

# JICA/FRICS FLOOD FORECASTING SYSTEM OF THE CHAO PHRAYA RIVER BASIN

19 June 2013

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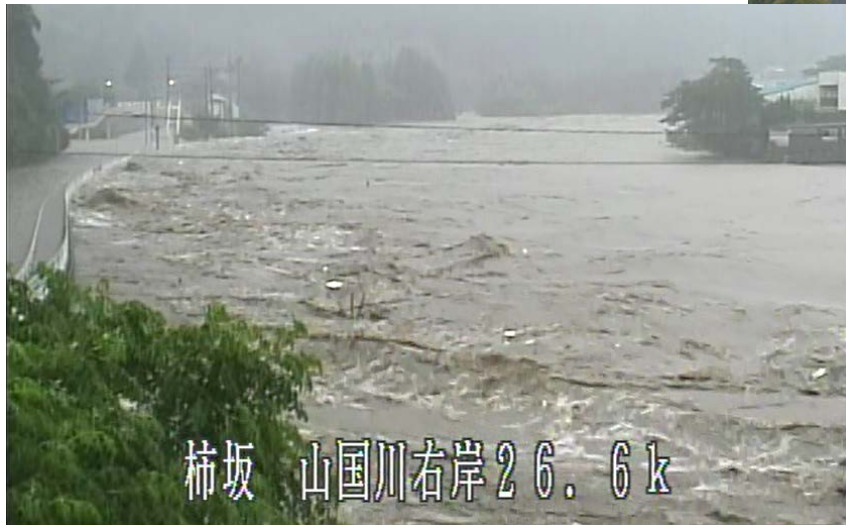
Foundation of River & Basin Integrated Communications



# FLOOD

- temporary covering by water of land not normally covered by water (EU Floods Directive)

**not a flood**

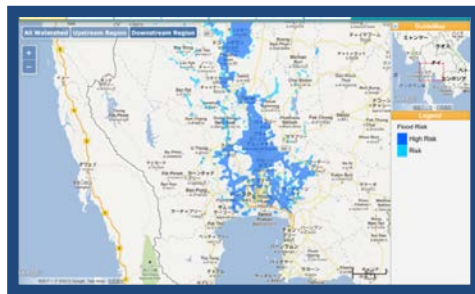


(if water does not spill over the bank)



# FLOOD FORECASTING

Not only the water level/flow rate of rivers, but also the situation of water over the (normally dry) land **must** be forecast.

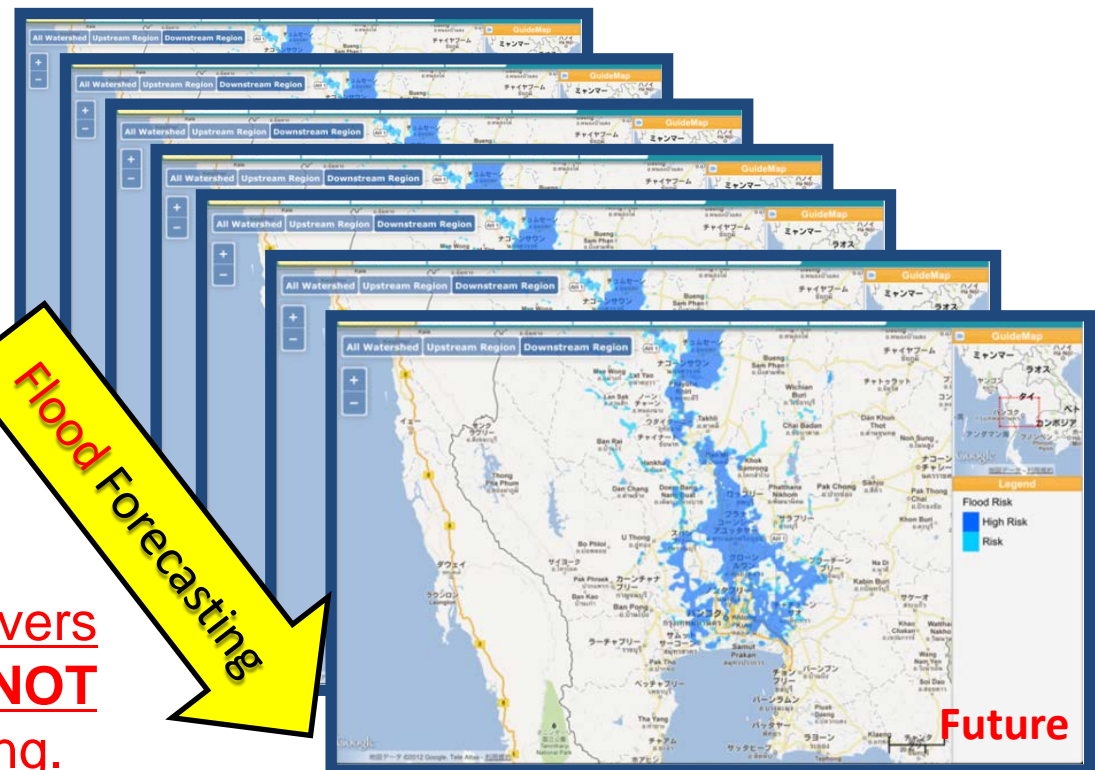


Present situation

Flood Forecasting

Strictly speaking

If water level/flow rate of rivers only are forecast, it is NOT considered as Flood Forecasting.

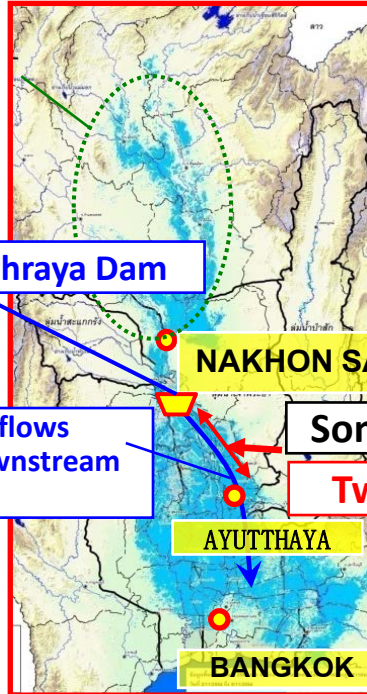


Future

# What happened during 2011 Flood?

## Physical Situation

6 Nov. 2011



Chao Phraya Dam

NAKHON SAWAN

Slow flood flows toward downstream areas

Some 120 km

Two Weeks

AYUTTHAYA

BANGKOK

Inundation forecast would be possible.

## Information

Short-term forecast of the direction of floodwater was most wanted.

Information that leads to action was wanted.

## Use of IT Devices (Private, Academic)

Facebook, Twitter, YouTube played an active part.

Source of information reliable?

## Outcries against the Government

- provide more accurate flood information;
- information on the broader situation, both in space and time

Forecast information (inundation) from responsible organization is longed for.

# With Forecast Inundation Information

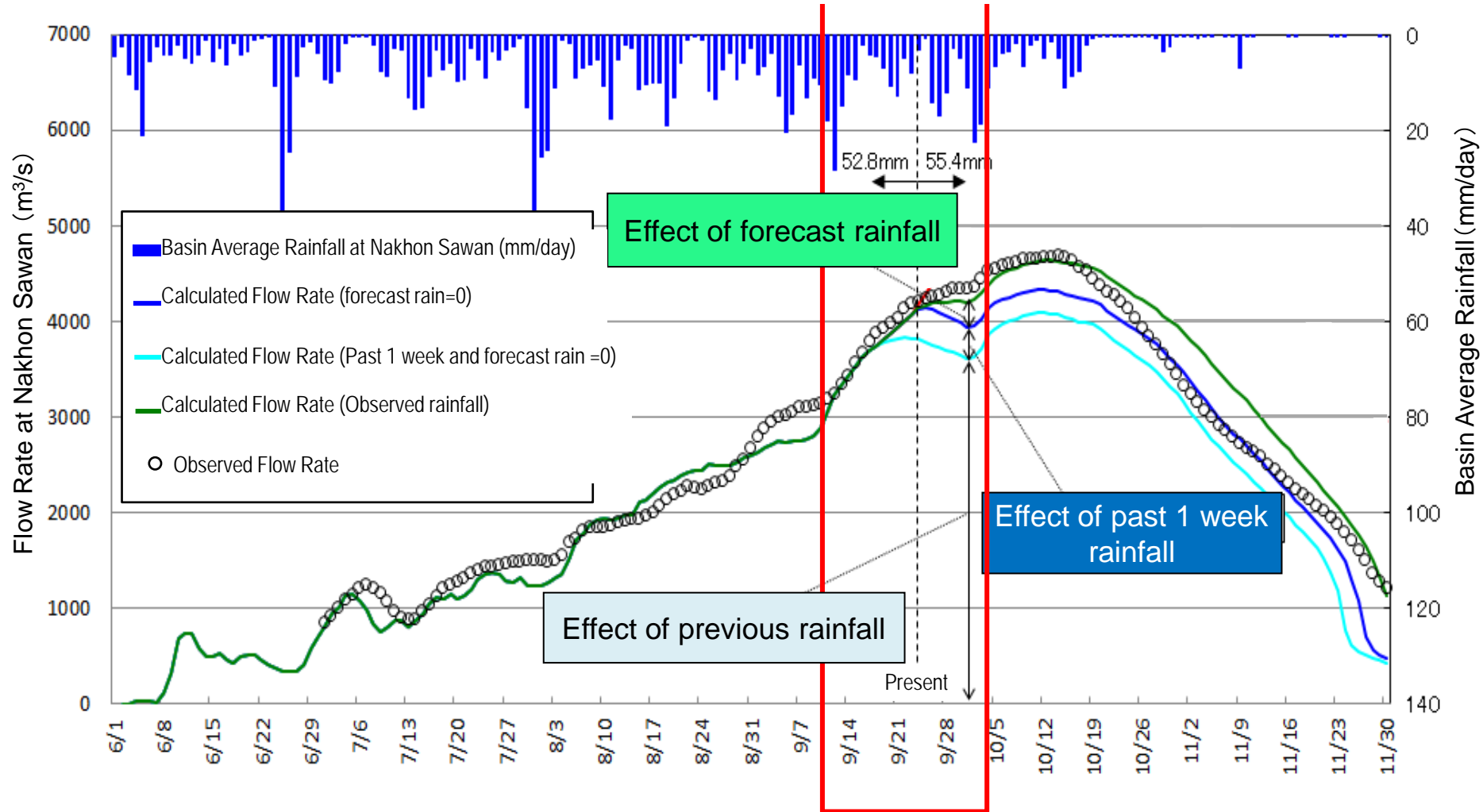
## (Farmers, factories, general public)

- Preparation for inundation (evacuation, sandbagging, moving cars)
- Cropping (even prematurely) before damaged
- Evacuation of products

## (Flood defense organizations)

- Effective countermeasures by emergency sandbagging, pumping
- Effective operation of water gats and dams
- Damage estimate of a levee break ( in some cases selection of beak point)

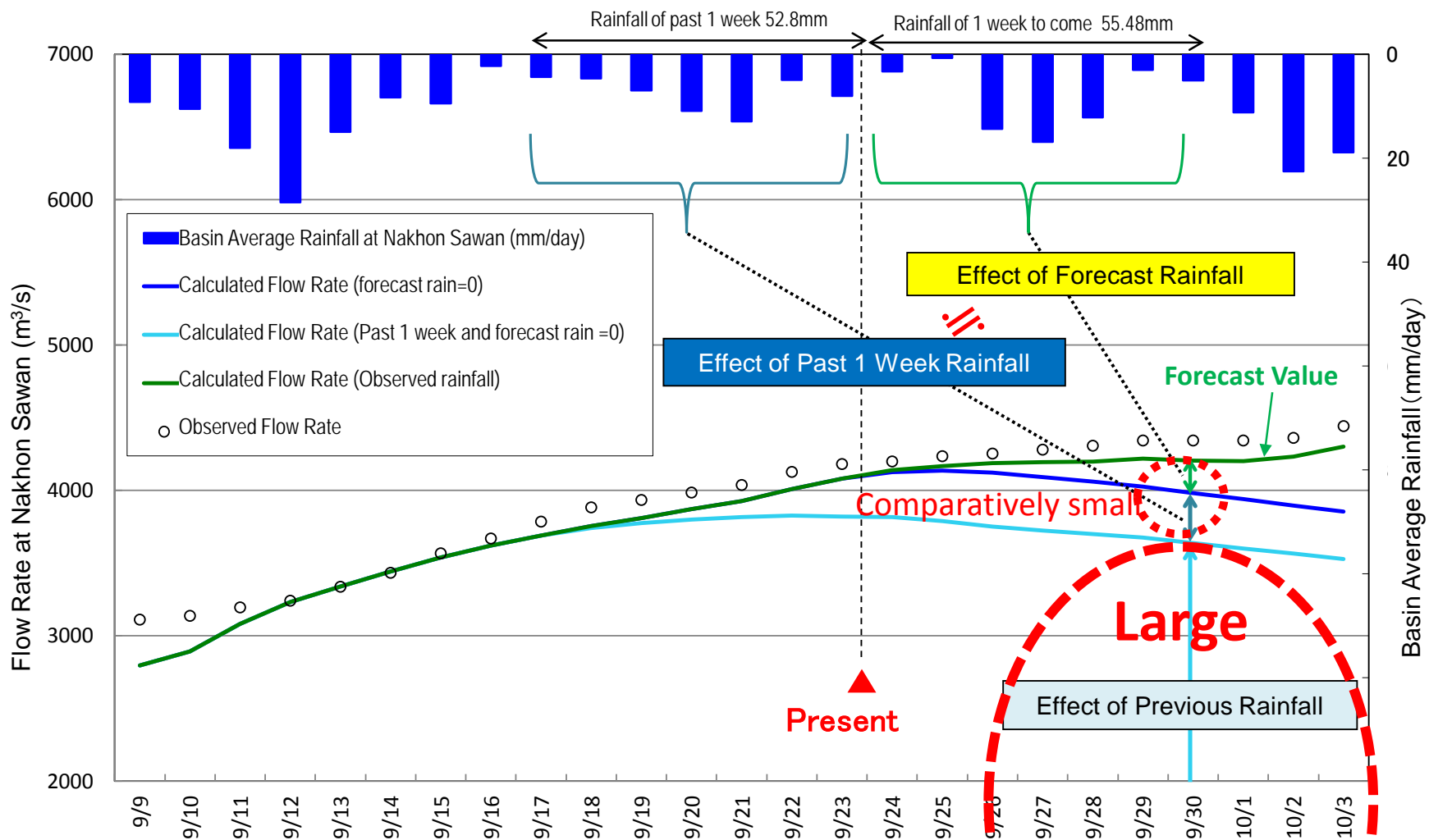
# Characteristics of The Chao Phraya River



**Flow rate at Nakhon Sawan and daily average rainfall over the upstream basin (2011 flood season)**

The graph indicates the flood duration of a few months.

# Characteristics of The Chao Phraya River



**Flow rate at Nakhon Sawan and daily average rainfall over the upstream basin (9 September – 3 October, 2011)**

Flow rate forecasting at Nakhon Sawan would be possible for 7 days with reasonable certainty.

# Uncertainty of Natural Disaster Information

## Uncertainties are involved in

- Natural phenomenon itself
- Limited observation
- Insufficient simulation techniques

Decision is to be made on the delivery of **uncertain** information based on its value in reducing **net** damage of the receivers.

In Japan, the majority agrees to use the forecast information understanding the accuracy of such information as it is.



# What is available in Flood Risk Information System?

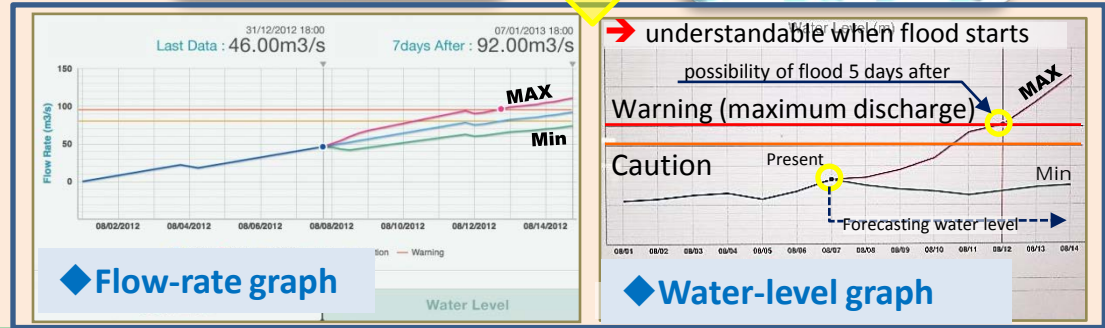
[2 types of display]

● Plane view

● Bird's eye view

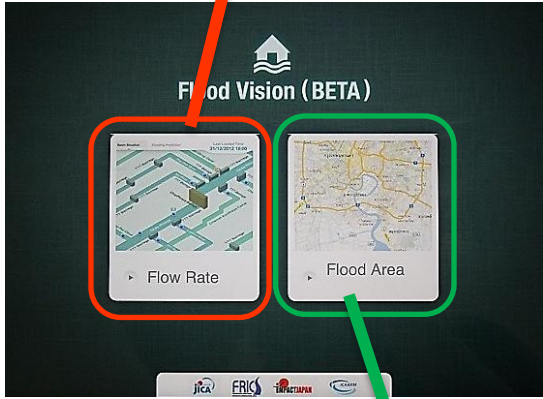


Flow rate



understandable when flood starts  
possibility of flood 5 days after  
Warning (maximum discharge)  
Caution Present  
Forecasting water level

Top page



Inundation area

Forecast of 1 - 7 days later

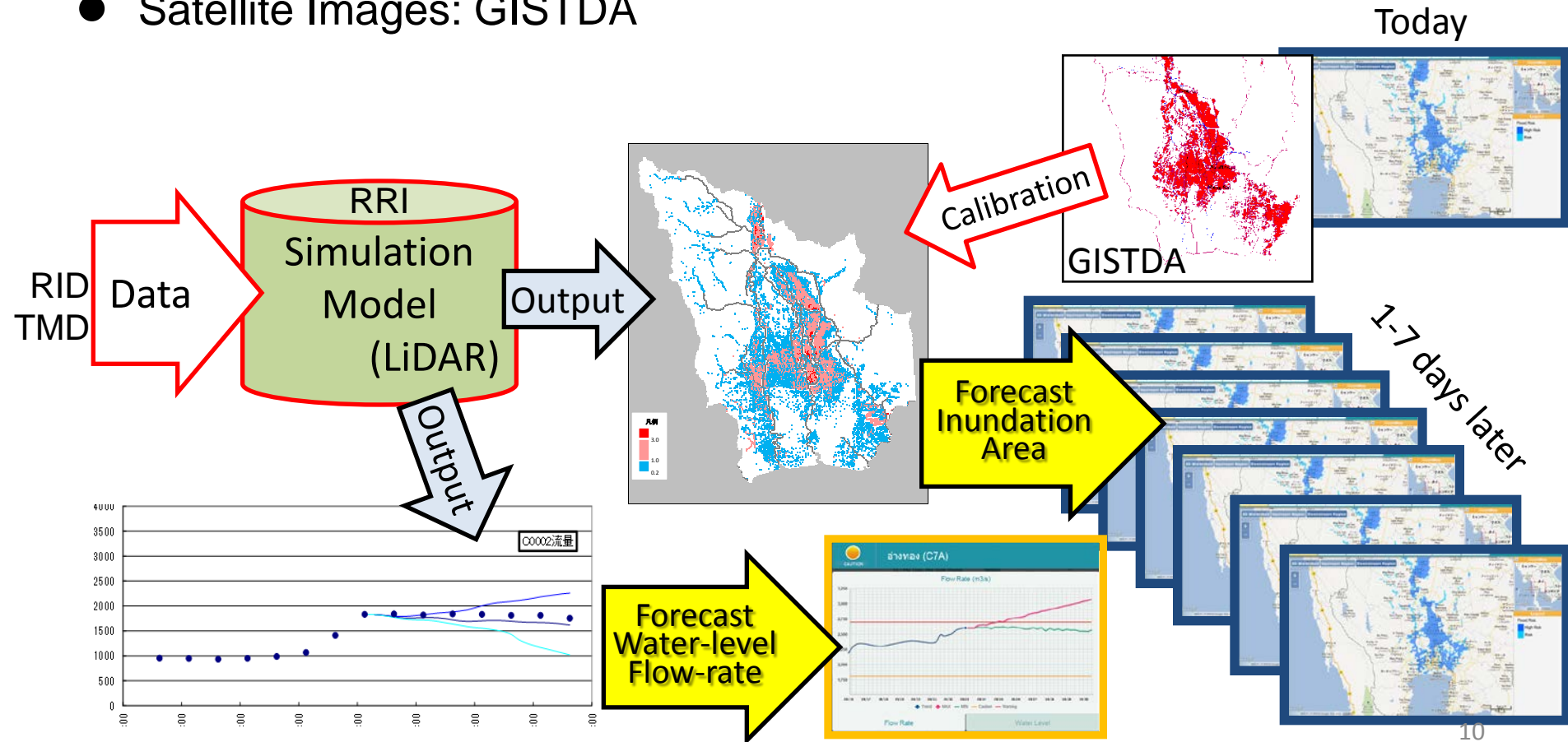


● display a color-coded inundation risk for each mesh

1. Forecast river flow-rate and water-level with **high accuracy (verified by the 2012 flood)**
2. Practical application of inundation forecast for such a wide area had **not ever seen anywhere in the world.** (RRI model, LiDAR data etc.)
3. Simulation **runtime** is **very short.**

# How the information created?

- Observation Data: Rainfall, Water-level, Discharge
- Simulation Models: RRI model
- Rainfall Forecast: Quantitative Precipitation Estimate (QPE)
- Detailed topography : LiDAR data
- Satellite Images: GISTDA

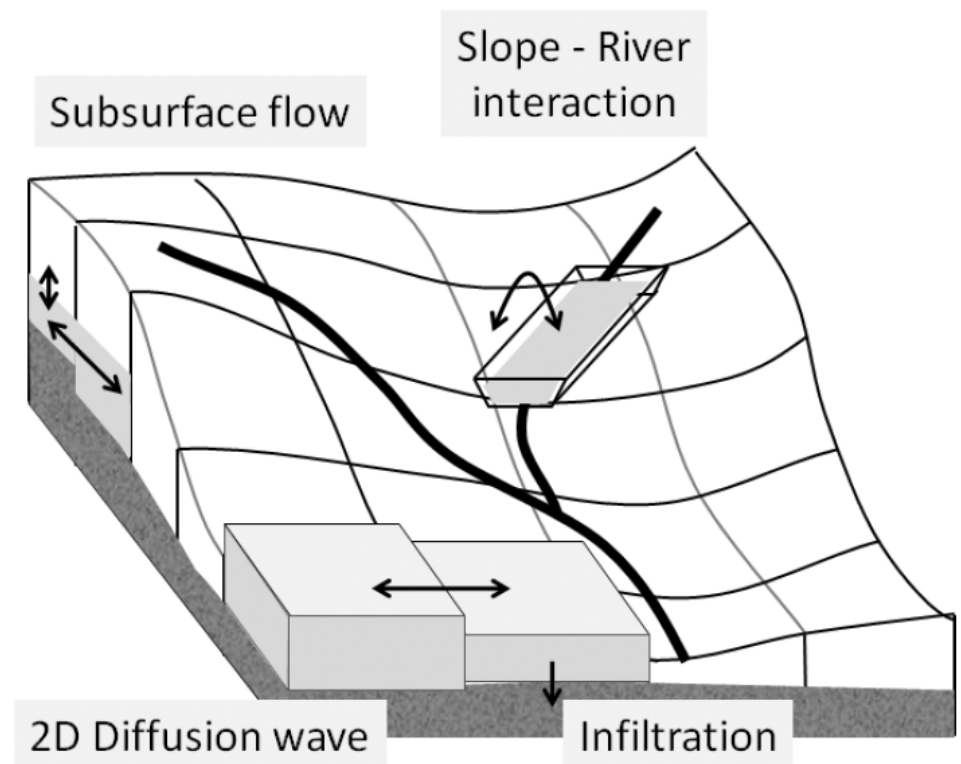


# RRI (Rainfall-Runoff-Inundation) Model of ICHARM

The RRI model analyses runoff into the river and inundation in the flood plain as a whole, dividing the basin into meshes.

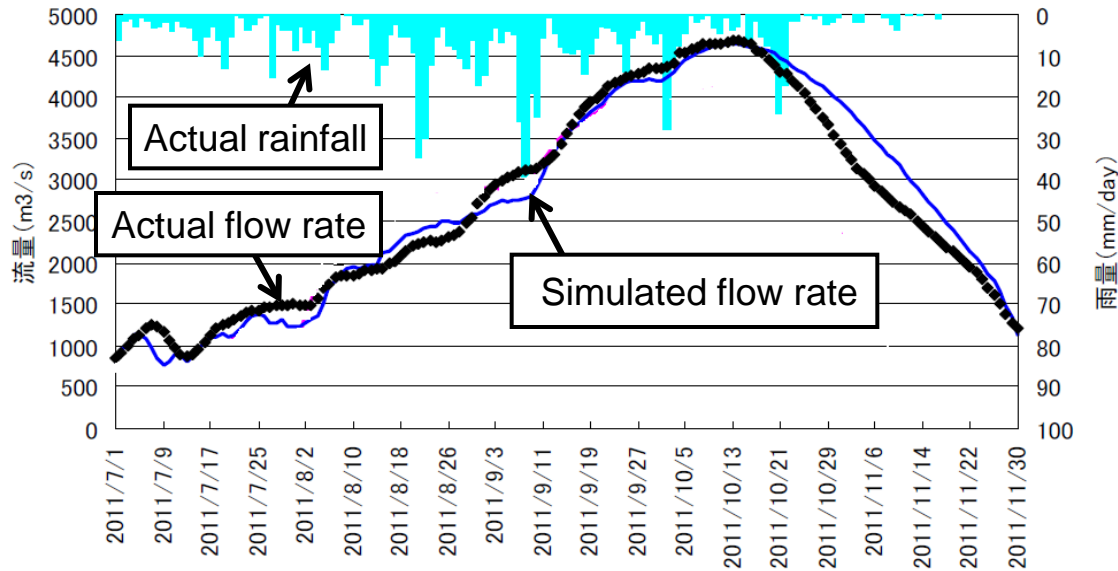
Features:

- two-dimensional runoff analysis model and one-dimensional river routing model.
- vertical and lateral infiltration flows underground
- exchange of water between runoff model and routing model calculated by an overflow formula.



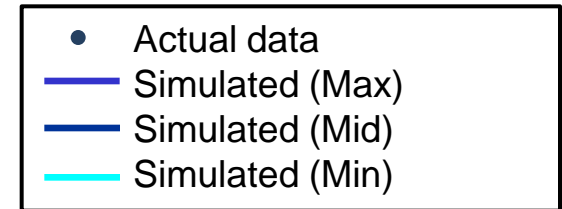
# Accuracy of forecast flow rate

## Comparison between actual and simulated flow rate in the 2011 flooding

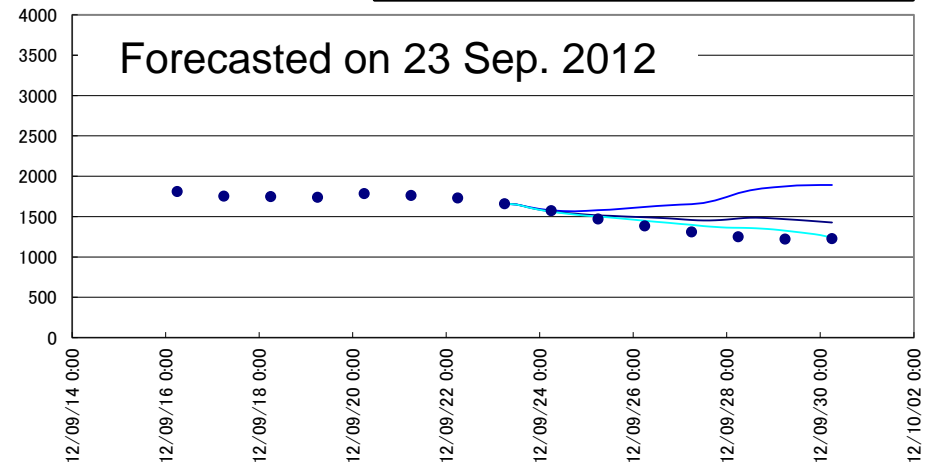
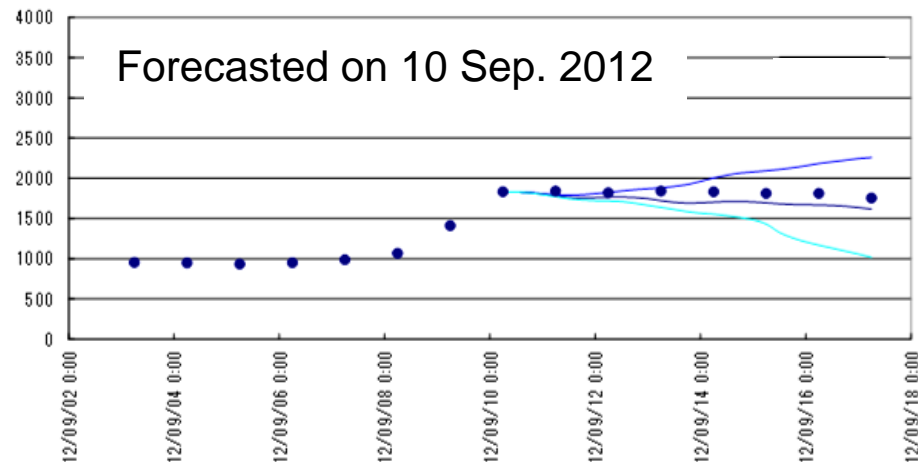


Flow rate at Nakhon Sawan

The 2006 flood was also applied to verify at various points.



## Forecasting in 2012 (flow rate at Nakhon Sawan)

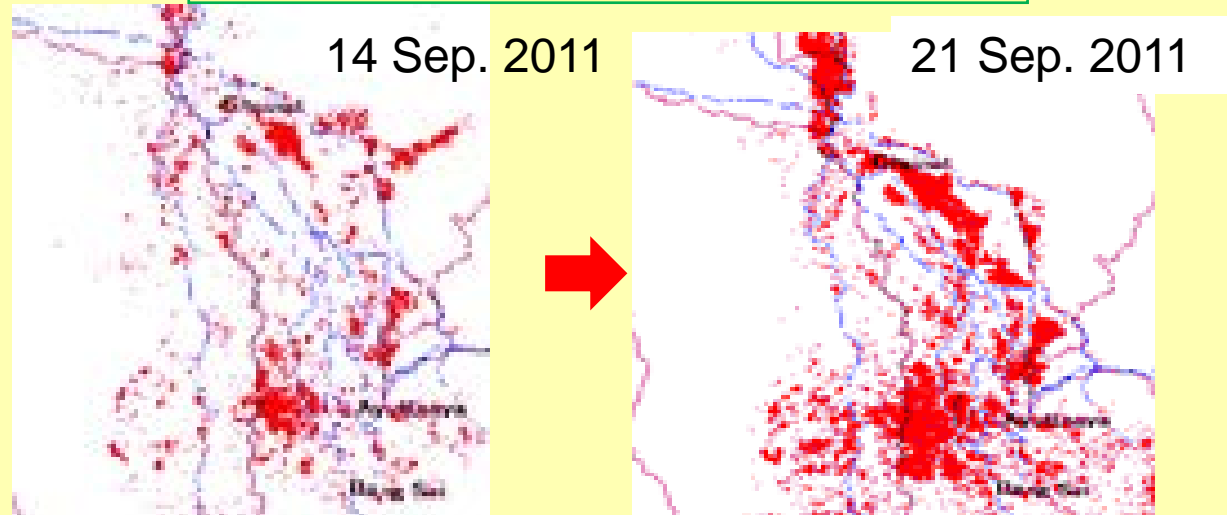


# Accuracy of forecasting (compared with GISTDA images)

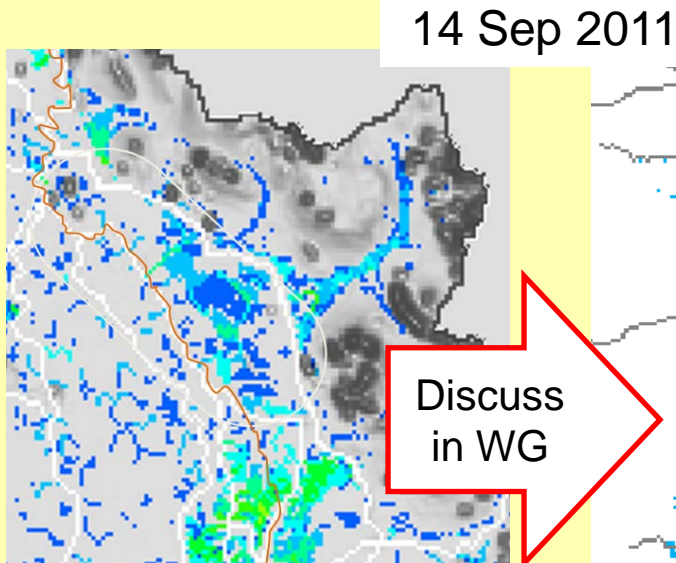
Correct understanding and forecasting become possible by using simulation, LiDAR data and GISTDA images.

Calculation speed is faster than MIKE series and others.

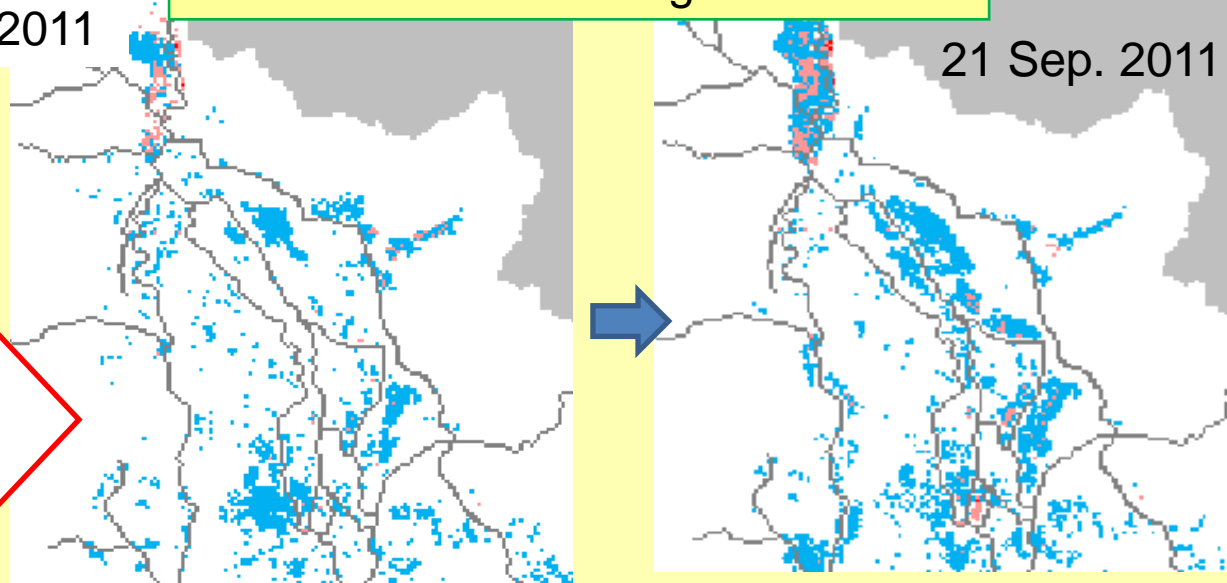
Actual data (GISTDA satellite image)



Simulation of prototype



Results of forecasting simulation



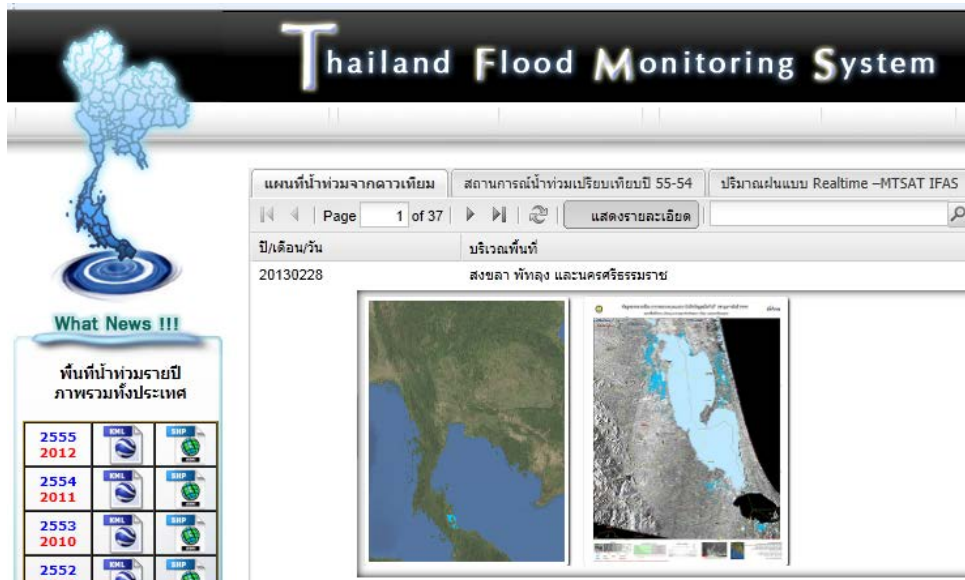
# Use of Satellite Image for Calibration

To reflect the actual flooding situation, GISTDA satellite images are applied to the simulation by the RRI model.

**However**, the satellite images do not give information on **inundation depth**, the following procedures are taken.

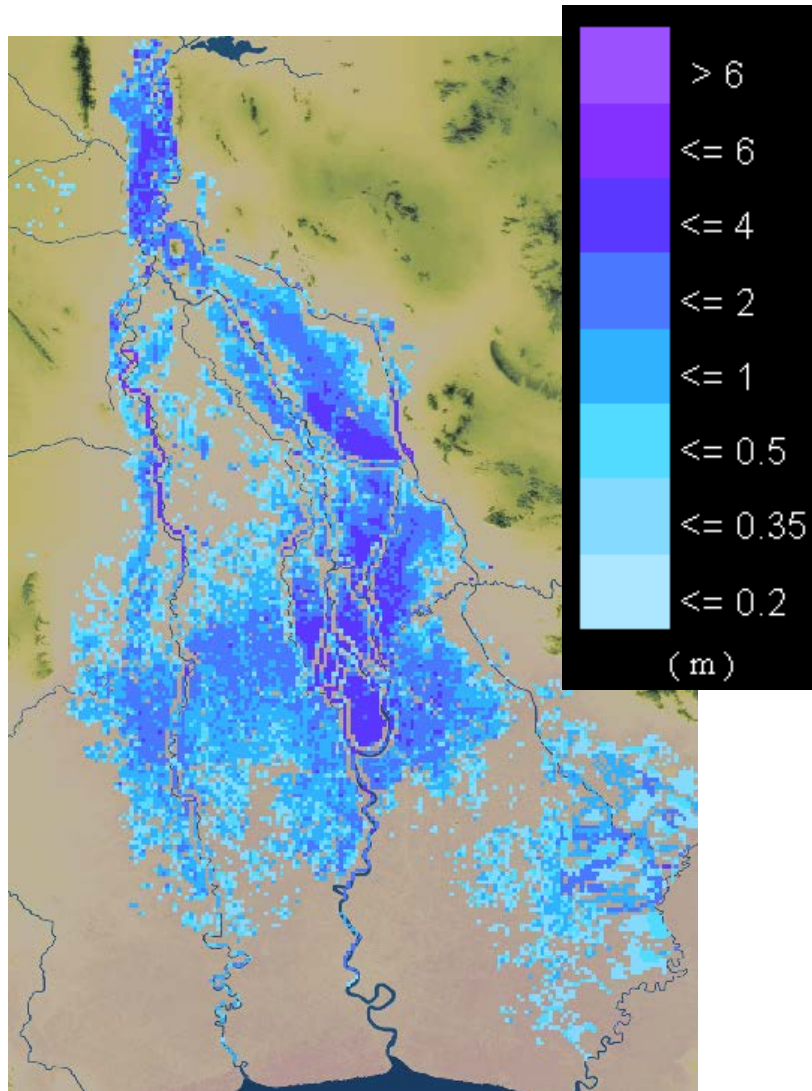
1. Correction (based on GISTDA image) made on the inundation calculation result of **7 days ago (initial condition)**;
2. Calculation carried out for **14 days** –(7 days for preliminary calculation and 7 days for forecasting);

3. **Correction** (based on **Today's** GISTDA image) made on the inundation calculation result of today;
4. Difference between today's value and forecast value is added to **the CORRECTED today's result** (for 2-7 day forecast).

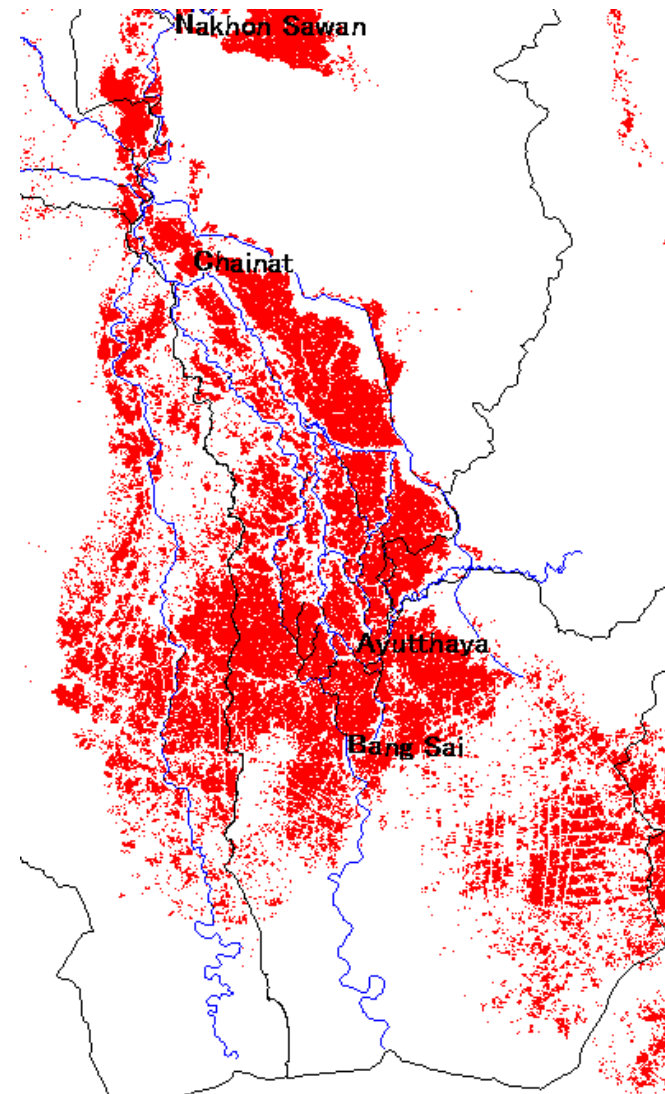


<http://flood.gistda.or.th/>

# Satellite Image with Inundation Depth?



**Simulated Inundation Area**



**GISTDA Satellite Image**

October 17, 2011

# Flood Risk Information System of the Chao Phraya River

-can forecast inundation areas

“Flood forecasting system” of its original meaning



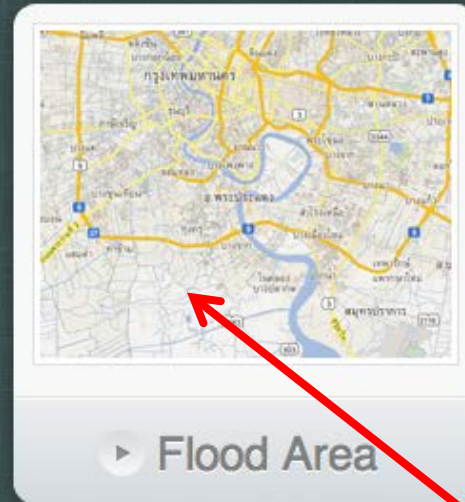
# Top Page

Help

Displays help documents

Big Button

## Flood Risk Information



Click and proceed to flow rate, water level forecast pages

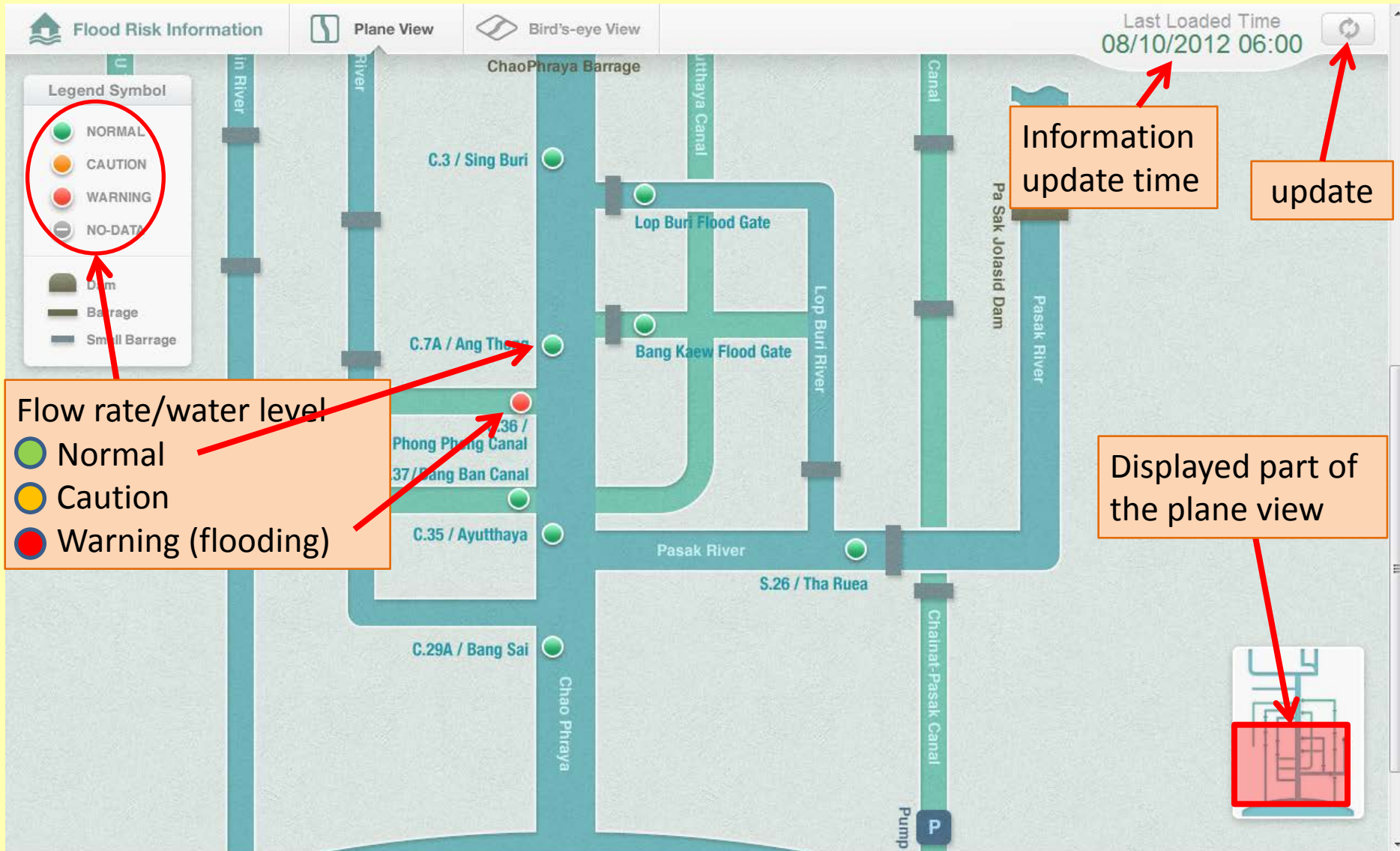
Click and proceed to inundation forecast pages

This site is under trial operation (delivered to the registered monitors only). English version is presented for now. Thai and Japanese versions are under preparation. When the weather is calm, and there is seldom possibility of flooding, the system maintenance will be performed. In this case, and for the time being, the information will be updated every other day.

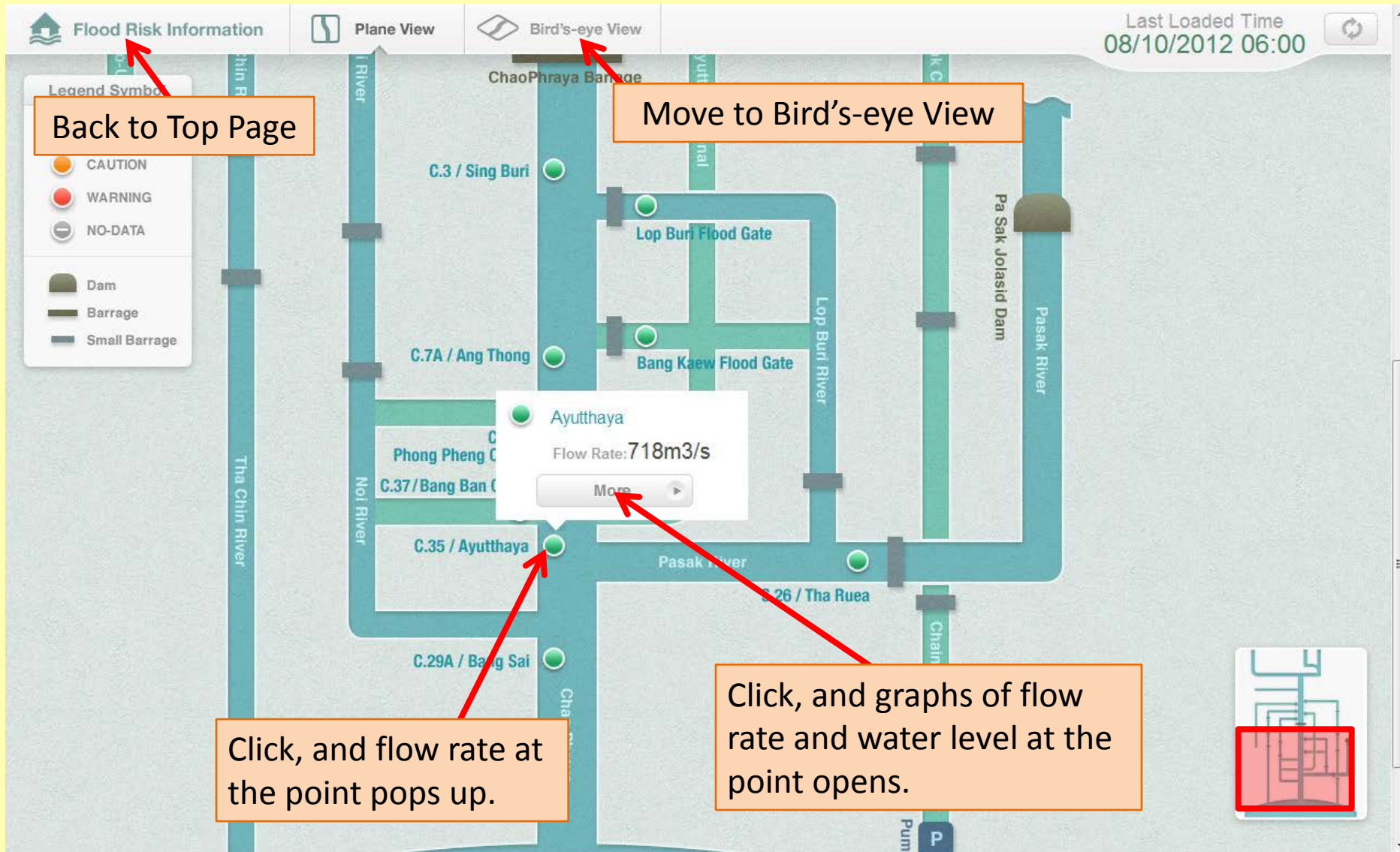
ภาษาไทย | English

Change between English and Thai versions.

# Schematic Diagram (Plane View)



# Schematic Diagram (Plane View)





Legend Symbol

- N
- A
- C
- W



CAUTION

# อ่างทอง (C7A)

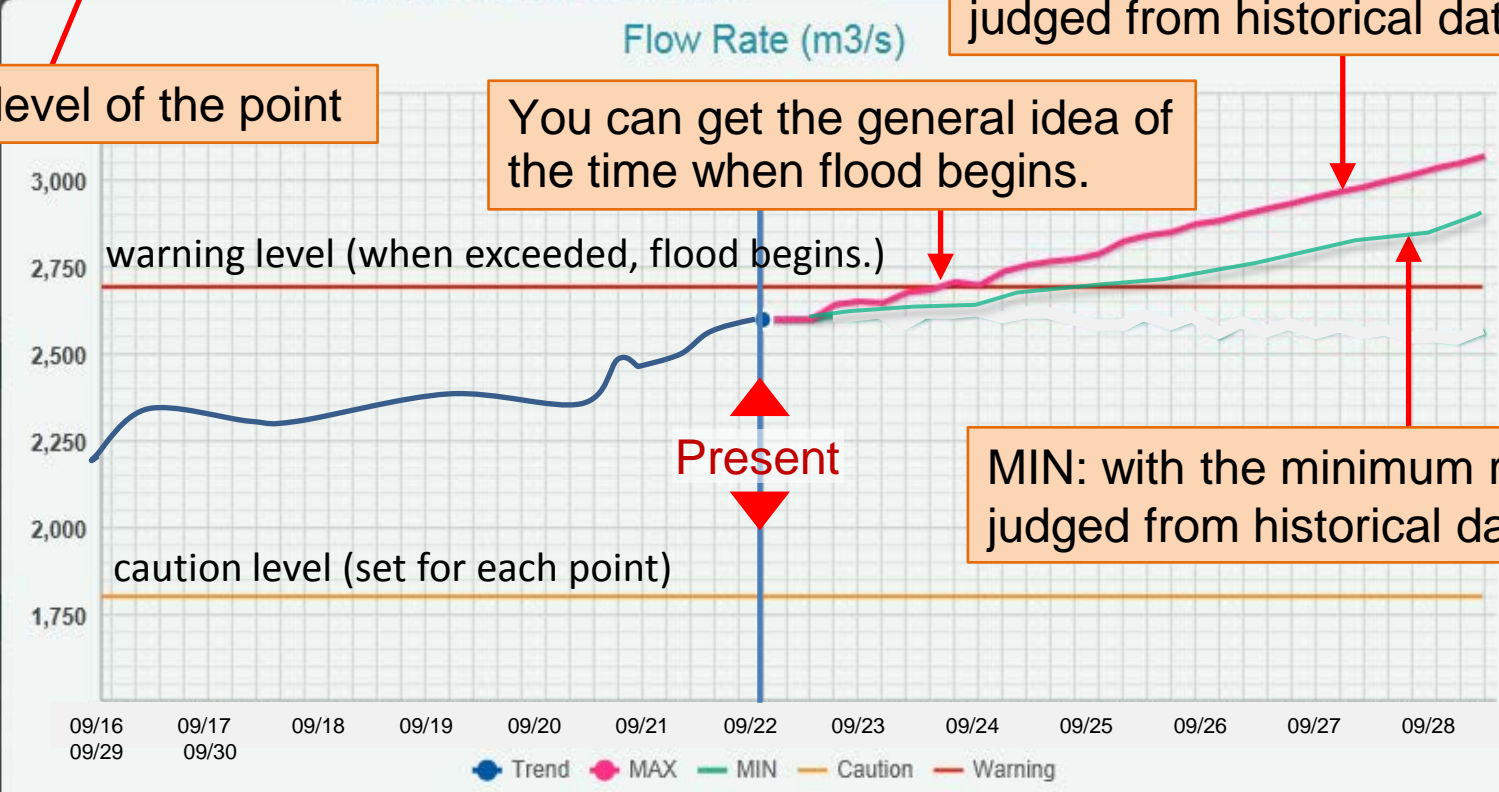
Close the graph



MAX: with the maximum rainfall judged from historical data

Risk level of the point

You can get the general idea of the time when flood begins.



MIN: with the minimum rainfall judged from historical data

Flow Rate

Water Level

Move to Flow Rate graph

Move to Water level graph

Legend Symbol

- NOI
- ATT
- CAI
- WA
- NO-
- Dar
- Bar
- Min
- Pon



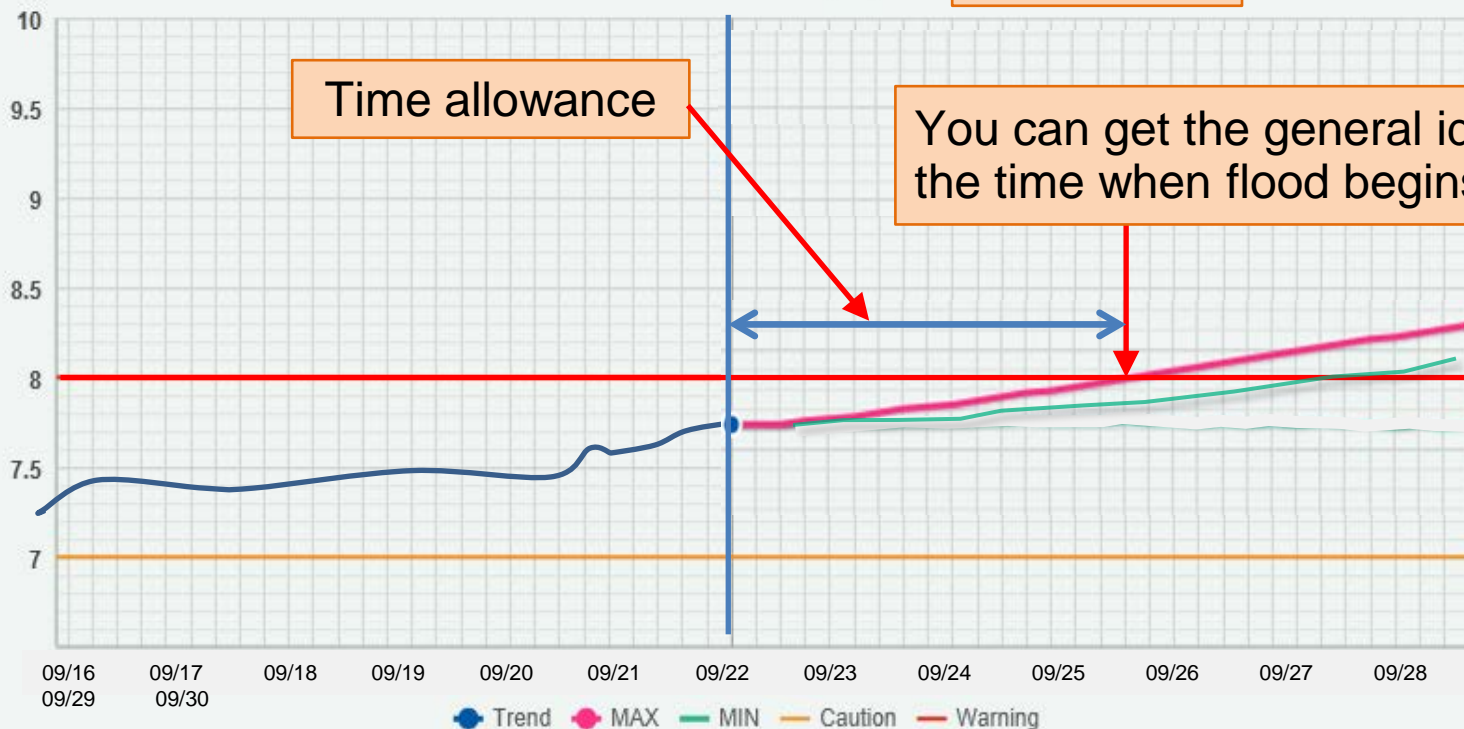
CAUTION

# อ่างทอง (C7A)



Water Level (m)

Water level



Flow Rate

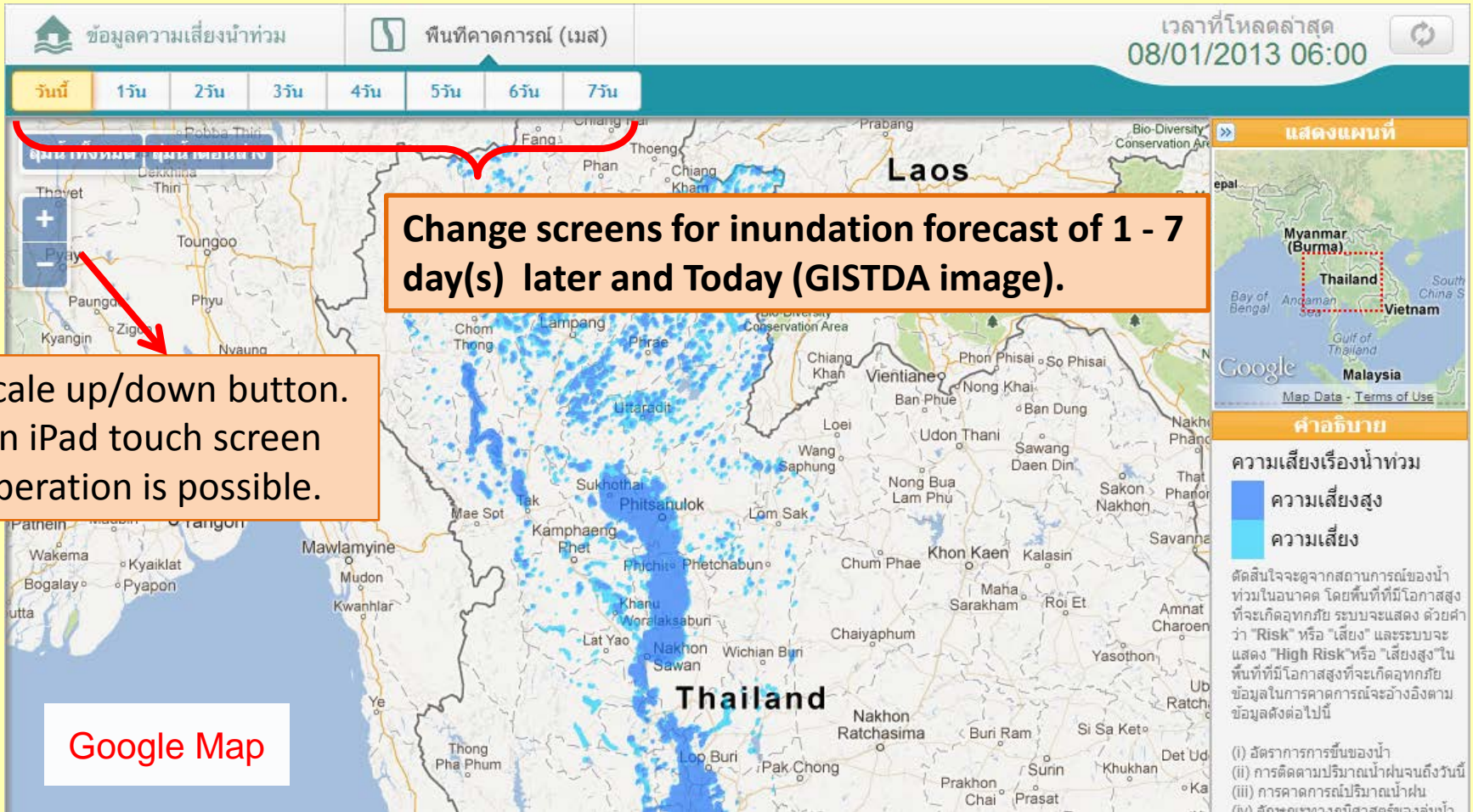
Water Level

Move to Flow Rate graph

Move to Water level graph

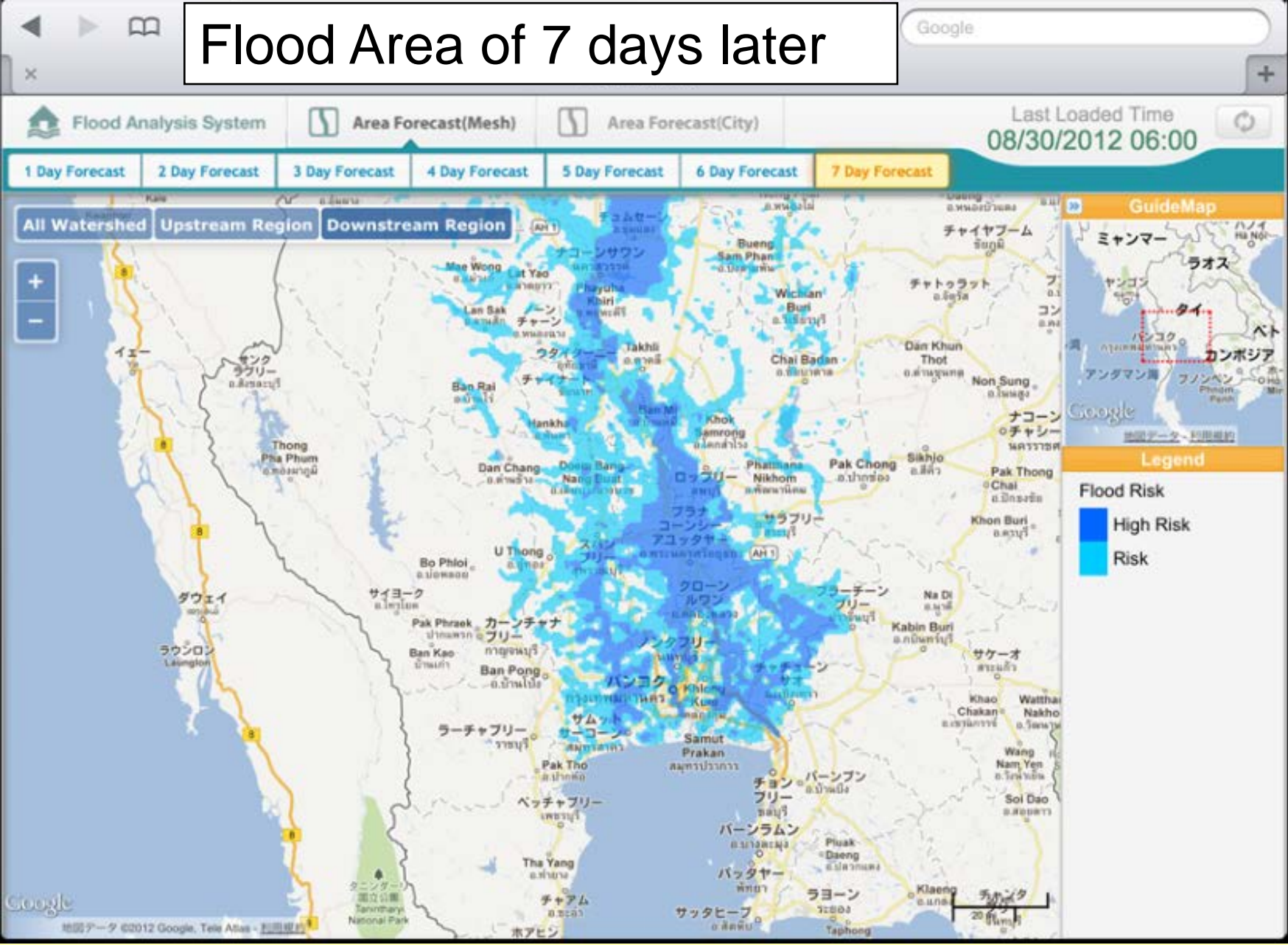
# Inundation Area

Inundation Extent Overwrapped on Google Map  
“High Risk” area (dark-blue), and “Risk” area (light-blue)



Risk: water depth between 20cm and 1.0m, High Risk: water depth more than 1.0m

# Flood Area of 7 days later



# Daily system operation

Data acquisition (rainfall, water-level, flow-rate and dam)

Program for converting to CSV format is under development.

รายงานผลการวัดปริมาณน้ำฝน  
ศูนย์ปฏิบัติการและเฝ้าระวังน้ำท่วมฉับพลัน สำนักชลประทานที่ 12 กรมชลประทาน  
วันที่ 31-6 เดือน มิถุนายน 2555

1. สถานีวัดน้ำฝน	ชื่อสถานี	พิกัด	ฝน	ความชื้นสัมพัทธ์ (%)	อุณหภูมิ (°C)	ความเร็วลม (km/h)	ทิศทางลม	ความกดอากาศ (mmHg)	ความกดอากาศ (hPa)	ทิศทางเมฆ (%)	ปริมาณน้ำฝน (mm)
1	วัดน้ำฝน	13 10 10	10	75	30	10	SE	1010	1010	10	10

Meteorological Observation at 0000 UTC on 12 August 2012

Station Name	PPP (hPa)	TX (C)	TX (F)	DW (C)	DW (F)	WIND (m/s)	WIND (mph)	WIND DIR	WIND GUST (m/s)	WIND GUST (mph)	REL HUM (%)	WIND DIR
Kao I Dang Station	1007.8	24.4	75.9	22.0	71.6	1.1	2.5	100	1.1	2.5	75	100
Khao Saranee	1008.5	23.5	74.3	20.0	68.0	1.1	2.5	100	1.1	2.5	75	100
Chiang Rai	1005.7	24.0	75.2	21.0	69.8	1.1	2.5	100	1.1	2.5	75	100
Chiang Rai (aep)	1006.5	23.5	74.3	19.0	66.2	1.1	2.5	100	1.1	2.5	75	100
Phayao	1006.5	23.0	73.4	18.0	64.4	1.1	2.5	100	1.1	2.5	75	100
Chiang Mai	1008.4	24.0	75.2	21.0	69.8	1.1	2.5	100	1.1	2.5	75	100
Doi Angkorajit	1004.5	23.0	73.4	18.0	64.4	1.1	2.5	100	1.1	2.5	75	100
Bluen	1005.0	25.0	77.0	21.0	69.8	1.1	2.5	100	1.1	2.5	75	100

RID  
Hydro Center etc.

TMD

Mail

Website

Automatic data transfer



Upload observation data and perform calculation

Save as CSV format

Perform calculation

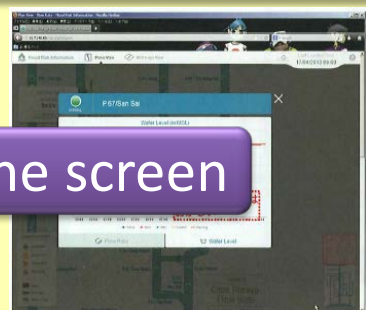
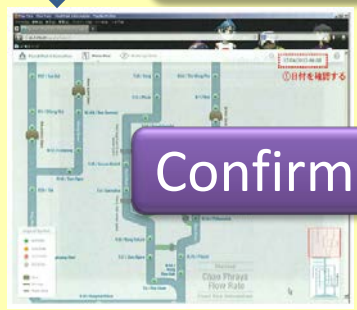
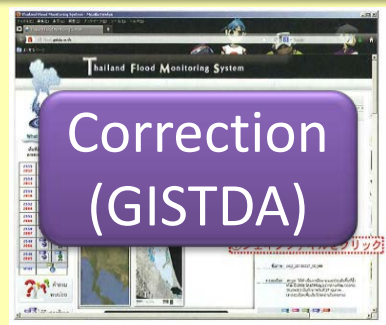
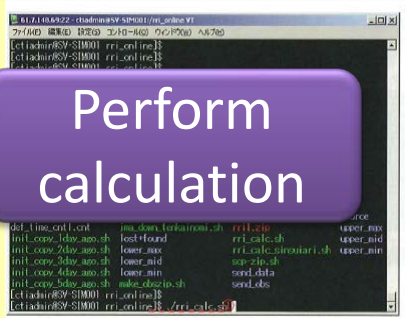
Correction (GISTDA)

Upload

Confirmation of displayed results

Confirm on the screen

If necessary, revise





# Development of “Simulator” Function

## Water management judgment tool of the government’s internal use

Effects of **dam** and **water gate** operation are simulated under multiple scenarios.

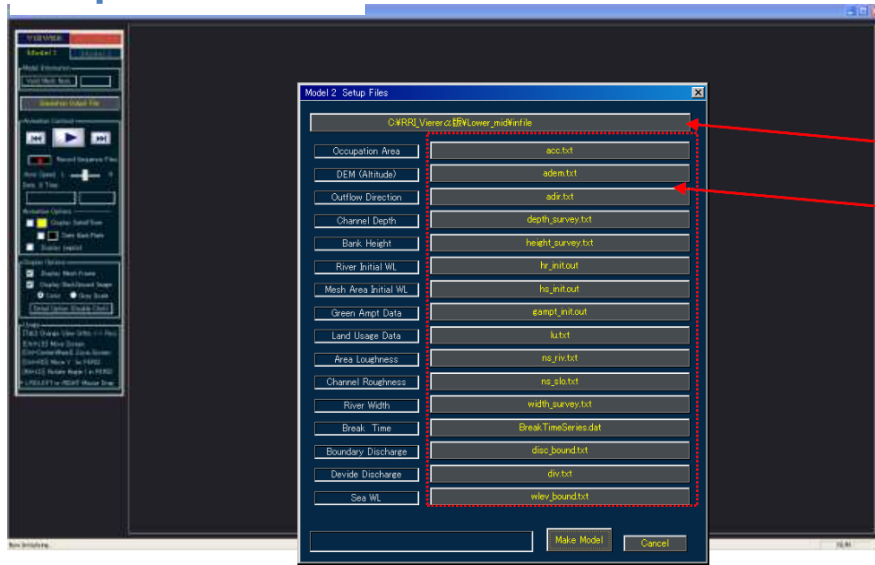
- Decision making on the operations of facilities based on the output (**forecast inundation areas, depth, volume**)

Effects of emergency countermeasures scenarios including **large-scale sandbagging** and deployment of **emergency drainage pumps** are simulated.

- Decision making on the countermeasures based on the output (**forecast inundation areas, depth, volume**)

# Simulator Input

## • Input data set



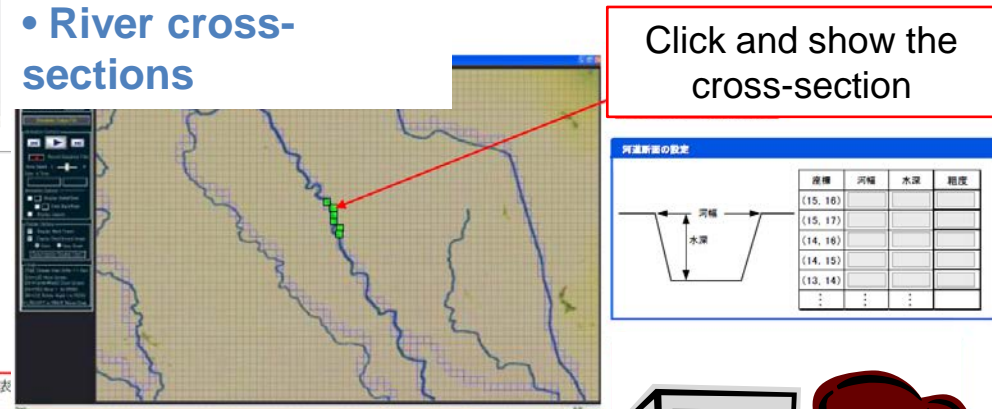
File name  
calculation  
conditions

## • Floodplain



Scale  
up/down

## • River cross-sections

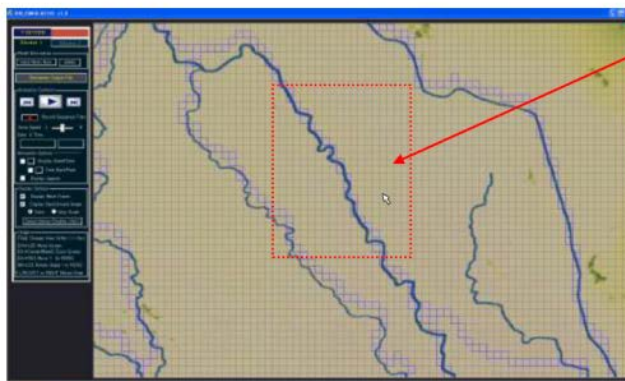


Click and show the  
cross-section

河川断面の数値

座標	河幅	水深	範囲
(15, 16)			
(15, 17)			
(14, 16)			
(14, 15)			
(13, 14)			
...	...	...	...

## • Ground level data



Ground  
level can  
be changed  
manually

地盤高の修正

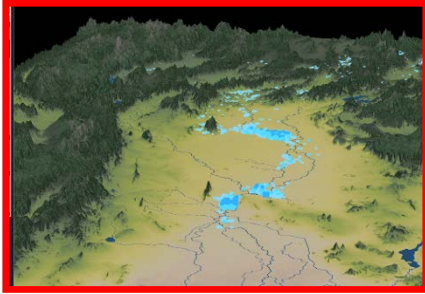
1.5	1.3	1.3	1.6
1.6	2.2	1.5	1.6
1.5	2.1	2.1	1.9
1.8	2.3	2.2	2.4
2.0	2.5	1.9	2.3
2.2	2.0	2.0	2.5

It runs on a PC that is  
connected to the Flood  
Risk Info System.

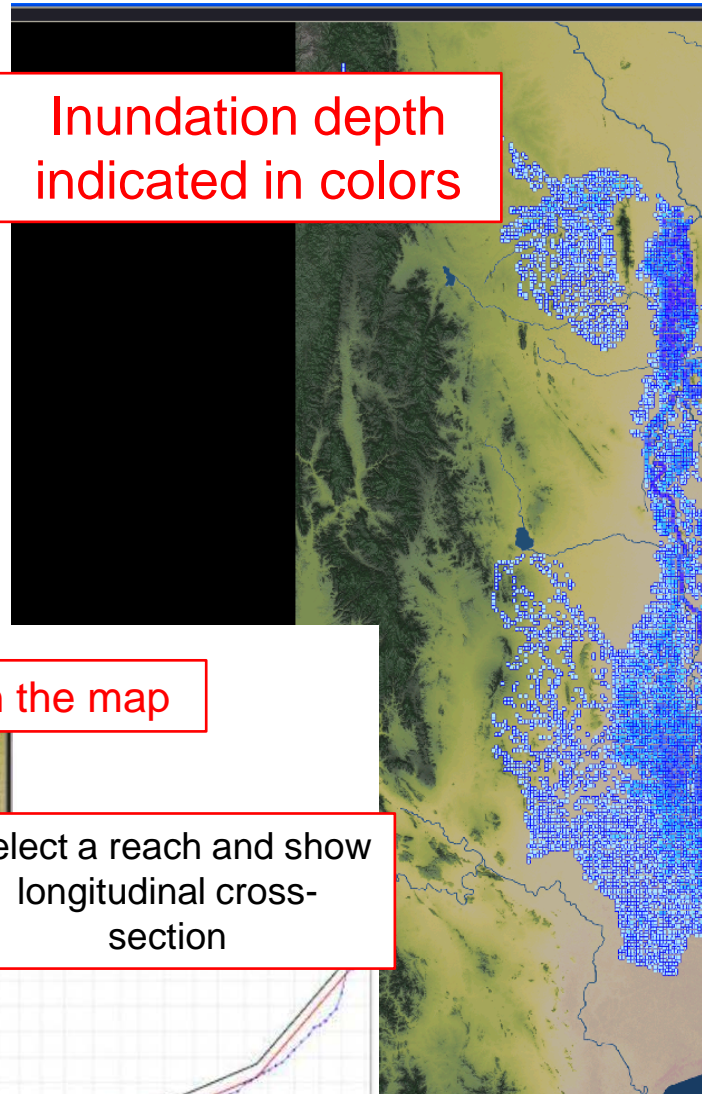


# Simulator Output

Animation display of simulated inundation

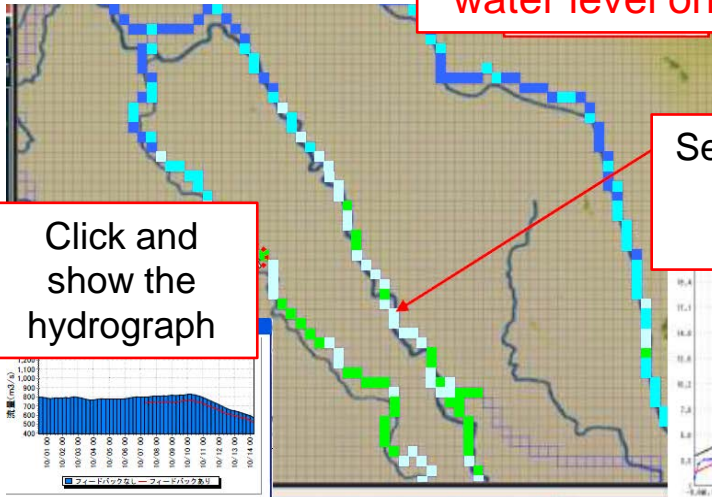


Bird's eye view for intuitive comprehension



Inundation depth indicated in colors

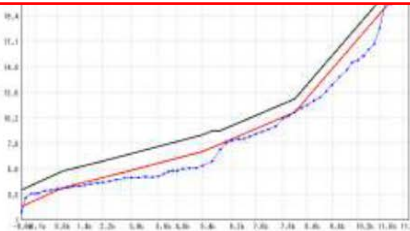
- Water level and flow rate



Click and show the hydrograph

water level on the map

Select a reach and show longitudinal cross-section



# Use of Simulator

Simulation under facility operation or urgent response:

To find a way how to operate for optimum effect on damage reduction

Simulation based on some operation scenarios

Dams, water gates, **emergency pumps, sandbagging**

Scenario A



Advance release

Gate operation

Drainage pumping

Large sandbag

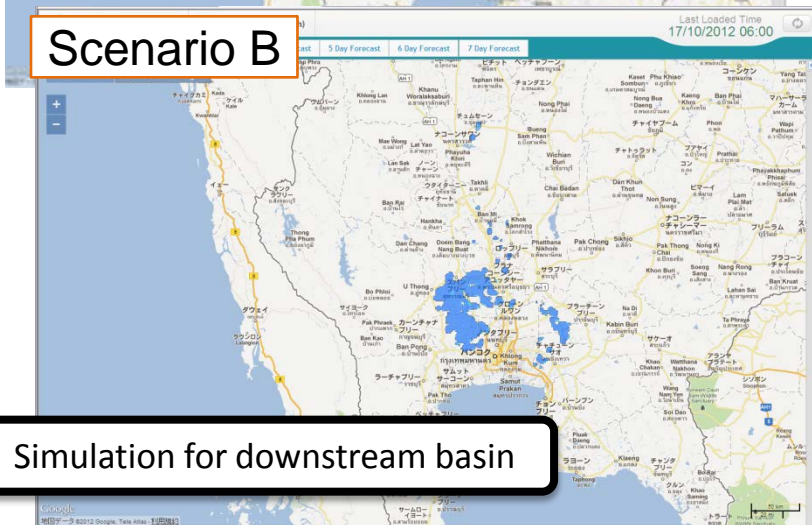
Discharge volume

Operating time

Time period

Location

Scenario B



Develop scenarios

Check effect on damage reduction

Optimum operation

Simulation for downstream basin

Request for operation, remote operation of facility, urgent measures

# Word of Caution

- Uncertainties involved in the natural phenomena, observations, and simulation should be well-understood by the users.
- The flood forecasting system should not simply display the calculation outputs, but be designed to furnish the users with necessary and not-misleading information effectively.

Thank you for your attention

[kuriki@river.or.jp](mailto:kuriki@river.or.jp)