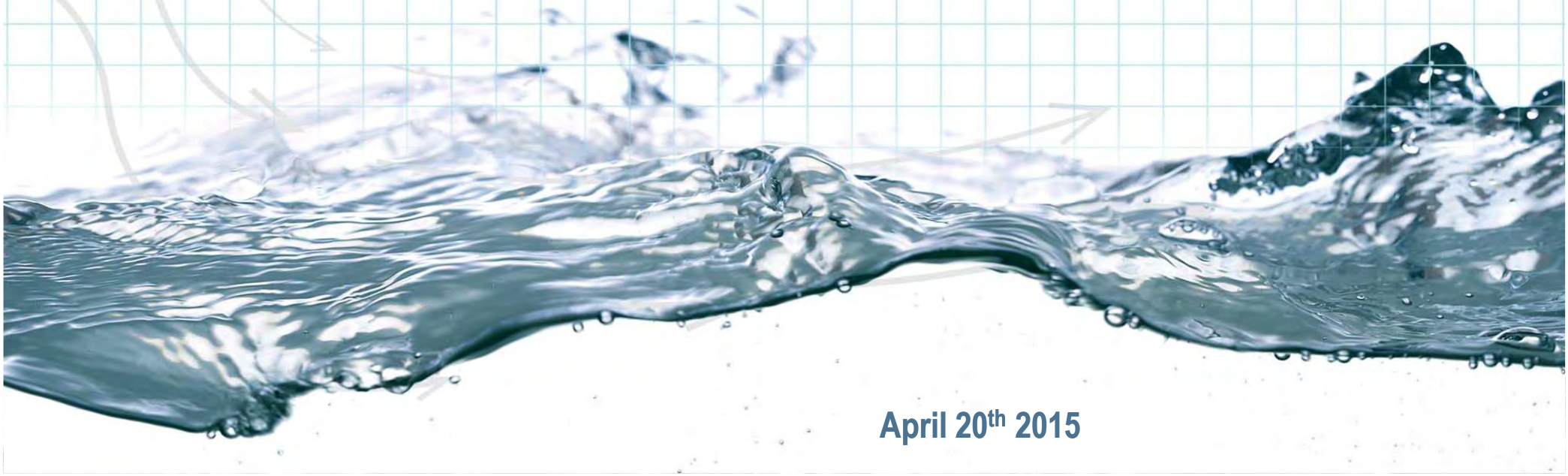
Training Programme for Officials of Royal Govt of Bhutan
20-24 April 2015

WELCOME
To
National Water Academy, Pune



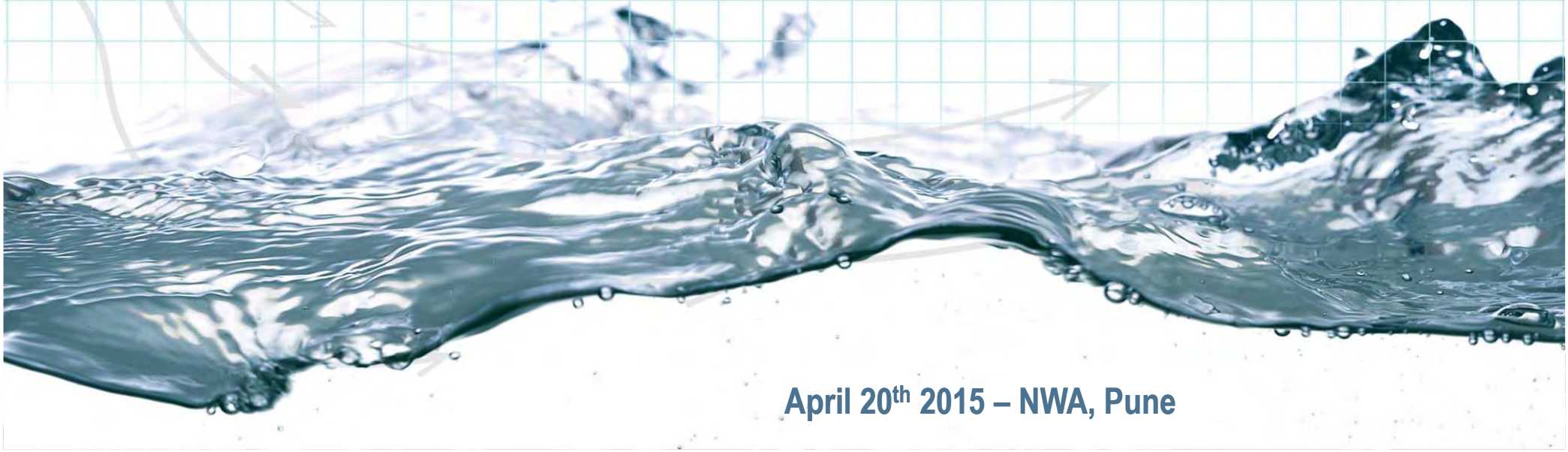
April 20th 2015

Training Programme for Officials of Royal Govt of Bhutan

Flood Management
Structural and Non Structural Measures

Sunil KUMAR

Director, National Water Academy, Pune

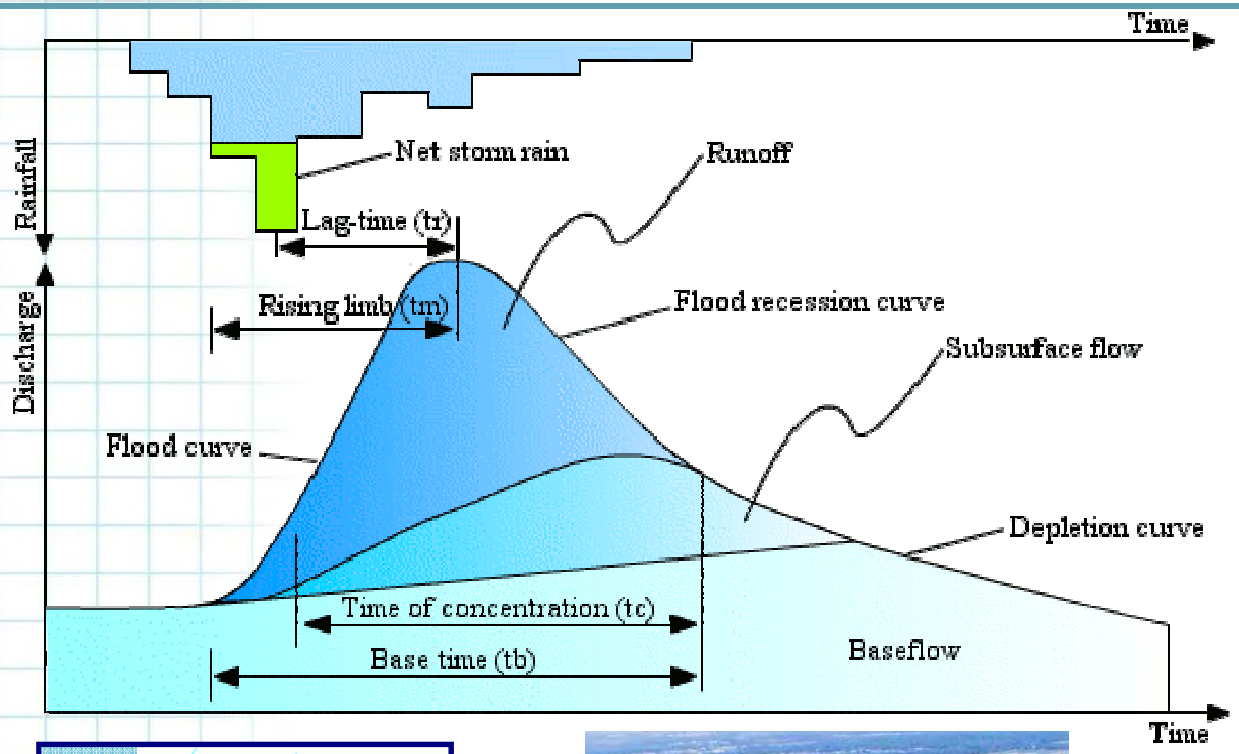


April 20th 2015 – NWA, Pune

Flood

When a large body of water rises and overflows onto a normally dry land, we call it a 'flood'.

Flood



Hydrologically, a flood is runoff caused by a spell of rainfall or overflow from a river or any other source.

Riverine Flooding (Fluvial)

Glacial Lake Outburst Flood (GLOF)

Storm Water Flooding (Pluvial)

Flash Floods

Coastal Floods

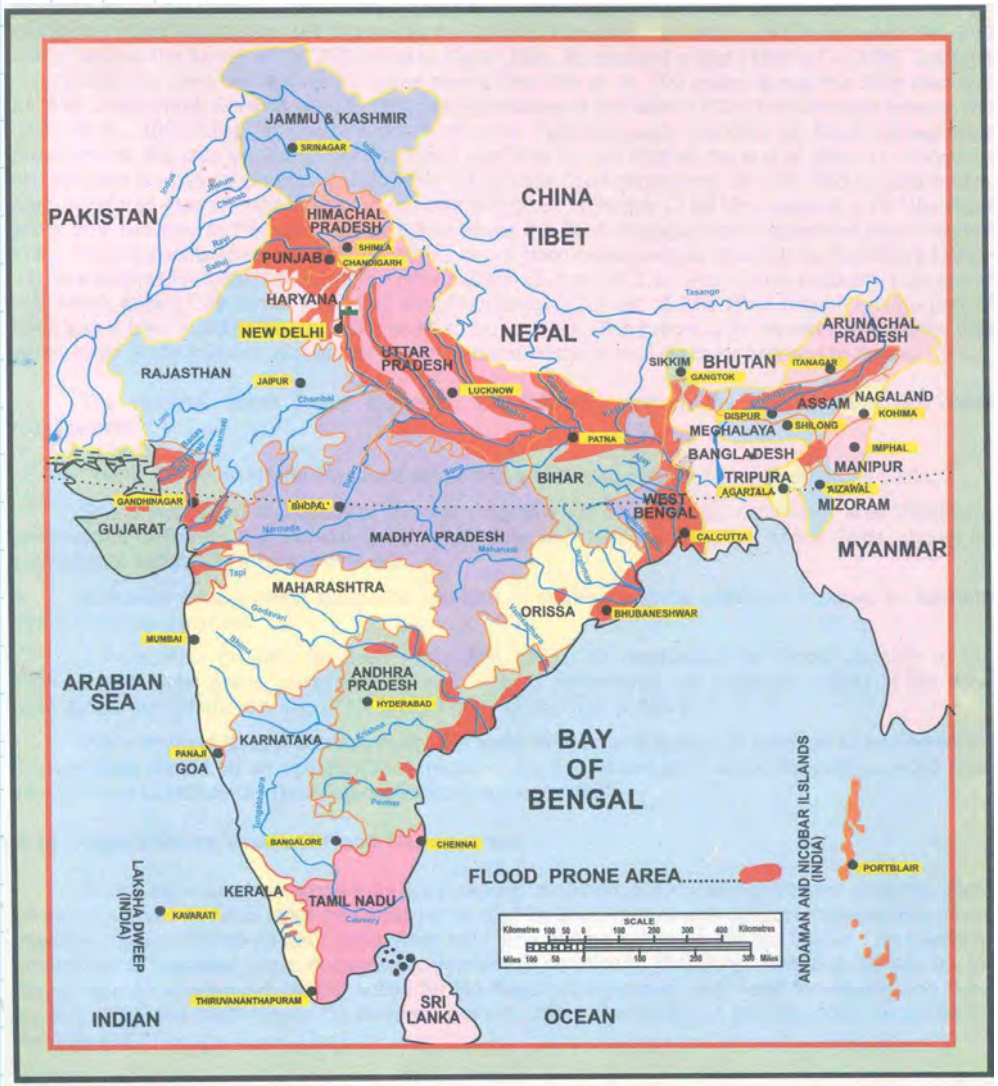
Urban Flooding

- Combination of Fluvial, Pluvial, Coastal & Flash Flooding.
- High intensity rainfall.
- Low infiltration.
- High Runoff.
- Insufficient drainage.

Urban Flooding

- High Risks & Damage Potential.
- Millions of people affected.
- Thousands of Business affected.
- Huge loss of property.
- Health & Sanitation problems.

Flood Scenario: India

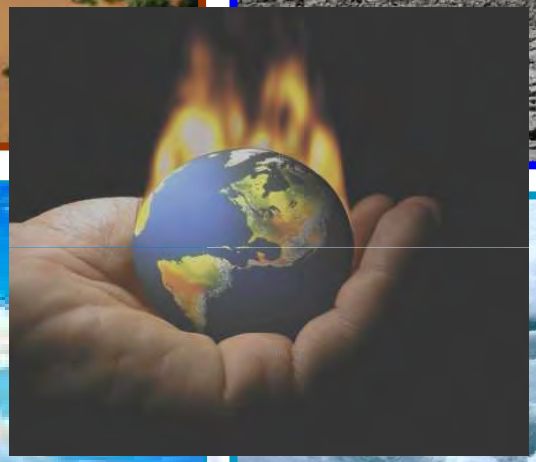


- Flood Prone Area- 49.81 MHa .
- Affected Crop Area- 3.7 MHa.
- Flood Prone Area mainly in: Brahmaputra-Ganga- Meghna river plains in North and Northeast India.

Flood Scenario: India

Flood Affected Area & Flood Damages in India (Abstract for the period 1953 to 2004)

Item	Unit	Average flood damage	Maximum damage (Year)	Damage During 2004
Area Affected	MH	7.63	17.50 (1978	8.03
Population Affected	Million	32.92	70.45 (1978)	34.22
Human Lives Lost	Nos.	1,590	11,316 (1977)	1275
Cattle Lost	Nos.	94,485	618248	63,869
Value of Damage to Crops	Rs. Crores	705.87	4,246.62 (2000)	615.07
Houses Damaged	Million	1.23	3.51 (1978)	1.49
Value of total Damage to Houses, Crops and Public Utilities	Rs. Crore	1,805.18	8,864.54 (2000)	3,336.59



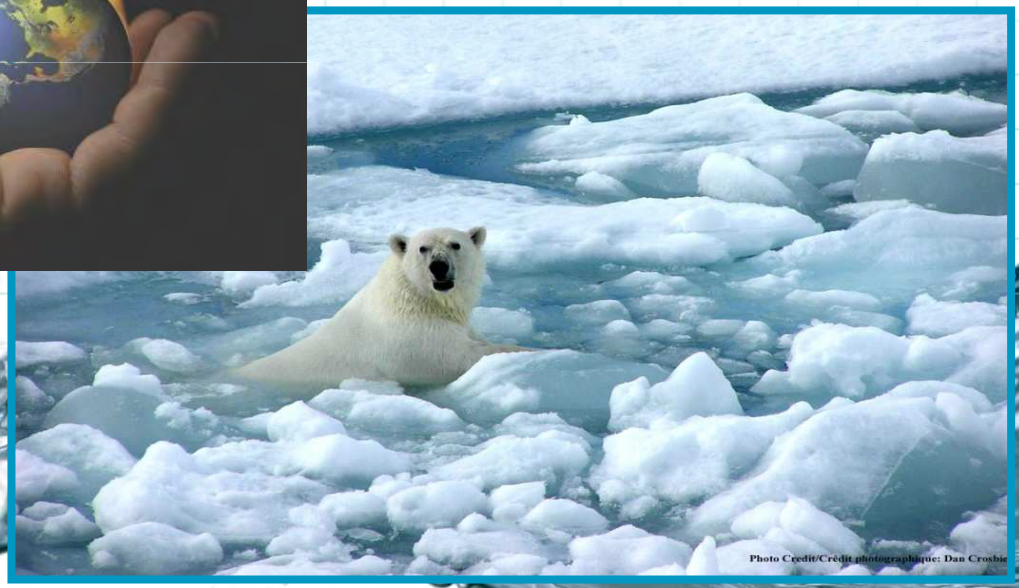


Photo Credit/Crédit photographique: Dan Crosbie

India-Bhutan Cooperation

- **1955 -** MEA, GOI sponsored a scheme - 19 Nos. of rain gauge stations and 8 Nos. of wireless stations were set up under the control of MEA and subsequently handed over to Royal Government of Bhutan
- **July 1979-** A scheme by MoWR for flood forecasting system on rivers common to India and Bhutan

  (Hydro-meteorological data collection and flood forecasting activities on common rivers)

India-Bhutan Cooperation

- A scheme titled **"Comprehensive Scheme for Establishment of Hydro-meteorological and Flood Forecasting Network on rivers Common to India and Bhutan"** is in operation
- 32 Hydro-meteorological/ meteorological stations located in Bhutan and being maintained by the Royal Government of Bhutan with funding from India
- The data utilized in India by the Central Water Commission for formulating flood forecasts.

India-Bhutan Cooperation

- A Joint Expert Team (JET) consisting of officials from the Government of India and Royal Government of Bhutan continuously review the progress and other requirements of the scheme.
- Joint Expert Team (JET) on Indian side is led by Chief Engineer, (B&BBO), CWC, Shillong.
- JET has so far met 29 times since its reconstitution in 1992.

Flood Management: Structural Measure

Reservoir / Dam

Flood Management: Structural Measure

Embankment

Flood Management: Structural Measure

Levee

Sacramento River Levee, USA

Flood Management: Structural Measure

Dikes

Flood Management: Structural Measure

River Training / Bank Protection

Flood Management: Structural Measure

River Training / Bank Protection

Flood Management: Structural Measure

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Flood Management: Structural Measure

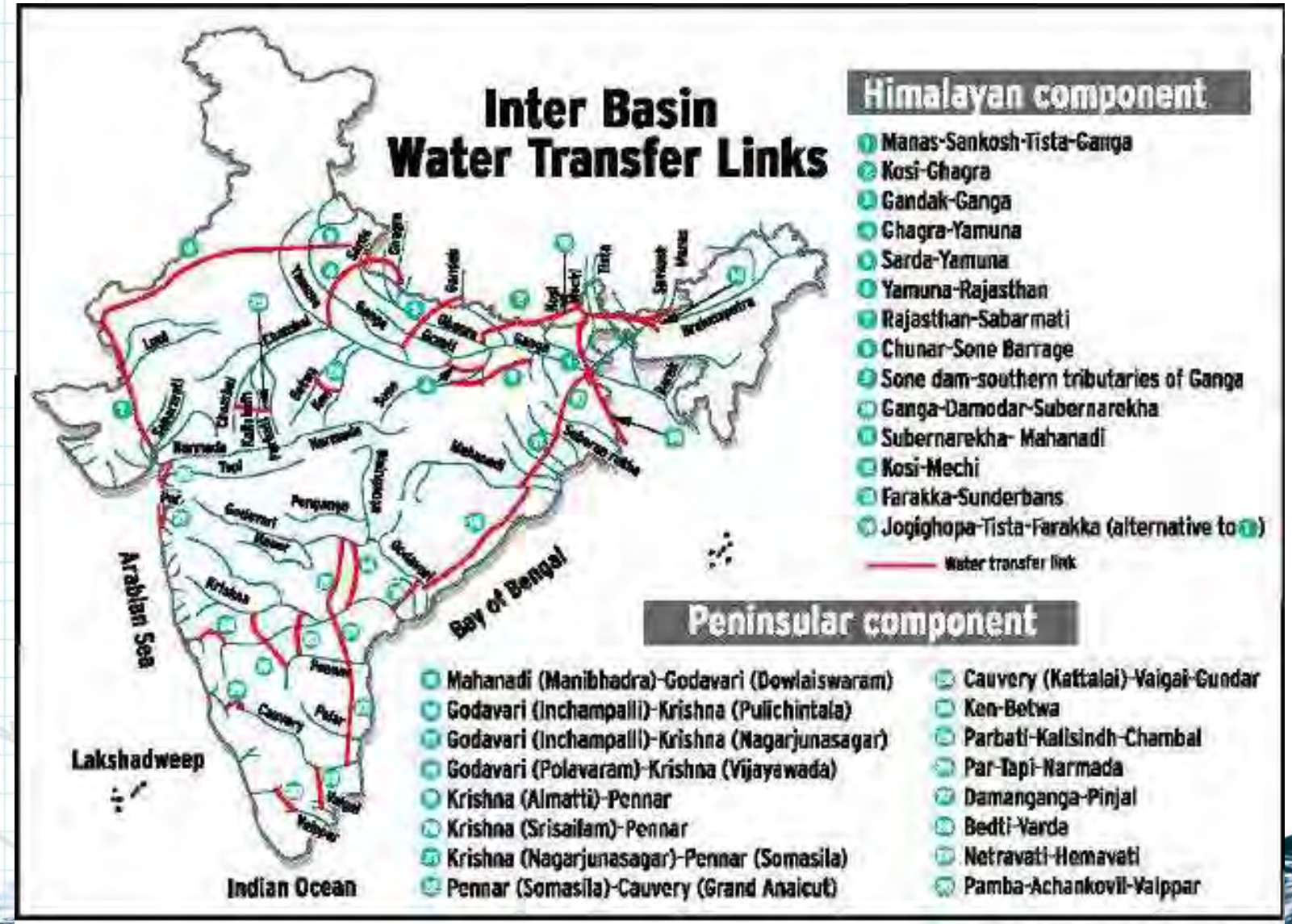
River Training / Bank Protection

Flood Management: Structural Measure

River Training / Bank Protection

Flood Management: Structural Measure

Interlinking of Rivers



Source: National Water Development Agency

Flood Management: Structural Measure

Thames Barrier

Flood Management : Structural Measure

Thames Barrier

Flood Management : Structural Measure

Thames Barrier

- One of the largest (520 m) flood barrier in the world;
- Operational since 1982;
- Over 100 flood defence closures;
- Designed to protect London against 1000 yrs return period discharge.

Flood Management

Non-Structural Measures

- Forecasting / Early Warning.
- Stakeholder's Awareness.
- Flood maps/ Flood Plain Zoning.
- Flood Insurance .

Flood Forecasting: India

- CWC is National Flood Forecasting Agency
- 175 flood forecasting stations
  - 147 Water level forecasting station
  - 28 inflow forecasting station
- Gauge-to-Gauge Correlation

Flood Forecasting: India

'Compendium of Guidelines in the field of Flood Management' by GFCC

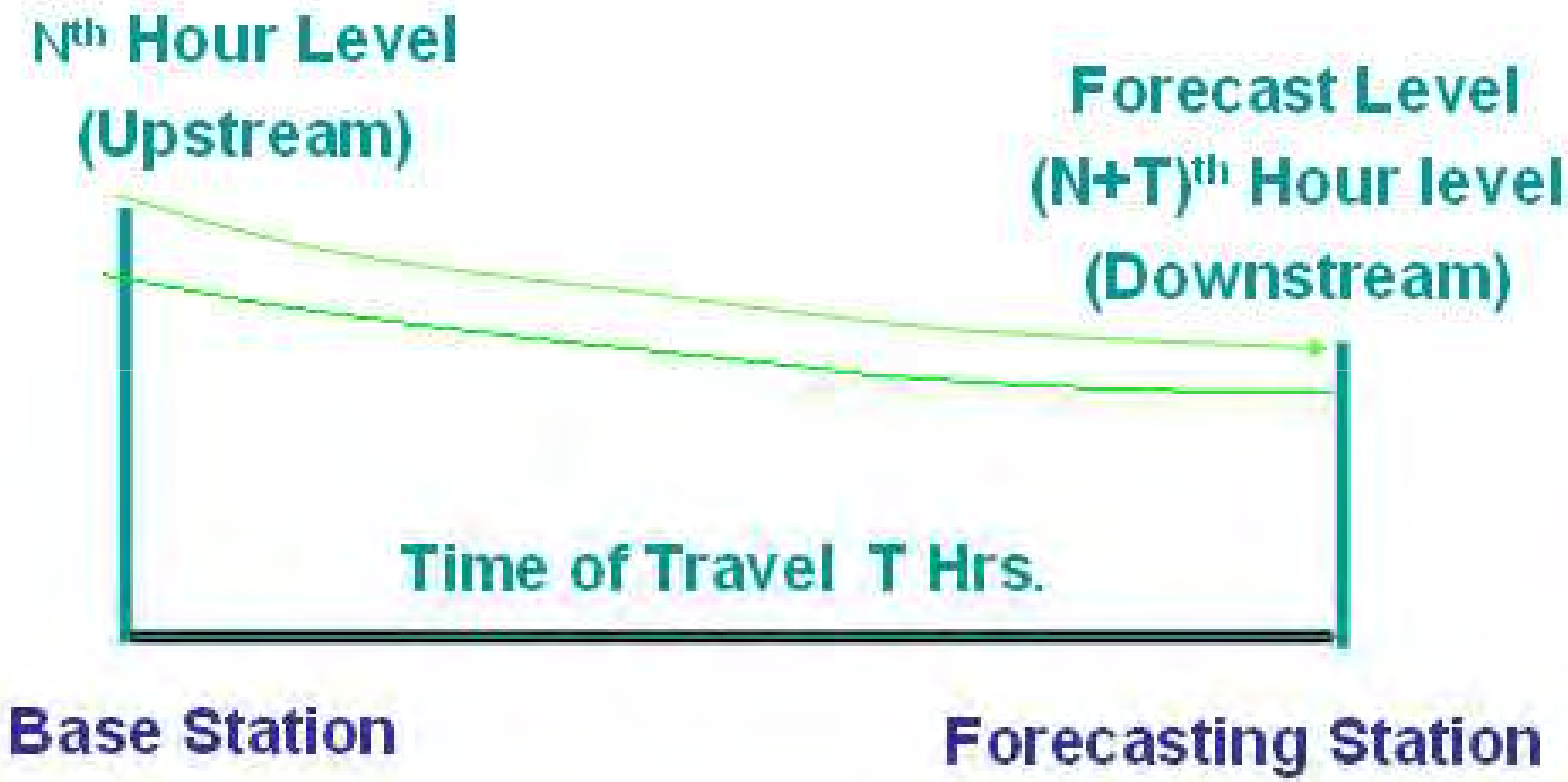
- **Danger Level** (0.3 m below the plinth level or 10 year Return period discharge)
- **Warning Level** (0.6 m to 1.0 m below the danger level)
- **Highest Flood Level** (highest flood ever recorded)
- **Very High Flood** (100 year return period discharge)
- **Flood Plain** (Land adjoining the channel which is inundated only during floods.)

Existing Flood Forecasting-India

Gauge to gauge Correlation

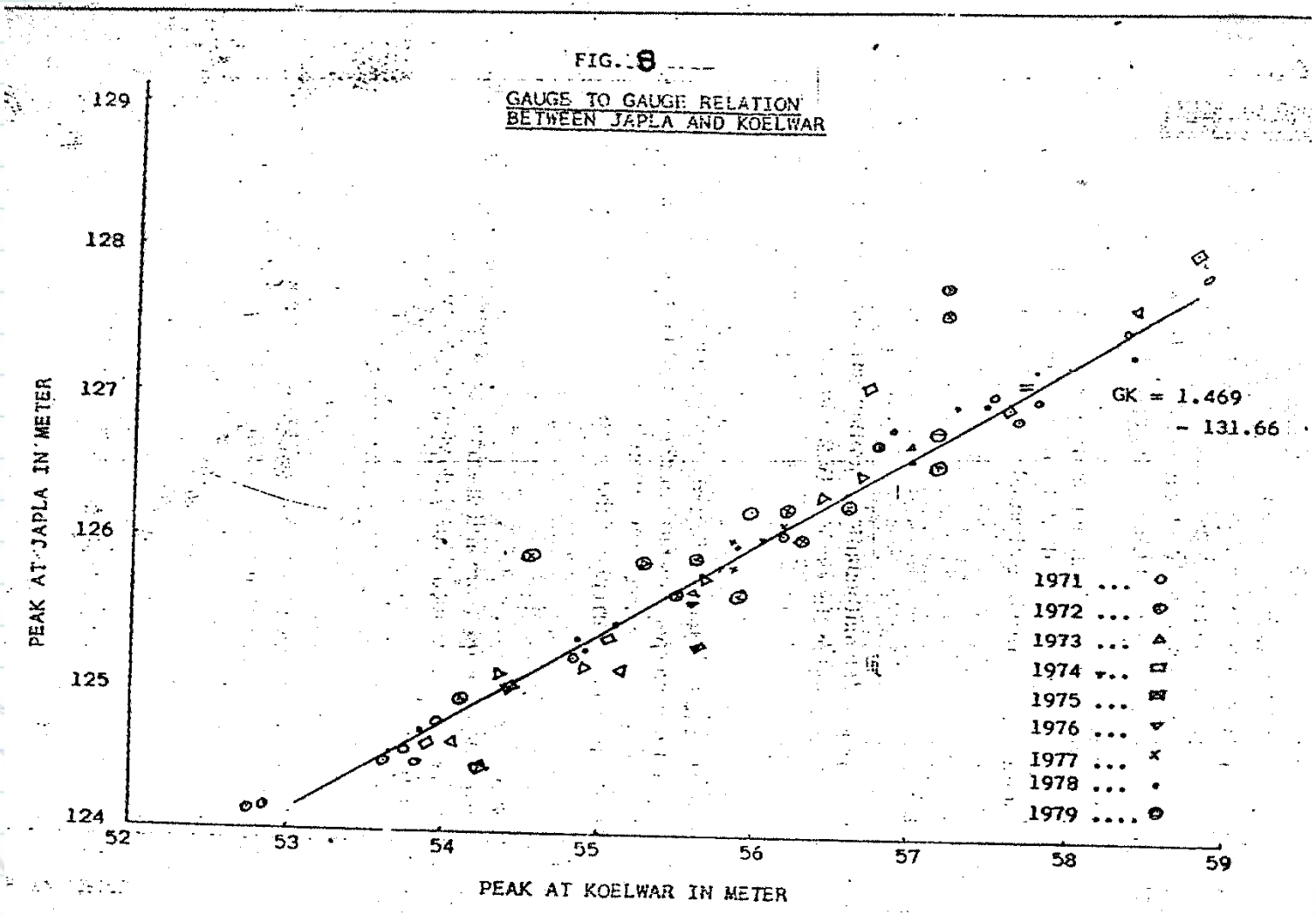
Existing Flood Forecasting-India

Gauge to gauge Correlation



Existing Flood Forecasting-India

Gauge to gauge Correlation



Existing Flood Forecasting-Shortcomings

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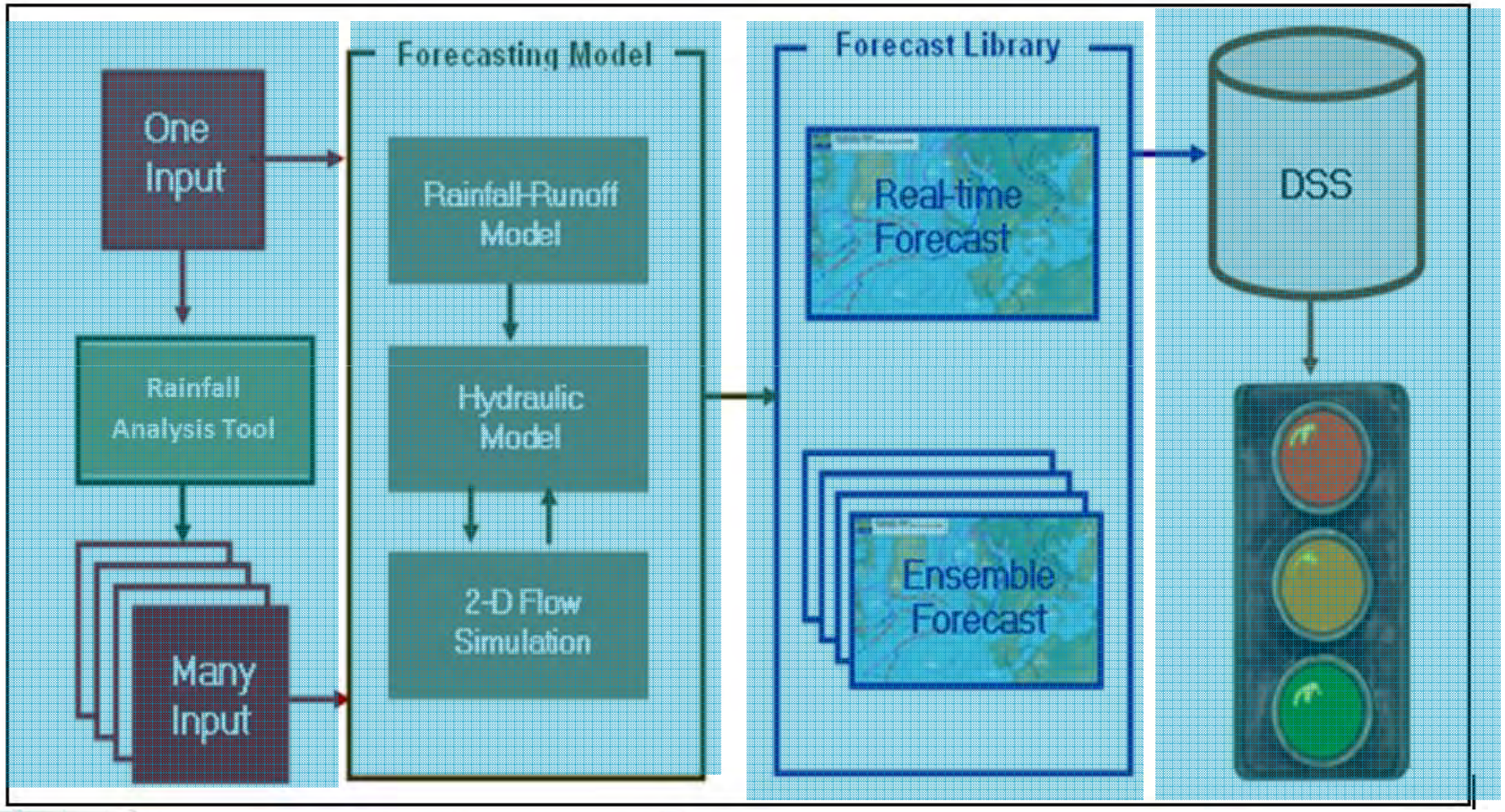
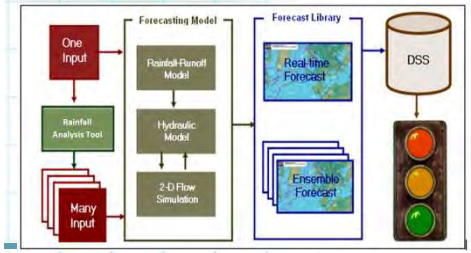
Existing Flood Forecasting-Shortcomings

- Lead time is insufficient for appropriate disaster preparedness
- Rainfall not incorporated.
- Very limited coverage.
- No information of depth, extent, duration of flooding.
- Only riverine flooding considered.

Existing Flood Forecasting-Shortcomings

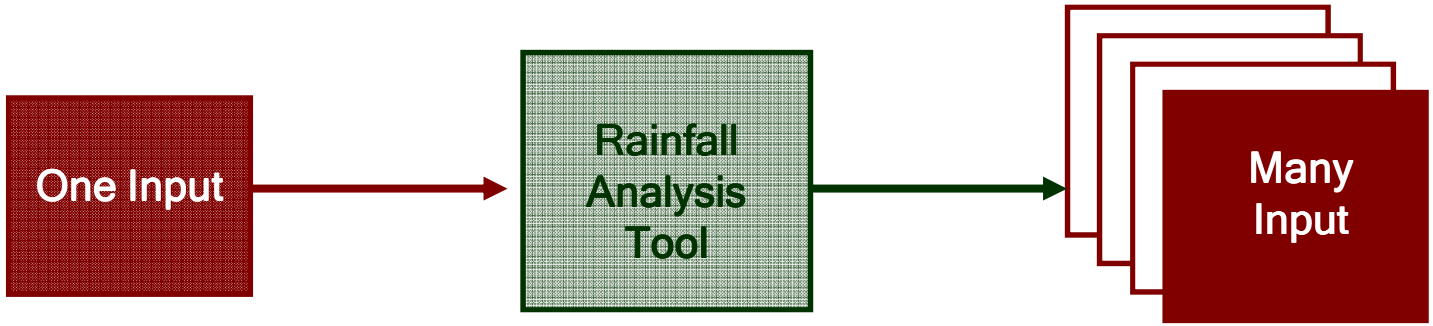
Integrated Flood Forecasting Model



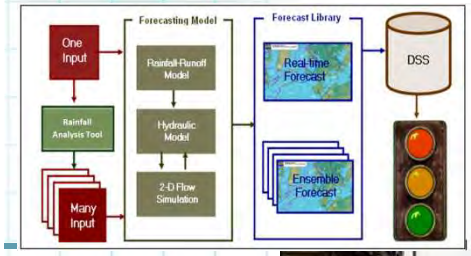


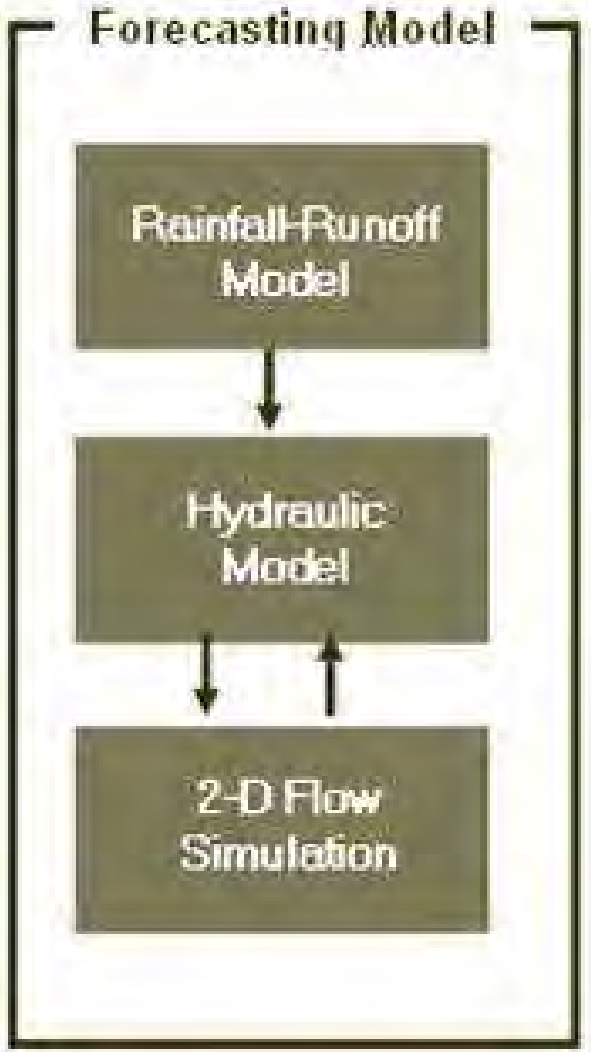
Rainfall Analysis

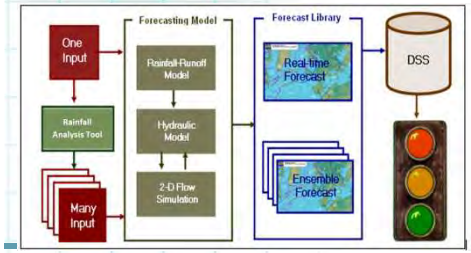
- One Rainfall Input – Deterministic
- Many Rainfall (ensembles) Input – Probabilistic



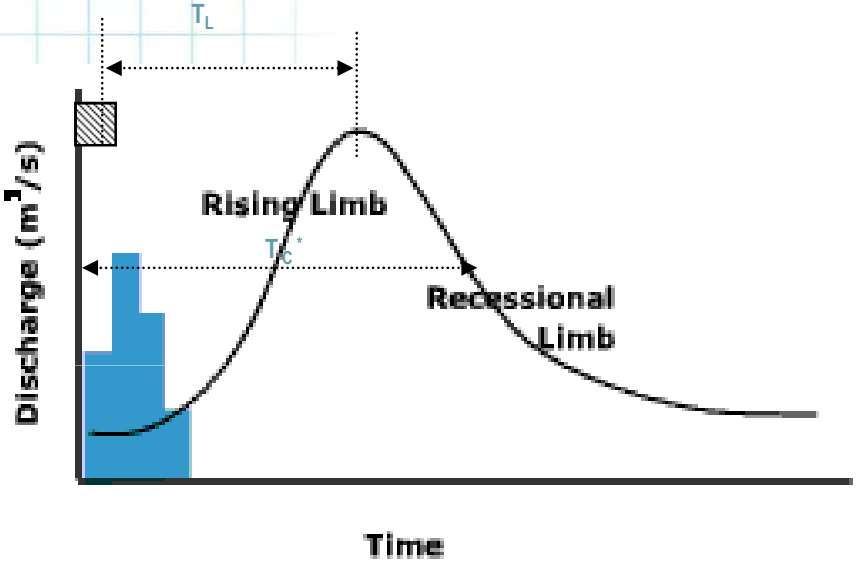
Urban Flood Forecasting Model





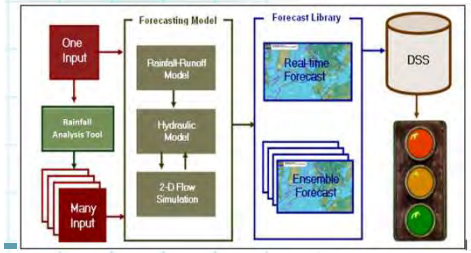


Flood Forecasting Model



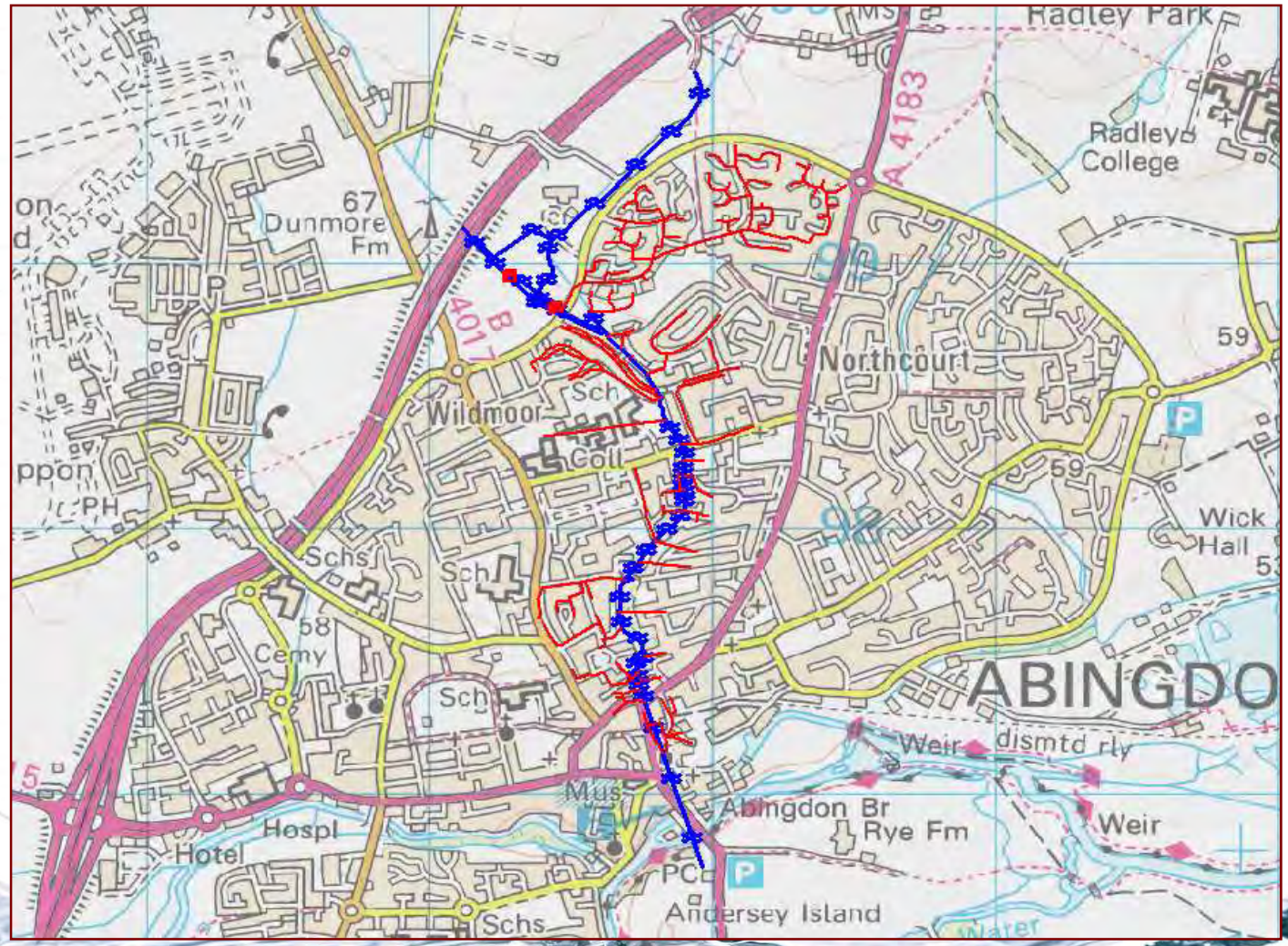
Rainfall-Runoff Modelling

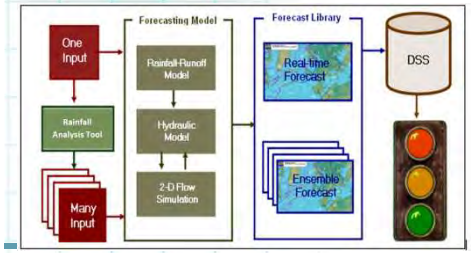
- Inflow, Upstream Boundary condition.
- Software: HEC HMS, SWAT, Mike Hydro, Mike SHE, SWMM etc..
- ArcGIS, ArcView GIS, Auto CAD etc. for catchment property.



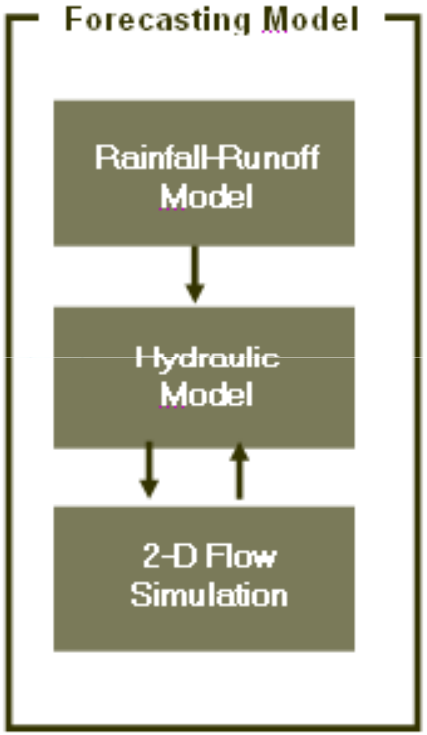
Urban Flood Forecasting Model

Hydraulic Modelling



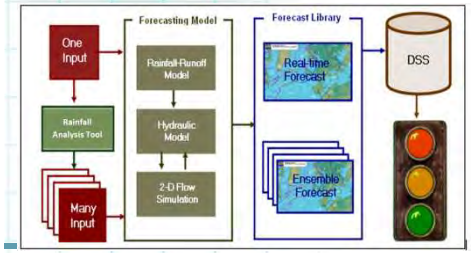


Urban Flood Forecasting Model

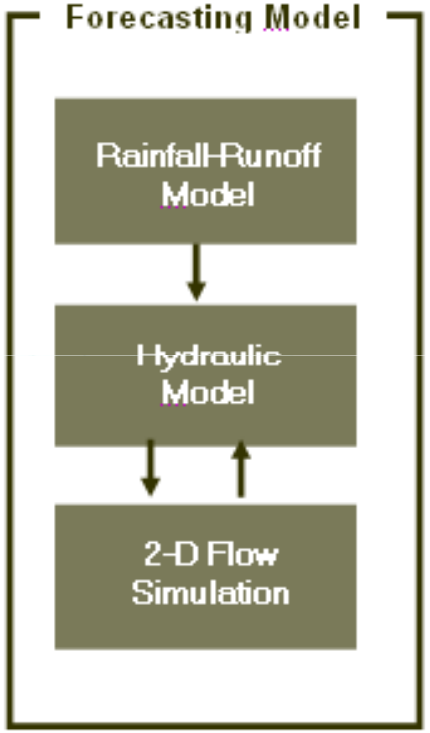


Hydraulic Modelling-River/Stream Network

- River/Stream Network: HEC RAS, Mike11, Infoworks RS, ISIS, NOAH 1D, SWAN etc.
- Drainage Network: EPANET, Infoworks CS, Mike Mouse, Water CAD etc.

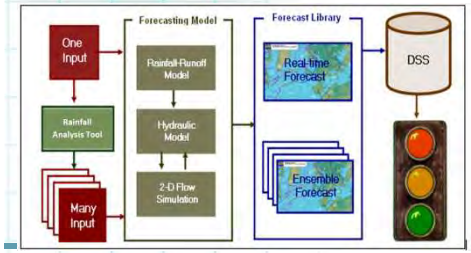


Flood Forecasting Model



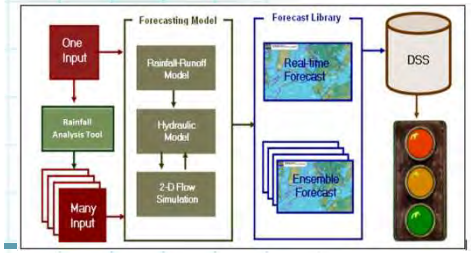
2-D Flow simulation

- **Requires fine resolution DEM.**
- **Accurate representation of urban features:** Buildings, roads, boundaries, footpaths, fences etc**.**
- **Software Tools: Infoworks 2D, Isis, Mike 21, Mike Flood, ISIS-2D, HEC RAS 2D, SOBEK etc.**

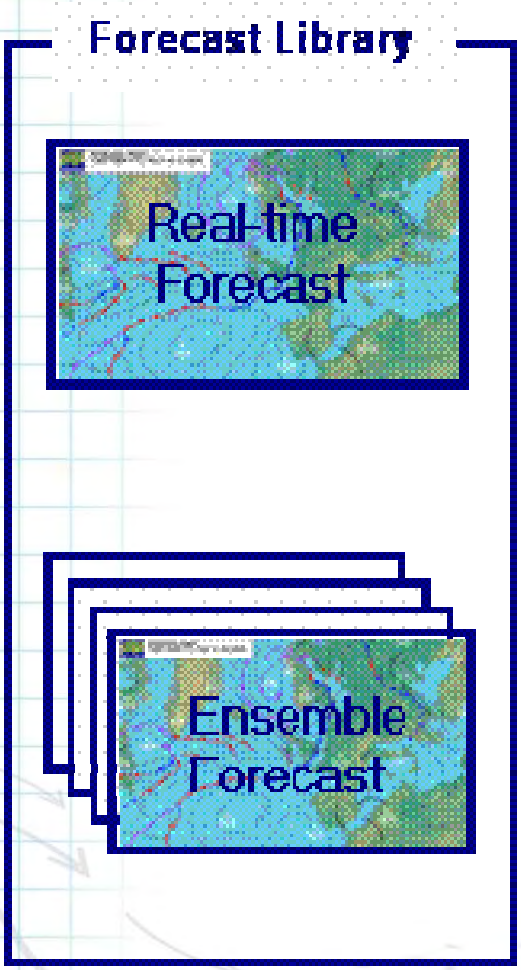


Flood Forecasting Model-Calibration

- Rainfall-Runoff Model / River Model - Observed discharge data
- Drainage Model – Observed data at crucial junctions.
- 2D Model – Flood depth, satellite data, anecdotal evidences.

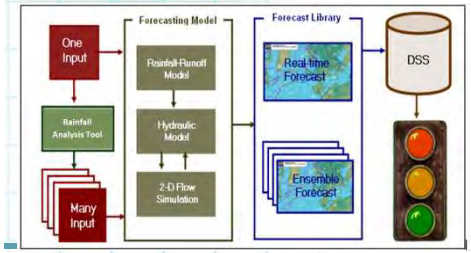


Flood Forecasting Model



Forecast Library

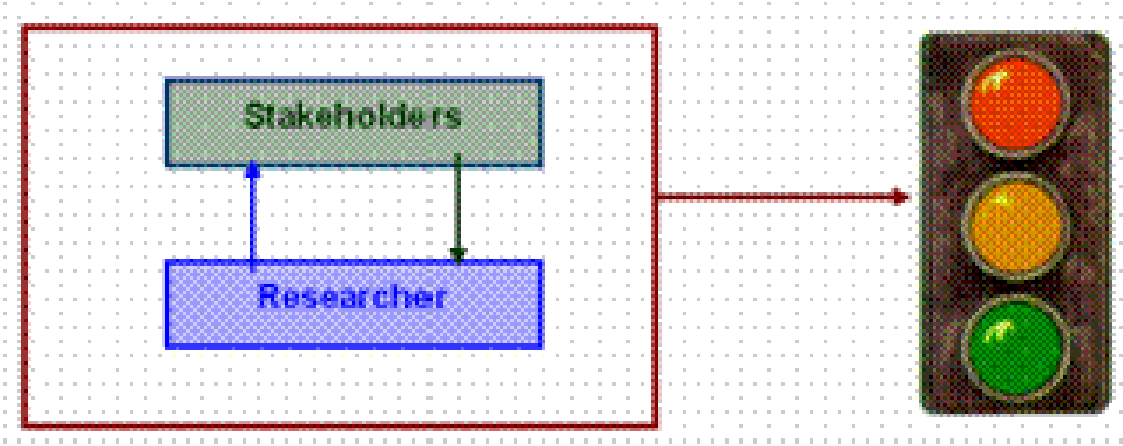
- Real time forecast
- Ensemble forecast
- Enabling long lead time
- Enabling ANN
- Assistance to decision making

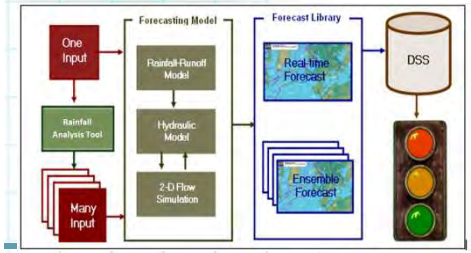


Flood Forecasting Model

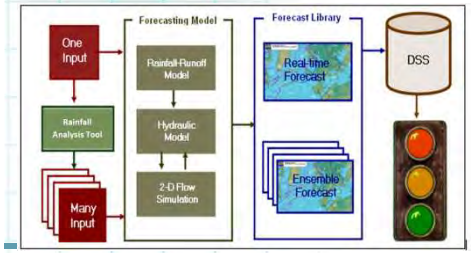
Decision Support System

- Warning Signals - Simple and clearly understandable
- To be decided jointly by stakeholders & Researchers





Case Study: Abingdon, UK



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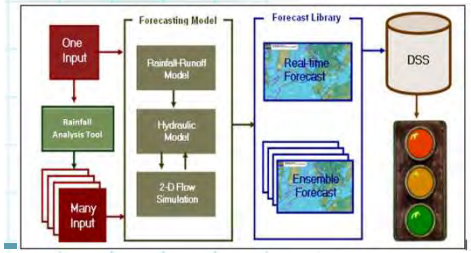

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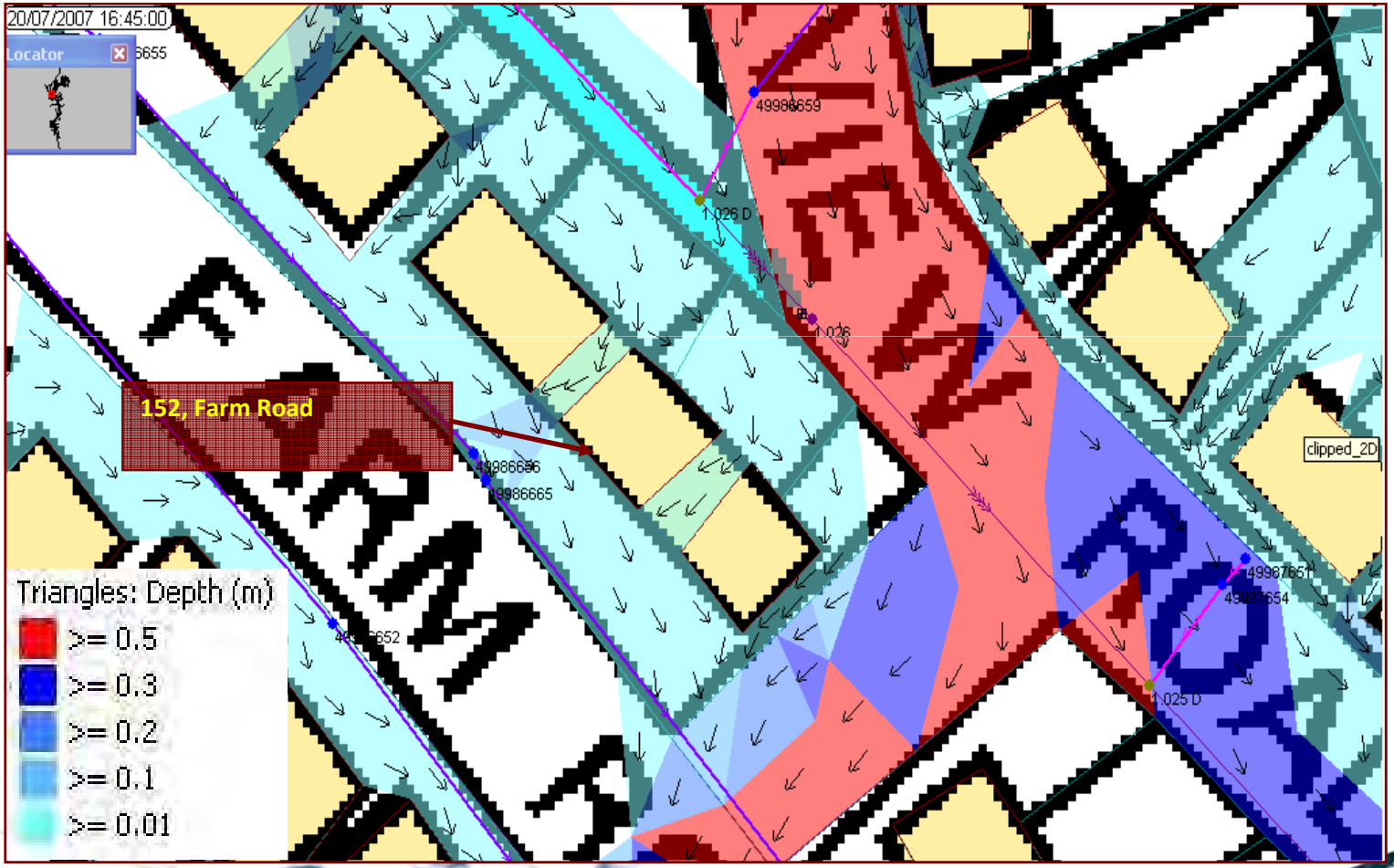

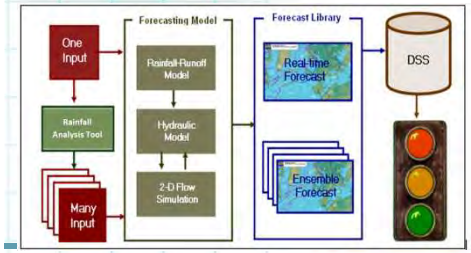

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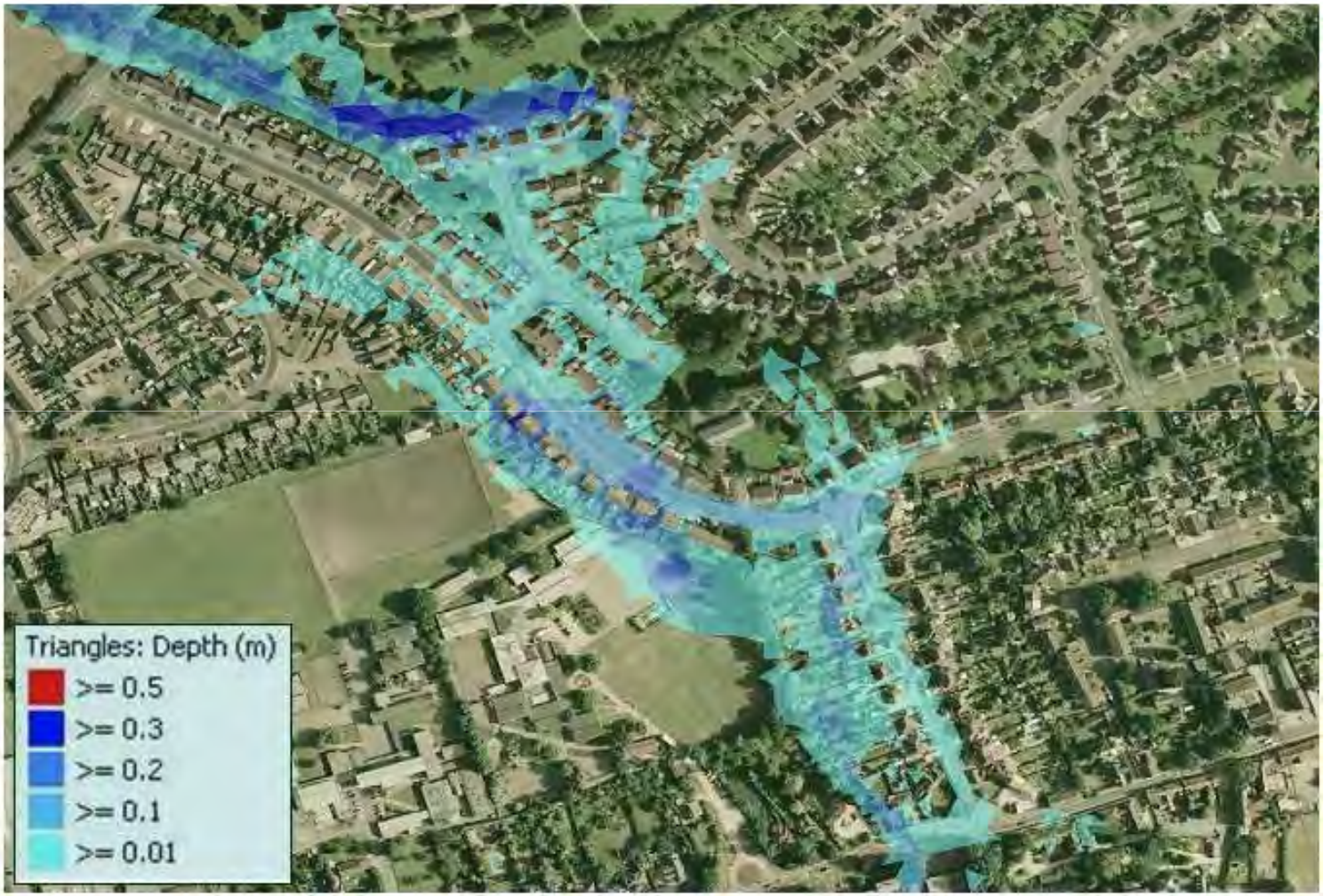

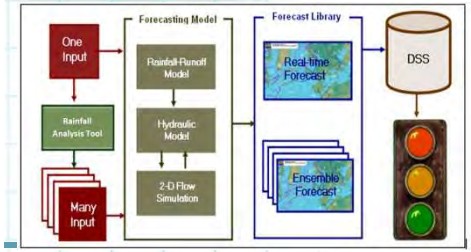

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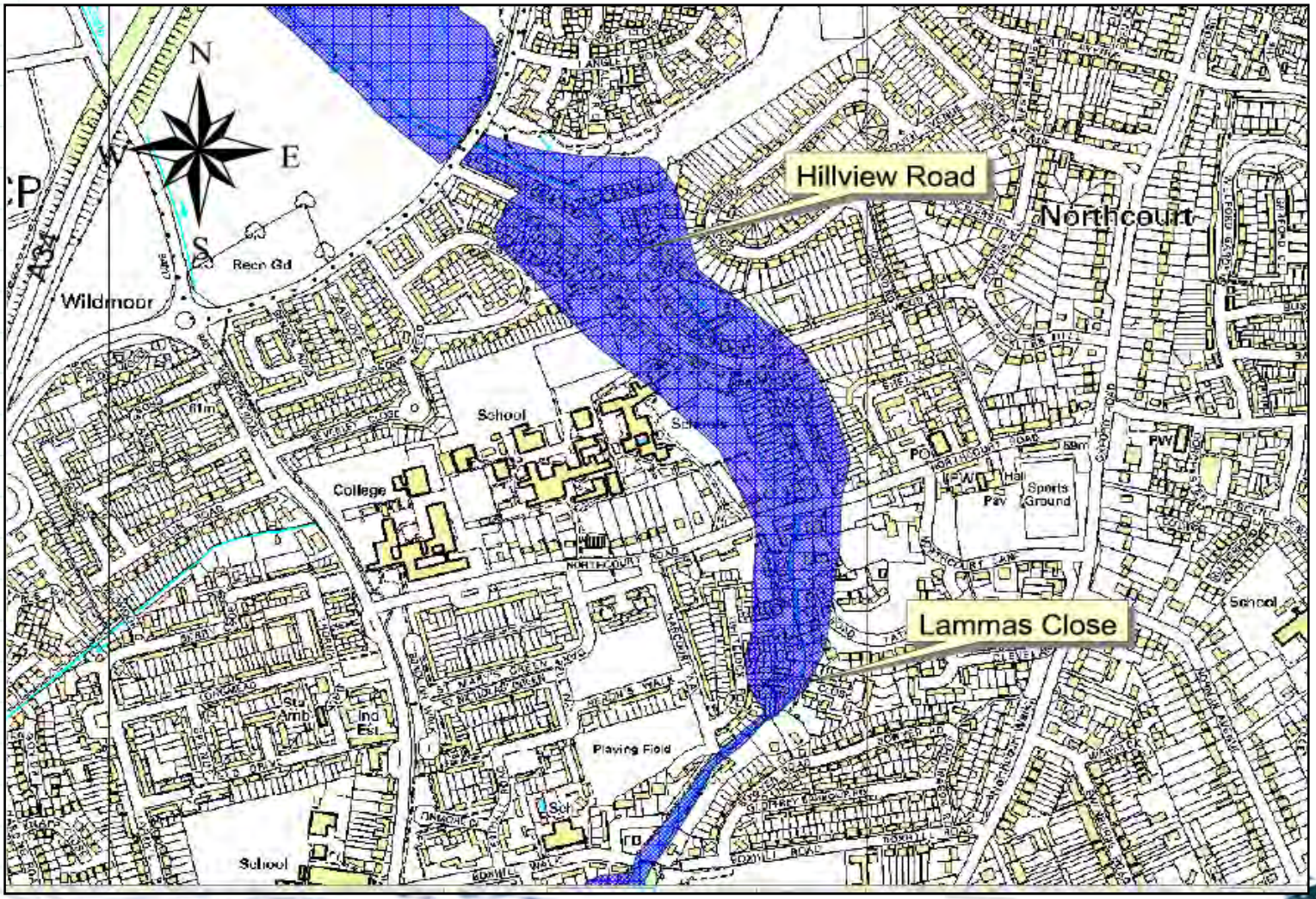
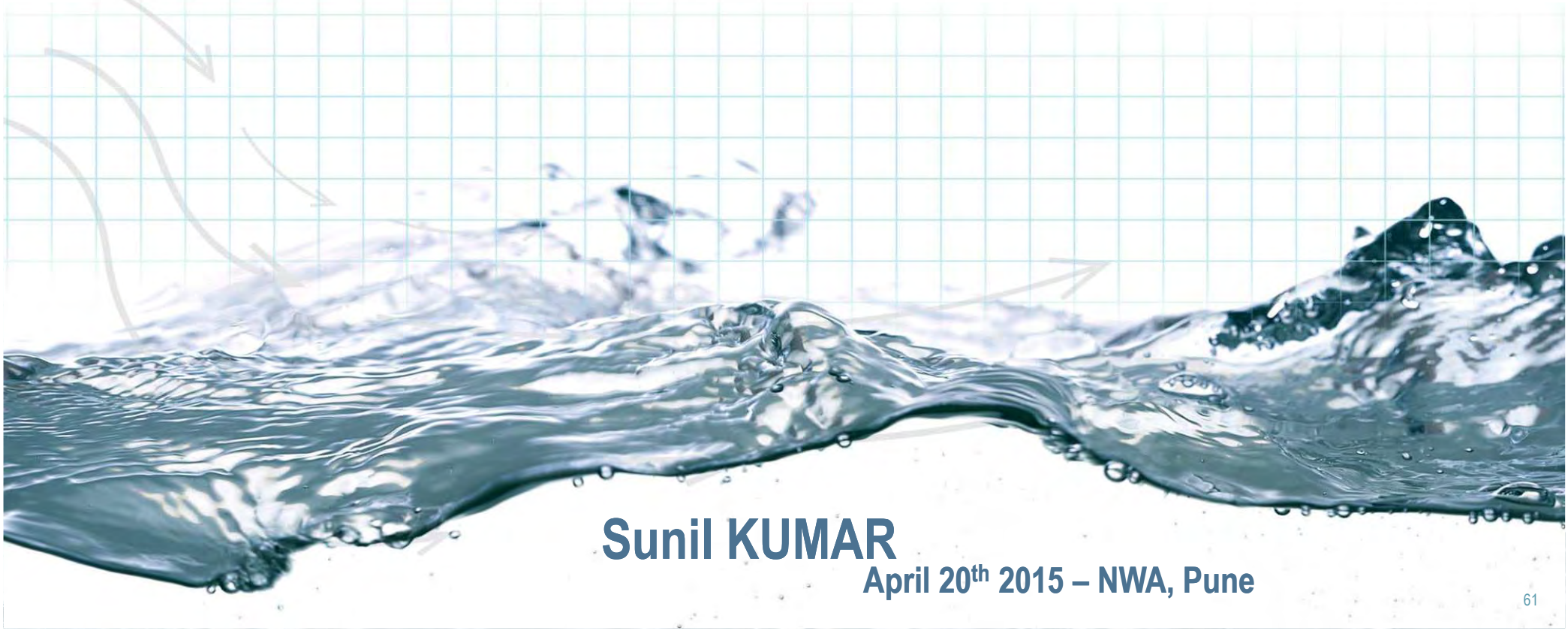


MANY THANKS



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