CHAPTER 6. FORMULATION OF FLOOD MITIGATION PLAN

6.1 PLANNING FRAMEWORKS FOR FLOOD MITIGATION

The principal objective of the Study is to formulate the comprehensive flood mitigation plan and further extend to clarification of the relevant environmental issues. Among others, the flood mitigation plan would be composed of the various structural and non-structural measures such as; channel improvement, flood diversion channel, flood retention/detention facilities, and flood forecasting/warning system. The relevant environmental improvement issues would also cover the various aspects including solid waste management, drainage/sewage management and watershed conservation.

Due to the above natures, the proposed plan would involve the various government agencies as well as private organizations/communities requiring the quantitative work volume and land acquisition. As the results, the 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 project would need to be implemented through the phased programs in line with the national development strategies.

6.1.1 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 6.1.1 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 6.1.1 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 6.1.2.

Table R 6.1.2 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)”.

6.1.2 Target Design Flood Scale of the Project

The target design flood scale is 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 Chapter 5). 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 6.1.3 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

The on-going river channel improvement for the Lai Nullah with financial assistance from ADB aimed at achieving the design flood level of 25-year return period, while the substantial channel flow capacity given by the on-going channel improvement is still limited to only at about 10-year return period according to verification based on the probable flood runoff discharges as simulated in the foregoing Chapter 5. Under such condition, it is virtually difficult to achieve the ultimate goal of 100-year return period all at once. In due consideration of these conditions, it is also proposed that the design flood scale of 25-year return period should be applied as the mid-term target of the objective flood mitigation plan.

6.1.3 Phased Programs and Target Project Completion Time

The proposed flood mitigation plan is 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 6.1.4.

Table R 6.1.4 Proposed Phased Flood Mitigation Program

Phased Program	Target Structural Design Level	Target Completion Year
Urgent Project	Indefinite*1	2005
Short-term Project	25-year return	2007
Lon-term Project	100-year return	2012

Note: *1: 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

*2; The project would need to continue even after completion of the long-term project until the basin stops its urbanization.

1) Urgent Project

The urgent project would be proposed among the components of the under-mentioned short-term project taking urgency and easiness of project implementation into account. The urgent project is assumed to complete by the year of 2005 to produce the immediate flood mitigation effect.

2) Short-term Project

As described in the foregoing subsection 6.1.2, 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 September 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.

3) Long-term Project

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 (1998-2012) and further incorporated into the national development plans of the "Ten Year Perspective Plan (2001-2011)" (refer to in the foregoing subsection 6.1.1). 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.

As stated above, the whole phased programs are to complete by the year of 2012, while the Lai Nullah basin, Islamabad in particular may expand the urban area even after the completion year of 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 relatively slow progress of 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 6.1.5. 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. From these viewpoints, the design discharge estimated under the land use states of year 2012 is applied to the whole of the urgent project, the short-tem project as well as the long-term project.

Table R 6.1.5 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

6.2 POTENTIAL STRUCTURAL FLOOD MITIGATION MEASURES

As the results of field reconnaissance, interview survey on the extent of the past floods, and review on the previous relevant studies, the followings are preliminarily scrutinized as the potential structural measures for the flood mitigation of Lai Nullah (refer to Fig. 6.2.1):

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

(2) Community pond 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 (i) the rainfall storage tank installed at individual house lot, (ii) the on-site flood detention pond and (iii) the infiltration facility.

Among others, the structural measures of the above items (1) to (4) are called the off-site structures and to be completed through a series of the urgent project, the short-term project and the long-term project by 2012 so as to cope with the design discharge from the whole catchment area. Each of the off-site structures has the large structural scales and produce immediate and large flood mitigation effect. Details of the off-site structural measures are as described in the following subsections 6.2.1 to 6.2.4.

The structural measure of the above item (5) is called the on-site structure to cope with the local flood/drainage problems and/or the increment of the peak runoff discharge inflicted by the land development as required. Each of the on-site structures has the far smaller flood mitigation effect as compared with the aforesaid off-site structures, and it is installed as supplement to the off-site structure, as required. The typical structural features of the on-site structures are introduced in the following subsection 6.2.5, but the definitive structural plan for the on-site structure, which is dominated by the local geophysical conditions, is not formulated in this Study.

6.2.1 River Channel Improvement

As described above, the on-going channel improvement of Lai Nullah above Chaklala Bridge could cope with the probable flood peak discharge of only 10-year return period, which is below the target design level of the aforesaid short-term project (i.e., 25-year return period). Hence, the further channel improvement is considered as one of the potential flood mitigation measures.

1) Extent of Channel Improvement

Judging from the river features and channel flow capacities as evaluated in the foregoing subsection 2.3, the maximum extent of the channel improvement may cover the following stretches of the mainstream and tributaries:

(a) *Mainstream of about 11.0 km from Chaklala Bridge (RD6+251) to Kattarian Bridge (RD17+210)*: The channel improvement is required to increase the channel flow capacity of the on-going river channel improvement;

(b) *Mainstream of about 1.1 km (RD4+077–RD5+227) below Chaklala Bridge*: This stretch is out of the extent of the on-going river channel improvement, but unconditionally requires enlargement of the cross-sections at the bottleneck in order to avoid the unfavorable adverse backwater effect to the channel flow conditions of the stretch of above item (a) (refer to the following subsection 2.3 in detail)

(c) *Three (3) tributaries of Bedarawali Kas, Tenawali Kas, and Saidpur Kas, which concentrate to the mainstream of Lai Nullah at Kattarian Bridge*: the flood flow of these tributaries are influenced by the backwater from the mainstream at Kattarian bridge, and may require a certain extent of channel improvement; and

(d) *Eight (8) tributaries, which flow into the mainstream between Chaklala Bridge and Kattarian Bridge*: these may require a certain extent of channel improvement associated with the channel improvement of the mainstream (refer to Table R 2.3.1).

The necessity of channel improvement for the above stretches are evaluated, and the channel improvement plans are proposed as described in the following items 2) to 5).

2) Channel Improvement Plan for Mainstream from Chaklala Bridge (RD6+251) to Kattarian Bridge (RD17+210)

Through the on-going channel improvement, the substantial extent of land acquisition has been made in the densely populated area of Rawalpindi. The further land acquisition has to require demolishing of the tremendous number of house/buildings closely packed along the river, which would cause the extremely serious frictions with the residents.

Judging from these social problems anticipated, the Steering Committee Meeting for the Study concluded in August 2002 that the right-of-way secured for the on-going channel improvement should be the maximum limit, and that the further widening of the river channel is no longer applicable. In accordance with this conclusion, the possible measure posterior to the on-going channel improvement is to be oriented to deepening of the riverbed instead of the river widening.

Deepening of the riverbed had been already proposed by the Rawalpindi Electric Supply Company in 1944 by blasting of the waterfall located about 2.5km downstream from Chaklala Bridge, while the proposal was finally ruled out due to adverse effects to the upstream bridges as well as the buildings along the river. Nevertheless, the adverse effects to the bridges and buildings could be offset by reconstruction and/or reinforcement for them, controlling of the flood flow velocity and/or providing of the bank protection and, therefore would not be the critical issue to rule out the proposal.

The proposed alignment, longitudinal profile, typical cross-sections and the relevant works for the channel deepening are as described hereinafter:

a) Alignment

The channel deepening is made on the designed riverbed of the on-going channel improvement. Accordingly, the proposed channel improvement follows the alignment of the on-going channel improvement.

b) Longitudinal Profile

The ongoing channel improvement maintains the existing channel bed slope of about 1/1,250. This bed slope has been formed by the long-term flow regime, and judged to be stable minimizing sedimentation and/or erosion. From these viewpoints, the existing channel slope of 1/1,250 is preferred as the optimum channel bed slope even after deepening of the channel improvement.

Partial deepening of the channel with using the groundsill will not be applicable to increase the overall channel flow capacity, and, the channel bed of the entire target river stretch should be lowered by a uniform depth with maintaining the channel bed slope 1/1,250.

On the premises of the above conditions, the optimum depth for lowering is assumed as 2m taking the following conditions into account:

(i) The on-going channel improvement is now in progress with its designed channel depth of 7.5m, which causes the maximum channel flow capacity of more than 3m/s. The excessive channel deepening would increase the unfavorable channel flow velocity far faster than 3m/s, causing difficulties in maintaining the river channel. In this connection, the allowable maximum channel velocity is provisionally assumed as 4m/s, and the allowable extent of channel deepening is assumed at 2m to control the channel flow velocity below the allowable limit.

(ii) The consistent channel bed slope of 1/1,250 would need to be maintained up to waterfall (RD3+800) about 2.5km downstream from Chaklala Bridge (refer to the following item 3). Under this condition, the channel deepening of more than 2m would require removal of waterfall and the extensive excavation of hard rocks, which outcrops below Murree Brewery (located about 700m upstream of the waterfall).

(iii) The channel deepening of 2m could avoid channel improvement of the upper tributaries of Bedarawali Kas, Tenawali Kas, and Saidpur Kas, as well as reconstruction of 11 bridges crossing over the tributaries.

The longitudinal profile for channel deepening is delineated, on the premises of the channel deepening by 2m with the channel bed slope of 1/1,250 as shown in Fig. 6.2.2.

c) Typical Cross-Sections

A compound section with high and low water channels is preferable in general due to advantages such as minimizing of embankment height and assuring of channel stability. The on-going channel improvement, however, adopted a single cross-section with a side-slope of 1 to 1.5, and the further channel improvement would also need to follow the same shape of cross-section due to difficulties of land acquisition. The dimensions of the typical cross-sections for the proposed channel deepening of Lai Nullah are as listed in the following Table R 6.2.1 (refer to Fig. 6.2.3):

Table R 6.2.1 Typical Cross-section of Proposed Channel Deepening

Section (Name of Bridge)				Width (m)		Depth (m)
Downstream		Upstream		Bottom	Top	
Name of Bridge	RD	Name of Bridge	RD			
Chaklala	6+215	Dhoke C. Din	8+060	38.4	69.9	9.5
Dhoke C. Din	8+060	Railway Road	8+325	36.4	67.9	9.5
Railway Road	8+325	Murree Road	8+628	36.2	67.7	9.5
Murree Road	8+628	Gawal Mandi	9+814	35.9	67.4	9.5
Gawal Mandi	9+814	City S. Road	10+790	35.2	66.7	9.5
City S. Road	10+790	Ratta A. Road	11+780	34.8	66.3	9.5
Ratta A. Road	11+780	Gunj Mandi	12+630	34.3	65.8	9.5
Gunj Mandi	12+630	Pir Wadhai	14+428	31.9	63.4	9.5
Pir Wadhai	14+428	Khayaban S.S.	14+100	29.5	60.9	9.5
Khayaban S.S.	14+100	Parrian	16+178	20.4	51.9	9.5
Parrian	16+178	Kattarian	17+210	18.5	50.0	9.5

d) Side Slope Protection

The on-going river channel improvement provides the side slope protection by stone pitching only along right and left banks of 100 feet (about 30m) upstream and 200 feet (about 60m) of each of the existing nine (9) bridges and reconstructed three (3) bridges. Other substantial parts of the stretch are left unlined without any side slope protection. According to the site inspection by the Study Team, however, the gully erosion has appeared on the surface of side slope along the unlined stretch, and it may develop further serious bank erosion and lead to collapse of riverbank.

The necessity of the side protection all along the stretch was once acknowledged in the design meetings for the on-going channel improvement, but finally turned down considering compatibility with the further channel improvement proposed in this Study. Thus, the side protection works for the on-going channel improvement could be regarded as the expedient, and it is indispensable to provide side slope protection all along the stretch for channel improvement as the permanent measure. Considering the current progress of bank erosion observed and the other channel conditions such as the channel depth of 9.5m and the expected maximum channel flow capacity of about 4m/s, the bolder concrete should be preferable as the type of the side protection instead of the stone pitching as proposed in the on-going river channel improvement.

e) Reconstruction and Reinforcement Works of Bridges

There exist nine (9) bridges crossing over the target river stretches (refer to Fig. 6.2.4). According to interview survey, the depth of their foundations, although it is unknown, is likely to be very shallow. Moreover, the top level of foundation is rather high as compared with the riverbed level and will be exposed by the channel deepening. Due to the these unfavorable conditions, all of the existing bridges would need to be reconstructed, should the channel deepening be implemented. The approximate length and width of these bridges to be reconstructed are as listed in Table 6.2.1.

In addition to the existing bridges, reconstruction works are now being undertaken for the following three (3) bridges through the on-going channel improvement: namely, (a) Dhoke Chiragh Din, (b) Gawal Mandi and (c) Pir Wadhai. All of these new bridges have the adequate foundation depth of more than 18m. However, as for Dhoke Chiragh Din, and Pir Wadhai Bridge, their top foundation would be exposed above the proposed riverbed level, should the riverbed be lowered by 2m as listed in Table R 6.2.2. Accordingly, these two (2) bridges would require the reinforcement works for their foundations.

Table R 6.2.2 Foundation of Bridges Reconstructed in On-going Channel Improvement

Name of Bridge	Riverbed Level after Deepening*	Number of Foundation	Level of Foundation		Foundation Depth	Exposure of Foundation
			Top	Tip		
Pir Wadhai	EL. 488.5m	4	EL. 490.5 m	EL. 471.3 m	20.2 m	2.0 m
Gawal Mandi	EL. 485.6m	4	EL. 483.6 m	EL. 464.4 m	20.2 m	-2.0 m
Dhoke Chiragh Din	EL. 484.1m	6	EL. 484.0 m	EL. 467.0 m	18.0 m	0.1 m

Source: Drawings for Reconstruction of Bridge, Urban Water Supply and Sanitation Project-Phase 1 for Rawalpindi, Mott Macdonald, 2002

3) Channel Improvement Plan for Main Stream (RD5+277-RD6+215) below Chaklala Bridge

As described in the foregoing section 2.3, realignment (short-cut)/enlargement of the meandering section (RD4+077 to RD5+277) has been completed by PMU, RDA (refer to Figs. 6.2.5 and 6.2.6), which could accommodate an adequate channel flow capacity, even when the channel above Chaklala Bridge is deepened by 2m. The existing channel from waterfall (RD3+800) to the short-cut section has also extensive cross-sectional flow area, which is far larger than the design cross-section of the above short-cut section. The channel improvement is, however, required to the section of about 1.0km in length (RD5+227 to RD6+215) sandwiched between the short-cut section around Murree Brewery Area and the on-going channel improvement above Chaklala Bridge in order to offset adverse backwater effect to the upper river section regardless to aforesaid channel deepening of the upper stretch from Chaklala Bridge.

a) Alignment

The objective channel improvement section (RD5+227 to RD6+215) has almost strait alignment, and any realignment is not required to the section (refer to Fig. 6.2.5).

b) Longitudinal Profile

The channel bed slope from waterfall (RD3+800) to the upstream end of short cut section (RD5+277) is about 1/1,250, almost same as that of the on-going channel improvement section from Chaklala Bridge (RD6+251) to Kattarian Bridge (RD17+210) (refer to Figs. 6.2.2 and 6.2.6). On the other hand, the channel depth from waterfall to the upstream end of short cut section is about 2m deeper than that of the on-going channel improvement section (refer to Fig. 6.2.2).

The objective improvement section has a steep bed slope of 1/180 forming a transition of the channel bed profile from the on-going channel section above Chaklala Bridge to the short-cut section as shown in Fig.6.2.2. It is also recognized that an extent of about 20 to 50m in width along the right and left bank of the objective channel improvement section (RD5+227 to RD6+215) is currently remained as vacant land.

Taking these river features into consideration, widening of the channel is preferred as the optimum channel improvement rather than channel deepening, and the existing channel bed profile should be remained with a minimal excavation.

c) Typical Cross-section

The typical cross-sections were prepared for the following two (2) cases: (a) the on-going channel improvement section above Chaklala Bridge is remained without further channel deepening; and (b) the on-going channel improvement section is further deepened by 2m as described in the above item 2).

The typical cross-sections should have the channel flow capacity to offset the aforesaid adverse backwater effect to the upstream section. On the premises of this required channel flow capacity and the above proposed longitudinal profile, the dimensions of the typical cross-sections for the above two cases are determined as listed in the following Table R 6.2.3 (refer to Figs. 6.2.7 and 6.2.8):

Table R 6.2.3 Typical Cross-section for Section from Waterfall to Chaklala Bridge

Case	States of Upstream from Chaklala Bridge	Dimensions of Cross-section		
		Width (m)		Depth (m)
		Bottom	Top	
Case A	The on-going channel improvement section remains without channel deepening	20.0	48.5	9.5
Case B	The on-going channel improvement section is further deepened by 2m	44.4	72.9	9.5

Note: (1) A single cross-section with a side-slope of 1 to 1.5 was adapted in the same way as the upstream of Chaklala Bridge.

(2) High water level is set at 1m below the bank level assuming 1m depth of free board

d) Side Slope Protection

Considering the channel depth of 9.5m and the expected maximum channel flow capacity of about 4m/s, the bolder concrete is adapted as the type of the side protection in the same way as the upper stretch from Chaklala Bridge.

4) Potential Channel Flow Capacity and Design Discharge of Lai Nullah

As described above, two (2) cases of channel improvement is proposed for the bottleneck section (RD5+277 to RD6+215) of about 1km in length below Chaklala Bridge. The first case is on the premises that the on-going channel improvement section above Chaklala Bridge remains without further channel deepening. This first case is unconditionally required to offset the adverse backwater effect and secure the design discharge of the on-going channel improvement.

The second case is subject to channel deepening of the on-going channel improvement above Chaklala Bridge. In this second case, the typical cross-section of the bottleneck section below Chaklala Bridge is enlarged as shown in Table R 6.2.3, and the riverbed of the on-going channel improvement is deepened by 2m. Due to these channel enlargements, the channel flow capacity would increase from 640 m^3/s to 900 m^3/s at Kattarian Bridge and from 1,000 m^3/s to 1,400 m^3/s at Chaklala Bridge as listed below.

Table R 6.2.4 Potential Channel Flow Capacity of Lai Nullah before and after Proposed Channel Improvement

Section of Lai Nullah				Potential Channel Flow Capacity (m^3/s)	
Downstream		Upstream		Before Deepening	After Deepening
Description	RD	Description	RD		
Short-cut section	4+077	Short-cut section	5+277	1,810	1,810
Proposed improvement section	5+277	Proposed improvement section	6+215	1,010	1,500
Chaklala Bridge	6+215	Dhoke C. Din Bridge	8+060	1,010	1,400
Dhoke C. Din Bridge	8+060	Railway Road Bridge	8+325	1,010	1,400
Railway Road Bridge	8+325	Murree Road Bridge	8+628	1,010	1,400
Murree Road Bridge	8+628	Gawal Mandi Bridge	9+814	970	1,370
Gawal Mandi Bridge	9+814	City S. Road Bridge	10+790	960	1,350
City S. Road Bridge	10+790	Ratta A. Road Bridge	11+780	950	1,330
Ratta A. Road Bridge	11+780	Gunj Mandi Bridge	12+630	940	1,320
Gunj Mandi Bridge	12+630	Pir Wadhai Bridge	14+428	910	1,290
Pir Wadhai Bridge	14+428	Khayaban S.S. Bridge	14+100	890	1,260
Khayaban S.S. Bridge	14+100	Parrian Bridge	16+178	690	960
Parrian Bridge	16+178	Kattarian Bridge	17+210	640	900

5) Necessity of Channel Improvement for Tributaries above Mainstream of Lai Nullah

As described above, the channel flow capacity of Lai Nullah is expected to increase to 900 m^3/s at Kattarian Bridge by the proposed channel deepening. It is estimated from the results of the hydrological analysis in Chapter 5 that the increased channel flow capacity of 900 m^3/s corresponds to the flood runoff discharges of 504 m^3/s from Bedarawali Kas, 244 m^3/s from Tenawali Kas and 152 m^3/s from Saidpur Kas. On the other hand, the existing flow capacities of the tributaries are estimated at 730 m^3/s for Bedarawali Kas, 320 m^3/s for Tenawali Kas and 200 m^3/s for Saidpur Kas (refer to the foregoing Table R.2.3.6). Thus, all of the tributaries have the adequate channel flow capacities larger that the runoff discharges equivalent to the increased flow channel capacity of Lai Nullah at Kattarian Bridge (refer to Table R 6.2.5). Accordingly, as long as the design discharge of Lai Nullah is set below 900 m^3/s at Kattarian Bridge, any channel improvement associated with the channel deepening of the mainstream is not required to the tributaries.

Table R 6.2.5 Existing Channel Flow Capacity and Probable Runoff Discharge of Tributaries above Kattarian Bridge

Name of Tributaries	Existing Channel Flow Capacity of Tributaries	Probable Runoff Discharge Equivalent to Design Discharge of 900m^3/s for Lai Nullah at Kattarian Bridge
Bedarawali Kas	730 m^3/s	504 m^3/s
Tenawali Kas	320 m^3/s	244 m^3/s
Saidpur Kas	200 m^3/s	152 m^3/s
Total	1,250 m^3/s	900 m^3/s

6) Necessity of Channel Improvement for Tributaries below Kattarian Bridge

As described in the foregoing section 2.3, there are nine (9) tributaries flowing into the mainstream of Lai Nullah from Kattarian Bridge to Chaklala Bridge. Among others, the channel cross-sectional survey was carried out for eight (8) tributaries during the first field survey. The field reconnaissance was further carried out to crosscheck the results of cross-section survey with using the results of GPS survey on the ground level along the tributaries. As the results, it was finally clarified that almost all part of the whole tributaries has the adequate bank level above the design high water level of the on-going channel improvement of the mainstream as shown in Fig. 6.2.9. Accordingly, any major flood protection work for the tributaries would not be required. Nevertheless, necessity of some minor bank protection is detected at the downstream end of the tributaries of Pir Wadhai Kassi (No. R4), Workshop Tributary (No. L4), Saddar Tributary (No. R1) and Dhok Churaghdin Tributary (No. L1).[1]

6.2.2 Community Pond

The possible site and the detailed structural plans for the proposed community pond are as described hereinafter:

1) Possible Site

A community pond has the function of temporarily storing runoff discharge on the way to the upper or middle reaches of a river and thus flattening the peak runoff discharge. This measure is very effective for mitigation of flood with a short flood concentration time and it

[1] The location of the tributaries are as shown in Fig. 2.3.1.

is technically managed to detain runoff discharge before joining into the lower rivers that do not have sufficient flow capacities. However, its applicability definitely depends on a suitable site that technically and regionally allows temporary inundation, because this type of facility requires large flood regulation capacity and a rather extensive land acquisition.

In the study area, possible sites for the community pond are very limited. In Rawalpindi, the land along the river course is fully and disorderly utilized as built-up area with dense population. In Islamabad, urbanization has been neatly promoted in the form of square lots, each of which is used for a specific purpose such as administration, commercial and residential areas.

Under the above land use conditions in the study area, the Fatima Jinnah Park covering an extent of 3 km^2 located in the north of the study area is a strong candidate of the site for the community pond (refer to Figs. 6.2.10 and 6.2.11). It was planned and constructed at administratively called Block F-9 as the National Park in the capital city in 1960's. The substantial part of it still remains as the vacant land without any major permanent structure.

Taking the above into consideration, the community pond is proposed to construct at the Fatima Jinnah Park. The principal advantages of the proposed pond are as enumerated below:

(a) Any land acquisition and house evacuation is not required,

(b) CDA, the administrator of the park has given the provisional consent to use the park as the community pond in view of the function of community pond to improve the amenity of the park,

(c) The community pond can widely produce the benefits such as leading to effective land use, lowering of land development cost and creating of the urban scenery through introduction of greening and water-based beautification.

2) Flood Diversion from Tributary of Bedarawali Kas

The catchment area of the community pond proposed on the tributary of the Tenawali Kas is about 16.6 km^2, which is equivalent to only 7 % of the Lai Nullah River Basin. Generally, the larger catchment area brings out the higher effectiveness of the flood mitigation function and the greater the cost advantage of the facilities. From this point of view, it is proposed to divert the flood discharge of the Bedarawali Kas to the community pond as shown in the following figure.

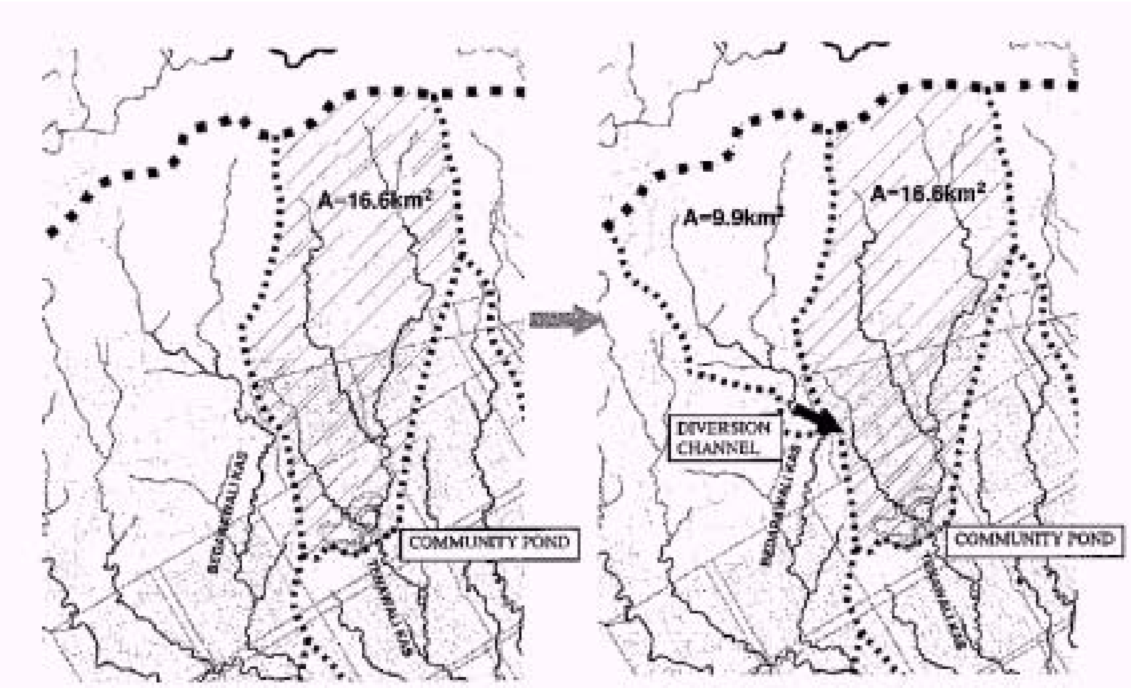

Fig. R 6.2.1 Flood Diversion from Tributary of Bedarawali Kas to Community Pond

The total catchment area of the community pond becomes about 26.5 km^2, which is equivalent to 11.3 % of the Lai Nullah River Basin. The length of the diversion channel is about 1,340 m (refer to Fig. 6.2.12).

3) Layout of Community Pond

The community pond should be designed hydraulically to have the flood mitigation function as described in the previous section. In the Fatima Jinnah Park, small dam with flood mitigation function is planed on the waterway immediately downstream of the confluence of two tributaries. The crest level of the small dam should be set below EL. 557.0 m so as to limit the temporally flood inundation area in the park. In addition to the flood mitigation function, those facilities contain a potential to provide the public amenity space and improve the scenery in the urban area. Accordingly, the environmental conditions of pond area would be improved so that the residents will easily and safely access and use the area. A community pond with some stages made through excavation is proposed to use the lower stage for water area and the higher stage for a recreation purpose such as garden, play ground, tennis courts and so on.

The plan and the cross sectional layout of the community pond is as shown in the following Fig. R 6.2.2 (refer to Fig. 6.2.13):

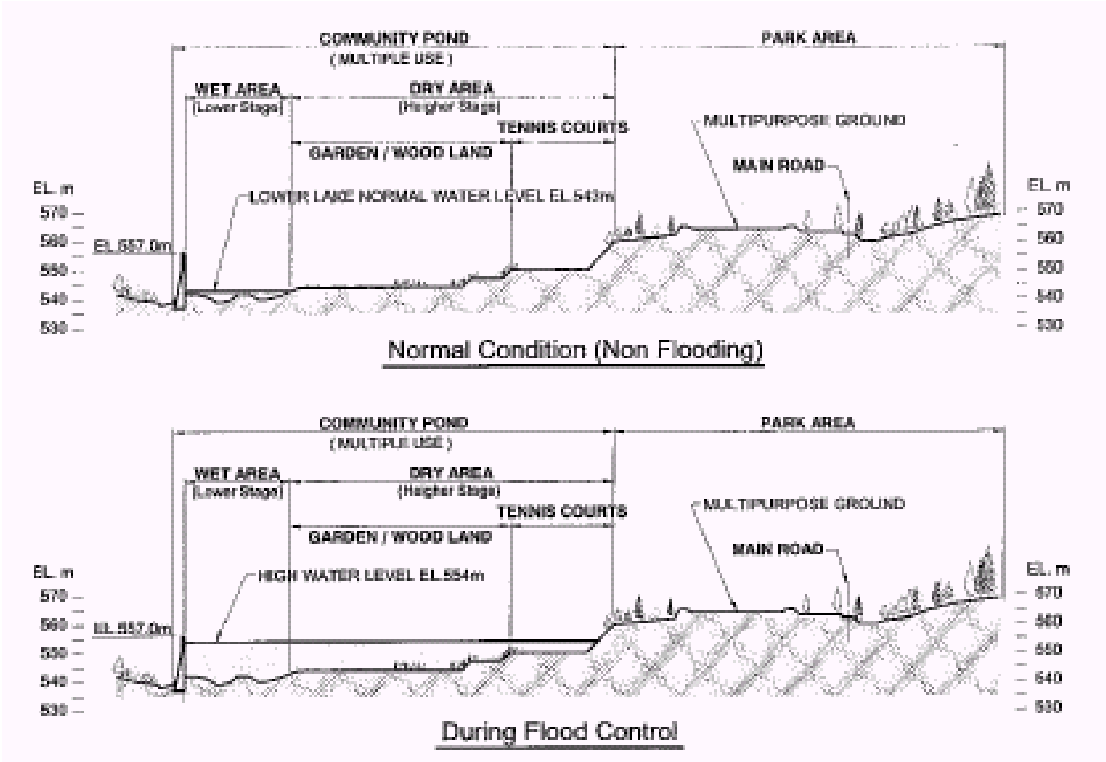

Fig. R 6.2.2 Cross Sectional Layout of Community Pond

4) Flood Mitigation Plan and Reservoir Capacity Allocation

As mentioned in the previous section, the flood mitigation capacity of the community pond is planned as the maximum development so as to limit the temporally flood inundation area in the park. Based on this concept, the proposed community pond is proposed to have a storage capacity to cut almost all the probable peak runoff discharge of 25-year return period, and reduce about 35% of the peak flood discharge even in case of 100-year return period at site.

These functions could increase the flood safety level of the downstream of Lai Nullah. Calculation results of flood mitigation effect at dam site are given in Fig. 6.2.14 and summarized as below:

Table R 6.2.6 Flood Mitigation Effect of Community Pond at Site

Return Period	Inflow			Regulated Peak Outflow Discharge (m^3/s)	Pond Surface Level (EL. m)	Pond Surface Area (km^2)	Peak Discharge Reduction Rate (%)
	Diverted Flood Discharge (m^3/s)	Flood Discharge (m^3/s)	Total (m^3/s)				
5-year	24	44	68	11	547.0	0.16	84
10-year	39	81	120	14	549.9	0.29	88
25-year	59	148	207	16	552.2	0.60	92
50-year	71	213	284	94	553.5	0.67	67
100-year	78	290	368	232	554.0	0.70	37

Pond storage curve of community pond is shown in Fig. 6.2.15, which is estimated using the topographic map of 1:5,000, which is newly prepared by the study.

5) Water Quality of Community Pond

The water quality of Tenawali Kas, which runs through the site of the community pond, is seriously deteriorated giving an offensive odor because of the polluted wastewater generated in the urbanized area. According to site investigation, however, the water quality diverted from the tributary of the Bedarawali Kas to the community pond is relatively good as compared with that of Tenawali Kas. Under these circumstances, the following measures were adopted as the structures to maintain the better water quality of the community pond:

(a) To construct the oxidation ponds to improve the water quality of inflow to the community pond;

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

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

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

6) Design Features of Facilities

From the aforesaid consideration, diversion channel from the tributary of the Bedarawali Kas, detention dam including dam body, spillway and outlet facilities, and facilities of multiple use of community pond shall be designed. Design features of the necessary facilities summarized as follows:

a) Pond

Catchment Area	:	26.5 km^2 (= 16.6 + 9.9 km^2)
Pond Surface Area	:	0.64 km^2
Maximum Water Surface	:	EL. 555.000 m
Surcharge Water Surface	:	EL. 553.000 m
Low Water Surface	:	EL. 543.000 m
Gross Storage Capacity	:	2,950,000 m^3
Effective Storage Capacity	:	2,900,000 m^3
Dead Storage Capacity	:	50,000 m^3

b) Dam Body on Waterway

Dam Type	:	Combined Dam
Dam Height above Foundation	:	20.0 m
Crest Elevation	:	EL. 557.000 m
Foundation Elevation	:	EL. 537.000 m

Crest Length	:	1,550.0 m Embankment Type L = 1,260 m Concrete Type L = 290 m
Crest Width	:	6.0 m
Concrete Gravity Portion	:	Upstream Vertical, Downstream 1:0.8
Embankment (Homogeneous) Portion	:	Upstream 1:3.5, Downstream 1:3.0

c) Spillway and Outlet Facilities for Dam

Design Flood (Inflow Peak Discharge)		
Emergency Spillway Design Flood	:	560 m^3/s (200-year probability x 120 %)
Flood Mitigation Capacity	:	210 m^3/s (25-year Probability)
Overflow Crest	:	Crest EL. 553.000 m, 100 m in length
Flood Control Outlet	:	H 1.0 m x W 1.0 m x 2, EL. 543.0 m
Outlet for Draw Down	:	H 1.0 m x W 1.0 m x 1, EL. 540.0 m

d) Check Dam upstream of Pond

Weir (Wet Stone Masonry)	:	H 1.5m x L 20 m x 1
Weir (Wet Stone Masonry)	:	H 1.5m x L 30 m x 1

e) Diversion Facilities

Fixed Weir on Tributary	:	2.5 m in height, 37 m in length Overflow Crest L = 16 m Orifice H 1.0 m x W 1.0 m x 2
Diversion Weir with Orifice	:	5.2 m in height, 20 m in length Orifice H 1.0 m x W 1.0 m x 1 Orifice H 1.5 m x W 1.5 m x 7
Diversion Channel (Wet Stone Masonry)	:	8 m in width, 1,340 m in length Water Depth D = 2.4 m

f) Facilities for Multiple Use of Community Pond

Public Facilities (Road, Bridge, Car Parking, Backfilling, etc.)
Sports and Recreation facilities (Multipurpose Ground, Tennis Court, etc.)
Amenity and Landscape (Water Front Open Space, Gardening, etc.)

g) Major Work Quantities

Surface Excavation		
Foundation Excavation	:	140,000 m^3
Reservoir Excavation	:	2,000,000 m^3
Dam Embankment	:	160,000 m^3
Backfilling (as Spoil Area)	:	700,000 m^3
Common Embankment (as Spoil Area)	:	300,000 m^3
Dam Concrete	:	27,000 m^3
Reinforced Concrete	:	4,000 m^3
Bridge	:	2 bridges
Main Road	:	L = 4,700 m, W = 20 m

6.2.3 Flood Mitigation Dam

The results of clarification on the possible flood mitigation dams are as described hereinafter:

1) Identification of Potential Dam Sites

A flood mitigation dam has also the function of temporarily storing runoff discharge on the way to the upper reaches of a river and thus flattening the peak runoff discharge. In the same way as the community pond, stored flows are subsequently returned to the downstream river at a reduced rate of flow. It is the core structure for flood regulation in contrast with channel improvement as a core structure for quick disposal of flood discharge.

Generally, the larger the catchment area of a flood mitigation dam, the more effective the flood peak cut. However, potential sites for flood mitigation dam are very limited in the study area due to its topographic condition. Almost all parts of the study area are classified into flat land formed on the Potwar plateau, and the mountainous area located at the northern end of the study area is only 15 % of the Lai Nullah basin.

In this study, the potential dam sites were preliminary identified regardless of their catchment area through the review of the previous report, the field reconnaissance and the study on the topographic map newly developed from data of IKONOS. The following six (6) dams are enumerated. Locations of potential dam sites are shown in Fig. 6.2.16.

2) Selection of Optimum Flood Mitigation Dam

Salient features of the six (6) potential dam sites identified in this study are summarized in the following table:

Table R 6.2.7 Features of Potential Dam Sites for Flood Mitigation

Item	Site-1	Site-2	Site-3	Site-4	Site-5	Site-6
1. River	Bedarawali Kas	Bedarawali Kas	Bedarawali Kas	Bedarawali Kas	Tenawali Kas	Tenawali Kas
2. Location	Flat Land	Mountainside	Mountainside	Mountainside	Mountainside	Mountainside
3. Geology	Loessic silt, Limestone	Limestone, Sandstone, Shale, Much folded, Many joints, Thick Riverbed	Limestone, Sandstone, Shale, Much folded, Many joints, Thick Riverbed	Limestone, Sandstone, Shale, Much folded, Many joints, Thick Riverbed	Limestone, Sandstone, Shale, Much folded, Many joints, Thick Riverbed	Limestone, Sandstone, Shale, Much folded, Many joints, Thick Riverbed
4. Land Use in Reservoir Area	Belonging to Block E-11, Being illegally developed by Private Developer	Unused Land such as Forest	Unused Land such as Forest	Unused Land such as Forest	Unused Land such as Forest	Unused Land such as Forest
5. Catchment Area (km^2)	19.7	1.6	2.5	3.7	1.9	4.0

In case that each flood mitigation dam has a capacity to cut the probable peak discharge of 100-year return period as much as possible, the design features of each dam and the cost effectiveness are given as below:

Table R 6.2.8 Design Features of Alternative Flood Mitigation Dams

Item	Site-1	Site-2	Site-3	Site-4	Site-5	Site-6
1. Required Total Storage Capacity (m^3) *1	3,040,000	250,000	390,000	560,000	290,000	610,000
2. Dam Height (m)	20.0	34.4	28.6	42.5	26.4	29.7
3. Crest Length (m)	840	150	155	180	130	230
4. Area below Maximum Water Level (km^2)	0.80	0.04	0.07	0.07	0.06	0.11
5. Embankment Volume (m^3)	300,000	358,000	217,000	521,000	164,000	378,000
6. Estimated Peak Cut Discharge (100-year) at Kattarian Bridge (m^3/s)	300	26	41	59	30	64
		220				
7. Cost (million Rs.)						
- Construction Cost	477	569	344	827	260	601
- Compensation Cost	1,620	4	7	7	6	11
- Total Cost	2,097	573	351	834	266	612
8. Cost / Peak Cut Discharge (7./6.) (Rs. / m^3/s) *2	7,000,000	22,000,000	8,600,000	14,100,000	8,900,000	9,600,000
		12,000,000				

*1 The required total storage capacity is estimated on the premise that the flood mitigation dam has a capacity to cut the probable peak discharge of 100-year return period as much as possible at site.

*2 Figures in this column show the cost effectiveness of flood mitigation dam. The smaller figure brings out the higher effectiveness of the flood mitigation function and the greater cost advantage of the facility.

The following matters can be seen in the above table:

(a) Among the identified six (6) potential dam sites, Site-1 located at Block E-11 is greatest advantage in terms of total cost per peak cut discharge in spite of its high compensation cost.

(b) The alternative dams identified at mountainside (Sites-2, 3, 4, 5, 6) have extremely large figures of total cost per peak cut discharge. The reasons are:

(i) Low efficiency of dam reservoir due to their steep riverbed slope,

(ii) Low efficiency of flood peak cut discharge due to their small catchment area,

(iii) High cost of foundation treatment due to their weathered and folded foundation.

From the above discussion, Site-1 was selected as the optimum site for flood mitigation dam.

3) Flood Mitigation Plan and Reservoir Capacity Allocation

The proposed flood mitigation dam could have a storage capacity to cut almost all the probable peak runoff discharge of 25-year return period, and reduce about 44% of the peak flood discharge at site even in case of 100-year return period.

These functions could increase the flood safety level of the downstream of Lai Nullah. The results of calculation on flood mitigation effect at dam site are given in Fig. 6.2.17 and summarized as below:

Table R 6.2.9　　Flood Mitigation Effect of Flood Mitigation Dam at Site

Return Period	Inflow (m^3/s)	Regulated Peak Outflow Discharge (m^3/s)	Reservoir Surface Level (EL. m)	Peak Discharge Reduction Rate (%)
5-year	45	4	567.1	91
10-year	86	5	568.5	94
25-year	162	6	570.8	96
50-year	236	65	572.2	72
100-year	325	183	572.8	44

Reservoir storage curve of the flood mitigation dam is shown in Fig. 6.2.18, which is estimated using the topographic map of 1:5,000 newly developed by the Study.

4) Design Features of Flood Mitigation Dam

From the aforesaid consideration, flood mitigation dam including dam body, spillway and outlet facilities shall be designed. The plan is shown in Fig. 6.2.19. Design features of the necessary facilities are summarized as follows:

a) Reservoir

Catchment Area	:	19.7 km^2
Reservoir Surface Area	:	0.62 km^2
Maximum Water Surface	:	EL. 574.000 m
Surcharge Water Surface	:	EL. 571.600 m
Low Water Surface	:	EL. 565.300 m
Gross Storage Capacity	:	3,040,000 m^3
Effective Storage Capacity	:	2,640,000 m^3
Dead Storage Capacity	:	400,000 m^3

b) Dam Body on Waterway

Dam Type	:	Fill Dam
Dam Height above Foundation	:	20.0 m
Crest Elevation	:	EL. 576.000 m
Foundation Elevation	:	EL. 556.000 m
Crest Length	:	840.0 m
Crest Width	:	5.0 m
Embankment Slope	:	Upstream 1:3.5, Downstream 1:3.0

c) Spillway

Design Flood (Inflow Peak Discharge)		
Emergency Spillway Design Flood	:	520 m^3/s (200-year probability x 120 %)
Flood Mitigation Capacity	:	170 m^3/s (25-year Probability)
Overflow Crest	:	Crest EL. 571.600 m, 70 m in length

d) Major Work Quantities

Surface Excavation	:	250,000 m^3
Dam Embankment	:	330,000 m^3
Mass Concrete	:	5,000 m^3
Reinforced Concrete	:	35,000 m^3

6.2.4 Flood Diversion Channel

The results of clarification on the possible flood diversion channel are as described hereinafter:

1) Preliminary Screening of Potential Diversion Channel Routes

As the final solution of the flood problem, diversion channel to adjacent rivers has been studied somewhere upstream of Rawalpindi city so that no flood passes through the city area. The routs of the diversion channel examined in the previous study and in this study are shown in the following Fig. R 6.2.3 and Table R 6.2.10.

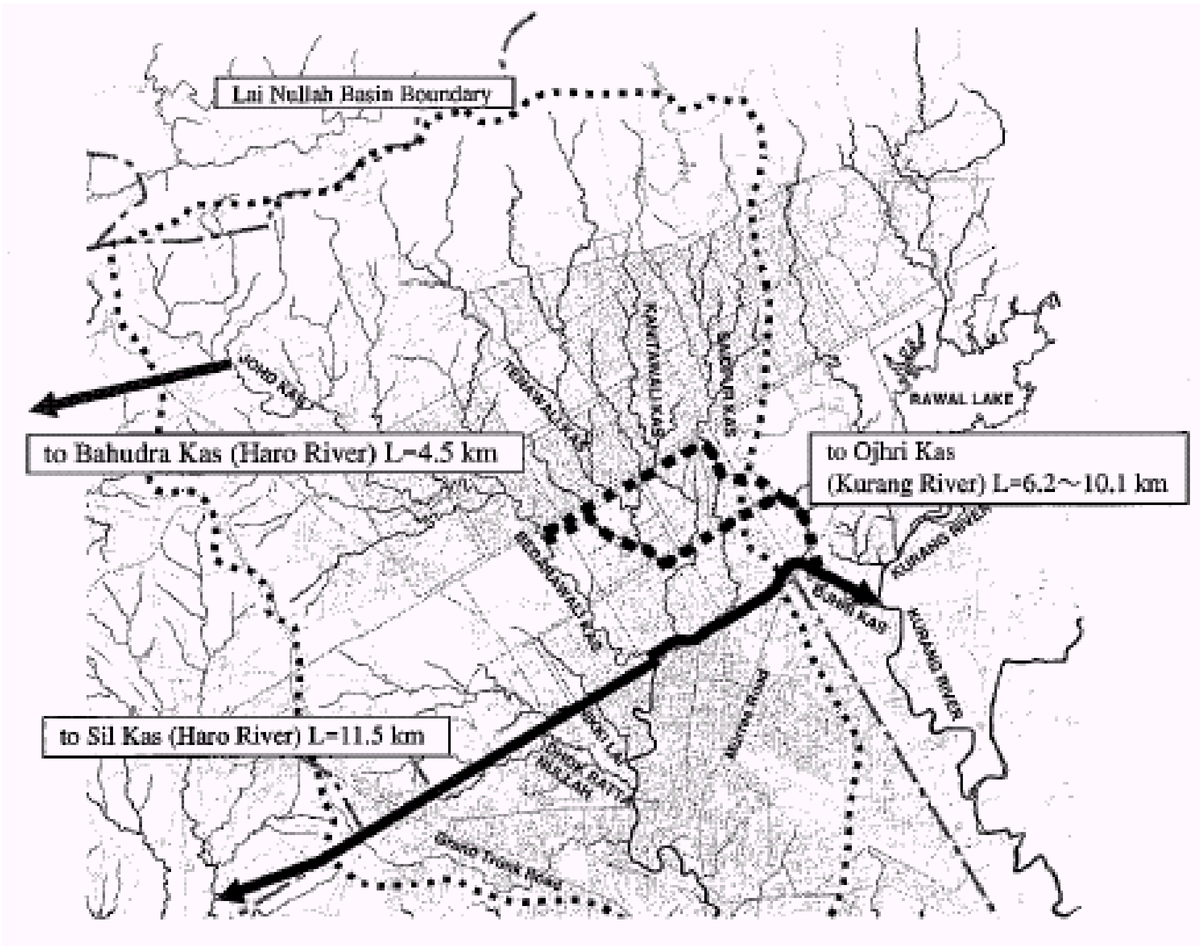

Fig. R 6.2.3 Potential Routes of Flood Diversion Channel

Table R 6.2.10 Potential Routes of Flood Diversion Channel

Routes of Diversion Channel	Diverted River/Tributary	Catchment Area (km^2)	Length of Channel (km)
to Bahudra Kas of Haro River	Johd Kas (Bedarawali Kas)	12	4.5
to Sil Kas of Haro River	Bedarawali Kas, Nikki Lai Dhok Ratta Nullah	103	11.5
to Ojhri Kas of Kurang River	Bedarawali Kas, Tenawali Kas Kanitawali Kas, Saidpur Kas	122 to 144	6.2 to 10.1

The diversion channel to the Bahudra Kas of the Haro River does not have any difficulties of land acquisition. However, its possible catchment area of tributary to be diverted is limited to only 12 km^2, equivalent to about 5 % of the Lai Nullah basin, and therefore, this diversion could not provide adequate relief.

The diversion channel to the Sil Kas of the Haro River planed to cut across hill area. Difference of land level among tributaries to be diverted and top of hill area is not less than 60 m. Thus, the extremely large excavation volume is required and, therefore this route is not practicable.

After exclusion of inappropriate routes, the diversion channel to the Ojhri Kas of the Kurang River remains as alternative routes to be studied.

2) Features of Alternative Routes

Three (3) alternative routes to divert flow into the Kurang River can be considered. They divert the flow of the four (4) main tributaries, namely, Bedarawali Kas Tenawali Kas, Kanitawali Kas and Saidpur Kas, and run through the urbanized area of Islamabad along the road and finally outfall into the Kurang River. Plan and longitudinal profiles of alternatives are shown in Fig. 6.2.20 and 6.2.21. Features of these alternatives are summarized as follows:

Table R 6.2.11 Features of Alternative Routes to Kurang River

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Route of Diversion Channel</th><th rowspan="2">Catchment Area (km^2)</th><th colspan="2">Riverbed Level (EL. m)</th><th rowspan="2">Possible Riverbed Slope</th><th rowspan="2">Channel Length (m)</th></tr>
<tr><th>Bedarawali Kas</th><th>Kurang River</th></tr>
<tr><td>Route-1</td><td>Along Kashimir Highway</td><td>122</td><td>515.0</td><td rowspan="3">488.0</td><td>1/700</td><td>10,155</td></tr>
<tr><td>Route-2</td><td>Along Khayaban-E-Johar Road (one block south from Route-1)</td><td>129</td><td>515.0</td><td>1/700</td><td>9,726</td></tr>
<tr><td>Route-3</td><td>Along Khyaban-E-Siryed Road (called I-J Principal Road)</td><td>144</td><td>495.0</td><td>1/1000</td><td>6,233</td></tr>
</table>

3) Selection of Optimum Route

The allowable maximum capacity of flood diversion channel is estimated at about 1,700 m^3/s taking the following factors into account: (a) the allowable limit of the right-of-way for the diversion channel, (b) the possible bed of the diversion channel and (c) the required improvement works of Kurang River as the outlet of the diversion channel[2]. The study on the optimum route of the diversion channel is carried out on the assumption that the capacity of flood diversion is fixed at 1,480 m^3/s, which corresponds to the design discharge of the diversion channel, if the proposed community pond (assumed as the strongest candidate of the priority project component) is constructed in the upper reaches. The required cross sectional area of each alternative is given in Fig. 6.2.22. Measure work quantities and compensation works are summarized as follows:

Table R 6.2.12 Measure Work Quantities and Compensation Works for Alternative Diversion Route

Measure Work Quantities

No.	Excavation (m^3)	Dike Embankment (m^3)	Side Slope Protection (m^2)	Sodding (m^2)	Bridge (bridges)
Route-1	7,900,000	70,000	158,000	295,000	12
Route-2	4,000,000	131,000	164,000	167,000	20
Route-3	5,000,000	16,000	106,000	153,000	16

Compensation Works

No.	Land Acquisition (m^2)			House Evacuation (houses)		
	Residential Area	Others	Total	in I-8, I-9	Along Ojhri Kas	Total
Route-1	5,700	312,000	317,700	0	19	19
Route-2	6,000	342,000	348,000	0	20	20
Route-3	41,900	176,000	217,900	76	13	89

From the above studies, cost of each alternative route is estimated as below:

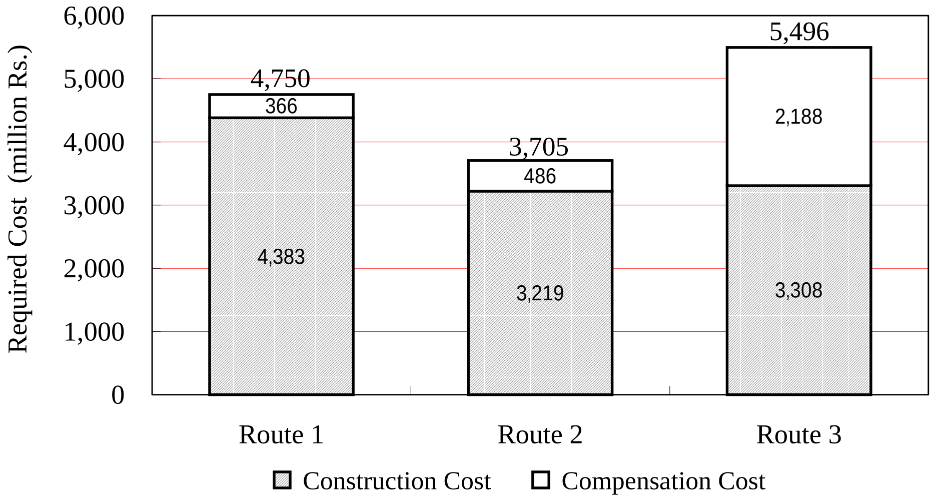

Fig. R 6.2.4 Cost Comparison of Alternative Routes

2 CDA commented in the Steering Committee Meeting on the Draft Final Report that the right-of-way for the route-2 of the diversion channel should be restricted to be a certain width. Due to the comment, the possible maximum diversion discharge for the alternative route-2 may fall below 1,700m^3/s. After detailed discussions, it is finally agreed by the Steering Committee that this matter would be clarified in the succeeding Feasibility Study (refer to item 2 in the Minutes of Steering committee Meeting on the Draft Final Report as attached to this Main Report).

It is concluded that the route-2 is the most suitable alternative for diversion channel to divert flood into Kurang River due to the following reasons:

(a) The route-2 is the most economical alternative, when their construction cost and compensation cost are contrasted.

(b) It is deemed to be difficult to implement construction of route-3 channel due to difficulties in evacuating many permanent houses located in Blocks I-8 and I-9.

(c) In case of route-2, no house evacuation in Blocks I-8 and I-9 is necessary.

It is proposed that the diversion channel would increase its flow capacity through the short-term project and the long-term project. The diversion channel will divert the flood runoff discharges of 25-year return period from Tenawali Kas and Saidpur Kas to Kurang River upon completion of the short-term project, and those of 100-year return period from Bedarawali Kas, Tenawali Kas and Saidpur Kas upon completion of the long-term project (refer to Figs. 6.2.23 to 6.2.25).

4) Necessary Treatment for Kurang River

The proposed flood diversion channel flows into Kurang River through its tributary named Ojhri Kas and finally pours into Soan River. Between these two (2) outlet rivers, Soan River has unquestionably the adequate channel flow capacity to accommodate the flood discharge from Kurang River as well as Lai Nullah. On the other hand, there are the bottleneck stretches along Kurang River, which even now cause the frequent flood overflow. In order to safely divert the proposed flood discharge into Kurang River, the necessary treatment works for the River was preliminarily evaluated taking its present channel flow capacity and the flood runoff discharge from the river basin into account.

a) Flood Discharge of Kurang River

There exists Rawal Dam on Kurang River about 5.6 km upstream from the outlet point of the flood diversion (i.e., at the confluence of Ojhri Kas). The dam reservoir is used as the major source for water supply to Rawalpindi, but at the same time, it has a certain effect on the flood mitigation for the downstream of Kurang River. That is, the water stage of the dam reservoir drops to EL. 531 m in the early of July from the normal water

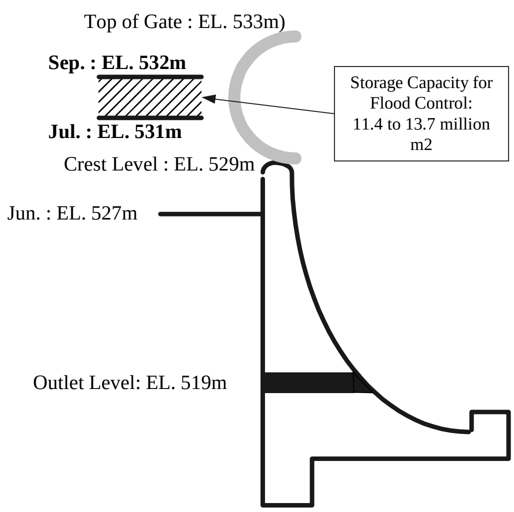

Fig. R 6.2.5 Water Stage of Rawal Dam Reservoir level of EL 532 m, and then it gradually rises finally recovering to the normal level in the end of September. The drop of water stage in the early of July could create a stage capacity of 13.7 million m^3 for flood mitigation (refer to Fig. R 6.2.5). This flood mitigation capacity could reduce the peak flood runoff discharge from the upper reaches of the dam and delay the time of occurrence of the peak discharge. In the flood of July 2001, the dam reservoir released its peak discharge of only 220 m^3/s after the flood of downstream is subsided.

The above flood mitigation capacity is, however, not always expected due to the gradual raise of the reservoir water stage as stated above. Depending on the timing of flood occurrence, the dam may possibly release the substantial discharge. According to the record of the dam outflow discharge, the annual maximum dam outflow discharge fluctuates year-by-year, and the largest value of about 1,300 m^3/s was recorded in 1988 as shown in Fig. R 6.2.6.

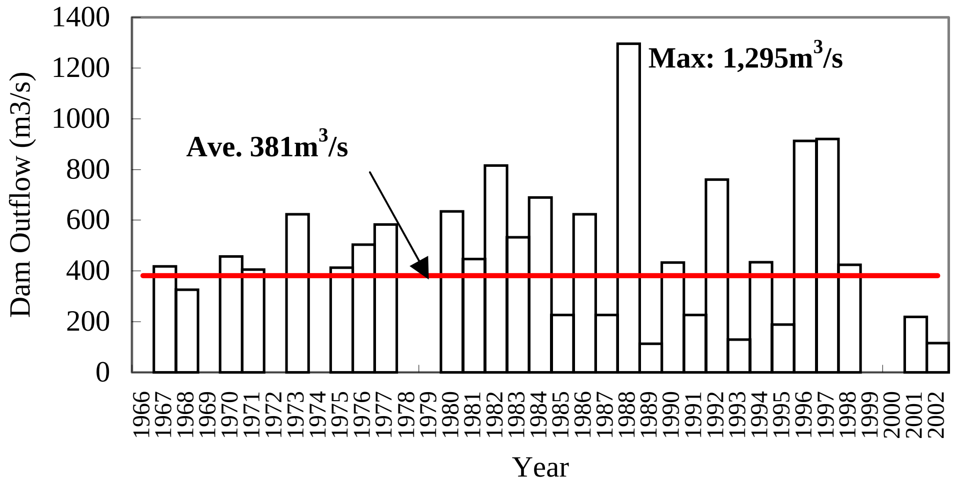

Fig. R 6.2.6 Annual Maximum Outflow Discharge from Rawal Dam

Thus, the peak dam outflow discharge is changeable depending on the complex factors of dam water stage, timing of flood occurrence and volume of the runoff discharge from the upper reaches of the dam reservoir.

Due to the above complex factors, it is virtually difficult to determine the designed dam outflow discharge through hydrological simulation. In this Study, however, the maximum dam outflow of about 1,300 m^3/s recorded in 1988 is provisionally assumed as the design discharge released from Rawal dam. The following items are further assumed, and it is concluded that the maximum peak discharge to be accommodated by Kurang River would be about 3,240 m^3/s at outlet point of the diversion channel (i.e., the confluence point with Ojhri Kas) (refer to Fig. R. 6.2.7):

(i) The peak flood runoff discharge of 100-year return period from the catchment area of Ojhri Kas is estimated at 310 m^3/s through the hydrological simulation.

(ii) The maximum discharge from the diversion channel would be about 1,630 m^3/s in the flood of 100-year return period assuming that any flood storage structures (i.e., the community pond in Fatima Jinnah Park and/or flood mitigation dam in Block E-11) are not constructed in the catchment area of the diversion channel.

(iii) It is assumed as the worst case, that the peak discharge from the diversion discharge could coincide with the peak discharge from Rawal dam and the catchment area of Ojhri Kas. In this case, the peak discharge to be accommodated by Kurang River is estimated to at about 3,240 m^3/s as the total of 1,630 m^3/s from the diversion channel, 1,300 m^3/s from Rawal Dam and 310 m^3/s the catchment area of Ojhri Kas.

b) Existing Channel Flow Capacity of Kurang River

The upstream channel of about 4.4 km in length from the outlet point of the proposed diversion channel to the confluence of Gumreh Kas (tributary of Kurang River) has U-shape cross-sections with the small channel depth of only about 2 m, although it has the rather large channel width of more or less 100 m. Moreover, the upstream channel has the very gentle channel bed slope of about 1/1,500. Due to these characteristics, the channel flow capacity of the upper reaches is limited to about 200 m^3/s, which is far smaller than the aforesaid expected maximum flow discharge of 3,240 m^3/s for Kurang River as listed below.

Table R 6.2.13 Hydraulic Channel Dimensions and Channel Flow Capacity of Kurang River

Name of Point	Distance from Rawal Dam Site (km)	Channel Bed Slope	Max. Depth (m)	Max. Width (m)	Hydraulic Radius (R) (m)	Max. Discharge (m^3/sec)
Soan Village	5.6	1/750	5.8	130	3.0	960
Shikrial Village	7.3	1/1500	2.1	110	1.3	140
Khanna Bridge	10.0	1/140	2.9	96	1.8	730
Karal Village	12.5	1/140	11.0	75	6.8	5,300

Source : Results of river channel survey by Small Dam Organization in 2001
Note : The villages of Soan, Shakrial and Khanna are located upstream from the confluence of Gumreh Kas, while Karal Village is downstream from the confluence of Gumreh Kas.

In contrast with the upstream, the downstream of Kurang River with a length of about 16 km between the confluences of Gumreh Kas (the tributary of Kurang River) and Soan River has the steep cliff at both of the left and right banks, and the steep channel bed slope of about 1/140. According to the results of the field reconnaissance and the uniform calculation based on the channel survey by the Small Dam Organization, the channel flow capacity of the downstream stretch is evaluated to be more than 5,300 m^3/s as listed above, which could adequately accommodate the above peak discharge of 3,240 m^3/s, even if the flood runoff discharge from the catchment area of Gumreh Kas is added.

It is, however, herein noted that the land development for the new residential area is now in progress at and around the confluence of Kurang River and Soan River. Through the land development, the river channel of Kurang along the residential has been filled-up, and the new short-cut channel has been constructed. According to the site investigation, the short-cut channel deems to have far lower channel flow capacity than its upstream channel, and the residential area itself becomes the great hindrance to discharge the flood flow of Kurang River into Soan River. In order to offset such unfavorable conditions, it is indispensable to immediately suspend the on-going land development and restore the channel flow capacity as in the past, regardless of construction of the flood diversion channel from Lai Nullah to Kurang River.

c) The Areas to be protected against Flood Overflow of Kurang River

There exist three (3) settlement areas, namely, Soan, Shikrial and Khanna Dak, along the upstream channel of Kurang River. These villages currently suffer the habitual flood inundation by the overflow from Kurang River. Should the proposed flood diversion channel be constructed, the flood flow discharge of Kurang River definitely increases and accretes the present flood damage to the villages in particular (refer to Fig. R 6.2.7).

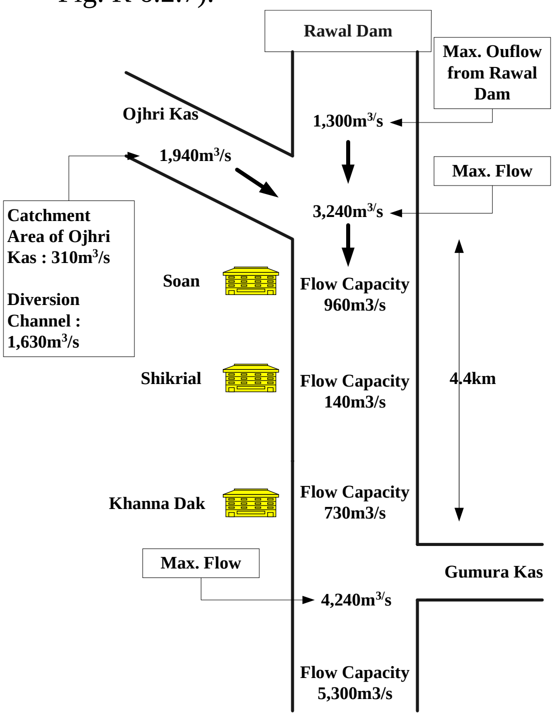

Fig. R 6.2.7 Channel Flow Capacity and Design Flow Discharge of Kurang River

Hence, the certain flood protection for the villages would become an indispensable precondition for selection of the flood diversion option. Nevertheless, apart from the settlement area of the villages, the substantial part of the rive-side along the upstream of Kurang is remained as the natural unused land and/or agricultural land. Accordingly, the major target of the objective flood mitigation could be limited to the settlement areas of the three (3) villages.

d) Flood Mitigation Measures Required to Kurang River

In order to offset the increment of flood damage potential of Kurang River inflicted by construction of the proposed flood diversion channel, establishment of the river reserve area and construction of the ring dike is proposed as shown in Fig. 6.2.26. The required work volumes for these proposed flood mitigation works are preliminarily estimated as listed in Table R 6.2.14. These are, however, subject to revision based on the further detailed topographic survey and hydrological analysis on the flood runoff discharge and the flood inundation.

Table R 6.2.14 Required Work Volume for Proposed River Reserve Area Ring Dike

Work Item	Work Volume
1. Length Ring Dike	
1.1 Right Dike for Soan Village	1,300 m
1.2 Right Dike for Shikrial Village	1,570 m
1.3 Right Dike for Khanna Dak Village	1,430 m
1.4 Left Dike for other dotted settlement areas	2,200 m
Total	6,500 m
2 Extent of Land Acquisition for Establishment of River Reserve Area and Construction of Ring Dike	334,000 m^2
3. Number of Necessary House Evacuation	220 houses

Details of the proposed river reserve area and ring dike are as described in the following items (i) to (iii):

(i) The area long the section of 10,930 m from Rawal Dam to the confluence of Gumura Kas should be delineated and gazetted to be the river reserve area as the buffer against the flood overflow and the right-of-way for the future river channel improvement works. Any unfavorable land development within the river reserve area should be prohibited.

The CDA has already declared the left and right bank of 1,000 feet in width each from the center of the river course as the river reserve area. However, the width of 2,000 feet (about 600m) in total covers the substantial part of the existing settlement area, and at the same time, it deems to be too spacious as compared with the potential extent of the flood inundation and the necessary extent for the future river improvement. From these viewpoints, the extent of the river reserve area is provisionally proposed at 200m in width from the center of the river cause (refer to Fig. 6.2.26).

(ii) A certain structural flood mitigation measures for the aforesaid three (3) villages namely Soan, Shikrial and Khanna Dak along Kurang River would be required to relive the villages from the adverse effect inflicted by construction of the proposed flood diversion channel. The villages are, however, rather sparsely dispersed along Kurang River, and therefore, the river channel improvement for the entire river stretch is not required. Instead, the ring dike is proposed to besiege the villages and prevent them from flood overflow of Kurang River.

(iii) Execution of the above river reserve area and the ring dike would require evacuation of about 220 houses. Such substantial number of house evacuation may create a social conflict and therefore would be addressed as the important issue for achievement of the proposed flood mitigation works for Kurang River. Nevertheless, the houses as the objectives of evacuation are even now exposed to the frequent flood damage and, any measure other than evacuation is not practical to get rid of such unfavorable conditions. Moreover, urban population of Rawalpindi is now being spilled over the possible flood inundation area particularly along right bank of Kurang River. Should the area along Kurang River be left behind without clearance of houses within the extent of the proposed river reserve area, the riverside along Kurang River would be finally saturated with the house and buildings like the current situation of Lai Nullah and remarkably increase the flood damage potential. In order to avoid such unfavorable conditions, the house evacuation would be indispensable even regardless to construction of the proposed flood diversion channel.

6.2.5 On-site Flood Detention Facilities

The on-site structures will involve the various structural types as described in the following items 1) to 4) which are individually installed at each new land development sites i.e., the new residential area, commercial area, or government office quarter (refer to Fig. 6.2.27 and Table 6.2.2)

1) Rainfall Storage Tank Installed at Individual House Lot

The rainfall storage tank is installed on the ground or in the building to collect rainwater from rooftop through roof gutters/pipes and store it so as to delay and reduce the peak runoff discharge. The standard type of the storage tank has a storage capacity of 2,000 liters, which could collect the rainfall from rooftop of $50m^2$ in average. Accordingly, the maximum rainfall depth to be stored in the rainfall tank is limited to only 40 mm (=2,000 liters ÷ 50 m^2), which is fulfilled by even 5-year return flood before its peak rainfall intensity occurs as shown in Fig R 6.2.8. Thus, the rainfall storage tank could hardly effect to reduce the peak runoff discharge, unless it is adopted in combination with the under-mentioned on-site flood detention pond and/or the infiltration facility. Moreover, the substantial flood mitigation effect could be achieved only when the rainfall storage tanks are installed at considerable parts of individual house lots in the basin.

Nevertheless, the rainfall storage tank has a potential function to be a subsidiary water resources (the rainfall harvesting) in addition to the function of flood mitigation (refer to subsection 8.5.5). In order to prevail the rainfall storage tanks, the following various expedients would be required:

(a) Dissemination of the effect of rainfall storage tank on water use among the residents;

(b) Preparation/revision of the byelaw and the Building Code to accommodate the rainfall storage tank at the individual house lot;

(c) Establishment of subsidiary system for installation of the rainwater tank; and

(d) Concession of property tax to the residents who install the rainwater tank.

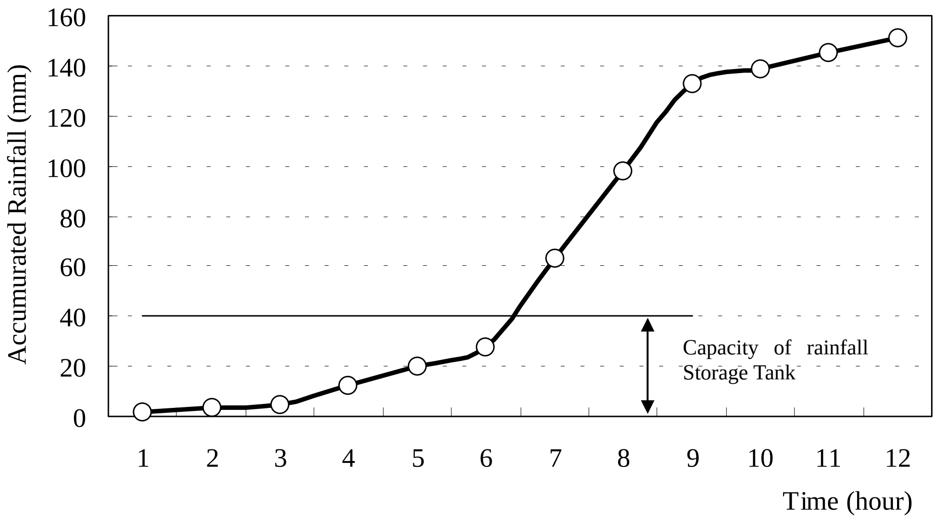

Fig. R 6.2.8 Design Storm Rainfall of 5-year Return Period

2) On-site Flood Detention Pond

The on-site flood detention pond is usually placed at the downstream end of the new land development area in order to offset the increment of the peak runoff discharges inflicted by the land development. The flood regulation effect by the on-site flood detention pond could extend to both of the following middle and large-scale floods (refer to Fig. 6.2.28):

(a) The small-scale floods (say in a rage of 5 to 10-year return period) to offset the excessive flood runoff over the flow capacity of the drainage channels immediately downstream from the land development area; and

(b) The large-scale floods (say in a rage of 25 to 100-year return period) to offset the excessive flood runoff over the flow capacity of the river channel, which is situated as the final outlet of the basin flood runoff discharges.

In order to perform the above regulation effect, the on-site flood detention ponds may have two (2) outlet holes as illustrated in Fig. 6.2.29. The small-scale floods are discharged through only the lower outlet, while the large-scale floods are discharged through both of the lower and upper holes.

When the vacant grass land and/or the natural forest of 1km^2 in extent is developed to the residential area (the moderately populated area like those in Islamabad), the probable peak discharge of 10-year return period is estimated to increase from 4 m^3/s/km^2 to 10 m^3/s/km^2 and that of 100-year return period from 16 m^3/s/km^2 to 23 m^3/s/km^2 as shown in Fig. 6.2.28.

The necessary storage capacity of the on-site flood detention pond to offset the above increments of peak flood runoff discharge is estimated at about 150,000 m^3 per 1km^2 of land development area assuming 4 to 7m as the average depth of pond. This on-site flood pond would have an extent of 30,000 to 50,000 m^2, which takes about only 3 to 5% of the entire land development area. The storage capacity as well as the extent of pond would increase in proportion to extent of the land development.

When the land development in the river basin is judged to cause the excessive peak flood runoff discharge over the flow capacity of the downstream drainage channel and/or river channel, the river administrator (or the land administrator) may be required to enforce the land developer, through bylaw, to provide the above on-site flood detention pond. Through construction of the on-site flood detention pond, the flood safety level of the river basin could be maintained irrespectively of land development in the basin.

3) Infiltration Facilities

Infiltration facilities are used to collect the rainfall and/or the flood runoff discharge and make them infiltrate into the ground so as to mitigate the flood runoff discharge. There are various types of the infiltration facilities as shown in Table 6.2.2. The facilities are, however, applicable only to the subsurface of gravel deposits and other permeable soil. Moreover, the infiltration capacity of the facilities easily drops due to clogging by sediments, and therefore, the facility could be installed only at paved areas and green belt, where little suspended solids is yielded.

4) Flood Detention Wall at Public Open Space

The storage measure of this type is such that a public open space (such as a sport ground and a car parking area) is enclosed by a low wall with a surrounding side drain and an outlet to collect the rainfall from an entire public compound (refer to Fig. 6.2.27). The maximum storage depth and storage time length should be limited in due consideration of the original purpose of the storage space as public utility.

Most of the facilities of this type are designed to have the maximum storage depth of 30 cm and the maximum storage time of 2 to 12 hours due to the original purpose of the storage space as the public utility. The size of the outlet should be determined on the premises that the storage will meet to the requirement of the maximum storage depth and storage time against the design hydrograph of the target design scale for urban drainage not allowing any overflow.

6.3 COMPARATIVE STUDY ON ALTERNATIVE COMBINATIONS OF STRUCTURAL MEASURES

The flood mitigation capacity of each of the possible off-site flood mitigation measures proposed in the foregoing subsections 6.2.1 to 6.2.4 is limited to a certain level due to the 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 clarified as the first approach to selection of the optimum combination.

(1) Necessary discharge to be regulated 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).

6.3.1 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 1,150 m^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 640 m^3/s at Kattarian Bridge. The difference between the probable peak flood discharge and the channel flow capacity is 510 m^3/s and 1,630m^3/s, which need to be offset by the followings (refer to Fig. R 6.3.1):

(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.

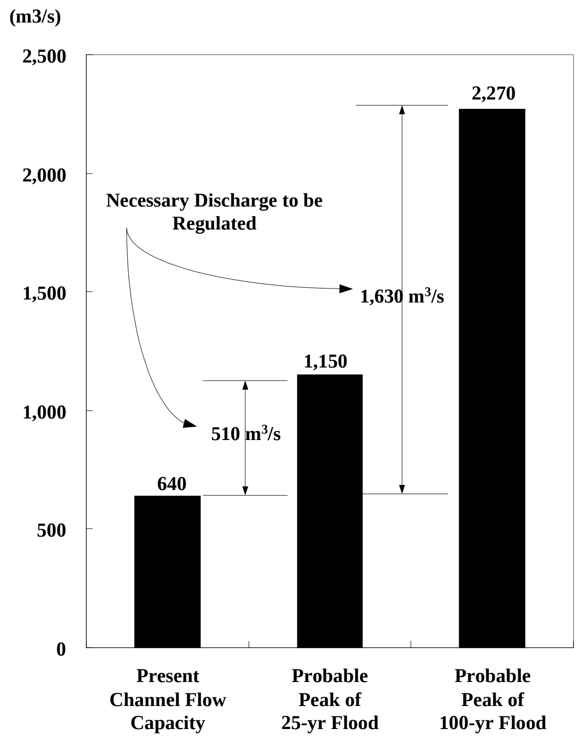

Fig. R 6.3.1 Concept of Necessary Discharge to be regulated

6.3.2 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 (refer to Chapter 5). As shown in the Table R 6.3.1, the probable peak discharges of 25-year return period at Kattarian Bridge could be reduced from about 1,150 m^3/s to 830 m^3/s by 320 m^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 2,270 m^3/s to 1,730 m^3/s by 540 m^3/s (24%). Thus, the community pond and the flood mitigation dam have the substantial effect to reduce the probable peak discharge of Lai Nullah at Kattarian Bridge by more than 20%.

Table R 6.3.1 Maximum Reduction of Probable Peak Flood Discharge of Lai Nullah at Kattarian Bridge by Proposed Flood Detention Facility

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 640 m^3/s to 900 m^3/s by 260 m^3/s (refer to the foregoing Table R 6.2.4). As for the flood diversion channel, the possible channel flow capacity is preliminarily evaluated to cover about 1,630 m^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 subsection 6.2.4). Based on these clarifications, the maximum flood mitigation capacities of the components for the alternative flood mitigation schemes are summarized as Table R 6.3.2.

Table R 6.3.2 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	Community Pond ＋ Dam	River Improvement	Flood Diversion
25-year	190	150	320	260	1,700
100-yer	240	300	520		

6.3.3 Alternative Flood Mitigation Schemes

As described in the above 1), the necessary discharges to be regulated at Kattarian Bridge are 510 m^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 800 m^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 design 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 schemes are preliminarily delineated as listed below.

Table R 6.3.3 Eligible Alternative Flood Mitigation of Measures

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 (1): ○= Included as the component of the alternative, × = Excluded as the component of the alternative

(2): All alternative schemes include the supplementary works to the on-going channel improvement in common in addition to the flood mitigation measures as listed above. The supplementary works are (a) 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 (b) improvement of the existing channel of Lai Nullah (RD5+277-RD6+215) below Chaklala Bridge.

6.3.4 Flood Mitigation Capacities Required to Components of Each Alternative Scheme

The flood mitigation capacities required to each of flood mitigation measures, which compose the alternative flood mitigation schemes are estimated based on (1) the necessary discharge to be regulated as described in subsection 6.3.1 and (2) the potential maximum capacity of each flood mitigation measures. The results of estimation are as summaries below:

Table R 6.3.4 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 (=640 m^3/s)

As listed above, it is concluded that the design level of 25-year return period for the short-term project could be achieved by the potential capacity 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.

6.3.5 Optimum Flood Mitigation Scheme

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 6.3.5 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	○	△	×	△	

1) Project Cost

Among others, the Alt. 6 has the least cost of long-term project below Rs. 7,500 million followed by Alt. 8 as listed in Table R 6.3.6. In contrast to the above Alts 6 and 8, other alternatives require the comparatively high cost of about Rs. 8,000 to 11,000 million. 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 80ha. 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 6.3.6 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) 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 6.3.7. 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 6.3.8). 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 6.3.7 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 6.3.8 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

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.

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.

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

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

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

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

(e) 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:

(a) Construction temporary bypasses to minimize traffic disruption;

(b) 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

(c) 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:

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

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

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

(d) 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.

6.3.6 Operation, Maintenance and Management Works for the Proposed Flood Mitigation Structures

The major works required to the operation, maintenance and management for the proposed structural measures, which consists of community pond, the river channel and the diversion channels, are as described hereinafter:

1) Community Pond

The principal works for operation, maintenance and management of the community pond would include the following items:

(a) Removal of deposits in the pond: This would be periodically required during a flood season from July to September in order to secure the designed storage capacity of the pond. In this connection, one (1) backhoe with bucket capacity of 0.45 m^3 and two (2) 10-ton capacity dump trucks were proposed as the required equipments to facilitate the objective control of the deposits.

(b) Safety control: The area of 0.16km^2 with a ground level below EL.545 m in and around the pond is subject to the probable flood inundation area of 10-year return period. In order to avoid the eventuality of visitors to be exposed to danger of flood, the area would need to be placed off limits during a flood season.

(c) Sanitary control: The water quality of the pond would be preserved by various facilities such as the oxidation ponds, the check dams and the bypass pipe not to allow the polluted water to flow into the community pond. Nevertheless, the periodical inspection on the water quality of the pond would be required and, in case of the unfavorable water quality detected through inspection, the pond would need to be dried up through the outlet of orifice.

2) River Channel and Flood Diversion Channel

The most critical issue on the maintenance for the river and diversion channel is addressed to removal of sediment, solid wastes and any other deposits in the channels particularly at the hydraulic critical points such as inlet of diversion points and piers of bridges. In order to cope with the issue, periodical removal of the deposits would be required throughout a year, and the emergency inspection/retrieval works be further required after a flood. The inspection and retrieval works on the side slope of the river channel would be also enumerated as an important issue for maintenance of the river channel, and the side protection works particularly against erosion of the side slope would be required according to the results of inspection.

6.4 POSSIBLE NON-STRUCTURAL FLOOD MITIGATION MEASURES

6.4.1 Flood Forecasting and Warning

The Pakistan Metrological Department PMD has monitored the storm rainfall of Lai Nullah through the existing four rainfall gauging stations and one weather surveillance radar installed in the compound of PMD Headquarter near Zero Point. TMA had also previously operated two (2) manual (off-line) water level gauging station at Gawal Mandi Bridge and Ratta Amral Bridge to monitor the flood water level of Lai Nullah. The existing rainfall gauging stations operated by PMD are, however, not equipped with the automatic data transmittal system, which cause difficulties in collecting the accurate gauged data in real-time base. The water level gauging stations used by TMA were also abandoned due to reconstruction of the bridges after the July 2001 flood.

The storm rainfall observed by PMD has been informed to by the relevant authorities (such as TMA, RDA and CDA) through the public telephone lines. Based on the information of storm rainfall and the flood water level of Lai Nullah, TMA in particular has disseminated the flood warning to the residents through the patrol cars and the sirens. However, the patrol cars hardly achieved the immediate dissemination of the flood warning, and the warning sires are decrepit decreasing reliability of function.

In the event of July 2001 flood, 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 74 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 immediately effect mitigation of the flood damage, the calamity of death in particular.

1) Proposed Organization Set-up for FFWS

For smooth operation of FFWS, the following improvement for existing organization is proposed (refer to Fig. 6.4.1):

(a) PMD would be the most eligible agency to undertake the integrated hydrological observation of the storm rainfall as well as the water level and the flood prediction. PMD would also take responsibilities to inform the results of the flood prediction to the relevant local government agencies such as TMA, RDA and RDB.

(b) The above local government agencies would take the responsibilities of flood dissemination to the residents in their respective jurisdiction areas based on the flood prediction by PMD.

(c) FFC should be the coordination body for PMD and other relevant government agencies to facilitate the daily overall maintenance and management for the whole facilities/equipment of FFWS and the basin-wide flood fighting and/or evacuation works as required.

2) Proposed Equipment and Telecommunication Network for FFWS

The proposed FFWS is composed of (a) rainfall/water level gauging stations, (b) Master Control Station, (c) Monitoring Station, (d) Executive Warning Control Room and, (e) Warning Posts. Location map of these gauging stations are as shown in Fig. 6.4.2. The proposed telecommunication network for these stations and the equipment required are as shown in Fig. 6.4.3 and Table 6.4.1**,** respectively. Briefs of the these stations/posts are further described hereinafter:

a) Rainfall Gauging Station

All of the existing four (4) rainfall stations are biased to eastern side of Lai Nullah Basin and, therefore, the western side of the basin is now situated as the hydrological blind area. In order to retrieve such unfavorable conditions, two additional rainfall gauging stations are proposed to be newly installed at the western side of the basin. Thus, the proposed FFWS is composed of the following six (6) rainfall gauging stations in total. All of the rainfall gauging stations would be equipped with the telemetry system, and the gauging data are automatically transferred from the rainfall stations to the Master Control Station through 400 MHz telemetry line.

Name of Station	Existing or New	Location		
		Latitude	Longitude	Located at
Chaklala	Existing	Lat.: 33^0 37’	Long: 73^0 37’	Islamabad International Airport
Islamabad	Existing	Lat.: 33^0 41’	Long: 73^0 03	National Agronomical Center
RAMC	Existing	Lat.: 33^0 37’	Long: 73^0 37’	Rawalpindi Agronomical Center
Saidpur	Existing	Lat.: 33^0 88’	Long: 73^0 05’	Seismological Observatory
Golra	New	Lat.: 33^0 41’	Long: 72^0 58’	Modern Veterinary Health Center
Bokra	New	Lat.: 33^0 33’	Long: 73^0 00’	Construction Machinery Training Institute

b) Water Level Gauging Station

The telemetry water level gauging station would be installed at five (5) following locations and the gauging data are automatically transferred to the Master Control Station through 400Mhz telemetry line. Among others, two water level gauging stations are installed along the mainstream of Lai Nullah at Kattarian Bridge and beside the Rawalpindi Fire Brigade Office (about 500m downstream from Gawal Mandi Bridge) in order to monitor the flood water level of the mainstream. Other three water level gauging stations would be installed in and around the proposed Community Pond in Fatima Jinnah Park to monitor the water level of the pond: two gauging stations for the water level of the two inlets channels of the pond and one for the water level of the pond itself. The overall location of the water level gauging stations are as listed below:

Name of Station	Existing or New	Location
Kattarian Bridge	New	At Kattarian Bridge on Khayaban-I-Sir Syed (I-J Principal Road)
Rawalpindi Fire Brigade	New	In the compound of Rawalpindi Fire Brigade Headquarter
Park-A	New	North inflow point of Tenawali Kas within the compound of Fatima Jinnah Park
Park-B	New	East inflow point of Tenawali Kas within the compound of Fatima Jinnah Park
Park-C	New	Community Pond proposed in Fatima Jinnah Park

c) Master Control Station

The Master Control Station is installed within the compound of PMD Headquarter at Zero Point. All rainfall and water level gauging data are transmitted to and processed by a sever installed at the Master Control Center on real-time base through 400MHz telemetry line connected between the Master Control Center and the aforesaid rainfall and water level gauging stations.

d) Monitoring Station

The Monitoring Station is installed at FFC, WASA of RDA and the control office of the community pond proposed in Fatima Jinnah Park. All flood information collected and processed by the Master Control Center is monitored by the client personnel computer at Monitoring Stations on real-time base through WAN with using excusive 5.2 GHz Wireless LAN. The Monitoring Stations would decide and arrange the necessary issues of the basin-wide flood warning, flood evacuation/rescuer, and control of community pond as required. Based on the monitors of the basin-wide flood conditions.

e) Executive Warning Control Room

The Executive Warning Control Room is installed at Rawalpindi Fire Brigade Headquarter. All flood information collected and processed by the Master Control Center is monitored by the client personnel computer at the Executive Warning Control Room on real-time base through WAN with using excusive 5.2 GHz Wireless LAN. The Executive Warning Control Room would evaluate the flood risk based on the monitored flood information and disseminate the flood warning to the residents through the under-mentioned warning sirens.

f) Warning Post

The warning posts would be distributed into the habitual flood inundation areas in Rawalpindi. The required number of the warning posts was provisionally estimated at ten (10) to cover the whole extent of the flood inundation areas. Out of the proposed ten (10) waning posts, the four (4) would be installed at the following locations. Other six (6) warning posts would be determined during the time for detailed design of the system.

Name of Station	Location		Remarks
Gawal Mandi	Lat.: 33^0 60’	Long. : 73^0 05’	Gawal Mandi Fire Office
Pir Wadhai	Lat.: 33^0 63’	Long. : 73^0 03	Pir Wadhai Fire Office
Warning Post C	Lat.: 33^0 60’	Long. : 73^0 07’	Waqar-un-Nisa College
Fatima Jinnah Park	Lat.: 33^0 43’	Long. : 73^0 04’	Within the compound of Fatima Jinnah Park

All of the warning posts are connected to the Executive Warning Control Room by telemetry line (400MHz). The Executive Warning Control Room will send the signals to the warning posts, as required, to blow warning sirens to the residents. The Executive Warning Control Room will also receive the signals from the warning post so as to confirm the execution of warning sirens

g) Configuration of Telecommunication Network

The telemetry line of remote transmission unit (RTU) with UHF band (400Mhz) would be connected between the rainfall/water level gauging stations and the Master Control Station in order to automatically transmit the flood information gauged by the rainfall gauging stations and the water level gauging to a server installed at Master Control Station. The telemetry line would be also linked between the Executive Warning Control Room and warning posts in order to transmit the signal to blow warning sirens to the residents. The Wide Area Network (WAN) with using excusive 5.2 GHz Wireless LAN would be further linked among the Master Control Station, the Monitor Station and Executive Warning Control Room in order to monitor the flood information collected and processed by the Master Control Station.

6.4.2 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: (1) the probable extent and depth of flood inundation and (2) 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 as shown in Fig. 6.4.4. The available evacuation centers as well as evacuation routes for each unit of the local communities should be further selected by the relevant local government agencies based on the base maps, and the flood risk map should be finalized. The flood risk map thus prepared should be disseminated to the public through a bulletin, an information board and other available information tools.

The total inundation area deeper than 0.3 m is estimated about 7.2 km^2, and deep inundation over 4 m is still anticipated in 1.3 km^2 low-lying areas along Lai Nullah and the tributaries even after the completion of the on-going ADB's Lai Nullah improvement project.

Table R 6.4.1 Flood Inundation Area

Inundation Depth	Inundation area by city (km^2)		
	Islamabad	Rawalpindi	Total
0.3 – 1m	0.26	1.57	1.84
1 – 2m	0.30	1.54	1.84
2 – 3m	0.15	1.11	1.26
3 – 4m	0.13	0.81	0.94
Greater than 4m	0.34	0.98	1.31
Total	1.18	6.01	7.18

6.5 STRENGTHENING OF INSTITUTIONAL SETUP AND CAPACITY BUILDING FOR FLOOD MITIGATION AND RIVER MANAGEMENT

There are several agencies concerned with flood mitigation and river management, while there is no agency to exclusively manage and/or administrate the entire Lai Nullah basin for flood mitigation. All of the agencies other than FFC are concerned with their own jurisdiction areas. As the results, it is difficult to have the consistent basin-wide river management from upstream to downstream. Under these conditions, the following issues on the present organization setup are pointed out:

(1) Flood mitigation plans may be formulated independently in each territory or control area by each agency with different scales and measures.

(2) In such plans, there may be some discrepancy or gap in the strategy of river management among territories or control areas, especially between upstream and downstream.

(3) As the results, flood mitigation plans could be hardly promoted especially when the coordination among agencies concerned is required.

(4) There are too many laws, acts and acts related to flood mitigation and river management, which causes difficulties in fully understanding the whole of the relevant legal arrangements.

(5) The statements in the laws, acts and acts related to flood mitigation and river management are relatively brief, and it may be difficult to cope with detailed issues on river management based on the statements laws, acts and acts related to flood mitigation and river management.

6.5.1 Strengthening of Organization Set-up

Strengthening of the organization setup would be achieved through (1) establishment of a new authority for the entire river management/administration or and (2) strengthening of the existing authorities relevant to the river management/administration. However, the establishment of a new authority in the above item (1) is evaluated to be virtually difficult, since there exist several authorities in charge of the river administration and/or administration, such as CDA and RDA, and establishment of a new authority may cause the serious conflict of roles with these existing authorities. From these viewpoints, the strengthening of the existing relevant river authorities is preferable, and the following items are proposed:

1) Establishment of Management Committee

The ECNEC had constituted a technical committee in 1984, under the Chairmanship of the Secretary of Ministry of Water and Power (MPW) for the smooth implementation of development projects in Lai Nullah, and another sub-committee was constituted in 1985 under the Chairmanship of CEA/CFFC and it was decided that FFC would act as lead agency for the Lai Nullah Project.

In order to strengthen the institutional setup for the river management/administration of Lai Nullah, there is dire need of reactivation of the Management Committee in the Ministry chaired by MWP with the principal members of FFC, CDA, RDA, TMA, RCB and SDO. The Management Committee may have monthly coordinate the issues regarding Lai Nullah, and through the coordination, the Management Committee would have the following principal functions:

(a) Support to financial arrangement of implementation of the master plan;

(b) General monitoring of progress of the Master Plan for flood mitigation of Lai Nullah; and

(c) Coordination on issues beyond control of FFC's Task Force between Federal and Provincial agencies, i.e., FFC, CDA, RDA, TMA, RCB and SDO.

2) Establishment of Task Force for Lai Nullah

FFC will shoulder the principal duty for implementation of Master Plan in Lai Nullah, while it has also a huge role to manage and coordinate the other major rivers in Pakistan as the routine works. In order to cope with the large work volume for implementation for Lai Nullah without fewer disturbances to the present routine works, it is recommended to set up a task force (or a project unit), which will exclusively handle the works for coordination for implementations relevant to Lai Nullah basin. The basic function of the proposed Task Force includes the following works (refer to Fig. 6.5.1):

(a) Review and modification of the Master Plan for flood mitigation and environmental improvement of Lai Nullah including implementation schedule.

(b) Explanation of the Master Plan to the agencies concerned and public.

(c) Financial arrangement for implementation of the Master Plan.

(d) Implementation of F/S for the project components included in the Master Plan if necessary.

(e) Allocation and instruction of the works including land acquisition and house evacuation of the project components to each agency responsible.

(f) Supervision and coordination for the works.

(g) Overall management and instruction of operation and maintenance works to the agencies concerned.

3) Preservation of the Existing Roles of the Relevant Authorities

On the premises of the above establishment of the Management Committee and the Task Force, the river management and administration should be jointly undertaken in principal by the existing relevant authorities, which include CDA, RDA, TMA, RCB and FFC. The major functions and/or responsibilities for these authorities are as proposed below:

Table R 6.5.1 Major Functions for Project Implementation

Agencies concerned	Major Functions/Responsibilities
FFC	Coordination for financing, planning, design, supervision, O&M* and others (land acquisition, logistics, etc)
CDA, RDA, TMA, RCB	Implementation of planning, design, supervision, O&M* and others in their territory or control area

*: Among the proposed flood mitigation structures, the community pond is placed in the jurisdiction area of CDA, and the usual operation and maintenance would be undertaken by CDA. However, the emergency removal of sediments in and around the pond after a flood may need to be undertaken by FFC

6.5.2 Strengthening of Legal Setup

There are many laws, acts and acts for the land administration but less for the river administration in Pakistan. As the results, when the river basin extends over more than two different jurisdiction areas, the river is administrated by the different land administrators, and the consistent river basin administration is hardly achieved. In order to improve such unfavorable conditions, it is indispensable to enact the “River management law or Water law”, which prescribes (a) the definitive unified river administrator, (b) the river reserve area to be administrated by the prescribed river administrator, (c) the authorities and responsibilities given to the administrator and (d) all other necessary items related to the river administration.

6.5.3 Capacity Building

Judging from the technical capacity of the staffs of the relevant agencies, the capacity building for the following programs would be required through the on-the-job trainings, the seminar/work shops and other relevant opportunities:

(1) Development of key management capability

(2) Financial and legal management capability

(3) Planning and design management capability including environmental knowledge

(4) S/V, O&M and Contract management capability

(5) Logistic support including public relation and coordination capability

The period for the on-the-job-training in particular would require one year before commencement of implementation of the proposed flood mitigation project for Lai Nullah and, other capacity building programs will be continued in parallel with the progress of the project implementation.