3.7 Project Evaluation

3.7.1 Initial Environmental Examination

Initial environmental examination (IEE) was conducted by using an environmental examination matrix with its vertical axis consisting of rows for project activities that might cause environmental impacts, and horizontal axis consisting of columns of environmental elements grouped in 3 categories: social environment, natural environment and environment pollution. As is shown in Table-I.3.34, the project activities consist of river improvement for the 5 rivers, construction of a diversion channels for Batu Merah River, check dams for 4 rivers (Ruhu, Tomu, Batu Gajah and Batu Gantung) and multipurpose dams for 3 rivers (Ruhu, Batu Gajah and Batu Gantung). For each of the project items, both the construction phase and operation phase are considered. The environmental elements are those specified in JICA Environmental Guidelines for River and Sabo Engineering. Three kinds of marks are used to identify the extent of impact of each project activity on each environmental item according to an analysis of environmental condition at the project sites. As a result, significant negative impact is identified on 3 environmental elements, and possible negative impact is envisaged on 11 environmental elements from some project activities. The following paragraphs give the rationale.

(1) Social Environment

Regarding social environment, impacts are anticipated on resettlement, economic activity, traffic & living facilities, solid waste and public health & sanitation.

Project implementation may require a resettlement program for a number of residential houses and some small scale public facilities, and all the river improvement and diversion channel construction activities may more or less affect traffic facilities in the related area.

The river improvement and diversion channel construction sites are all at the downstream area where residential houses are densely distributed. Although the local government has put forward a regulation that river banks with a width of 10-15 meters should be vacant as access road for river inspection, there are still many houses built very close to the river. This makes it difficult to plan river course widening and diversion channel route without impacts on any existing house. The multipurpose dam sites have been carefully located at the upstream sides of the Ruhu, Batu Gajah and Batu Gantung rivers to eliminate large scale resettlement. However, about 20 houses will have inevitably to be relocated from the site of Batu Gajah River as will a public health center from the site of Batu Gantung River. Related to resettlement, certain impact on economic activity should also be considered.

The construction work for river improvement, especially river bed excavation will result in generating large quantities of solid waste. Its transportation and final disposal have to be well planned. Similar problem may be encountered during the constructions of dams and diversion channels. As has been described in Section 1.5, the 5 rivers currently act as sewage and garbage receivers due to lack of public sewers and insufficient garbage collection. Therefore, solid waste excavated from the river bed will include sewage sludge. Offensive odor may be emitted at the excavation site and during sludge transportation to a final disposal site.

Table-I.3.34 Environmental Examination Matrix

Project Area	Project Phase	River Basin	Project Item	Resettlement	Economic Activity	Traffic & Living Facilities	Community Separation	Archaeological & Cultural Properties	Water Right / Right of Common	Public Health & Sanitation	Solid Waste	Risk of Disaster	Topography & Geography	Soil Erosion	Groundwater	Lake and Rivers	Coastal Area	Flora & Fauna	Meteorology	Landscape	Air Pollution	Water Pollution	Soil Pollution	Noise & vibration	Ground Subsidence	Offensive Odor
Ambon Central Area	Construction Phase	Ruhu	River	×	△	△				△	×						△					△		△		△
			Dam								△		△	△								△		△		
			Check Dam			△					△											△		△		
		Batu Merah	River			△				△	×						△					△		△		△
			Diversion	×	△	△					△				×							△		△		
		Tomu	River			△				△	×						△					△		△		△
			Check Dam			△					△											△		△		
		Batu Gajah	River	×	△	△				△	×						△					△		△		△
			Dam	×	△	△					△		△	△								△		△		
			Check Dam			△					△											△		△		
		Batu Gantung	River	×	△	△				△	×						△					△		△		△
			Dam	△	△	△					△		△	△								△		△		
			Check Dam			△					△											△		△		
	Operation Phase	Ruhu	River																							
			Dam												△							△				
			Check Dam																							
		Batu Merah	River																							
			Diversion												×											
		Tomu	River																							
			Check Dam																							
		Batu Gajah	River																							
			Dam												×							△				
			Check Dam																							
		Batu Gantung	River																							
			Dam												×							△				
			Check Dam																							

River: River Improvement Dam: Dam Constraction Check Dam: Check Dam Construction △: Possible Negative Impact ×: Significant Negative Impact Shade: No Negative Impact

(2) Natural Environment

Regarding natural environment, impacts are anticipated on topography/geology, soil erosion, coastal area and groundwater

Dam construction may involve great scale excavation and banking of earth. Its impact on topography, geography and soil erosion should be further investigated.

The 5 rivers flow directly into the Ambon Bay and sediment runoff has coursed coastal pollution. During river improvement, sediment content in the river stream will unavoidably increase and possible impact on coastal area should be considered.

During the operation phase, groundwater is the only environmental element on which impact is anticipated from the multipurpose dams. In the Study Area, groundwater is the main source of water supply. Many wells and springs are scattered along the river and replenished by river water permeation. Since the dam will lift water level in the reservoir area, this will change the amount of replenishment from surface flow to groundwater aquifers. Groundwater at downstream side of the dam will also be influenced. Hydrogeological analysis will be necessary for an assessment of this impact.

(3) Environmental Pollution

Regarding environmental pollution, the impacts on water pollution, noise & vibration, and offensive odor are anticipated.

Construction of the dams, check dams, diversion channels, and river improvement may somewhat affect river flow and increase pollutant load to the river, such as SS from construction work, oil and grease from construction machinery, BOD and other pollutants from workers at the work site etc.

When the multipurpose dams are also used for water supply, water quality conservation will be very important for the reservoirs. For the Ruhu Dam, since a sanitary landfill site is at the upstream side of the reservoir area, the effluent from that site may more or less affect the water quality in the reservoir in the future. This should be taken into consideration before project implementation. Well management of garbage dumping and treatment of the effluent emitted from the landfill site shall be required.

Similar consideration should also be given to the Batu Merah and Batu Gantung Dams. Further study shall be necessary for identifying the pollution sources to the reservoirs, predicting water quality in the future, and recommending measures for water quality protection and improvement.

Noise and vibration from construction machinery and vehicles may more or less affect the life of residents near a work site and/or transportation road, for all the facility constructions and river improvement work.

Offensive odor may be emitted from the river bottom materials dredged out during the river improvement work, since large quantities of sewage sludge and garbage have been dumped to the rivers so far. This is related to the problem of public health mentioned above.

3.7.2 Economic Evaluation

(1) Basis for Economic Evaluation

(a) General Concept

The economic evaluation for this project was performed by comparing the present value (at the beginning of the year 1998) of costs and benefits that occur in different time periods. The benefits, which will start to materialize immediately after the completion of the construction of each flood control facility, are comprised of several types of damage alleviation to be achieved by the flood control facilities - damage to general assets (houses/buildings, household goods and industry inventories), damage to infrastructure and damage from disruption of businesses.

The yearly average of flood damage alleviation can be calculated as shown in Table-I.3.35. Table-I.3.36 shows the yearly averages of damage alleviation of the five rivers, after the completion of construction, estimated by the study team.

Table-I.3.35 Calculation of Yearly Average of Flood Damage Alleviation

Flood Discharge Level	Annual Probability	Annual Average Probability	Estimated Damage	Average Estimated Damage	Average Annual Damage	Cumulative Average Annual Damage
Q_0	N_0	-	$L_0(=0)$	-	-	-
Q_1	N_1	N_0-N_1	L_1	$(L_0+L_1)/2$	$(N_0-N_1)*(L_0+L_1)/2$	$(N_0-N_1)*(L_0+L_1)/2$
Q_2	N_2	N_1-N_2	L_2	$(L_1+L_2)/2$	$(N_0-N_1)*(L_0+L_1)/2$	$(N_0-N_1)*(L_0+L_1)/2 + (N_0-N_1)*(L_0+L_1)/2$
Q_m	N_m	$N_{m-1}-N_m$	L_m	$(L_{m-1}+L_m)/2$	$(N_{m-1}-N_m)*(L_{m-1}+L_m)/2$	$(N_0-N_1)*(L_0+L_1)/2 + \cdots (N_{m-1}-N_m)*(L_{m-1}+L_m)/2$

Table-I.3.36 Yearly Averages of Damage Alleviation of the Five Rivers

Name of River	Yearly Average of Damage Alleviation		
Return Period	5-year	10-year	30-year
Ruhu	Rp. 2,087 million	Rp. 2,401 million	Rp. 2,879 million
Batu Merah	Rp. 6,485 million	Rp. 6,973 million	Rp. 8,157 million
Tomu	Rp. 2,132 million	Rp. 2,535 million	Rp. 3,534 million
Batu Gajah	Rp. 3,521 million	Rp. 4,246 million	Rp. 5,801 million
Batu Gantung	Rp. 2,300 million	Rp. 2,508 million	Rp. 2,865 million
T	Rp. 16,525 million	Rp. 18,663 million	Rp. 23,236 million

Source: Study Team

The amount of money described above will be saved every year due to the construction of flood control facilities. After effects of real GDP growth to the property value in the study area were added, the present value of the project was obtained by discounting these numbers to the beginning of the year 1998.

(b) Assumptions for Economic Analysis for Master Plan Study

Economic analysis was conducted under the following assumptions:

Price level:	End of December 1996
Design scale:	30 years

Project life:	50 years
Maintenance costs:	0.5% of the total construction costs
Shadow pricing	Standard conversion rate 85%
Growth rate of property value:	5.0 % per annum
Construction period	From 1999 to 2003 for separate cases From 1999 to 2007 for the entire project
Costs and benefits for multi-purpose dams	Rp 890 /m^3 for distribution pipes and OM costs Rp 2,500 /m^3 for water supply benefits

<Price Level>
The price level for the estimation of costs and benefits was set at the end of December 1996. The exchange rate for the Master Plan was fixed at Rp 2,500 to US$ 1.00 for the calculation purpose.

<Design Scale>
The return period was set at 30 years at the Master Plan level, taking into account the standard return period for flood control facilities applied in Indonesia.

<Project Life>
The economic life of the project was set at 50 years; the residual value of the facilities is considered to be zero after 50 years when they will need to be replaced.

<Maintenance Costs>
The maintenance work is assumed to require 0.5% of the total construction costs every year. The maintenance activities will be necessary from the following year after the completion of construction through the last year of the project life.

<Shadow Pricing>
Taxes and duties must be deducted from financial costs in order to obtain economic costs. A 85% standard conversion rate was applied at the Master Plan level.

<Growth Rate of Property Value>
The same rate as the product of per capita GDP and population increase in the Central City estimated by the study team - 5.0% per year - was applied for the growth rate of the property value.

<Construction Period>
Five year construction period - from 1999 to 2004 - was applied for the economic analysis of each of the five rivers, while nine year period - from 1999 to 2007 - was applied for the implementation of the entire project. Construction of the dam in Ruhu River was assumed to be started in 2004 in the latter case.

<Costs and Benefits for Water Supply>
In addition to the costs for purification facilities and pipelines mentioned in Section 3.4, Rp 890 /m^3 was added in multi-purpose dam options as water distribution costs including distribution pipes, administration and operation, estimated from the PDAM financial report. Water loss was assumed to be 40%. On the benefit side of water supply, willingness to pay by Ambon City residents was estimated at Rp 2,500 /m^3 through field investigations. This is an actual buying price of water that people are paying to water tank lorries.

(2) Economic Analysis

(a) Economic Analysis on Each of the Five Rivers

Table-I.3.37 shows the results of economic analysis on the construction of the flood control facilities for each of the five rivers, based on the assumption that all the facilities are constructed in five years:

Table-I.3.37 Economic Cost, NPV, B/C and IRR of Flood Control Facilities in Each of the Five Rivers

Case		Economic Cost	NPV at 10%	B/C at 10%	IRR
Ruhu	River improvement (5 year return period) <A-1>	Rp 12,066 million	Rp 22,456 million	3.4	20.8%
	River improvement and flood control dam <A-2>	Rp 56,948 million	- Rp 813 million	0.98	9.9%
Batu Merah	River improvement and diversion channel <B>	Rp 43,550 million	Rp 90,614 million	3.6	21.8%
Tomu	River improvement <C>	Rp 22,347 million	Rp 36,514 million	3.1	19.7%
Batu Gajah	River improvement and flood control dam <D-1>	Rp 50,093 million	Rp 49,359 million	2.3	16.4%
Batu Gantung	River improvement and flood control dam <E-1>	Rp 38,418 million	Rp 13,588 million	1.5	12.6%

Note : All cases are 30-year return period design scale excluding (*) River Improvement (5-year return period) for Ruhu River.

A 10% discount rate, which is standard for public work projects in Indonesia, was applied for this study. Construction of flood control facilities in each river is overall assessed to be feasible, showing IRR of between 10 % to 22%. The high IRR which can be attained in river improvement option for Ruhu River (A-1) is severely affected if a flood control dam is constructed (A-2) in order to achieve a 30 year return period, reducing the IRR to the marginal level.

Flood control dams can be upgraded, with additional investment, into multi-purpose dams which can supply water to downtown Ambon. The following table shows economic returns of flood control facilities when flood control dams are upgraded into multi-purpose dams.

Table-I.3.38 Economic Cost, NPV, B/C and IRR of Options with Multi-purpose Dams

Case		Economic Cost	NPV at 10%	B/C at 10%	IRR
Ruhu	River improvement and multi-purpose dam <A-3>	Rp 77,094 million	Rp 18,965 million	1.2	12.1%
Batu Gajah	River improvement and multi-purpose dam <D-2>	Rp 76,594 million	Rp 45,628 million	1.7	14.4%
Batu Gantung	River improvement and multi-purpose dam <E-2>	Rp 53,634 million	Rp 6,256 million	1.1	10.9%

Construction of multi-purpose dams in Batu Gajah and Batu Gantung rivers imposes a burden on economic returns of the project. The IRR goes down when the flood control dams in Batu Gajah and Batu Gantung rivers are upgraded into multi-purpose dams since the IRR for incremental costs and benefits of these rivers are 8.3% and 3.2%, respectively. These additional investments are not economically efficient. On the other hand, upgrading the flood control dam in Ruhu River into a multi-purpose dam will give a positive impact on the IRR; the IRR for its incremental costs and benefits is 19.4%.

(b) Economic Analysis on the Project as a Whole

In order to assess the feasibility of the entire project, economic returns of the following six combinations were examined.

- Option 1: A-1, B, C, D-1, E-1
- Option 2: A-2, B, C, D-1, E-1
- Option 3: A-3, B, C, D-1, E-1
- Option 4: A-3, B, C, D-2, E-1
- Option 5: A-1, B, C, D-2, E-2
- Option 6: A-3, B, C, D-2, E-2

Table-I.3.39 Economic Cost, NPV, B/C and IRR of the Project as a Whole

Option	Economic Cost	NPV at 10%	B/C at 10%	IRR
Option 1	Rp 166,473 million	Rp 175,923 million	2.7	17.5%
Option 2	Rp 211,356 million	Rp 166,366 million	2.4	16.7%
Option 3	Rp 231,501 million	Rp 181,077 million	2.4	16.9%
Option 4	Rp 258,003 million	Rp 183,149 million	2.3	16.4%
Option 5	Rp 208,191 million	Rp 174,421 million	2.4	16.4%
Option 6	Rp 273,219 million	Rp 179,576 million	2.2	16.0%

The entire project is assessed to be feasible in each of the cases. The option without a multi-purpose dam (Option 1) shows the highest IRR of all the options. Construction of multi-purpose dams in Batu Gajah and Batu Gantung rivers - Option 4, 5 and 6 -decreases the IRR of the Project.

3.7.3 Financial Considerations

(1) Budgetary Procedures

The budget formation procedures in Indonesia are a mixture of bottom-up and top-down systems. First, a budgetary committee is formed at the district level (municipalities or provinces) which discusses, coordinates and consolidates requests from sub-districts (Kecamatan), Bappeda and other departments. The requests are forwarded to the budgetary committee for discussion at the provincial level, and then finalized at the national level. After approval of the budgetary framework by the Presidency, the provincial government mainly takes charge of the allocation and execution of the budget. Although the final budgetary allocation often differs from original requests, it should be noted that each implementing agency does not always respect the changes when executing the budget. As a result, public works projects are not always carried out in a consistent manner, but rather implemented in an ad hoc fashion.

For each public works project, the provincial government determines whether the implementing agency will be at the provincial or municipal level. The source of the budget, national, provincial or municipal, is also determined for each project at the provincial level. Although most of the new and/or large projects are still implemented by the provincial level because of insufficient technical capability at the municipal level, operational and maintenance activities are gradually being transferred to the municipality, under the PU's decentralization policy.

(2) Public Works Budget of Maluku Province

Maluku Province PU executed an operational budget of around Rp 125 billion for the fiscal year 1995/96, of which 19% was used for the projects of DGWRD. Table-I.3.40 shows the budget plan in 1996/97 of the provincial PU.

Table-I.3.40 Maluku Province PU Budget (Plan), 1996/97 (million Rp)

Source of Budget / Implementing Agency	National Budget	Loans	Provincial Budget	Total
DGWRD	25,285	5,667	1,663	32,615
DGHW	38,169	10,298	41,373	89,840
DGHS	23,923	525	2,555	27,003
Total	87,377	16,490	45,591	149,458

Source: Bina Program, Maluku Province

Although there are three budget sources for the province, there is no substantial distinction between project types under the national budget and the provincial budget.

Although Ambon City represents 11% of the total provincial population, only 5% of the provincial budget is allocated to the city. Table-I.3.41 shows the allocation of the PU provincial budget to Ambon City.

The budget of DGWRD includes allocations for the strengthening of the check dam of Batu Merah (Rp 50 million), the realignment of Batu Gantung (Rp 100 million), the excavation of sediment (Rp 150 million), and the repair of the parapet (Rp 80 million).

Table-I.3.41 PU Budget (Plan) Allocated to Ambon City in 1996/97 (million Rp)

Source of Budget / Implementing Agency	National Budget	Loans	Provincial Budget	Total
DGWRD	-	-	593	593
DGHW	666	-	727	1,393
DGHS	4,182	525	301	5,008
Total	4,842	525	1,621	6,994

Source: Bina Program, Maluku Province

(3) Public Works Budget of Ambon City

The budget executed by the Ambon City PU itself is quite small, corresponding to only 3% of the provincial PU budget. Rehabilitation, maintenance and upgrading are the main activities. The following table shows the constitution of the budget executed by the Ambon City PU. (Ambon City does not yet have a water resource department.)

Table-I.3.42 Ambon City PU Budget (Realization), 1995/96 (million Rp)

Source of Budget / Implementing Agency	National Budget	Loans	Provincial Budget	Municipal Budget	Total
DGHW (municipality)	2,275	470	-	15	2,760
DGHS (municipality)	952	25	250	276	1,503
Total	3,227	495	250	291	4,263

Source: Financial Department, Ambon City

(4) Financing Capacity of Maluku Province and Ambon City

Considering that most of the provincial budget has been used for the development of the wide under-developed area of Maluku Province, it would not be appropriate to drastically change the focus of the allocation of the limited provincial budget from irrigation and road construction in rural areas to flood control in urban areas. It also goes without saying that Ambon City does not have its own financial capacity to invest in a new infrastructure project. If the provincial budget is the only available fund for this project, the project will have to focus solely on minor rehabilitation or upgrading; the scale of the project will have to be limited to less than Rp 1 billion. A fully-fledged flood control project can only be financed by additional budget from the central Government and/or through a loan.

(5) Financing Plan by the Central Government

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 at the central level has sent questionnaires to provincial governments for the purpose of identifying future flood control projects which could be financed by OECF 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.

CHAPTER 4 PRIORITY PROJECT

4.1 Selection of Priority Project

Priority projects are selected from the Flood Control Master Plan generally under the *following criteria* :

- **Economic Feasibility** : To realize earlier benefit, projects with high economic feasibility should be selected.
- **Urgent Requirement** : *Projects with urgent requirement for flood damage protection* should be selected.
- **Less Social and Environmental Impact** : Projects with less social and environmental impact should be selected.

Non structural measures and structural measures were proposed as the flood control master plan. Non structural measures are as important as structural measures and the priority is also high. For instance, land use regulation or vegetation improvement is said to be effective to mitigate flood peak discharge. Establishment of management organization, flood forecast and warning system or flood fighting system is also effective for reducing flood damage. However, it is difficult to estimate the quantitative effectiveness of these non-structural flood control measures.

In this study, priority projects were selected from the structural flood control measures. The projects of Phase-1 in the implementation schedule are selected as priority projects. The composition of the priority projects are shown in Table-I.4.1.

Table-I.4.1 Composition of Priority Projects

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

4.2 Plan of Priority Project

4.2.1 General Conditions

(1) Objectives of the Priority Projects

The objectives of the priority projects are set as follows :

- To mitigate flood damage which occurs annually along the five rivers (Ruhu, Batu Merah, Tomu, Batu Gajah and Batu Gantung) in the central part of Ambon City;
- To supply raw water for domestic and industrial use in Ambon City;
- To improve the river environment by appropriate facilities and to improve water quality and quantity by developed maintenance flow.

(2) Basic Conditions

(a) Target Year for Planning

The target year for planning is set at 2015, same as the Flood Control Master Plan. This target year is utilized to determine water demand and supply in the future. However water demand and supply in the following 15 years, i.e. until the year 2030, is also taken into account for the long term water utilization plan.

(b) Target Completion Year

The target year for completion of priority projects is set at 2007/08 starting from the year of 1998/99. An implementation period of 10 years (1998/99 - 2007/08) is deemed appropriate by the feasibility study.

(c) Planning Scale in the Priority Projects

Planning scale is set at 30-year return period for the four rivers in the center of the city, namely Batu Merah River, Tomu River, Batu Gajah River and Batu Gantung River. The planning scale of Ruhu River, which is out of the center of the city, is also set at 30-year return period but river improvement works as a priority project is planned with 5-year return period in the short term.

(d) Design Rainfall and Hyetograph

Design rainfall and design hyetograph of all the target rivers are set the same as each other and are shown as follows:

Design Rainfall	: 422 mm (30-year return period)
Design Hyetograph	: 1990/6/6 Flood (Figure-I.4.1)
- Actual Daily Rainfall	: 214.2 mm
- Enlarging Ratio	: 1.970

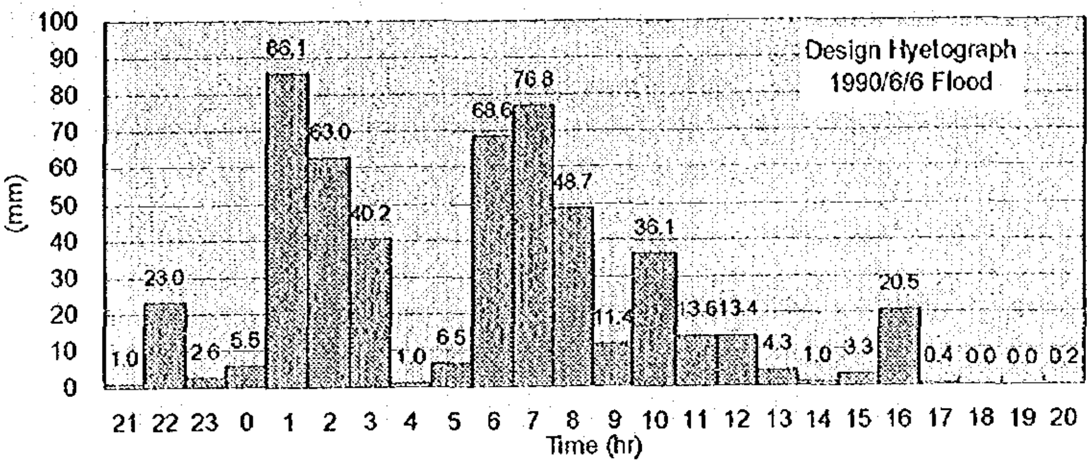


Figure-I.4.1 Design Hyetograph : 1990/06/06 Flood

4.2.2 Ruhu River Project

The downstream of Ruhu River is improved with the design discharge equivalent to 5-year return period. In order to achieve the security against flood with 30-year return period, a multi-purpose dam is planned to be constructed at 3k000 from the river mouth. From the fact that sedimentation is progressing around the estuary, large sediment is expected to flow down to the sea during flooding and is also one of flood causes. Therefore, a check dam is planned at 6k100 from the river mouth, located at the end of the reservoir.

- 0k000 - 1k600 : River improvement with 5-year return period
- 3k000 : Multi-purpose dam
- 6k100 : Check dam

Priority project in Ruhu River was selected to be river improvement with 5-year return period and a check dam, which are studied as follows.

(1) Planning Criteria

Design scale of Ruhu River improvement is set at 5-year return period for the priority project in short term. Reference points, basin division, runoff model and design discharge distribution are indicated in Figure-I.4.2.

(2) River Improvement Plan

River improvement plan of Ruhu River is summarized in Table-I.4.4 and Figure-I.4.4 based on the following study:

(a) River Improvement Range

River improvement range is set from river mouth to 1k600 i.e. 1,600m length. There are currently no flood walls constructed to the upstream of 1k600, which is like a natural river. The houses upstream are located in relatively higher place and no flood damages were reported. Then the upstream river from 1k600 is judged not to be necessary to be improved.

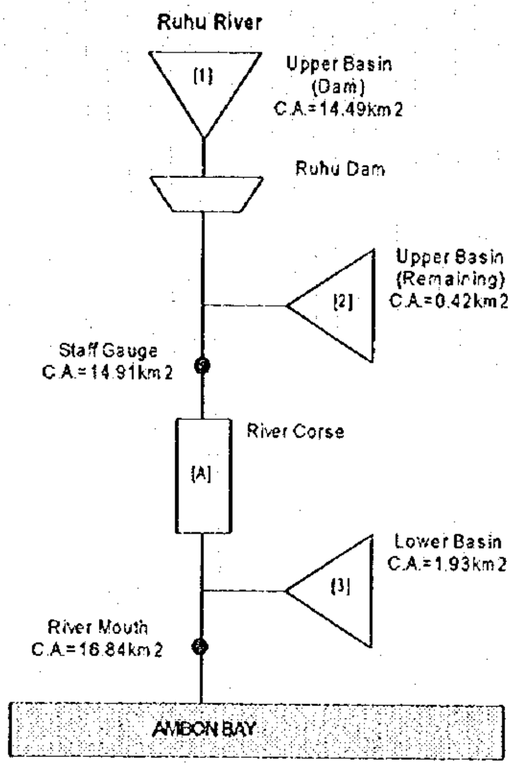
River Improvement Range : 0k000 - 1k600 (Length 1,600m)

Design Scale of Flood Control Plan : 5-year return period in short term (priority project)

Reference Point and Basin Division

Basin Name	Catchment Area. (km²)
[1] Upper Basin (Dam)	14.49
[2] Upper Basin (Remaining)	0.42
[3] Lower Basin	1.93
Total	16.84

Reference Point	Catchment Area (km²)
Staff Gauge	14.91
River Mouth	16.84

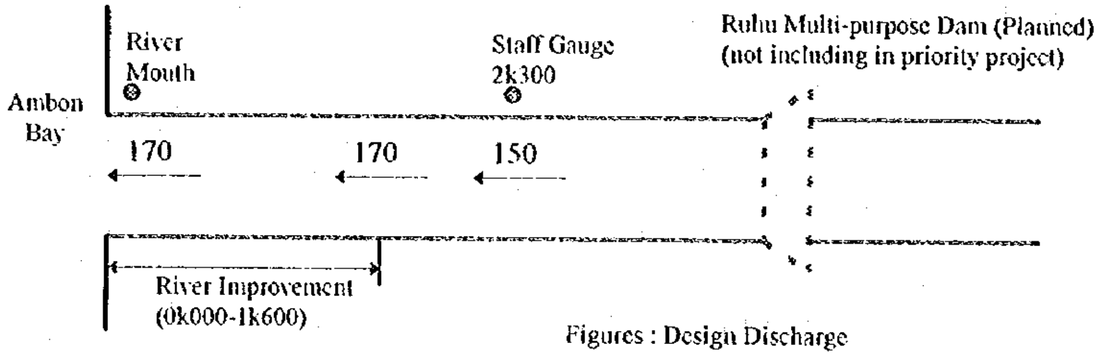


Storage Function Model

Coefficient of Storage Function
- Upper Basin : k=35, p=1/3, Tl=0
- Lower Basin : k=30, p=1/3, Tl=0
- River Course A : k=1.2, p=0.6, Tl=0

Primary Runoff Rate : 0.9
Saturated Runoff Rate : 1.0
Saturated Rainfall : 100 mm

Flood Runoff Model



Design Discharge Distribution

Figure-I.4.2 Planning Criteria of Ruhu River Flood Control Plan

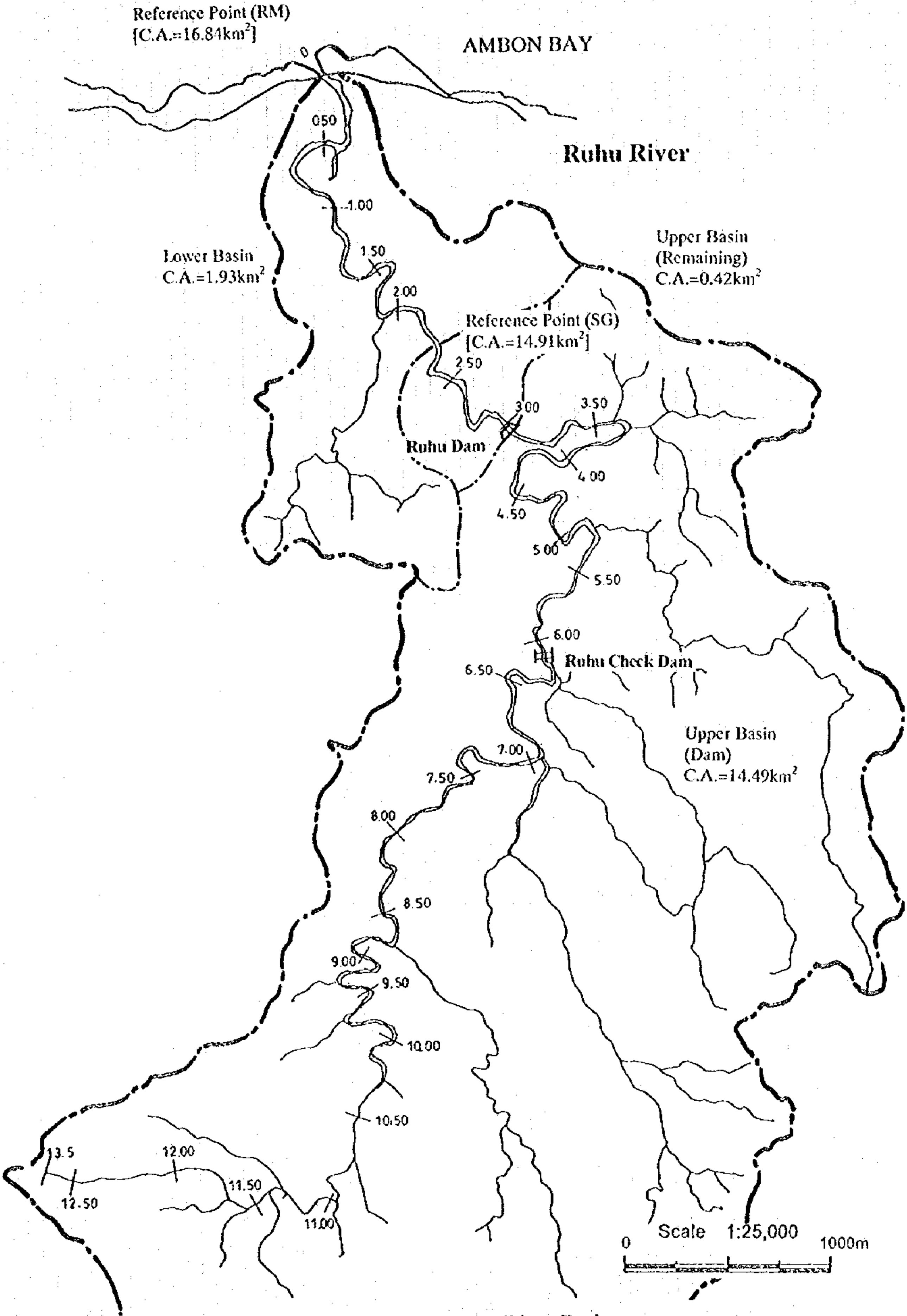


Figure-I.4.3 Ruhu River Basin

(b) River Course Alignment

River course alignment followed current river course with no new channel.

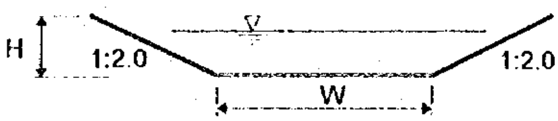
(c) Planned River Bed (Slope, Excavation)

Planned riverbed slope of the downstream from 0k000 to 0k525 was set level at EL.-1.00m, which is the nearly current deepest river bed level. Because there are much sedimentation along the estuary, of which area would be necessary to be excavated if deeper river bed excavation would be applied.

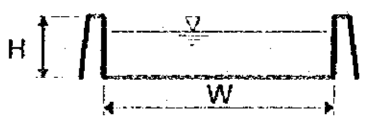
Planned riverbed of the upstream from 0k525 was set at I=1/420 in line with the current upstream riverbed slope. Three cases of excavation depth, 1.0m, 0.5m and 0.0m below the deepest riverbed, were studied. Of these cases the shallowest excavation case was adopted because of economical reason, even though river bed excavation has advantage for enlarging discharge capacity and facilitating inner water drainage.

(d) Standard Cross Section (Heightening, Widening)

The planned standard cross section was set trapezoid in the downstream and rectangular in the upstream as follows:



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

Based on uniform and non-uniform flow calculation on the design discharge 170 m^3/sec equivalent to 5-year return period, the following flood wall heightening and section widening were planned. Three-sided concrete channel was not planned because of relatively wide river width

- The river section from 0k000 to 0k500 is relatively wide and excavation works is enough for the design discharge. The planned river width is set at 28.0 m there.
- The sections from 0k850 to 0k950 and 1k050 were planned to be widened to 17.0 m on the right side, because of following reasons:
  - => This section is very narrow with 13.8 - 16.0 m width.
  - => Water level raising would be affected 400m upstream without widening
  - => The left side of these sections is utilized for pig/chicken farms or no households.
- The flood walls from 0k250 to 1k350 were planned to be heightened by 0.1-0.7m of right side (0.4m on average) and 0.1-0.9m of left side (0.4m on average).

(e) Bridge Improvement

The list of bridges in Ruhu River is shown in Table-I.4.2. The clearance between bridge underside elevation and H.W.L. is judged to be enough (more than 0.6m) but the bridges of No.4 and No.6 are necessary to be improved.

Table-I.4.2 List of Bridges in Ruhu River

No.	Distance (m)	Bridge Underside Elevation (EL.m)	Bridge Pier Number	Bridge Pier Width (m)	Bridge Width (m)	*1 Objec-tives	Clearance (m)		Depth of *2 Excavation at Pier (m)		Remarks
1	0k017	3.346	-	-	7.00	VR	2.31	O	-	O	Truss bridge
2	0k059	1.703	2	2.00	8.00	VR	0.64	O	1.40	X	Old bridge (not in use)
3	0k074	3.900	-	-	-	WP	2.79	O	-	O	Pipe line
4	1k018	4.350	1	25.00	2.00	FPB	1.59	O	0.50	X	Suspension bridge
5	1k359	4.800	1	25.00	2.00	FPB	1.22	O	0.20	O	Suspension bridge
6	1k554	5.950	-	-	4.00	VR	1.76	O	1.90	X	Concrete bridge

*1 Objectives (Vehicle Road, Foot Path Bridge, Water Pipe, Others)
*2 Excavation Depth below Deepest Riverbed

(f) Drainage Improvement

The list of drainage in Ruhu River is shown in Table-I.4.3. The method of drainage improvement will be studied in the chapter of facility design.

Table-I.4.3 List of Drainage in Ruhu River

No.	Distance (m)	Side	Bottom Elevation (EL.m)	Section Width (m)	Section Height (m)	Objectives	Remarks
1	0k433	L	0.440	1.00	0.50	HD	
2	0k481	L	0.680	1.00	0.50	HD	Covered by garbage
3	0k533	R	0.500	1.20	1.50	CD	Covered by garbage
4	0k638	L	1.220	1.00	0.50	CD	
5	0k647	L	1.070	1.00	0.50	CD	
6	0k747	R	0.924	0.90	0.50	HD	
7	0k788	R	1.240	0.90	0.50	HD	
8	0k798	R	1.350	0.90	0.50	HD	
9	0k886	R	1.420	1.00	0.50	HD	
10	0k058	R	2.900	0.90	0.50	HD	Covered by tree
11	1k108	R	1.990	0.90	0.60	HD	
12	1k158	R	1.550	0.90	0.40	HD	
13	1k213	R	1.070	1.00	0.50	Toilet	
14	1k305	R	3.150	1.00	0.50	HD	Covered by tree
15	1k361	L	3.670	-	-	HD	
16	1k506	L	2.380	1.40	2.00	HD	New drainage

* Objectives (City Drainage, Home Drainage, Toilet, Others)

(3) Check Dam Plan

Taking into account of topographical and geological condition in the basin catchment, as well as river condition of upstream and downstream, sediment discharge and allowable sediment discharge were studied in Chapter 3.2. As a results, a check dam at 6k100, the upstream of the planned Ruhu Multi-purpose Dam (refer to Figure-I.4.3), are proposed with 40,000 m^3 of sediment reservoir capacity, designed as 10 years storage volume based on bed load flow shortfall. The catchment area of the check dam is 10.9 km^2 and design discharge of spillway is 281 m^3/sec with 100-year return period.

Table-I.4.4 Ruhu River Improvement Plan

		Current Condition						Planning Condition																	
Section No.	Profile No.	Cumulative Distance (m)	Dpst. Bed Level (EL.m)	Ave. Bed Level (EL.m)	River Width (m)	Left Bank (EL.m)	Right Bank (EL.m)	Riverbed Level (EL.m)	Water Level (EL.m)	Top of Dike (EL.m)	Design Qp (m3/s)	River Width (m)	Water Height (m)	Slope I	R.bed at Wall Left (EL.m)	R.bed at Wall Right (EL.m)	Dike Height (m)	Excavation Depth Ave. (m)	Excavation Depth Deepest (m)	Excavation Depth R.bed at Wall L (m)	Excavation Depth R.bed at Wall R (m)	Heightneing Left (m)	Heightneing Right (m)	Widening Length (m)	Concrete Channel
1	RH0	0.00	-0.73	-0.42	160.25	2.02	2.20	-1.00	0.80	1.40	170	28.00	1.80	-	-0.75	-0.15	2.40	0.58	0.27	0.25	0.85	-	-	-	-
2	B1	47.10	-2.36	-0.92	79.40	2.55	2.54	-1.00	1.03	1.63	170	28.00	2.03	-			2.63	0.08	-			-	-	-	-
3	RH0A	50.00	-2.31	-0.23	81.29	4.63	4.69	-1.00	1.04	1.64	170	28.00	2.04	-	-2.10	-0.50	2.64	0.77	-	-	0.50	-	-	-	-
4	B2	58.70	-2.31	-0.32	63.65	3.27	3.20	-1.00	1.06	1.66	170	28.00	2.06	-			2.66	0.68	-			-	-	-	-
5	B3	74.40	-2.09	-0.65	48.90	2.09	1.56	-1.09	1.11	1.71	170	28.00	2.11	-			2.71	0.35	-			-	0.15	-	-
6	RH1	100.00	-1.74	-0.35	28.00	2.07	1.46	-1.00	1.17	1.77	170	28.00	2.17	-	0.25	1.45	2.77	0.65	-	1.25	2.45	-	0.31	-	-
7	RH1A	150.00	-0.74	-0.04	41.25	2.00	2.30	-1.00	1.28	1.88	170	28.00	2.28	-	-0.20	-0.20	2.88	0.96	0.26	0.80	0.80	-	-	-	-
8	RH2	200.00	-0.73	0.00	44.41	1.96	2.15	-1.00	1.36	1.96	170	28.00	2.36	-	-0.45	0.25	2.96	1.00	0.27	0.55	1.25	0.00	-	-	-
9	RH2A	250.00	-0.92	0.03	44.26	1.93	2.23	-1.00	1.44	2.04	170	28.00	2.44	-	-0.60	0.20	3.04	1.03	0.08	0.40	1.20	0.11	-	-	-
10	RH3	300.00	-0.43	0.12	41.58	2.08	2.23	-1.00	1.50	2.10	170	28.00	2.50	-	-0.60	0.40	3.10	1.12	0.57	0.40	1.40	0.02	-	-	-
11	RH3A	350.00	-0.60	0.18	38.21	1.92	2.33	-1.00	1.56	2.16	170	28.00	2.56	-	0.15	0.90	3.16	1.18	0.40	1.15	1.90	0.24	-	-	-
12	RH4	400.00	-0.81	0.03	38.30	2.04	2.13	-1.00	1.61	2.21	170	28.00	2.61	-	0.35	-1.00	3.21	1.03	0.19	1.35	0.00	0.17	0.08	-	-
13	RH4A	450.00	-0.58	0.16	37.65	2.29	1.85	-1.00	1.66	2.26	170	28.00	2.66	-	0.95	-0.50	3.26	1.16	0.42	1.95	0.50	-	0.41	-	-
14	RH5	500.00	-0.57	0.00	29.60	2.10	1.96	-1.00	1.66	2.26	170	28.00	2.66	-	0.55	0.15	3.26	1.00	0.43	1.55	1.15	0.16	0.30	-	-
15	RH5A	550.00	-0.57	0.22	22.29	1.98	2.06	-0.94	1.66	2.26	170	17.00	2.60	420	0.30	0.75	3.20	1.16	0.37	1.24	1.69	0.28	0.20	-	-
16	RH6	600.00	-0.47	0.01	17.80	2.12	2.27	-0.82	1.66	2.26	170	17.00	2.48	420	0.25	0.25	3.08	0.83	0.35	1.07	1.07	0.14	-	-	-
17	RH6A	650.00	-0.42	0.03	17.05	2.29	2.31	-0.70	1.81	2.41	170	17.00	2.51	420	0.05	0.80	3.11	0.73	0.28	0.75	1.50	0.12	0.10	-	-
18	RH7	700.00	-0.27	0.06	17.25	2.14	2.13	-0.58	1.97	2.57	170	17.00	2.55	420	0.15	0.30	3.15	0.64	0.31	0.73	0.88	0.43	0.44	-	-
19	RH7A	750.00	-0.08	0.22	19.68	2.40	2.24	-0.46	2.10	2.70	170	17.00	2.56	420	0.15	0.80	3.16	0.68	0.38	0.61	1.26	0.30	0.46	-	-
20	RH8	800.00	-0.03	0.30	22.10	2.05	2.37	-0.34	2.22	2.82	170	17.00	2.57	420	-0.40	1.25	3.17	0.64	0.31	-	1.59	0.77	0.45	-	-
21	RH8A	850.00	-0.20	0.08	13.80	2.05	2.24	-0.23	2.35	2.95	170	17.00	2.57	420	0.75	0.75	3.17	0.31	0.03	0.98	0.98	0.90	0.71	3.20	-
22	RH9	900.00	0.27	0.24	15.59	2.41	2.40	-0.11	2.47	3.07	170	17.00	2.58	420	2.20	2.20	3.18	0.35	0.38	2.31	2.31	0.66	0.67	1.41	-
23	RH9A	950.00	0.26	0.38	16.00	2.57	2.55	0.01	2.59	3.19	170	17.00	2.58	420	2.75	2.75	3.18	0.37	0.25	2.74	2.74	0.62	0.64	1.00	-
24	RH10	1000.00	0.30	0.65	20.08	2.83	3.19	0.13	2.71	3.31	170	17.00	2.58	420	1.20	0.45	3.18	0.52	0.17	1.07	0.32	0.48	0.12	-	-
25	B4	1018.10	0.39	0.63	20.30	4.08	4.09	0.17	2.76	3.36	170	17.00	2.59	420			3.19	0.46	0.22			-	-	-	-
26	RH10A	1050.00	0.43	0.82	15.00	2.91	3.43	0.25	2.83	3.43	170	17.00	2.58	420	1.35	1.35	3.18	0.57	0.18	1.10	1.10	0.52	0.00	2.00	-
27	RH11	1100.00	0.38	0.89	20.15	3.01	3.42	0.37	2.95	3.55	170	17.00	2.58	420	1.65	0.80	3.18	0.52	0.01	1.28	0.43	0.54	0.13	-	-
28	RH11A	1150.00	0.37	0.86	19.00	3.23	3.55	0.49	3.08	3.68	170	17.00	2.59	420	1.10	1.45	3.19	0.37	-	0.61	0.96	0.45	0.13	-	-
29	RH12	1200.00	0.49	1.16	19.83	3.14	4.12	0.61	3.21	3.81	170	17.00	2.60	420	1.50	1.75	3.20	0.55	-	0.89	1.14	0.67	-	-	-
30	RH12A	1250.00	0.58	1.38	29.65	3.43	4.37	0.73	3.32	3.92	170	17.00	2.59	420	1.20	0.25	3.19	0.65	-	0.47	-	0.49	-	-	-
31	RH13	1300.00	1.01	1.48	22.50	3.64	4.49	0.85	3.44	4.04	170	17.00	2.59	420	1.95	0.90	3.19	0.63	0.16	1.10	0.05	0.40	-	-	-
32	RH13A	1350.00	1.14	1.39	17.60	3.69	4.51	0.96	3.55	4.15	170	17.00	2.59	420	1.20	1.50	3.19	0.43	0.18	0.24	0.54	0.46	-	-	-
33	B5	1359.20	1.20	1.44	18.00	4.73	4.71	0.99	3.58	4.18	170	17.00	2.59	420			3.19	0.45	0.21			-	-	-	-
34	RH14	1400.00	1.13	1.56	17.30	4.80	4.55	1.08	3.67	4.27	170	17.00	2.59	420	1.60	2.25	3.19	0.48	0.05	0.52	1.17	-	-	-	-
35	RH14A	1450.00	1.36	1.65	15.20	4.82	4.67	1.20	3.67	4.27	170	15.00	2.47	420	2.50	3.75	3.07	0.45	0.16	1.30	2.55	-	-	-	-
36	RH15	1500.00	1.16	1.40	21.00	5.16	3.06	1.32	4.01	4.61	170	15.00	2.68	420	0.80	3.00	3.28	0.08	-	-	1.68	-	1.55	-	-
37	RH15A	1550.00	1.40	2.25	22.35	6.06	5.47	1.44	4.18	4.78	170	15.00	2.74	420	3.45	1.80	3.34	0.81	-	2.01	0.36	-	-	-	-
38	B6	1553.50	1.60	2.33	20.90	5.51	5.51	1.45	4.19	4.79	170	15.00	2.74	420			3.34	0.88	0.15			-	-	-	-
39	RH16	1600.00	1.70	2.84	22.95	5.51	5.77	1.56	4.34	4.94	170	15.00	2.78	420	3.60	2.05	3.38	1.28	0.14	2.04	0.49	-	-	-	-
Average																	3.09	0.68	0.25	1.09	1.15	0.39	0.38	1.90	

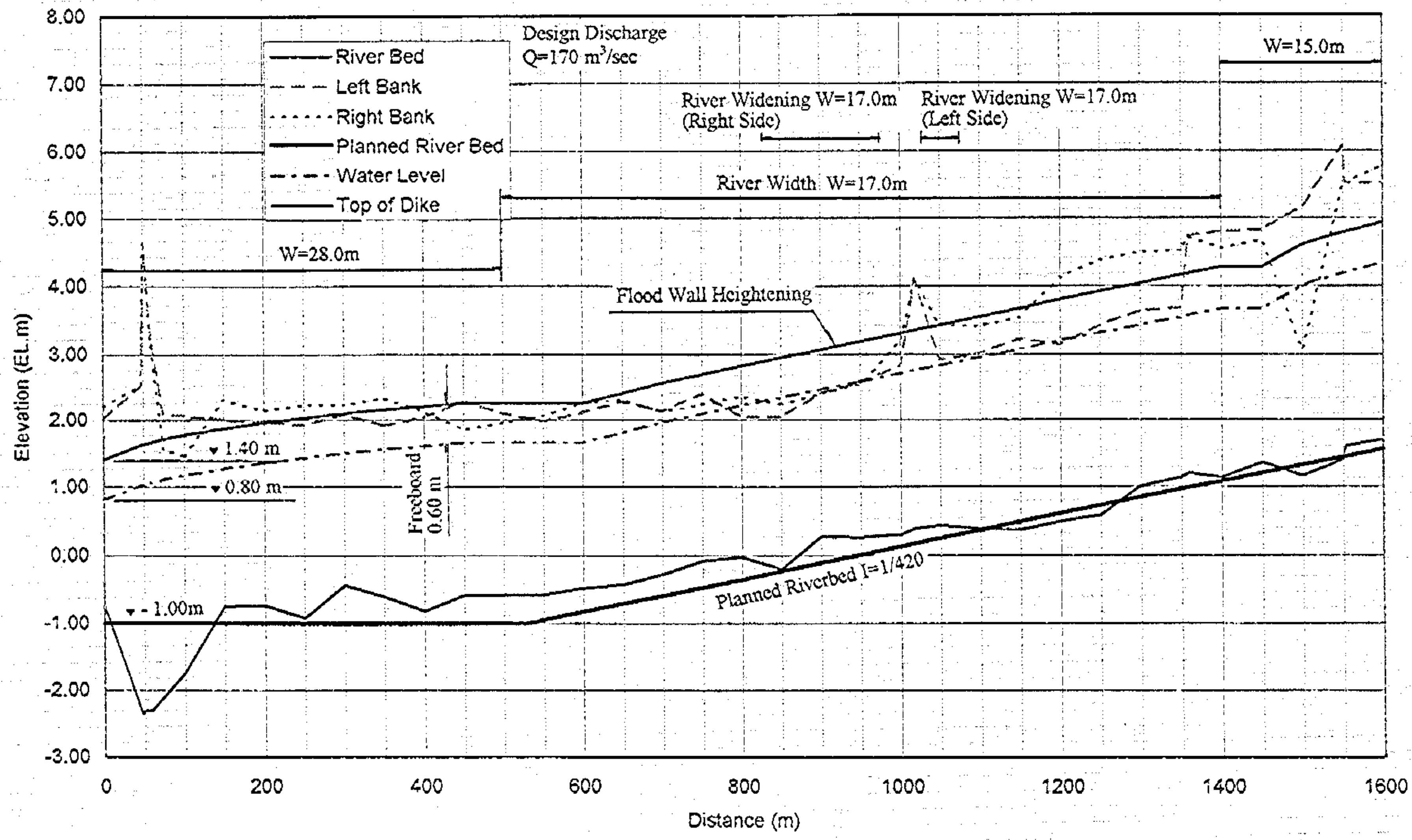


Figure-I.4.4 Longitudinal Section of Ruhu River Improvement Plan

4.2.3 Batu Merah River Project

The downstream of Batu Merah River is improved with 5-year return period. In order to achieve the security against flood with 30-year return period, a diversion tunnel is planned to be constructed at 1k400 from the river mouth. As the existing check dam is located at 2k500 from the river mouth, no check dam is planned in Batu Merah River.

- 0k000 - 1k500 : River improvement with 5-year return period
- 1k400 : Diversion tunnel

(1) Planning Criteria

Design scale of Batu Merah River flood control plan is set at 30-year return period. Reference points, basin division, runoff model, design flood discharge and design discharge distribution are indicated in Figure-I.4.5.

(2) *River Improvement Plan*

River improvement plan of Batu Merah River is summarized in Table-I.4.7 and Figure-I.4.7 based on the following study:

(a) River Improvement Range

River improvement range is set from river mouth to 1k500, i.e. 1,500m length. V-shape valley is extended in the upstream of 1k500 and there are houses along both side of the river. These houses are protected against flood by raising their houses by about 1 m. Therefore, the upstream of 1k500 is not planned to be improved.

River Improvement Range : 0k000 - 1k500 (Length 1,500m)

(b) River Course Alignment

River course alignment basically followed current river course but new diversion tunnel is planned from 1k400 to the sea 850 m north of Batu Merah River Mouth.

(c) Planned River Bed (Slope, Excavation)

Planned riverbed slope of the downstream from 0k000 to 0k250 was set level at EL.-1.00m, which is the nearly current deepest river bed level. Because the river section is enough wide and high so that it is not necessary to be excavated and heightened.

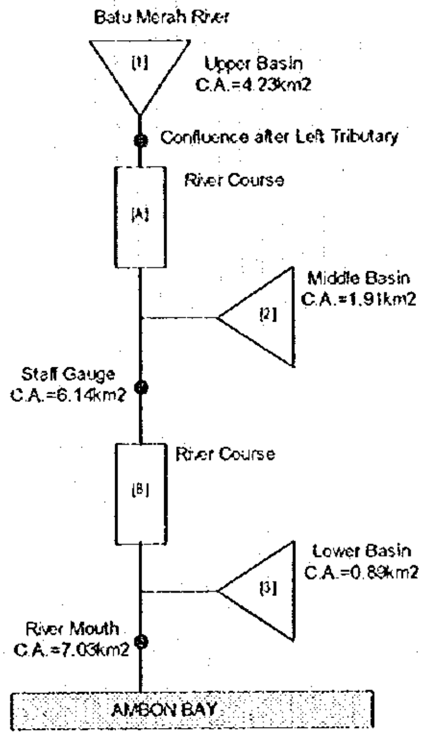
Planned riverbed of the upstream from 0k250 was set at I=1/320 in line with the current riverbed slope. Three cases of excavation depth, 1.0m, 0.5m and 0.0m below the deepest riverbed, were studied. Of these the case of 0.5m excavation depth was adopted because of following reasons:

- More than 1m flood walls heightening is needed in the case of 0.0m excavation depth and it costs more due to structural strengthening, comparing with the case less than 1 m flood wall heightening.

Design Scale of Flood Control Plan : 30-year Return Period

Reference Point and Basin Division

Basin Name	Catchment Area. (km²)	Reference Point	Catchment Area (km²)
[1] Upper Basin	4.23	Staff Gauge	6.14
[2] Middle Basin	1.91	River Mouth	7.03
[3] Lower Basin	0.89		
Total	7.03		

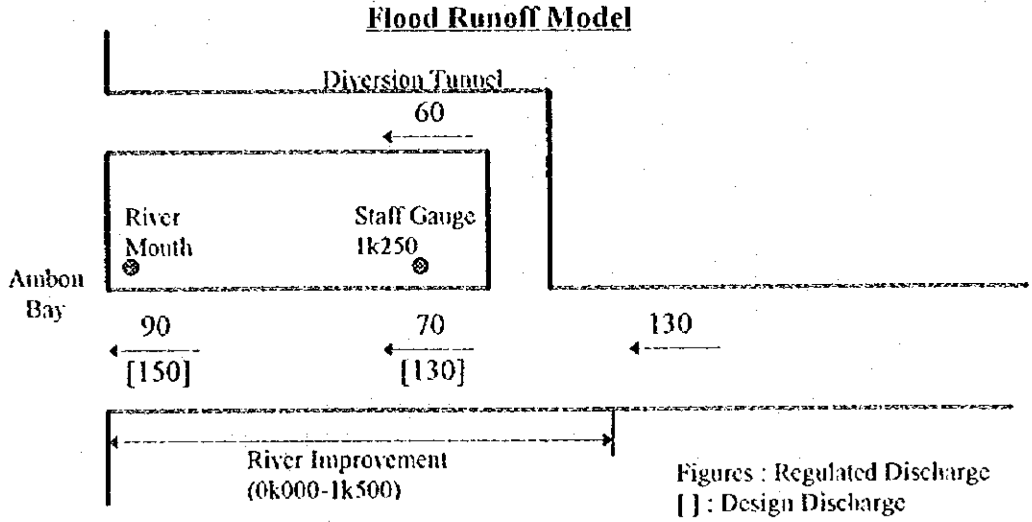


Storage Function Model

Coefficient of Storage Function
- Upper Basin : k=21, p=1/3, Tl=0
- Middle Basin : k=23, p=1/3, Tl=0
- Lower Basin : k= 4, p=1/3, Tl=0
- River Course A : k=0.6, p=0.6, Tl=0
- River Course B : k=0.6, p=0.6, Tl=0

Primary Runoff Rate : 0.9
Saturated Runoff Rate : 1.0
Saturated Rainfall : 100 mm

Flood Runoff Model



Design Discharge Distribution

Figure-I.4.5 Planning Criteria of Batu Merah River Flood Control Plan

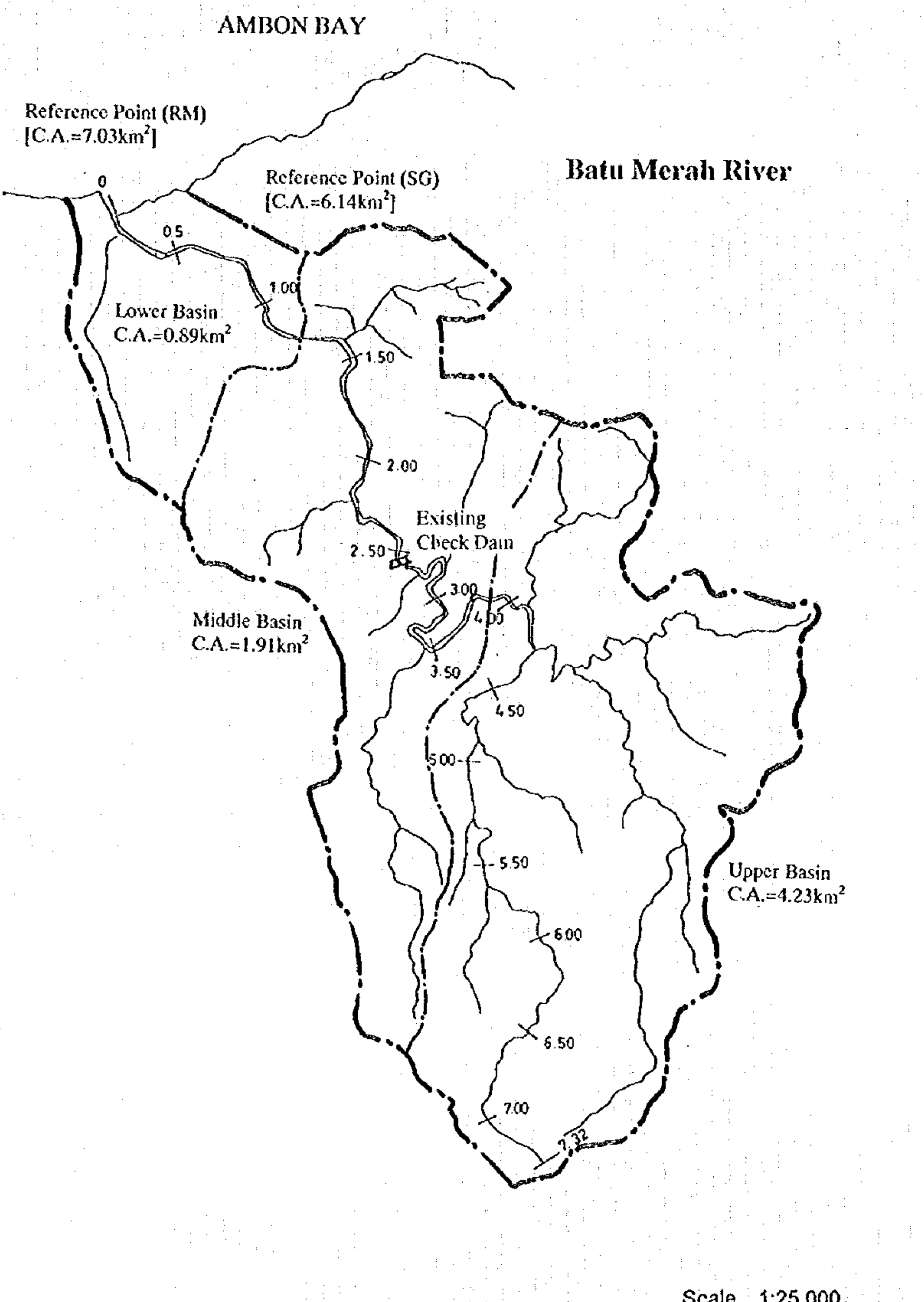
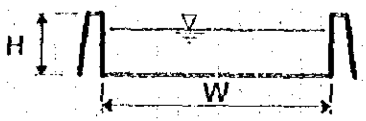


Figure-I.4.6 Batu Merah River Basin

- The case of 1.0m excavation depth needs structural strengthening to existing flood walls and it cost very much, even though river bed excavation has advantage for enlarging discharge capacity and facilitating inner water drainage.
- Then the medium case of 0.5m excavation depth was adopted.

(d) Standard Cross Section (Heightening, Widening)

According to the current river section with flood walls, the planned standard cross section was set rectangular as follows:



0k000-0k200	: W=20.0m, H=2.4-2.7m
0k250-0k390	: W=16.0m, H=2.4-2.7m
0k400-0k850	: W=10.0m, H=2.6m
0k900-1k250	: W= 8.0m, H=3.0m
1k300-1k400	: W= 7.0m, H=2.8m
1k450-1k500	: W=10.0m, H=3.1m

Based on uniform and non-uniform flow calculation on the design discharge 90 m^3/sec for 0k000-1k250, 70 m^3/sec for 1k250-1k400, and 130 m^3/sec for 1k400-1k500,equivalent to 5-year return period, the following flood wall heightening and section widening were planned.

- As for the river sections from 0k300 to 1k500, both side of flood walls are planned to be heightened at almost all of the section by 0.1-1.0m (0.5 m on average).
- Along the right side of the river from 0k400 to 0k800, urban redevelopment plan, which includes construction of river inspection road with the width of 2.5m. This project is planned to start from 1998/99. Therefore the river sections from 0k450 to 0k750, of which width is very narrow with 6.7 - 7.7 m, were planned to be widened to 10m at the right side, in line with the said project.
- The river sections from 1k100 to 1k350 need to be widened to 7-8m width because of too narrow sections with 4.5-7.0m.
- The river sections from 1k400 to 1k500 need to be widened to 10m width because the diversion tunnel inlet is planned to be installed
- Three-sided concrete channel is planned from 0k400 to 1k500, in order to enlarge discharge capacity so as to be reduce roughness.

(e) Bridge Improvement

The list of bridges in Batu Merah River is shown in Table-I.4.5. The clearance between bridge underside elevation and H.W.L. is judged to be enough (more than 0.6m) but the bridge of No.4 is necessary to be improved.

(f) Drainage Improvement

The list of drainage in Batu Merah River is shown in Table-I.4.6. The method of drainage improvement will be studied in the chapter of facility design.

Table-I.4.5 List of Bridges in Batu Merah River

No.	Distance (m)	Bridge Underside Elevation (EL.m)	Bridge Pier Number	Bridge Pier Width (m)	Bridge Width (m)	*1 Objectives	Clearance (m)		Depth of *2 Excavation at Pier (m)		Remarks
1	0k009	2.50	-	-	8.00	VR	1.68	O	0.45	O	
2	0k116	1.75	-	-	7.00	VR	0.75	O	-	O	
3	0k377	3.50					2.40	O	-	O	Telecom pipe
4	0k386	2.60	1	1.80	9.00	VR	1.48	O	1.00	X	
5	0k636	3.50	-	-	1.00	FPB	1.29	O	-	O	Suspension bridge
6	0k993	5.40	-	-	2.00	FPB	1.68	O	-	O	

*1 Objectives (Vehicle Road, Foot Path Bridge, Water Pipe, Others)
*2 Excavation Depth below Deepest Riverbed

Table-I.4.6 List of Drainage in Batu Merah River

No.	Distance (m)	Side	Bottom Elevation (EL.m)	Section Width (m)	Section Height (m)	Objectives	Remarks
1	0k110	L	0.28	0.50	0.60	CD	
2	0k110	R	0.99	0.40	0.60	CD	
3	0k185	L	0.76	2.00	1.20	CD	
4	0k221	L	0.53	0.60	0.50	HD	
5	0k394	L	0.22	0.80	1.50	CD	
6	0k394	R	0.22	1.00	1.20	CD	
7	0k404	L	0.35	2.00	1.50	HD	
8	0k474	L	0.49	1.10	0.85	HD	
9	0k548	L	0.69	0.70	0.80	HD	
10	0k649	L	1.14	0.60	0.70	CD	
11	0k651	L	1.14	1.00	1.00	HD	
12	0k756	L	1.30	0.70	0.60	HD	
13	1k434	R	4.43	0.60	0.60	HD	
14	1k442	L	5.35	0.60	0.60	HD	

* Objectives (1:City Drainage, 2: Home Drainage, 3:Toilet, 4:Others)

(3) Diversion Inlet Plan

The diversion inlet was planned as follows:

- 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

The upstream river of planned diverted section was planned as 7.0 m width, 3.50 m high water level, 4.10 m flood wall height and 1/320 riverbed slope. Assuming that frequency of flow down to the diversion is set at 3 times a year, initial discharge to start diversion is set at 20 m3/sec. In this case, the water depth is calculated to be 0.94 m in the upstream before diversion and 0.6 - 1.0 m in the downstream section.

Table-I.4.7 Batu Merah River Improvement Plan

Section No.	Profile No.	Cumulative Distance (m)	Current Condition: Dpst.Bed Level (EL.m)	Ave. Bed Level (EL.m)	River Width (m)	Left Bank (m)	Right Bank (m)	Planning Condition: Riverbed Level (EL.m)	Water Level (EL.m)	Top of Dike (EL.m)	Design Qp (m3/s)	River Width (m)	Water Height (m)	Slope 1/	R.bed at Wall Left (EL.m)	R.bed at Wall Right (EL.m)	Dike Height (m)	Excavation Depth Ave. (m)	Excavation Depth Deepest (m)	Excavation Depth R.bed at Wall L (m)	Excavation Depth R.bed at Wall R (m)	Heightening Left (m)	Heightening Right (m)	Widening Length (m)	Concrete Channel
1	BM0	0.00	-1.29	-0.95	25.60	2.29	2.28	-1.00	0.80	1.40	90	20.00	1.80	-	-1.00	-0.65	2.40	0.05	-	0.00	0.35	-	-	-	-
2	B1	8.90	-1.38	-0.79	25.40	2.55	2.68	-1.00	0.82	1.42	90	20.00	1.82	-			2.42	0.21	-			-	-	-	-
3	BM0A	50.00	-1.14	-0.70	23.25	2.11	2.37	-1.00	0.90	1.50	90	20.00	1.90	-	-1.10	-0.60	2.50	0.30	-	-	0.40	-	-	-	-
4	BM1	100.00	-1.08	-0.58	22.35	2.06	2.32	-1.00	0.98	1.58	90	20.00	1.98	-	-0.60	-0.10	2.58	0.42	-	0.40	0.90	-	-	-	-
5	B2	116.30	-0.93	-0.48	22.10	2.82	2.90	-1.00	1.00	1.60	90	20.00	2.00	-			2.60	0.52	0.07	1.00	1.00	-	-	-	-
6	BM1A	150.00	-1.10	-0.28	20.20	2.13	1.94	-1.00	1.04	1.64	90	20.00	2.04	-	-0.35	0.95	2.64	0.72	-	0.65	1.95	-	-	-	-
7	BM2	200.00	-0.54	0.04	21.65	1.82	1.68	-1.00	1.10	1.70	90	20.00	2.10	-	1.10	0.45	2.70	1.04	0.46	2.10	1.45	-	0.02	-	-
8	BM2A	250.00	-0.12	0.11	18.40	1.72	1.62	-1.00	1.10	1.70	90	16.00	2.10	-	0.05	0.45	2.70	1.11	0.88	1.05	1.45	-	0.08	-	-
9	BM3	300.00	-0.08	0.33	18.60	1.41	1.65	-0.84	1.10	1.70	90	16.00	1.95	320	0.05	0.95	2.55	1.17	0.76	0.89	1.79	0.29	0.05	-	-
10	BM3A	350.00	-0.20	0.45	16.20	1.55	1.79	-0.69	1.10	1.70	90	16.00	1.70	320	0.25	1.10	2.39	1.14	0.89	0.94	1.79	0.15	-	-	-
11	B3	377.00	0.20	0.40	16.20	1.55	1.79	-0.60	1.10	1.70	90	16.00	1.70	320				1.00	0.80			0.15	-	-	-
12	B4	386.00	-0.43	0.43	16.90	3.24	3.22	-0.58	1.12	1.72	90	16.00	1.70	320				1.01	0.15			-	-	-	-
13	BM4	400.00	-0.03	0.34	12.90	1.81	1.33	-0.53	1.47	2.07	90	10.00	2.00	320	-0.20	1.15	2.60	0.87	0.50	0.33	1.68	0.26	0.74	-	Concrete
14	BM4A	450.00	0.17	0.42	8.65	1.85	1.83	-0.38	1.63	2.23	90	10.00	2.00	320	1.05	0.05	2.60	0.80	0.55	1.43	0.43	0.38	0.40	1.35	Concrete
15	BM5	500.00	0.28	0.51	8.75	2.14	2.04	-0.22	1.78	2.38	90	10.00	2.00	320	0.70	0.15	2.60	0.73	0.50	0.92	0.37	0.24	0.34	1.25	Concrete
16	BM5A	550.00	0.58	0.72	8.80	2.03	2.01	-0.06	1.94	2.54	90	10.00	2.00	320	0.80	0.50	2.60	0.78	0.64	0.86	0.56	0.51	0.53	1.20	Concrete
17	BM6	600.00	0.66	0.91	9.70	2.31	2.11	0.09	2.09	2.69	90	10.00	2.00	320	1.00	0.90	2.60	0.82	0.57	0.91	0.81	0.38	0.58	0.30	Concrete
18	B5	635.60	0.76	0.86	9.00	2.52	2.52	0.21	2.21	2.81	90	10.00	2.00	320			2.60	0.66	0.56			0.29	0.29	1.00	Concrete
19	BM6A	650.00	0.66	1.02	7.00	2.82	2.29	0.25	2.25	2.85	90	10.00	2.00	320	1.10	0.80	2.60	0.77	0.41	0.85	0.55	0.03	0.56	3.00	Concrete
20	BM7	700.00	0.21	0.47	6.70	2.40	2.25	0.41	2.41	3.01	90	10.00	2.00	320	2.40	0.60	2.60	0.06	-	1.99	0.19	0.61	0.76	3.30	Concrete
21	BM7A	750.00	0.86	1.02	5.50	2.57	2.54	0.56	2.56	3.16	90	10.00	2.00	320	2.30	0.85	2.60	0.46	0.30	1.74	0.29	0.59	0.62	4.50	Concrete
22	BM8	800.00	1.32	1.34	10.70	2.69	2.54	0.72	2.72	3.32	90	10.00	2.00	320	1.30	1.10	2.60	0.62	0.60	0.58	0.38	0.63	0.78	-	Concrete
23	BM8A	850.00	1.38	1.86	14.60	3.83	3.08	0.88	2.88	3.48	90	10.00	2.00	320	1.40	2.15	2.60	0.99	0.51	0.53	1.28	-	0.40	-	Concrete
24	BM9	900.00	1.77	2.00	8.50	2.97	3.86	1.03	3.43	4.03	90	8.00	2.40	320	1.90	2.15	3.00	0.97	0.74	0.87	1.12	1.06	0.17	-	Concrete
25	BM9A	950.00	2.08	2.16	9.50	4.12	3.24	1.19	3.59	4.19	90	8.00	2.40	320	2.05	2.05	3.00	0.97	0.89	0.86	0.86	0.07	0.95	-	Concrete
26	B6	992.55	1.54	1.94	8.00	5.03	5.02	1.32	3.72	4.32	90	8.00	2.40	320			3.00	0.62	0.22			-	-	-	Concrete
27	BM10	1000.00	1.48	1.97	9.00	3.37	3.45	1.34	3.74	4.34	90	8.00	2.40	320	2.50	1.60	3.00	0.63	0.14	1.16	0.26	0.97	0.89	-	Concrete
28	BM10A	1050.00	1.55	2.17	8.60	3.60	4.24	1.50	3.90	4.50	90	8.00	2.40	320	2.50	2.45	3.00	0.67	0.05	1.00	0.95	0.90	0.26	-	Concrete
29	BM11	1100.00	1.85	2.23	7.00	3.66	3.65	1.66	4.06	4.66	90	8.00	2.40	320	1.90	2.85	3.00	0.57	0.19	0.24	1.19	1.00	1.01	1.00	Concrete
30	BM11A	1150.00	2.40	2.44	6.20	3.82	3.77	1.81	4.21	4.81	90	8.00	2.40	320	2.40	2.40	3.00	0.63	0.59	0.59	0.59	0.99	1.04	1.80	Concrete
31	BM12	1200.00	2.60	2.78	7.80	4.01	4.92	1.97	4.37	4.97	90	8.00	2.40	320	2.50	2.95	3.00	0.81	0.63	0.53	0.98	0.96	0.05	0.20	Concrete
32	BM12A	1250.00	2.62	2.90	9.00	5.17	4.27	2.13	4.53	5.13	90	8.00	2.40	320	2.50	3.00	3.00	0.78	0.50	0.38	0.88	-	0.86	-	Concrete
33	BM13	1300.00	3.01	3.27	6.60	4.51	4.54	2.28	4.53	5.13	70	7.00	2.20	320	3.20	3.50	2.84	0.99	0.73	0.92	1.22	0.62	0.59	0.40	Concrete
34	BM13A	1350.00	3.60	3.58	4.50	4.86	4.75	2.44	4.64	5.24	70	7.00	2.20	320	3.50	3.00	2.80	1.14	1.16	1.06	0.56	0.38	0.49	2.50	Concrete
35	BM14	1400.00	3.64	3.73	5.55	4.96	4.86	2.59	4.79	5.39	70	7.00	2.20	320	3.75	3.60	2.80	1.14	1.05	1.16	1.01	0.43	0.53	1.45	Concrete
36	BM14	1400.00	3.64	3.73	5.55	4.96	4.86	2.59	5.09	5.69	130	10.00	2.50	320	4.00	3.95	3.10	1.14	1.05	1.41	1.36	0.73	0.83	4.45	Concrete
37	BM14A	1450.00	3.72	3.78	6.40	5.25	5.14	2.75	5.25	5.85	130	10.00	2.50	320	4.00	3.95	3.10	1.03	0.97	1.25	1.20	0.60	0.71	3.60	Concrete
38	BM15	1500.00	3.49	3.76	6.00	5.31	5.19	2.91	5.41	6.01	130	10.00	2.50	320	3.50	4.90	3.10	0.85	0.58	0.59	1.99	0.70	0.82	4.00	Concrete
39	B7	1534.60	3.32	3.63	8.50	7.35	7.27																		
40	BM15A	1550.00	3.37	3.58	5.40	5.62	5.60																		
41	BM16	1600.00	3.75	3.90	5.00	5.72	5.82																		
Average																	2.70	0.72	0.50	0.88	0.91	0.52	0.52	1.72	

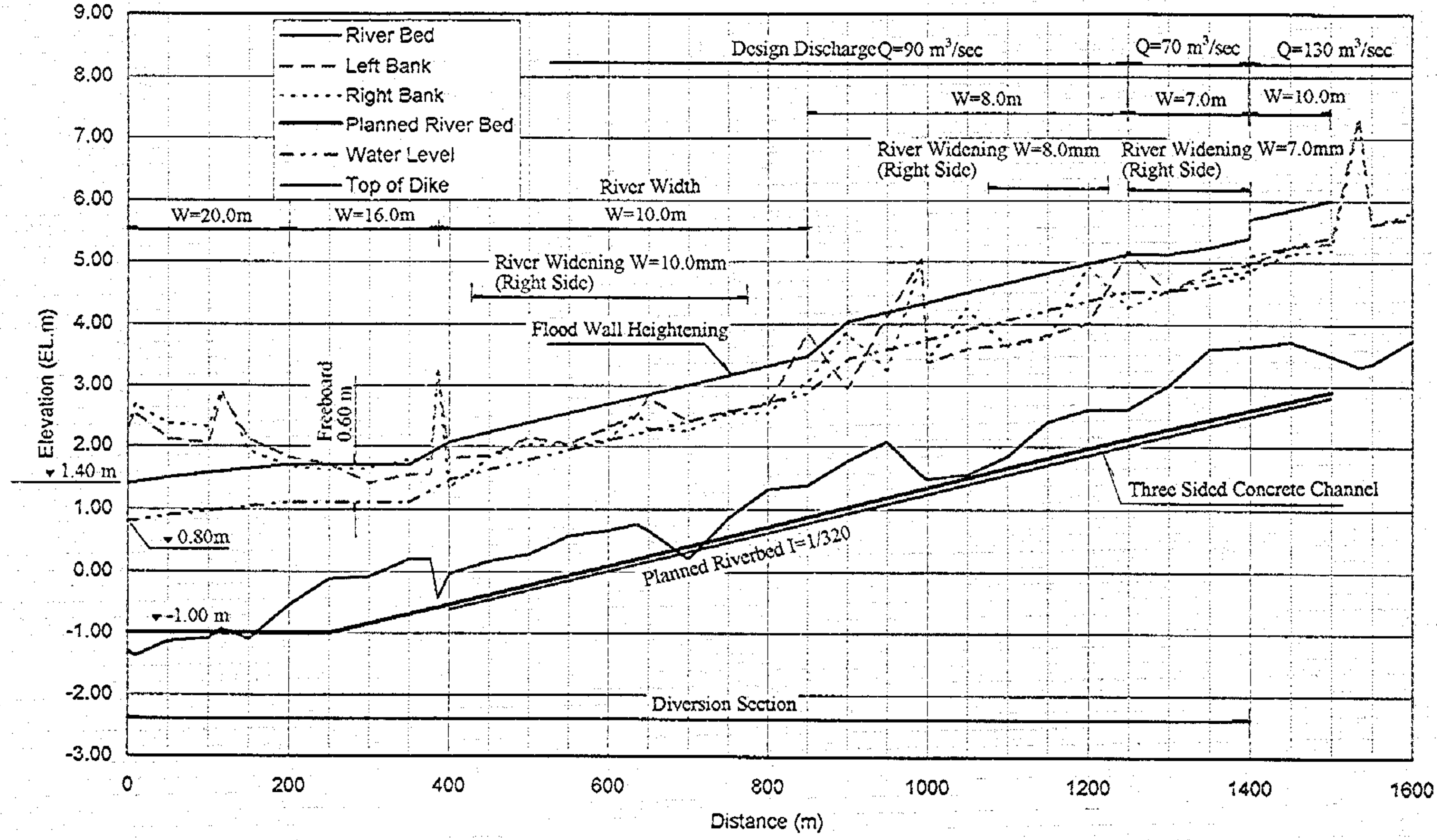


Figure-I.4.7 Longitudinal Section of Batu Merah River Improvement Plan

4.2.4 Tomu River Project

Tomu River is improved with 30-year return period. A check dam is also planned at 3k500 from the river mouth because of the fact that sedimentation is progressing in the river course, and is one of flood causes.

- 0k000 - 2k700 : River improvement with 30-year return period
- 3k500 : Check dam

(1) Planning Criteria

Design scale of Tomu River flood control plan is set at 30-year return period. Reference points, basin division, runoff model, design flood discharge and design discharge distribution are indicated in Figure-I.4.8.

(2) River Improvement Plan

River improvement plan of Tomu River is summarized in Table-I.4.10 and Figure-I.4.10 based on the following study:

(a) River Improvement Range

River improvement range is set from river mouth to 2k700 i.e. 2,700m length. There are currently no flood walls constructed upstream of 2k700, which is like a natural river. The houses upstream are located in relatively higher place and the upstream river from 2k700 is judged not to be necessaiy to be improved.

River Improvement Range : 0k000 - 2k700 (2,700m)

(b) River Course Alignment

River course alignment followed current river course with no new channel.

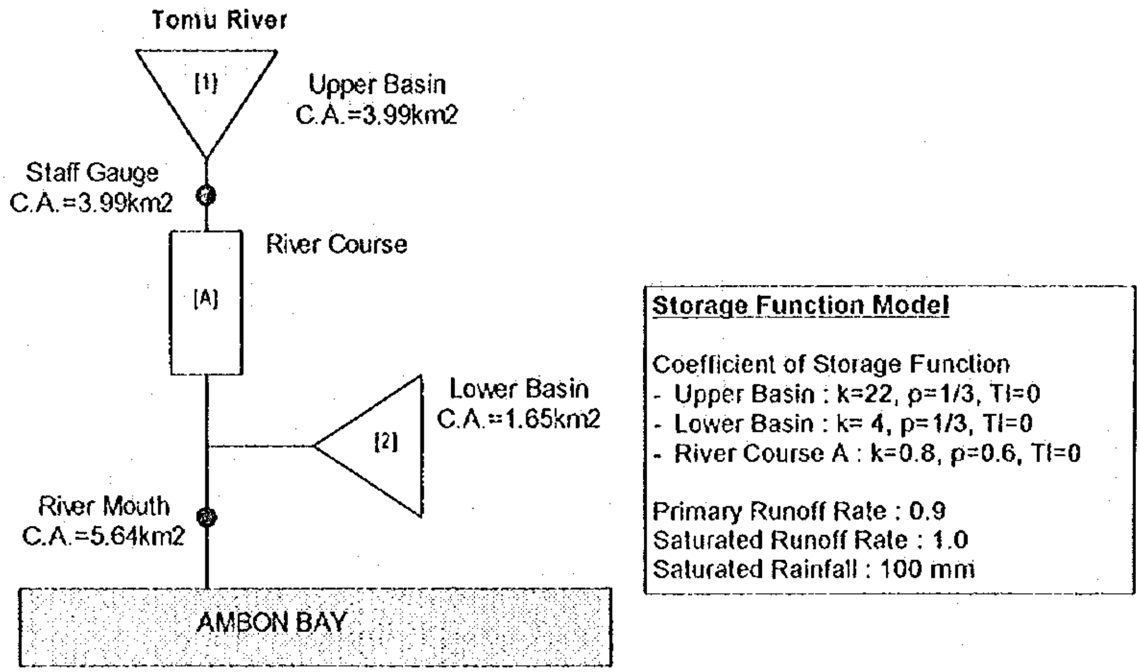
(c) Planned River Bed (Slope, Excavation)

Planned riverbed slope (I) was set at I=1/250 from the river mouth to 2k100 and at I=1/100 in the upstream of 2k100, in line with the current riverbed slope. Three cases of excavation depth, 1.0m, 0.5m and 0.0m below the deepest riverbed, were studied. Of these cases the shallowest excavation case was adopted because of economical reason, even though river bed excavation has advantage for enlarging discharge capacity and facilitating inner water drainage.

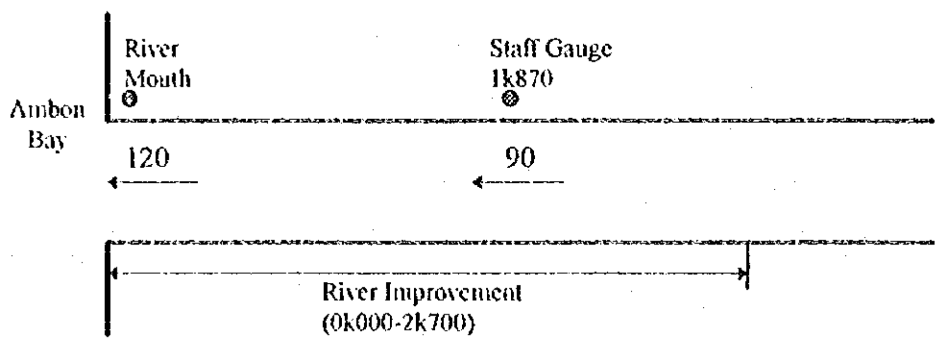
Design Scale of Flood Control Plan : 30-year Return Period

Reference Point and Basin Division

Basin Name	Catchment Area. (km^2)	Reference Point	Catchment Area (km^2)
[1] Upper Basin	3.99	Staff Gauge	3.99
[2] Lower Basin	1.65	River Mouth	5.64
Total	5.64		



Flood Runoff Model



Design Discharge Distribution

Figure-I.4.8 Planning Criteria of Tomu River Flood Control Plan

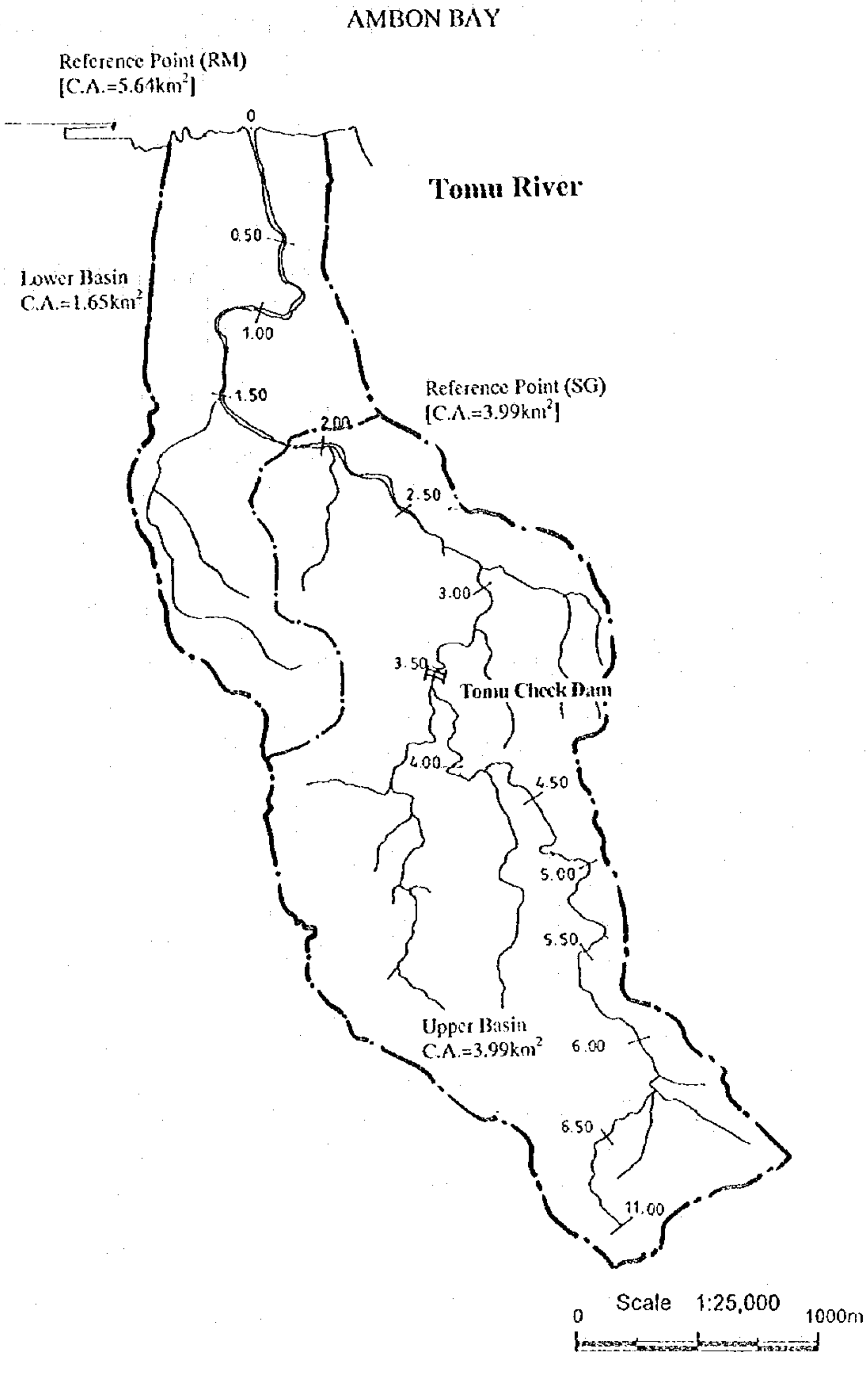
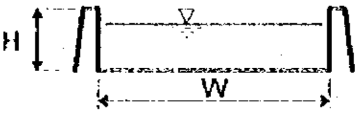


Figure-I.4.9 Tomu River Basin

(d) Standard Cross Section (Heightening, Widening)

According to the current river section with flood walls, the planned standard cross section was set rectangular as follows:



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

Based on uniform and non-uniform flow calculation on the design discharge 120 m^3/sec for 0k000-1k500 and 90 m^3/sec for 1k500-2k700, equivalent to 30-year return period, the following flood wall heightening and section widening were planned.

- Flood wall heightening is planned to be less than 1.0m mainly at the upstream of 1k550. Average raised height of flood walls is 0.6m in the right side and 0.7m in the left side.
- As for the river section from 0k650 to 1k000, river alignment is winding and width is narrowest, as well as riverside land elevation is so low that residents have suffered from flood damage. It could be judged that these sections are necessary to be improved drastically although resettlement is requested. Thus river widening is planned to 12.0m width on the right side where there is some room for widening.
- Three-sided concrete channel is planned in all the improved sections, in order to enlarge discharge capacity so as to be reduce roughness.

(e) Bridge Improvement

The list of bridges in Tomu River is shown in Table-1.4.8. Considering clearance between bridge underside elevation and H.W.L.(more than 0.6m) and excavation condition, the bridges of No.1, 2, 7 and 9 are necessary to be improved.

Table-1.4.8 List of Bridges in Tomu River

No.	Distance (m)	Bridge Underside Elevation (EL.m)	Bridge Pier Number	Bridge Pier Width (m)	Bridge Width (m)	*1 Objectives	Clearance (m)		Depth of *2 Excavation at Pier (m)		Remarks
1	0k008	1.50	-	-	7.00	VR	0.70	O	1.30	X	
2	0k309	1.70	-	-	5.00	VR	0.32	X	-	O	to Hotel under construction
3	0k347	3.90	-	-	-	O	2.36	O	-	O	
4	0k406	2.70	1	1.20	7.00	VR	0.95	O	0.45	O	
5	1k033	5.40	1	1.40	7.00	VR	0.76	O	0.25	O	
6	1k404	6.25	2	1.00	7.00	VR	0.76	O	0.35	O	
7	1k750	7.60	-	-	1.00	FPB	-0.03	X	-	O	
8	1k823	8.50	-	-	1.00	FPB	0.60	O	-	O	
9	2k007	8.65	-	-	2.00	FPB	0.20	X	-	O	
10	2k308	11.55	-	-	2.00	FPB	1.42	O	-	O	
11	2k645	14.95	-	-	1.50	FPB	1.42	O	-	O	

*1 Objectives (Vehicle Road, Foot Path Bridge, Water Pipe, Others)
*2 Excavation Depth below Deepest Riverbed

(f) Drainage Improvement

The list of drainage in Tomu River is shown in Table-I.4.9. The method of drainage improvement will be studied in the chapter of facility design.

Table-I.4.9 List of Drainage in Tomu River

No.	Distance (m)	Side	Bottom Elevation (EL.m)	Section Width (m)	Section Height (m)	Objectives	Remarks
1	0k016	L	0.075	0.60	1.20	CD	
2	0k028	R	0.390	0.90	0.40	CD	
3	0k050	L	0.520	0.80	1.20	CD	
4	0k137	L	0.050	0.90	0.80	CD	
5	0k319	L	-	1.20	1.20	CD	
6	0k413	R	1.170	0.90	0.50	CD	
7	0k638	R	1.280	0.60	0.90	HD	
8	0k771	R	1.430	1.00	0.50		
9	0k882	R	2.780	0.90	0.60	HD	
10	1k123	L/R	2.760	0.80	0.70	CD	
11	1k159	L	3.010	0.50	0.60	HD	
12	1k277	L	3.680	1.00	0.50		
13	1k478	R	3.743	0.70	0.90	HD	
14	1k869	L	6.100	0.90	0.60	HD	
15	2k050	L	7.210	0.90	0.70	HD	
16	2k100	L	7.600	0.80	0.60	HD	
17	2k169	R	7.870	0.90	1.20	HD	
18	2k497	L	10.890	1.20	0.90	HD	

* Objectives (CD: City Drainage, HD: Home Drainage, T: Toilet, O: Others)

(3) Check Dam Plan

Taking into account of topographical and geological condition in the basin catchment, as well as river condition of upstream and downstream, sediment discharge and allowable sediment discharge were studied in Chapter 3.2. As a results, a check dam at 3k500 (refer to Figure-I.4.9) is proposed with 37,000 m^3 of sediment reservoir capacity, designed as 10 years storage volume based on bed load flow shortfall. The catchment area of the check dam is 2.7 km^2 and design discharge of spillway is 73 m^3/sec with 100-year return period.

Table-I.4.10(1) Tomu River Improvement Plan

Section No.	Profile No.	Cumulative Distance	Current Condition: Dpst.Bed Level (EL.m)	Ave. Bed Level (EL.m)	River Width (m)	Left Bank (EL.m)	Right Bank (EL.m)	Planning Condition: Riverbed Level (EL.m)	Water Level (EL.m)	Top of Dike (EL.m)	Design Qp (m3/s)	River Width (m)	Water Height (m)	Slope 1/	R.bed at Wall Left (EL.m)	R.bed at Wall Right (EL.m)	Dike Height (m)	Excavation Depth Ave. (m)	Excavation Depth Deepest (m)	Excavation Depth R.bed at Wall L (m)	Excavation Depth R.bed at Wall R (m)	Heightneing Left (m)	Heightneing Right (m)	Widening Length (m)	Concrete Channel
1	TM0	0.00	-1.00	-0.52	25.60	1.82	2.82	-1.50	0.80	1.40	120	14.00	2.30	250	-1.05	-0.80	2.90	0.98	0.50	0.45	0.70	-	-	-	Concrete
2	B1	8.40	-1.11	-0.55	27.20	3.35	3.35	-1.47	0.80	1.40	120	14.00	2.27	250			2.87	0.92	0.36			-	-	-	Concrete
3	TM0A	50.00	-0.93	-0.63	16.45	1.97	2.04	-1.30	0.80	1.40	120	14.00	2.10	250	-0.40	-0.50	2.70	0.67	0.37	0.90	0.80	-	-	-	Concrete
4	TM1	100.00	-0.87	-0.48	16.05	2.09	1.91	-1.10	0.80	1.40	120	14.00	1.90	250	-0.20	-0.75	2.50	0.62	0.23	0.90	0.35	-	-	-	Concrete
5	TM1A	150.00	-0.82	-0.42	15.35	2.24	2.00	-0.90	0.80	1.40	120	14.00	1.70	250	0.05	-0.20	2.30	0.48	0.08	0.95	0.70	-	-	-	Concrete
6	TM2	200.00	-0.64	-0.25	16.25	1.87	1.96	-0.70	0.97	1.57	120	14.00	1.67	250	-0.25	0.05	2.27	0.45	0.06	0.45	0.75	-	-	-	Concrete
7	TM2A	250.00	-0.55	-0.24	14.60	2.06	2.07	-0.50	1.16	1.76	120	14.00	1.66	250	0.15	0.15	2.26	0.26	-	0.65	0.65	-	-	-	Concrete
8	TM3	300.00	-0.21	0.00	14.95	2.29	2.15	-0.30	1.36	1.96	120	14.00	1.66	250	0.06	0.15	2.26	0.30	0.09	0.36	0.45	-	-	-	Concrete
9	B2	308.50	-0.27	-0.08	14.70	2.31	2.05	-0.27	1.38	1.98	120	14.00	1.65	250			2.25	0.19	-			-	-	-	Concrete
10	B3	347.40	-0.46	0.37	22.45	3.28	2.78	-0.11	1.54	2.14	120	14.00	1.65	250			2.25	0.48	-			-	-	-	Concrete
11	TM3A	350.00	0.01	0.17	16.40	2.56	2.22	-0.10	1.55	2.15	120	14.00	1.65	250	0.25	0.20	2.25	0.27	0.11	0.35	0.30	-	-	-	Concrete
12	TM4	400.00	-0.47	0.46	25.90	3.25	3.56	0.10	1.74	2.34	120	14.00	1.64	250	0.30	0.30	2.24	0.36	-	0.20	0.20	-	-	-	Concrete
13	B4	406.10	0.10	0.56	20.80	3.21	3.18	0.12	1.75	2.35	120	14.00	1.62	250			2.22	0.44	-			-	-	-	Concrete
14	TM4A	450.00	-0.19	0.60	16.15	3.61	3.51	0.30	1.90	2.50	120	14.00	1.60	250	1.10	0.05	2.20	0.30	-	0.80	-	-	-	-	Concrete
15	TM5	500.00	0.71	0.82	12.40	4.32	3.81	0.50	2.06	2.66	120	14.00	1.56	250	1.50	1.70	2.16	0.32	0.21	1.00	1.20	-	-	1.60	Concrete
16	TM5A	550.00	0.94	1.13	18.00	4.62	3.97	0.70	2.20	2.80	120	14.00	1.50	250	1.05	0.95	2.10	0.43	0.24	0.35	0.25	-	-	-	Concrete
17	TM6	600.00	0.67	1.05	14.60	4.00	3.87	0.90	2.33	2.93	120	14.00	1.43	250	1.10	1.85	2.03	0.15	-	0.20	0.95	-	-	-	Concrete
18	TM6A	650.00	0.93	1.04	8.85	3.90	4.04	1.10	2.97	3.57	120	12.00	1.87	250	1.80	2.00	2.47	-	-	0.70	0.90	-	-	3.15	Concrete
19	TM7	700.00	0.80	1.48	14.10	4.24	4.15	1.30	3.17	3.77	120	12.00	1.87	250	2.25	1.30	2.47	0.18	-	0.95	0.00	-	-	-	Concrete
20	TM7A	750.00	1.19	1.73	10.10	4.56	4.27	1.50	3.38	3.98	120	12.00	1.88	250	2.50	2.50	2.48	0.23	-	1.00	1.00	-	-	1.90	Concrete
21	TM8	800.00	1.47	1.52	7.75	4.44	4.35	1.70	3.58	4.18	120	12.00	1.88	250	2.20	2.50	2.48	-	-	0.50	0.80	-	-	4.25	Concrete
22	TM8A	850.00	1.60	1.78	9.25	4.81	4.44	1.90	3.78	4.38	120	12.00	1.88	250	1.90	2.60	2.48	-	-	0.00	0.70	-	-	2.75	Concrete
23	TM9	900.00	1.80	2.03	9.20	5.04	4.70	2.10	3.99	4.59	120	12.00	1.89	250	2.85	3.10	2.49	-	-	0.75	1.00	-	-	2.80	Concrete
24	TM9A	950.00	2.04	2.22	10.95	5.12	4.89	2.30	4.21	4.81	120	12.00	1.91	250	3.00	3.10	2.51	-	-	0.70	0.80	-	-	1.05	Concrete
25	TM10	1000.00	2.16	2.56	13.85	5.15	4.92	2.50	4.45	5.05	120	12.00	1.95	250	1.40	2.95	2.55	0.06	-	-	0.45	-	0.13	-	Concrete
26	B5	1033.10	2.75	3.01	16.20	5.93	5.99	2.65	4.64	5.24	120	12.00	2.00	250			2.60	0.38	0.12			-	-	-	Concrete
27	TM10A	1050.00	2.61	2.73	12.70	5.04	5.02	2.70	4.87	5.47	120	12.00	2.17	250	3.10	3.25	2.77	0.03	-	0.40	0.55	0.43	0.45	-	Concrete
28	TM11	1100.00	2.77	3.04	17.85	5.30	5.54	2.90	4.87	5.47	120	15.00	1.97	250	2.80	4.60	2.57	0.14	-	-	1.70	0.17	-	-	Concrete
29	TM11A	1150.00	2.77	3.28	28.55	3.40	5.86	3.10	4.87	5.47	120	15.00	1.77	250	3.10	4.00	2.37	0.18	-	0.00	0.90	2.07	-	-	Concrete
30	TM12	1200.00	3.13	3.42	23.85	5.88	5.51	3.30	4.87	5.47	120	15.00	1.57	250	3.30	3.85	2.17	0.12	-	0.00	0.55	-	-	-	Concrete
31	TM12A	1250.00	3.65	3.90	23.00	6.14	6.14	3.50	5.04	5.64	120	15.00	1.54	250	4.05	3.95	2.14	0.40	0.15	0.55	0.45	-	-	-	Concrete
32	TM13	1300.00	3.79	4.08	26.65	6.29	6.41	3.70	5.20	5.80	120	15.00	1.50	250	4.10	3.95	2.10	0.38	0.09	0.40	0.25	-	-	-	Concrete
33	TM13A	1350.00	4.01	4.19	24.30	6.45	6.34	3.90	5.35	5.95	120	15.00	1.45	250	4.10	4.35	2.05	0.29	0.11	0.20	0.45	-	-	-	Concrete
34	TM14	1400.00	4.15	4.50	23.70	6.62	6.11	4.10	5.49	6.09	120	15.00	1.39	250	4.05	4.60	1.99	0.40	0.05	-	0.50	-	-	-	Concrete
35	B6	1403.50	4.31	4.53	32.50	6.95	6.93	4.11	5.49	6.09	120	15.00	1.38	250			1.98	0.42	0.20			-	-	-	Concrete
36	TM14A	1450.00	4.29	4.62	11.00	7.02	6.95	4.30	5.61	6.21	120	15.00	1.31	250	5.00	4.15	1.91	0.32	-	0.70	-	-	-	4.00	Concrete
37	TM15	1500.00	4.54	5.09	15.70	7.08	7.18	4.50	5.72	6.32	120	15.00	1.22	250	4.65	5.65	1.82	0.59	0.04	0.15	1.15	-	-	-	Concrete
38	TM15A	1550.00	4.74	4.90	8.60	6.53	6.78	4.70	6.84	7.44	90	8.00	2.14	250	5.00	5.00	2.74	0.20	0.04	0.30	0.30	0.91	0.66	-	Concrete
39	TM16	1600.00	5.00	5.14	10.00	7.09	7.01	4.90	7.04	7.64	90	8.00	2.14	250	5.00	5.10	2.74	0.24	0.10	0.10	0.20	0.55	0.63	-	Concrete
40	TM16A	1650.00	5.40	5.48	13.10	7.10	7.10	5.10	7.24	7.84	90	8.00	2.14	250	5.30	5.30	2.74	0.38	0.30	0.20	0.20	0.74	0.74	-	Concrete
41	TM17	1700.00	5.53	5.58	9.60	7.17	7.15	5.30	7.44	8.04	90	8.00	2.14	250	5.55	5.55	2.74	0.28	0.23	0.25	0.25	0.87	0.89	-	Concrete
42	B7/17A	1750.00	5.63	5.65	8.40	7.50	7.52	5.50	7.63	8.23	90	8.00	2.13	250	5.65	5.65	2.73	0.15	0.13	0.15	0.15	0.73	0.71	-	Concrete

Table-L4.10(2) Tomu River Improvement Plan

Section No.	Profile No.	Cumulative Distance	Current Condition: Dpst.Bed Level (EL.m)	Ave. Bed Level (EL.m)	River Width (m)	Left Bank (EL.m)	Right Bank (EL.m)	Planning Condition: Riverbed Level (EL.m)	Water Level (EL.m)	Top of Dike (EL.m)	Design Qp (m3/s)	River Width (m)	Water Height (m)	Slope 1:	R.bed at Wall Left (EL.m)	R.bed at Wall Right (EL.m)	Dike Height (m)	Excavation Depth Ave. (m)	Excavation Depth Deepest (m)	Excavation Depth R.bed at Wall L (m)	Excavation Depth R.bed at Wall R (m)	Heightneing Left (m)	Heightneing Right (m)	Widening Length (m)	Concrete Channel
43	TM18	1800.00	5.66	5.77	8.90	7.48	7.65	5.70	7.82	8.42	90	8.00	2.12	250	5.75	5.80	2.72	0.07	-	0.05	0.10	0.94	0.77	-	Concrete
44	B8	1822.50	5.75	6.00	8.20	7.50	7.64	5.79	7.90	8.50	90	8.00	2.11	250			2.71	0.21	-			1.00	0.86	-	Concrete
45	TM18A	1850.00	5.73	6.06	11.10	7.84	7.93	5.90	8.00	8.60	90	8.00	2.10	250	5.70	6.20	2.70	0.16	-	-	0.30	0.76	0.67	-	Concrete
46	TM19	1900.00	6.15	6.33	8.80	7.97	7.99	6.10	8.16	8.76	90	8.00	2.06	250	6.15	6.75	2.66	0.23	0.05	0.05	0.65	0.79	0.77	-	Concrete
47	TM19A	1950.00	6.44	6.59	8.55	8.18	8.18	6.30	8.30	8.90	90	8.00	2.00	250	7.00	6.60	2.60	0.29	0.14	0.70	0.30	0.72	0.72	-	Concrete
48	TM20	2000.00	6.69	6.77	12.45	9.08	8.60	6.50	8.42	9.02	90	8.00	1.92	250	6.80	6.90	2.52	0.27	0.19	0.30	0.40	-	0.42	-	Concrete
49	B9	2006.50	6.32	6.41	11.80	9.32	9.35	6.53	8.45	9.05	90	8.00	1.92	250			2.52	-	-			-	-	-	Concrete
50	TM20A	2050.00	7.03	7.22	12.75	8.70	11.36	6.70	8.53	9.13	90	8.00	1.83	250	6.95	7.35	2.43	0.52	0.33	0.25	0.65	0.43	-	-	Concrete
51	TM21	2100.00	6.89	7.19	13.45	8.47	10.65	6.90	8.62	9.22	90	8.00	1.72	250	7.30	7.20	2.32	0.29	-	0.40	0.30	0.75	-	-	Concrete
52	TM21A	2150.00	7.42	7.52	9.20	8.63	10.38	7.10	8.70	9.30	90	8.00	1.60	100	7.60	7.60	2.20	0.42	0.32	0.50	0.50	0.67	-	-	Concrete
53	TM22	2200.00	7.42	7.69	12.40	10.12	9.11	7.30	8.77	9.37	90	8.00	1.47	100	7.65	6.00	2.07	0.39	0.12	0.35	0.70	-	0.26	-	Concrete
54	TM22A	2250.00	7.67	8.05	7.70	9.62	11.00	7.80	9.55	10.15	90	7.00	1.75	100	8.50	9.60	2.35	0.25	-	0.70	1.80	0.53	-	-	Concrete
55	TM23	2300.00	8.10	8.72	8.55	11.12	11.91	8.30	10.05	10.65	90	7.00	1.75	100	8.05	10.30	2.35	0.42	-	-	2.00	-	-	-	Concrete
56	B10	2307.70	8.17	8.29	10.40	12.34	12.34	8.38	10.13	10.73	90	7.00	1.75	100			2.35	-	-			-	-	-	Concrete
57	TM23A	2350.00	8.51	8.84	12.55	10.76	13.15	8.80	10.55	11.15	90	7.00	1.75	100	8.45	9.50	2.35	0.04	-	-	0.70	0.39	-	-	Concrete
58	TM24	2400.00	8.59	9.13	7.00	11.23	12.46	9.30	11.05	11.65	90	7.00	1.75	100	11.20	10.80	2.35	-	-	1.90	1.50	0.42	-	-	Concrete
59	TM24A	2450.00	9.25	9.75	8.35	12.69	11.66	9.80	11.55	12.15	90	7.00	1.75	100	11.35	10.40	2.35	-	-	1.55	0.60	-	0.49	-	Concrete
60	TM25	2500.00	10.52	10.67	7.95	12.70	12.61	10.30	12.06	12.66	90	7.00	1.76	100	10.55	10.95	2.36	0.37	0.22	0.25	0.65	-	0.04	-	Concrete
61	TM25A	2550.00	10.56	10.78	8.60	13.91	13.99	10.80	12.56	13.16	90	7.00	1.76	100	12.60	12.60	2.36	-	-	1.80	1.80	-	-	-	Concrete
62	TM26	2600.00	11.39	11.43	7.00	14.76	14.20	11.30	13.07	13.67	90	7.00	1.77	100	13.20	13.20	2.37	0.13	0.09	1.90	1.90	-	-	-	Concrete
63	B11	2644.50	11.42	11.76	7.40	14.22	14.35	11.75	13.53	14.13	90	7.00	1.79	100			2.39	0.02	-			-	-	-	Concrete
64	TM26A	2650.00	11.48	11.69	8.65	13.90	14.04	11.80	13.58	14.18	90	7.00	1.78	100	11.90	11.90	2.38	-	-	0.10	0.10	0.28	0.14	-	Concrete
65	TM27	2700.00	11.73	12.24	8.75	13.58	13.86	12.30	14.10	14.70	90	7.00	1.80	100	11.85	12.15	2.40	-	-	-	-	1.12	0.84	-	Concrete
66	TM27A	2750.00	13.38	13.75	14.90	18.29	17.69																		
67	TM28	2800.00	13.93	14.39	19.35	18.51	17.95																		
68	TM28A	2850.00	14.05	15.81	28.55	19.22	19.66																		
69	TM29	2900.00	15.08	15.75	12.65	18.01	18.42																		
Average																	2.39	0.32	0.18	0.55	0.68	0.73	0.57		

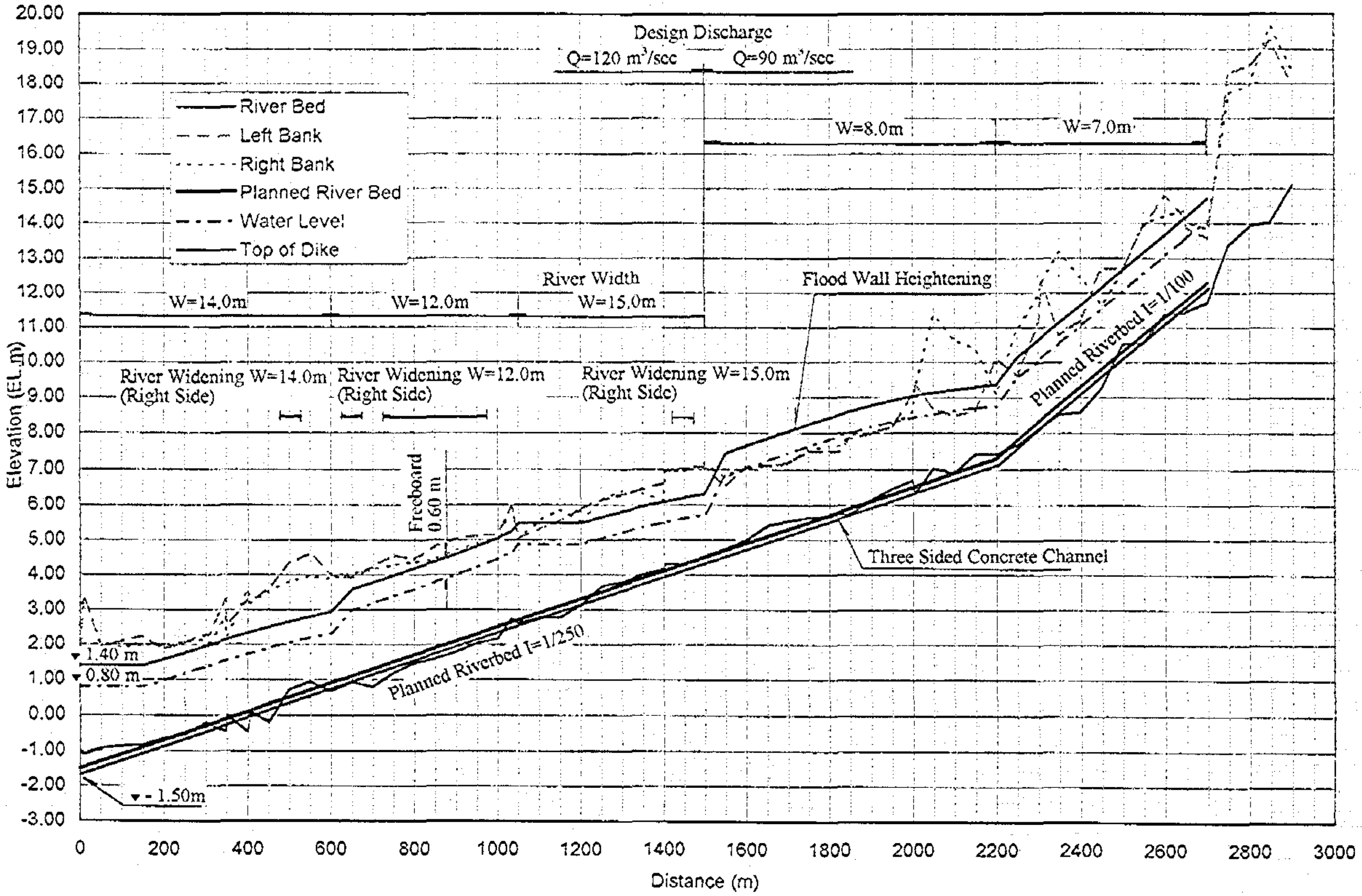


Figure-I.4.10 Longitudinal Section of Tomu River Improvement Plan

(3) River Amenity Improvement

(a) Location and Current Condition

Tomu River is the small river which flows down to the sea in the center of Ambon city. As Mardika Bus Terminal, Victoria Park and Mardika Market are located along the downstream of Tomu River, this seems to be the best place for river amenity improvement.

This area can be seen in the photo shown below. Mardika Bus Terminal is at the right side and the Victoria Park at the left side. The current river and river water are not clean. However many people gather to the bus terminal and the area has a waterfront atmosphere due to the sea and river water. Also this area has a plan of river improvement with excavation. Therefore the Study Team has planned this area, the downstream of Tomu River, to improve river amenity.

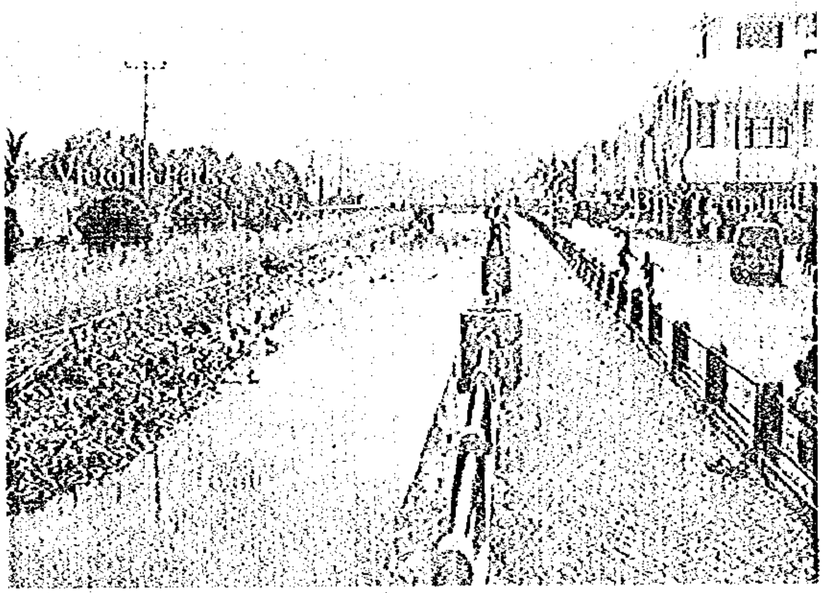


Photo : Downstream view of Tomu River near the sea

(b) Concept and Contents of 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, 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.

(c) River Amenity Improvement Image

Amenity improvement image of Tomu River is shown in Figure-I.4.11 and Figure-I.4.12.

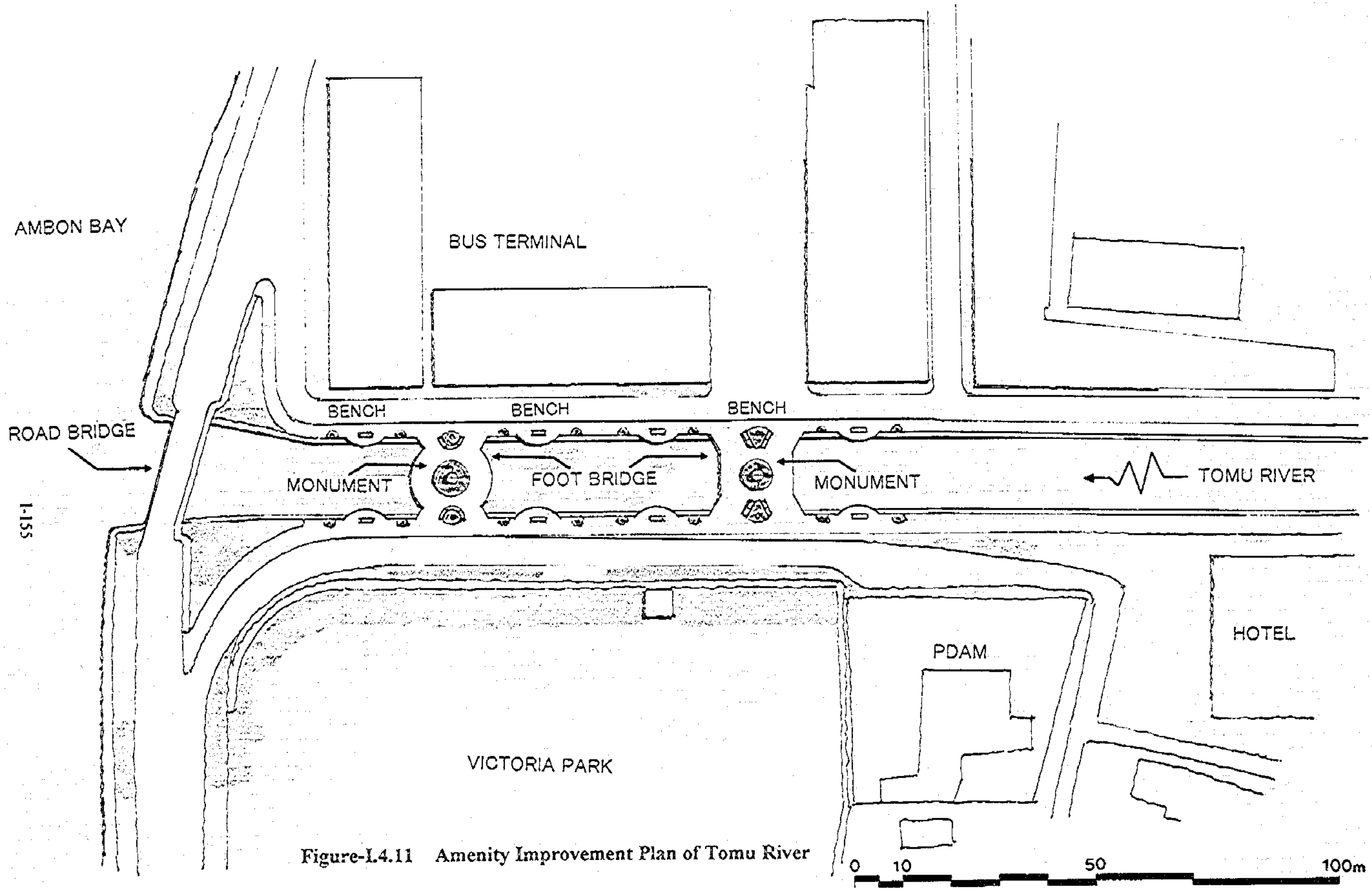


Figure-I.4.11 Amenity Improvement Plan of Tomu River

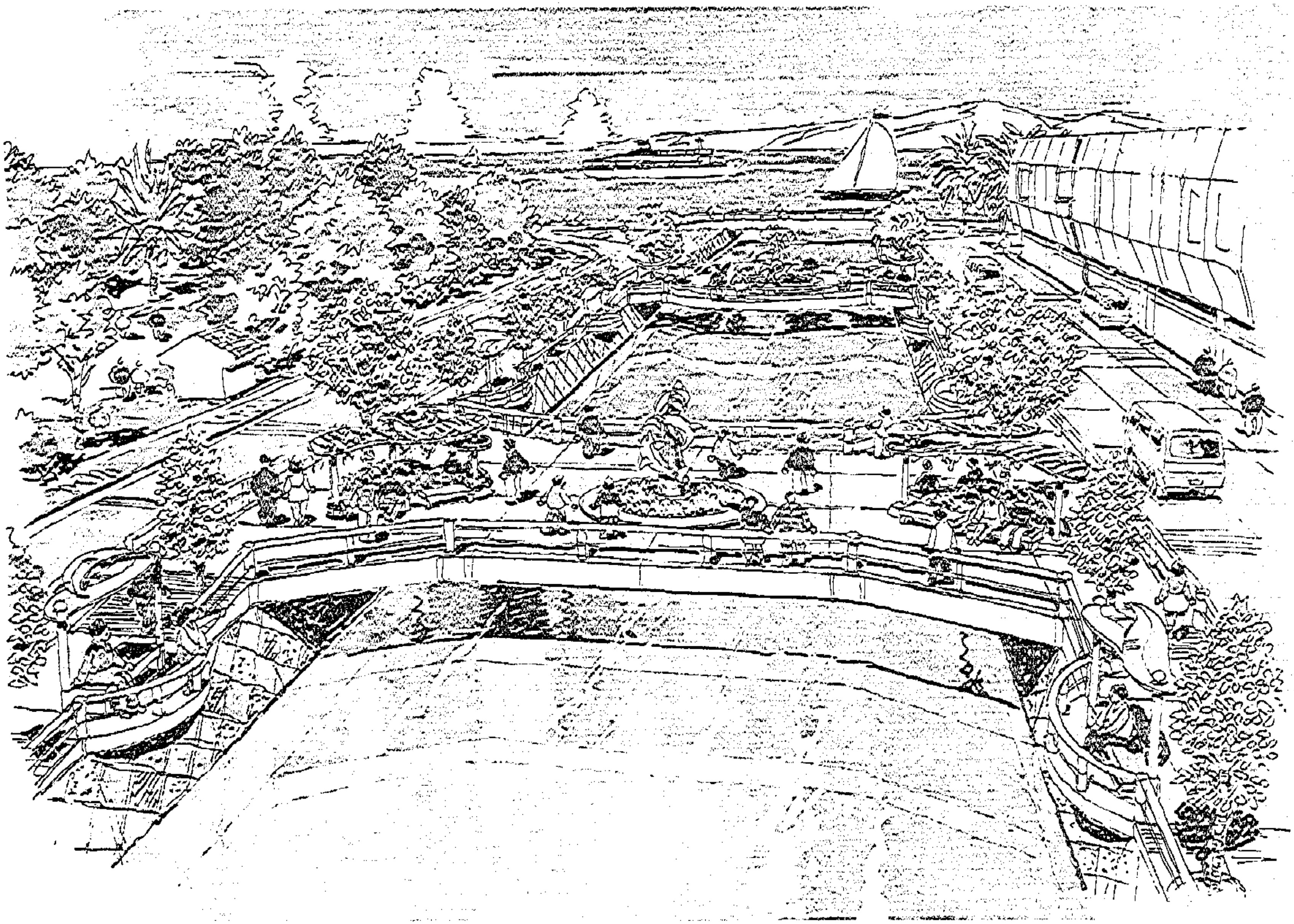


Figure-I.4.12 Amenity Improvement Image of Tomu River

4.2.5 Batu Gajah River Project

The downstream of Batu Gajah River is improved with 10-year return period. In order to achieve the security against flood with 30-year return period, a multi-purpose dam is planned to be constructed at 3k100 from the river mouth. This multi-purpose dam has the function of flood control, city water supply and river water maintenance. In order to reduce the sedimentation into the dam reservoir, a check dam is planned at 4k250 from the river mouth.

- 0k000 - 2k200 : River improvement with 10-year return period
- 3k100 : Multi-purpose dam
- 4k250 : Check dam

(1) Planning Criteria

Design scale of Batu Gajah River flood control plan is set at 30-year return period. Reference points, basin division, runoff model, design flood discharge and design discharge distribution are indicated in Figure-I.4.13.

(2) River Improvement Plan

River improvement plan of Batu Gajah River is summarized in Table-I.4.13 and Figure-I.4.15 based on the following study:

(a) River Improvement Range

River improvement range is set from river mouth to 2k200 i.e. 2,200m length. There are currently no flood walls constructed upstream of 2k800, which is like a natural V-shape river and houses are located on higher land. On the other hand, flood inundated area is the downstream from around 2k000 and the upstream river from 2k200 has steep river bed slope (I=1/65) and a few line of houses in low land along the river. Thus the upstream river from 2k200 is judged not to be necessary to be improved.

River Improvement Range : 0k000 - 2k200 (2,200m)

(b) River Course Alignment

River course alignment followed current river course with no new channel.

(c) Planned River Bed (Slope, Excavation)

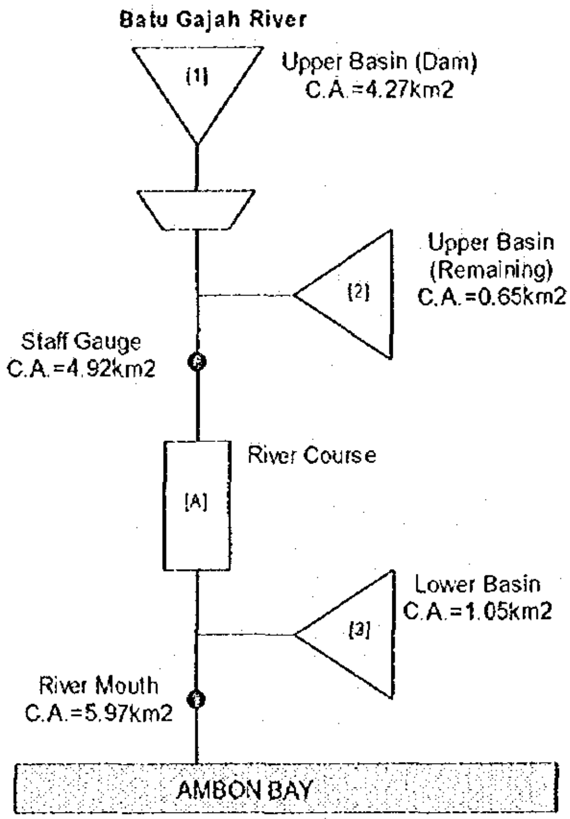
Planned riverbed slope (I) was set at I=1/240 for 0k000-0k900 and I=1/160 for 0k900-2k200, in line with the current riverbed slope. Three cases of excavation depth, 1.0m, 0.5m and 0.0m below the deepest riverbed, were studied. Of these cases the shallowest excavation case was adopted because of economical reason, even though river bed excavation has advantage for enlarging discharge capacity and facilitating inner water drainage.

Design Scale of Flood Control Plan : 30-year Return Period

Reference Point and Basin Division

Basin Name	Catchment Area (km²)
[1] Upper Basin (Dam)	4.27
[2] Upper Basin (Remaining)	0.65
[3] Lower Basin	1.05
Total	5.97

Reference Point	Catchment Area (km²)
Staff Gauge	4.92
River Mouth	5.97

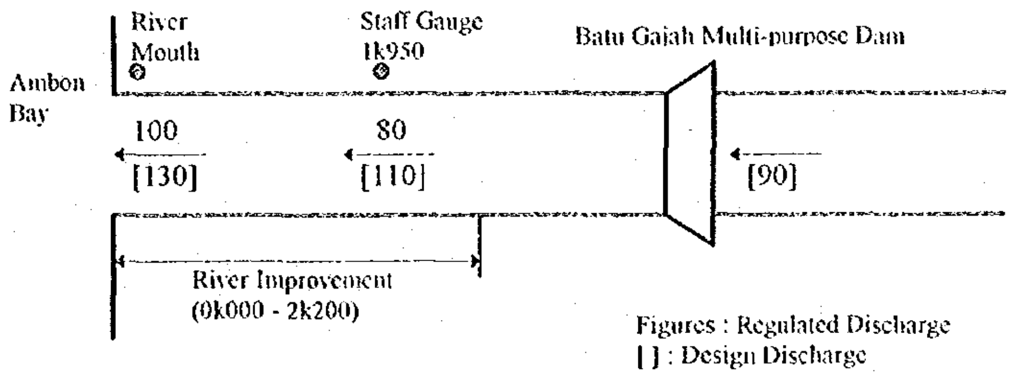


Storage Function Model

Coefficient of Storage Function
- Upper Basin : k=23, p=1/3, Tl=0
- Lower Basin : k= 4, p=1/3, Tl=0
- River Course A : k=0.7, p=0.6, Tl=0

Primary Runoff Rate : 0.9
Saturated Runoff Rate : 1.0
Saturated Rainfall : 100 mm

Flood Runoff Model



Design Discharge Distribution

Figure-I.4.13 Planning Criteria of Batu Gajah River Flood Control Plan

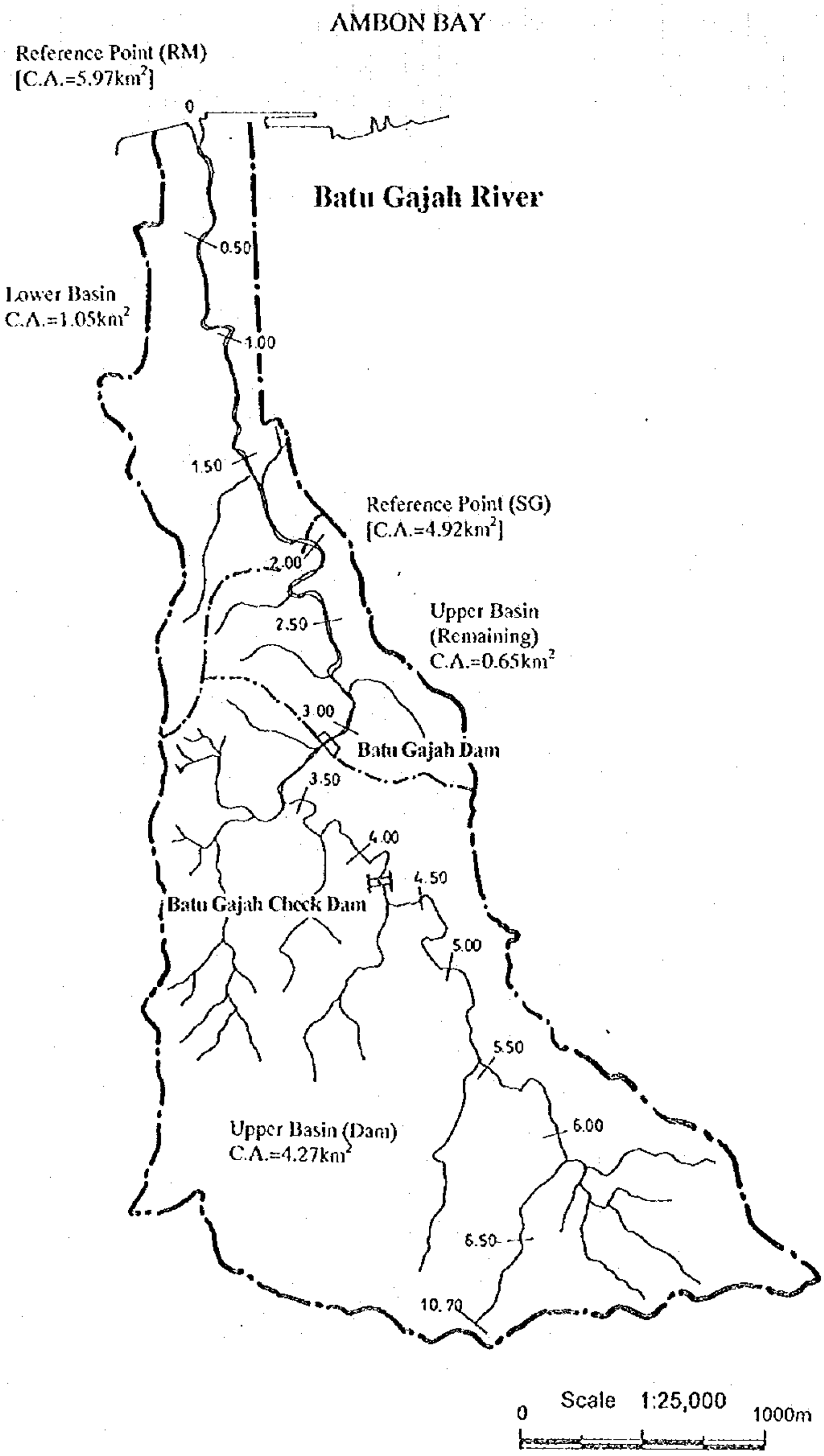
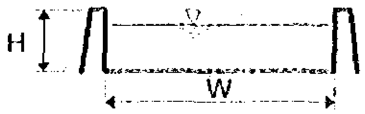


Figure-I.4.14 Batu Gajah River Basin

(d) Standard Cross Section (Heightening, Widening)

According to the current river section with flood walls, the planned standard cross section was set rectangular as follows:



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

Based on uniform and Non-uniform flow calculation on the design discharges of 100 m^3/sec equivalent to 10-year return period, the following flood wall heightening and section widening were planned.

- The river sections at which flood wall heightening is planned, are mainly from 0k500 to 0k750 and from 1k400 to 1k600. The flood walls was planned to be heightened by 0.1-1.3m of right side (0.5m on average) and 0.1-1.2m of left side (0.5m on average).
- There are partly narrow sections with the width of 5.9-7.5m, where widening works were planned, to the width of 8.0m in the river sections at 0k500, 0k700, 1k200, to the width of 9.0m at 1k500 and to 7.0m at 2k050 and 2k150.
- Three sided concrete channel is planned in the river sections from 0k250 to 2k200, which is gentle in slope and narrow in width, in order to enlarge discharge capacity and to lessen flood wall heightening so as to reduce roughness.

(e) Bridge Improvement

The list of bridges in Batu Gajah River is shown in Table-I.4.11. Considering clearance between bridge underside elevation and H.W.L.(more than 0.6m) and excavation condition, the bridges of No.1 to No.8 are necessary to be improved.

Table-I.4.11 List of Bridges in Batu Gajah River

No.	Distance (m)	Bridge Underside Elevation (EL.m)	Bridge Pier Number	Bridge Pier Width (m)	Bridge Width (m)	*1 Objectives	Clearance (m)		Depth of *2 Excavation at Pier (m)		Remarks
1	0k424	3.20	-	-	7.00	VR	0.87	O	1.40	X	
2	0k744	5.25	1	-	-	O	0.95	O	1.50	X	Telkom pipe
3	0k750	4.40	1	1.20	7.00	VR	0.07	X	1.80	X	
4	1k344	7.50	-	-	4.00	FPB	0.20	X	-	O	
5	1k629	10.25	1	25.00	2.00	FPB	1.18	O	1.25	X	
6	1k835	10.75	1	0.20	1.56	FPB	0.50	X	0.30	O	
7	1k919	10.85	-	-	1.20	FPB	0.16	X	-	O	
8	2k007	12.45	-	-	0.80	FPB	0.57	X	-	O	
9	2k070	13.50	-	-	1.00	FPB	1.23	O	-	O	
10	2k130	14.75	-	-	1.50	FPB	2.09	O	-	O	
11	2k344	18.40	-	-	2.00	FPB	-	-	-	-	1 motorcycle only
12	2k586	21.30	-	-	2.00	FPB	-	-	-	-	1 motorcycle only
13	2k650	21.05	-	-	2.00	FPB	-	-	-	-	1 motorcycle only
14	2k801	22.10	-	-	1.50	FPB	-	-	-	-	

*1 Objectives (Vehicle Road, Foot Path Bridge, Water Pipe, Others)
*2 Excavation Depth below Deepest Riverbed

(f) Drainage Improvement

The list of drainage in Batu Gajah River is shown in Table-I.4.12. The method of drainage improvement will be studied in the chapter of facility design.

Table-I.4.12 List of Drainage in Batu Gajah River

No.	Distance (m)	Side	Bottom Elevation (EL.m)	Section Width (m)	Section Height (m)	Objectives	Remarks
1	0k105	L	0.846	0.40	0.70	HD	
2	0k115	L	0.845	0.40	0.70	HD	
3	0k146	L	0.769	0.60	0.70	CD	
4	0k193	L	0.769	1.00	1.00	HD	
5	0k441	R	2.134	0.60	0.55	CD	
6	0k765	R	2.622	0.50	0.90	CD	
7	0k859	L	2.820	0.60	0.90	HD	
8	0k901	L	3.848	1.10	0.65	HD	
9	0k962	L	3.547	1.50	1.30	HD	
10	1k098	R	4.090	0.40	0.60	HD	
11	1k105	R	5.902	0.40	0.60	HD	
12	1k485	L	6.690	1.90	1.20	HD	
13	1k496	R	6.440	1.00	0.80	HD	
14	1k524	R	6.630	0.60	0.60	HD	
15	1k608	L	7.793	0.70	0.80	HD	
16	1k665	R	7.990	0.53	0.80	-	
17	1k743	L	8.760	0.89	0.65	HD	
18	1k953	L	9.820	1.10	0.68	HD	
19	2k064	L	11.814	0.70	0.70	HD	
20	2k098	L	11.640	0.60	0.80	HD	Covered by garbage
21	2k154	L	12.080	0.63	0.70	-	

* Objectives (City Drainage, Home Drainage, Toilet, Others)

(3) Check Dam Plan

Taking into account of topographical and geological condition in the basin catchment, as well as river condition of upstream and downstream, sediment discharge and allowable sediment discharge were studied in Chapter 3.2. As a results, a check dam at 4k250, the upstream of Batu Gajah Multi-purpose Dam (refer to Figure-I.4.14), are proposed with 10,000 m^3 of sediment reservoir capacity, designed as 10 years storage volume based on bed load flow shortfall. The catchment area of the check dam is 2.8 km^2 and design discharge of spillway is 74 m^3/sec with 100-year return period.

Table-I.4.13(1) Batu Gajah River Improvement Plan

Section No.	Profile No.	Cumulative Distance	Current Condition: Dpst.Bed Level	Ave. Bed Level	River Width	Left Bank	Right Bank	Planning Condition: Riverbed Level	Water Level	Top of Dike	Design Qo	River Width	Water Height	Slope 1/	R.bed at Wall: Left	Right	Dike Height	Excavation Depth: Ave.	Deepest	R.bed at Wall		Heightening: Left	Right	Widening Length	Concrete Channel
1	GJ0	0.00	-0.91	-0.51	54.30	1.87	1.90	-1.00	0.80	1.40	100	15.00	1.80	240	-1.00	-0.50	2.40	0.49	0.09	0.00	0.50	-	-	-	-
2	GJ0A	50.00	-0.98	-0.09	38.05	2.19	2.22	-0.79	0.87	1.47	100	15.00	1.66	240	-0.09	0.60	2.26	0.70	-	0.70	1.39	-	-	-	-
3	GJ1	100.00	-0.75	-0.20	37.15	2.05	1.95	-0.58	1.10	1.70	100	15.00	1.69	240	-0.75	0.20	2.29	0.38	-	-	0.78	-	-	-	-
4	GJ1A	150.00	-0.50	0.09	21.45	2.09	2.00	-0.38	1.32	1.92	100	15.00	1.70	240	-0.05	0.20	2.30	0.47	-	0.33	0.58	-	-	-	-
5	GJ2	200.00	0.12	0.48	15.70	2.17	2.18	-0.17	1.49	2.09	100	15.00	1.65	240	0.80	0.95	2.25	0.65	0.29	0.97	1.12	-	-	-	-
6	GJ2A	250.00	0.32	0.53	10.35	2.57	1.38	0.04	1.84	2.44	100	10.00	1.80	240	0.40	1.00	2.40	0.49	0.28	0.36	0.96	-	1.06	-	Concrete
7	GJ3	300.00	0.20	0.70	11.55	2.64	2.56	0.25	2.01	2.61	100	10.00	1.76	240	0.25	1.45	2.36	0.45	-	0.00	1.20	-	0.05	-	Concrete
8	GJ3A	350.00	0.67	1.00	12.20	2.72	2.81	0.46	2.16	2.76	100	10.00	1.70	240	0.90	1.40	2.30	0.54	0.21	0.44	0.94	0.04	-	-	Concrete
9	GJ4	400.00	0.87	1.22	17.90	3.45	3.00	0.67	2.29	2.89	100	10.00	1.62	240	1.40	0.95	2.22	0.55	0.20	0.73	0.28	-	-	-	Concrete
10	B1	423.50	0.93	1.81	20.60	5.01	5.03	0.76	2.33	2.93	100	10.00	1.57	240			2.17	1.05	0.17			-	-	-	Concrete
11	GJ4A	450.00	1.00	1.54	12.40	3.33	3.22	0.88	2.41	3.01	100	10.00	1.53	240	2.05	1.40	2.13	0.67	0.13	1.18	0.53	-	-	-	Concrete
12	GJ5	500.00	1.45	1.61	7.00	3.43	3.38	1.08	3.34	3.94	100	8.00	2.26	240	1.50	2.00	2.86	0.53	0.37	0.42	0.92	0.51	0.56	1.00	Concrete
13	GJ5A	550.00	1.55	1.85	8.95	3.88	3.60	1.29	3.55	4.15	100	8.00	2.26	240	1.60	2.50	2.86	0.56	0.26	0.31	1.21	0.27	0.55	-	Concrete
14	GJ6	600.00	1.91	2.14	9.30	3.76	3.67	1.50	3.76	4.36	100	8.00	2.26	240	2.50	2.20	2.86	0.64	0.41	1.00	0.70	0.60	0.69	-	Concrete
15	GJ6A	650.00	2.03	2.14	8.00	3.80	3.90	1.71	3.96	4.56	100	8.00	2.25	240	2.10	2.20	2.85	0.43	0.32	0.39	0.49	0.76	0.66	-	Concrete
16	GJ7	700.00	1.92	2.18	6.80	3.99	3.98	1.92	4.16	4.76	100	8.00	2.24	240	2.20	1.80	2.84	0.26	0.00	0.28	-	0.77	0.78	1.20	Concrete
17	B2	744.35	2.09	2.28	19.30	4.41	3.55	2.10	4.30	4.90	100	8.00	2.19	240			2.79	0.18	-			0.49	1.35	-	Concrete
18	B3/7A	750.00	2.11	2.34	20.20	5.15	4.38	2.13	4.33	4.93	100	8.00	2.21	240			2.81	0.22	-			-	0.55	-	Concrete
19	GJ8	800.00	2.56	2.78	11.38	6.03	6.21	2.33	4.47	5.07	100	8.00	2.14	240	2.85	2.90	2.74	0.45	0.23	0.52	0.57	-	-	-	Concrete
20	GJ8A	850.00	2.03	2.86	8.16	6.21	6.29	2.54	4.61	5.21	100	8.00	2.07	240	3.60	2.10	2.67	0.32	-	1.06	-	-	-	-	Concrete
21	GJ9	900.00	2.80	3.37	9.59	6.36	6.60	2.75	4.73	5.33	100	8.00	1.98	240	2.80	3.45	2.58	0.62	0.05	0.05	0.70	-	-	-	Concrete
22	GJ9A	950.00	3.26	3.67	11.57	6.68	6.89	3.06	5.05	5.65	100	8.00	1.98	160	2.20	3.99	2.58	0.61	0.20	-	0.93	-	-	-	Concrete
23	GJ10	1000.00	3.57	3.82	9.10	6.70	7.37	3.38	5.39	5.99	100	8.00	2.01	160	4.10	3.55	2.61	0.45	0.20	0.73	0.18	-	-	-	Concrete
24	GJ10A	1050.00	4.06	4.21	9.25	7.10	7.58	3.69	5.71	6.31	100	8.00	2.03	160	5.50	3.90	2.63	0.52	0.37	1.81	0.21	-	-	-	Concrete
25	GJ11	1100.00	3.95	4.40	9.40	6.96	7.36	4.00	6.05	6.65	100	8.00	2.05	160	4.80	3.95	2.65	0.40	-	0.80	-	-	-	-	Concrete
26	GJ11A	1150.00	4.44	4.88	10.60	8.07	7.40	4.31	6.42	7.02	100	8.00	2.11	160	4.14	5.50	2.71	0.57	0.13	-	1.19	-	-	-	Concrete
27	GJ12	1200.00	4.71	4.98	7.50	8.07	7.72	4.63	6.92	7.52	100	8.00	2.30	160	6.05	4.60	2.90	0.36	0.09	1.43	-	-	-	0.50	Concrete
28	GJ12A	1250.00	5.24	5.35	9.10	7.44	7.31	4.94	6.92	7.52	100	9.00	1.98	160	5.50	5.25	2.58	0.41	0.30	0.56	0.31	0.08	0.21	-	Concrete
29	GJ13	1300.00	5.21	5.57	10.70	7.85	7.88	5.25	7.04	7.64	100	9.00	1.79	160	5.15	5.80	2.39	0.32	-	-	0.55	-	-	-	Concrete
30	B4	1343.50	5.49	5.73	11.40	8.22	8.21	5.52	7.30	7.90	100	9.00	1.78	160			2.38	0.21	-			-	-	-	Concrete
31	GJ13A	1350.00	5.53	5.85	10.30	8.73	8.09	5.56	7.34	7.94	100	9.00	1.78	160	6.10	5.50	2.38	0.29	-	0.54	-	-	-	-	Concrete
32	GJ14	1400.00	5.96	6.07	9.30	7.03	7.32	5.88	7.67	8.27	100	9.00	1.79	160	6.15	6.75	2.39	0.20	0.09	0.28	0.88	1.24	0.95	-	Concrete
33	GJ14A	1450.00	5.93	6.47	12.95	7.68	7.97	6.19	7.97	8.57	100	9.00	1.79	160	6.10	7.00	2.39	0.28	-	-	0.81	0.89	0.60	-	Concrete
34	GJ15	1500.00	6.40	6.71	11.45	7.97	8.24	6.50	8.28	8.88	100	9.00	1.78	160	6.90	6.40	2.38	0.21	-	0.40	-	0.91	0.64	-	Concrete
35	GJ15A	1550.00	6.73	7.20	13.30	8.49	8.85	6.81	8.58	9.18	100	9.00	1.77	160	7.75	6.90	2.37	0.39	-	0.94	0.09	0.69	0.33	-	Concrete
36	GJ16	1600.00	7.13	7.50	7.50	9.21	9.29	7.13	8.90	9.50	100	9.00	1.78	160	7.20	8.00	2.38	0.38	0.00	0.08	0.88	0.29	0.21	1.50	Concrete
37	B5	1629.40	7.04	7.99	14.50	10.26	10.15	7.31	9.07	9.67	100	9.00	1.76	160			2.36	0.68	-			-	-	-	Concrete
38	GJ16A	1650.00	6.98	8.00	13.55	10.17	9.49	7.44	9.20	9.80	100	9.00	1.76	160	8.60	7.60	2.36	0.56	-	1.36	0.16	-	0.31	-	Concrete
39	GJ17	1700.00	8.01	8.48	13.85	10.45	10.07	7.75	9.49	10.09	100	9.00	1.74	160	8.00	8.80	2.34	0.73	0.26	0.25	1.05	-	0.02	-	Concrete
40	GJ17A	1750.00	8.33	8.28	14.35	10.61	9.82	8.06	9.78	10.38	100	9.00	1.71	160	8.15	8.20	2.31	0.22	0.27	0.09	0.14	-	0.56	-	Concrete
41	GJ18	1800.00	8.43	8.85	9.65	11.24	12.16	8.38	10.07	10.67	100	9.00	1.70	160	9.20	6.60	2.30	0.48	0.05	0.82	0.23	-	-	-	Concrete
42	B6	1835.00	8.85	9.16	15.20	11.69	11.72	8.59	10.25	10.85	100	9.00	1.65	160			2.25	0.57	0.26			-	-	-	Concrete
43	GJ18A	1850.00	9.02	9.39	13.70	11.25	11.25	8.69	10.34	10.94	100	9.00	1.66	160	9.05	9.05	2.25	0.70	0.33	0.36	0.36	-	-	-	Concrete

Table-I.4.13(2) Batu Gajah River Improvement Plan

			Current Condition					Planning Condition																	
Section No.	Profile No	Cumulative Distance	Dpst.Bed Level	Ave. Bed Level	River Width	Left Bank	Right Bank	Riverbed Level	Water Level	Top of Dike	Design Qp	River Width	Water Height	Slope I	R.bed at Wall Left	R.bed at Wall Right	Dike Height	Excavation Depth Ave.	Excavation Depth Deepest	Excavation Depth R.bed at Wall		Heightneing Left	Heightneing Right	Widening Length	Concrete Channel
44	GJ19	1900.00	9.25	9.74	14.40	11.31	11.85	9.00	10.59	11.19	100	9.00	1.59	160	9.20	10.00	2.19	0.74	0.25	0.20	1.00	-	-	-	Concrete
45	B7	1918.90	9.34	9.72	12.32	12.12	12.24	9.12	10.69	11.29	100	9.00	1.57	160			2.17	0.60	0.22			-	-	-	Concrete
46	GJ19A	1950.00	9.47	9.91	9.25	11.75	11.45	9.31	10.83	11.43	100	9.00	1.52	160	9.60	10.95	2.12	0.60	0.16	0.29	1.64	-	-	-	Concrete
47	GJ20	2000.00	9.88	9.98	7.10	12.68	13.09	9.63	11.85	12.45	100	7.00	2.22	160	10.10	9.80	2.82	0.36	0.26	0.48	0.18	-	-	-	Concrete
48	B8	2007.40	9.96	9.97	7.40	12.68	12.68	9.67	11.88	12.48	100	7.00	2.21	160			2.81	0.30	0.23			-	-	-	Concrete
49	GJ20A	2050.00	10.05	10.55	6.40	12.73	12.83	9.94	12.16	12.76	100	7.00	2.22	160	10.15	11.00	2.82	0.61	0.11	0.21	1.06	0.03	-	0.60	Concrete
50	B9	2070.00	10.26	10.75	9.20	13.87	13.86	10.06	12.27	12.87	100	7.00	2.21	160			2.81	0.69	0.20			-	-	-	Concrete
51	GJ21	2100.00	10.46	10.76	8.00	12.85	14.87	10.25	12.46	13.06	100	7.00	2.21	160	11.30	11.60	2.81	0.51	0.21	1.05	1.35	0.21	-	-	Concrete
52	B10	2129.90	10.75	11.06	7.00	15.26	15.32	10.44	12.66	13.26	100	7.00	2.22	160			2.82	0.62	0.31			-	-	-	Concrete
53	GJ21A	2150.00	10.94	11.22	5.85	13.18	14.92	10.56	12.77	13.37	100	7.00	2.21	160	11.60	11.15	2.81	0.66	0.38	1.04	0.59	0.19	-	1.15	Concrete
54	GJ22	2200.00	11.21	11.39	7.40	13.84	13.64	10.88	13.10	13.70	100	7.00	2.23	160	11.90	11.90	2.83	0.52	0.34	1.03	1.03	-	0.06	-	Concrete
55	GJ22A	2250.00	12.39	12.89	8.80	15.00	16.05																		
56	GJ23	2300.00	13.21	13.53	12.60	15.13	15.70																		
57	B11	2343.90	13.72	14.26	10.00	18.86	18.77																		
58	GJ23A	2350.00	13.79	14.23	10.60	16.36	17.69																		
59	GJ24	2400.00	13.45	14.44	14.00	17.65	17.01																		
Average																	2.52	0.49	0.22	0.60	0.73	0.50	0.53		

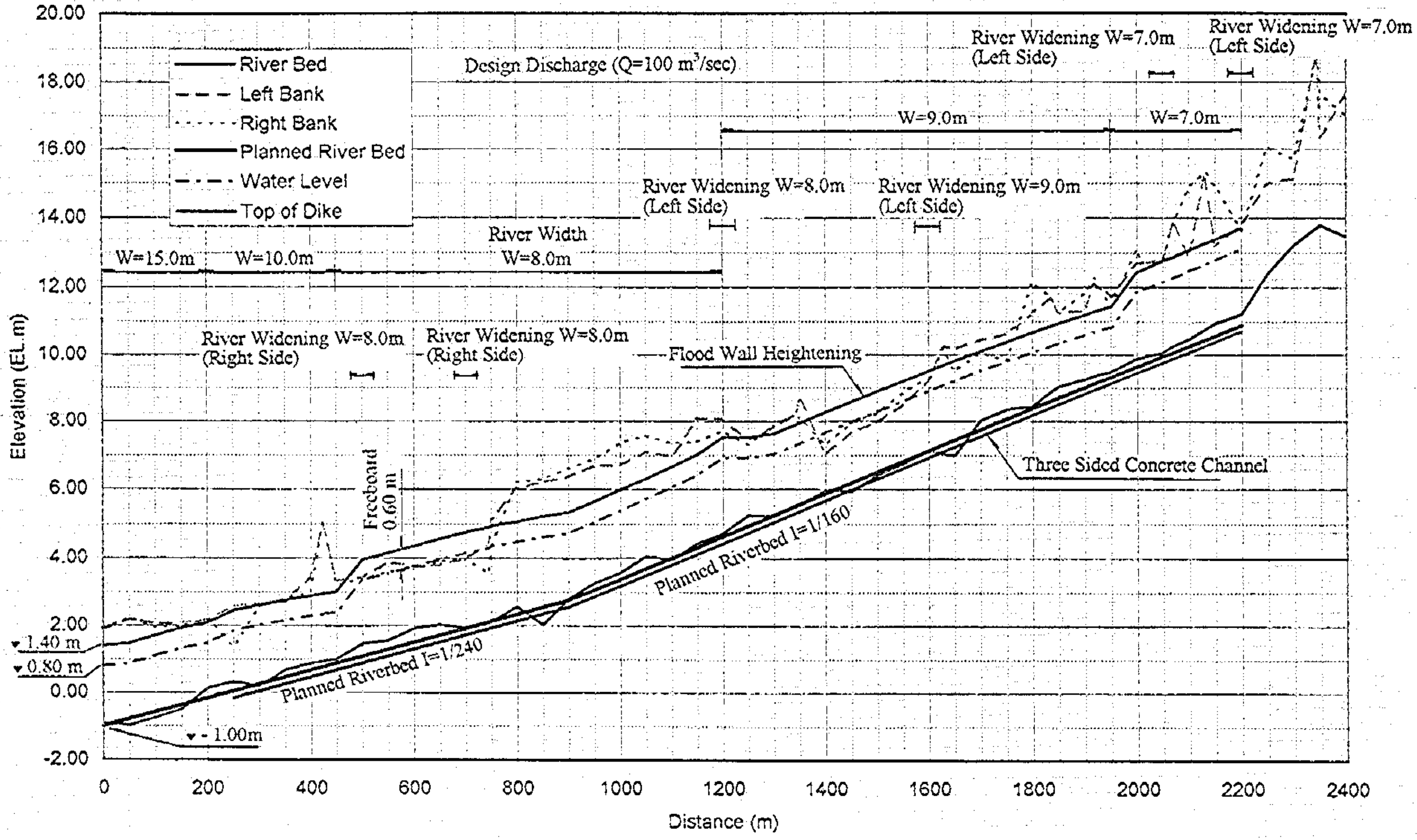


Figure-I.4.15 Longitudinal Section of Batu Gajah River Improvement Plan

(4) Batu Gajah Multi-purpose Dam Plan

(a) Flood Regulation Plan by Dam

<Flood Regulation System and Calculation Method>

The most reliable and effective method shall be applied for flood regulation system by dam. There are the four methods, namely 1) Natural Control Method, 2) Constant Discharging Method, 3) Constant Rate Control Method, and 4) Constant Rate and Discharging Method. In view of the small dam basin area (less than 20 km^2) and ease of operation and maintenance, the Natural Control Method has been adopted as the flood regulation system. Spillways are gate-less type, i.e. not fitted with gates for flood control.

Flood regulation effect by a dam is calculated applying the following equations, using a relationship between water level and reservoir volume.

$$\frac{I_1+I_2}{2}\times\Delta t=\frac{O_1+O_2}{2}\times\Delta t+(S_2-S_1)$$

$$\frac{O_2}{2}\times\Delta t+S_2=\frac{I_1+I_2}{2}\times\Delta t-\frac{O_1}{2}\times\Delta t+S_1$$

where,

	I_1, I_2	: Inflow to reservoir at the time of t_1 and t_2
	O1, O2	: Outflow from reservoir at the time of t_1 and t_2
	S1, S2	: Reservoir volume at the time of t_1 and t_2
	Δt	: Calculation time interval

Discharge from spillway (weir/conduit) is calculated using following equations:

$H/h \le 1.3$: $Q = 1.8\cdot b\cdot H^{1.5}$

$H/h \ge 2.0$: $Q = 0.9\cdot b\cdot h\cdot\sqrt{2g(H-h/2)}$

1.3<H/h<2.0 : to complement with straight line and take Q using both above equations

where,

	H	: Water height over spillway weir (m)
	h	: Spillway height (m)
	b	: Spillway width (m)
	Q	: Discharge (m^3/sec)

<Flood Regulation Plan>

The relationship between Water Level and Reservoir Volume of Batu Gajah Dam is shown in Figure-I.4.16.

Flood regulation calculation was carried out changing the size of the spillway, 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. The calculation results are shown in Table-I.4.14. Discharge characteristics of the main spillway including the emergency spillway are shown in Figure-I.4.17.

Flood control plan of Batu Gajah Dam (hydrograph) and flood discharge distribution of Batu Gajah River are shown in Figure-I.4.18 and Figure-I.4.19.

Elevation (EL.m)	Height (m)	Area ('000m²)	Volume ('000m³)	Accumulated Volume ('000m³)
35	-	0.000	0.000	0.000
40	5	3.236	8.090	8.090
45	5	7.465	26.753	34.843
50	5	24.073	78.845	113.688
55	5	47.367	178.600	292.288
60	5	66.847	285.535	577.823
65	5	89.178	390.063	967.885
70	5	114.805	509.958	1,477.843
75	5	147.265	655.175	2,133.018

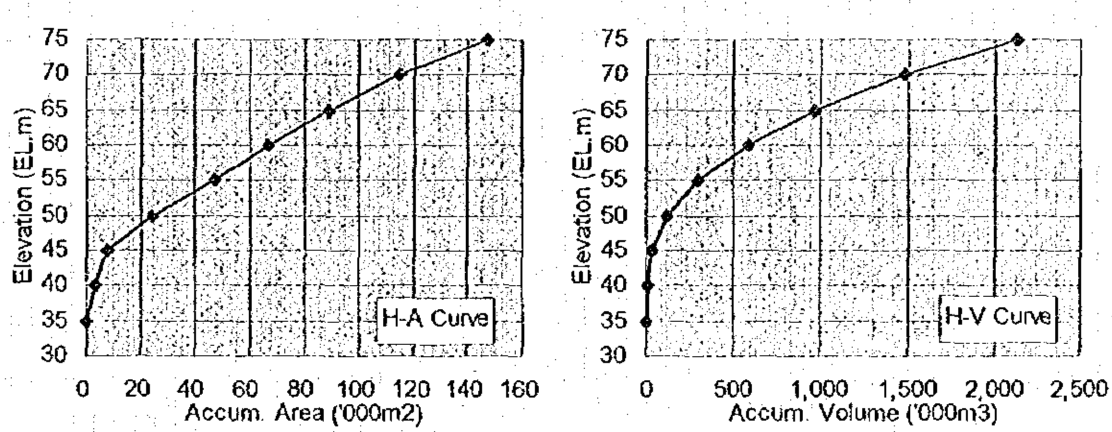


Figure-I.4.16 Water Level and Reservoir Volume of Batu Gajah Dam

Table-I.4.14 Flood Regulation Calculation Result (Batu Gajah Dam)

Item		Unit	1990/06 Flood
<Reference Points>			
River Mouth	Peak Discharge	m³/sec	123
	Regulated Peak Discharge	m³/sec	98
	Regulated Amount	m³/sec	25
Staff Gauge	Peak Discharge	m³/sec	101
	Regulated Peak Discharge	m³/sec	80
	Regulated Amount	m³/sec	21
<Dam>			
Peak Inflow		m³/sec	88
Maximum Discharge from Spillway		m³/sec	70
Discharge from Spillway at Peak Inflow		m³/sec	64
Regulated Amount		m³/sec	24
Net Flood Storage Capacity Vn		m³	338,000
Design Flood Storage Capacity (Vd=1.2Vn)		m³	406,000
Rainfall Depth Equivalent to Vd		mm	95
Surcharge Water Level		EL.m	70.50
<Main Spillway>			
Type		-	Overflow
Crest Level		EL.m	66.60
Width		m	6.5
Height (Water Height)		m	3.3

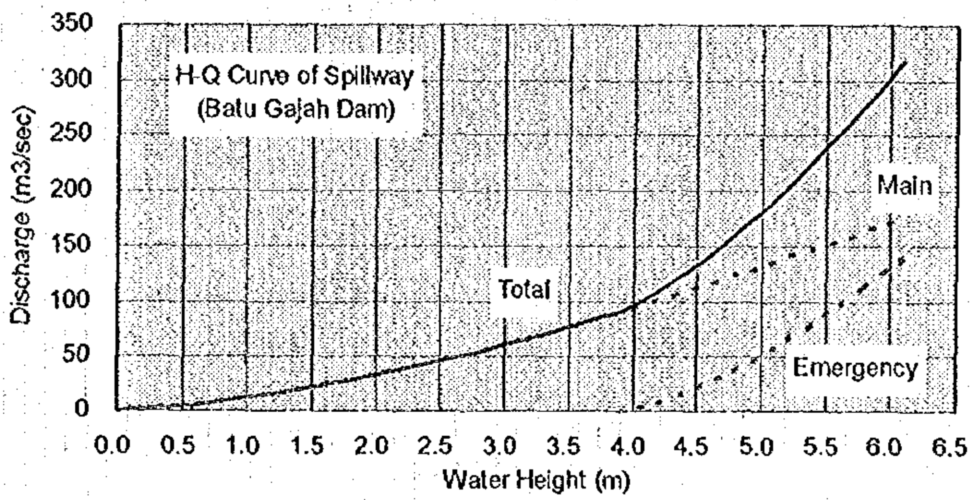


Figure-I.4.17 Spillway H-Q Curve of Batu Gajah Dam

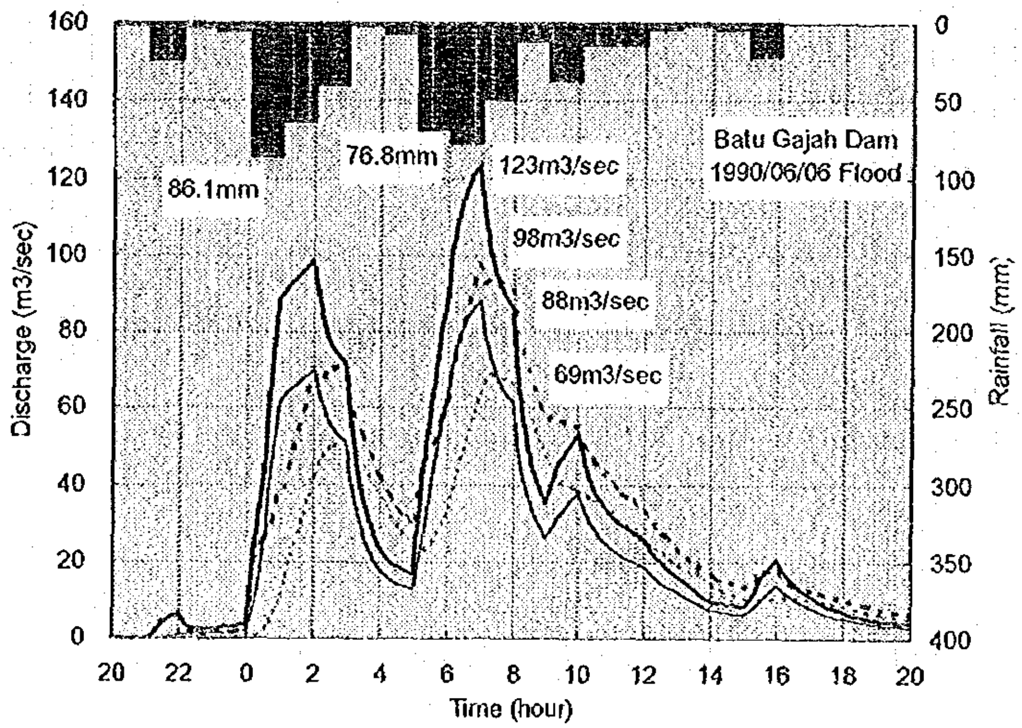


Figure-I.4.18 Flood Control Plan of Batu Gajah Dam

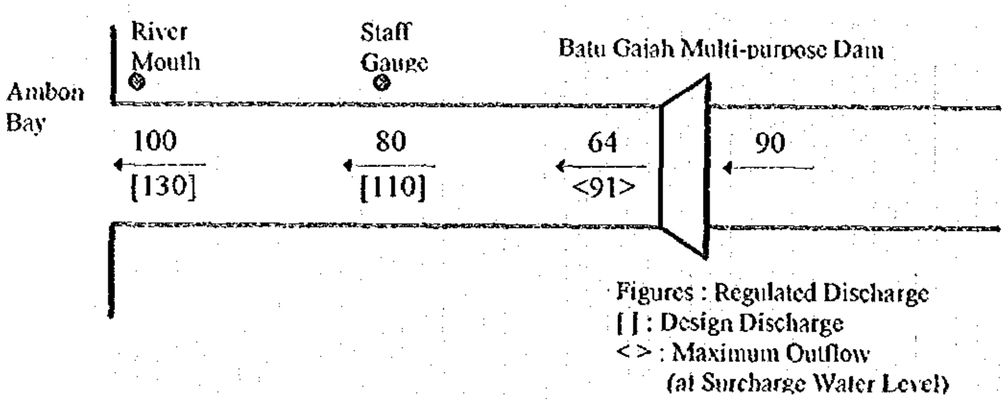


Figure-I.4.19 Flood Discharge Distribution of Batu Gajah River

(b) Batu Gajah Multi-Purpose Dam

Based on the flood regulation plan by the dam and water utilization plan explained in Section 3.4, Batu Gajah Multi-purpose Dam were planned. The specification of the dam is determined as shown in Table-I.4.15 and the dam reservoir volume allocation is shown in Figure-I.4.20.

Table-I.4.15 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	
Spillway	Main Spillway : Type	-	Free Overflow	
	: Structure - Width	m	6.50	
	- Height	m	3.90	
	Emergency Spillway : Type	-	Free Overflow	Qp=190 m^3/sec
	: Structure - Width	m	24.00	(2,000-year)
	- Height	m	1.50	

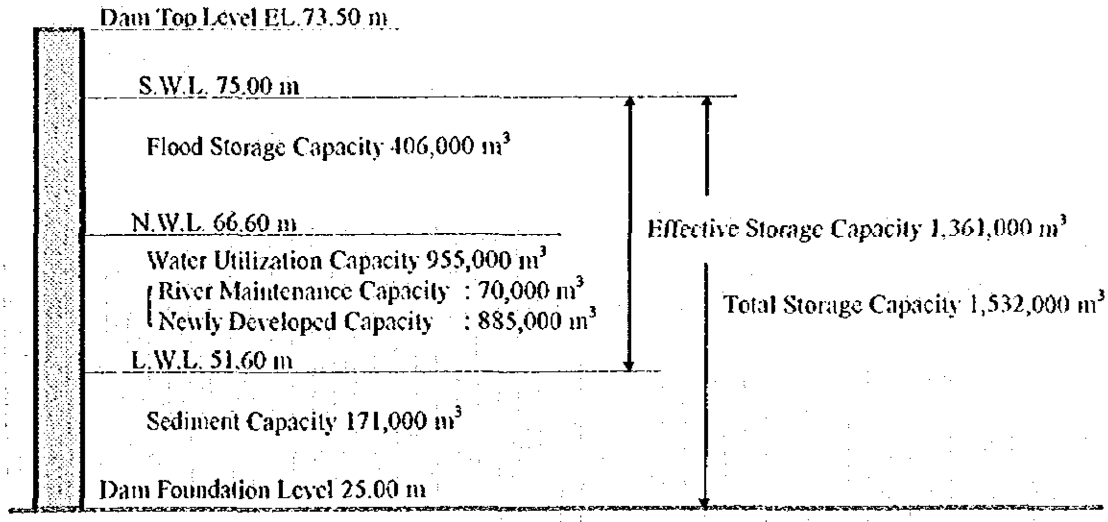


Figure-I.4.20 Reservoir Volume Allocation for Batu Gajah Dam

4.2.6 Batu Gantung River Project

The downstream of Batu Gantung River is improved with 10-year return period. In order to achieve the security against flood with 30-year return period, a multi-purpose dam is planned to be constructed at 2k950 from the river mouth. This multi-purpose dam has the function of flood control, city water supply and river water maintenance. In order to reduce the sedimentation into the dam reservoir, a check dam is planned at 4k000 from the river mouth.

- 0k000 - 1k450 : River improvement with 10-year return period
- 2k950 : Multi-purpose dam
- 4k000 : Check dam

(1) Planning Criteria

Design scale of Batu Gantung River flood control plan is set at 30-year return period. Reference points, basin division, runoff model, design flood discharge and design discharge distribution are indicated in Figure-I.4.21.

(2) River Improvement Plan

River improvement plan of Batu Gantung River is summarized in Table-I.4.18 and Figure-I.4.23 based on the following study:

(a) River Improvement Range

River improvement range is set from river mouth to 1k450 i.e. 1,450m length. There are currently no flood walls constructed upstream of 1k450, which is like a natural V-shape river and very few houses are located along the river. Thus the upstream river from 1k450 is judged not to be necessary to be improved.

River Improvement Range : 0k000 - 1k450 (1,450m)

(b) River Course Alignment

River course alignment followed current river course with no new channel.

(c) Planned River Bed (Slope, Excavation)

Planned riverbed slope of the downstream from 0k000 to 0k150 was set level at EL.-1.00m, which is the nearly current deepest river bed level at the river mouth. Because the river section is enough wide and high so that it is not necessary to be excavated and heightened.

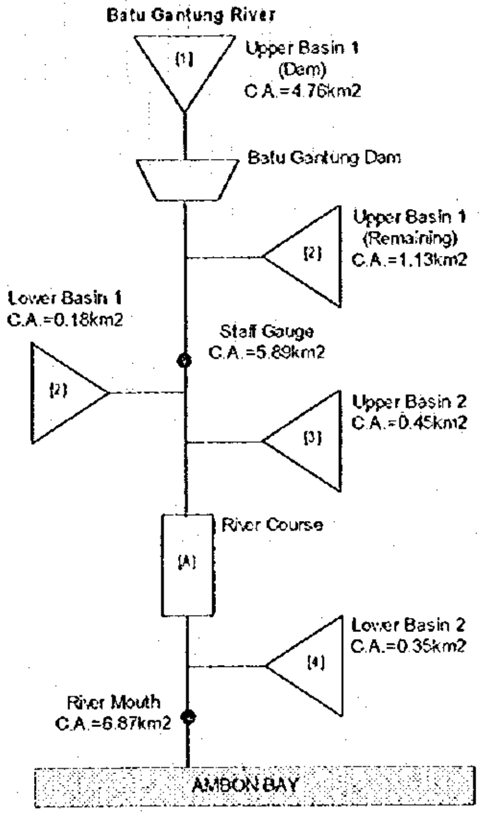
Planned riverbed of the upstream was set at I=1/230 from 0k150 to 0k400 and at 1/180 in the upstream of 0k400, in line with the current upstream riverbed slope. Three cases of excavation depth in the upstream, 1.0m, 0.5m and 0.0m below the deepest riverbed, were studied. Of these cases the shallowest excavation case was adopted because of economical reason, even though river bed excavation has advantage for enlarging discharge capacity and facilitating inner water drainage.

Design Scale of Flood Control Plan : 30-year Return Period

Reference Point and Basin Division

Basin Name	Catchment Area (km²)
[1] Upper Basin 1 (Dam)	4.76
[2] Upper Basin 1 (Remaining)	1.13
[3] Lower Basin 1	0.18
[4] Upper Basin 2	0.45
[5] Lower Basin 2	0.35
Total	6.87

Reference Point	Catchment Area (km²)
Staff Gauge	5.89
River Mouth	6.87

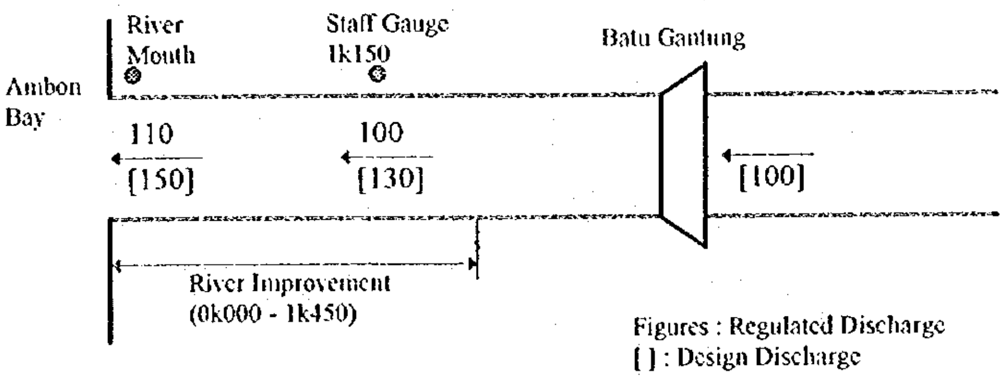


Storage Function Model

Coefficient of Storage Function
- Upper Basin1 : k=21, p=1/3, Tl=0
- Upper Basin2 : k=10, p=1/3, Tl=0
- Lower Basin1 : k= 3, p=1/3, Tl=0
- Lower Basin2 : k= 3, p=1/3, Tl=0
- River Course A : k=0.4, p=0.6, Tl=0

Primary Runoff Rate : 0.9
Saturated Runoff Rate : 1.0
Saturated Rainfall : 100 mm

Flood Runoff Model



Design Discharge Distribution

Figure-I.4.21 Planning Criteria of Batu Gantung River Flood Control Plan

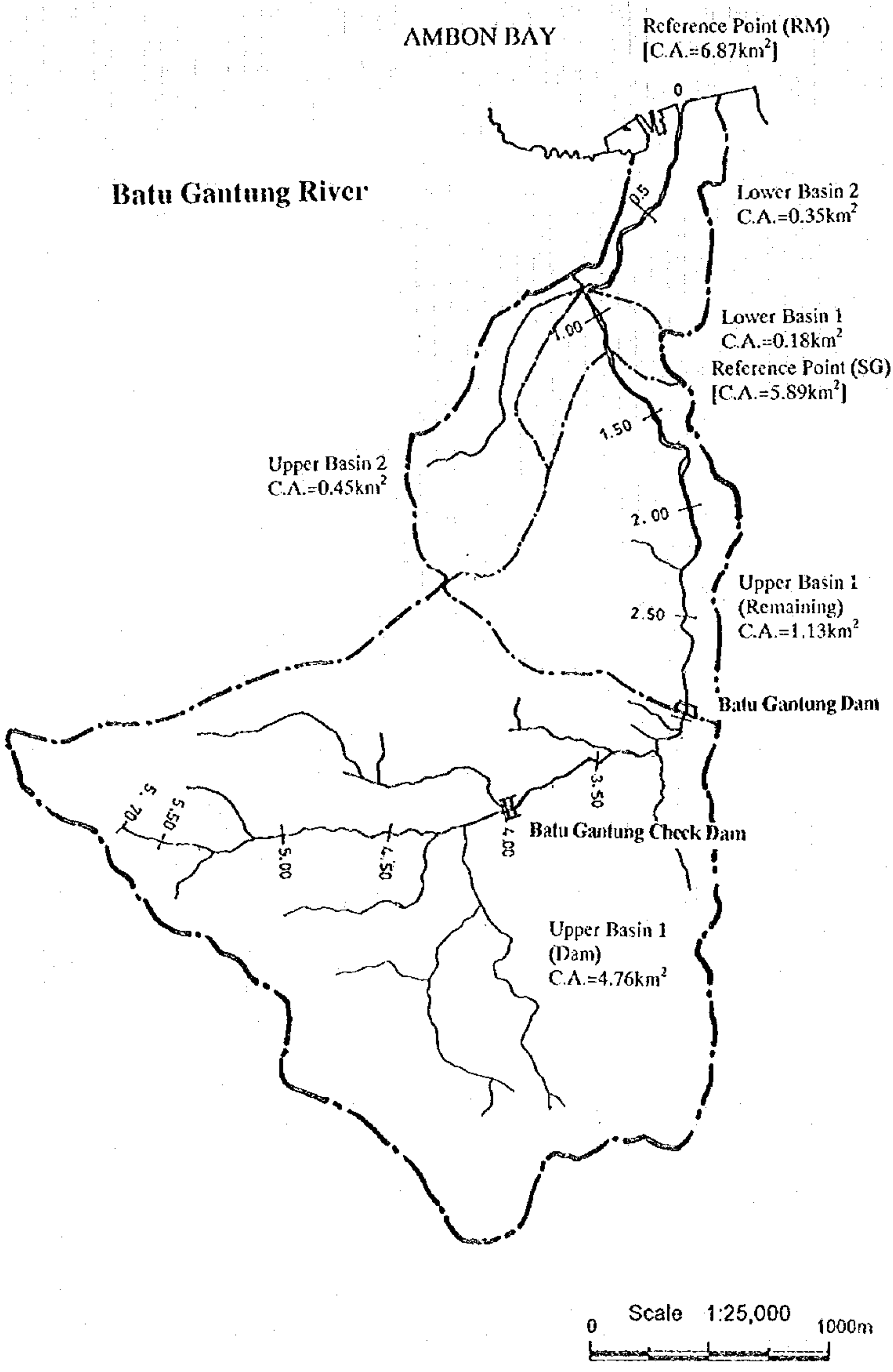
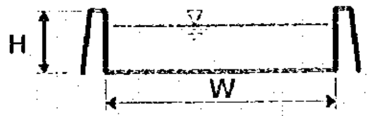


Figure-I.4.22 Batu Gantung River Basin

(d) Standard Cross Section (Heightening, Widening)

According to the current river section with flood walls, the planned standard cross section was set rectangular as follows:



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

Based on uniform and non-uniform flow calculation on the design discharges of 110 m^3/sec for 0k000-0k950 and 100 m^3/sec for the upstream of 0k950 equivalent to 10-year return period, the following flood wall heightening and section widening were planned.

- The river sections from 0k200 to 0k350 is narrower than its upstream and downstream sections with 7.85-9.85 m width, then it would be good to be widened. However because there are many houses closely each other along the both sides of the river, it is decided that excavation and three sided concrete channel is applied to this section with no widening.
- There are partly narrow sections with the width of 5-7 m, where widening works were planned, to the width of 10.0m in the river section at 0k450, to 8.0-10.0m at 0k850-0k900, to 6.0m at 1k100, to 7.0m at 1k200 and 1k300.
- Most of sections need flood wall heightening. The height of flood walls to be raised is 0.6 m in the right side and 0.7 m in the left side on average.
- Three sided concrete channel is planned in the upstream of 0k150 with 1,350m length.

(e) Bridge Improvement

The list of bridges in Batu Gantung River is shown in Table-I.4.16. Considering clearance between bridge underside elevation and H.W.L.(more than 0.6m) and excavation condition, the bridges of No.1 and No.2 are necessary to be improved.

Table-I.4.16 List of Bridges in Batu Gantung River

No.	Distance (m)	Bridge Underside Elevation (EL.m)	Bridge Pier Number	Bridge Pier Width (m)	Bridge Width (m)	*1 Objectives	Clearance (m)		Depth of *2 Excavation at Pier (m)		Remarks
1	0k400	3.05	2	1.50	7.00	VR	0.25	X	1.40	X	Concrete bridge
2	0k769	6.85	1	1.50	6.00	VR	3.10	O	0.40	X	Concrete bridge
2'	1k211	8.60	-	-	1.00	FPB	1.51	O	-	O	Wooden bridge
3	1k336	8.65	-	-	2.50	FPB	1.04	O	-	O	Concrete bridge

*1 Objectives (Vehicle Road, Foot Path Bridge, Water Pipe, Others)
*2 Excavation Depth below Deepest Riverbed

(f) Drainage Improvement

The list of drainage in Batu Gantung River is shown in Table-I.4.17. The method of drainage improvement will be studied in the chapter of facility design.

Table-I.4.17 List of Drainage in Batu Gantung River

No.	Distance (m)	Side	Bottom Elevation (EL.m)	Section Width (m)	Section Height (m)	Objectives	Remarks
1	0k140	R	0.43	0.60	1.20	CD	
2	0k189	R	0.39	0.90	0.60	HD	Drainage is not well-functioned
3	0k230	R	0.14	0.50	0.60	CD	
4	0k429	R	1.38	0.80	0.50	CD	Damaged
5	0k864	R	3.32	1.50	1.50	HD	
6	0k970	L	4.48	1.50	2.00	HD	Left side of the wall is cracked
7	1k051	L	4.89	0.60	0.80	HD	
8	1k096	L	4.92	0.80	1.20	HD	
9	1k265	R	5.40	1.20	1.20	HD	Covered by garbage

* Objectives (City Drainage, Home Drainage, Toilet, Others)

(3) Check Dam Plan

Taking into account of topographical and geological condition in the basin catchment, as well as river condition of upstream and downstream, sediment discharge and allowable sediment discharge were studied in Chapter 3.2. As a results, a check dam at 4k000, the upstream of the Batu Gantung Multi-purpose Dam (refer to Figure-I.4.22), are proposed with 36,000 m^3 of sediment reservoir capacity, designed as 10 years storage volume based on bed load flow shortfall. The catchment area of the check dam is 3.1 km^2 and design discharge of spillway is 83 m^3/sec with 100-year return period.

(4) Batu Gantung Multi-purpose Dam Plan

(a) Flood Regulation Plan by Dam

<Flood Regulation System and Calculation Method>

The Natural Control Method is adopted as the flood regulation system for the same reasons of Batu Gajah Dam. The calculation method is also the same.

<Flood Regulation Plan>

The relationship between water level and reservoir volume of Batu Gantung Dam is shown in Figure-I.4.24.

Flood regulation calculation was carried out changing the size of the spillway, 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. The calculation results are shown in Table-I.4.19. Discharge characteristics of the main spillway including the emergency spillway are shown in Figure-I.4.25.

Flood control plan of Batu Gantung Dam (Hydrograph) and flood discharge distribution of Batu Gantung River are shown in Figure-I.4.26 and Figure-I.4.27.

Table-I.4.18 Batu Gantung River Improvement Plan

Section No.	Profile No.	Cumulative Distance	Current Condition: Dpst.Bed Level (EL.m)	Current Condition: Ave. Bed Level (EL.m)	Current Condition: River Width (m)	Current Condition: Left Bank (EL.m)	Current Condition: Right Bank (EL.m)	Planning Condition: Riverbed Level (EL.m)	Planning Condition: Water Level (EL.m)	Planning Condition: Top of Dike (EL.m)	Planning Condition: Design Qp (m3/s)	Planning Condition: River Width (m)	Planning Condition: Water Height (m)	Planning Condition: Slope 1/	Planning Condition: R.bed at Wall Left (EL.m)	Planning Condition: R.bed at Wall Right (EL.m)	Dike Height (m)	Excavation Depth: Ave. (m)	Excavation Depth: Deepest (m)	Excavation Depth: R.bed at Wall L (m)	Excavation Depth: R.bed at Wall R (m)	Heightening Left (m)	Heightening Right (m)	Widening Length (m)	Concrete Channel
1	GT0	0.00	-0.97	-0.66	18.50	2.76	2.16	-1.00	0.80	1.40	110	15.00	1.80		-0.40	0.40	2.40	0.34	0.03	0.60	1.40	-	-	-	-
2	GT0A	50.00	-0.96	-0.47	18.50	0.17	2.02	-1.000	1.26	1.86	110	15.00	2.26		-0.80	0.25	2.86	0.53	0.04	0.20	1.25	1.69	-	-	-
3	GT1	100.00	-0.65	-0.31	15.40	1.34	1.98	-1.000	1.42	2.02	110	15.00	2.42		0.40	1.30	3.02	0.69	0.35	1.40	2.30	0.68	0.04	-	-
4	GT1A	150.00	-0.50	-0.19	10.50	2.07	0.24	-1.000	1.93	2.53	110	7.00	2.93		-0.20	-0.20	3.53	0.81	0.50	0.80	0.80	0.46	2.29	-	Concrete
5	GT2	200.00	-0.44	-0.10	8.30	2.19	0.40	-0.783	1.94	2.54	110	7.00	2.72	230	0.20	0.20	3.32	0.68	0.34	0.98	0.98	0.35	2.14	-	Concrete
6	GT2A	250.00	-0.06	0.15	9.85	2.13	2.48	-0.565	2.13	2.73	110	7.00	2.70	230	-0.05	0.10	3.30	0.72	0.51	0.52	0.67	0.60	0.25	-	Concrete
7	GT3	300.00	0.17	0.28	8.60	2.42	2.61	-0.348	2.37	2.97	110	7.00	2.71	230	0.70	0.40	3.31	0.63	0.52	1.05	0.75	0.55	0.36	-	Concrete
8	GT3A	350.00	0.28	0.48	7.85	2.56	2.67	-0.130	2.80	3.40	110	7.00	2.93	230	0.75	0.60	3.53	0.61	0.41	0.88	0.73	0.84	0.73	-	Concrete
9	B1/GT4	400.00	0.58	1.02	22.60	4.02	3.98	0.087	2.80	3.40	110	10.00	2.72	230			3.32	0.93	0.49			-	-	-	Concrete
10	GT4A	450.00	0.57	0.87	7.05	2.78	2.72	0.365	2.80	3.40	110	10.00	2.44	180	2.10	2.85	3.04	0.51	0.21	1.74	2.49	0.62	0.68	2.95	Concrete
11	GT5	500.00	0.90	1.20	10.20	3.12	3.03	0.643	2.80	3.40	110	10.00	2.16	180	1.60	1.60	2.76	0.56	0.26	0.96	0.96	0.28	0.37	-	Concrete
12	GT5A	550.00	1.19	1.48	10.65	3.27	3.31	0.920	2.80	3.40	110	10.00	1.88	180	1.80	1.55	2.48	0.56	0.27	0.88	0.63	0.13	0.09	-	Concrete
13	GT6	600.00	1.36	1.53	11.75	3.48	3.57	1.198	2.96	3.56	110	10.00	1.76	180	1.40	1.85	2.36	0.33	0.16	0.20	0.65	0.08	-	-	Concrete
14	GT6A	650.00	1.66	1.93	12.30	2.90	3.26	1.476	3.21	3.81	110	10.00	1.73	180	1.70	2.00	2.33	0.45	0.18	0.22	0.52	0.91	0.55	-	Concrete
15	GT7	700.00	1.65	2.24	13.85	3.94	3.99	1.754	3.43	4.03	110	10.00	1.68	180	2.50	1.80	2.28	0.49	-	0.75	0.05	-	0.04	-	Concrete
16	GT7A	750.00	2.17	2.35	13.00	4.30	4.52	2.031	3.66	4.26	110	10.00	1.63	180	2.10	2.40	2.23	0.32	0.14	0.07	0.37	-	-	-	Concrete
17	B2	769.00	2.39	2.52	15.80	7.33	7.34	2.137	3.75	4.35	110	10.00	1.61	180			2.21	0.38	0.19			-	-	-	Concrete
18	GT8	800.00	2.21	2.57	10.95	4.53	4.69	2.309	3.88	4.48	110	10.00	1.57	180	2.60	3.15	2.17	0.26	-	0.29	0.84	-	-	-	Concrete
19	GT8A	850.00	2.75	2.91	9.50	5.91	5.62	2.587	4.08	4.68	110	10.00	1.49	180	3.50	3.40	2.09	0.32	0.16	0.91	0.81	-	-	0.50	Concrete
20	GT9	900.00	2.84	3.10	7.60	4.95	6.08	2.865	4.83	5.43	110	8.00	1.96	180	3.35	3.50	2.56	0.24	-	0.49	0.64	0.48	-	0.40	Concrete
21	GT9A	950.00	3.24	3.35	9.10	5.65	6.29	3.143	5.04	5.64	110	8.00	1.89	180	3.60	3.70	2.49	0.21	0.10	0.46	0.56	-	-	-	Concrete
22	GT10	1000.00	3.55	3.59	6.75	6.44	6.42	3.420	6.12	6.72	100	6.00	2.70	180	3.90	3.95	3.30	0.17	0.13	0.48	0.53	0.28	0.30	-	Concrete
23	GT10A	1050.00	3.70	3.74	6.25	6.82	6.84	3.698	6.44	7.04	100	6.00	2.74	180	4.20	3.95	3.34	0.04	0.00	0.50	0.25	0.22	0.20	-	Concrete
24	GT11	1100.00	3.65	3.83	5.25	6.42	6.78	3.976	7.03	7.63	100	6.00	3.05	180	5.80	5.80	3.65	-	-	1.82	1.82	1.21	0.85	0.75	Concrete
25	GT11A	1150.00	4.27	4.34	11.85	5.27	7.29	4.254	7.03	7.63	100	7.00	2.78	180	4.40	4.50	3.38	0.09	0.02	0.15	0.25	2.36	0.34	-	Concrete
26	GT12	1200.00	4.36	4.59	6.80	7.78	7.63	4.531	7.03	7.63	100	7.00	2.50	180	5.05	4.95	3.10	0.06	-	0.52	0.42	-	-	0.20	Concrete
27	GT12A	1250.00	4.57	4.85	8.20	7.06	7.99	4.809	7.12	7.72	100	7.00	2.31	180	5.00	5.40	2.91	0.04	-	0.19	0.59	0.66	-	-	Concrete
28	GT13	1300.00	4.97	5.23	6.50	7.50	7.46	5.087	7.40	8.00	100	7.00	2.32	180	4.20	4.35	2.92	0.14	-	-	-	0.50	0.54	0.50	Concrete
29	B3	1335.80	5.27	5.43	10.45	9.29	9.48	5.286	7.61	8.21	100	7.00	2.32	180			2.92	0.14	-			-	-	-	Concrete
30	GT13A	1350.00	5.56	5.75	7.00	8.06	8.11	5.365	7.66	8.26	100	7.00	2.30	180	6.45	6.90	2.90	0.39	0.20	1.09	1.54	0.20	0.15	-	Concrete
31	GT14	1400.00	5.77	5.97	7.15	8.67	8.41	5.643	7.95	8.55	100	7.00	2.30	180	6.97	6.85	2.90	0.33	0.13	1.33	1.21	-	0.14	-	Concrete
32	GT14A	1450.00	6.53	6.85	10.20	9.11	9.07	5.920	8.23	8.83	100	7.00	2.31	180	6.80	8.30	2.91	0.93	0.61	0.88	2.38	-	-	-	Concrete
33	GT15	1500.00	10.76		16.00	14.59	15.90																		
34	GT15A	1550.00	12.78		17.02	18.03	18.00																		
35	GT16	1600.00	15.26		19.52	19.53	19.73																		
Average																		0.42	0.25	0.73	0.94	0.66	0.56	0.88	

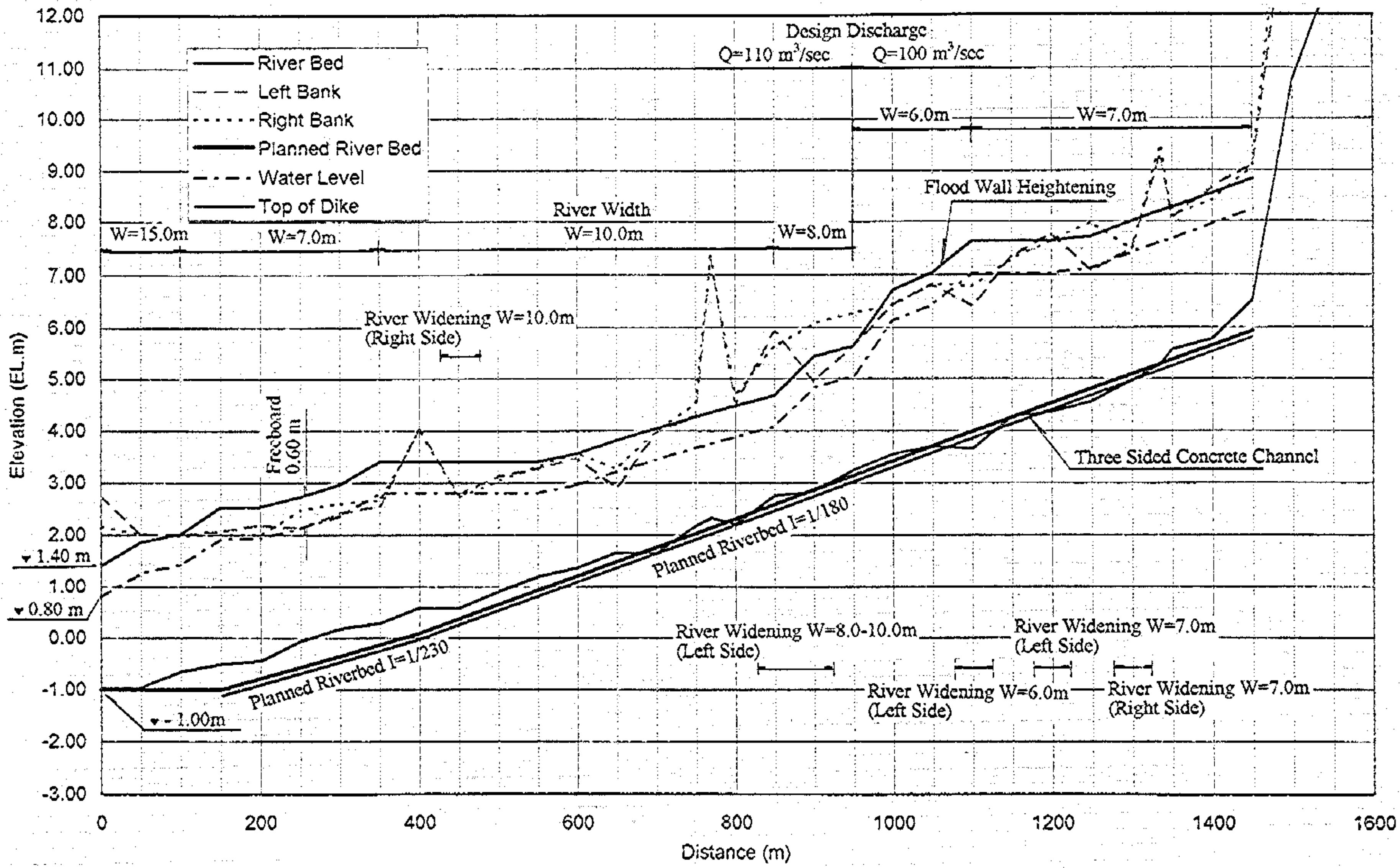


Figure-I.4.23 Longitudinal Section of Batu Gantung River Improvement Plan

Elevation (EL.m)	Height (m)	Area ('000m²)	Volume ('000m³)	Accumulated Volume ('000m³)
70	-	0.000	0.000	0.000
75	5	4.580	11.450	11.450
80	5	11.678	40.645	52.095
85	5	30.202	104.700	156.795
90	5	53.457	209.148	365.943
95	5	72.782	315.598	681.540
100	5	97.454	425.590	1,107.130
105	5	122.383	549.593	1,656.723
110	5	195.927	795.775	2,452.498

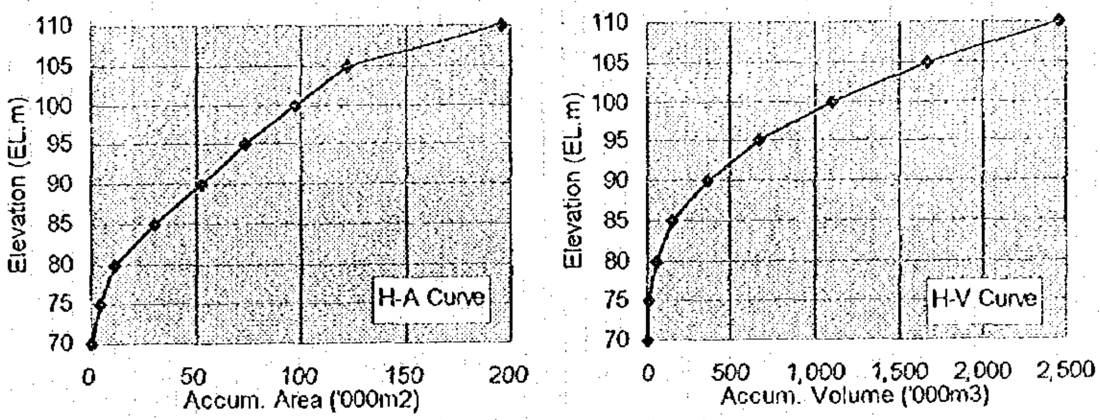


Figure-I.4.24 Water Level and Reservoir Volume of Batu Gantung Dam

Table-I.4.19 Flood Regulation Calculation Result (Batu Gantung Dam)

Item		Unit	1990/06 Flood
<Reference Points>			
River Mouth	Peak Discharge	m³/sec	143
	Regulated Peak Discharge	m³/sec	110
	Regulated Amount	m³/sec	33
Staff Gauge	Peak Discharge	m³/sec	123
	Regulated Peak Discharge	m³/sec	91
	Regulated Amount	m³/sec	32
<Dam>			
Peak Inflow		m³/sec	99
Maximum Discharge from Spillway		m³/sec	73
Discharge from Spillway at Peak Inflow		m³/sec	67
Regulated Amount		m³/sec	32
Net Flood Storage Capacity		m³	422,000
Design Flood Storage Capacity		m³	507,000
Rainfall Depth Equivalent to Vd		mm	107
<Main Spillway>			
Type		-	Conduit
Crest Level		EL.m	96.80
Width		m	4.20
Height (Inlet Height)		m	4.20

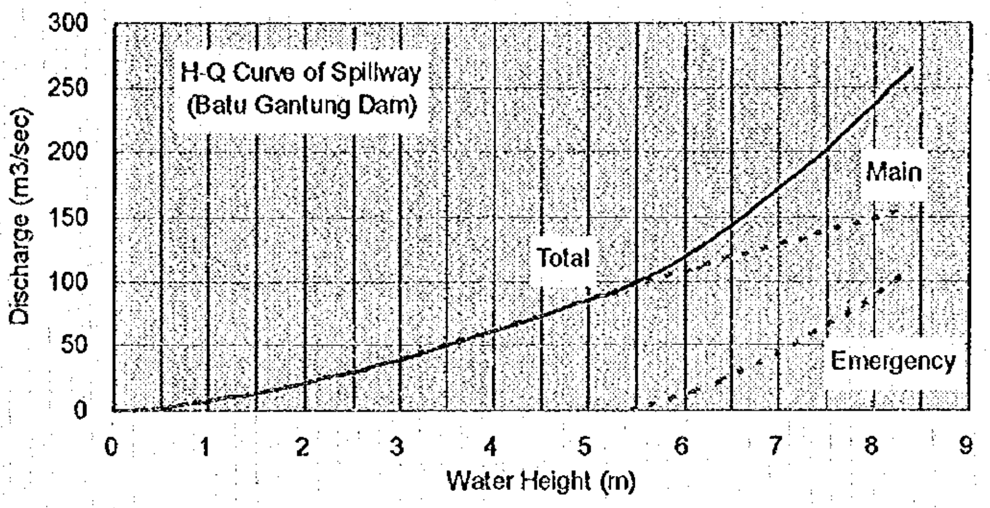


Figure-I.4.25 Spillway H-Q Curve of Batu Gantung Dam

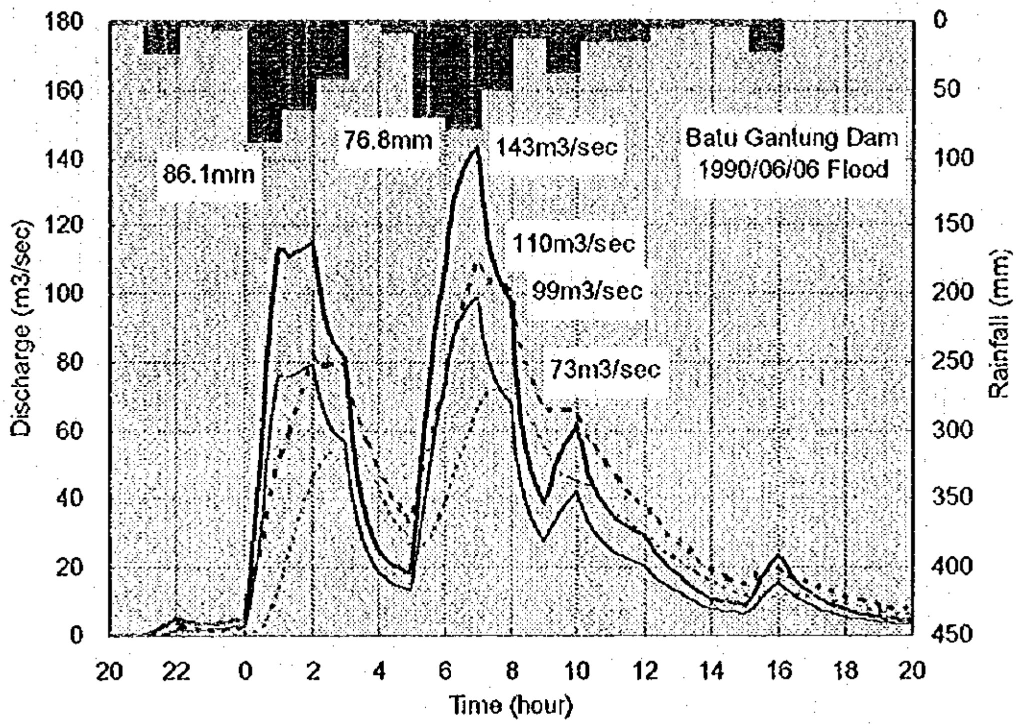


Figure-I.4.26 Flood Control Plan of Batu Gantung Dam

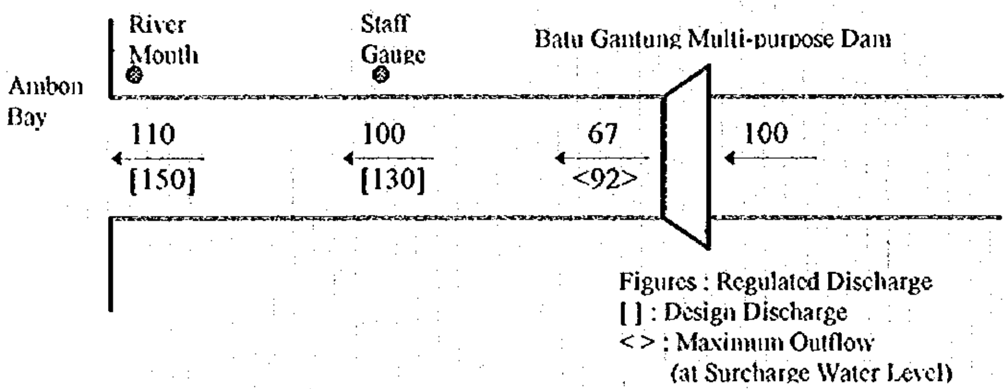


Figure-I.4.27 Flood Discharge Distribution of Batu Gantung River

(b) Batu Gantung Multi-Purpose Dam

Based on the flood regulation plan by the dam and water utilization plan explained in Section 3.4, Batu Gantung Multi-purpose Dam were planned. The specification of the dam is determined as shown in Table-I.4.20 and the dam reservoir volume allocation is shown in Figure-I.4.28.

Table-I.4.20 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	
Spillway	Main Spillway	: Type	-	Conduit	
		: Structure - Width	m	4.20	
		- Height	m	4.20	
	Emergency Spillway	: Type	-	Free Overflow	Qp=220 m^3/sec
		: Structure - Width	m	11.00	(2,000-year)
		- Height	m	1.50	

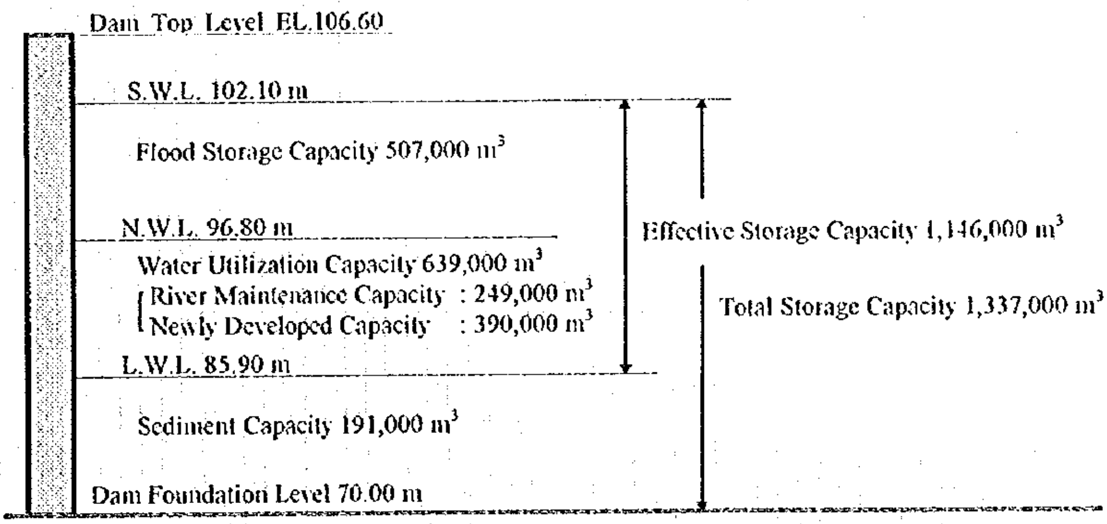


Figure-I.4.28 Reservoir Volume Allocation for Batu Gantung Dam