FLOOD FORECASTING AND FLOOD DEFENSE IN PAKISTAN

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Managing Flood Risk, Reliability and Vulnerability
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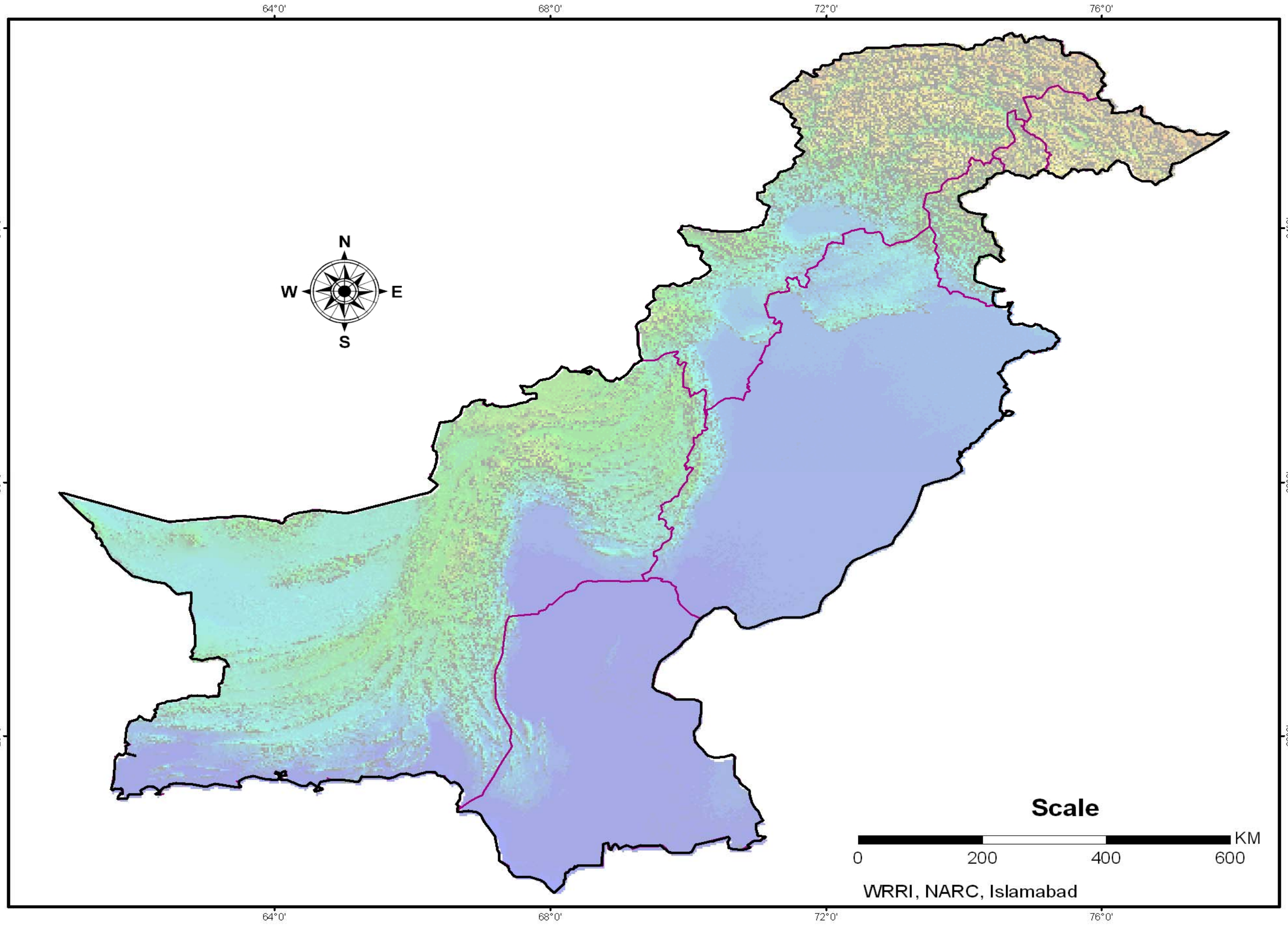
Institute for Catastrophic Loss Reduction


INDUS
CHINA
AFGHANISTAN
PAKISTAN
INDIA
NEPAL
TURKMENISTAN
XINJIANG UYGUR AUTONOMOUS REGION
EAST TURKESTAN
K2 8611 m
Noushak 7485 m
HIMALAYAS
TIBETAN PLATEAU
TIBET
Mazar-i-Sharif
Herāt
Harirud
Murgap
Kabul
Kabul
Mount Sikaram
Peshawar
Islamabad
Srinagar
Indus
Jammu
Pathankot
Gujrat
Sargodha
Faisalabad
Lahore
Ludhiana
Jullundur
Patiala
Badrinath
Haridwar
Saharanpur
Meerut
Bhatinda
Sirsa
Hisar
New Delhi
Kandahar
Quetta
Deri-Ghazi Khan
Bahāwalpur
Rahimyar Khan
Sukkur
IRAN
Bikaner
Sikar
Alwar
Agra
Bareli
Manaslu 8163 m
Sitapur
Lucknow
Darbhanga
Kanpur
Jaunpur
Patna
Varanasi
Allahabad
Jodhpur
Ajmer
Gwalior
Nawabshah
Mirpur Khas
Hyderabad
Karachi
Pali
Kota
Shivpuri
Satna
Rewa
Udaipur
INDIA
Sagar
Bharatpur
Ranchi
Arabian Sea
INDIAN OCEAN



64°0'
68°0'
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Scale
KM
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200
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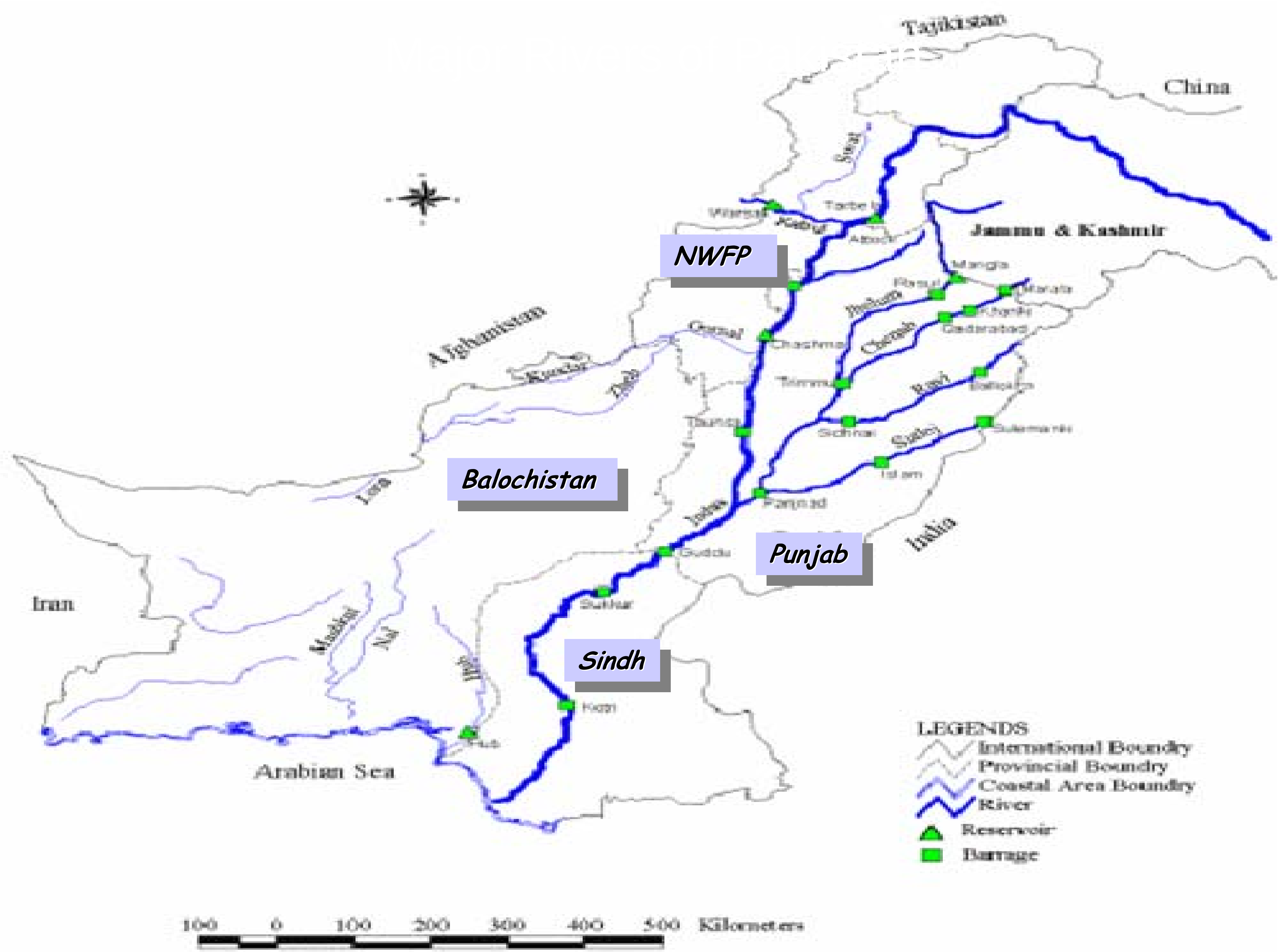
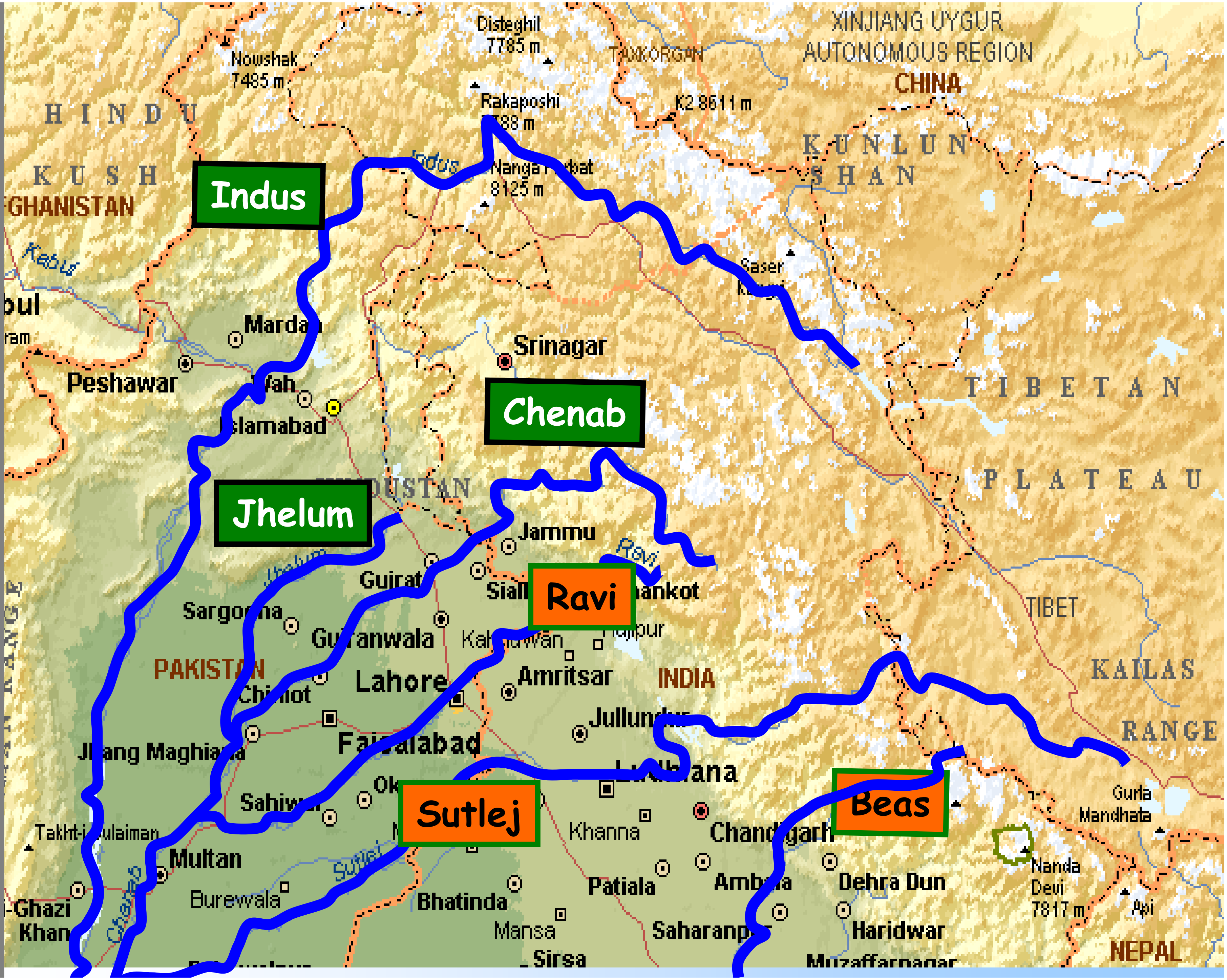
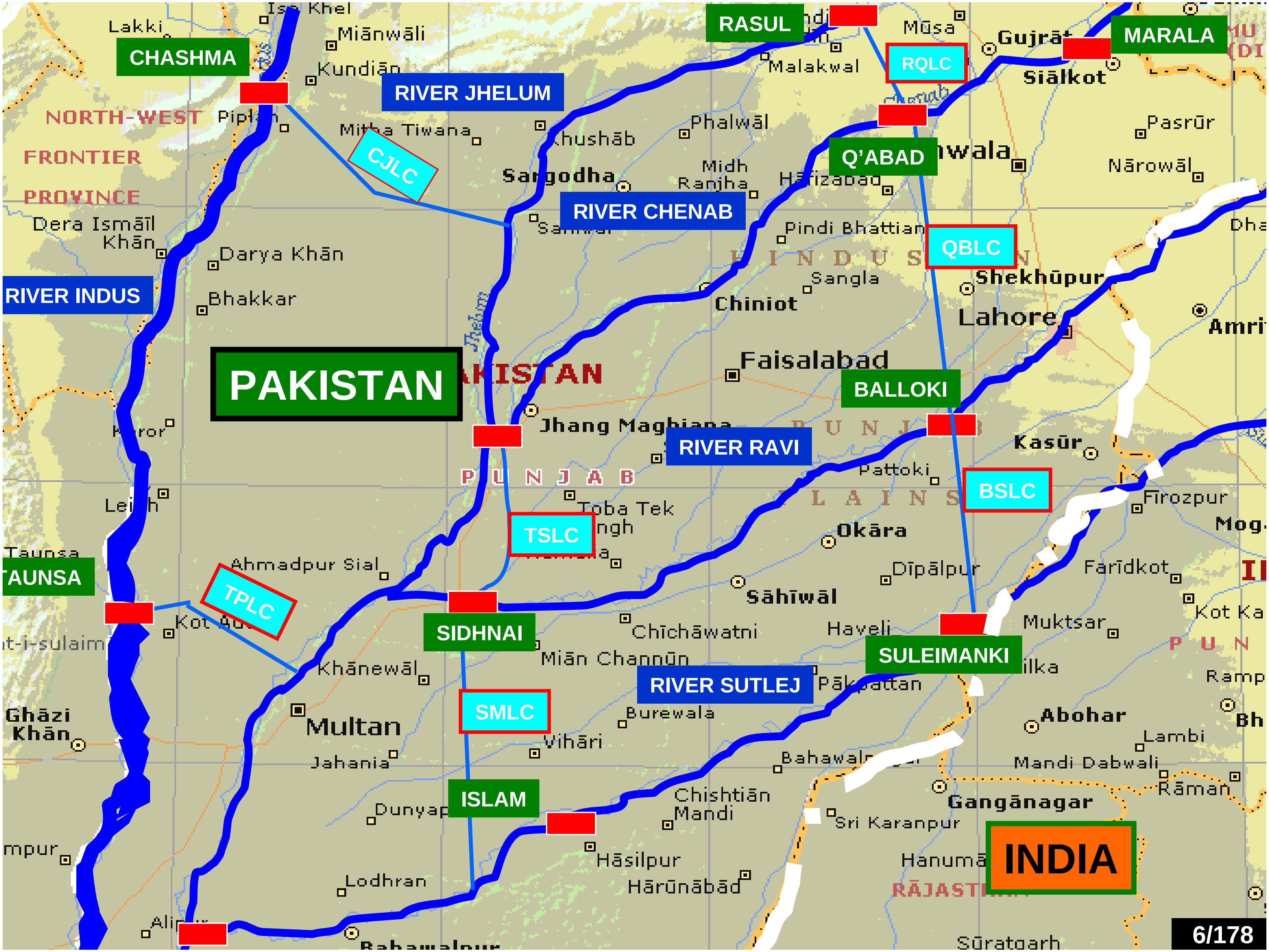
600
WRRI, NARC, Islamabad



Tajikistan
China
Jammu & Kashmir
Afghanistan
Iran
India
Arabian Sea
NWFP
Balochistan
Punjab
Sindh
Swat
Tarbela
Warsak
Kabul
Attock
Mangla
Rasul
Marala
Khanki
Qadirabad
Jhelum
Chenab
Gomal
Chashma
Trimmu
Ravi
Balloki
Sutlej
Sidhnai
Sulemanki
Islam
Taunsa
Indus
Panjnad
Guddu
Sukkar
Kotri
Hub
Zhob
Lora
Nal
Mashkel
LEGENDS
International Boundry
Provincial Boundry
Coastal Area Boundry
River
Reservoir
Barrage
100 0 100 200 300 400 500 Kilometers

THE INDUS BASIN




CHASHMA
RIVER JHELUM
RASUL
MARALA
RQLC
CJLC
Q'ABAD
RIVER CHENAB
QBLC
RIVER INDUS
PAKISTAN
BALLOKI
RIVER RAVI
BSLC
TSLC
TAUNSA
TPLC
SIDHNAI
SULEIMANKI
RIVER SUTLEJ
SMLC
ISLAM
INDIA
NORTH-WEST
FRONTIER
PROVINCE
Lakki
Mianwali
Kundian
Mitha Tiwana
Khushab
Sargodha
Phalwal
Midh Ranjha
Malakwal
Musa
Gujrat
Sialkot
Pasrur
Narowal
Hafizabad
Pindi Bhattian
Sangla
Shekhupura
Lahore
Chiniot
Faisalabad
Jhang Maghiana
Dera Ismail Khan
Darya Khan
Bhakkar
Layyah
Kasur
Pattoki
Toba Tek Singh
Okara
Dipalpur
Sahiwal
Ahmadpur Sial
Chichawatni
Haveli
Mian Channun
Khanewal
Multan
Pakpattan
Burewala
Vihari
Jahania
Bahawalnagar
Chishtian Mandi
Dunyapur
Hasilpur
Harunabad
Lodhran
Bahawalpur
Ghazi Khan
Firozpur
Faridkot
Muktsar
Abohar
Mandi Dabwali
Ganganagar
Sri Karanpur
Suratgarh

Major Floods of Indus Basin in Pakistan

Year	Monetary Losses (Billion Rs)	Lives Lost (No.)	Villages Affected (No.)	Area Flooded (Miles2)
1950	9.08	2,910	10,000	7,000
1955	7.04	679	6,945	6,000
1956	5.92	160	11,609	29,065
1973	5.82	474	9,719	16,200
1975	12.72	126	8,628	13,645
1976	64.84	425	18,390	32,000
1978	41.44	393	9,199	11,952
1988	15.94	508	100	4,400
1992	98.00	1,008	13,208	15,140
1995	7.00	591	6,852	6,518

FLOOD PROBLEM IN PAKISTAN

- Economic damages resulting from annual flooding is a major burden on the country.
- Floods have havoc over the years,
- agricultural
- communication infrastructure,
- Infrastructures (Buildings, Roads, …etc)

with damages worth Rs 225 billion (US $ 4 billion) recorded for the ten largest floods since country's independence in 1947. Almost 8000 lives have been lost during these floods.

FLOODING MECHANISMS

- There are three reason for flooding

1) Floods in the Indus Basin occur in late summer (July to September) during monsoonal rains.
   - In the upper to mid reaches of the Basin, it is generally the tributaries like Jhelum and Chenab Rivers, which are the cause of flooding rather than the Indus River itself.
   - Since many rivers are also snow-fed, an early monsoon may combine with peak snowmelt runoff to exacerbate flooding.

- The monsoon low or depression that causes intense rain develops either in Arabian Sea or Bay of Bengal. Major flooding is generally associated with the depression from the Bay of Bengal moving across India in west/north-westerly direction and then turning north at the border with Pakistan.

- Heavy rains occur due to orographic lifting at the high mountain ranges in the river catchments.

- Generally the heavy rainfalls are limited to the Chenab, Jhelum, Ravi and Sutlej

- River catchments, however, occasionally, the depression can cross further north into the Indus River catchment.

INSTITUTIONAL ARRANGEMENTS FOR FLOOD MANAGEMENT

- *Flood Forecasting Division.*

The FFD of the Pakistan Meteorological Department plays a central role in the flood forecasting and warning in the country.

- *Provincial Irrigation and Drainage Authority.*

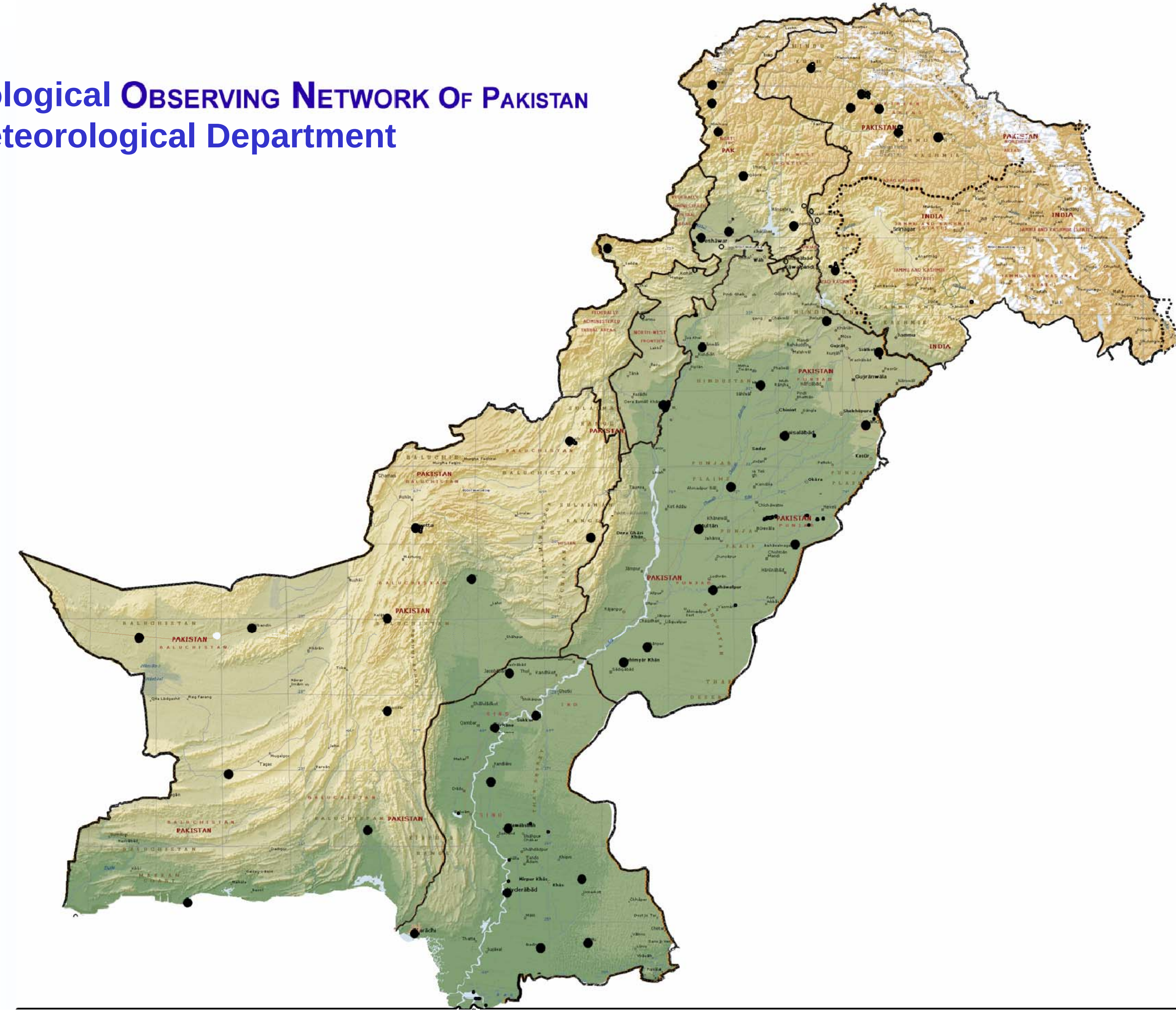
The Authority plays a prominent role in flood management through planning, design, construction and maintenance of flood protection works.

- *Water and Power Development Authority.*

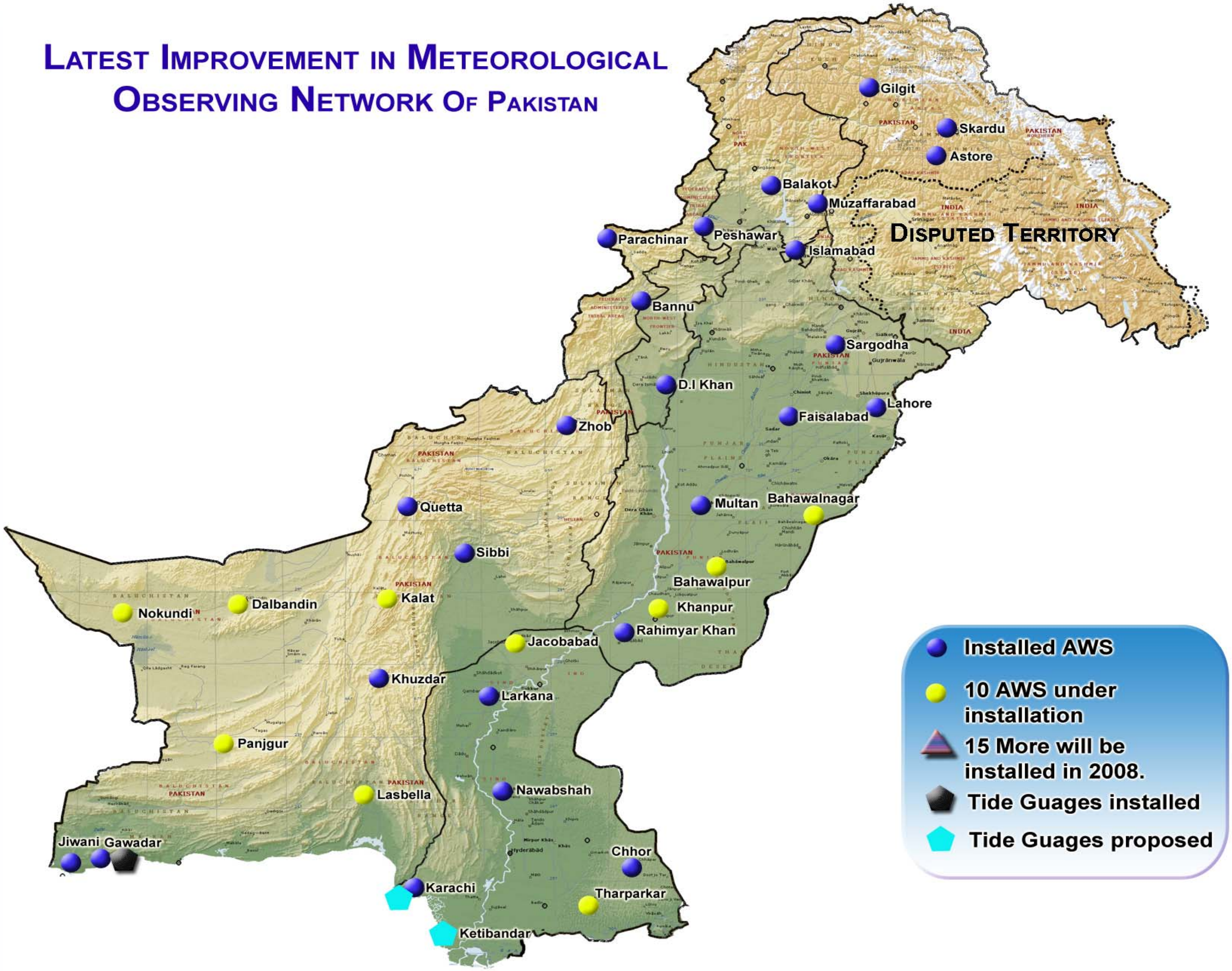
The authority is the custodian of Tarbela and Mangla dams and undertakes the day to day reservoir management for irrigation flow releases

- ***Provincial Relief Department.***
- **Pakistan Army.**
- ***Emergency Relief Cell.***
- ***Civil Defence Organisation.***
- ***Federal Flood Commission.***

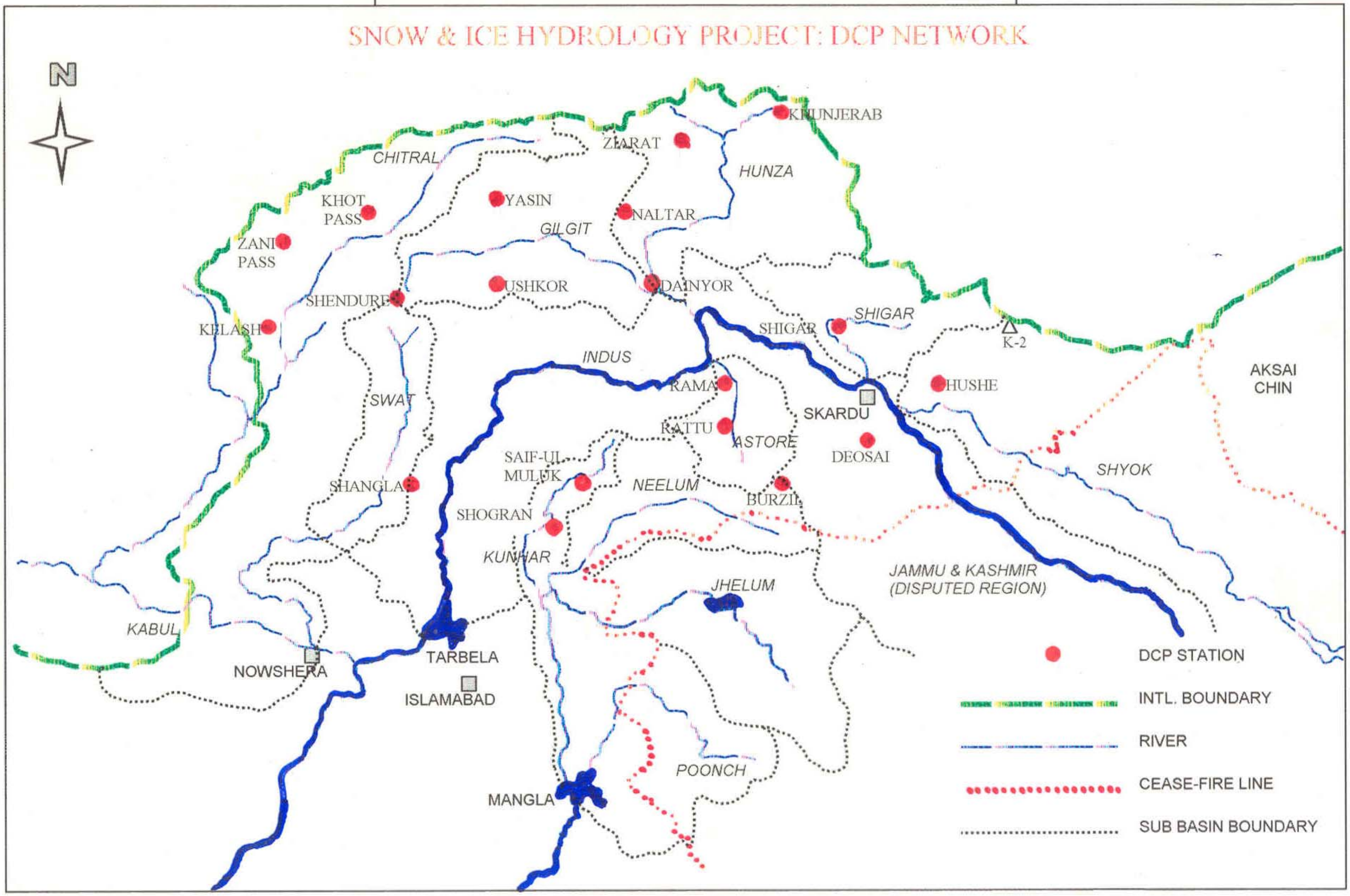
Meteorological Observing Network of Pakistan
Meteorological Department

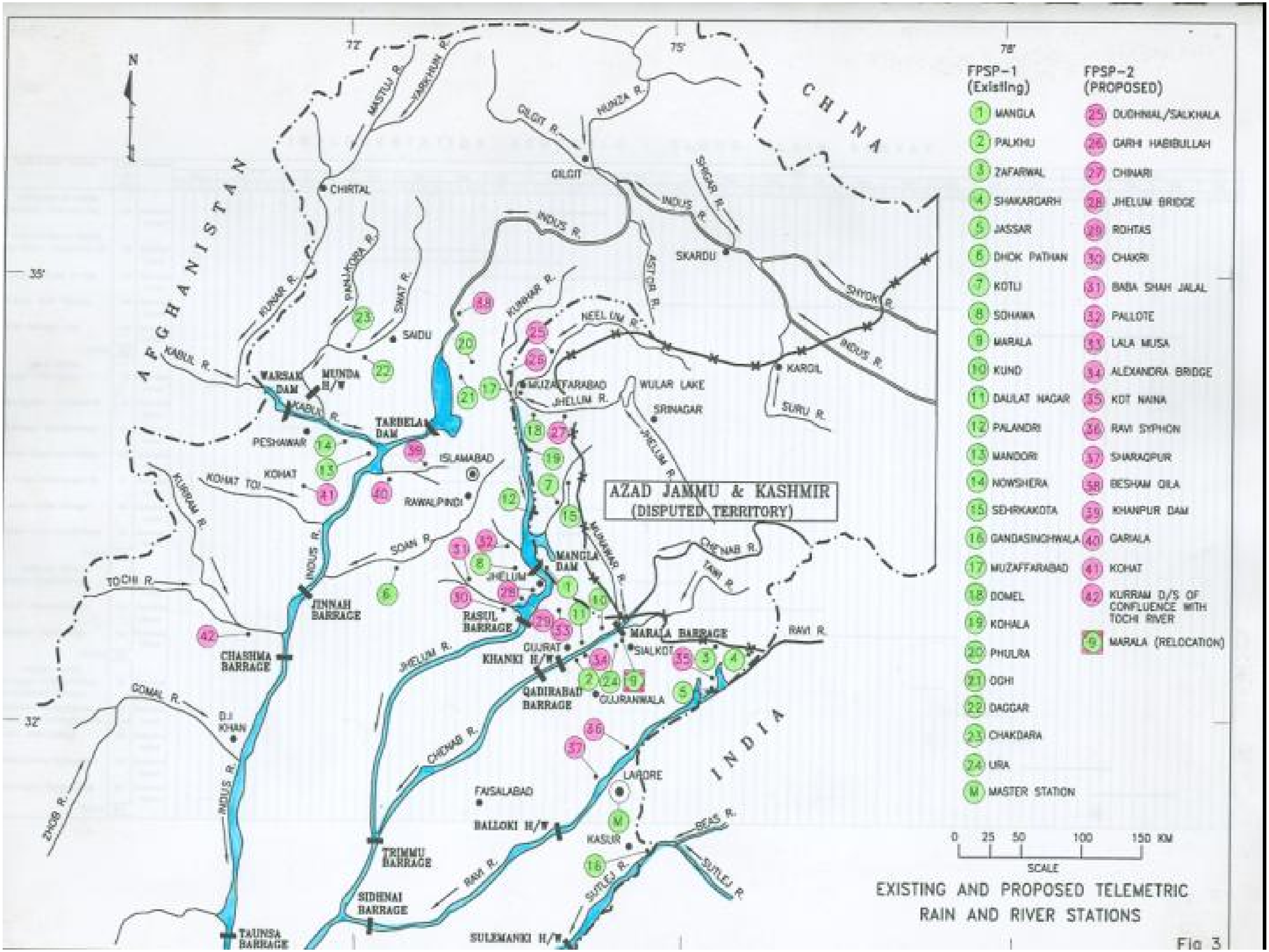


Latest Improvement in Meteorological Observing Network of Pakistan



PAKISTAN WATER AND POWER DEVELOPMENT

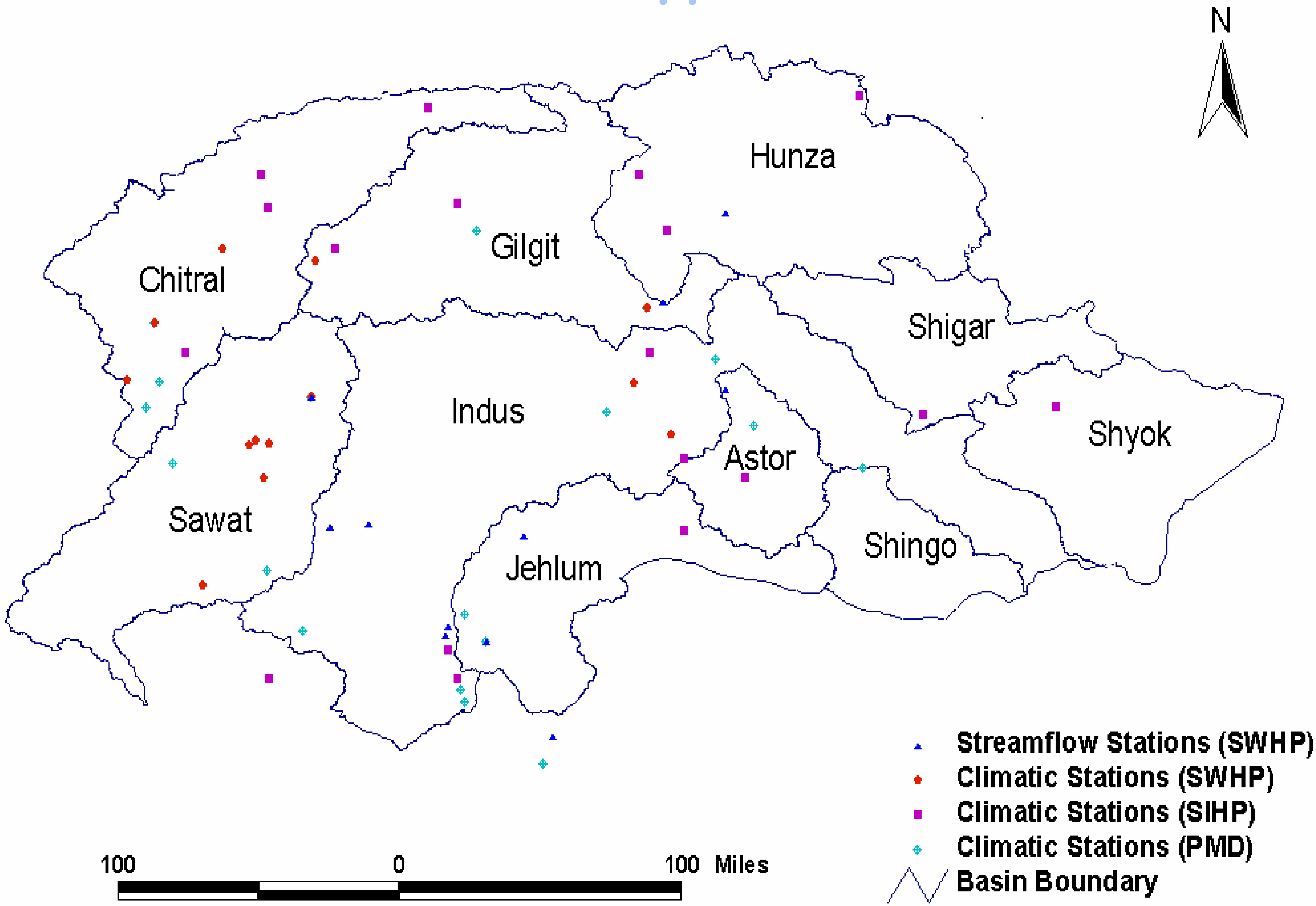


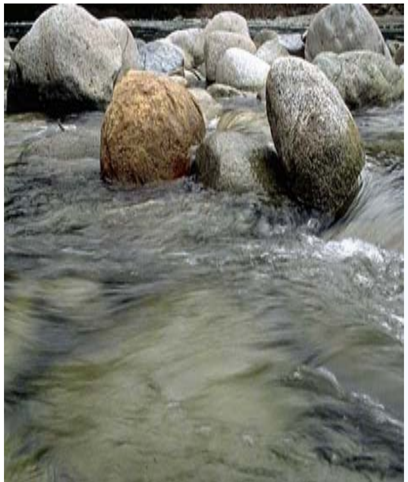


EXISTING AND PROPOSED TELEMETRIC RAIN AND RIVER STATIONS

Fig 3

Sub-basins in Upper Indus





PART-I

HYDROLOGY AND WATER RESOURCES OF PAKISTAN

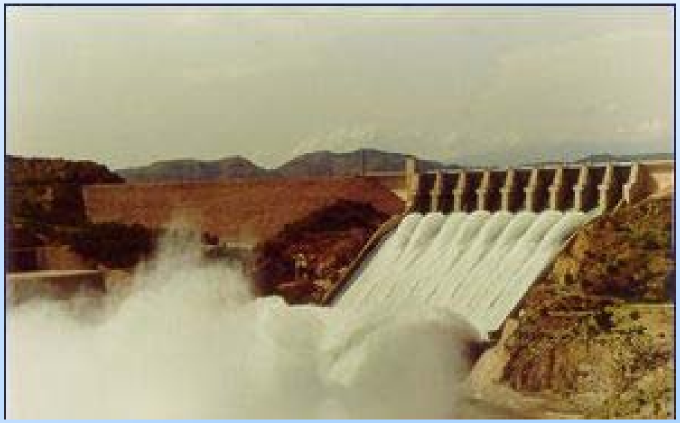
INDUS RIVER SYSTEM

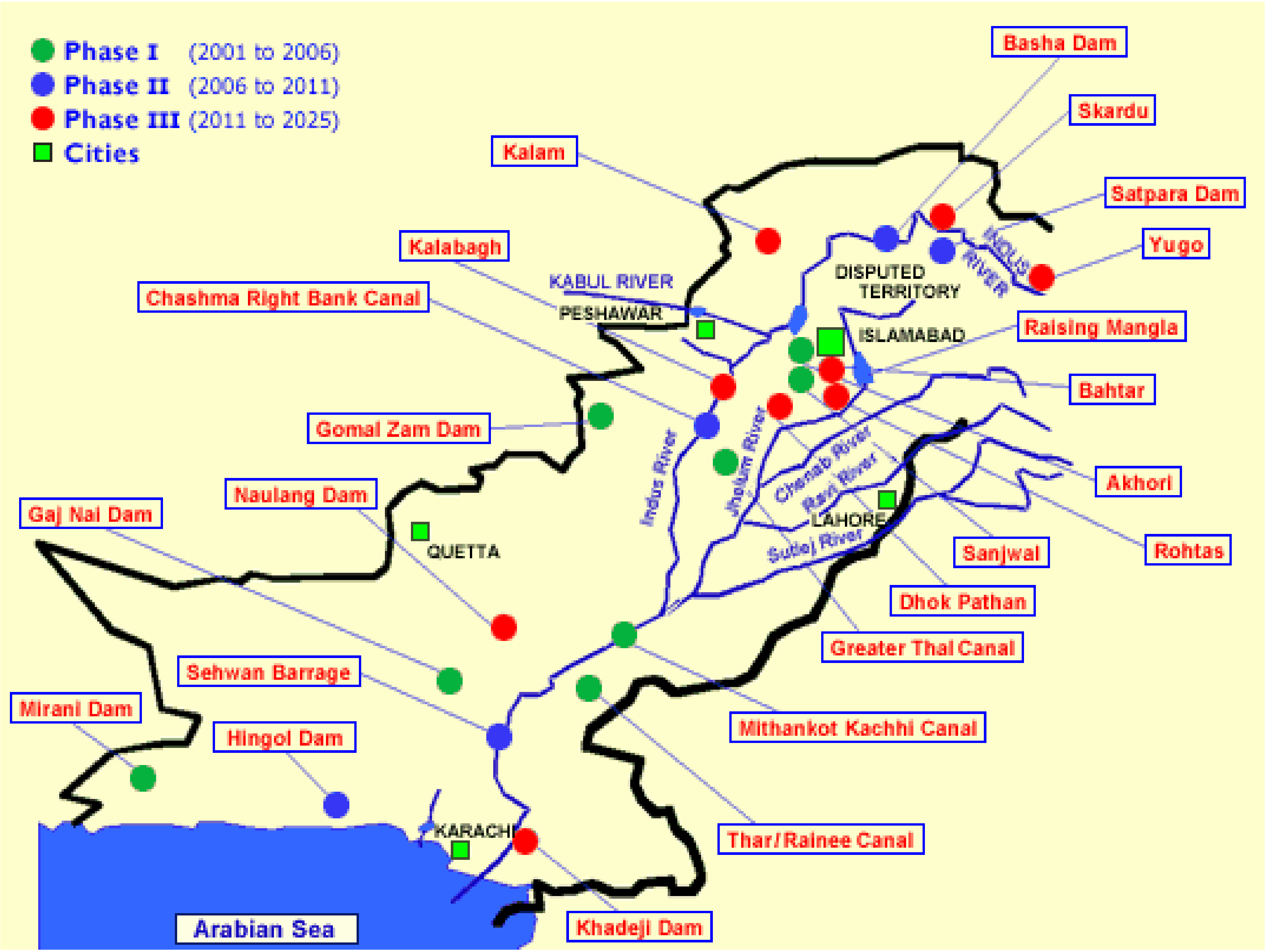
5 Major Rivers

4 Large Reservoirs

23 Barrages/headworks

45 Canal Commands

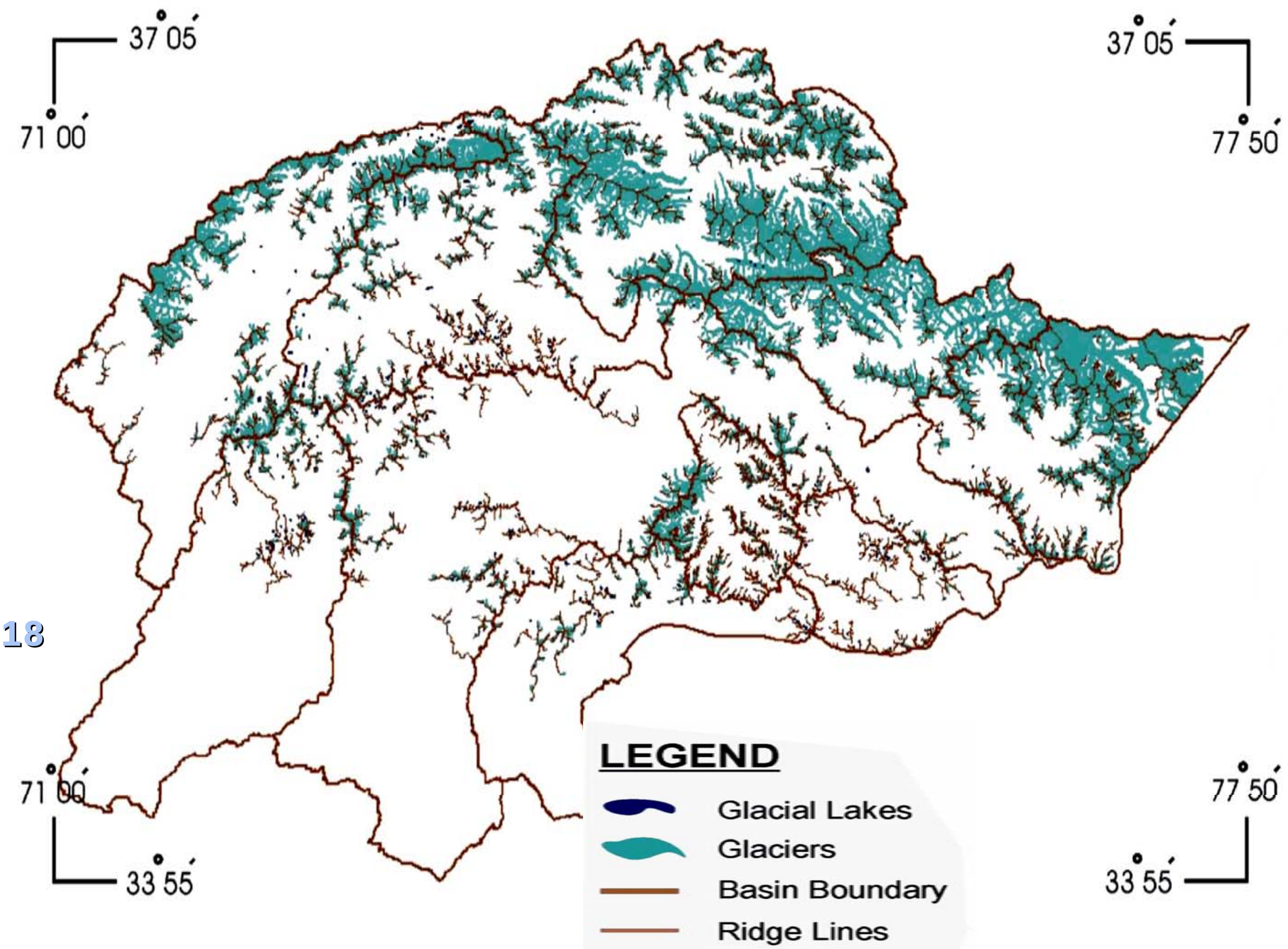




Phase I (2001 to 2006)
Phase II (2006 to 2011)
Phase III (2011 to 2025)
Cities
Basha Dam
Skardu
Kalam
Satpara Dam
Yugo
Kalabagh
Chashma Right Bank Canal
KABUL RIVER
PESHAWAR
DISPUTED TERRITORY
INDUS RIVER
ISLAMABAD
Raising Mangla
Bahtar
Gomal Zam Dam
Indus River
Jhelum River
Chenab River
Ravi River
Akhori
Naulang Dam
Gaj Nai Dam
QUETTA
LAHORE
Sutlej River
Sanjwal
Rohtas
Dhok Pathan
Greater Thal Canal
Sehwan Barrage
Mirani Dam
Hingol Dam
Mithankot Kachhi Canal
KARACHI
Thar/Rainee Canal
Khadeji Dam
Arabian Sea

WATER RESOURCES OF INDUS BASIN

Glaciers of Upper Indus Basins



Total Area 5,218

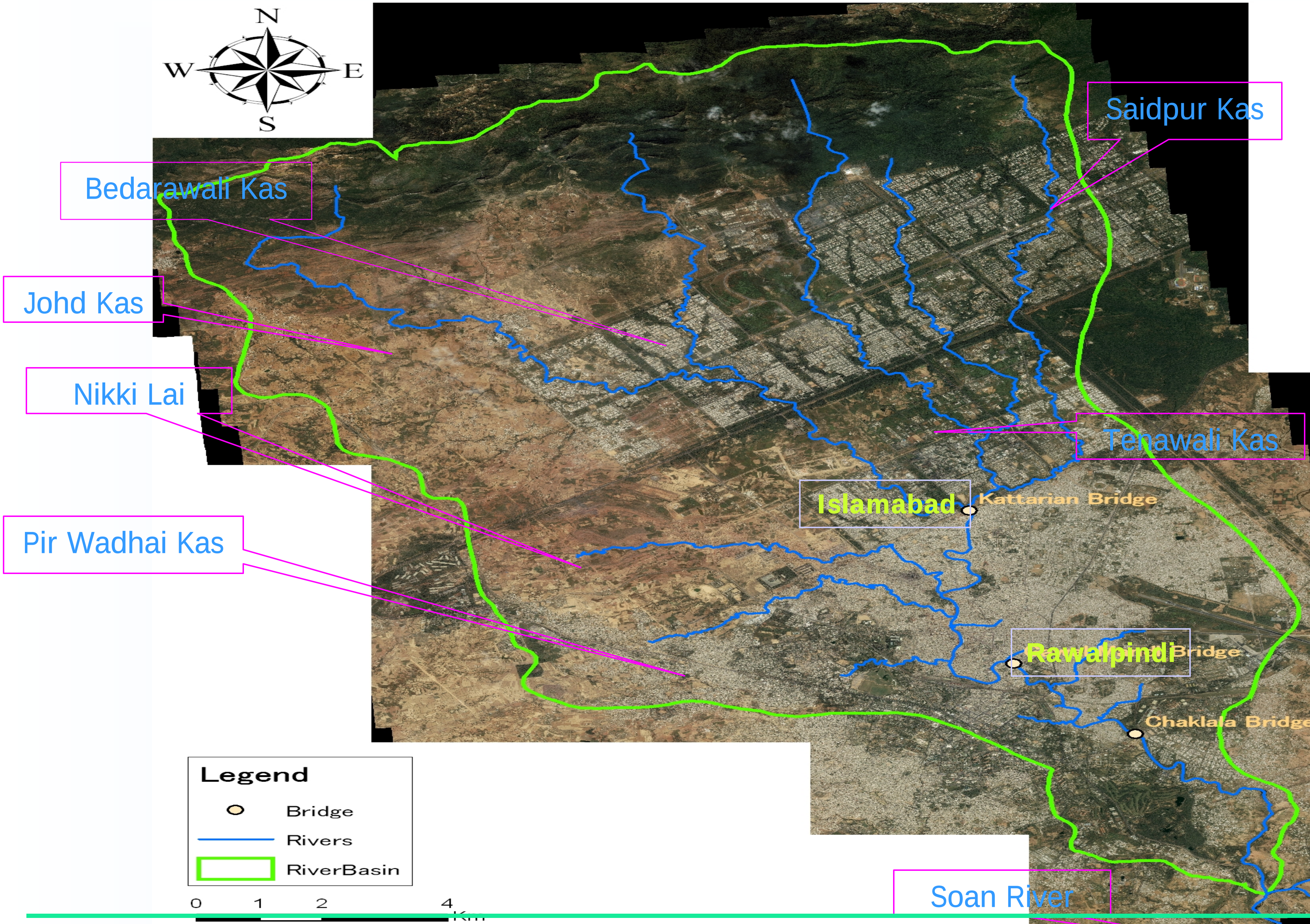
Source: WRRI, NARC (2005) " Inventory of glaciers"

FLOOD FORECASTING

&

WARNING SYSTEM

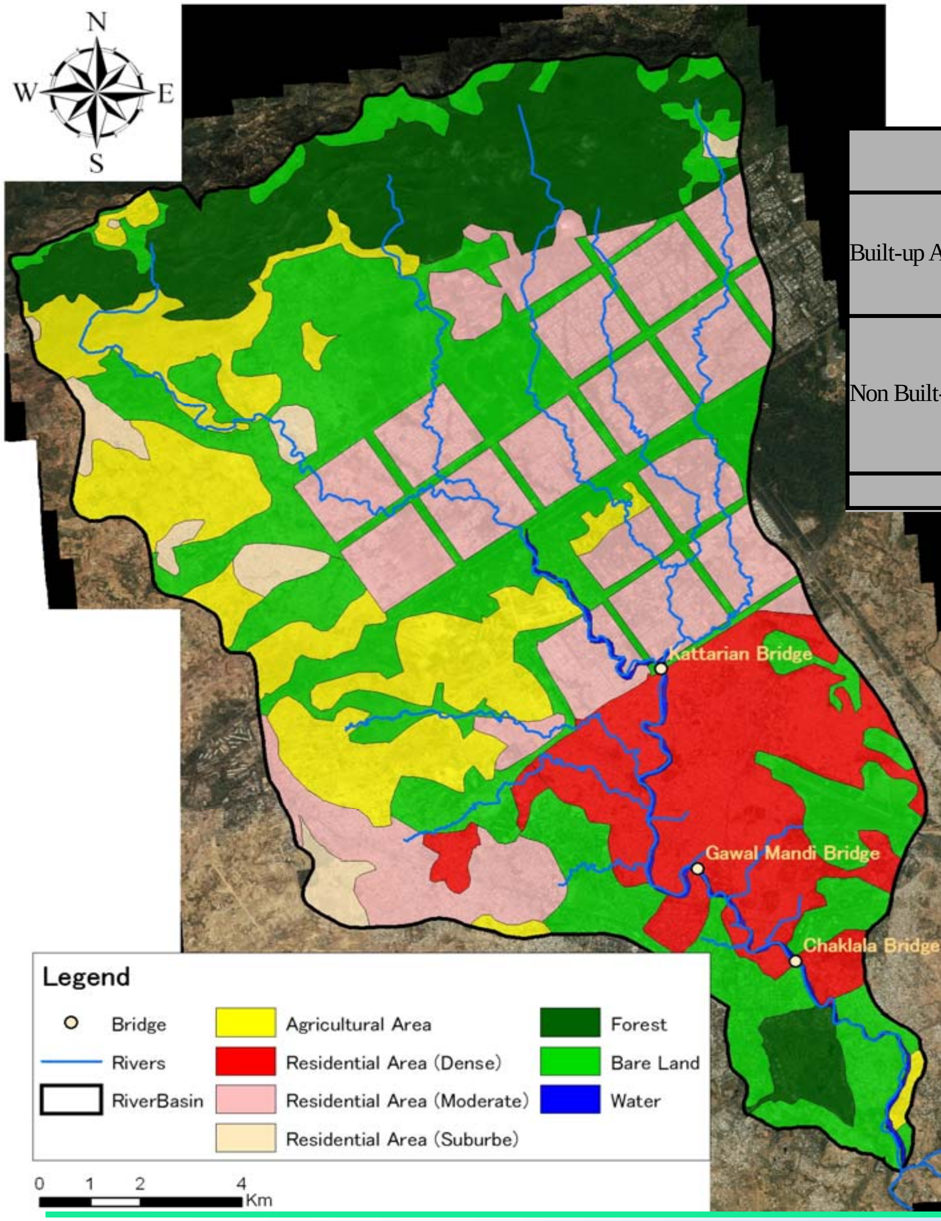
Case Study: Nala Lai



Source: Pakistan Meteorological Department

Lai Nullah Basin Area

Socio-economic Condition



Land Use		Present (2001) (km²)	Present (2001) (%)	2012 (km²)	2012 (%)	2030 (km²)	2030 (%)
Built-up Area	Densely Populated	31.2	13.3	35.2	15	38.8	16.5
	Moderately Populated	53.3	22.7	68.6	29.2	95.2	40.5
	Suburbs	6.1	2.6	5.6	2.4	2.3	1
	Sub-total	90.6	38.6	109.4	46.6	136.3	58.0
Non Built-up Area	Agricultural Area	33.4	14.2	29.1	12.4	11.4	4.9
	Forest	34.9	14.8	32.3	13.8	32	13.6
	Green and Bare Land	74.3	31.6	62.4	26.6	53.5	22.8
	Water Body	1.6	0.7	1.6	0.7	1.6	0.7
	Sub-total	144.2	61.3	125.4	53.5	98.5	42.0
Basin Total		234.8	100	234.8	100	234.8	100

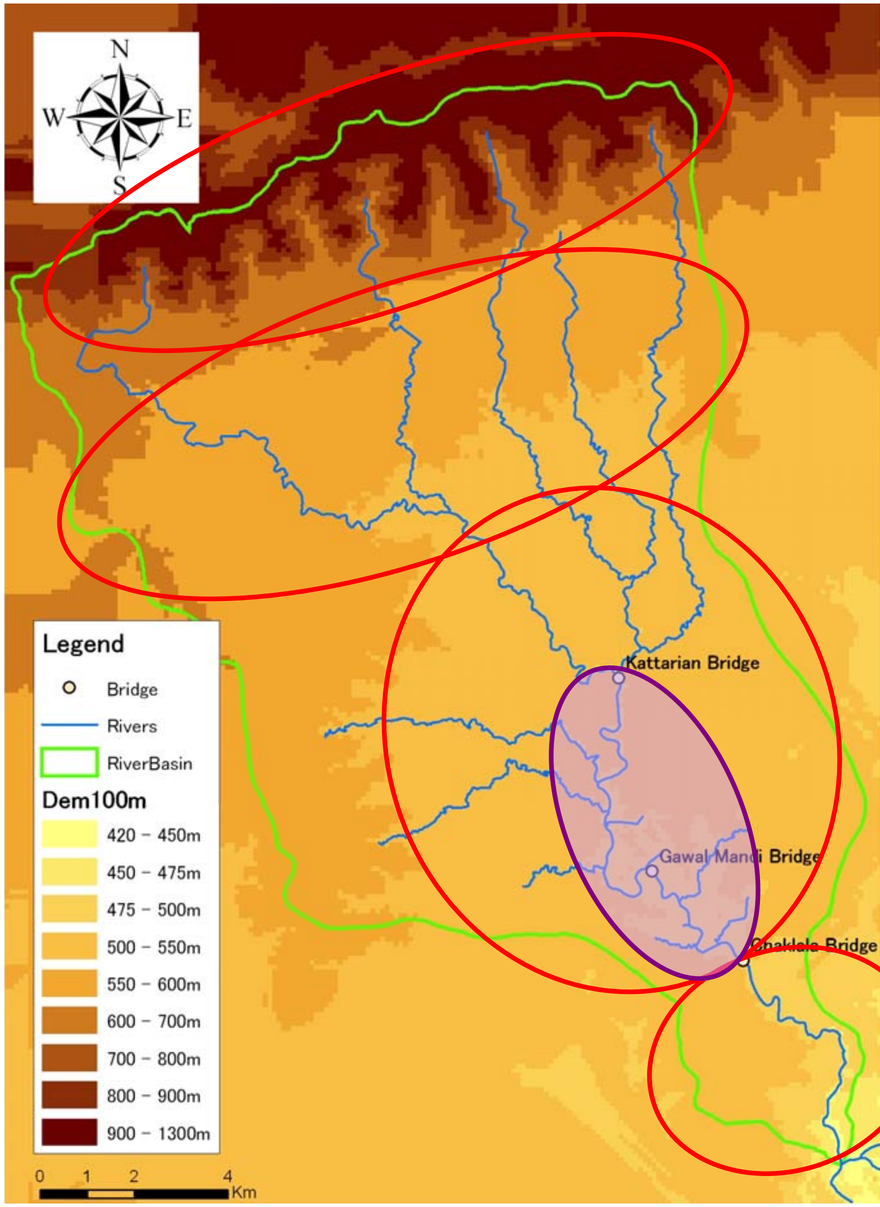
The built-up area will increase in the future, while agriculture, bare land and forest area decrease as the population growth.

Land Use Map in 2001

Source: Pakistan Meteorological Department

Lai Nullah Basin Area

Geographical Condition



(1)The Margalla range

stans behind Islamabad city area and forms the notth boundary of the Lai Nullah basin.

(2)The foot of the range

expands over the built-up area of Islamabad city with a gradual slope from North to South.

(3)The alluvium plain

is developed from Islamabad to the upper part of the Rawalpindi area above Chaklala Bridge

(4)The valley area

forms a definite steep valley with several cascades.

Lai Nullah Basin Area

River Features

Upstream from Kattarian Bridge

Major three tributaries
- Bedarawali Kas
- Tenawali Kas
- Saidpur Kas

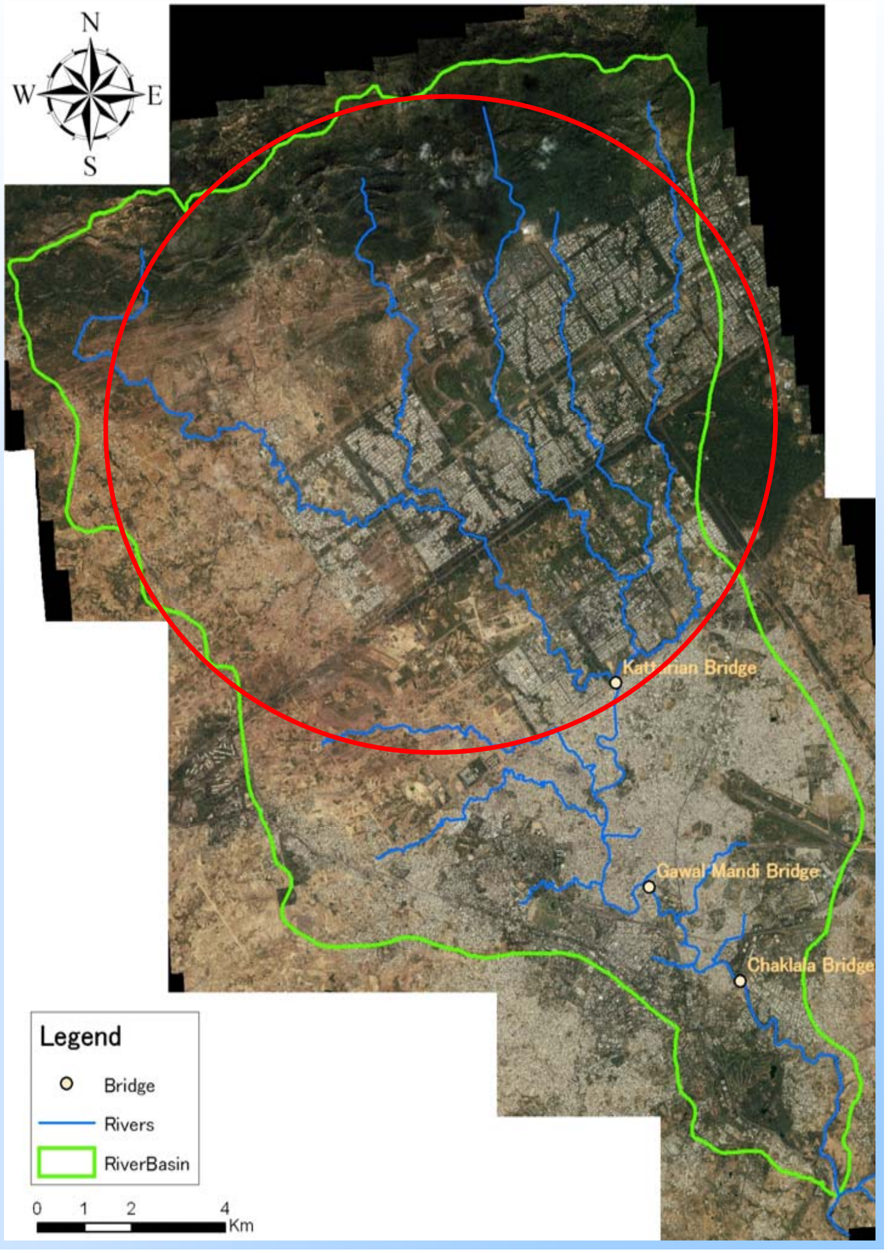
Rather spacious cross-section with less meandering alignment

Channel bed-slope : more than 1/500

The upper stretches of the tributaries have never caused any serious flood overflow.

The lower stretches of the tributaries is under influence of backwater of Lai Nullah.

Extensive flood inundation occurred in Block I-8 and 9 of Islamabad in 2001.



Source: Pakistan Meteorological Department

Lai Nullah Basin Area

River Features

Middle Stream between Kattarian Bri. to Chaklala Bri.

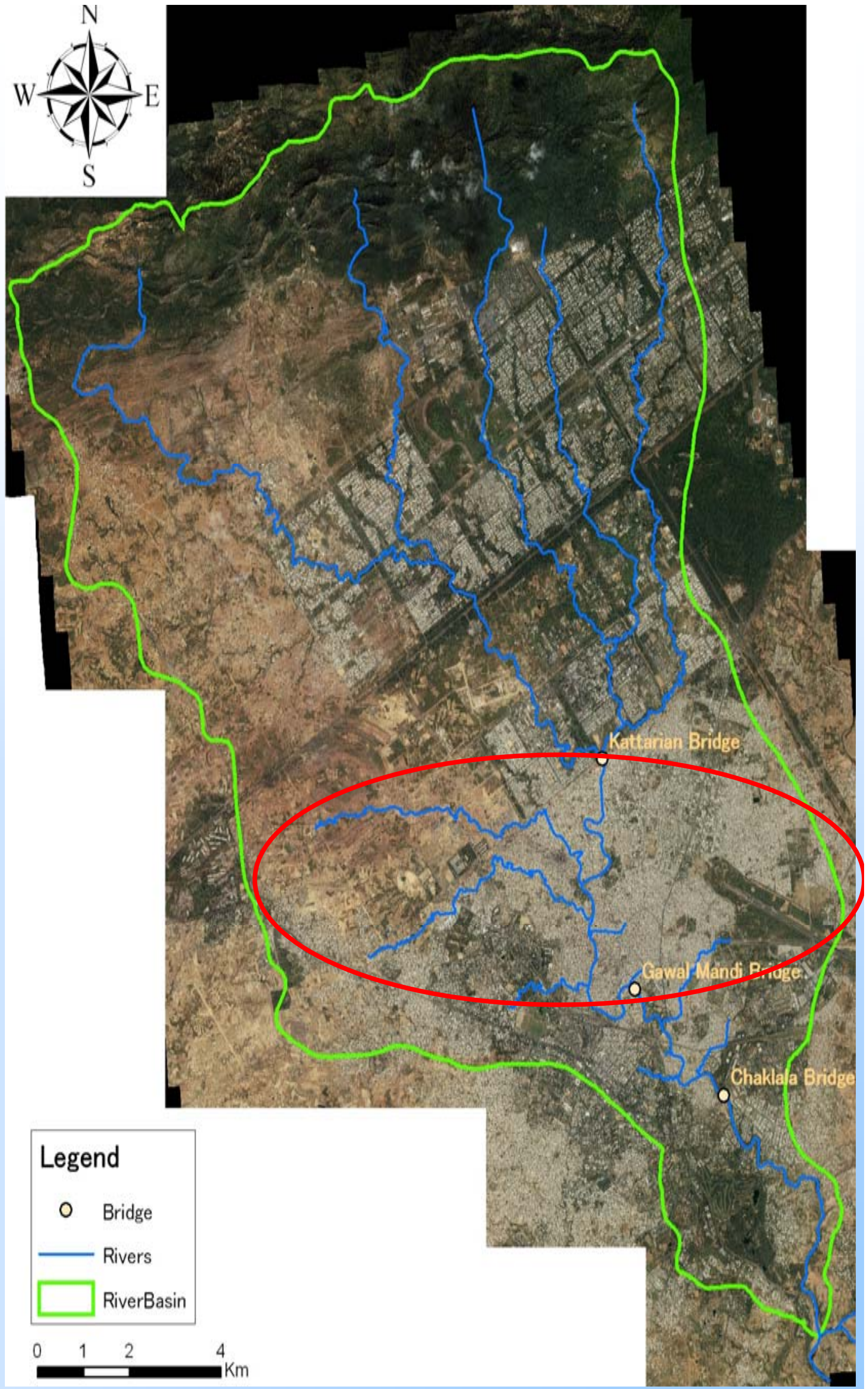
Lai Nullah passes through the Rawalpindi Area.

The area is on the flat alluvium plain with several meandering portions

Channel bed-slope : 1/1,250

The stretch has frequently caused the flood overflow.

Channel flow capacity increased less than 300m^3/s to more than 600m^3/s by ADB project.



Source: Pakistan Meteorological Department

Lai Nullah Basin Area

River Features

Middle Stream from Chaklala Bri. to Waterfall

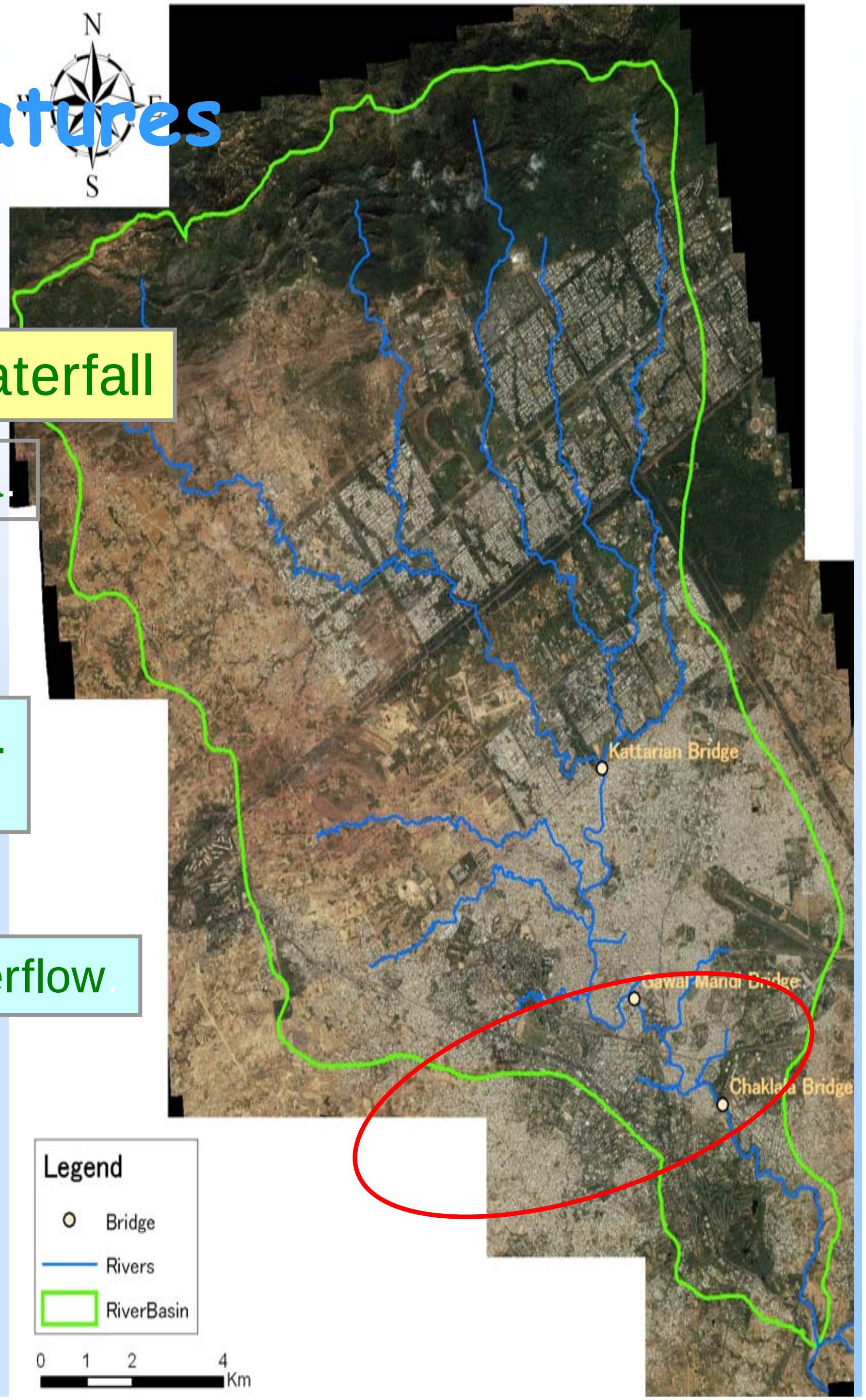
Lai Nullah passes through the Cantonment Area.

There was a heavily meandering section before.
(This section was improved by ADB project)

Channel bed-slope : 1/1,250

The stretch has frequently caused the flood overflow.

Source: Pakistan Meteorological Department



Lai Nullah Basin Area

River Features

Downstream from Waterfall to Confluence with Soan River

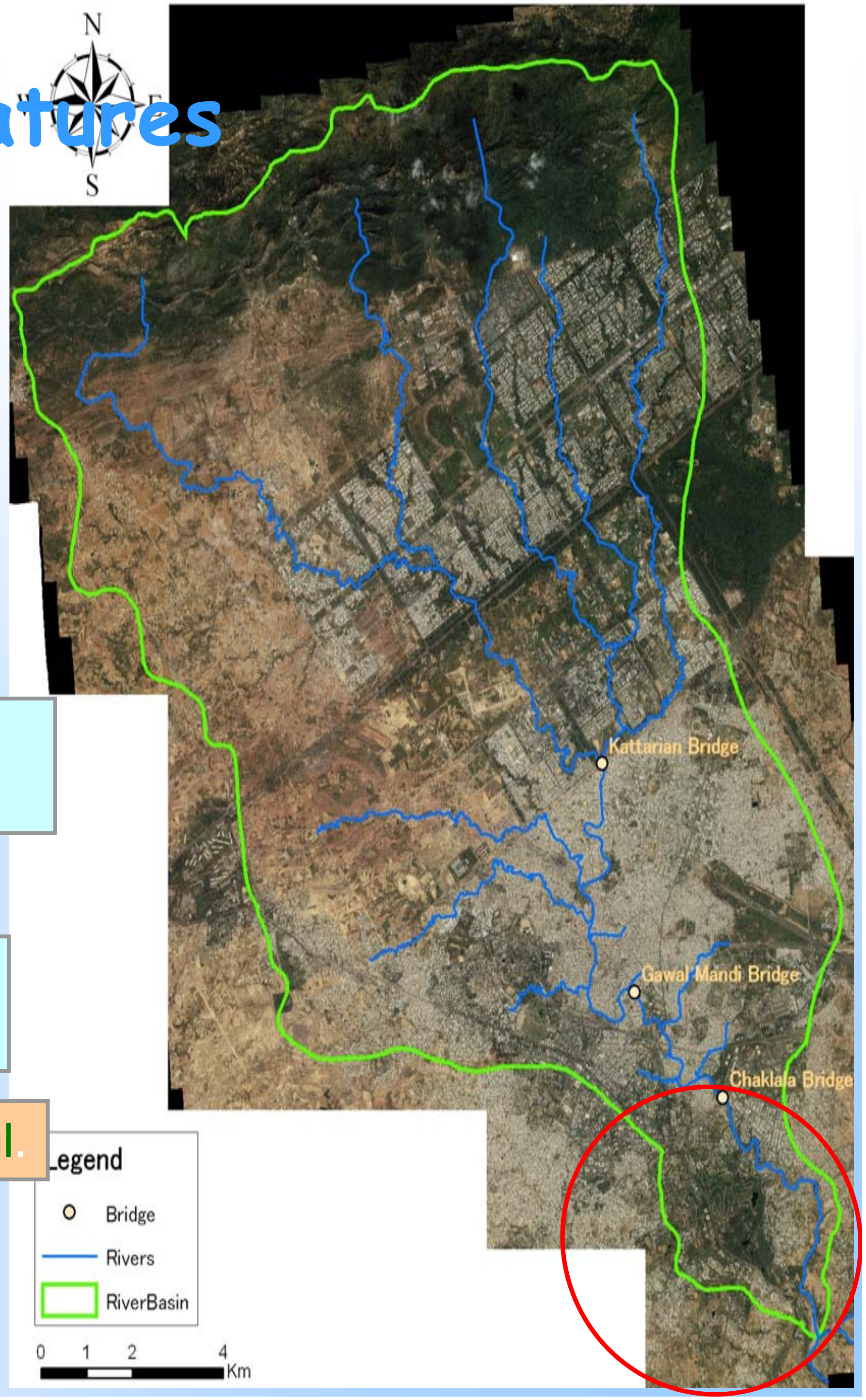
Lai Nullah passes less populated Area.

The Lai Nullah meets the first waterfall about 3,800m upstream from G.T. Road Bridge.

Channel bed-slope : 1/70

The section has the rather large channel width and depth.

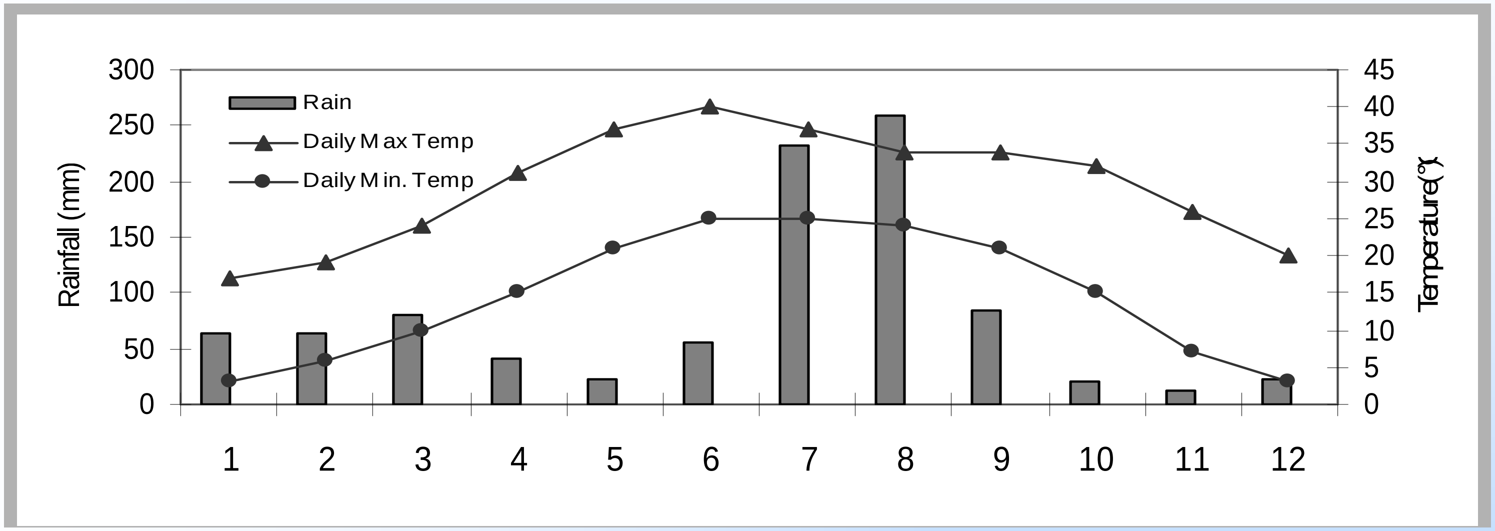
The flood damage along this stretch could be nil.



Source: Pakistan Meteorological Department

Lai Nullah Basin Area

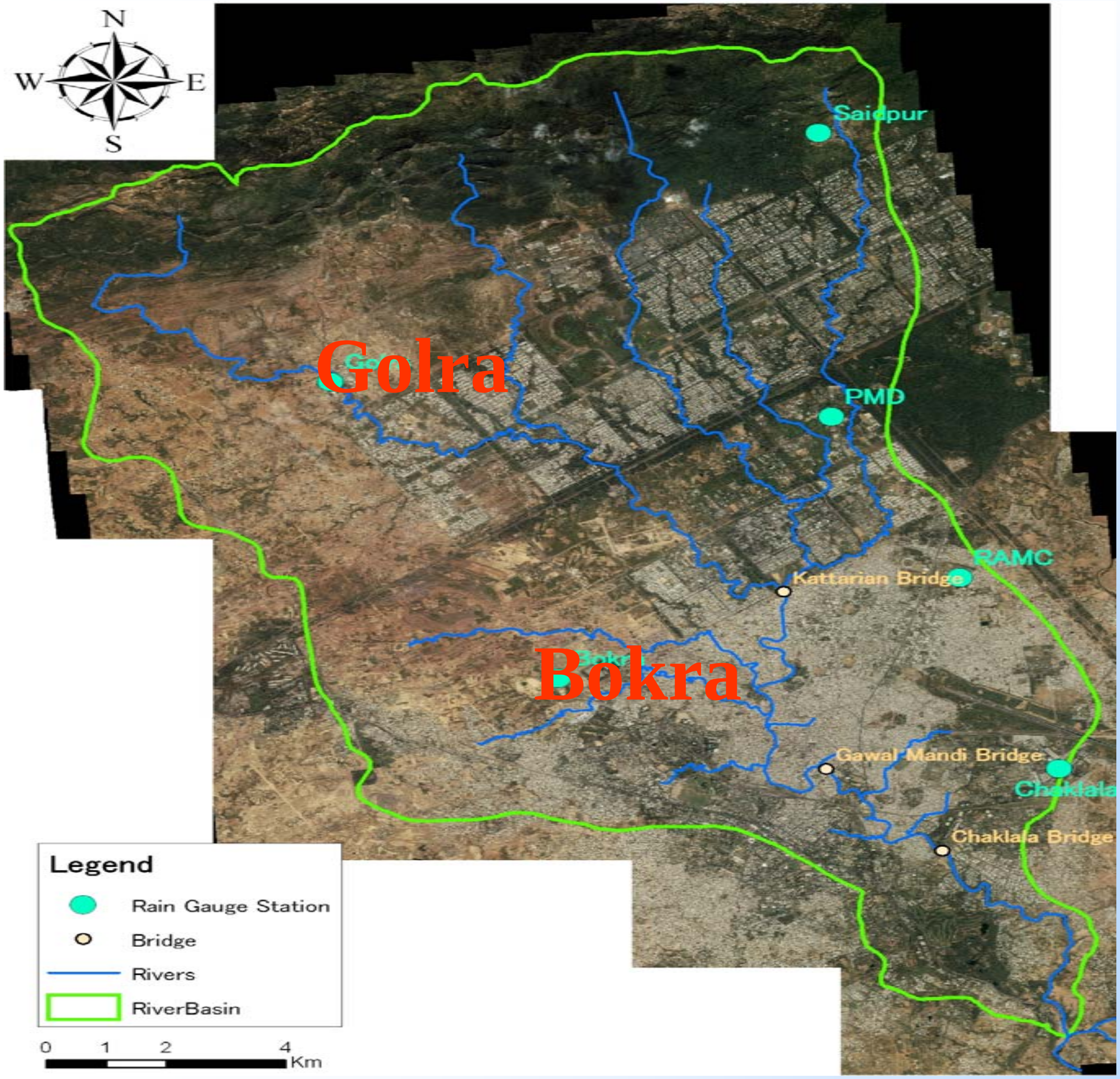
Climate



- Subtropical Triple Season Moderate Climate Zone
- Hot summer (40^{0}C) and Cold winter(near0^{0C})
- Rainy Season (July to September)
- Annual Rainfall is 1,000mm (rainy season is 600mm).
- Thunderstorm activity is higher in the monsoon season.

Lai Nullah Basin Area

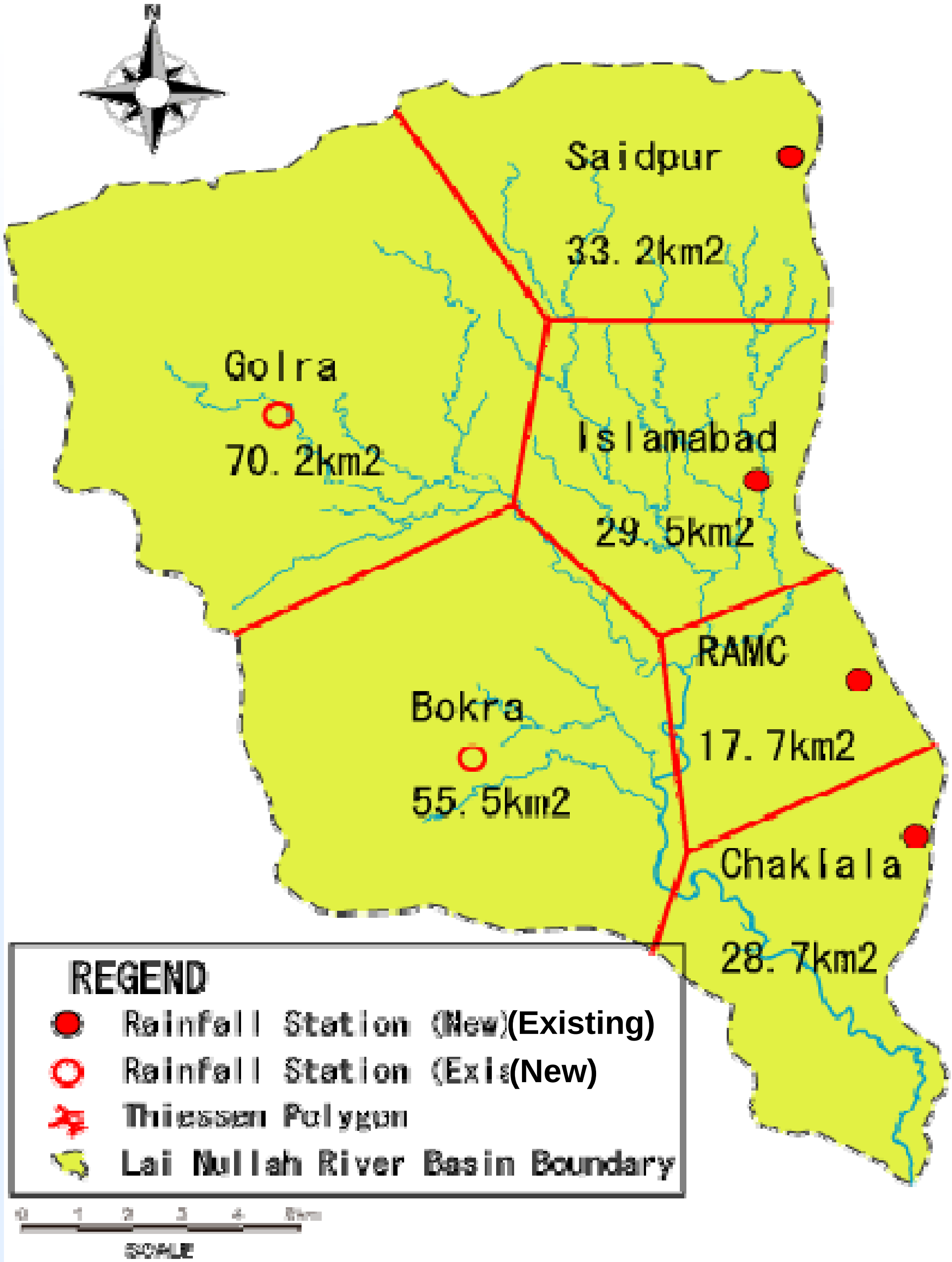
Rain Gauge Station



Existing
Saidpur
PMD (Islamabad)
RAMC
Chaklala

New
Golra
Bokra

Rainfall Observational Network



Lai Nullah Basin Area

Past Flood

Flood Year

Year	Date	Year	Date
1944	August 13	1985	No Data
1957	No Data	1988	No Data
1966	July 31	1890	No Data
1970	No Data	1994	July 3
1972	No Data	1995	July 24
1976	No Data	1996	July 29
1977	No Data	1997	August 27
1978	No Data	2001	July 23
1981	No Data	2002	August 13
1982	August 10	N/a	N/a

19 years at least in 59 year

➡ Once in every 3 years

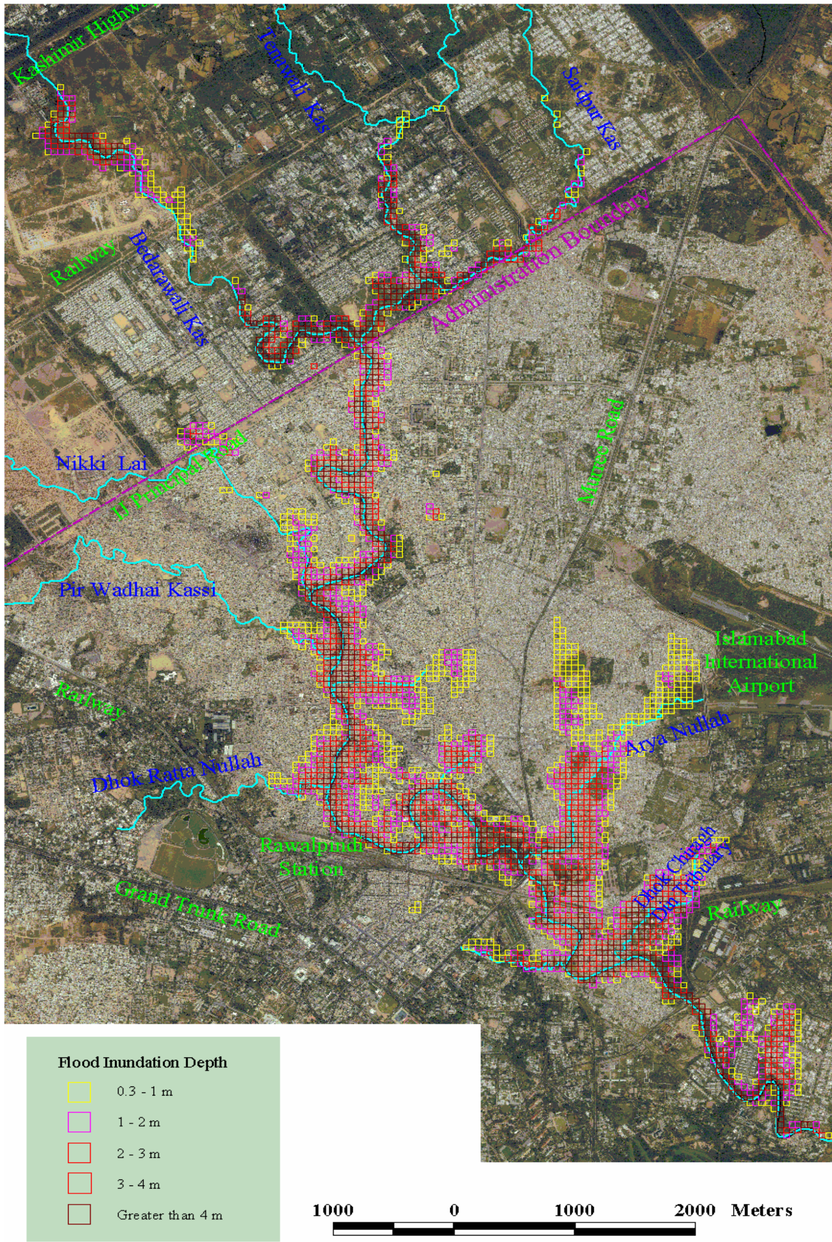
Recorded flood mark at Gawal Mandi Bridge by TMA

Year	Maximum Water Level		Discharge (m^3/s)
	(ft)	(m)	
1966	25	494.02	450
1970	30	495.54	700
1972	26	494.32	500
1976	25	494.02	450
1977	30	495.54	700
1978	25	494.02	450
1981	29	495.24	650
1982	32	496.15	850
1994	31	495.85	770
1995	26	494.32	500
1996	20	492.50	270
2001	41	498.90	2,870*
2002	22	493.10	320

Source: Pakistan Meteorological Department

Lai Nullah Basin Area

the 2001 Flood



Source: Pakistan Meteorological Department

✓The largest flood

✓Rainfall at Islamabad Station was recorded at 620mm in 10hrs from 6:00 to 16:00 (PST) on 23 July 2001.

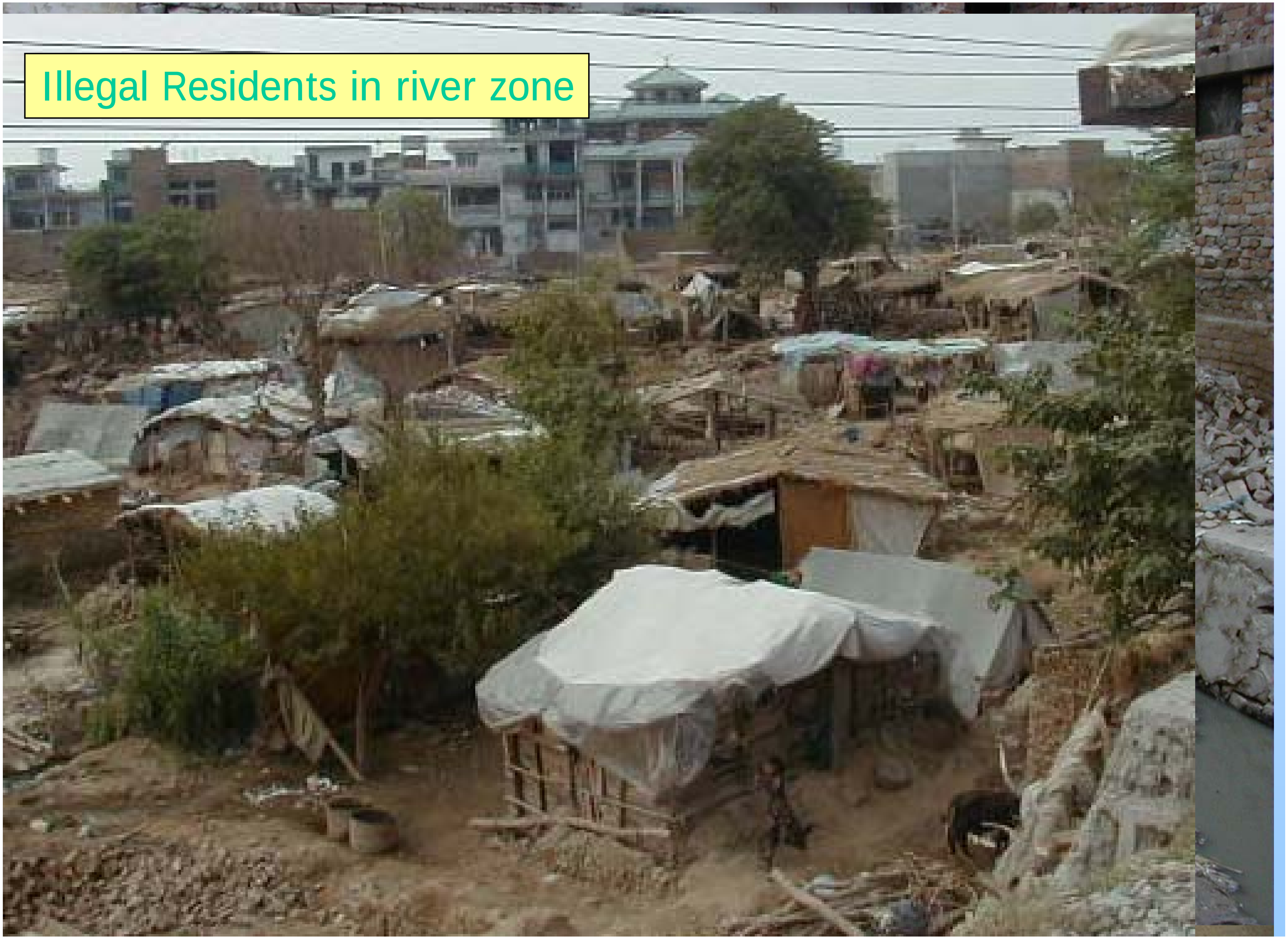
✓The rainfall was caused by freak combination:

(a) intense heating on the surface
(b) presence of mid latitude westerly trough and
(c) moisture feeding through monsoon flow.

Inundation depth was 4m or over
Inundation duration was 6hours or more

The flood was too fast to allow them to evacuate. (Interview Survey)

The Main Cause of the Inundation of 2001 flood



Responsible and Implementing Agencies of the Project

(1) Agency Responsible for the Project

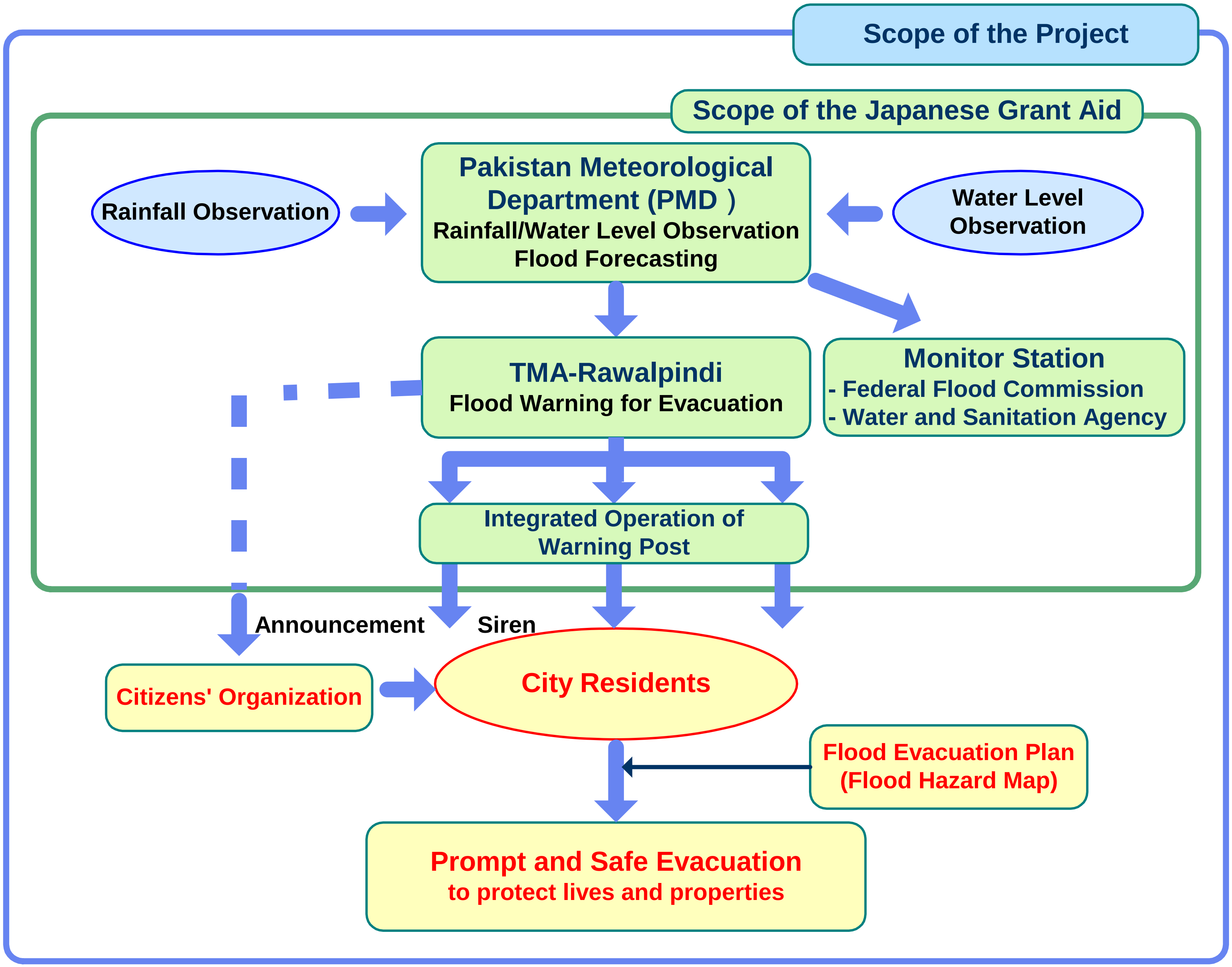
- FFC is the agency, overall responsible for the Project.

(2) Implementing Agency for the Project

- PMD is the implementing agency for issuance of flood related information.

- TMA of Rawalpindi is the implementing agency for issuance of flood warning through blow of siren.

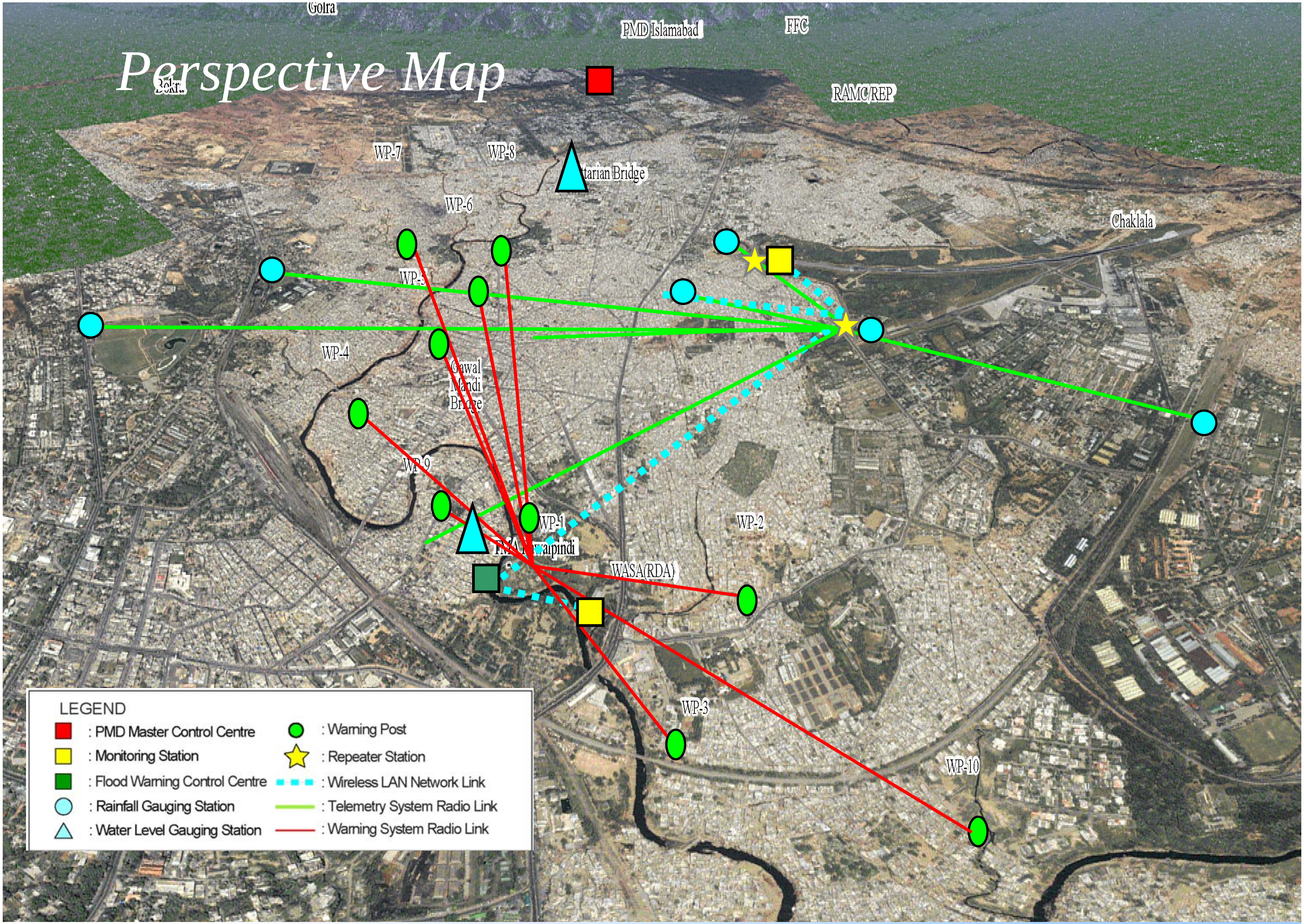
Scope of the Project



Source: Pakistan Meteorological Department

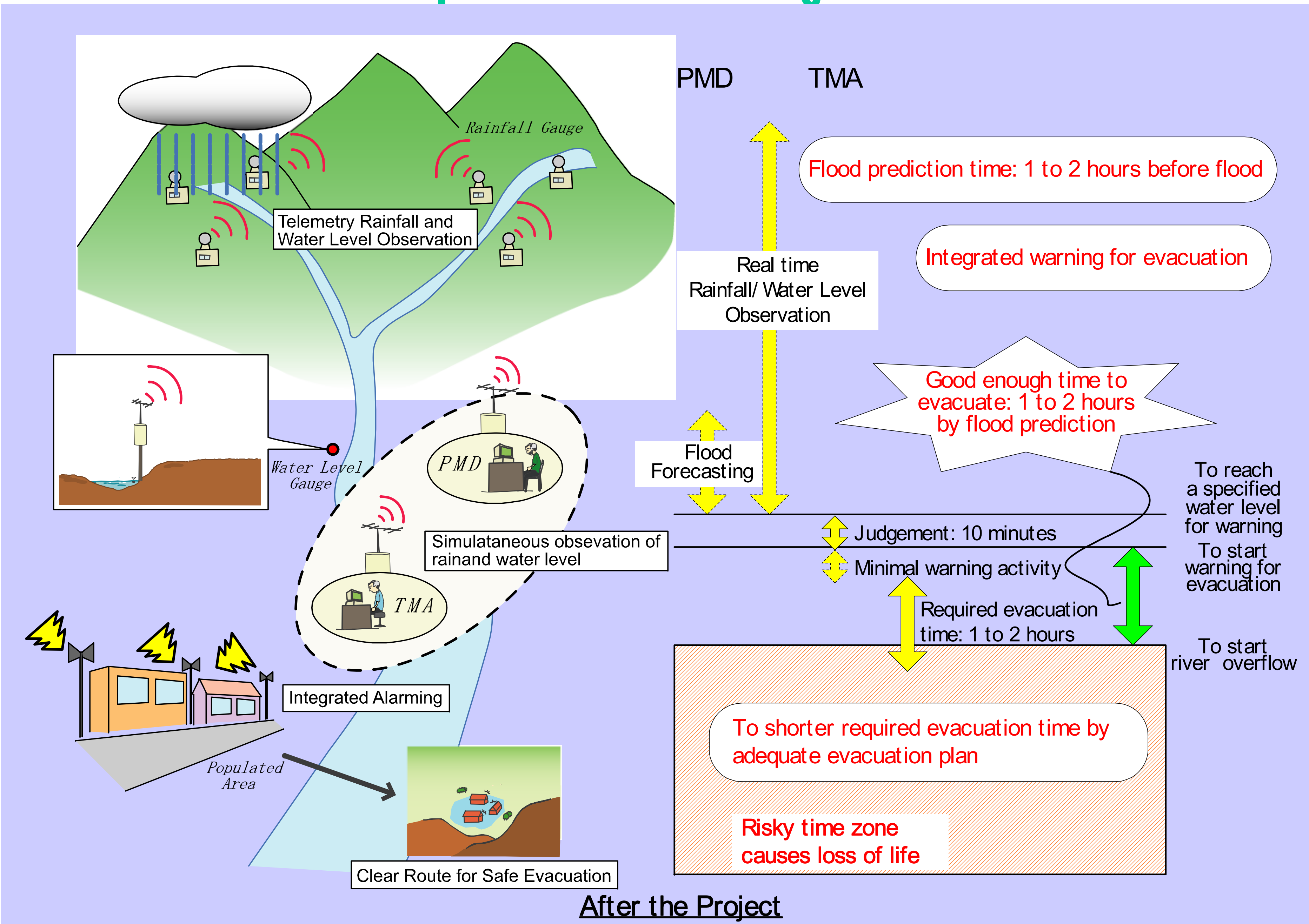
Station	Function	Organization in charge
1. Master Control Center		
PMD, Islamabad	• Flood forecasting data collection • Data processing • Dissemination of flood information to related agencies	• PMD
2. Rainfall Gauging Station		
2.1 PMD, Islamabad, Saidpur, Gorla, Gorla,Bokla,RAMC, Chaklala	Automatic rainfall data observation (Telemetry subsystem)	• PMD
3. Water Level Gauging Station		
3.1 Kattarian Bridge	Automatic water level data observation (Telemetry subsystem)	• PMD
3.2 Gawal Mandi Bridge		
4. Repeater Station		
4.1 RAMC Telemetry Repeater	• Repeater function for telemetry	PMD
4.2 RAMC Wireless LAN Repeater	• Repeater function for wireless LAN	
5. Monitoring Station		
5.1 FFC	Flood information monitoring (Data transmission subsystem)	FFC
5.2 WASA	Flood information monitoring (Data transmission subsystem)	WASA
6. Flood warning control centre		
TMA Rawalpindi: - Warning Control & Supervision - Flood Information Monitoring	Control and supervision of warning system	CDG/TMA
	Flood information monitoring (Data transmission subsystem)	
7. Flood Warning Post		
7.1 WP-1: TMA Rawalpindi	Flood evacuation warning by motor siren and loudspeaker	TMA

Perspective Map



Source: Pakistan Meteorological Department

Output of the Project



Source: Pakistan Meteorological Department

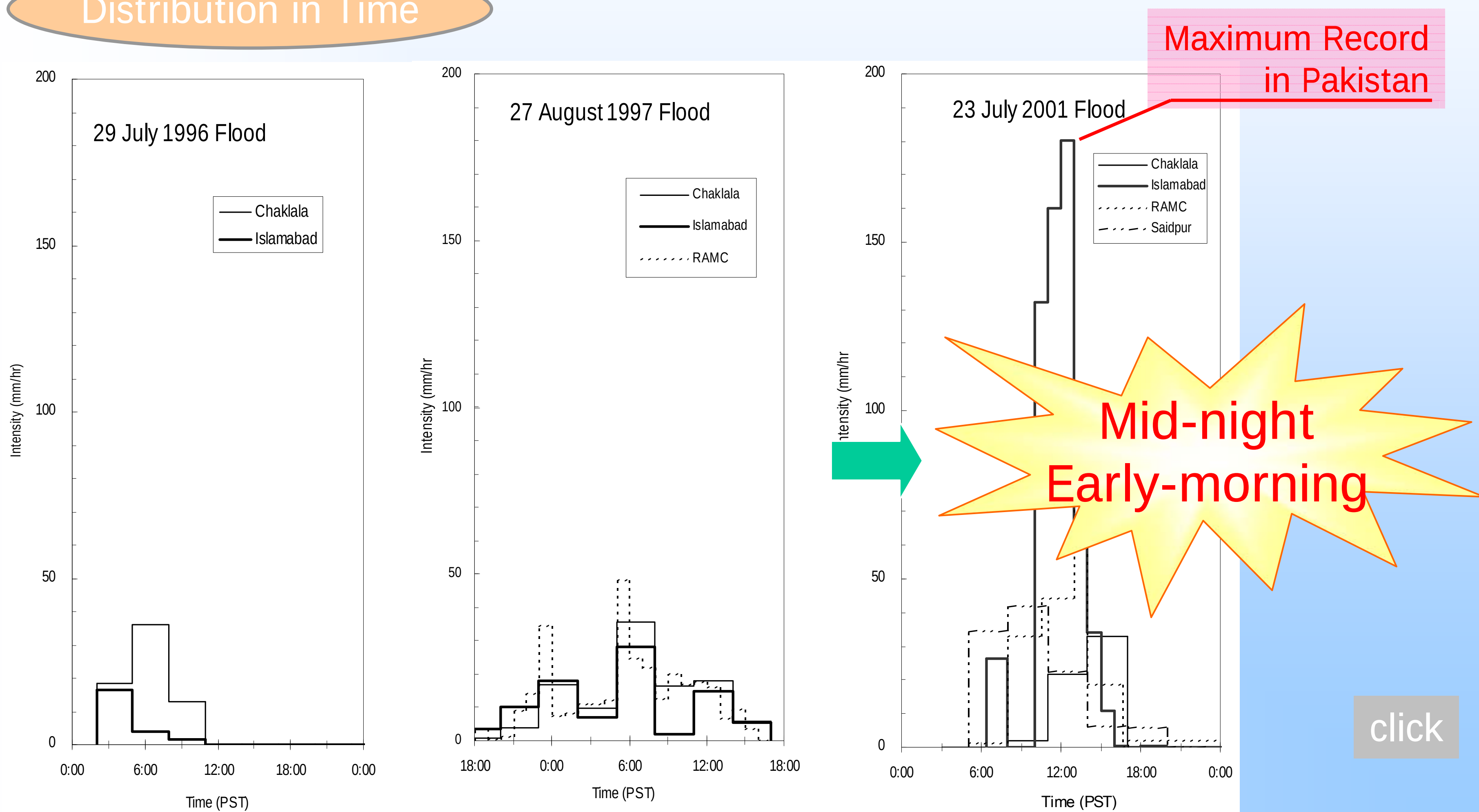
Forecasting a Flood

Using Mike 11

Rainfall Characteristics

"When does it rain?" is important information for FFWS and evacuation.
- Morning?
- Daytime?
- Night time?

Distribution in Time



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Simulation Model

Objectives of the simulation analyses

- To clarify the flood inundation mechanism in the Lai Nullah Basin
- To determine the basic hydrological parameters for designing countermeasures, such as design discharge and design water level
- To examine effects of conceivable countermeasures.

Flow of Flood Simulation

Runoff Calculation from Sub-basins
(SCS Unit-hydrograph method)
(MIKE11)

↓

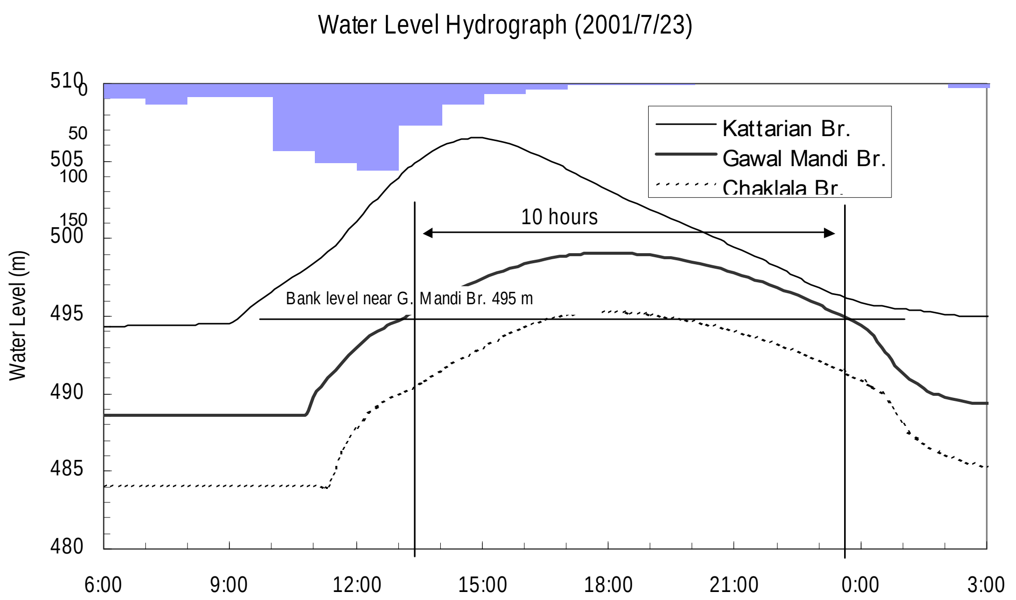
Flood Routing
(Dynamic one-dimensional model)
(MIKE11)

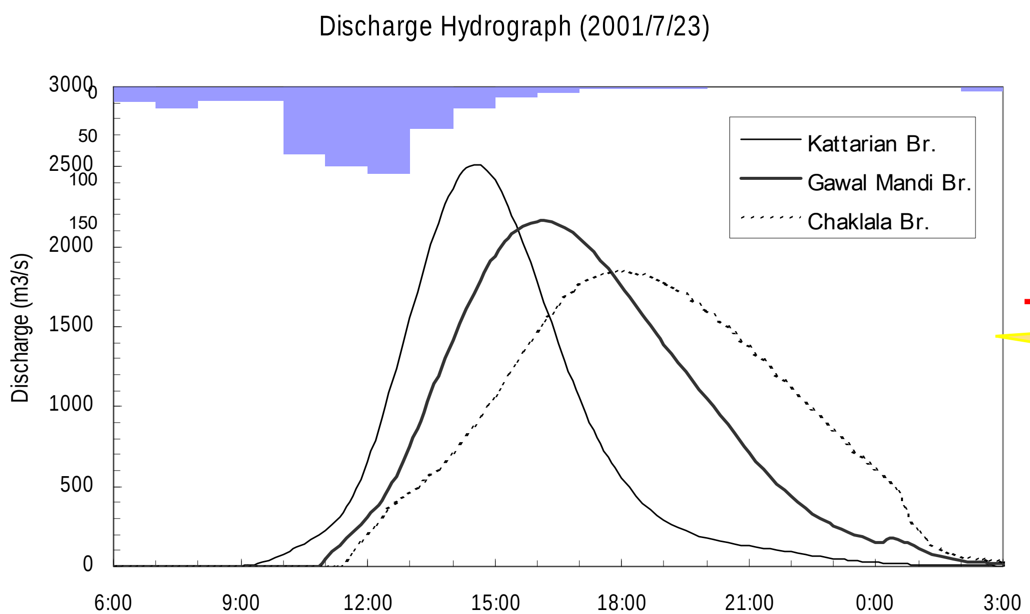
↓

Flood Mapping
(MIKE11 GIS)

Source: Pakistan Meteorological Department

Runoff Characteristics





Source: Pakistan Meteorological Department

Peak Rainfall :13:00

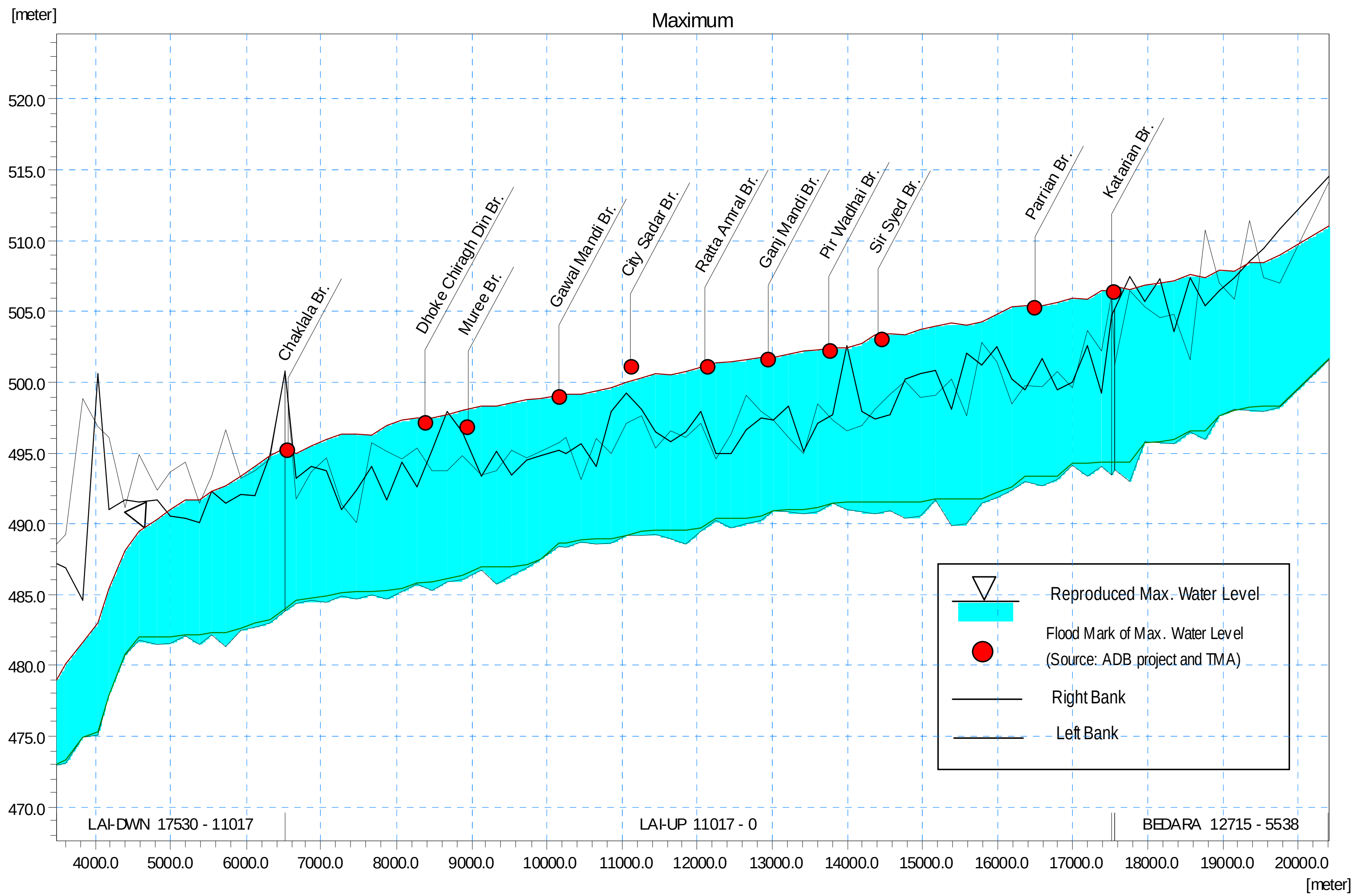
Peak water level
Kattarian Br. :15:00
Gawal Mandi Br. :18:00

Peak Discharge
Kattarian Br. :14:30
Gawal Mandi Br. :16:00

The flood came in a flash!!!

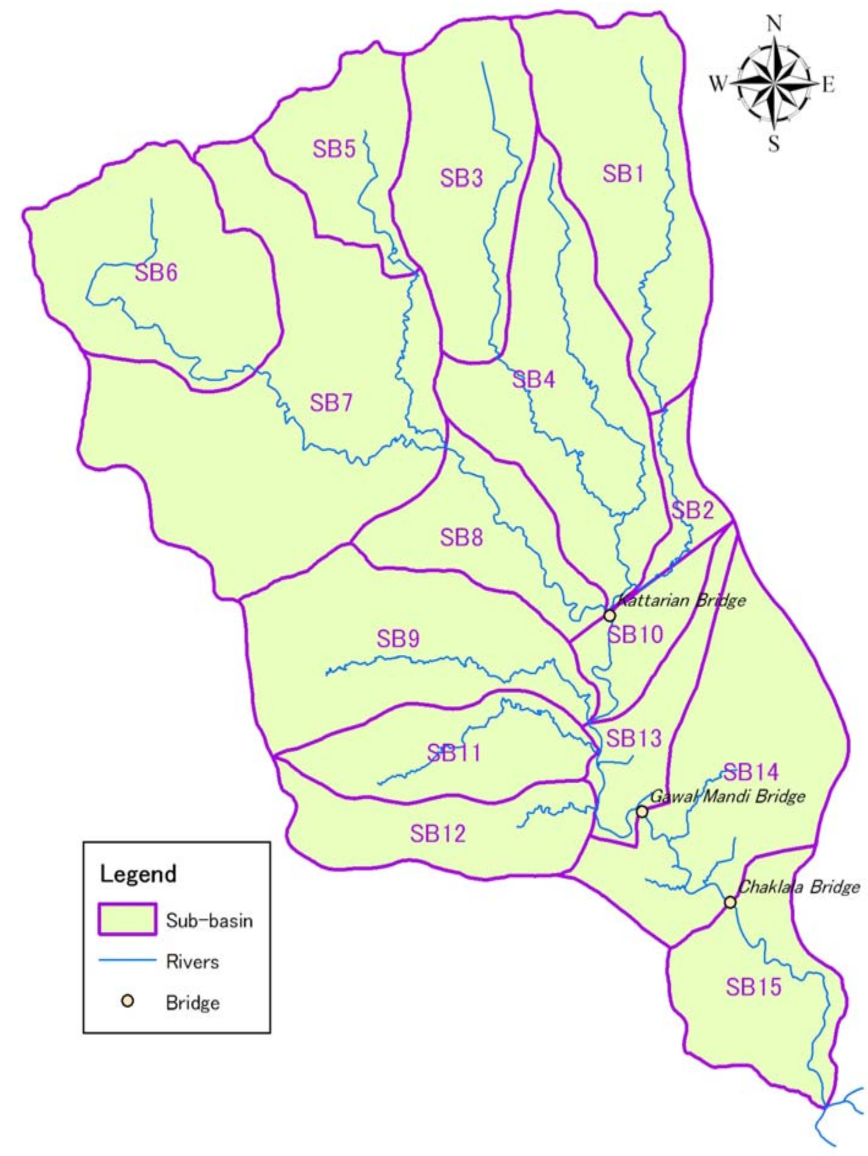
The peak difference between rainfall and discharge is only 2hours.

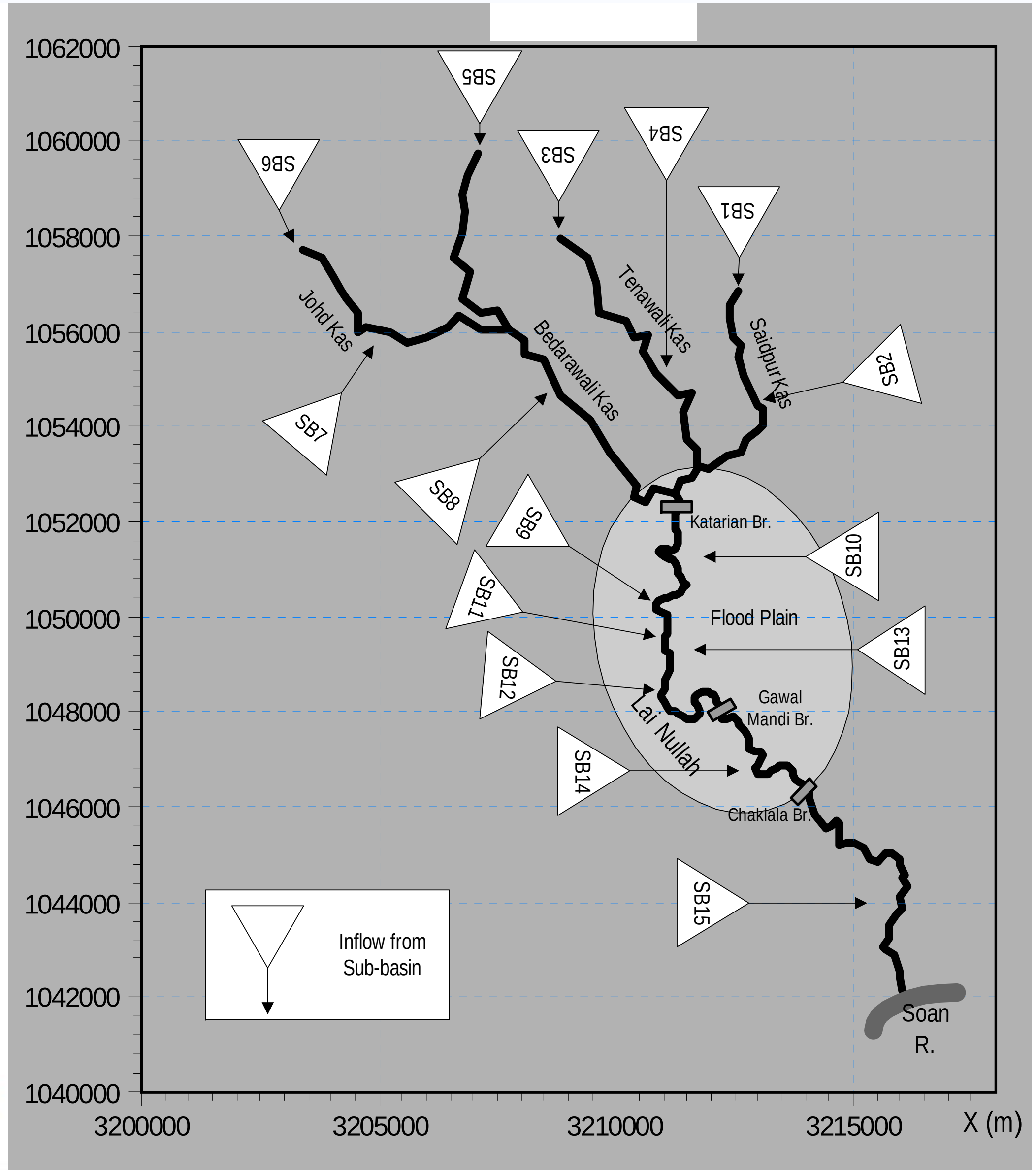
Runoff Characteristics



Source: Pakistan Meteorological Department

Simulation Model Set-up

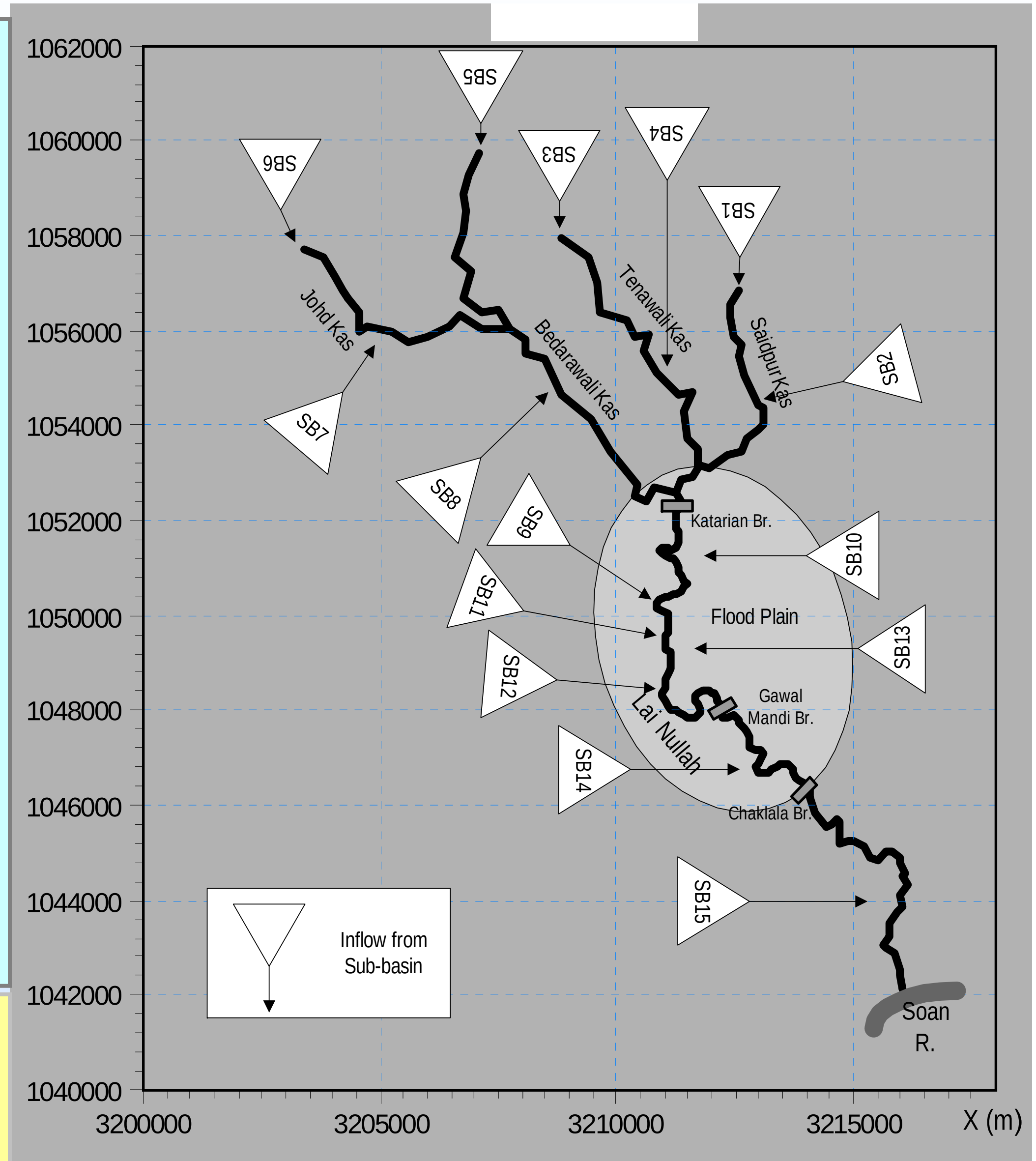




Simulation Model Set-up

- A unit-hydrograph method based on the SCS Curve Number was selected to estimate runoff discharge from 15 sub-basins.
- The estimated runoff discharges were further used as inflow data to river network for the flood routing.
- The main river, Lai Nullah, and four major tributaries, Saidpur Kas, Tenawali Kas, Bedarawali Kas and Johd Kas were considered.

Runoff is estimated by SCS Unit-hydrograph Method



Source: Pakistan Meteorological Department

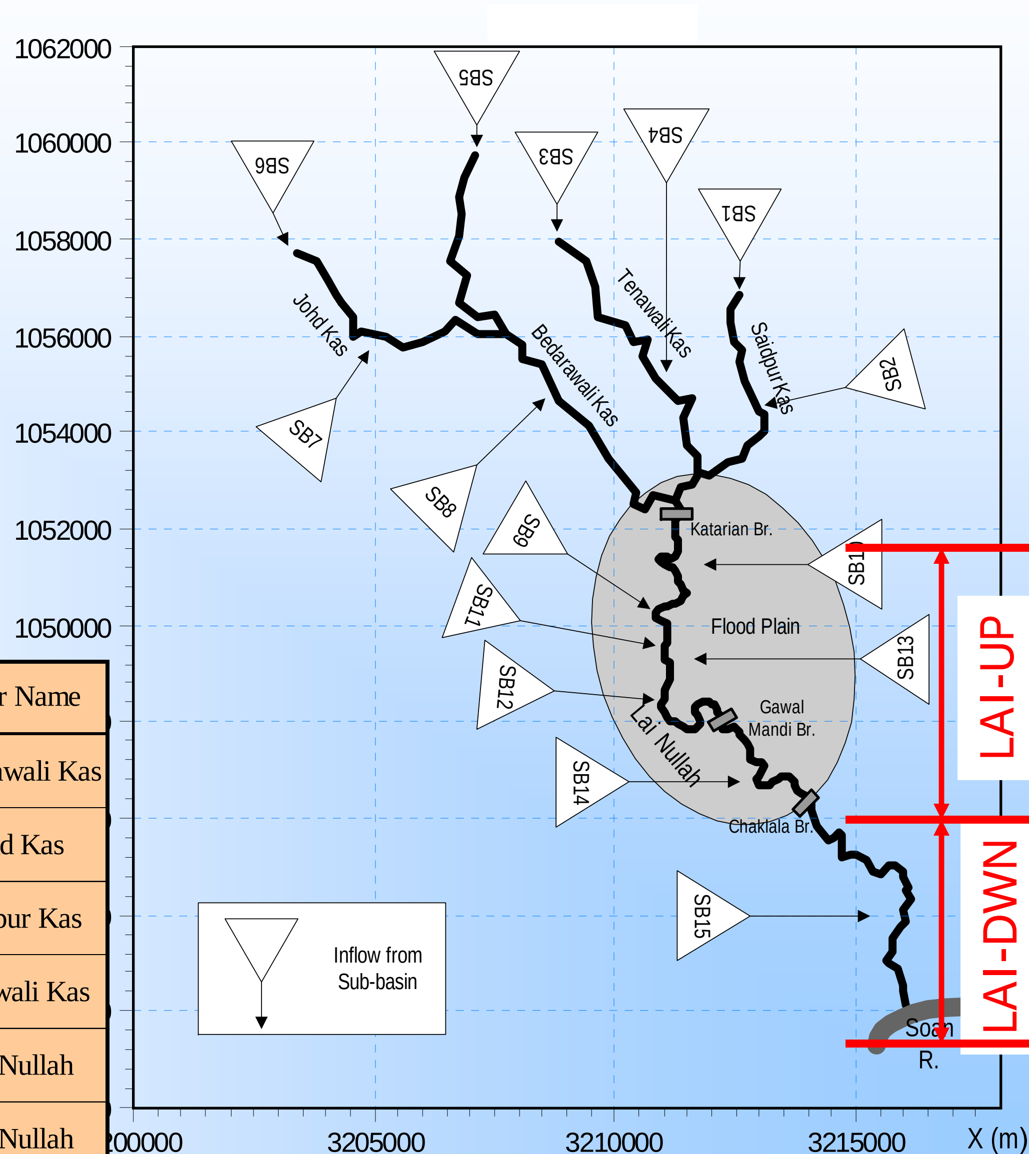
Flood Routing

Network Data

The flood routing is made along the river network consisting of the five rivers.

River	Stretch	Length (km)
Lai Nullah	Kattarian Br. to Soan River	17.5
Saidpur Kas	Zero Point to Tenawali Kas	5.8
Tenawali Kas	Jinnah Avenue to Bedarawali Kas	8.7
Bedarawali Kas	E-9 to Lai Nullah	12.7
Johd Kas	Golra Village to Bedarawali Kas	7.3

ranch Name	Topo-ID (FFWS Model in 2007)	Manning's Number n	River Name
EDARA	JICA-2002	high water channel = 0.050 low water channel = 0.035	Bedarawali Kas
OHD	JICA-2002	high water channel = 0.050 low water channel = 0.035	Johd Kas
AIDPUR	JICA-2002	high water channel = 0.050 low water channel = 0.035	Saidpur Kas
ENA	JICA-2002	high water channel = 0.050 low water channel = 0.035	Tenawali Kas
AI-UP	ADB-PRO-LOOPCUT	0.03	Lai Nullah
AI-DWN	LOOPCUT(CHG)	high water channel = 0.050 low water channel = 0.035	Lai Nullah



Source: Pakistan Meteorological Department

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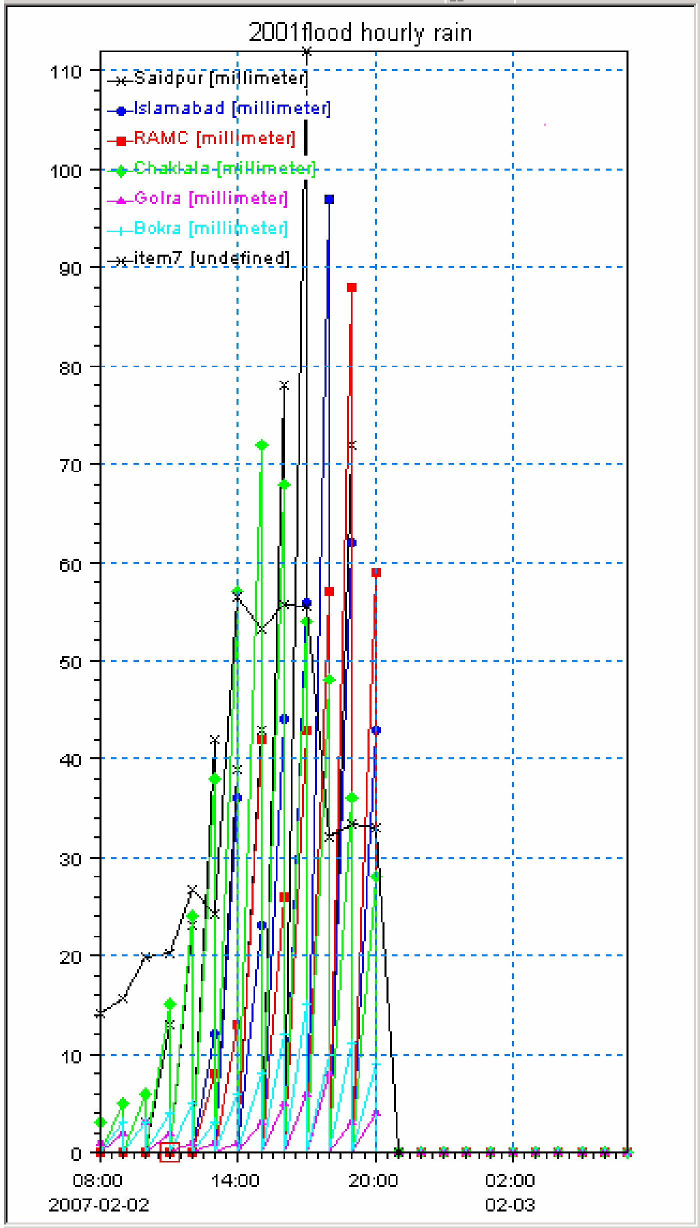

	Time	1:Saidpur [	2:Islamaba	3:RAMC [mi	4:Chaklala [	5:Golra [mil	6:Bokra [mi	7:item7 [un
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1	2/2/2007 9:00:00 AM	0	0	0	5	2	3	15.6
2	2/2/2007 10:00:00 AM	3	0	0	6	3	3	19.8
3	2/2/2007 11:00:00 AM	13	0	0	15	2	4	20.3
4	2/2/2007 12:00:00 PM	23	0	0	24	1	5	26.7
5	2/2/2007 1:00:00 PM	42	12	8	38	1	3	24.3
6	2/2/2007 2:00:00 PM	39	36	13	57	1	6	56.4
7	2/2/2007 3:00:00 PM	43	23	42	72	3	8	53.3
8	2/2/2007 4:00:00 PM	78	44	26	68	5	12	55.8
9	2/2/2007 5:00:00 PM	112	56	43	54	6	15	55.5
10	2/2/2007 6:00:00 PM	97	97	57	48	8	10	32.1
11	2/2/2007 7:00:00 PM	72	62	88	36	3	11	33.4
12	2/2/2007 8:00:00 PM	59	43	59	28	4	9	33
13	2/2/2007 9:00:00 PM	0	0	0	0	0	0	0
14	2/2/2007 10:00:00 PM	0	0	0	0	0	0	
15	2/2/2007 11:00:00 PM	0	0	0	0	0	0	
16	2/3/2007 00:00:00	0	0	0	0	0	0	
17	2/3/2007 1:00:00 AM	0	0	0	0	0	0	
18	2/3/2007 2:00:00 AM	0	0	0	0	0	0	
19	2/3/2007 3:00:00 AM	0	0	0	0	0	0	
20	2/3/2007 4:00:00 AM	0	0	0	0	0	0	
21	2/3/2007 5:00:00 AM	0	0	0	0	0	0	
22	2/3/2007 6:00:00 AM	0	0	0	0	0	0	
23	2/3/2007 7:00:00 AM	0	0	0	0	0	0	

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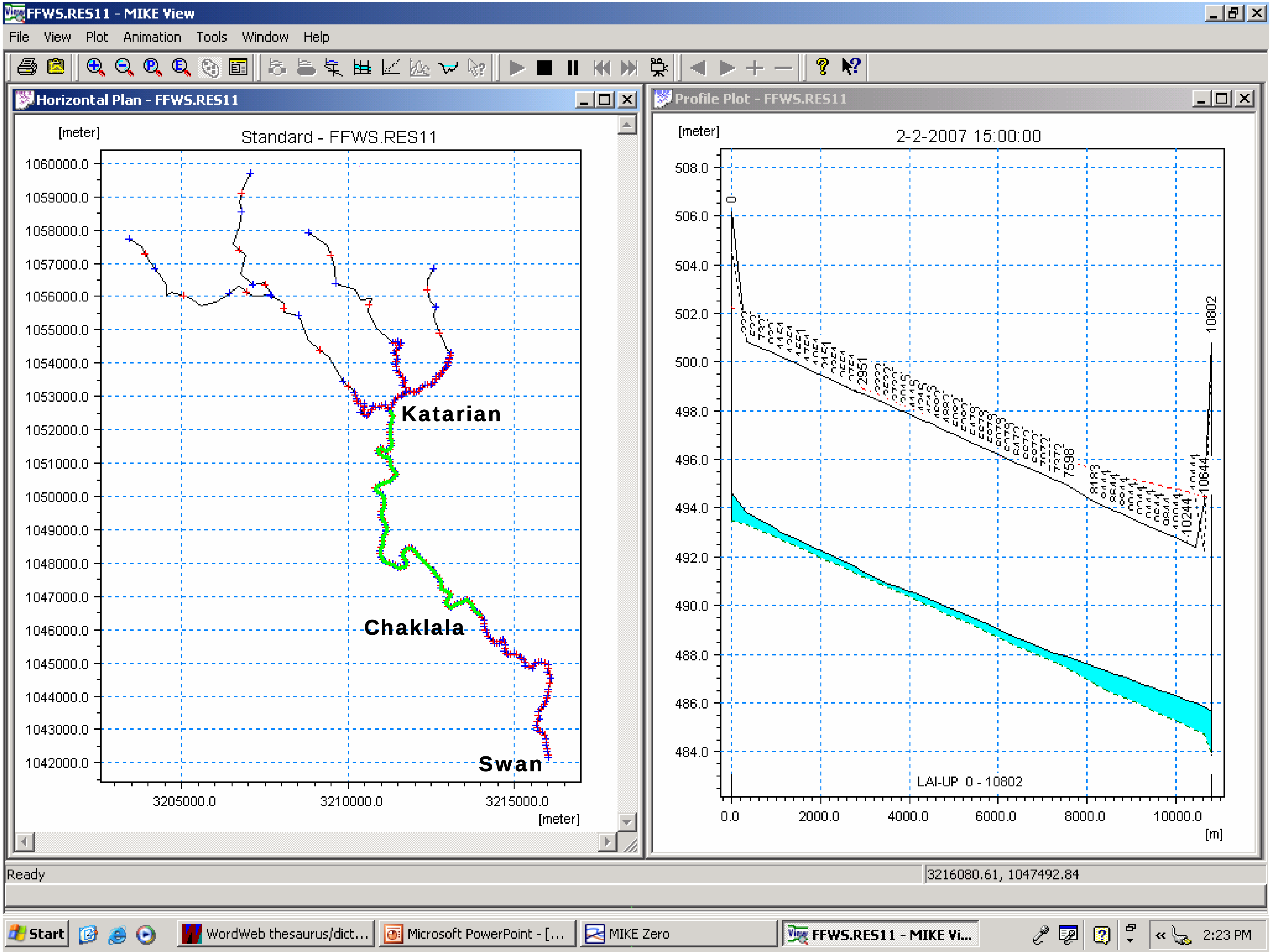

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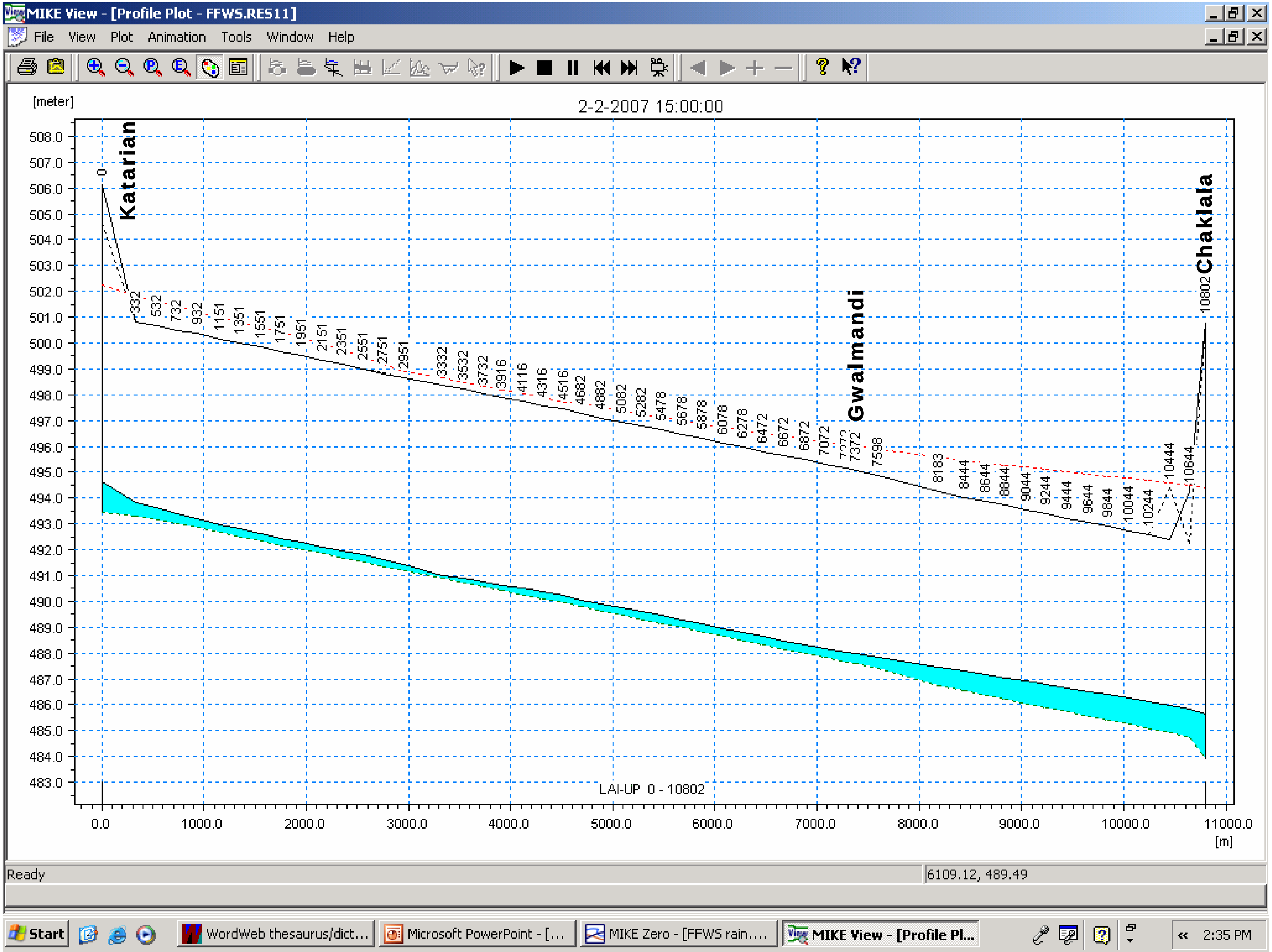

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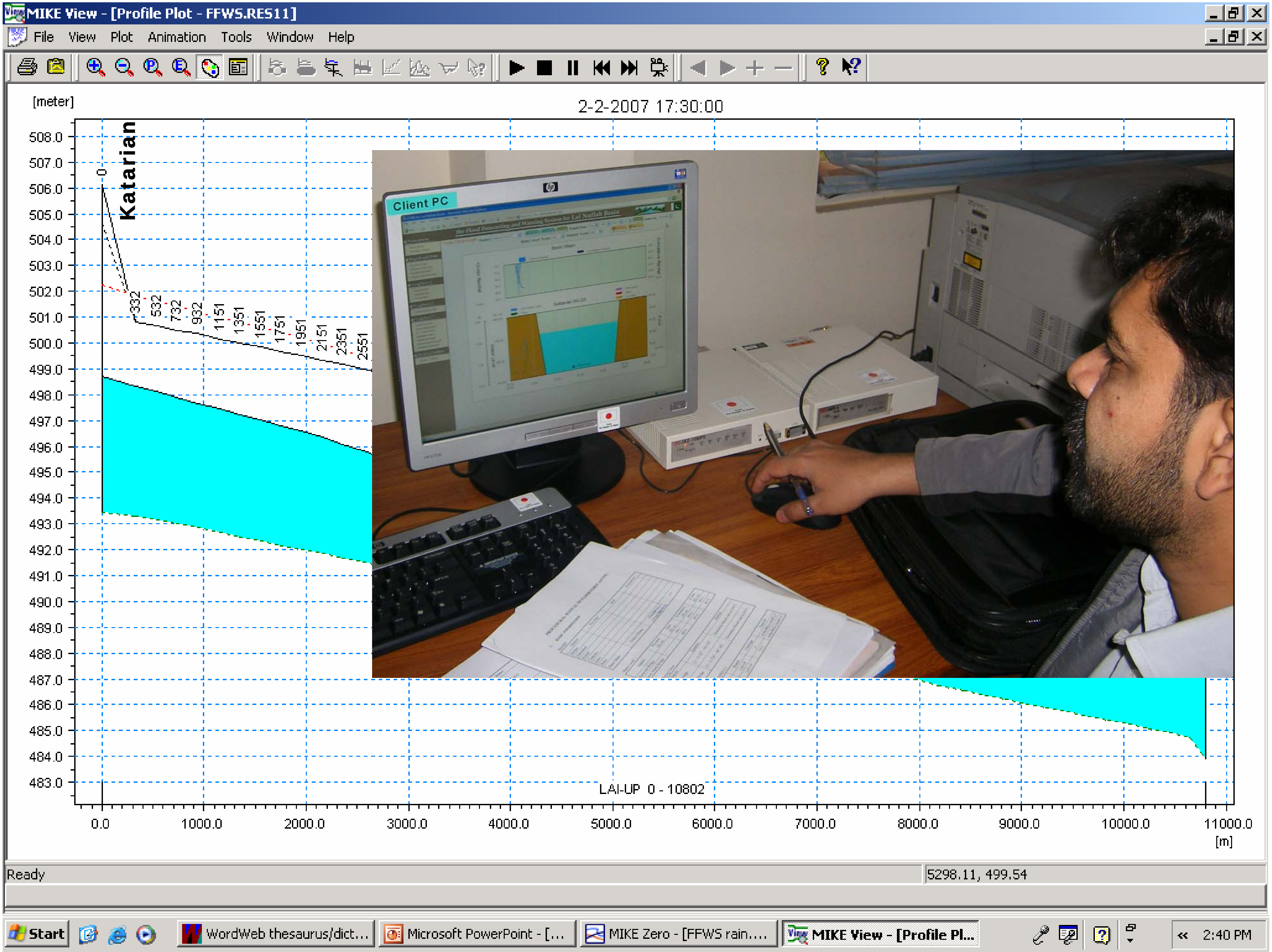
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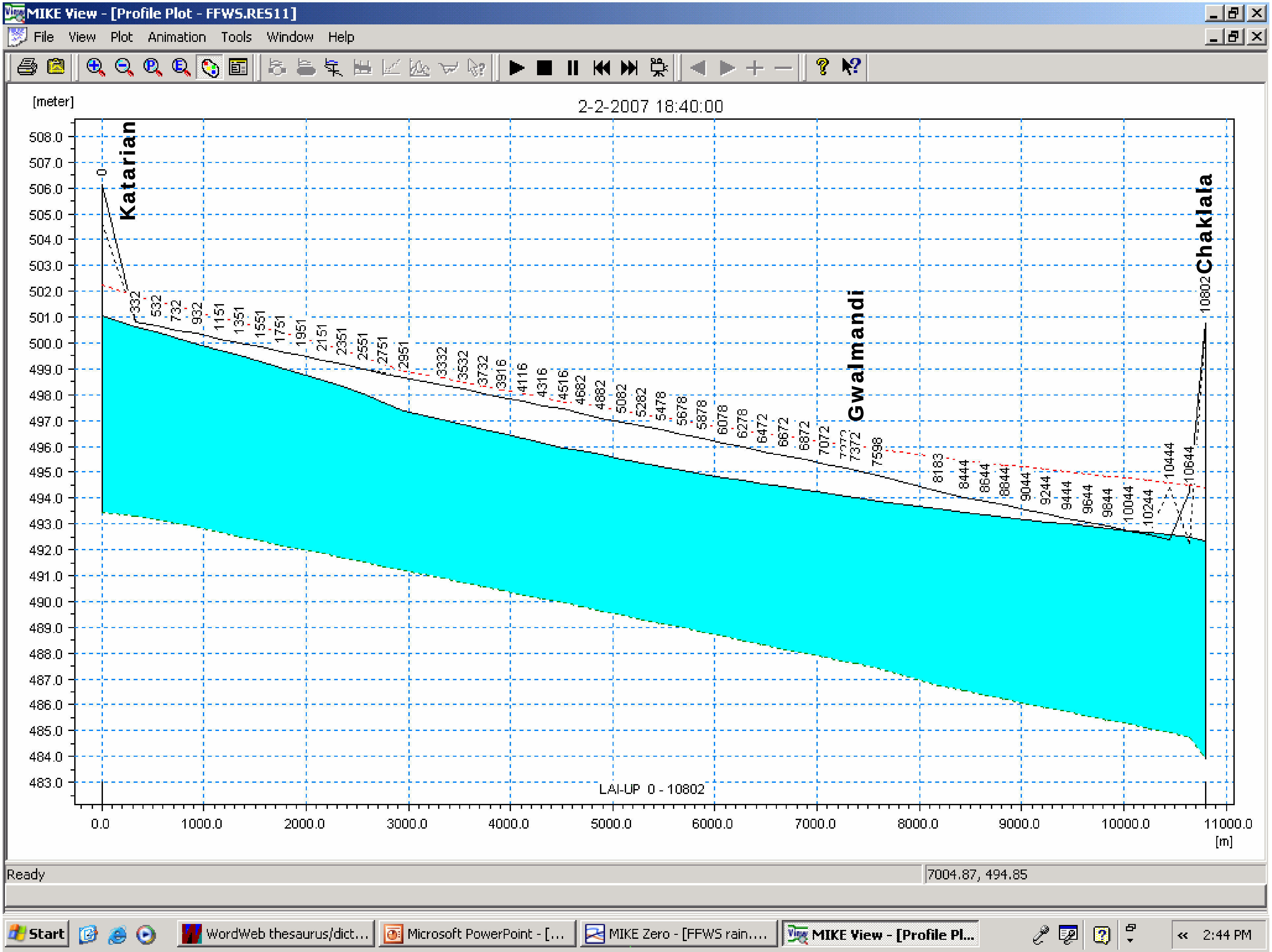
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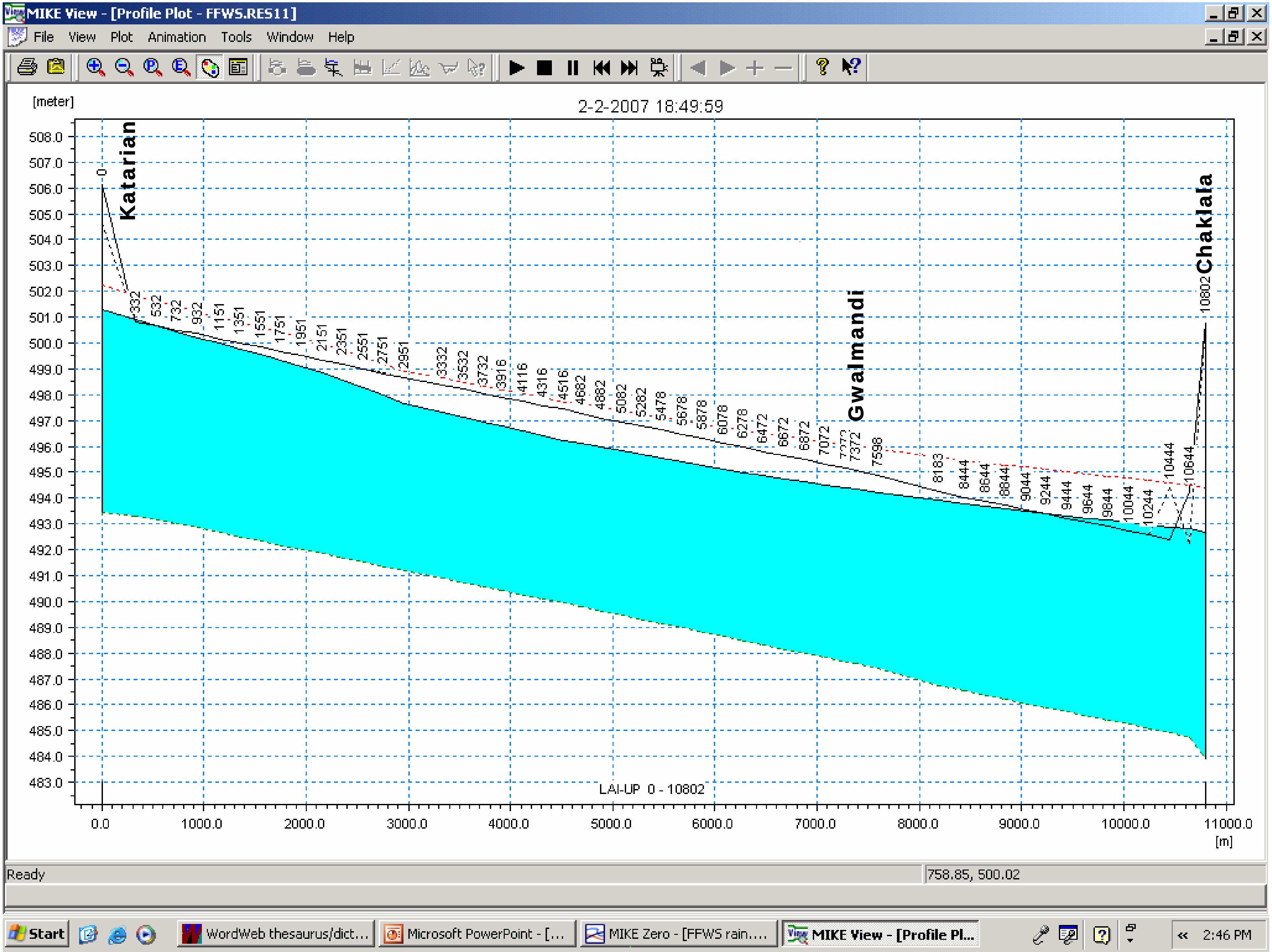

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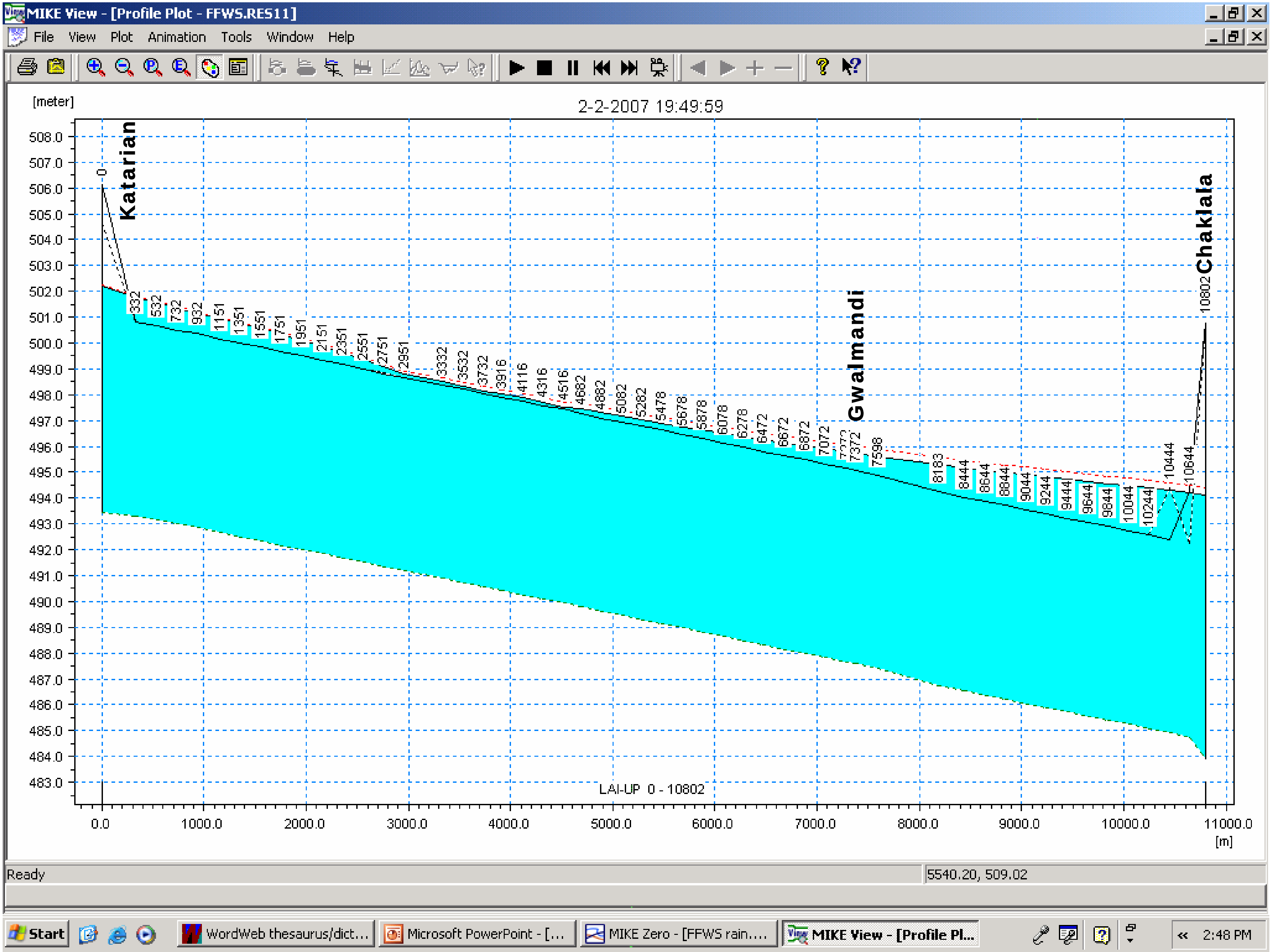

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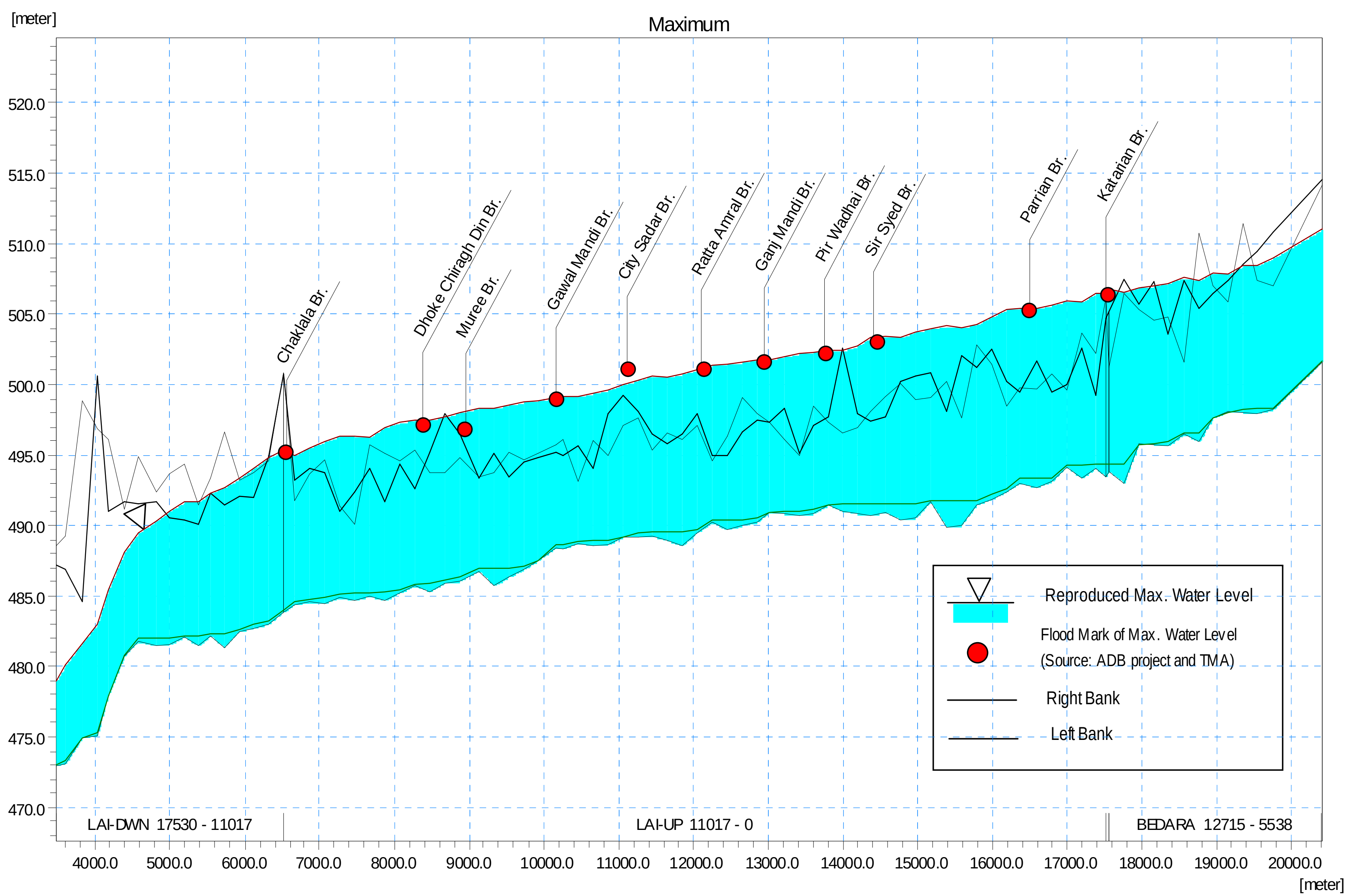
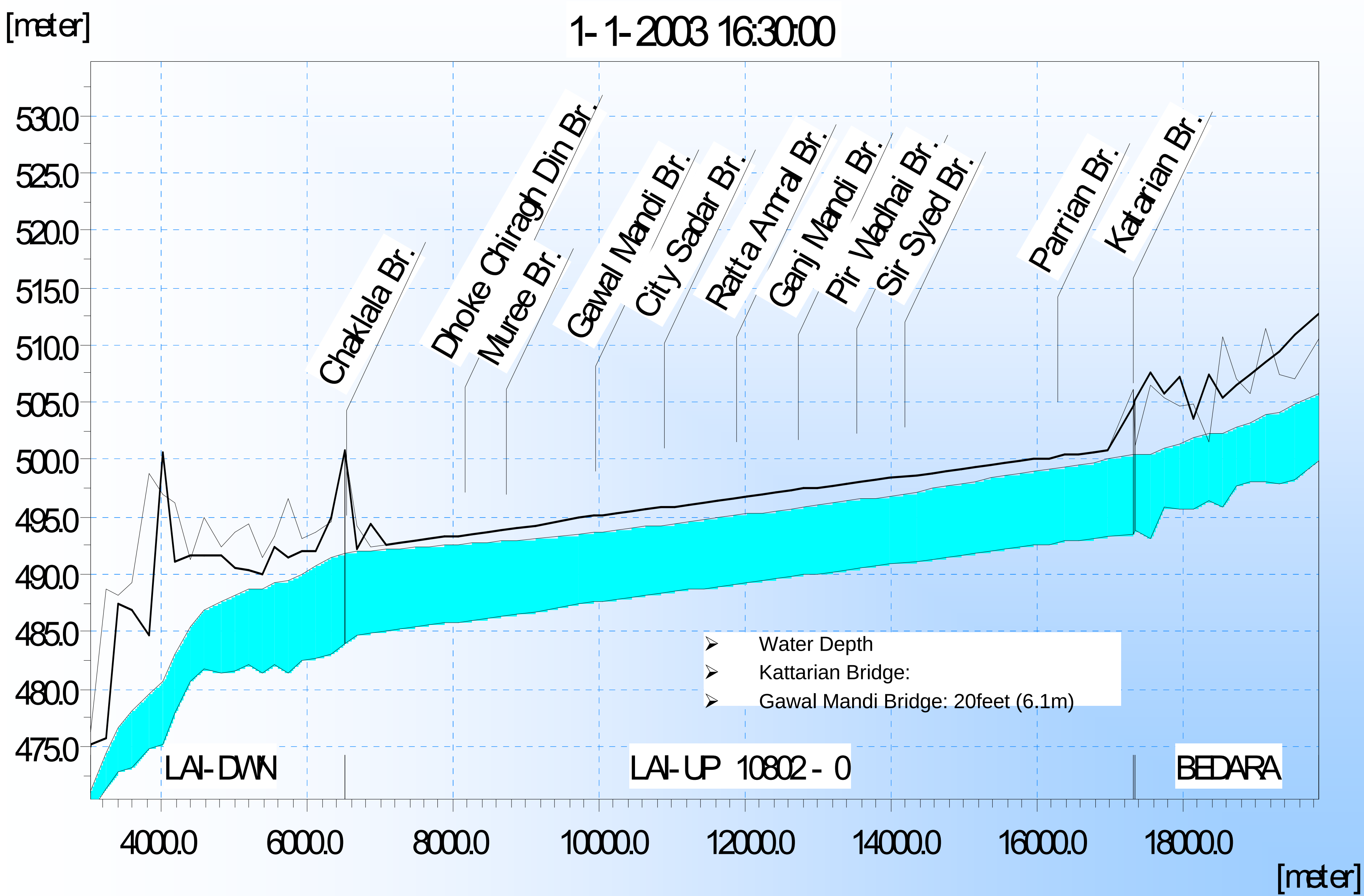
Flood Routing
Calculation Result



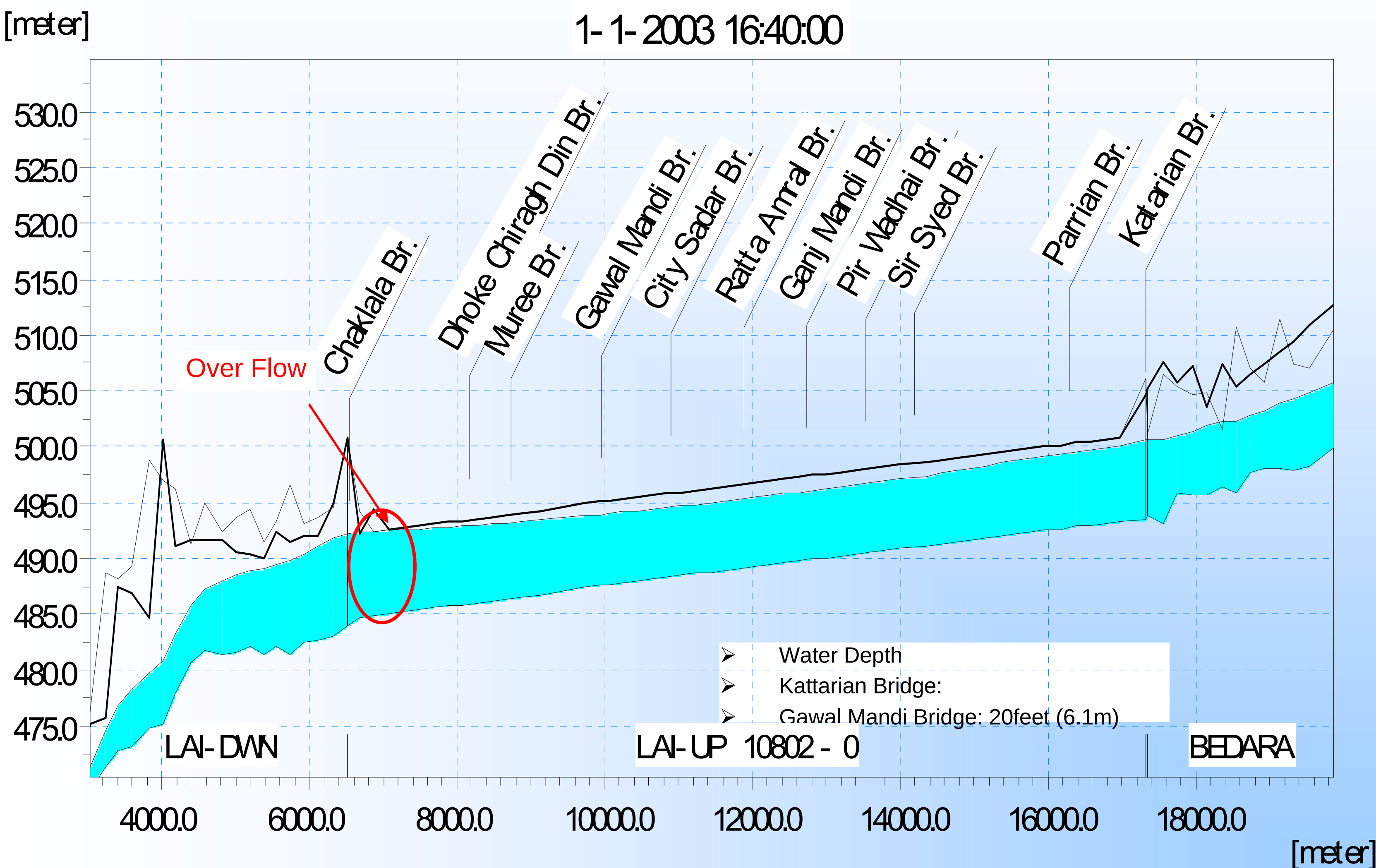
Present Criteria of Evacuation



Water Level Profile (Issuance of Warning)

Source: Pakistan Meteorological Department

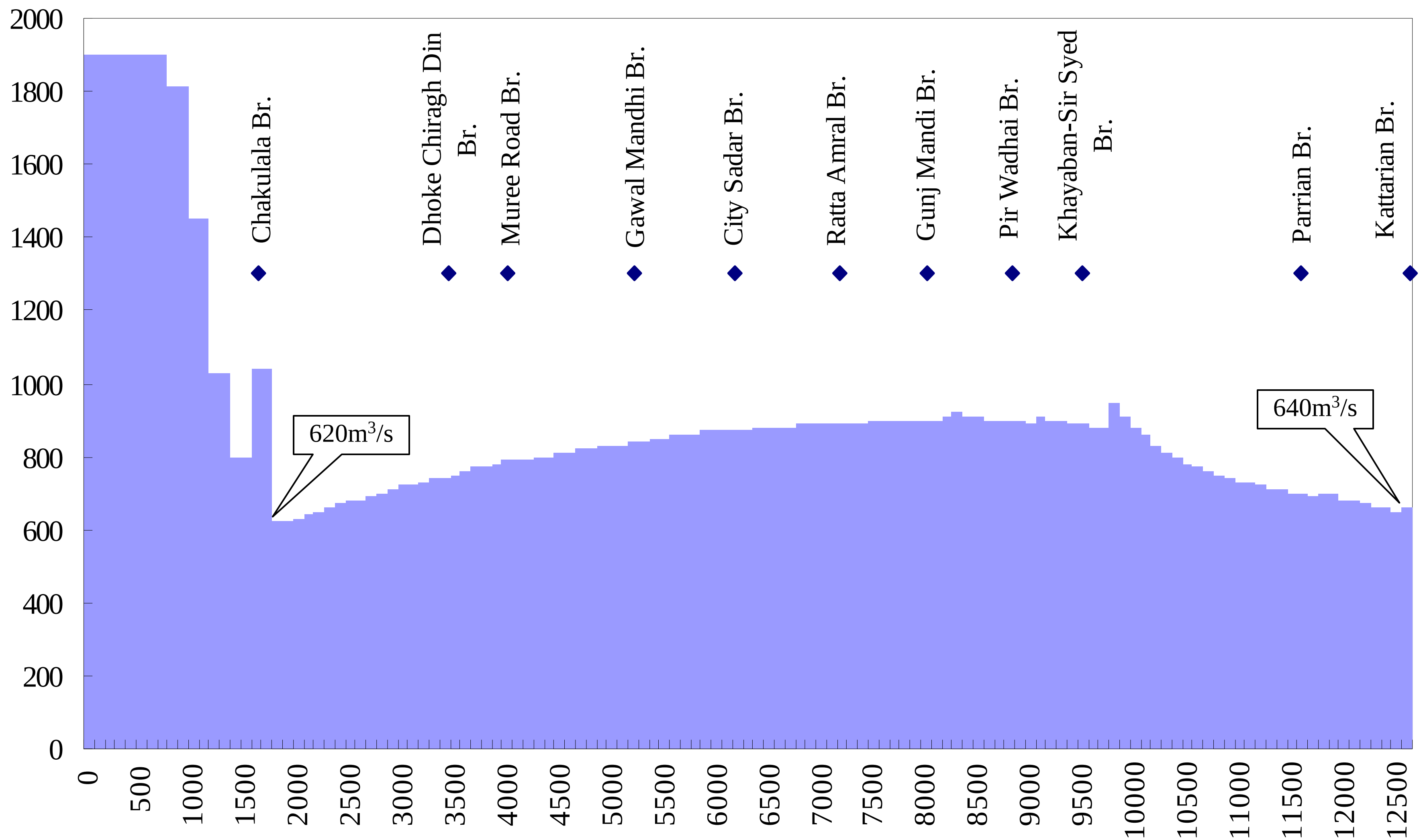
Present Criteria of Evacuation



Water Level Profile (Issuance of Warning)

Source: Pakistan Meteorological Department

Flow Capacity of Lai Nullah River



Flow Capacity Profile of Lai Nullah River

Source: Pakistan Meteorological Department

Table3.1 Water Level Criteria

Criteria Water Level	Kattarian Bridge Water Level m	Kattarian Bridge Water Depth ft	Gawal Mandi Bridge Water Level m	Gawal Mandi Bridge Water Depth ft	Remarks
Rank-A Water Level	499.6	20.0	492.7	17.2	Minimum of [2] and [3]
Rank-B Water Level	498.1	15.1	491.2	12.1	Minimum of [4] , [5] and [6]
Rank-C Water Level	496.5	10.0	489.8	7.5	[7]

		Kattarian Bridge Discharge m^3/s	Kattarian Bridge Water Level m	Gawal Mandi Bridge Discharge m^3/s	Gawal Mandi Bridge Water Level m	Remarks	
[1]	Design Discharge	2,270	505.6	2,640	498.3		
[2]	Min.Flow Capacity	640	500.0	620	492.7	Japan Danger Stage Criterio	(Bankful Discharge)
[3]	Existing Criterion	559	499.6	839	493.6	Present Criterio of Rawalpindi	(20-feet above riverbed)
[4]	50% of [2]	320	498.2	310	491.2	Japan Warning Stage Criterio (a)	
[5]	Based on 5-year Model Hyeto	330	498.2	390	491.6	Japan Warning Stage Criterio (c)	*1
[6]	Mean of [3] and [7]	306	498.1	325	491.2	Japan Warning Stage Criterio (b)	*2
[7]	20% of [2]	128	496.5	124	489.8	Japan Advisory Stage Criterio (a)	
	Ground Level	1,948	504.7	1,261	495.0		
	Riverbed Level	-	493.5	-	487.5		

*1 : Japan Criterio is 3-year but simulation was done with minimum model hyet of 5-year.

*2 : Meaning like criterio (b) of Japan Warning Stage

1 feet = 0.3048 m

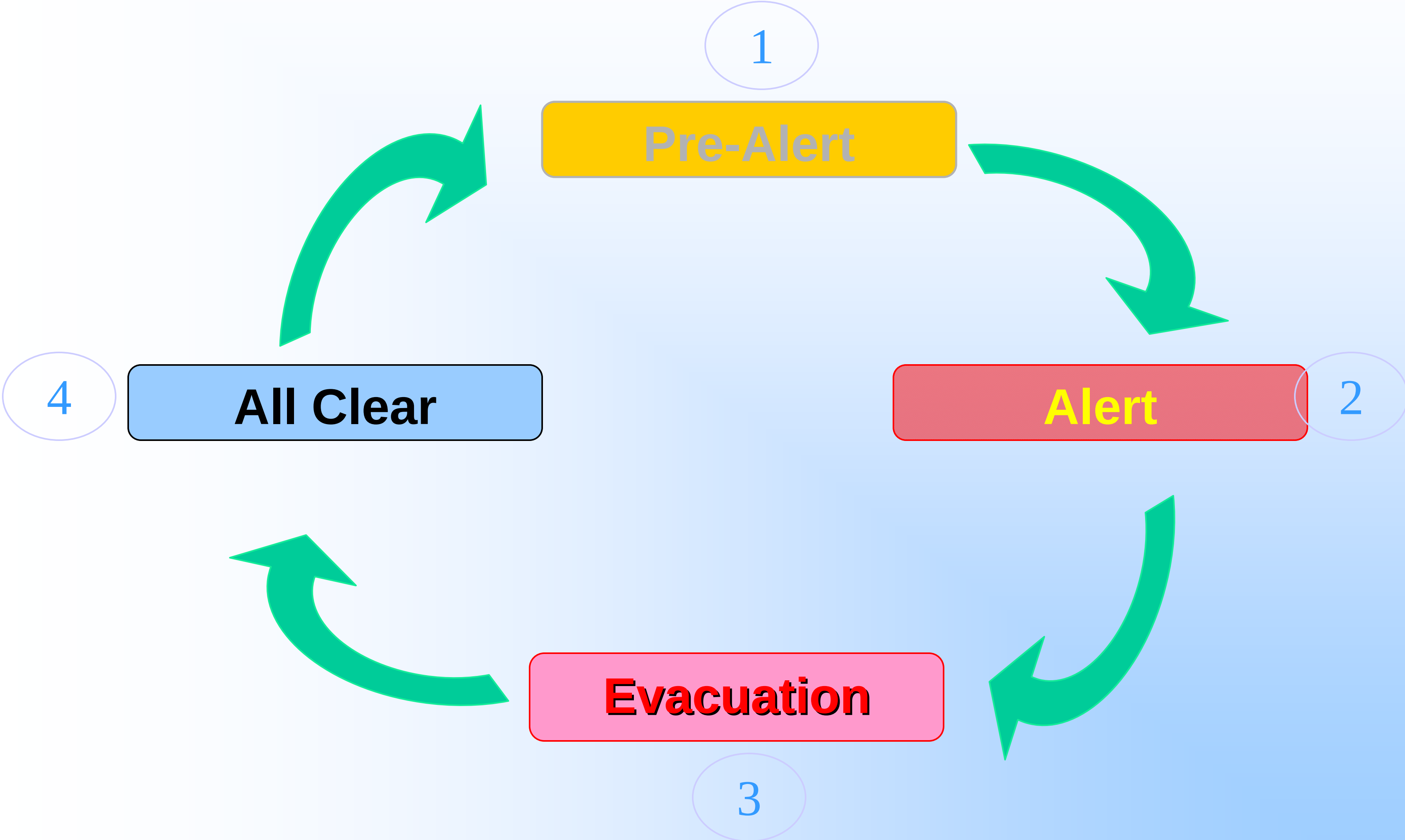
Rank-A water level corresponds to the Danger Stage

Rank-B corresponds to the Warning Stage

Rank-C corresponds to the Advisory Stage

Source: Pakistan Meteorological Department

Flood Warning Code



Flood Warning Code

Pre-Alert

50mm / 180min (calculated after every 10 minutes)

Each agency should take position to Flood Watch.

Broadcast heavy rainfall and flood prediction, if the rainfall intensity is bigger than the above figures.

Alert

- **Rainfall**

50mm / 60min ; 135mm / 180min.

- **Water Level**

Kattarian Bridge : **496.5m (10 feet from riverbed)**

GawalMandi Bridge : **489.8m (7.5 feet from riverbed)**

Broadcast flood warning, if the rainfall intensity and raising water level is higher than the above mentioned figures.

Flood Warning Code

Evacuation

Kattarian Bridge

Pattern1: Water Level exceed Alert Level *and* Rainfall exceed Alert Level

Pattern2: Water Level exceed 499.6m (20 feet from riverbed)

Gawal Mandi Bridge

Pattern1: Water Level exceed Alert Level *and* Rainfall exceed Alert Level

Pattern2: In case of Kattarian Warning

Pattern3: Water Level exceed 493.6m (20 feet from riverbed)

Broadcast siren and announcement for evacuation in case of “Evacuation”.

Flood Warning Code

All Clear

All flood watches and flood warnings are cleared, if no flood is expected and the rainfall intensity and declining water level is smaller than the following :

- **Rainfall**

  20mm /per 180min.

and

- **Water Level**

  Kattarian Bridge : **496.5m (below alert level)**

  Gawal Mandi Bridge : **489.8m (below alert level)**

Flood Warning Code

The possible time for evacuation
(excluding decision making, operation time, etc.)

Old criterion (20 feet from riverbed)		New Flood Warning Code
10 minutes	→ **lengthened**	One and half hour

Telemetry and Data Transmission System in PMD

SUPERVISORY & CONTROL SYSTEM IN TMA.

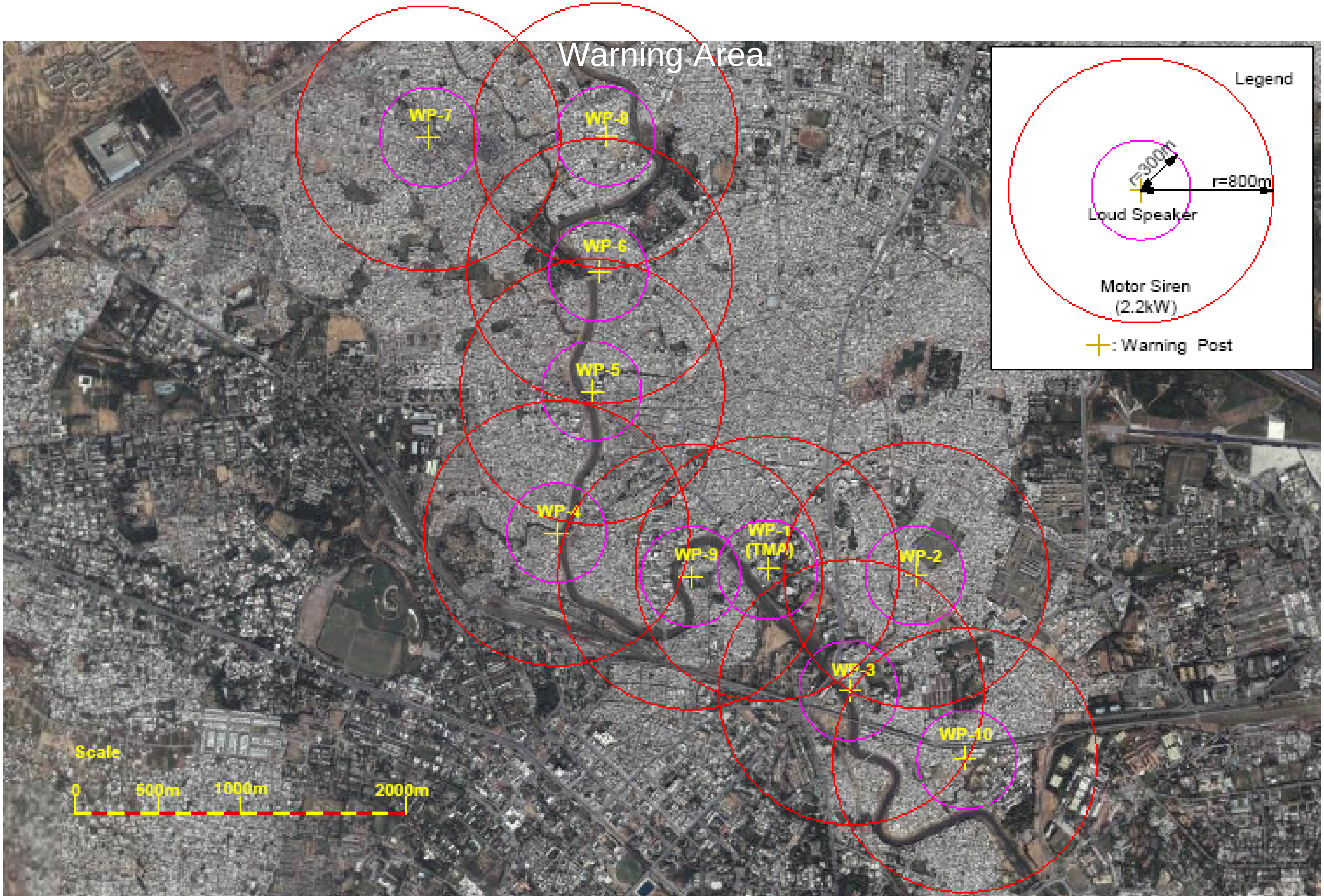
- It control all the 10 warning Posts present in different vicinity of the City along the Nullah Lai

Source: Pakistan Meteorological Department

Remote Controlled Warning Posts (10 Station)

- There are 10 Warning Posts.
- 5 in Up Stream
- 5 in Down Stream
- Each warning Post operated from TMA by Radio Waves.
- Each Post Comprises of 4 Speakers, One emergency light and One Siren
- In Case of Power Failure a battery is installed which provide backup to the warning post for 5 days.

Source: Pakistan Meteorological Department



THE PROJECT FOR THE IMPROVEMENT OF THE FLOOD FORECASTING AND WARNING SYSTEM FOR LAI NULLAH BASIN

Fig.1 Warning Area of Siren and Loud Speaker


Warning System
Warning Station Status
Warning Control
Operation Record
Warning Printer Control
Maintenance
Exit
River Basin Map
Hard Copy
Dec 14, 2006 15:40
Warning Reset
Emergency Stop
Warning Station Status
River Basin Map
Status Display
Detailed Status
Warning Control
Control Mode Selection
Operation
Operation
Warning Printer Control
Warning Printer Control
Maintenance
Periodic Check
Exit
Exit
WP-07 Pir Wadhai FS
WP-08 Khayaban Park
WP-06 Pir Wadhai Br
WP-05 Ganj Mandi Br
WP-01 TMA
WP-04 Ratta Amral Br
WP-09 Gawal Mandi
WP-02 Arian Mohallah
WP-03 Moti Mehal
WP-10 Dhok Chraghdin
Speaker Station
Siren Station
Sounding
Broadcasting
Lighting
Normal
Abnormal
Master Station Status
Controlling
Sending
Printer Off
Periodic Check Off
Equipment Abnormal

Rainfall during June 2007 in Balochistan

Climatic Stations	June 1-29, 2007	Monthly Normal
Barkhan	44	43
Dalbandin	103*	0.9
Gwadar	52	**
Jiwani	78*	0.8
Kalat	89*	5.3
Khuzdar	73*	12.6
Lasbela	135*	7.8
Nokkundi	80*	0
Ormara	0	0.5
Panjgur	141*	4
Pasni	104*	0.4
Quetta	82*	1.5
Sibi	176*	5.5
Turbat	226	**
Zoab	67*	14.7

Flood Damage in Balochistan during June 2007

Figure 7. Damage to electric supply in Noshki

: to the railway track in Noshki

Figure 4. Floodwater in Dasht, Mastung

Figure 8. Damage to tubewells in Noshki

Figure 6. Damaged bridge in Mach, Bolan

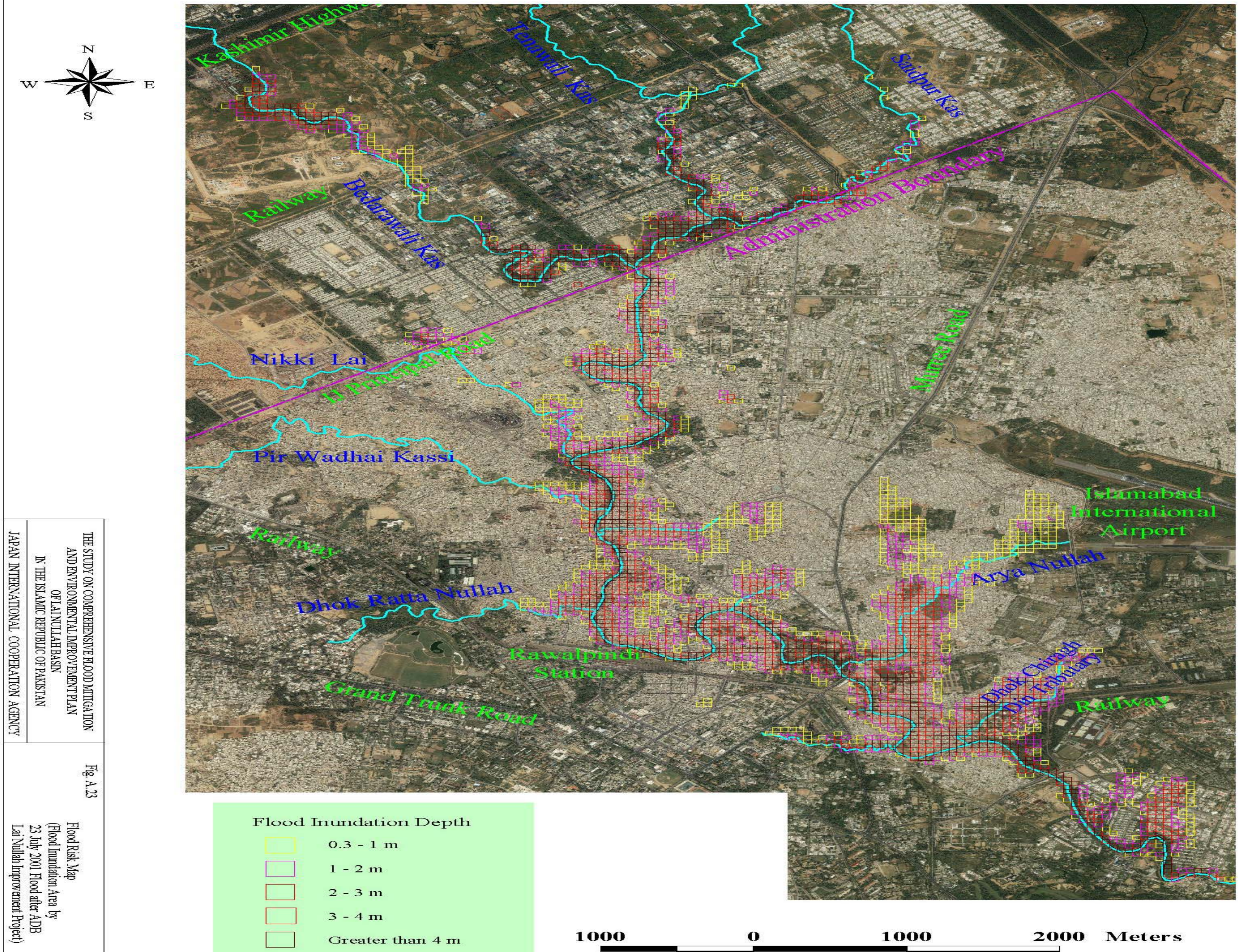
Figure 3. Floodwater in Jaffarabad

Flood Damage in Balochistan during June 2007

Figure 9. Damage to agriculture and rural housing, Noshki

Figure 10. Damage to agriculture in Kharan

Thank You



THE STUDY ON COMPREHENSIVE FLOOD MITIGATION AND ENVIRONMENTAL IMPROVEMENT PLAN OF LAI NULLAH BASIN IN THE ISLAMIC REPUBLIC OF PAKISTAN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. A.23

Flood Risk Map
(Flood Inundation Area by
23 July 2001 Flood after ADB
Lai Nullah Improvement Project)