



# New Initiatives taken for Flood Reduction and Management after Super Flood of 2014 in Chenab River



**Speaker (Day 1)**

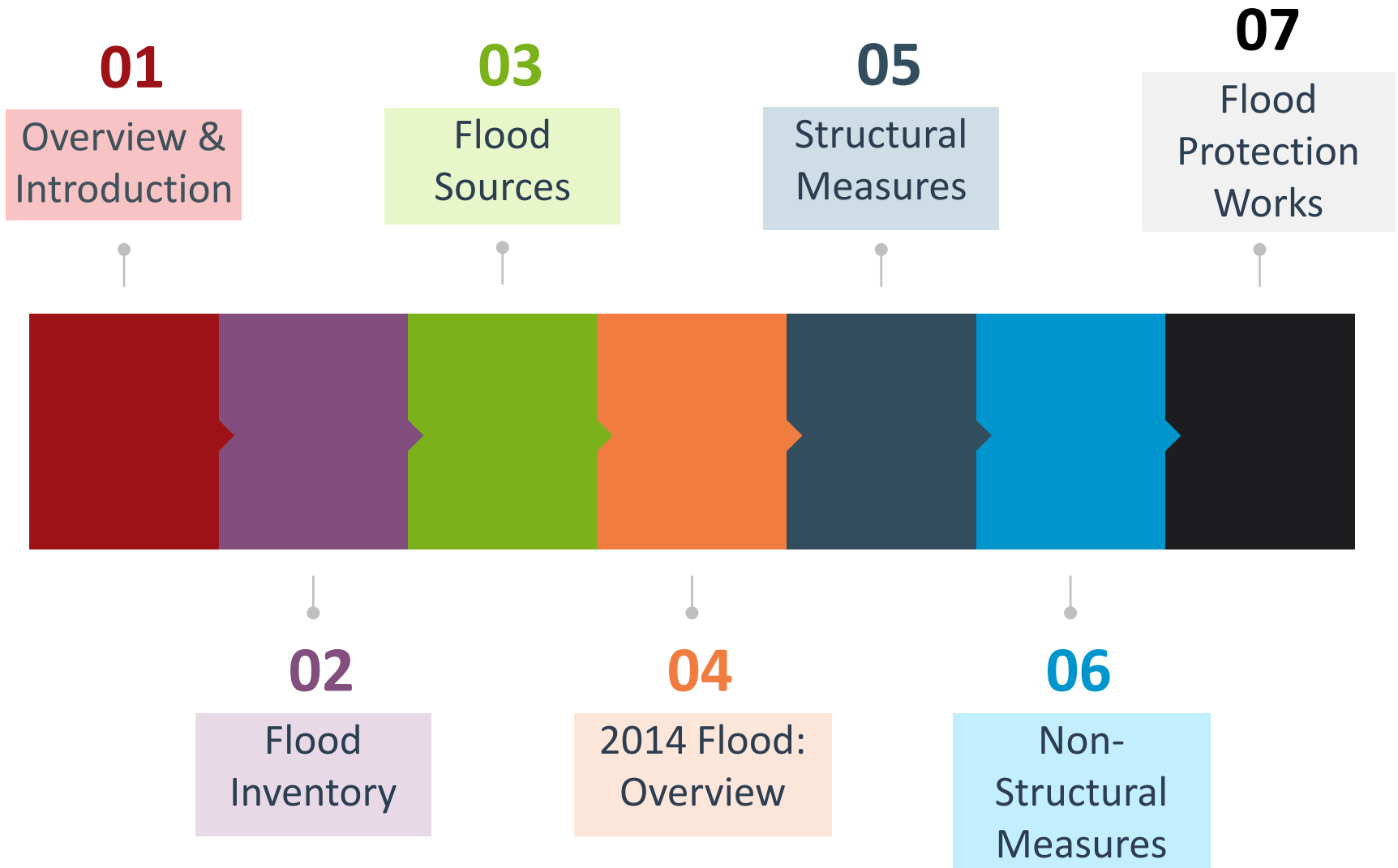
Habib Ullah Bodla

Chief PMIU/FRAU

Aug 30, 2017

Punjab Irrigation Department, Pakistan

# Sequence

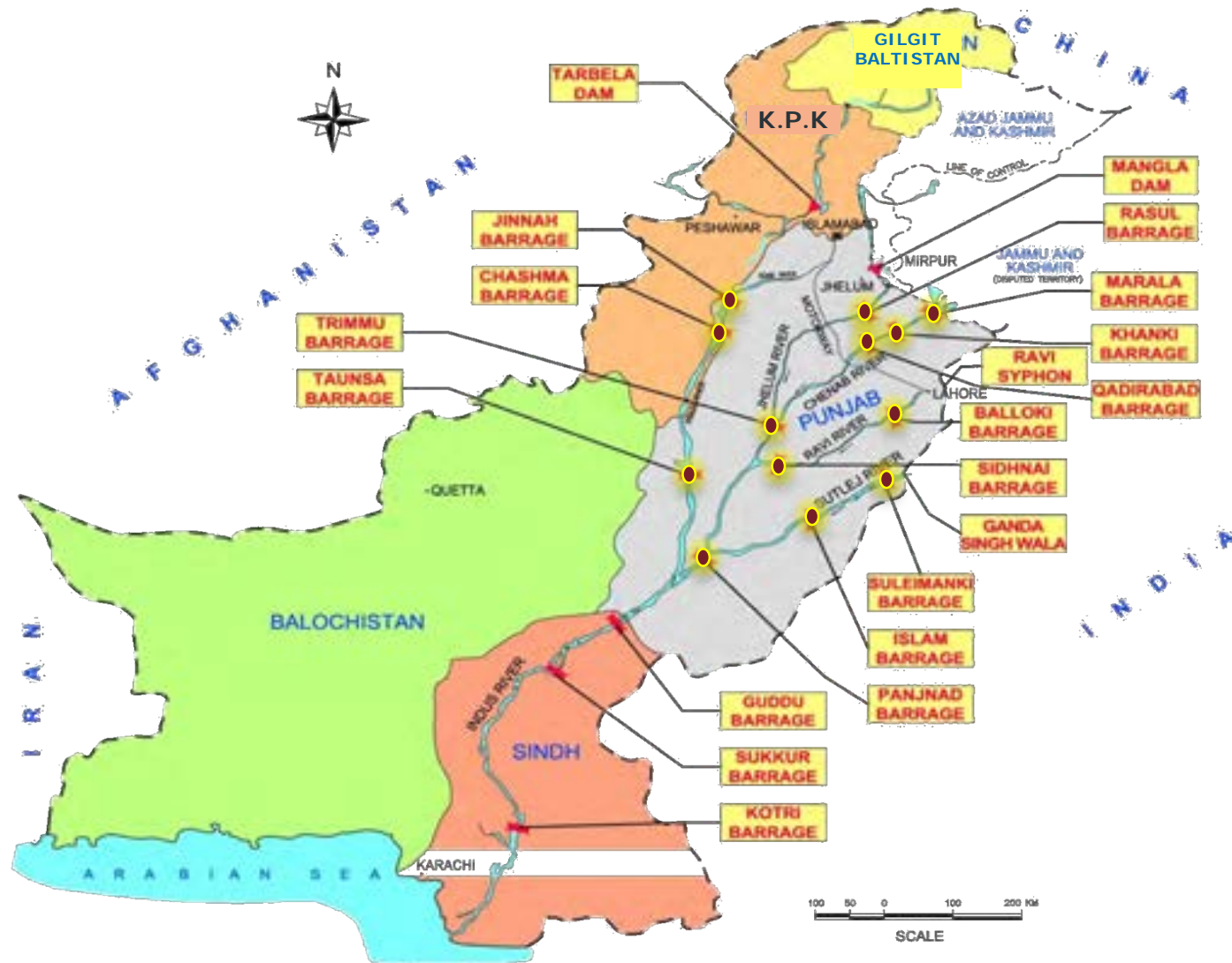


# Overview

- World's largest contiguous irrigation system, contributes 21% of GDP and employs 50% of labour force
- Supplying 51.69 MAF (53% of Indus flows) to 21.34 m acres
- Estimated replacement cost of PID infrastructure: US\$ 32billion

Main Components	No	Length (miles)	Value (Rs. b)	Budget Allocation
Barrages/Headworks	13	-	277	<ul style="list-style-type: none"> <li>▪ Total ADP: Rs. 41 billion                             <ul style="list-style-type: none"> <li>– Local component: 50-60%</li> <li>– Foreign component: 40-50%</li> </ul> </li> <li>▪ Total O&amp;M: Rs. 16.55 billion                             <ul style="list-style-type: none"> <li>– M&amp;R: Rs. 7.67 billion</li> <li>– Establishment: Rs. 8.88 billion</li> </ul> </li> </ul>
Inter-river link canals	10	568	224	
Main canal systems	24	3593	1444	
Other canals	2794	21385	874	
Drainage system	-	9110	224	
River training works	794	329	135	
Embankments	375	1998	58	
Small dams: CCA 71000 acres	56	-	60	

# Indus River System



# Flood Inventory

Zone	Embankments		River training works	
	No	Length (km)	No	Length (km)
Lahore	95	636.288	156	137.824
Faisalabad	18	371.584	53	55.488
Sargodha	78	411.008	247	78.832
Multan	74	618.448	157	71.232
DG Khan	70	747.296	132	149.008
Bahawalpur	40	432.16	49	37.008
Total	375	3216.784	794	529.392

# Flood Sources & Responsibility

## Irrigation Department

- Riverine floods
- Flash floods: Hill torrents including Aik, Deg, Palkhu and Bhimber

## Local Government, Public Health

- Storm water: urban flooding
- Sewerage carrying drains: Urban flooding (e.g. Lehi and Bhed)

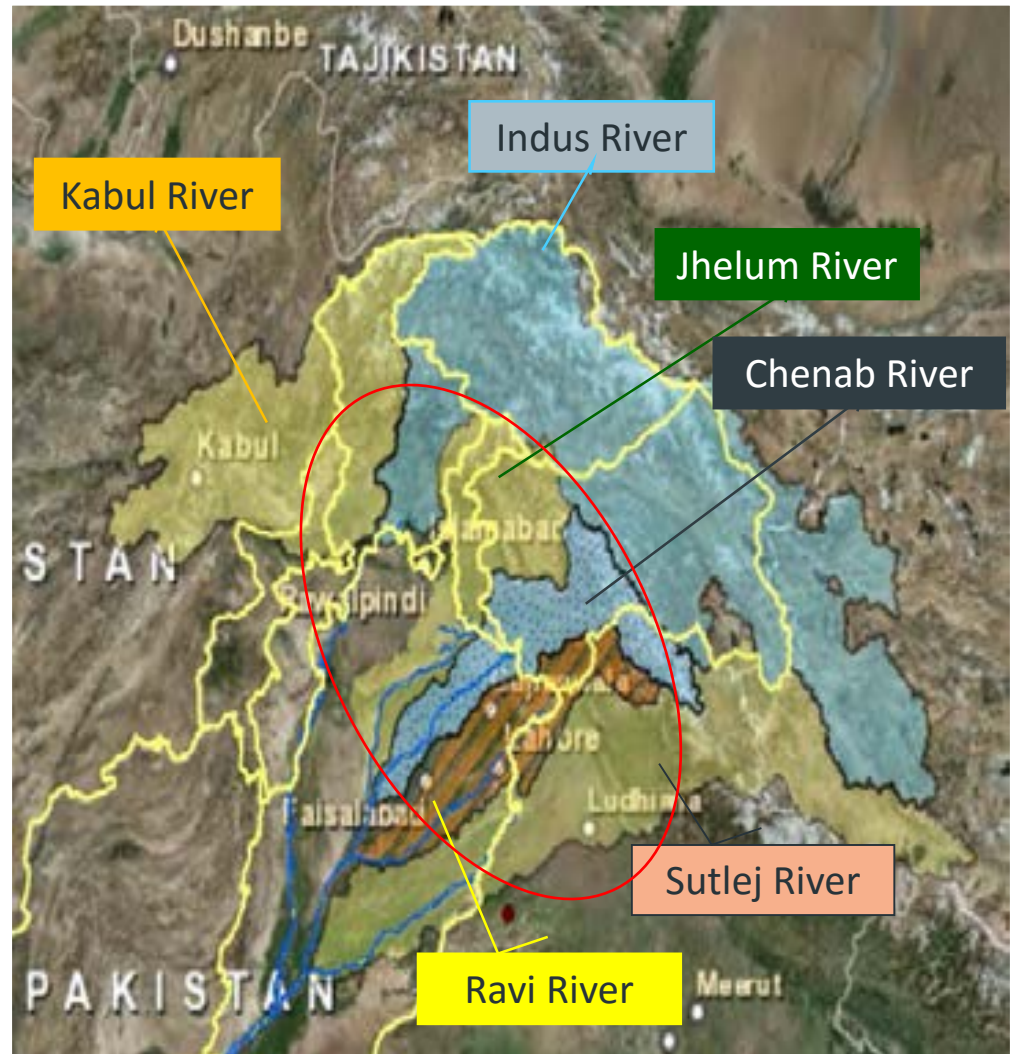
## Specific Responsibilities

- Measurement, assessment and provision of information on discharges and flood levels to all concerned
- Regulation of discharge
- Protection of barrages and other irrigation infrastructure
- Protection of public infrastructure
- Protection of major cities and towns
- Coordination with all stakeholders



# 2014 Flood: Overview

- Cloud burst and heavy rainfall in catchment areas from 1<sup>st</sup> to 6<sup>th</sup> September
- Generating exceptionally high floods in Chenab and Jhelum
- Medium flood in Ravi
- Highest recorded floods in tributaries of Chenab and Ravi viz Deg, Palkhu and Aik
- Sutlej and Indus remained quite



# Measures to Control Flood

## Structural Measures

- [Improved bridge designs](#) to reduce afflux and their flood related impact
- [Breaching sections](#): Effectiveness and elimination of the need for breaching
- [Strengthening of dykes](#), new methods for their emergency management
- [Site specific measures](#)
- [Capacity enhancement of barrages](#)

## Non-structural Measures

- [Better flood forecast and warning](#) by PMD and Irrigation Department
- [Flood plains regulation](#) to reduce obstructions and damages
- [Flood zone mapping](#)
- [Improved reservoir operation](#)
- [Improved organizational structure](#) for barrages
- Improved procedures for flood management – rewriting of Irrigation Manual of Practices



# Flood Protection Works

Financial mode	No of works	Cost (Rs. m)	Completion by Jun 17	Throw forward
WB assisted	27	9151.000	-	27
ADB assisted	121	6662.710	111	10
ADP new	15	12959.508	2	13
ADP ongoing	26	18719.842	8	18
PSDP	9	4651.070	1	8
M&R completed	92	1686.237	92	-
M&R ongoing	8	112.464	-	8
Total	297	53942.830	214	83

**T**hank **Y**ou!

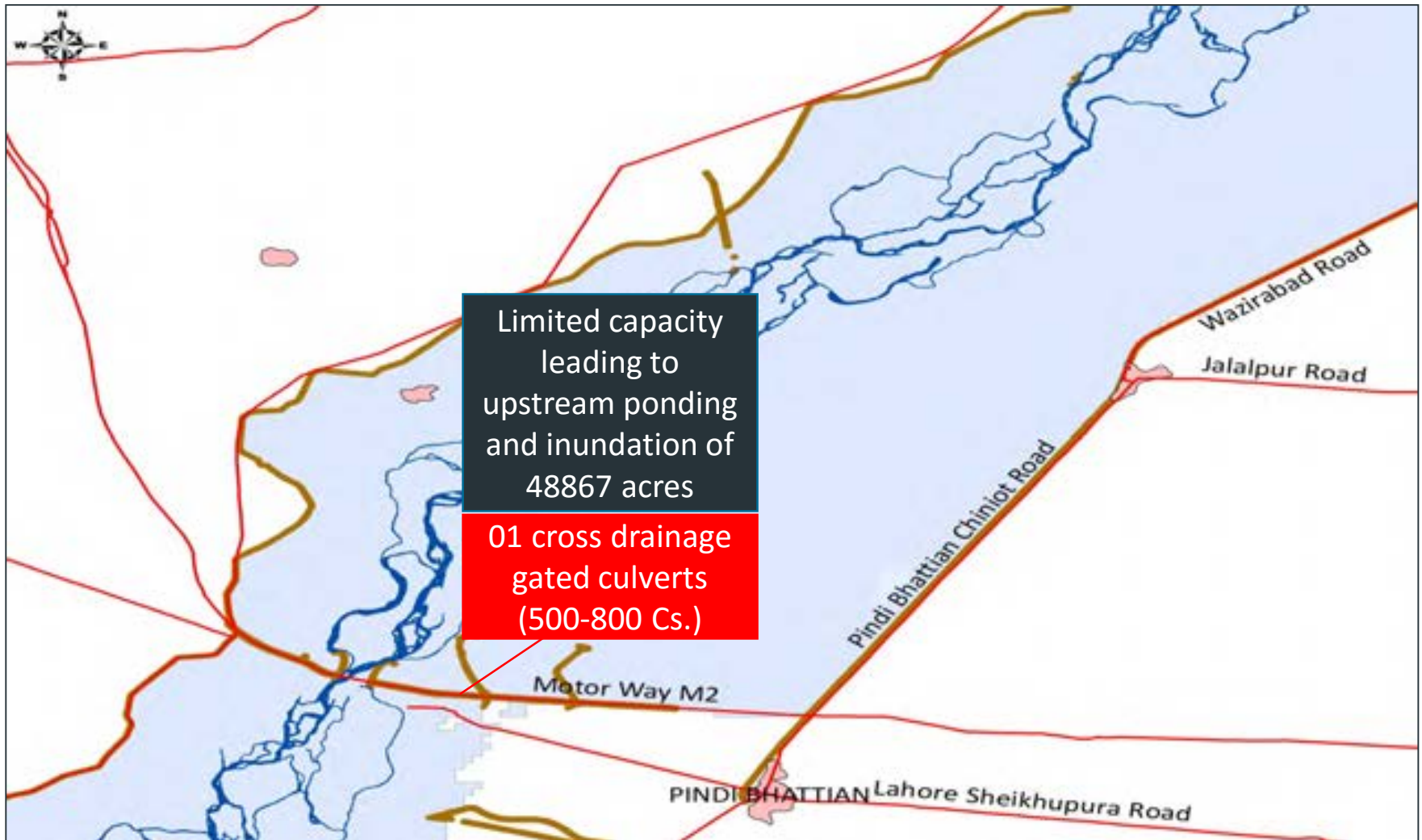
# Bridges in Punjab: Overview

Existing bridges		42		Chenab River			
Under construction		6		Bridge site	Length	Ravi River	
Indus River				Bridge site	Length		
Indus		Length		Alexandria	2244 ft	Shahdara	1350 ft
				Talibwala	3256 ft	Old GT Road	1485 ft
				Chiniot	1850 ft		1755 ft
				Chiniot-Sargodha	1720 ft		2176 ft
Flood year	Discharge	Observed Flood Levels					
		Alexandria	Chiniot	Rewaz	Shershah		2176 ft
Aug 1973	769659	755.00	593.30	523.00	392.62		1500 ft
Sep 1988	776896	755.30	595.60	521.20	391.60	ana	1428 ft
Sep 1992	845090	755.80	595.70	520.50	391.70		1500 ft
Aug 1996	766860	754.20	596.20	521.50	392.30		1098 ft
Sep 2014	861464	755.40	596.70	524.10	393.90	hang	1440 ft
						n-Shorkot	689 ft

# Inadequate Waterway: Alexandra Bridge



# Inadequate Cross Drainage: Taibwala





# Maintaining Existing Waterway

- Providing cunettes and training works to use flows to flush sediment deposit

Chocked portion of bridge

Bridge	Designed waterway	Available clear waterway
Riwaz	2200 ft	1700 ft (77 %)
Chund	2490 ft	1643 ft (66%)
Shershah	3400 ft	1800 ft (52%)
Alexandra	2244 ft	2100 ft (87%)

# Hydraulic Model Testing

## Previous Procedure

Bridge design by sponsor

ToR decided by sponsor

Model run to verify design as per given ToR

Results shared with sponsor

No specific focus on flood risk

## Proposed Procedure

Bridge design by sponsor

ToR decided by Expert Committee

Model run to verify design as per decided ToR

Results approved by Expert Committee and Canal Officer

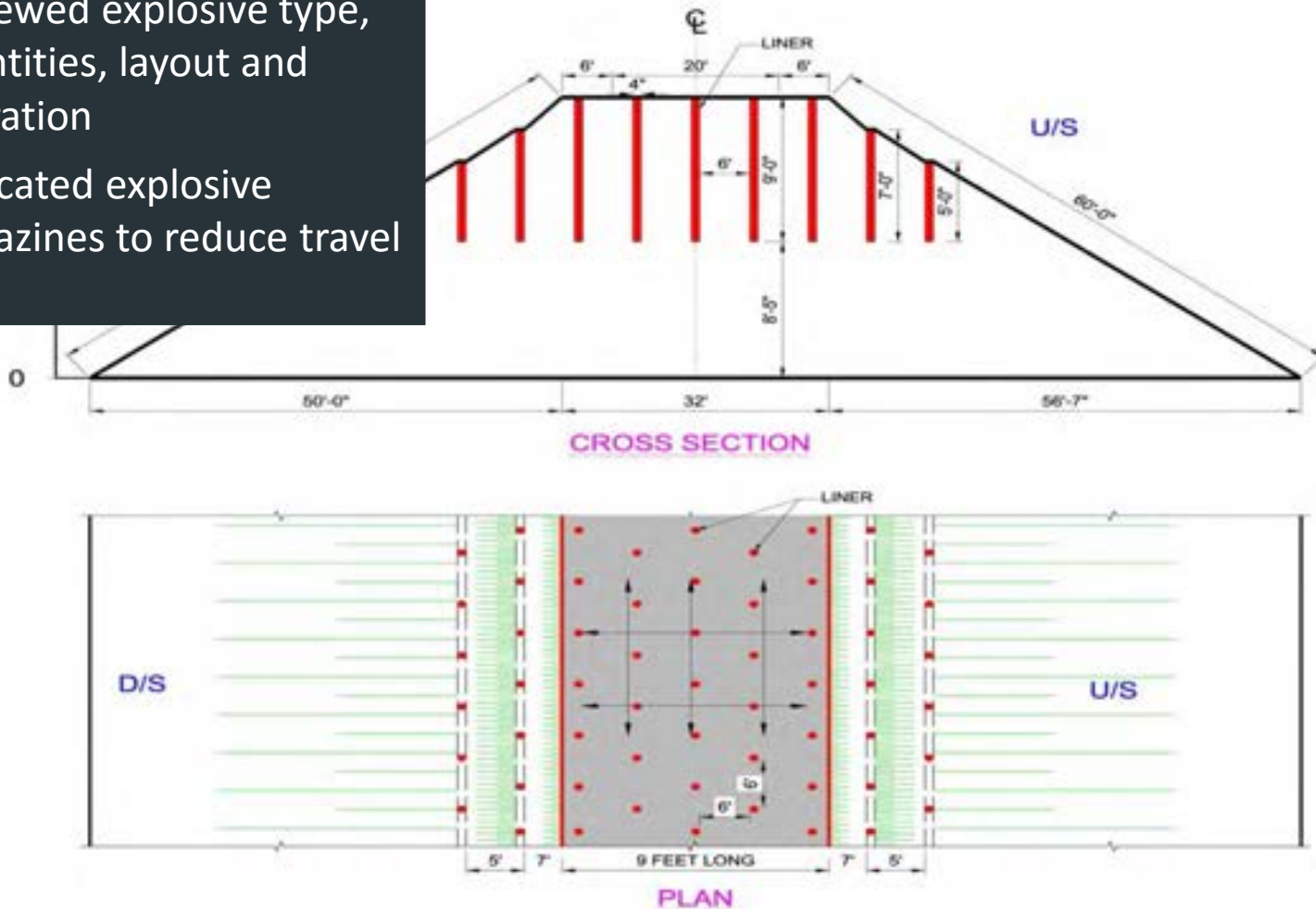
Results shared with sponsor





# Operation of Breaching Section

- Reviewed explosive type, quantities, layout and operation
- Relocated explosive magazines to reduce travel time



# Breach Operation Committee

## Existing Composition

- Convener: Representative of department owning structure at which breaching section is located
- District Coordination Officer
- Representative from Highways Department
- Representative from Irrigation Department
- Representative Pakistan Army

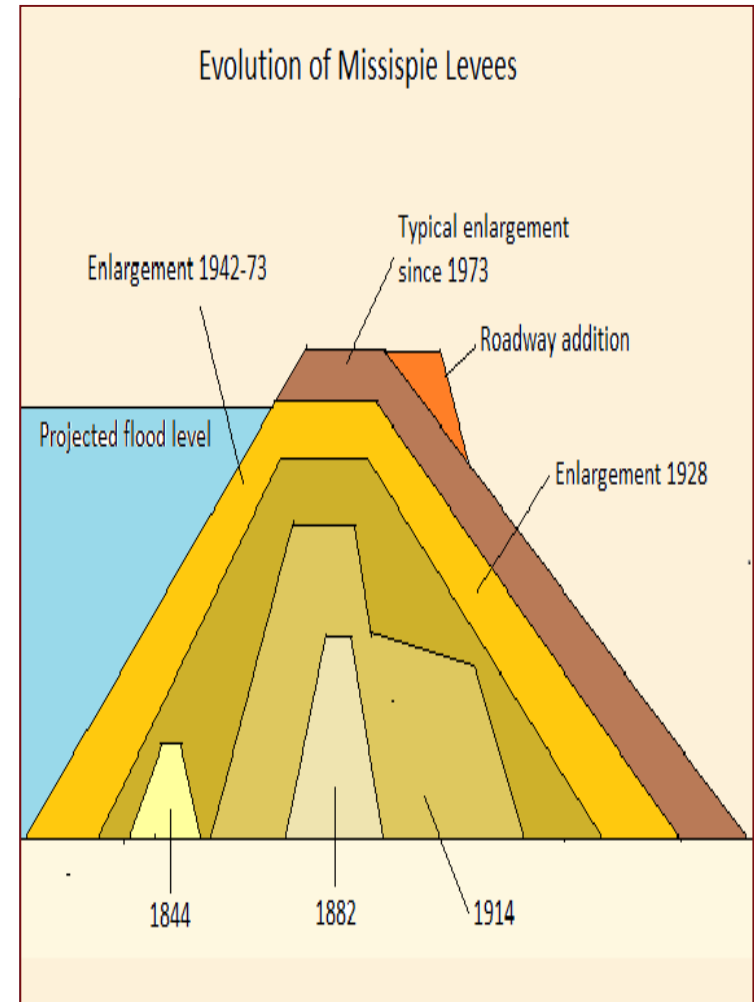
## Proposed Composition

- Convener: District Coordination Officer
- Representative of department owning structure at which breach section is located
- Representative from Highways Department
- Representative from Irrigation Department
- Representative Pakistan Army

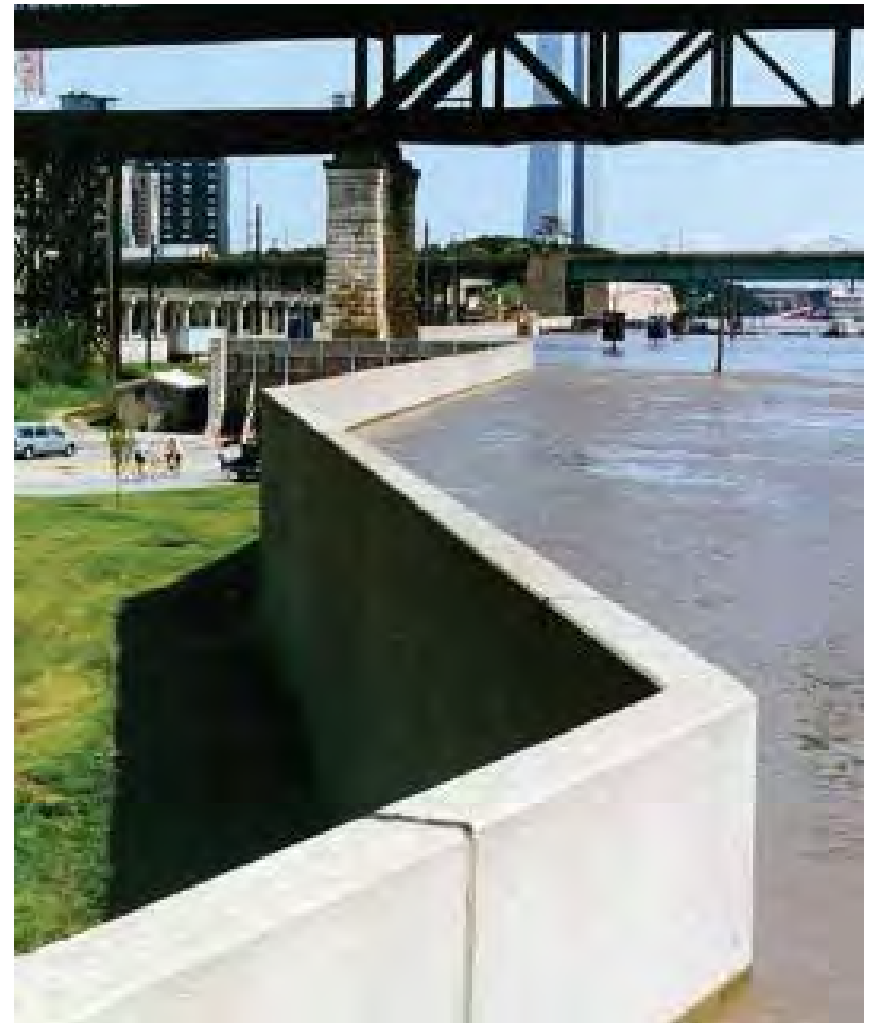
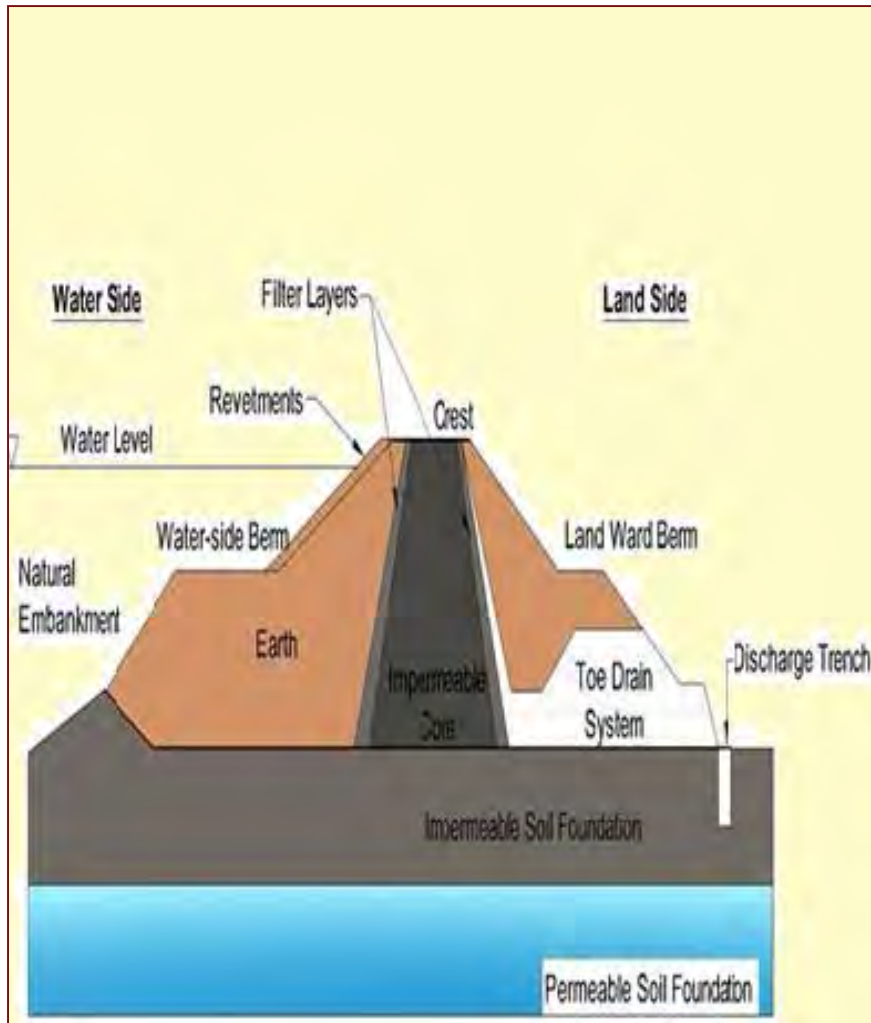


# Design & Construction: Present Methods

- Constructed by heaping local material
- Width and slopes provided to cover seepage line, height decided in view of last observed highest flood level
- No consideration for soil quality despite its link with seepage
- No protection against most causes of failure
- Cost effective
- But multiple risks gravely effect confidence in its ability to provide required protection



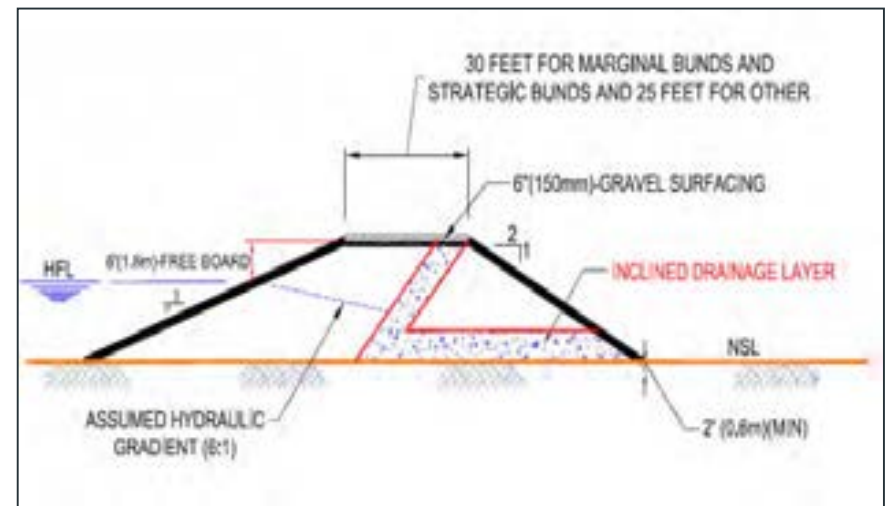
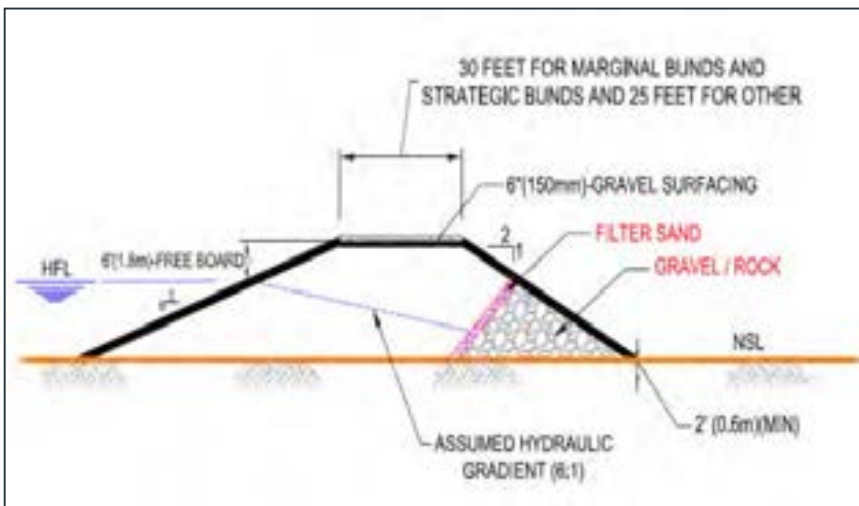
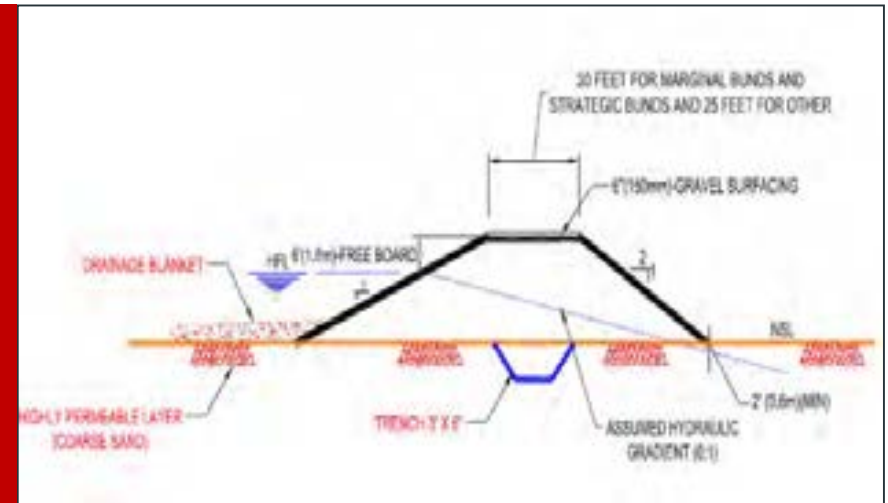
# Need for a New Design



# Basic New Designs

## Important Features

- Solution based engineering designs
- Can provide better protection against major vulnerabilities
- Site specific intervention decided after taking into account soil characteristics and other factors



# Categorization of Dykes

## Category A Dykes

- Sufficient safety against all common vulnerabilities
- Relatively expensive
- Protection of major urban centers, Left Marginal Bunds and other critical sites

## Category C Dykes

- Existing design: prone to risks but can work satisfactorily
- Cost effective
- Protection of rural areas and agricultural lands

## Category B Dykes

- Sufficient safety against most important vulnerability as per site condition
- Not as expensive as Category A dyke
- Protection of urban centers and other important sites

## Approximate Requirement

Length Category A dykes	113.70 miles
Length Category B dykes	350.76 miles
Length Category C dykes	1618.64 miles
Total	2083 miles



# New Methods

Collapsible barriers



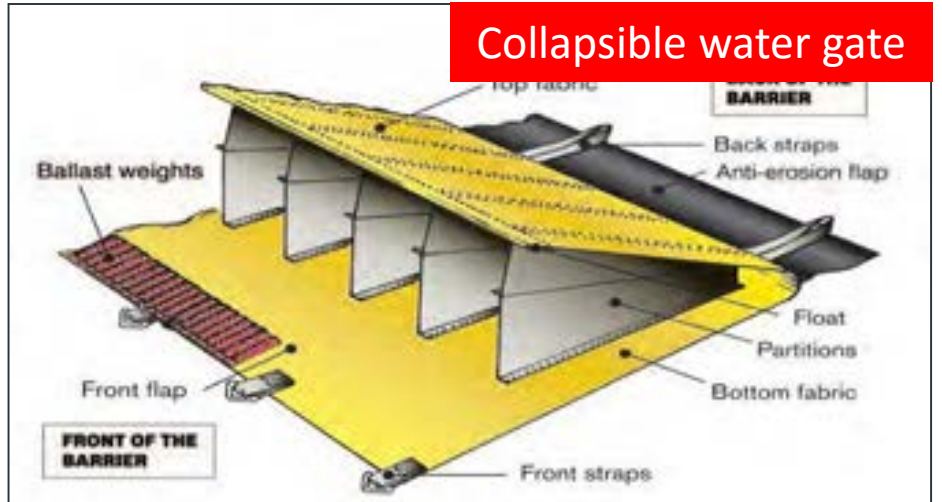
Water inflated barriers



Sheet piling

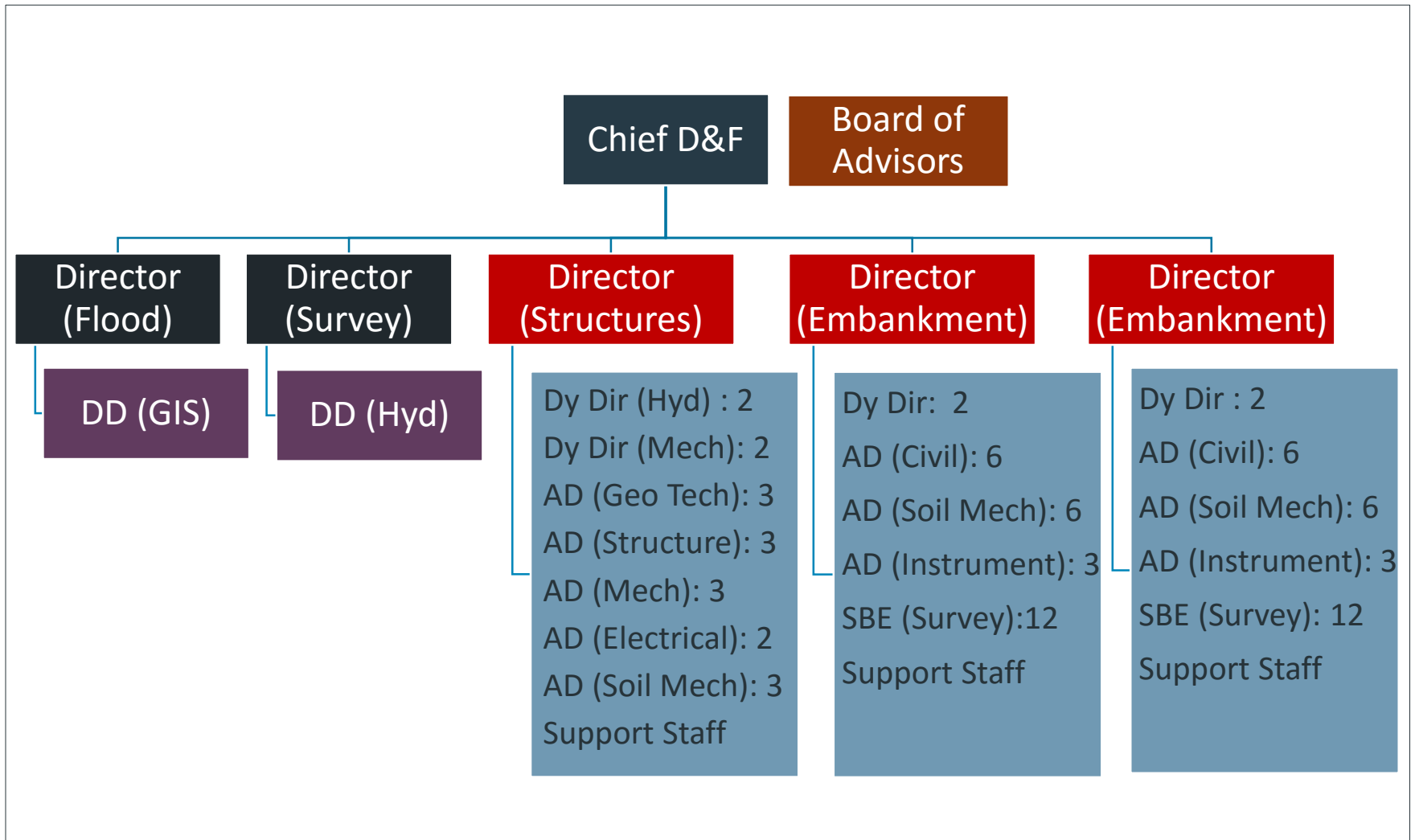


Collapsible water gate



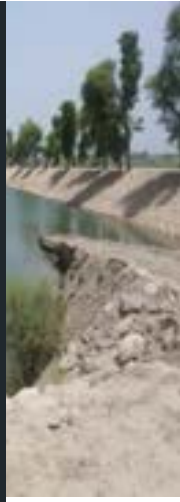


# Safety Evaluation Unit



# Safety Evaluation of Hydraulic Structures

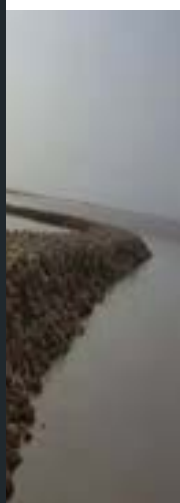
- A core staff of 46 officers, 09 staff arranged by converting existing positions
- Each year two regular inspections: immediately after flood and before commencement of next flood
- Maintain database of inspections, health status, geo technical information of flood protection infrastructure
- Ensure rectification of observations
- Complex matters referred to the Board of Advisors



Head Regulator



Canal Fall



Stud



# Testing of New Designs

- Design review of 17 dykes
- NESPAK recommendation: Providing impermeable, rodent proof core in critical dykes having geo-technical issues
- Four materials considered for core
- Construction methodology tested
- Results: Sheet piling for most sensitive dykes, Bentonite-cement-clay slurry for others

Parameter	Slurry	Sheet Pile
Cost per run foot:	Rs. 3065	Rs. 12551
Life:	20-40 Year	100 Year
Handling, constructability:	Very difficult	Easy
Quality assurance:	Very difficult	Easy
Damage to existing dyke:	Significant	No damage
Previous use in Pakistan:	Very rare	In Sindh
Protection levels:	Untested	Maximum



# Medium Term: DCRIP & FERRP

DCRIP (WB)	FERRP (ADB)	Soft interventions
<ul style="list-style-type: none"> <li>▪ Subprojects: 27 (cost Rs.9151m)</li> <li>▪ Duration: 4 years (2019)</li> <li>▪ Important projects:               <ul style="list-style-type: none"> <li>– Strengthening of Extension Minchin Flood Bund (Rs.509m)</li> <li>– Strengthening River Training Works of Islam Headworks (Rs.385m)</li> <li>– Restoration of Lakhi Flood Bund (Rs.293m)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>▪ Subprojects: 98 (cost Rs.6662.711m)</li> <li>▪ Duration: 3 years (2018)</li> <li>▪ Important projects:               <ul style="list-style-type: none"> <li>– Protection of Jhelum city (Rs.1687m)</li> <li>– Remodeling of Muzaffargarh, Akbar and Nawabpur, Jhang Flood Bunds (Rs.2435m)</li> <li>– Remodeling of LMB, Taunsa, Qadirabad and Marala Headworks (Rs.824m)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>▪ Establishment of hydraulic structures safety evaluation unit (Rs.20m)</li> <li>▪ Establishment of flood risk assessment unit (Rs.70m)</li> <li>▪ Training and capacity building (Rs.67.75m)</li> <li>▪ Assistance in flood zone mapping (Rs.40m)</li> <li>▪ Support in use of numerical models for hydraulic research (Rs.100m)</li> </ul>

DCRIP stands for “Disaster Climate Resilience Improvement Project”

FERRP stands for “Flood Emergency Reconstruction & Resilience Project”



# Capacity Enhancement of Barrages

River	Barrage	Designed Capacity (Lac Cs)	Main outcome	Remarks
Indus	<a href="#">Kalabagh</a>	9.50	Capacity restored to 9,50,000 Cs	Completed
Chenab	<a href="#">Khanki</a>	8.00	Capacity enhancement to 11,00,000 Cs	Completed
	<a href="#">Trimmu</a>	6.45	Capacity enhancement to 8,75,000 Cs	Completion by Apr 2019
	Punjnad	7.00	Capacity enhancement to 8,70,000 Cs	Completion by Mar 2020
Ravi	<a href="#">Balloki</a>	2.25	Capacity enhancement to 3,80,000 Cs	Completed
Sutlej	<a href="#">Sulemanki</a>	3.25	Capacity restored to 3,25,000 Cs	Completed

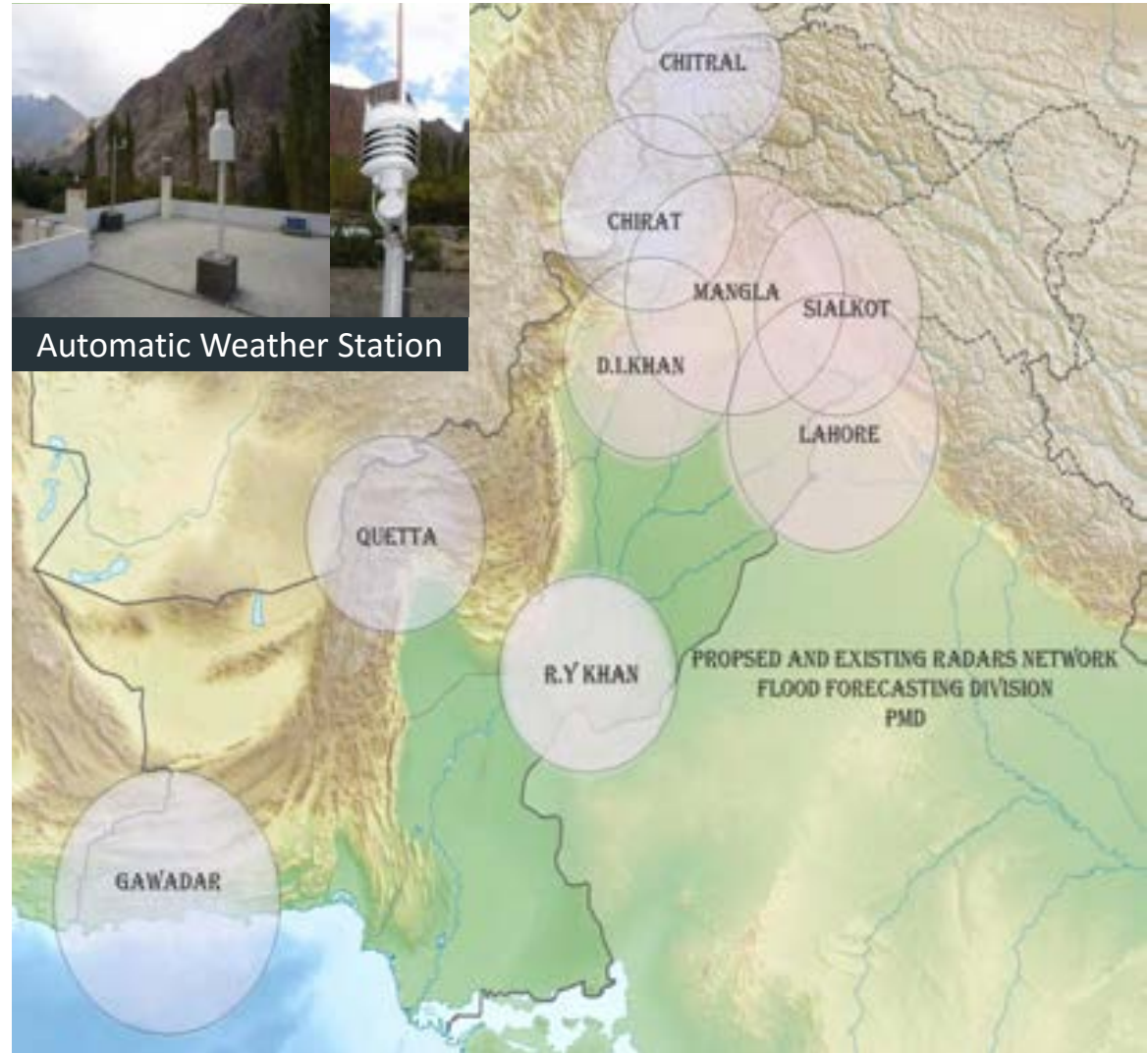


# Radar Coverage

- Up-gradation or replacement of radars at Lahore and Sialkot cover catchment areas of Jhelum, Chenab, Ravi, Beas and Sutlej
- Radar at RY Khan monitors path taken by Monsoon lows from Rajhistan to generate advance warning
- Major gap (for Punjab) exist in upper limb of Indus and hill torrents in DG Khan and Rajanpur

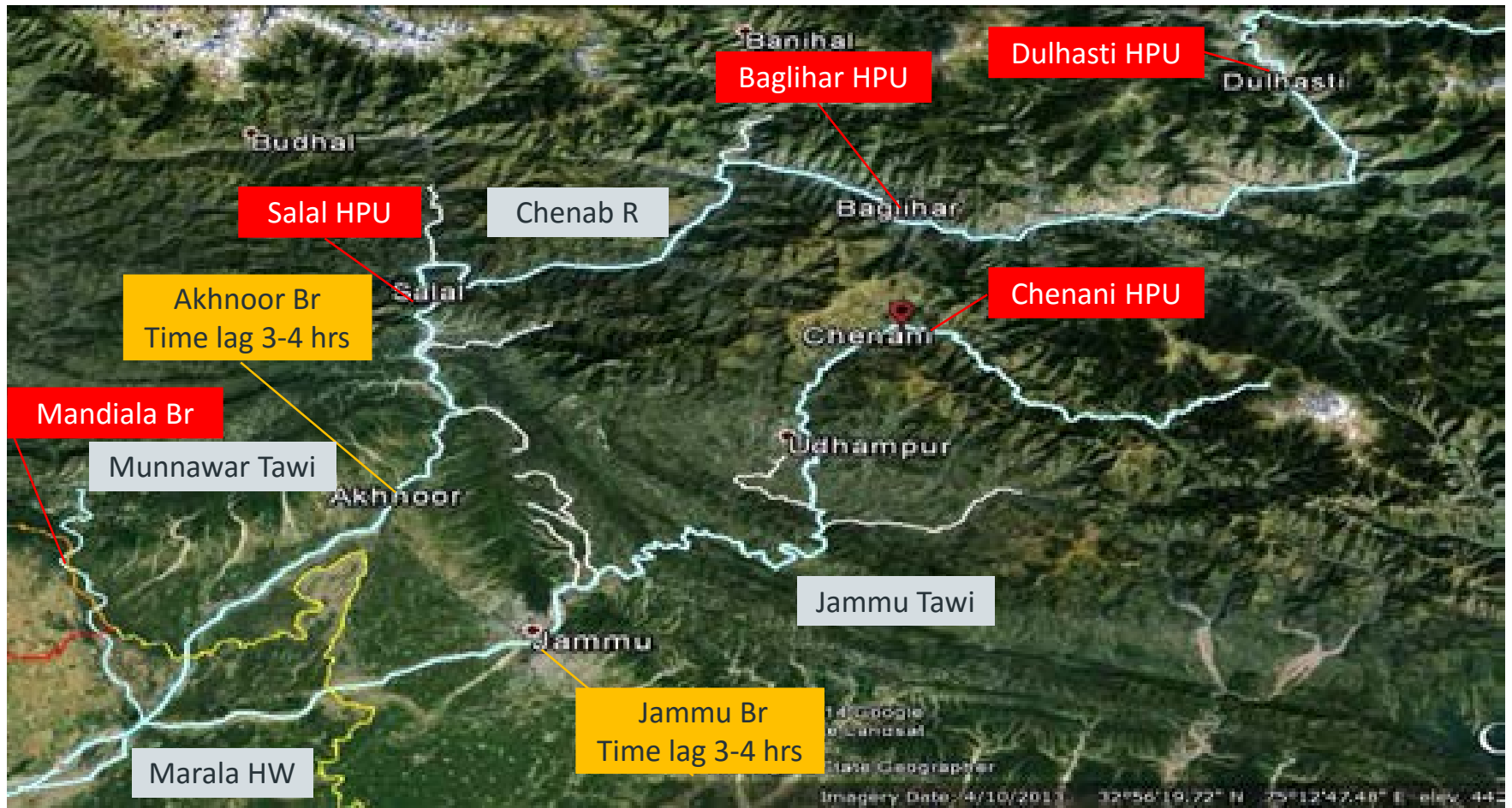


Automatic Weather Station





# Improved International Reporting

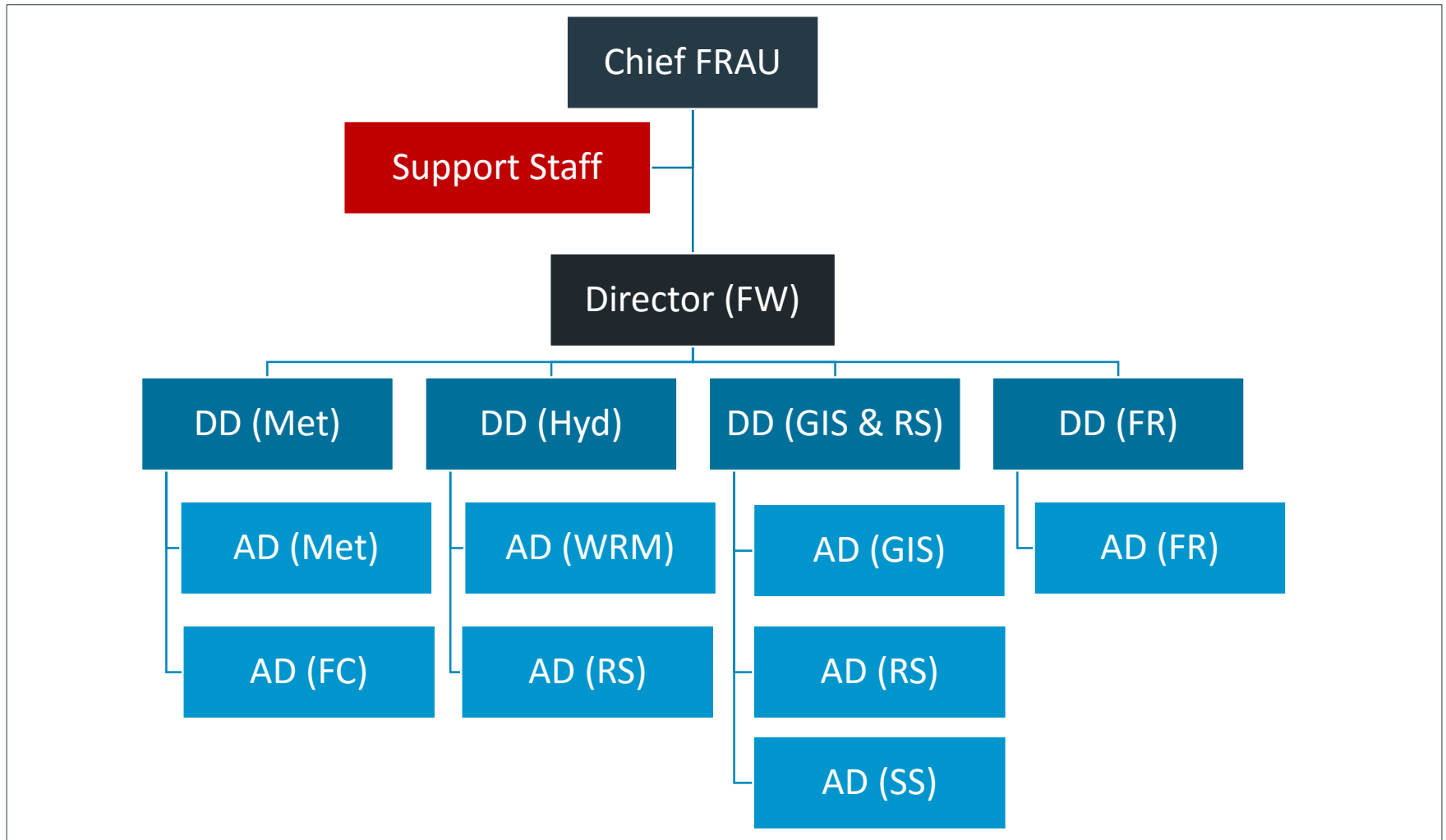




# Improved International Reporting



# Flood Risk Assessment Unit



# Major Tasks

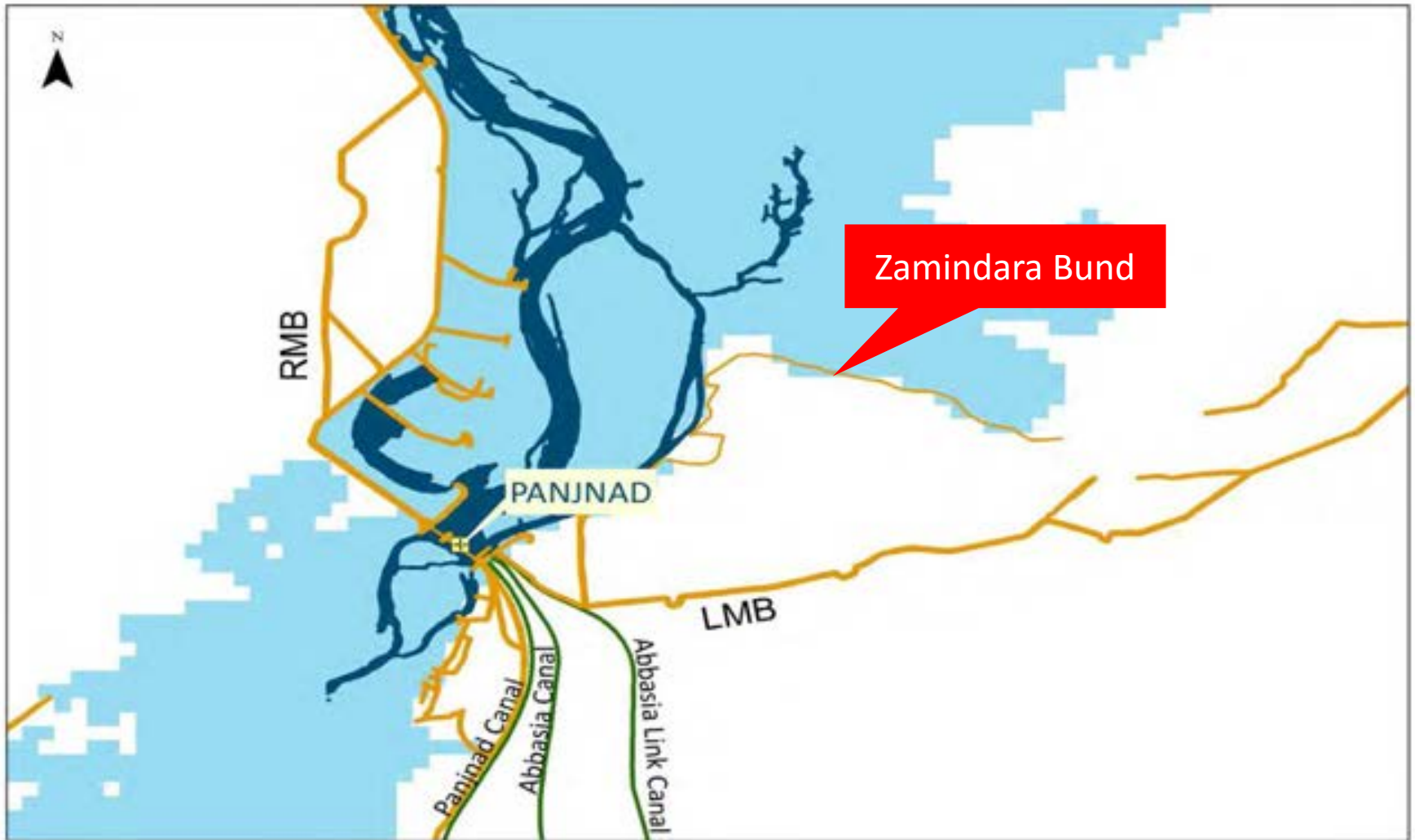
- [Rainfall forecasting](#) (2 to 3 Day)
- [Estimation and forecast](#) of flood peaks by integrated Hydrological and Hydraulic Models (1 to 2 Days)
- [Estimation of flood peak propagation](#)
- [Identification of Areas/Villages under threat](#) at specific range of discharges with in flood plain
- Dissemination of inundation prediction maps and relevant reports to field officers for better management and decision making
- Daily monitoring and processing of flood situation by daily satellite imagery
- In case of breach of bund or canal, identification of villages under threat of inundation and predict water paths using GIS



# Flood Plain Regulation Act

- Government authorized to notify natural course of rivers etc. and area required for undertaking a future water resource development project to be subject to the Act
- All construction in notified area whether public or private to be subject to permission from a committee notified by Government
- Any construction considered to be dangerous on ground of structural safety or flood related impact on other structures to be prohibited
- Requirement upon respective local government and other relevant authorities to specify special building code
- Unauthorized construction an offence and power to remove it
- Right of appeal and review against decisions

# Removal of Zamindara Bunds





# Pond Area

Headworks	Pond area	Wildlife	Forest	Army	Private	Irrigation
Marala	1675	1245	-	430	-	-
Taunsa	25932	16225	-	-	9707	-
Trimmu	3680	3680	-	-	-	-
Islam	9989	6989	-	-	3000	-
Sulemanki	2852	-	-	2852	-	-
Balloki	2953	2953	-	-	-	-
Rasul	5256	1016	-	548	-	3692
Jinnah	3893	3893	-	-	-	-
	48	-	-	-	-	-
	5	-	-	547	-	-
	7	-	1378	-	178	7095
	42	-	1378	4377	12885	10787

- Approx return @ Rs. 7000 per acre = Rs. 421m per annum
- Sufficient to meet cost of maintaining pond area and clear waterway of bridges





# Flood Zone Mapping

- Topographical maps for major rivers and important tributaries developed and shared with field formation for flood mitigation
  - ✓ [Flood Plain and Flood Risk Mapping \(River-wise\)](#)
  - ✓ [District Level Submergence Plan](#)
  - ✓ [Flood Management Atlas](#)
  - ✓ [Flood Plain Demarcation](#)
  - ✓ [Classified Spatial Extents of Flood Inundation using historic satellite imagery](#)



# Improved Flood Management Committee

- Dam authorities continued to fill the dam instead of high to very high flood warning from 5<sup>th</sup> – 7<sup>th</sup> Sep
- Outflow maintained to 7513 Cs from 3<sup>rd</sup> – 5<sup>th</sup> Sep
- Outflows increased abruptly in no time in such a way that inflow = outflow (Q = 486269 Cs)
- Repeat flooding from Jhelum despite presence of Mangla Dam indicated problems with dam SOPs

DD Security

New committee

CE Mangla

FFC

IRSA

PID

AJK

RE WAPDA

- Equal voting rights of members and chairperson
- WAPDA would still have control to ensure dam safety
- In case of Tarbela, a nominee from Sindh shall be included



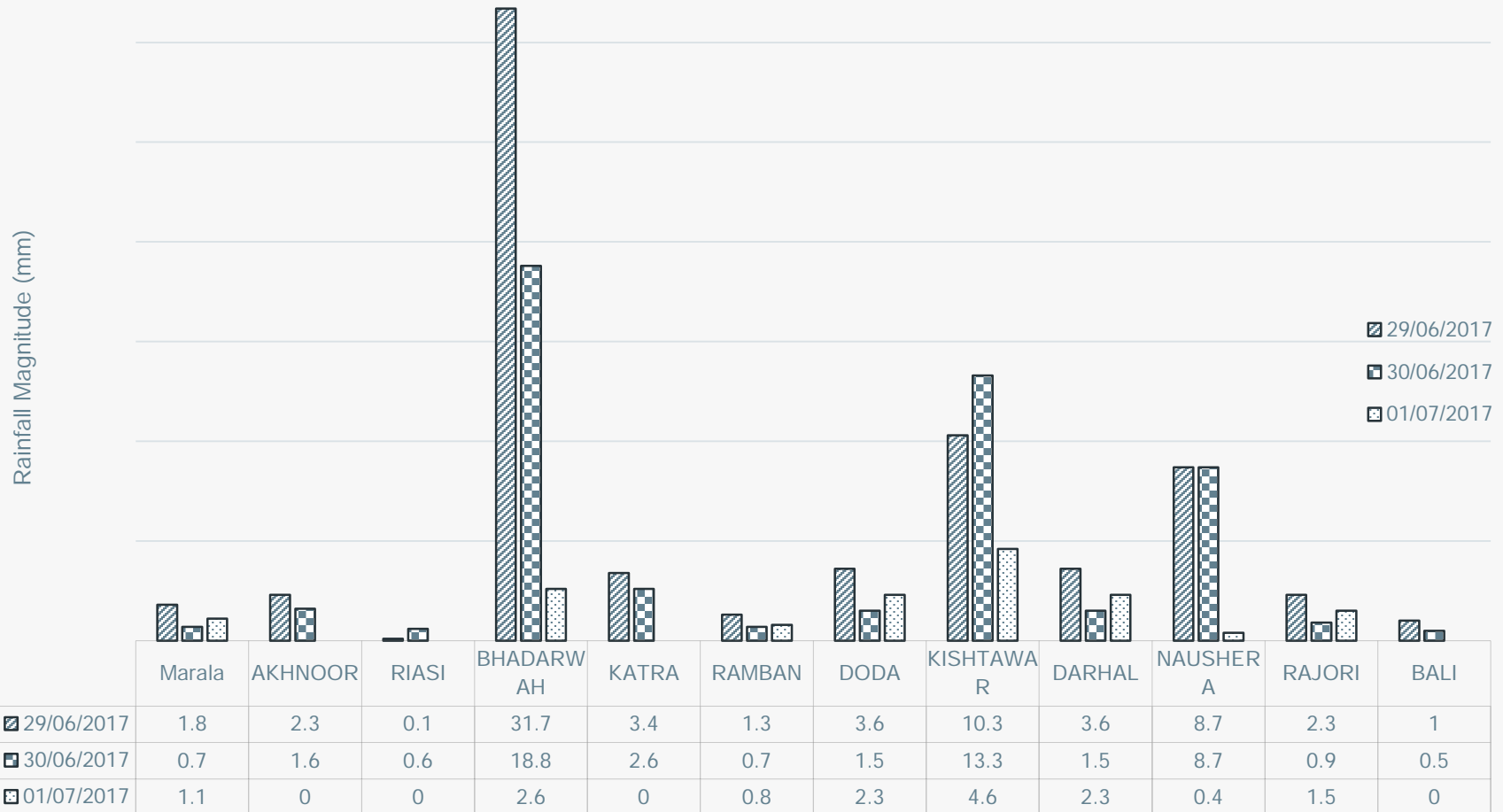
# Qualification of Barrage Staff

Position	Qualifications	Experience
Executive Engineer	B.Sc. Civil Engineering, preferably M.Sc. Civil Engineering or a related discipline	<ul style="list-style-type: none"><li>▪ Minimum 3 year experience of barrage operation as SDO</li><li>▪ 3 year experience of flood management</li><li>▪ Good service record</li></ul>
Sub-Divisional Officer	B.Sc. Civil Engineering, preferably M.Sc in Civil Engineering or a related discipline	<ul style="list-style-type: none"><li>▪ General experience of 5 years in the Department including 2-3 years experience of flood management</li><li>▪ Good service record</li></ul>
Sub-Engineer	Diploma in Civil Technology Preferably B. Tech/B. Tech. Honours	<ul style="list-style-type: none"><li>▪ General experience of 5 years in the Department</li><li>▪ Good academic and service record</li></ul>

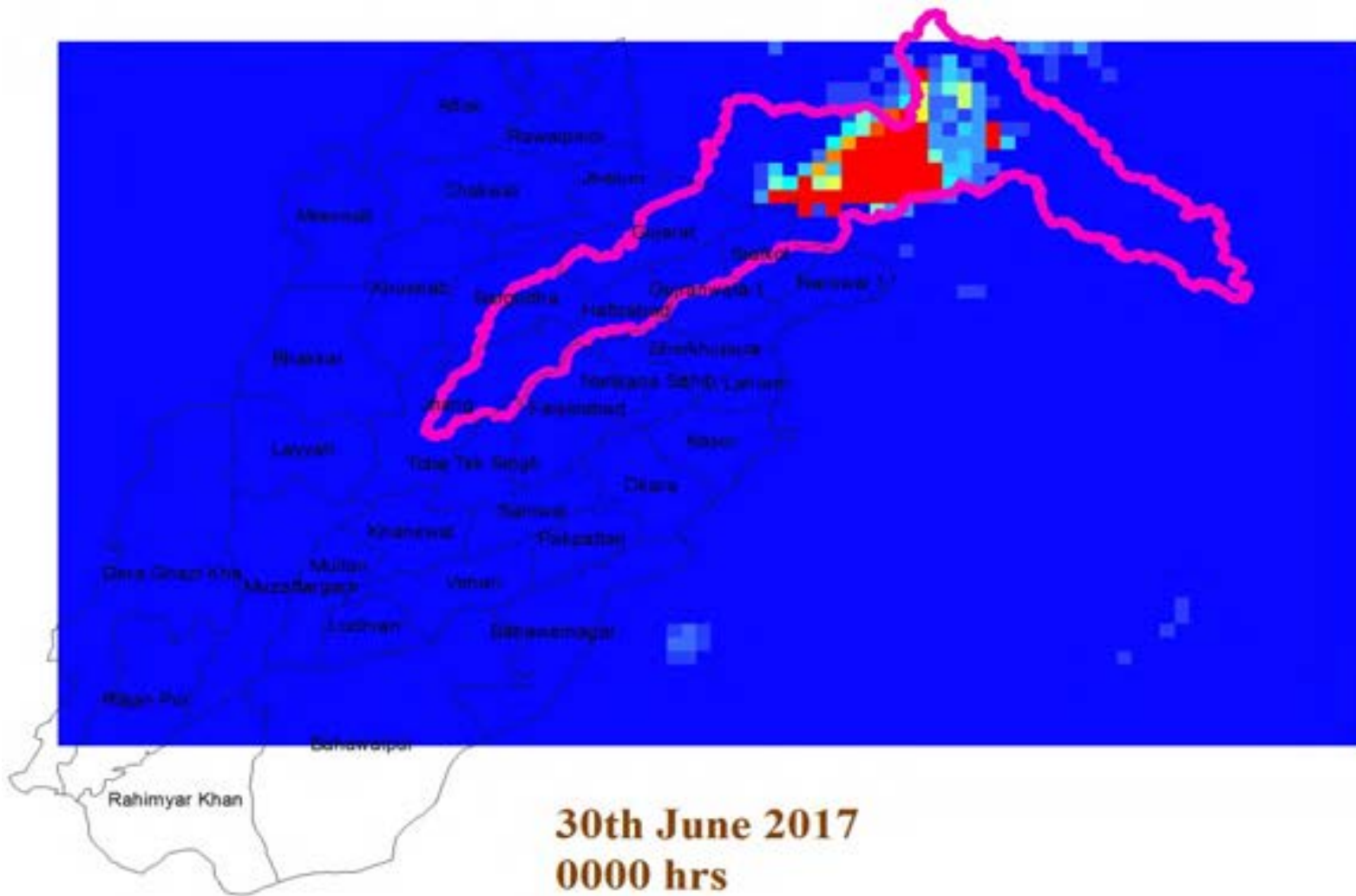


# Rainfall Forecast

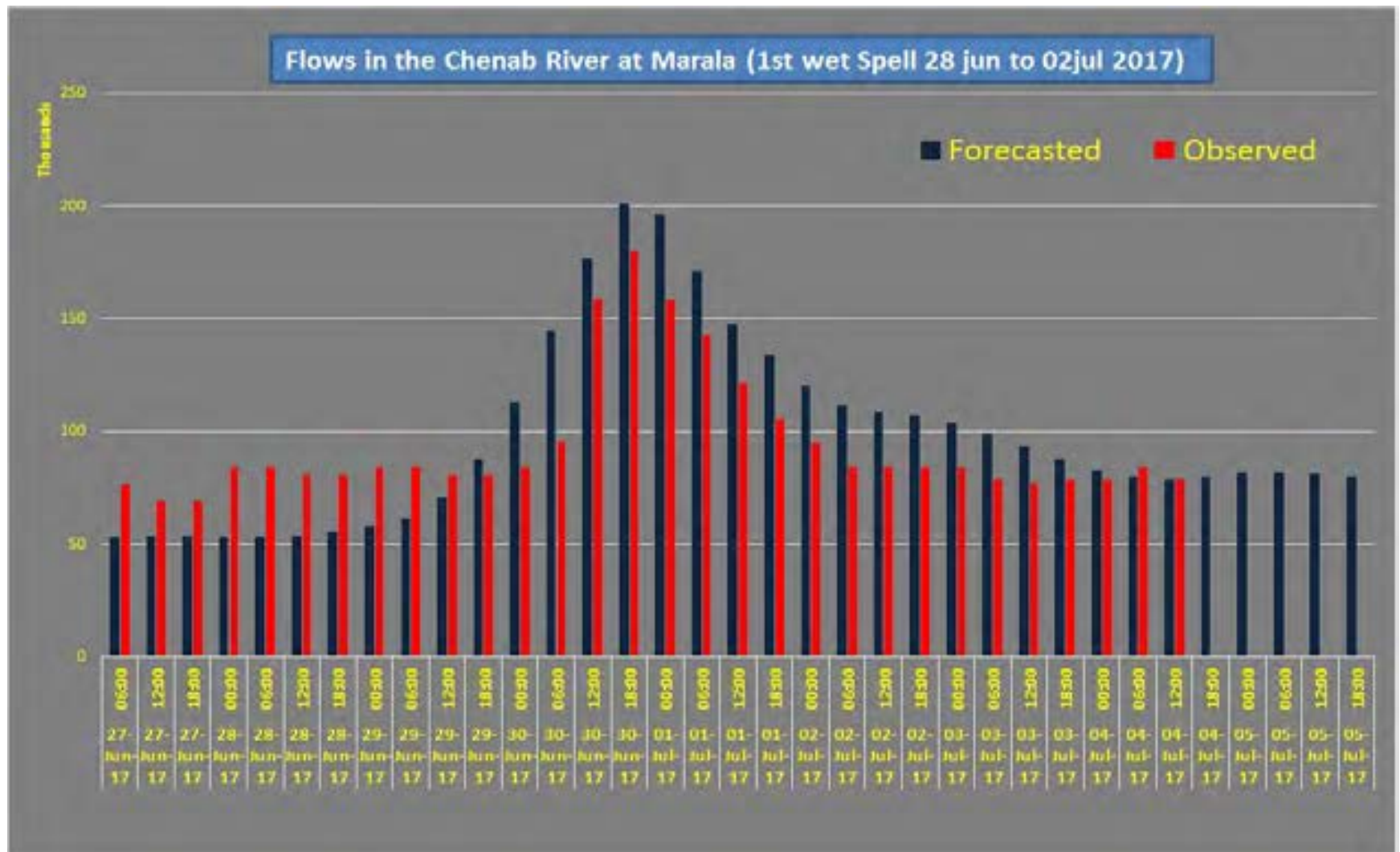
Forecasted Rainfall for Chenab River Catchments (29/06/2017)



# Real time Storm Observation

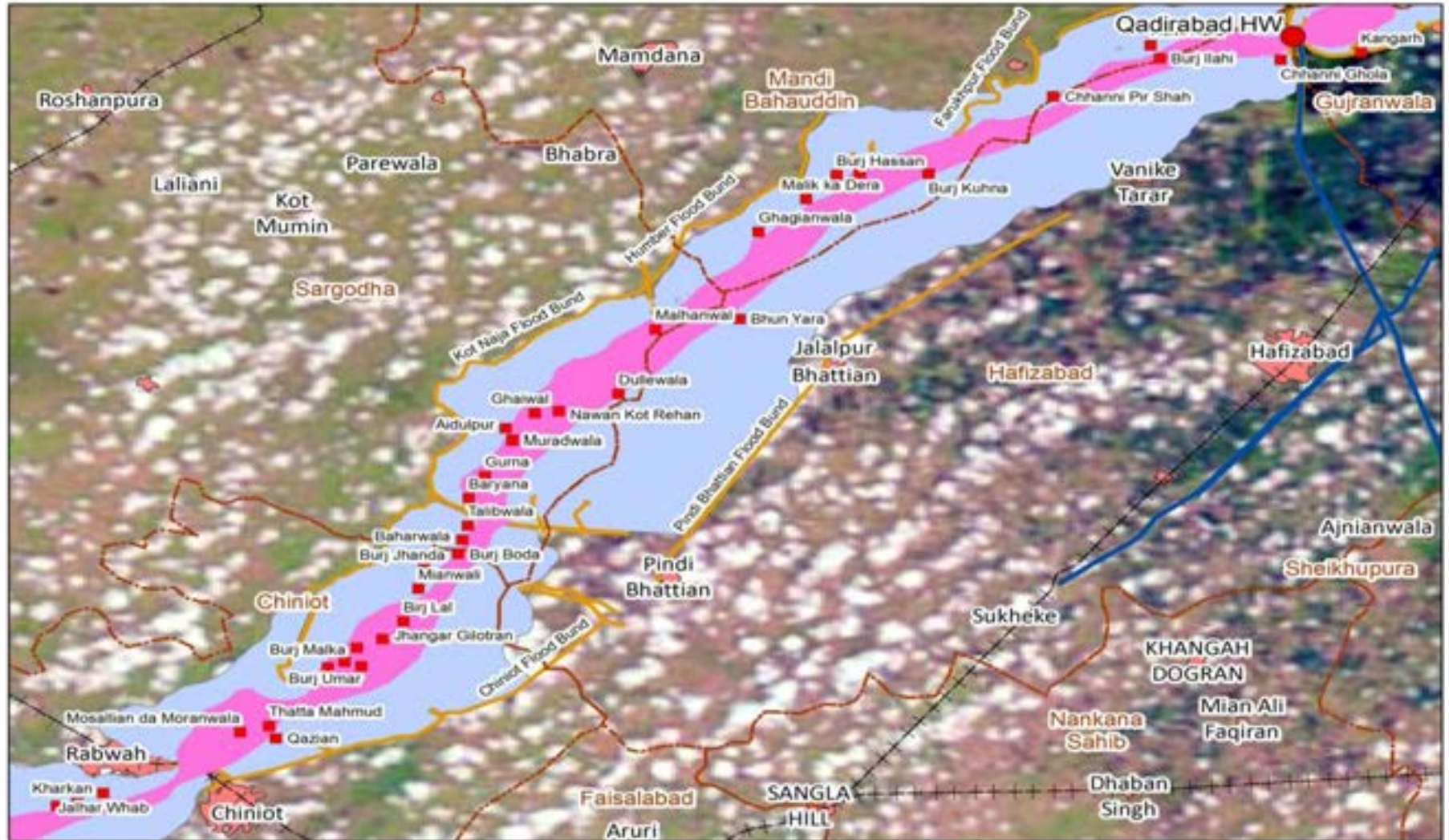


# Forecasted and Observed Flows





# Villages under Threat



# Jinnah Barrage

Aerial View



SCADA control room



Replacement of barrage gate



Rehabilitated Kalabagh Rly Br





# New Khanki Barrage

Old Khanki Weir



Tunnel Type Silt Excluder



New Khanki Barrage



Gantry Crane



# Trimmu Barrage

Concrete Batching Plant



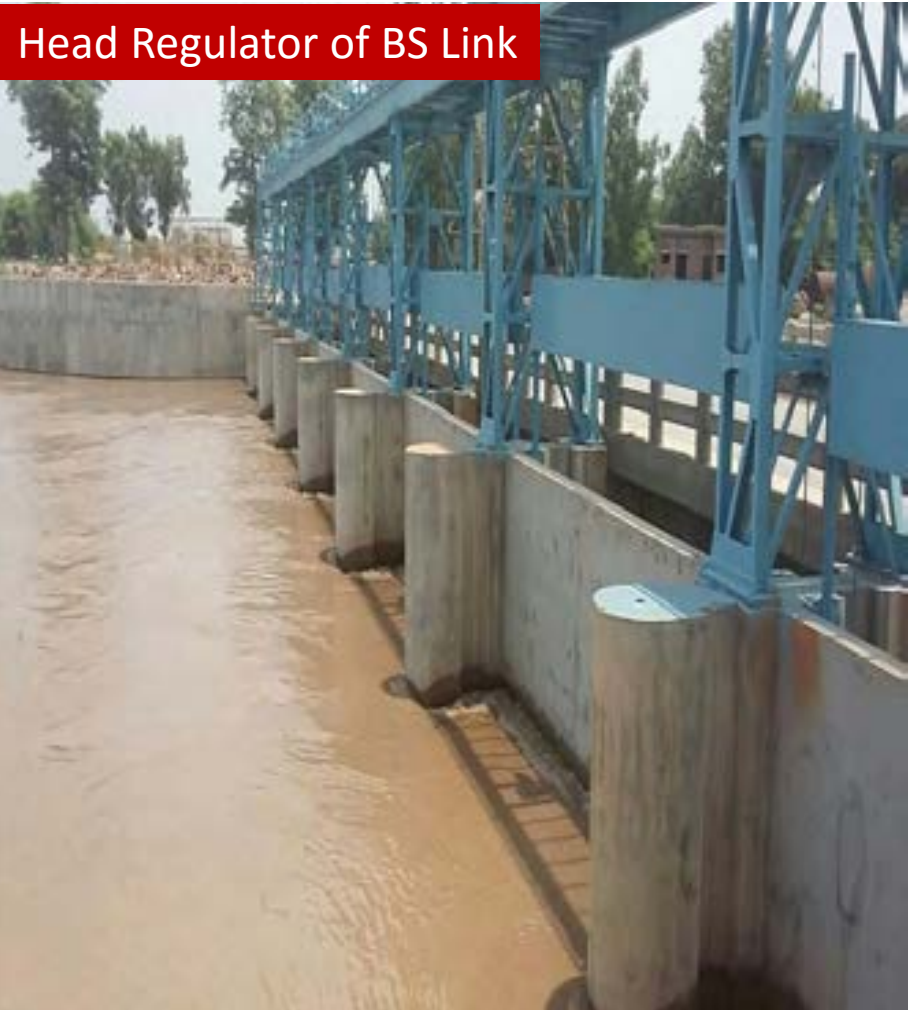
Construction of additional Bays



Strengthening of Barrage Floor



# Balloki Barrage





# Sulemanki Barrage

Driving of Sheet Piles



Settlement of Divide Wall



Replacement of gates



Repaired Divide Wall







GOVERNMENT OF PAKISTAN  
 MINISTRY OF WATER AND POWER  
 PROJECT MANAGEMENT & POLICY IMPLEMENTATION UNIT (PMPIU)

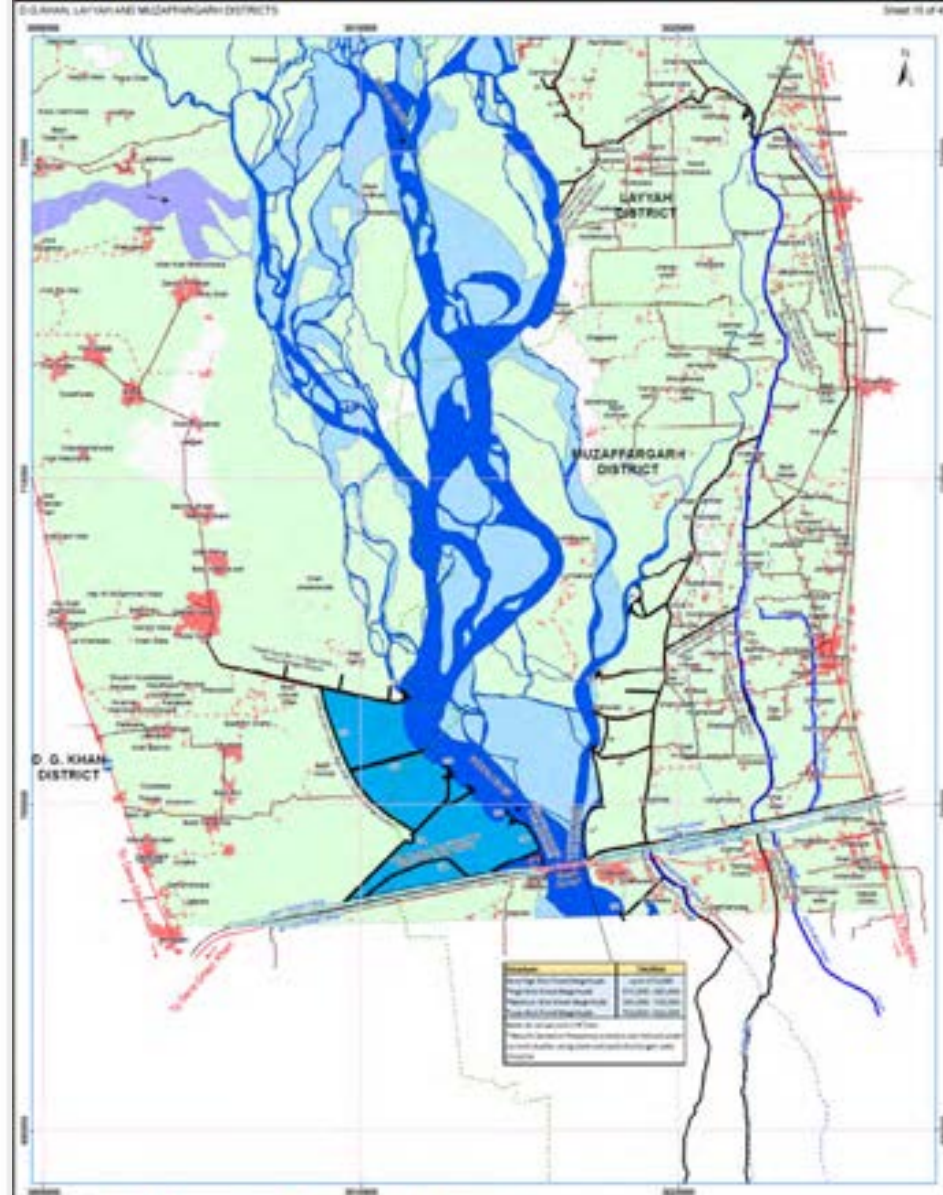
Water Sector Capacity Building and Advisory  
 Services Project (WCAP)

Development of National Flood Protection Plan-IV (NFPP-IV)  
 and Related Studies to Enhance the Capacity of  
 Federal Flood Commission-FFC

## FLOOD PLAIN AND FLOOD RISK MAPPING

### RIVER UPPER INDUS (RIVER INDUS IN PUNJAB AND KHYBER PAKHTUKHWA)

JANUARY 2016





GOVERNMENT OF PAKISTAN  
 MINISTRY OF WATER AND POWER  
 PROJECT MANAGEMENT & POLICY IMPLEMENTATION UNIT (PMPIU)

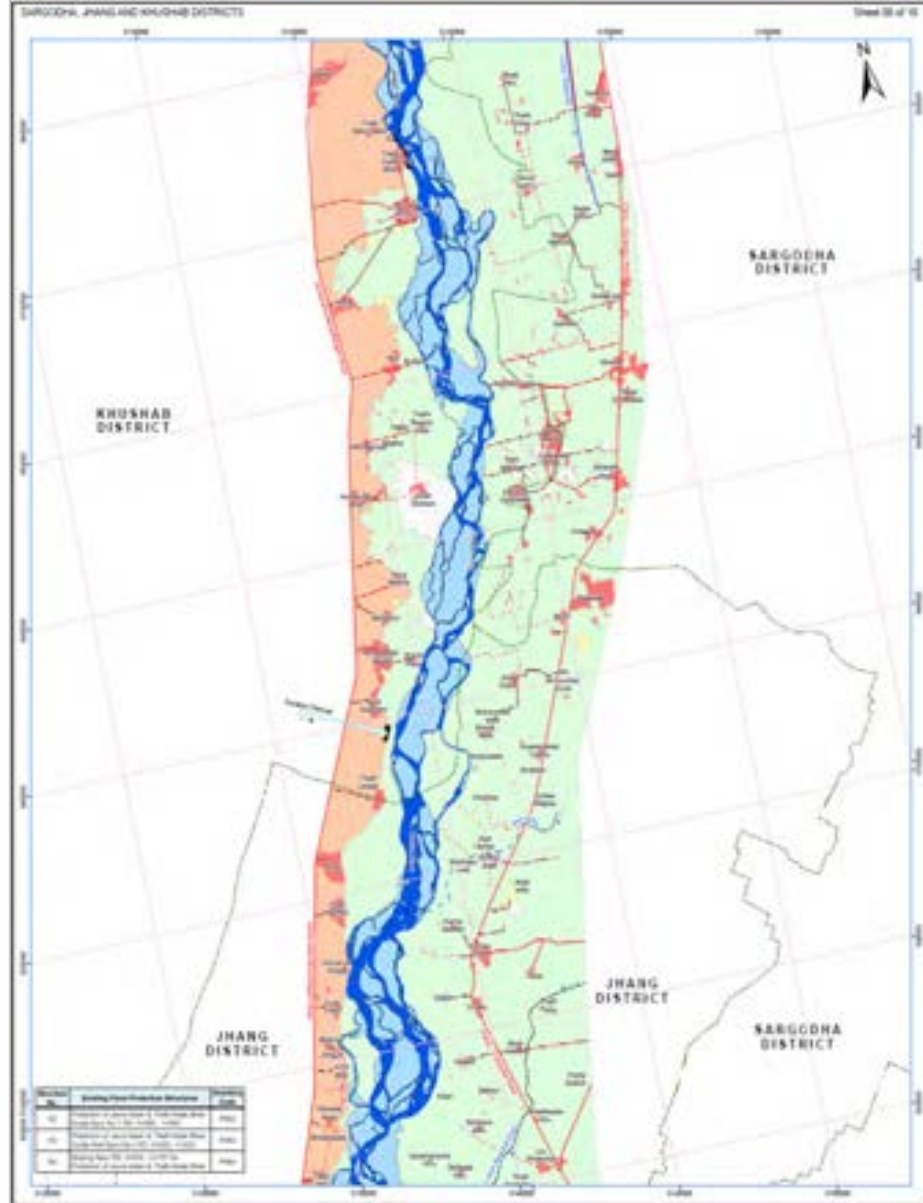
Water Sector Capacity Building and Advisory  
 Services Project (WCAP)

Development of National Flood Protection Plan-IV (NFPP-IV)  
 and Related Studies to Enhance the Capacity of  
 Federal Flood Commission-FFC

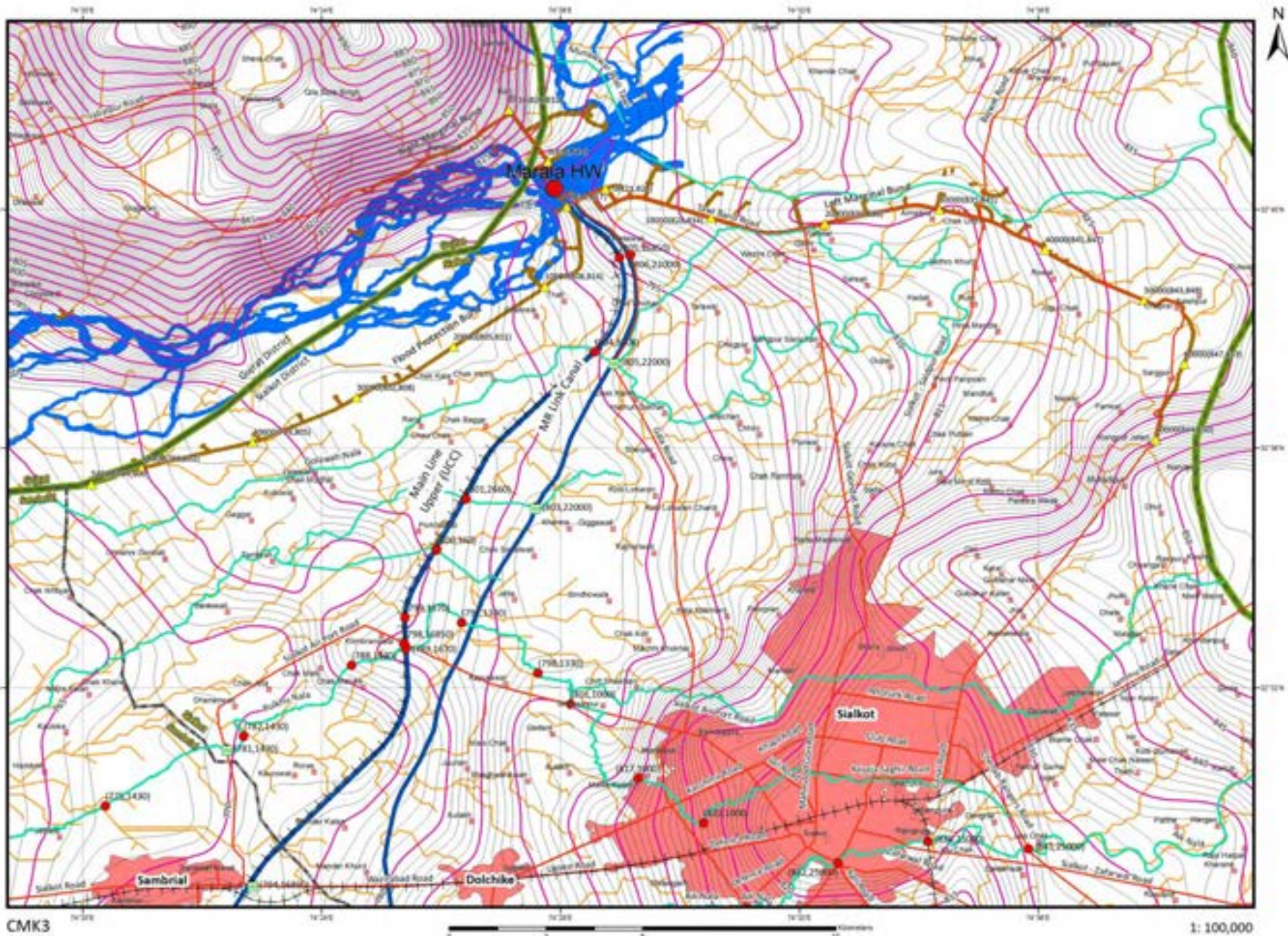
## LANDUSE AND DISTRICT LEVEL SUBMERGENCE PLANS

### DISTRICT JHANG PUNJAB PROVINCE

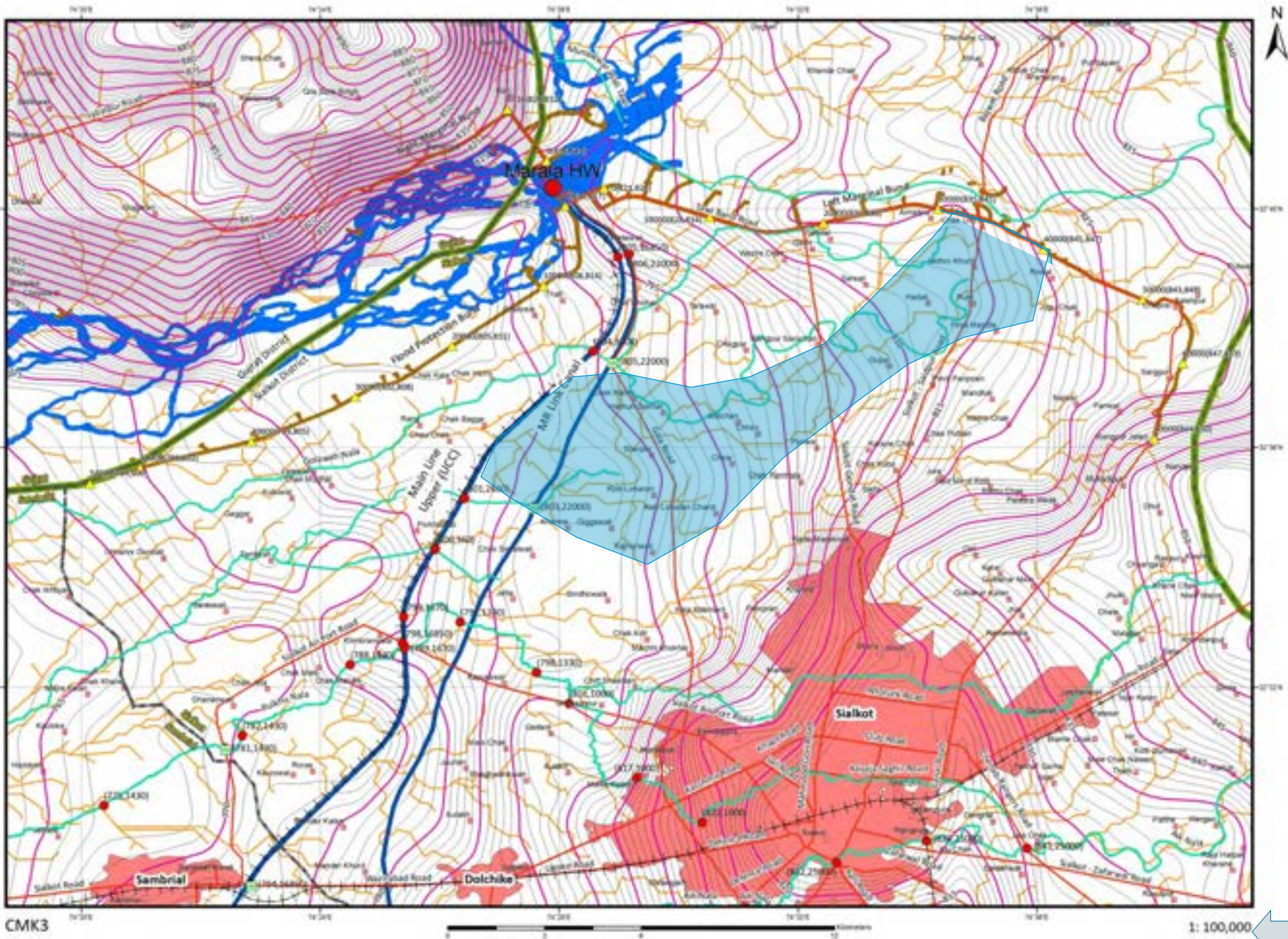
JANUARY 2016











CMK3

1: 100,000





ID	Longitude	Latitude	River	River Bank	Division	Circle	Irrigation Zone
3692	73.190251	31.922000	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3693	73.197605	31.909685	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3694	73.188405	31.897560	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3695	73.174278	31.885430	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3696	73.181602	31.877157	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3697	73.182470	31.862769	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3698	73.173212	31.852401	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3699	73.162832	31.841732	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3700	73.170038	31.829266	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3701	73.180160	31.818476	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3702	73.188657	31.807818	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3703	73.153782	31.800621	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3704	73.138391	31.794701	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3705	73.110938	31.791145	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3706	73.113806	31.781239	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3707	73.099434	31.774608	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3708	73.083289	31.770888	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3709	73.066677	31.768030	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3710	73.050748	31.763224	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3711	73.042410	31.764503	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3712	73.035299	31.757078	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3713	73.020112	31.751119	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3714	73.004285	31.745972	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3715	72.988816	31.741700	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3716	72.974205	31.748036	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3717	72.970025	31.737776	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3718	72.960608	31.727060	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3719	72.967205	31.712992	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3720	72.947544	31.701291	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3721	72.934856	31.691958	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3722	72.919665	31.686067	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3723	72.904198	31.680140	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3724	72.890845	31.671615	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3725	72.874630	31.668951	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3726	72.858181	31.663139	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3727	72.842698	31.658771	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3728	72.827551	31.651303	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3729	72.812523	31.644615	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3730	72.797310	31.638275	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3731	72.782317	31.631954	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3732	72.766834	31.626476	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3733	72.751796	31.619894	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3734	72.736196	31.614280	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3735	72.723169	31.605190	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3736	72.707294	31.600393	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3737	72.691095	31.596243	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3738	72.674668	31.598038	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3739	72.658305	31.601298	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3740	72.642500	31.595645	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3741	72.627090	31.591757	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3742	72.610269	31.586876	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD
3743	72.597097	31.581309	Chenab	Left Bank	FSD Canal	LCC West	FAISALABAD

