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## INTRODUCTION

Floods are the one of the most destructive natural disasters, and its effects can only be reduced by accurate forecast and its timely dissemination to the concerned agencies and public. The quantum of flood depends upon the type of rainfall and its duration, which can be monitored through weather radars, satellite, computer models and telemetric network & by the network of meteorological observatories. Pakistan Meteorological Department (PMD) has its own network of weather radars & meteorological observatories while telemetric rainfall of the catchments area is received through Water and Power Development Authority (WAPDA).

The Flood Forecasting Division Lahore, since its beginning is serving the nation by issuing flood forecasts during each flood season (15<sup>th</sup> June, 2009 to 15<sup>th</sup> October). The compilation of flood report after each flood season is an annual feature observed by Flood forecasting division (FFD) Lahore of Pakistan Meteorological Department (PMD).

Flood report for the year 2009 has been prepared under the able guidance and kind instructions of Director General, Meteorological Services and Chief Meteorologist FFD. It contains all the details relating to flood forecasting like tracks i.e. the paths of monsoon lows/depressions, rainfall during wet spells, hydrographs of flood peaks, monthly and seasonal Isohyetal maps, normal isopercental maps, area weighted Rainfall, Rainfall normal maps, damages and losses due to floods, flood limits, flood evaluation report, reduced Level of Water in the Indus River and recommendation.

It is worth mentioning here that water availability forecast for the Kharif Season was also issued on experimental basis for the Tarbela and Mangla Dams. It was anticipated that 76 MAF water would be available for the Kharif Season. It was mainly based on the snowmelt contribution. This forecast was issued at the start of Kharif Season. It also included the Monsoon rainfall contribution. However, the Monsoon rainfall contribution was not upto the expectation and a revised less forecast Monsoon rainfall (-30% below normal) was issued due to Elnino development. Consequently the water availability forecast was also affected at the end of the season and it was observed that total volume arrived in these two dams was 63.24 MAF against the forecast of 76 MAF.

Credit is also given to Federal Flood Commission Islamabad for taking immediate and prompt actions as coordinating agency in case of any flood event through out the country besides providing technical and financial assistance to the quarters for enhancing their capabilities and capacity building.



## **HYDROMETEOROLOGICAL REPORT 2009**

### **1. HIGHLIGHTS**

- 1.1 A total number of four Monsoon lows/Depressions originated from the Bay of Bengal, however only three out of these four were able to reach in the vicinity of Pakistan.
- 1.2 The seasonal precipitation (July to September) Isopercental pattern indicates above normal rainfall over lower Sindh whereas slightly above normal rainfall was experienced over lower NWFP & adjoining Punjab. Western Balochistan remained almost dry during the monsoon season 2009.
- 1.3 During July 2009, unprecedented torrential rainfall over southern & southeastern Sindh caused urban flooding in the area.
- 1.4 Nine rain bearing spells occurred during monsoon season 2009.
- 1.5 On all Pakistan basis 26% below normal rainfall was recorded during Monsoon season 2009, while PMD predicted 30% below normal.
- 1.6 Flood Forecasting Division, Lahore continued to maintain the liaison with the dam operating authorities at Mangla and Tarbela, in order to link the dam operations with the weather/flood forecasts.
- 1.7 Generally, normal flow conditions prevailed in all the major rivers during flood season 2009.



## 2. TRACKS OF LOWS/DEPRESSIONS DURING MONSOON SEASON-2009:

During monsoon season (15<sup>th</sup> June to 15<sup>th</sup> October) 2009, four monsoon lows/depressions originated from Bay of Bengal and moved west-northwest wards. The tracks of the lows/depression are shown in fig. I.

### TRACKS OF MONSOON LOW/DEPRESSION

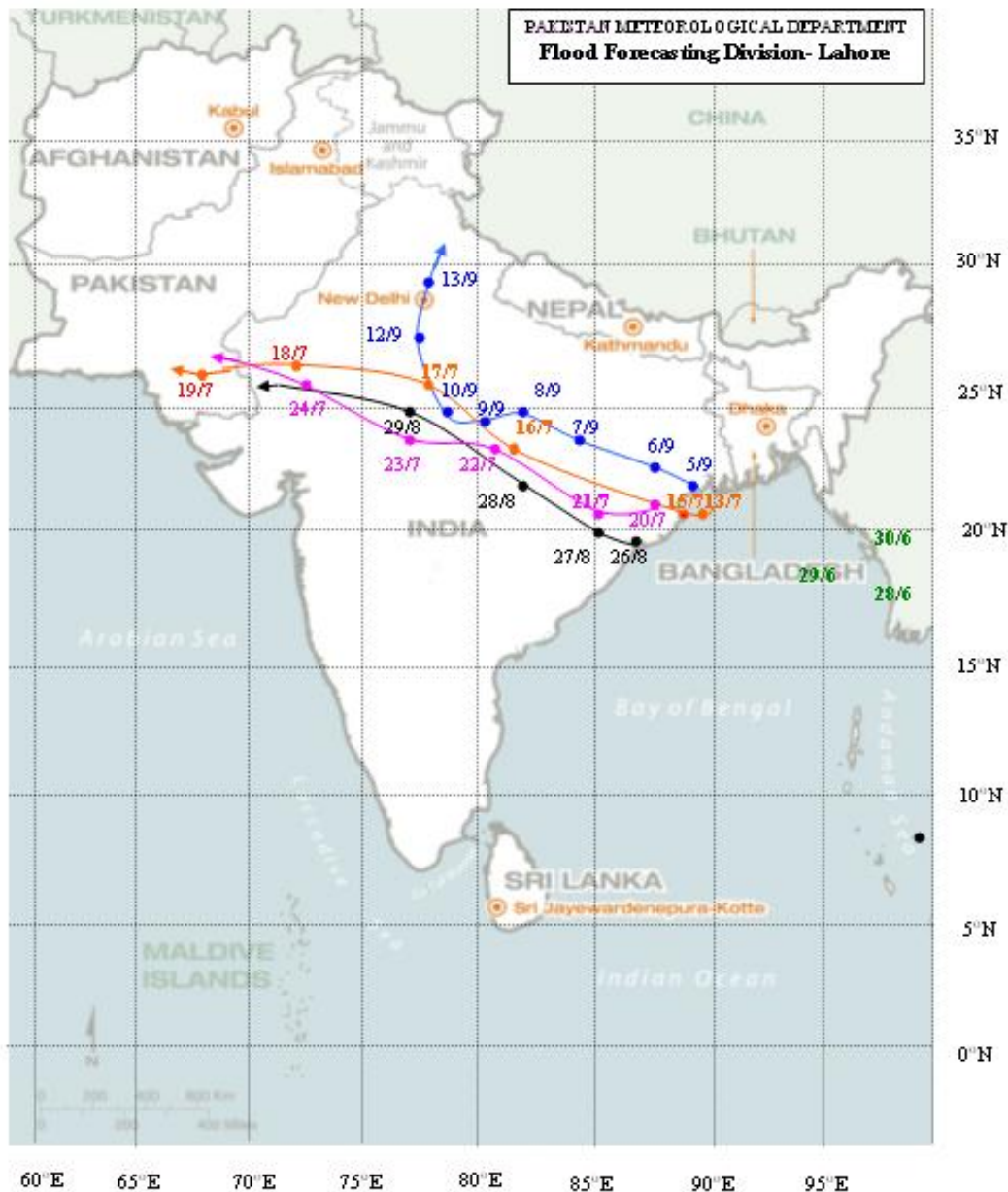


Fig.1 : Tracks of Monsoon low/Depression during Flood season 2009



Two monsoon Lows/depressions were formed over Bay of Bengal during the month of July. First monsoon low was developed over Northwest Bay of Bengal on 13<sup>th</sup> July 2009 and converted into depression on 14<sup>th</sup>. It adopted a west-northwest track, then started losing its strength and turned into well marked low on 15<sup>th</sup> July. After crossing Madhya Pradesh (India) it finally reached over Southeastern parts of Rajasthan on 18-07-2009 as a monsoon low .It moved continuously in the same direction and reached over Sindh on 19<sup>th</sup> July, 2009 where the torrential rains were recorded which caused urban flooding in the area. The second monsoon low developed over northwest Bay of Bengal on 20<sup>th</sup> July,2009 which again developed into depression on 21<sup>st</sup> July, 2009, it also took the same course as first, weakening gradually and reached the southern parts of Rajasthan on 24<sup>th</sup> July 2009 as a low, and from here it moved further towards Sindh where it later on dissipated. Due to this weather system moderate rains with isolated heavy falls were recoded over south & Southeastern parts of Sindh.

During the month of August only one monsoon low developed in the Bay of Bengal on 27-08-2009, which initially moved rapidly in a northwesterly direction and reached over southeast Madhya Pradesh India on 28-08-2009. After moving west northwestwards it reached Northwest Madhya Pradesh (India) and adjoining Rajasthan on 29-08-2009 and weakened gradually. Under its influence moderate to heavy rainfalls were recorded over southeast Sindh.

During the month of September, only one monsoon low originated from North Bay of Bengal, on 05-09-2009, which took a west northwesterly course till it reached over northern parts of Madhya Pradesh on 10-09-2009. From here it moved north-northeastwards and dissipated over there without affecting Pakistan.

### **3. SIGNIFICANT HYDROMETEOROLOGICAL EVENTS DURING THE MONTH OF JUNE, 2009:**

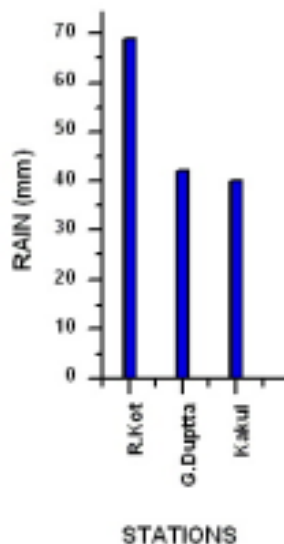
#### **3.1 METEOROLOGICAL EVENTS:**

During the month of June 2009 no Monsoon low was developed over Bay of Bengal and Arabian Sea , which could produce significant rainfall in Pakistan. The rainfall which occurred over Pakistan during the June was due to the accentuation of seasonal low, passing of westerly waves in the north of the country and influx of monsoon current from Arabian Sea. Only one rainfall spell occurred during the period, which is described here.



### 3.1.1 WET SPELL OF JUNE 2009 ( FROM 15-06-2009 TO 17-06-2009):

During this spell scattered rainfall of light to moderate intensity was reported from the upper catchments of river Indus and Jhelum along with Central and southern Punjab. Significant accumulated rainfall during this spell is shown in fig. 2



*Figure 2: Rainfall during wet spell from 15-06-2009 to 17-06-2009*

### 3.1.2 RIVER POSITION DUE TO THE SPELL:

No significant change in any river was observed and all the major rivers and nullahs maintained their normal flows during the spell.

### 3.1.3 RIVER POSITION DURING JUNE 2009:

Generally all the rivers, hill torrents and nullahs maintained their normal flows during the period and no significant flood peak was recorded in any major river. The only significant hydrological feature, which was a result of snow melting during the month, was generally a medium flood level base flow in the river Kabul at Nowshera.

## 4. SIGNIFICANT HYDROMETEOROLOGICAL EVENTS DURING THE MONTH OF JULY 2009:

### 4.1 METEOROLOGICAL EVENTS:

Two monsoon lows developed during the month of July 2009. The first monsoon low developed in the Bay of Bengal, in the end of second week on 14<sup>th</sup> July, 2009. It



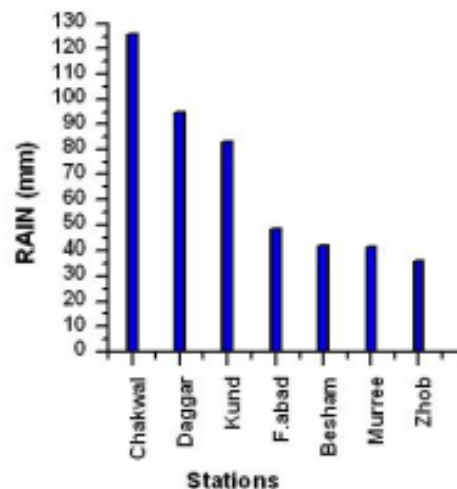
adopted a west-northwest course and after crossing Madhya Pradesh (India), it finally reached over Southeastern parts of Rajasthan on 18-07-2009 and moving continuously in the same direction, reached over Sindh on 19<sup>th</sup> July, 2009. Due to this weather system torrential rains were recorded in southern and southeastern Sindh specially over Karachi, Thatta & Badin districts. Urban flooding was also observed in these areas.

The second monsoon low developed over northwest Bay of Bengal on 20-07-2009. It also took the same course as first and reached the southern parts of Rajasthan on 24<sup>th</sup> July 2009. From here it moved further towards Sindh where it dissipated.

Due to this weather system moderate rain with isolated heavy falls were recorded over south & Southeastern Sindh. Five rain bearing systems were observed during the month, which are described below.

#### **4.1.1 FIRST WET SPELL ( FROM 30-06-2009 TO 04-07-2009):**

This spell lasted for five days. It was due to the combined effect of westerly wave and, accentuation of seasonal low, resulting in the incursion of monsoon current from Arabian Sea in the Punjab and Kashmir. The intensity of rainfall during this spell ranged between light to moderate with one or two heavy falls. Significant spell wise accumulated rainfall is shown in figure 3.



*Figure 3: Rainfall during wet spell from 30-06-2009 to 04-07-2009*

#### **4.1.2 RIVER POSITION DURING THE SPELL:**

All the major rivers maintained their normal flows and no flood situation was observed in any river.

#### **4.1.3 SECOND WET SPELL OF JULY 2009 (FROM 13-07-2009 TO 15-07-2009):**



The second rainfall spell of July 2009 and third of the season was mainly caused due to the passage of westerly wave, accentuation of seasonal low and penetration of moist current from Arabian sea. During this spell light to moderate rainfall was recorded over northeast and south Punjab, Kashmir and upper NWFP. Significant rainfall in the spell is shown below in figure 4.

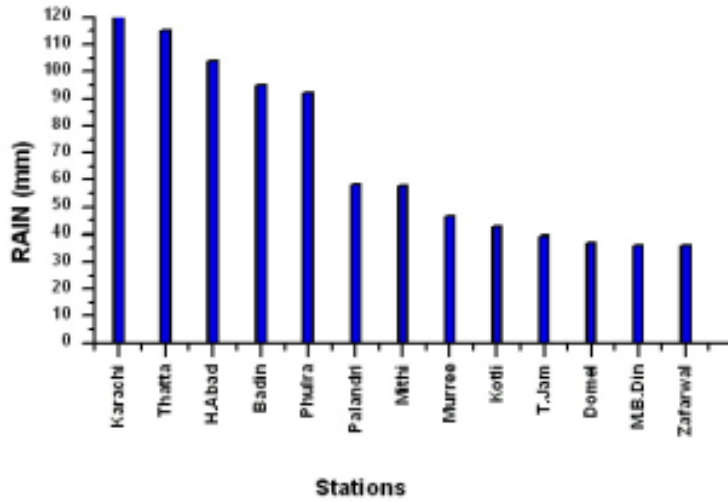


Figure 4: Rainfall during wet spell from 13-07-2009 to 15-07-2009

**4.1.4 RIVER POSITION DURING THE SPELL:**

Due to this wet spell two Low flood peaks were recorded, one in river Indus at Chashma and second in river Chenab at Marala as shown in figures 5 & 6.

Marala Inflow/Outflow From 25<sup>th</sup> July To 31<sup>st</sup> July 2009

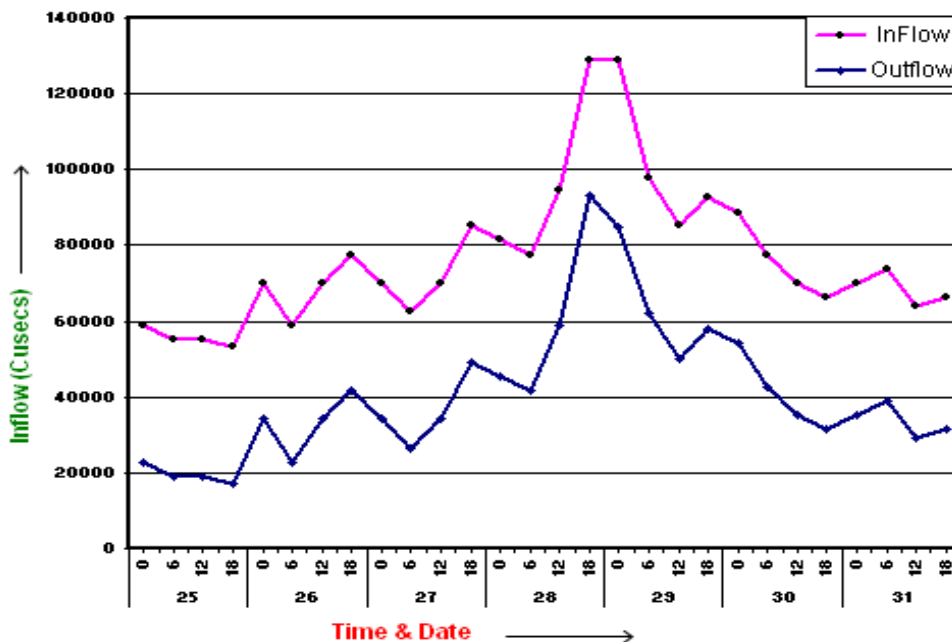




Figure 5: Marala Inflow/Outflow from 25<sup>th</sup> July to 31<sup>st</sup> July 2009

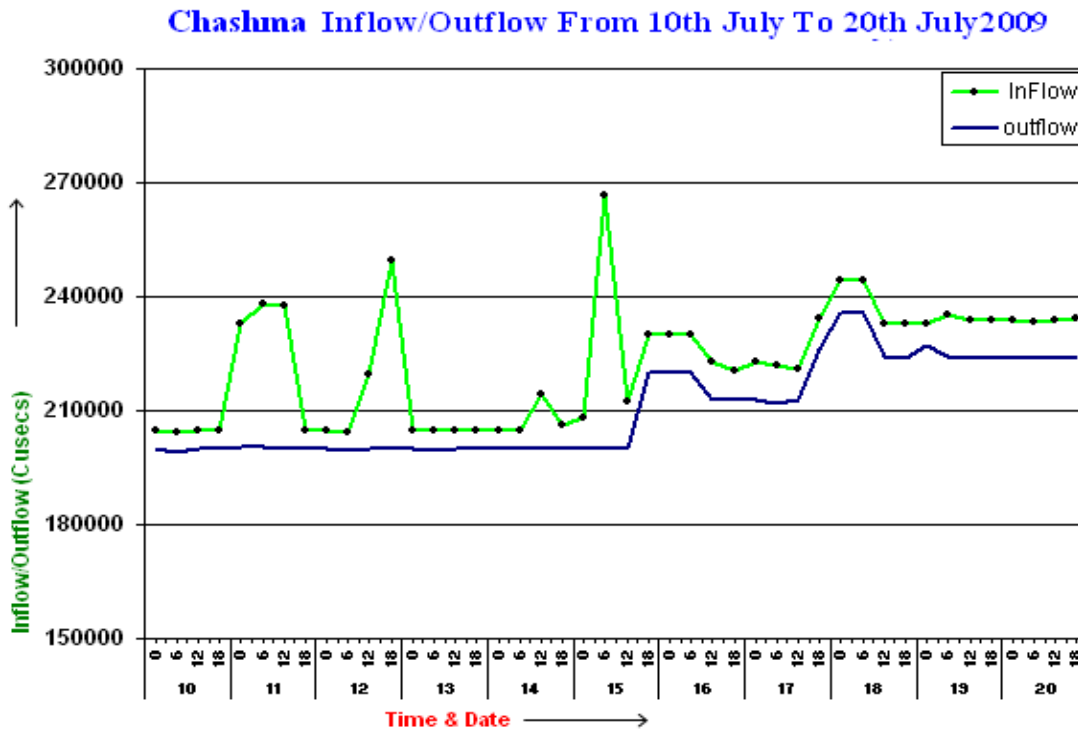


Figure 6: Chashma Inflow/Outflow from 10<sup>th</sup> July to 20<sup>th</sup> July 2009

#### 4.1.5 **THIRD WET SPELL OF JULY 2009 (FROM 18-07-2009 TO 19-07-2009):**

The third rainfall spell of July 2009 and fourth of the season was mainly due to a low-pressure system, originally developed over Bay of Bengal on 14-07-2009. It moved in west-northwest direction and after crossing Madhya Pradesh (India) it finally reached over Southeastern parts of Rajasthan on 18-07-2009 and moving continuously in the same direction was located over Sindh on 19<sup>th</sup> July, 2009. Due to this weather system torrential rain was recorded in southern and southeastern Sindh specially over Karachi, Hyderabad, Thatta & Badin districts. Urban flooding was also observed in these areas. This system also produced light to moderate rainfall over north Punjab & Kashmir. Significant rainfall during the spell is shown in figure 7.

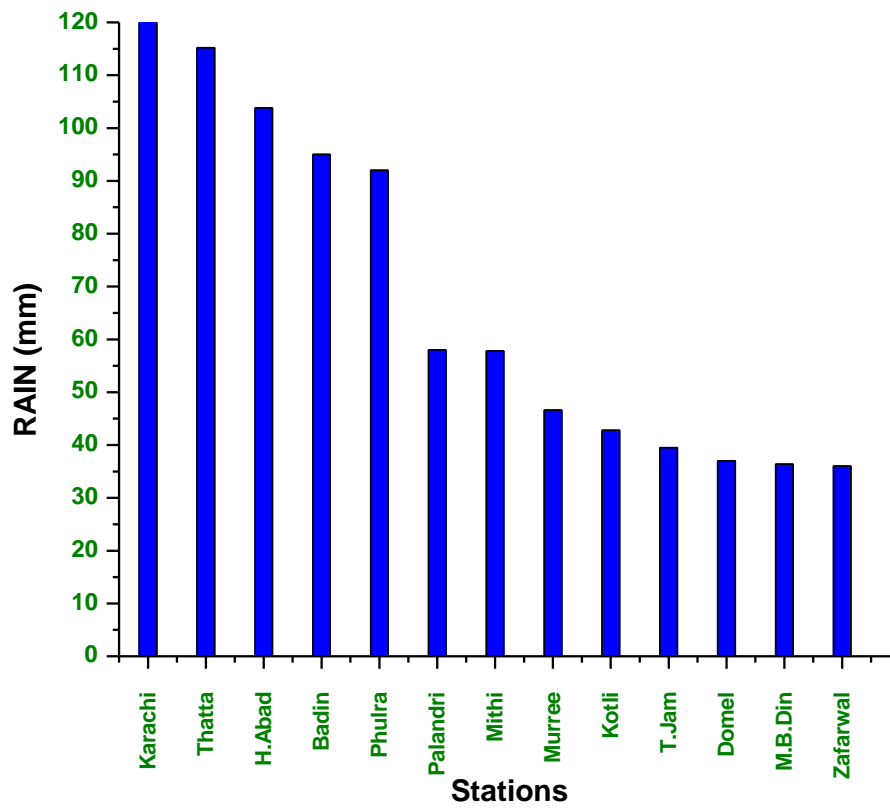


Figure 7: Rainfall during wet spell from 18-07-2009 to 19-07-2009

#### 4.1.6 RIVERS POSITION DURING THE SPELL:

As a result of this spell, a low level flood peak was recorded in river Indus at Tarbela as shown in the figure 8, while all the other major rivers remained below low flood level.



### Tarbela Inflow/Outflow From 17th July To 25th July 2009

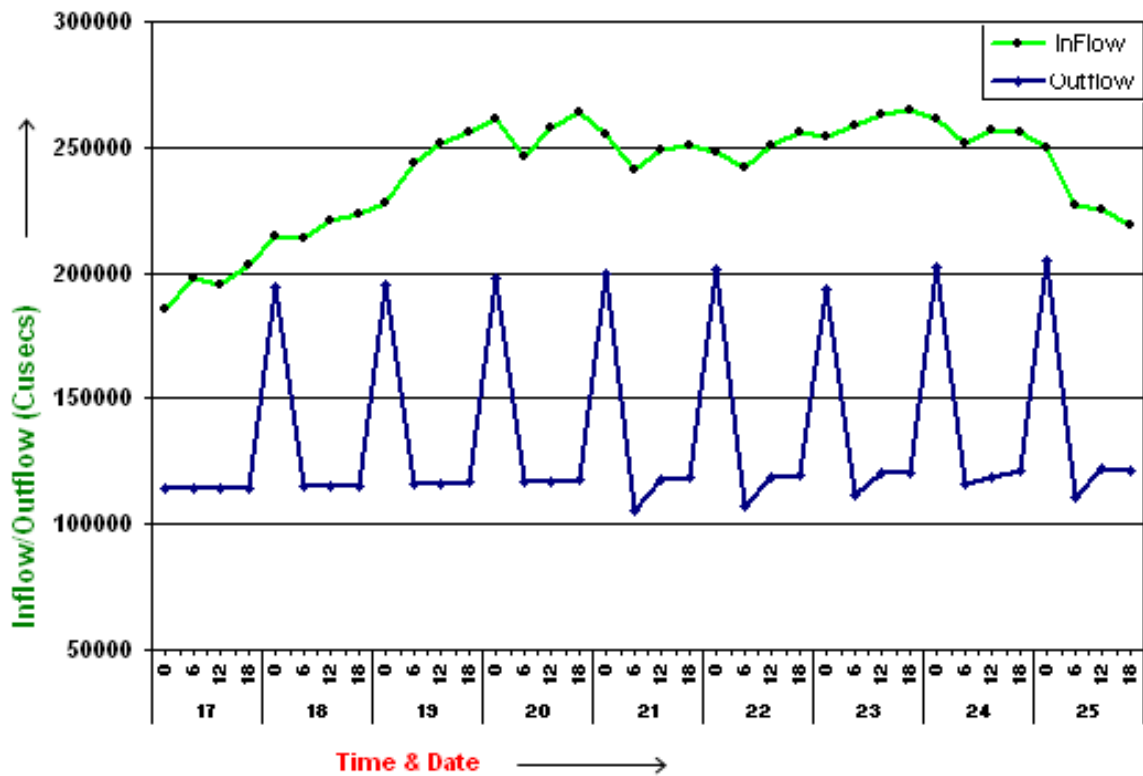


Figure 8: Tarbela Inflow/Outflow from 17<sup>th</sup> July to 25<sup>th</sup> July 2009.

#### 4.1.7 FOURTH WET SPELL (FROM 21-07-2009 TO 25-07-2009):

The fourth rain-bearing spell of July 2009 and fifth of the season was mainly due to a monsoon low. Which developed over northwest Bay of Bengal on 20<sup>th</sup> July-2009.

It took the same course (west-northwest track as in previous cases) and reached southern Rajasthan on 24<sup>th</sup> July 2009. From here it moved further towards Sindh and dissipated there on 25<sup>th</sup> July-2009. Due to this weather system moderate rain with isolated heavy fall was recorded over south & Southeastern Sindh along with upper NWFP, Northern areas and Kashmir. Significant spell wise accumulated rainfall is shown in figure 9.

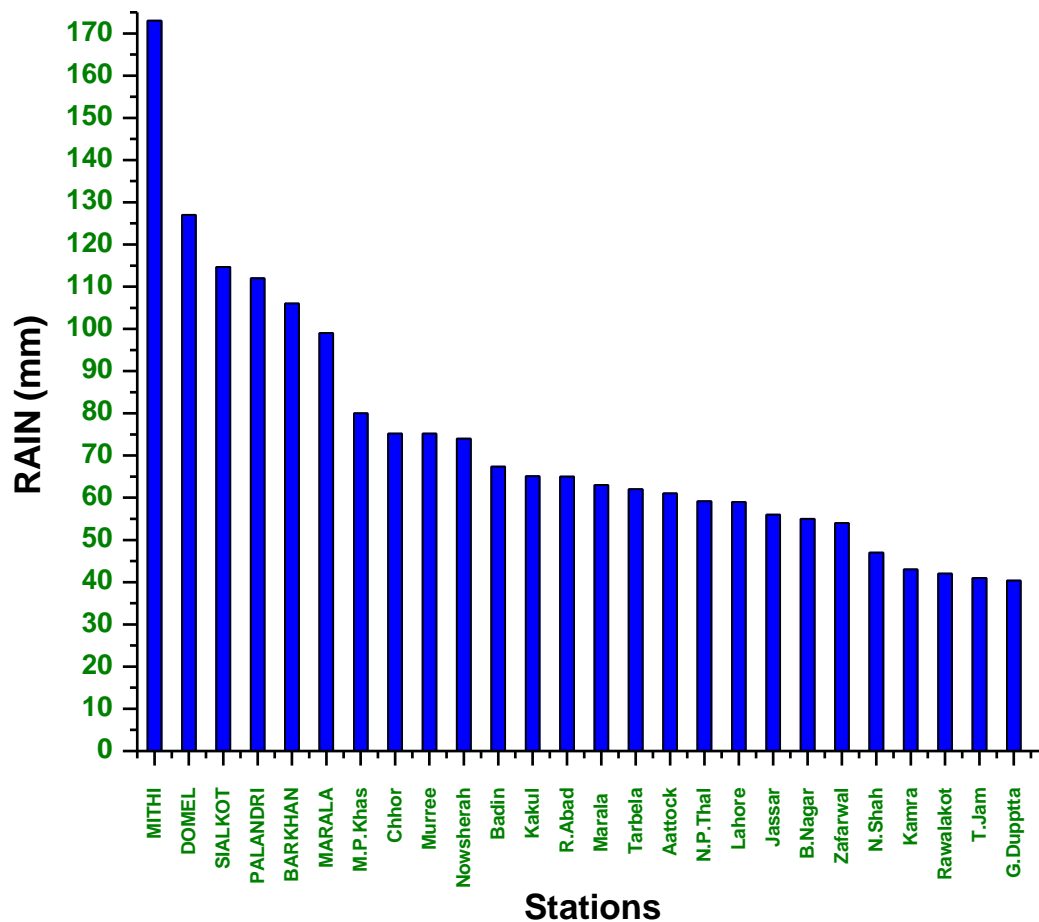


Figure 9: Rainfall during wet spell from 21-07-2009 to 25-07-2009

#### 4.1.8 RIVER POSITION DURING THE SPELL:

As a result of this wet spell, a flood peak of Low level was observed in river Indus at Tarbela on 23<sup>rd</sup> July-2009, while all the other major rivers remained below low flood level.

#### 4.1.9 FIFTH WET SPELL OF JULY 2009 FROM 27-07-2009 TO 30-07-2009

The Fifth rainfall spell of July 2009 and sixth of the season was mainly caused due to the passage of westerly wave, accentuation of seasonal low and penetration of moist current from Arabian sea. During this spell light to moderate rainfall was recorded over northeast Punjab, Kashmir and upper NWFP. Significant rainfall in this spell is shown in figure10.

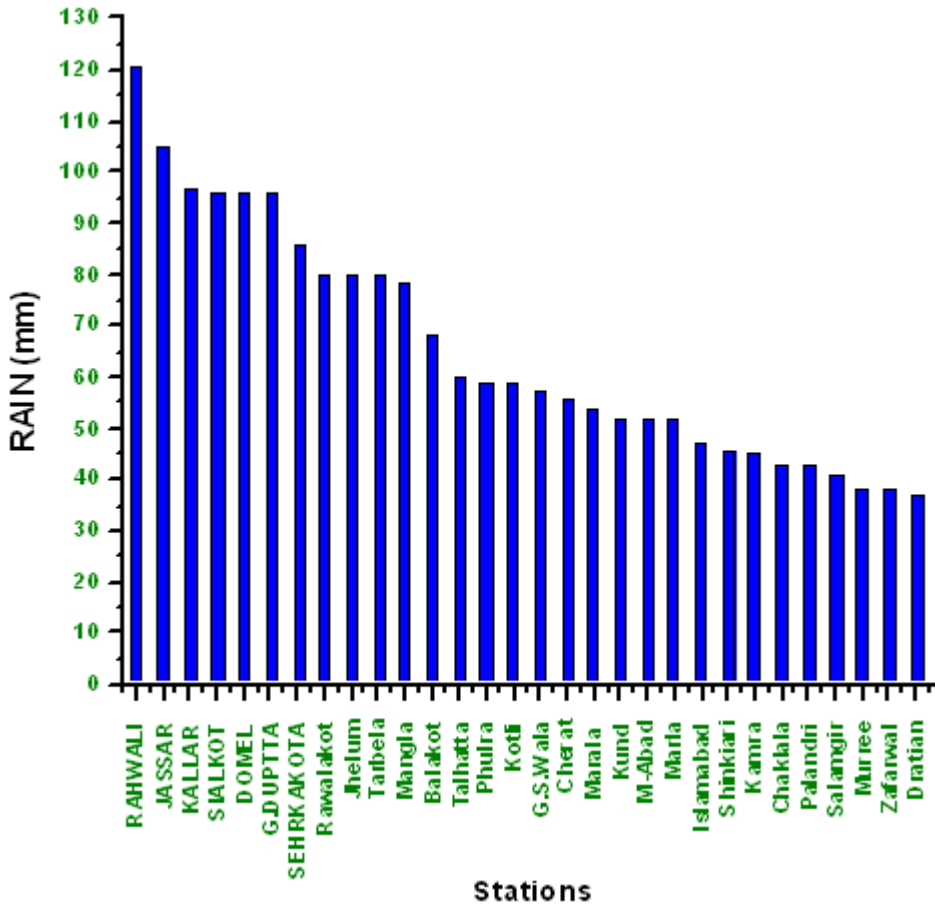


Figure 10: Rainfall during wet spell from 27-07-2009 to 30-07-2009

**4.1.10 RIVER POSITION DURING THE SPELL:**

Due to this wet spell low level flood peaks were recorded in river Chenab at Marala & Khanki, in river Jhelum at Mangla and also in river Indus at Tarbela and Kalabagh .as shown in figures 11 to 15. A warning was issued well in time and all the concerned agencies were informed accordingly. No damage was reported.

Marala Inflow/Outflow From 25<sup>th</sup> July To 31<sup>st</sup> July 2009

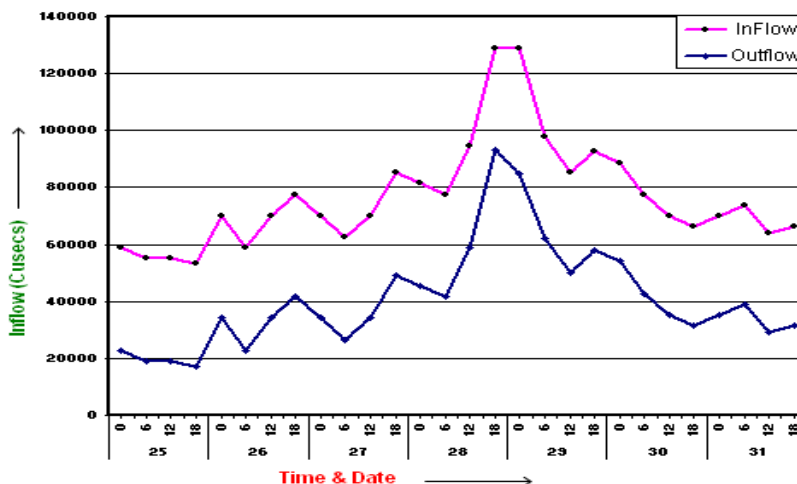


Figure 11: Marala Inflow/Outflow from 25<sup>th</sup> July to 31<sup>st</sup> July



Khanki Inflow/Outflow from 26-07-2009 to 03-08-2009

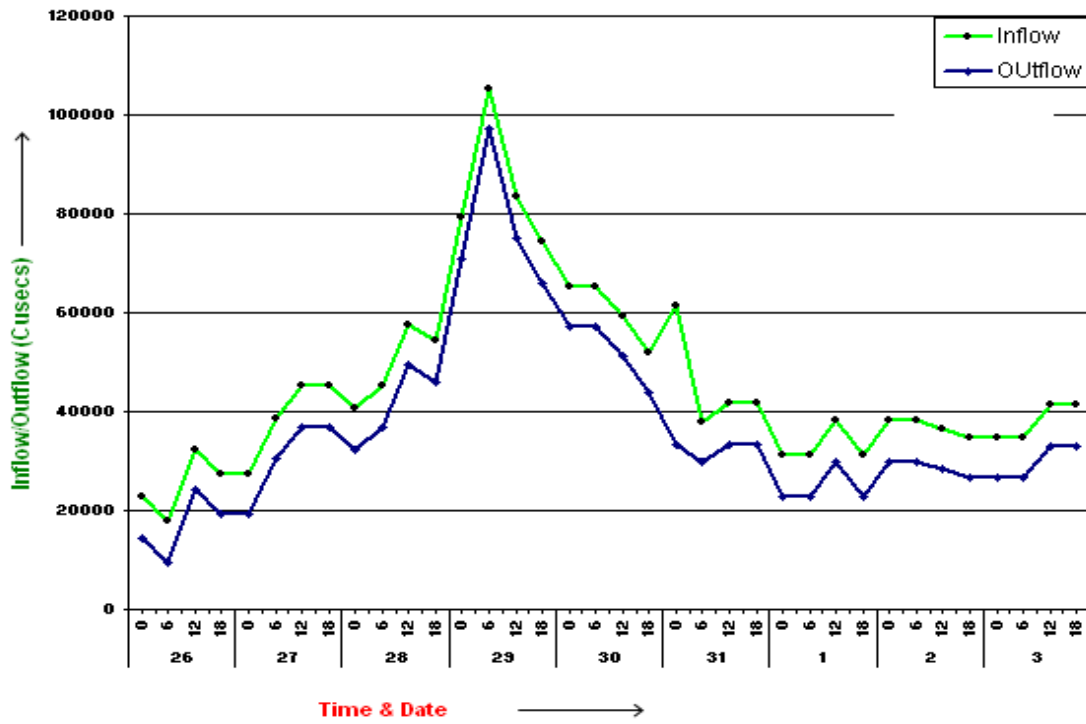


Figure 12: Khanki Inflow/Outflow from 26-07-2009 to 03-08-2009

Mangla Inflow/Outflow from 25th July to 31st July

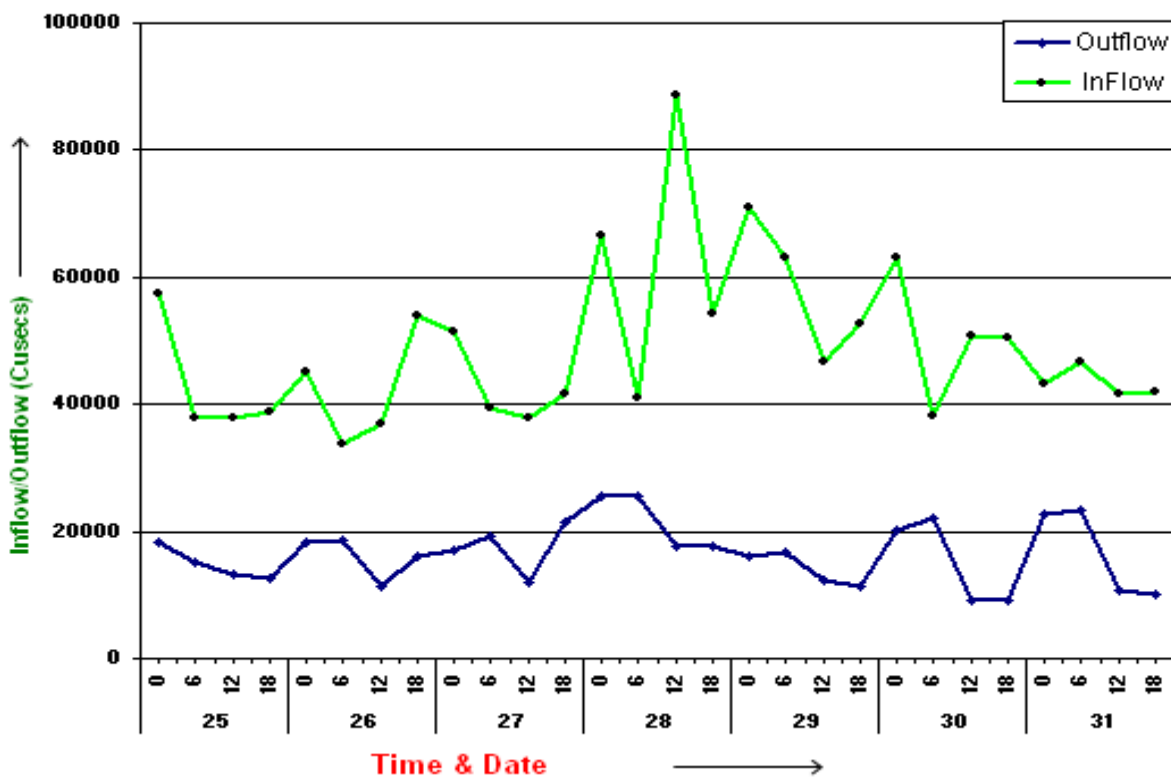


Figure 13: Mangla Inflow/Outflow from 25<sup>th</sup> July to 31<sup>st</sup> July



Tarbela Inflow/Outflow from 23-07-2009 to 03-08-2009

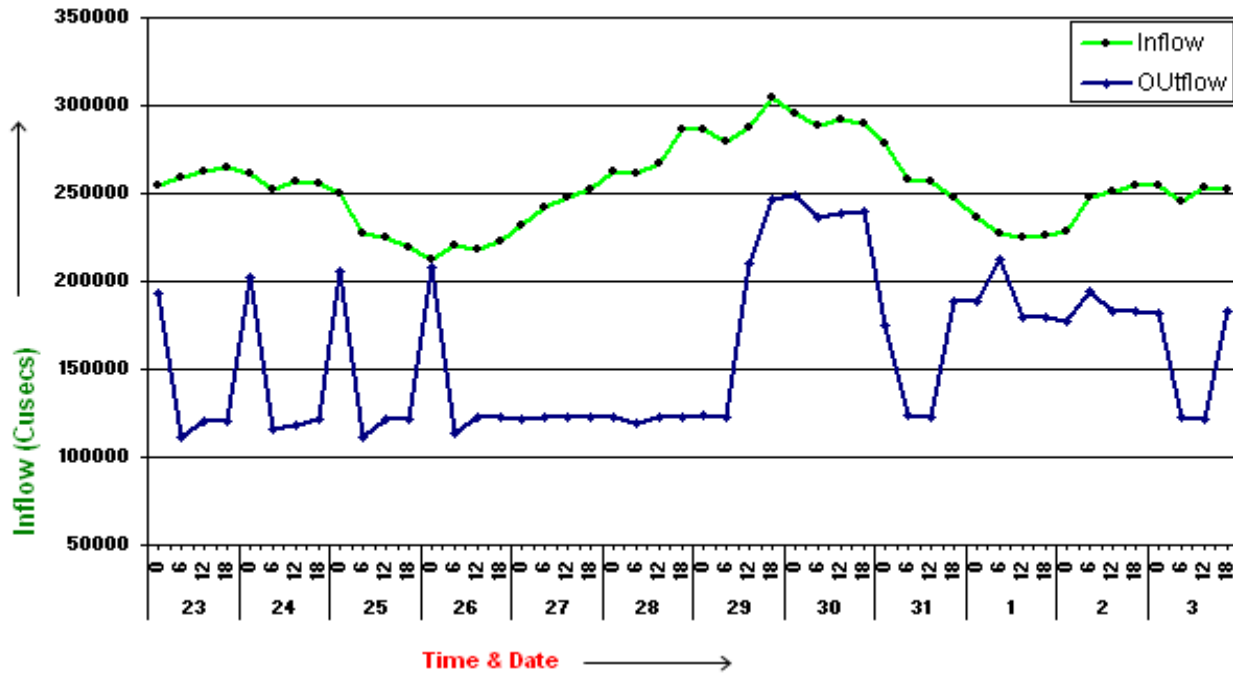


Figure 14: Tarbela Inflow/Outflow from 23-07-2009 to 03-08-2009

Kalabagh Inflow/Outflow from 28-07-2009 to 05-08-2009

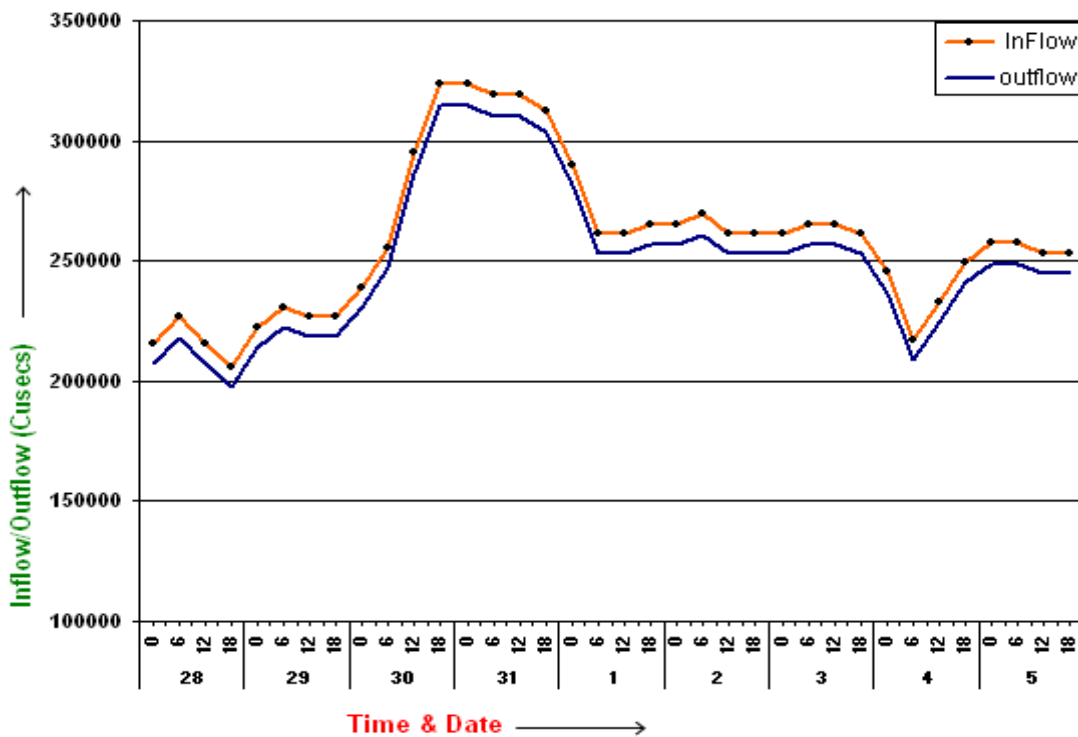


Figure 15: Kalabagh Inflow/Outflow from 28-07-2009 to 05-08-2009



#### 4.1.11 RAINFALL PATTERN FOR THE MONTH OF JULY 2009

Isohyetal map of July 2009 indicates that the maximum precipitation occurred in sub mountain districts of Punjab and southern slopes of Pir Panjal range of lesser Himalaya in Kashmir. Three rainfall maxima exceeding 200 mm. occurred one in northeast Punjab (Sialkot) and other over north Punjab (Murree) and third around southeast Sindh. One lesser maximum exceeding 100 mm occurred over northeast Balochistan (Bar Khan) as shown in figure 16.

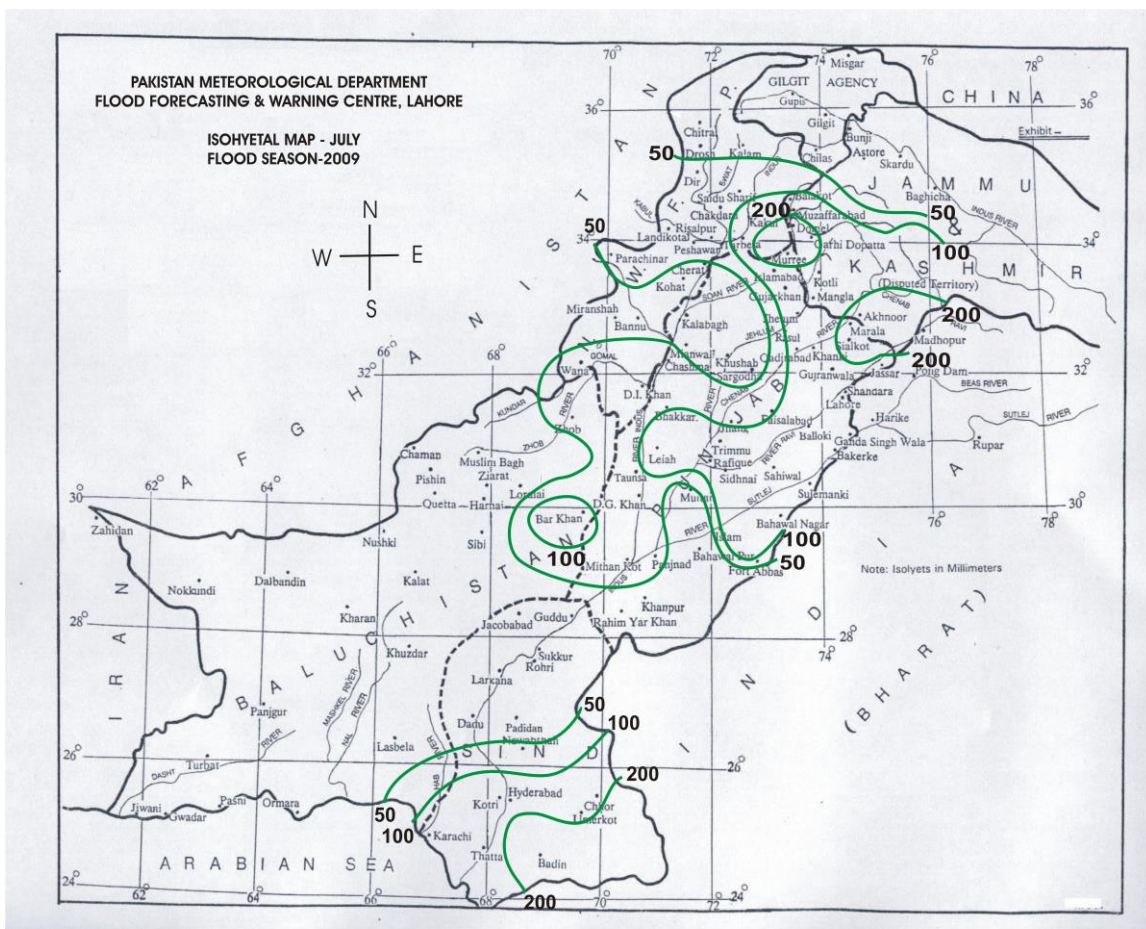


Figure 16: Isohyetal Map of July 2009.

The normal distribution of precipitation for the month of July (1971-2000) is shown in the fig. 17. While viewing the monthly rainfall of July 2009 on province basis NWFP received 48.1% below normal rainfall, Punjab received 22.6% below normal, Balochistan received 14.5 % below normal rainfall where as Sindh received 80.6% above normal rainfall of. On all Pakistan basis 9.3 % below normal rainfall was received during the month of July-2009.



#### 4.1.12 GRIDID PRECIPITATION DATA FOR PAKISTAN REGION:

APHRODITE “Asian Precipitation Highly-Resolved Observational Data Integration towards Evaluation of the Water Resources” is the project to develop state-of-the-art daily precipitation datasets with high-resolution over Asia. The datasets are based on a dense rain-gauge network, and created by sophisticated quality control and interpolation algorithm.

Using Aphrodite system daily Girded data for Pakistan region has been interpolated at  $0.05^\circ$  resolution for 1961-2007. Domain of data is as follows.

Longitude: 60.025 to 78.475 : No. of Grid Points: 370

Latitude: 23.025 to 37.475 No. of Grid Points: 290

Using this monthly & seasonal monsoon data, climatological normal for 1971-2000 has been calculated.

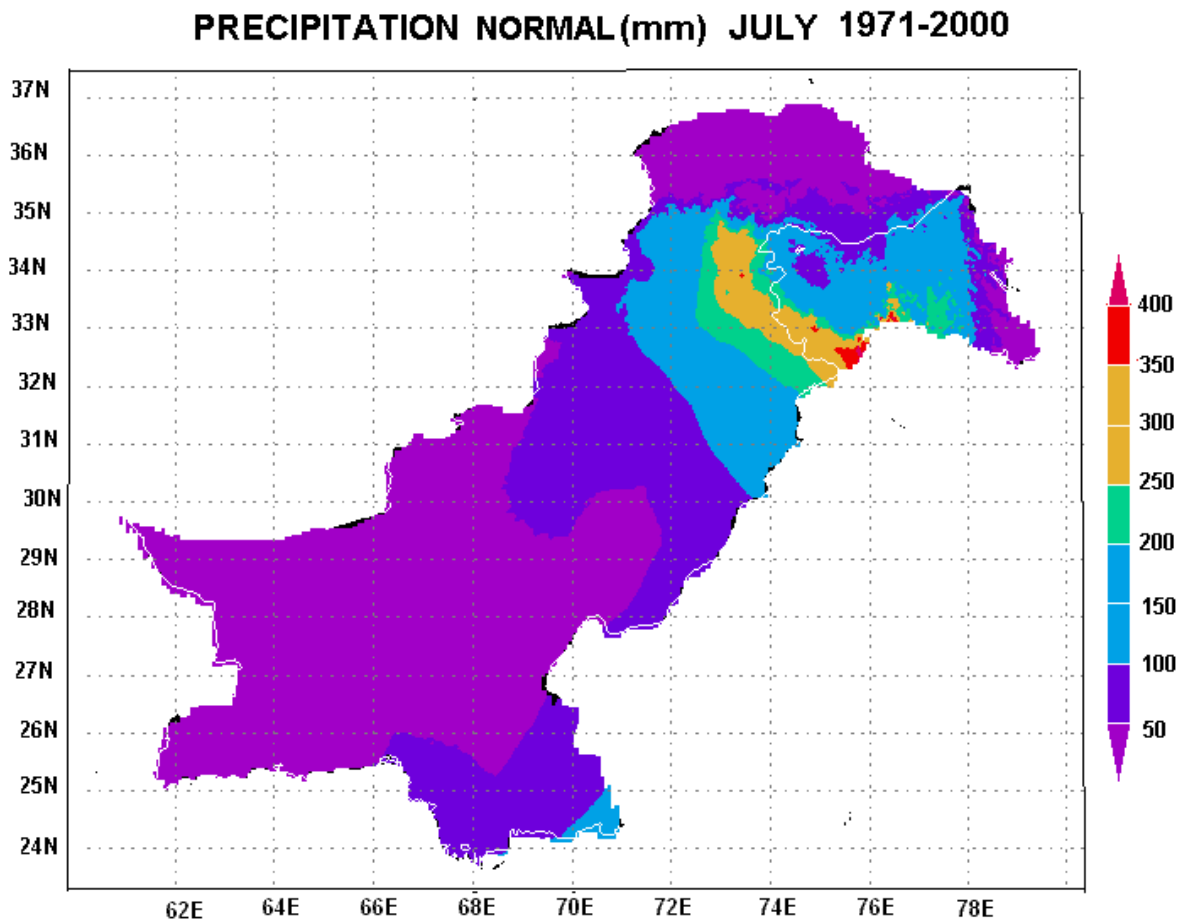


Figure 17: Normal precipitation of July, 2009



## 5. SIGNIFICANT HYDROMETEOROLOGICAL EVENTS DURING THE MONTH OF AUGUST 2009:

### 5.1 METEOROLOGICAL EVENTS:

Only one monsoon low developed over the Bay of Bengal on 27-08-2009 which initially moved rapidly in a northwesterly direction and reached over southeast Madhya Pradesh (India) on 28-08-2009 and moving west northwestwards reached Northwest Madhya Pradesh and adjoining Rajasthan on 29-08-2009. Under its influence moderate to heavy rainfall was recorded over southeast Sindh.

#### 5.1.1 FIRST WET SPELL OF AUGUST 2009 (FROM 16-08-2009 TO 19-08-2009):

With passing of westerly wave, accentuation of seasonal low due to westerly wave and induction of moderate southwest monsoon current into Pakistan, moderate with scattered heavy rainfalls occurred during this spell over the Upper NWFP, Kashmir & north Punjab. Significant accumulated rainfall is shown below: -

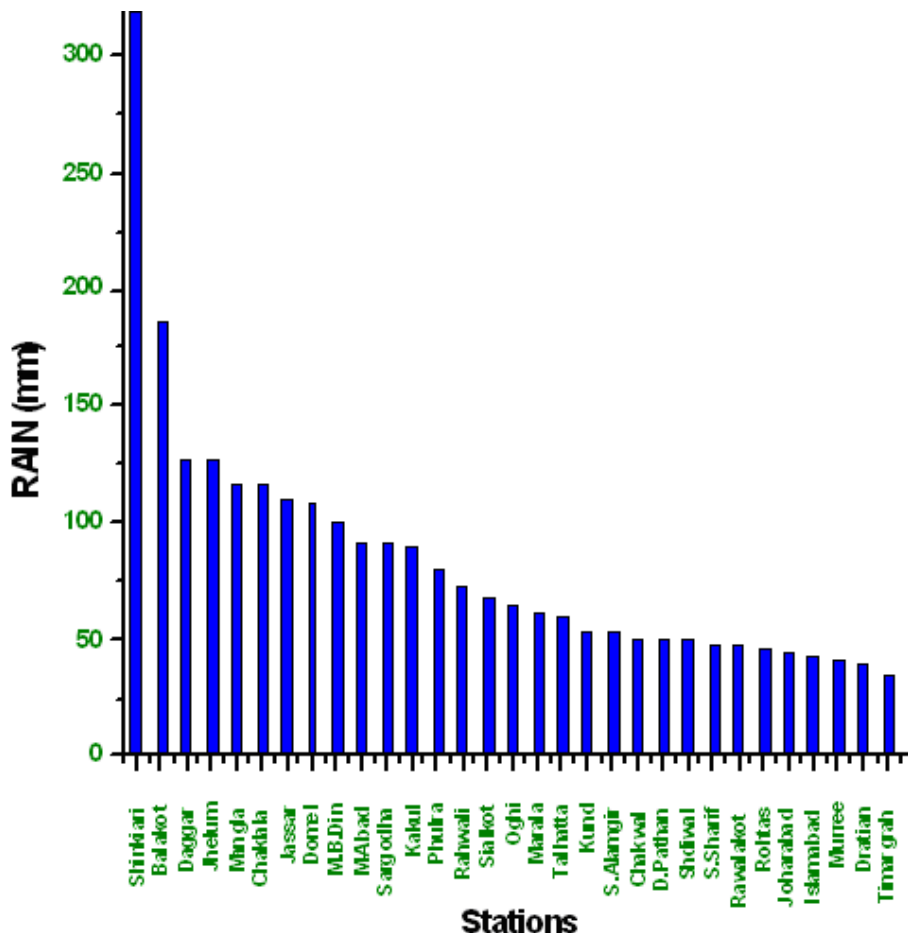


Figure 18: Rainfall during wet spell from 16-08-2009 to 19-08-2009



### 5.1.2 RIVER POSITION DURING THE SPELL:

As a result of this wet spell, a Medium flood peak was observed in river Indus at Chashma and second in River Kabul at Nowshera and third in river Jhelum at Mangla. A low flood situation also developed in the river Indus at Tabela and Kalabagh.

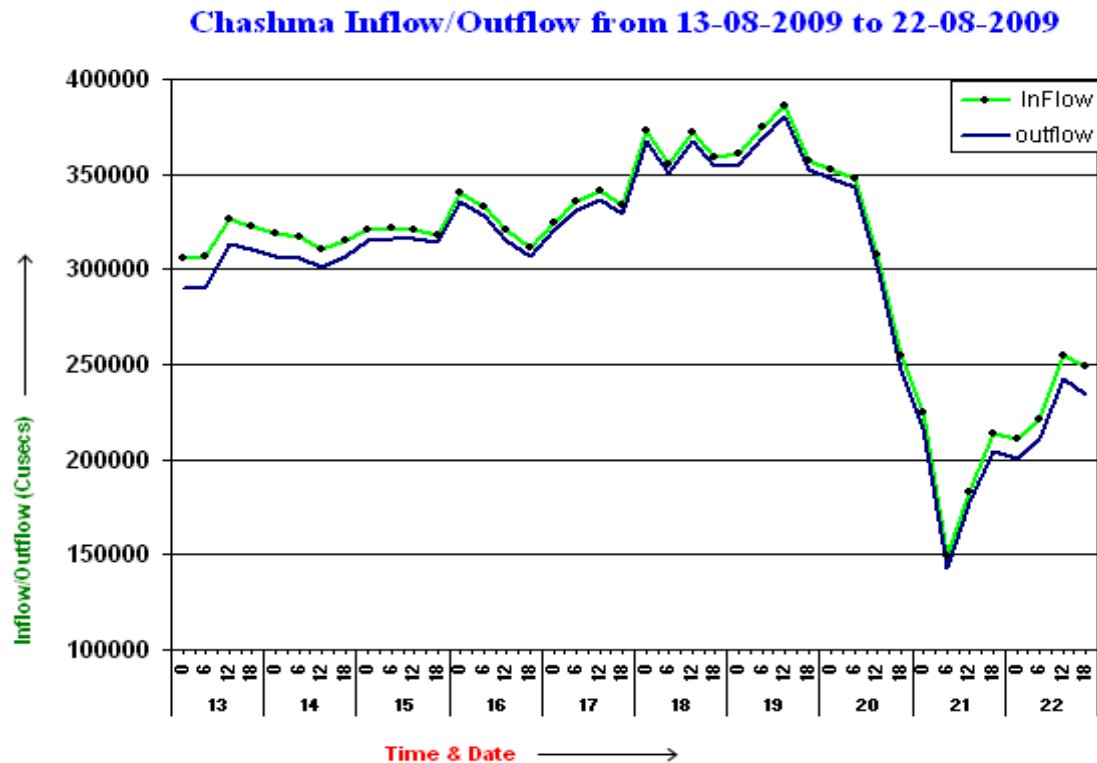


Figure 19: Chashma Inflow/Outflow from 13-08-2009 to 22-08-2009

It has been observed during the period 13<sup>th</sup> to 22<sup>nd</sup> August that the inflow value at Chashma was reported greater than the outflow from Kalabagh as shown in fig 20, whereas it should have been generally in the reverse order. Although Kurram river and Gambila river join Indus river between Kalabagh and Chashma near Isa-Khel after a course of more than 200 miles. However, the difference between outflow from Kalabagh and inflow at Chashma should be reasonable to match the discharge of Kurram and Gambilla rivers. But strangely enough, the difference is too high, which is unjustifiable. This office requested Project Director, H&WM WAPDA & FFC to supply the discharge of Kurram & Gambilla rivers on six hourly daily basis but the request has been unresponsive. In this condition FFD would be in helpless condition to forecast the medium or high flood quantitatively at Chashma.



**Kalabagh Outflow and Chashma Inflow from 10-08-2009 to 22-08-2009**

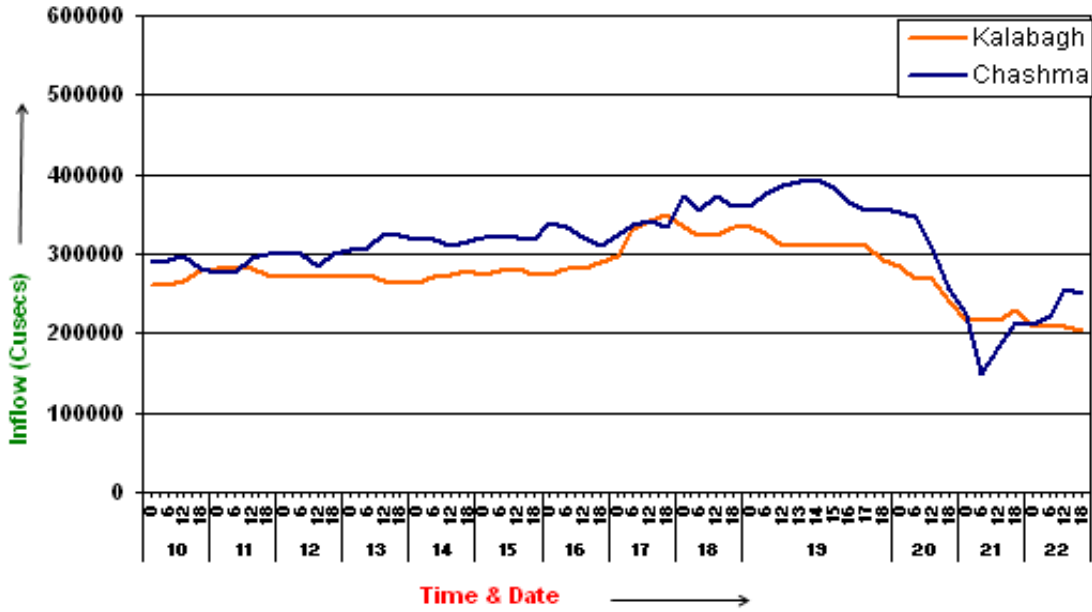


Figure 20: Kalabagh outflow and Chashma Inflow from 10-08-2009 to 22-08-2009

**Kabul Discharge from 13-08-2009 to 22-08-2009**

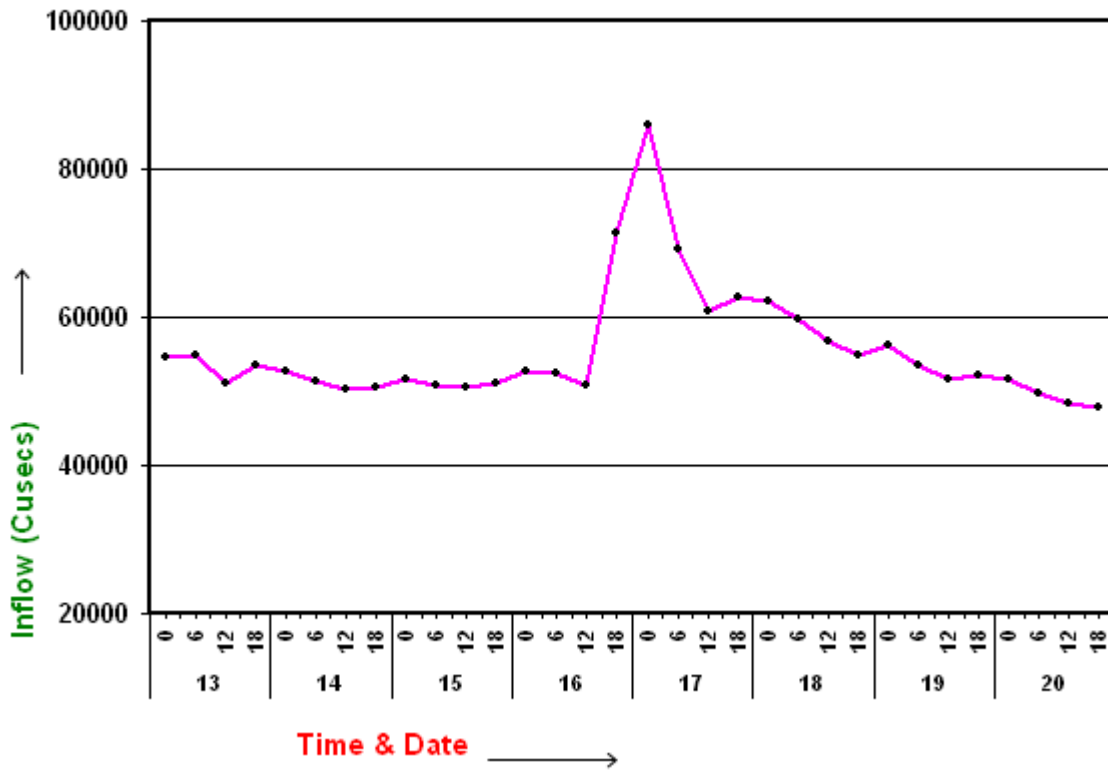


Figure 21: Kabul Discharge from 13-08-2009 to 20-08-2009



Tarbela Inflow/Outflow from 12-08-2009 to 22-08-2009

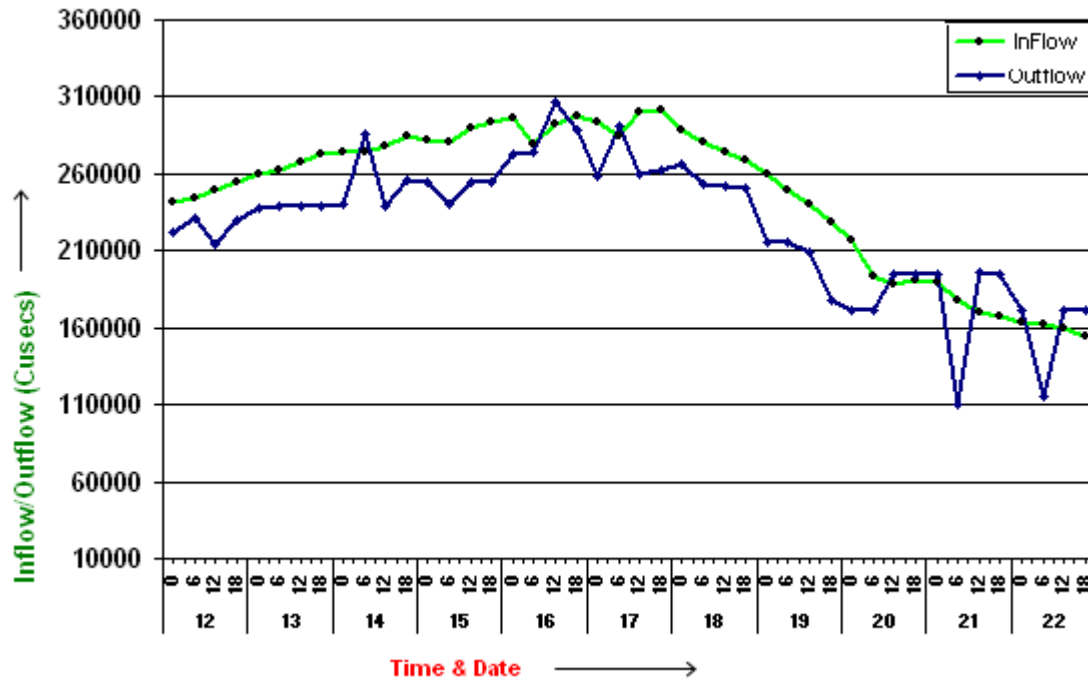


Figure 22: Tarbela Inflow/Outflow from 12-08-2009 to 22-08-2009

Kalabagh Inflow/Outflow from 13-08-2009 to 22-08-2009

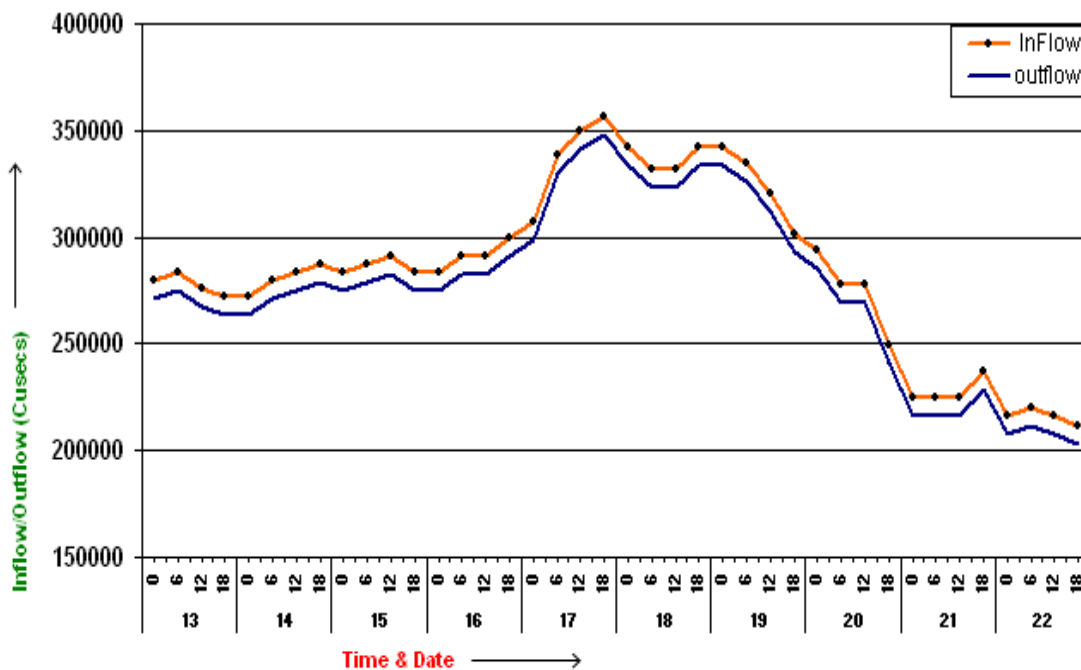


Figure 23: Kalabagh Inflow/Outflow from 13-08-2009 to 22-08-2009

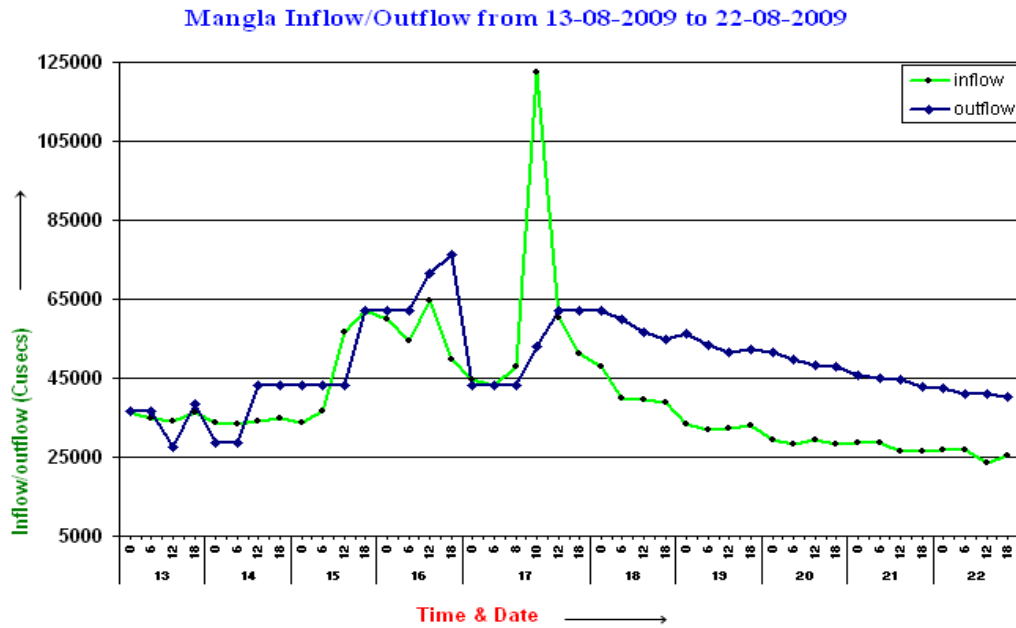


Figure 24: Mangla Inflow/Outflow from 13-08-2009 to 22-08-2009

### 5.1.3 SECOND WET SPELLOF AUGUST 2009 ( FROM 25-08-2009 TO 27-08-2009):

Incursion of southwest & southeast monsoon currents into Pakistan and westerly wave over the northern parts of the country caused this spell. Light to Moderate rain occurred during this spell over Punjab & Kashmir. Significant Spell-wise accumulated rainfall is shown below: -

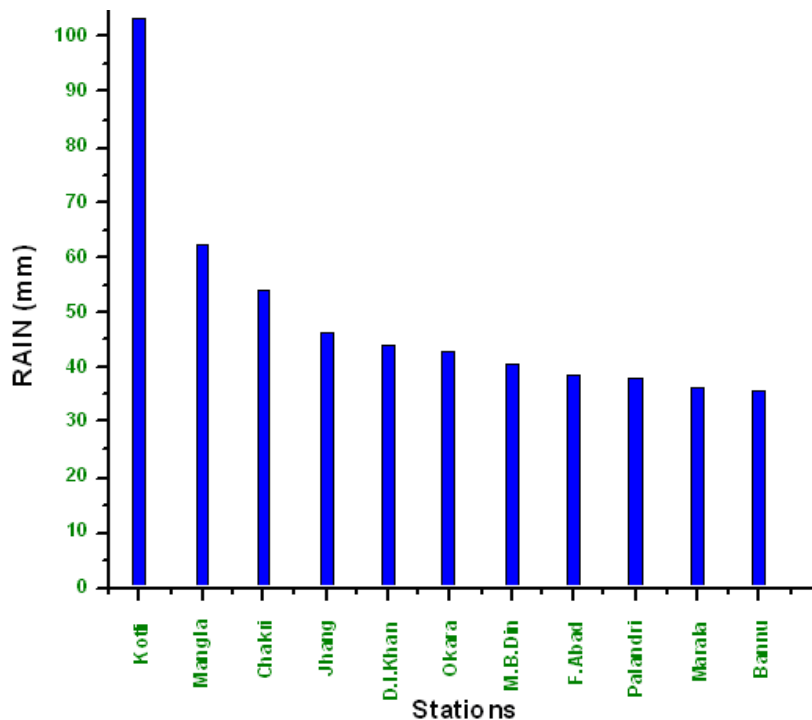




Figure 25: Rainfall during wet spell from 24-08-2009 to 27-08-2009

#### 5.1.4 RIVER POSITION DURING THE SPELL:

No peak of any flood level was observed during the spell.

#### 5.1.5 RAINFALL PATTERN FOR THE MONTH OF AUGUST 2009:

One-rainfall maxima exceeding 300 mm in the month of August 2009 was located around Balakot. Two lesser maxima exceeding 50 mm were located on around southern Sindh and second around Khuzdar in Balochistan.

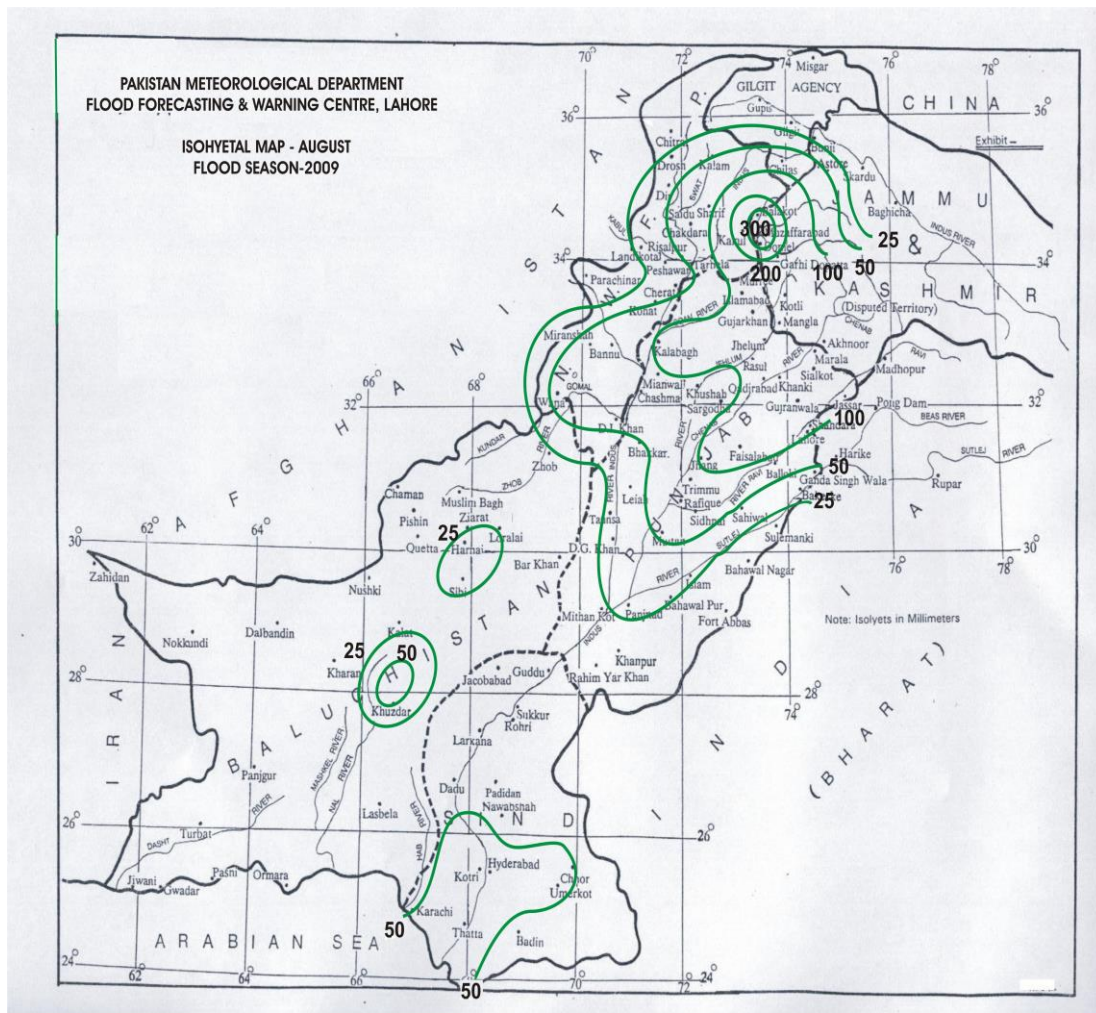
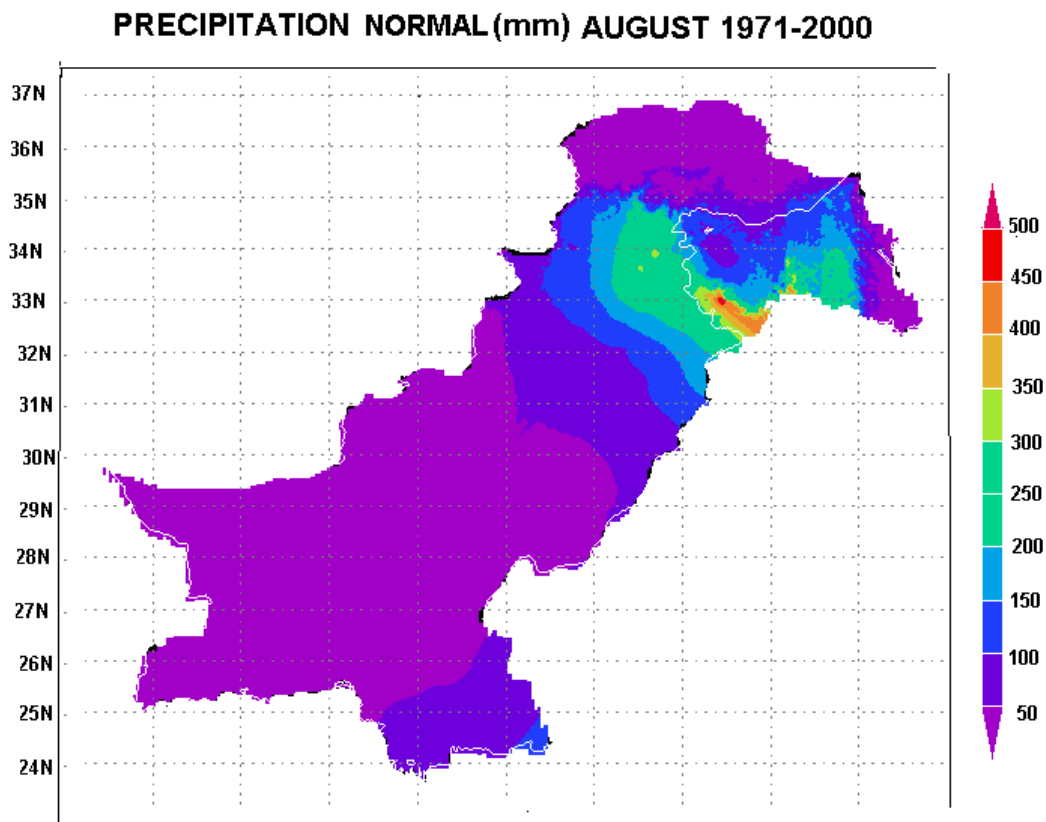


Figure 26: Isohyetal Map of August 2009



The monthly rainfall of August 2009 on province basis (Sr. No. 9) NWFP received 33.1% below normal rainfall Punjab received 31.4% below normal, Balochistan received 62.6 % below normal rainfall and Sindh received 54.5% below normal rainfall . While on all Pakistan bases 40.9 % below normal rainfall of was recoded during the month of August-2009.



*Figure 27: Normal rainfall Map of August*

## **6. SIGNIFICANT HYDROMETEOROLOGICAL EVENTS DURING THE MONTH OF SEPTEMBER 2009:**

### **6.1 METEOROLOGICAL EVENTS:**

During this month only one monsoon Depression originated from North Bay of Bengal, on 05-09-2009, which took a west northwesterly course till it reached over



northern parts of Madhya Pradesh. on 10-09-2009. From here it moved north-northeastwards and dissipated. Only one rainfall spell was recorded during the month of September 2009.

### 6.1.1 FIRST RAINFALL SPELL OF SEPTEMBER 2009 (FROM 31-08-2009 TO 04-09-2009):

The seasonal low over Balochistan got accentuated due to moving of westerly wave which increased the incursion of monsoon current from Arabian Sea and a low pressure area over Sindh, resulting moderate rain with isolated heavy falls were observed over Southeastern Sindh, north Punjab NWFP & Kashmir. Significant Spell-wise accumulated rainfall is shown in fig. 28.

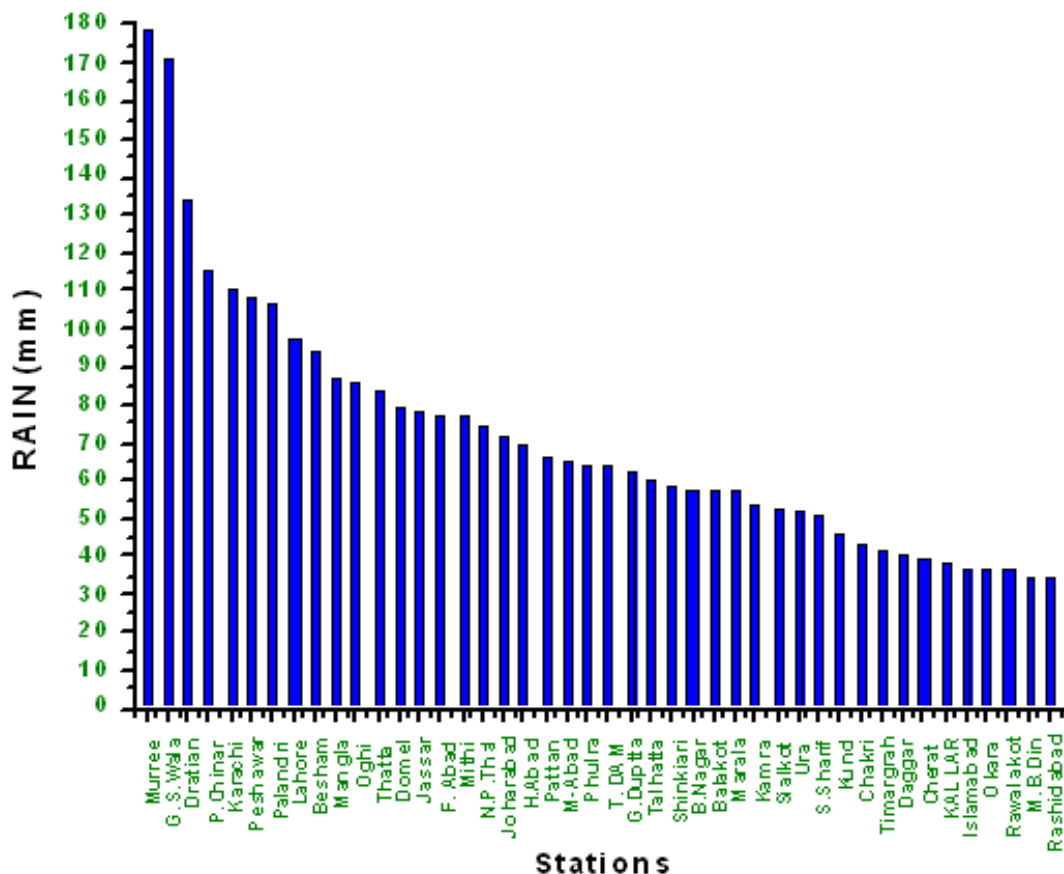


Figure 28: Rainfall during wet spell from 31-08-2009 to 04-09-2009



### 6.1.2 RIVER POSITION DURING THE SPELL:

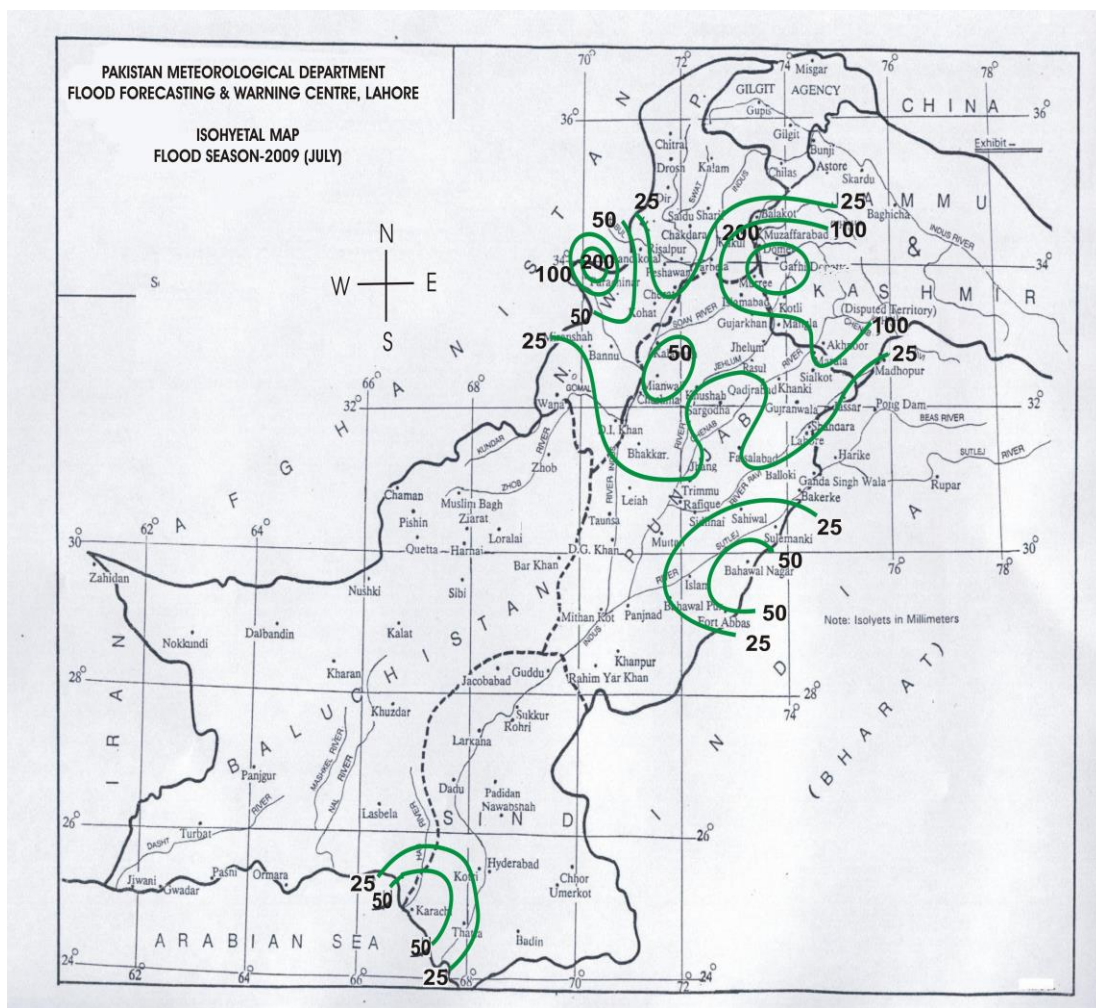
No significant change in the river was observed during the spell.

### 6.1.3 RIVER POSITION DURING SEPTEMBER, 2009:

All the major rivers and nullahs maintained their normal flow conditions at all the sites.

### 6.1.4 RAINFALL PATTERN FOR THE MONTH OF SEPTEMBER 2009:

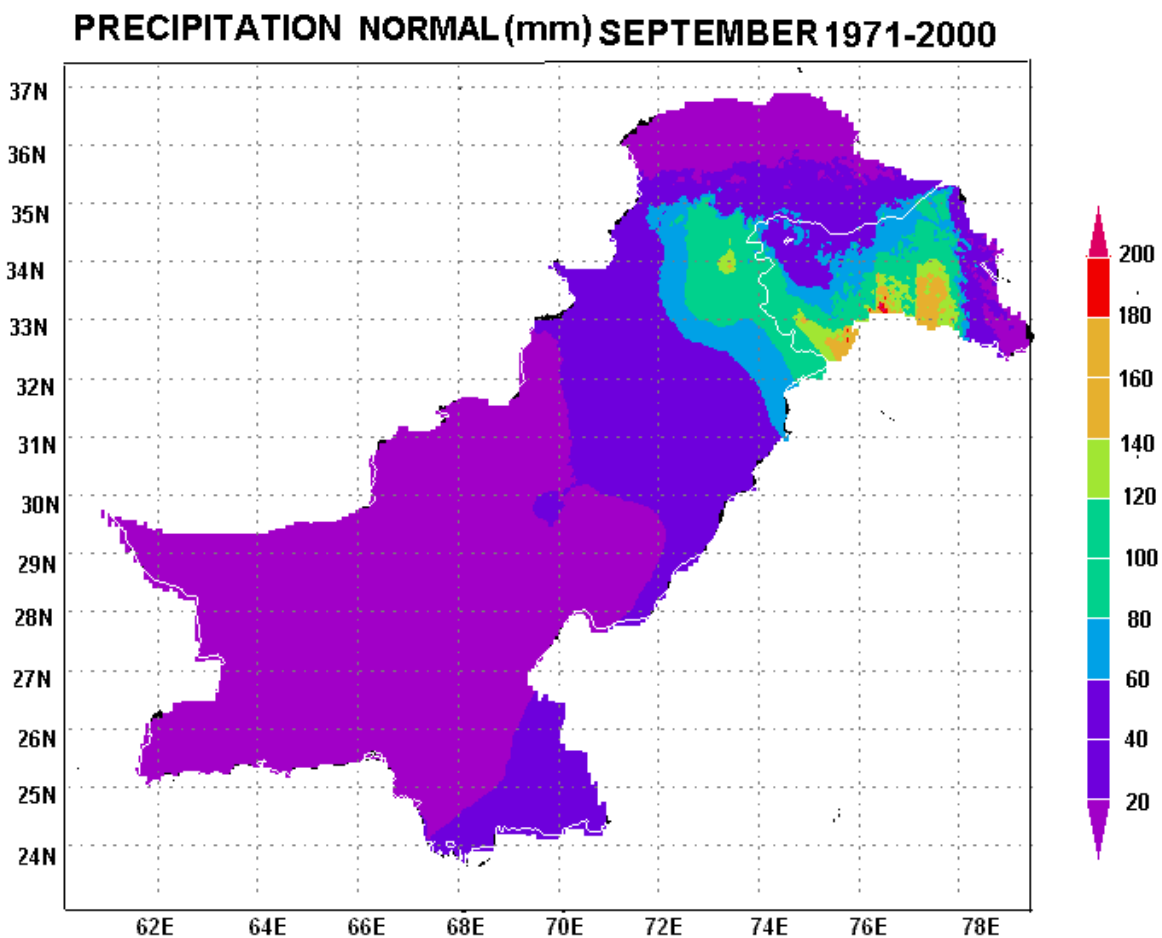
One rainfall maximum of more than 200 mm was observed during the month of September 2009 around Parachinar. One lesser maximum exceeding 100 mm occurred over north Punjab around Murree as shown in figure below.





*Figure 29: Isohyetal Map September, 2009*

While viewing the monthly rainfall of September 2009 on all Pakistan 36.5% below normal rainfall was observed & on province wise basis (Sr. No. 9) NWFP received 16.9 % below normal rainfall, Punjab received 25.7 % below normal, Balochistan received 75.0 % below normal rainfall and Sindh received 59% below normal rainfall.



*Figure 30: Normal rainfall Map of September*

## **7. SEASONAL ISOHYETAL MAP FROM JULY TO SEPTEMBER 2009:**

The main belt of maximum precipitation is along the sub mountain area of Punjab, parts of Kashmir. Two rainfall maxima exceeding 400 mm, one which took



place during the monsoon season, is located over Kashmir and other over northeast Punjab around Sialkot. One lesser rainfall maximum exceeding 300 mm is located over Parachinar. Southern & southeastern Sindh also received more than 200 mm of rainfall during the season.

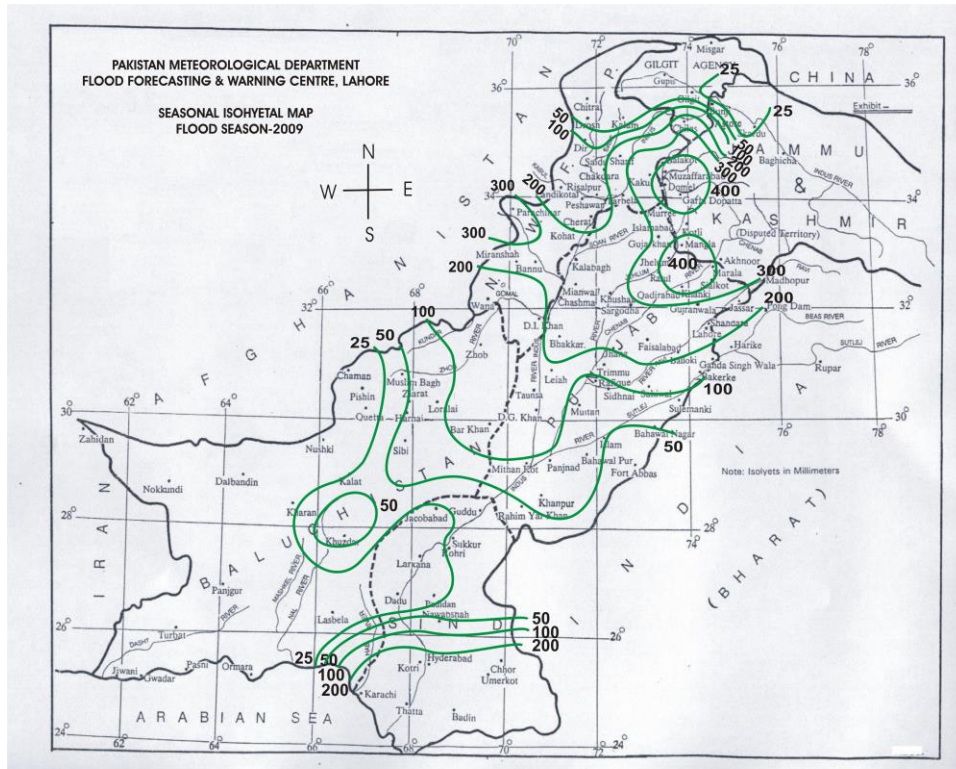
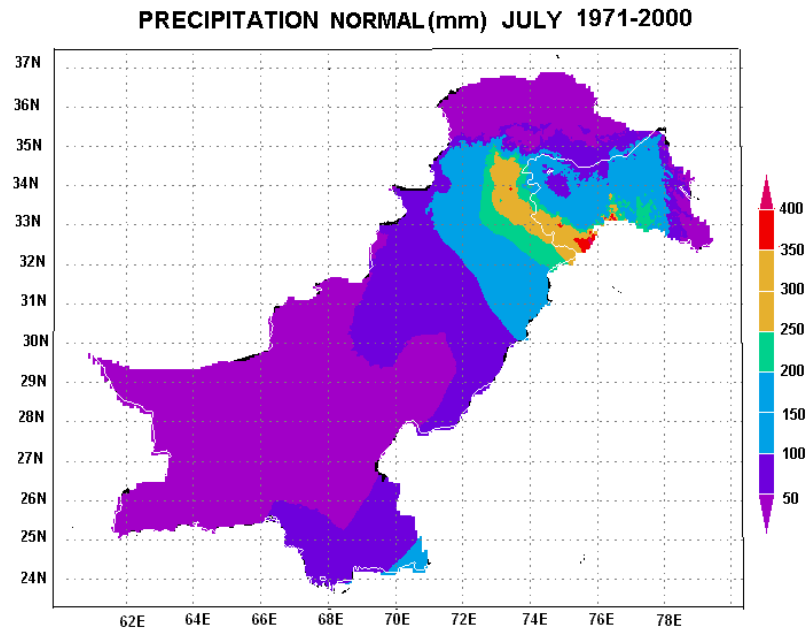


Figure 31: Seasonal (July-Sep) 2009 Isohyetal Map

Viewing the Seasonal rainfall (June to September) 2009 on all Pakistan basis (26%) below normal rainfall was recorded & on province basis NWFP received (36.9%) below normal rainfall. Punjab received (26.5%) below normal, Balochistan received 40.8 % below normal rainfall and Sindh received (5%) above normal rainfall.



*Figure 32: Seasonal (July-Sep) Normal 1961 to 2004*

## 8. SEASONAL ISOPERCENTAL MAP OF NORMAL PRECIPITATION FROM JULY TO SEPTEMBER 2009:

The seasonal precipitation isopercental map indicates that most parts of the country received below normal rainfall. However Southern & southeastern Sindh received above normal rainfall. Slightly above normal rainfall was also recorded over lower NWFP & adjoining Punjab as shown below.

### SEASONAL ISOPERCENTAL MAP

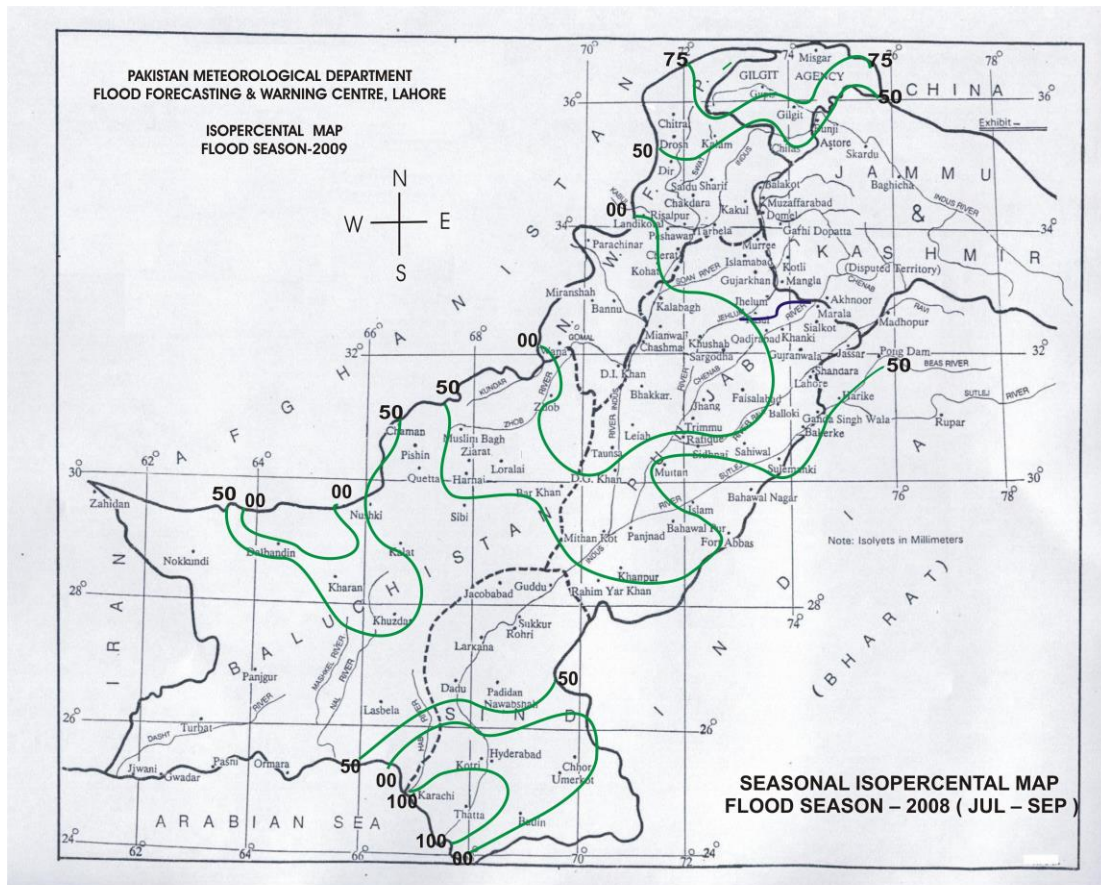


Figure 33: Seasonal Isopercental Map (July – Sep) 2009

## 9. SEASONAL PRECIPITATION AND FLOW PREDICTION.

Pakistan received moderately below normal rainfall (-26%). While Viewing the Seasonal rainfall on province wise basis, NWFP received 36.9% below normal, Punjab received 26.5% below normal, and Balochistan received 40.8 % below normal rainfall while Sindh received 5% above normal rainfall.

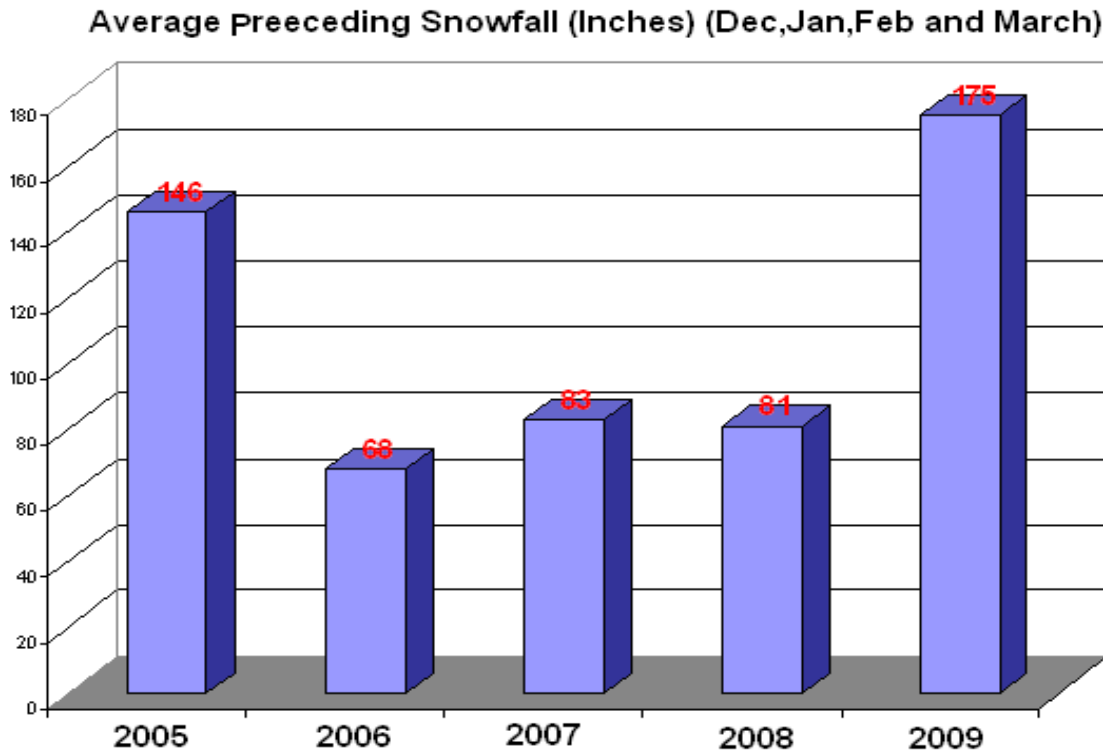
### AREA WEIGHTED RAINFALL (JULY TO SEPTEMBER 2009)

Percentage Departure				
Region	JULY	AUGUST	SEPTEMBER	JUL-SEPT
Pakistan	-9.3	-40.9	-36.5	-26.0
NWFP	-48.1	-33.1	-16.9	-36.9
Punjab	-22.6	-31.4	-25.7	-26.5



Balochistan	-14.5	-62.6	-75.0	-40.8
Sindh	80.6	-54.5	-59.0	5.0

**Table: 1**



*Figure 34: Average winter snowfall (INCHES) (Dec, Jan, Feb, March)*

Tarbela is considered as the largest earth-filled dam of the world. The total catchment area above Tarbela is spread over 65,000 sq. miles (168,000 sq. kilometers) which largely brings in snowmelt supplied in addition to some monsoon rains. Its flows depend on different factors i.e., 60% flow from glaciers, 30% flow from snow melt & only 10% flow from rainfall in the catchments (Dr. Hayley Fowler, Newcastle university, UK)

This type of river hydrology is defined by monthly hydrograph. Precipitation and temperature are the factors determining the character of hydrology. A study of snow hydrology indicates that in similar climatic conditions the type of hydrology is same. However, because of difference in climate the snow type hydrology is considerably different in continental location.

In this report the average winter snowfall (inches) are shown in figure 34. An average winter snow fall was reported 146 inches in 2005, & average winter



snowfall reported 175 inches in 2009. . This figure indicates that snowfall in 2009 reported more than 2005 . Statistics showed that flow from glacier depends on the mean temperature of the catchments area.

Indus flow variation depends on the average winter snowfall and precipitation in catchment area. This year PMD predicted below normal rainfall but the average snowfall was more than the previous years. PMD predicted that volume of flow would be normal and maximum conservation level would possibly be achieved.

In spite of 37% & 27 % less monsoon rains in NWFP & Punjab respectively the maximum conservation level of Tarbela and Mangla could be attained mainly due to heavy snowfall in the preceding winter (shown in the above graph) which resulted into continues enhanced base flow in the Jhelum and Indus rivers.

It is worth mentioning here that water availability forecast for the Kharif Season was also issued on experimental basis for the Tarbela and Mangla Dams. It was anticipated that 76 MAF water would be available for the Kharif Season. It was mainly based on the snowmelt contribution. This forecast was issued at the start of Kharif Season. It is also included the Monsoon rainfall contribution. However, the Monsoon rainfall contribution was not upto the expectation and the revised less forecast Monsoon rainfall (-30% below normal) was issued due to Elnino development. Consequently the water availability forecast was also affected at the end of the season and it was observed that total volume arrived in these two dams was 63.24 MAF against the forecast of 76 MAF. Detail of the observed volume are shown in tab- 2.

### **KHARIF SEASON OBSERVED, VOLUME, 2009**

Month	Tarbela (MAF)	Mangla (MAF)	Marala (MAF)	Kabul (MAF)
April,	2.18	2.96	1.04	2.23
May,	4.67	3.73	1.59	3.44
June,	8.16	3.25	2.21	3.33
July,	13.14	3.12	4.08	4.88
August	13.62	2.16	3.96	3.22



September,	4.98	1.27	1.60	1.25
Total (Kharif Season, 2009)	46.75	16.49	14.48	18.35

**Table: 2****10 DETAILS OF LOSSES/DAMAGES DUE TO RAINFALL/FLOOD-2009**

**This information has been provided by National disaster management authority  
(NDMA) ISLAMABAD**

Sr.	Province	Persons Died	Houses Damaged	Villages Affected	Cattle Died
1	<b>SINDH</b>	83	1262	30	104
2	<b>PUNJAB</b>	2	84	59	-
3	<b>BALUCHISTAN</b>	-	-	-	-
4	<b>NWFP</b>	24	4875	22	270
5	<b>AK&amp;NA</b>	-	-	-	-
6	<b>TOTAL</b>	109	6221	111	374

**Table:3****11. FLOOD FORECAST EVALUATION REPORT:**

The Flood Forecasting evaluation for 2009 for each category of flood is given here as under: -

Sr. No.	RIVER	SITE	ACTUAL UPSTREAM PEAK DISCHARGE			Forecasted Discharge in Thousand of Cusecs	Percentage Accuracy of Forecast
			Date	Discharge In Cusecs	Flood Limit		
1	Chenab	Marala	13-07-2009	104990	LOW	75-90	86%



2	Chenab	Marala	28-07-2009	129963	LOW	80-120	92%
3	Chenab	Khanki	29-07-2009	105358	LOW	45-90	86%
4	Jhelum	Mangla	28-07-2009	88591	LOW	60-90	100%
5	Indus	Tarbela	19-07-2009	261000	LOW	250-280	100%
6	Indus	Tarbela	28-07-2009	286000	LOW	265-285	99%
7	Indus	Tarbela	29-07-2009	304000	LOW	270-300	99%
8	Indus	Kalabagh	30-07-2009	323489	LOW	270R350	100%
9	Indus	Chashma	30-07-2009	257315	LOW	250R340	100%
10	Kabul	Nowshera	22-07-2009	92300	MIDIUM	90-95	100%
11	Kabul	Nowshera	29-07-2009	91200	MEDIUM	80-95	100%
12	Ravi	Balloki	02-08-2009	41615	LOW	38-42	100%
13	Ravi	Balloki	19-08-2009	43886	LOW	40-45	100%
14	Jhelum	Mangla	17-08-2009	122323	MEDIUM	60-100	82%
15	Indus	Tarbela	08-08-2009	285000	LOW	260-290	100%
16	Indus	Tarbela	17-08-2009	302000	LOW	290-340	100%
17	Indus	Kalabagh	06-08-2009	290241	LOW	250-275	95%
18	Indus	Kalabagh	17-08-2009	356820	LOW	340-380	100%
19	Indus	Chashma	07-08-2009	283019	LOW	270-290	100%
20	Indus	Chashma	08-08-2009	317585	LOW	280-300	94%
21	Indus	Chashma	19-08-2009	390025	MEDIUM	330-375	96%
22	Indus	Taunsa	11-08-2009	261501	LOW	250-270	100%
23	Indus	Taunsa	21-08-2009	346392	LOW	345-370	100%
24	Indus	Guddu	24-08-2009	264612	LOW	260-280	100%

R: Rising

**Table: 4**

The overall accuracy of the forecast issued by FFD Lahore during the flood season 2009 has been calculated which shows a good 97% against all odds.

## 12. FLOOD LIMITS (IN LACS OF CUSECS):

RIVER	SITE	DESIGN CAPACITY	LOW	MED	HIGH	VERY HIGH	EXCEPTIONALLY HIGH
KABUL	NOWSHERA	-	0.45	0.47	1.0	2.0	4.0
INDUS	WARSAK	15.0	0.30	0.45	1.0	2.0	4.0
	TARBELA	15.0	2.5	3.75	5.0	6.5	8.0



	ATTOCK	-	2.5	3.75	5.0	6.5	8.0
	KALABAGH	9.5	2.5	3.75	5.0	6.5	8.0
	CHASHMA	9.5	2.5	3.75	5.0	6.5	8.0
	TAUNSA	10.0	2.5	3.75	5.0	6.5	8.0
	GUDDU	12.0	2.0	3.5	5.0	7.0	9.0
	SUKKUR	9.0	2.0	3.5	5.0	7.0	9.0
	KOTRI	8.5	2.0	3.0	4.5	6.5	8.0
JHELUM	KOHALA	-	1.0	1.5	2.0	3.0	4.0
	MANGLA	10.6	0.75	1.1	1.5	2.25	3.0
	RASUL	8.5	0.75	1.1	1.5	2.25	3.0
CHENAB	MARALA	11.0	1.0	1.5	2.0	4.0	6.0
	KHANKI	8.0	1.0	1.5	2.0	4.0	6.0
	QADIRABAD	8.07	1.0	1.5	2.0	4.0	6.0
	TRIMMU	6.45	1.5	2.0	3.0	4.5	6.0
	PANJNAD	7.0	1.5	2.0	3.0	4.5	6.0
RAVI	JASSAR	2.75	0.5	0.75	1.0	1.5	2.0
	RAVI SYPHON	4.5	0.4	0.65	0.9	1.35	1.8
	SHAHDARA	2.5	0.4	0.65	0.9	1.35	1.8
	BALLOKI	2.25	0.4	0.65	0.9	1.35	1.8
	SIDHNAI	1.5	0.3	0.46	0.6	0.9	1.3
SUTLEJ	SULEMANKI	3.25	0.5	0.8	1.2	1.75	2.25
	ISLAM	3.0	0.5	0.8	1.2	1.75	2.25

Table: 5

### 13: REDUCED LEVEL OF WATER IN THE INDUS RIVER SYSTEM:

The Indus River, its tributaries originate in the Karakoram, Hindukush, and the Himalayan regions along the north and northeastern borders of Pakistan. The Indus River System form a link between two great natural reservoirs, the **snow and glaciers** in the mountains and the groundwater contained by the alluvium Indus Plains of the Punjab and Sindh in the Provinces of Pakistan. The water from the Indus River and its tributaries supports the bulk of the agricultural water supply for its 160 million people. Dams on the



main stem of the Indus River and its tributaries produce about 45% of the electrical energy for Pakistan.

*Table 6:  
Showing annual flow-rates of major rivers  
between 1922-61, 1985-1995, 1996-2000 and 2001-08*

River	Average Annual Flow (1922-61) MAF	Average Annual Flow (1985-95) MAF	Average Annual Flow (1996-2000) MAF	Average Annual Flow (2001-08) MAF
Indus	93	62.7	61.07	57.35
Jhelum	23	26.6	21.00	18.87
Chenab	26	27.5	26.81	22.97
Ravi	7	5.0	2.11	2.55
Kabul	26	23.4	19.42	19.10
Total	189.0	148.8	130.41	120.84

**Table:6**

The table 6 shows average annual flow-rates of major rivers between 1922-61, 1985-1995, 1996-2000 and 2001-08. The figures indicate sharp decrease in water flow in the rivers during last several years. The low level of water-flow in the rivers is an indicative of reduced quantity of water in the glaciers. The situation in River Indus clearly indicates decrease in quantity of water by 32% from 1922-61 to the period of 1985-1995 and further reduced to 3% during 1996-2001 as compared to 1985-1995 & finally reduced by 6% during 2001-2008. It is in fact significant reduction of 38.3% in the last eight decades.

#### **14: RECOMMENDATIONS:**

Keeping in view the above, some recommendations have been proposed.

##### **(i) PROPER TRAINING & UNDERSTANDING:**

The general public especially the stakeholders must have adequate knowledge of the weather system and the forecasting of the system. For this purpose some training, education



must be imparted to the responsible section of the public and amongst the stakeholders so that dissemination of the forecast may be realized in true sense.

(ii) **MEDIA ROLE:**

Local print & electronic media should also understand the purpose of the flood forecast and should refrain from dishing out wrong or confused information to the public that may result in spreading panic & chaos in the civil population.

(iii) **SINGLE VOICE:**

The flood forecast issuing authority has a unique role in flood forecasting standard operation procedure, which should not be compromised, because the focal person has all the knowledge and data regarding the building or recession of the flood wave. Any wrong or mutilated picture of flood may result in increasing the difficulties and aggravating the situation.

(iv) **INFRASTRUCTURE DEVELOPMENT:**

The general public should be aware of the flood prone areas and may be discouraged to raising any structure within the area. Government should mark & advertise flood prone areas through the print and electronic/press media for the information of the public. No utility services like gas, telephone, electricity should be provided in the flood prone areas particularly within the riverbanks. Proper record may be maintained regarding the raising of building in the specified areas.

In the hilly areas where flash flooding usually creates havoc, construction of building should also be disallowed in the vicinity of the hill torrents paths. Similarly edges of the roads near rivers should be banned for construction of any big structure like shopping centers, educational institutions, hotels, Govt. office buildings etc.

(v) **DISCHARGE AT KURRAM GARHI AND DARRAE- TANG:**

Discharge at above-mentioned areas has a key role to forecast for the upstream discharge at Chashma, which was not being transmitted to FFD Lahore. Necessary measures should be taken in this regard.



## 15. SUGGESTION

Kashmir is the source from where Pakistan's water reservoirs originate. In future water is going to be a crucial issue, there is need to conduct comprehensive study on our glaciers and to develop a model to determine water melt from glaciers.

Water conservation plan should be enforced at national level.