2.3 SEDIMENT DISASTERS

2.3.1 VOLCANIC ACTIVITIES AND DISASTERS

Sediment disasters in the Study Area can be classified into primary disasters caused by the direct movement of volcanic ejecta from Mt. Semeru's activities and secondary disasters caused by the shift of this ejecta by rainwater.

The activities of Mt. Semeru have been recorded since 1818. According to these records, Mr. Semeru has not been continuously active since 1818 but active and dormant periods have appeared in turn. It is presently in the midst of the active period which started in 1940 and volcanic activities are continuous with small eruption with explosions seen almost everyday. Occasionally, it ejects lava and nue ardente which flow as far as the piedmont 10km away from the crater, causing damage to forests, coffee plantations and agricultural fields. This is called a primary disaster and areas which are subject to this possible direct attack from the crater are currently designated as non-inhabitant areas.

As primary volcanic products which are ejected from the crater and deposited in valleys are loose and unstable, rainfall can easily stimulate their collapse resulting in a debris flow called lahar which may eventually flood on reaching a fan, thus causing extensive damage. This phenomenon is called a secondary disaster. There are two types of lahar, i.e. hot lahar where hot volcanic ejecta flows down after a short deposit period and cold lahar which flows down after becoming cold. The occurrence of lahar is obviously frequent during Mt. Semeru's active periods, verified by the records of past disasters.

According to these records, Mt. Semeru's crater used to face east but now faces the southeast or south, supplying sediment in that direction. This is the reason for the frequent occurrence of sediment disasters recently seen in the K. Rejali and

K. Glidik basins. The distribution of the past sediment disasters is shown in Fig.-2.13. The latest large disaster occurred in May, 1981. The damage to people's lives and assets in the Study Area caused by this disaster were very extensive, as can be seen in Table-2.7.

2.3.2 DISASTER COUNTERMEASURES

Countermeasures which are classified as emergency measures, short-term countermeasures and long-term countermeasures have been prepared with the Mt. Semeru Project Office as the main promoter against a possible sediment disaster caused by the Mt. Semeru.

(1) Emergency Measures

When lahar suddenly occurs and attacks the inhabitants, the Mt. Semeru Project Office conducts the following activities in cooperation with other related local administrative organizations.

- Warning of lahar to the inhabitants.
- Protection of communities from lahar by the construction of temporary dikes.
- Evacuation of the victims to safe places.

(2) Short-Term Countermeasures

The following operations are carried out as urgent short-term countermeasures.

- Monitoring of Mt. Semeru's volcanic activities.
- Monitoring of lahar floods.
- Setting-up of possible disaster areas (refer to Fig.-2.14).
- Setting-up of warning systems.
- Setting-up of places for evacuation.
- Emergency constructions.
- Rainfall observation.

Table-2.7 The Victims and Casulaties by Lahar in May 1981*

No.	Victims & Casualties	Items	Unit	Amount	Note
1	Man	Died	Person	257	
		Missing	Person	112	
		Serious injured	Person	42	
		Insured	Person	85	
2	Wealths & Properties	Houses	Piece	535	destroyed
		Rice field	Ha.	539	buried
		Rice field PII	Ha.	-	buried
		Dry fields	Ha.	43	buried
		Yards	Ha.	27.61	buried
3	Plants	Coffee trees	Ha.	115	destroyed
		Coconut trees	Piece	80	destroyed
		Rice plant	Ha.	140	destroyed
		Other	Ha.	25	destroyed
4	Economical and Agricultural Facilities	Intake gate	Ha.	9	destroyed
		Channel	Piece	1	buried
		Road	Km	2.5	buried
		Bridge	Piece	2	buried
		Check Dam	Piece	6	1 serious damaged
		River Bank	m	680	destroyed
		Telephone network	m	8,000	destroyed
5	Buildings	Mosque	Piece	1	destroyed
		Madrasah 1)	Piece	1	destroyed
		Langgar 2)	Piece	2	destroyed
		Schools	Piece	1	destroyed
6	Domestic Animals	Cow		58	destroyed
		Goat		117	destroyed
		Chicken		336	destroyed

1) School of moslem, teaching general education and religion, commonly elementary schools level
2) Small mosque
*) Source: Statistic Service Report of District of Lumajang

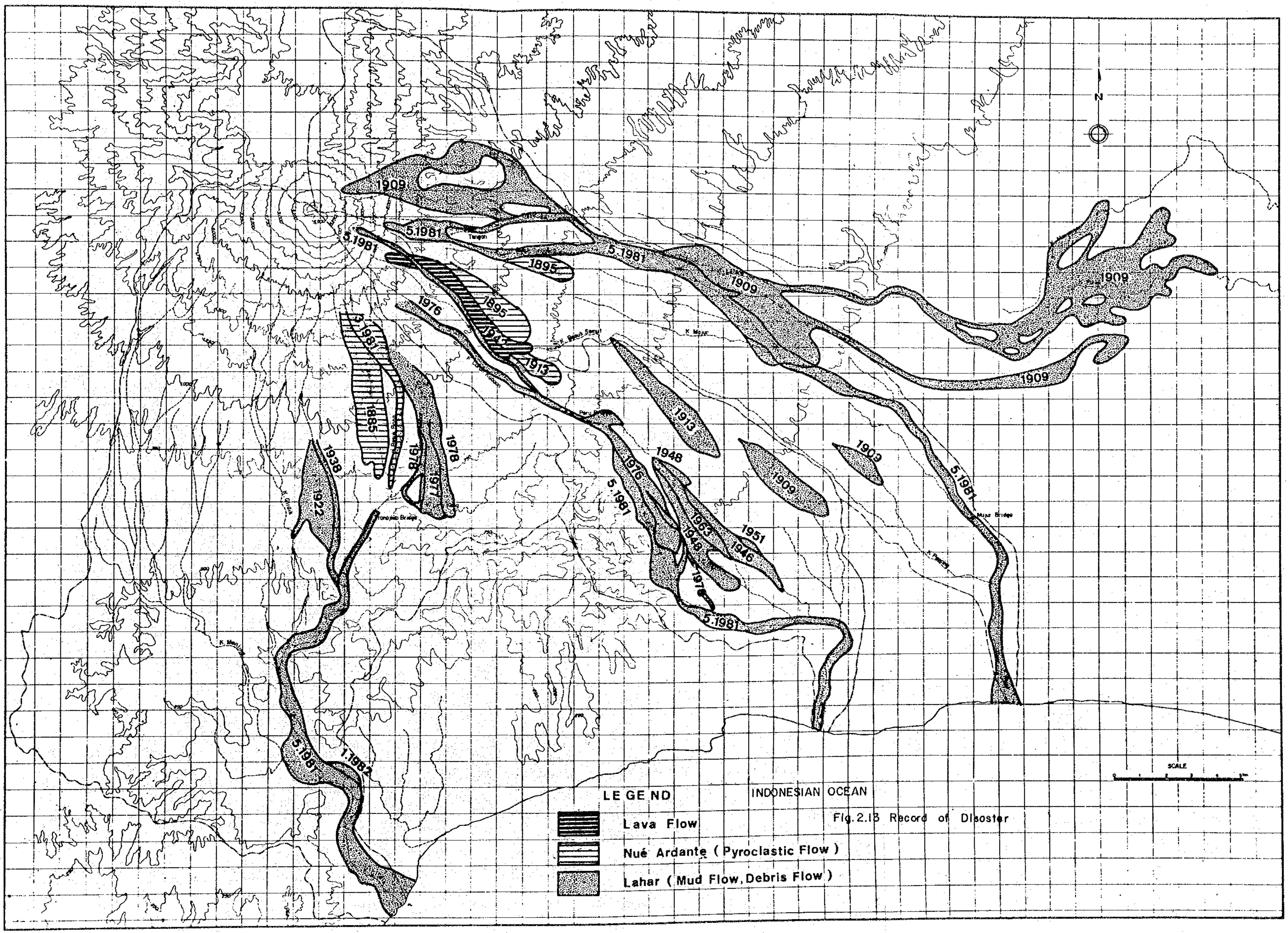


Fig.2.13 Record of Disaster

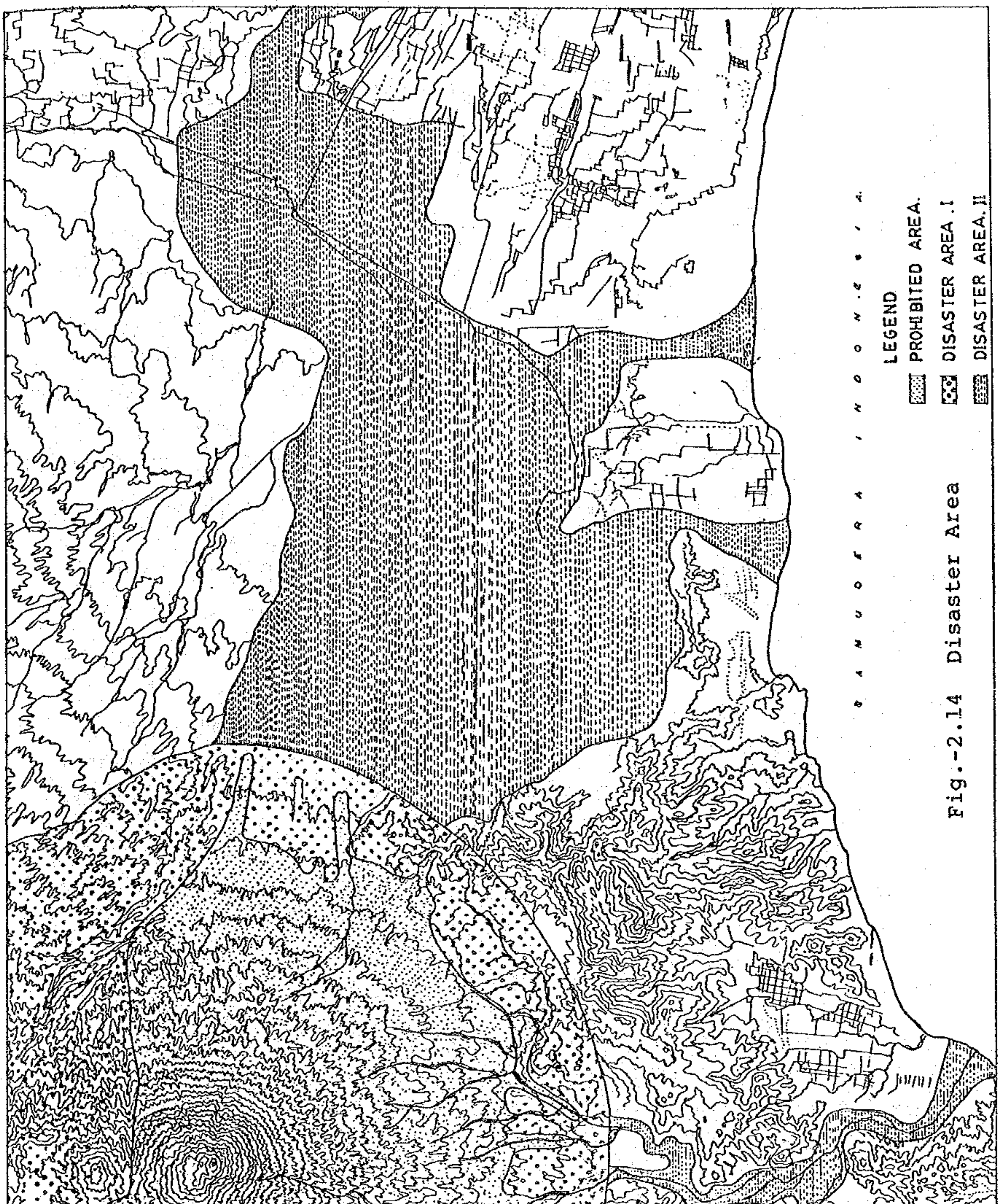


Fig.-2.14 Disaster Area

(3) Long-Term Countermeasures

The Mt. Semeru Project Office has prepared a Master Plan to achieve the prevention of damage to human lives and the mitigation of damage to assets in a long-term perspective and is constructing various urgent facilities.

By 1982, the construction of 6 sabo dams and one consolidation work as well as dikes at about 30 locations, etc. were completed.

3. VOLCANIC DEBRIS CONTROL PLAN

3.1 BACKGROUND

3.1.1 EXISTING MASTER PLAN

There exist Sabo master plans prepared by the Government of Indonesia (the Existing Master Plans) for the area covered by the Study. These master plans were prepared before and after the great disaster of May, 1981.

The Existing Master Plans aim at improving the socio-economic situation in the disaster area through construction of multi-purpose facilities and establishment of warning system.

3.1.2 REVISION OF THE EXISTING MASTER PLAN

The Existing Master Plans were reviewed by the Study Team on the basis of new survey data including the disaster in May, 1981 for the main purpose of the selection of priority projects.

As a result of review, problems in the Existing Master Plans were identified, modification in the sediment control plan and the warning system plan was proposed as discussed in the chapter 3, 4 and 5. Preliminary plan of water resources development through multi-purpose facilities was also proposed as described in the chapter 6.

The revisions for the Exsisting Master Plans (the Revised Master Plans) were proposed. The outline is shown on Table-3.1 and Fig.-3.2. Principal proposed revisions are summarized as follows:

① In the Existing Master Plan, design sediment volume is rather hypothetically calculated, and simply shared to the storage volume of facility. In the Revised Master Plans, however, it is computed using the sediment runoff-control simulation model based on the hydraulics of sediment ransport and affect of facility is sought by totalizing the sediment volume allocated to each sediment control function of facility computed by the same way. Such sediment control functions as sediment yield suppression, sediment runoff regulation, sediment runoff storage and sediment transport adjustment are employed. Refer to Fig.-3.1.

② Proposals for the reinforcement of warning system comprised of: i) information gathering system, ii) information processing system and iii) public information system are offered. Latest electronic devices are introduced to improve the existing warning system.

③ Water resource potential are studied and preliminary water resources development plans are proposed.

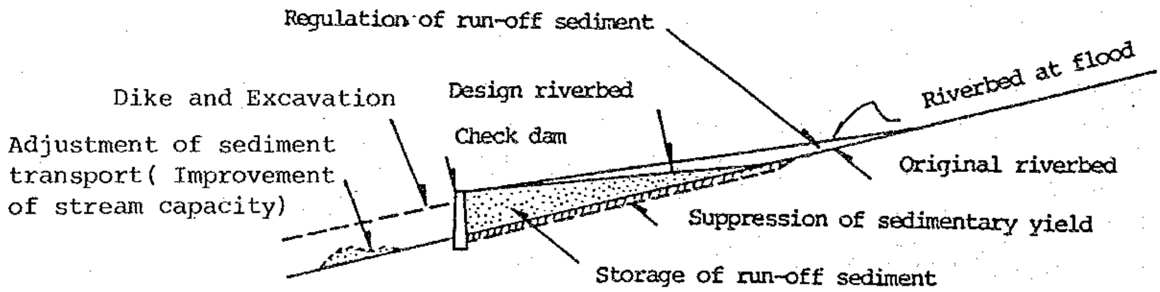


Fig.-3.1 Sediment Control Function

Table-3.1 Proposed Revisions for the Existing Master Plans

Item		Existing Master Plans			Proposed Revisions		
Objective		To protect the disaster area from Lahar disaster and to improve the socio-economic condition.			No revision		
Sediment control plan	Disaster prevention area	Areas along the river channel.			Identify possible disaster areas. Areas are classified into 5 groups.		
	Magnitude of plan	K. Mujur 50 years K. Rejali 70 years K. Glidik 2 years			100 years		
	Design reference point	Not established			One sabo reference point and supplementary reference points are established.		
	Sediment volume dealt with by the plan	K. Mujur $10,144,000\ m^3$ K. Rejali $8,500,000\ m^3$ K. Glidik $4,400,000\ m^3$			K. Mujur $5,040,000\ m^3$ $5,220,000\ m^3$ $4,500,000\ m^3$		
	Sediment control function F1: Sediment Yield Suppression F2: Sediment Runoff Regulation F3: Sediment Runoff Storage F4: Sediment Transport Adjustment	K. Mujur F3 by check dam and sand pockets.			K. Mujur F1 and F2 by check dam F3 by sand pocket F4 by dike and etc.		
		K. Rejali F3 by check dam F4 by channel work			K. Rejali F1 and F2 by check dam F3 by sand pocket F4 by diversion channel and etc.		
		K. Glidik F4 by embankment			K. Glidik F1 and F2 by check dam F4 by dike		
	Facility	K. Mujur	K. Rejali	K. Glidik	K. Mujur	K. Rejali	K. Glidik
	Check dam	24 units	5 units	0	11 units	9 units	9 units
	Sand pocket	1 unit	0	0	3 unit	1 unit	0
	Consolidation dam	4 units	0	20 units	12 units	22 units	0
	Dike	5.0 km	0.6 km	4 km	8.8 km	9.5 km	9.6 km
	Spur dike	0	12 units	0	0	0	0
	Channel work	0	9.5 km	6 km	0	0	0
	River excavation	0.6 km	0	0	6.8 km	0	0
	Diversion channel	-	-	-	-	1 unit	-
	Construction cost (Maintenance cost/year)	K. Mujur	K. Rejali	K. Glidik	K. Mujur	K. Rejali	K. Glidik
		$Rp10.9x10^9$ (0)	$Rp10.9x10^9$ ($Rp0.05x10^9$)	$Rp8.9x10^9$ ($Rp0.1x10^9$)	$Rp32x10^9$ ($Rp0.06x10^9$)	$Rp33x10^9$ $Rp0.04x10^9$)	$Rp23x10^9$ (0)
	Construction term	K. Mujur	K. Rejali	K. Glidik	K. Mujur	K. Rejali	K. Glidik
		10 years	10 years	10 years	15 years	20 years	13 years
Warning system		Necessity for reinforcement of information collection system and telephone communication system is indicated.			Reinforcement of the following warning systems was proposed Information collection system Information processing system Public information system		
Water conservation		Not mentioned.			Preliminary water conservation plan in K. Rejali including the K. Lengkong fan is proposed.		

3.2 SEDIMENT CONTROL PLAN

3.2.1 BASIC ITEMS OF SEDIMENT CONTROL PLAN

(1) Purpose of Plan

The sediment disaster around Mt. Semeru is classified into following two types; 1 Primary disaster caused directly by the volcanic eruption activities. 2 Secondary disaster caused by debris flow which originates due to a heavy rainfall. Since almost all disasters in the study area are the secondary disaster, objective of this sediment control plan lies in preventing and mitigating the damages from the secondary disaster.

(2) Disaster Prevention Areas

The disaster prevention areas covered by the sediment control plan are the possible disaster areas (Fig.-3.1) prepared by the Study on the basis of the past disaster records and the topographical conditions. Such informations on the disaster prevention area of each basin as Kecamatan and Desa, properties, assets, inhabitants and etc. are shown in Table-3.2 and 3.3.

Table-3.2 Kecamatan and Desas in the Disaster Prevention Areas

Basin	Name of Kecamatan	Name of Desa
K. Mujur	Pasirian	Nguter, Selok Awar-2, Madu Rejo, Semeru
	Tempeh	Jastisari, Lempeni, Pandawangi, Gesang
	Candipuro	Penaggal, Kloposawit, Tumpeng, Sumber Mujur
K. Rejali	Pasirian	Kali Beno, Bades, Madu Rejo
	Candipuro	Jarit, Jugosari, Sumberejo, Sumberwuluh, Tambeh Rejo
	Pronojiwo	Supiturang, Oro-oro Ombo
K. Glidik	Pronojiwo	Sidomulyo, Supiturang, Tamanayu
	Tempursari	Kuliulingsari, Tempurejo, Purorejo, Togalrejo
	Ampel Gading	Ampel Gading

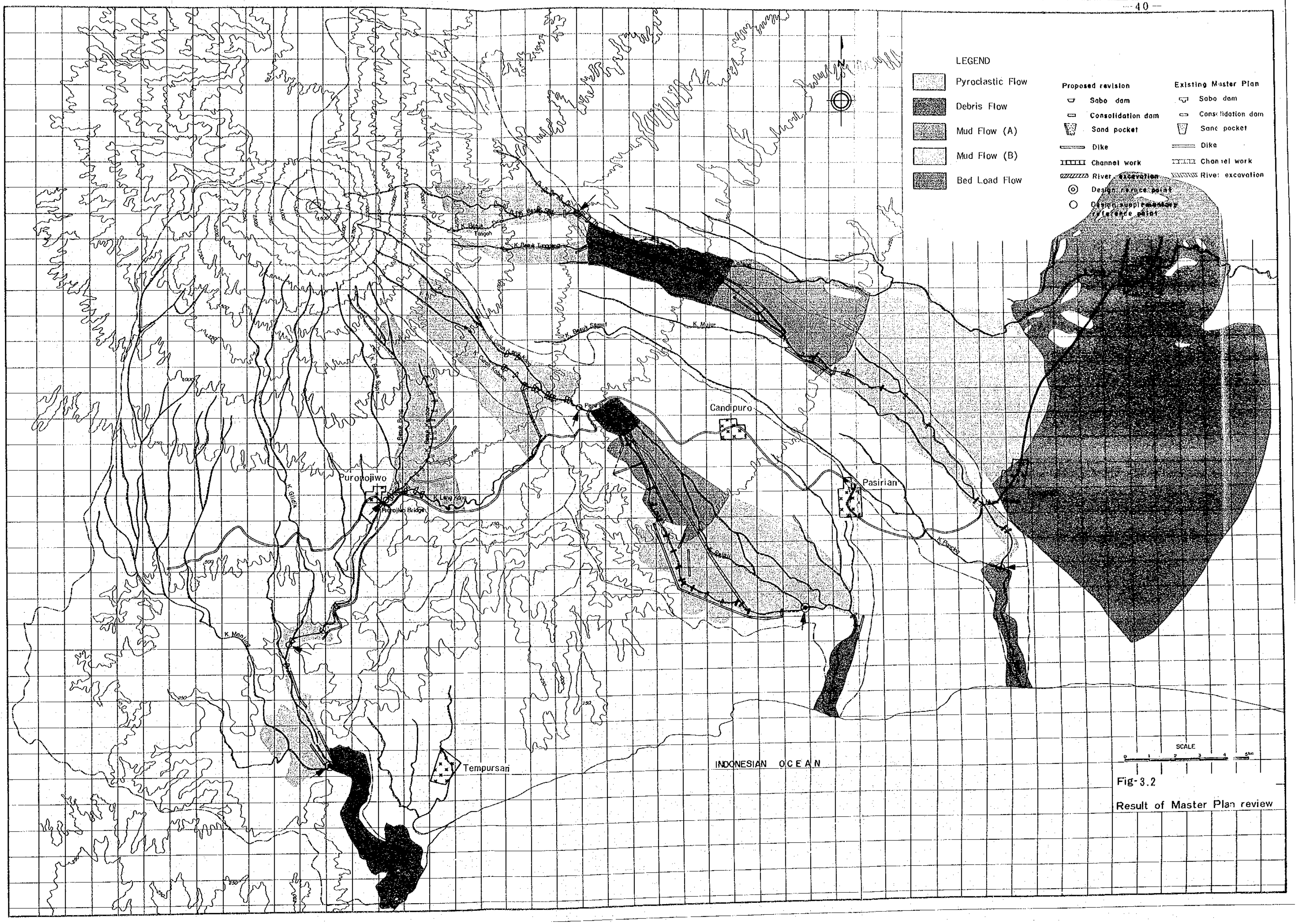


Fig-3.2

Result of Master Plan review

Table-3.3 Properties in the Disaster Prevention Area

Item	Unit	K. Mujur	K. Rejali	K. Glidik	Total
Buildings	house	46,013 (4,345)	3,226	1,287	50,526
Cultivated fields	ha	14,290 (1,637)	1,260	389	15,939
Animals	head	243,465 (27,953)	11,073	4,923	259,461
People	person	201,662 (19,644)	14,797	6,237	222,696
Area	km^2	207.1 (28.7)	40.5	17.6	265.2

( ): After the completion of the Urgent Rehabilitation Project

(3) Magnitude of Plan

The magnitude of plan is determined to be 100 year-return period so that the plan is technically and economically feasible and the past tragic disaster never repeat again.

(4) Design Reference Point

One design reference point and several design supplementary reference points were set up in each river basin as check points to determine sediment volume to be controlled. Refer to Fig.-3.2.

(5) Design Sediment Volume

The design sediment volume to be controlled for each basin was established as below, on the basis of the result from sediment runoff-control simulation.

- K. Mujur: $5.0 \times 10^6 m^3$
- K. Rejali: $5.2 \times 10^6 m^3$
- K. Glidik: $4.5 \times 10^6 m^3$*

* Not included runoff sediment from the right branches K. Glidik and K. Manjing of K. Glidik.

3.2.2 SEDIMENT CONTROL FACILITY PLAN IN K. MUJUR

K. Mujur is not so active as K. Glidik and K. Rejali and low in occurrence frequency of sediment disaster because the crater of Mt. Semeru is faced to the south direction, i.e. to the direction of K. Glidik at present. However once breakings or land slides take place at the upper stream of BS. Sat, BS. Tengah and BS. Tunggeng, flood erodes and washes away the sediment to the alluvial fan area and finally causes a big sediment disaster.

In the left bank area of the K. Mujur, there are Kec. Lumajang and Kec. Temph where many properties are concentrated. In the past, sediment flooded to the direction of these towns and gave big damages.

In the Existing Master Plan for K. Mujur, all the design control sediment is to be stored in the check dams and sand pockets planned. However, since the storage capacity will be exceeded with harmless sediment in a few years if no removal will be carried out, it is unreasonable to adopt an only storage system as sediment control system.

Accordingly, the construction order and sediment control system should be as follows. Refer to Fig.-3.3.

- The first step of the sediment control is urgently to take measures to prevent flood to Kec. Lumajang and Kec. Temph.

- The second step is to regulate runoff sediment and to suppress sediment yield of riverbed deposit at the upper stream region to prevent sediment flooding at the Des. Keloposawit region.

- The third step is to store runoff sediment at the region between Des. Keloposawit and Des. Karancolic to prevent sediment flooding in the fan area. Besides, river channel improvement works and embankments should be carried out in order to prevent flooding at places where the river bends.

- The fourth final step is to carry out protection work for intakes at the time when the riverbed beings lowering because of sediment control facilities in the upper stream.

In accordance with the above considerations, sediment control facilities in K. Mujur are planned as shown in Table-3.4. The sediment volume to be controlled by each facility is allocated on the basis of the result from the sediment runoff-control simulation.

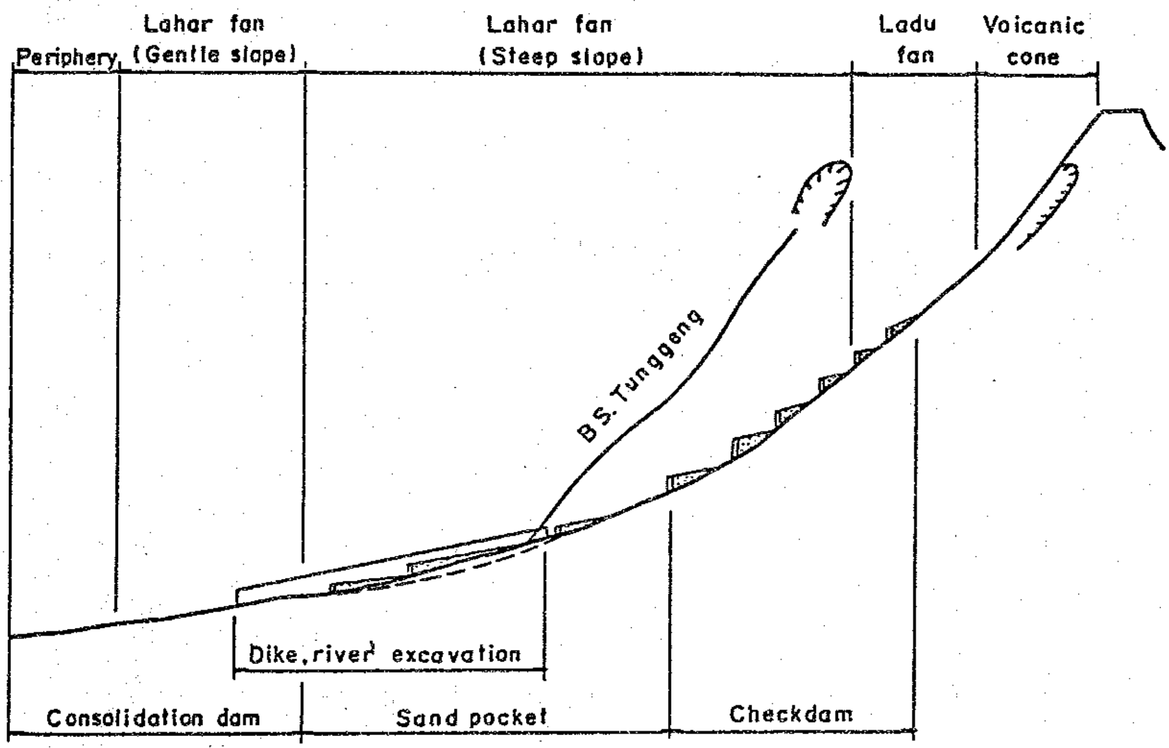


Fig.-3.3 Schematic Drawing of Sediment Control Facility in K. Mujur

Table-3.4 Sediment Control Facility Plan for K. Mujur

Construction Order	Stage Target	Sediment Control Facilities: Type of Work	Function	Name	Specification		Sediment Control Volume ($10^3 m^3$)
1st stage		Check dam	Sediment yield suppression Sediment runoff regulation	BS. Sat Chedk Dam-2			164
				BS. Sat Check Dam-3			94
Urgent dike improvement project	Prevention of sediment runoff to Kec. Lumajang and Kec. Temph			BS. Sat Check dam-4	H=6.5m	L= 100m	15
		Dike	Sediment transport adjustment	Kertosari Dike	H=2.5-7.8m	L=1210m	
				Dike of Kertosari Sand Pocket	H=2.5-7.8m	L=2130m	
				Dike of Keloposawit Sand Pocket	H=2.5-7.8m	L=2000m	
				Kakangcolik Dike	H=2.5-7.8m	L=1350m	
				River excavation 1	L= 711m	V=33800m^3	
				2	L=1161m	V=104000m^3	
2nd stage	Flood prevention at the upper stream of the fan	Check dam	Sediment yield suppression Sediment runoff regulation	BS. Sat Check dam-5	H= 8m	L=190	30
				BS. Sat Check dam-6	H= 8m	L=170	130
				7	H=19m	L=300	1,050
				8	H=11m	L=120	240
				9	H=17m	L=190	340
				10	H=17m	L=110	278
				Sumbersari Check dam	H=17m	L=750	635
		Dike	Sediment transport adjustment	Dike-5 (Leces)	H= 5m	L=480m	
				Dike-1	H= 5m	L=300m	
				2 (Kalancolik)	H=5m	L=450m	
				3	H=5m	L=450m	
				River excavation	L=2850m	(BS. Tunggeng)	
					L=2090m	(K. Mujur)	
3rd stage	Flood prevention at the lower stream of the fan	Sand pocket	Sediment runoff storage	Kertosari Sand Pocket	Dike Spillway	H=6m L=230m 2 units	1,414
				Keloposawit Sand Pocket	Dike Spillway	H=6m L=300m 3 units	313
				Benda Sand Pocket	Dike Spillway	H=8m L=2800m 2 units	423
4th stage	Protection of intake	Consolidation dam	Sediment transport adjustment	CD-1 - CD-12	12 units		
						Total	5,216

3.2.3 SEDIMENT CONTROL FACILITY PLAN IN K. REJALI

Large quantity of sediment is discharged from the upper stream area of K. Rejali basin because the area consists of Curah Kobo'an exposed to direct sediment yield from volcanic crater and Curah Lengkong with a large-scale breaking area. Therefore recently (since 1946) sediment flood takes place in the alluivial fan area almost once every 2 or 4 years. And the river channel always changes its position in this fan area. These characteristics indicate that the K. Rejali fan is just in the midst of formation and very active.

In the Existing Master Plan for K. Rejali, 30% of runoff sediment are to be stored in check dams and the rests are to be flushed out to the sea through the channel work designed along the old K. Rejali river course in the center of the fan. However, it seems technically difficult to flush 70% of runoff sediment out to the sea at a stretch.

Accordingly, the construction order and sediment control system should be as follows. Refer to Fig.-3.4.

- As the first step of the sediment control plan in such an active fan, it is important to reduce sediment inflow into the fan. Sediment yield suppression and sediment runoff regulation shall be performed at the deep valley in the upper stream from gulch of the K. Curah Kobo'an. However, there are not enough check dam sites to control whole design sediment volume in the K. Curah Kobo'an. Therefore, the diversion channel shall be planned to transport sediment from K. Curah Kobo'an to K. Lengkong.

- As the second step, fixation of the river course, conversion of sediment flow type and storage of runoff sediment shall be performed at the head area.

- As the third step, the local flood at the fan and more downstream area shall be prevented effectively.

- As the fourth final step, after the riverbed in the fan is lowered to the desired level as a result of the above-mentioned countermeasures, the river course and the riverbed shall be fixed.

In accordance with the above considerations, sediment control facilities in K. Rejali are summarized in Table-3.5.

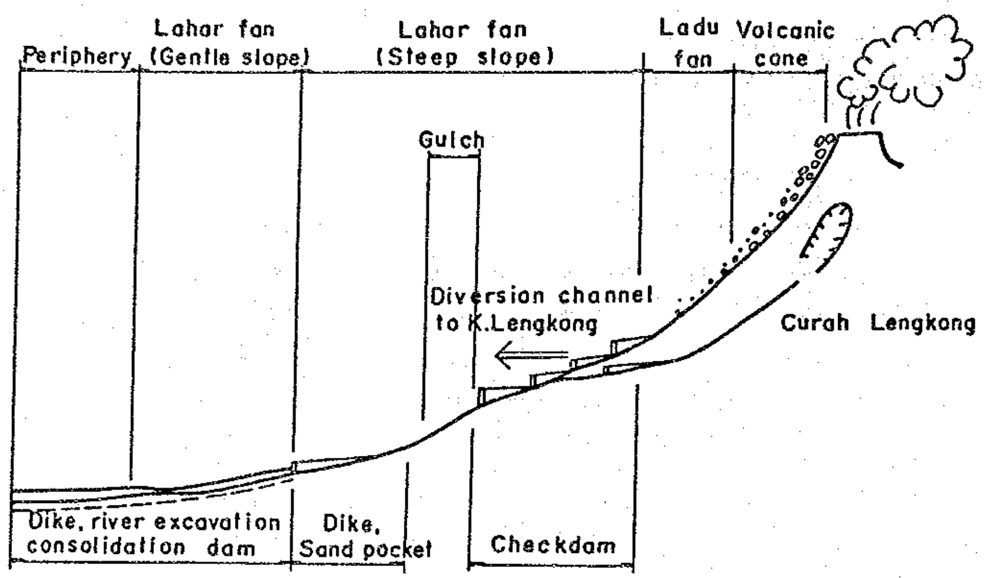


Fig.-3.4 Schematic Drawing of the Plan of Sediment Control Facilities in K. Rejali

Table-3.5 Sediment Control Facility Plan for K. Rejali

Construction Order	Stage Target	Sediment Control Facilities: Type of Work	Function	Name	Specification	Sediment Control Volume (10^3m^3)
1st step	- Reduction of runoff sediment into the alluvial fan	Check dam	Sediment yield suppression Sediment runoff regulation	BS. Kobo'an Check Dam-3	H=12m L= 58m	90
				4	H=11m L=221m	660
				5	H=12m L=235m	90
				6	H=23m L=438m	430
				7	H=22m L=170M	300
				Curah Lengkong Check Dam-1	H=10m L=53m	160
				2	H=18m L=55m	80
		Diversion work	Sediment transport adjustment	Channel	L=1350m	2,220
				K. Lengkong Check Dam-7	H=10m L=145m	
				6	H= 8m L=305m	
				5	H= 8m L=163m	
				4	H= 8m L=170m	
				3	H=10m L=193m	
2nd stage	- Fixing of watercourse at the top of the fan - Conversion of sediment flow type - Storage of runoff sediment	Dike	Sediment transport adjustment	K. Leprak Dike-12	H= 6m L=280m	
				13	H= 6m L=975m	
		Sand pocket	Sediment runoff storage	K. Leprak Sand Pocket-1	Dike H=4m L=1050m Spillway H=8m L= 185m	250
				K. Leprak Sand Pocket-2	Dike H=7m L=800m Spillway H=8m L=820m	730
				K. Leprak Sand Pocket-3	Dike H=3m L=1130m Spillway H=8m L= 125m	360
3rd stage	- Protection of local flood area	Dike	Sediment transport adjustment	K. Leprak Dike-14	H=5m L=1000m	
				15	H=5m L= 740m	
				16	H=5m L= 200m	
				17	H=5m L= 200m	
				18	H=5m L= 300m	
				19	H=5m L= 220m	
				20	H=5m L=1350m	
				21	H=5m L= 550m	
				22	H=5m L= 100m	
				23	H=5m L= 270m	
				24	H=5m L= 600m	
				25	H=5m L= 350m	
		River excavation			B=60m C=3.5m L=1750m	
4th stage	Fixing of watercourse and riverbed	Consolidation dam	Sediment stansport adjustment	K. Leprak CD-2 - 22	Number of location = 21	
		Cross dike			H=5m L=2350m	

3.2.4 SEDIMENT CONTROL FACILITY PLAN IN K. GLIDIK

The Existing Master Plan for K. Glidik was prepared only to protect the area of K. Lengkong Fan, which is an upper tributary of K. Glidik. Overall sediment control covering the entire basin of K. Glidik has not been planned.

There are great quantity of Lahar deposit in K. Lengkong Fan area. Therefore, those Lahar deposit should be suppressed at the first. Secondly, sediment runoff should be regulated at the middle reach in order to protect the valley-bottom plain at the down reach from flooding. Refer to Fig.-3.4.

In accordance with above considerations, sediment control facilities in K. Glidik are planned as shown in Table-3.6.

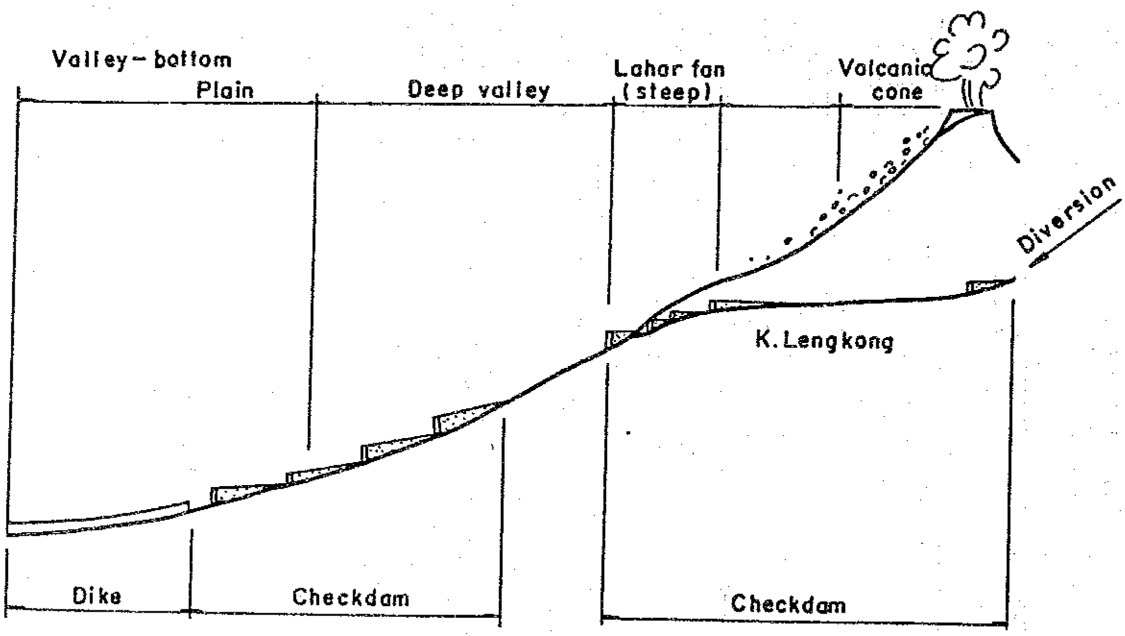


Fig.-3.5 Schematic Drawing of the Plan of Sediment Control Facility in K. Glidik

Table-3.6 Sediment Control Facility Plan for K. Glidik

Construction Order	Stage Target	Sediment Control Facilities: Type of Work	Function	Name	Specification	Sediment Control Volume (10^3m^3)
1st stage	Control of increase run-off sediment due to partial conversion of runoff sediment from BS. Kobo'an	Check dam	Sediment yield suppression Sediment runoff regulation	K. Glidik Check Dam-9	H=10m L=145m	2
				8	H= 8m L=305m	165
				7	H= 8m L=163m	22
				6	H= 8m L=170m	12
				5	H=10m L=193m	360
2nd stage	Reduction of inflow sediment into the valley bottom plain of K. Glidik	Check dam	Sediment yield suppression Sediment runoff regulation	K. Glidik Check Dam-4	H=22m L=221m	2,100
				3	H=15m L=326m	440
				2	H=15m L=448m	480
				1	H=14m L=630m	980
3rd stage	Prevention of local flood in the valley bottom plain and fixing of watercourse	Dike	Sediment transport adjustment	Dike 1 - 14	H= 6m L=9600m	
					Total	4,561

3.2.5 CONSTRUCTION SCHEDULE

The construction schedule of each basin is proposed as shown in Table-3.7, considering the priority of basin, budgetary conditions and so on.

Table-3.7 Construction Schedule

Sediment Control Plan	Time Schedule (Year) 0–10	10–20	20–30	30–40	40–
K. Mujur	1st	2nd	3rd	4th	
K. Rejali	1st	1st	2nd, 3rd	4th	
K. Glidik	1st	2nd		3rd,	4th

3.2.6 COST ESTIMATION

Estimation of Project Cost for sediment control plan for each river basin was calculated according to the following estimation standards. These costs are summarized in Table-3.11.

① Project cost is comprised of construction cost, land acquisition cost, engineering service cost, government administration cost and contingency.

② All costs are calculated at the standard unit price as of December, 1982 on the basis of the preliminary design prepared in the Study of sediment control.

③ Costs of materials, machinery and engineering service unavailable in Indonesia are claculated on the basis of CIF Surabaya port from Japan.

Table-3.8 Cost of Sediment Control Plan

Plan	Cost 10^9 Rp				
	Total	1st Step	2nd Step	3rd Step	4th Step
K. Mujur	31.9	2.8	15.7	13.0	0.4
K. Rejali	33.3	27.7	3.7	1.4	0.5
K. Glidik	23.2	5.6	8.2	6.6	2.8
Total	88.4	36.1	27.6	21.0	3.7

3.3 DEBRIS FLOW WARNING SYSTEM PLAN

3.3.1 PURPOSE OF THE PLAN

The sediment disaster in the Study Area tends to cause a great loss of lives as seen in the past records of October 1976 (the number of victims amounted to 119) and of May 1981 (Victims rose to 369). Such a tragedy has an unfathomable impact on the local society.

It would take a long period of time to prevent perfectly such a sediment disaster by implementing "Sediment Control Facility Plan" shown above. Therefore, it would be imperative to carry out the execution of debris flow warning system project along with the sediment control plan. The debris warning system will take effect in three years from beginning of the project.

The purpose of the debris flow warning system plan is mainly to save lives from the debris flow disaster (secondary disaster), which is caused by the heavy rainfall, by strengthening the existing warning system.

3.3.2 OUTLINE OF DEBRIS FLOW WARNING SYSTEM

(1) Existing Warning System

The existing monitoring and warning system around Mt. Semeru consists of the following organizations and communication network.

① Volcanological observation station; public telephone circuit

② Flood observation station; telephone circuit for the irrigation office

③ Observation branch station by Mt. Semeru Project office; radio communication circuit.

④ Local government tele-communication (L.G.T.C.) system; radio communication circuit.

⑤ Traditional warning system; tongtong made from hollow wood.

⑥ Evacuation hill

The weakpoint in the existing warning system lies in the information gathering system and information processing system carried out by manpower. Also the terminal warning system is not effective enough to communicate to the inhabitants surely.

(2) Basic Policy of Establishing the Warning System

The debris flow warning system should be established by strengthening the existing system in the following manner.

① Strengthening of the Information Gathering System

- Install radar raingauges with a view to collecting information over a wide area around Mt. Semeru.

- Install rainfall observation stations, flood observation stations and debris flow observation stations at major points in the subject area of the Project.

- Install telemeters at the observation stations and introduce radio communication between the observation stations and the central monitoring station to overcome problems resulting from the cable telephone circuits.

② Supplementing the Centralized Monitoring Function

Install a central monitoring station, engaged in the prediction of debris flow by centralized processing and the control of gathered information as well as the swift announcement of the evacuation warning.

③ Strengthening of the Public Announcement System

Install speakers at the areas in danger of debris flow.

(3) Structure of the System

The advanced debris flow warning system was planned according to the above basic policy. The structure of the system is shown in Fig.-3.6. The system consists of three system explained below.

① Information Collection System

The information collection system gathers data which is required to predict or to perceive the occurrence of a debris flow and to analyze the mechanism of the debris flow. It consists of the followings:

- Rainfall Observation System
  Small radar raingauge
  Rainfall telemeter
- Water Level Observation System
  Water level telemeter
- Debris Flow Observation System
  Debris flow sensing unit
  I.T.V. unit

② Information Processing System

Information processing system is concentrated on the information processing center. The Information Processing Center is to control and process data gathered by the information system and predict the occurrence of debris flow and give the evaucation warning to people living in the disaster areas. The Information Processing Center will be installed at the Mt. Semeru Project Office.

③ Public Information System

The public information system is to address the evacuation warning according to the judgement of the information processing center without delay to people living in the possible disaster areas. This warning is to be done by speakers installed in the most dangerous area. The address of the warning to general areas will be carried out by the existing communication network.

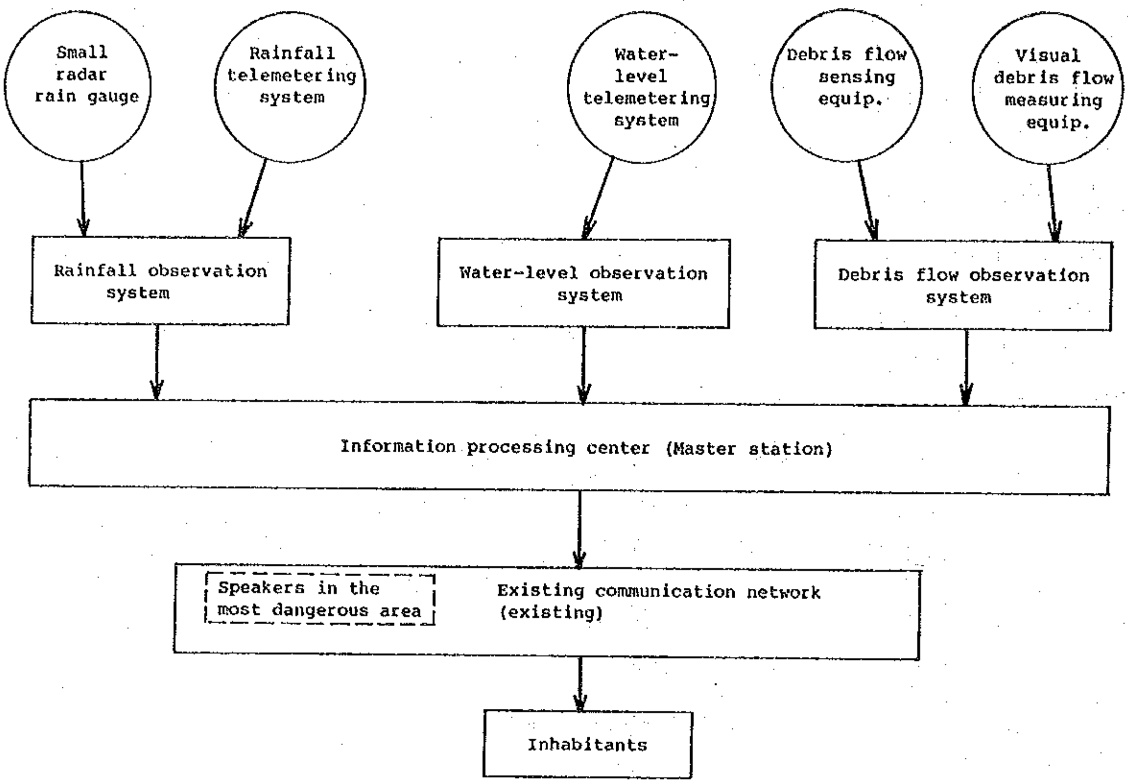


Fig.-3.6 Structure of Debris Flow Warning System

3.3.3 DEBRIS FLOW EVACUATION SYSTEM

It is also indispensable for the sound save of lives from sediment disaster to establish the debris flow evacuation system. Preparation of the system should be carried out consulting the disaster potential map as shown in Fig.-3.7 in contact with the local organization concerned.

The disaster potential map was drawn based on the topographical condition and the sediment hydraulics. In the map, red-colored, yellow-colored and white-colored are mean high, medium and low grade of disaster potential respectively.

In preparation of the evacuation system, the following items should be taken into consideration.

① The evacution system should be established so as to fit to the characteristics of the debris flow (volume, velocity, height of front, etc) in this area. At first, therefore, it is important that informations on the debris flow should be gathered and analyzed.

② It is disirable that Inhabitants living in the high (red-colored) and medium (yellow-colored) grade area will evacuate out of the possible disaster area at a disaster.

③ In case of the above-mentioned evacuation taking longer time comparing with the reach of the debris flow, it is disiarable that inhabitants evacuatate into lower grade area, where should be constructed evacuation hills.

④ The evacuation hill should be constructed on the upland and should be strong enough against the attack by debris flow.

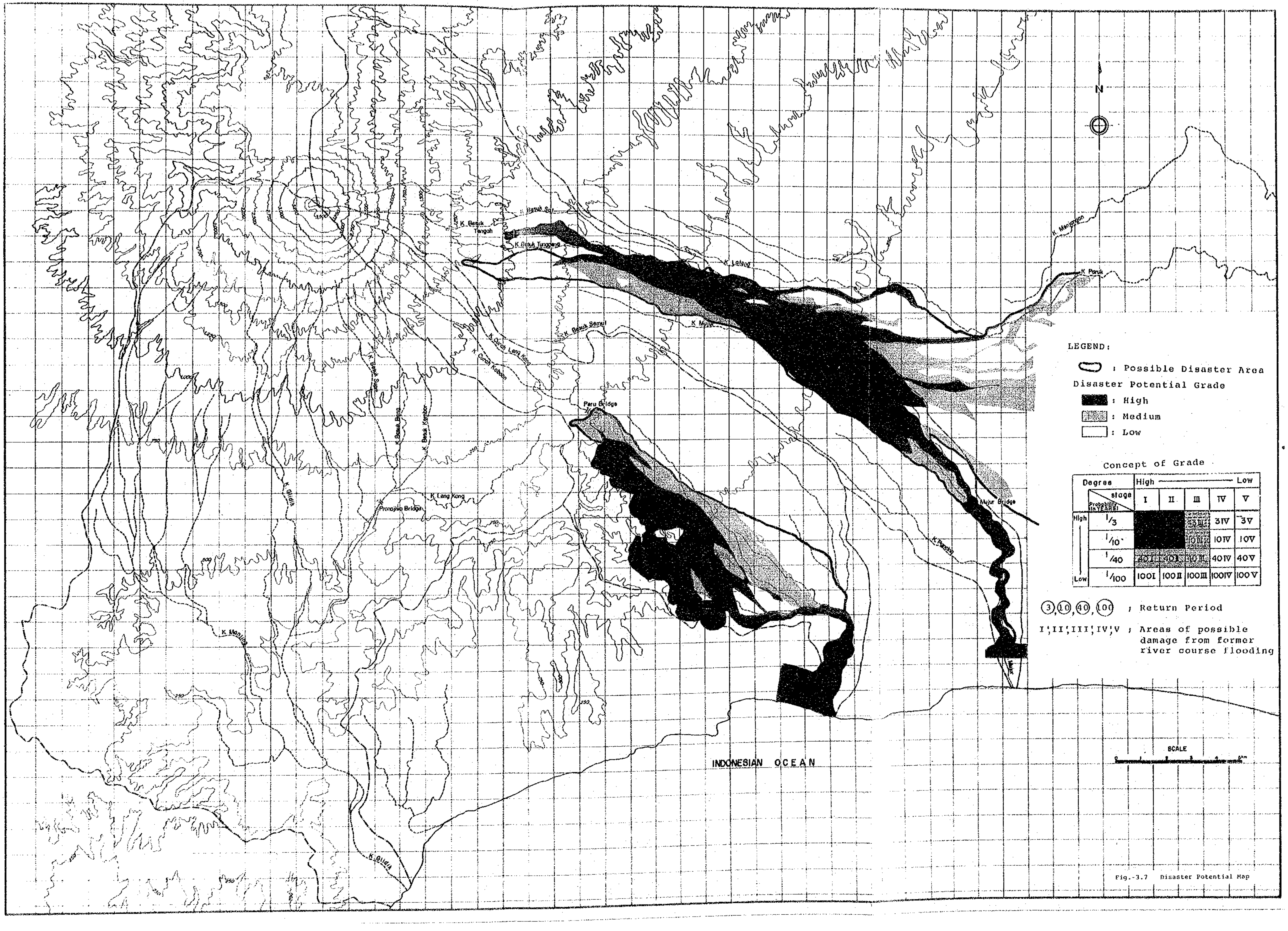


Fig.-3.7 Disaster Potential Map

3.4 SELECTION OF PRIORITY PROJECTS

The urgent rehabilitation project loaned by OECF has recently started and will bring about substantial effect to the K. Mujur basin in the near future. Therefore, the first priority should be given to the sediment control facility project in K. Rejali and the second priority to that in K. Mujur according to the following considerations.

① After the completion of the urgent rehabilitation project, the K. Mujur basin will become more safety than the other basin. Some 180,000 people and the properties in the area of 178km^2 would be secured soon, though the following countermeasures as shown in Table-3.3 should be executed successively.

② The recent sediment disaster is frequently being occurred in the K. Rejali basin than in the K. Mujur basin.

The debris flow warning system project around Mt. Semeru southeastern slope should be recommended as the first priority project in combination with the sediment control facility project due to the following reasons.

① The sediment disaster in the Study Area tends to cause a great loss of lives.

② The full completion of the sediment control facility project would be a long period.

③ The warning system with main purpose of human lives conservation will soon take effect on the entire area.

4. THE FIRST PRIORITY PROJECT

The first priority project consists of hard and soft counter-measure for sediment disaster:

- Sediment control facility project for K. Rejlai basin;
- Debris flow warning system project for the entire disaster area of K. Mujur, K. Rejali and K. Glidik.

4.1 SEDIMENT CONTROL FACILITY PROJECT

4.1.1 ALTERNATIVE PLANS

The selection of alternative plans from among those projects described in the K. Rejali Master Plan was made on the basis of the following considerations.

① The construction of the sediment control facilities should, in principle, be executed according to the work order given in the Plans.

② The frequency of disasters in the K. Rejali basin has increased since 1942 when the upper stream of the BS. Semut was diverted to the K. Rejali river system. Because of this, it would be desirable to execute the diversion work designed to transform the present overfit situation back to the original state existing before 1942. The diversion work should take precedence.

③ According to the empirical judgement, debris flood at the top of the fan will cease when a half of the sediment discharged into the fan has been successfully controlled. After that, the construction of the planned sediment control facilities in the K. Leprak fan area can be started.

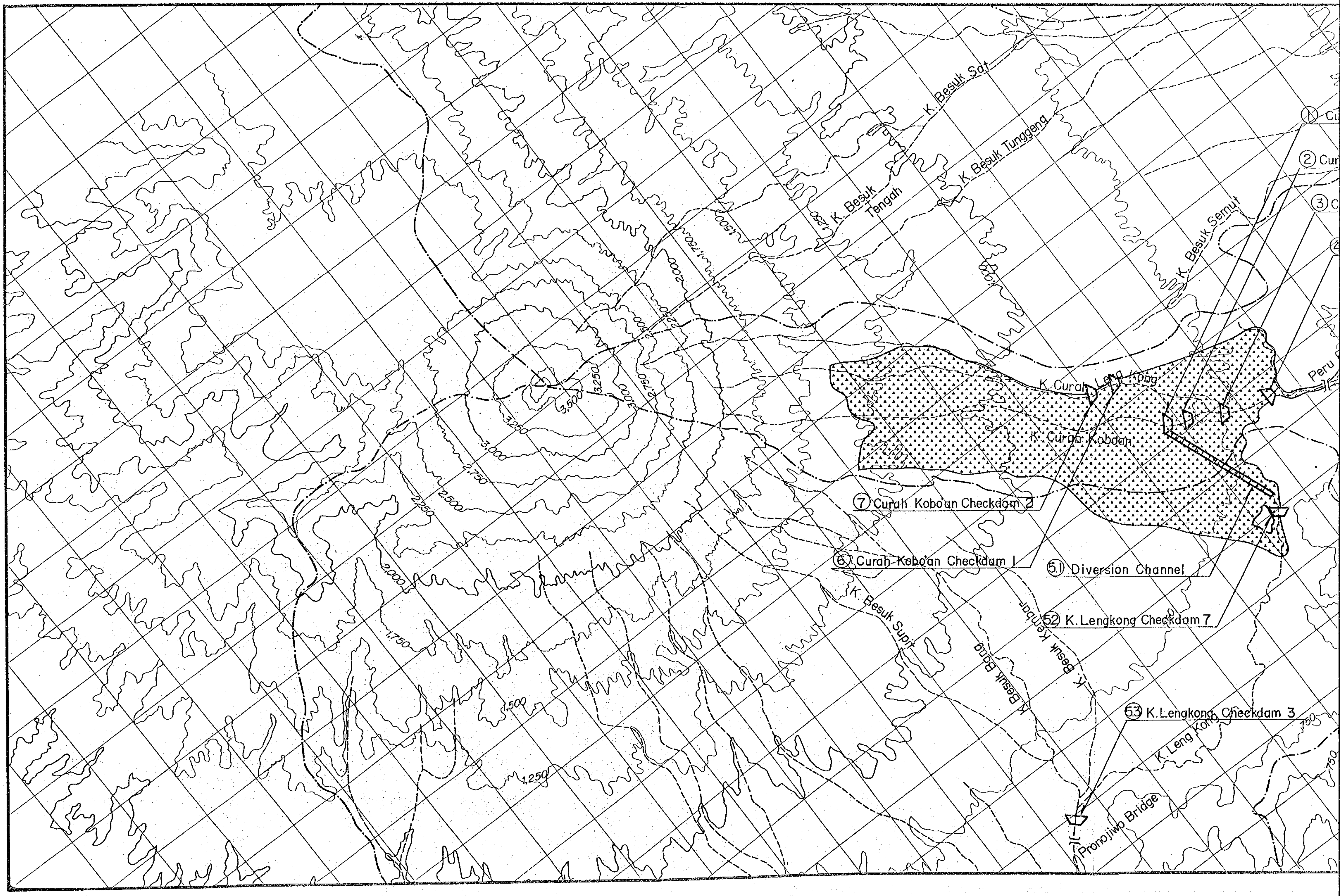
Based on the above consideration, four alternatives are selected as shown in Table-4.1 and Fig.-4.1.

Table-4.1 Alternatives for First Priority Project

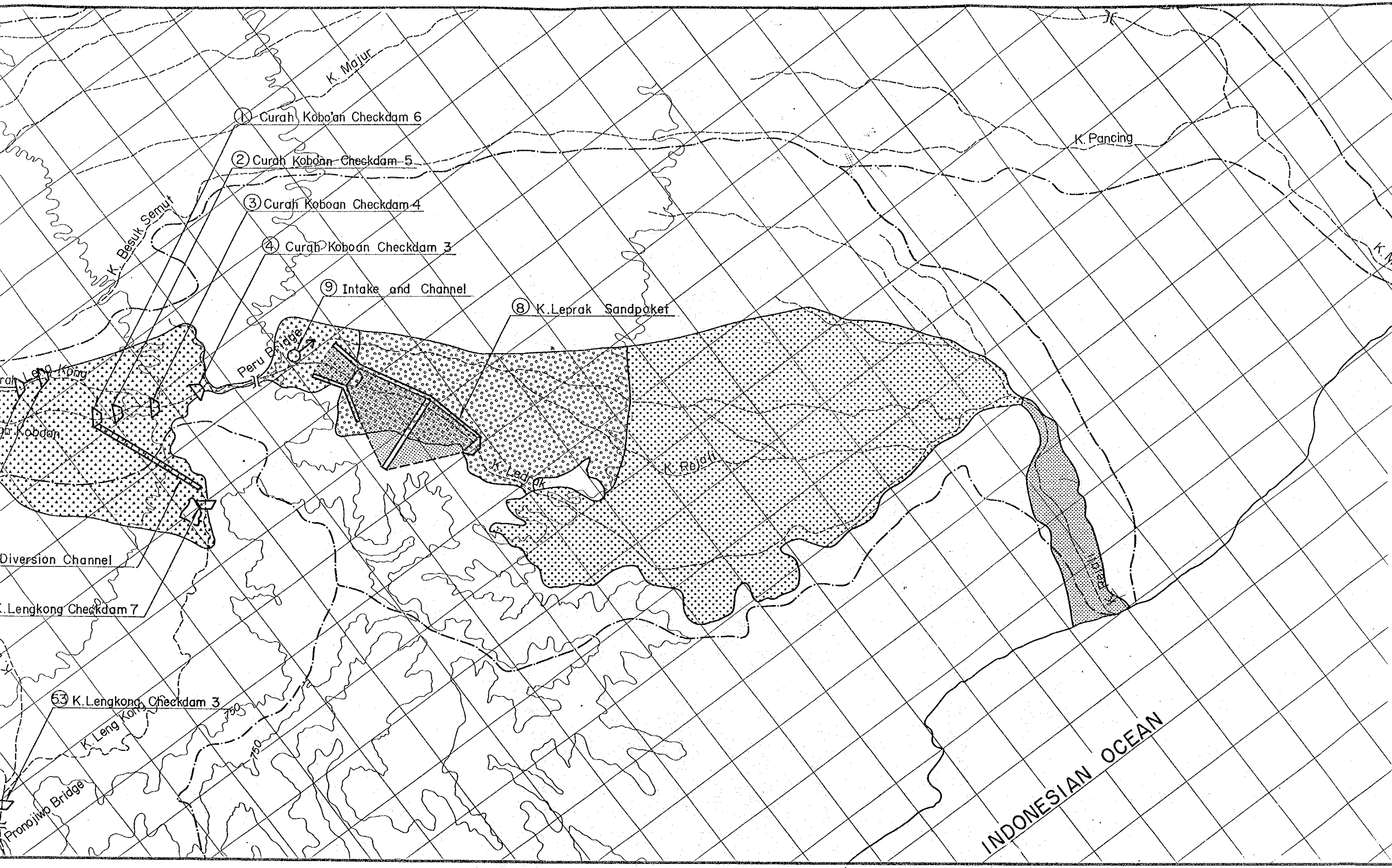
Alterna-tives	Work Stage	Type of Work	Combination of Facilities	Design Magnitude (Probability Years)
P1-1	1st Stage	Diversion	1,5,9,	13
P1-2	"	Check Dam & Diversion	1,2,3,4,5,6, 7,9,	40
P1-3	1st & 2nd Stage	Diversion & Sand Pocket	1,5,8,9,	50
P1-4	"	Check Dam, Diversion & Sand Pocket	1,2,3,4,5,6 7,8,9	90

Facility No.	Name of Facility	
1.	Curah Kobo'an Check Dam	No. 6
2.	"	No. 5
3.	"	No. 4
4.	"	No. 3
5.	Diversion Work	
	Channel	
	K. Lengkong Check Dam	No. 7
	"	No. 3
6.	Curah Lengkong Check Dam	No. 1
7.	"	No. 2
8.	K. Leprak Sand Pocket	
9.*	Intake and Channel	

* No.9 is facility for water conservation.



K. Besuk Sat
K. Besuk Tunggeng
K. Besuk Tengah
K. Besuk Semut
K. Curah Leng Kong
K. Curah Koboan
7 Curah Kobo'an Checkdam 2
6 Curah Kobo'an Checkdam 1
5.1 Diversion Channel
5.2 K. Lengkong Checkdam 7
5.3 K. Lengkong Checkdam 3
K. Besuk Supit
K. Besuk Bang
K. Besuk Kembar
K. Leng Kong
Pronojiwo Bridge
3,500
3,250
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250



K. Majur
① Curah Kobo'an Checkdam 6
② Curah Koboan Checkdam 5
③ Curah Koboan Checkdam 4
④ Curah Koboan Checkdam 3
⑨ Intake and Channel
⑧ K. Leprak Sandpoket
K. Pancing
K. Besuk Semut
Peru Bridge
K. Leprak
K. Rejali
Diversion Channel
K. Lengkong Checkdam 7
53 K. Lengkong Checkdam 3
K. Leng Kong
750
Pronojiwo Bridge
INDONESIAN OCEAN

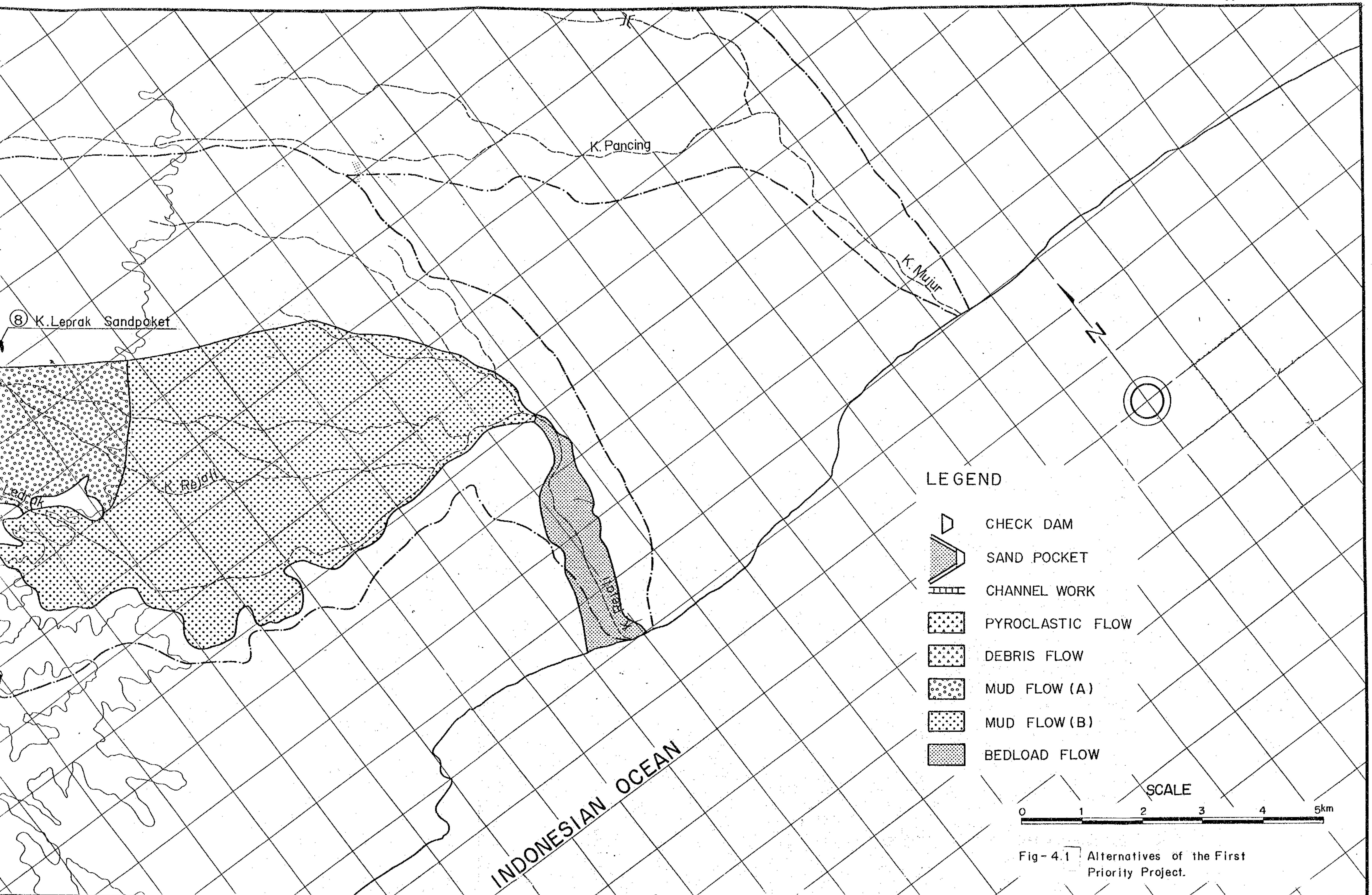


Fig-4.1 Alternatives of the First Priority Project.

4.1.2 PROJECT COST

Drawing for the cost estimation is done on the basis of "Technical Standard of River and Sediment Control, Ministry of Construction, Japan (Tentative)" and the examples constructed in Japan and Indonesia.

(1) Outline of Facilities

① Curah Koboan Check Dam No. 6

It is designed to be as high as possible from the standpoint of topography and foundation conditions, because the dam is aiming at raising the elevation of the intake of the diversion channel. It is a gravity-type concrete dam. Since the foundation ground is gravels, an apron and a water cushion shall be used jointly as an energy dissipator.

② Curah Koboan Check Dam No. 5

It is planned as one of the step dams composed of Curah Koboan Check Dam No.2, No.3, No.4 and No.6 aiming at sediment runoff regulation. It is gravity-type concrete dam with gravel foundation. Regarding water cushion and apron, the design concept is the same as for No.6 above.

③ Curah Koboan Check Dam No. 4

It is to raise the height of the existing check dam (Curah Koboan Check Dam No.1), which fortunately sits on rock foundation, by 11m as there are only a very few available excellent dam sites with rock foundation in Curah Koboan.
The spillway is to be a gravity-type concrete dam. The left wing is to be earth dam covered with an approximately 1m thick concrete wall. The configuration of both the spillway and wing is such as to wrap around the existing Check Dam.

④ Curah Koboan Check Dam No. 3

It is planned aiming at sediment runoff regulation at a bit upstream from the bottleneck of BS. Koboan. It is a gravity-type concrete dam with rock foundation. The design width of the spillway is narrow at 30m in consideration of the downstream bottleneck of the river channel.

⑤ Diversion Works

The diversion works are comprised of the following three facilities.

Diversion channel:

It is a waterway to divert all runoff sediment from Curah Koboan to K. Lengkong. The design riverbed gradient is i = 1/40; the width of channel bottom is B = 30m. To prevent erosion, the slope length of 7m from the riverbed on both banks shall be protected by Gabion work and consolidation dams constructed at the intervals of 200m. The design depth of the channel is 5-15m.

K. Lengkong Check Dam No. 7:

It is designed to regulate sediment diverted by the waterway at its outlet. It is a gravity-type concrete dam on gravel and weathering tertiary laminar foundation. To enhance the sediment tractive capacity at normal years and to effect flush-out of accumulated sediment, the spillway shall have compound cross-section of low water bed and flood bed.

K. Lengkong Check Dam No. 3 (Pronojiwo Dam):

It is a base key dam to prevent erosion of Lahar deposits in K. Lengkong Fan caused by diverted running water from a diversion channel and to regulate the run-off sediment from B. Bang. It is a gravity type concrete dam on andesite foundation.

Since volcanic products nue ardente extends as far as the immediate upstream of this dam site, it is designed to have large enough spillway section. There is a fall created as a result of advanced erosion of the riverbed at the sub dam downstream. To prevent such further vertical erosion, the fall shall be covered with concrete.

⑥ Curah Lengkong Check Dam No. 1 and

⑦ Curah Lengkong Check Dam No. 2

Suitable locations for check dams with large sediment control effect are few in the Curah Lengkong. Curah Lengkong Check Dam

No.1 and No.2 are one of the comparatively suitable dam sites for sediment yield suppression and sediment run-off regulation. They are gravity-type concrete dams with short crest length. Since the foundation is gravels, they should have both concrete apron and water cushion by sub-dam.

⑧ K. Leprak Sand Pocket

K. Leprak sand pocket is planned to store sediment runoff on the head of the fan to prevent sediment flooding on the fan. At present, the K. Leprak runs through the highest point located at the center of the alluival fan as shown in Fig.-4.2. Therefore, if the river floods at this point, the influence will be extensive. Flood-inundated area can be decreased by shifting the watercourse to lower zone. While, on the other hand, there will be little influence on the lower reaches if the watercourse is shifted to the right-bank side because the topography of the right bank side is mountainous. Therefore, the sand pocket should be planned to be constructed near the right bank.

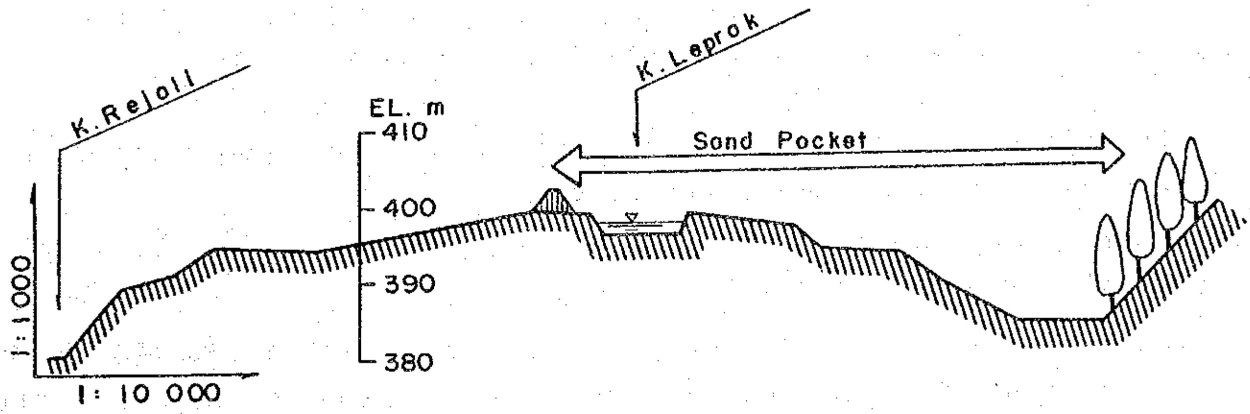


Fig.-4.2 Cross Section of Leprak Fan

The sand pocket is comprised of three consolidation dams and dikes of total 2,980m in length. The consolidation dams are constructed to fix the direction of the water course to the design river course as well as to distribute runoff sediment in a uniform manner in the sand pocket area.

The consolidation dams planned at either the entrance or exist of the sand pocket shall be gravity-type concrete dams. The consolidation dam planned in the middle of the sand pocket shall be made with rock baskets to allow for a change in the position of spillway. Thereby the efficient flush out of accumulated sediment will be promoted (Refer to Fig.-4.3).

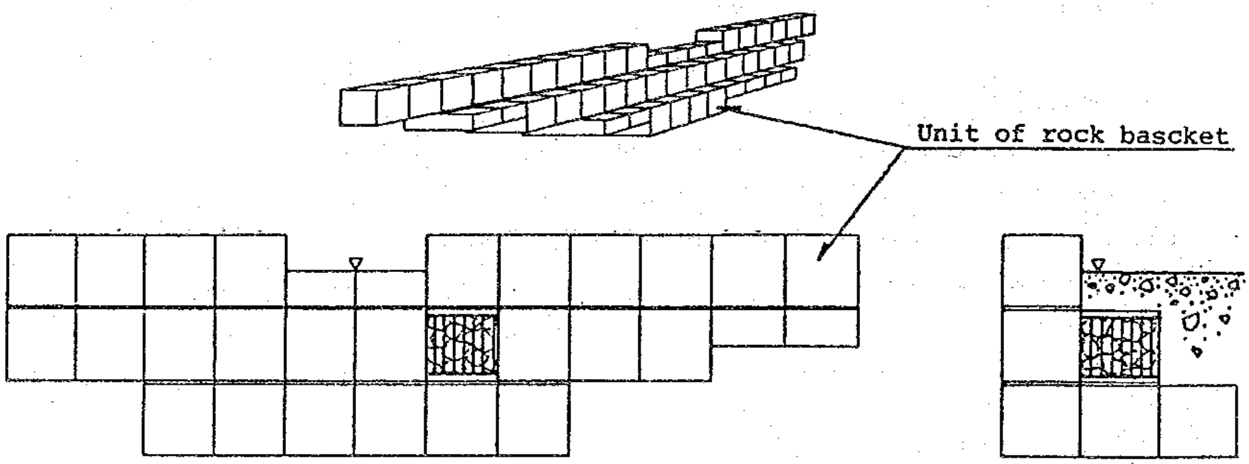


Fig.-4.3 Consolidation Dam of Rock Basket

The height of a dyke at either side of the sand pocket shall be more than 3m above the design riverbed.

(9) Intake and Channel

They are planned to supply the water to the unirrigated paddy field area along the old river course of the K. Rejali. The intake should be constructed making use of the existing K. Leprak check dam No.1. The channel leads the water from the intake to the old river course of the K. Rejali including tunnel of 430m length.

(2) Conditions for Cost Estimation

The project cost consists of the following items.

① Constructon Cost Direct Cost Materials Cost
Machine Hiring Cost
Labour Cost
Indirect Cost = Direct Cost x 15%
Preparation Works: 10%
Interests for construction,
tax: 5%

② Land Acquisition Cost

③ Engineering Service Cost = ① x 20%

④ Government Administration Cost = ① x 4%

⑤ Contingency Reserve Price Escalation (for financial cost only)
Foreign Currency = 5% per annum
Local Currency = 10% per annum
Physical Contingency = ① x 10%

After a rough design of each facility was made, the cost estimation was done on the basis of unit cost of materials, labour cost and labour efficiency in Lumajang Prefecture of East-Java of Indonesia. Standard unit price is based on the price of Dec. 1982.

The cost of those materials and machines, not available in Indonesia, was calculated by using the C.I.F. price at Surabaya as the border price.

The land acquisition cost is necessary expense incurred to purchase land for construction of facilities as well as to pay for lots which have been rendered unfit for farming by the said facilities.

The engineering service cost is necessary expense incurred for design works, preparation of tender documents and construction supervision. The distribution ratio of this cost to construction cost is determined based on the implementation program described later.

The government administration cost is necessary expense for the project site office to be paid directly by the Indonesian government during the course of execution of the construction works. The distribution ratio of this cost to construction cost is determined after carefully considering the figures from past record of Mt. Semeru Project Office.

(3) Economic Cost

The economic cost of each sediment control facility is given in Table-4.2.

Table-4.2 Economic Cost of Sediment Control Facility for the First Priority Project

(Based on fiscal year 1982 standard price)

No.	Name		Life (Years)	Economic Cost (10^6 Rp)
1.	Curah Kobo'an Check Dam	No. 6	80	9,805
2.	"	No. 5	"	578
3.	"	No. 4	"	3,212
4.	"	No. 3	"	203
5.	Diversion Works		"	7,495
6.	Curah Lengkong Check Dam	No. 1	"	102
7.	"	No. 2	"	317
8.	K. Leprak Sand Pocket		50	3,090
9.	Intake and Channel		80	292

4.1.3 PROJECT BENEFIT

(1) Estimation Method of Project Benefit

Economic benefit through construction of sediment control facilities is classified into three categories: i) mitigation effect of direct damage, ii) mitigation effect of indirect damage and iii) effect on water conservation.

The process of the mitigation effect of direct and indirect damage are shown in Fig.-4.4.

The water conservation effect is found as the increment of crops owing to the sediment control project.

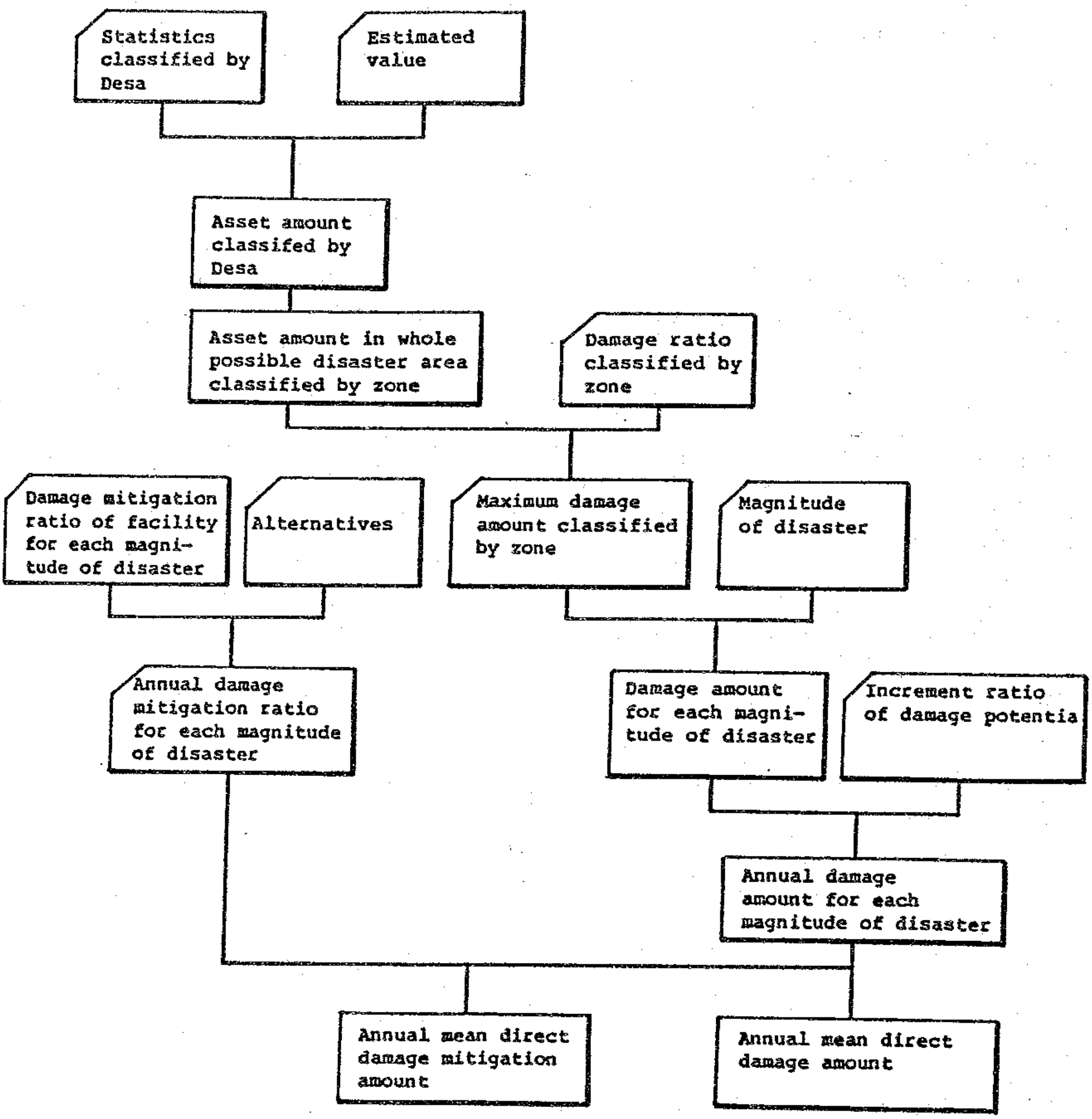


Fig.-4.4(1) Flow Chart of Estimation of Direct Damage Mitigation Amount

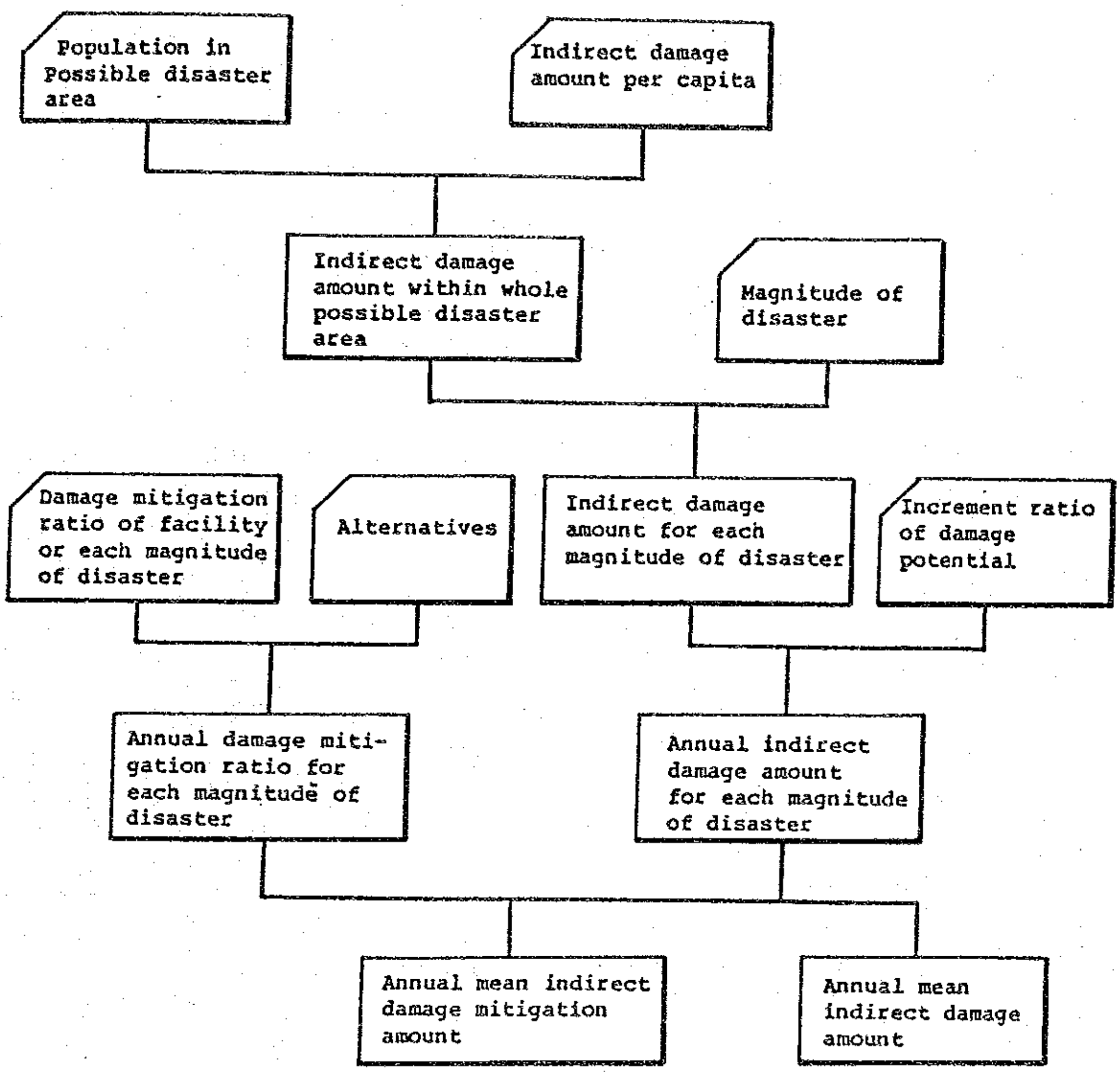


Fig.-4.4(2) Flow Chart of Estimation of Indirect Damage Mitigation Amount

(2) Disaster Model

(A) Possible Disaster Area

The extent of area likely to suffer sediment disaster judging from its disaster history and topographical features has been determined and identified the possible disaster area. It is the area where a sediment flow from the upper basin may flood and cause sediment disaster. The possible disaster area is divided into five zones in terms of type of disaster, thickenss of sediment deposit and topographical factors.

The possible disaster area secured by the first priority facility project is composed of K. Rejali and K. Glidik basin. Refer to Table-4.3, 4.4 and 4.5.

Table-4.3 Possible Disaster Area

(Unit: km^2)

River System	Zone					
	I	II	III	IV	V	Total
K. Rejali	-	1.68	9.89	26.28	2.67	40.52
K. Glidik	-	0	0	9.23	8.35	17.58
Total	-	1.68	9.89	35.51	11.02	58.10

Table-4.4 Desas in the Possible Disaster Area of K. Rejali

Name of Kecamatan	Name of Desa
Pasirian	Kali Beno, Bades, Madu Rejo
Candipuro	Jarit, Jugosari, Sumberejo, Sumberwuluh, Tambah Rejo
Pronojiwo	Supiturang, Oro-oro Ombo

Table-4.5 Desas in the Possible Disaster Area of K. Glidik

Name of Kecamatan	Name of Desa
Pronojiwo	Sidomulyo, Supiturang, Tamanayu
Tempursari	Kaliulingsari, Tempurejo, Purorejo, Tagalrejo
Ampel Gading	Ampel Gading

(B) Design Sediment Volume

The sediment discharge at each reference point is determined for each probable return period using the sediment runoff-control simulation model. The difference in sediment discharge between a supplementary reference point at the top of the upper stream and a design reference point at the bottom of the lower stream in the fan is the sediment volume which may cause disaster in the possible disaster area. This is design sediment volume. Design sediment volume computed for each probable return period is shown in Table-4.6. The details of the simulation are discussed in Supporting Report (1) and Part G of Supporting Report (5).

Table-4.6 Design Sediment Volume for K. Rejali and K. Glidik
($10m^3$ m^3)

Return Period (Year)	River Sytem	
	K. Rejali	K. Glidik
3	1,610	1,510
5	1,940	1,830
10	2,390	2,310
20	3,020	3,200
40	3,680	3,700
70	4,510	4,200
100	5,220	4,500
Potential disaster area	16,240	9,050

(C) Magnitude of Disaster

The magnitude of disaster indicates the severify of disaster. It is given as a ratio of a disaster area to the possible disaster area.

The magnitude of disaster, shown in Table-4.7, is determined on the following suppositions. Refer to Fig.-4.6.

- The thickness of sediment deposit is constant in each of the five zones and has no relation to the deposit volume of the sediment. This is determined on the basis of study of deposit thickness caused by disasters in the past.

- Accordingly, the sediment flooding area in each zone is in proportion to flooding sediment volume, and constant by each magnitude of disaster under constant sediment control facilities.

- Judging from the characteristics of sediment flooding on the alluvial fan, which has much runoff sediments, the likelihood of occurrence of disaster at any given point in the possible disaster area is thought to be equal.

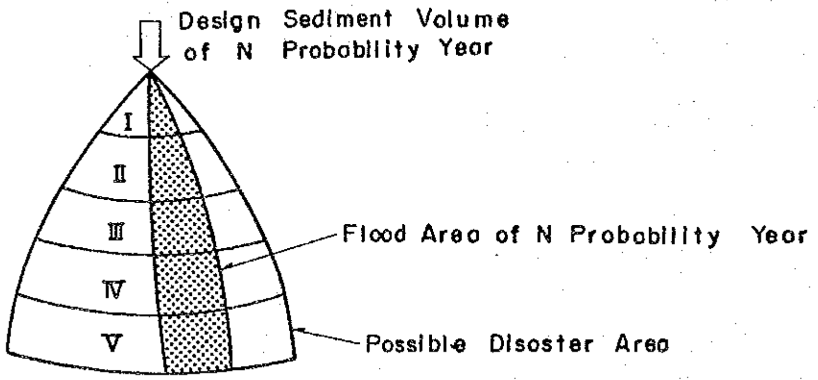


Fig.-4.5 Sediment Flooding Model

Table-4.7 Magnitude of Disaster

River System	Probable Return Period							Total Possible Disaster Area
	3	5	10	20	40	70	100	
K. Rejali	0.099	0.120	0.147	0.186	0.226	0.278	0.321	1.000
K. Glidik	0.167	0.202	0.255	0.354	0.410	0.464	0.498	1.000

(D) Damage ratio

A damage ratio indicates a degree of property damage suffered from sediment flooding. The coefficient for each property, determined by the thickness of sediment deposit as defined in the "Outline of Economic Study on Flood Control", is shown in Table-4.8.

Table-4.8 Damage Ratio According to the Thickness of Sediment Deposit

Type of Property	Thickness of Sediment Deposit	50 cm and under	50 cm to 99 cm	100 cm and Over
House		0.43	0.57	
Household goods		0.50	0.69	
Office	Depreciable assets	0.54	0.63	
	Livestock	0.48	0.56	
Farmhouse and Fisherman's House	Depreciable assets	0.37	0.45	
	Stocks	0.58	0.69	
Crops	Paddy rice	0.70	1.00	1.00
	Others	0.68	0.81	1.00

* Quoted from "Outline of Economic Study on Flood Control" (Revised Proposal) August, 1977 - Ministry of Construction, River Bureau, River Planning Section of Japan.

The thickness of sediment deposit is determined for each zone, based on the investigation results. See Table-4.9.

Table-4.9 Average Thickness of Sediment Deposit

(Unit: m)

Name of Basin	Possible Disaster Zone				
	I	II	III	IV	V
K. Rejali	2.22	0.60	0.47	0.36	0.42
K. Glidik	2.22	-	-	0.60	0.42

(3) Direct Damage

(A) List of Damages

The direct damage from sediment disaster consists of the following items.

- General assets
- Agricultural products
- Livestocks and fowls
- Human productivities
- Public facilities
- Sediment removal expense

(B) Estimated Damage Potential in Possible Disaster Area

The estimated damage potential in the possible disaster area of K. Rejali and K. Glidik basin at 1982 standard price are shown in Table-4.10 and 4.11 respectively.

Table-4.10 Estimated Damage Potential in Possible Disaster Area of K. Rejali

(Unit: 10^6 Rp)

Item \ Zone	I	II	III	IV	V	Total
General Assets	2,171	518	3,712	6,053	573	13,027
Agricultural Products	147	22	157	292	30	648
Livestocks & Fowls	174	44	288	630	51	1,187
Human Productivities	4,664	714	5,006	9,556	1,000	20,940
Public Facilities	257	205	150	100	22	734
Total	7,413	1,503	9,313	16,631	1,676	36,536

(Based on fiscal year 1982 standard price)

Table-4.11 Estimated Damage Potential in Possible Disaster Area of K. Glidik

(Unit: 10^6 Rp)

Item \ Zone	I	II	III	IV	V	Total
General Assets	250	0	0	1,412	972	2,634
Agricultural Products	67	0	0	152	119	338
Livestocks & Fowls	0	0	0	86	291	377
Human Productivities	2,136	0	0	3,242	3,619	8,997
Public Facilities	82	0	0	28	7	117
Total	2,535	0	0	4,920	5,008	12,463

(Based on fiscal year 1982 standard price)

(C) Increment of damage potential

The rate of increase of damage potential is decided as shown in Table-4.12, taking into account the rate of increase of the agricultural production amount and the population of Kab. Lumajang. The potential damage value shown in Table-4.10 is raised according to Table-4.12 for project life of 40 years.

Table-4.12 Annual Rate of Increase of Damage Potential

Item	Annual Rate of Increase	
	Next 10 yrs	Following 10 yrs
General Property	1.17%	1.17%
Agricultural Products	7	3.5
Livestock and Poultry	3	1.5
Inhabitants	1.17	1.17
Public Facilities	1.17	1.17

(D) Direct damage

The maximum direct damage which shows direct damage for whole the possible disaster area is sought by summing up the value to be calculated by multiplying each damage potential for each zone by each damage ratio. Details are discussed in Supporting Report (2). The direct damage for each probable return period is sought by multiplying each direct damage by each magnitude of disaster. Refer to Table-4.13 and 4.14.

Table-4.13 Direct Damage of K. Rejali

(10^6 Rp)

Return Period	Asset	Crop	Cattle	People	Facility	Reh.Land	Total
3	475	34	18	116	8	709	1,360
5	576	41	22	141	10	859	1,649
10	706	51	27	173	12	1,053	2,022
20	893	64	35	219	16	1,332	2,559
40	1,085	78	42	266	19	1,619	3,109
70	1,334	96	52	327	24	1,991	3,824
100	1,541	110	60	377	27	2,299	4,414
Max. Direct Damage	4,800	344	186	1,175	85	7,162	13,752

Table-4.14 Direct Damage of K. Glidik

(10^6 Rp)

Return Period	Asset	Crop	Cattle	People	Facility	Reh.Land	Total
3	183	34	9	99	1	687	1,013
5	222	41	11	120	1	831	1,226
10	280	52	14	152	1	1,049	1,548
20	389	72	20	211	2	1,456	2,150
40	450	84	23	244	3	1,686	2,490
70	510	95	26	276	3	1,908	2,818
100	547	102	28	296	3	2,048	3,024
Max. Direct Damage	1,098	204	56	595	6	4,113	6,072

(4) Indirect Damage

Deterioration of services caused by suspension of economic activities in the disaster area and expense for restoring damaged infrastructures are deemed as indirect damages brought about from the sediment disaster.

The indirect damage consists of the following items.

- Food supply from food supply centre
- Purchase of sugar
- Construction of shelters
- Purchase of blankets
- Purchase of fish
- Operating expenses for shelters
- Voluntary rescue activities
- Safety guarantee activities
- Provision of communication facility
- Medical expenses and funeral cost
- Rice (Distributed in Kind)

The indirect damage amount per capita in the disaster area was set up based on the expense for the above-mentioned item in the 1981 May disaster. The indirect damage amount was found by multiplying the population with the disaster area by the indirect damage amount per capita. Subsequent calculations of the indirect damage were conducted with the same procedure as that for the direct damage.

(5) Direct and Indirect Damage Mitigation Effect by Sediment Control Facilities

(A) Sediment Control Effect

The sediment control facilities would reduce the sediment volume which would otherwise pours into the possible disaster area. The damage mitigation effect of the sediment control facilities is given as a difference in the extent of damage with and without the facilities. The difference above are in proportion to the sediment control volume by each facility.

Sediment control volume of each facility is given as a difference between run-off sediment volume with and without the facilities. Design control sediment volume of each facility in K. Rejali for each probable return period is shown in Table-4.15.

The K. Lengkong check dam-No.3, planned at just downstream from the confluence of K. Lengkong and B. Bang as the one of the diversion works, has the sediment control effect for K. Glidik basin. Refer to Table-4.16.

Table-4.15 Sediment Control Volume of each facility in K. Rejali

(10^3 m^3)

Facility \ Return Period (year)	3	5	10	20	40	70	100
1) Curah Kobo'an Check Dam No.6	430	430	430	430	430	430	430
2) " No.5	90	90	90	90	90	90	90
3) " No.4	660	660	660	660	660	660	660
4) " No.3	90	90	90	90	90	90	90
5) Diversion Work	700	980	1,320	1,680	2,000	2,100	2,200
6) Curah Lengkong Check Dam No.2	160	160	160	160	160	160	160
7) " No.1	80	80	80	80	80	80	80
8) K. Leprak Sand Pocket	1,340	1,340	1,340	1,340	1,340	1,340	1,340

Table-4.16 Sediment Control Volume of K. Lengkong check dam No. 3 for K. Glidik Basin

(10^3 m^3)

Facility \ Return Period (year)	3	5	10	20	40	70	100
K. Lengkong Check Dam No.3	800	520	180	0	0	0	0

(B) Damage Mitigation Effect

The annual direct and indirect damage mitigation amount are given by multiplying the annual direct and indirect damages amount by the damage mitigation rate.

This damage mitigation rate is given to each facility and each probability year and is a proportion of the design control sediment volume against the design sediment volume.

(6) Water Conservation Effect

It is possible to transform current devastated land and fields where sugar cane, maize, soy beans and cassava are cultivated into stable paddy fields by irrigation, while sediment disaster is mitigated by the construction of sediment control facilities.

The difference, therefore, between the current crops and the prospective crops from paddy fields can be regarded as one of the benefits of the water conservation effect. However, to achieve this benefit, it is necessary to construct additional facilities such as intakes, etc. besides the sediment control facility.

Accordingly, while the water conservation effect is accounted as a favourable effect of the sediment control plan, the construction cost of those additional facilities is accounted for in the project cost.

To attain the mean water conservation amount, the area where land stabilization can be expected due to the construction of the sediment control facility is decided first. The amount of water that can possibly be supplied to this area by the construction of the additional facilities is then estimated. The annual crops increase in the area as a result of this developed water amount is then regarded as the mean water conservation amount.

(7) Annual Benefit

The annual direct and indirect damage mitigation amount and the water conservation amount at 1992, when the all works will have been completed, are shown in Table-4.17.

Table-4.17 Annual Benefit at 1992

(Unit: 10^6Rp)

Plan \ Item	Direct damage mitigation amount	Indirect damage mitigation amount	Water conservation amount
Plan-1	1,106	2	594
Plan-2	1,439	3	594
Plan-3	1,446	3	594
Plan-4	1,452	3	594

4.1.4 EVALUATION

(1) Economic Evaluation

Using the costs and benefits described in 4.1.2 and 4.1.3 respectively, economic analysis for each alternative was carried out. The results are summarized in Table-4.18 and Fig.-4.6 for the period of the project life of 40 years.

As shown in Table-4.18 and Fig.-4.6, alternative Pl-3 shows the highest I.R.R. (Internal Rate of Return) of 8.92%. It is desirable, therefore, that the design magnitude is at 50 probability years, which belongs to Pl-3, from economic point of review.

Table-4.18 Results of Economic Evaluation for the First Priority Facility Project

Alter-natives	Combination of Facilities	Design Scope (Probability Year)	Economic Cost 10^6 Rp	Maintenance Cost 10^6 Rp/Year	I.R.R.	Total Benefit 10^9 Rp
Pl-1	1,5,9	13	17,591	2	8.55	77.8
Pl-2	1,2,3,4,5, 6,7,9	40	22,003	2	8.44	94.3
Pl-3	1,5,8,9	50	20,681	38	8.92	93.5
Pl-4	1,2,3,4,5, 6,7,8,9	90	25,093	38	7.58	96.6

Facility No.	Name of Facility	
1.	Curah Kobo'an Check Dam	No.6
2.	"	No.5
3.	"	No.4
4.	"	No.3
5.	Diversion Work Channel	
	K. Lengkong Check Dam	No.7
	"	No.3
6.	Curah Lengkong Check Dam	No.1
7.	"	No.2
8.	K. Leprak Sand Pocket	
9.	Intake and Channel	

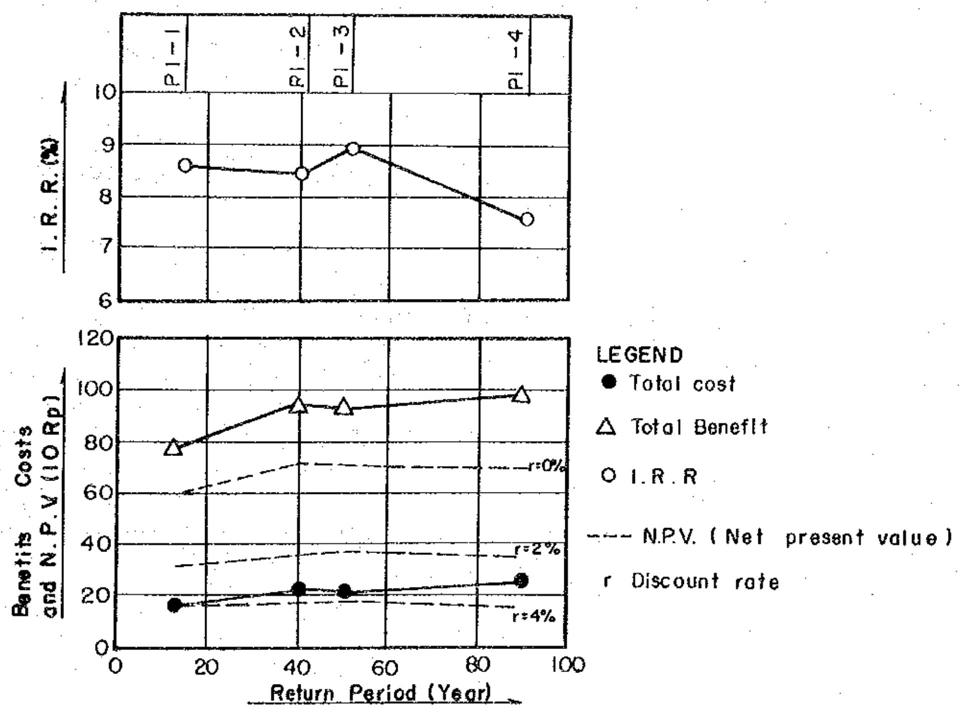


Fig.-4.6 I.R.R., Total Benefit and Total Cost of Alternatives for the First Priority Facility Project

(2) Social Evaluation

The possible disaster area of K. Rejali has some 15 thousands inhabitants and much properties as shown in Table-4.19. As shown by records of sediment disaster, a lot of people and properties are always confronted with fear of disaster.

Those who had lost their houses were transmigrated to other places and, as such, social insecurity brought about by the sediment disaster is high in the area.

It is impossible to prevent these damages by mere construction of local dike; and therefore, a comprehensive sediment control work in the area is needed.

Although economic value of intangible benefits which contribute greatly to the maintenance of social stability in the area would be difficult to assess, a sediment control project is extremely important. Such intangible benefits are listed below.

- Protection of Human Life
- Stabilization of Inhabitant's Livelihood:
  Safety, security and stability of inhabitants will be strengthened by freeing them from the fear of debris disaster.

Table-4.19 Properties in the Possible Disaster Area of K. Mujur

Item	Quatntity	Item	Quantity
Mosque and Church	32 houses	Cultivated field	1260 ha
School	14 "	Liestock	2601 heads
Factory	5 "	Poultry	8472 "
Store	38 "	People	14,797 persons
House and Office	3,137 "		

(3) Total Evaluation

As stated previously, I.R.R. of all alternative plans here is between 7.58% and 8.92%. Execution of a plan will certainly strengthen the basis of the total development plan for the area. Therefore the porject of this nature is indispensable.

Design magnitude of a plan should be 50 years, for I.R.R. begins to decline beyond this period as shown in Fig.-4.4. Accordingly, the alternative Pl-3 which enjoys the highest I.R.R. is recommended.

4.1.5 IMPLEMENTATION PLAN OF FIRST PRIORITY FACILITY PROJECT

This section describes the implementation plan of alternative P1-3 which is recommended as the first priority facility project.

(1) Outline of Project

Facilities to be constructed by the first priority facility project are shown in Table-4.20 and drawings in Supplement-4.

Table-4.20 Outline of First Priority Facility Project

Name of River	Name of Facility	Specifications	
K. Rejali	Curah Kobo'an CHD-6	H=23 m Vc=120,800m	L=438 m Vs=2,112,000m
	Diversion channel	L=1,350m Ve=566,000m	B=30m Vg=7300m
	K. Leprak Sand Pocket	Consolidation dam 3 Vc=14,300m Vem=155,000m	 Vs=4,300m Vg=15,000m
	Intake and Channel	L=430m	
K. Glidik	K. Lengkong CHD-3 (Pronojiwo Dam)	H=10m Vc=42,700m	L=2330 Ve=24,000m
	K. Lengkong CHD-7	H=10m Vc=4,670m	L=145m Ve=4,000m

H: Dam height
B: Width of channel
Vc: Concrete volume
Vem: Embankment volume
L: Length of dam or channel
Vs: Steel basket volume
Vg: Gabion work volume

(2) Construction Schedule

The construction period of the first priority facility project is six years including surveying, detail designing and preparatory works.

Schedule for the entire construction works is shown in Table-4.21. Annual construction quantity is shown in Table-4.22.

Table-4.21 Project Work Schedule for the First Priority Facility Project

Fiscal year / Description	1st	2nd	3rd	4th	5th	6th
	1987	1988	1989	1990	1991	1992
	4 9 3	4 9 3	4 9 3	4 9 3	4 9 3	4 9 3
1. Engineering Service						
(Design, Tender and Procurement Process)						
(1) B. Kobo'an check dam No.6						
(2) Diversion channel						
(3) K. Lengkong check dam No.3						
(4) " No.7						
(5) Leprak sand pocket						
(6) Intake and channel						
(7) Construction equipment and spare parts						
(8) Construction supervision						
2. Civil Works						
(1) B. Kobo'an check dam No.6						
(2) Diversion channel						
(3) K. Lengkong check dam No.3						
(4) " No.7						
(5) Leprak sand pocket						
(6) Intake and channel						
(7) Preparation work						

Table-4.22 Annual Construction Quantity for the First Priority Facility Project

Work Item \ Fiscal Year / Year	1st 1987	2nd 1988	3rd 1989	4th 1990	5th 1991	6th 1992
1. Concrete Work (m^3)						
B.Kobo'an check dam No.6		15,000	43,000	43,000	20,000	
Leprak Sandpocket					14,300	
K.Lengkong check dam No.3					8,000	34,700
K.Lengkong check dam No.7						6,500
2. Excavation (m^3)						
Diversion channel			280,000	286,000		
B.Kobo'an check dam No.6			69,000			
K.Lengkong check dam No.3					24,000	
K.Lengkong check dam No.7						4,000
3. Embankment (m^3)						
Leprak sandpocket			60,000	50,000	45,000	
4. Gabion work (m^3)						
Diversion channel			1,300	4,000	2,000	
Leprak sandpocket				6,000	9,000	
4. Steel basket (m^3)						
Leprak sandpocket			15,000	15,000	13,000	
6. Tunnel (m)						
Intake and tunnel						430m

(3) Construction Method and Equipment

The main work of the project is the placement of large quantities of concrete for the B. Kobo'an check dam No.6 and the K. Lengkong check dam No.3, and the extensive excavation work for the diversion channel.

In addition, there is a special work, i.e. the rock basket work at the K. Leprak sandpocket.

Works other than that mentioned above will be dealt with by the ordinary construction method, employed in the Mt. Semeru Project, using construction equipment owned by the Mt. Semeru Project Office.

(A) Method of Concrete Work

With the manpower method of dam concrete placing which has been used up until now, the annual maximum concrete placing volume is estimated to be around 7,000 m^3. This method will not, therefore, be capable of meeting the concrete placing requirement for either the B. Kobo'an check dam No.6 or the K. Lengkong check dam No.3. The production of concrete aggregate, the production of concrete and the concrete placing are accordingly planned to be carried out using machines.

The central plant system is employed for the production of concrete, and the aggregate plant and concrete plant will be set up at the same place as where the K. Leprak sandpocket is planned. The concrete produced there will be transported to the dam site by truck mixers and will be placed using the cable crane and the crawler crane. These construction machines are selected adequate on the basis of the given construction volume and period. Refer to Fig.-4.7.

Places where the aggregate can be collected are the K. Mujur fan, the K. Leprak fan and the K. Lengkong fan. Since 42% of the sand at the K. Lengkong fan, however, consists of minutes grains, i.e. silt with a diameter less than 0.074 mm, it is inadequate to be used as concrete aggregate. As a result, the aggregate and concrete plants are planned at the K. Leprak fan which is near the dam sites and where a large volume of aggregate can be possibly obtained.

Masonry concrete will be used for the dam body owing to financial reasons and because of the need to reduce the hardening calorific value. Stones, a diameter of more than 80 mm, will be stuffed by the crawler crane and then the spaces surrounding them will be filled with plain concrete.

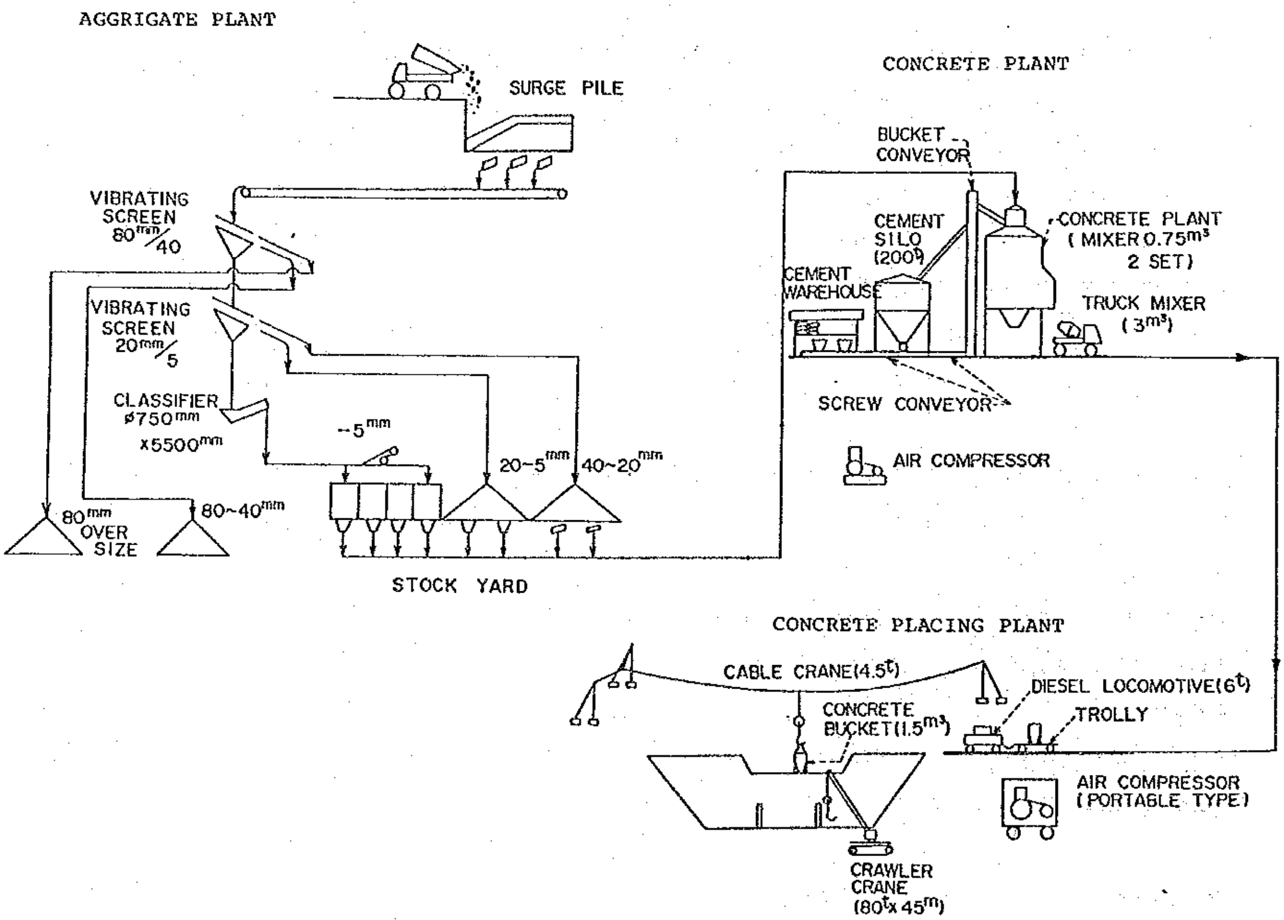


Fig.-4.7 Method of Concrete Work for the First Priority Project

(B) Excavation Method of Diversion Channel

Since a lot of water exists in the area around Sumber Sary where the diversion channel is planned, spring water is expected at the time of excavation. Excavation work, therefore, will be mainly done by the back hoe (1.4 m^3) with the supplementary use of a ripper dozer (25 t). Excavated sediment will be loaded directly with the back hoe to a dump truck, transported to the spoil bank and then banked by a bulldozer and a vibration roller. The excavation of the diversion channel will commence at the lower stream area, moving up to the upper stream area.

(C) Construction Method of Rock Basket

The rock basket is similar to the gabion mattress although its durability is higher as it uses formed steel instead of gabion wire. This rock basket will be used as construction material for the consolidated dam, planned at the middle point of the K. Leprak sandpocket.

The measurements of a rock basket unit are 2.2m x 1m x 1m and both its assembly and stone stuffing will be done by hand.

(D) Method of Other Construction Work

The excavation of the dam foundation will be mainly done by back hoe with supplementary assistance by hand.

Sediment within the channel will be excavated by back hoe (1.4 m^3) and bulldozer (25 t) and will be used for the construction of the dike. The banking and tamping will be done by bulldozer (16 t).

Masonry concrete will be used for the purpose of dam concrete, where the required volume is under 7,000 m^3/year, and construction will be done by hand, as has been the case until now.

(E) Construction Equipment

Construction equipment and spare parts to be newly purchased for the main work are as shown in Table-4.23.

Table-4.23 Price List of Construction Equipment for the First Priority Facility Project

Item	Description Power (KW)	Weight (Ton)	Amount (10^3 Yen)	Remarks
1. Equipment				
(1) Aggregate Plant	2,107 PS 207.65 KW	354.1	274,622	
(2) Concrete Plant	1,417 PS 33.65 KW	530.9	149,278	
(3) Concrete Placing Plant	2,360 PS 930.2 KW	864	971,846	
(4) Paving Equipment	315 PS 109 KW	64.1	94,500	
(5) Earth Work Equipment		248	329,047	
(6) Laboratory Equipment			5,000	
Sub Total	6,199 PS 1,459.5 KW	2,061.1	1,824,293	
2. Spare Parts				
(1) Aggregate Plant			47,223	
(2) Concrete Plant			43,943	
(3) Concrete Placing Plant			202,734	
(4) Paving Equipment Plant			32,790	
(5) Earth Work Equipment			59,600	
(6) Laboratory Equipment			2,000	
Sub Total			388,290	
Total			2,212,583	

(4) Cost

According to the above-mentioned construction procedure, the project cost is summarized as shown in Table-4.24. Refer to Table-4.25.

Table-4.24 Financial Cost of the 1st Priority Facility Project

Item		Foreign Currency 10^6 Yen	Local Currency 10^6 Rp	Total 10^6Yen
1. Construction equipment		1,825	-	1,825
2. Spare parts and consumable materials		389	-	389
3. Civil works		1,029	9,538	4,561
4. Land acquisition		-	370	137
5. Engineering services		932	909	1,269
6. Government administration		-	584	216
7. Contingency		723	4,462	2,376
Total	10^6Yen	4,898	5,876	10,774
	10^6Rp	13,225	15,864	29,089
	(%)	45.7%	54.7%	100%

(Based on the price level of fiscal year 1982)
Yen Evaluation: 1US$ = ¥240 = Rp650, 1 Yen = 2.7 Rp

(5) Evaluation

The economic cost was also refined and amounts to 20,525 million Rp as shown in Table-4.26.

As a result of the economic analysis using the refined cost, total benefit and I.R.R. of the first priority facility project are concluded as 90,760 million Rp. and 8.8% respectively. Refer to Table-4.27.

The difference of economic costs between Table-4.27 and Table-4.18 lies in the engineering service cost because the economic cost in Table-4.27 was refined based on the implementation program.

Table-4.25 Annual Financial Cost of The 1st Priority Project

Item	1		2		3		4		5		6		Total		Grand Total
	F.C. 10^6Yen	L.C. 10^6Rp	F.C. 10^6Yen	L.C. 10^6Rp	F.C. 10^6Yen	L.C. 10^6Rp	F.C. 10^6Yen	L.C. 10^6Rp	F.C. 10^6Yen	L.C. 10^6Rp	F.C. 10^6Yen	L.C. 10^6Rp	F.C. 10^6Yen	L.C. 10^6Rp	10^6yen
1. Construction equipment	1,825	-	-	-	-	-	-	-	-	-	-	-	1,825	-	1,825
2. Spare parts and consumable materials	149	-	60	-	60	-	60	-	60	-	-	-	389	-	389
3. Civil works	-	840	86	1,879	224	1,946	2217	1,518	387	1,668	115	1,687	1,029	9,538	4,561
4. Land acquisition	-	250	-	110	-	0	-	10	-	0	-	0	-	370	137
5. Engineering services	266	184	169	145	137	145	131	145	112	145	117	145	932	909	1,269
6. Government administration	-	134	-	90	-	90	-	90	-	90	-	90	-	584	216
7. Contingency	224	140	47	446	85	675	105	761	176	1,074	86	1,366	723	4,462	2,376
Total	2,464	1,549	362	2,670	506	2,856	513	2,524	735	2,977	818	3,288	4,898	15,864	10,774
Japanese Yen	2,464	573	362	989	506	1,058	513	935	735	1,103	318	1,218	4,898 (45.5%)	5,876 (54.5%)	
Equivalent x 10^6 yen	3,037		1,351		1,564		1,448		1,838		1,536		10,774		

Yen evaluation US$1 = ¥240 = Rp 650 (1982), ¥ = 2.7 Rp

Table-4.26 Annual Economic Cost of The 1st Priority Project

(Based on the Price level of fiscal year 1982)

Item	1		2		3		4		5		6		Total		Grand Total
	F.C. 10^6Yen	L.C. 10^6Rp	F.C. 10^6Yen	L.C. 10^6Rp	F.C. 10^6Yen	L.C. 10^6Rp	F.C. 10^6Yen	L.C. 10^6Rp	F.C. 10^6Yen	L.C. 10^6Rp	F.C. 10^6Yen	L.C. 10^6Rp	F.C. 10^6Yen	L.C. 10^6Rp	10^6yen
1. Construction equipment	0	-	301	-	600	-	403	-	291	-	339	-	1,934	-	1,934
2. Civil works	-	521	68	1,321	337	1,448	272	1,116	223	1,206	125	1,254	1,025	6,866	3,568
3. Land acquisition	-	250	-	110	-	0	-	10	-	0	-	0	-	370	137
4. Engineering services	219	165	137	120	111	120	107	120	93	120	100	120	767	765	1,050
5. Government administration	-	132	-	93	-	93	-	93	-	93	-	93	-	597	221
7. Contingency	241	1,175	556	1,808	1,153	1,827	861	1,473	668	1,561	620	1,614	4,099	9,458	7,602
Total	241	1,175	556	1,808	1,153	1,827	861	1,473	668	1,561	620	1,614	4,099	9,458	7,602

Table-4.27 Economic Evaluation of the First Priority Project

YEAR	COST TOTAL	COST CONSTRUCTION	COST MAINTENANCE	BENEFIT TOTAL	BENEFIT DIRECT	BENEFIT INDIRECT	BENEFIT IRRIG.	BENEFIT SALVAGE V.
1987	1825.0	1825.0	.0	.0	.0	.0	.0	.0
1988	3310.0	3310.0	.0	.0	.0	.0	.0	.0
1989	4941.0	4941.0	.0	.0	.0	.0	.0	.0
1990	3796.0	3796.0	.0	.0	.0	.0	.0	.0
1991	3363.0	3363.0	.0	257.3	256.8	.6	.0	.0
1992	3291.0	3289.0	2.0	853.6	259.0	.6	594.0	.0
1993	38.0	.0	38.0	2046.1	1431.8	3.2	611.0	.0
1994	38.0	.0	38.0	2073.5	1441.2	3.3	629.0	.0
1995	38.0	.0	38.0	2100.1	1450.8	3.3	646.0	.0
1996	38.0	.0	38.0	2128.9	1460.5	3.4	665.0	.0
1997	38.0	.0	38.0	2156.8	1470.4	3.4	683.0	.0
1998	38.0	.0	38.0	2184.8	1480.4	3.4	701.0	.0
1999	38.0	.0	38.0	2208.1	1490.6	3.5	714.0	.0
2000	38.0	.0	38.0	2218.5	1501.0	3.5	714.0	.0
2001	38.0	.0	38.0	2229.1	1511.5	3.6	714.0	.0
2002	38.0	.0	38.0	2239.8	1522.2	3.6	714.0	.0
2003	38.0	.0	38.0	2250.8	1533.1	3.6	714.0	.0
2004	38.0	.0	38.0	2261.9	1544.2	3.7	714.0	.0
2005	38.0	.0	38.0	2273.2	1555.5	3.7	714.0	.0
2006	38.0	.0	38.0	2284.7	1567.0	3.8	714.0	.0
2007	38.0	.0	38.0	2296.5	1578.6	3.8	714.0	.0
2008	38.0	.0	38.0	2308.4	1590.5	3.9	714.0	.0
2009	38.0	.0	38.0	2320.5	1602.6	3.9	714.0	.0
2010	38.0	.0	38.0	2332.9	1614.9	4.0	714.0	.0
2011	38.0	.0	38.0	2345.4	1627.4	4.0	714.0	.0
2012	38.0	.0	38.0	2358.2	1640.2	4.0	714.0	.0
2013	38.0	.0	38.0	2371.3	1653.2	4.1	714.0	.0
2014	38.0	.0	38.0	2384.5	1666.4	4.1	714.0	.0
2015	38.0	.0	38.0	2398.0	1679.8	4.2	714.0	.0
2016	38.0	.0	38.0	2411.8	1693.5	4.2	714.0	.0
2017	38.0	.0	38.0	2425.8	1707.5	4.3	714.0	.0
2018	38.0	.0	38.0	2440.0	1721.7	4.3	714.0	.0
2019	38.0	.0	38.0	2454.6	1736.2	4.4	714.0	.0
2020	38.0	.0	38.0	2469.4	1750.9	4.4	714.0	.0
2021	38.0	.0	38.0	2484.4	1765.9	4.5	714.0	.0
2022	38.0	.0	38.0	2499.8	1781.3	4.5	714.0	.0
2023	38.0	.0	38.0	2515.4	1796.9	4.6	714.0	.0
2024	38.0	.0	38.0	2531.4	1812.8	4.7	714.0	.0
2025	38.0	.0	38.0	2547.7	1829.0	4.7	714.0	.0
2026	38.0	.0	38.0	13097.0	1845.5	4.8	714.0	10532.7

DISCOUT RATE	ACCUM. DISCOUNTED COST	ACCUM. DISCOUNTED BENEFIT	B/C RATIO	NPV
0	21818.	90760.	4.1599	68942.
1	20823.	70678.	3.3942	49855.
2	19929.	55800.	2.8000	35871.
3	19116.	44645.	2.3355	25529.
4	18370.	36180.	1.9695	17810.
5	17682.	29679.	1.6785	11997.
6	17041.	24625.	1.4450	7584.
7	16442.	20650.	1.2559	4208.
8	15880.	17488.	1.1012	1608.
9	15351.	14945.	.9735	-407.
10	14852.	12877.	.8671	-1974.
11	14379.	11179.	.7775	-3199.
12	13930.	9772.	.7015	-4158.
13	13504.	8596.	.6365	-4908.
14	13099.	7603.	.5805	-5495.
15	12712.	6760.	.5318	-5952.
16	12344.	6039.	.4892	-6305.
17	11992.	5417.	.4517	-6575.
18	11656.	4878.	.4185	-6778.
19	11334.	4408.	.3889	-6926.
20	11027.	3997.	.3625	-7030.
21	10732.	3635.	.3387	-7097.
22	10449.	3314.	.3172	-7135.
23	10178.	3030.	.2977	-7148.
24	9918.	2777.	.2800	-7141.
25	9668.	2550.	.2638	-7117.
26	9427.	2347.	.2489	-7080.
27	9196.	2164.	.2353	-7032.
28	8974.	1999.	.2227	-6975.
29	8760.	1850.	.2111	-6911.
30	8554.	1714.	.2004	-6840.

INTERNAL RATE OF RETURN 8.80 PER CENT

4.2 DEBRIS FLOW WARNING SYSTEM PROJECT

4.2.1 PROJECT FEATURE

(1) Purpose of the Project

The disaster in this area tends to cause a great loss of lives. The completion of the sediment control facility to prevent such a disaster perfectly would be a long period.

The debris flow warning system is established on entire area of Mt. Semeru south-eastern slope for the purpose of saving the human life as soon as possible.

(2) Structure of the Debris Flow Warning System

The debris flow warning system recommended as the first priority project consists of the following:

① Information colletion system

The information collection system gathers data which is required to predict the occurrence of a debris flow and to give warning for danger, and sends these data to the information processing center. It consists of the followings:

- Rainfall Observation System

Samll radar raingauge system	1 station
Rainfall telemetering station	8 stations

- Water Level Observation System

Water level telemetering station	6 stations

- Debris Flow Observation System

Debris flow sensing station	4 stations
Debris flow visual measuring station	2 stations

- Repeater station — 1 station

② Information Processing System

The information processing system is to store and control various data used for judging to give a warning to people or not. It does not include an analysis program and a software which can predict the occurrence of a debris flow.

It concentrated on the information processing center located at the Mt. Semeru Project Office.

③ Public Information System

The public information system is to address the evacuation warning according to the judgement of the information processing center without delay to people living in the possible disaster areas.

It consists of the followings:

- 11 Speaker stations at the most dangerous area of debris flow.
- Existing communication network in the general areas.

The outline of the system and locations are given in Fig.-4.8 and Fig.-4.9 respectively.

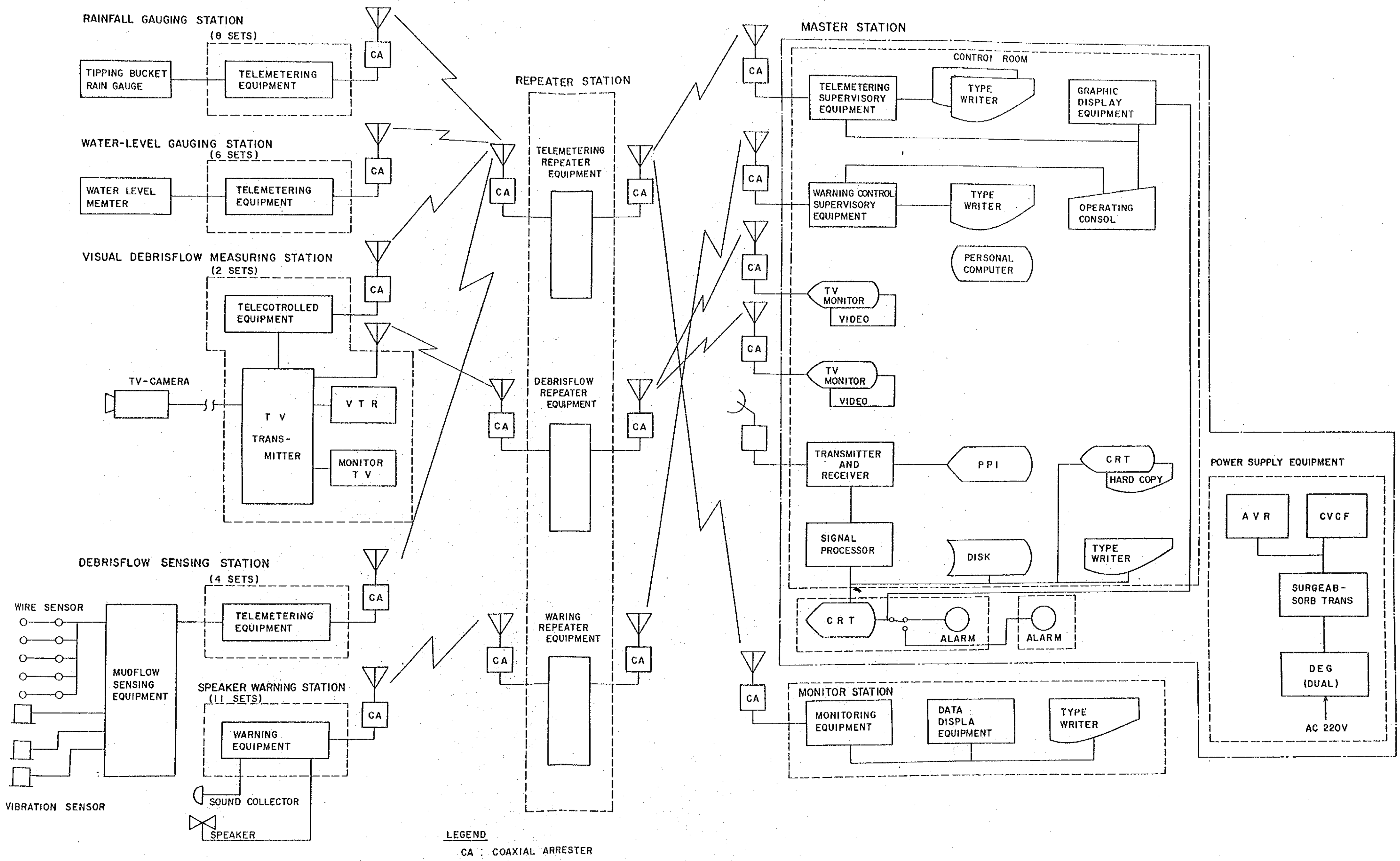
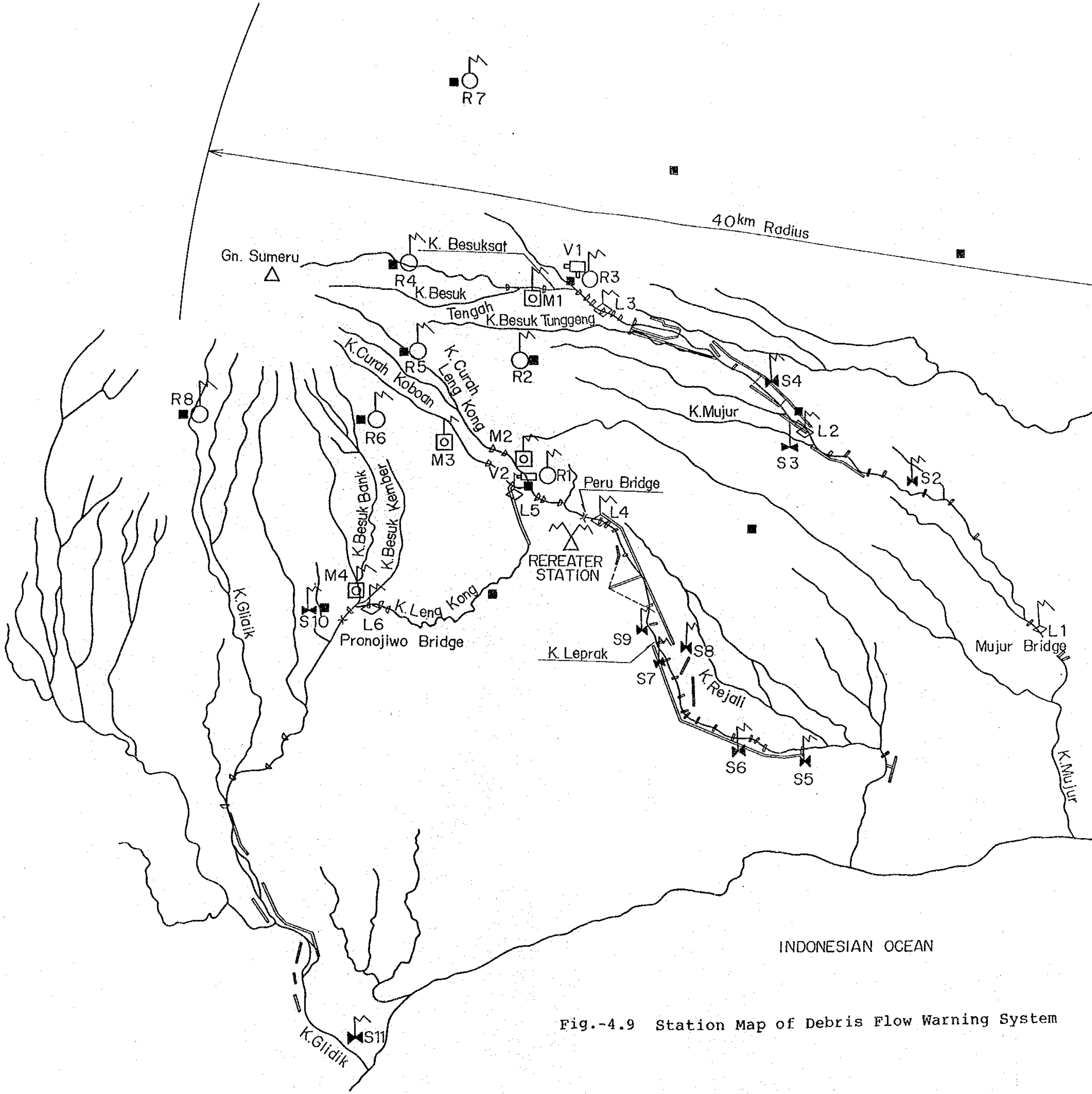


Fig.-4.8 Diagram of Debris Flow Warning System



Symbol	Station	Q. Ty
	RADAR RAINGAUGE STATION	1
	RAINFALL GAUGING STATION	8
	WATER LEVEL GAUGING STATION	6
	DEBRISFLOW SENSING STATION	4
	VISUAL DEBRISFLOW MEASURING STATION	2
	REPEATER STATION	1
	MASTER STATION	1
	MONITORING STATION	1
	SPEAKER WARNING STATION	11

Fig.-4.9 Station Map of Debris Flow Warning System

4.2.2 MAIN EQUIPMENTS

Main equipments required for the above system are shown in Table-4.28.

Table-4.28 Equipment of the Debris Flow Warning System

System	Station	Equipment	Quantity
Information processing system	Master station	1. Supervisory equipment	1 set
		2. Samll radar raingauge equipment	1 set
		3. Visual receiving equipment	2 sets
		4. Warning control equipment	1 set
		5. Power supply equipment	1 set
		6. Personal computer	1 set
	Monitoring station	1. Monitoring equipment	1 set
		2. Receiver	1 set
		3. Antenna	1 set
		4. Data display equipment	1 set
		5. Typewriter	1 set
Information collection system	Repeater station	1. Repeater equipment	3 sets
		2. Radio equipment	4 sets
		3. Telecontrolled equipment	1 set
		4. Antenna equipment	3 sets
		5. Power supply unit	2 sets
	Rainfall observation station	1. Telemetering equipment	8 sets
		2. Radio equipment	8 sets
		3. Antenna equipment	8 sets
		4. Rainfall gauging equipment	8 sets
		5. Solar cells power supply equipment	8 sets
	Water level observation station	1. Telemetering equipment	6 sets
		2. Radio equipment	6 sets
		3. Antenna equipment	6 sets
		4. Water level gauging equipment	6 sets
		5. Solar cells power supply equipment	6 sets
	Debris flow sensing observation station	1. Telemetering equipment	4 sets
		2. Radio equipment	4 sets
		3. Antenna equipment	4 sets
		4. Debris flow sensing equipment	4 sets
		5. Solar cells power supply equipment	4 sets
	Debris flow visual measuring station	1. Telecontrolled equipment	2 sets
		2. Radio equipment	2 sets
		3. Antenna equipment	2 sets
		4. TV transmitter	2 sets
		5. TV camera	2 sets
		6. Monitor TV	2 sets
		7. VTR	2 sets
		8. Solar cells power supply equipment	2 sets
Public information system	Speaker station	1. Warning equipment	11 sets
		2. Radio equipment	11 sets
		3. Antenna equipment	11 sets
		4. Loud speaker equipment	11 sets
		5. Sollar cells power supply equipment	11 sets
		6. Sound collector	11 sets

4.2.3 MANAGEMENT OF THE SYSTEM

At the information processing center, which is the backbone of the entire system, the data gathered by the information system is displayed, recorded and announced to the related organizations. The management of the system is shown in Fig.-4.10.

In order to achieve the effective management of the system, it will be necessary to both maintain the entire equipment in perfect working order and to continuously improve the system based on the collected data.

Manuals for checking and repairing of the system and collecting the data should be prepared during the test operation of a year.

The preparation and improvement of the analysis program for predicting of debris flow occurrences should not be included in this project. They will be achieved over a long period as a daily activity of the Mt. Semeru Project Office.

4.2.4 EVALUATION

The sediment disaster around Mt. Semeru tends to cause a great loss of lives as is seen in the past records. The establishment of the debris flow warning system will be able to protect human life from such disasters. Stabilization of inhabitant's livelihood also will be strengthened and social activity will be increased though they are intangible. Inhabitants and properties in the possible disaster area covered by the debris flow warning system are as shown in Table-4.29.

Table-4.29 Properties in the area covered by the Debris Flow Warning System

Item	Quantity	Item	Quantity
People	40,700 persons	School	32 houses
Mosque and church	82 houses	Hospital	1 house
Factory	16 "	House and office	8,600 "
Store	110 "	Cultivated field	3,300 ha

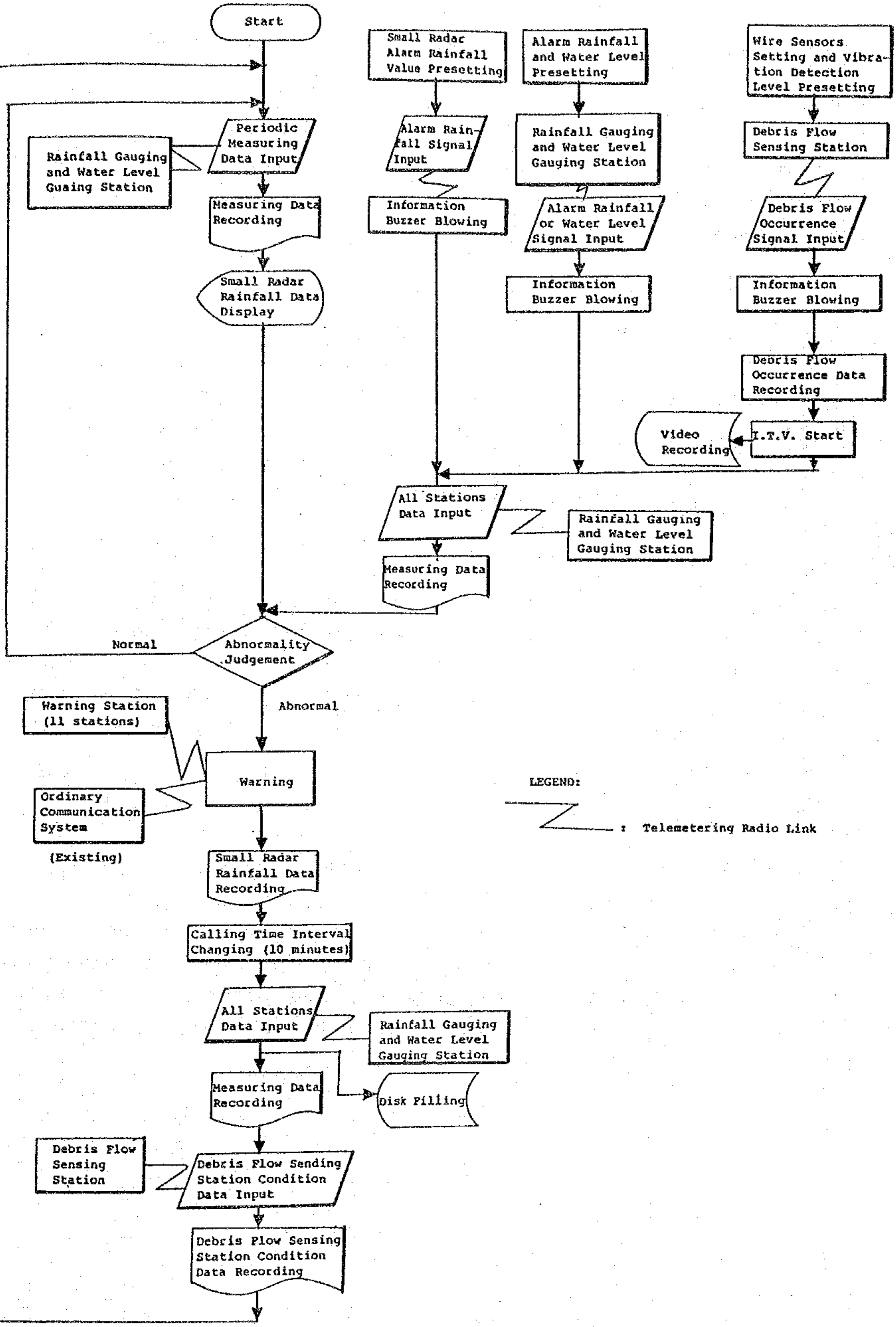


Fig.-4.10 Flow Chart of Application for Debris Flow Warning System

4.2.5 IMPLEMENTATION PLAN OF DEBRIS FLOW WARNING SYSTEM PROJECT

(1) Project Work Schedule

The debris flow warning system project consists of the design & equipment procuration, civil work & installation and operation. Execution of these works needs five years. The project work schedule is shown in Table-4.30.

(2) Design and Equipment Procuration

The detail design and the assist work for the equipment procuration should be carried out by an engineer of high capability. The detail design consists of the system design, the electric circuit design, the foundation design for equipments and the wave propagation test on the job site.

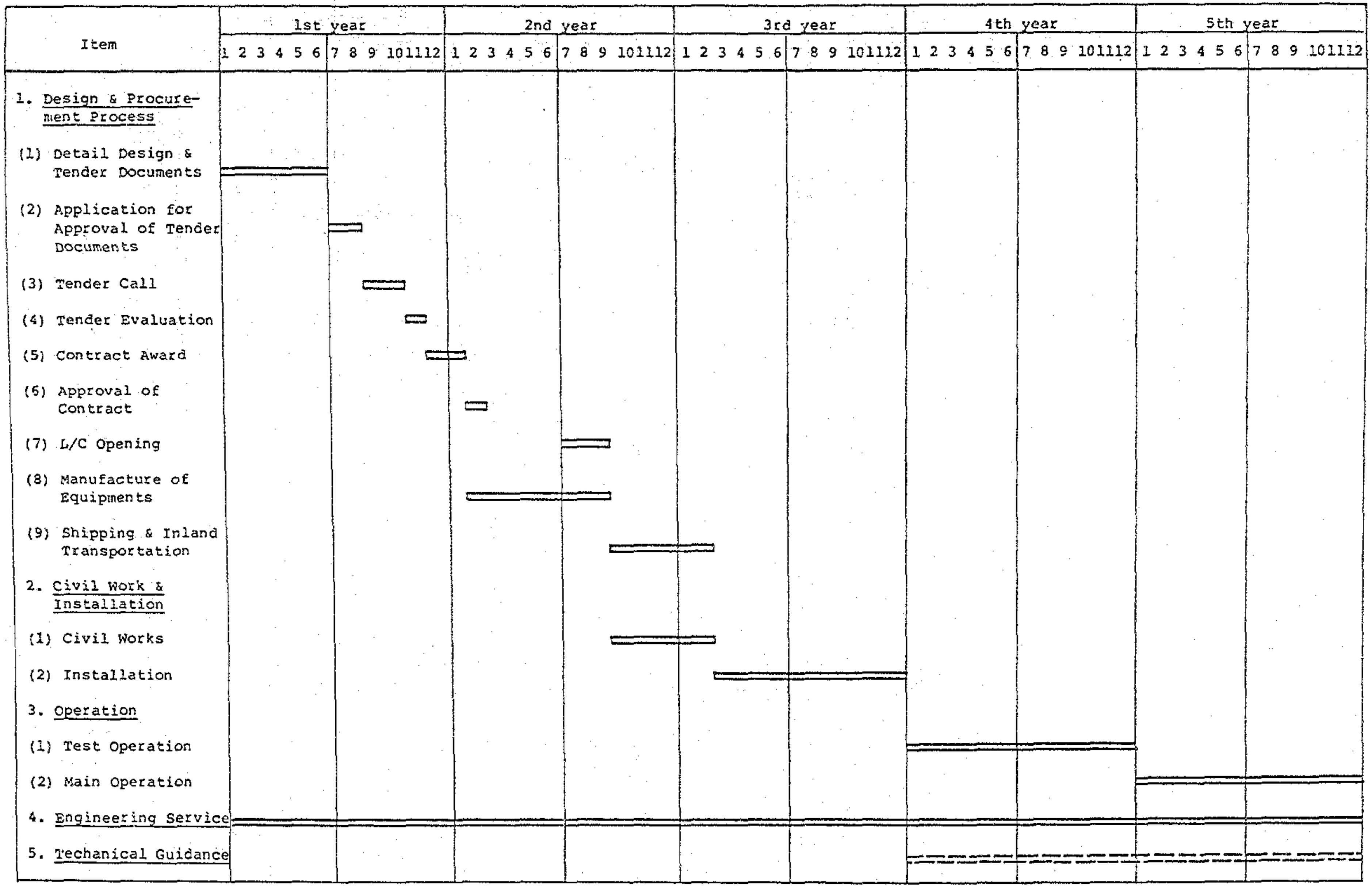
(3) Civil Work and Installation

The foundation works and the access roads of various stations should first be executed. The installation works of equipments, then, should be executed successively. The installation work includes the adjustment and testing of the entire equipments. It should be carried out by an engineer of high capability.

(4) Operation

After the adjustment and testing of entire equipments, a test operation of one year and a main operation of one year should be executed. During the test operation, manuals for checking and repairing of the system and collecting data should be prepared. During the main operation, the practice of actual repairing works should be executed by the Mt. Semeru Project Office with the assist of the consultant.

Table-4.30 Project Work Schedule for Warning System



4.2.6 PROJECT COST

The financial cost of the debris flow warning system was calculated in the same basis as in the sediment control facility plan. Its cost is summarized in Table-4.31.

Table-4.31 Financial Cost of the Debris Flow Warning System

Item	Foreign Currency 10^6 yen	Local Currency 10^6 Rp	Total 10^6 yen
1. Equipment	905.8	0	905.8
1.1 Main equipment	747.2		
1.2 Test equipment & maintenance tool	158.6		
2. Spare parts & Accessories	66.7	0	66.7
3. Construction & Installation	119.0	124.9	165.2
3.1 Construction	7.9	104.4	
3.2 Installation	95.6	2.5	
3.3 Inland transportation of equipments	0	1.7	
3.4 Preparation work	15.5	16.3	
4. Land acquisition	0	0.2	0.1
5. Engineering service	519.7	422.3	676.1
6. Government administration	0	17.8	6.6
7. Contingency	230.8	122.3	276.1
Total 10^6Yen	1,842.0	254.6	2,096.6
Total 10^6Rp	4,973.4	687.5	5,660.9
Total (%)	87.9%	12.1%	100%

(Based on the price level of fiscal year 1982)

Yen Evaluation: 1US$ = ¥240 = Rp650, 1Yen = 2.7Rp

4.2.7 PHASING PLAN OF DEBRIS FLOW WARNING SYSTEM PROJECT

Execution of the debris flow warning system project can be phased at four stages classified from the standpoint of function.

The structure of the system at each stage is shown in Table-4.32 and their financial costs are shown in Table-4.33, Table-4.34 and Table-4.35. The financial cost of the fourth final stage is as the same as in Table4.31.

Table-4.32 Phasing Plan of the Debris Flow Warning System Project

Phase	Structure of System		Project Period (month)	Financial Cost (10^6 Yen)
1	1. Rainfall gauging station	8 stations	24	1,021
	2. Debris flow sensing station	4 stations		
	3. Telemetering repeater station	9 stations		
	4. Supervisory equipment	1 set		
2	Above-mentioned systems		29	1,408
	5. Small radar raingauge equipment	1 set		
3	Above-mentioned systems		29	1,895
	6. Water level gauging station	6 stations		
	7. Warning control equipment	1 set		
	8. Warning repeater equipment	1 set		
	9. Personal computer	1 set		
	10. Speaker warning station	11 stations		
4	Above-mentioned systems		29	2,097
	11. Debris flow visual measuring stations	2 stations		
	12. Monitoring station	1 station		

Table-4.33 Financial Cost at 1st Stage of the Warning System Project

	Foreign Currency (10^6 Yen)	Local Currency (10^6 Rp)	Total (10^6 Yen)
1. Equipment	335.8	0	335.8
1.1 Main equipment	278.0	0	278.0
1.2 Test equipment & maintenance tool	57.8	0	57.8
2. Spare Parts & Accessories	20.1	0	20.1
3. Construction & Installation	47.7	88.5	80.5
3.1 Construction	4.4	75.2	32.3
3.2 Installation	37.1	1.3	37.6
3.3 Inland transportation of equipments	0	0.6	0.2
3.4 Preparation work	6.2	11.5	10.5
4. Land Acquisition	0	0.04	0.01
5. Engineering Service	342.5	287.3	448.9
6. Government Administration	0	5.5	2.0
7. Contingency	101.4	88.0	134.0
Total	847.5	469.34	1,021.31

Table-4.34 Financial Cost at 2nd Stage of the Warning System Project

	Foreign Currency (10^6 Yen)	Local Currency (10^6 Rp)	Total (10^6 Yen)
1. Equipment	497.2	0	492.7
1.1 Main equipment	433.6	0	433.6
1.2 Test equipment & maintenance tool	59.1	0	59.1
2. Spare Parts & Accessories	34.5	0	34.5
3. Construction & Installation	66.0	91.1	99.7
3.1 Construction	5.3	77.1	33.9
3.2 Installation	52.1	1.6	52.7
3.3 Inland transportation of equipments	0	0.6	0.2
3.4 Preparation work	8.6	11.8	13.0
4. Land Acquisition	0	0.04	0.01
5. Engineering Service	489.9	299.8	600.9
6. Government Administration	0	10.8	4.0
7. Contingency	142	91.3	175.8
Total	1225.1	493	1,407.7

Table-4.35 Financial Cost at 3rd Stage of the Warning System Project

	Foreign Currency (10^6 Yen)	Local Currency (10^6 Rp)	Total (10^6 Yen)
1. Equipment	776.1	0	776.1
1.1 Main equipment	648.0	0	648.0
1.2 Test equipment & maintenance tool	128.1	0	128.1
2. Spare Parts & Accessories	39.4	0	39.4
3. Construction & Installation	113	96.5	148.7
3.1 Construction	7.5	80	37.1
3.2 Installation	90.8	2.9	91.9
3.3 Inland transportation of equipments	0	1.2	0.4
3.4 Preparation work	14.7	12.4	19.3
4. Land Acquisition	0	0.2	0.1
5. Engineering Service	519.1	422.3	675.5
6. Government Administration	0	16.1	6.0
7. Contingency	206.9	113.7	249
Total	1,654.5	648.8	1,894.8

4.3 TOTAL PROJECT COST OF THE FIRST PRIORITY PROJECT

Total financial cost of the first priority project, which consists of the sediment control facility plan and the debris flow warning system plan, is estimated at Rp. 34.7 x 10^9 (¥12.9 x 10^9) and summary is shown in Table-4.36.

Table-4.36 Financial Cost of The First Priority Project

Item	Debris Flow Warning System Plan			Sediment Control Facility Plan			Total		
	F.C. (10^6Yen)	L.C. (10^6Rp)	Total (10^6Yen)	F.C. (10^6Yen)	L.C. (10^6Rp)	Total (10^6Yen)	F.C. (10^6Yen)	L.C. (10^6Rp)	Total (10^6Yen)
1. Equipment Cost	905.8	0	905.8	1,825	-	1,825	2,730.8	0	2,730.8
2. Spare Parts & Accessories	66.7	0	66.7	389	-	389	455.7	0	455.7
3. Civil Work	119.0	124.9	165.2	1,029	9,538	4,561	1,148.0	9,662.9	4,726.2
4. Land Acquisition	0	0.2	0.1	-	370	137	0	370.2	137.1
5. Engineering Services	519.7	422.3	676.1	932	909	1,269	1,451.7	1,331.3	1,945.1
6. Government Administration		17.8	6.6	-	585	217	0	602.8	223.6
7. Contingency	230.8	122.3	276.1	723	4,462	2,376	953.8	4,584.3	2,652.1
Total	1,842.0	687.5	2,096.6	4,898	15,864	10,774	6,740.0 52.4%	16,551.5 47.6%	12,870.6 (100%)

Based on the price level of fiscal year 1983/1982

Yen evaluation 1US$ = ¥240 = Rp 650

F.C.: Foreign currency portion

L.C.: Local currency portion