Guidelines for Requirement of field data for development and application of Mathematical Models for Flood Forecasting

1 Introduction

Flood Forecasting is a necessary part of flood management. Flood Forecasting may be defined as "the process of estimating the future stages or flows and its time sequence at selected points along the river during floods". Flood Forecasts refer to prediction of "the crest and its time of occurrence" and logical extension to the stages of the river above a specified water level called the "Warning level". This warning level is generally 1 meter below the "Danger Level" fixed in consultation with the beneficiary, i.e., the concerned state authorities.

On the basis of the analytical approach for development of the flood forecasts, the methods of flood forecasting can be classified in the following two categories:

1. Methods based on Statistical approach, and
2. Methods based on mechanism of formation and propagation of flood.

In the first category, the forecasting methods, which are generally graphical or in the form of mathematical relationship, are developed with the help of historical data, using the statistical analysis. These include simple gauge-to-gauge relationships, gauge-to-gauge relationships with some additional parameters and rainfall-peak stage relationship. These relationships can be easily developed and are most commonly used in India as well as other countries of the world.

In the second category, the forecasting methods which are based on hydrological process and principle of propagation of flood are developed using various mathematical statements and relationship. These methods are, in principle, simplified and logical representation of the complex natural system of hydrological cycle. These methods required large number of relevant data and a lot of computation. The advent of digital computers provide the ease in the solution to this complex exercise. Therefore development of application of mathematical models have increased tremendously and engineering and operation hydrology most often involves consideration of some kind of mathematical models.

Central Water Commission is also using mathematical models for Flood Forecasting and continuously progressing in the development of models to cover more stations and reaches of rivers. However large data is required to be collected for application of a good model. The data needs to be collected in methodological way and need to be correct and consistent.

2 Objective:

The objective of the guideline for requirement of field data is to bring uniformity in data collection and make the data collection more comprehensive so that the collected data can be used for various purposes.

In Central Water Commission data are collected by various field offices for different purposes. These data may be made useful for many other purposes if the scope of data collection is slightly enlarged and few additional parameters are collected. These guidelines will make the data collection more generic and enhance their usefulness for broader purposes.

The systematic data collection will save time, money and manpower involved in data collection in the long run.

For example, the cross section data for river routing does not require the bearing of cross section, but if the longitude and latitude and bearing is observed, the cross section data can be utilized in morphological study. Thus simply inclusion of bearing in cross section data will make it useable for morphological study as well.

These guidelines cover the data required for mathematical modelling for Flood Forecasting for Indian rivers in general. These will also help in deciding/selecting the river reaches for application of Flood Forecasting model and location of observation sites required for that.

3. Data required for mathematical models for flood forecasting

The mathematical models generally require hydro-meteorological and topographical data which are detailed in the following paragraphs. (The detailed methods of collecting the hydro meteorological data, density of observation network etc., are given in the Flood Forecasting Manual)

3.1 Hydro meteorological data:

Following hydro meteorological data are required for the development of mathematical models. The format for Hydromet data for mathematical model is enclosed at Annexure-I.

3.1.1 Discharge data:

At every upstream boundary of the model (starting point of the model in main river /tributaries) discharge data are required. The discharge data are generally observed once in a day. The water level data is observed on hourly basis during monsoon, therefore the hourly discharge may be computed with the help of stage-discharge (water level-discharge) relations. This will be very useful in the areas of flash floods since they are of short duration. The availability of discharge data on hourly basis will improve the calibration of the model.

In addition, discharge data are also required at some intermediate points (between upstream boundary and downstream boundary) for the purpose of calibration/checking.

Manning's coefficient (Manning's 'n') for high and low flood flows should also be provided for all the Discharge Observation Stations.

3.1.2 Water Level data:

At downstream boundary of the model (i.e. last station / End point of the model) water level data is required. However the downstream boundary station cannot be a forecast station. The water level data should be observed hourly. However in place of water level data, stage-discharge relationship can also be applied at the downstream boundary. In such case, the forecast can be prepared for the downstream boundary station also. As far as possible, the Stage-Discharge relationship at each station should be developed. This would help in converting the stage/Water Level to discharge.

In addition, water level data are also required at some intermediate points (between upstream boundary and downstream boundary) for the purpose of calibration / checking.

3.1.3 Rainfall data:

Rainfall data of various stations in the catchment between upstream boundary and downstream boundary are required. The rainfall data should be observed hourly. Raingauge stations should be uniformly spread all across the catchment. Rainfall of all the stations will be used by the model for computing the average rainfall in the catchment.

3.1.4 Evaporation data:

Evaporation data of various stations (i.e. pan evaporation as well as reservoir based evaporation data) in the catchment between upstream boundary and downstream boundary are required. Daily observation would be useful. However weekly or monthly evaporation values can be used in the model without significantly affecting the results.

3.2 Topographical data

3.2.1 Toposheet and Map:

The toposheet and map showing catchment, sub catchments, locations of data observation stations (Rainfall, Evaporation, Gauge & Discharge station etc.), Flood Forecasting Stations, important water resources projects, important landmarks should be prepared. Also the locational detail of these stations (i.e. Longitude and Latitude) may be collected. This is required for defining the model set up i.e. River Network, Upstream and Downstream boundaries and creation of Thiessen polygons to assign the weightages to rainfall stations for calculating the mean areal rainfall in the catchment/sub catchments.

In the models, river network can be digitized using background image. Therefore, the map/toposheet may be scanned (softcopy) which can be used for digitizing the river network, sub catchments and preparation of Thiessen Polygon.

3.2.2 Cross sectional data:

Cross section data of main river and tributaries (which are part of model) are required from upstream boundary to downstream boundary at close interval. The cross section data should represent the true geometry of the river system. The cross sectional data being collected for morphological studies may also be utilized for flood forecasting models. The format for recording cross sectional data is given in Annexure-II.

The following points may be considered while taking the cross sectional data

1. In the straight / uniform river reaches the distance between the two cross sections may be more. In general cross sections spacing may be kept at 3 to 5 km interval for rivers in plain terrain while 0.5 km to 1 km for rivers in hilly terrain.
2. The cross sections should be taken at every location where **abrupt change in width** of the river occurs.
3. The cross sections should be taken at location of **abrupt change in slope of the** river bed.
4. In the meandering reaches of river system, the distance between cross sections may be reduced and location of cross sections should be such that the shape/plan form of the river is properly represented.
5. The cross sections should be extended upto the Highest Flood Level (HFL).
6. All the cross sections should be recorded preferably from left bank.
7. Left and Right Banks should be clearly indicated.
8. The cross sections should extend upto top of embankment in the rivers with embankments. The level of bottom of the embankments should also be recorded.
9. In case there is any hydraulic structure (i.e. weir or barrage/dam) within the model boundary, the cross section should be taken close to the structure on both sides i.e upstream and down stream of the structure.

3.3 Hydraulic Structures:

The details of the hydraulic structures likes dams, barrages, weirs etc., within model boundary may also be collected. The details should include location (Chainage, Latitude & Longitude), salient features, rating curve of structure (design discharge capacity of structure for different upstream water levels) for spillway/weir/barrage etc. and hydraulic properties of the structure. In case of run-off the river scheme, if any lateral diversion of river water is being done for considerable reach of river, then its details may also be included.

Any other relevant information may also be collected.

Annexure-I

Format for Hydromet Data

Rainfall data

Station Name : ……………

Date and time (dd-mm-yyyy HH:mm:ss)	Rainfall (in mm)
01-01-2011 05:00:00	5
01-01-2011 06:00:00	2
01-01-2011 07:00:00	1
01-01-2011 08:00:00	4
01-01-2011 09:00:00	0

Discharge data

Station Name : ……………

Date and time (dd-mm-yyyy HH:mm:ss)	Discharge (in cubic meter per sec)
01-01-2011 08:00:00	500
02-01-2011 08:00:00	200
03-01-2011 08:00:00	150
04-01-2011 08:00:00	200
05-01-2011 08:00:00	400

Water Level data

Station Name : ……………

Date and time (dd-mm-yyyy HH:mm:ss)	Water Level (in meter)
01-01-2011 08:00:00	122.12
01-01-2011 09:00:00	122.14
01-01-2011 10:00:00	122.15
01-01-2011 11:00:00	122.16
01-01-2011 12:00:00	122.18

Evaporation data

Station Name : ……………

Date and time (dd-mm-yyyy HH:mm:ss)	Evaporation (in mm)
01-01-2011 08:00:00	5
11-01-2011 08:00:00	2
21-01-2011 08:00:00	1
1-02-2011 08:00:00	4
11-02-2011 08:00:00	6

ANNEXURE-II

INFORMATION REQUIRED WITH CROSS-SECTIONAL DATA

1. General Information

- Name of the River
- Name of the Division
- Name of the Basin
- Index map of river with locations of cross-sections
- Total no. of identified cross-sections
- Numbering/naming of cross section for identification (ID No.)
- Location of Zero Chainage with Latitude & Longitude
- Chainage of every cross-section along the centre line of river
- Identification details to located the cross section (location plan of cross section) should be prepared for every cross section
- Observed Manning's resistance coefficient (Manning's 'n') for high and low flood events at nearby CWC gauging site
- Location of important landmarks (towns, city, important places etc.)

2. Specific Information of Cross-Section

- River Name:
- Date of Survey:
- Cross section ID(River-Month-Year-Section No.); e.g (Rapti-11-2009-CS21)
- Chainage:
- Location of Starting point (Zero RD) of cross section with Latitude & Longitude:
- Bearing of Cross-section:
- RL of Bench Mark (GTS):

Details of Cross-section

RD (m)	Bed Level with respect to MSL (m)
0	-
10	-
20	-