SUPPORTING REPORT

PART-F

FACILITY DESIGN AND COST ESTIMATE

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

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1.1 Summary of Flood Control Master Plan

The flood control plans of river improvement and diversion works are summarized in Table-F.1.1. Flood regulation plan by dam is summarized in Table-F.1.2. The location of the flood control plan projects is shown in Figure-F.1.1.

Table-F.1.1 Flood Control Plan for River Improvement and Diversion Works

Item		Ruhu	Batu Merah	Tomu	Batu Gajah	Batu Gantung
Improvement Scale (Return Period)		5-year	5-year	30-year	10-year	10-year
Improvement Range	Section	0'000-1'600	0'000-1'500	0'000-2'700	0'000-2'800	0'000-1'450
Planned River Width	W (m)	15.0-28.0	7.0-20.0	7.0-15.0	7.0-15.0	6.0-15.0
Planned River bed Slope	I	1/550	1/320	1/250,1/100	1/240,1/160 1/100	1/230, 1/160
Planned EL. of R.M	EL.m	-2.50	-2.30	-2.50	-2.00	-2.20
River-bed Formation	Section	-	-	2'150-2'700	2'100-2'585	-
River-bed Excavation	Section	0'000-1'600	0'000-1'500	0'000-2'150	0'000-2'100	0'000-1'450
	Depth (m)	1.0-1.6	1.1-1.4	1.0-1.3	1.1-1.5	1.1-1.3
	L (m)	1,600	1,500	2,150	2,100	1,450
Concrete Channel	Section	-	0'400-1'500	1'500-2'700	-	0'150-0'350
	L (m)	-	1,100	1,600	-	200
Flood Wall Heightening	Section	0'650-1'000	0'400-1'500	1'800-2'700	0'250-2'750	0'450-1'300
: Left	ΔH (m)	0.10-0.50	0.10-1.30	0.1-0.3	0.1-0.8	0.1-0.4
	L (m)	350	1,000	250	450	350
: Right	ΔH (m)	0.10-0.3	0.10-1.30	0.24	0.10-0.90	0.10-0.30
	L (m)	350	1,150	50	550	200
River Widening	Section	0'800-1'000	0'650-0'800	0'650-0'950	0'700, 2'150	0'450, 1'100
	L (m)	150	100	300	100	100
	W (m)	17.0	8.5	12.0	8.5, 7.0	10.0, 6.0
	Side	Right	Left	Right	Right, Left	Right, Left
Estuary Improvement	L (m)	355	20	20	50	50
Bridge Improvement	Number	4	5	10	13	4
Drainage Improvement	Number	17	14	19	25	9
River Diversion						
- Type	-	-	Tunnel	-	-	-
- Planned Diversion Pt			1k400			
- Length	L (m)	-	900	-	-	-
- Gradient	I	-	1/450	-	-	-
- Diameter	D (m)	-	6.0	-	-	-

Table-F.1.2 Major Structural Features of Dams

Item		Unit	Batu Gajah Dam	Batu Gantung Dam
<Reference Points>				
River Mouth	Peak Discharge	m^3/sec	143	123
	Regulated Peak Discharge	m^3/sec	110	98
	Regulated Amount	m^3/sec	33	25
Staff Gauge	Peak Discharge	m^3/sec	123	101
	Regulated Peak Discharge	m^3/sec	91	80
	Regulated Amount	m^3/sec	32	21
<Dam>				
Peak Inflow		m^3/sec	88	99
Maximum Discharge from Spillway		m^3/sec	70	73
Discharge from Spillway at Peak Inflow		m^3/sec	64	67
Regulated Amount		m^3/sec	24	32
Net Flood Storage Capacity Vn		m^3	338,000	422,000
Design Flood Storage Capacity (Vd=1.2Vn)		m^3	406,000	507,000
Rainfall Depth Equivalent to Vd		mm	95	107
Surcharge Water Level		EL.m	70.50	102.10
<Main Spillway>				
Type		-	Overflow	Conduit
Crest Level		EL.m	66.60	96.80
Width		m	6.50	4.20
Water Height		m	3.90	4.20

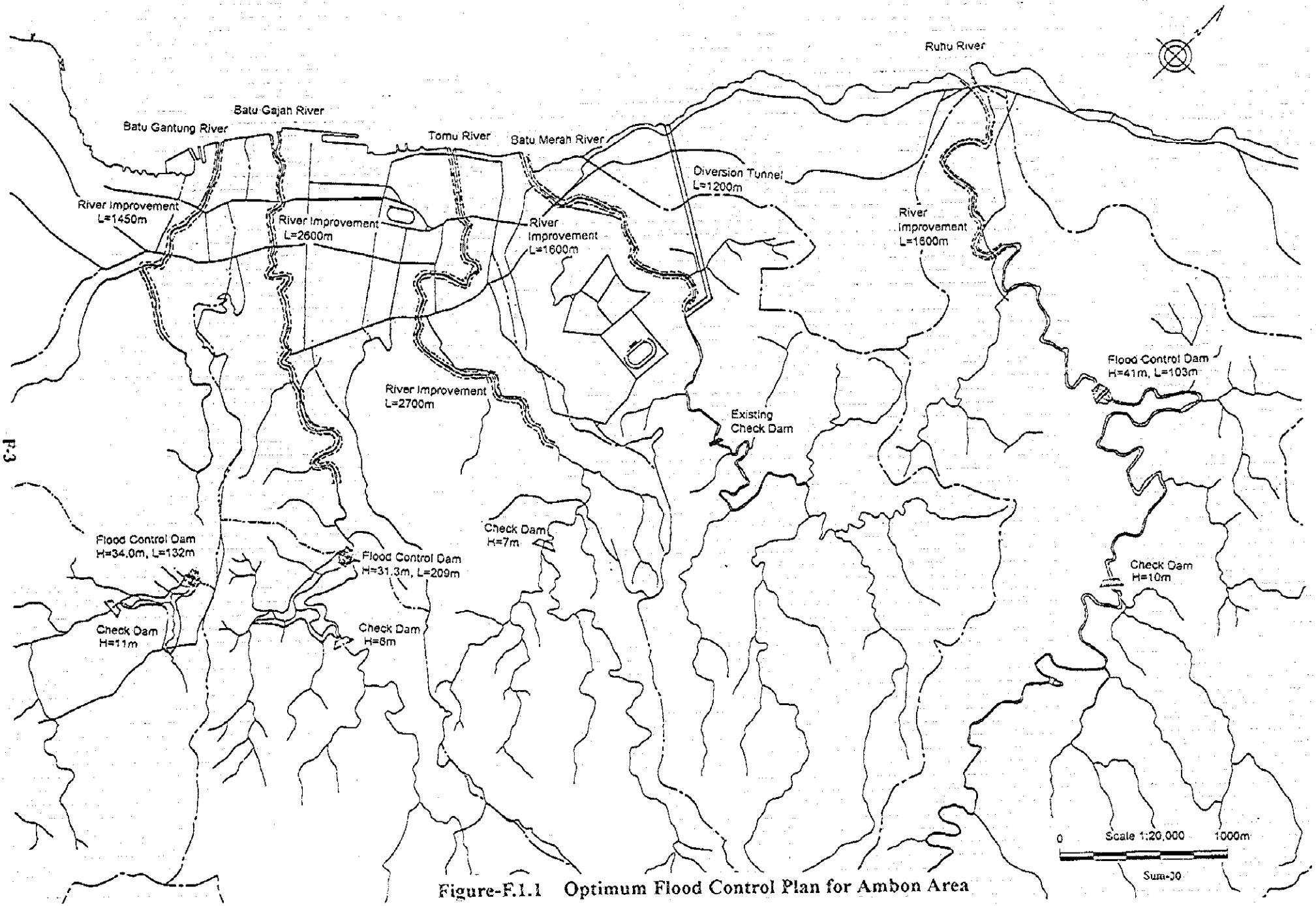


Figure-F.1.1 Optimum Flood Control Plan for Ambon Area

1.2 Project Cost of Master Plan

The estimated project cost for each alternative plan is shown in Table-F.1.3. The alternative flood control master plans for each river are as shown in Table-F.1.4.

Table-F.1.3 Project Cost of Alternative Plans

Alternative Plan		Construction Cost (Million Rp)				Indirect Cost (30%)	Land Cost (Million Rp)			Project Cost (Million Rp)
		River Improvement	Dam	Diversion	Sub Total		Land Cost	Resettlement Cost	Sub Total	
Ruhu	1	23,351			23,351	7,005	7,650	5,145	12,795	43,151
	2	9,323	31,344		40,667	12,200	10,950	1,400	12,350	65,217
	3	20,932	28,691		49,623	14,887	13,150	5,145	18,295	82,805
	4	21,332		2,833	24,165	7,250	5,148	5,250	10,398	41,813
	5	23,465		2,502	25,967	7,790	5,193	6,195	11,388	45,145
Batu Merah	1	29,368			29,368	8,810	3,488	5,600	9,088	47,266
	2	9,966	21,831		31,797	9,539	6,058	5,600	11,658	52,994
	3	23,315	19,818		43,133	12,940	7,188	9,695	16,883	72,956
	4	9,966		29,055	39,021	11,706	158	350	508	51,235
	5	23,315		22,505	45,820	13,746	2,138	4,445	6,583	66,149
Tomu	1	18,753			18,753	5,626			0	24,379
	2	1,328	33,801		35,129	10,539	3,875		3,875	49,543
	3	6,170	24,368		30,538	9,161	2,700		2,700	42,399
	4	3,598		12,980	16,578	4,973	1,238	1,190	2,428	23,979
	5	6,360		9,339	15,699	4,710	1,181	1,190	2,371	22,780
Batu Gajah	1	34,584			34,584	10,375	2,475	5,145	7,620	52,579
	2	6,626	37,188		43,814	13,144	2,700	700	3,400	60,358
	3	9,091	32,485		41,576	12,473	2,325	700	3,025	57,074
Batu Gantung	1	24,274			24,274	7,282	2,375	4,550	6,925	38,481
	2	9,068	34,434		43,502	13,051	3,275		3,275	59,828
	3	9,734	28,116		37,850	11,355	2,525		2,525	51,730

Table-F.1.4 Alternative Plans for each River

Item		River Improvement	Dam	Diversion	Remarks
Ruhu River	Alternative1	30Year R.P	-	-	
	Alternative2	5Year R.P	○	-	
	Alternative3	10Year R.P	○	-	
	Alternative4	5Year R.P	-	○	
	Alternative5	10Year R.P	-	○	
Batu Merah River	Alternative1	30Year R.P	-	-	
	Alternative2	5Year R.P	○	-	
	Alternative3	10Year R.P	○	-	
	Alternative4	5Year R.P	-	○	
	Alternative5	10Year R.P	-	○	
Tomu River	Alternative1	30Year R.P	-	-	
	Alternative2	5Year R.P	○	-	
	Alternative3	10Year R.P	○	-	
	Alternative4	5Year R.P	-	○	
	Alternative5	10Year R.P	-	○	
Batu Gajah River	Alternative1	30Year R.P	-	-	
	Alternative2	5Year R.P	○	-	
	Alternative3	10Year R.P	○	-	
Batu Gantung River	Alternative1	30Year R.P	-	-	
	Alternative2	5Year R.P	○	-	
	Alternative3	10Year R.P	○	-	

CHAPTER 2 FACILITY DESIGN

2.1 Design Criteria

The design for river improvement works, dams and reservoirs, diversion channels and check dams shall basically follow the "Flood Control Manual, Volume III: Guidelines for Design and Implementation, Ministry of Public Works, Republic of Indonesia" (hereinafter "Manual III"). Concerning items not specified in Manual III, "Manual for River Works in Japan: Design Volume, Ministry of Construction, Japan" shall be applied.

2.2 Design of River Improvement Works

2.2.1 General

The design conditions of river improvement are as described below.

(1) The river improvement works for the five rivers - Ruhu River, Batu Merah River, Tomu River, Batu Gajah River and Batu Gantung River - are composed of riverbed excavation works, flood wall heightening, concrete channel works and river widening.

(2) Parts of the existing floodwalls are broken due to floods that occurred in the past. As these parts could not be identified, 30% of the length of each river was assumed as the distance of floodwall requiring strengthening or reconstruction.

(3) It is difficult to estimate the base level of existing floodwall from the present riverbed. Based on existing materials, the thickness of footing for the existing floodwall is estimated at 1.25m. The river improvement works were planned in such a way that the depth of riverbed excavation will not exceed 1.0m for the purpose of securing safety of the existing floodwall at the time of riverbed excavation. It is necessary to place sheet piles in front of the footing when excavating deeper than the footing base level of the floodwall.

(4) Maximum height of floodwall heightening was set at 1.0m. As excessive load is applied to the existing floodwall due to heightening of floodwall, it is necessary to reinforce the existing floodwall. In such cases, footing shall extrude to the river side.

(5) Existing bridges (roadway bridges, footpath bridges) will have to be replaced following heightening and widening of floodwalls.

(6) Drainage backflow prevention gate will be built according to the size of existing inlet as a measure for prevention of backflow to the inflow tributary.

2.2.2 Riverbed Excavation

Riverbed excavation is a method for increasing the cross section area of the river by removing debris (containing large quantities of sediments, waste and sludge). As based on the depth mentioned above, maximum excavation was set at 1.0m of floodwall foundation. In areas where excavation partially exceeds 1.0m, excavation is performed after installation of sheet piles. Typical cross section of riverbed excavation is as shown in Figure-F.2.1.

Since the excavated material is considerably contaminated by household drainage and other sources, it shall be planned at locations that are not subject to secondary contamination from runoff at earth disposal site. The volume of excavation at each river is as shown in Table-F.2.1.

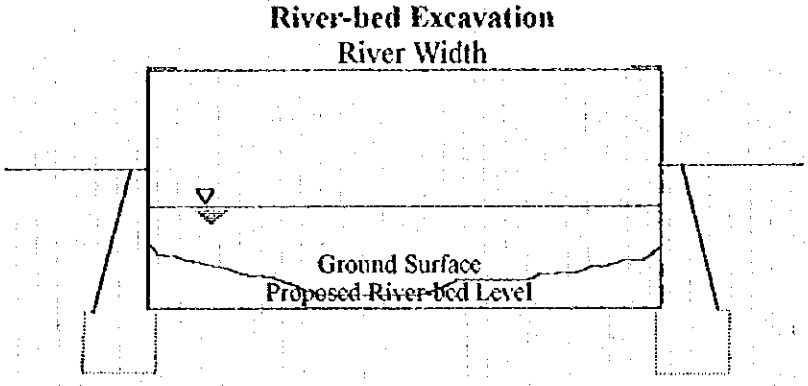


Figure-F.2.1 Typical Cross Section of Riverbed Excavation

Table-F.2.1 River Excavation Volume for Each River

River Name	Excavation length	Excavation maximum depth (m)	Excavated volume (m^3)	Sheet pile(m)
Ruhu	1,600 m	2.74	25,900	600
Batu Merah	1,400 m	1.79	20,600	1,140
Tomu	2,400 m	1.20	28,000	1,010
Batu Gajah	2,200 m	1.81	18,800	920
Batu Gantung	1,450 m	2.49	12,300	620
Total	9,050 m		105,600 m^3	4,290

2.2.3 Floodwall Heightening

Floodwall shall be heightened by not more than 1.0m at locations where the existing floodwall is low. When the height reaches 1.0m or higher, the water level inside the channel will increase and the safety of existing floodwall will be reduced. When the water level increases by 1.0 m against the existing floodwall, allowing the footing to extrude by 1.5m satisfies the stability requirement. In addition, when heightening the existing floodwall, the existing concrete is broken down and reinforcing bars are inserted before constructing the new wall. Typical cross section of floodwall heightening is as shown in Figure-F.2.2. The flood wall heightening quantities are as shown in Table-F.2.2

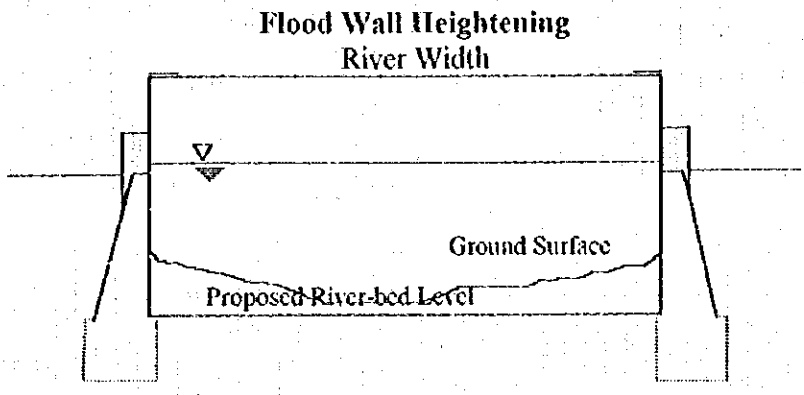


Figure-F.2.2 Typical Cross Section of Floodwall Heightening

Table-F.2.2 Quantities for Floodwall Heightening

River Name	River Distance	Distance of Heightening	Concrete (m^3)	Flood wall Heightening
Ruhu	1,600 m	(R) 506 m (L) 1,000 m	350	0.12~1.55 m
Batu Merah	1,400 m	(R) 508 m (L) 1,100 m	400	0.02~1.01 m
Tomu	2,400 m	(R) 707 m (L) 975 m	550	0.13~0.94 m
Batu Gajah	2,200 m	(R) 602 m (L) 632 m	300	0.04~0.95 m
Batu Gantung	1,450 m	(R) 633 m (L) 949 m	400	0.08~1.21 m
Total	9,050 m	7,612 m	2,000 (m^3)	

2.2.4 Concrete Channel Works

Concrete channel works increase the discharge capacity of the river by excavating the riverbed and covering it with concrete. When placing concrete at the riverbed, it is necessary to divert the river course during curing of the concrete. Although the thickness of concrete floor slab is generally 20 to 50 cm, the planned thickness shall be 30cm for all five rivers because the water velocity is low. Typical cross section of concrete channel is as shown in Figure-F.2.3. The quantities of concrete channel works for each river is as shown in Table-F.2.3.

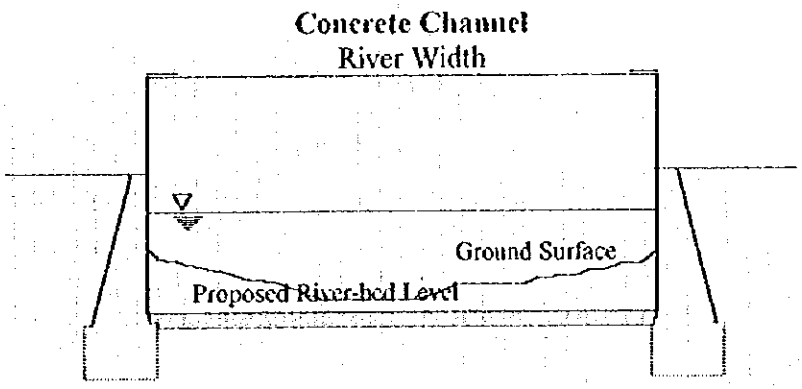


Figure-F.2.3 Typical Cross Section of Concrete Channel

Table-F.2.3 Quantities for Concrete Channel Works

River Name	River Distance	Length of Concrete Channel	Concrete (m^3)	Excavation (m^3)
Ruhu	1,600 m	—	—	
Batu Merah	1,400 m	1,000 m	2,600	2,600
Tomu	2,400 m	2,400 m	11,400	11,400
Batu Gajah	2,200 m	1,950 m	6,000	6,000
Batu Gantung	1,450 m	1,300 m	3,650	3,650
Total	9,050 m	6,650 m	23,650	23,650

2.2.5 River Widening

River widening will be under taken at narrow sections of the river improvement. Widening of narrow sections is performed by erecting sheet piles for earth retention on the riverside land of the existing floodwall. Then the existing floodwall is destroyed and a L-shaped retaining wall is built. The footing of the retaining wall shall be planned in such a way that it will extrude to the river side. The footing length was decided at 2.5m because the retaining wall will be 4.0m high. Standard cross section of river widening is as shown in Figure-F.2.4. River widening also requires land acquisition and resettlement of houses. The quantities for river widening are as shown in Table-F.2.4

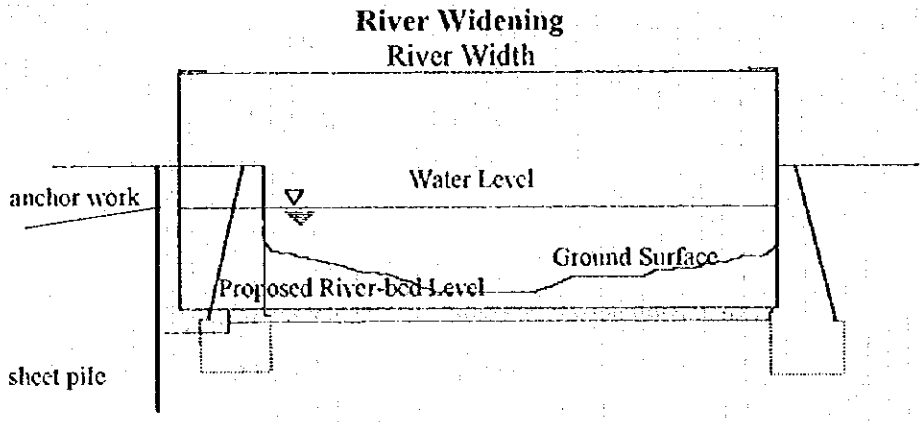


Figure-F.2.4 Typical Cross Section of River Widening

Table-F.2.4 Quantities for River Widening

River Name	River Distance (m)	Length of River Widening (m)	Excavation (m^3)	Concrete (m^3)	Land Acquisition (m^2)	Resettlement
Ruhu	1,600m	204.0m	800	800	615	5
Batu Merah	1,400m	792m	2,500	2,500	1,250	21
Tomu	2,400m	410m	1,000	1,000	1,781	10
Batu Gajah	2,200m	362m	1,000	1,000	859	19
Batu Gantung	1,450m	260m	800	800	791	26
Total	9,050m	2,028m	6,100	6,100	5,296	81

2.2.6 Reconstruction of Bridges

Several existing bridges (roadway bridges, footpath bridges) will have to be reconstructed or rehabilitated following river improvement. It is not possible to stop the present traffic when replacing roadway bridges. For this reason, it is necessary to build a temporary bridge and temporarily divert the traffic while building the new bridge. Reconstruction and rehabilitation of bridges that are required for river improvement are as shown in Table-F.2.5. In addition to these, construction of 28 footpath bridges used for crossing the rivers will be needed.

Table-F.2.5 Road Bridges to be Reconstructed or Rehabilitated

River Name	Distance	Existing Bridge Condition			Type	Note
		Width (m)	Length (m)	Pier		
Ruhu	1+553.5	4	21	–	Reconstruction	Excavation of Abutment Site
Batu Merah	0+386	9 (7 + 1x2)	19	1	Rehabilitation	Temporary Support is possible
Tomu	0+406.1	9 (7 + 1x2)	22	1	Rehabilitation	Temporary Support is possible
	1+033.1	10 (8 + 1x2)	16	1	Reconstruction	Can not use Temporary Support because Bridge is 2 span/2 Girder
	1+403.5	9 (7 + 1x2)	34	2	Rehabilitation	Temporary Support is possible
Batu Gajah	0+750	8.5 (6.5 + 1x2)	28.5	1	Reconstruction	Can not use Temporary Support because Bridge is 2 span/2 Girder
Batu Gantung	0+400	9 (7 + 1x2)	22.5	2	Reconstruction	Can not use Temporary Support because Bridge is 3 span/3 Girder
	0+769	8 (6 + 1x2)	17	1	Reconstruction	Can not use Temporary Support because Bridge is 2 span/2 Girder

Total: 8 bridges

2.2.7 Drainage Backflow Prevention Gates

Drainage from urban areas and smaller streams flow into each river. The location of each inlet was obtained from 1/500 scale topographic maps. As these inlets vary in size depending on the inflow channel, inlet size was divided into 3 categories. In addition, the gate structure for the 3 categories of inlets was divided as follows.

Type A	W > 1.0m	: Steel slide gate
Type B	0.5m < W < 1.0m	: Wooden slide gate
Type C	W < 0.5m	: Wooden stop logs

The number of gates for each river is as shown in Table-F.2.6. In total, there are 14 locations for Type A, 65 locations for Type B and 6 locations for Type C.

Table-F.2.6 Type of Drainage Backflow-Prevention Gate

No.	Ruhu River			Batu Merah River			Tomu River			Batu Gajah River			Batu Gantung River		
	Distance	Site	Type	Distance	Site	Type	Distance	Site	Type	Distance	Site	Type	Distance	Site	Type
1	0+432.5	L	B	0+110	L	B	0+016	L	B	0+105.1	L	C	0+140	R	B
2	0+480.5	L	B	0+110	R	C	0+027.5	R	B	0+115	L	C	0+189	R	B
3	0+532.5	R	A	0+185	L	A	0+050	L	B	0+145.8	L	B	0+230	R	B
4	0+637.5	L	B	0+221	L	B	0+137.8	L	B	0+192.9	L	B	0+429	R	B
5	0+646.5	L	B	0+394	L	B	0+318.5	L	A	0+441.4	R	B	0+863.5	R	A
6	0+747.3	R	B	0+394	R	B	0+413.2	R	B	0+765.1	R	B	0+970	L	A
7	0+787.5	R	B	0+403.9	L	A	0+638	R	B	0+859.1	L	B	1+051	L	B
8	0+798.3	R	B	0+474.3	L	A	0+771	R	B	0+901.1	L	A	1+096	L	B
9	0+885.5	R	B	0+548	L	B	0+881.6	R	B	0+962.1	L	A	1+265	R	A
10	1+058.0	R	B	0+648.7	L	B	1+122.5	L	B	1+098	R	B			
11	1+108.4	R	B	0+651.2	L	B	1+122.5	R	B	1+105.4	L	B			
12	1+157.6	R	B	0+756.3	L	B	1+158.9	L	B	1+485.4	L	A			
13	1+213.0	R	B	1+433.9	R	B	1+276.5	L	B	1+496.2	R	B			
14	1+304.9	R	B	1+442.2	L	B	1+477.5	R	B	1+524.2	R	B			
15	1+361.0	R	Cx3				1+869	L	B	1+608.3	L	B			
16	1+506	L	A				2+050	L	B	1+665.3	R	B			
17							2+100	L	B	1+742.8	L	B			
18							2+169	R	B	1+953	L	A			
19							2+497	L	A	2+063.6	L	B			
20										2+097.7	L	B			
21										2+154.2	L	B			
22										2+495	R	B			
23										2+586.2	R	B			
24										2+611.4	L	B			
25										2+651.9	L	B			

Type A : 1.01 m < Drainage Width, Type B : 0.5 m < Drainage Width <1.0 m, Type C : 0.49 m > Drainage Width

2.2.8 Design Drawings and Construction Quantities

Plans, longitudinal profiles, standard cross section profiles, bridge repairs and backflow prevention gate structures for river improvement of the five rivers are shown in Drawing-1 through Drawing-16 in Appendix-10. Construction quantities required for the river improvement of each river are as shown in Table-F.2.7.

To calculate the quantities of sheet piles, those used for riverbed excavation and concrete channel construction were added to those used for river widening. The total quantities of these sheet piles was estimated at 25% of the length of each river. Ground anchors are planed to hold sheet piles at 2.0m spacing along the length of the river widening construction.

Table-F.2.7 Main Quantities for River Improvement

Item	Ruhu	Batu Merah	Tomu	Batu Gajah	Batu Gantung	Total
Main River Improvement Works						
Riverbed Excavation (m^3)	25,900	20,600	28,000	18,800	12,300	105,600
Concrete of Flood Wall (m^3)	3,050	7,200	15,900	9,950	6,550	42,650
Sheet Pile (m)	600	1,140	1,010	920	620	4,290
Ground Anchor (Number)	100	400	205	180	130	1,015
Drainage Improvement (Number)						
Gate Type A	2	3	2	4	3	14
Gate Type B	13	10	17	19	6	65
Gate Type C	3	1	-	2	-	6
Bridge Improvement (Number)						
Reconstruction : Foot Bridge	3	4	7	12	2	28
: Road Bridge	1	-	1	1	2	5
Rehabilitation : Road Bridge	-	1	2	-	-	3
Compensation						
Land Acquisition (m^2)	615	1,250	1,781	859	791	5,296
Resettlement (House)	5	21	10	19	26	81

2.3 Batu Merah River Diversion Work

2.3.1 Design Dimensions of Diversion Tunnel

The river diversion was planned as a tunnel (length = 1,200m) diverted from 1k400 directly to Ambon Bay about 800m north from the river mouth of Bath Merah River. Design conditions for the diversion tunnel are as follows.

(1) The main river discharge of $130m^3/s$ is divided between the diversion tunnel and the main stream with $60m^3/s$ diverted to the diversion tunnel.

(2) High Tide Sea-level at Ambon Bay is estimated at 0.80m.

(3) The method of diversion shall be fixed weir.

(4) The diversion tunnel shall be a standard horseshoe shaped tunnel with flow velocity not exceeding 7.0m/s.

2.3.2 Examination of Diversion Tunnel Location

The location of Batu Merah diversion tunnel was decided as follows. In addition, the results of comparison between Alternative A and Alternative B of the diversion tunnel route are as shown in Figure-F.2.5 and Table-F.2.8.

(1) The location of fixed weir on main stream was decided at a point located 1,400 m from the river mouth. The master plan route of the diversion tunnel has to cross the right bank tributary and therefore causes problems to the structure of the tunnel. In addition, the tunnel horizontal alignment is curved and is not favorable in terms of construction. For this reason, the ridge located just downstream of the right bank tributary was decided as the diversion point.

(2) The location of the outlet was decided at a 400m section of Ambon Bay where harbor facilities are not located. As shown in Figure-F.2.5, there is a harbor facility on the Ruhu River side and another harbor facility on the Merah River side. The outlet will therefore be limited to the 400m section that will not affect these facilities. However, these areas have high concentration of houses which means that land acquisition and resettlement will be required for the outlet facility.

(3) As a result of comparing Alternative A and B, Alternative A was selected for the location of the discharge tunnel outlet.

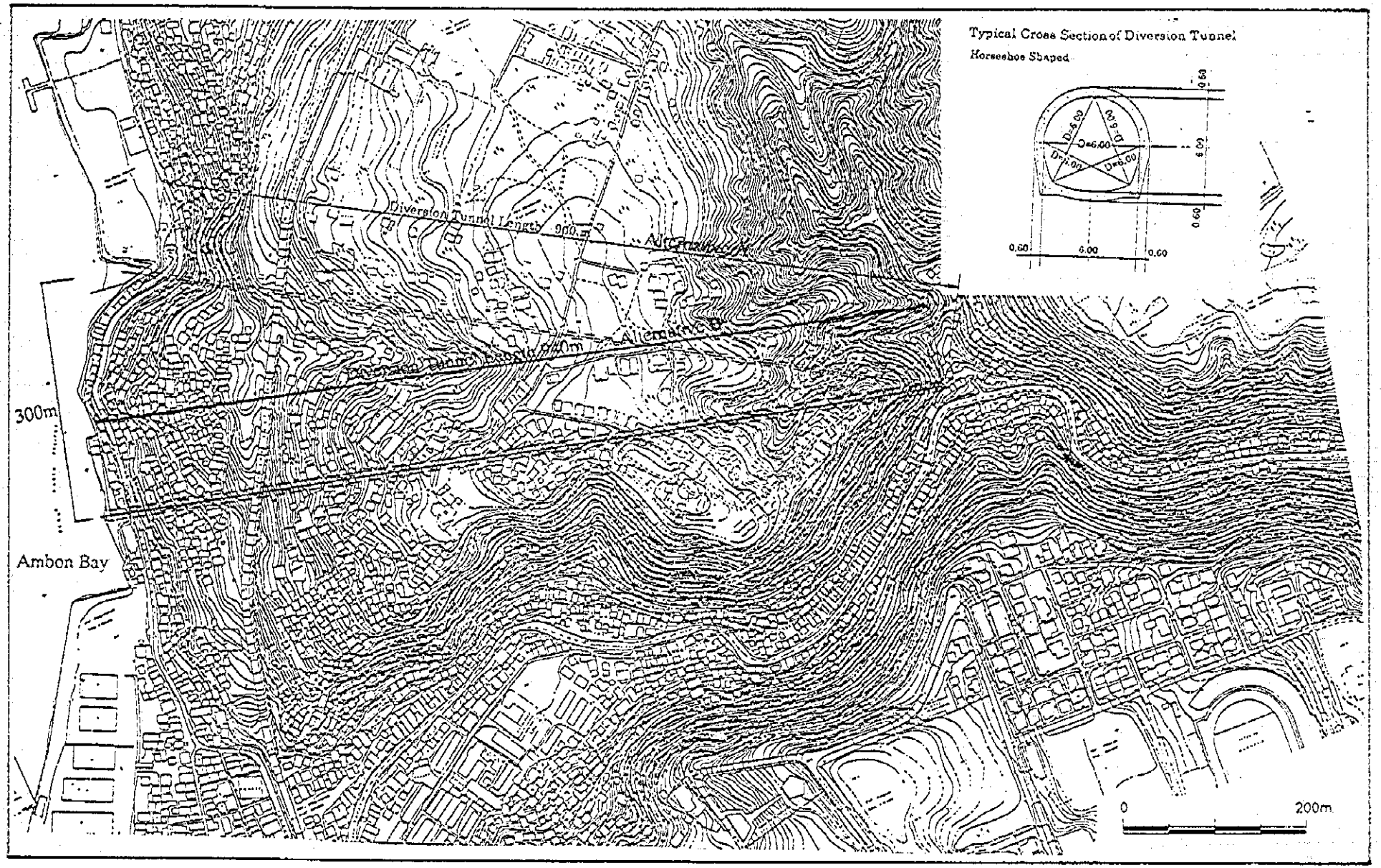


Figure-F.2.5 Diversion Tunnel Alternatives

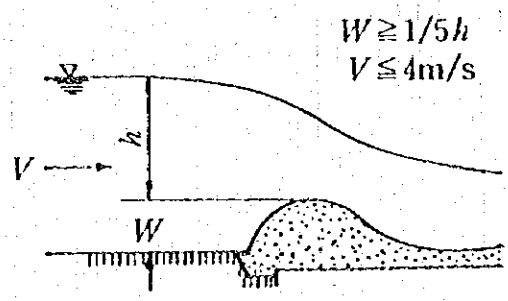
Table-F.2.8 Diversion Tunnel Alternatives

	Alternative A	Alternative B
Inlet		
Outlet	Ambon Bay 800m north from the river mouth of Batu Merah	Ambon Bay 500m north from the river mouth of Batu Merah
Tunnel Length	900m	940m
Tunnel Diameter	6.0m	6.5m
Tunnel Gradient	1/450	1/470
Resettlement Houses	0	30 houses
Selected Alternative	O	×

2.3.3 Fixed Weirs

(1) Main Stream Fixed Weir

In view of the location of diversion fixed weir and the diversion tunnel inlet, the location of the fixed weir on the main stream was decided at a point 1,400m from the river mouth of Batu Merah River. Channel structure downstream of the 1,400m point is concrete channel with riverbed elevation of 2.39m and channel depth of 2.20m. The ideal overflow of main stream fixed weir and the conditions at the upstream inflow channel shall be as shown below.



The design dimensions of the main stream fixed weir obtained from the flow regime of the downstream point to satisfy these conditions are as shown in Table-F.2.9. In addition, a 2.00m wide channel will be built at the center of the weir as a function of main stream fixed weir to discharge debris that flows downstream.

Table-F.2.9 Dimensions of Main Stream Fixed Weir

	Downstream channel	Fixed Weir	Upstream channel	Remarks
Riverbed Elevation	3.39 m	4.39 m (H=1.0 m)	3.79 m	W=0.6 m, H=2.60 $\frac{W}{H}$=0.23≥0.2
Water Depth	2.20 m	2.60 m	3.20 m	h_1=2.60, h_2=1.20 m h_2/h_1=0.46≦$\frac{2}{3}$(ok)
Channel Width	10.00 m	10.00 m	10.00 m	
Weir Overflow Coefficient	—	1.7	—	
Flow Velocity	3.18 m/s	2.69 m/s	2.56m/s	

(2) Diversion Channel Weir

The types of diversion channel weir considered were front fixed weir, which is the same as that used in the main stream, or horizontal overflow weir. Horizontal overflow weir was selected because it has the same diversion discharge as the main stream and because of the need to make the discharge channel weir higher than the main stream fixed weir. The shape of weir that satisfies the ideal overflow requirements of the weir is as follows. In addition, the starting discharge of the horizontal overflow weir shall be about 25 m^3/s and smaller floods will flow to the main stream. The channel height required for this purpose is 0.9 m. Therefore, the crest elevation of the horizontal overflow weir was set at 5.29 m. Design dimensions of the horizontal overflow weir are as shown in Table-F.2.10.

Table-F.2.10 Dimensions of Diversion Channel Weir

	Downstream channel	Fixed Weir	Upstream channel	Remarks
Riverbed Elevation	4.390 m	5.290 m	3.79 m	W=1.9 m, H=1.70 m $\frac{W}{H}=0.88 \geqq 0.2$
Water Depth	1.333 m	1.70 m	3.20 m	$h_1=1.70$, $h_2=0.833$ m $h_2/h_1=0.49 \leqq \frac{2}{3}$(ok)
Channel Width	18.00 m	18.00 m	18.00 m	
Weir Overflow Coefficient	—	1.5	—	
Flow Velocity	2.5 m/s	1.96 m/s	1.08 m/s	

2.3.4 Diversion Tunnel

(1) Diversion Tunnel

Alternative A was adopted for the diversion tunnel. The tunnel gradient is determined by the location of the inlet and outlet of the diversion tunnel. The conditions for determining the design cross section of the tunnel were decided as follows.

i) Design discharge shall be 130 % of planned discharge = 60 m^3/s x 1.30 = 78 m^3/s

ii) Flow velocity inside the tunnel shall not exceed 7 m/s.

iii) Roughness coefficient shall be increased by 50 % based on the lining inside the tunnel, n = 0.015 x 1.5 = 0.023

iv) The shape of the tunnel shall be standard horseshoe as the cross section is large.

v) Design discharge flow depth shall be the depth of the actual flow.

The structure of diversion tunnel is as shown in Table-F.2.11.

Table-F.2.11 Dimensions of Diversion Tunnel

Item	Dimension	Remarks
Outlet Level	0.80m	High Tide Sea Level
Inlet Level	2.80m	
Tunnel Length	900m	
Tunnel Gradient	1/450	
Diameter of Cross Section	6.00m	Horseshoe shape section
Flow Velocity	2.95m/s	≦7.0m/s
Water Depth	3.78m	0.63D

The hydraulic characteristic curve for the tunnel cross section shall be as shown in Figure-F.2.6.

Depth	A (m^2)	V (m^3/s)	Q (m^3/s)
0.6	2.106	1.12	2.4
1.2	5.245	1.77	9.3
1.8	8.615	2.20	19.0
2.4	12.132	2.51	30.5
3.0	15.718	2.74	43.1
3.6	19.292	2.91	56.1
4.2	22.723	3.03	68.9

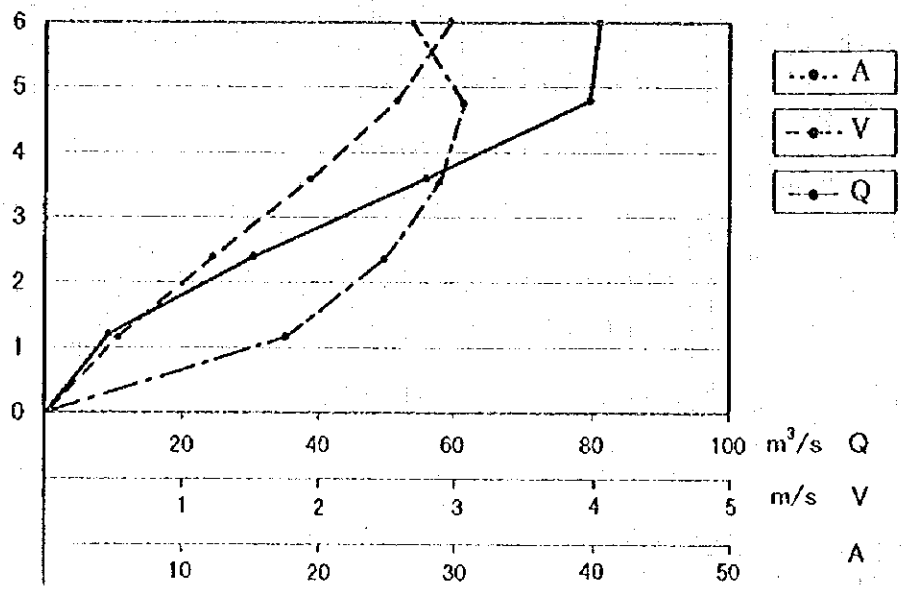


Figure-F.2.6 Hydraulic Characteristic Curve for the Diversion Tunnel

(2) Transition of Discharge Tunnel

In the transition of the discharge tunnel, hydraulic energy of the uppermost stream channel and hydraulic energy of the discharge tunnel are calculated to check the flow capacity. The results of calculation are as follows.

① Tunnel Inlet

$$E_1 = h + \frac{V^2}{2g} + P = 2.80 + 3.78 + \frac{2.95^2}{2 \times 9.8} 7.02m$$

② Transition Inlet

$$E_2 = h + \frac{V^2}{2g} + P = 4.39 + 1.79 + \frac{4.19^2}{2 \times 9.8} = 7.08m$$

Whereas, marginal depth of the channel outlet is obtained by the following equation.

$$hc = 3\sqrt{\frac{Q^2}{gB^2}} = 1.79m$$

B = Channel width 8.00m
Q = Design discharge 60.0 m^3/s

2.3.5 Design Drawing and Construction Quantities

The plan, longitudinal profile and spillway approach structure for Batu Merah River diversion tunnel are as shown in Drawings 17 through 19 in Appendix-10. Construction quantities for Batu Merah River diversion tunnel are as shown in Table-F.2.12..

Table-F.2.12 Construction Quantities for Diversion Tunnel

Item	Tunnel	Inlet	Outlet
Length	900 m	37 m	60 m
Excavation	A=45.4 m^2, 40,900 m^3	4,100 m^3	1,400 m^3
Concrete	A=15.5 m^2, 13,950 m^3	830 m^3	320 m^3
Supporting Work	900 m	-	-
Sheet Pile	-	-	100 m

2.4 Dam Design

2.4.1 Dam Dimensions

Dam dimensions for priority projects Batu Gajah Dam and Batu Gantung Dam are as shown in Table-F.2.13. Dam reservoir allocation is shown in Figure-F.2.7.

Table-F.2.13 Dam Design Conditions

Details	Unit	Batu Gajah Dam		Batu Gantung Dam	
Catchment Area	km^2	4.27		4.76	
Surcharge Water Level (SWL)	EL.m	70.50		102.10	
Normal Water Level (NWL)	EL.m	66.60		96.80	
Low Water Level (LWL)	EL.m	51.60		85.90	
Effective Storage for Water Supply	m^3	955,000		639,000	
Design Discharge	m^3/s	90 m^3/s	30 year	92 m^3/s	30 year

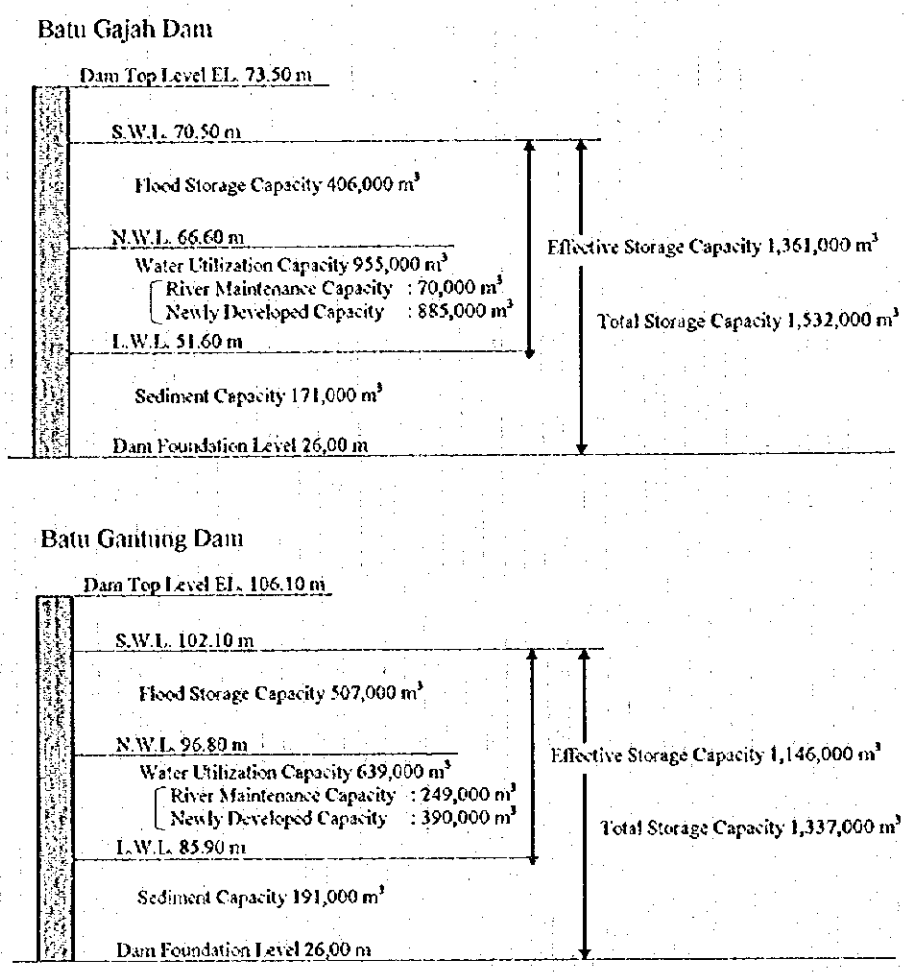


Figure-F.2.7 Reservoir Volume Allocation for Batu Gajah Dam and Batu Gantung Dam

2.4.2 Dam Design Conditions

The design requirements for each dam are as shown in Table-F.2.14. Design requirements were decided by taking the following conditions into consideration.

(1) The discharge used in river diversion works design was the 10 year probability flood discharge.

(2) According to the design standard, the discharge to be used in emergency spillway design is the 1/1,000 year probability flood discharge. In view of the limited availability of precipitation data and short runoff time due to small river basin area, the 1/2000 year probability flood discharge was adopted.

(3) Emergency spillway shall have a natural adjustment method planned using an open channel or conduit.

Table-F.2.14 Design Flood Discharge

Details	Batu Gajah Dam		Batu Gantung Dam	
	Discharge	Scale	Discharge	Scale
Design Discharge	90 m^3/s	30-year	92 m^3/s	30-year
Diversion	80 m^3/s	10-year	82 m^3/s	10-year
Emergency Spillway	190 m^3/s	2,000-year	190 m^3/s	2,000-year

2.4.3 Design of Main Dam

(1) Dam Axis

The dam axes of Batu Gajah Dam and Batu Gantung Dam, GJ-2 and GT-1, were selected in the Master Plan and geological survey was then carried out at the dam axes.

(2) Dam Type

After geological survey of the dam sites, quaternary limestone was found to be distributed at the dam site and reservoir area. Rock fill dams with inclined clay core were adopted because water leakage prevention measures are necessary and because dam foundation rock strength is not expected to be strong enough.

(3) Dam Crest Elevation

The dam crest elevation should be decided to be safe against flood discharge, reservoir water wave caused by wind and earth quake, and other allowances. Dam crest elevation was decided as follows:

[Dam Crest Elevation]=[S.W.L.]+[Emergency Spillway Depth]+[Freeboard 3 m]

Dam crest elevations are shown in Table-F.2.15.

Table-F.2.15 Dam Crest Elevation

Particulars	Batu Gajah Dam	Batu Gantung Dam
Surcharge Water Level (SWL)	EL. 70.50m	EL. 102.10m
Overflow Depth of Emergency Spillway	1.5m	1.5m
Freeboard	3.0m	3.0m
Dam Crest Elevation	EL. 75.00m	EL. 106.60m

(4) Structure of Dams

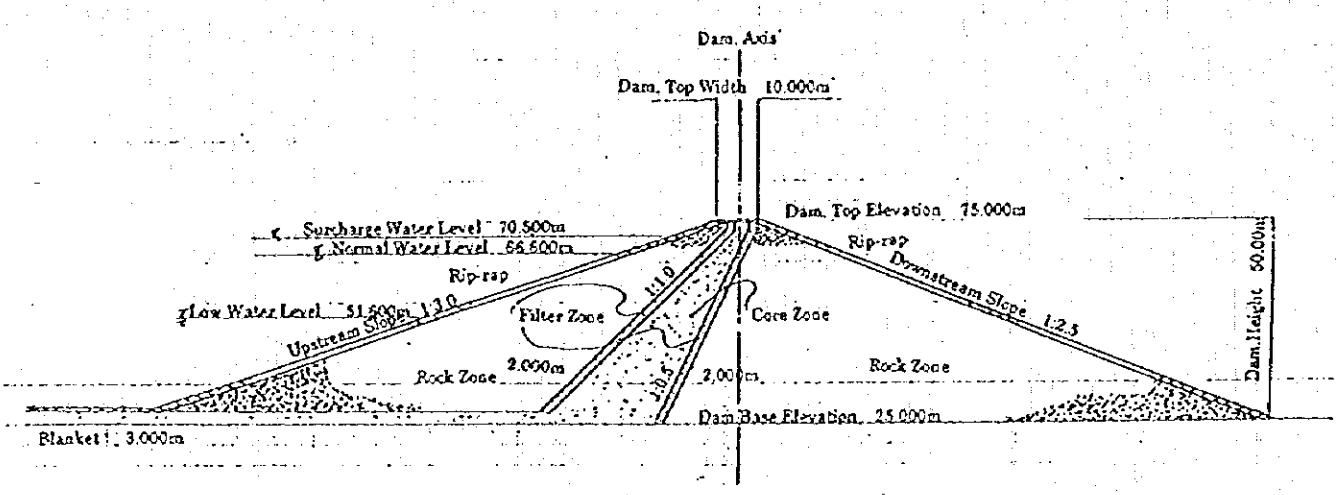
The proposed dam structures are shown in Table-F.2.16.

Table-F.2.16 Typical Dam Structures

Details	Batu Gajah Dam	Batu Gantung Dam
Crest Elevation	75.00 m	106.60 m
Crest Width	10.00 m	10.00 m
Upstream Slope	1:3.0	1:3.0
Downstream Slope	1:2.5	1:2.5
Dam Base Elevation	25.00 m	70.00 m
Dam Height	50.0 m	36.6 m
Dam Type	Rock fill dam with inclined clay core	Rock fill dam with inclined clay core

While general values were used for the downstream and upstream slopes, it is necessary to perform soil tests and carry out a stability analysis based on the results. In addition, the crown width of the dam was decided at 10.00 m in consideration of protection for the core area. Standard cross section diagrams of Gajah Dam and Batu Gantung Dam are as shown in Figure-F.2.8.

Batu Gajah



Batu Gantung

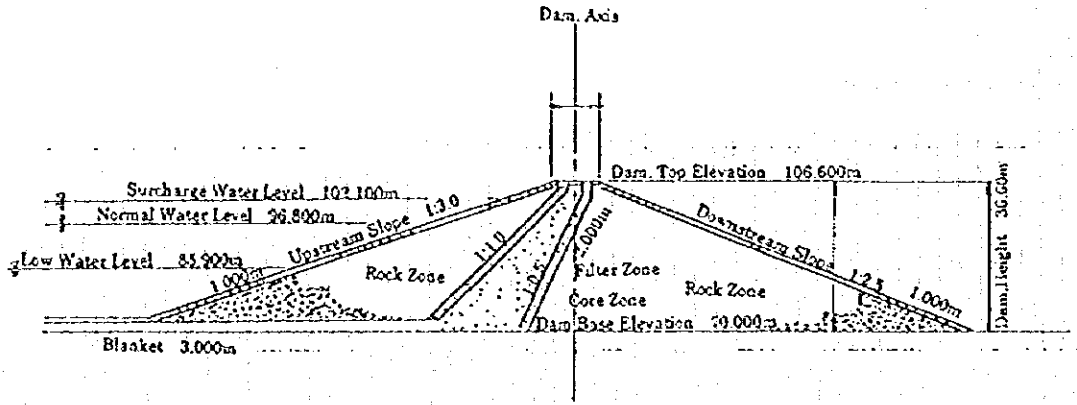


Figure-F.2.8 Typical Dam Cross Sections

2.4.4 Design of Dam Spillways

Dam spillways comprise an outlet spillway or conduit and an emergency spillway. Each spillway will have to have the functions indicated below.

(1) Outlet Spillway / Conduit

Regular spillway shall be an open channel when the difference between normal water level and surcharge water level is small and a conduit when the difference between the two is large. An outline of the regular spillways is shown in Table-F.2.17.

(2) Emergency Spillway

Emergency spillway shall be a non-gate type facility that discharges the design flood discharge of the dam along with the discharge from outlet conduit. The location of emergency spillway was planned on the right bank for Batu Gajah Dam and on the left bank for Batu Gantung Dam. An outline of the emergency spillways is as shown in Table-2.18.

Table-F.2.17 Outline of Spillway / Conduit

Items	Batu Gajah Dam	Batu Gantung Dam
Unregulated Peak Discharge	88 m^3/s	99 m^3/s
Regulated Peak Discharge	64 m^3/s	67 m^3/s
Maximum Discharge	90 m^3/s	92 m^3/s
Type	Open Channel	Conduit
Spillway / Conduit Elevation	EL.66.60 m	EL.96.80 m
Outlet Spillway / Conduit	B6.5m×H3.9 m	B4.2m×H4.2 m
Surcharge Water Level	70.50m	102.1m
Normal Water Level	66.60 m, H=3.9 m	96.8 m, H=5.3 m

Table-F.2.18 Outline of Emergency Spillways

Items	Batu Gajah	Batu Gantung	Remarks
Dam Design Discharge	190 m^3/s	220 m^3/s	1/2,000 return period
Conduit	Open Channel EL.66.60 m B6.5×H3.9 m	Conduit EL.96.80 m B4.2×H4.2 m	
Dam Design Water Level	72.00 m	103.60 m	Over flow depth 1.5 m
Outflow from Conduit	146.8 m^3/s C=1.8	141.5 m^3/s C=0.7	
Outflow from Spillway	43.2 m^3/s	78.5m^3/s	
Emergency Spillway	C=1.8 B13.5 m×H1.5 m	C=1.8 B12.0 m×H1.5 m	
Emergency Spillway Length	245.0 m	192.0 m	

2.4.5 Reservoir Protection

During geological survey of the dam sites, quaternary limestone was found to be distributed at the dam sites and reservoir areas of both rivers. Thus water leakage prevention measures as shown in Figure-F.2.9 are designed in the reservoir areas as follows:

- Riverbed area : Concrete channel
- Gentle slope area : Soil blanket
- Steep slope area : Shotcrete

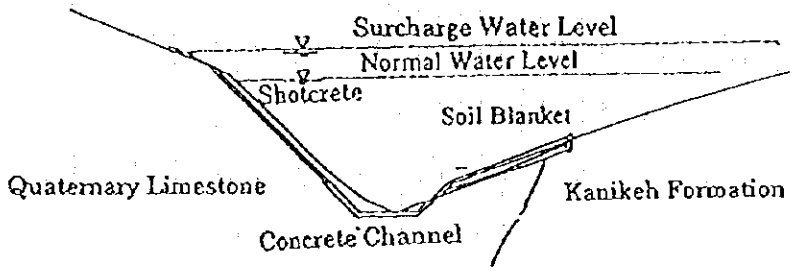


Figure-F.2.9 Typical Cross Section of Reservoir Protection

2.4.6 Diversion Tunnel

It is necessary to divert the river water before starting the dam excavation work. River diversion is often achieved by a tunnel in the case of a fill dam. The location of diversion tunnel is determined considering topographic and geological conditions. An outline the required river diversions is as shown in Table-2.19.

Table-F.2.19 Outline of River Diversion

	Batu Gajah Dam	Batu Gantung Dam	Remark
Dam Design Discharge	66 m^3/s	74 m^3/s	10 year return period
Location	Left Side	Left Side	
Gradient	1/140	1/140	
Tunnel Type	Horseshoe	Horseshoe	
Diameter	4.5 m	4.5 m	
Length of Tunnel	398.0 m	192.0 m	
Outlet Elevation	35.15 m	81.63 m	
Inlet Elevation	38.00 m	83.00 m	

2.4.7 Structural Features of the Dams

The major structural features of the dams are shown in Table-F.2.20. In addition, the design drawings of Batu Gajah Dam and Batu Gantung Dam are as shown in Drawings 21 to 26 in Appendix-10.

Table-F.2.20 Major Structural Features

Item	Batu Gajah	Batu Gantung
Reservoir		
Gross Storage Capacity	1,532,000m^3	1,337,000m^3
Effective Storage Capacity	1,361,000m^3	1,146,000m^3
Flood Water Level (FWL)	72.000 m	103.600 m
Surcharge Water Level (SWL)	70.5000 m	102.1000 m
Normal Water Level (NWL)	66.600 m	96.800 m
Low Water Level (LWL)	51.600 m	85.900 m
Sediment level	51.600 m	85.900 m
Effective Depth	18.900 m	16.700 m
Surface Area at SWL	0.11 km^2	0.11 km^2
Catchment Area	4.27 km^2	4.76 km^2
Dam		
Type	Rock Fill Dam with Inclined Clay Core	
Dam Crest Elevation	EL. 75.00m	EL. 106.60m
Height	50.00m	36.60m
Freeboard	3.00 m	3.00 m
Crest Length x Crest Width	240 x 10	100 x 10
Non-overflow Crest Elevation	EL. 75.00m	EL. 106.60m
Overflow Crest Elevation	EL. 66.60 m	EL. 96.80 m
Volume of Dam	597,000 m^3	159,000 m^3
Base Width	52.00m	25.00m
Dam Slope : Upstream	1 : 3.0	1 : 3.0
: Downstream	1 : 2.5	1 : 2.5
Spillway		
Type	Non Gated Type	Non Gated Type
Discharge Capacity	190m^3/s (2,000-year)	220m^3/s (2,000-year)
Emergency Spillway		
Overflow Crest Elevation	EL. 70.50 m	EL. 102.10 m
Overflow Depth	1.5m	1.5m
Length	13.5m	12.0m
Diversion Tunnel Works		
Number	1	1
Length of Tunnel	398.00m	192.00m
Inner Diameter	4.5 m	4.5 m
Total Design Capacity	66 m^3/s	74 m^3/s

2.4.8 Construction Quantities for the Dams

Construction quantities for the dams are shown in Table-F.2.21.

Table-F.2.21 Quantities for Dam Construction

Item	Batu Gajah Dam	Batu Gantung Dam	Remark
Diversion Tunnel			
(1) Length	398.0 m	217.0 m	
(2) Diameter	4.5 m	4.5 m	
(3) Excavation	10,800 m^3	5,900 m^3	
(4) Concrete	3,550 m^3	1,940 m^3	
Dam Body			
(1) Core	108,000 m^3	26,000 m^3	
(2) Filter	47,000 m^3	11,000 m^3	
(3) Rock	442,000 m^3	122,000 m^3	
(4) Excavation	115,000 m^3	37,000 m^3	
Spillway			
(1) Excavation	included in Dam Body Excavation		
(2) Concrete	12,420 m^3	10,580 m^3	
Reservoir			
(1) Blanket Protection	47,000 m^2	40,000 m^2	
Intake Gate	1 set	1 set	
Approach (Road)	1 set	1 set	
Control Building	1 set	1 set	

2.5 Check Dams

2.5.1 Basic Conditions

Basic conditions of check dam design are shown in Table-F.2.22. The most suitable dam site location was selected for each river as shown in Drawings 27 and 28 in Appendix-10, taking into account 1) securing enough sediment volume capacity, 2) few resettlement households. For Ruhu, Batu Gajah and Batu Gantung Rivers, check dam sites were selected just upstream of the reservoirs for the purpose of reducing sediment inflow to the reservoirs. Design discharge was set as 100-year return period, calculated from the river flood control plan in accordance with ratio of catchment areas.

Table-F.2.22 Check Dam Design Condition

River	Ruhu	Tomu	Batu Gajah	Batu Gantung	Remarks
Dam Site Location	6k100 Upstream of RH-1 Dam	3k500	4k250 Upstream of GJ-1	4k000 Upstream of GT-1	See Drawings 27 & 28
Catchment Area (km^2)	10.9	2.7	2.8	3.1	
Design Discharge (m^3/sec)	281.0	72.5	73.8	82.9	100-year return period
Proposed Capacity (m^3)	40,000	37,000	10,000	36,000	

2.5.2 Design of Check Dam

– Dam Structure Type

Check dams are designed as masonry gravity dams.

– Dam Height

Dam heights are defined for each dam so as to enable storage of proposed sediment capacity, using H-V Curves indicated in Table-F.2.23.

Table-F.2.23 H-V Curve of Check Dams

[Ruhu River]

Elevation	Height	Area	Average	Volume	Accumulative
EL. (m)	(m)	(m^2)	(m^2)	(m^3)	(m^3)
63		0			
65	2	13,040	6,520	13,040	13,040
70	5	58,320	35,680	178,400	191,440

Note : Proposed Sediment Capacity V = 40,000 m^3
Dam Height = (40,000-13,040)/(191,440-13,040)*5+2 = 2.8 m

[Tomu River]

Elevation	Height	Area	Average	Volume	Accumulative
EL. (m)	(m)	(m^2)	(m^2)	(m^3)	(m^3)
43		0			
45	2	1,878	939	1,878	1,878
50	5	34,516	18,197	90,985	92,863

Note : Proposed Sediment Capacity V = 37,000 m^3
Dam Height = (37,000-1,878)/(92,863-1,878)*5+2 = 3.9 m

[Batu Gajah River]

Elevation EL. (m)	Height (m)	Area (m^2)	Average (m^2)	Volume (m^3)	Accumulative (m^3)
88		0			
90	2	1,220	610	1,220	1,220
95	5	4,540	2,880	14,400	15,620
100	5	12,260	8,400	42,000	57,620

Note : Proposed Sediment Capacity V = 10,000 m^3
Dam Height = (10,000-1,878)/(15,620-1,878)*5+2 = 5.1 m

[Batu Gantung River]

Elevation EL. (m)	Height (m)	Area (m^2)	Average (m^2)	Volume (m^3)	Accumulative (m^3)
133		0			
135	2	14,596	7,298	14,596	14,596
140	5	75,400	44,998	224,990	239,586

Note : Proposed Sediment Capacity V = 36,000 m^3
Dam Height = (36,000-14,596)/(239,586-14,596)*5+2 = 2.5 m

– Spillway

Height of spillway should be set by the following formula.

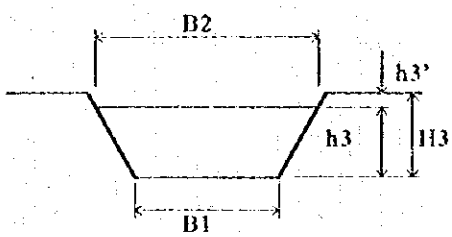
$H_3 = h_3 + h_3'$

H_3: Height of spillway (m)
h_3: Overflow depth (m)
h_3': Freeboard (m)

Overflow depth (h_3) is calculated as follows.

$Q = 2/15 * C * sqr(2 * g) * (3B_1+2B_2) * h_3^{3/2}$

Q: Design discharge (m^3/sec)
C: Overflow coefficient (0.6)
g : Gravity acceleration (9.8 m/sec^2)
B_1: Width of spillway crest (m)
B_2: Width of overflow water surface (m)



According to the above formula, specification of check dam spillways is set as shown in Table-F.2.24.

Table-F.2.24 Specification of Check Dam Spillways

River	Design Discharge (m^3/sec)	Crest Elevation EL.(m)	Overflow Depth h_3 (m)	B_1 (m)	B_2 (m)	Freeboard h_3' (m)	H_3 (m)	Top of Spillway EL.(m)
Ruhu	281	65.8	4.17	17.00	21.14	0.80	4.97	70.77
Tomu	73	39.4	1.89	15.00	16.89	0.60	2.49	41.89
Batu Gajah	74	119.6	2.44	10.00	14.87	0.60	3.04	122.64
Batu Gantung	83	113.5	2.96	8.00	10.96	0.60	3.56	117.06

Note: Freeboard (h_3') is set according to design discharge as follows .
$Q < 200 m^3$/sec... $h_3' = 0.6$ m, $200 < Q < 500$ m^3/sec... $h_3' = 0.8$ m

– Sub-dam and Front Apron

Location and height of sub-dam and thickness of front apron are set using the following formula.

$$L = (1.5 - 2.0)*(H_1 + h_3)$$
$$= 2.0*(H_1 + h_3)$$
$$H_2 = (1/3 - 1/4)*(H_1 + t)$$
$$= 1/3 * H_1$$
$$t = 0.1 * (0.6H_1 + 3h_3 - 1.0)$$

where :

- L: Distance between main-dam and sub-dam (m)
- H_2: Height of sub-dam (m)
- t : Thickness of front apron (m)
- H_1: Height from front apron of main-dam (m)
- h_3: Overflow depth (m)

Using the above formula, specification of sub-dam and front apron is set as shown in Table-F2.25.

Table-F.2.25 Specification of Sub-dam and Front Apron

River	H_1 (m)	h_3 (m)	L (m)	t (m)	H_2 (m)
Ruhu	2.80	4.17	13.94 ≒ 14.00	1.32 ≒ 1.35	1.38 ≒ 1.40
Tonu	3.90	1.89	11.58 ≒ 11.60	0.71 ≒ 0.75	1.55 ≒ 1.55
Batu Gajah	5.10	2.44	15.08 ≒ 15.10	0.94 ≒ 0.95	2.02 ≒ 2.05
Batu Gantung	2.50	2.96	10.92 ≒ 10.95	0.94 ≒ 0.95	1.15 ≒ 1.15

– Design of Check Dams

As described above, specifications of the check dams are shown in Table-F.2.26. Design drawings for each dam are shown in Drawings 27 and 28 in Appendix-10.

Table-F.2.26 Specification of Check Dams

River	Ruhu	Tonu	Batu Gajah	Batu Gantung
Dam Type	Masonry Gravity Dam			
Basement Elevation EL(m)	62.0	34.5	115.5	110.0
Dam Height (m)	3.8	4.9	6.1	3.5
Dam Length (m)	51.0	39.0	32.0	25.0
Overflow Depth (m)	4.17	1.89	2.44	2.96
Free Board (m)	0.80	0.60	0.60	0.60
Spillway Height (m)	4.97	2.69	3.04	3.56
Spillway Crest Width (m)	17.0	15.0	10.0	8.0
Dam Volume (m^3)	1,000	800	750	300

2.6 Land Reclamation

a) Potential Locations for Land Reclamation

Two locations were considered as potential areas for land reclamation, namely the south west side of Ruhu rivermouth at Tantui and the south west side of Batu Gantung rivermouth at Wai Nitu.

b) Discussions with Related Organizations

Following discussions with the related organizations, including at the Local Coordination Meeting held in Ambon on 22 July 1997, it was decided that the preferred location was the area near to Wai Nitu as BAPPEDA already have a plan to improve the area and construct a new road (RTBL Block Plan). Further discussions were held with the Ministry of Transport, the Harbourmaster and Administrator of Ambon Port and the Director of Waiame Dockyard to gain consensus for the proposed land reclamation. All parties strongly supported the proposal and welcomed the opportunity to improve this area of Ambon Bay.

c) Survey of Wai Nitu Area

Preliminary design of the land reclamation area was undertaken based on the existing bathymetric map of Ambon Bay and the 1:1000 BPN maps of Ambon city. An additional sounding survey was also undertaken to confirm the water depth and location of wrecked ships.

d) Preliminary Design of Land Reclamation Area

Based on the existing maps and the additional survey, preliminary design of the proposed land reclamation area at Wai Nitu was undertaken as shown in Drawing 29 of Appendix-10. The maximum depth for the sea wall necessary to enclose the land reclamation area was assumed as - 2.0 m below mean sea level - a typical cross section of the sea wall is also shown. The final surface elevation of the land reclamation area was assumed as + 2.0 m above mean sea level. From these maps, the available area for land reclamation and the potential volume for disposal of excavated material was calculated as shown in Table-F.2.27.

Table-F.2.27 Available Area for Land Reclamation

Name	Type	Area	Average Depth	Total Volume	Sea Wall Dimension	
					Average Height	Total Length
Wai Nitu	New Reclamation	6.56 ha	3.0 m	196,800 m^3	4.5 m	865 m

CHAPTER 3 CONSTRUCTION PLAN AND SCHEDULE

3.1 Planning Conditions

The planning conditions of the construction plan for the project is as follows:

(1) Division of Project Construction

The project construction works were divided into four main construction works as follows:

(1) River Improvement Works
(2) Land Reclamation Works
(3) Diversion Tunnel Works
(4) Dam Construction Works

(2) Construction Conditions

A year can be divided into the dry season and rainy season in Ambon. From existing rainfall data, the rainy season is assumed to be from May to August and the dry season from September to April.

River improvement works are planned to be concentrated in the dry season. The number of working days is set at 16.6 days/month for construction and 22.3 days/month for other construction works, taking into account that core embankment works would be affected by rain. (Refer to Appendix-1)

(3) Transportation Routes for Construction Material

It is necessary to decide the transportation routes for construction material, taking into account 1) current road condition to the dam sites, 2) vehicle transportation condition.

3.2 Construction Plan for River Improvement Works

Construction plan for river improvement works is planned considering the following:

(1) Package Division and Excavation Volume

Due to difficulties of access to the vicinity of river improvement sites, river improvement sections are planned to be divided into the following 24 packages, each package of 400 m length. Excavation quantities by package and river are shown in Table-F.3.1.

Table-F.3.1 Package Division and Excavation Quantities

River	Length	Packages	Excavation
Ruhu River	1,600 m	4	25,900 m^3
Batu Merah River	1,400 m	4	20,600 m^3
Tomu River	2,400 m	6	28,000 m^3
Batu Gajah River	2,200 m	6	18,800 m^3
Batu Gantung River	1,450 m	4	12,300 m^3
Total	9,050 m	24	105,600 m^3

(2) Construction Equipment and Working Days

Necessary construction equipment and working days are as follows:

(a) Excavation Work Period

- Construction equipment : 0.6 m^3 excavator
- Unit Excavation Quantities : 259 m^3/day (37 m^3/hour * 7 hours/day)
  : 5,775m^3/month (Working days : 22.3 days/month)

(b) Excavation Work Period

Riverbed excavation is planned to be carried out from the downstream, taking into account river diversion during construction. Riverbed excavation work will be carried out during the 8 months of dry season from September to April each year.

(c) Concrete Placement

Sheet piles for temporary diversion and dump truck transportation for excavated material could disturb concrete placement of flood walls due to limited construction space. Therefore concrete placement is planned to be carried out starting from the section unaffected by truck transportation. Assuming 2 parties for concrete placement, the construction length per month is estimated to be 300 m/month.

(3) Construction Schedule for River Improvement Works

Construction schedule of the work items, such as placement of sheet piles, riverbed excavation and concrete placement, is shown in Table-F.3.2 and Table-F-3.3.

(a) Construction Period for River Improvement Works

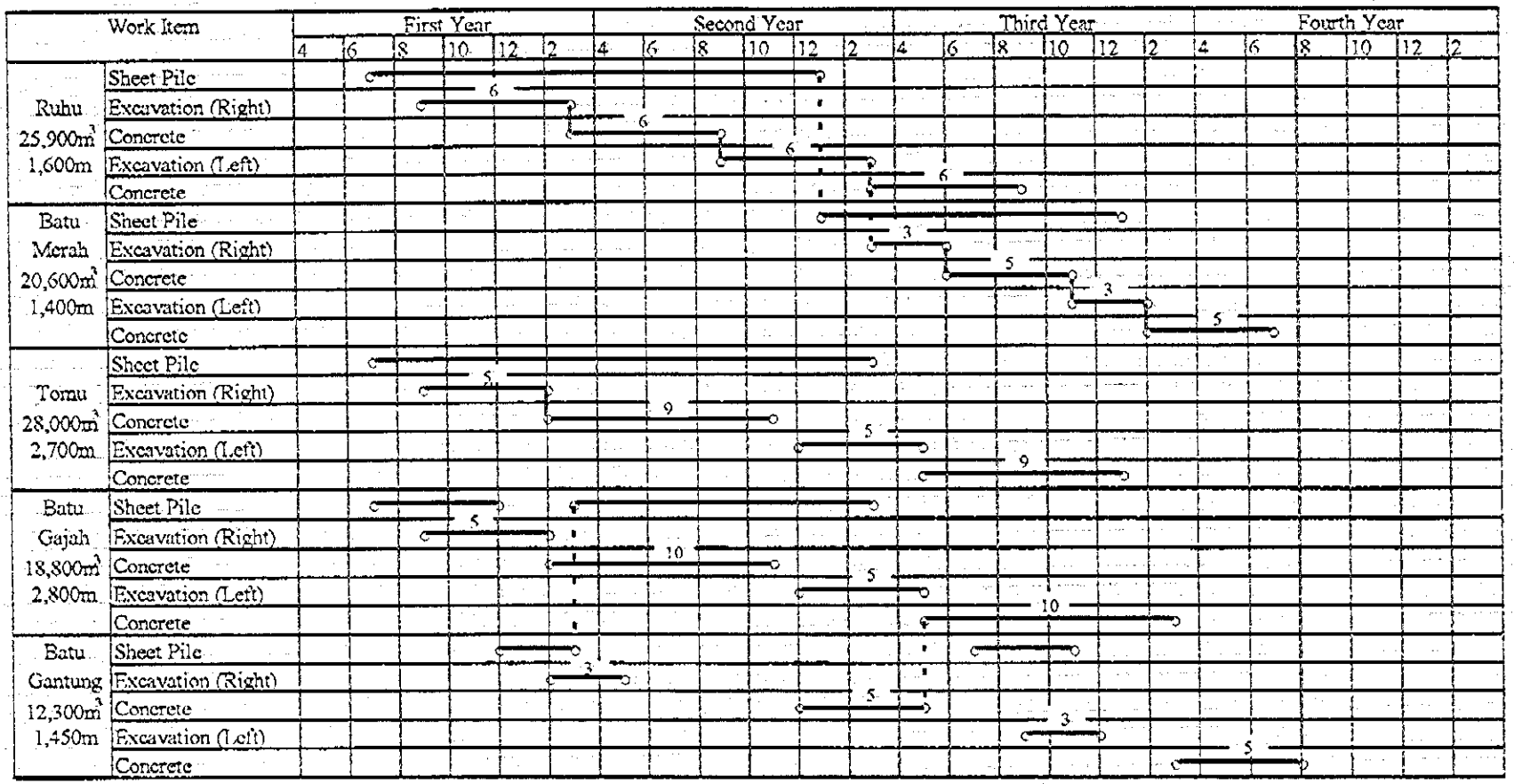
In river improvement works, 2 parties for sheet pile works, 2 parties for riverbed excavation and 2 parties for concrete placement are needed. Therefore, the following construction periods are necessary including preparation works:

- Ruhu River and Batu Merah River : 23 months
- Tomu River and Batu Gantung River : 27 months
- Batu Gajah River : 15 months

Table-F.3.2 Time Required for River Improvement Works

River	Excavation	Widening	Concrete Channel	Total
Ruhu River	4.5 months	2.0 months	-	6.5 months
Batu Merah River	3.6 months	8.0 months	4.7 months	16.3 months
Tomu River	4.9 months	4.0 months	8.0 months	16.9 months
Batu Gajah River	3.3 months	3.6 months	7.4 months	14.3 months
Batu Gantung River	2.2 months	2.6 months	4.9 months	9.7 months
Total	18.5 months	20.2 months	25.0 months	63.7 months

Table-F.3.3 Construction Schedule for River Improvement Works



(4) Bridge Improvement and Drainage Improvement

Bridge improvement and drainage improvement are planned to be carried out during construction of the other river improvement works.

3.3 Construction Plan of Batu Merah River Diversion Works

Construction plan of Batu Merah River diversion works is planned considering the following.

(1) Construction of Diversion Tunnel

Diversion tunnel is planned to be excavated from the outlet, talking into account drainage and removal of waste material during construction. Excavation method adopted is the whole section excavation method, because of the small tunnel section which is 6.0m in diameter and 30 m^2 in section area. Assuming 1.5 m/day of tunnel excavation, applying progress rate of other tunnel excavation works, it is estimated to take a total 28 months (900 m/1.5m/day = 600 days) for the diversion tunnel excavation. Concrete lining works for the tunnel are planned to be carried out in parallel with the excavation.

(2) Construction of Diversion Inlet

Construction of the diversion inlet is planned to be carried out after the completion of tunnel excavation, due to difficulties in transportation of waste material. It is estimated to take 4 months for construction of the diversion inlet.

(3) Construction of Diversion Outlet

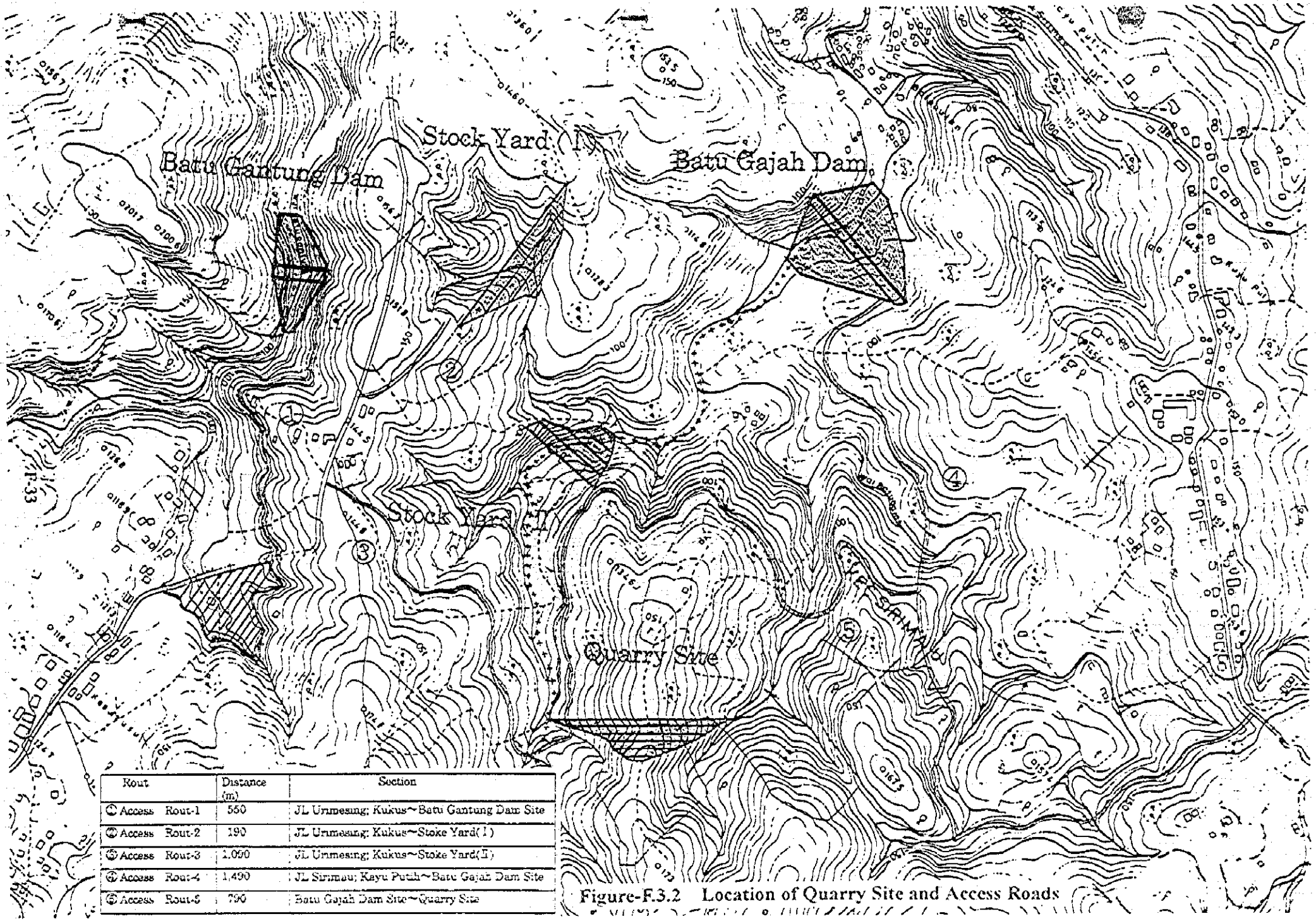
Part of the diversion outlet structure is planned to be used as a temporary stock yard for construction equipment and material by placing sheet piles. These temporary works should be the first works in the construction of the Batu Merah diversion, even though the diversion outlet works is planned to be the final works. It is estimated to take 4 months for construction of the diversion outlet.

3.4 Dam Construction Plan

Construction plan of dam construction works is planned considering:

(1) Quarry Site

Core, filter and rock materials of the dams are planned to be quarried from just upstream of both dams within the same river basin, on the basis of the results from soil and rock material tests. Construction materials for both dams are planned to be taken from same quarry site. The location of the quarry site is shown in Figure-F.3.1.



Rout		Distance (m)	Section
① Access	Rout-1	550	JL Urimessing; Kukus~Batu Gantung Dam Site
② Access	Rout-2	190	JL Urimessing; Kukus~Stoke Yard(I)
③ Access	Rout-3	1,090	JL Urimessing; Kukus~Stoke Yard(II)
④ Access	Rout-4	1,490	JL Sirimau; Kayu Putih~Batu Gajah Dam Site
⑤ Access	Rout-5	790	Batu Gajah Dam Site~Quarry Site

Figure-F.3.2 Location of Quarry Site and Access Roads

(2) Access Road

Access roads connecting both dam sites to the existing road and the quarry site are planned as shown in Figure-F.3.1. The width of access roads is set at 8.0 m. Excavation quantities and construction period of access road works are shown in Table-F.3.4.

Table-F.3.4 Access Roads

Access Road	Length	Planned Excavation Volume	Construction Period
Access road No.1	550 m	8,800 m	1.5 months
Access road No.2	190 m	3,100 m	0.5 months
Access road No.3	1,090 m	17,500 m	3.0 months
Access road No.4	1,490 m	23,900 m	4.0 months
Access road No.5	790 m	12,700 m	2.0 months
Total	4,110 m	66,300 m	11.0 months

(3) Leakage Prevention Measures for Reservoirs

Leakage prevention measures for both dam reservoirs are needed. Before construction of diversion works, riverbed leakage prevention measures using concrete channel works should be implemented.

(4) River Diversion Works

River diversion works are planned as tunnels, the length and construction period of which are shown in Table-F.3.5.

Table-F.3.5 Length and Construction Period of River Diversion Tunnels

Dam	Tunnel Length	Progress	Construction Period
Batu Gajah Dam	398.0 m	1.5 m/day	265 days
Batu Gantung Dam	192.0 m	1.5 m/day	128 days

(5) Main Dams

Excavation (31 t Bulldozer, 1.2m^3 Excavator)

Dam	Excavation Volume	Progress	Construction Period
Batu Gajah Dam	155,000 m^3	791 m^3/day	196 days
Batu Gantung Dam	37,000 m^3	791 m^3/day	47 days

Embankment (Tamping Roller : 20.7-24.5 t)

Dam	Embankment Volume	Progress	Construction Period
Batu Gajah Dam	108,000 m^3	539 m^3/day	200 days
Batu Gantung Dam	26,000 m^3	539 m^3/day	48 days

(6) Spillways

Spillway works are planned to be carried out in line with the main dam embankment works .

3.5 Construction Schedule

Construction schedule is shown in Table-F.3.6, prepared based on consideration of the above construction plan (1),(2),(3),(4). The construction works of the project were divided into four components namely 1) river improvement works, 2) diversion tunnel, 3) dam construction and 4) land reclamation. The works are planned to be constructed according to the following construction schedule, having a total construction period of 5 years (60 months) from April 2002 to March 2006.

- River Improvement Works of Ruhu, Batu Merah, Tomu, Batu Gajah and Batu Gantung rivers are planned to be constructed over 40 months from April 2002 to July 2005.
- Batu Merah Diversion Tunnel is planned to be constructed over 40 months from April 2002 to July 2005
- Batu Gajah and Batu Gantung Dam construction works are planned to be constructed over 57 months from April 2002 to December 2006.
- Land Reclamation work near Wai Nitu is planned to be constructed over 14 months from April 2002 to July 2003.

Table-F.3.6 Construction Schedule

Item	Unit	2002						2003						2004						2005						2006						2007					
		A	J	A	O	D	F	A	J	A	O	D	F	A	J	A	O	D	F	A	J	A	O	D	F	A	J	A	O	D	F	A	J	A	O	D	F
1.River Improvement Works																																					
1.1 Preparatory Works	Ls																																				
1.2 River Bed Excavation	105,600 m3																																				
1.3 Concrete Work	42,650 m3																																				
1.4 Dramage Gate Works																																					
1.5 Bridge Improvement																																					
1.6 Sheet Pile																																					
1.7 Anchor Work																																					
2.Diversion Tunnel																																					
2.1 Preparatory Works	Ls																																				
2.2 Tunnel Excavation	40,900 m3																																				
2.3 Concrete Lining	13,950 m3																																				
2.4 Inlet Works	Ls																																				
2.5 Outlet Works	Ls																																				
3.Dam Construction																																					
3.1 Preparatory Works	Ls																																				
3.2 Access Road	4,110 m																																				
3.3 Resoriver Protection																																					
(1) Batu Gajah	Ls																																				
(2) Batu Gantung	Ls																																				
3.4 Diversion Tunnel																																					
(1) Batu Gajah	398 m3																																				
(2) Batu Gantung	192 m3																																				
3.5 Excavation																																					
(1) Batu Gajah	155,000 m3																																				
(2) Batu Gantung	37,000 m3																																				
3.6 Embankment																																					
(1) Batu Gajah	571,000 m3																																				
(2) Batu Gantung	159,000 m3																																				
3.7 Spillway																																					
(1) Batu Gajah	12,420 m3																																				
(2) Batu Gantung	10,580 m3																																				
3.8 Initial Filling	Ls																																				
4. Land Reclamation																																					
4.1 Sea Wall																																					

CHAPTER 4 COST ESTIMATE

4.1 General Conditions of Cost Estimate

(1) Standards for Cost Estimate

Labor and materials rates for major work items such as excavation, embankment, stone masonry, concrete etc. are based on the following standards used in Indonesia.

1) Construction Cost Estimate Standard
(Dasar Pengusunan Anggaran Biaya Bangunan)

2) Principal Manual of Works with Machinery
(Pedomon Pokok Pelaksanaan Pekerjaan dengan Menggunakan Peralatan)

(2) Composition of Project Cost

The project cost of the flood control plan consists of the construction cost, compensation cost, administration cost, contingency, engineering services cost and Government Tax.

(a) Construction Cost
Construction cost is the cost required for the construction of main structures and other related works, including the preparatory works.

(b) Compensation Cost
Compensation cost consists of land aquisition, resettlement of households, temporary use of land and compensation for properties.

(c) Administration Cost
Administration cost of the Government is assumed to be 5% of the total amount of construction cost and compensation cost in order to cover the cost of supervision and management by Government staff.

(d) Contingency
Contingency consists of price contingency and physical contingency. Price contingency is assumed to be 2% per annum for the construction cost, compensation cost and engineering services cost. Physical contingency is assumed to be 5% of the total amount of construction cost, compensation cost and price contingency.

(e) Engineering Services Cost
The engineering services will cover the whole duration of the project construction period including the pre-construction period, from the review of tender documents to the completion of the project. The cost for this item was estimated including physical and price escalation contingencies.

(3) Unit Prices and Exchange Rates

The following currency exchange rates (as of September 1997) were employed in the calculation of unit prices, land acquisition cost, etc..

US$ 1 = ¥ 120 = Rp. 2,928 ¥ 1 = Rp. 24.4

Unit prices were determined based on the current cost of labor, natural materials, equipment cost, etc (refer to Table-F.4.1, F.4.2 and F.4.3 and Figure-F.4.1)

Table-F.4.1 Labor Cost in Ambon City

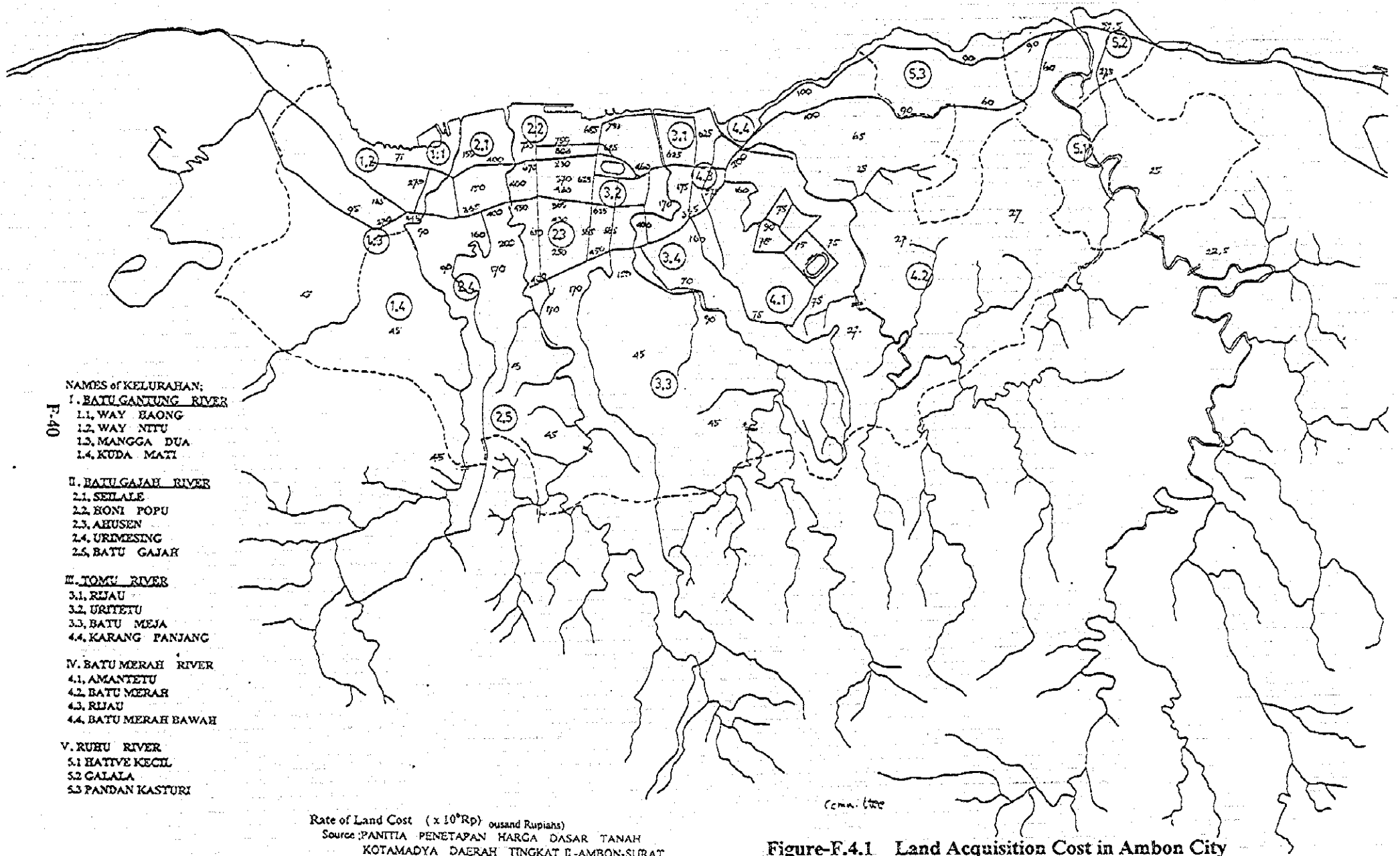
Description	Unit Price (Rp/man. day)					Overtime (Rp/hr)
	1992	1993	1994	1995	1996	(1996)
Foreman	6,500	6,750	7,000	6,500	7,500	1,500
Labor (skilled)	6,500	6,750	7,000	7,000	7,000	1,500
Labor (common)	5,500	6,000	6,000	6,000	6,000	1,250
Operator	10,800	11,000	12,500	12,500	12,500	3,000
Assistant Operator	5,500	5,000	6,000	6,500	6,500	1,500
Driver	7,000	7,500	1,000	10,000	10,000	1,500
Mechanic	12,000	13,500	15,000	15,000	15,000	3,000
Electrician	12,000	13,500	15,000	15,000	15,000	3,000
Chief Mason	6,500	6,500	7,000	7,000	7,500	3,000
Mason	5,500	5,500	5,500	6,000	6,000	2,000
Surveyor	17,500	20,000	22,500	22,500	25,000	3,000
Assistant Surveyor	15,000	17,500	17,500	17,500	20,000	1,500
Chief Carpenter	6,500	6,500	7,000	7,000	7,500	3,000
Carpenter	5,500	5,500	5,500	6,000	6,000	2,000
Plasterer	5,500	5,500	5,500	6,000	6,000	2,000
Chief Steel Bar Worker	6,500	6,500	7,000	7,000	7,500	3,000
Steel Bar Worker	5,500	5,500	5,500	6,000	6,000	2,000
Gabion Net Maker	5,500	5,500	5,500	6,000	6,000	2,000

Table-F.4.2 Material Cost in Ambon City

Description	Unit	Unit Price (Rp)				
		1992	1993	1994	1995	1996
Gasoline	l	700	700	700	700	700
Diesel Oil	l	375	375	375	375	375
Mobil Oil	l	4,250	4,250	4,250	4,250	4,250
Gear Oil	l	4,500	4,500	4,500	4,500	4,500
Hydraulic Oil	l	4,500	4,500	4,500	4,500	4,500
Grease	m^3	15,000	15,000	15,000	15,000	15,000
Engine Oil (Diesel)	Kg	4,250	4,250	4,250	4,250	4,250
Sand for Concrete	m^3	20,000	25,000	30,000	35,000	38,500
Sand for Other	m^3	12,500	15,000	15,000	25,000	33,800
Gravel for Concrete	m^3	25,000	30,000	35,000	4,500	44,000
Gravel for Backfill	m^3	20,000	23,000	23,000	37,500	38,000
Stone for Masonry	m^3	22,000	30,000	40,000	4,500	44,000
Stone for Gabion	m^3	18,000	24,000	30,000	37,500	38,500
Brick	Brick	100	100	100	100	150
Reinforcement Bar	Kg	1,000	100	1,075	1,075	1,275
Nail	Kg	2,000	2,000	2,100	2,100	2,400
Wire for Rebar	Kg	1,750	2,300	3,000	3,000	3,000
Shaped Steel	Kg	3,500	5,000	6,500	7,500	7,500
Gabion Wire	Kg	1,000	1,000	1,000	1,100	1,300
Timber Sheet (formwork)	m^2	140,000	190,000	235,000	260,000	300,000
	(2 class)					
Portland Cement	40 kg	7,500	9,000	10,200	13,800	17,400

Table-F.4.3 Unit Cost for Construction Work

No.	Code	Description	Unit	1992	1993	1994	1995	1996
		Soil Construction:						
1	A1	Common Excavation	m^3	3,525	3,912	3,925	4,312	5,658
2	A2	Common Excavation : depth 1.00 m	m^3	4,698	4,711	4,758	5,194	6,569
3	A4	Wet Soil Excavation	m^3	7,050	7,825	7,850	8,625	9,575
4	A5	Rock Excavation	m^3	9,300	10,429	10,462	11,495	11,750
5	A18	Sand Embankment	m^3	17,258	19,565	27,910	36,890	41,325
6	A19	Soil Embankment	m^3	17,610	20,565	27,960	36,890	41,325
		Masonry & Concrete:						
7	G1	Stone Compaction	m^3	60,000	68,625	74,000	83,000	85,375
8	G2	Stone Filling	m^3	43,200	47,987	49,950	59,250	62,813
9	G3	Stone Filling with mortar (depth 0.25 m)	m^3	11,218	13,424	15,863	17,961	18,713
10	G1	Crushed Rock Compaction	m^3	60,000	68,625	74,000	74,500	76,375
11	G32f	Stone Masonry mix 1:5	m^3	120,150	122,820	131,519	141,320	151,565
12	G32k	Stone Masonry mix 1:2	m^3	152,873	153,390	155,659	175,095	185,659
13	G32h	Stone Masonry mix 1:4	m^3	129,825	132,510	133,004	144,042	160,313
14	G32h	Crushed Rock Masonry mix 1:4	m^3	117,825	128,910	133,004	144,042	160,313
15	G32i	Crushed Rock Masonry mix 1:3	m^3	125,280	130,110	133,872	145,347	171,449
16	G33i	Brick Masonry 1:2	m^3	143,280	155,738	174,404	176,404	205,204
17	G33i	Brick Masonry 1:3	m^3	132,253	145,528	187,127	189,129	210,029
18	G33i	Brick Masonry 1:4	m^3	125,188	134,068	156,756	167,750	211,528
19	G33i	Brick Masonry 1:5	m^3	118,130	125,818	154,303	160,364	168,144
20	G42	Concrete mix 1:2:4	m^3	147,498	153,440	155,903	165,904	227,066
21	G42	Concrete mix 1:3:5	m^3	136,650	143,600	145,616	155,616	198,602
22	Sup.V	Reinforced Concrete 1:2:3	m^3	159,810	180,800	188,680	208,900	212,680
23	Sup.V	- Steel Bar 90kg	m^3	505,800	550,628	564,180	594,668	620,410
24	Sup.V	- Steel Bar 100kg	m^3	527,210	573,375	587,080	617,925	644,880
25	Sup.V	- Steel Bar 110kg	m^3	548,620	596,153	609,980	640,853	669,300
26	Sup.V	- Steel Bar 125kg	m^3	580,735	630,244	644,330	671,600	706,055
27	Sup.V	- Steel Bar 150kg	m^3	634,260	687,113	701,580	734,213	767,230
28	Sup.V	- Steel Bar 175kg	m^3	687,785	743,981	758,830	792,356	828,405
29	Sup.V	Formwork Material	m^2	47,600	50,600	52,600	54,600	60,000
30	G44	Concrete Floor 1:3:6 thickness 7cm	m^2	9,864	10,395	10,800	11,657	11,910
31	G44	Concrete Floor 1:3:6 thickness 5cm	m^2	7,046	7,425	7,715	8,326	8,508
32	G50h	Plaster mix 1:2 thickness 10mm	m^2	3,726	5,569	6,050	6,169	7,704
33	G50j	Plaster mix 1:3 thickness 10mm	m^2	3,479	5,101	5,367	5,673	6,869
34	G50n	Plaster mix 1:4 thickness 10mm	m^2	3,207	4,582	4,972	5,000	6,154
35	G50o	Plaster mix 1:5 thickness 10mm	m^2	3,192	4,555	4,722	4,722	5,548



Rate of Land Cost (x 10^3Rp) ousand Rupiahs)
Source :PANITIA PENETAPAN HARGA DASAR TANAH
KOTAMADYA DAERAH TINGKAT II -AMBON-SURAT
KEPUTUSAN No.01/PHD/1996

Figure-F.4.1 Land Acquisition Cost in Ambon City

4.2 Unit Cost of Main Construction Work Items

Unit cost of main construction work items are shown in Table-F.4.4.

Table-F.4.4 Unit Cost of Main Construction Work Items

Work Item	Unit	Unit Price(Rp.)	Foreign(%)	Local(%)
1. River Improvement				
1.1 Preparatory Work (7%)	L.S			
1.2 River Bed Excavation	m^3	15,000	87	13
1.3 Concrete Flood Wall	m^3	737,000	25	75
1.4 Gate Work				
Type A	Piece	16,900,000	90	10
Type B	Piece	8,940,000	50	50
Type C	Piece	4,400,000	0	100
1.5 Bridge Improvement				
Reconstruction	Bridge	630,000,000	43	57
Rehabilitation	Bridge	400,000,000	39	61
Other (28 Foot Bridges, Pipe Lines)	L.S	448,000,000	83	17
1.6 Sheet Pile	m	1,995,000	80	20
1.7 Anchor Work	Piece	3,950,000	80	20
1.8 Check Dam	m^3	737,000	25	75
2. Diversion Tunnel Work				
(Batu Merah River)				
2.1 Preparatory Work (7%)	L.S			
2.2 Tunnel Excavation	m^3	62,300	60	40
2.3 Concrete Lining	m^3	884,400	25	75
2.4 Other Work				
Excavation	m^3	15,000	87	13
Concrete	m^3	737,000	25	75
3. Dam Construction				
3.1 Preparatory Work	L.S			
3.2 Access Road	m	151,000	87	13
3.3 Reservoir Sealing Coat	m^2	450,000	50	50
3.4 Diversion Tunnel	m	9,600,000	31	69
3.5 Excavation	m^3	14,700	83	17
3.6 Embankment	m^3	25,000	75	25
3.7 Spillway Concrete	m^3	737,000	25	75
4. Land Reclamation				
4.1 Sea Wall	m	7,140,000	80	20

4.3 Construction Cost of Works

Construction and land acquisition costs for each river are presented in Table-F.4.5.

Table-F.4.5 Main Construction Cost and Land Acquisition Cost

Unit : Rp.million

Ruhu River

Work Item	Quantity	Project Cost	Foreign	Local Currency
1. Preparatory Work	1	407	193	214
2. Main Construction		5,807	2,758	3,049
2.1 River Improvement	1,600 m	5,807	2,758	3,049
2.2 Diversion Tunnel	-	-		
2.3 Dam Construction	-	-		
2.4 Land Reclamation	-	-		
Sub Total		6,214	2,951	3,263
3. Land Acquisition		287		287
3.1 Land Acquisition	615 m^2	62		62
3.2 Settlement	5 house	225		225

Batu Merah River

Work Item	Quantity	Project Cost	Foreign	Local Currency
1. Preparatory Work	1	1,813	692	1,121
2. Main Construction		25,895	9,877	16,018
2.1 River Improvement	1,400 m	10,078	4,979	5,099
2.2 Diversion Tunnel	900 m	15,817	4,898	10,919
2.3 Dam Construction		-	-	-
2.4 Land Reclamation		-	-	-
Sub Total		27,708	10,569	17,139
3. Land Acquisition		2,335		2,335
3.1 Land Acquisition	4,250 m^2	850		850
3.2 Settlement	33 house	1,485		1,485

Tomu River

Work Item	Quantity	Project Cost	Foreign	Local Currency
1. Preparatory Work		1,210	454	756
2. Main Construction		17,282	6,486	10,796
2.1 River Improvement	2,400 m	17,282	6,486	10,796
2.2 Diversion Tunnel		-	-	-
2.3 Dam Construction		-	-	-
2.4 Land Reclamation		-	-	-
Sub Total		18,492	6,940	11,552
3. Land Acquisition		1,252		1,252
3.1 Land Acquisition	1,781 m^2	802		802
3.2 Settlement	10 house	450		450

Batu Gajah River

Work Item	Quantity	Project Cost	Foreign	Local Currency
1. Preparatory Work	1	4,650	2,459	2,191
2. Main Construction		66,430	35,097	31,333
2.1 River Improvement	2,200 m	11,784	4,686	7,098
2.2 Diversion Tunnel	-			
2.3 Dam Construction	1	54,646	30,411	24,235
2.4 Land Reclamation				
Sub Total		71,080	37,556	33,524
3. Land Acquisition		7,334		7,334
3.1 Land Acquisition	192,959 m^2	4,229	-	4,229
3.2 Settlement	69 house	3,105	-	3,105

Batu Gantung River

Work Item	Quantity	Project Cost	Foreign	Local Currency
1. Preparatory Work	1	3,087	1,581	1,506
2. Main Construction		44,092	21,765	22,327
2.1 River Improvement	1,450 m	8,382	3,466	4,916
2.2 Diversion Tunnel	-			
2.3 Dam Construction	1	35,710	18,299	17,411
2.4 Land Reclamation	-			
Sub Total		47,179	23,346	23,833
3. Land Acquisition		6,026		6,026
3.1 Land Acquisition	149,291 m²	4,811		4,811
3.2 Settlement	27 house	1,215		1,215

Table-F.4.6(1) Economic Project Cost of Work Items

Unit : Rp. million

Work Item	Ruhu 1,600m		Batu Merah 1400m		Tonu 2,400m		Batu Gajah 2,200m		Batu Gantung 1,450m	
	Q'ty	Cost	Q'ty	Cost	Q'ty	Cost	Q'ty	Cost	Q'ty	Cost
1.1 Preparatory Work	1	407	1	706	1	1,210	1	825	1	587
1.2 River Bed Excavation	25,900	389	20,600	309	28,000	420	18,800	282	12,300	185
1.3 Concrete	3,050	2,248	7,200	5,306	15,900	11,719	9,950	7,333	6,550	4,828
1.4 Gate Work		163		145		186		247		105
Type A	2	34	3	51	2	34	4	68	3	51
Type B	13	116	10	89	17	152	19	170	6	54
Type C	3	13	1	5	-	-	2	9	-	-
1.5 Bridge Improvement		678		464		1,542		822		1,292
Type A	1	630	-	-	1	630	1	630	2	1,260
Type B	-	-	1	400	2	800	-	-	-	-
Type C	3	48	4	64	7	112	12	192	2	32
1.6 Sheet Pile	600	1,197	1,140	2,274	1,010	2,015	920	1,836	630	1,237
1.7 Anchor Work	100	395	400	1,580	205	810	180	711	130	514
1.8 Check Dam	1,000	737	-	0	800	590	750	553	300	221
Sub Total (1)	6,214		10,784		18,492		12,609		8,969	
2.1 Land Acquisition	615	62	1,250	250	1,781	802	859	387	791	356
2.2 Settlement	5	225	21	945	10	450	19	855	26	1,170
Sub Total (2)	287		1,195		1,252		1,242		1,526	
Economic Cost	7,768		13,480		23,115		15,761		11,211	
Construction Cost	6,214		10,784		18,492		12,609		8,969	
Indirect Cost (25%)	1,554		2,696		4,623		3,152		2,242	
First Year	1,036		1,797		3,082		2,101		1,495	
Second Year	1,407		2,440		4,184		2,851		2,027	
Third Year	1,775		3,081		5,283		3,603		2,563	
Fourth Year	1,775		3,081		5,283		3,603		2,563	
Fifth Year	1,775		3,081		5,283		3,603		2,563	

Land Acquisition Cost:
- Ruhu River: 100×10^3 Rp/m²
- Merah River: 200×10^3 Rp/m²
- Tonu River: 450×10^3 Rp/m²
- Gajah River: 450×10^3 Rp/m²
- Gantung river: 450×10^3 Rp/m²

Resettlement: Rp 45×10^6 /house

Table-F.4.6(2) Economic Project Cost of Work Items

Unit:Rp.Million

Work Item	Dam Construction				Diversion		Disposal	
	Batu Gajah		Batu Gantung		Batu Merah		Wai Nitu	
	Q'ty	Cost	Q'ty	Cost	Q'ty	Cost	Q'ty	Cost
1.1 Preparatory Work					1	1,107		
1.2 Tunnel Excavation					40,900	2,548		
1.3 Concrete Lining					13,950	12,338		
1.4 Excavation					5,500	83		
1.5 Concrete Work					1,150	848		
2.1 Preparatory Work	1	3,825	1	2,500				
2.2 Access Road	2,100	317	2,050	310				
2.3 Reservoir Sealing	47,500	21,150	40,000	18,000				
2.4 Diversion Tunnel	398	3,821	217	2,083				
2.5 Excavation	155,000	2,279	37,000	544				
2.6 Embankment	597,000	14,925	159,000	3,975				
2.7 Spillway Concrete	12,420	9,154	10,580	7,798				
2.8 Intake	1	3,000	1	3,000				
3.1 Preparatory Work							1	432
3.2 Sea Wall							865	6,176
Sub Total (1+2+3)	58,471		38,210		16,924		6,608	
4.1 Land Acquisition	92,100	3,842	148,500	4,455	3,000	600		
4.2 Resettlement	50	2,250	1	45	12	540		
Sub Total (4)	6,092		4,500		1,140			
Economic Cost	73,089		47,763		21,155		8,260	
Construction Cost	58,471		38,210		16,924		6,608	
Indirect Cost (25%)	14,618		9,553		4,231		1,652	
First Year	9,745		6,369		2,821		1,101	
Second Year	13,226		8,643		3,829		1,495	
Third Year	16,706		10,917		4,835		1,888	
Fourth Year	16,706		10,917		4,835		1,888	
Fifth Year	16,706		10,917		4,835		1,888	

4.4 Project Cost Estimate

The total project cost is 302.05 billion Rupiah (12.38 billion Yen), estimated at September 1997 prices, as summarized in Table-F.4.7. Of the total project cost, 242.84 billion Rupiah (9.95 billion Yen) will be financed by OECF loan. The remaining portion of the project cost: 59.21 billion Rupiah (2.43 billion Yen) will be financed by the national budget. The disbursement schedule of the project is summarized in Table-F.4.8.

Table-F.4.7 Summary of the Project Cost

Item	Local Portion (Mil. Rp)	Foreign Portion (Mil. Yen)	Total Rp. Equivalent (Mil. Rp)	Total Yen equivalent (Mil. Yen)
1. Civil Works	141,837	4,281	246,302	10,094
(a) Direct Cost	104,065	4,077	203,555	8,342
- Base Cost	90,633	3,551	177,281	7,266
- Price Escalation (2% per year)	13,432	526	26,274	1,076
(b) Physical Contingency (5% of a)	5,203	204	10,178	417
(c) Government Administration (5% of a)	10,178	-	10,178	417
(d) Government Tax (10% of (a + b + c))	22,391	-	22,31	918
2. Land Acquisition & Compensation	23,732	-	23,732	973
(a) Direct Cost	19,613	-	19,613	804
- Base Cost	17,234	-	17,234	706
- Price Escalation (2% per year)	2,379	-	2,379	98
(b) Physical Contingency (5% of a)	981	-	981	40
(c) Government Administration (5% of a)	981	-	981	40
(d) Government Tax (10% of (a + b + c))	2,157	-	2,157	89
3. Consulting Engineering Services	17,888	585	32,015	1,312
(a) Direct Cost	14,265	557	27,719	1,136
- Base Cost	12,723	492	24,723	1,013
- Price Escalation (2% per year)	1,542	65	2,996	123
(b) Physical Contingency (5% of a)	713	28	1,386	57
(c) Government Tax (10% of (a + b))	2,910	-	2,910	119
Grand Total	183,457	4,866	302,049	12,379

[Note] Base for cost estimation : September 1997
Conversion rates : 1 US$ = Rp 2,928 = Y120 Rp/Y = 24.40 Y/Rp = 0.041

Table-F.4.8 Annual Disbursement Schedule of the Project

Unit:Million Rupiah

Items			Total	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Consulting Engineering S.												
Construction												
Land Acquisition & Comp.												
1	Construction Cost		246,302				49,708	50,699	51,716	52,748	27,055	14,375
a	Direct Cost		203,555				41,081	41,900	42,741	43,593	22,359	11,880
	Package-1	-Base Cost	58,471				9,745	9,745	9,745	9,745	9,745	9,746
		-Price Esc.	9,402				1,014	1,230	1,449	1,673	1,901	2,134
		<Total>	67,873				10,759	10,975	11,194	11,418	11,646	11,880
	Package-2	-Base Cost	44,818				8,964	8,963	8,964	8,963	8,964	
		-Price Esc.	6,685				933	1,131	1,333	1,539	1,749	
		<Total>	51,503				9,897	10,094	10,297	10,502	10,713	
	Package-3	-Base Cost	27,708				6,927	6,927	6,927	6,927		
		-Price Esc.	3,815				721	874	1,030	1,189		
		<Total>	31,523				7,648	7,801	7,957	8,116		
	Package-4	-Base Cost	24,706				6,177	6,176	6,177	6,176		
		-Price Esc.	3,401				643	779	919	1,060		
		<Total>	28,107				6,820	6,955	7,096	7,236		
	Package-5	-Base Cost	21,578				5,395	5,394	5,395	5,394		
		-Price Esc.	2,971				562	681	802	926		
		<Total>	24,549				5,957	6,075	6,197	6,320		
b	Contingency	5% of a	10,178				2,054	2,095	2,137	2,180	1,118	594
c	Administration	5% of a	10,178				2,054	2,095	2,137	2,180	1,118	594
d	Tax : 10% of (a+b+c)		22,391				4,519	4,609	4,701	4,795	2,460	1,307
2	Land Acquisition & Comp.		23,732			3,761	3,837	3,914	3,992	4,072	4,156	
a	Direct Cost		19,613			3,109	3,171	3,234	3,299	3,365	3,435	
		-Base Cost	17,234			2,872	2,872	2,872	2,872	2,872	2,874	
		-Price Esc.	2,379			237	299	362	427	493	561	
b	Contingency	5% of a	981			155	159	162	165	168	172	
c	Administration	5% of a	981			155	159	162	165	168	172	
d	Tax : 10% of (a+b+c)		2,157			342	349	356	363	370	378	
3	Consulting Engineering S.		32,015	4,456	4,545	1,236	3,784	3,859	3,936	4,015	4,095	2,088
a	Direct Cost		27,719	3,858	3,935	1,070	3,276	3,341	3,408	3,476	3,546	1,808
		-Base Cost	24,723	3,708	3,708	989	2,967	2,967	2,967	2,967	2,967	1,483
		-Price Esc.	2,996	150	227	81	309	374	441	509	579	325
b	Contingency	5% of a	1,386	193	197	54	164	167	170	174	177	90
c	Tax : 10% of (a+b+c)		2,910	405	413	112	344	351	358	365	372	190
Grand Total			302,049	4,456	4,545	4,998	57,329	58,472	59,645	60,835	35,306	16,463
OEC Loan Portion			242,838	4,051	4,132	1,124	46,575	47,504	48,456	49,423	27,200	14,373

[Note] Base for cost estimation : September 1997

Conversion rates : 1 US$ = Rp 2,928 = Y120 Rp/Y = 24.40 Y/Rp = 0.041