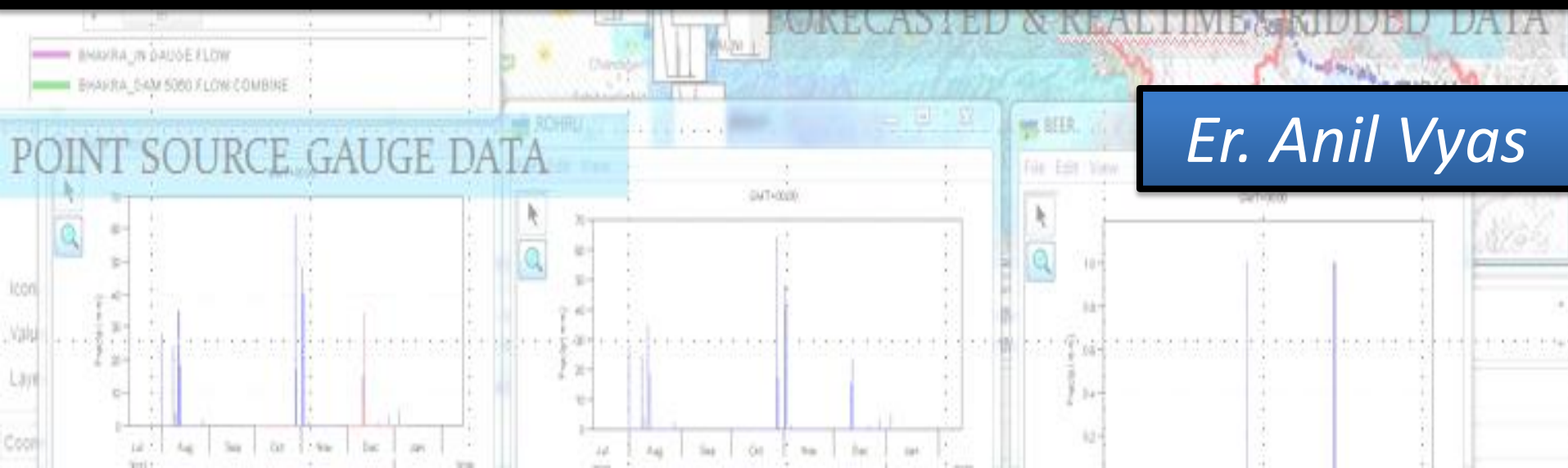


# REAL TIME DECISION SUPPORT SYSTEM OF BHAKRA BEAS MANAGEMENT BOARD



*Er. Anil Vyas*

# The Organization

**Bhakra-Nangal Project- A Joint Venture Punjab, Haryana and Rajasthan.**

**Bhakra Management Board- Under Punjab Reorganization Act 1966 on 1<sup>st</sup> Oct. 1967 for administration, maintenance & operation of Bhakra Nangal Project.**

**Beas Construction Board- For construction of Beas Project.**

**Bhakra Management Board was renamed as Bhakra Beas Management Board (BBMB) w.e.f. from 15<sup>th</sup> May 1976 after transfer of Beas Project on its completion by Beas Construction Board.**

# Functions

Regulation of the supply of water from Bhakra Nangal & Beas Projects to the States of Punjab, Haryana & Rajasthan.

Regulation of the supply of power generated at BBMB Power Houses to Power utilities of Punjab, Haryana, HP, Rajasthan, Chandigarh and some Common Pool Consumers.

In the year 1999, BBMB was entrusted with additional function of providing and performing engineering & related technical consultancy services.

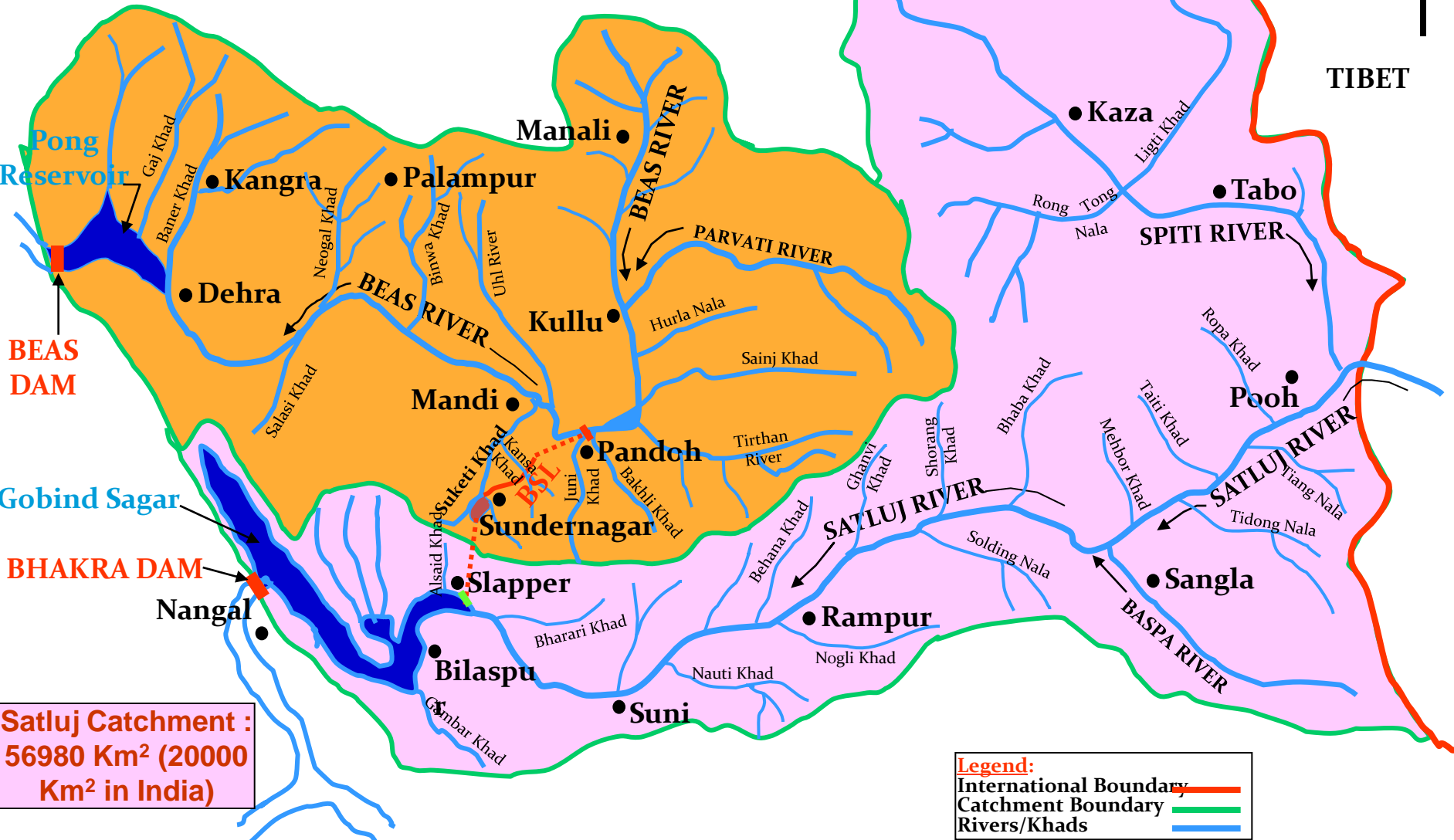
# CATCHMENT OF BEAS-SATLUJ(INDIA)

## Bhakra Beas Management Board(BBMB)

Beas Catchment:  
12560 Km<sup>2</sup>



TIBET



Gobind Sagar

BHAKRA DAM

Satluj Catchment :  
56980 Km<sup>2</sup> (20000  
Km<sup>2</sup> in India)

**Legend:**  
International Boundary  
Catchment Boundary  
Rivers/Khads

# CATCHMENT OF BEAS-SATLUJ(INCLUDING CHINA)

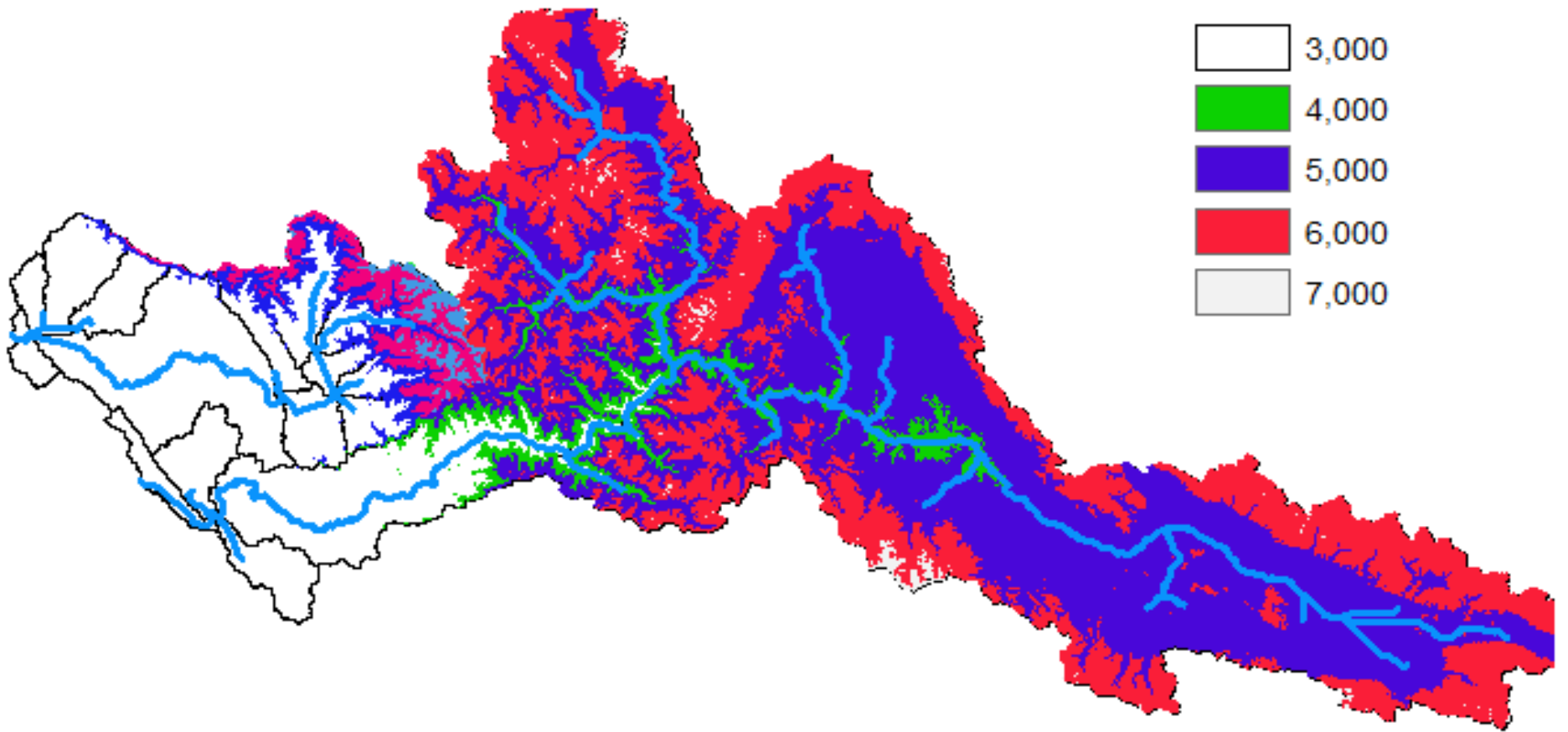
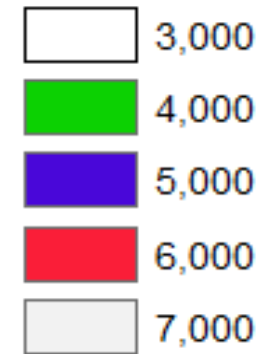
## Bhakra Beas Management Board(BBMB)



# SATLUJ BEAS TERRAIN

## Bhakra Beas Management Board(BBMB)

### Legend



# BHAKRA DAM WITH NANGAL HYDEL CHANNEL & ANANDPUR HYDEL CHANNEL



# VITAL INSTALLATIONS BHAKRA DAM

**SPILLWAY**  
**CAPACITY 197300 cusecs**

**BHAKRA DAM**  
**Concrete Straight Gravity**  
**Height of Dam = 740 feet**

**POWER HOUSES**  
**INSTALLED CAPACITY**  
**=1343 MW**

Water filter Plant

Grid Sub Station

Sutlej River

Google<sup>IN</sup>



# VITAL INSTALLATIONS PONG DAM

बन सम्मिलयन

Water Sports Complex

वाटर स्पोर्ट्स  
कॉम्प्लेक्स

**PONG DAM**

**Earth core gravel shell**

**Height = 435 feet**

Pong Dam

GSS

**Power House**

**Generation = 396 MW**

Overhead  
Water Tank  
ओवरहेड  
वाटर टैंक

**MAHARANA PRATAP  
SAGAR**

**Gross Storage = 6.95  
MAF**

Beas River

**SPILLWAY**

**Overflow gated chute**

**Capacity = 4,37,000 cusecs**

Beas River

# VITAL INSTALLATIONS PANDOH DAM

**PANDOH DAM**  
Earth-cum-rock fill

**Pandoh Reservoir**  
Capacity = 33,240 acre ft

**SPILLWAY**  
Orifice type gates chute  
Capacity = 351000 cusecs

**PANDOH BAGGI TUNNEL**  
Capacity = 9005 cusecs



Beas River

Pandoh Lake  
पण्डोह लेक

Beas River

Google

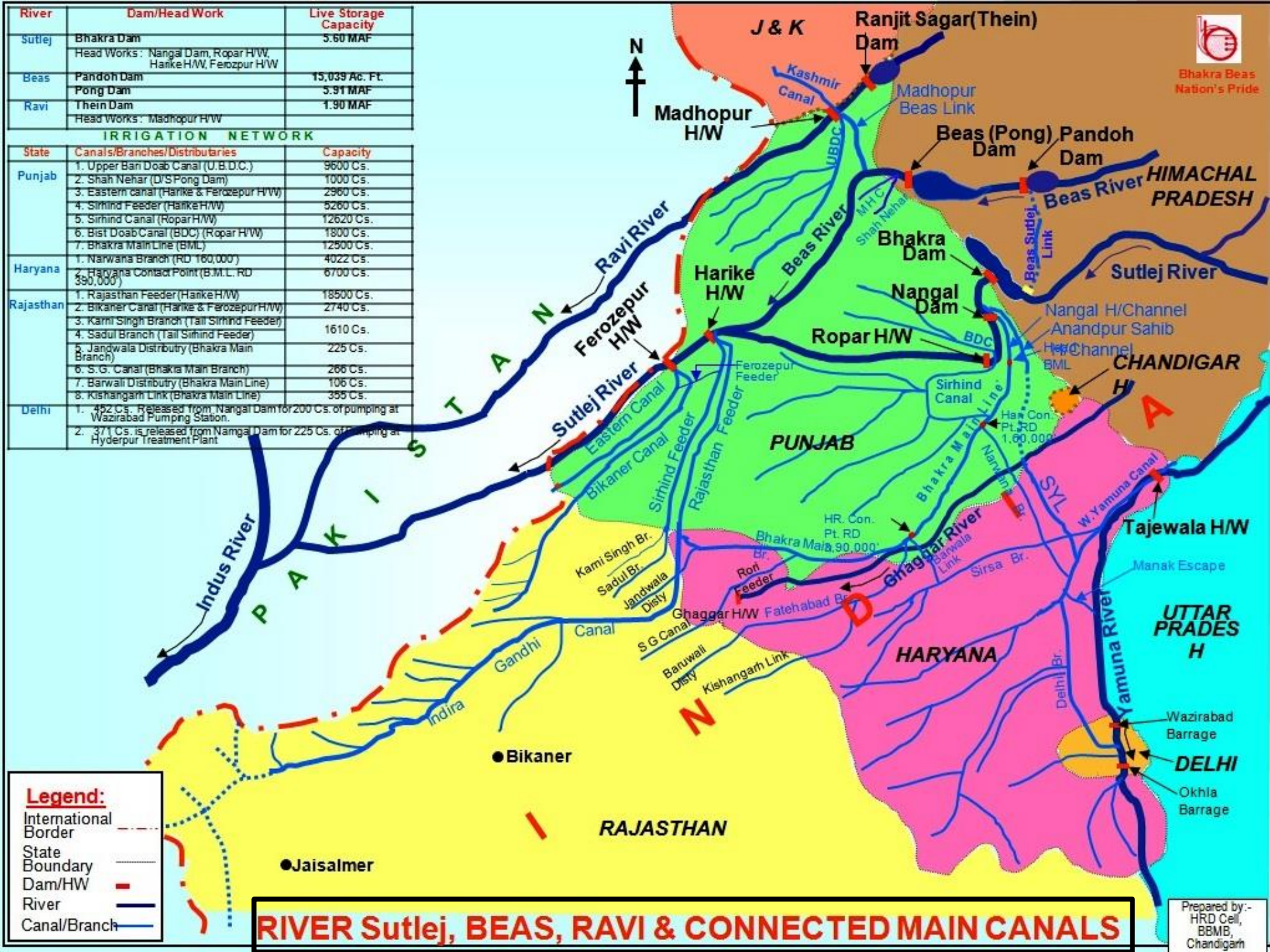


Bhakra Beas  
Nation's Pride

River	Dam/Head Work	Live Storage Capacity
Sutlej	Bhakra Dam	5.60 MAF
	Head Works: Nangal Dam, Ropar H/W, Hanke H/W, Ferozpur H/W	
Beas	Pandoh Dam	15,039 Ac. Ft.
	Pong Dam	
Ravi	Thein Dam	1.90 MAF
	Head Works: Madhopur H/W	

### IRRIGATION NETWORK

State	Canals/Branches/Distributaries	Capacity
Punjab	1. Upper Bari Doab Canal (U.B.D.C.)	9600 Cs.
	2. Shah Nehar (D/S Pong Dam)	1000 Cs.
	3. Eastern canal (Hanke & Ferozpur H/W)	2900 Cs.
	4. Sirhind Feeder (Hanke H/W)	5260 Cs.
	5. Sirhind Canal (Ropar H/W)	12620 Cs.
	6. Bist Doab Canal (BDC) (Ropar H/W)	1800 Cs.
	7. Bhakra Main Line (BML)	12500 Cs.
Haryana	1. Narwana Branch (RD 160,000)	4022 Cs.
	2. Haryana Contact Point (B.M.L. RD 390,000)	6700 Cs.
Rajasthan	1. Rajasthan Feeder (Hanke H/W)	18500 Cs.
	2. Bikaner Canal (Hanke & Ferozpur H/W)	2740 Cs.
	3. Kami Singh Branch (Tail Sirhind Feeder)	1610 Cs.
	4. Sadul Branch (Tail Sirhind Feeder)	225 Cs.
	5. Jandwala Distributry (Bhakra Main Branch)	266 Cs.
	6. S.G. Canal (Bhakra Main Branch)	106 Cs.
	7. Barwail Distributry (Bhakra Main Line)	355 Cs.
	8. Kishangarh Link (Bhakra Main Line)	355 Cs.
Delhi	1. 452 Cs. is released from Nangal Dam for 200 Cs. of pumping at Wazirabad Pumping Station.	
	2. 371 Cs. is released from Nangal Dam for 225 Cs. of pumping at Hyderpur Treatment Plant	



**Legend:**

- International Border
- State Boundary
- Dam/HW
- River
- Canal/Branch

## RIVER Sutlej, BEAS, RAVI & CONNECTED MAIN CANALS

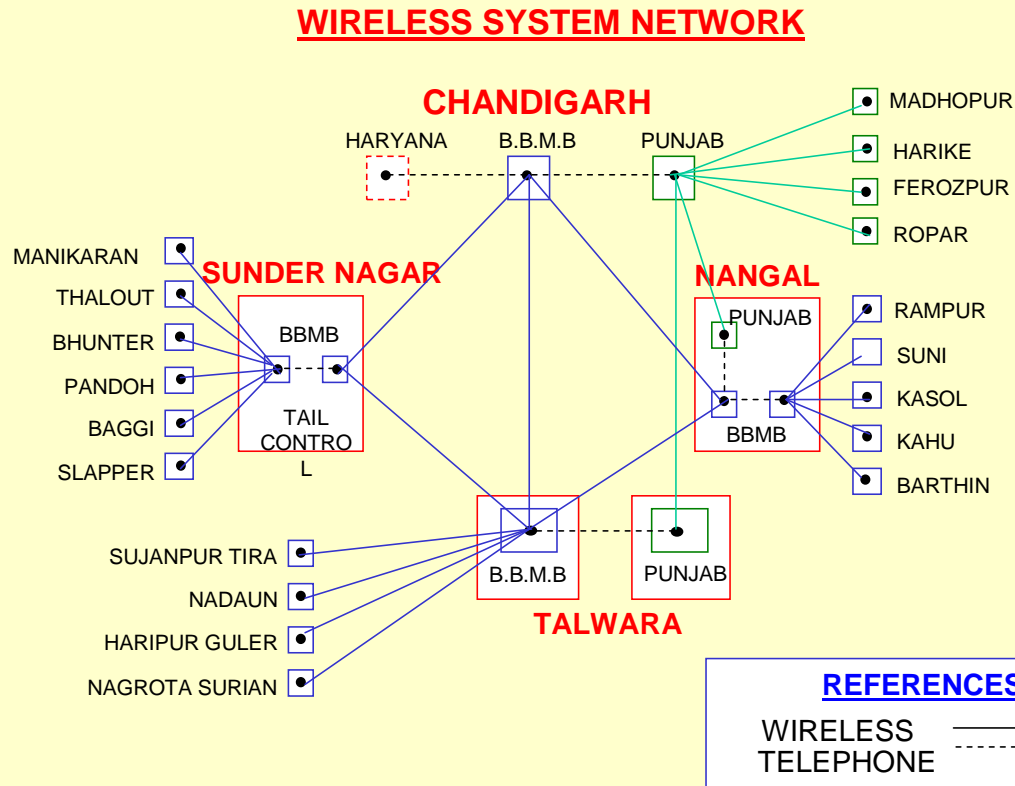
Prepared by:-  
HRD Cell,  
BBMB,  
Chandigarh

## Manual Hydro-Metrological Stations in Sutlej & Beas Catchments

Nomenclature	No. of Instruments	
	Sutlej	Beas
Snow Observatory	4	-
Snow Gauge Stations	17	-
Rain Gauges Stations	13	24
Discharge Sites	9	15
Evaporimeter	6	6
Meteorological Observatory	1	2
TOTAL	50	47

# Hydro-meteorological Data Acquisition System Wireless Network

## Hydro-Meteorological Data Acquisition And Transmission



## LIMITATIONS OF MANUAL SYSTEM

Obsolete Communication System

Partial Coverage of Catchment Area

Forecasts Variance

Poor Decision Making Tool

Dependence on Remote Man Power



**REAL TIME DECISION SUPPORT SYSTEM  
(HYDROLOGY –PROJECT)  
BHAKRA BEAS MANAGEMENT BOARD**

## Data and Information Needed by Water Managers to make informed operation decisions, are:--

Current and potential future scenarios of precipitation.

Data that describes the current state of channels, and water management facilities, including reservoirs, diversions, and other controllable features of the system.

Information about the likely future state (e.g., one hour to two weeks) of the watersheds, channels, and management facilities.

Weather conditions, including air temperature, precipitation depths and rates, and evaporation depths and rates.

Watershed states such as snow accumulation etc.

Discharge and other conditions in streams, rivers, canals, and other waterways.

Real Time and probable future information of Upstream/Downstream power projects such as power generation, discharge through turbines/spillways.



# ACTIVITIES UNDER HYDROLOGY PROJECT

**MODELING OF RIVER BASINS (SATLUJ & BEAS)**

**CALIBRATION OF MODELS WITH HISTORICAL DATA**

**UPGRADATION OF EXISTING HYDROMETROLOGICAL NETWORK**

**ESTABLISHMENT OF RTDSS CENTRE AT CHANDIGARH & WORKSTATIONS AT PROJECT STATIONS**

**LINKING OF DATA ACQUISITION SYSTEM WITH DEVELOPED MODELS**

**FINE TUNING & DEVELOPMENT OF REAL TIME DECISION SUPPORT SYSTEM**

# MODELING

RIVER BASIN OR CATCHMENT

RIVER ANALYSIS

RESERVOIR SIMULATION

WATER DISTRIBUTION

DOWN STREAM FLOODING

DISSEMINATION OF INFORMATION

# Real Time Decision Support System

Information Flow Process

## Data Acquisition System

Telemetry Data

IMD Data

GFS FORECAST

ECMWF FORECAT

NASA Satellite  
Precipitation

Manual Observation Data

## Data Storage and Management

DATA PROCESSING

DATA STORAGE

DATA VISULIZATION

## Modeling Tools

Weighted Rainfall

Rainfall Runoff

Snow Melt

Hydrodynamic

Allocation Model

Flood Models

## Results Visualization and Dissemination

Realtime DSS Interface

Workstations

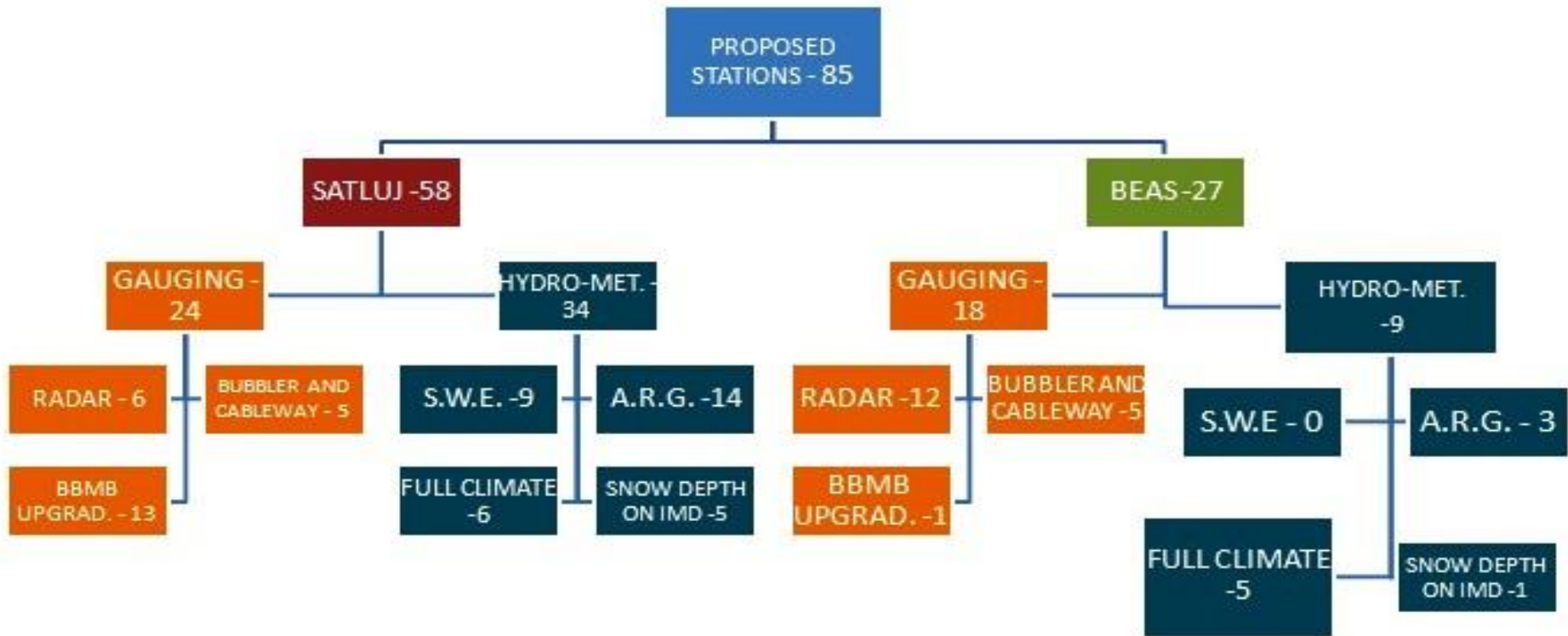
Remote Locations

Website – Dashboard

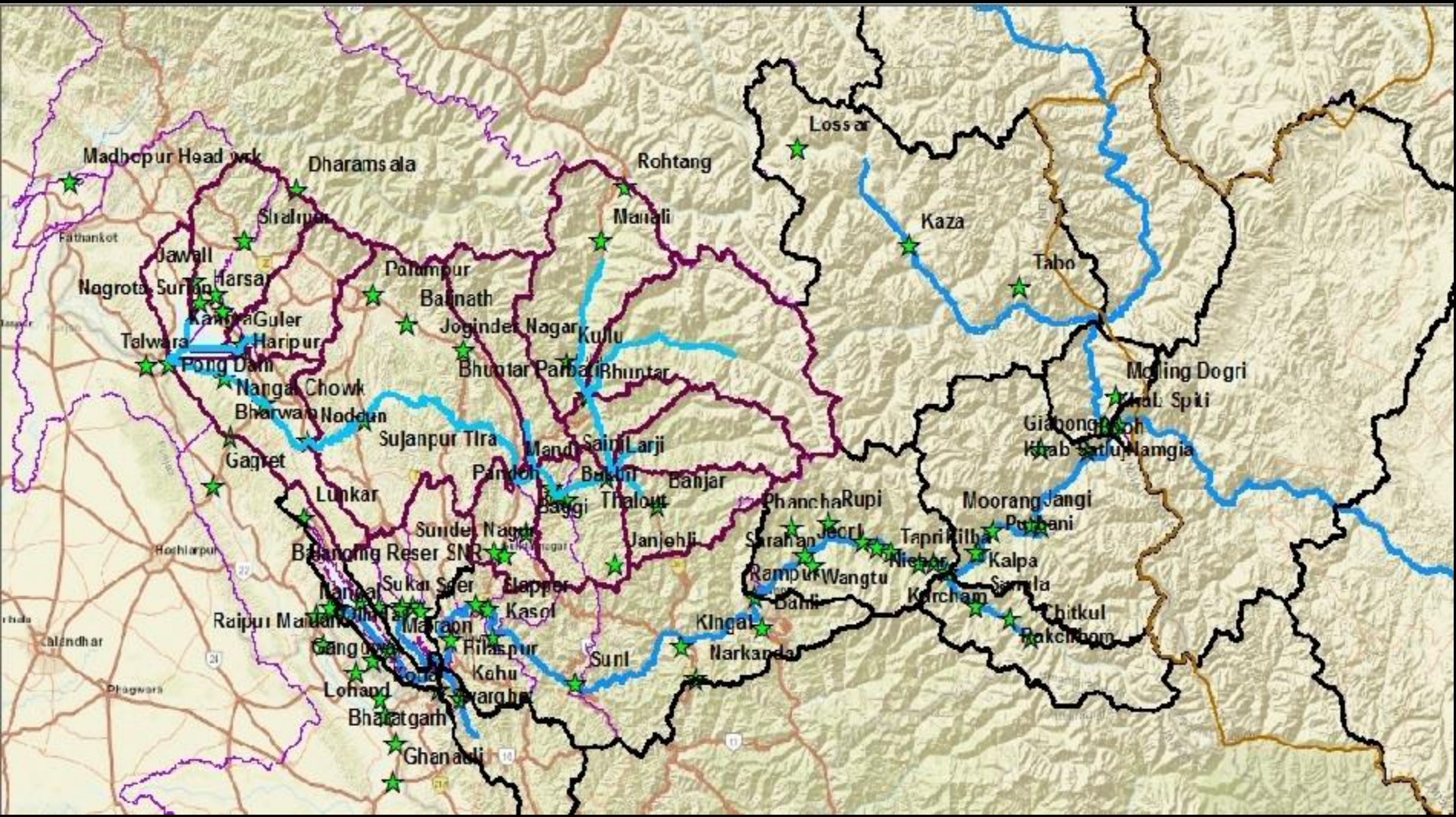
Daily Reports

Email and SMS Alerts

# Real Time Data Acquisition System



# LOCATION MAP OF BBMB OBSERVATION STATIONS IN SATLUJ BEAS CATCHMENT



# Telemetry Data – Full Climatic Station



<sup>22</sup> Full Climatic Station Installed at Kalpa, Elevation 9046 ft

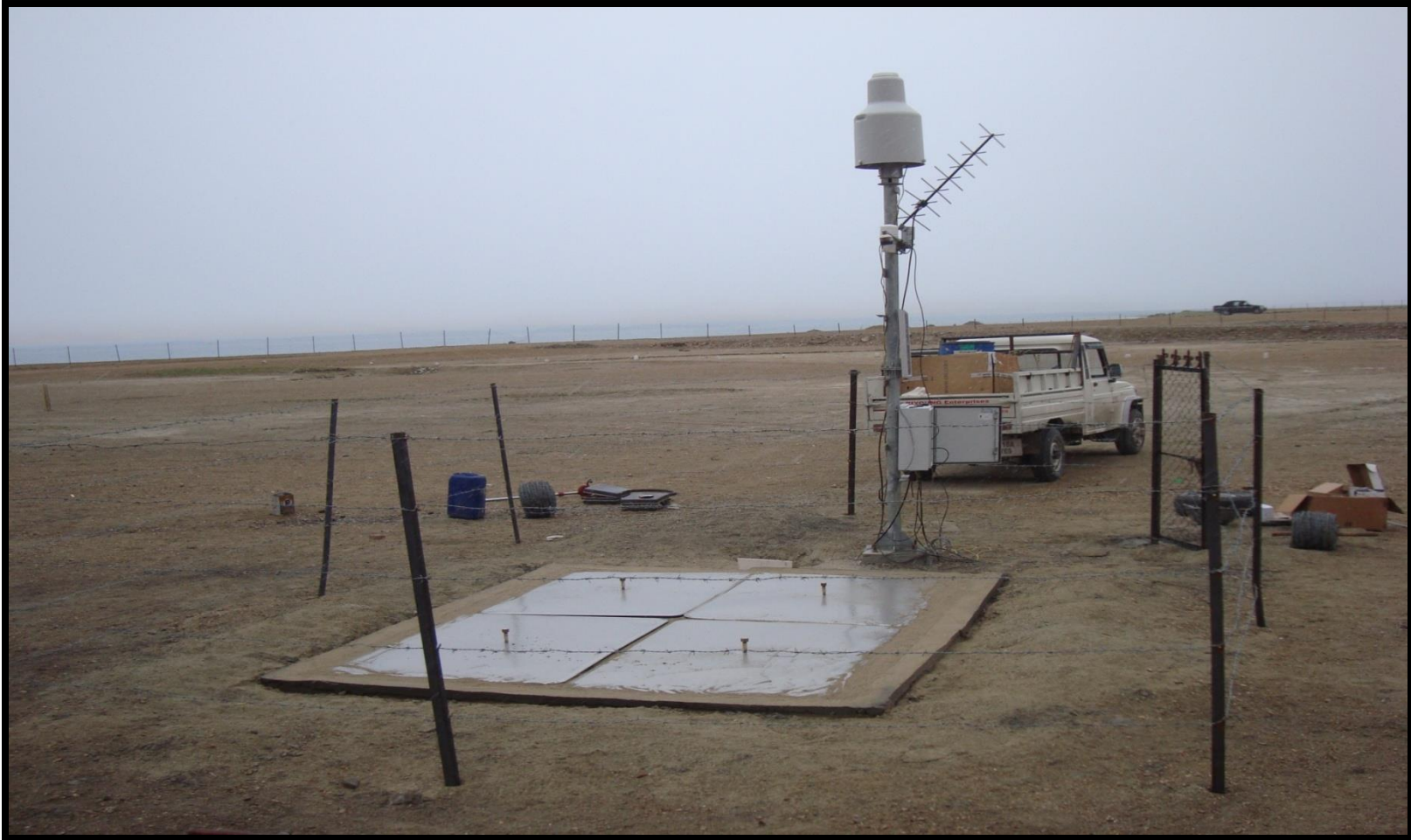
# Telemetry Data – Full Climatic Station



**Full Climatic Station Installed at Pandoh Dam, Elevation 2949 ft**

# Telemetry Data – Snow Water Equivalent

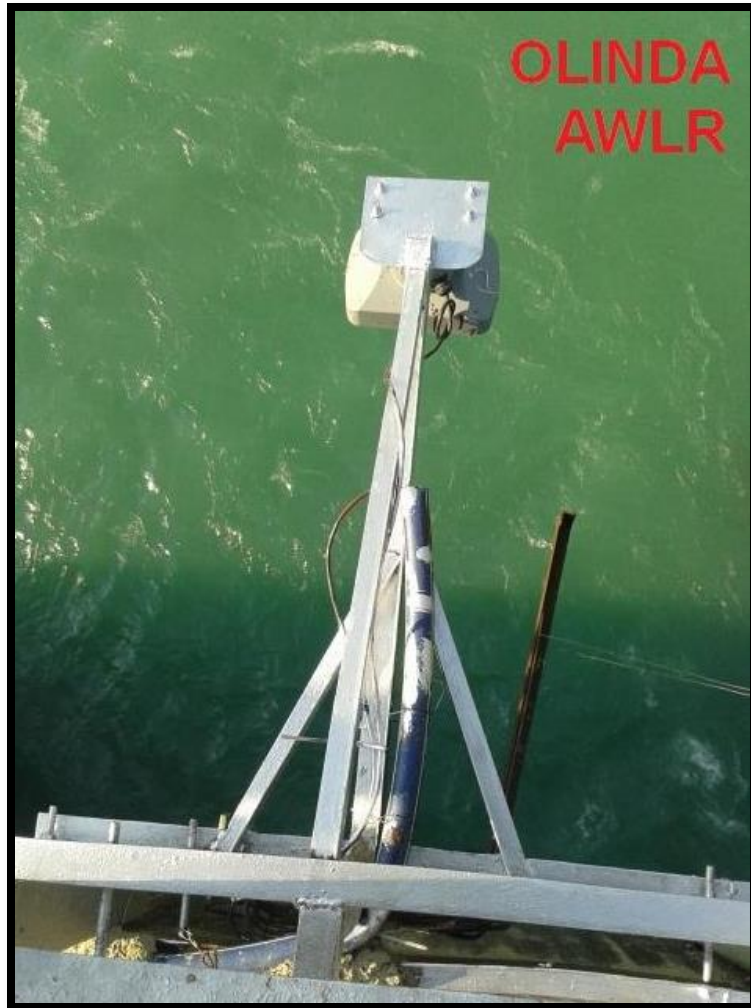
Data Acquisition System



24 Snow Pillow Installed at Tso-Morari, Elevation 14845 ft



## Telemetry data – Water level recorders



# ADCP in Operation - Rampur

Data Acquisition System

RAMPUR - Cableway



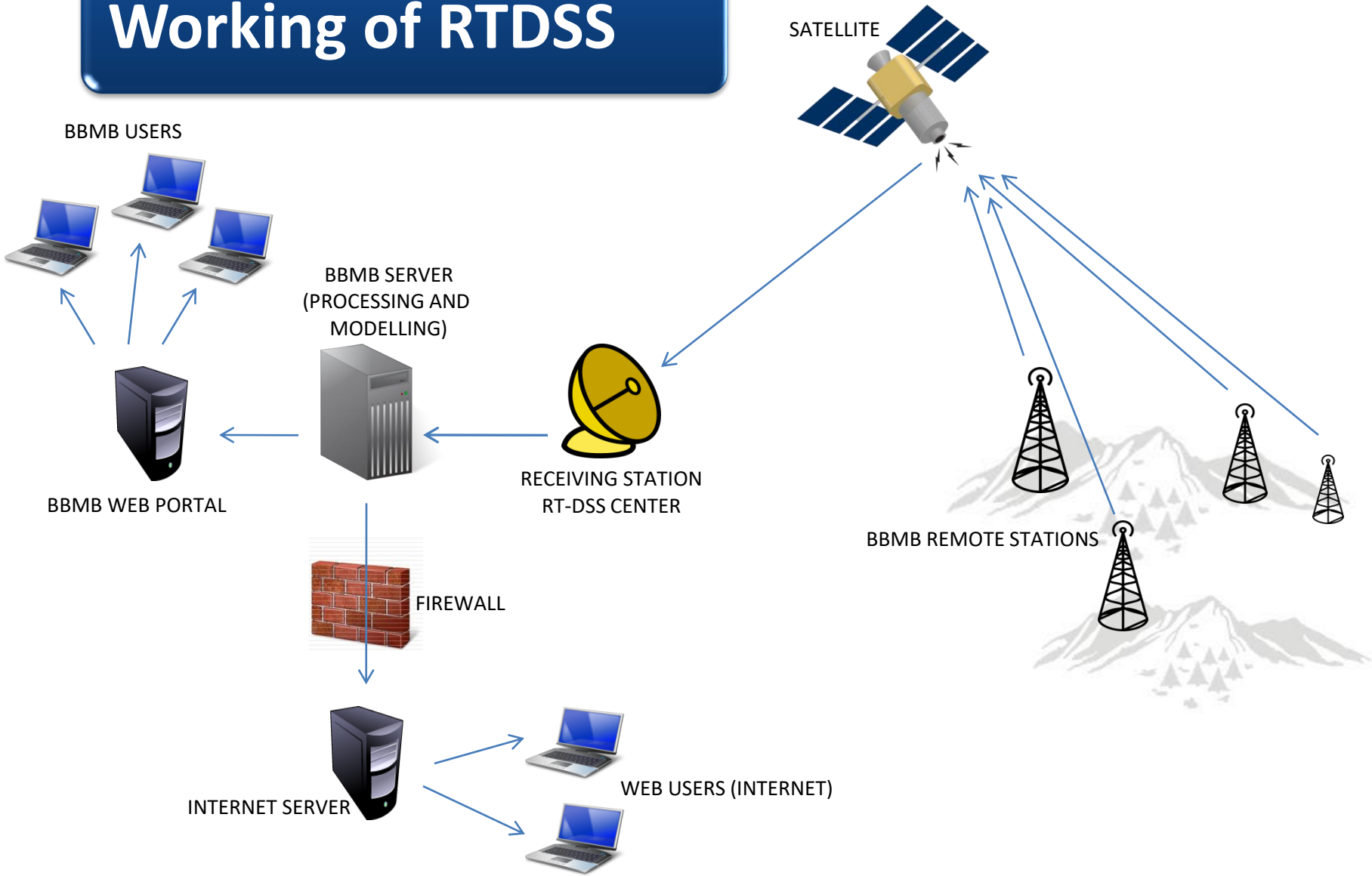
RAMPUR - Cableway



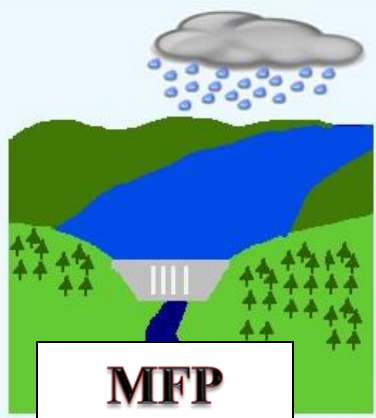
RAMPUR - ADCP



# Working of RTDSS



**HEC-RTS 3.0 IS A PUBLIC VERSION OF CWMS-CAVI WHICH CAN BE RUN FROM PC WITH DIFFERENT MODELING COMPONENTS LIKE MET-VUE, MFP, HMS, RAS, RES-SIM & FIA WITH HEC-GRID-UTILITY & HEC-DSS ON A SINGLE PLATFORM**



**HEC-RTS**  
Version 3.0.1  
August 29, 2016

Hydrologic Engineering Center  
Institute for Water Resources  
U.S. Army Corps of Engineers  
609 Second Street  
Davis CA, 95616

**MFP**

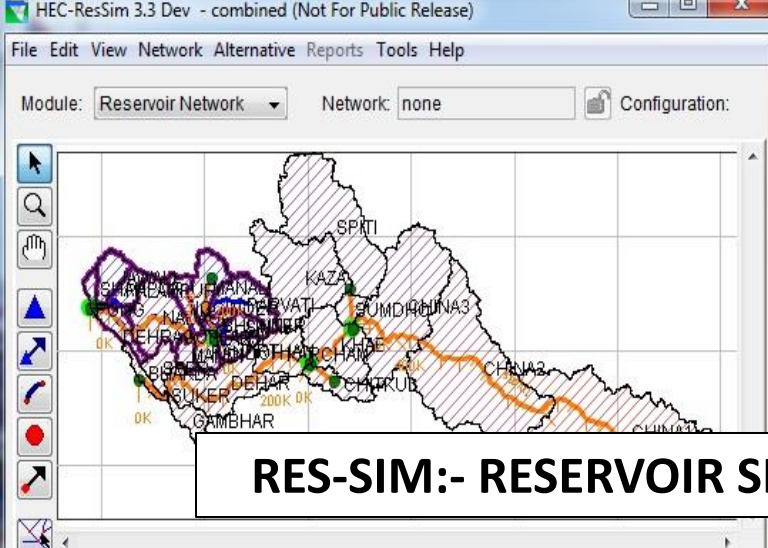
US Army Corps of Engineers

[www.hec.usace.army.mil](http://www.hec.usace.army.mil)

HEC-ResSim 3.3 Dev - combined (Not For Public Release)

File Edit View Network Alternative Reports Tools Help

Module: Reservoir Network Network: none Configuration:



**RES-SIM:- RESERVOIR SIMULATION**

Messages

- GFS
- ECMWF
- TRMM
- IMD
- UPDATE DSS
- test\_imd
- IMD FORECA
- BBMB

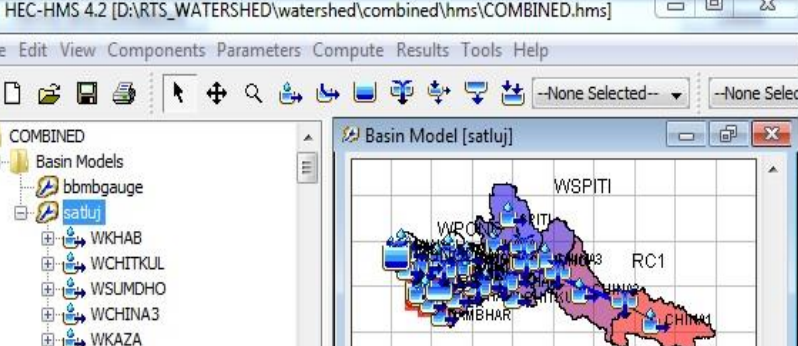
HEC-HMS 4.2 [D:\RTS\_WATERSHED\watershed\combined\hms\COMBINED.hms]

File Edit View Components Parameters Compute Results Tools Help

COMBINED

- Basin Models
  - bbmbgauge
  - satluj
  - WKHAB
  - WCHITKUL
  - WSUMDHO
  - WCHINA3
  - WKAZA

Basin Model [satluj]

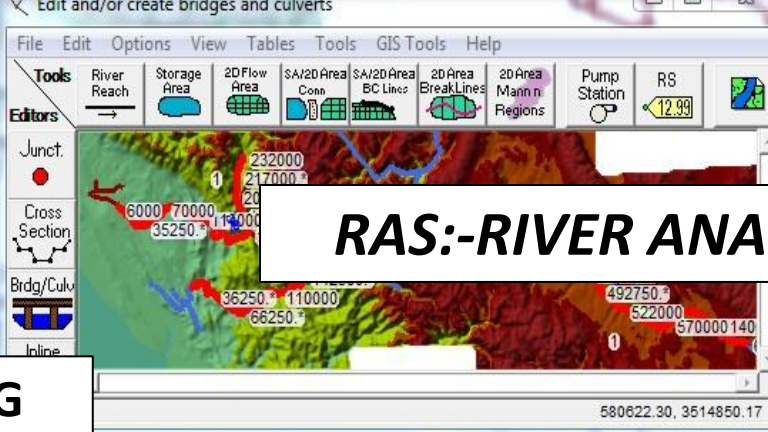


Edit and/or create bridges and culverts

File Edit Options View Tables Tools GIS Tools Help

Tools: River Reach, Storage Area, 2D Flow Area, SA/2D Area Conn, SA/2D Area BC Lines, 2D Area Break Lines, 2D Area Mann n Regions, Pump Station, RS

Editors: Junct., Cross Section, Brgd/Culv, Inline



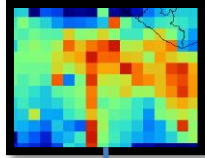
**RAS:-RIVER ANALYSIS**

580622.30, 3514850.17

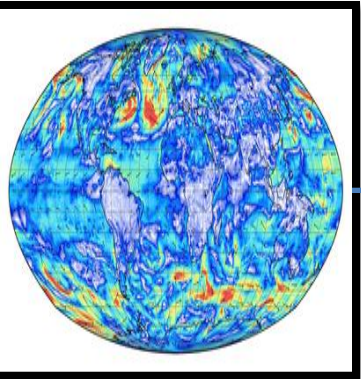
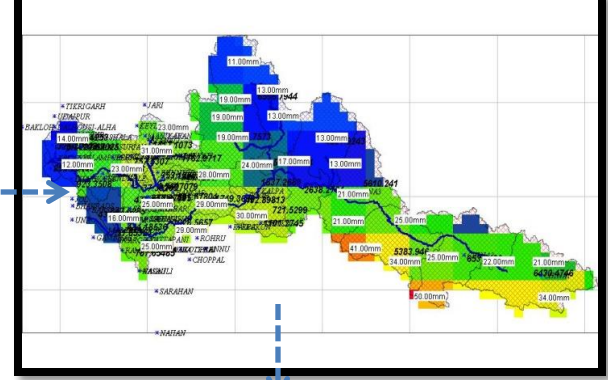
**HMS:-- HYDROLOGICAL MODELLING**

# FORECASTING SYSTEM & EVENT ANALYSIS

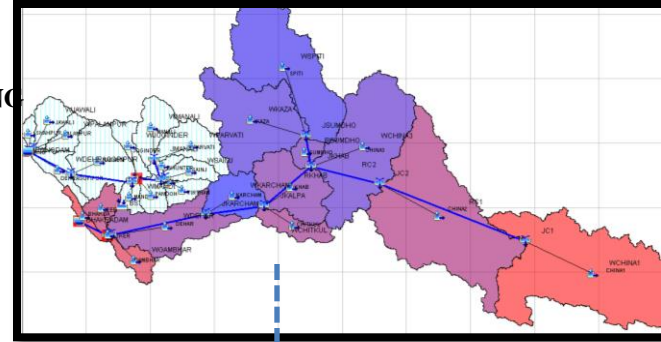
REAL TIME DATA



PRECIPITATION  
TEMPERATURE

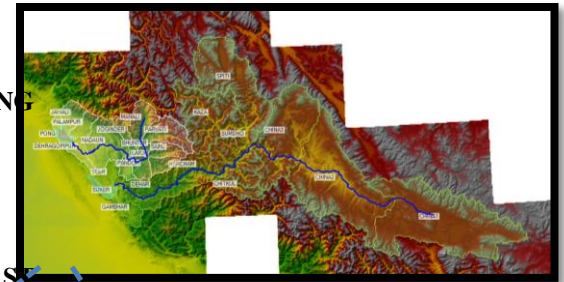


HYDROLOGICAL MODELLING



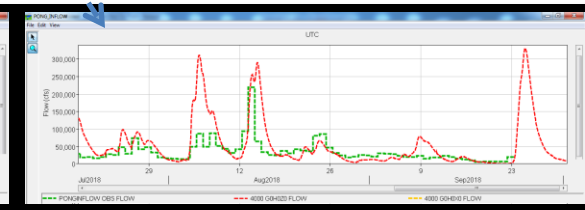
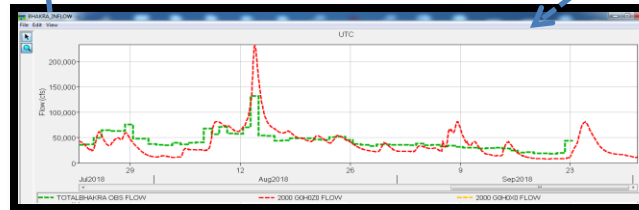
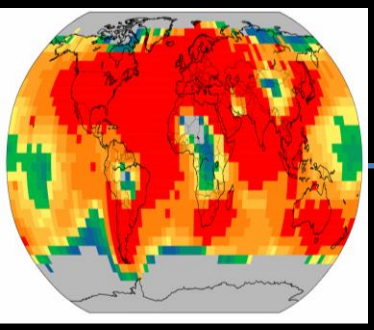
DOWNLOADING &  
PROCESSING

HYDRODYNAMIC MODELLING



HYDROLOGICAL FORECAST

WEATHER FORECASTING  
SERVERS GFS & ECMWF



QPF QTF SNOW

# The Downloaded data from various sources reformatted by pre-configured macros and scripts

The screenshot displays the HEC-RTS software interface. On the left, the 'Time Series Icon Editor' is open, showing a table of data sources and their associated scripts. The table is divided into two sections: one for 'GFS' and one for 'ECMWF'. The 'GFS' section includes sources like 'DOWNLOAD', 'UNZIP', 'EXTRACT', 'PREC\_DSS', 'TEMP\_DSS', and 'ZONAL\_CSV'. The 'ECMWF' section includes 'DOWNLOAD', 'UNZIP', 'EXTRACT', 'GEN\_ASC\_PREC', 'ASC\_TIFF\_DIFF', and 'PREC\_DSS'. A 'Run' button is visible at the bottom of the editor.

In the background, a map of a region in Punjab, India, is shown with several data sources marked: GFS, ECMWF, TRMM, BBMB, IMD, IMD\_FORECAST, GPM, and MERGED. A command prompt window is overlaid on the map, showing the following commands and output:

```
C:\Windows\system32\cmd.exe
C:\Users\tech\Desktop\HEC-RTS_3.0.1\HEC-RTS>cd\
C:\>cd python27
C:\Python27>cd ArcGIS10.1
C:\Python27\ArcGIS10.1>echo "Author: Anmol Bhardwaj"
"Author: Anmol Bhardwaj"
C:\Python27\ArcGIS10.1>echo "email: anmol.bhardwaj5@gmail.com"
"email: anmol.bhardwaj5@gmail.com"
C:\Python27\ArcGIS10.1>python.exe "D:\Anmolpys\A_TifTodsswithzonal.py" "D:\TRMM14\current" "D:\TRMM14\current" "D:\Database\Shapefiles\BBMB_BUFFER.shp" "D:\Database\Shapefiles\BBMB.shp"
Processing: 3B42RT.2016100100.7.03hr.tif
3B42RT.2016100100
```

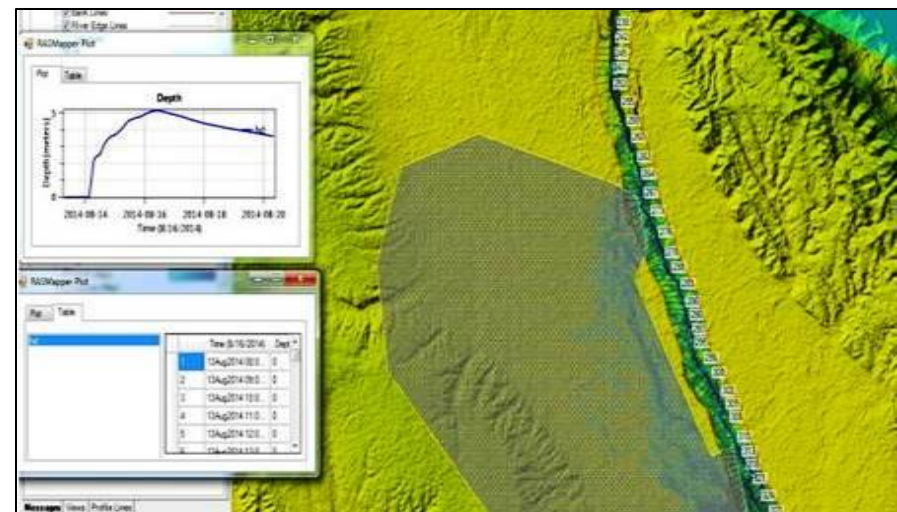
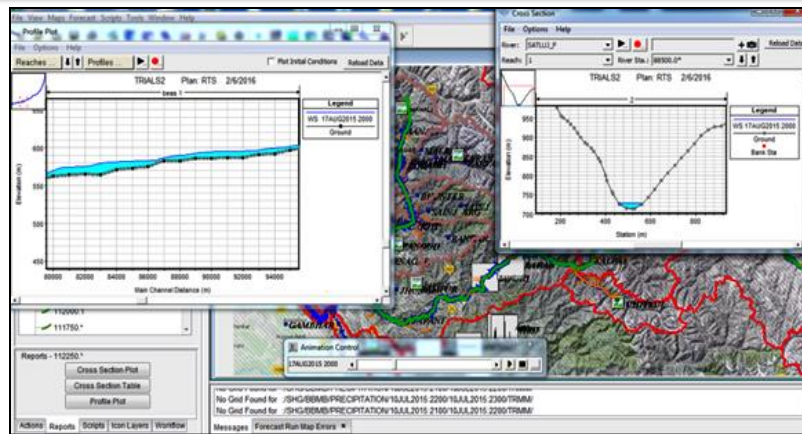
# MODELING RESULTS AND ANIMATIONS

THE FULL NETWORK OF BBMB (SATLUJ AND BEAS BASIN) CAN BE TRACKED REAL TIME WITH THE VARIOUS SENSORS PLACED IN THE BASIN AND MODEL OUTPUTS

[Tracking animation1.avi](#)

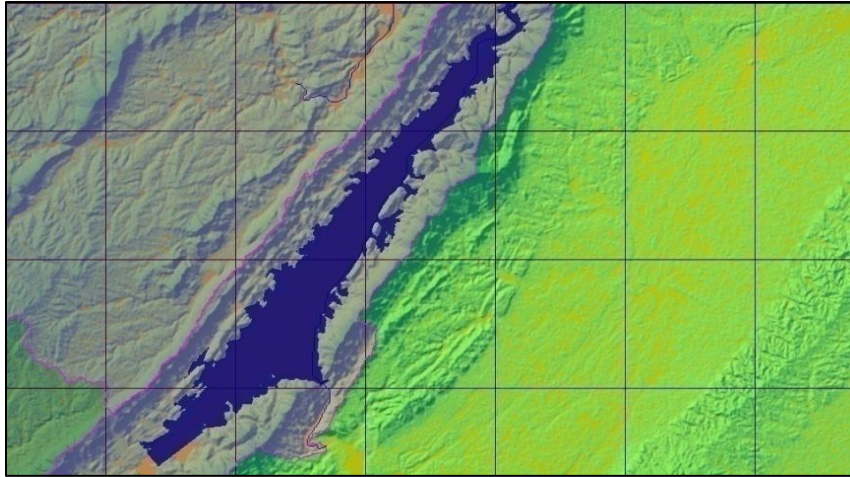


## 1 D HYDRODYNAMIC MODEL PROFILES RIVER L-SECTION AND X-SECTIONS

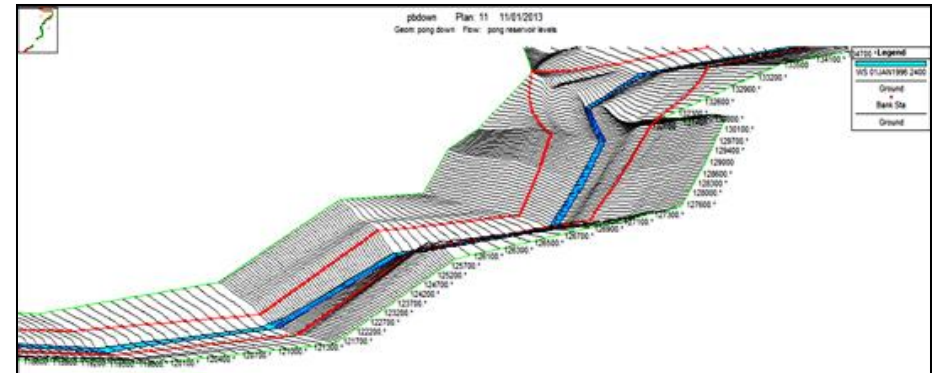


## 2-D FLOOD MODELS FOR THE FLOOD PRONE AREAS D/S OF RESERVOIRS

# MAPPER AND RIVER PROFILES

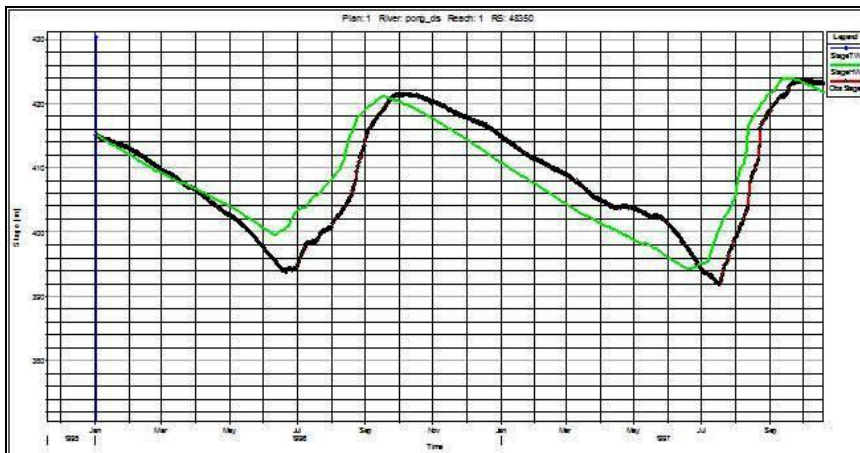


THE RIVER PROFILE WITH TERRAIN  
CAN BE SEEN RAS MAPPER



RIVER PROFILE ANIMATION

[river animation.avi](#)

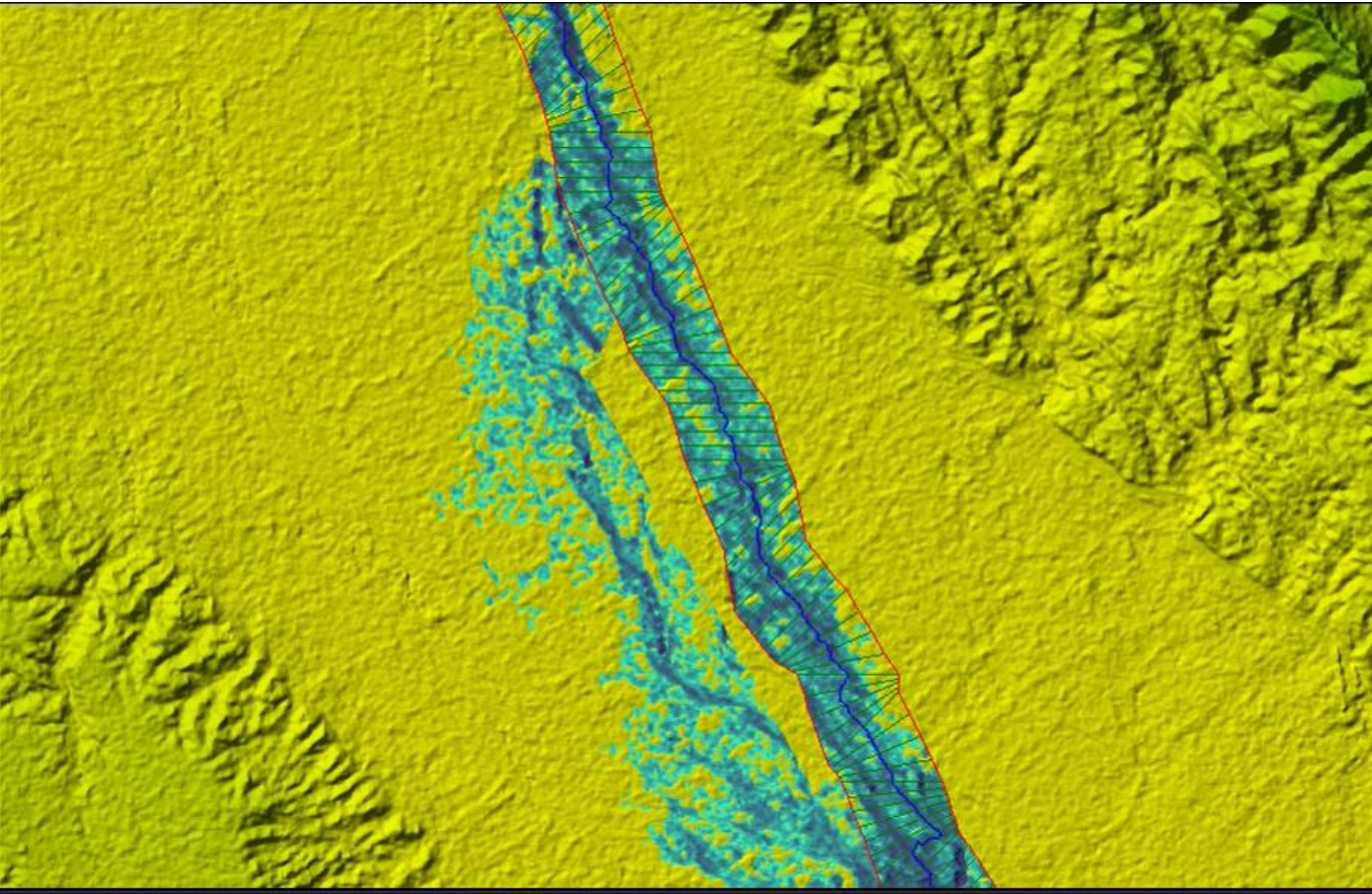


RESERVOIR LEVELS FOR THE  
FORECASTED INFLOWS AND OUT  
FLOWS CAN BE SIMULATED IN THE  
HYDRO DYNAMIC MODEL

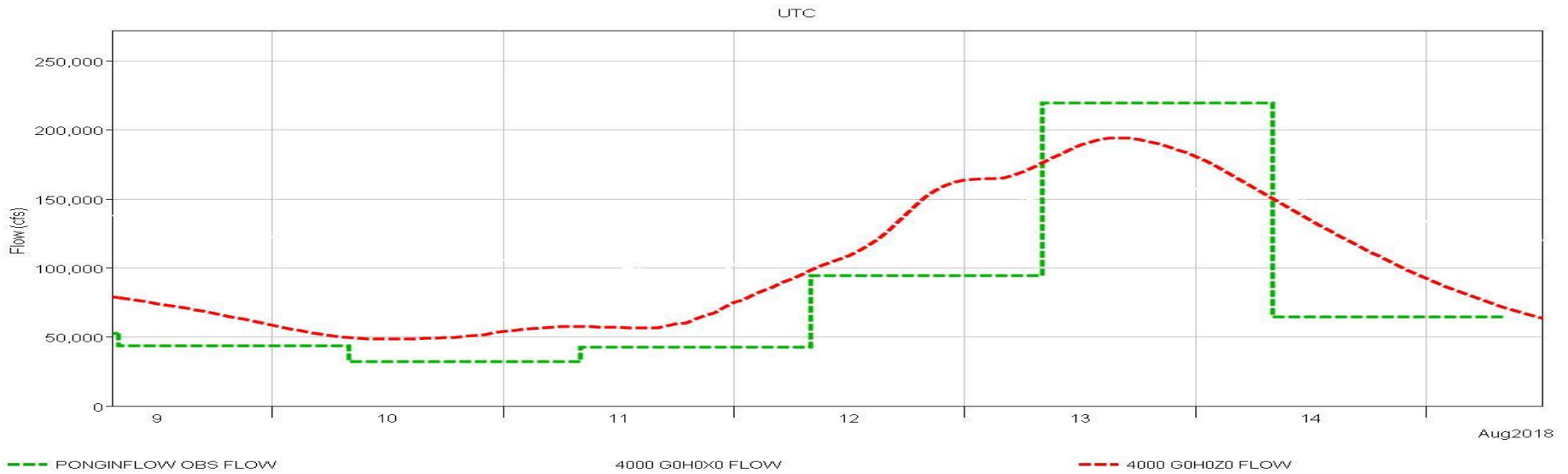
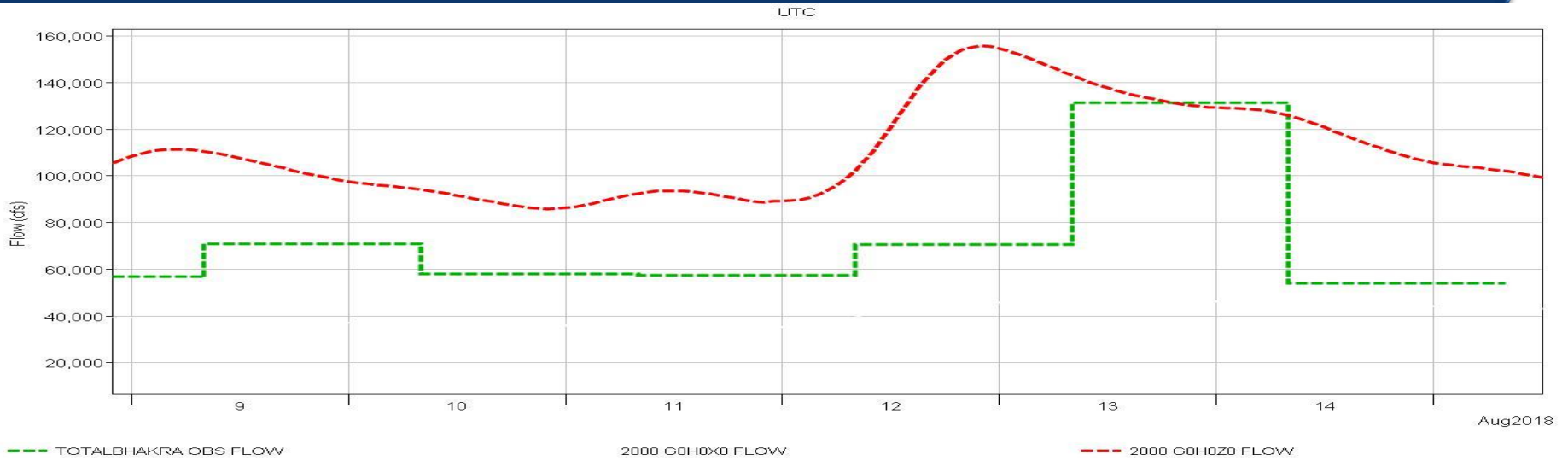
[Ras pong dam.avi](#)



## Anticipation of Downstream flooding Area and Depth

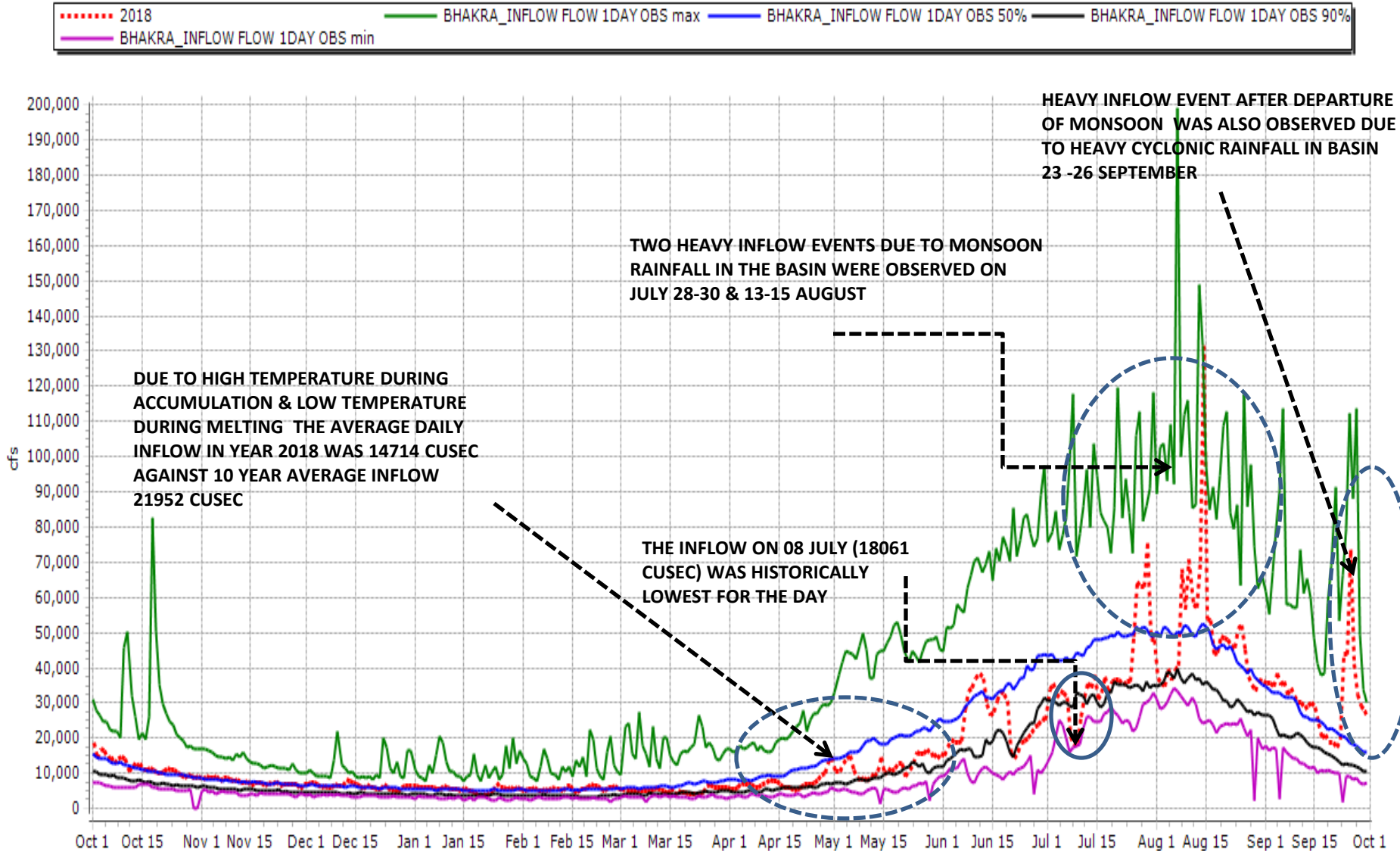


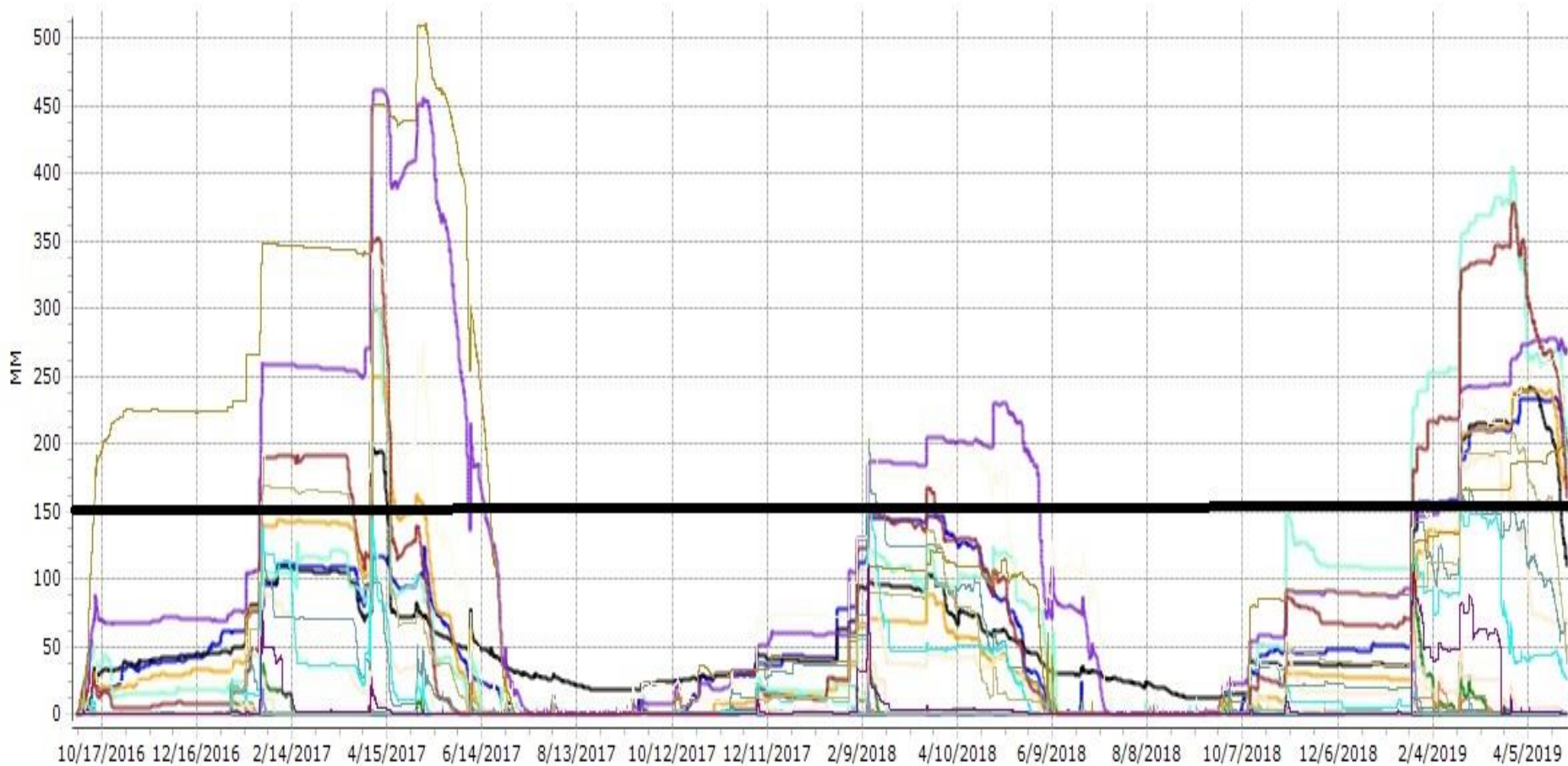
# THE INFLOW HYDROGRAPHS FOR PONG AND BHAKRA DAM INFLOWS BASED ON QPF AND QTF FROM GFS



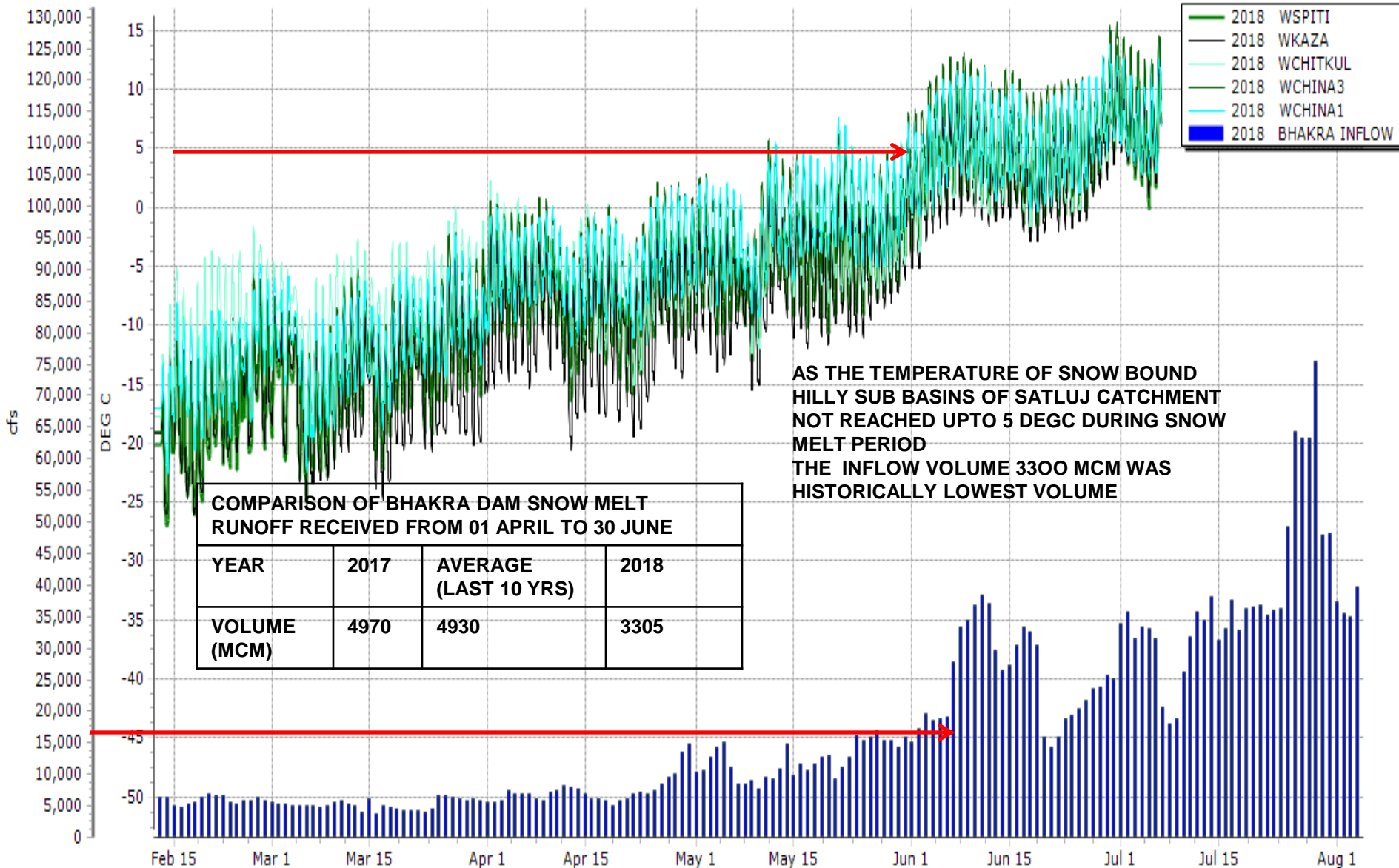
# ANALYSIS OF RESULTS

COMPARISON OF BHAKRA DAM INFLOW FOR WATER YEAR 2018 (OCTOBER-SEPTEMBER) WITH 50 & 90 % PROBABLE INFLOW , MAXIMUM AND MINIMUM INFLOW PATTERN





THE EFFECT OF LOW TEMPERATURE OF SNOW BOUND SUBBASINS OF SATLUJ BASINS ON INFLOW OF BHAKRA DAM DURING SNOW MELT 2018



# RESERVOIR OPERATION OBSERVED vs SIMULATED at TOF (INFLOW, OUTFLOW & LEVEL)

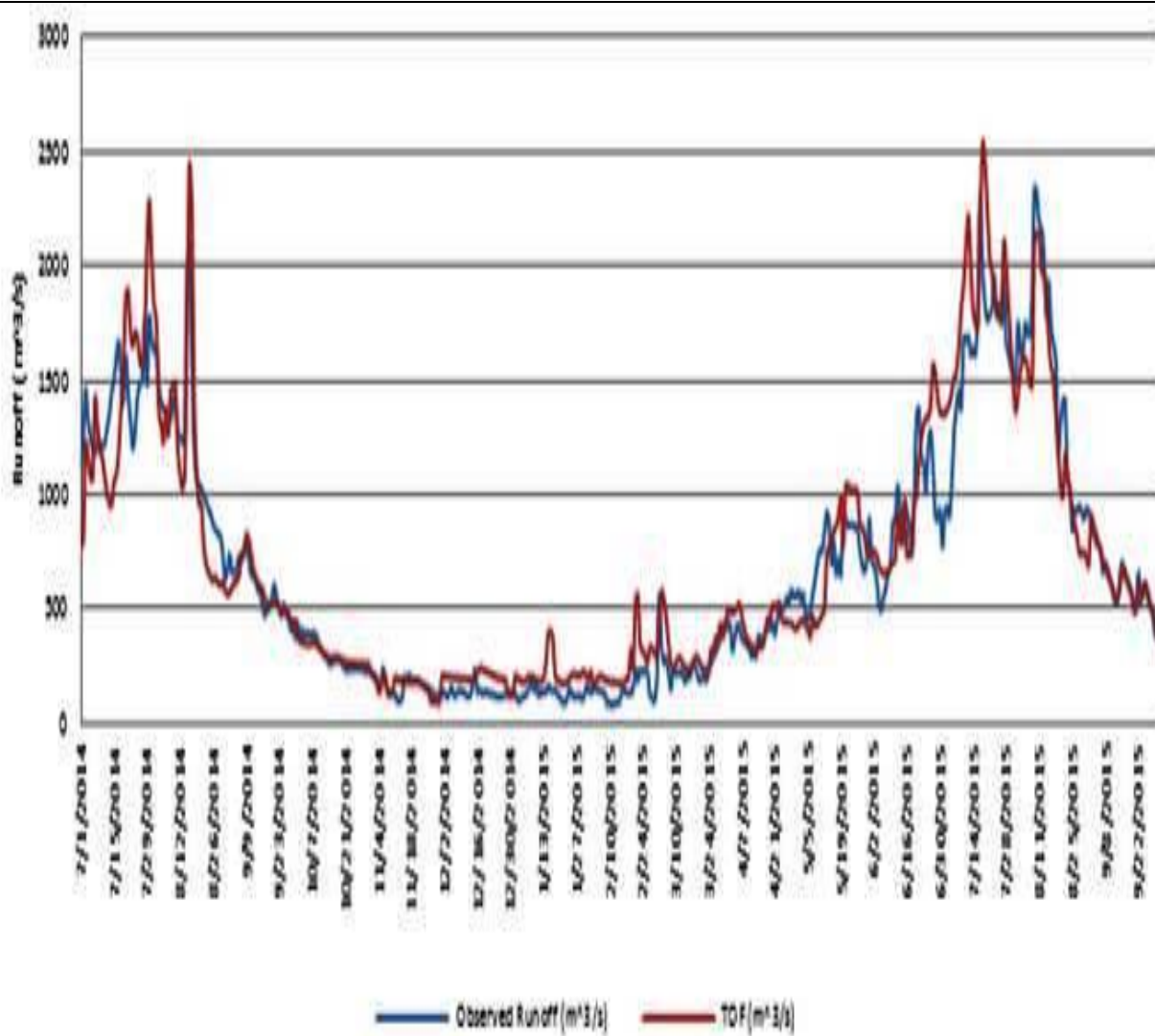
## RESULTS VISUALIZATION AND DISSEMINATION

WEBSITE  
DASHBOARD

RESERVOIR OPERATION  
(INFLOW, OUTFLOW &  
LEVEL)

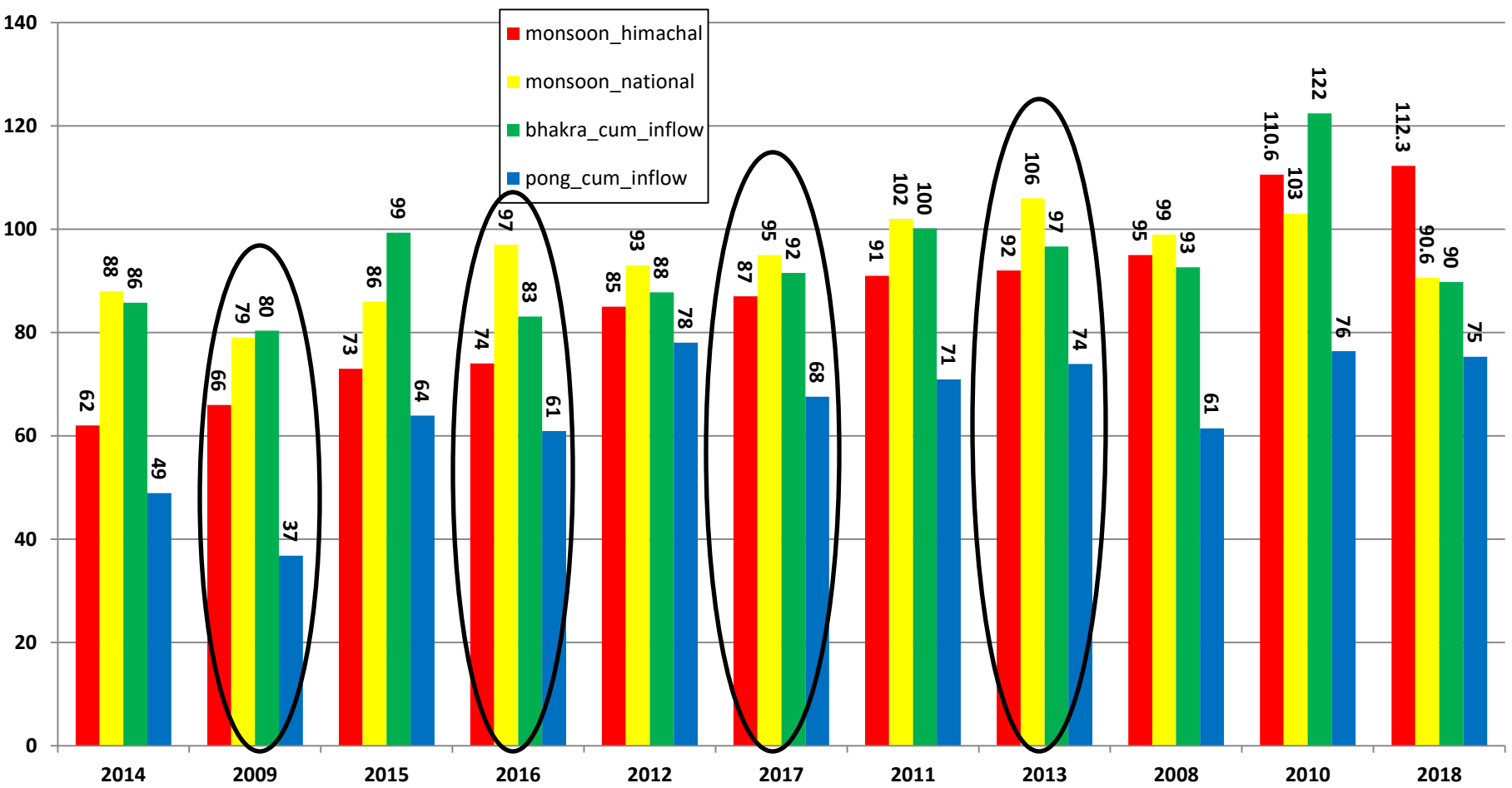
INFLOW FORECAST  
(SHORT & MEDIUM  
TERM)

OBSERVED vs  
SIMULATED



# SCENARIO ANALYSIS FOR BHAKRA AND PONG DAM WATER LEVEL

# MONSOON PERFORMANCE IN HIMACHAL AND INDIA WITH BHAKRA AND PONG DAM INFLOWS(\*100 MCM)



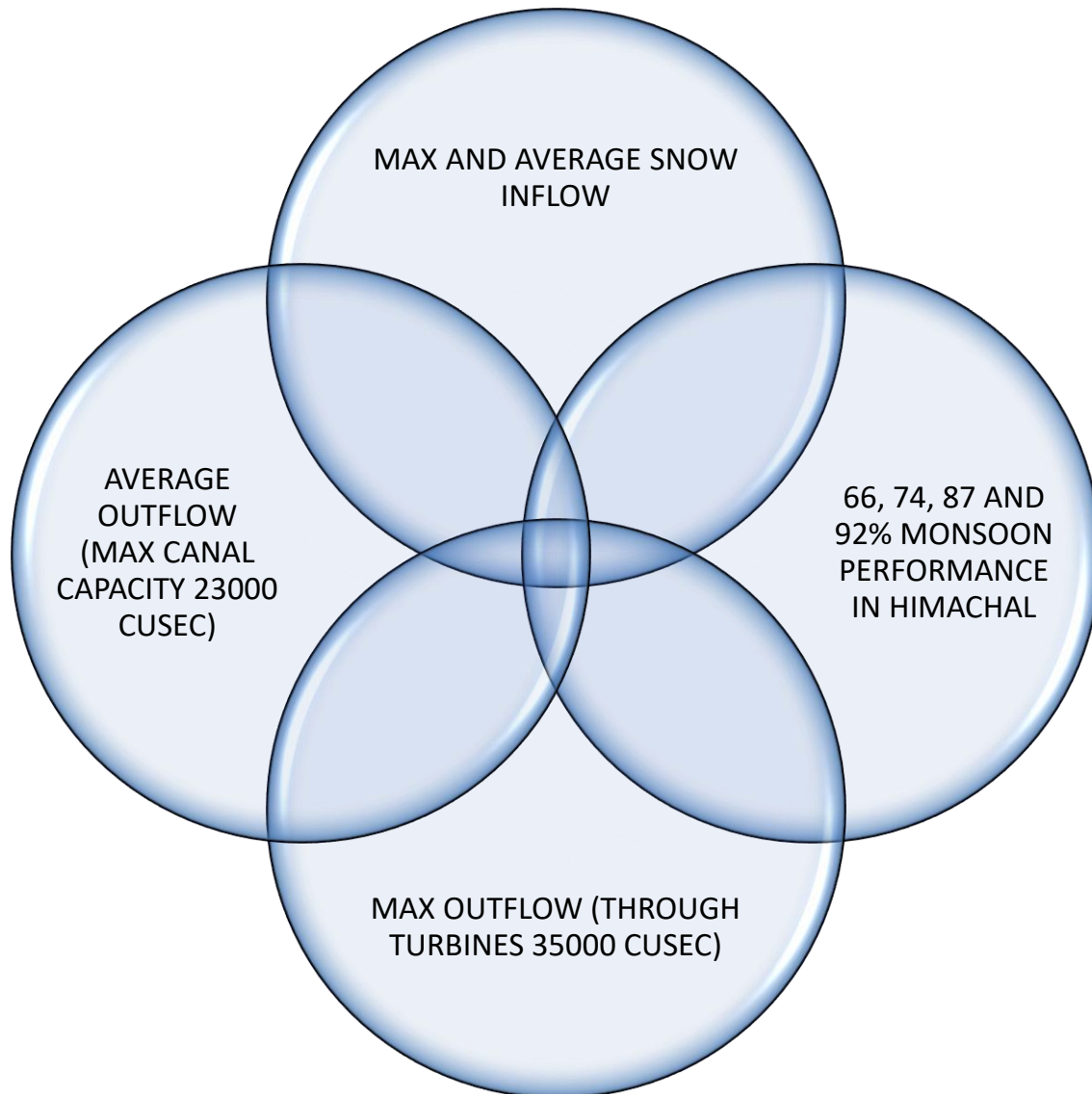


# INFLOW SELECTION FOR BHAKRA AND PONG DAM

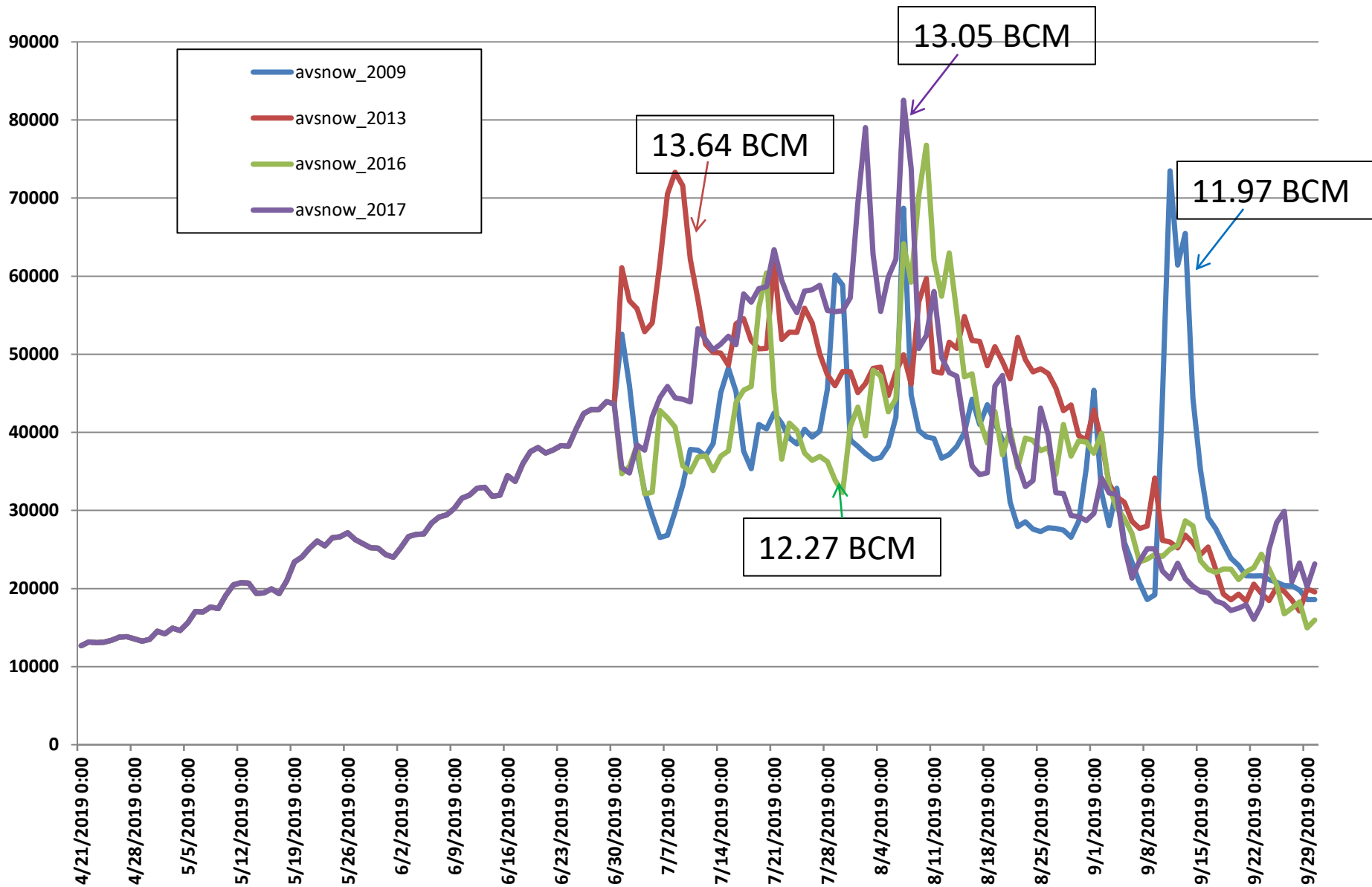
- As per IMD and Skymet forecast the monsoon in India will be below average i.e. ~96 & 93% respectively
- Monsoon inflow scenario were generated for ~66%, 74% and 87% and 92% in himachal pradesh.
- Maximum and average snow inflows were taken for analysis.
- For Bhakra and Pong Dam, the inflow years selected are 2009(66%), 2013(92%), 2016(74%) & 2017(87%) respectively.

*\*Monsoon percentage are for Himachal Pradesh*

# INFLOW AND OUTFLOW SCENARIOS OF BHAKRA RESERVOIR

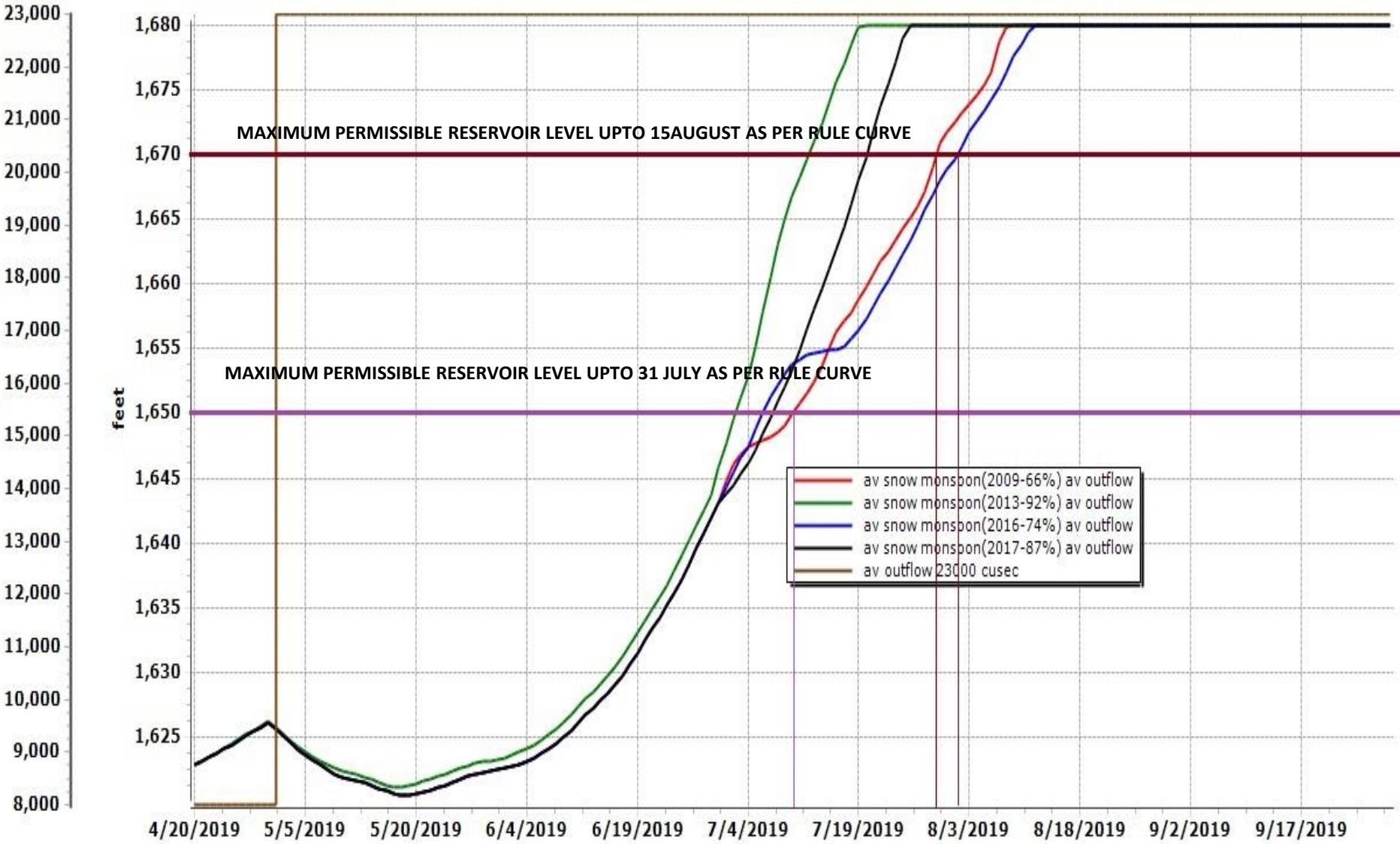


# AVERAGE SNOWMELT RUN OFF AND DIFFERENT INFLOWS FOR BHAKRA DAM (21-04-19 TO 20-09-19)



# BHAKRA DAM RESERVOIR LEVELS SCENARIOS WITH AV SNOWMELT RUNOFF AND OUT FLOW EQUAL TO CANAL CAPACITY (23000 CUSEC)

## BHAKRA DAM RESERVOIR SCENARIOS BY TAKING AVERAGE SNOW & 66 %, 92%, 74% & 87% AND AVERAGE OUTFLOW(23000 CUSEC)





THANK YOU

---

