SECTOR D

OPTIMUM FLOOD MITIGATION PLAN

VOLUME 3: SUPPORTING REPORT

SECTOR D: OPTIMUM FLOOD MITIGATION PLAN

TABLE OF CONTENTS

LIST OF TABLES IN REPORT

LIST OF FIGURES IN REPORT

SECTOR D OPTIMUM FLOOD MITIGATION PLAN

1. PLANNING FRAMEWORKS FOR FLOOD MITIGATION

1.1 Relevant National Development Plan

The updated national development strategies in Pakistan are formulated through "Three-year Plans (2001-2004)" and the "Ten Year Perspective Plan (2001-2011)" drafted by the Planning Commission taking into account the recommendations and suggestions from the relevant federal and provincial government agencies. These two (2) national development plans involve the various sectors and, among others, the sector of flood mitigation is derived from the "National Flood Mitigation Plan (NFPP)" prepared by the Federal Flood Commission (FFC).

Before establishment of NFPP, the Provincial Irrigation Departments and the relevant federal agencies used to prepare their own flood protection plans only within their jurisdiction areas without inter-provincial coordination. Such localized plans tended to cause the unnecessary disputes between the upstream and downstream provinces, and the inefficient project investment. Hence, the NFPP was established to implement the nation-wide flood mitigation plans unifying the proposals from various provinces and federal government agencies.

Two (2) phases of NFPP have been implemented during the recent two decades (1978 to 1998); namely Phase I (NFPP-I) for 1978-1988 and Phase II (NFPP-II) for 1988-1998. The draft of Phase III (NFPP-III) has further been prepared for the project implementation from 1998 to 2012. The investment cost for the NFPPs had remarkably increased from Rs. 1,630 million for NFPP-I to Rs. 16,360 million for NFPP-II. The investment cost in NFPP-III is further scheduled to increase to Rs. 25,965million as listed below.

Table R D.1 Investment Cost and Schemes Implemented under NFPP

Phase of NFPP	Classification	Investment Cost		Number of Schemes
		By Local Fund (Rs. Million)	By Foreign Fund (US$ Million)	
NFPP-1 (1978-88)	Normal Annual Development Program	1,630	0	311
NFPP-II (1988-98)	Normal Annual Development Program	2,541	0	170
	Flood Protection Sector Project-I (FPSP-1)	4,860	131	257
	1988 Flood/Rain Damage Restoration Project	2,300	200	2,065
	1924-94 Flood/Rain Damage Restoration Project	6,659	193	1980
	Total of NFPP-II	16,360	524	4,472
NFPP-III (1998-12)	Normal Annual Development Program (2000-2012)	2,400	Not fixed	Not fixed
	Flood Protection Sector Project-II (FPSP-I1) (1998-2004)	16,184	Not fixed	Not fixed
	Flood Protection Sector Project-III (FPSP-II1) (2005-2012)	7,381	Not fixed	Not fixed
	Total of NFPP-III	25,965	Not fixed	Not fixed

Note (1) : The investment cost and number of schemes for NFPP-I and II are the value actually invested, while the investment cost for NFPP-III are the proposed value as of 2001.
Note (2) : The investment cost for local fund under NFPP-III could be reduced provided that the financial assistance by the foreign fund could be induced.
Source : Annual Flood Report 2001, by FFC for NFPP-I and II
National Flood Protection Plan-III for NFPP-III

A particular attention in the above Table R D.1 is given to the phased programs applied to NFPP-II and III. That is, the projects in NFPP-I were implemented solely through the "Normal Annual Development Program", which is based on the actual annual requirement, while those in NFPP-II and III are implemented through not only the "Normal Annual Development Program" but also phased developments programs called "Flood Protection Sector Project (FPSP)". Thus, the importance of the flood protection projects in Pakistan is being recognized and the strategic nation-wide flood protection projects are steadily being implemented through the phased programs.

The structures as the primary output of the NFPP-I, II, III consist of the flood protection bunds (embankment), the channel protective spurs and the hill torrents structures. The length of the flood protection bunds and number of spurs so far constructed has reached 5,822km and 363 lots in total, respectively as listed in Table R D.2.

Table R D.2 Length of Existing Flood Protection Bund and Spurs

Name of Province	Length of Flood Bund (km)	Number of Spurs
(a) Punjub	2,749	151
(b) Sindh	2,422	36
(c) Northern West Frontier Province	290	176
(d) Balochistan	361	-
Total	5,822	363

Source: National Flood Protection Plan-III (1998-2012), May 2001 by FFC

The outputs of the NFPPs also cover the non-structural measures such as improvement of flood forecasting/warning system through expansion of the weather radar gauging system and data processing system to facilitate the flood management works. An attempt in the NFPP was further made to create public awareness so to enhance participation of beneficiary to the relevant flood prevention works.

The outputs of NFPPs are, however, oriented to flood protection and channel conservation for the nation-wide large rivers such as Indus River and its principal tributaries Chenab, Ravi, Sutlej and Jhelum Rivers. On the other hand, NFPP has given less attention to protection of the urban flood, particularly to the flood overflow from the small rivers similar to the Lai Nullah. That is, the urban flood tends to be regarded as the issue of urban drainage under jurisdiction of a local government, and the urban flood protection plan has been formulated and/or implemented by each of the competitive local government authorities on the ad-hoc basis with less compliance to the national development strategy.

The flood overflow in the urban areas tends to cause the disastrous damage with death of people as the progress of the intensive urbanization, and seriously inflict the national socio-economic deteriorations. Accordingly, it is indispensable to delineate the nation strategy for urban flood mitigation, and the NFPP should cover this category as the further challenge. From these

viewpoints, the Study will be made on the premises that the proposed flood mitigation plan for Lai Nullah should be newly programmed in the NFPP-III and further incorporated into the national development plans of the aforesaid "Three-year Plans (2001-2004)" and the "Ten Year Perspective Plan (2001-2011)".

1.2 Target Design Flood Scale of the Project

The target design flood scale is preliminarily proposed at 100-year return period as the ultimate goal of the project from viewpoints of the following items (1) to (3).

(1) The flood in July 2001 is regarded as the recorded maximum flood, and its recurrence probability is evaluated to be little under 100-year return period (refer to Sector A). The target design flood level should cover this recurrence probability of the recorded maximum flood.

(2) The Steering Committee for the Study through the meeting on the Inception Report preferred that the target design level of the long-term flood mitigation for the Lai Nullah should reach 100-year return period at least.

(3) There does not exist any definitive guideline for the design flood scale to be applied to the urban centers in Pakistan. Nevertheless, the flood damage of the Study area, which encompasses the twin cities of Islamabad and Rawalpindi, could bring out the significant adverse effect to the national development In order to avoid such nation-wide adverse effect, the Asian countries apply the design flood scales of 100-year return period for their capitals or major cities as listed below:

Table R D.3 Design Flood Level for River running through Capital and/or Major Cities of Asian Countries

Country	River	Major City in River Basin	Population of the City (million)	Design Flood (return period)	Remarks
Japan	Tone	Tokyo	12.0	200	Completed
Thailand	Chao Phraya	Bangkok	7.6	100	Planned
Philippines	Pasig-Marikina	Manila	9.5	100	Planned
Indonesia	Ciliwung	Jakarta	10.0	100	Completed
Malaysia	Klang	Kuala Lumpur	1.5	100	Planned
Vietnam	Red	Hanoi	2.1	100	Planned

1.3 Phased Programs and Target Project Completion Time

The flood mitigation plan is composed of the various structural and non-structural measures. Among others, the structural-measures are proposed to make Lai Nullah Basin free from the flood overflow caused by the probable runoff discharge below the above design flood level of the structures. On the other hand, the principal purpose of the non-structural measures is

oriented to mitigation of the flood damage caused by the probable runoff discharge over the design scale.

However, the target design level of 100-year return period would require the quantitative work volume and land acquisition. As the results, the overall structural mitigation plan would lead to the long implementation period and the project investment cost that may take up a substantial share of the annual national development budget. On the other hand, the flood mitigation effects are urgently and at the same time, progressively required to prevent the target areas (i.e., Islamabad and Rawalpindi) from the recurrent disastrous flood damage and enhance the better urban environments. Accordingly, the proposed structural flood mitigation plan would need to be implemented through the phased programs in line with the national development strategies.

From the above viewpoints, the proposed flood mitigation plan is provisionally divided into the three (3) phased programs in order to achieve the immediate flood mitigation effects and at the same time to achieve the long-term sustainable flood mitigation effect. The target structural design level and the target completion year for the phased programs are as listed in Table R D.4.

Table R D.4 Proposed Phased Flood Mitigation Program

Phased Program	Target Structural Design Level	Target Completion Year
Urgent Project	Indefinite*	2005
Short-term Project	25-year return	2007
Lon-term Project	100-year return	2012
Program posterior to Long-term Project	100-year return	Indefinite*2

Note: *: Regardless to the design level, the urgent project is implemented as the priority component of the short-term project in order to produce the immediate flood mitigation effect

As described above, the on-going channel improvement for Lai Nullah from Kattarian Bridge to Chaklala could hardly achieve its original design flood level of 25-year return flood, and a certain supplementary and/or reinforcement works are required to reach the original design level. Hence, the short-term project is proposed to fulfill the design level of 25-year return period. The on-going channel improvement is scheduled to complete by March 2003, and, thereby target completion year of the entire the short-term project is provisionally assumed at 2007 considering that the components of the short term project would require the further detailed field investigations and clarification of technical and economical viability.

The urgent project is among the components of the above short-term project taking urgency and easiness of project implementation into account. The urgent project is to be completed within a few years (by the year of 2005 assumed in the Study) to produce the immediate flood mitigation effect.

The ultimate target design level of 100-year return period for the flood mitigation of Lai Nullah would be achieved through the long-term project. The objective flood mitigation plan for the

Lai Nullah contains the significant effect to the national and regional socio-economy, and it should be implemented in line with the relevant national development plans. In this connection, the flood mitigation plan for Lai Nullah proposed in this Study should be newly programmed in the NFPP-III and further incorporated into the national development plans of the aforesaid "Three-year Plans (2001-2004)" and the "Ten Year Perspective Plan (2001-2011)". Taking the implementation period of these relevant national development plans into consideration, the target completion year for the long-term project is preliminarily assumed at 2012.

1.4 Design Discharge Adopted to Phased Programs

Lai Nullah basin, Islamabad in particular may expand the urban area even after the completion of the long-term project in 2012. The progress of urbanization would curtail the non-built-up area such as vacant land and natural forest, which are not sealed by pavement and contain many low pits contributing to the natural flood retarding effect. As the results, Islamabad (i.e., the upper reaches of Lai Nullah above Kattarian Bridge) may gradually increase its basin peak flood runoff discharge.

CDA has projected to complete the urban development plan of Islamabad by the year of 2030. According to the urban development plan of Islamabad, however, the upper reaches of Lai Nullah basin above Kattarian Bridge (i.e., the jurisdiction area of Islamabad) would have the less urbanization from present up to 2030, that is: the urbanized area of the basin will increase from 32.4% in 2001 to 42.7% in 2012 and 49.6% in 2030. Due to such limited extent of urbanization, any significant difference is not seen in the probable peak runoff discharges in 2001, 2012 and 2030 as shown in Table R D.5. Accordingly, it is expected that the flood safety level achieved by the long-term project would be ever sustained even after completion of the long-term project, and any flood mitigation program posterior to the long-term project would not be required.

Taking the insignificant differences of the probable peak runoff discharges from 2001 to 2030 into account, it is also assumed that the design discharge in the land use states of year 2012 could be applied to the whole of the urgent project, the short-tem project as well as the long-term project,.

Table R D.5 Probable Flood Runoff Discharge and Urbanized Ration of Lai Nullah Basin

Description		Year 2001	Year 2012	Year 2030
1. Probable Flood Discharge of Lai Nullah at Kattarian Bridge	5-year return period	310 m^3/s	330 m^3/s	350 m^3/s
	25-year return period	1,110 m^3/s	1,150 m^3/s	1,180 m^3/s
	100-year-return period	2,200 m^3/s	2,270 m^3/s	2,290 m^3/s
2. Urbanized Ratio* of Lai Nullah Basin above Kattarian Bridge		32.4%	42.7%	49.6%

Note*: Urbanized Ration means the share of built up area (=residential area + commercial area + industrial Area) to the total extent

2. COMPARATIVE STUDY ON ALTERNATIVE COMBINATIONS OF STRUCTURAL MEASURES

The followings are preliminarily scrutinized as the potential structural measures for flood mitigation of Lai Nullah as described in Sectors B and C in detail.

(1) River channel Improvement of Lai Nullah and its tributaries;

(2) Community pond used as the flood detention facility at Fatima Jinnah Park in Islamabad;

(3) Flood mitigation dam to be placed in the area administratively called Block E-11 of Islamabad;

(4) Flood diversion channel to divert the flood discharge from tributaries of Bedarawali Kas, Tenawali Kas and Saidpur Kas to Kurang river;

(5) On site-flood detention facilities such as (a) the rainfall storage tank installed at individual house lot, (b) the flood detention wall at public open space, (c) the on-site flood detention pond and (d) the infiltration facility.

The flood mitigation capacity of each of the above potential measures is limited to a certain level due to topographic conditions, hydrological conditions and various social/environmental conditions. Accordingly, the single measure may not cope with the target design flood of the short-term as well as the long-term project. Hence, a combination of the measures would be required to achieve the target flood mitigation, and the optimum combination would be selected among the alternative combinations of the measures. From these points of view, the following issues are preliminarily clarified as the first approach to section of the optimum combination.

(1) Required disposal discharge as expressed by difference between the present channel flow capacity of Lai Nullah and the probable peak flood runoff discharge corresponding to the target design scales;

(2) Potential maximum flood mitigation capacity expected to each of the above flood mitigation measures;

(3) Eligible alternative flood mitigation schemes composed of the above flood mitigation measures taking the above items (1) and (2); and

(4) Flood mitigation capacity required to each of components of eligible alternative flood mitigation schemes to cope with the required disposal discharge of the above item (1).

2.1 Necessary Discharge to be Regulated

Kattarian Bridge, among the reference points of Lai Nullah, is located at the inflow point of the on-going channel improvement. The probable peak flood runoff discharges at Kattarian Bridge

are estimated at 1,150m^3/s for the target design level of the short-term project (25-year return period) and 2,270m^3/s for the long-term project (100-year return period), respectively. On the other hand, the channel flow capacity of Lai Nullah upon completion of the on-going river channel is limited only to 640m^3/s at Kattarian Bridge. The difference between the probable peak flood discharge and the channel flow capacity is 510m^3/s and 1,630m^3/s, which need to be offset by the followings (refer to Fig. R D.1):

(1) Reduction of the peak runoff discharge by the proposed community pond or flood detention dam; or

(2) Increment of channel flow capacity by the further river channel improvement (by deepening of the riverbed) or the flood diversion.

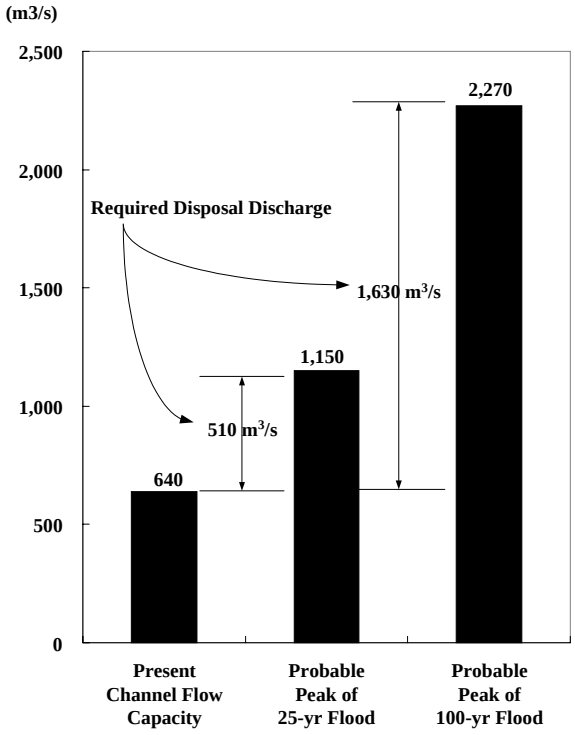

Fig. R D.1 Concept of Required Discharge

2.2 Potential Maximum Capacity of Each Flood Mitigation Measure

The maximum possible reduction of probable peak discharges by the community pond and/or the flood mitigation dam was estimated through the hydrological simulation. As shown in the Table R D.6, the probable peak discharges of 25-year return period at Kattarian Bridge could be reduced from about 1,150m^3/s to 830m^3/s by 320m^3/s (28%), should both of the community pond and flood mitigation dam be constructed on the premises of their maximum development of storage capacities (i.e., 2.90 million m^3 for the community pond and 2.64 million m^3 for the flood mitigation dam). The peak discharge of 100-year return period could be also reduced from

2,270m^3/s to 1,730m^3/s by 540m^3/s (24%). Thus, the community pond and the flood mitigation dam have the substantial effect to reduce the probable peak discharge by more than 20%.

Table R D.6 Maximum Reduction of Probable Peak Flood Discharge by Proposed Flood Detention Facility at Kattarian Bridge

Flood Detention Facility Applied	Live Storage Capacity (million m^3)	Catchment Area of Facility (km^2)	Flood Mitigation Effect at Kattarian Bridge (m^3/s)			
			25-year return period		100-year return period	
			Peak (m^3/s)	Reduction (m^3/s)	Peak (m^3/s)	Reduction (m^3/s)
1 No facility	0	0	1,150	0	2,270	0
2 Community Pond	2.90	26.5	960	190	2,030	240
3 Dam	2.64	19.7	1,000	150	1,970	300
4 2 + 3	5.54	46.2	830	320	1,750	520

The river channel improvement is made by channel bed deepening, and upon its completion, the channel flow capacity at Kattarian Bridge could be increased from 640m^3/s to 900m^3/s by 260m^3/s (refer to Sector B). As for the flood diversion channel, the possible channel flow capacity is preliminarily evaluated to cover about 1,630m^3/s taking the following factors into account: (a) the allowable limit of the right-of-way along the diversion route, (b) the possible channel bed slope of the diversion route and (c) the required improvement works of Kurang River, the outlet of diversion channel (refer to Sector C). Based on these clarifications, the maximum flood mitigation capacities of the components for the alternative flood mitigation schemes are summarized as below.

Table R D.7 Summary on Maximum Flood Mitigation Capacity of Each Potential Measure at Kattarian Bridge

Return Period	Maximum Flood Mitigation Capacity of Potential Flood Mitigation Measure (m^3/s)				
	Reduction of Peak Discharge			Increment of Flow Capacity	
	Community Pond	Flood Mitigation Dam	Pond + Dam	River Improvement	Flood Diversion
25-year	190	150	320	260	1,700
100-yer	240	300	520		

2.3 Alternative Flood Mitigation Plans

As described above, the required discharges to be regulated at Kattarian Bridge are 510m^3/s for 25-year return period and 1,630 m^3/s for 100-year return period. On the other hand, the maximum flood mitigation capacity as the total by the community pond, the flood mitigation dam and the river channel improvement is 580 m^3/s for 25-year return flood and 800m^3/s for 100-year return flood. Accordingly, the flood diversion would not be necessarily required to cover the aforesaid disposal discharge of 25-year return period, while the flood diversion would be indispensable for the disposal discharge of 100-year return period. Taking all possible combinations of the flood mitigation measures based on the conditions into account, the alternative flood mitigation plans are delineated as listed in Table R D.8.

Table R D.8 Eligible Alternative Flood Mitigation Plans

Alt. No.	Measures to be included and not included into the Alternatives			
	Measure to reduce the peak flood discharge		Measures to increase the flood flow capacity	
	Community Pond	Flood Mitigation Dam	River Improvement	Flood Diversion
Alt. 1	○	○	○	○
Alt. 2	○	×	○	○
Alt. 3	×	○	○	○
Alt. 4	○	○	×	○
Alt. 5	×	×	○	○
Alt. 6	○	×	×	○
Alt. 7	×	○	×	○
Alt. 8	×	×	×	○

Note:○ = Included as the component of the alternative, × = Excluded as the component of the alternative

The flood mitigation capacities required to each of the structural flood mitigation measures, which compose the alternative flood mitigation schemes are estimated based on (1) the required discharge to be regulated and (2) the potential maximum capacity of each flood mitigation measures (refer to subsection 2.2). The results of estimation are as summaries below:

Table R D.9 Flood Discharge Disposed at Kattarian Bridge by Alternative Flood Mitigation Schemes

Channel Flow Capacity	Probable Peak Discharge	Required Disposal Discharge*	Discharge Disposed by Alternative Combinations of Measures (m^3/s)				
			Alt. No.	Reduction of Peak Discharge by		Increment of Flow Capacity by	
				Community Pond	Flood Mitigation Dam	River Improvement	Flood Diversion
25-year Return Period	1,150	510	Alt. 1	320		190	-
			Alt. 2	190	-	260	60
			Alt. 3	-	200	260	50
			Alt. 4	320		-	190
			Alt. 5	-	-	260	250
			Alt. 6	190	-	-	320
			Alt. 7	-	200	-	310
			Alt. 8	-	-	-	510
100-year Return Period	2,270	1,630	Alt. 1	450		260	920
			Alt. 2	150	-	260	1,220
			Alt. 3	-	300	260	1,070
			Alt. 4	450		-	1,180
			Alt. 5	-	-	260-	1,370
			Alt. 6	150	-	-	1,480
			Alt. 7	-	300	-	1,330
			Alt. 8	-	-	-	1,630

*: Required Disposal Discharge = Probable peak discharge – Channel flow capacity upon completion of the on-going channel improvement (=640m3/s)

As listed above, the design level of 25-year return period proposed as the target of the short-term could be achieved by a combination of the community pond, the flood mitigation dam and the river channel improvement without dependence to the flood diversion. As for the design level for 100-year return period, however, the flood diversion is indispensable, and the share of the disposal discharge by the flood diversion would be more than half of the total disposal discharge.

2.4 Optimum Structural Flood Mitigation Plan

The optimum flood mitigation plan was determined through comparison of the alternative schemes based on the project cost, the compensation works, the immediate flood mitigation effect, and other relevant social/natural environmental impacts by the project into consideration. As the results, the following evaluation was made, and the Alternative 6, which is principally composed of the community pond in Fatima Jinnah Park and the flood diversion, was selected as the alternative scheme. The detailed viewpoints of each evaluation items are as described in the following items 1) to 4).

Table R D.10 Evaluation of the Alternative Flood Mitigation Schemes

Alt. No.	Evaluation ○ : Preferable × : Not preferable △ : Fair				Remarks
	Project Cost	Compensation	Immediate Flood Mitigation Effect	Social/Natural Environmental Impacts	
Alt. 1	×	×	○	×	
Alt. 2	△	△	○	×	
Alt. 3	×	×	×	×	
Alt. 4	×	×	○	×	
Alt. 5	△	△	×	×	
Alt. 6	○	△	○	△	Optimum Scheme
Alt. 7	×	×	×	×	
Alt. 8	○	△	×	△	

2.4.1 Evaluation on Project Cost

Among others, the Alt. 6 has the least cost of long-term project below 7,500 million Rs. followed by Alt. 8 as listed in Table R D.11. In contrast to the above Alts 6 and 8, other alternatives require the comparatively high cost of about 8,000 to 11,000 million Rs. They contain the flood mitigation dam and the river channel improvement as their components of flood mitigation structures, and the relatively high cost could be attributed to the land acquisition for the flood mitigation dam and the re-construction cost of bridges for the river channel improvement.

The flood mitigation dam in particular would require the land acquisition of about 80 ha. The land belongs to the private owner and it is located at Block 11 adjacent to the center of Islamabad. Due to these conditions, the land acquisition cost for the flood mitigation is evaluated to be almost same market value as the residential area of Islamabad, and therefore, the flood mitigation dam would require the high project cost as compared with its limited flood effect.

As for the river channel improvement, the proposed channel deepening from Chaklala Bridge to Kattarian Bridge would require reconstruction of the existing ten (10) bridges and reinforcement of the new bridges, which are now in progress through the on-going channel improvement by

RDA. Due to the cost for reconstruction/reinforcement of these bridges, the entire project cost for the proposed channel deepening becomes comparatively high.

Table R D.11 Project Cost of Alternative Flood Mitigation Schemes for Long-Term Project

(Unit: million Rs.)

Alt. No.	Measure to reduce the peak flood discharge		Measures to increase the flood flow capacity		Supplementary to On-going River Improvement*	Total
	Community Pond	Flood Mitigation Dam	River Improvement (Deepening of Channel)	Flood Diversion		
Alt. 1	851	2,792	1,948	4,239	873	10,702
Alt. 2	851	-	1,948	4,901	873	8,573
Alt. 3	-	2,792	1,948	4,486	873	10,099
Alt. 4	851	2,792	-	4,803	873	9,319
Alt. 5	-	-	1,948	5,178	873	7,999
Alt. 6	851	-	-	5,605	873	7,330
Alt. 7	-	2,792	-	5,068	873	8,733
Alt. 8	-	-	-	6,574	873	7,448

*: Includes the side-protection for the entire stretch of the on-going river improvement section from Chaklala Bridge to Kattarian Bridge (RD6+251-RD17+210), and the improvement of the existing channel of Lai Nullah (RD5+277-RD6+215) below Chaklala Bridge

2.4.2 Evaluation on Compensation Works

When the flood mitigation dam is included as one of the components for the alternative flood mitigation schemes, the extent of land acquisition tends to remarkably increase as shown in Table R D.12. Moreover, the private land developer had commenced development of the residential area in and around the proposed dam reservoir in October 2002, and a substantial progress of development has been achieved, although the development is being illegally made without approval by CDA, the land administrator for the subject area. Difficulties are also foreseeable in acquiring land, because the land acquisition is subject to consent of many private owners for the subject land.

As for the house evacuation required to the project, all alternatives require the relatively small number of houses of less than about 270 houses to be evacuated (refer to Table R D.13). Out of the 270 houses, 220 houses are required to all of the alternatives in common due to necessity of the proposed channel improvement of Kurang River as the outlet of the proposed diversion channel. All of these houses are, however, built within the habitual flood inundation area, and the limits of the river reserve area declared by CDA Moreover, most of the houses are the temporary structures/the shanties. Due to these backgrounds, the fewer disputes on the house evacuation are expected.

There also exist about 30 houses to be evacuated for construction of the flood mitigation dam. In contrast to the above houses to be evacuated for improvement of Kurang River, these houses are located in the on-going residential development area, and difficulties are foreseeable in relocating them. From viewpoints of the foreseeable difficulties in relocating the houses as well

as the aforesaid difficulties of land acquisition, the alternatives, which include the flood mitigation dam, would not be preferable as the component of the optimum scheme.

Table R D.12 Land Acquisition Required to Alternative Flood Mitigation Schemes for Long-term Project

(Unit: m^2)

Alt. No.	Measure to reduce the peak flood discharge		Measures to increase the flood flow capacity		Supplementary to On-going River Improvement*	Total
	Community Pond	Flood Mitigation Dam	River Improvement (Deepening of Channel)	Flood Diversion		
Alt. 1	0	798,000	13,000	290,000	8,000	1,109,000
Alt. 2	0	-	13,000	321,000	8,000	342,000
Alt. 3	-	798,000	13,000	301,000	8,000	1,120,000
Alt. 4	0	798,000	-	315,000	8,000	1,121,000
Alt. 5	-	-	13,000	333,000	8,000	354,000
Alt. 6	0	-	-	348,000	8,000	356,000
Alt. 7	-	798,000	-	329,000	8,000	1,135,000
Alt. 8	-	-	-	366,000	8,000	374,000

*: For the improvement of the existing channel of Lai Nullah (RD5+277-RD6+215) below Chaklala Bridge

Table R D.13 Number of House Evacuation Required to Alternative Flood Mitigation Measures for Long-term Project

(Unit: houses)

Alt. No	Measure to reduce the peak flood discharge		Measures to increase the flood flow capacity			Total
	Community Pond	Flood Mitigation Dam	River Improvement (Deepening of Channel)	Flood Diversion		
				Construction of Diversion	Improvement of Kurang River	
Alt. 1	0	30	0	20	220	270
Alt. 2	0	-	0	20	220	240
Alt. 3	-	30	0	20	220	270
Alt. 4	0	30	0	20	220	270
Alt. 5	-	-	0	20	220	240
Alt. 6	0	-	0	20	220	240
Alt. 7	-	30	0	20	220	270
Alt. 8	-	-	0	20	220	240

2.4.3 Immediate Flood Mitigation Effect

Among the components of the flood mitigation measures, the community pond would not cause any social problem (such as dispute on house evacuation/land acquisition, traffic disruption and splits of the local communities) in nature, and therefore the early commencement of its construction is expected. Moreover, the required construction period is estimated at only 2 years, which is far shorter than those for other proposed structural measures.

Lai Nullah below Kattarian Bridge would have a channel flow capacity to cope with the probable peak flood runoff discharge of 10-year return period through the on-going river channel improvement by RDA, which is scheduled to complete by September 2003. Upon completion of the community pond, the channel flow capacity would be lifted up to meet the probable peak runoff discharge of 13-year return period. Moreover, even in case of the probable

flood runoff of more than 13-year return period, the probable flood inundation area as well as inundation depth would be substantially reduced due to the flood detention effect of the community pond.

From the above viewpoints, the alternatives, which include the community pond as their component of the structural measures, are preferable in the aspect of the immediate effect of the flood mitigation effect.

2.4.4 Relevant Social and Natural Environment Influenced by the Project

Each of the structural measures included into the alternative flood mitigation schemes would contain potentials of adverse impact to the social and natural environments as enumerated below.

(1) Traffic disruption by the river channel improvement and the flood diversion;

(2) Dispute over house evacuation/land acquisition by the flood mitigation dam;

(3) Replacement of the underground public facilities such as cables and water pipes by the flood diversion;

(4) Change of flow regime of Lai Nullah by the flood diversion; and

(5) Deterioration of the water quality in the community pond.

The flood diversion is indispensable to all of the alternatives, and its potential adverse effects could be avoided through the countermeasures; such as:

(1) Construction temporary bypasses to minimize traffic disruption;

(2) Progressive replacement of the underground public facilities for a long-term so as to minimize the adverse effect of the interruption of the facilities; and

(3) Securing of the maintenance flow for Lai Nullah by construction of the appropriate diversion structures and maintenance channel so as to minimize the change of the flow regime of Lai Nullah.

Deterioration of the water quality in community pond could be also minimized and/or improved better than the present through the following designs:

(1) To construct the oxidation ponds to improve the water quality of inflow;

(2) To construct the check dams to stop the garbage flowing to the pond;

(3) To construct the diversion channel to bring the clean discharge from the adjacent river (i.e., Bedarawali Kas) into the pond; and

(4) To alternate the existing route of low flow of Tenawali Kas, which now gives an offensive odor, and not connect it to the pond.

As stated above, the potential adverse effects of the flood diversion and the community pond could be minimized by adopting the several practical countermeasures. On the other hand, the flood mitigation dam and the river channel improvement are likely to have the fatal adverse social effects. That is, the flood mitigation dam would cause the serious dispute over the house evacuation and/or land acquisition as described above. As for the river channel improvement, the proposed channel deepening from Chaklala Bridge to Kattarian Bridge would require reconstruction/ reinforcement of the thirteen (13) bridges as mentioned above. These bridges currently take an important role for traffic of Rawalpindi, and interruption of these bridges due to river improvement would cause the serious traffic disruption and further deterioration of the regional economy.

3. IMPLEMENTATION PROGRAM

3.1 Implementation Program for Flood Mitigation Project

The phased implementation programs for each of the component measures in the structural flood mitigation plan is prepared taking the necessary construction period and the significance of flood mitigation effects into account. The implementation program is also prepared for the proposed non-structural flood mitigation measures such as the flood forecasting and warning system and the dissemination of the flood risk maps. Details of these non-structural measures are as described in Sector A. The non-structural flood mitigation measures are provisionally assumed to progressively complete by the target year of 2012 in parallel with implementation of the structural measures so as to fulfill the maximum flood mitigation effect. The overall implementation program for the flood mitigation projects is as summarized in Table R D.14.

Table R D.14 Overall Implementation Program

Sector	Scheme	Phased Program		
		Urgent (2004-05)	Short-term (2005-07)	Long-Term (2008-12)
1. Structural Flood Mitigation Project	1.1 Community Pond at the Fatima Jinnah Park	○		
	1.2 Flood Diversion			
	(1) Flood diversion from Bedarawali Kas to Tenawali Kas			○
	(2) Flood diversion from Tenawali Kas to Kurang River		○	○
	(3) Improvement of Kurang River		○	○
	1.3 Supplementary works for on-going river channel improvement			
	(1) River improvement below Chaklala Bridge	○		
	(2) Side slope protection works of the on-going improvement section		○	
2. Non-structural Flood Mitigation Project	2.1 Establishment of flood forecasting and warning system	○		
	2.2 Establishment of flood risk map		○	○

3.1.1 Flood Mitigation Measures for Urgent Project

Among the proposed flood mitigation measures, the following two structural measures and one non-structural measure are selected as the components of the Urgent Project considering the immediate mitigation of flood damage and the possible completion within the target implementation period by the year of 2005.

1) Improvement of the section of Lai Nullah (RD5+277-RD6+216) below Chaklala Bridge

The river improvement of the section of Lai Nullah between Chaklala Bridge and Kattarian Bridge (RD6+216-17+210) is now in progress and scheduled to complete by September 2003. The realignment/enlargement of the meandering section around Murree Brewery Area (RD4+077-RD5+277) has also been completed as the supplementary work of the river improvement.

However, the section (RD5+277-RD6+216) sandwiched between the above river improvement sections is left behind without any channel improvement. It is verified that the section forms bottleneck causing the adverse backwater effect to the on-going river improvement section above Chaklala Bridge. Accordingly, the river improvement of the section is urgently required to offset the adverse backwater effect and to preserve the design flow capacity of the on-going channel improvement.

2) Construction of Community Pond

The substantial part of the park Fatima Jinnah Park as the construction site of the community pond is still remained as the vacant land without any major permanent structure. CDA, the administrator of the park has given the provisional consent to use the park as the flood detention facility, in view of the function of community pond to improve the amenity of the park. Due to these conditions, construction of the community pond would not require any house evacuation and land acquisition, which avail the early commencement of construction. Moreover, the required construction period is provisionally estimated at about 2 years, whereof the community pond could be completed by the target year of 2005 for the Urgent Project. Moreover, The community pond could have cut almost all the probable peak runoff discharge of 25-year return period, and reduce about 35% of the park flood discharge even in case of 100-year return period. These functions could increase the flood safety level of the downstream of Lai Nullah. Thus, the proposed community pond would contribute the significant flood mitigation effect to the downstream of Lai Nullah.

3) Reinforcement and Expansion of the Existing Flood Forecasting and Warning System

In the event of July 2001 flood, Pakistan Metrological Department (PMD) observed an extra-ordinary scale of rainfall intensity in Lai Nullah through its weather surveillance radar and rainfall gauging. Judging from the results of the observation, PMD predicted a possibility of serious flood overflow along Lai Nullah a few hours before its actual occurrence. In spite of the advanced awareness of the flood, the flood caused the death of 75 people.

Should the existing flood gauging, communicating and warning system be strengthened, the more accurate and immediate flood information could be systematically collected, and the death calamity as experienced in 2001 flood would be relieved. From these viewpoints, the improvement of the existing flood forecasting and warning system is proposed as an eligible measure to immediate effect mitigation of the flood damage, the calamity of death in particular.

3.1.2 Flood Mitigation Measures for Short-term Project

The Short-term Project with its target completion year of 2007 would include the flood diversion channel for the design scale of 25-year return period as the structural measure and the establishment of the flood risk maps as the non-structural measures.

1) Flood Diversion Channel for Short-term Project

The flood diversion channel for the design scale of 25-year return period would be completed by the year 2007 as the provisional flood mitigation measure for the under-mentioned flood diversion channel with the design scale of 100-year return period. The diversion channel will divert the flood runoff discharge from Tenawali Kas and Saidpur Kas into Kurang River. In addition, the flood runoff discharge from the tributary of Bedarawali Kas would be indirectly diverted, through Community Pond, Tenawali Kas, and the diversion channel. The design discharges of the diversion channel are as listed below (refer to Fig. R D.2):

Table R D.15 Design Discharge of Diversion Channel in Short-term Project

Section	Design Flow Capacity (m^3/s)
Tributary of Bedarawali Kas to Tenawali Kas (Community Pond)	70
Tenawali Kas to Saidpur Kas	70-140
Saidpur Kas to Ojhri Kas	320
Ojhri Kas to Kurang River	470

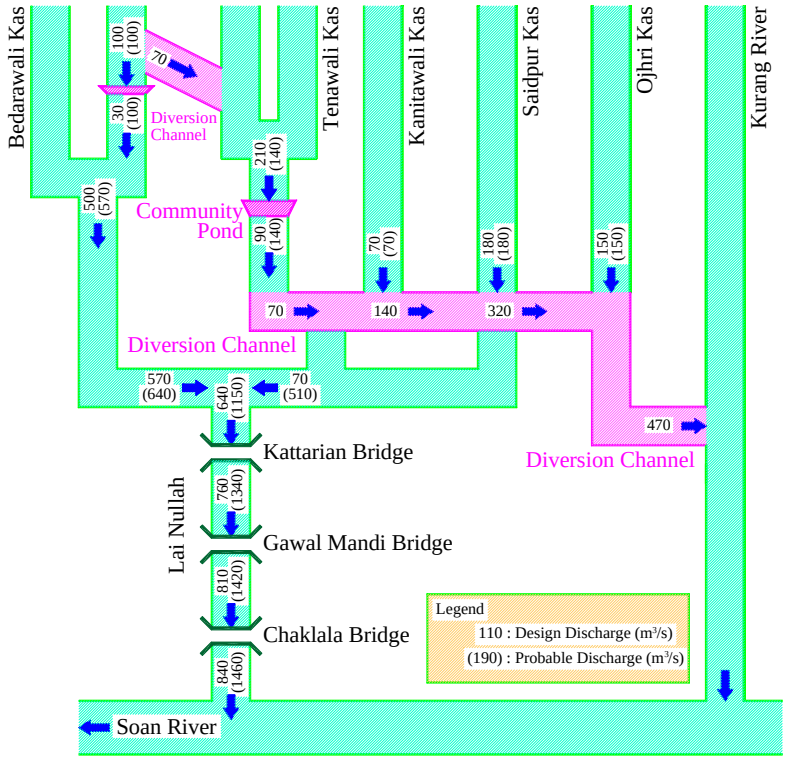

Fig. R D.2 Design Discharge for Short-term Project (25-year Return Period)

2) Establishment of Flood Risk Map

Dissemination of the flood risk map is broadly adapted in the world as one of the useful non-structural flood mitigation measures. Through dissemination of the flood risk map, the residents could aware the extent of the possible flood inundation area and the available evacuation routes during a flood. The flood risk map could also be the guidance for appropriate urban planning and land development. The flood risk map, in general, contains the information on: (a) the extent and depth of the probable flood inundation and (c) the evacuation centers and evacuation routes to be taken during a flood. The base maps for the extent and depth of the probable flood inundation was delineated in this Study. The flood risk map thus prepared should be disseminated to the public through a bulletin, an information board and other available information tools.

However, the available evacuation centers as well as evacuation routes for each unit of the local communities need to be selected by the relevant local government agencies based on the base maps, and the flood risk map should be finalized. Accordingly, establishment of the flood risk map would require a substantial period. Moreover, the evacuation centers and the evacuation routes would need to be progressively modified in accordance with expansion of the built-up area. From these viewpoints, establishment of the flood risk map is assumed to complete in the period of short-term period and need to be revised through the period of the long-term project.

3.1.3 Flood Mitigation Measures for Long-term Project

The Long-term Project with its target completion year of 2012 would include the flood diversion channel for the design scale of 100-year return period as the structural measure and the establishment of the flood risk maps as the non-structural measures continued from the above short-term Project. Through the Long-term Project, a new diversion channel will connect a channel with a flow capacity of 600-980m^3/s from Bedarawali Kas to Tenawali Kas. Moreover. The divert channels from Tenawali Kas to Kurang River completed in the Short-term Project will be also expanded as listed below (refer to Fig, R D.3):

Table R D.16 Comparison of Design Discharges of Diversion Channel for Short-term and Long-term Project

Section	Design Flow Capacity (m^3/s)	
	Short-term Project	Long-term Project
Tributary of Bedarawali Kas to Tenawali Kas (Community Pond)	70	80
Bedarawali Kas to Tenawali Kas	-	600
Tenawali Kas to Saidpur Kas	70-140	980-1,120
Saidpur Kas to Ojhri Kas	320	1,480
Ojhri Kas to Kurang River	470	1,790

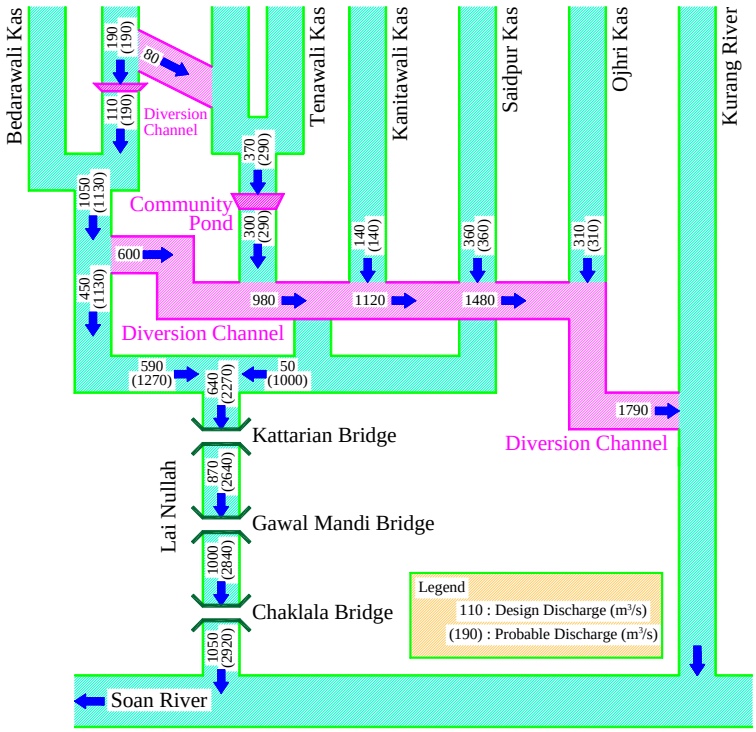

Fig. R D.3 Design Discharge for Long-term Project (100-year Return Period)

3.2 Implementation Program for Relevant Environmental Improvement and Strengthening of Organization Setup

The implementation program covers the phased action programs for the relevant environmental improvement measures such as the removal of encroachment along the river course, the control of garbage dumped into the river and the drainage and sewerage improvement. These environmental improvement measures would effect to sustain the designed flood mitigation capacity of the structural measures and create the appropriate environmental conditions of Lai Nullah. There are several on-going and projected environmental implement plans such as improvement of sewerage treatment plant at Block I-9 in Islamabad City and the Urban Water Supply & Sanitation Project, Phase –1 and 2 (UWSSP-1 & 2), Rawalpindi City. Therefore, the implementation programs for the environmental improvement measures are prepared taking the implementation schedules committed and/or proposed for these on-going and projected projects into consideration into consideration. The strengthening of the institutional setup would be also raised as one of the important issues to facilitate the overall river administration and management. From the viewpoints, the implementation program is also prepared for the strengthening of institutional setup aspect. The implementation program is proposed based on the above assumptions and conditions and summarized as shown in Table R D.17.

Table R D.17 Implementation Program for Environmental Improvement and Strengthening of Organization Setup

Sector	Scheme	Phased Program		
		Urgent (2004-05)	Short-term (2005-07)	Long-Term (2008-12)
1. Related Environmental Improvement Project	1.1 Land use control			
	(1) Formulation of a step-wise resettlement plan	○		
	(2) Execution of the resettlement plan and demolishing of the site		○	○
	1.2 Control of solid wastes dumped into the river			
	(1) Apprehension of the volume of solid wastes	○		
	(2) Legislation of the acts for the solid waste management		○	○
	(3) Formulation and execution for reduction and recycle and solid waste			○
	1.3 Improvement of drainage and sewerage			
	(1) Improvement of sewerage treatment plant in Islamabad	○		
	(2) UWSSP-I	○		
	(3) UWSS-2		○	
	(4) Drainage and sewerage improvement for area of RCB		○	○
2.. Strengthening of Institutional Setup	1.1 Establishment of Management Committee for the integrated administration of Lai Nullah	○		
	1.2 Establishment of Task Force for implementation of flood mitigation project of Lai Nullah	○		
	1.3 Demarcation of roles and authorities of the relevant land administrators	○		
	1.4 Capacity building	○	○	○