3.3.2 Selection of Optimum Design Scale for Master Plan

(1) Selection of Optimum Design Scale

The Bantyiketu river system, which consists of the Bantyiketu, Kurtume and Kechene rivers, is selected for the study on the optimization of design scale for the flood control master plan. This river basin is conceivable as a representative river system in Addis Ababa from the viewpoints of natural conditions, regional socio-economy and land use.

The comparative study is made on the three scales of basic flood discharges, namely, 20, 30 and 40-year return period. The construction costs and benefits are estimated for the plans of the alternative design scales. Further, the said Alternative 2 for the respective rivers are applied for selection of optimum design scale from a viewpoint of minimization of resettlement due to flood control plan. Based on preliminary design of the respective alternative plans, construction cost and benefit accrued from implementation of the works are estimated. Further, economic internal rate of return (EIRR) is examined. The results are as follows:

Table 3.10 Alternative Design Scales for Main River Channel and Tributary

River	Flood Protection Level / Design Scale (return period of probable flood, years)		
	Case 1	Case 2	Case 3
Kechene (Tributary)	10	20	30
Kurtume (Tributary)	10	20	30
Bantyiketu (Main River Channel)	20	30	40
Cost (Million Birr)	113.8	117.7	136.7
EIRR (%)	11.2	11.4	9.9

The above table shows that the highest EIRR indicates 30-year return period for main river channel among three design flood scales. As a result of this study, the design scale is selected against probable 30-year flood for the main river channels (Bantyiketu, Kebena and Little Akaki) and probable 20-year flood for tributaries (Kechene, Kurtume and Hanku), respectively. The basic flood discharge for each river is shown in Figure 3.10 to 3.14.

(2) Design Discharge Distribution

Distribution of design flood discharge for each flood control alternative is elaborated in line with assessment of individual scales of flood control structures. A scale of each

structure is assessed on the basis of design flood discharge as well as topographic configuration, minimizing resettlement and siting/combination of structures for flood control effectiveness. The distribution of design flood discharge for each alternative is shown in Figure 3.10 to 3.14.

3.3.3 Preliminary Design

(1) Technical Guidelines

For design of flood regulating reservoir by weir and flood diversion tunnel, there are no design guidelines made or generally used by Ethiopian authorities. The guidelines for these two kinds of river structure are therefore quoted from Design Standard of River and Sabo Structures edited by Ministry of Construction, Japan. For other river structures like retaining wall and dike, there are design guidelines, Ethiopian Building Code Standard (EBCS), published by Ministry of Works and Urban Development, 1995.

(2) Weir

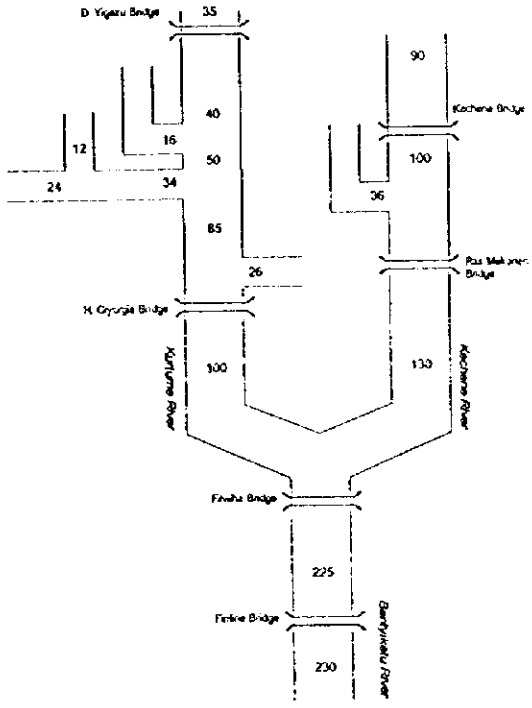
In the alternative plans, total five weirs are contemplated, namely, one at the Kechene river, two at the Kebena river and one at the Abo river, a tributary of the Kebena river.

All the weirs consist of a main weir, a sub-weir and a stilling basin. The sub-weir is situated at the downstream end of stilling basin. Both main weir and sub-weir are concrete gravity type. The stilling basin is made of reinforcing concrete. To downstream of sub-weir, gabion mats are furnished on riverbed to prevent scouring and erosion.

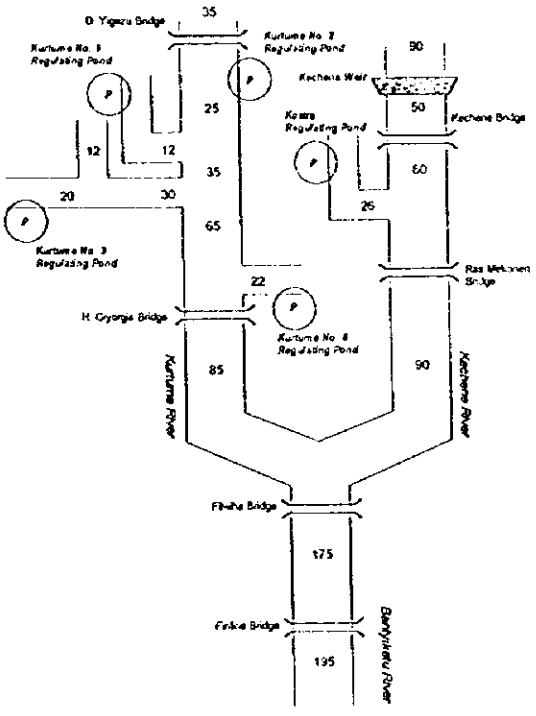
The main weir has a non-gated spillway at weir crest and orifice outlets as river outlet facility near the bottom of weir. Spillway is designed for probable 100-year flood and spill out only when such a large flood tales place. Orifice outlets near the bottom of weir are to discharge floods of small to medium scale as well as stream flow required in downstream areas.

A conceptual figure of weir is shown in Figure 3.15. The preliminary design of weir is conducted using the topographic maps with a scale of 1:2,000 published in 1995 for Addis Ababa Water Supply Project Stage IIIA. Main features of weir are summarized in Table 3.11.

Basic Flood (Probable 30-Year Flood)



Alternative 1



Alternative 2

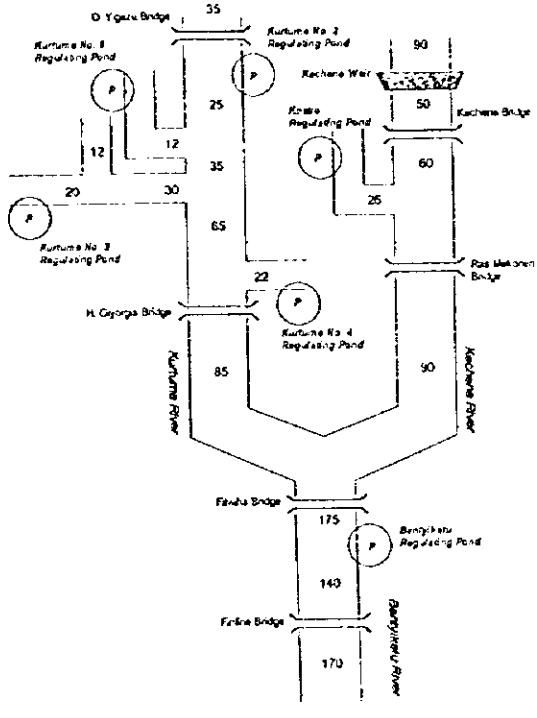
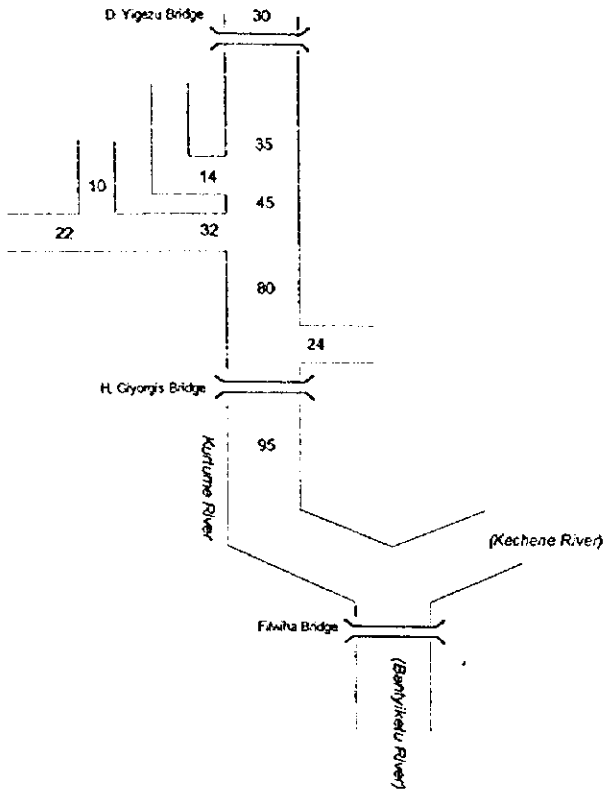
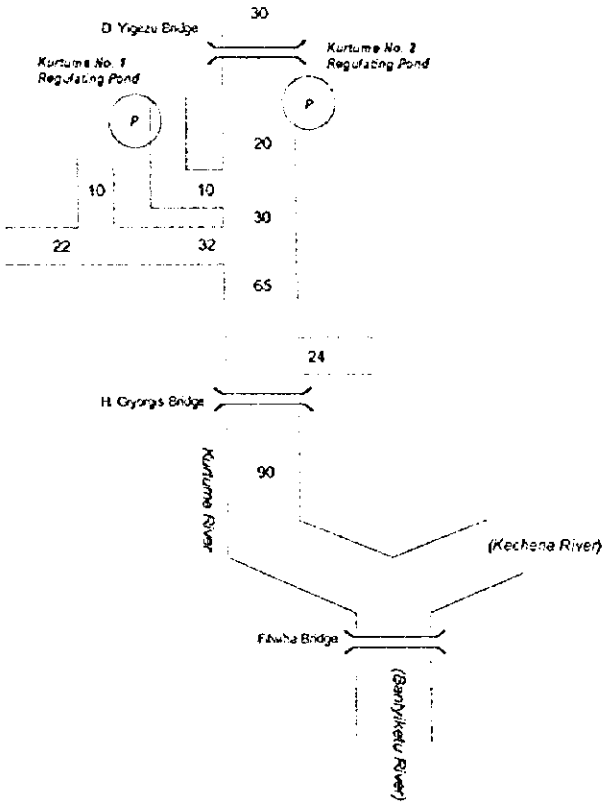


Figure 3.10 Design Discharge Distribution of Bantyiketu River System

Basic Flood (Probable 20-Year Flood)



Alternative 1



Alternative 2

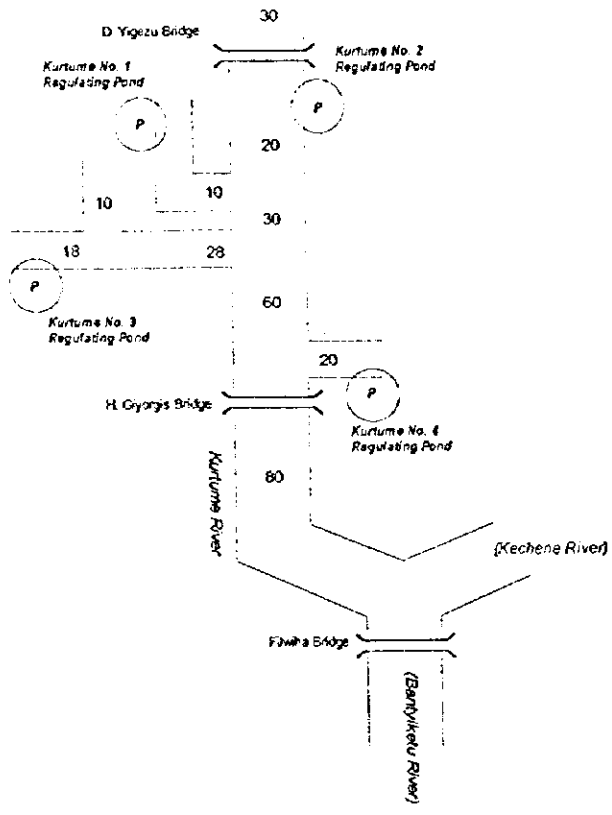
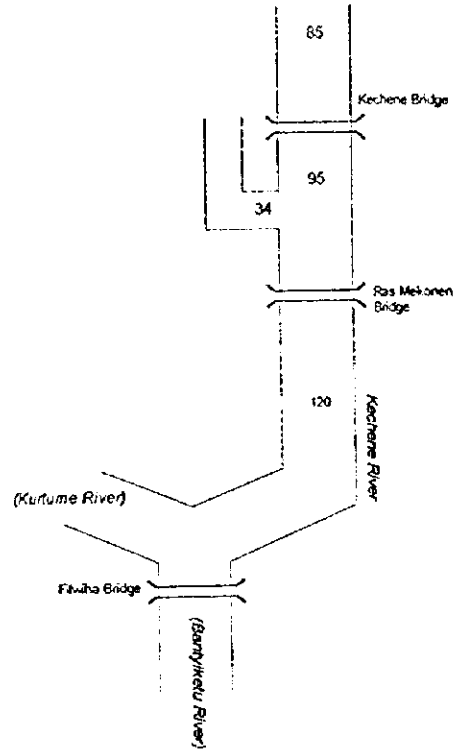
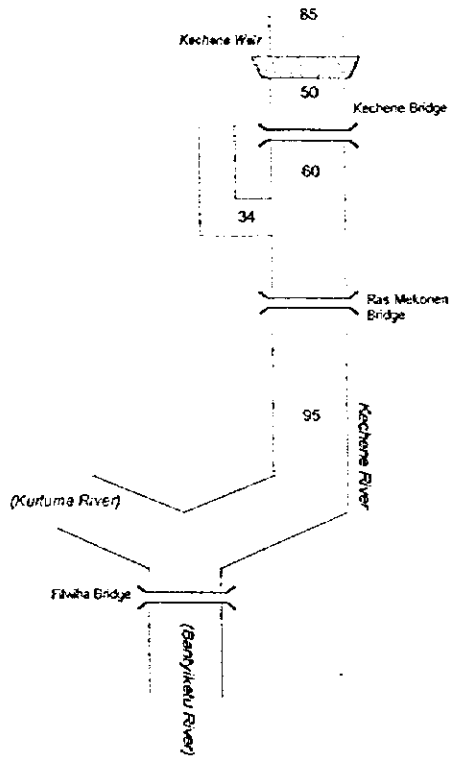


Figure 3.11 Design Discharge Distribution of Kurtume River

Basic Flood (Probable 20-Year Flood)



Alternative 1



Alternative 2

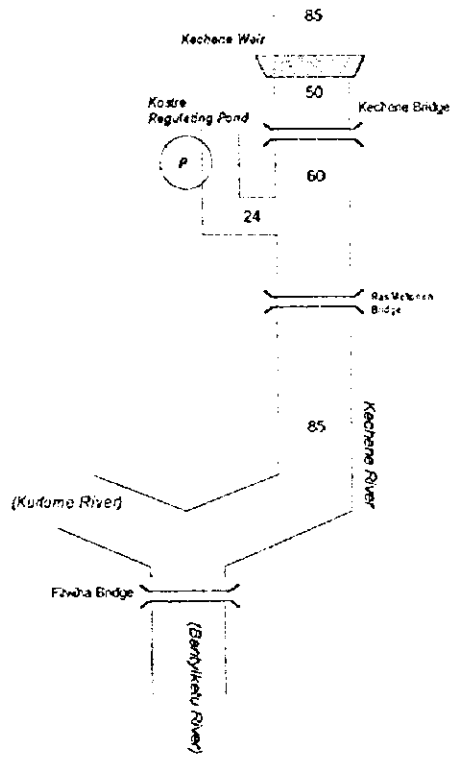


Figure 3.12 Design Discharge Distribution of Kechene River

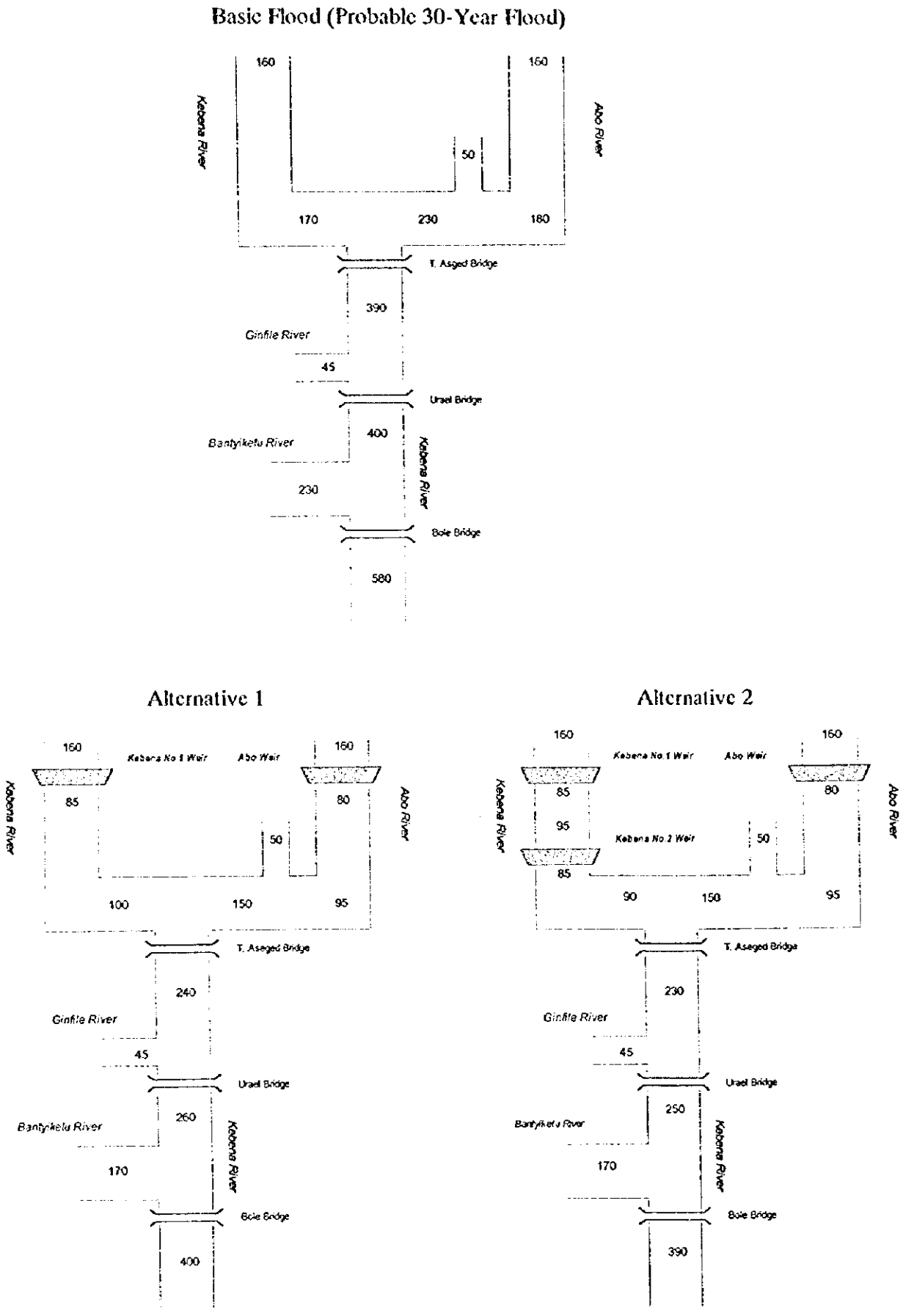


Figure 3.13 Design Discharge Distribution of Kebena River System

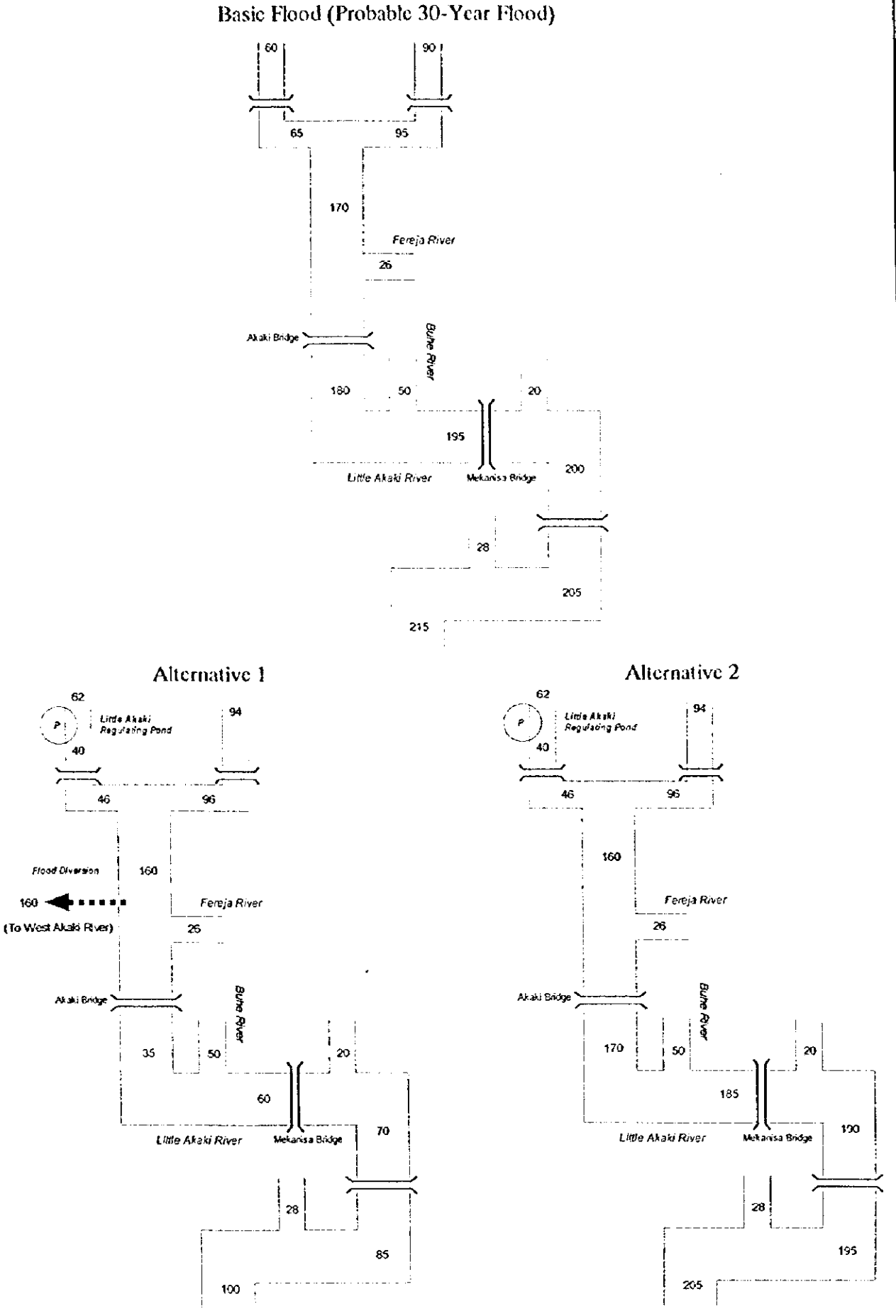


Figure 3.14 Design Discharge Distribution of Little Akaki River System

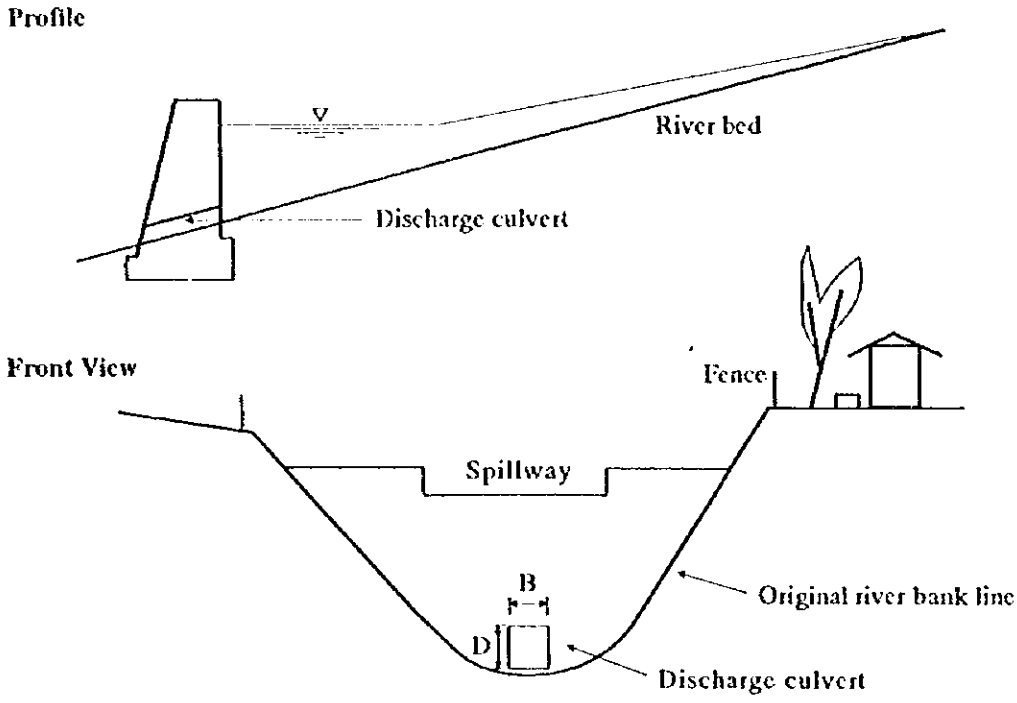


Figure 3.15 Conceptural Figure of Weir

Table 3.11 Major Features of Weir

	Kechene	Kebena No. 1	Kebena No. 2	Abo
Type	Concrete Gravity	Concrete Gravity	Concrete Gravity	Concrete Gravity
Reservoir Storage (m^3)	115,000	212,000	22,000	332,000
Weir Height (m)	20	25	14	24
Crest Length (m)	154	189	106	191
Crest Width (m)	2	2	2	2
Slope of Upstream Face	Vertical	Vertical	Vertical	Vertical
Slope of Downstream Face	1 : 0.7	1 : 0.7	1 : 0.7	1 : 0.7
Spillway				
Width (m)	20	25	25	25
Design Discharge (m^3/sec)	120	210	210	210
Orifice				
Width (m) × Height (m)	1.2 × 1.2	1.5 × 1.3	1.5 × 1.5	1.5 × 1.3
Nos.	3	3	3	3
Design Discharge (m^3/sec)	50	85	85	80

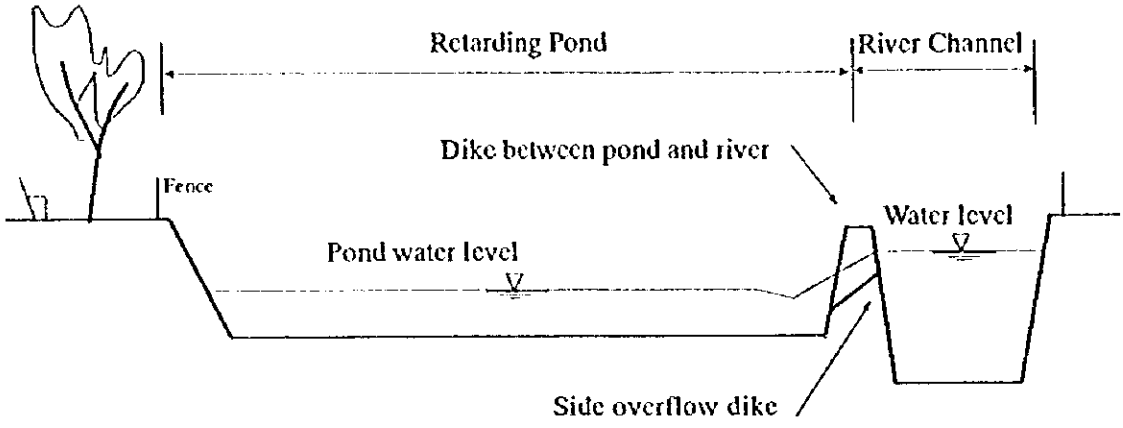
(3) Regulating Pond

In the alternative plans, total seven regulating ponds are contemplated, that is, four at the Kurtume river, one at the Kostre river which is a tributary of the Kechene river, one at the Bantyiketu river and one at the Little Akaki river.

All the regulating ponds are constructed by excavation of ground in riparian areas. Along riverside of pond, an inlet dike and an outlet facility are built. The inlet dike is made of soil embankment armored by wet masonry along its surface. The outlet facility is made of wet masonry, furnished with a flap gate. Flood flow is designed to overflow the crest of the inlet dike into the pond and is returned through the flap gate to the river when the water stage of the river becomes lower. The flap gate made of stainless steel is proposed from the aspect of maintenance-free policy. For the purpose to avoid scouring, gabion mats are placed on the riverbed and the pond's bed next to the inlet dike as well as the riverbed adjacent to the outlet facility.

A conceptual figure of regulating pond is shown in Figure 3.16. The preliminary design of regulating pond is conducted using the topographic maps with a scale of 1:2,000 published in 1995 for Addis Ababa Water Supply Project Stage IIIA. Main features of regulating pond are summarized in Table 3.12.

Cross Section of Regulating Pond and River



Plan of Regulating Pond and River

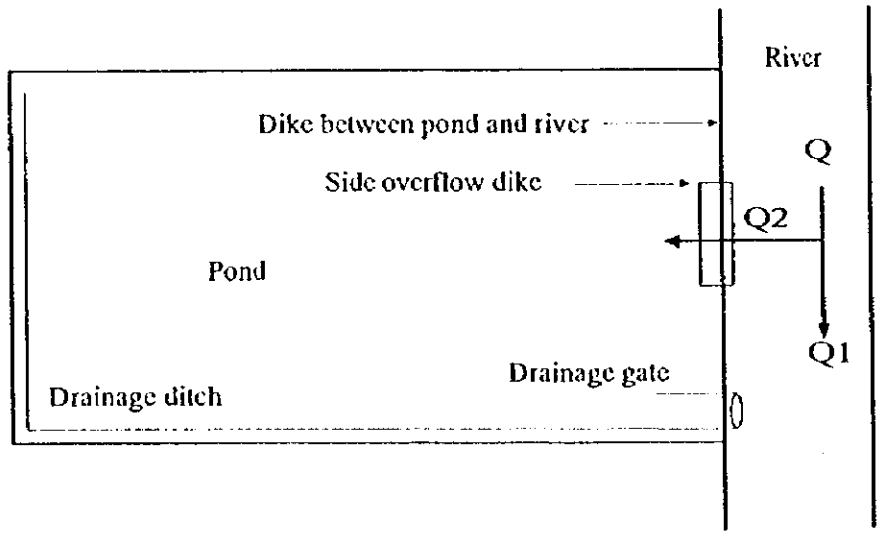


Figure 3.16 Conceptural Figure of Regulating Pond

Table 3.12 **Major Features of Regulating Pond**

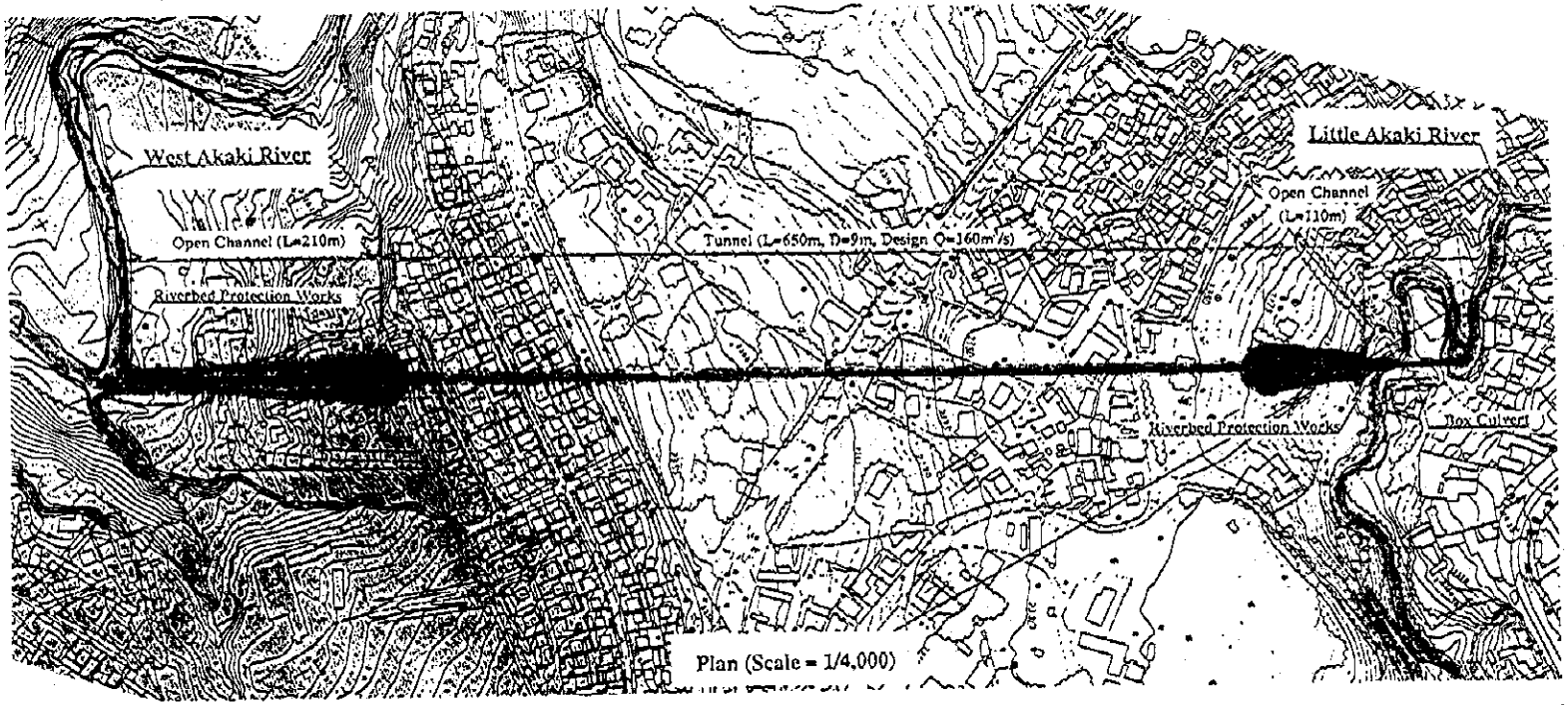
	Kostre	Kurtume No. 1	Kurtume No. 2	Kurtume No. 3	Kurtume No. 4	Bantyi-ketu	Little Akaki
Storage (m^3)	21,000	7,200	23,000	12,000	7,200	54,000	54,000
Surface Area (m^2)	7,900	4,300	9,200	5,000	2,500	29,000	13,500
Design Discharge into Pond (m^3/sec)	14	6	17	9	6	35	22

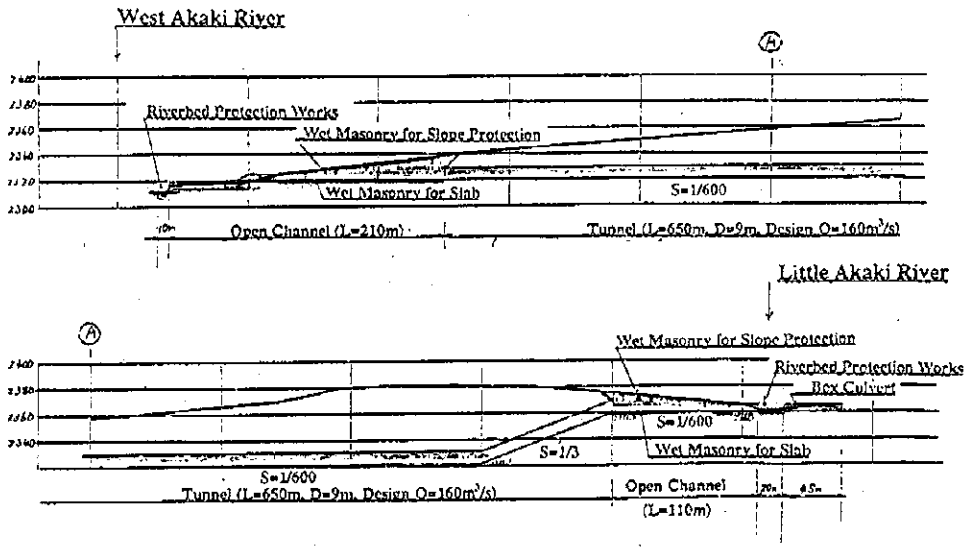
(3) Flood Diversion

In the alternative plans, a flood diversion tunnel with design discharge of 160 m^3/sec, inside diameter of 9 meters and length of 650 meters, is proposed to divert floods from the Little Akaki river to the West Akaki river. Both upstream and downstream from the tunnel extends open channels, 320 meters in total. The floor and side slopes of the open channels are lined with wet masonry for protection. A minimum 10 meters of overlaying soils thickness is attained above the crown of the tunnel. Gabion mats are furnished on the riverbed adjacent to the open channels both upstream and downstream to prevent souring of riverbed.

The longitudinal slope of the tunnel floor is 1/600 except the first 100 meters long portion adjacent to the inlet portal where the longitudinal slope of the tunnel is 1/3. If the slope of the tunnel is 1/600 in its entire length to constrain flow velocity inside the tunnel below 5 m/sec as stipulated in the aforementioned Japanese Design Standard, total length of tunnel is about 200 meters and the rest become an open channel. This causes a significant magnitude of resettlement of houses and relocation of public facilities, which is socially unacceptable at all.

The plan and the longitudinal section of the Little Akaki flood diversion tunnel are shown in Figure 3.17. The preliminary design of regulating pond is conducted using the topographic maps with a scale of 1:2,000 published in 1995 for Addis Ababa Water Supply Project Stage IIIA. Main features of flood diversion tunnel are summarized in Table 3.13.





Profile (Scale = 1/4,000)

Figure 3.17 Plan and Profile of Little Akaki Flood Diversion

Table 3.13 Major Features of Flood Diversion

Total Length of Flood Diversion	980 m	
Tunnel	Length	: 650 m
	Slope	: 1/3 (first 100 m from tunnel inlet) : 1/600 (other portion)
	Diameter	: 9 m
Open Channel	Upstream of Tunnel	
	- Length	: 110 m
	- Slope	: 1/600
	Downstream of Tunnel	
	- Length	: 210 m
	- Slope	: 1/600
Design Discharge	160 m^3/sec	

(4) River Channel Improvement

The river channel improvement works consist of channel excavation, embankment (dike), construction of flood protection wall and riverbank protection. To control velocity in the river channel is also inevitable measure. Drop structures will be constructed as needed. Further, it is desired that some bridges with small span which act as a velocity and flow control, be left as they are. Conceptual Figures of river channel improvement works are shown in Figure 3.18.

Food water level for river channel is calculated applying uniform flow calculation by Manning's formula.

$$Q = A \times R^{2/3} \times I^{1/2} / n$$

where,

Q : *discharge* (m^3/*sec*)

A : *flow area* (m^2)

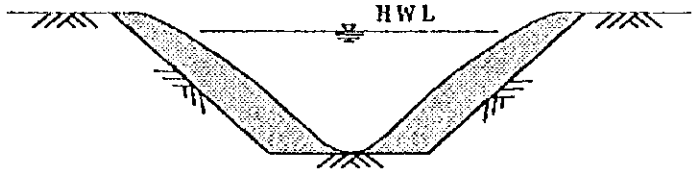
R : *hydraulic radius* (*m*)

I : *slope of riverbed*

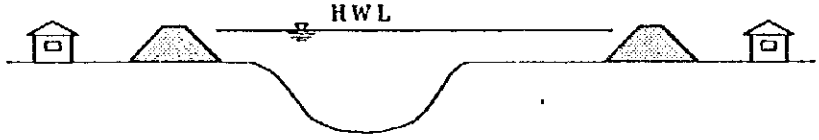
n : *Manning's coefficient of roughness*

Considering existing river conditions, the Manning's coefficient of roughness after river channel improvement is assumed 0.040. A type of river channel improvement work for river stretch is decided in considerations of design discharge, present carrying capacity of river channel and conditions of riverine areas. Design flood levels are calculated for different river stretches with their design discharges, respectively.

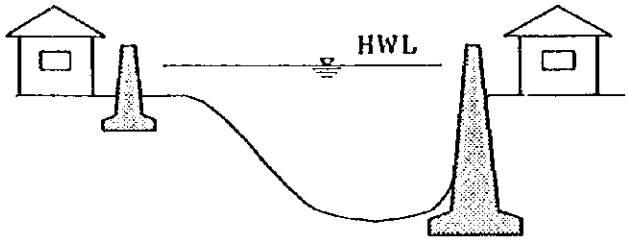
Channel Excavation



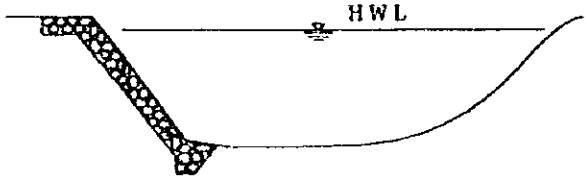
Earth Dike



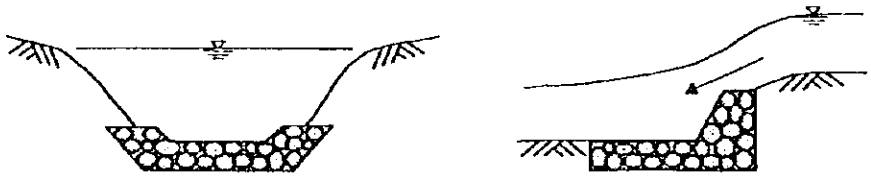
Flood Wall



Slope Protection



Drop Structure



Velocity Control Structure

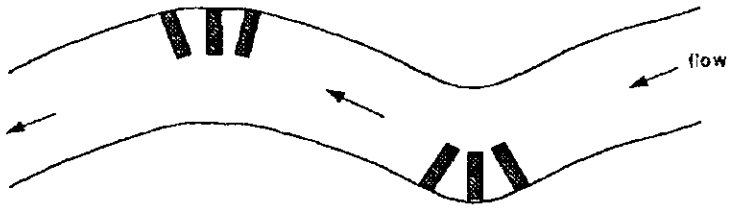


Figure 3.18 Conceptual Figures of River Channel Improvement Works

The river channel improvement works for the alternative plans are summarized in Table 3.14.

Table 3.14 Major Features of River Channel Improvement

River system	Alternative 1		Alternative 2	
Bantyiketu	(Kurtume River)		(Kurtume River)	
	Flood Wall	: 1,100 m	Flood Wall	: 800 m
	Bank Protection for Bridge	: 10	Bank Protection for Bridge	: 10
	Velocity Control Structures	: 10	Velocity Control Structures	: 10
	(Kechene River)		(Kechene River)	
	Flood Wall	: 1,500 m	Flood Wall	: 980 m
	Bank Protection for Bridge	: 7	Bank Protection for Bridge	: 7
	Repair of Bridge Abutment	: 1	Repair of Bridge Abutment	: 1
	Velocity Control Structures	: 10	Velocity Control Structures	: 10
	(Bantyiketu River)		(Bantyiketu River)	
	Excavation	: 65,000 m^3	Excavation	: 33,500 m^3
	Flood Wall	: 2,450 m	Flood Wall	: 1,950 m
	Reconstruction of Intake	: 1	Reconstruction of Intake	: 1
	Reconstruction of Aqueduct	: 1	Reconstruction of Aqueduct	: 1
	Bank Protection	: 300 m	Bank Protection	: 300 m
Kebena	Flood Wall	: 3,100 m	Flood Wall	: 2,400 m
	Bank Protection for Bridge	: 12	Bank Protection for Bridge	: 12
	Velocity Control Structures	: 10	Velocity Control Structures	: 10
Little Akaki	Flood Wall	: 1,050 m	Excavation	:215,000 m^3
	Bank Protection for Bridge	: 9	Flood Wall	: 1,650 m
	Velocity Control Structures	: 16	Bank Protection for Bridge	: 9
			Velocity Control Structures	: 16
Hanku	Reconstruction of 2 Culverts			

3.3.4 Drainage Improvement

(1) Basic Concept

Flood control measures will mitigate the damage due to the overflowing of flood from rivers, but it does not always mitigate the damage due to the inundation resulting from the poor condition of drainage. But since the objective of this Study is the preparation of flood control master plan and is not the preparation of drainage master plan, the drainage improvement is here proposed very locally just as the auxiliary measures for to enhance the flood control plan in Addis Ababa.

(2) Objective Area

The local drainage area that drains to the Bantyiketu river in the reaches between the confluence of the Kurtume and the Kechene rivers and the Finfine bridge site on the Menelik II avenue has poor condition of drainage of local storm. This area is one of the most important areas in Addis Ababa from the view point of existence of important agencies of the central government of Ethiopia and the international agencies, and the place of importance of the road and railway transportation.

In due consideration of the above from the socio-economic viewpoint, this area is selected for the objective area for drainage improvement. The drainage area is identified by existing topographic maps with a scale of 1:2,000 and is shown in Figure 3.19.

(3) Design Scale

In due consideration of the balance with the design scale of flood control plan in Addis Ababa and the rainfall intensity generally adopted in other countries, rainfall intensity of 30 mm/hour is adopted for the design scale for drainage improvement. This corresponds to the return period of 1.5 years.

(4) Methodology and Basic Features

In consideration of low cost and easy maintenance in future, road side ditch is proposed as the structural measures for drainage improvement. In addition, the road side ditch is proposed just as the terminal drainage ways to the Bantyiketu river. It is considered that secondary and tertiary drainage ways would be prepared or improved after drainage master plan is formulated in future. Basic features of the drainage improvement are shown in Table 3.15.

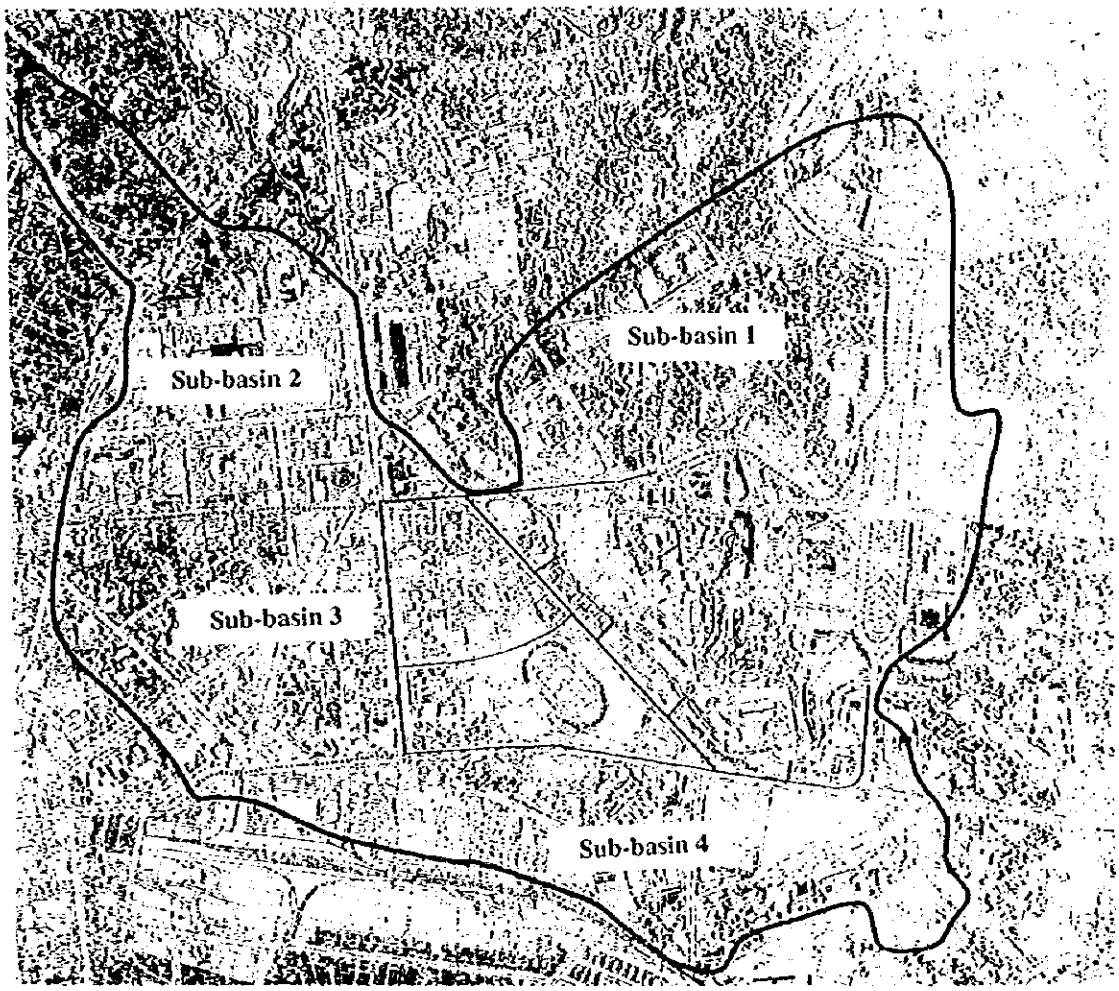


Figure 3.19 **Drainage Basin for Drainage Improvement and Proposed Alignment of Drainage Ditch**

Table 3.15 Major Features of Drainage Improvement

Drainage Basin	2.48 km^2 consisting of 4 sub-basins
Length of Drainage Ditch	Total Length 4,000 m
Design Discharge	2.6 m^3/sec for sub-basin 1 3.1 m^3/sec for sub-basin 2 3.6 m^3/sec for sub-basin 3 3.1 m^3/sec for sub-basin 4
Typical Section of Drainage Ditch	Width : 0.7 m Depth : 0.7 m

3.3.5 Cost Estimate

(1) Conditions and Assumption for Cost Estimate

Project construction cost comprises 1) construction cost, 2) resettlement cost, 3) engineering services cost, 4) administration cost, 5) physical contingency and 6) price contingency. The following are the conditions and assumption for the project cost estimate

- Project cost is estimated at the price level as of June 1997.
- Exchange rate used in the cost estimate is shown as follows:
  US$ 1.0 = Birr 6.8 = J.Yen 114.7-.
- Construction works will be executed on contract basis through international competitive bidding. All the labor, materials and equipment required for the construction works will be provided by the contractors themselves. The construction cost is estimated as a construction contract price.
- Resettlement cost does not include land acquisition cost, because the whole land belongs to the government of Ethiopia.
- Engineering services, such as design and supervision, will be executed on international contract basis. The engineering services cost is estimated at 15% of construction cost. The engineering services cost is estimated as an engineering services contract price.
- Administration cost is estimated at 10% of construction cost.
- Cost is estimated in foreign currency and local currency portions. The foreign currency portion includes foreign labor wages, imported materials and equipment cost, international transportation cost and contractors' indirect cost. The local currency portion includes local labor wages, local materials cost, inland

transportation cost, contractors' indirect cost, resettlement cost and administration cost.

- Physical contingency is provided as 20% of the total of construction cost, resettlement cost engineering services cost and administration cost.
- Price contingency is calculated based on the escalation rates of 3% per annum for foreign currency portion and of 6% for local currency portion.

(2) Unit Prices of Major Construction Works

Construction unit prices of major works are estimated through unit rate analysis and through comparison with some unit prices of past contract examples. Major construction unit prices are listed below.

Table 3.16 Unit Prices of Major Construction Works

Unit: Birr

	Work item	Unit	F/C portion	L/C portion	Total
1.	Excavation, common, hauling 7.5km	m^3	31	17	48
2.	Excavation, rock, hauling 5km	m^3	84	24	108
3.	Form for ordinary concrete	m^2	23	109	132
4.	Ordinary concrete, 240kg, crane	m^3	147	919	1,066
5.	Reinforcing bar, deformed	kg	0	7	7
6.	Wet masonry	m^3	0	423	423

3.3.6 Selection of Structural Measures

As discussed in the previous section, two alternative plans of structural measures are provided for the five rivers in the three river systems, respectively. Comparative study of the alternative plans is conducted applying the evaluation criteria described below. The evaluation criteria are provided on the condition that both two alternative plans by river have same effectiveness for flood control, namely, economic benefits of two alternatives are equivalent in flood damage reduction.

For the purpose of comparative study, evaluation points are given to each alternative plan according to the items of the evaluation criteria. Selection of structural measures by river is concluded on the basis of the total of the evaluation points for all the items of the evaluation criteria. An alternative plan indicating higher score is selected for each river.

Table 3.17 Evaluation Criteria for Alternative Plans

Item	Description	Evaluation Point
(1) Technical Aspect		
Ordinary	Design and construction of structures are not so difficult and can be conducted by means of normal technique prevailing in Ethiopia.	5
Difficult	Design and construction of structure require some particular technique or machinery that are not commonly available in Ethiopia.	3
(2) Financial Aspect		
Not Costly	Cost is less than that of another alternative plan.	7
Costly	Cost is higher than that of another alternative plan.	5
(3) Social Impact		
Small	Number of houses subject to resettlement is smaller than those of another alternative plan.	5
Large	Number of houses subject to resettlement is larger than those of another alternative plan.	0

As a conclusion of comparative study, the followings are selected as the structural measures of flood control plan for the respective rivers as shown in Table 3.18. The results of comparative study are summarized in Table 3.19.

Table 3.18 Selected Structural Measures by River

River	Selected Alternative	Structural Measures
Kechene River	Alternative 2	1 Reservoir by Weir
		1 Regulating Pond
		River Channel Improvement
Kurtume River	Alternative 2	4 Regulating Ponds
		River Channel Improvement
Bantyiketu River	Alternative 2	1 Regulating Pond
		River Channel Improvement
Kebena River	Alternative 1	2 Reservoirs by Weir
		River Channel Improvement
Little Akaki River	Alternative 1	1 Regulating Pond
		1 Flood Diversion
		River Channel Improvement

Table 3.19 (1/2) Summary of Comparative Study of Alternative Plans

Kurtume River

Item	Alternative 1	Alternative 2
Outline of Structural Measures	2 Regulating Ponds River Channel Improvement	4 Regulating Ponds River Channel Improvement
(1) Technical Aspect Difficulty (Point)	Ordinary (5)	Ordinary (5)
(2) Financial Aspect Cost (Point)	31 Million Birr Costly (5)	29 Million Birr Not Costly (7)
(3) Social Impact Resettlement (Point)	70 houses Large (0)	20 houses Small (5)
Total Point	10	17
Selection		Selected

Kechene River

Item	Alternative 1	Alternative 2
Outline of Structural Measures	1 Reservoir by Weir 1 Regulating Pond River Channel Improvement	1 Reservoir by Weir 1 Regulating Pond River Channel Improvement
(1) Technical Aspect Difficulty (Point)	Ordinary (5)	Ordinary (5)
(2) Financial Aspect Cost (Point)	53 Million Birr Costly (5)	42 Million Birr Not Costly (7)
(3) Social Impact Resettlement (Point)	30 houses Large (0)	5 houses Small (5)
Total Point	10	17
Selection		Selected

Bantyketu River

Item	Alternative 1	Alternative 2
Outline of Structural Measures	River Channel Improvement	1 Regulating Pond River Channel Improvement
(1) Technical Aspect Difficulty (Point)	Ordinary (5)	Ordinary (5)
(2) Financial Aspect Cost (Point)	48 Million Birr Costly (5)	47 Million Birr Not Costly (7)
(3) Social Impact Resettlement (Point)	30 houses Large (0)	2 houses Small (5)
Total Point	10	17
Selection		Selected

Note: Cost consists of construction cost, resettlement cost, engineering service cost, administration cost and physical contingency.

Table 3.19 (2/2) Summary of Comparative Study of Alternative Plans

Kebena River

Item	Alternative 1	Alternative 2
Outline of Structural Measures	2 Reservoirs by Weir River Channel Improvement	3 Reservoirs by Weir River Channel Improvement
(1) Technical Aspect Difficulty (Point)	Ordinary (5)	Ordinary (5)
(2) Financial Aspect Cost (Point)	136 Million Birr Not Costly (7)	156 Million Birr Costly (5)
(3) Social Impact Resettlement (Point)	10 houses Small (5)	80 houses Large (0)
Total Point	17	10
Selection	Selected	

Little Akaki River

Item	Alternative 1	Alternative 2
Outline of Structural Measures	1 Regulating Pond 1 Flood Diversion River Channel Improvement	1 Regulating Pond River Channel Improvement
(1) Technical Aspect Difficulty (Point)	Difficult (3)	Ordinary (5)
(2) Financial Aspect Cost (Point)	128 Million Birr Costly (5)	89 Million Birr Not Costly (7)
(3) Social Impact Resettlement (Point)	10 houses Small (5)	100 houses Large (0)
Total Point	13	12
Selection	Selected	

Note: Cost consists of construction cost, resettlement cost, engineering service cost, administration cost and physical contingency.

3.4 Non-structural Measures

3.4.1 River Management

Proposed facilities involved in the flood control master plan must be operated and maintained so as to discharge design flood safely and function properly in line with the respective purposes. In this viewpoint, the following measures are proposed.

(1) Authorization of River Zone (Region 14 Administration Level)

For the purpose of river management, it is necessary to delineate the river zone covering river channel and some extent on both riverbanks. The river zone is utilized for operation and maintenance of river channel and facilities, flood fighting and other activities related to river management.

In order to achieve this purpose, an authorization of the river zone is required with a legislation of municipal bylaw. AFCPO, Steering Committee and concerned organizations in Region 14 Administration are in charge of such legislation. This legislation is proposed to start as soon as possible. Delineation of river zone area is proposed as follows.

Location with flood wall : 5 meters outside from wall
Location without wall : 5 meters outside from river bank line

In relation with the above legislation, it is desired to prohibit to construct private facilities and to pitch garbage and soil in the authorized area or into the river channel, which are described below.

(2) Social Education for River and Flood (Region 14 Administration and Community Level)

It is one of important activities to enhance public awareness for river and flood. Rivers need to be regarded as public properties, namely, not only drainage ways but open spaces with green area in the city.

Firstly, it is desired to enlighten public awareness for rivers. It is proposed to hold forum and ceremony or concert to "Love River". Also campaigns through mass media of TV and radio are proposed to enlighten the public awareness.

Secondly, it is proposed to prohibit disposal of solid waste and soil into the river zone, with a legislation of municipal bylaw in connection with the said authorization of river zone.

AFCPO and the related communities are recommended to be in charge of such enlightenment under directions of the Steering Committee. This activity is recommended to start as soon as possible.

(3) Guideline of Structural Design (AFCPO of Region 14 Administration)

The flood control facilities are desired to design and construct appropriately for their purposes. For this purpose, a guideline of design needs to be prepared for major structures involved in the proposed flood control master plan.

It seems that the Ethiopian guidelines presently available are not sufficient for the said river structures. For the flood control master plan, the guidelines for weir and tunnel are quoted from Design Standard of River and Sabo Structures edited by Ministry of Construction, Government of Japan. Some Ethiopian design standards are also useful for design of flood wall and drainage facilities.

3.4.2 Watershed Management (Bureau of Agriculture of Region 14 Administration)

Conservation of soil and flood retention function in the mountain areas is an essential part of the non-structural measures from the viewpoint of not only flood control to directly reduce runoff to downstream reaches but also environment. Accordingly, reforestation of the deforested areas in the mountain areas and planting of trees in the open spaces of urban areas are proposed.

The reforestation in Addis Ababa is presently conducted by the different organizations for the purposes of fuel wood production, soil conservation and recovery of indigenous woodland. In the Region 14 Administration, the Bureau of Agriculture is implementing the reforestation.

From the practical viewpoint these reforestation activities are proposed to continue to the future but may require coordination and integration.

3.4.3 Flood Risk Management

(1) Flood Warning System (Region 14 Administration and Community Level)

The floods in the mountainous areas are brought to the urban areas in short time with from 1 to 2 hours. Therefore, it is quite difficult to promptly forecast flood scale. In this regard, a warning system by siren is a practical tool of flood damage mitigation. The warning is made when the accumulated rainfall amount exceeds 8 mm per 10 minutes. This activity is proposed to proceed by AFCPO and the community level (Kebele) in line with the existing available National Disaster Prevention and Preparedness Management Policies.

In this system, 3 rainfall observatory stations are installed in the mountain areas of the Kebena, Kechene and Little Akaki rivers. Along 6 major river channels of the Bantyiketu, Kechene, Kurtume, Kebena, Little Akaki including a part of West Akaki and Hanku rivers, small towers for siren and electrical lines are installed with an approximate distance of 500 meters.

The following are the required works.

a)	Rainfall observatory station with telephone	:	3 places
b)	Total length of system	:	40,000 m
c)	Small tower with siren	:	60 nos.
d)	Electrical line	:	40,000 m

Installation of the warning system is proposed to carry out by AFCPO and its implementation is proposed to start in the preparatory stage of priority projects.

(2) Flood Fighting (Community Level)

It is a valuable activity to carry out flood fighting, to minimize flood damage to be brought in the flooding time. This activity is proposed to proceed in the community level (Kebele) in line with the existing available National Disaster Prevention and Preparedness Management Policies. Further, it is necessary to train riverine people through periodical exercise.

AFCPO under directions of Steering Committee is proposed to take a leadership in the activity, in cooperation with the existing available organization of National Committee

for Early Warning (NCEW) in the said National Disaster Prevention and Preparedness Management Policies. This activity is also proposed to start from the coming rainy season and the exercise, as soon as possible before the coming rainy season.

The construction of storage houses with necessary materials and tools are required for this activity. The storage houses to be constructed are 2 each in the respective rivers of the Kurtume, Kechene, Bantyiketu, Kebena, Little Akaki and Hanku rivers.

(3) Storage of Storm Water in the Basin (Community Level)

It is also desired to temporarily store storm water at gardens in private houses, open spaces in public facilities and campuses of universities. Water thus kept is also very useful for various domestic use. Such devise has a surprising effect not only to decrease run-off into the rivers but also to save water consumption in domestic purposes.

In this activity, a campaign of enlightenment for community level will be a main work. Works and Urban Development Bureau is desired to take a leadership as a main implementation body. This activity is also proposed to start from the coming rainy season.

3.5 Summary of Flood Control Master Plan

3.5.1 Structural Measures

The features of the structural measures of the flood control master plan are summarized as follows. Locations of the proposed structures are shown in Figure 3.20.

Table 3.20 (1/2) Proposed Structural Measures

River System	Proposed Structural Measures			
	Reservoir by Weir	Regulating Pond	Channel Improvement	Others
Bantyiketu				
Kurtume River		• Kurtume No.1 Regulating Pond - Storage: 7,200 m^3 • Kurtume No.2 Regulating Pond - Storage: 23,000 m^3 • Kurtume No.3 Regulating Pond - Storage: 12,000 m^3 • Kurtume No.4 Regulating Pond - Storage: 7,200m^3	• Floodwall - 800 m • Bank Protection for Bridge - 10 bridges • Velocity Control Structure - 10 locations	
Kechene River	• Kechene Weir - Storage: 115,000 m^3	• Kostre Regulating Pond - Storage: 21,000 m^3	• Floodwall - 980 m • Bank Protection for Bridge - 7 bridges • Velocity Control Structure - 10 locations	• Repair of Bridge Abutment - 1 bridge
Bantyiketu River		• Bantyiketu Regulating Pond - Storage: 54,000 m^3	• Excavation - 33,500 m^3 • Floodwall - 1,950 m • Bank Protection - 300 m	• Drainage Improvement - Road Side Ditch: 4,000 m • Rehabilitation of Aqueduct - 1 location

Table 3.20 (2/2) Proposed Structural Measures

River System	Proposed Structural Measures			
	Reservoir by Weir	Regulating Pond	Channel Improvement	Others
Kebena Kebena River	• Kebena No.1 Weir - Storage: 212,000 m³ • Abo Weir - Storage: 332,000 m³		• Floodwall - 3,100 m • Bank Protection for Bridge - 12 bridges • Velocity Control Structure - 10 locations	
West Akaki West Akaki River				• (Land Use Regulation)
Little Akaki Little Akaki River		• Little Akaki Regulating Pond - Storage: 54,000 m³		• Flood Diversion - 970 m Channel: 320 m Tunnel: 650 m
Hanku Hanku River				• Reconstruction of 2 Culverts • (Land Use Regulation)

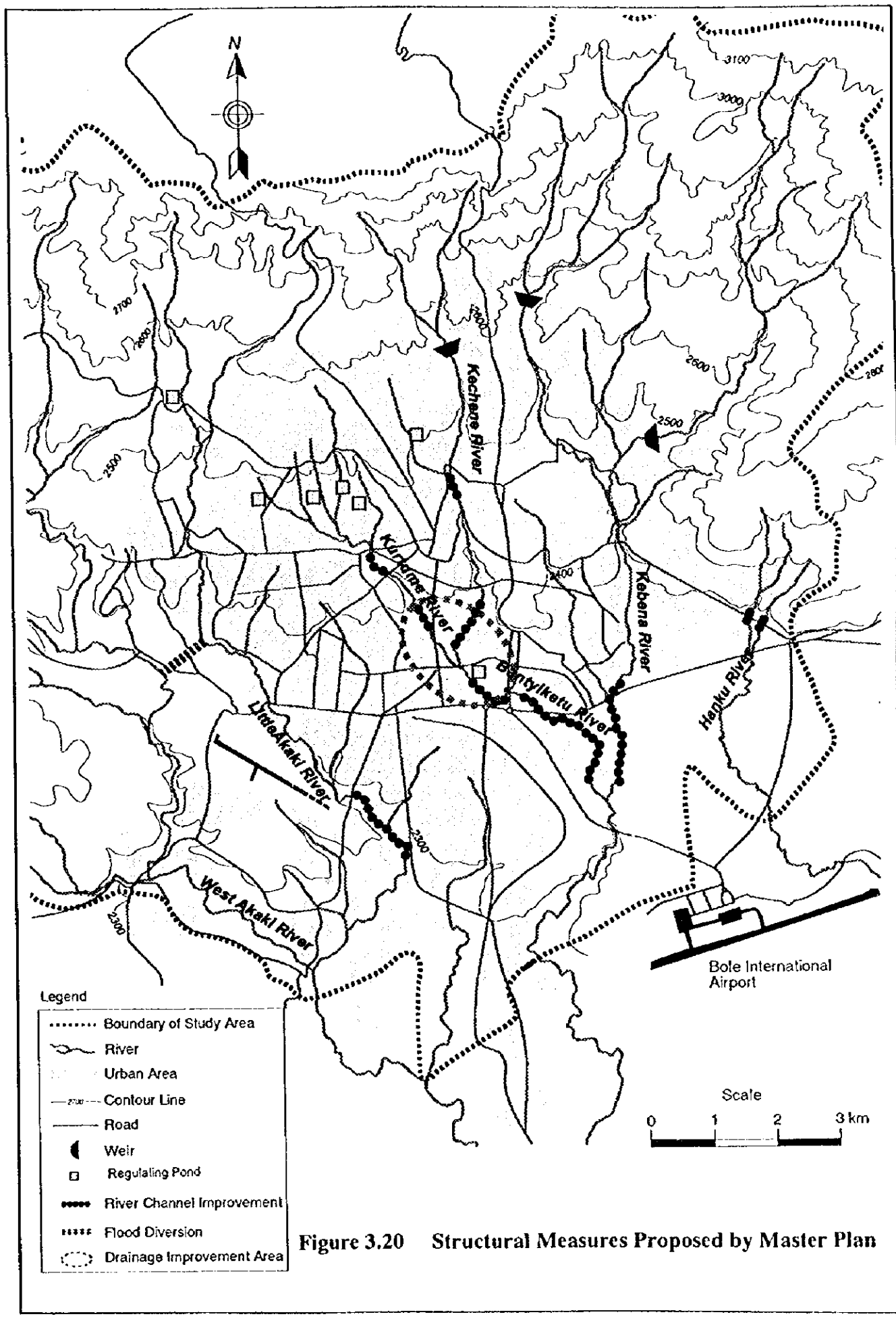


Figure 3.20 Structural Measures Proposed by Master Plan

3.5.2 Non-structural Measures

The features of the non-structural measures of the flood control master plan are summarized as follows.

Table 3.21 Proposed Non-structural Measures

Proposed Non-structural Measures	Descriptions
River Management	
Authorization of River Zone	Delineation of river zone covering river channel and extent of 5 meters from both river banks for river management activities
Social Education for River and Flood	Enlightenment of public awareness for river and flood to maintain proper river conditions
Guidelines of Structural Design	Preparation of guidelines for design of river channel and river structures
Watershed Management	
Reforestation	Recovery and conservation of woodland in upper basins
Flood Risk Management	
Flood Warning System	Installation of rainfall gauges, communication lines and sirens for flood warning activities
Flood Fighting System	Sand bagging, temporary protection for erosion and evacuation etc. to be organized by community
Storm Water Storage	Provision temporary storage at open spaces in public facilities

3.6 Project Cost

3.6.1 Structural Measures

The project cost is estimated as the sum of construction cost, resettlement cost, administration cost, engineering service cost, physical contingency and price contingency.

Implementation of the structural measures in the master plan is expected to commence after completion of this Study in May 1998. Construction of priority project(s) will start in the year 2000. All the structural measures in the master plan will be completed in the end of the year 2020. The period of implementation therefore amounts to 23 years. Implementation of the structural measures will be proceeded by river system according to the priority order as discussed in the succeeding section 4.1. For each river system, period of implementation including pre-construction and construction stages is scheduled as follows. Details of the implementation plan are described in the succeeding section 3.9.

a) Bantyiketu River System : 1998 - 2004
b) Little Akaki River System: 2003 - 2011
c) Hanku River System : 2010 - 2013
d) Kebena River System : 2012 - 2020

In compliance with the implementation plan, the project cost for the structural measures in the master plan is estimated. The project cost for structural measures amounts to 751.2 million Birr for the structural measures as shown in Table 3.22.

Table 3.22 Project Cost for Structural Measures

(Unit: 1,000 Birr)

	F/C	L/C	Total
1. Bantyiketu river system			
(1) Construction cost	27,938	44,588	72,526
(2) Resettlement cost	0	7,359	7,359
(3) Engineering services	9,791	1,088	10,879
(4) Administration cost	0	7,253	7,253
Total of (1) - (4)	**37,729**	**60,288**	**98,017**
(5) Contingency	7,546	12,058	19,604
Total of (1) - (5)	**45,275**	**72,346**	**117,621**
(6) Price escalation	6,981	23,978	30,959
Total of (1) - (6)	**52,256**	**96,324**	**148,580**
2. Kebena river system			
(1) Construction cost	14,585	72,625	87,210
(2) Resettlement cost	0	4,297	4,297
(3) Engineering services	11,774	1,308	13,082
(4) Administration cost	0	8,721	8,721
Total of (1) - (4)	**26,359**	**86,951**	**113,310**
(5) Contingency	5,272	17,390	22,662
Total of (1) - (5)	**31,631**	**104,341**	**135,972**
(6) Price escalation	25,225	230,879	256,104
Total of (1) - (6)	**56,856**	**335,220**	**392,076**
3. Little Akaki river system			
(1) Construction cost	46,994	36,249	83,243
(2) Resettlement cost	0	2,946	2,946
(3) Engineering services	11,237	1,249	12,486
(4) Administration cost	0	8,324	8,324
Total of (1) - (4)	**58,231**	**48,768**	**106,999**
(5) Contingency	11,646	9,754	21,400
Total of (1) - (5)	**69,877**	**58,522**	**128,399**
(6) Price escalation	26,674	52,928	79,602
Total of (1) - (6)	**96,551**	**111,450**	**208,001**
4. Hanku river system			
(1) Construction cost	217	583	800
(2) Resettlement cost	0	0	0
(3) Engineering services	108	12	120
(4) Administration cost	0	80	80
Total of (1) - (4)	**325**	**675**	**1,000**
(5) Contingency	65	135	200
Total of (1) - (5)	**390**	**810**	**1,200**
(6) Price escalation	215	1,124	1,339
Total of (1) - (6)	**605**	**1,934**	**2,539**
5. Whole of master plan			
(1) Construction cost	89,734	154,045	243,779
(2) Resettlement cost	0	14,602	14,602
(3) Engineering services	32,910	3,657	36,567
(4) Administration cost	0	24,378	24,378
Total of (1) - (4)	**122,644**	**196,682**	**319,326**
(5) Contingency	24,529	39,337	63,866
Total of (1) - (5)	**147,173**	**236,019**	**383,192**
(6) Price escalation	59,095	308,909	368,004
Total of (1) - (6)	**206,268**	**544,928**	**751,196**

Note: - Price level; June 1997, US$ 1.0 = Birr 6.8 = J.Yen 114.7
- Tax is included in the cost.

3.6.2 Non-structural Measures

The non-structural measures in the master plan will be implemented in parallel with the structural measures up to the year 2020.

As mentioned previous section, several kinds of instruments and materials need to be installed for implementation of the proposed non-structural measures. The project cost for non-structural measures is estimated as installation cost for required instruments and materials as shown in Table 3.23. The project cost for the non-structural measures in the master plan amounts to 11.9 million Birr.

Table 3.23 Project Cost for Non-structural Measures

(Unit: Thousand Birr)

Item	Bantyi-ketu	Kebeba	Little Akaki	Hanku	Total
1. River management					
- Staking for administrative river zone	96	36	48	0	180
2. Watershed management					
- Nursery preparation for reforestation	22	46	24	8	100
3. Flood risk management					
- Flood warning system					
Rainfall observatory station (3 nos.)	31	31	31	0	93
Tower with siren (60 nos.)	2,080	780	1,040	0	3,900
System line (40 km)	706	335	409	56	1,506
- Flood fighting system					
Storage house (12 nos.)	600	200	300	100	1,200
Total of (1. – 3.)	**3,535**	**1,428**	**1,852**	**164**	**6,979**
4. Physical contingency	707	286	370	33	1,396
Total of (1. – 4.)	**4,242**	**1,714**	**2,222**	**197**	**8,375**
5. Price Contingency	1,773	716	929	82	3,500
Total of (1. – 5.)	**6,015**	**2,430**	**3,151**	**279**	**11,875**

3.6.3 Project Cost for the Master Plan

As a conclusion of the project cost estimate, the project cost for the master plan amounts to 763.1 million Birr consisting of 751.2 million Birr for the structural measures and 11.9 million Birr for the non-structural measures.

On the other hand, the annual operation and maintenance cost is estimated at 1.42 million Birr/year consisting of 1.27 million Birr/year for the structural measures and 0.15 million Birr/year for the non-structural measures, respectively.

3.7 Organization and Institution

3.7.1 Organizational Framework

(1) Present Situation

The Region 14 Administration initiated the Addis Ababa Flood Control and Prevention Project after the serious flood occurred in August 1994. The project follows the policy of the National Disaster Prevention Preparedness and Management and aims at implementing restoration of flood damages in 1994 including urgent flood protection measures and resettlement of inhabitants who lost their houses due to the flood. In addition, investigation and implementation of long-term flood control measures are also the objectives of the project.

The Steering Committee of Addis Ababa Flood Control and Prevention Project was established at the commencement of the said project with its role of policy and decision-making for plan and implementation of flood protection measures. Under the Steering Committee, the Addis Ababa Flood Control and Prevention Project Office (AFCPO) was organized. AFCPO is responsible for plan and implementation of flood protection measures on practical basis.

Beside the above-mentioned organizations, there are community organizations under the present institutional system in Ethiopia. The National Disaster Prevention and Preparedness Management is supported by the institutional system (Zone, Wereda and Kebele) to make hierarchical ordering of disaster prevention activities to communities.

(2) Necessary Roles for Implementation of Flood Control Master Plan

According to the present organizational framework described above, the Steering Committee of the Addis Ababa Flood Control and Prevention Project will be a responsible organization to control the implementation of the flood control master plan. The role of the Steering Committee will cover establishment of implementation policy for the entire scope of the flood control master plan and decision-making for necessary procedures including budgeting, legal arrangement, coordination with relevant organizations and other administrative matters.

AFCPO will be in charge of all the practical works for the implementation of the flood control master plan. Its role will cover river management, project management, and operation and maintenance for both structural and non-structural measures.

The community organizations will practice actual activities of the non-structural measures of flood warning, flood fighting and public education. AFCPO will consult the communities to popularize the non-structural measures and supervise their activities. The Steering Committee will help to provide necessary institutional arrangement for such non-structural measures.

(3) Requirements for Organizational Framework

AFCPO has carried out the restoration and urgent flood protection works after the 1994 flood under the Steering Committee headed by the President of the Region 14 Administration. As mentioned above, the role of AFCPO also covers investigation and implementation of long-term flood protection measures in Addis Ababa. However, the present activities of AFCPO are likely to be limited to local works like design and construction supervision of flood protection wall. The organization of AFCPO has not been fully constructed due to insufficient assignment of experts and supporting staffs prescribed in the present organization structure. A major reason of such status of AFCPO is that authorized long-tem plan for flood protection has not been available in Addis Ababa.

It is strongly recommended that the organizational framework should be reconstructed and reinforced for the implementation of the flood control master plan. As seen in the present organization of the Region 14 Administration, the bureaus and authorities under the Economic Sector undertake the public works in Addis Ababa. The bureaus and authorities have powers and are sufficiently staffed for achieving their responsibilities.

The flood control master plan will be implemented as public works in Addis Ababa. The role of the Steering Committee and AFCPO, which are presently designated as organization in charge of flood protection, will cover the various kind of responsibilities for both structural and non-structural measures. Especially, AFCPO will have the responsibilities for all the practical works for the implementation. However, it is difficult for the present AFCPO to achieve the responsibilities further required.

Consequently, it is proposed that the organizational framework for the flood control master plan will be formulated in the similar manner to the present bureaus or authorities in the Region 14 Administration in terms of responsibilities, powers and staffing.

As a proposal by this Study, a new organizational framework is shown in Figure 3.21. This comprises 'Addis Ababa River Board' entirely controling the implementation of the flood control master plan, and 'Addis Ababa River Management Authority' executing practical works for the implementation such as plan, design, construction supervision, operation and maintenance.

3.7.2 Institutional Framework

(1) Present Situation

River management comprises various aspects related to river. Major items of river management are described as follows:

a) Flood
b) Watershed conservation
c) Water use
d) River and related structures
e) River environment

At present, AFCPO of the Region 14 Administration is designated as the organization in charge of river management in Addis Ababa. However, institutional and legal background for river management has not been fully established in Addis Ababa. The present activities of AFCPO are therefore quite limited as described before in terms of river management.

The Addis Ababa Master Plan authorized in 1994 has recommended the preservation of 'informal green area' along the rivers in the city.

Reforestation activities are conducted by the different organizations for the purposes of recovery of vegetation, protection of soil erosion and supply of fuel wood.

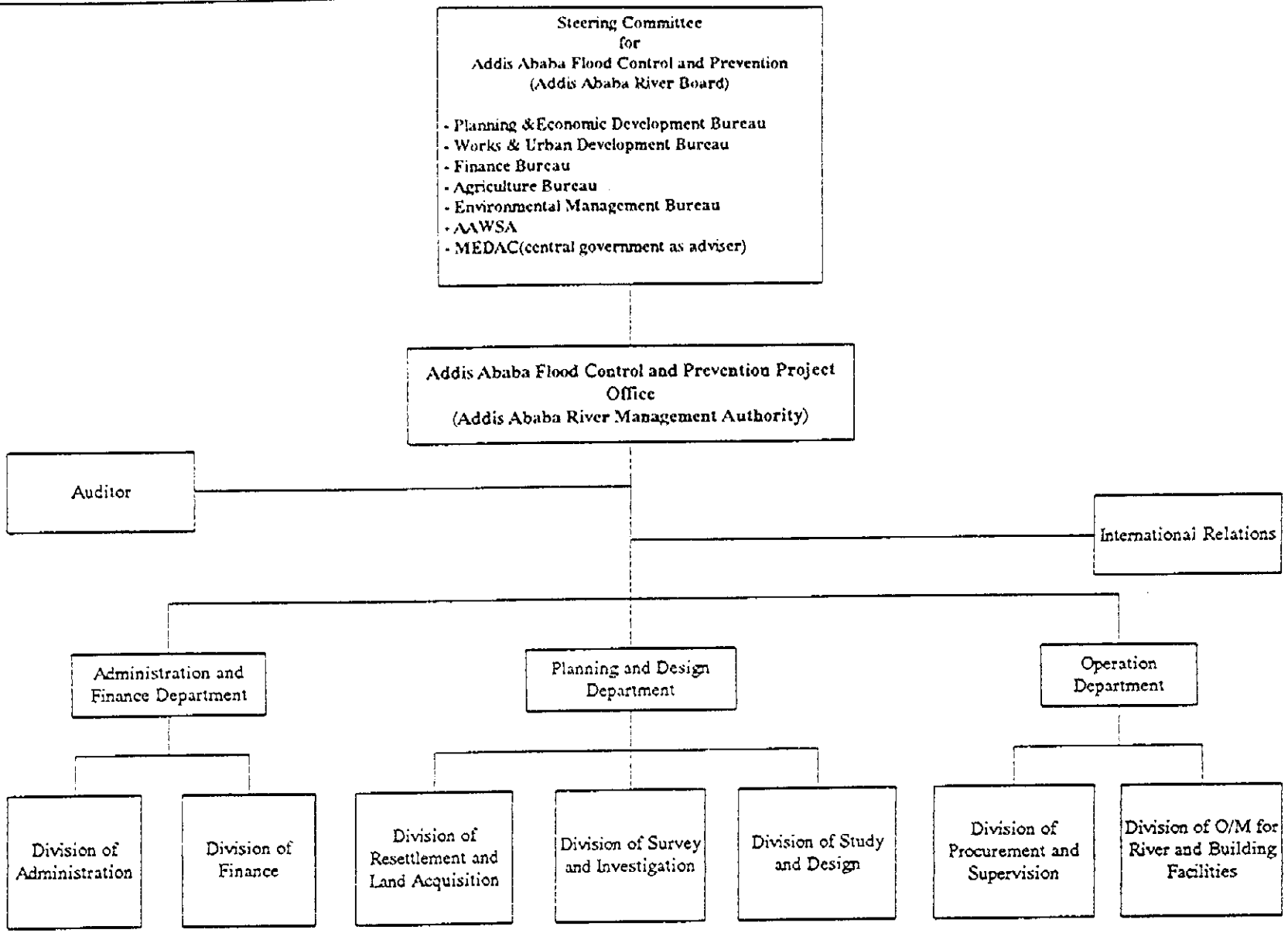


Figure 3.21 Proposed Organization Chart of Addis Ababa Flood Control and Prevention Project

The National Disaster Prevention and Preparedness Management by the federal government aims at providing precaution and relief action in case of disasters. The Addis Ababa Flood Control and Prevention Project of the Region 14 Administration was initiated according to this policy.

(2) Requirements for Institutional Framework

For the implementation of the flood control master plan, first of all, legal background for river management needs to be clarified and established. The Steering Committee and AFCPO will be authorized as organization for river management in the Region 14 Administration.

Legal arrangement for river management will be conducted by the parliament of the Region 14 Administration with the proposal of the Steering Committee. AFCPO will provide necessary information to the Steering Committee on the basis of investigations and studies for individual matters on river management.

Authorization of river zone is a base of river management and needs to be enforced in the earliest stage of the implementation of the flood control master plan. Regulations for land use, permissions and prohibitions will be established as bylaw of the Region 14 Administration. Necessary adjustments for river zone will be provided with informal green area designated by the Addis Ababa Master Plan.

Reforestation is presently conducted by the different organizations other than AFCPO. It is therefore proposed that these organizations will continue their reforestation activities but AFCPO will need to make consultations with them from the viewpoints of river management.

The National Disaster Prevention and Preparedness Management has the institutional system for disseminating precautions and relief actions throughout the country. Whereas, flood warning and fighting require a similar institutional system for involvement of community organizations. It is therefore proposed that flood warning and fighting will be proceeded with the National Disaster Prevention and Preparedness Management. The Steering Committee will coordinate establishment of required institutional system for flood risk management.

3.8 Operation and Maintenance

3.8.1 Structural Measures

(1) River and Related Structures

In the rivers in the Study Area, several river structures for flood protection, which are flood wall, riverbank protection and riverbed protection, have been constructed by Addis Ababa Flood Control and Prevention Project Office (AFCPO) as well as private sectors. Whereas, the structural measures by this Study consist of flood control reservoirs by weir, regulating ponds, river channel improvement including excavation, embankment (dike), riverbank protection, riverbed protection and flow velocity control structures. Other than the river structures for flood protection, there are the Gefersa dam and irrigation intake weirs for water use. Bridges, water supply pipelines and sewers across or along the rivers are also regarded as related structure to flood control plan. All these structures are concerned with flood control plan and need to be taken into consideration.

(2) Operation and Maintenance Works

River and river structures for flood protection need to be properly operated and maintained so as to keep their functions as originally designed. Basic operation and maintenance activities consist of inspection works and maintenance works.

Inspection works aim at monitoring the situation of river and river structures. Periodical inspection works are conducted for detecting obstacles (garbage, wooden log, sediment, etc.) and deterioration causing malfunction of river and river structures. Special inspection works are also required during flood in order to monitor their performance.

Maintenance works consist of periodical maintenance works and rehabilitation or reconstruction works. Cleaning of obstacles and minor repair are conducted by means of periodical maintenance works. When serious deterioration or overage is detected, rehabilitation or reconstruction works are provided.

An operation and maintenance manual prescribing method of the aforementioned works in detail needs to be prepared.

(3) Responsibility of Organizations

AFCPO requires authorization of its powers and responsibilities to control all the rivers and related structures mentioned above in order to maintain designed functions of river channels and related structures.

AFCPO will be principally responsible for operation and maintenance of rivers and related structures, which have been constructed by AFCPO and will be constructed in the course of the implementation of the flood control master plan.

For flood protection walls constructed by private sectors, AFCPO will conduct inspection to detect any problem from the viewpoints of river management. AFCPO will direct the owners to maintain their structure and give the order of improvement if required. After the commencement of the flood control master plan, construction of private structure without permission by AFCPO will be prohibited in the river zone.

The Gefersa dam and irrigation intakes have been constructed by public organizations. Such organizations are responsible for operation and maintenance of their own structures. Besides, AFCPO will also conduct inspection from the viewpoints of flood protection. AFCPO will recommend or order the organizations to improve their structures if any problem is detected. For construction of new structure in river zone, AFCPO will consult the organization in charge to coordinate with the flood control master plan.

The same conditions will be applied for bridges, water supply pipelines, sewers and other related structures constructed by public works. The Steering Committee will be in charge of coordination between AFCPO and organizations concerned.

3.8.2 Non-structural Measures

(1) River Management

After authorization of river zone, illegal activities in the zone will be strictly prohibited. Major prohibited activities are:

a) Dumping garbage, soil or other waste materials,
b) Wastewater effluent,
c) Construction or building works,

d) Removal of plants, soil sand, gravel, stone or rock, and
e) Damaging or modifying riverbank and existing structures.

AFCPO will make inspection and monitoring in river zone. When such illegal activities are detected, the Region 14 Administration will undertake proper counter actions in accordance with laws and regulations.

In relation to the river management in the Study Area, improvement of social infrastructures and enlightenment of public awareness for river will be important solutions to prevent the said illegal activities. These are:

a) Garbage collection and disposal system,
b) Wastewater and excreta collection and disposal system,
c) Provision of low cost house for people living in riparian area, and
d) Campaign and education.

These will be very helpful for achieving the objectives of river management, which are not only flood protection but also improvement of river environment. It is therefore proposed that the Region 14 Administration will make necessary efforts to improve the social infrastructures and enlighten public awareness.

Land use for riparian areas of the West Akaki and Hanku rivers will be regulated based on the concept of informal green area by the Addis Ababa Master Plan. AFCPO will recommend delineation of land use regulation. The Works and Urban Development Bureau of the Region 14 Administration (WUDB), the implementing organization of the Addis Ababa Master Plan, will authorize the land use regulation after approval by the Region 14 Administration. AFCPO will conduct inspection and monitoring of the land use regulation in cooperation with WUDB.

(2) Watershed Management

At present, the following organizations proceed reforestation in Addis Ababa.

a) Bureau of Agriculture of Region 14 Administration
b) Enterprise of Addis Ababa Fuel Wood Development and Marketing Organization
c) Ethiopian Heritage Trust and Other Agencies

These organizations have different objectives of reforestation, namely, soil conservation, fuel wood production and recovery of indigenous woodland. Even though the objectives and future plans are different at present, it is suggested that the organizations continue the reforestation activities in Addis Ababa with their experiences, and that coordination and integration will be necessary between the organizations for the purpose of effective watershed management.

It is also proposed that AFCPO will participate in the reforestation and make consultations with the organizations from the viewpoints of river management.

(3) Flood Risk Management

The community organizations will conduct operation and maintenance for flood risk management. Major items are:

a) Inspection and maintenance of equipment for flood warning (rainfall gauge, communication line, radio, siren, etc.),
b) Inspection and maintenance of facilities for flood fighting (storehouse, stored materials, etc.)
c) Periodical training of flood warning and fighting activities, and
d) Education and popularization of flood warning and flood fighting activities.

Leaders of communities will be requested to conduct these works. AFCPO will direct the operation and maintenance works. Performance of communication and information system for flood warning and fighting will be periodically confirmed by all the organizations concerned with flood risk management upon direction by the Steering Committee.

3.9 Overall Evaluation of Master Plan

3.9.1 Economic Evaluation

(1) Flood Damage

Evaluation of project is made at the price level of June 1997 and applied foreign exchange rate is one U.S. dollar equivalent to 6.80 Birr and one Birr equivalent to 0.0593 Japanese Yen.

Benefit of a flood control project is estimated from difference of flood damage between those with and without project. In other words, it is flood damage reduction benefit. Flood damage is estimated as the direct damage, indirect damage, and other damage.

Direct flood damage is estimated as the damage to properties on the following items.

a) General assets:

Residence and other buildings for commercial sector, factory, and public services, and household effects and indoor moveable of buildings specified above,

b) Agricultural properties:

Various kinds of crops on farmland, and

c) Infrastructure:

Roads, channel, canal and public utilities related to water and electricity supply.

Indirect damage is estimated as the damage to economic activities due to their stagnation.

Other damage includes the followings:

a) Paralysis of function as the capital city in social, economical, political and diplomatic aspects,
b) Cost of emergency measures made by central and/or rural government,

c) Termination of public services such as transportation, communication, electricity, and water supply,
d) Loss due to interruption of traffic,
e) Inconvenience of citizens' life,
f) Insanitary and danger of infectious diseases, and
g) Injury to human lives.

Distribution of the properties in the Study Area is based on the statistical data and projection made in this Study. In order to estimate the flood damage, unit value of damageable properties per hectare is calculated by kebeles in flood prone area.

Flood damage is estimated, in principle, from properties in flooding area multiplying damage rates depending on the flood condition. Annual mean flood damage is estimated from the flood damage of various magnitude of flood and probability of occurrence (See Figure 3.22).

The annual mean flood damage of the Study Area is estimated at 22.46 million Birr equivalent in 1997 and 41.77 million Birr in 2020, respectively, and those in each river system are as presented below.

Table 3.24 Annual Mean Flood Damage in the Study Area

River System	Annual Mean Flood Damage (Million Birr)	
	Year 1997	Year 2020
Bantyiketu	9.97	16.06
Kebena	3.50	6.65
Little Akaki	8.93	18.92
Hanku	0.06	0.14
Total	22.46	41.77

(2) Cost-Benefit Analysis

Cost-benefit analysis is made using accounting price (world price equivalent). It is made by a cash flow analysis using three types of indicators, i.e. economic internal rate of return (EIRR), benefit cost ratio (B/C), and net present value (NPV). Using a discounting procedure, benefit and cost of the project occurring at different points in time can be compared in terms of present values.

EIRR is a rate which meets the total of the discounted benefits and the total of the discounted costs. B/C is the ratio of the total of the discounted benefits and the total of the discounted costs. NPV is the difference between the total of the discounted benefits and the total of the discounted costs. Applied discount rate for calculation of B/C and NPV is 10%, the rate used to be applied for economic evaluation of development projects in Ethiopia. All these indicators are commonly used for economic evaluation of the same types of projects.

On the basis of economic cost and benefit, the economic evaluation of is carried out for the flood control plan by river system consisting of both structural and non-structural measures. Economic internal rate of return (EIRR), cost-benefit ratio (B/C) and net present value (NPV) of each flood control plan is obtained as follows.

Table 3.25 Summary of Cost-benefit Analysis for Flood Control Plan by River System

River System	EIRR (%)	B/C	NPV (Million Birr)
Bantyiketu	11.7	1.17	11.4
Kebena	3.5	0.42	-38.9
Little Akaki	10.6	1.07	4.8
Hanku	7.2	0.72	-0.3

3.9.2 Initial Environmental Examination (IEE)

(1) Objectives

The main objectives of the Initial Environmental Examination (IEE) are to clarify environmental issues related to the flood control master plan, and to provide information to guide Environmental Impact Assessment (EIA) in the feasibility study.

(2) Environmental Items

The flood control master plan includes; 1) construction of flood wall and dyke system, 2) river channel excavation for widening, 3) construction of flood regulating weir, 4) construction of flood diversion, 5) construction of flood regulation pond.
The environmental items for IEE are selected from common items related to these plans based on the Guidelines of the EIA for River and Sand Control Projects of JICA (1994). Consequently, the following items are selected for the IEE:

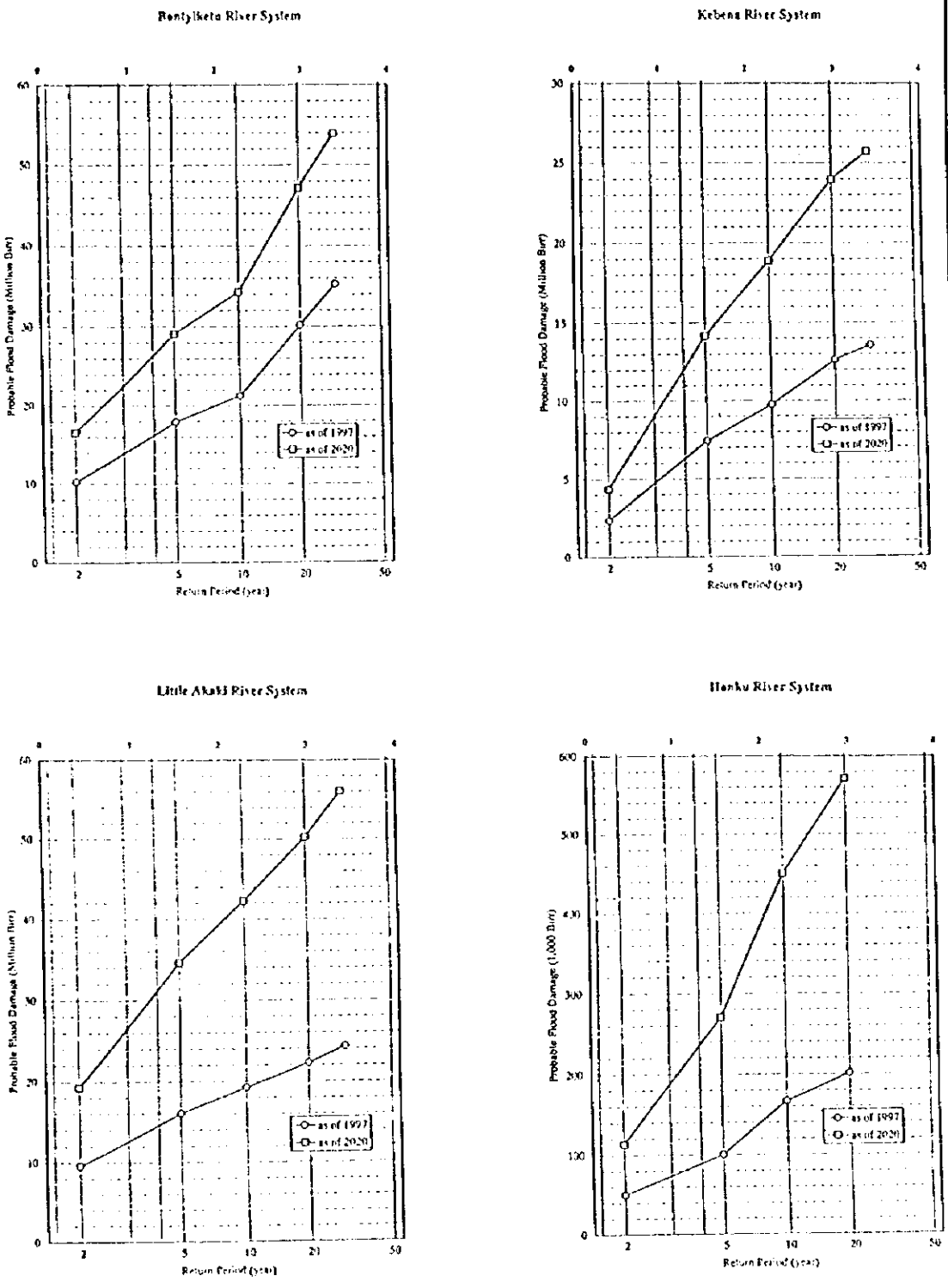


Figure 3.22 Probable Flood Damages

Table 3.26 Items for Initial Environmental Examination in the Study Area

Social Environmental Issues	Nature Environmental Issues	Environmental Pollution Issues
- Resettlement	- Topography and geology	- Air pollution and noise
- Impairment of the transportation system	- Ground water	- Water quality deterioration
- Communities	- River flow regime	- Noise and vibration
- Encroachment on historical Assets	- Flora and fauna	
- Water rights	- Aesthetics and landscapes	
- Solid waste		

(3) Initial Environmental Examination (IEE)

The objective rivers of the flood control master plan are; the West Akaki, Little Akaki, Bantyiketu, Kechene, Kurtume, Kebena, and Hanku rivers.

Among these, the master plan on the West Akaki river is limited to only non-structural measures since the present river channel carrying capacities are sufficient to the basic design discharge. Accordingly IEE here does not touch on the West Akaki river.

Significance for proceeding to Environmental Impact Analysis (EIA) among the IEE items has been classified in the respective schemes by the following classes; (A) mostly significant, (B) significant, (C) significant but relatively minor, (D) No effect is expected. The results are shown in Table 3.27.

Table 3.27 Results of Initial Environmental Examination

Structural Measures	Environmental Item													
	Social Environment						Nature Environment					Pollution		
	Resettlement	Transportation system	Communities	Historical assets	Water rights	Solid waste	Topography and geology	Ground water	River flow regime	Flaura and fauna	Aethetics and landscape	Air pollution	Water quality deterioration	Noise and vibration
Bantyiketu River System														
- Weir	C	D	D	D	D	D	C	C	C	D	C	C	D	B
- Regulationg pond	D	D	D	D	D	D	D	D	D	D	C	D	D	C
- Channel improvement	C	D	C	D	D	D	D	D	D	D	C	C	C	C
Kebena River System														
- Weir	C	D	D	D	D	D	C	C	C	D	C	C	D	B
- Channel improvement	C	D	C	D	D	D	D	D	D	D	C	C	C	C
Little Akaki River System														
- Diversion tunnel	C	C	C	D	D	D	C	C	C	D	C	C	D	C
- Regulating pond	D	D	D	D	D	D	D	D	D	D	C	D	D	C
- Channel improvement	C	D	C	D	D	D	D	D	D	D	C	C	C	C
Hanku River System														
- Culvert	D	D	C	D	D	D	D	D	D	D	C	C	C	C

A : very significant B : significant C : significant but relatively minor D : not significant

3.9.3 Overall Evaluation

Overall evaluation of the flood control master plan are summarized in Table 3.28 and described below.

Table 3.28 Overall Evaluation of Flood Control Master Plan

Features	River System				Overall
	Bantyiketu	Kebena	Little Akaki	Hanku	
Outline of Project	- 1 Weir - 6 Regulating Pond - River Channel Improvement - Drainage Improvement	- 2 Weirs - River Channel Improvement	- 1 Flood Diversion - 1 Regulating Pond - River Channel Improvement	- 2 Culverts	
Project Cost (million Birr)					
Structural Measures	148.6	392.1	208.0	2.5	751.2
Non-Structural Measures	6.0	2.4	3.2	0.3	11.9
Total	154.6	394.5	211.2	2.8	763.1
EIRR (%)	11.7	3.5	10.6	7.2	10.8
B/C	1.17	0.42	1.07	0.72	1.08
NPV (million Birr)	11.4	-38.9	4.8	-0.3	9,315
Beneficial Population (person)	610,000	280,000	42,000	35,000	1,345,000
Beneficial Area (km^2)	51	40	33	9	105
Resettlement	small	small	small	small	small
Land Use	Class-B	Class-D	Class-C	Class-D	
Environmental Impact	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant

Note: EIRR : Economic Internal Rate of Return
B/C : Benefit/Cost Ratio
NPV : Net Present Value
Class-A : Mainly Government Agencies
Class-B : Mainly Government Agencies, Commercial Area and Residential Area
Class-C : Mainly Densely Built-up Residential Area
Class-D : Mainly Residential Area

(1) Technical Aspects

The major construction works of the structural measures consists of the followings:

a) Reservoir by Weir

- Excavation
- Concrete work

b) Regulating Pond

- Excavation
- Masonry work

c) River Channel Improvement

- Excavation
- Masonry work

d) Flood Diversion

- Tunnel work
- Excavation
- Masonry work

e) Draining Improvement

- Excavation
- Concrete work

Design and construction technique prevailing in Ethiopia will be applicable for the regulating pond, river channel improvement, and drainage improvement.

The construction of weir will be of concrete gravity type with some 20 meters height. There are some experiences of similar or greater scale of dam construction for water supply and hydropower project in Ethiopia.

The tunnel works of excavation and concrete lining will require some particular machinery and construction technique. These have not been common in Ethiopia but are employed by some water supply and hydropower projects designed in the recent years.

In compliance with the considerations above, the master plan are regarded as technically viable in general, although design and construction of weir and flood diversion may require qualified engineers and contractors supposed to be employed from foreign countries.

(2) Project Cost

The project cost for the master plan consists of construction cost, resettlement cost, administration cost, engineering service cost, physical contingency and price contingency. The project cost amounts to 761.3 million Birr.

According to the implementation plan described in the succeeding section, annual disbursement will be 33 million Birr/year. This amount of annual disbursement is much larger than the annual budget of AFCPO in the recent years.

Annual disbursement of the sum of administration cost and resettlement cost will be 2.3 million Birr/year on average, which is within the said annual budget of AFCPO.

(3) Economic Evaluation

The cost-benefit analysis for the master plan is conducted in compliance with annual disbursement of the project cost, annual operation and maintenance cost, and annual flood damage reduction benefit. These are obtained year by year from those for the respective river systems to be implemented according to the priority order. The term of the cost-benefit analysis is set at 50 years that is regarded as project life.

As a result of the cost-benefit analysis for the flood control master plan, EIRR is obtained at 10.8%. B/C and NPV are 1.08 and 9,315 million under the discount rate of 10%, respectively.

(4) Social and Environmental Impact

1) Beneficial Population

Flood damage is generally composed of the following items.

a) Direct Damage

- General assets,
- Agricultural properties, and
- Infrastructures.

b) Indirect Damage

- Economic loss of good and services.

c) Other Damage

- Paralytic functions of various social systems,
- Cost for emergency measures, and
- Threat to human life (injury, disease, etc.).

As known from the kinds of flood damage, beneficial population covers not only residents in flooding area but people concerned with flooding area in terms of social and economic activities. On the basis of analysis of the available statistical data of Addis Ababa, the beneficial population by the implementation of the master plan is estimated at 134.5 million in the target year 2020.

2) Resettlement

Resettlement is a common problem for flood control project, especially for urbanized area. The flood control master plan is therefore formulated to minimize resettlement in riparian areas. The basic concept of the structural measures is that flood discharge will be regulated by flood retention or diversion facilities as much as possible in upstream reaches and remaining discharge to downstream reaches will be protected by river channel improvement. As a result, the estimated number of houses subject to resettlement is not large with an order of 0 to 30 houses for the respective river systems.

3) Land Use

From the land use classification indicated here, 85% of the beneficial area is covered mainly with governmental, commercial and densely built-up residential areas.

4) Initial Environmental Examination (IEE)

The results of IEE indicate that most of the items examined by IEE result in minor or no environmental impact, and that significant impact may be anticipated on noise/vibration during construction. It is therefore concluded that environmental impact is not significant in general and regarded as acceptable.

(5) Overall Evaluation

As a conclusion of overall evaluation, the flood control master plan indicates sufficient viability from the viewpoints discussed above.

From financial view, the required annual disbursement is rather large and much higher than the present budget of AFCPO. However, Addis Ababa is the capital city of

Ethiopia and has been threatened by serious flooding, especially in 1978 and 1994. Such social disturbance by disaster in the capital city causes significant impediment to economic development not only for Addis Ababa but also the whole country. It is therefore recommended that master plan is to be implemented as basic infrastructures of the capital city, and that the Federal Government and the Region 14 Administration are requested to make necessary efforts of financial arrangement for the implementation.

From economical view, EIRR of 10.8% is a reasonable rate. Moreover, the implementation of the mater plan will also create intangible benefits that are not counted into the flood damage reduction benefits as monetary value. Most important one is social stability in line with reduction of threat by disaster. This will contribute to sustainable economic growth of the country. In addition, the implementation of the master plan will create a lot of employment opportunities during design and construction stages. When such intangible benefits are taken into account, it is concluded that the master plan provides sufficient economic viability.

3.10 Implementation Plan

3.10.1 Structural Measures

The implementation plan of the structural measures are formulated in compliance with priority order by river system, periods of pre-construction and construction stages and disbursement schedule of project cost.

As discussed in the succeeding section, the priority order of river systems are: 1) Bantyketu river system including Kechene and Kurtume rivers, 2) Little Akaki river system, 3) Hanku river system, and 4) Kebena river system. The structural measures will therefore be implemented according to this priority order.

Pre-construction stage includes the periods of feasibility study, financial arrangement and detailed design as described below:

a) Feasibility study : 0.5-year
b) Financial arrangement : 1-year
c) Detailed design : 1-year

For ease of financial arrangement and avoiding a huge disbursement concentration in a short period, stage wise implementation is applied. The implementation of the structural measures for each river system is divided into two stages except the Hanku river system that is of small scale projects compared with the others. The stage wise implementation plan for each river system is prepared on the basis of engineering viewpoints of flood control effectiveness by structures. In general, flood regulating structures will be constructed in advance and river channel improvement will be implemented later. Construction period is dependent on the scale of structures to be constructed in a stage. Stage wise implementation for each river system is shown below.

Table 3.29 Stage Wise Implementation Plan

Priority Order	River System	Stage	Structural Measures	Implementation Period
1	Bantyiketu	1	- Kechene Weir	1998 - 2002
			- Kostre Regulating Pond	
			- Bantyiketu Regulating Pond	
			- River Channel Improvement of Bantyiketu river	
			- River Channel Improvement of Kechene river	
			- Drainage Improvement	
		2	- Kurtume No.1 Regulating Pond	2000 - 2004
			- Kurtume No.2 Regulating Pond	
			- Kurtume No.3 Regulating Pond	
			- Kurtume No.4 Regulating Pond	
			- River Channel Improvement of Kurtume river	
2	Little Akaki	1	- Little Akaki Regulating Pond	2003 - 2010
			- Flood Diversion	
		2	- River Channel Improvement of Little Akaki river	2008 - 2011
3	Hanku		- 2 Culverts	2010 - 2013
4	Kebeba	1	- Kebena Weir	2012 - 2018
			- Abo Weir	
		2	- River Channel Improvement of Kebena River	2016 - 2020

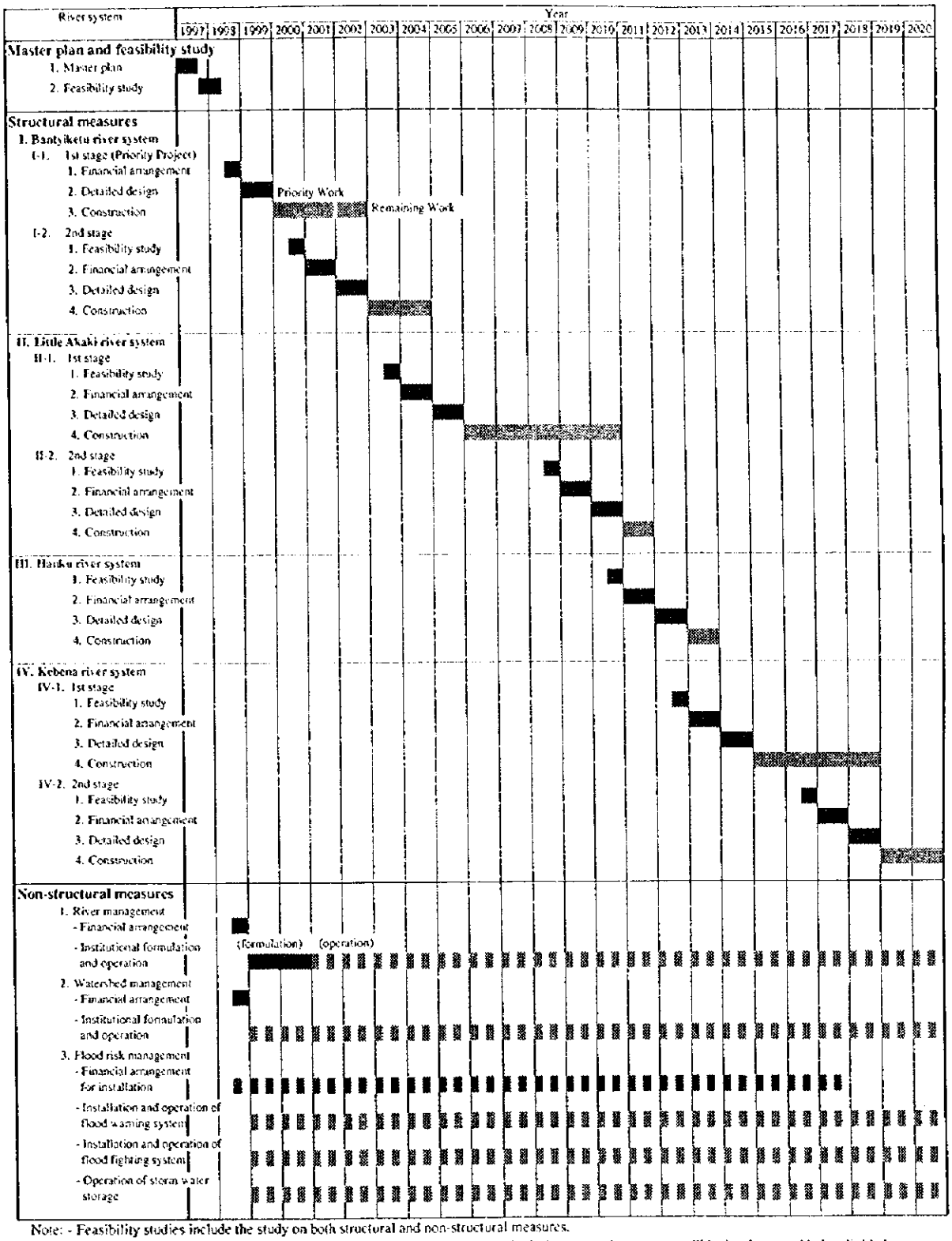
Note: Implementation period consists of feasibility study, financial arrangement, detailed design and construction.

The proposed implementation plan is shown in Figure 3.22. It is expected that the construction works of the structural measures will commence in the year 2000 at the earliest. All the construction works will be completed in the end of 2020.

3.10.2 Non-structural Measures

The non-structural measures will be implemented along with the structural measures until the year 2020. The proposed implementation plan is shown in Figure 3.22.

Among the non-structural measures, authorization of river zone and establishment of regulation to prohibit illegal activities in river zone need to be realized as soon as possible. It is proposed that preparatory works including financial arrangement and institutional formulation for these two items of the non-structural measures will be initiated immediately after completion of this Study.



Note: - Feasibility studies include the study on both structural and non-structural measures.
- All the master plan projects will be implemented river by river in order of priority. Each river system will be implemented being divided into two stages, except for the Hanku river system, i.e. 1st stage and 2nd stage.
- Construction period of each stage is scheduled so that the yearly disbursement amount of construction cost should not exceed 500 million Japanese yen (equivalent 30 million Birr).

Figure 3.23 Proposed Implementation Plan of Master Plan Projects

CHAPTER 4 SELECTION OF PRIORITY PROJECTS FOR FEASIBILITY STUDY

4.1 Priority by River System

The evaluation is made in order to determine the project implementation priority and select a river system to be taken up for selection of the priority project(s). Criteria for the evaluation are followings:

a) Technical Aspects

Project is technically viable with a moderate scale of construction work.

b) Financial Aspects

Project cost is within a moderate amount.

c) Economic Aspects

Economic Internal Rate of Return (EIRR) is high rate.

d) Social Impact

Beneficiaries are many in terms of number of population and socio-economic activities. Number of houses subject to resettlement is small.

e) Environmental Impact

Negative environmental impact is not significant and acceptable.

The evaluation of priority is conducted applying a similar manner to that of the comparative study of alternative plans discussed in the previous section. Priority of river system is concluded on the basis of the total of the evaluation points for all the items of the evaluation criteria. A river system indicating highest score is taken up as the highest priority river system. The items of evaluation criteria and evaluation points are summarized in Table 4.1.

Priority of river systems is studied for the four river systems, namely, the Bantyiketu river system including the Kechene and Kurtume rivers, the Kebena river system, the Little Akaki river system and the Hanku river system. The priority order of river systems is evaluated as shown in Table 4.2. The Bantyiketu river system including the

Kechene and Kurtume rivers indicates the highest score of the total evaluation points. The priority order of the river systems is concluded as follows:

a) 1st : Bantyiketu river system including Kechene and Kurtume rivers,
b) 2nd : Little Akaki river system,
c) 3rd : Kebena river system, and
d) 4th : Hanku river system.

Table 4.1 Evaluation Criteria for Priority by River System

Item	Criteria	Point
Financial Aspect		
Cost per Beneficiary (C/B)	C/B < 190 Birr	10
	190 Birr < C/B < 290 Birr	7
	290 Birr < C/B < 390 Birr	5
	C/B > 390 Birr	3
Economic Aspect		
EIRR	EIRR > 13%	10
	13% > EIRR > 10%	7
	10% > EIRR > 5%	5
	EIRR < 5%	3
Social Impact		
Beneficial Population	Population > 450,000	10
	450,000 > Population > 350,000	7
	350,000 > Population > 250,000	5
	Population < 250,000	3
Resettlement	Number of houses subject to resettlement is small (< 30)	10
	Number of houses subject to resettlement is large (> 30)	0
Characteristics of Land Use	Class-A : Mainly government agencies	10
	Class-B : Mainly government agencies, commercial area and residential area	7
	Class-C : Mainly densely built-up residential area	5
	Class-D : Mainly residential area	3
Environmental Impact by IEE	Not significant	10
	Significant	0

Note : 1) In Cost per Beneficiary (C/B), 290 Birr is average cost per beneficiary for all the river systems, derived by rounding $(122 + 138 + 130 + 1.4) \times 10^6/((610 + 280 + 420 + 35) \times 10^3)$. 190 Birr is defined as the average of cost per beneficiary for all the alternatives of the priority river system derived by rounding (200 + 198 + 211 + 185 + 179)/5.

2) In Beneficial Population, 350,000 is the average beneficial population of the four river systems (Bantyiketu, Kebena, Little Akaki, Hanku), derived by rounding (610,000 + 280,000 + 420,000 + 35,000)/4.

3) In Resettlement, 30 is defined as a maximum numer of houses resettled by a project undertaken by Addis Ababa Flood Control Poject Office (AFCPO) until now.

Table 4.2 Summary of Evaluation of Priority by River System

Item	River System			
	Bantyiketu	Kebena	Little Akaki	Hanku
Outline of the Project				
Improvement Works	-1 Weir -6 Regulating Ponds -Channel Improvement	-2 Weirs -Channel Improvement	-Flood Diversion -1 Regulating Pond -Channel Improvement	-2 Culverts
Financial Aspects				
Cost (million Birr)	122	138	130	1.4
Cost per Beneficiary (Birr)	198	493	310	40
(Point)	(7)	(3)	(5)	(10)
Economic Aspects				
EIRR (%)	11.7	3.5	10.6	7.2
(Point)	(7)	(3)	(7)	(5)
B/C	1.17	0.42	1.07	0.72
NPV (million Birr)	11.4	-38.9	4.8	-0.3
Social Impact				
Beneficial Population	610,000	280,000	420,000	35,000
(Point)	(10)	(5)	(7)	(3)
Resettlement	Small	Small	Small	Small
(Point)	(10)	(10)	(10)	(10)
Characteristic of Land Use	Class-B	Class-D	Class-C	Class-D
(Point)	(7)	(3)	(5)	(3)
Environmental Impact by IEE	Not significant	Not significant	Not significant	Not significant
(Point)	(10)	(10)	(10)	(10)
Total of Evaluation Point	(51)	(34)	(44)	(41)
Priority Order	1	4	2	3

Note: Cost consists of construction cost, resettlement cost, engineering service cost, administration cost and physical contingency for both structural and non-structural measures.

4.2 Selection of Structural Measures

4.2.1 Alternative Plans

As discussed above, the Bantyiketu river system including the Kechene and Kurtume rivers is evaluated with the highest priority among the four river systems in the Study Area. The structural measures for the Bantyketu river system is to be implemented in the earliest stage of the flood control master plan as indicated in the implementation plan.

The implementation of the structural measures for the Bantyiketu river system will require rather large financial sources, compared with the present budgeting situations of AFCPO to be designated as implementing organization. This will be a first experience for AFCPO to implement flood control project with a comparatively large scale. In consideration of these aspects, a stage wise implementation is proposed as indicated in the implementation plan. Namely, some of the structural measures in the Bantyiketu river system are selected as priority projects that are to be implemented at the earliest.

Selection of priority projects is carried out in compliance with a scale of investment, flood control effectiveness evaluated from benefit/cost analysis, and social and natural impacts. The structural measures in the Bantyiketu river system consist of several measures of a reservoir by weir, regulating ponds, river channel improvement and drainage improvement. The alternative plans for selection of priority projects are therefore formulated by means of the primary evaluation mainly from technical viewpoints. The following five alternative plans are taken into consideration.

a) The Alternative 1 consists of all the proposed structures in the Bantyiketu river system as priority projects. This alternative is therefore the same as the structural measures of the flood master plan for the Bantyketu river system.

b) The Alternative 2 considers the implementation of the structural measures for the Bantyiketu and Kechene rivers as first stage, and those for the Kurtume river are implemented in latter stage. Priority projects correspond with the first stage implementation.

c) The Alternative 3 considers the implementation of the structural measures for the Bantyiketu and Kurtume rivers as first stage, and those for the Kechen river are implemented in latter stage. Priority projects correspond with the first stage implementation.

d) The Alternative 4 is similar to the Alternative 2, namely, the Bantyiketu and Kechene rivers are incorporated into first stage. However, the Alternative 4 excludes the river channel improvement of the Kechene river from priority projects.

c) The Alternative 5 is also similar to the Alternative 2, namely, the Bantyiketu and Kechene rivers are incorporated into first stage. However, the Alternative 5 excludes the river channel improvement of both Bantyiketu and Kechene rivers from priority projects.

The drainage improvement is incorporated into all the alternative plans above with due considerations of its urgent necessity for the center of the capital city. The alternative plans are summarized in Table 4.3.

Table 4.3 Alternative Plans for Selection of Priority Projects

Structural Measures	Alternative				
	1	2	3	4	5
Kurtume River					
- 4 Regulating Ponds	O	-	O	-	-
- River Channel Improvement	O	-	O	-	-
Kechene River					
- 1 Reservoir by Weir	O	O	-	O	O
- 1 Regulating Pond	O	O	-	O	O
- River Channel Improvement	O		-	-	-
Bantyiketu River					
- 1 Regulating Pond	O	O	O	O	O
- River Channel Improvement	O	O	O	O	-
- Drainage Improvement	O	O	O	O	O

4.2.2 Evaluation and Selection of Priority Projects

The evaluation of the alternative plans and the selection of priority projects are conducted applying the same manner as that of the evaluation of priority by river system discussed in the previous section. The selection of priority projects is concluded on the basis of the total of the evaluation points for all the items of the evaluation criteria. An alternative plan indicating highest score is taken up as priority projects. The items of evaluation criteria and evaluation points are also the same as those of the evaluation of prioirty by river system.

The alternative plans are evaluated as shown in Table 4.4. The Alternative 4 indicates the highest score of the total evaluation points. The selection of priority projects is summarized as follows:

Table 4.4 Summary of Selection of Priority Projects

Item	Alternative				
	1	2	3	4	5
Financial Aspects					
Cost (million Birr)	122	93	80	87	75
Cost per Beneficiary (Birr)	200	198	211	185	179
(Point)	(7)	(7)	(7)	(10)	(10)
Economic Aspects					
EIRR (%)	11.7	12.6	12.1	13.3	11.9
(Point)	(7)	(7)	(7)	(10)	(7)
B/C	1.17	1.27	1.22	1.35	1.20
NPV (million Birr)	11.4	15.6	11.0	18.9	9.3
Social Impact					
Beneficial Population	610,000	470,000	380,000	470,000	420,000
(Point)	(10)	(10)	(7)	(10)	(7)
Resettlement	Small	Small	Small	Small	Small
(Point)	(10)	(10)	(10)	(10)	(10)
Characteristic of Land Use	Class-B	Class-B	Class-B	Class-B	Class-B
(Point)	(7)	(7)	(7)	(7)	(7)
Environmental Impact by IEE	Not significant	Not significant	Not significant	Not significant	Not significant
(Point)	(10)	(10)	(10)	(10)	(10)
Overall Evaluation					
(Overall Point)	(51)	(51)	(48)	(57)	(51)
Priority Project				Selected	

Note: Cost consists of construction cost, resettlement cost, engineering service cost, physical contingency and price contingency for both structural and non-structural measures for both structural and non-structural measures.

4.3 Selection of Non-structural Measures

The non-structural measures proposed by the flood control master plan are river management, watershed management and flood risk management as described below.

a) River Management

- Authorization of river zone
- Social education for river and flood
- Guidelines for structural design

b) Watershed Management

- Reforestation

c) Flood Risk Management

- Flood warning system
- Flood fighting system
- Storm water storage

The non-structural measures for priority projects are selected from the viewpoints of urgent necessity, technical and institutional practicability.

Authorization of river zone is an essential matter for the flood control master plan. Necessary legislation for river zone needs to be enforced in the earliest stage of the implementation.

Social education for river and flood helps to enhance effectiveness of the said legislation to prevent illegal activities in the river zone. In addition, it contributes to popularization of flood warning and fighting to be managed by community organizations.

Reforestation is an on-going activity conducted by several public organizations. These organization are requested to continue their activities from practical viewpoints but coordination and integration will be necessary for the purpose of effective watershed management.

The concept of flood warning and fighting corresponds with the policy of the National Disaster Prevention and Preparedness Management, which is supported by the

institutional system covering the community organizations of Zone, Wereda, and Kebele. Therefore, it is a practical and effective way that flood warning and fighting system are established in combination with the said institutional system.

Storm water storage will be popularized by means of public information and campaign. Besides, there is another way to develop on-site storage facilities as a part of urban drainage system. It is therefore expected that storm water storage will be developed with future urban drainage plan in line with the Addis Ababa Master Plan.

As a conclusion of the considerations above, the following non-structural measures are incorporated into the priority projects for the succeeding feasibility study.

a) River Management

- Authorization of river zone
- Social education for river and flood

b) Flood Risk Management

- Flood warning system
- Flood fighting system

4.4 Priority Projects for Feasibility Study

The selected priority projects are summarized in Table 4.5 and Figure 4.1. The features of the priority projects are based on the results of the master plan and are subject to be updated in the succeeding feasibility study.

Table 4.5 Priority Projects for Feasibility Study

(1) Structural Measures

Objective Rivers	
- Bantyiketu river	• Catchment area = 5.4 km^2
	• Length = 4.5 km
- Kechene river	• Catchment area = 13.6 km^2
	• Length = 11.2 km
Project Features	
- Kechene weir	• Concrete gravity type
	• Height = 20 m
	• Reservoir storage = 115,000
- Kostre regulating pond	• Pond storage = 21,000 m^3
- Bantyiketu regulating pond	• Pond storage = 54,000 m^3
- River channel improvement of Bantyiketu river	• Channel excavation : 33,500 m^3
	• River bank protection : 300 m
	• Flood wall : 1,950 m
- Drainage improvement	• Drainage area = 2.48 km^2
	• Length of road side ditch = 4,000 m
- Associated works	• Repair of bridge abutment : 1 no.
	• Rehabilitation of aqueduct : 1 no.
	• Rehabilitation of irrigation intake : 1 no.

(2) Non-structural Measures

River Management	
- Authorization of river zone	• Delineation of river zone for river management: 5 m width from both river bank
	• Prohibition of illegal activities in river zone
- Social education for river and flood	• Enlightenment of public awareness for river and flood
Flood Risk Management	
- Flood warning system	• Installation of rainfall gauges, communication lines, and sirens
- Flood fighting system	• Involvement of community organizations to flood fighting
	• Construction of storehouses with necessary materials for flood fighting

(3) Project Cost and Benefit

Project Cost	
- Structural measures	99,483
- Non-structural measures	6,005
- Total	105,498
Project Benefit	
- Beneficial population	470,000
- EIRR	13.3%
- B/C	1.35

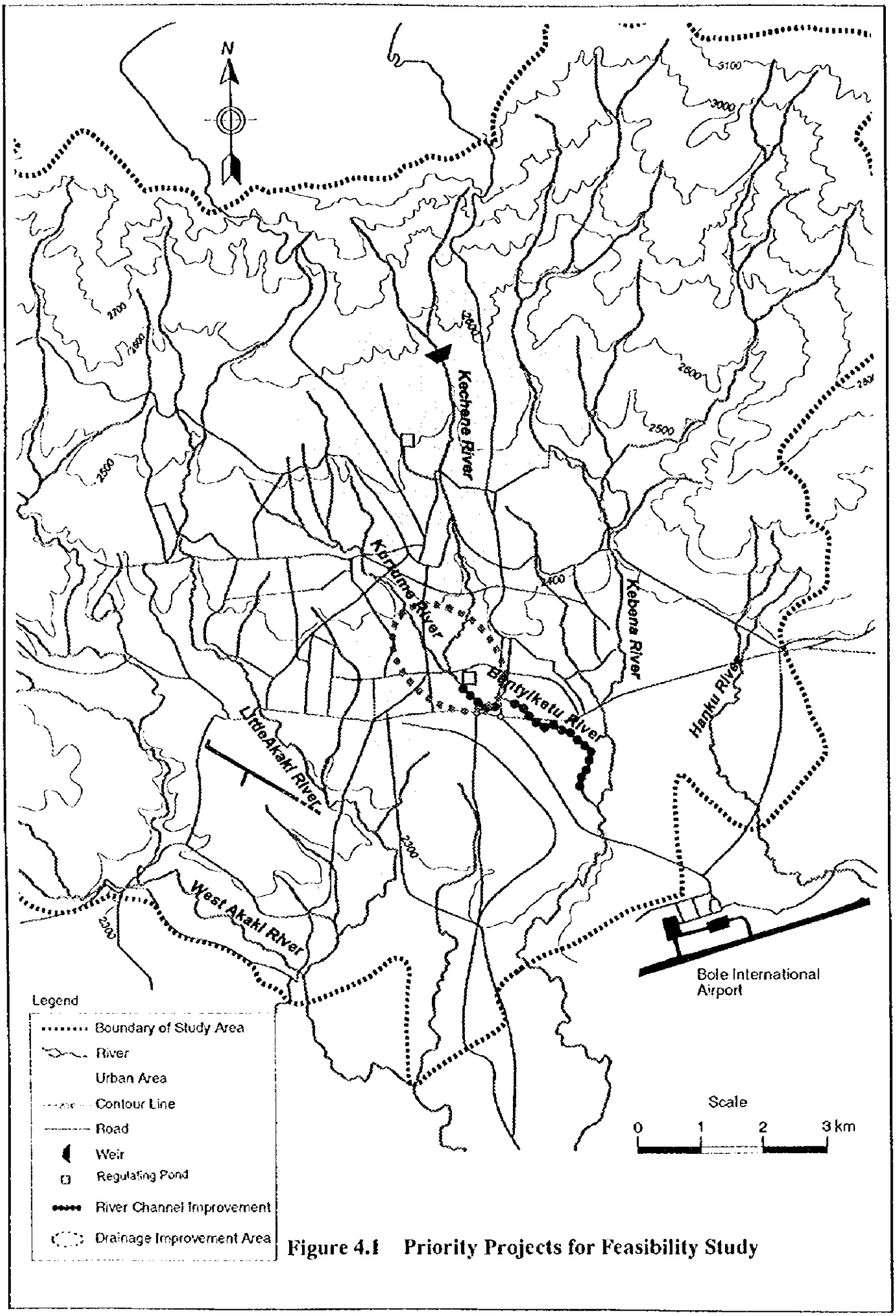


Figure 4.1 Priority Projects for Feasibility Study

CHAPTER 5 FEASIBILITY STUDY ON PRIORITY PROJECTS

5.1 Present Conditions of Projects Area

5.1.1 Rivers and Related Structures

Objective rivers of the priority projects are as follows:

a) Lower Kebena river: Bole railway bridge to confluence with the Bantyiketu river,
b) Bantiketu river: confluence with the Kebena to Filwiha bridge including Bantyiketu Regulating pond site,
c) Lower Kechene river: Filwiha bridge to upstream of Kechene 2nd bridge,
d) Lower Kostre river: Kostre retarding pond site, and
e) Upper Kechene river: Kechene weir site.

A field reconnaissance survey was conducted in the initial stage of the feasibility study. The objectives are to confirm the present conditions of the rivers and riparian areas, namely, topographic features, land use and existing structures concerned.

(1) Lower Kebena River

A total length of this reach from Bole bridge to the confluence of the Bantyiketu is around 0.8 km. Major river channel conditions of this reach are summarized below.

Table 5.1 Major Features of Lower Kebena River

Reach	Length (km)	Average gradient of river bed	Average Width (m)	Average Channel Depth (m)
from Bole bridge to Confluence with Bantyiketu	0.81	1/100	25	8

In this reach, ground elevation of the left bank is entirely low than those of the right bank. Flood exceeding the channel capacity is accordingly subject to overflow towards the left riparian areas. Many houses built on the left bank are therefore protected by floodwall. The river channel just upstream of the Bole bridge is prone to bank erosion.

Major existing river and related structures are summarized as follows:

a) Floodwalls,
b) Railway bridge (1 bridge),
c) Road bridge (1 bridge),
d) Sewers with manholes, and
e) Water supply pipes.

Location map of river and related structure is shown in Figure 5.1

(2) Bantyiketu River

A total length of the Bantyiketu river from the confluence to the Filwiha bridge is around 4.5 km. Major river channel features of the Bantyiketu are as follows.

Table 5.2 Major Features of Bantyiketu River

Reach	Length (km)	Average gradient of river bed	Average Width (m)	Average Channel Depth (m)
from Confluence with Kebena to Intake weir	0.61	1/150	18	5
from Intake Weir to Bantyiketu Bridge	1.92	1/150	20	3 - 5
from Bantyiketu Bridge to Finfine Bridge	0.66	1/115	25	3
from Finfine Bridge to Filwiha Bridge	1.27	1/140	18	4

Major existing river and related structures are summarized below:

a) Floodwalls,
b) Intake weir (2 weirs),
c) Road bridge (11 bridges),
d) Aqueduct with foot-pass (1 set),
e) Drainage culvert (2 major culverts and others),
f) Sewers with manholes, and
g) Water supply pipes.

The Bantyiketu river is practically subdivided into four reaches. The results of the field reconnaissance survey are therefore summarized by reach as described below.

1) Confluence with Kebena to Intake Weir

The left bank of this reach is low land and utilized as cultivated land. Water for the cultivation is supplied through an existing intake weir. Location of the intake weir is shown in Figure 5.1. There is no house in the riparian areas prone to flooding.

2) Intake Weir to Bantyiketu Bridge

There exists a natural retarding basin in the upstream of the intake weir. A part of the retarding basin in the left bank is designated as a city park. Such natural retarding basin functions as a buffer in the case of exceeding flood towards the lower reaches.

Around downstream of an aqueduct with foot-pass in the upper part of this reach, river width is considerably constricted. Flood flow is subject to overtop towards the right bank where low lands and residential areas extend.

Location map of river and related structure in this reach is shown in Figure 5.2

3) Bantyiketu Bridge to Finfine Bridge

In this reach of the Bantyiketu, there exist many houses in riparian area on the right bank. Such houses are prone to flooding. On the other hand, continuous floodwall is constructed to protect the complex of the European Community of Africa (ECA) and the agencies of United Nations. There exists a drainage culvert from the said complex at the middle of this reach.

Location map of river and related structure in this reach is shown in Figure 5.3.

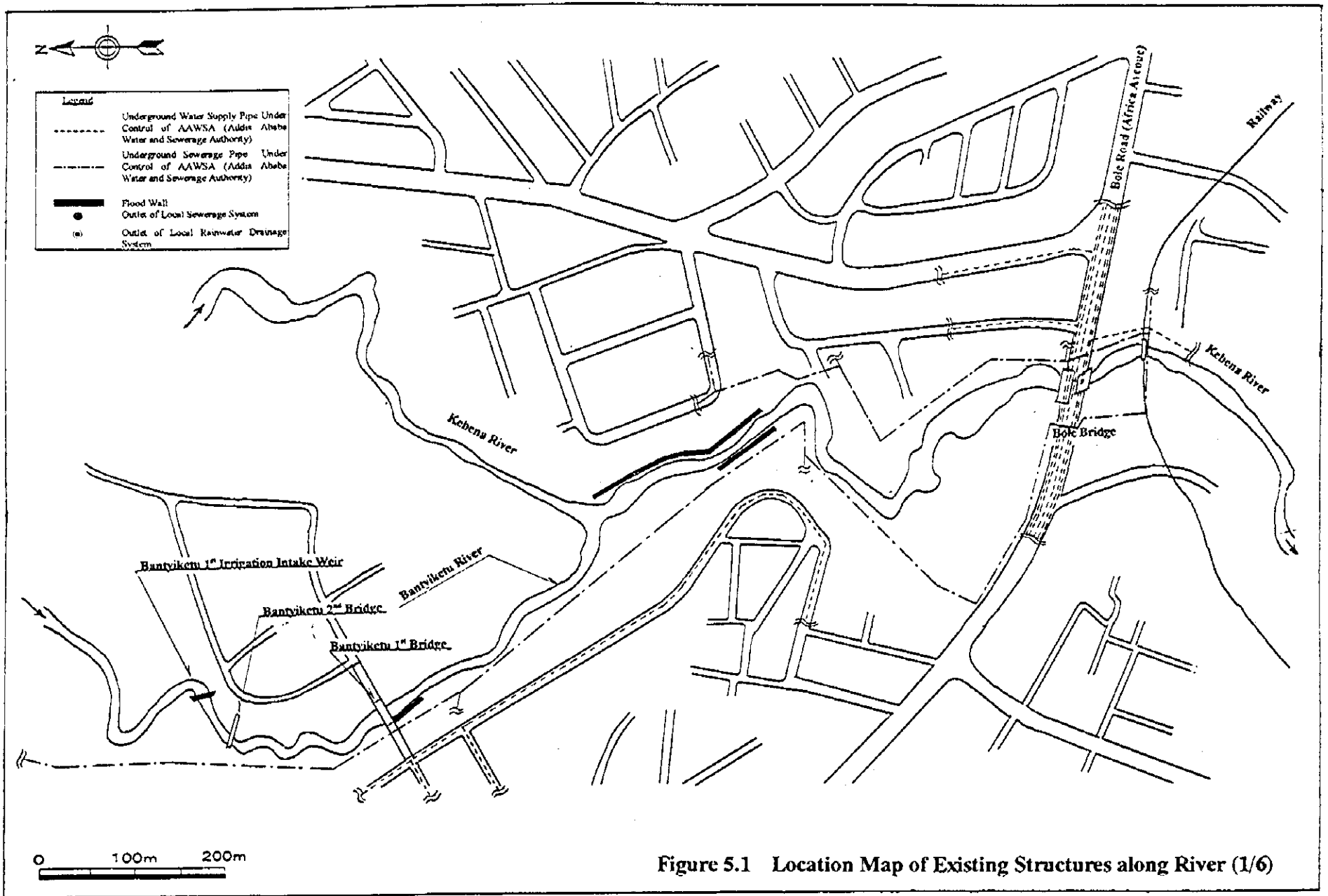


Figure 5.1 Location Map of Existing Structures along River (1/6)

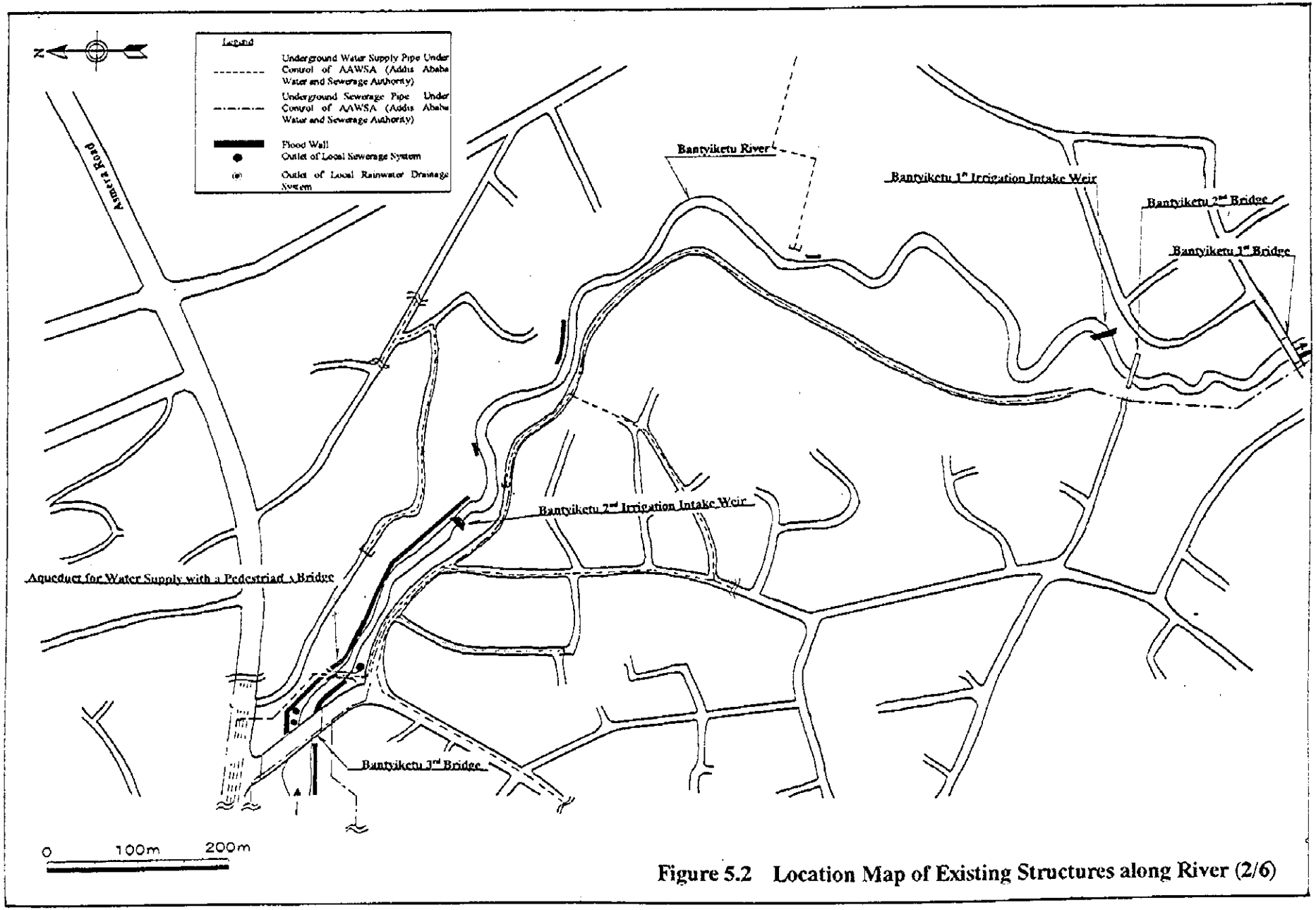


Figure 5.2 Location Map of Existing Structures along River (2/6)

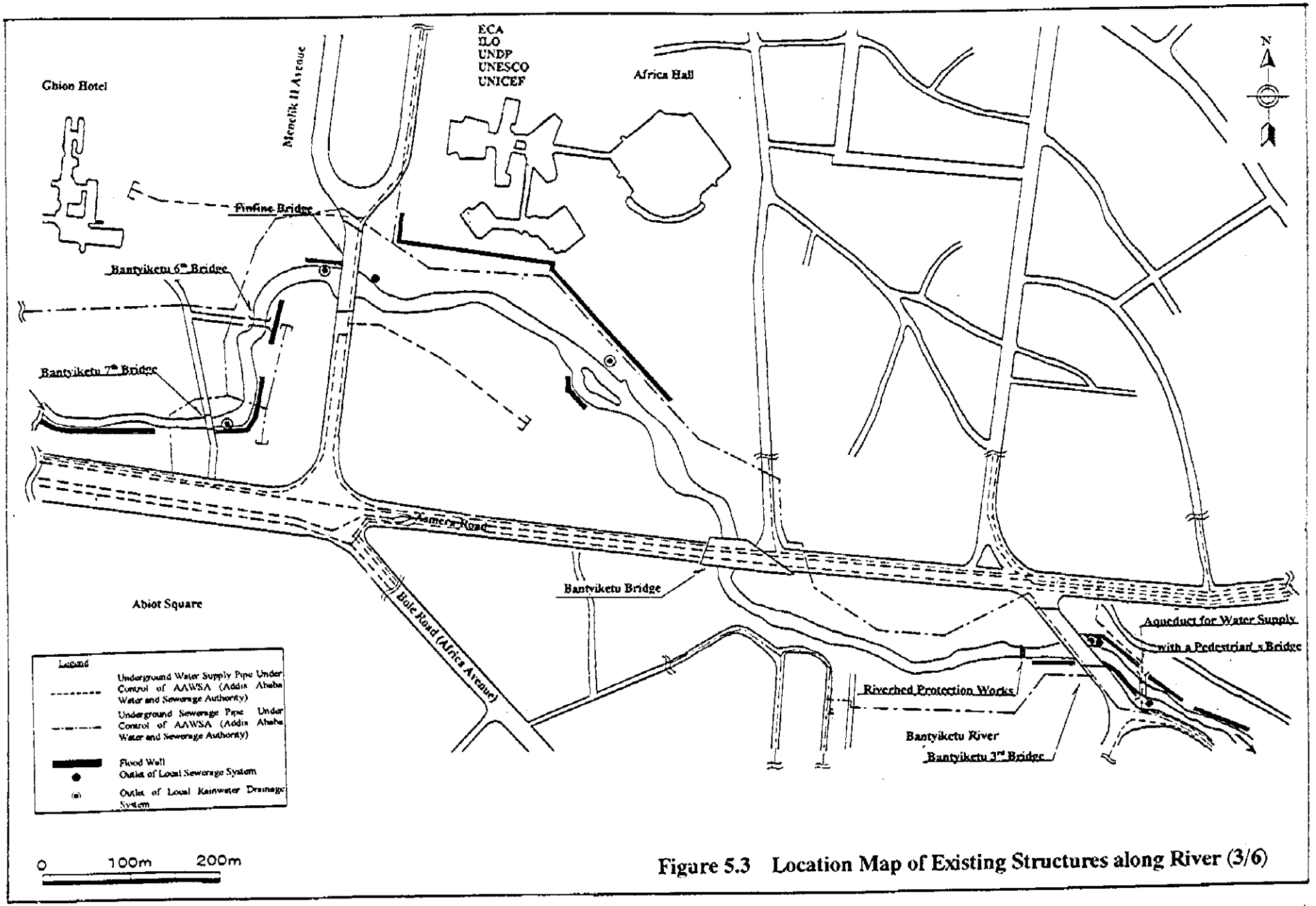


Figure 5.3 Location Map of Existing Structures along River (3/6)

4) Finfine Bridge to Filwiha Bridge

The dense building complexes locate of the right bank of this reach. These complexes are privately guarded by floodwall. However, there exist some locations prone to overtopping. Accordingly, flood flow exceeding channel capacity overtops towards the right riparian areas. The left bank is mainly occupied by the complex of the Ghion Hotel.

A drainage culvert from the right riparian area joins the Bantyiketu just downstream of the Bantyiketu 7th bridge to the Ghion Hotel complex. The size of the culvert is around 2.7 meters in height and 2.7 meter in width.

Just upstream of the Bantyiketu 9th bridge to Ghion Hotel, a building laid across the river channel is being constructed. The works are to provide two lanes of box culvert having a dimension of 7 meters in high, 6.5 meters in wide and 75 meters in length. The flow area of the culverts is around 1.5 times of the average flow area in the lower and upper reaches.

An open area of the grasslands extends over the left bank just below the Filwiha bridge. A part of this open area is to be modified as a regulating pond to decrease a peak of flood discharge to the downstream reaches. The foundation rock at the proposed site of the regulating pond appears to be underlain by basalt, which is the same as the rock outcropped at the adjacent riverbed, as deep as the outcropping rock at the riverbed. A sewerage pipeline of the Addis Ababa Water Supply and Sewerage Authority (AAWSA) exists under the proposed site

Location map of river and related structure in this reach is shown in Figure 5.4.

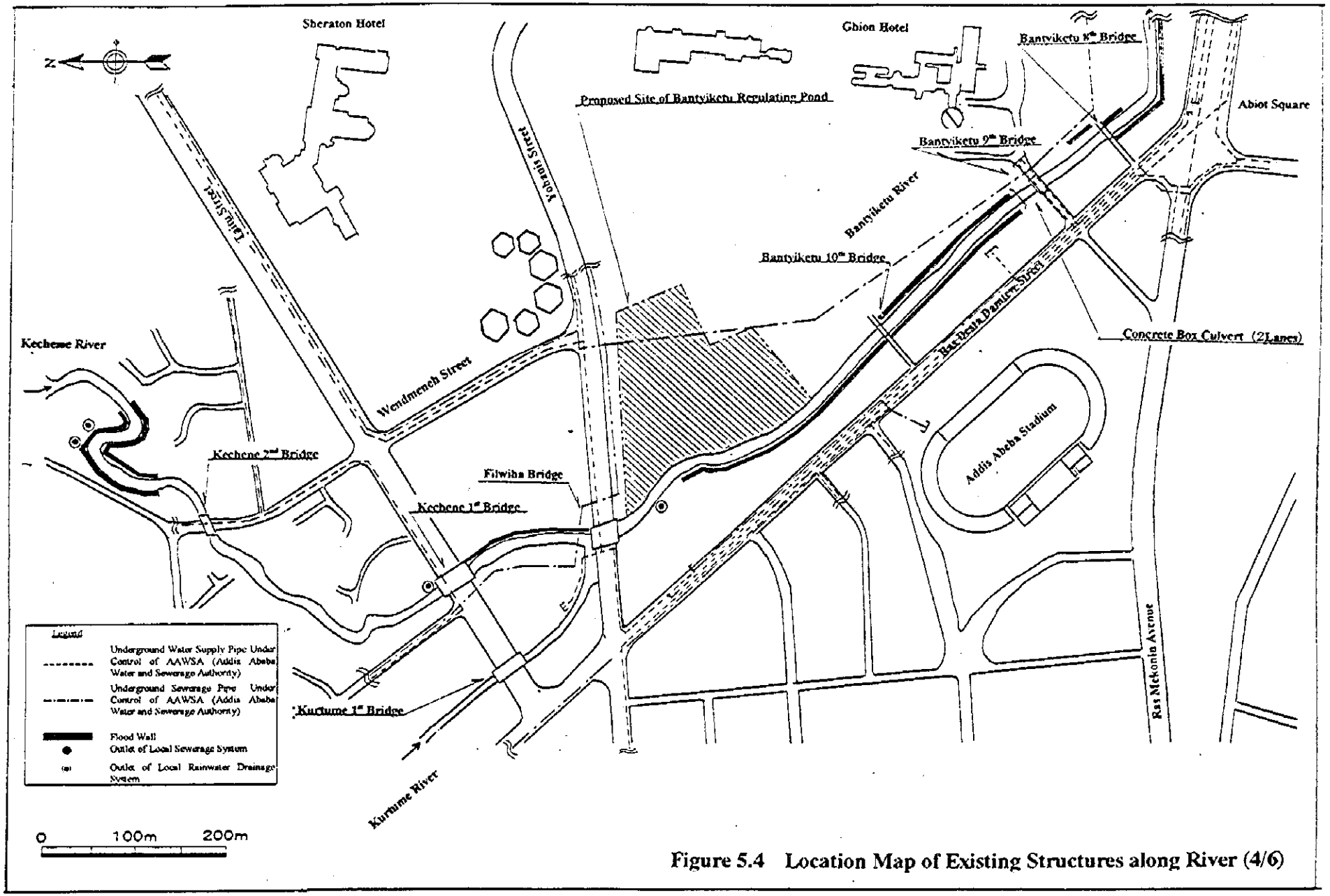


Figure 5.4 Location Map of Existing Structures along River (4/6)

In connection with the construction of the Bantyiketu regulating pond, the Master Plan Development and Inspection Department of the Region 14 Administration has planned the following two projects.

a) Construction of Road Connecting Yohanis Street and Ras Danitew Street

This road is planned connecting Yohanis Street with Ras Danitew Street. A proposed route runs along the western and southern edge of the proposed Bantyiketu regulating pond and then crosses over the Bantyiketu river. As a long-term plan, the road will further extend to the south, separated from the Ras Danitew Street. Elevated road and fly-over across the Bantyiketu river and the Ras Danitew Street are therefore under consideration.

b) Construction of Public Park

Two parks are planned as model parks in Addis Ababa. The proposed regulating pond area is planned as one of the model parks. For the year of 1997/98, detailed design is to be conducted. The park in the pond area is to be prepared as a multipurpose public park for recreation, festival, open theater, exhibition, and so on.

Both the above projects need to be carried out jointly with the construction of the Bantyiketu regulating pond. A close coordination between the said Department and the Addis Ababa Flood Control and Prevention Project Office (AFCPO) is needed for their project implementations.

(3) Lower Kechene River

The lower Kechene from the confluence with the Bantyiketu to the upstream of the Kechene 2nd Bridge having a total length of 2.8 km is running through the dense residential areas.

The Kechene river is practically subdivided into two reaches. The results of the field reconnaissance survey are therefore summarized by reach as described below. The major channel features of this reach are as follows.

Table 5.3 Major Features of Lower Kechene River

Reach	Length (km)	Average gradient of river bed	Average Width (m)	Average Channel Depth (m)
from Filwiha Bridge to Kechene 3rd Bridge	1.51	1/65	15	6
from Kechene 3rd Bridge to Upstream of Kechene 4th Bridge	1.30	1/45	25	8

Both the banks of this reach are low in elevation, especially in the area between the 1st and 2nd bridges. Accordingly, those riparian areas are prone to inundation.

As the countermeasures for this problem, AFCPO has a plan to construct floodwall on both the sides for an approximate length of 300 meters. The urgent works of the above are summarized below.

a) Work Item

- Construction of floodwall: 300 meters in long on the left and 340 meters on the right
- Repair of bridge abutment of 2nd bridge and its foot protection

b) Construction Cost

- About 2.9 million Birr

c) Tentative Implementation Schedule

- Tendering: by the end of February 1998
- Commencement of construction works: March 1998
- Construction Period: 6 months

The following are the existing river and related structures in the lower Kechene river as shown in Figure 5.5 and 5.6.

a) Floodwalls,
b) Road bridge (2 bridges),
c) Sewers with manholes, and
d) Drainage culverts (2 major culverts and others).

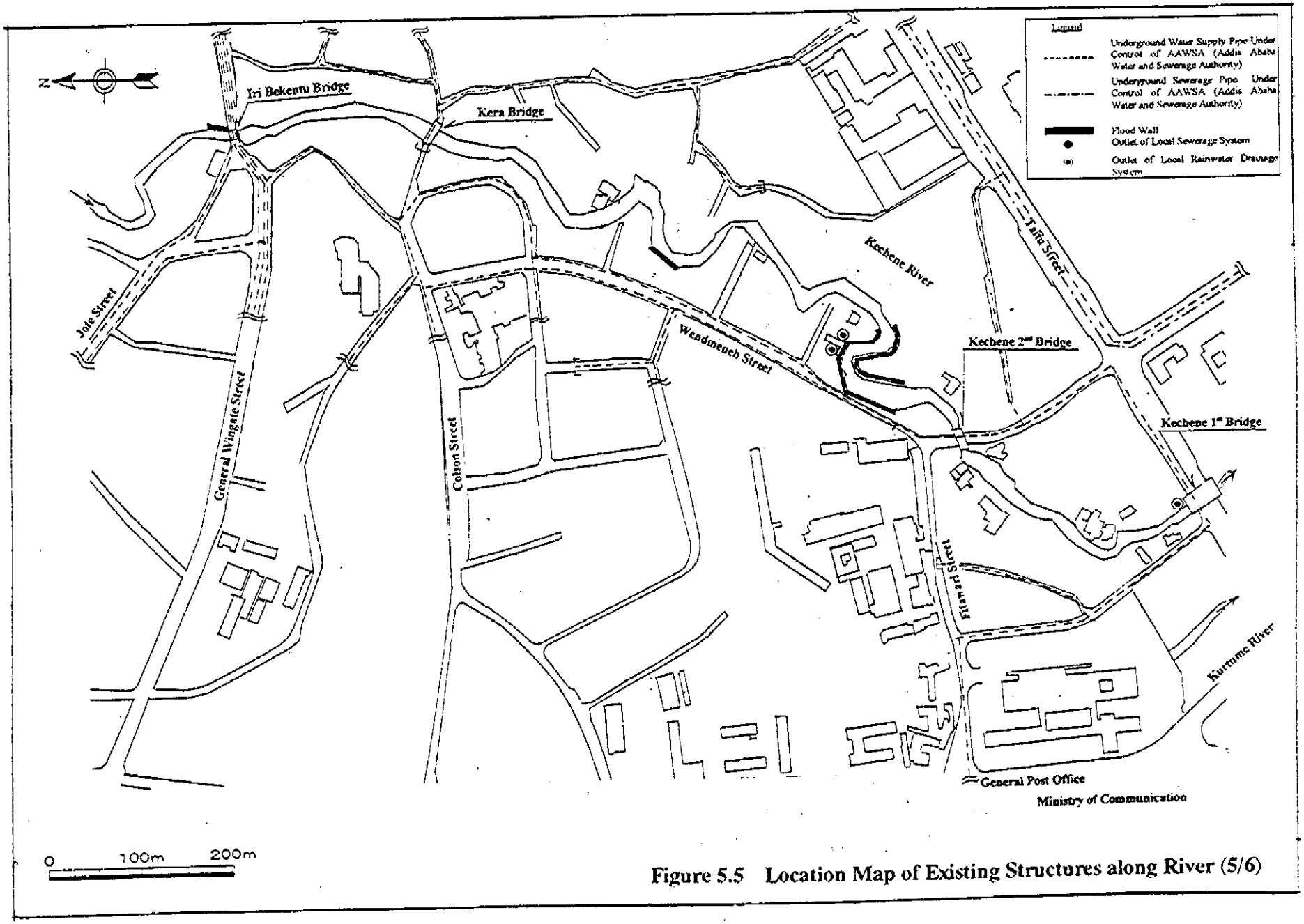


Figure 5.5 Location Map of Existing Structures along River (5/6)

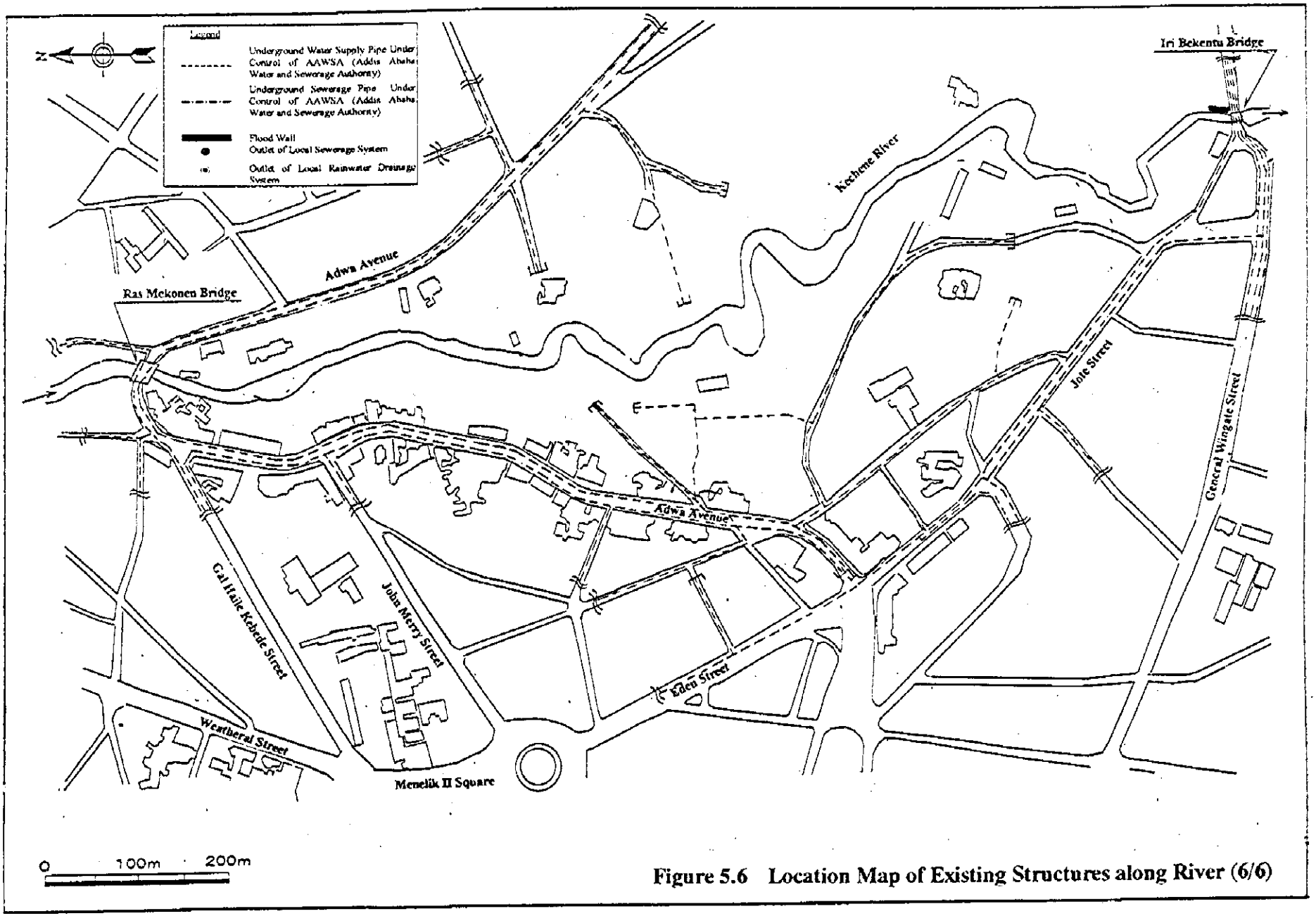


Figure 5.6 Location Map of Existing Structures along River (6/6)

(4) Kostre Regulating Pond Site

The proposed site of the regulating pond locates on the left bank in the lower reach of the Kostre that of the right tributary of the Kechene river. The proposed site has been utilized as a football ground. The total area of the football ground is around 8,000 m^2. Location map of the site is shown in Figure 5.7.

There is no house within the proposed site. The foundation rock at the proposed site of the regulating pond appears to be basalt, the same as the rock outcropped at the adjacent riverbed and to lie as deep as the outcropping rock at the riverbed.

(5) Kechene Weir Site

The proposed site of the Kechene weir locates just upstream of the Kechene bridge in the upper Kechene river. The river channel at the proposed site is wide valley. It seems that there are 4 to 5 houses to be affected by backwater in the reservoir of the proposed weir. Location map of the site is shown in Figure 5.8.

Geologically, the proposed weir site is underlain by basalt, without distinct joints/cracks and sufficiently hard to be suitable for foundation of the weir. The basalt is overlain with sandstone at the left abutment and tuff at the right abutment, both of which are highly weathered and jointed and as deep as about 5 meters from the ground.

The major dimensions of the river channel around weir site are as follows.

Table 5.4 Major Features of Kechene Weir Site

Reach	Length (km)	Average gradient of river bed	Average Width (m)	Average Channel Depth (m)
From Kechene Bridge to 1.2 km upstream	1.20	1/25	30 - 80	12

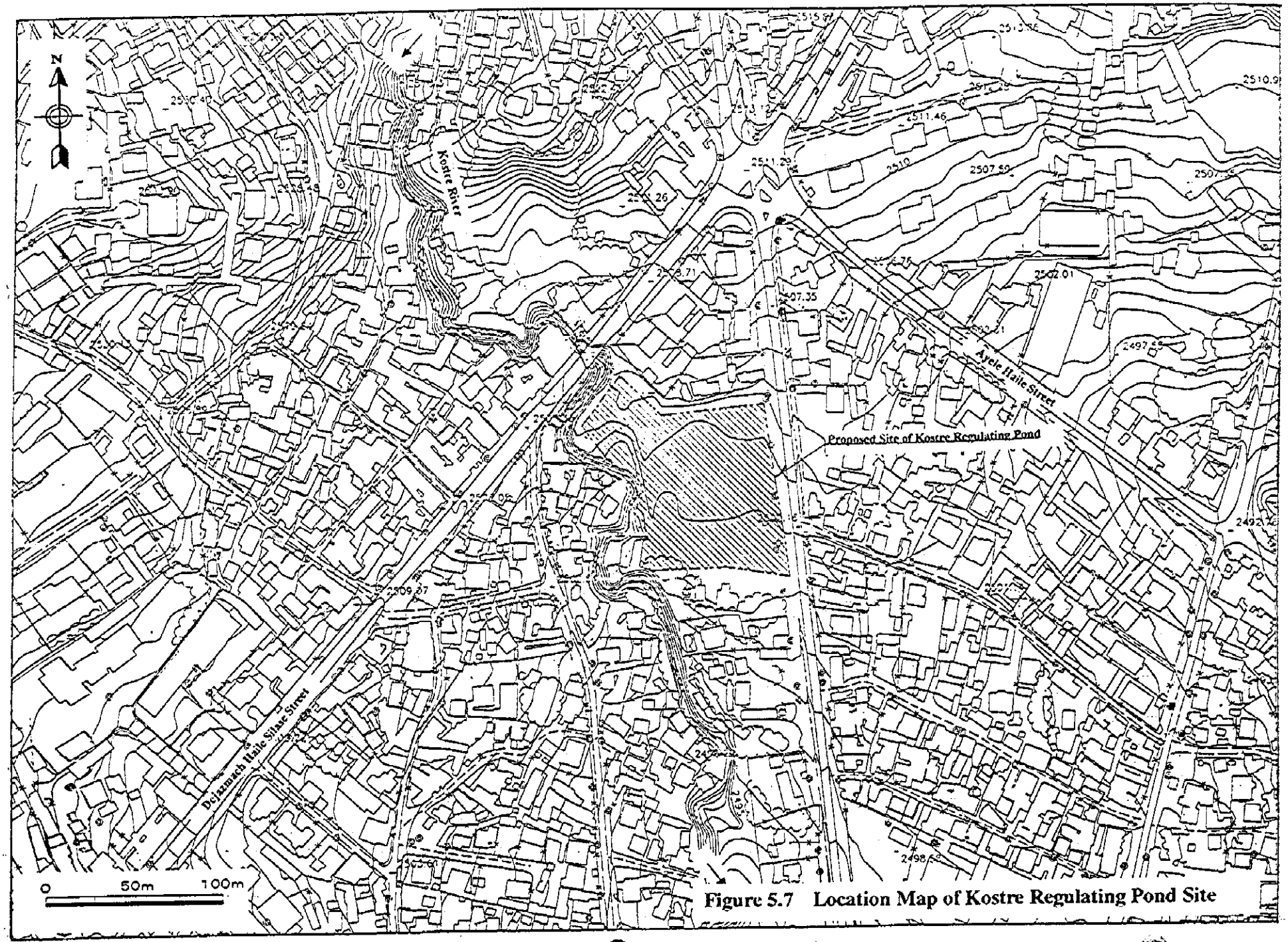


Figure 5.7 Location Map of Kostre Regulating Pond Site

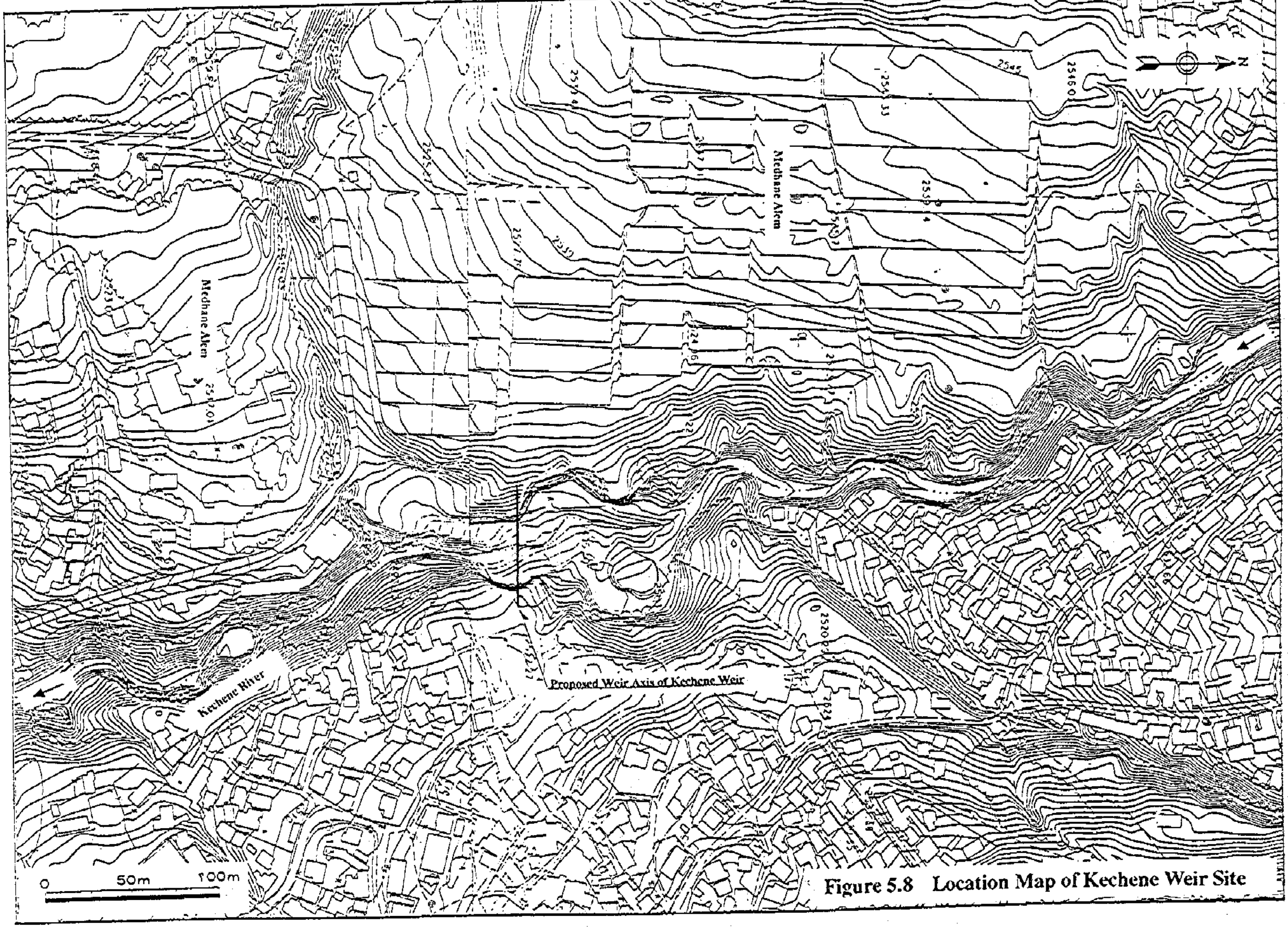


Figure 5.8 Location Map of Kechene Weir Site