchment areas at the location of each staff gauge and for each river basin are also indicated.

Table-1.7 Installed and Existing Observation Stations

Item	Station Code	River or Basin	Condition	Catchment Area (km^2)	
				Station	Total
Staff Gauge	S-RH-1	Ruhu River	Renewal	14.91	16.84
	S-BM-1	Batu Merah River	New	6.14	7.03
	S-TM-1	Tomu River	Renewal	3.99	5.64
	S-GJ-1	Batu Gajah River	Renewal	4.92	6.61
	S-GT-1	Batu Gantung River	New	5.89	6.87
AWLR	AW-TM-1	Tomu River	New	3.99	5.64
ARR	AR-TM-1	Tomu River Basin	New	-	-
	AR-GT-1	Gunung Nona	Existing	-	-

Note. AWLR : Automatic Water Level Recorder, ARR : Automatic Rainfall Recorder

(b) Flow Regime

Due to lack of discharge observation data, the H-Q curves were thus obtained by using the results of the uniform flow calculation with a roughness coefficient of n = 0.050 mainly for low flow condition. Flow regime for the target rivers was obtained by reviewing the data of past 10 years. Since there are only two years' observation data (from October 1994 to September 1996) of daily average water level, those for the other 8 years were estimated by using the daily flow rate data and considering a proportional conversion factor of the annual rainfall. The flow regimes are shown in Table-1.8.

Table-1.8 Flow Regime

Year	Flow Regime (m^3/s)							Volume of Run-off ($10X6m^3$)	Depth of Run-off (mm)
	Mean	Maximum (1)	High (95)	Median (185)	Low (275)	Drought (355)	Minimum (365)		
Ruhu River									
Mean	1.77	33.91	1.65	0.91	0.55	0.28	0.16	56.06	3,760
Specific Q	11.90	227.44	11.08	6.11	3.72	1.86	1.10	-	-
Tomu River									
Mean	0.34	4.00	0.47	0.14	0.12	0.11	0.06	10.56	2,647
Specific Q	8.45	100.14	11.88	3.52	3.02	2.82	1.61	-	-
Batu Gajah River									
Mean	0.39	5.03	0.43	0.22	0.13	0.10	0.00	12.13	2,459
Specific Q	7.84	102.18	8.65	4.41	2.69	1.96	0.00	-	-

Notes : - Rainfall data for the years 1984, 1987-1989 and 1994 are not available.
- Specific Q : Specific Discharge ($m^3/s/100km^2$)

(4) Experienced Flood Damage

Based on the flood damage survey, the inundation area of the 1984/06/18 flood, 1990/08/19 flood, 1996/08/22 flood and an annual flood for each river were drawn. Inundation area, inundation flood water depth, inundation hours and the number of hours required for cleaning / repairing damaged houses were assessed.

(5) Flood Forecasting and Warning System

(a) Flood Forecasting System

Floods, as one of the natural disasters in traditional society life, can be forecast by interpreting natural indications such as rainfall. For inhabitants in Ambon, flood forecasting is only based upon the experienced rainy season in June, July and August. In addition to forecasting based upon experience, Central Meteorological Office Ambon said that flood occurrence depends completely on the rainfall intensity and flood will occur if the rainfall reaches 230-450 mm/day.

(b) Flood Warning System

In certain areas, flood warning information is usually provided by the mosque drum, church bell, traditional wooden signal drum or other means depending on local conditions. Flood information is also given from the government level directly or indirectly by telephone. However, for most people living in the study area, generally there is no flood warning system. It is found that the most common warning system is limited to shouting on the river banks.

1.1.4 Water Use and Demand

(1) Current Water Use

(a) 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 via reservoirs to a distribution network. 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.

Per capita water consumption has been estimated for both household connections and public taps. PDAM assumes that approximately 53,000 people obtained water from household connections in 1995 and the per capita consumption is estimated at 98.5 liters/capita/day (lcd). The number of households using water from public taps is approximately 4,600, or about 30,000. This figure is equivalent to a per capita consumption of 50 lcd.

(b) 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 45% of the total sales in the central city 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.

(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-1.9 below are presented graphically in Figure-1.5.

Table-1.9 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

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 :

(a) Domestic Water Demand

Population Projection
The projection of population growth for the Study Area and for the whole of Ambon city was outlined previously in Section 1.1.1.

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. In addition it is also assumed that water supply coverage will be extended to 100% by the target year of 2030.

Per Capita Water Consumption
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.

(b) Non Domestic Water Demand

Non domestic water demand for government, commercial and industrial users currently accounts for 30% of the total water supplied by PDAM in the central Ambon area. It is assumed that the water demand by such consumers will remain at 45% of the total supplied in the central Study Area.

(c) System Losses

Current water losses are estimated by PDAM to account for nearly 40% of the total water volume abstracted. 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.

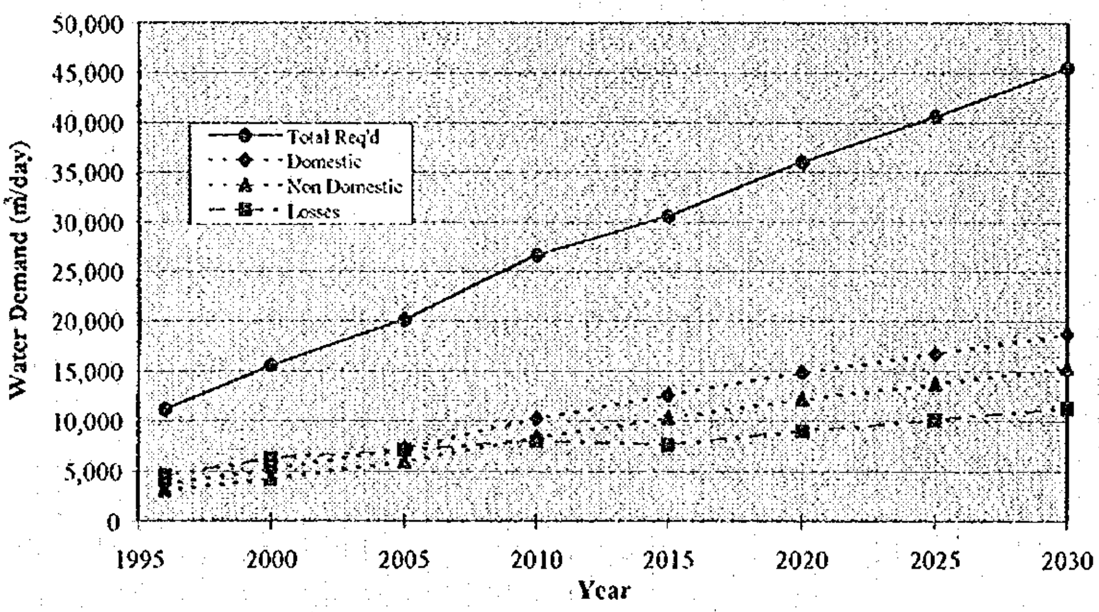


Figure-1.5 Future Water Demand Projection (Study Area : Central City)

1.1.5 Environment

(1) Social Environment

(a) Resettlement and Land Acquisition

Ambon City has a couple experiences in land acquisition and resettlement. The largest resettlement took place for the construction of the fishery port in Pandan Kasturi (Kelurahan Batu Merah), implemented by the provincial level of the Directorate of Fishery, Ministry of Agriculture in the fiscal years 1985/86 and 1986/87. The project was initially financed by the national government, but the financing was eventually taken over by the Asian Development Bank due to budget constraints.

(b) Historical Sites and Protected Areas

In the Study Area, there are three historical sites designated by Maluku Province Government as protected cultural properties: Victoria Fort, Devil Foot Print and Japanese Cave. Near the Study Area, two forest areas, Gunung Sirimau and Gunung Nona, have been designated as protected areas by Maluku Province Government. Only a small part of the Gunung Sirimau Forest Area is within Ruhu River watershed but to the far upstream area, and the Gunung Nona Forest Area is completely outside the Study Area.

(c) Public Health

In Ambon Municipality, there are 9 hospitals with a total number of 849 beds in 1995. Considering the total population of 286,475 (datum of 1995), the medical service is at a level of 337.5 persons/bed on average. There are also 17 community health centers and 30 sub-centers for simple medical care. There are totally 1,161 staff working for medical service, including 74 doctors and pharmacists and 625 nurses.

(d) Disasters

In the Study Area, river flooding is the main natural disaster which has resulted in serious damage. As for other natural disasters, there are no records at all. However, on December 31, 1996 earthquakes occurred in Ambon area several times with the magnitude of the biggest two quakes as 5.5 and 5.3 degrees on Richter scale and people in Central Ambon area experienced strong shake.

(e) Environmental Sanitation

In the Study Area, PDAM water supply system includes water resources (springs and wells), reservoirs and main water transfer pipes. Its distribution network mainly covers the central part of Ambon Municipality and serves about 30% of population in 1996. There is no public sewer system in Ambon and therefore natural rivers and streams receive most of the domestic sewage and even night soil from all residential areas and finally discharge them into the Ambon Bay. Many toilets are located directly on the rivers.

(f) Solid Waste

Regarding facilities employed in Ambon Municipality for solid waste collection and disposal, there had been only one open dump site for final disposal until 1995. A new sanitary landfill site was put into service in 1996. However, heaps of garbage are seen everywhere on road sides, river banks, sea shore and residential areas. Arbitrary dumping of garbage into the river is another reason of river water contamination.

(2) Natural Environment

(a) Flora and Fauna

Flora in the Study Area can be categorized as those in the protected forest, community forest, agroforestry area and gardening area. Data were collected regarding the main species in these areas. Wildlife in the Study Area is dominated by several species of birds found in the forest area and there are also wild boar, monitor lizard, snake, deer and wild dogs. The number of species are decreasing gradually with the increase of human activity such as deforestation and hunting.

(b) Coastal Environment

The 5 rivers in the Study Area flow into the Ambon Bay which is a harvest area for fishery industry, functions as a passage for marine transportation and possesses tourist attractions, and therefore is very important to Ambon's development. Study results show the characteristics of biodiversity of the Ambon Bay and its high potential of fishery production. Unfortunately the coastal environment has been deteriorated recently due to human activities with the development in the relate areas, especially the coastal area near central Ambon. Deterioration of coral reefs and mangrove forests is the most serious result.

(c) Landscape

Topographically the Central Ambon can be categorized to three zones: sea front, plateau and mountain zones. With different characteristics, the three zones composite a unique landscape of this area. The sea front zone faces the Ambon Bay where rugged coastline bends counterclockwise to the inner bay side and extends to the outer bay side. Ambon Bay is famous for its beaches with various sand texture and beautiful coral reefs which attracts tourists from all the world for marine activities as diving, snorkeling etc.

(3) Environmental Pollution

(a) Water Pollution

In the Study Area, there are few existing data on river water quality due to lack of water quality monitoring. The results of water quality analysis conducted during this Study show that the 5 rivers in the Study Area have been severely polluted. It can be seen that sewage and night soil are flowing into the river from houses, public facilities, toilets etc. Dumping garbage into the river is also a habit of the residents living near the river.

(b) Ocean Pollution

There are no monitoring data about water quality in the Ambon Bay. Sediment from river runoff is the main pollutant for the Ambon Bay. Besides pollutant runoff from the river, dumping garbage and sewage directly into the sea is another reason for ocean pollution.

(c) Others

There are no monitoring data on air quality in the Study Area. However, air quality is thought to be good because there is almost no source of exhaust fumes except automobiles on the street. Offensive odor is often emitted from places where heaps of garbage are decomposing or night soil and sewage are stagnated. The situation is serious in downstream area of the rivers. However, no data are available on offensive odor analysis.

1.2 Flood Analysis

1.2.1 Rainfall Analysis

(1) Representative Rainfall Station and Basin Mean Rainfall

There are two meteorological (rainfall) stations in Ambon Island, namely Gunung Nona and Pattimura Ambon. Since Pattimura Ambon has both daily and hourly rainfall data over a long period and Gunung Nona has many missing data, Pattimura Ambon was decided to be used as the representative rainfall station for daily rainfall, hourly rainfall and rainfall intensity analysis.

(2) Rainfall Probability Analysis

(a) Daily and Hourly Probable Rainfall

Table-1.10 shows the daily and hourly probable rainfall based on the annual maximum data of daily and hourly rainfall in representative rainfall station, namely Pattimura Ambon. Probability analysis was carried out using the Least Square Method, Moment Method, Iwai's Method and Gumbel's Method. Of these, the result from the Moment Method is adopted for probable rainfall in the study area because the result best fits the available data.

Table-1.10 Daily and Hourly Probable Rainfall [Pattimura Ambon]

Return Period (year)	2	3	5	10	20	30	50	100	200
Probable Daily Rainfall (mm)	171.8	212.1	259.5	321.9	384.6	421.9	469.9	537.0	606.7
Probable Hourly Rainfall (mm)	45.1	52.5	60.7	70.9	80.6	86.2	93.1	102.5	112.0

Note : - Calculated by Moment Method
- Annual Maximum Daily Rainfall Data of 32 years from 1959 to 1995
- Annual Maximum Hourly Rainfall Data of 14 years from 1959 to 1995

(b) Rainfall Intensity Curve

The rainfall intensity curves/formula were set by the Talbot Formula using the probable daily rainfall and probable hourly rainfall of Pattimura Ambon.

(3) Flood Rainfall

The maximum daily rainfall was recorded at 455 mm/day on August 28, 1988. Many of the flood rainfall have no hourly data, notably only two data out of the top 10 daily flood rainfalls. Of these flood rainfalls, the hyetograph of the main flood with hourly rainfall data is shown in Figure-1.6. As can be seen from the figure, the hyetograph of this rainfall does not form smooth, mountain-shaped curves, but show many intermittent or sudden increases and decreases. This indicates that rainfall comes sporadically and locally in Ambon area.

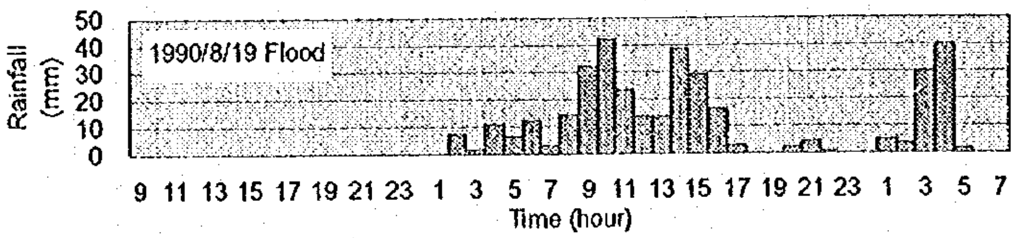


Figure-1.6 Hyetograph of Main Flood Rainfall in Ambon

1.2.2 Flood Runoff Analysis

(1) Design Rainfall

(a) Flood Hyetograph

The top five flood rainfalls with daily and hourly data were selected as candidates for design rainfall, namely 1986/06/18, 1988/07/19, 1990/06/06, 1990/08/19 and 1996/08/22 floods. However, of these rainfall events, the big rainfalls that caused severe flood damage on 1984/06/22 and 1989/06/21, and another flood on 1988/08/28 are not included because there are no hourly rainfall data available.

(b) Probable Rainfall Depth and Enlarging Ratio

A period of one day is employed as the duration of design rainfall based on the following reasons :

- According to the hyetograph of the main rainfalls, the period of dominant rainfall leading to peak discharge is judged to be within 1 day.
- The basin catchment areas of the five target rivers are relatively small with variation from 5 km^2 to 17 km^2 and freshet and depletion of flood water seem to be fast.

(2) Flood Runoff Modeling

(a) Flood Runoff Model Used in the Study

In the Study, *Storage Function Method* is employed for flood runoff analysis and the validity of the results - river discharges - are checked by *Rational Formula*.

(b) River Basin Division

Each of the target river basins is divided into two or four sub-basins, taking into account the locations of staff gauges and main confluence. River basins division is drawn in Figure-1.7.

(c) Establishment of Runoff Model

Based on the basin division, basin models for the five target rivers were established as shown in Figure-1.8.

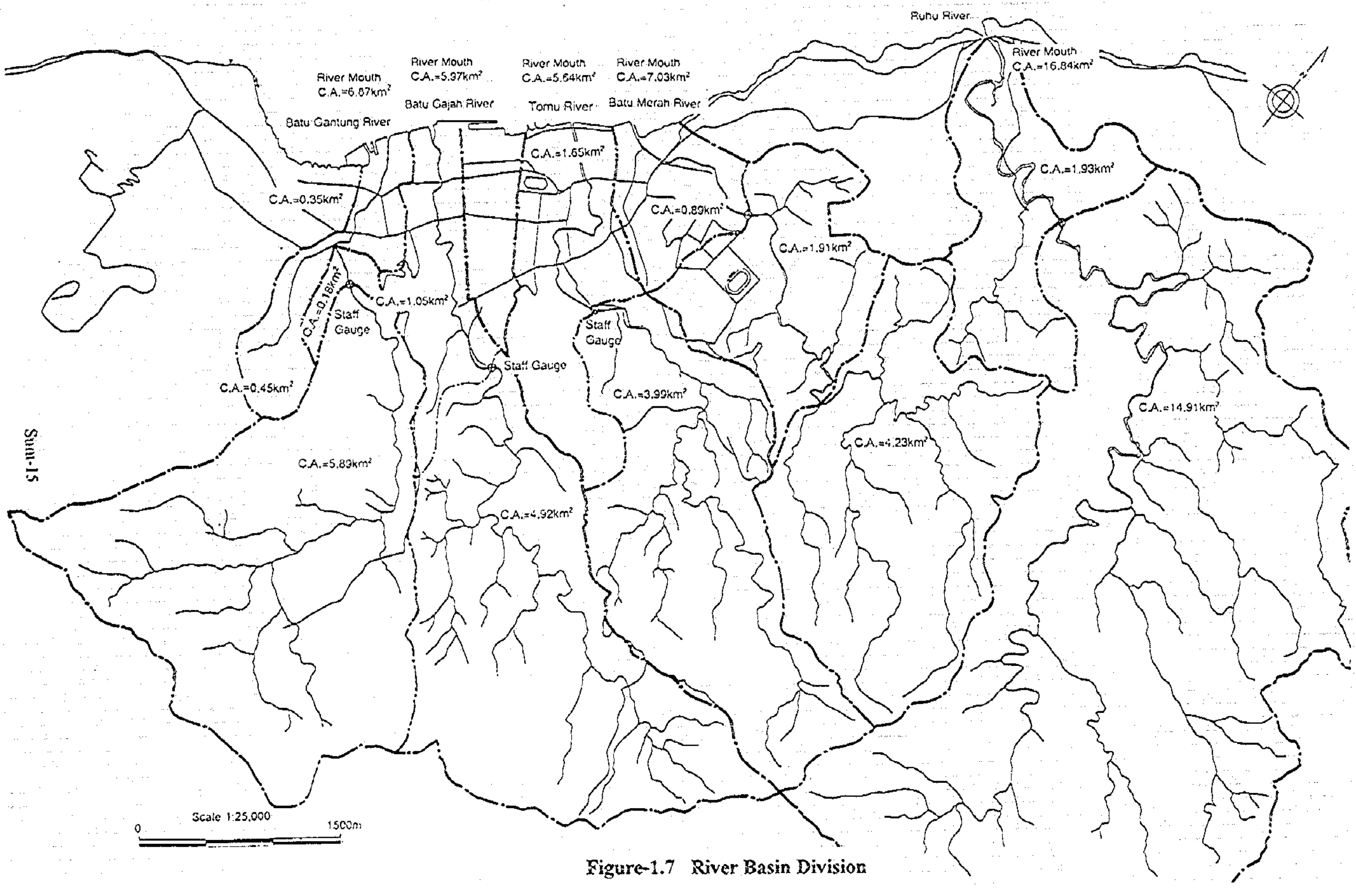


Figure-1.7 River Basin Division

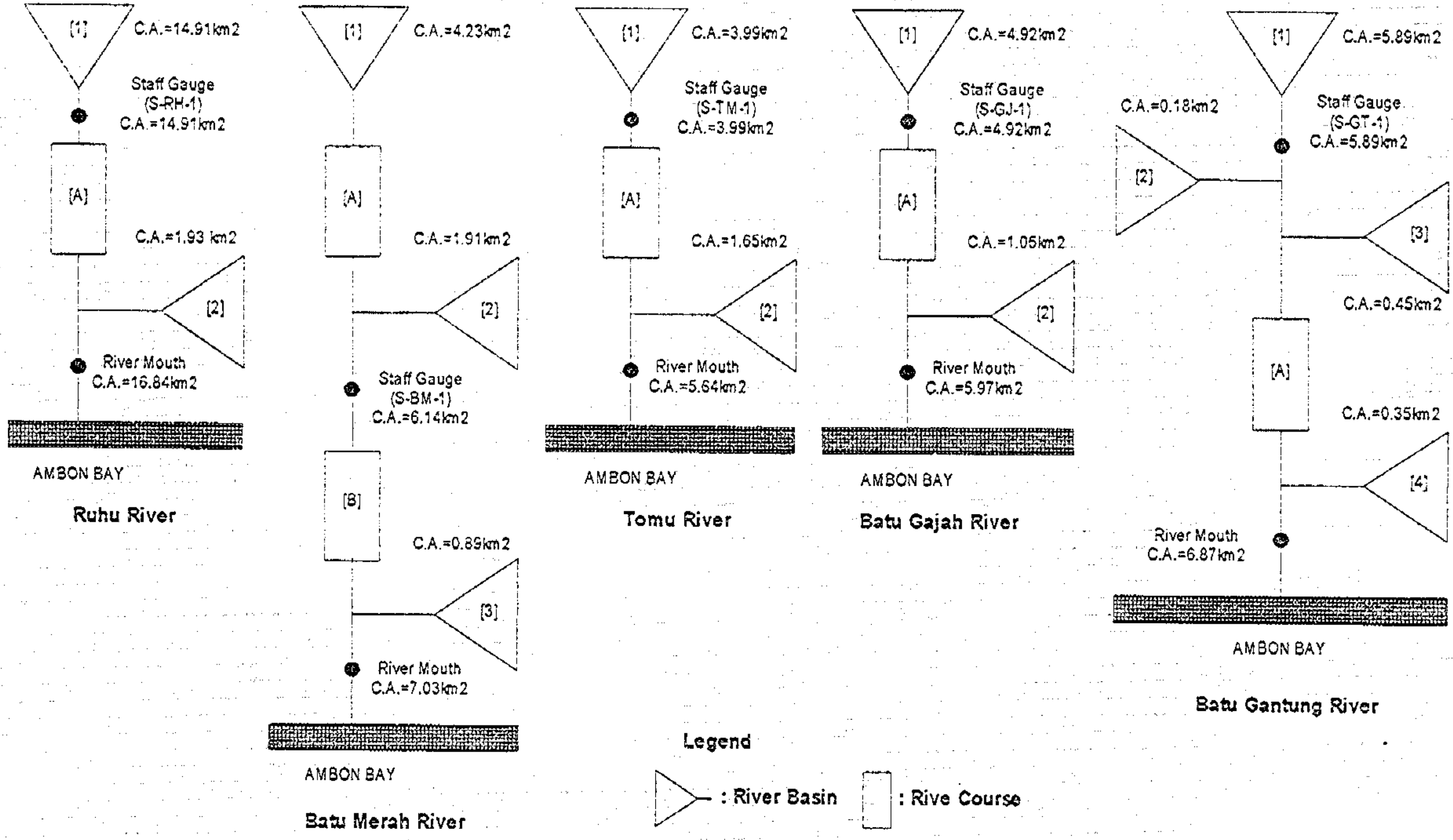


Figure-1.8 Basin Model

(3) Flood Discharge

(a) Runoff Calculation

Using the runoff model established in the former section, flood discharge for each return period was calculated for five floods, namely, the floods of 1984/06/18, 1988/07/18, 1990/06/06, 1990/08/19 and 1996/08/22.

(b) Peak Flood Discharge and Flood Hydrograph

Peak flood discharge for each return period is determined as shown in Table-1.11, employing 1990/06/06 flood with a "Cover Factor" of 80 %. The cover factor is defined as the degree how far the peak discharge of a selected hyetograph satisfies those of the hydrograph group. The following items have been taken in to consideration:

- The 1988/07/19 flood shows the maximum peak discharge. However the maximum hourly rainfalls after enlarging actual rainfall data is 1.4 to 1.9 times larger than probable hourly rainfalls. Then the 1988/07/19 flood hyetograph after enlarging is concluded to be too large as estimation of runoff.
- The peak discharges of 1984/06/18, 1990/08/19 and 1996/08/22 floods are nearly the same but smaller than the other.
- The second largest peak discharges is calculated with the 1990/06/06 flood. The maximum hourly rainfalls after enlarging actual rainfall data is within 0.8-1.1 times of probable hourly rainfalls of various return period.

The hydrograph of each river at river mouth with 5, 10, 30, 50-year return period is presented in Figure-1.9.

Table-1.11 Design Peak Discharge (Design Flood : 1990/06/06)

River	Reference Point	C.A. (km^2)	Item	Design Peak Discharge (m^3/sec) by Design Scale								
				2	5	10	20	30	50	70	100	200
Ruhu	S-RH-1	14.49	Q	79	150	200	251	281	319	345	373	429
			Specific-Q	5.5	10.4	13.8	17.3	19.4	22.0	23.8	25.7	29.6
	River Mouth	16.84	Q	90	168	223	280	314	358	387	418	482
			Specific-Q	5.3	10.0	13.2	16.6	18.6	21.3	23.0	24.8	28.6
Batu Merah	S-BM-1	6.14	Q	42	73	94	115	127	143	153	164	186
			Specific-Q	6.8	11.9	15.3	18.7	20.7	23.3	24.9	26.7	30.3
	River Mouth	7.03	Q	49	84	108	132	145	163	175	188	213
			Specific-Q	7.0	11.9	15.4	18.8	20.6	23.2	24.9	26.7	30.3
Tomu	S-TM-1	3.99	Q	28	48	61	75	83	93	99	107	121
			Specific-Q	7.0	12.0	15.3	18.8	20.8	23.3	24.8	26.8	30.3
	River Mouth	5.64	Q	41	69	87	106	117	131	141	151	172
			Specific-Q	7.3	12.2	15.4	18.8	20.7	23.2	25.0	26.8	30.5
Batu Gajah	S-GJ-1	4.92	Q	33	58	75	92	101	114	122	131	149
			Specific-Q	6.7	11.8	15.2	18.7	20.5	23.2	24.8	26.6	30.3
	River Mouth	5.97	Q	42	71	91	111	123	138	148	159	181
			Specific-Q	7.1	12.1	15.4	18.8	20.7	23.1	25.0	26.8	30.4
Batu Gantung	S-GT-1	5.89	Q	42	72	91	111	123	137	147	158	179
			Specific-Q	7.1	12.2	15.4	18.8	20.9	23.3	25.0	26.8	30.4
	River Mouth	6.87	Q	50	84	107	130	143	160	172	184	209
			Specific-Q	7.3	12.2	15.6	18.9	20.8	23.3	25.0	26.8	30.4

Note : Q : Discharge (m^3/sec) Specific-Q : Specific Discharge (m^3/sec/km^2)

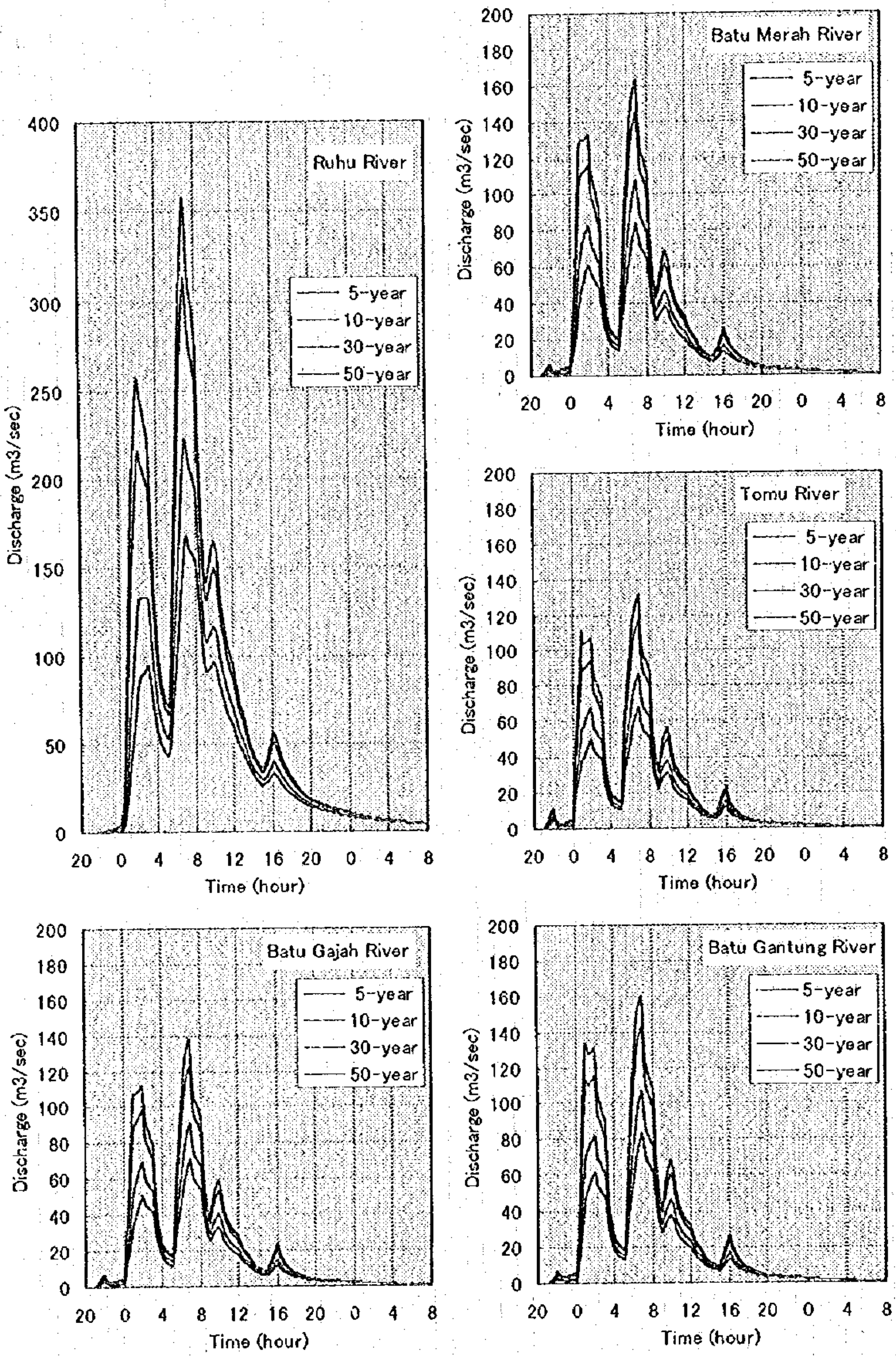


Figure-1.9 Design Flood Hydrograph

1.2.3 Flood Damage Analysis

(1) Discharge Capacity of River Channels

Longitudinal and cross sectional river surveys for the five target rivers were carried out during this Study. The results of these surveys were used to assess the current discharge capacity of the rivers. This cross section data was compiled and the non-uniform flow calculation method was used to obtain stage discharge (H / Q) curves for every cross section over a range of flows up to a maximum of 250 m^3/sec (400 m^3/sec for Ruhu river). Manning's Roughness was assumed to be 0.025. The discharge capacity at each section was then estimated by comparing the left and right bank heights to the calculated stage discharge curves.

Table-1.12 Summary Result of Discharge Capacity

River Name	Capacity (m^3/sec) - Non Uniform Flow				Capacity (m^3/sec) - Uniform Flow			
	No Freeboard		0.6m Freeboard		No Freeboard		0.6m Freeboard	
	Average	Extreme	Average	Extreme	Average	Extreme	Average	Extreme
Ruhu River	60 - 80	50	40 -50	34	60 -80	44	40 - 60	30
Batu Merah River	30 - 40	24	20 - 30	15	20 - 30	17	15 - 25	9
Tomu River	40 - 50	22	20 - 30	10	40 - 50	21	20 - 30	8
Batu Gajah River	30 - 50	23	20 - 40	11	40 - 60	24	20 - 40	10
Batu Gantung River	40 - 60	36	20 - 40	20	50 -70	38	30 - 50	22

(2) Estimation of Flood Damage

It is necessary to estimate future flood damages in the "without project" case, in order to quantify the benefits of the "with project" case. In this study, the flood damage analysis was carried out in the following manner:

1) Flooded areas and water levels for the past three major floods and annual floods were established through interviews and contour analysis.
2) Damages from the above floods were estimated.
3) A "flood discharge - damage value" curve was drawn based on the results of above 2).
4) Yearly average of damage alleviation (yearly benefits of the project) was derived from probabilities of several water amount cases.

(a) Damage to General Assets

Several records on the total amount of damage to houses and buildings and the location of the inundated areas were found for the floods of 1984 and 1989. After comparing the damage situation as ascertained from interviews with the standard damage rate used in Japan, the study team judged that it would be reasonable to apply the Japanese damage rate which is based on past experience in Japan.

The study team estimated the value of each type of general asset in all the flooded areas through a field investigation and made a zoning map based on this information. In addition, the data on the height of flood water was obtained through the interviews for the flood damage survey with around 200 residents in the study area.

(b) Damage to Infrastructure

Very limited data on the damage to infrastructure were obtained from organizations responsible for the construction and maintenance of infrastructure. To estimate the damage to infrastructure, the study team applied the Japanese standard damage rate.

(c) Damage from Disruption of Businesses

It takes several days until normal commercial activities can resume after the occurrence of floods. Interviews with residents showed how many days it took them to clean/repair their houses. On average, 1.5 days were needed when the water level was less than 50cm, 2.5days when it was 50 to 99cm, and 3.5days when it was 100cm to 199cm, 4.5days when 200 to 299cm, and 5.5days when more than 300cm.

(d) Estimation of Past Flood Damage

The damages from the three past major floods and the annual flood were estimated.

(e) Estimation of Assumed Flood Damage

Flood damage at probable discharge with 30-year and 100-year return period were estimated. In this case, assuming that all the flood discharge flows inside the river course, the flood water level is calculated by using non-uniform flow calculation .Referring to the estimated flood water level, local topography of flooded area, the past flooded area and water depth, the flooded area and water depth with 30-year and 100-year return periods were studied. The flooded area with 100-return period is presented in Figure-1.10.

(3) Flood Discharge - Damage Curve

(a) Estimation of the Past Flood Discharge

The flood discharges of 1984/06/22, 1989/06/22 and 1996/08/22 floods were approximately estimated at the most upstream of the flooded area. The estimation method is similar to that of the assumed flood damage and is described as follows:

1) Based on the interviews of flood damage survey, the flooded water depth is obtained at the upstream cross section of the flooded area.
2) Assuming that all of flood discharge flows inside of the river course, flood discharge is calculated by using non-uniform flow calculation based on river water level, namely flood water level.

(b) Flood Discharge - Damage Value Curve

Based on the above flood damage study, relationship between flood discharge and flood damage value is estimated, taking into account of the following :

- The flood discharge with no damage is assumed as the discharge capacity of each river.
- Damaged flood occurred 2-3 times a year in all five rivers.
- The flood of 1996/08/22 was estimated to be 3-year return period.
- The floods of 1984/06/22 and 1989/06/22 were estimated to be nearly the same scale and equivalent to the 10-year return period.
- Flood damage of 30-year and 100-year return period were estimated by the Study Team.

The relationship between flood discharge and damage value is shown in Figure-1.11 for each river.

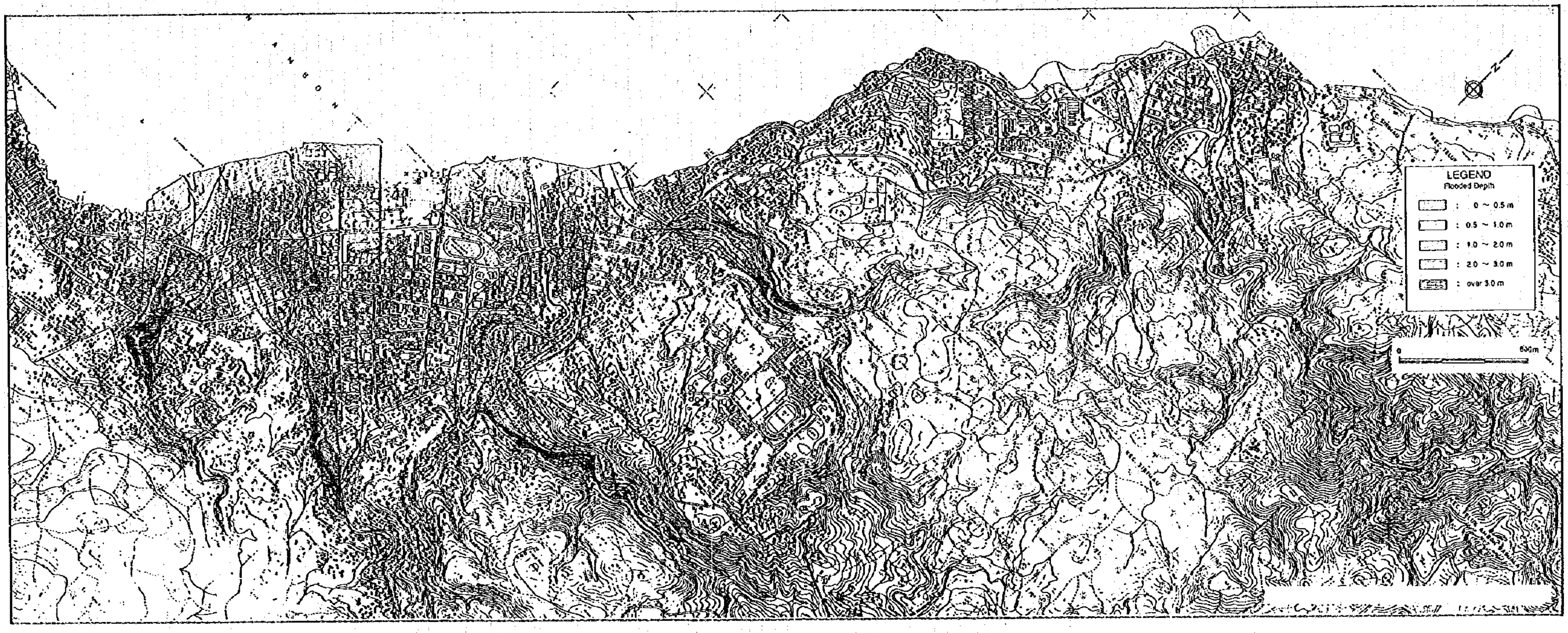


Figure-1.10 Estimated Flooded Area with 100-year Return Period

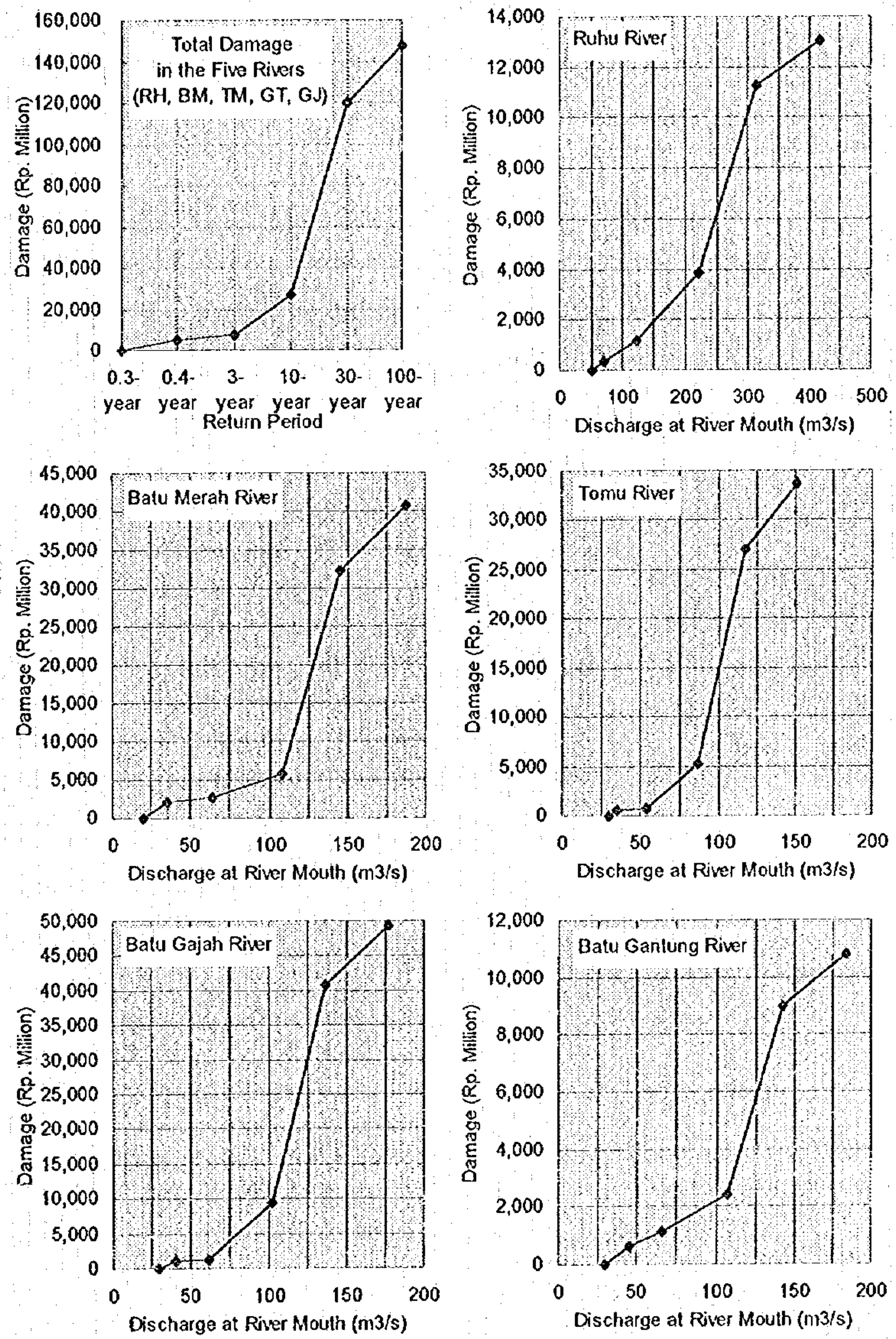


Figure-1.11 Flood Discharge / Flood Scale - Damage Value Curve

1.3 Flood Control Master Plan

1.3.1 Basic Planning Conditions and Policies

In preparation of the flood control master plan for Ambon Area, various planning conditions and policies are set as shown in Table-1.13.

Table-1.13 Basic Policy of Flood Control Plan for Ambon Area

Items	Description
Plan Conditions	
- Target Year	Flood Control Plan : Year of 2015 Water Utilization Plan : Year of 2015 and 2030
- Protected Area	The protected area covered by this plan is the central part of Ambon city. This area, the possible flood prone area, includes the downstream parts of the five (5) target river basins : (Ruhu, Merah, Tomu, Gajah, Gantung).
- Design Scale	30 - year return period
- Target of Plan	- Mitigation of flood damage by structural and non-structural measures - Improve of river environment conditions through the implementation of flood control measures. - Presentation of water resources development plan for domestic use of Ambon city through the design of multipurpose dams and reservoirs.
Flood Control Measures	
- Structural Measures and Non-structural Measures	To fully achieve the main target of the plan (mitigation of flood damage), the Master Plan shall include structural measures and non-structural measures for flood control and sediment control.
- Water Development and River Environment Conservation	In preparation of the Master Plan, plans for river environment conservation and water development for future domestic use through multipurpose dams are proposed
- Structural Measures	Structural flood control measures enable the design flood to flow safely into the sea without flooding, directly controlling flood flow in or along the river course. Structural measures include 1) river improvement work to increase flow capacity of the river course and 2) dams and diversion channels to decrease the flood peak discharge into the river course.
- Non-structural Measures	Non-structural flood control measures are measures other than structural flood control measures to mitigate flood disasters and include various methods for flood runoff suppression, for flood proofing and for facilitation of flood control activities.
- Alternative Plans and Optimum Measures	To identify the optimum structural measures plan for flood control, alternative plans are examined including river improvement work (large scale) with no other measures and river improvement work (small scale) in combination with other measures (dams or diversion channels).

1.3.2 Structural Flood Control Measures

As structural flood control measures for the five target rivers, river improvement works, flood control dams, diversion channels and check dams were studied as follows:

(1) Study of Structural Measures

(a) River Improvement Works

The proposed measures for river improvement works are: 1) River-bed Formation, 2) River-bed Excavation, 3) Flood Wall Heightening, 4) Concrete Channel, 5) River Widening.

The priority for adopting a measure is generally set based on the above order, considering each river condition, social impact, economic efficiency, city drainage system and so on. River improvement plan for the design flood (30-year return period) is examined and smaller scale plans (5-year and 10-year return period) for combination plan with dam or diversion channel are also studied. Table-1.14 presents the river improvement plans for each river.

Table-1.14 River Improvement Alternative Plans

River	Items	5-year	10-year	30-year
(1) Ruhu River	Design Discharge (m^3/s)	170	230	320
	River-bed Formation Length (m)	1,600	1,600	1,600
	River-bed Excavation, Depth & Length (m)	1.0, 1,600	1.0, 1,600	1.0, 1,600
	Concrete Channel Length (m)	-	-	-
	F/Wall Heightening Length(m) Left, Right	300, 350	300, 350	420, 500
	River Widening Length (m)	300	1,100	1,100
	Bridge Improvement Number	3	3	3
	Land Acquisition Area (m^2)	1,500	10,000	17,000
	Resettlement Household Number	40	147	147
(2) Batu Merah River	Design Discharge (m^3/s)	90	110	150
	River-bed Formation Length (m)	1,600	1,600	1,600
	River-bed Excavation, Depth & Length (m)	1.0, 1,600	1.0, 1,600	1.0, 1,600
	Concrete Channel Length (m)	1,200	1,200	1,400
	F/Wall Heightening Length(m) Left, Right	1,010, 1,070	970, 800	970, 800
	River Widening Length (m)	70	950	1,200
	Bridge Improvement Number	1	1	1
	Land Acquisition Area (m^2)	350	4,750	7,750
	Resettlement Household Number	10	127	160
(3) Tomu River	Design Discharge (m^3/s)	70	90	120
	River-bed Formation Length (m)	2,700	2,700	2,700
	River-bed Excavation, Depth & Length (m)	-	0.8, 2,100	0.8, 2,100
	Concrete Channel Length (m)	-	-	2,100
	F/Wall Heightening Length(m) Left, Right	770, 600	130, 20	130, 20
	River Widening Length (m)	-	-	-
	Bridge Improvement Number	4	2	4
	Land Acquisition Area (m^2)	-	-	-
	Resettlement Household Number	-	-	-
(4) Batu Gajah River	Design Discharge (m^3/s)	80	100	130
	River-bed Formation Length (m)	2,600	2,600	2,600
	River-bed Excavation, Depth & Length (m)	1.0, 2,100	1.0, 2,100	1.0, 2,100
	Concrete Channel Length (m)	-	700	1,900
	F/Wall Heightening Length(m) Left, Right	140, 150	230, 150	230, 230
	River Widening Length (m)	-	-	1,100
	Bridge Improvement Number	3	3	3
	Land Acquisition Area (m^2)	-	-	5,500
	Resettlement Household Number	-	-	147
(5) Batu Gantung River	Design Discharge (m^3/s)	90	110	150
	River-bed Formation Length (m)	1,450	1,450	1,450
	River-bed Excavation, Depth & Length (m)	1.0, 1,450	1.0, 1,450	1.0, 1,450
	Concrete Channel Length (m)	250	900	1,300
	F/Wall Heightening Length(m) Left, Right	50, 0	100, 100	-
	River Widening Length (m)	-	-	550
	Bridge Improvement Number	2	2	2
	Land Acquisition Area (m^2)	-	-	2,750
	Resettlement Household Number	-	-	73

(b) Flood Control Dams

Based on consideration of topographical and geological conditions, 13 locations for candidate dam sites, two or three for each river, were selected in the hilly areas of the five rivers. Each dam site was evaluated from the technical, economical and social view points, comparing such factors as dam volume, reservoir area and compensation items (houses and public facilities) and the most appropriate dam site for each river was selected. In view of the small basin areas (less than 20 km^2) and to ensure ease of operation and maintenance, the Natural Control Method was adopted as the flood regulation system for all the planned dams. Spillways are gate-less type, i.e. not fitted with gates for flood control. The design scale of flood control plan for all the rivers is set at 30-year return period. The design flood hydrograph is the flood pattern of June 6, 1990. The flood control dam for each river is planned based on the improved river conditions with the design scales of 5-year and 10-year return period. Following design of dams and reservoirs, the specification shown in Table-1.15 was derived.

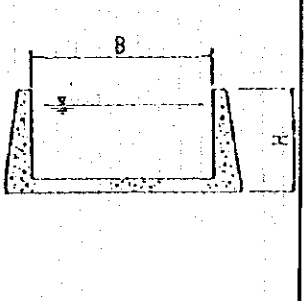
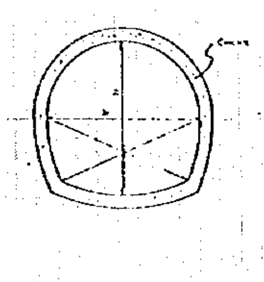
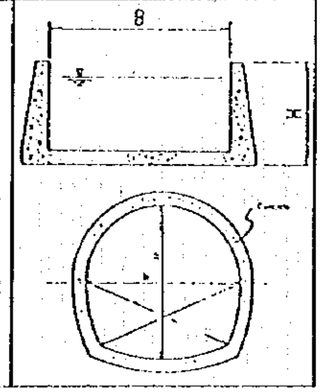
Table-1.15 Specifications of Dams and Reservoirs

Items		Ruhu RH-1		Batu Merah BM-2		Tomu TM-1		Batu Gajah GJ-2		Batu Gantung GT-1	
Design Scale of River		1/5	1/10	1/5	1/10	1/5	1/10	1/5	1/10	1/5	1/10
Catchment Area (km^2)		14.49		4.97		2.71		4.37		4.76	
Unregulated peak discharge (m^3/sec)	Dam	273		103		57		90		99	
	River Mouth	314		145		117		123		143	
Dam outflow at peak inflow (m^3/sec)		125	167	47	69	9	28	46	67	46	66
Regulated peak discharge (m^3/sec)	Dam	138	197	51	77	10	30	51	70	50	71
	River Mouth	170	230	90	110	70	90	80	100	90	110
Cut discharge (m^3/sec)	Dam	148	106	56	34	48	29	44	23	53	33
	River Mouth	144	84	55	35	47	27	43	23	53	32
Sediment Capacity (1000 m^3)		580		199		109		175		191	
River Maintenance Capacity (1000 m^3)		251		86		47		76		83	
Flood Storage Capacity (1000 m^3)		2,272	1,528	869	536	1,047	399	574	357	725	425
Effective Storage Capacity (1000 m^3)		2,523	1,779	955	622	1,094	446	650	433	808	508
Total Storage Capacity (1000 m^3)		3,103	2,359	1,154	821	1,203	555	825	608	999	699
Low Water Level (EL.m)		46.4		17.8		45.4		57.2		86.4	
Normal Water Level (EL.m)		48.8		19.6		46.4		59.4		88.4	
Surcharge Water Level (EL.m)		60.0	57.6	27.0	25.1	59.2	52.8	68.0	65.3	99.5	96
Dam Top Elevation (EL.m)		64.0	61.6	31.0	29.1	63.2	56.8	72.0	69.3	103.5	100
Dam Base Elevation (EL.m)		23.0		6.0		34.0		38.0		66.0	
Freeboard (m)		4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Dam Height (m)		41.0	38.6	25.0	23.1	29.2	22.8	34.0	31.3	37.5	34.0
Dam Crest Length (m)		103.0	98.0	134.0	126.0	183.0	164.0	220.0	209.0	145.0	132
Dam Foundation Length (m)		10.0	10.0	24.0	24.0	70.0	70.0	70.0	70.0	20.0	20.0
Flood Conduit	Width (m)	3.7	5.3	2.5	4.3	1.0	2.0	2.4	3.5	2.2	3.0
	Height (m)	3.7	5.3	2.5	4.3	0.8	2.0	2.4	3.5	2.2	3.0
Dam Slope	Upstream	1:3.0	1:3.0	1:3.0	1:3.0	1:3.0	1:3.0	1:3.0	1:3.0	1:3.0	1:3.0
	Downstream	1:2.5	1:2.5	1:2.5	1:2.5	1:2.5	1:2.5	1:2.5	1:2.5	1:2.5	1:2.5
Dam Top Width (m)		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Dam Volume (1000 m^3)		201	172	115	94	271	159	406	335	228	174
Land Acquisition Area (1000m^2)		411	346	236	202	155	108	108	93	111	95
Resettlement Household (number)		-	-	150	150	-	-	20	20	-	-

(c) Diversion Channel/Tunnel

To decrease the discharge into the downstream reaches, diversion channel plans are studied. Of the five target river systems, diversion channel plans are applicable to only three rivers (Ruhu, Batu Merah and Tomu) due to the topographical conditions of the rivers. For the other two rivers (Batu Gajah and Batu Gantung), diversion channels are not practical. The objective of a diversion channel is to transport the flood discharge which is in excess of the existing river capacity. Diversion plans are examined regarding two cases of river improvement works, namely the design scales of 5 and 10-year return period. Diversion channels for the three river systems are planned and designed and the specifications of each diversion channel are summarized in Table-1.16.

Table-1.16 Specifications of Diversion Channels

Items	Ruhu River		Batu Merah River		Tomu River	
	DIV-RH1	DIV-RH2	DIV-BM1	DIV-BM2	DIV-TM1	DIV-TM2
General Description	Partial (5year) River Course Improvement with Diversion Channel	Partial (10year) River Course Improvement with Diversion Channel	Partial (5year) River Course Improvement with Diversion Channel	Partial (10year) River Course Improvement with Diversion Channel	Partial (5year) River Course Improvement with Diversion Channel	Partial (10year) River Course Improvement with Diversion Channel
Design Discharge	150 m^3/sec	90 m^3/sec	60 m^3/sec	40 m^3/sec	50 m^3/sec	30 m^3/sec
<Inlet>						
Location	1k100	1k100	1k600	1k600	2k700	2k700
River-bed Level	EL. -0.50 m	EL. -0.50 m	EL. 2.70 m	EL. 2.70 m	EL. 11.70 m	EL. 11.70 m
High Water Level	EL. 2.31 m	EL. 2.20 m	EL. 5.50 m	EL. 5.50 m	EL. 13.20 m	EL. 13.50 m
<Outlet>						
Location	0k500	0k500	850 m north from River Mouth	850 m north from River Mouth	0k800	0k800
River-bed Level	EL. -1.59 m	EL. -1.59 m	EL. 0.00 m	EL. 0.00 m	EL. 1.50 m	EL. 0.70 m
High Water Level	EL. 1.41 m	EL. 1.41 m	EL. 0.80 m	EL. 0.80 m	EL. 3.70 m	EL. 3.40 m
<Channel / Tunnel>						
Total Length - Tunnel - Open Channel	290 m - 290 m	290 m - 290 m	1,200 m 1,200 m -	1,200 m 1,200 m -	1,150 m 900 m 250 m	1,150 m 900 m 250 m
Gradient	1/270	1/270	1/440	1/440	1/110	1/110
Land Acquisition	1,540 m^2	1,540 m^2	1,200 m^2	1,200 m^2	2,476 m^2	2,476 m^2
Resettle Household	30	30	-	-	34	34
Size of Tunnel and Channel	Open Channel B x H = 7.0m x 3.5m	Open Channel B x H = 6.0m x 3.2m	Tunnel D = 5.8m A = 25.4 m^2	Tunnel D = 5.1m A = 19.7 m^2	Open Channel B x H = 4.0m x 2.6m Tunnel D = 4.2m A = 13.3 m^2	Open Channel B x H = 3.5m x 2.2m Tunnel D = 3.5m A = 9.3 m^2
Typical Cross Section						

(d) Check Dams

Due to the excess sediment and the sediment transport capacity of the river course, the river channel bed in the downstream areas (central Ambon city) is gradually rising and eventually this sedimentation causes flooding. To cope with this situation, a check dam for each river basin is necessary. As one check dam already exists in the middle reach of Batu Merah river, four check dams are planned in the other river systems. The specifications of the proposed check dams are presented in Table-1.17.

Table-1.17 Outline of Check Dams

River	Location	Basement Elevation EL.(m)	Dam Height (m)	Dam Length (m)	Sediment Capacity (m^3)	Dam Volume (m^3)	Land Acquisition (m^2)
Ruhu	RH-1 Dam Site	EL.40m	10m	50 m	40,000	2,500	33,000
Tomu	TM-1 Dam Site	EL.45m	7 m	110 m	37,000	2,700	30,000
Batu Gajah	Upstream of GJ-2 Dam	EL.70m	8 m	80 m	10,000	2,600	16,000
Batu Gantung	Upstream of GT-1 Dam	EL.100m	11 m	40 m	36,000	2,400	6,000

Note. Resettlement households are nothing for all the check dams.

(2) Alternative Flood Control Plans and Cost Estimate

Integrating the results of the study for the structural flood control measures, alternative plans for each river with the design scale of 30-year return period were proposed and the project costs were estimated. Table-1.18 presents the summary of the alternative flood control plans.

(3) Identification of Optimum Plan

The optimum flood control plan for each river system is selected as Table-1.18 and follows. These selected plans are presented in Table-1.19 and in Figure-1.12. Table-1.20 presents the project cost and compensation conditions of the flood control master plan in the Study Area.

< Ruhu > FCP-RH2: River Improvement [5], F/Control Dam, Check Dam
The most reasonable scale of river improvement is 5-year scale due to less resettlement number. Dam and diversion channel are planned as combination measures to complete full scale plan of 30-year. In comparison with diversion channel plan, dam plan has the following advantages: 1) no resettlement, 2) new water resources development with an additional storage. This will meet a large volume of the future water demand in Ambon. Therefore, FCP-RH2 was adopted as an integrated and reasonable plan.

< Batu Merah > FCP-BM4: River Improvement [5], Diversion Channel
The most economical plan is FCP-BM1 costing Rp. 47,266 million (92 % of FCP-BM4) and the third most economical plan is FCP-BM2 costing Rp. 52,994 million (103 % of FCP-BM4). However, for these plans it is necessary to resettle 160 households. Therefore, the second most economical plan with the least resettlement of 10 households, FCP-BM4 plan was adopted.

< Tomu > FCP-TM1: River Improvement [30]
The most economical plans excluding FCP-TM1 are FCP-TM5 costing Rp. 24,691 million (94 % of FCP-TM1) and FCP-TM4 costing Rp. 25,890 million (98 % of FCP-TM1). These are the plans including a flood control dam where it is necessary to resettle 34 households. FCP-TM1 plan is the third most economical plan but the project costs are only 2-6 % higher than the first and second most economical plans. Therefore, FCP-TM1 plan was adopted.

< Batu Gajah > FCP-GJ3: River Improvement [10], F/Control Dam, Check Dam

The project costs of all the options are nearly the same as each other. The most economical plan is FCP-GJ1 costing Rp. 54,438 million (92 % of FCP-GT3), but it is necessary to resettle 147 households and could not be adopted. For the other two plans, it is necessary to resettle only 20 households and the more economical plan of these, FCP-GJ3 was adopted.

< Batu Gantung > FCP-GT3: River Improvement [10], F/Control Dam, Check Dam

The most economical plan is FCP-GT1 costing Rp. 32,145 million (71 % of FCP-GT3) but it is necessary to resettle 73 households. It could not be adopted although the project cost is 29 % less than FCP-GT3. The other two plans have no resettlement households and of these, the more economical plan FCP-GT3 was adopted.

Table-1.18 Identification of Optimum Flood Control Plan

Ruhu River Plan	FCP-RH1	FCP-RH2	FCP-RH3	FCP-RH4	FCP-RH5
Project Composition	R/Imp [30] Check Dam	R/Imp [5] F/C Dam Check Dam	R/Imp [10] F/C Dam Check Dam	R/Imp [5] Diversion Check Dam	R/Imp [10] Diversion Check Dam
Project Cost (Rp. Million)	44,932	66,998	84,586	43,594	46,838
Resettlement Households	147	40	147	150	177
Identification Evaluation	△	○	△	△	△
Economical Feature	○	△	X	○	○
Social Impact	X	○	X	X	X
Water Development Possibility	X	○	○	X	X
Batu Merah River Plan	FCP-BM1	FCP-BM2	FCP-BM3	FCP-BM4	FCP-BM5
Project Composition	R/Imp [30]	R/Imp [5] F/C Dam	R/Imp [10] F/C Dam	R/Imp [5] Diversion	R/Imp [10] Diversion
Project Cost (Rp. Million)	47,266	52,994	72,956	51,235	66,149
Resettlement Households	160	160	277	10	127
Identification Evaluation	△	○	△	○	△
Economical Feature	○	○	X	○	△
Social Impact	△	△	X	○	△
Water Development Possibility	X	○	○	X	X
Tomu River Plan	FCP-TM1	FCP-TM2	FCP-TM3	FCP-TM4	FCP-TM5
Project Composition	R/Imp [30] Check Dam	R/Imp [5] F/C Dam Check Dam	R/Imp [10] F/C Dam Check Dam	R/Imp [5] Diversion Check Dam	R/Imp [10] Diversion Check Dam
Project Cost (Rp. Million)	26,290	51,454	44,310	25,890	24,691
Resettlement Households	-	-	-	34	34
Identification Evaluation	○	○	○	△	△
Economical Feature	○	X	△	○	○
Social Impact	○	○	○	△	△
Water Development Possibility	X	○	○	X	X
Batu Gajah River Plan	FCP-GJ1	FCP-GJ2	FCP-GJ3	-	-
Project Composition	R/Imp [30] Check Dam	R/Imp [5] F/C Dam Check Dam	R/Imp [10] F/C Dam Check Dam	-	-
Project Cost (Rp. Million)	54,438	62,217	58,933	-	-
Resettlement Households	147	20	20	-	-
Identification Evaluation	△	○	○	-	-
Economical Feature	○	X	△	-	-
Social Impact	X	○	○	-	-
Water Development Possibility	X	○	○	-	-
Batu Gantung River Plan	FCP-GT1	FCP-GT2	FCP-GT3	-	-
Project Composition	R/Imp [30] Check Dam	R/Imp [5] F/C Dam Check Dam	R/Imp [10] F/C Dam Check Dam	-	-
Project Cost (Rp. Million)	32,145	48,952	45,198	-	-
Resettlement Households	73	-	-	-	-
Identification Evaluation	△	○	○	-	-
Economical Feature	○	X	△	-	-
Social Impact	△	○	○	-	-
Water Development Possibility	X	○	○	-	-

Note R/Imp : River Improvement ([]:Design scale of river improvement) F/C Dam : Flood Control Dam
Shade : Optimum flood control plan

Table-1.19 Optimum Flood Control Plan

Item		Ruhu	Merah	Tomu	Gajah	Gantung
		FCP-RH2	FCP-BM4	FCP-TM1	FCP-GJ3	FCP-GT3
<River Improvement Plan>						
Improvement Scale (Return Period)		5-year	5-year	30-year	10-year	10-year
River-bed Formation Length (m)		1,600	1,600	2700	2,600	1,450
River-bed Excavation	Depth (m)	1.00	1.00	0.80	1.00	1.00
	Length (m)	1,600	1,600	2,100	2,100	1,450
Concrete Channel Length (m)		-	1,200	2,100	700	900
F/Wall Heightening Length (m)	Left	300	1,010	130	230	100
	Right	350	1,070	20	150	100
River Widening Length (m)		300	70	-	-	-
Bridge Improvement Number		3	1	4	3	2
<Flood Control Dam>						
Dam Type		Rock Fill	-	-	Rock Fill	Rock Fill
Dam Height (m)		41.0	-	-	31.3	34.0
Dam Length (m)		103.0	-	-	209.0	132.0
<Diversion Channel>						
Type		-	Tunnel	-	-	-
Length		-	1,200	-	-	-
Standard Section - Width (m)		-	5.8	-	-	-
Standard Section - Height (m)		-	5.8	-	-	-
<Check Dam>						
Dam Height (m)		10	-	7	8	11
Storage Capacity (m^3)		40,000	-	37,000	10,000	36,000

Table-1.20 Project Cost and Compensation Conditions

Project Composition	Construction Cost (Rp Million)	Indirect Cost (Rp Million)	L/Acquis. & Comp. Cost (Rp Million)	Total Project Cost (Rp Million)	Land Acquisition (m^2)	Resettlement Household (number)
Ruhu	42,037	12,611	12,350	66,998	445,500	40
River Improvement	9,323	-	-	-	1,500	40
Flood Control Dam	31,344	-	-	-	411,000	0
Check Dam	1,370	-	-	-	33,000	0
Batu Merah	39,021	12,147	508	51,235	1,550	10
River Improvement	9,966	-	-	-	350	10
Diversion Channel	29,055	-	-	-	1,200	0
Tomu	20,223	6,067	0	26,290	30,000	0
River Improvement	18,753	-	-	-	0	0
Check Dam	1,470	-	-	-	30,000	0
Batu Gajah	43,006	12,902	3,025	58,933	109,000	20
River Improvement	9,091	-	-	-	0	0
Flood Control Dam	32,485	-	-	-	93,000	20
Check Dam	1,430	-	-	-	16,000	0
Batu Gantung	32,941	9,882	2,375	45,198	101,000	0
River Improvement	7,327	-	-	-	0	0
Flood Control Dam	24,284	-	-	-	95,000	0
Check Dam	1,330	-	-	-	6,000	0
Total Five	177,228	53,609	18,258	248,654	687,050	70
River Improvement	54,460	-	-	-	1,850	50
Flood Control Dam	88,113	-	-	-	599,000	20
Diversion Channel	29,055	-	-	-	1,200	0
Check Dam	5,600	-	-	-	85,000	0

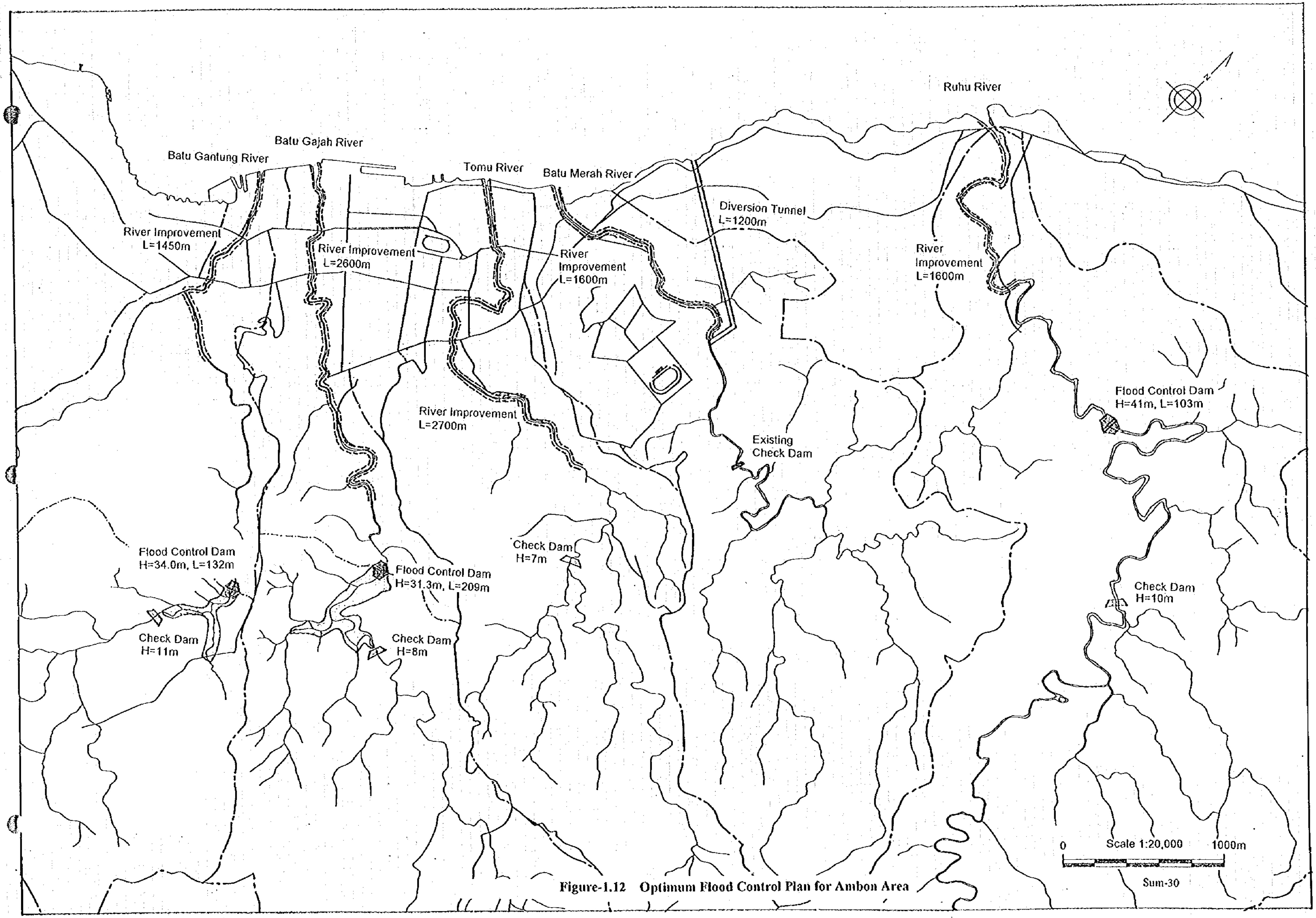


Figure-1.12 Optimum Flood Control Plan for Ambon Area

1.3.3 Non-structural Flood Control Measures

Non-structural flood control measures are defined as measures other than structural flood control measures constructed along the river to mitigate flood disasters. The targets of non-structural measures are:

1) To suppress flood runoff (including sediments)
2) To improve flood proofing function and
3) To facilitate flood prevention activities.

On the basis of the current and future forecast conditions of the target river basins, practical non-structural measures are chosen as described in the Table-1.21 and entered into the Master Plan.

Table-1.21 Non-structural Flood Control Measures for Ambon Area

Objectives	Methods	Contents	Target Area
Suppression of Flood Runoff	Land Use Regulation	Land use restriction to maintain forest and natural flood retention areas etc. based on Land Use Plan authorized by Local Government	Whole Area
	Vegetation Improvement	Active improvement of vegetation to reduce flood and sediment discharge through reforestation and re-greening	Upland Area
	Off-site Storage	Regulation reservoir to store increasing flood and sediment discharge caused by large scale land development	Whole Area
	Lowland Infiltration	To decrease rain water discharge using permeable sewerage system , infiltration wells and permeable pavement roads	Lowland Area
Improvement of Flood Proof Function	Land Use Regulation	To restrict land use in flood prone areas by authorized regulation	Whole Area
	Flood Proof Facilities	To promote flood proof public facilities and private buildings by land elevation and water proofing works	Lowland Area
Facilitation of Flood Disaster Prevention Activities	Management Organization	Establishment of flood management organization for total flood control system	-
	Flood Forecast & Warning System	Establishment of flood forecast and warning system to facilitate flood fighting and evacuation	Lowland Area
	Flood Risk Map	To prepare flood risk map and officially advise inhabitants	Lowland Area
	Flood Fighting System	Organization of flood fighting system including soft and hard systems for emergency Flood preparedness	Lowland Area
	River Management Zone	Installation of river management zone along the designated reaches	Lowland Area
	Public Awareness	Publication of flood control system including flood control measures and implementation schedule	-
	Human Resource Development	Training for personnel involved with flood control activities	-

1.3.4 River Environment Management

From the result of water pollution analysis, it is clear that the pollutant load generated from all the river basin areas has already been at a level to cause serious pollution of river water. Generally speaking, the construction of a sewerage system should be the most effective measure for a reduction in pollutant load to improve river water quality. However, according to the present condition of socio-economy and the function of the five rivers in the Study Area, it is not considered realistic to recommend sewerage system construction in this flood control master plan. Instead, possible measures are proposed for river environment management in accordance with the objectives of water utilization.

(1) Recommendations for Dam-Reservoir and Upper Stream Area

For all the multi-purpose dams proposed in the master plan, their reservoirs and upper stream areas can be put into one category with the following objectives of water utilization and river environment management : 1) Purpose of water utilization : source water for water supply; 2) Objective of water quality : grade B or higher according to the Government Regulation No. 20/1990. The measures to be taken shall include the following :

- Remove all toilets from the river and promote the use of septic tanks;
- Prevent all sewers from discharging sewage directly into the river or reservoir by building small scale infiltration basins;
- Strengthen garbage collection and prevent any solid waste from being dumped into the river or reservoir;
- Prevent people from washing and bathing in the reservoir area.

(2) Recommendations for Other Areas

For the areas downstream of the multi-purpose dams and the rivers without dam construction, the objectives of water use and river environment management are as follows:

1) Purpose of water use: washing and bathing for the residents living by the river;
2) Objective of water quality: free from fecal pollutants, garbage and concentrated discharge of any sewage water.

Since an improvement of river water quality to a level as high as grade A or B is not realistic within the framework of this master plan, a minimum objective of water quality is proposed from a viewpoint of sanitation. Accordingly, the following measures can be recommended:

- Remove all toilets from the river and promote the use of septic tanks;
- Strengthen garbage collection and prevent any solid waste from being dumped into the river;
- Carry out an inspection of all the drainage outlets to the river. At places where large quantities of sewage water are discharged into the river from a business, workshop or office building, installation of wastewater treatment facilities to be required.

(3) Sanitary Education

For effective river environment management, sanitary education is indispensable for calling public awareness to the importance of environment protection and water quality improvement. Sanitary education should be incorporated with the measures mentioned above for water quality improvement.

1.3.5 Water Utilization Plan

(1) Water Resources Development

The demand for city water in Ambon will continue to increase and it is essential that alternative sources of water supply are identified and developed. In order to meet the shortfall between demand and supply, newly developed discharge of 8,000 m^3/day can be provided from Batu Gajah Dam and 2,500 m^3/day from Batu Gantung Dam. This will be sufficient to satisfy the shortfall until 2015, assuming that PDAM develop and improve other water sources in accordance with the Water Supply Systems Development Plan. Increased exploitation of groundwater is not recommendable because of fears of depletion and salt water intrusion. In the longer term to 2030, additional developed water will be required from Ruhu Dam with 16,000 m^3/day of new development discharge. The water utilization plan for Ambon Central Area is shown in Table-1.22.

Table-1.22 City Water Development Plan - Ambon Central Area

Items		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

(2) Multi-purpose Dam Plan

The flood control dams in Ruhu River, Batu Gajah River and Batu Gantung River were proposed as part of the optimum flood control plan. After consideration of the water utilization for domestic use in the Study Area of Ambon City, multi-purpose dams were proposed as shown in Table-1.23.

Table-1.23 Specifications of Multi-purpose Dams and Reservoirs

Items		Ruhu Dam	Gajah Dam	Gantung Dam
Catchment Area	(km^2)	14.49	4.37	4.76
Sediment Capacity	(1000 m^3)	580	175	191
Water Development Capacity	(1000 m^3)	1,064	955	639
Flood Control 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
Dam Top Elevation	(m)	67.7	78.6	106.9
Dam Base Elevation	(m)	23.0	38.0	66.0
Dam Height	(m)	44.7	40.6	40.9
Dam Volume	(1000 m^3)	235	404	262
Dam Crest Length	(m)	112.0	200.0	139.0
Conduit	(m)	B3.9m x H3.9m	B8.0m x H3.40	B4.1m x H4.1m
Land Acquisition Area	(1000m^2)	515,000	148,000	139,000
Resettlement Household	(number)	-	30	-
Flood Control at Dam Site	(m^3/s)	159	22	32
Developed Water Volume	(m^3/days)	16,000	8,000	2,500
Construction Cost of Dam	(Rp. Mil)	36,646	49,480	35,306

1.3.6 Implementation Schedule

The implementation schedule of the Flood Control Master Plan was prepared as shown in Table-1.24, giving higher priority to the projects which show higher economic efficiency and less negative social impact.

Table-1.24 Implementation Schedule of Flood Control Master Plan

Items \ Fiscal Year	(1) 1998 99	(2) 1999 00	(3) 2000 01	(4) 2001 02	(5) 2002 03	(6) 2003 04	(7) 2004 05	(8) 2005 06	(9) 2006 07	(10) 2007 08	(11) 2008 09	(12) 2009 10	(13) 2010 11	(14) 2011 12	(15) 2012 13
Structural Measures															
<<< Phase-1 >>>															
1-1 Preparation															
(a) Procurement															
- Consultant	XX														
- Contractor			XX	XX											
(b) Detailed Design		XX	XX												
1-2 Consulting Services															
(a) Survey and Design		XX	XX												
(b) Tender Assistance			XX	XX											
(c) Supervision					XX	XX	XX	XX	XX	XX					
1-3 Construction															
5 Rivers' Improvement					XX	XX	XX	XX							
4 Check Dams					XX	XX									
Merah Diversion					XX	XX									
Batu Gajah Dam					XX	XX	XX	XX	XX	XX					
Batu Gantung Dam					XX	XX	XX	XX	XX	XX					
<<< Phase-2 >>>															
2-1 Preparation															
(a) Procurement															
- Consultant						XX									
- Contractor								XX	XX						
(b) Detailed Design							XX	XX							
2-2 Consulting Services															
(a) Survey and Design							XX	XX							
(b) Tender Assistance								XX	XX						
(c) Supervision										XX	XX	XX	XX	XX	XX
2-3 Construction															
Ruhu Dam										XX	XX	XX	XX	XX	XX
Non-Structural Measures															
- Management Organization	XX														
- Forecast/Warning System		XX	XX	XX	XX										
- Flood Risk Map		XX	XX												
- Flood Fighting System		XX	XX	XX	XX										
- Public Awareness		XX	XX												
- Human Development		XX	XX	XX	XX	XX	XX	XX	XX						
- Land Use Regulation		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==
- Vegetation Improvement		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==
- Off site Storage		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==
- Infiltration in Lowland		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==
- Land Use Regulation		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==
- Flood Proof Facility		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==
- River Management Zone		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==

[Note] XX: Mainly dealt by Flood Control Project Office
Z Z: Planned by Special Committee, = =: Implemented by each Related Organization

1.3.7 Evaluation of Plan

(1) Initial Environmental Examination

The objectives of the initial environmental examination (IEE) are to examine any possible impacts on the environment in both the construction phase and operation phase. As a result of IEE, significant negative impact is identified on 3 environmental elements, namely resettlement, solid waste and groundwater. Possible negative impact is envisaged on 8 environmental elements from some project activities. The environmental element of both significant and possible negative impact is as shown in Table-1.25.

Regarding other environmental elements, no negative impacts are anticipated from any of the project activities.

Table-1.25 Environmental Examination Matrix

River Basin	Ruhu			B. Merah		Tomu		B. Gajah			B. Gantung		
Facilities	R/I	C/D	Dam	R/I	D/T	R/I	C/D	R/I	C/D	Dam	R/I	C/D	Dam
<Construction Phase>													
Social Environment													
Resettlement	×	-	-	-	Δ	-	-	×	-	×	×	-	-
Economic Activity	Δ	-	Δ	-	Δ	-	-	Δ	-	Δ	Δ	-	Δ
Traffic and Living Facilities	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Pub. Health and Sanitation	Δ	-	-	Δ	-	Δ	-	Δ	-	-	Δ	-	-
Solid Waste	×	Δ	Δ	×	Δ	×	Δ	×	Δ	Δ	×	Δ	Δ
Natural Environment													
Topography and Geology	-	-	Δ	-	-	-	-	-	-	Δ	-	-	Δ
Soil Erosion	-	-	Δ	-	-	-	-	-	-	Δ	-	-	Δ
Groundwater	-	-	-	-	×	-	-	-	-	-	-	-	-
Coastal Area	Δ	-	-	Δ	-	Δ	-	Δ	-	-	Δ	-	-
Environmental Pollution													
Water Pollution	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Noise and Vibration	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Offensive Odor	Δ	-	-	Δ	-	Δ	-	Δ	-	-	Δ	-	-
<Operation Phase>													
Social Environment													
Resettlement	-	-	-	-	-	-	-	-	-	-	-	-	-
Economic Activity	-	-	-	-	-	-	-	-	-	-	-	-	-
Traffic and Living Facilities	-	-	-	-	-	-	-	-	-	-	-	-	-
Pub. Health and Sanitation	-	-	-	-	-	-	-	-	-	-	-	-	-
Solid Waste	-	-	-	-	-	-	-	-	-	-	-	-	-
Natural Environment													
Topography and Geology	-	-	-	-	-	-	-	-	-	-	-	-	-
Soil Erosion	-	-	-	-	-	-	-	-	-	-	-	-	-
Groundwater	-	-	Δ	-	×	-	-	-	-	×	-	-	×
Coastal Area	-	-	-	-	-	-	-	-	-	-	-	-	-
Environmental Pollution													
Water Pollution	-	-	Δ	-	-	-	-	-	-	Δ	-	-	Δ
Noise and Vibration	-	-	-	-	-	-	-	-	-	-	-	-	-
Offensive Odor	-	-	-	-	-	-	-	-	-	-	-	-	-

R/I: River Improvement, C/D: Check Dam, Dam: Multipurpose Dam
×: Significant Negative Impact, Δ: Possible Negative Impact, -: No Negative Impact

(2) Economic Evaluation

Economic analysis at the Master Plan level was conducted under the following assumptions: 1) price level: end of December 1996, 2) design scale: 30-year return period, 3) project life: 50 years, 4) maintenance costs: 0.5% of the total construction costs per year, 5) shadow pricing: standard conversion rate 85%, 6) property value growth rate: 5.0% per year.

Table-I.26 shows the results of economic analysis on the construction of the flood control facilities for each of the five rivers and on the entire project, based on the assumption that all the facilities are constructed in five years for separate cases and in nine years for the entire project. Construction of flood control facilities in each river is assessed to be feasible, presenting IRR of between 10.9 % and 21.8%. Among others, Batu Merah and Tomu rivers present high IRR. The entire project is also assessed to be feasible, attaining 16.0% IRR.

Table-I.26 Economic Evaluation of Flood Control Plan for Ambon Area

River System	Facilities	Economic Cost Million Rp	Net Present Value at 10% Million Rp	Benefit/Cost at 10%	Internal Rate of Return
Ruhu	River improvement and multi-purpose dam	77,094	18,965	1.2	12.1 %
Batu Merah	River improvement and diversion channel	43,550	90,614	3.6	21.8 %
Tomu	River improvement	22,347	36,514	2.1	19.7 %
Batu Gajah	River improvement and multi-purpose dam	76,594	45,628	1.7	14.4 %
Batu Gantung	River improvement and multi-purpose dam	53,634	6,256	1.1	10.9 %
Five Rivers		273,219	179,576	2.2	16.0 %

Note. The figures for each river are based on the assumption that all the facilities are constructed in the first five years. The figures for the five rivers is based on the implementation schedule.

(3) Financial Consideration

The total budget in DGWRD for the fiscal year 1996/97 is Rp 3,098 billion, of which Rp 958 billion is financed through foreign loans. Rp 430 billion is allocated for flood control projects, of which more than 50% is currently financed through foreign loans.

The DGWRD envisages that most likely two new projects could be financed by OECF every year. The flood control project in Ambon City is a strong candidate for such financing, since Ambon City is the administrative and commercial center of Maluku Province. Consistent with the Government's development policy in the eastern regions, this project is also expected to be given high priority, although the decision to invest is contingent on the cost-effectiveness and impact of the project itself. If this project is adopted, operational and maintenance costs will also be financed through the central Government. If an OECF loan is not available for this project, the project will have to be scaled down due to the central Government's budgetary constraints. Although it would be ideal to take long-term flood control measures, the investment would be obliged to focus only on the most critical project components.

1.4 Priority Project

1.4.1 Selection of Priority Project

Taking into account of Economic Feasibility, Urgent Requirement and Less Social and Environmental Impact, priority projects were selected from the Flood Control Master Plan as shown in following Table-1.27.

Table-1.27 Composition of Priority Projects

River	Target of Planning Scale in Priority Projects	Component
Ruhu River	5-year return period	(1) River Improvement (5-year return period) (2) Check Dam
Batu Merah River	30-year return period	(1) River Improvement (5-year return period) (2) Diversion Channel
Tomu River	30-year return period	(1) River Improvement (30-year return period) (2) Check Dam
Batu Gajah River	30-year return period	(1) River Improvement (10-year return period) (2) Multi-purpose Dam (3) Check Dam
Batu Gantung River	30-year return period	(1) River Improvement (10-year return period) (2) Multi-purpose Dam (3) Check Dam

1.4.2 Plan of Priority Project

(1) General Conditions

<Objectives of the Priority Projects>

- To mitigate flood damage which occurs annually along the five rivers,
- To supply raw water for domestic and industrial use in Ambon City,
- To improve the river environment and to improve water quality and quantity

<Basic Conditions>

- Target Year for Planning : Year of 2015
- Target Completion Year : Fiscal Year of 2007/08
- Planning Scale : 30-year return period but 5-year Ruhu River.
- Design Rainfall : 422 mm (30-year return period)
- Design Hyetograph : 1990/6/6 Flood

(2) Ruhu River Project

(a) River Improvement Plan

River improvement range is set from river mouth to 1k600 i.e. 1,600m length with design discharge distribution of the following Figure-1.13. Longitudinal Section and standard cross sections of Ruhu River Improvement Plan are shown in Figure-1.14.

(b) Check Dam Plan

- Dam Site Location : 6k100 (Upstream of RH-1 Dam)
- Catchment Area : 10.9 km^2
- Design Discharge : 281.0 m^3/sec (100-year return period)
- Proposed Capacity : 40,000 m^3

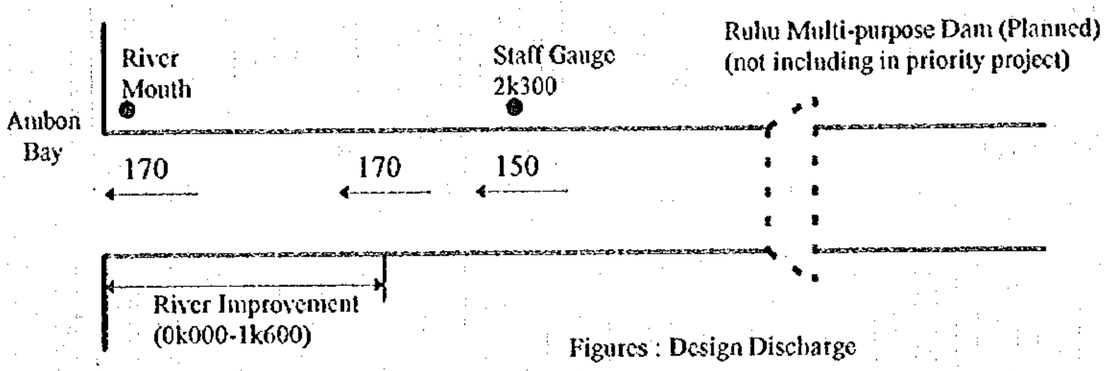
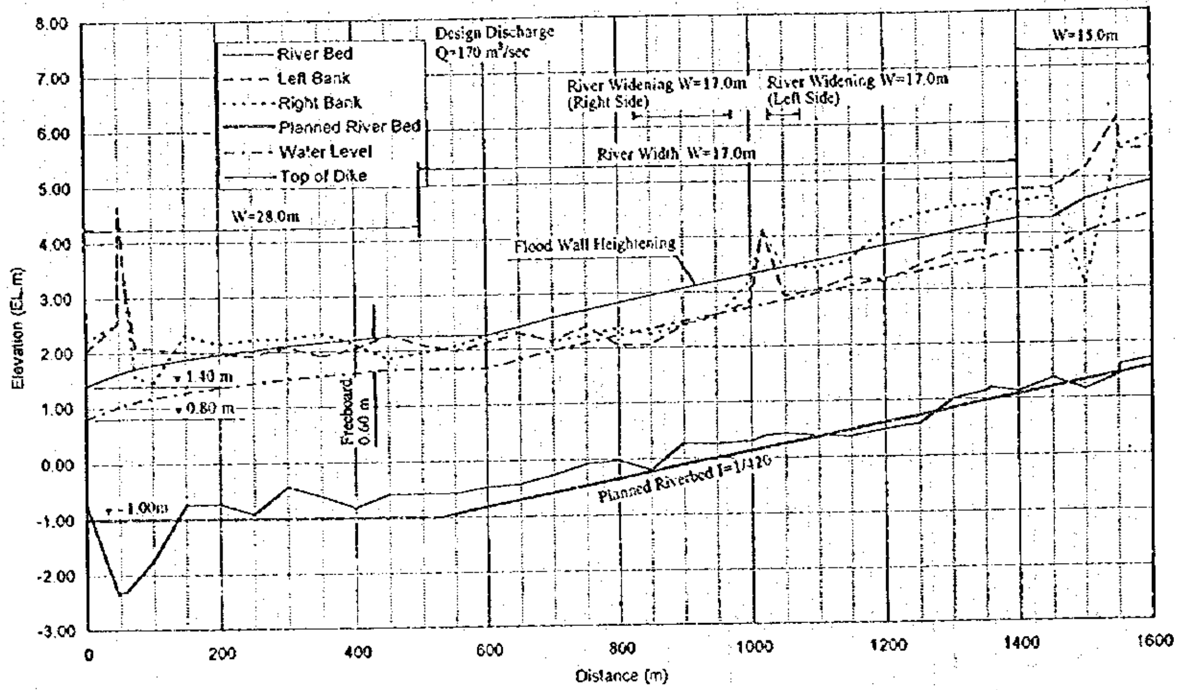
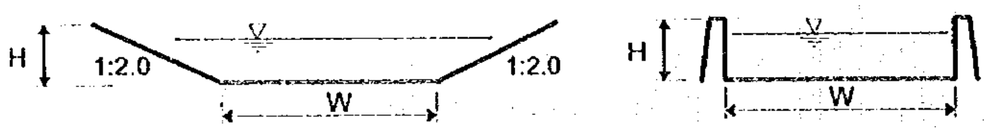


Figure-1.13 Design Discharge Distribution (Ruhu River)

[Longitudinal Section]



[Standard Cross Section]



0k000-0k450 : W=28.0m, H=2.4-3.3m

0k500 : W=28.0m, H=3.3m
0k550-1k400 : W=17.0m, H=3.2m
1k450-1k600 : W=15.0m, H=3.4m

Figure-1.14 Ruhu River Improvement Plan

(3) Batu Merah River Project

(a) River Improvement Plan

River improvement range is set from river mouth to 1k500 i.e. 1,500m length with design discharge distribution of the following Figure-1.15. Longitudinal Section and standard cross sections of Batu Merah River Improvement Plan are shown in Figure-1.16.

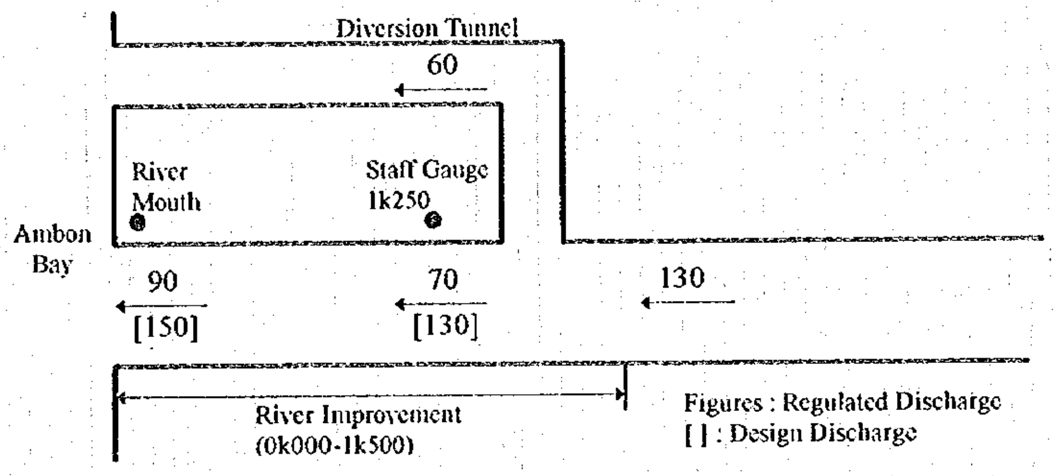
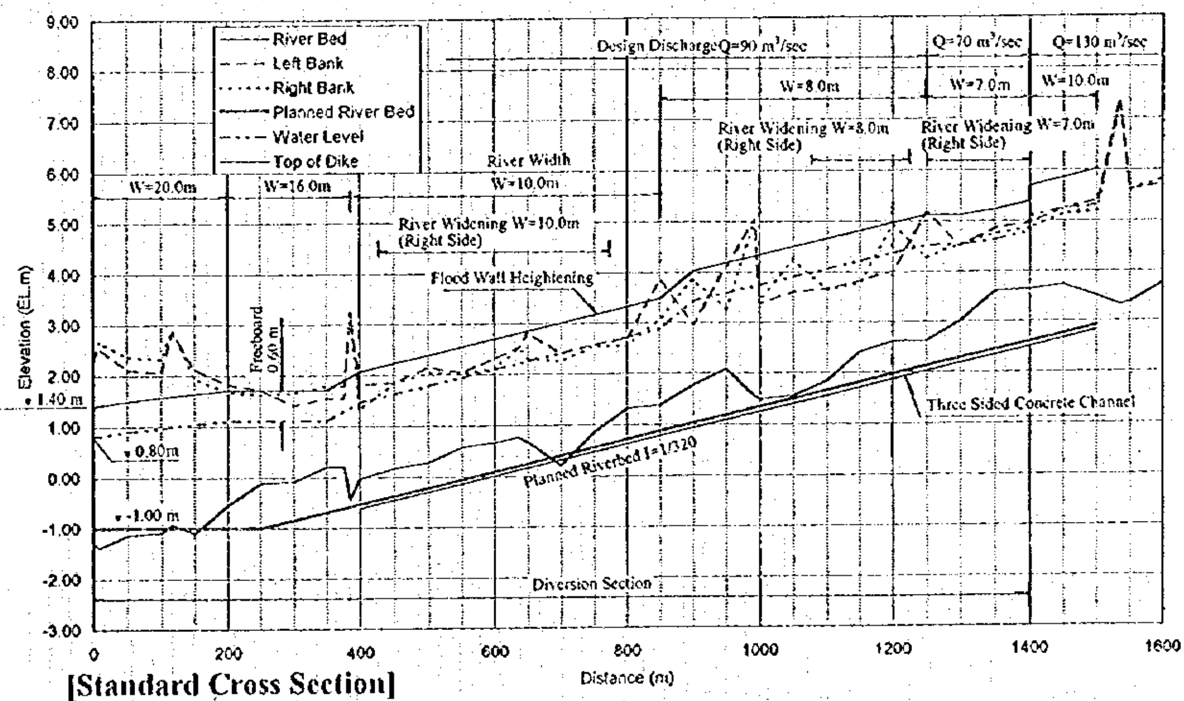
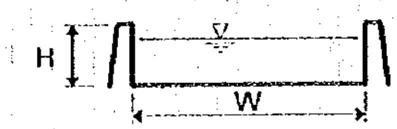


Figure-1.15 Design Discharge Distribution (Batu Merah River)

[Longitudinal Section]



[Standard Cross Section]



0k000-0k600 : W=14.0m, H=2.0-2.9m
0k650-1k050 : W=12.0m, H=2.5-2.6m
1k100-1k500 : W=15.0m, H=1.9-2.6m
1k550-2k200 : W= 8.0m, H=2.1-2.7m
2k250-2k700 : W= 7.0m, H=2.4m

Figure-1.16 Batu Merah River Improvement Plan

(b) Diversion Inlet Plan

- Planned Diversion Section : 1k400
- Discharge Distribution : Upstream : 130 m^3/sec
  Diversion : 60 m^3/sec
  Downstream : 70 m^3/sec
- Diversion Works : Side Weir
- Initial discharge to start diversion : 20 m^3/sec

(4) Tomu River Project

(a) River Improvement Plan

River improvement range is set from river mouth to 2k700 i.e. 2,700m length with design discharge distribution of the following Figure-1.17. Longitudinal Section and standard cross sections of Tomu River Improvement Plan are shown in Figure-1.18.

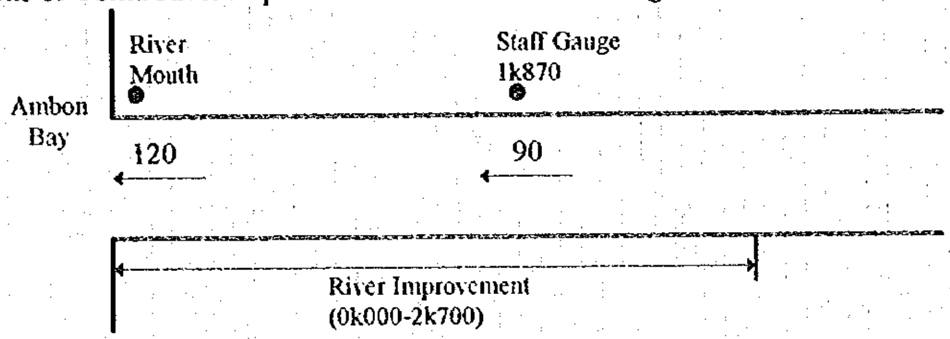


Figure-1.17 Design Discharge Distribution (Tomu River)

[Longitudinal Section]

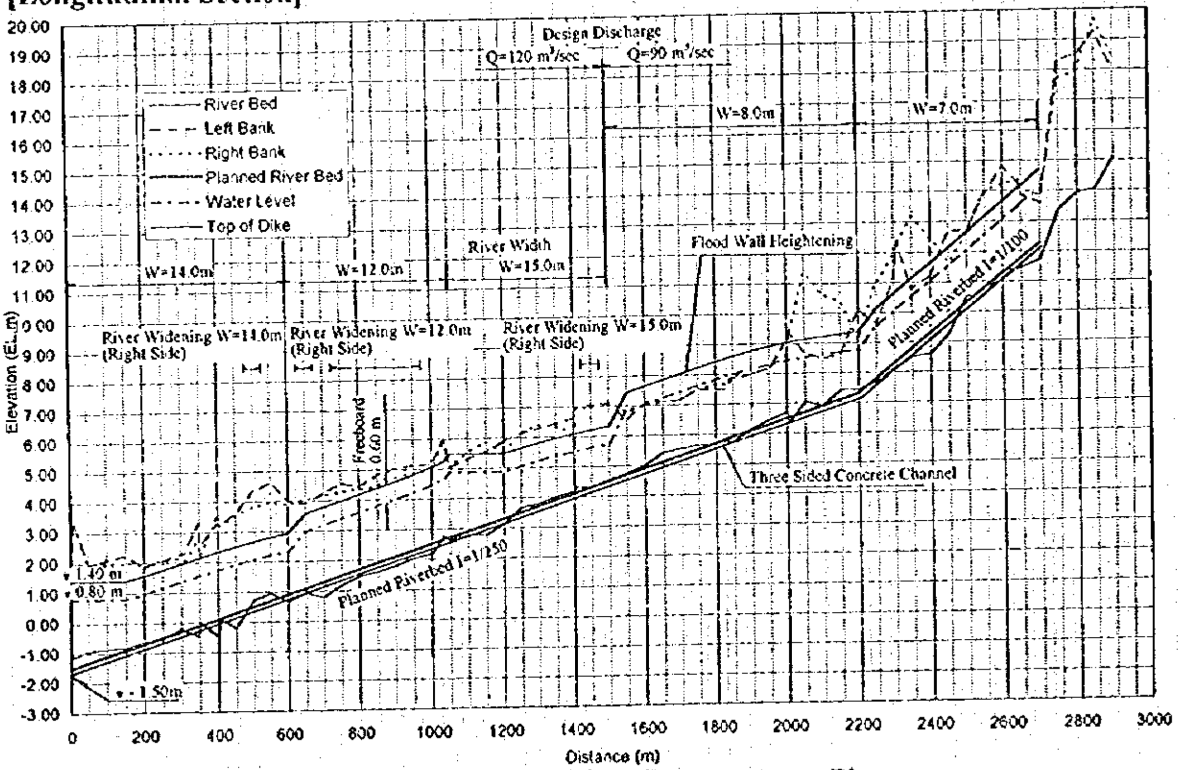
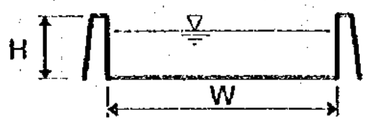


Figure-1.18(1) Tomu River Improvement Plan

[Standard Cross Section]



0k000-0k600	: W=14.0m, H=2.0-2.9m
0k650-1k050	: W=12.0m, H=2.5-2.6m
1k100-1k500	: W=15.0m, H=1.9-2.6m
1k550-2k200	: W= 8.0m, H=2.1-2.7m
2k250-2k700	: W= 7.0m, H=2.4m

Figure-1.18(2) Tomu River Improvement Plan

(b) Check Dam Plan

- Dam Site Location : 3k500
- Catchment Area : 2.7 km^2
- Design Discharge : 73 m^3/sec (100-year return period)
- Proposed Capacity : 37,000 m^3

(c) River Amenity Improvement

Tomu River amenity improvement would be implemented as a monument of the Ambon flood control project. The contents of Tomu River amenity improvement are set as follows:

- To setup wide foot bridges in order to connect both sides of the river between Mardika Bus Terminal and Victoria Park.
- To arrange trees for shade and flowering plants for amenity
- This area should be a breathing area or a oasis for city people
- Flood walls should not be concrete but natural.

Amenity improvement image of Tomu River is shown in Figure-1.19.

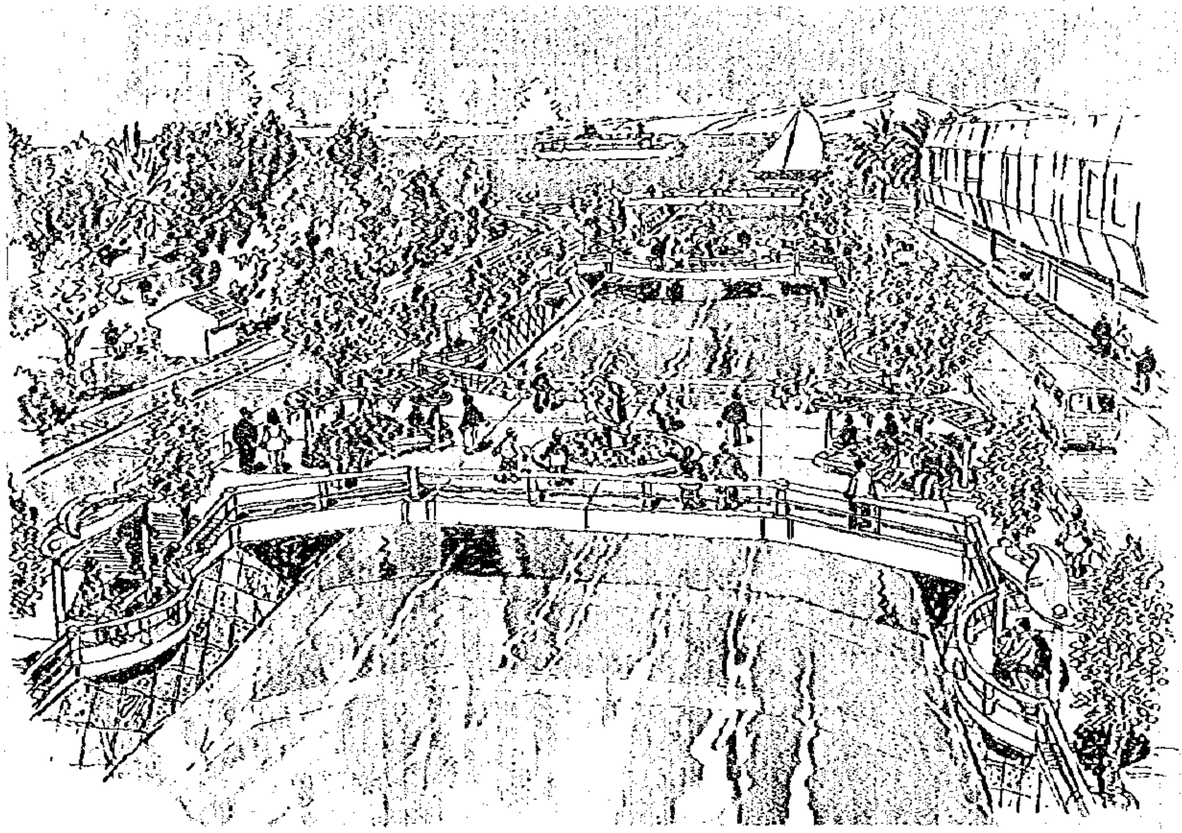


Figure-1.19 Amenity Improvement Image of Tomu River

(5) Batu Gajah River Project

(a) River Improvement Plan

River improvement range is set from river mouth to 2k200 i.e. 2,200m length with design discharge distribution of the following Figure-1.20. Longitudinal Section and standard cross sections of Batu Gajah River Improvement Plan are shown in Figure-1.21.

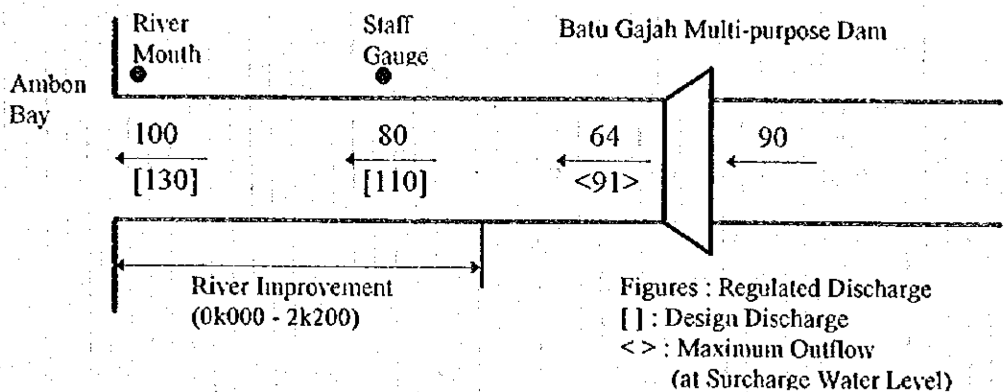
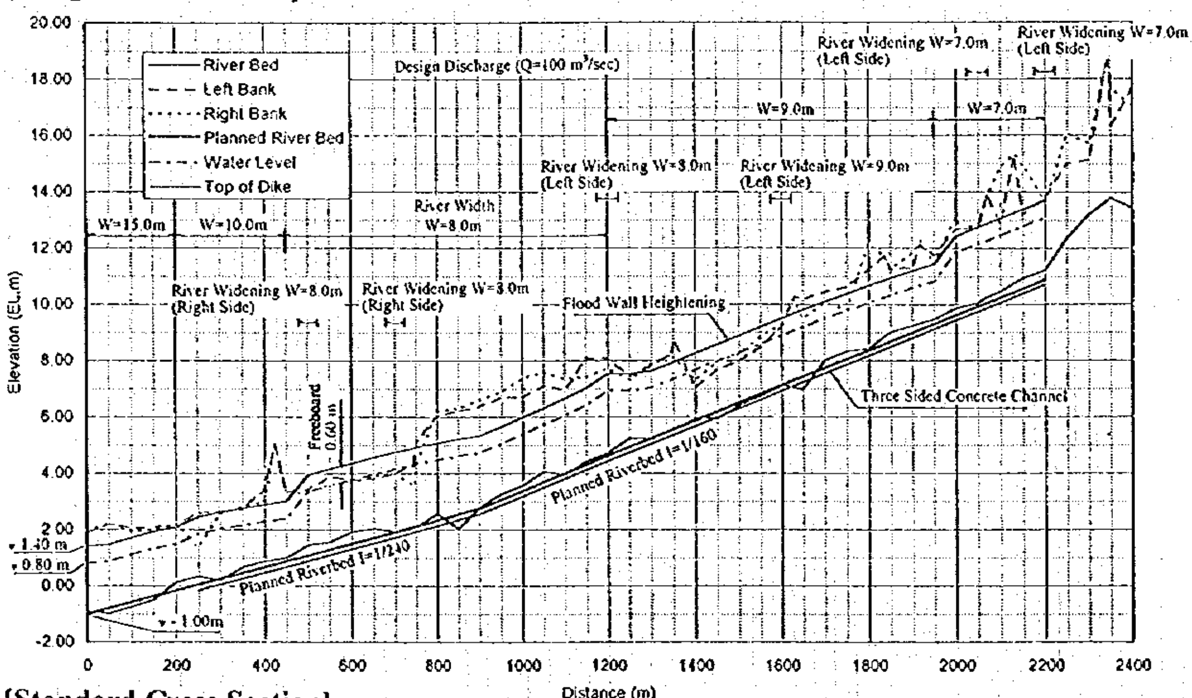
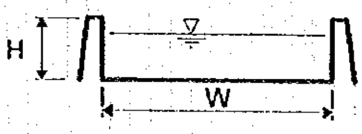


Figure-1.20 Design Discharge Distribution (Batu Gajah River)

[Longitudinal Section]



[Standard Cross Section]



0k000-0k200 : W=15.0m, H=2.3-2.4m
0k250-0k450 : W=10.0m, H=2.1-2.4m
0k500-1k200 : W= 8.0m, H=2.6-2.9m
1k250-1k950 : W= 9.0m, H=2.1-2.6m
2k000-2k200 : W= 7.0m, H=2.8m

Figure-1.21 Batu Gajah River Improvement Plan

(b) **Check Dam Plan**

- Dam Site Location : 4k250
- Catchment Area : 2.8 km^2
- Design Discharge : 74 m^3/sec (100-year return period)
- Proposed Capacity : 10,000 m^3

(c) **Batu Gajah Multi-purpose Dam Plan**

In flood regulation plan by Batu Gajah Dam, the Natural Control Method is adopted as the flood regulation system and flood regulation calculation was carried out, so as to become less than 100 m^3/sec and 80 m^3/sec at the reference points of river mouth and staff gauge points. As water utilization plan newly development discharge was set at 8,000 m3/day. Based on the above study, the specification of Batu Gajah Multi-purpose Dam is determined as shown in Table-1.28 and the dam reservoir volume allocation is shown in Figure-1.22.

Table-1.28 Specification of Batu Gajah Multi-purpose Dam

Items		Unit	Specification	Remarks
Reservoir	Catchment Area	km^2	4.27	
	Reservoir Area	m^2	144,000	
	Total Storage Capacity	m^3	1,532,000	
	Effective Storage Capacity	m^3	1,361,000	
	Flood Storage Capacity	m^3	406,000	
	Water Utilization Capacity	m^3	955,000	
	: River Maintenance Capacity	m^3	70,000	3,700 m^3/day
	: New Development Capacity	m^3	885,000	8,000 m^3/day
	Sediment Capacity	m^3	171,000	400 m^3/km^2/year
	Design High Water Level (H.W.L.)	EL.m	71.50	
	Surcharge Water Level (S.W.L.)	EL.m	70.50	
	Normal Water Level (N.W.L.)	EL.m	66.60	
	Low Water Level (L.W.L.)	EL.m	51.60	
Dam	Dam Type	-	Rock Fill	
	Dam Top Level	EL.m	75.00	
	Dam Foundation Level	EL.m	25.00	
	Dam Height	m	50.00	

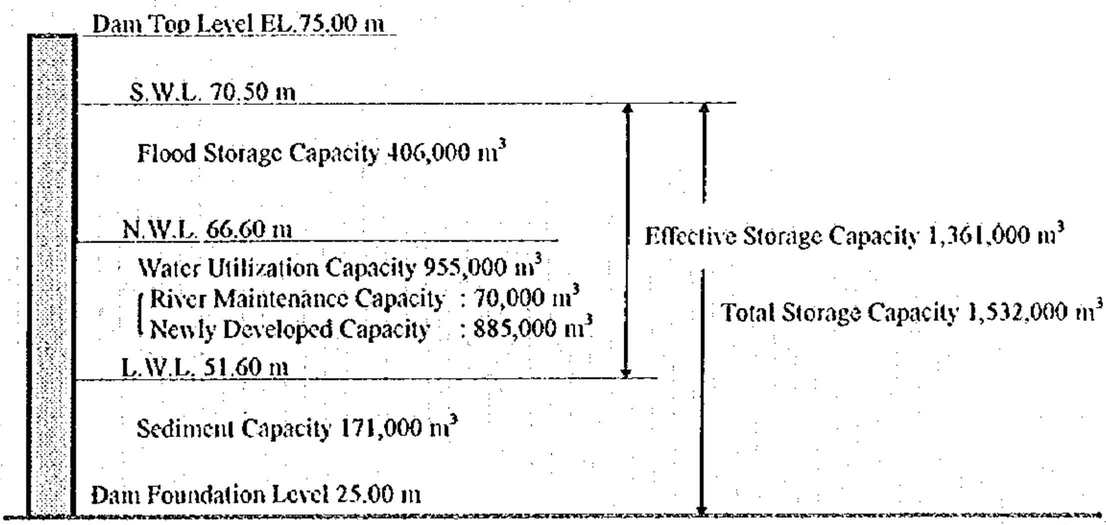


Figure-1.22 Reservoir Volume Allocation for Batu Gajah Multi-purpose Dam

(6) Batu Gantung River Project

(a) River Improvement Plan

River improvement range is set from river mouth to 1k450 i.e. 1,450m length with design discharge distribution of the following Figure-1.23. Longitudinal Section and standard cross sections of Batu Gantung River Improvement Plan are shown in Figure-1.24.

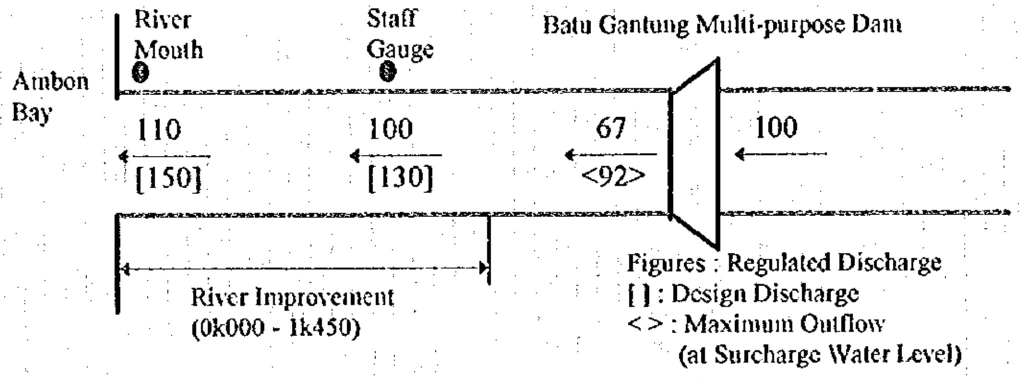
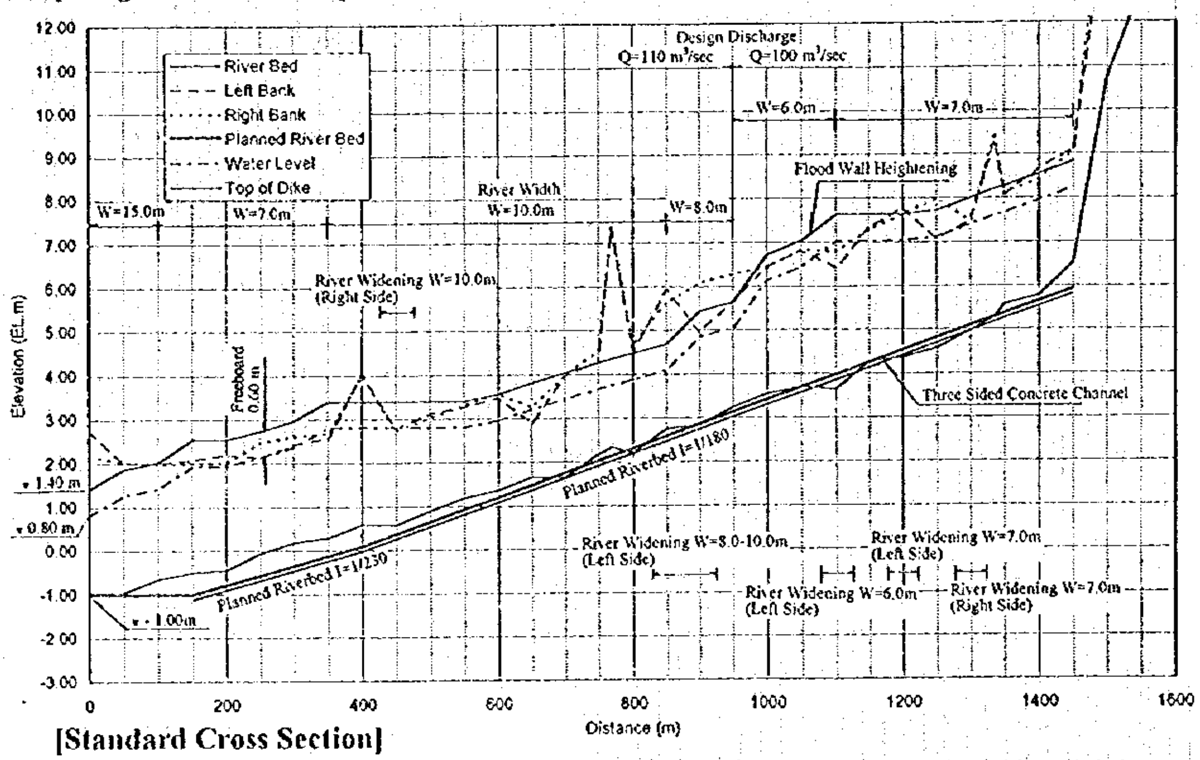
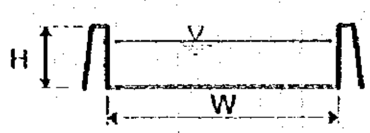


Figure-1.23 Design Discharge Distribution (Batu Gantung River)

[Longitudinal Section]



[Standard Cross Section]



0k000-0k150	: W=15.0m, H=2.4-3.0m
0k200-0k350	: W= 7.0m, H=3.3-3.5m
0k400-0k850	: W=10.0m, H=2.1-3.3m
0k900-0k950	: W= 8.0m, H=2.5-2.6m
1k000-1k100	: W= 6.0m, H=3.3-3.7m
1k150-1k450	: W= 6.0m, H=2.9-3.4m

Figure-1.24 Batu Gantung River Improvement Plan

(b) Check Dam Plan

- Dam Site Location : 4k000
- Catchment Area : 3.1 km^2
- Design Discharge : 83 m^3/sec (100-year return period)
- Proposed Capacity : 36,000 m^3

(c) Batu Gantung Multi-purpose Dam Plan

In flood regulation plan by Batu Gantung Dam, the Natural Control Method is adopted as the flood regulation system and flood regulation calculation was carried out , so as to become less than 110 m^3/sec and 100 m^3/sec at the reference points of river mouth and staff gauge points. As water utilization plan newly development discharge was set at 2,500 m^3/day. Based on the above study, the specification of Batu Gantung Multi-purpose Dam is determined as shown in Table-1.29 and the dam reservoir volume allocation is shown in Figure-1.25.

Table-1.29 Specification of Batu Gantung Multi-purpose Dam

Items		Unit	Specification	Remarks
Reservoir	Catchment Area	km^2	4.76	
	Reservoir Area	m^2	139,000	
	Total Storage Capacity	m^3	1,337,000	
	Effective Storage Capacity	m^3	1,146,000	
	Flood Storage Capacity	m^3	507,000	
	Water Utilization Capacity	m^3	639,000	
	: River Maintenance Capacity	m^3	249,000	2,070 m^3/day
	: Newly Development Capacity	m^3	390,000	2,500 m^3/day
	Sediment Capacity	m^3	191,000	400 m^3/km^2/year
	Design High Water Level (H.W.L.)	EL.m	104.10	
	Surcharge Water Level (S.W.L.)	EL.m	102.10	
	Normal Water Level (N.W.L.)	EL.m	96.80	
	Low Water Level (L.W.L.)	EL.m	85.90	
Dam	Dam Type	-	Rock Fill	
	Dam Top Level	EL.m	106.60	
	Dam Foundation Level	EL.m	70.00	
	Dam Height	m	36.60	

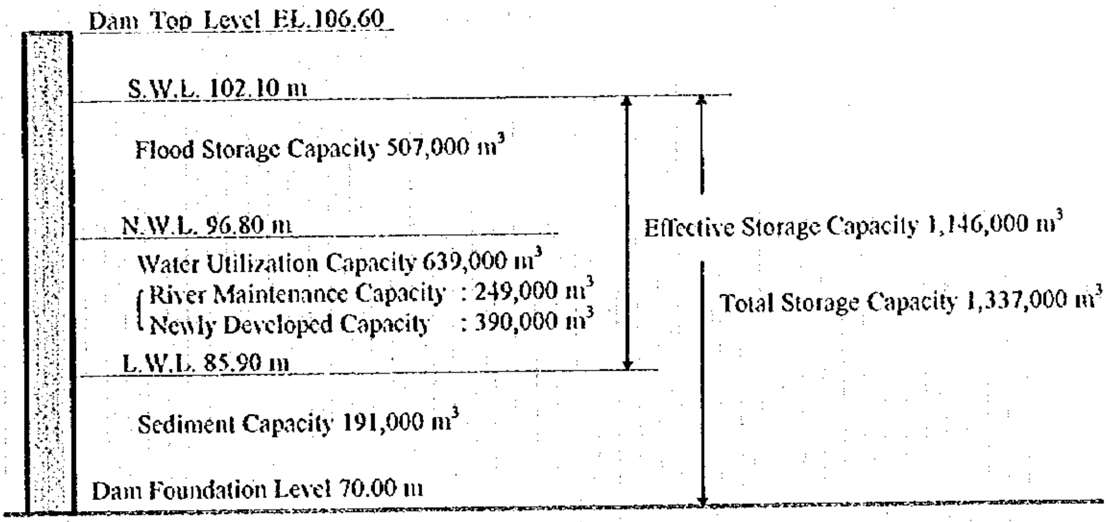


Figure-1.25 Reservoir Volume Allocation for Batu Gantung Multi-purpose Dam