Adaptation measures for Flood Planning and River Basin Disaster Resilience and Sustainability by All

October 13,2022

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CONTENTS

1. Japan's Recent Disasters

In Recent years, natural disasters occur across Japan as frequently as almost every year.

2015 to 2017

Heavy rains in Kanto and Tohoku regions in Sept. 2015

(1) Flood damage due to embankment collapse of Kinugawa River (Joso City, Ibaraki Pref.)

Kumamoto earthquake in 2016

(2) Landslide disaster caused (Minamiaso Village, Kumamoto Pref.)

Typhoon 10 in Aug. 2016

(3) Flood damage due to flooding of Omoto River(Iwaizumi Town, Iwate Pref.)

Heavy rains in northern part of Kyushu region in Jul. 2017

(4) Flood damage caused by Katsuraga (Asakura City, Fukuoka Pref.)

2018

Heavy rains in July

(5) Flood damage caused by Odagawa River (Kurashiki City, Okayama Pref.)

Typhoon 21

(6) Flood damage at Rokko Island, Port of Kobe (Kobe City, Hyogo Pref.)

Hokkaido Eastern Iburi earthquakes

(7) Landslide disaster caused (Atsuma Town, Yufutsu County, Hokkaido Pref.)

2019

Boso Peninsula Typhoon

(8) Utility poles and trees collapsed (Kamogawa City, Chiba Pref.)

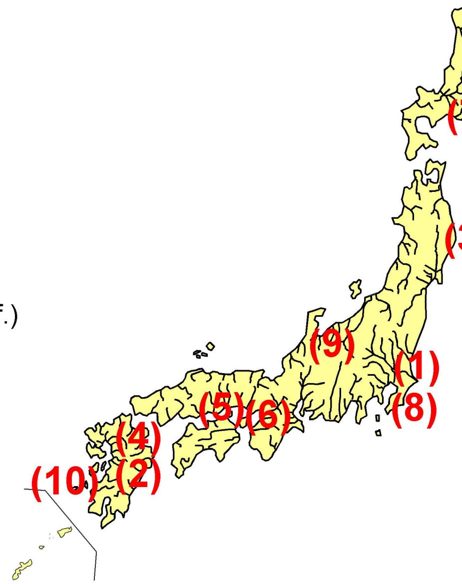
Eastern Japan Typhoon

(9) Flood damage caused by Chikuma River (Nagano City, Nagano Pref.)

2020

Heavy rains in July

(10) Flood damage caused by Kuma River (Hitoyoshi City, Kumamoto Pref.)



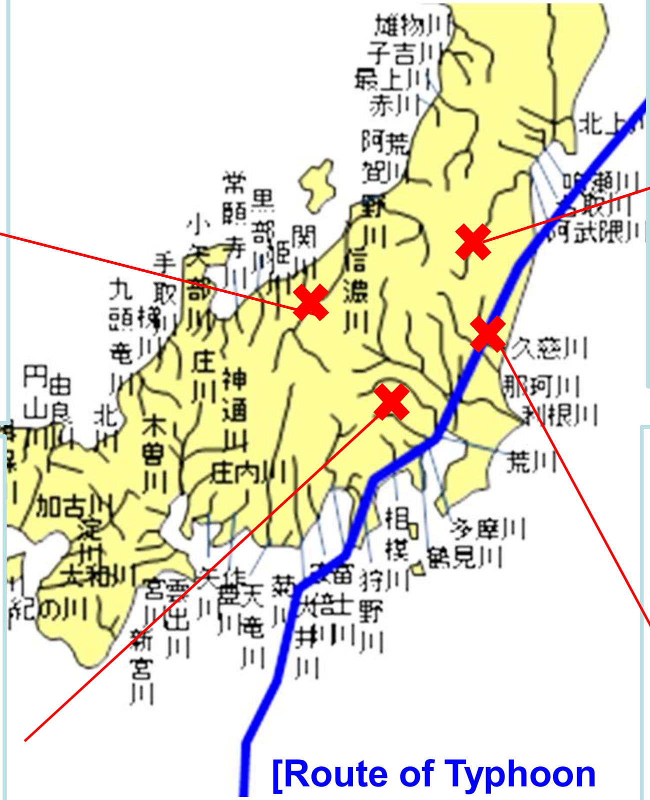
Damage from the 2019 East Japan Typhoon (Typhoon 19)

〇 River collapses and landslides occurred in a very extensive areas due to the heavy rains from the 2019 East Japan Typhoon (Typhoon 19), which caused a severe damage including 77 dead, 8 people missing, 7,231 totally or partially collapsed houses and 66,938 inundated houses

*Cabinet Office “Damage conditions related to Typhoon 19 in 2019 (22nd report)" (as of 7:30 on October 25, 2020)

Shinano River system Chikuma River
(Nagano city Nagano pref.)

Inundation of about 25,000 ha in nationally managed rivers



[Route of Typhoon No. 19]

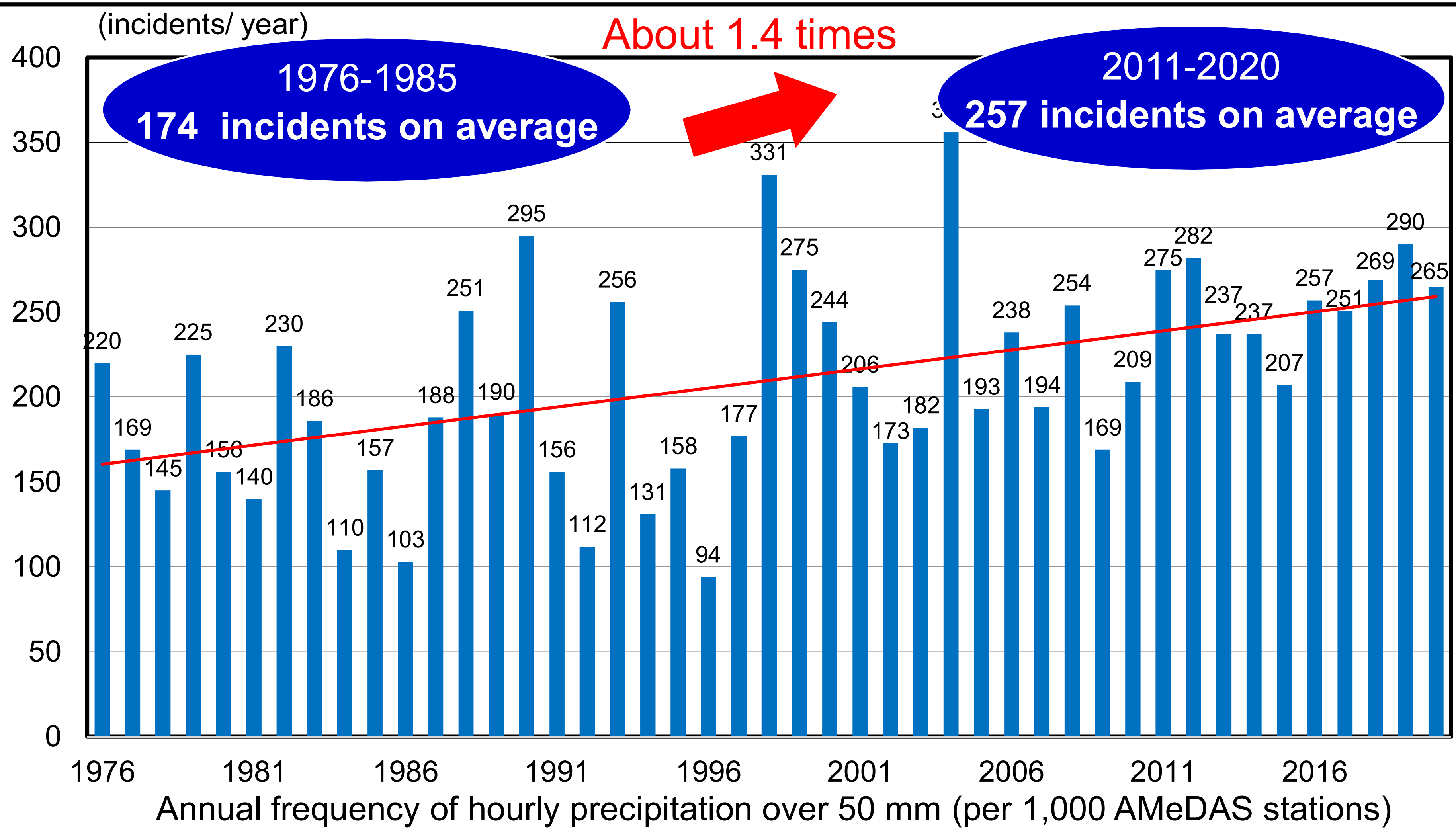
Abukuma River system Abukuma River
(Sukagawa City, Fukushima Pref, etc.)

Arakawa River Oppe River Toki River
(Kawagoe City, Saitama Pref, etc.)

Kuji River system Kuji River Sato River
(Hitachiomiya City, Ibaraki Pref, etc.)

Long-term changes in the frequency of heavy rain of short duration

◎ Frequency of heavy rain (over 50 mm/hour) of short duration increased about 1.4 times in 30 years



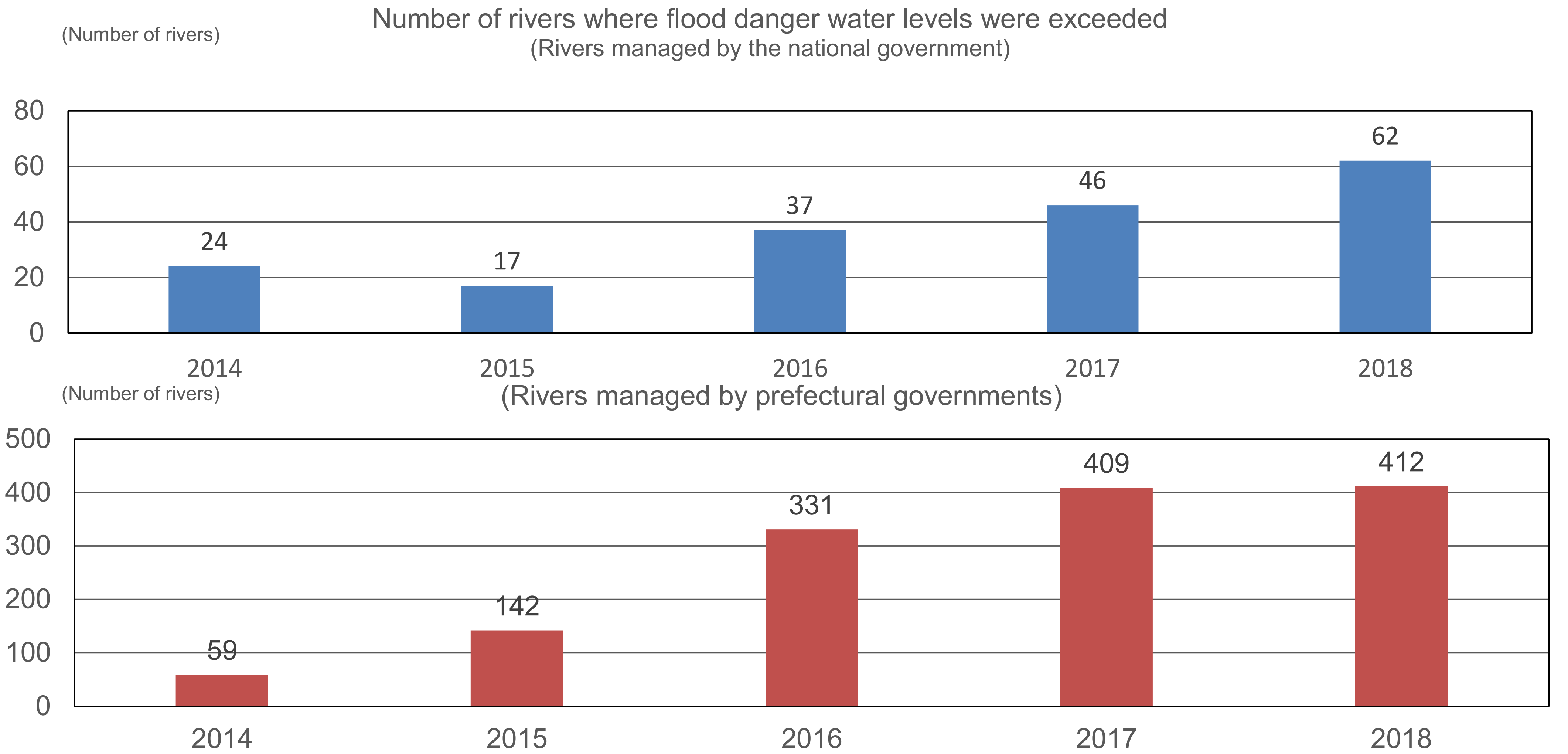
* Data from the previous year is added in January every year.

* There were originally about 800 AMeDAS stations in 1976. The number increased to about 1,300 in 2016. In order to remove the effect of the difference in the number of stations depending the year, comparison is made after conversion to frequency per 1,000 stations.

* Excluded are radio robot rain-gauge stations that were deployed in mountainous areas but later abolished.

Intensification of disasters due to climate change, etc.
(Number of rivers where flood danger water levels were exceeded)

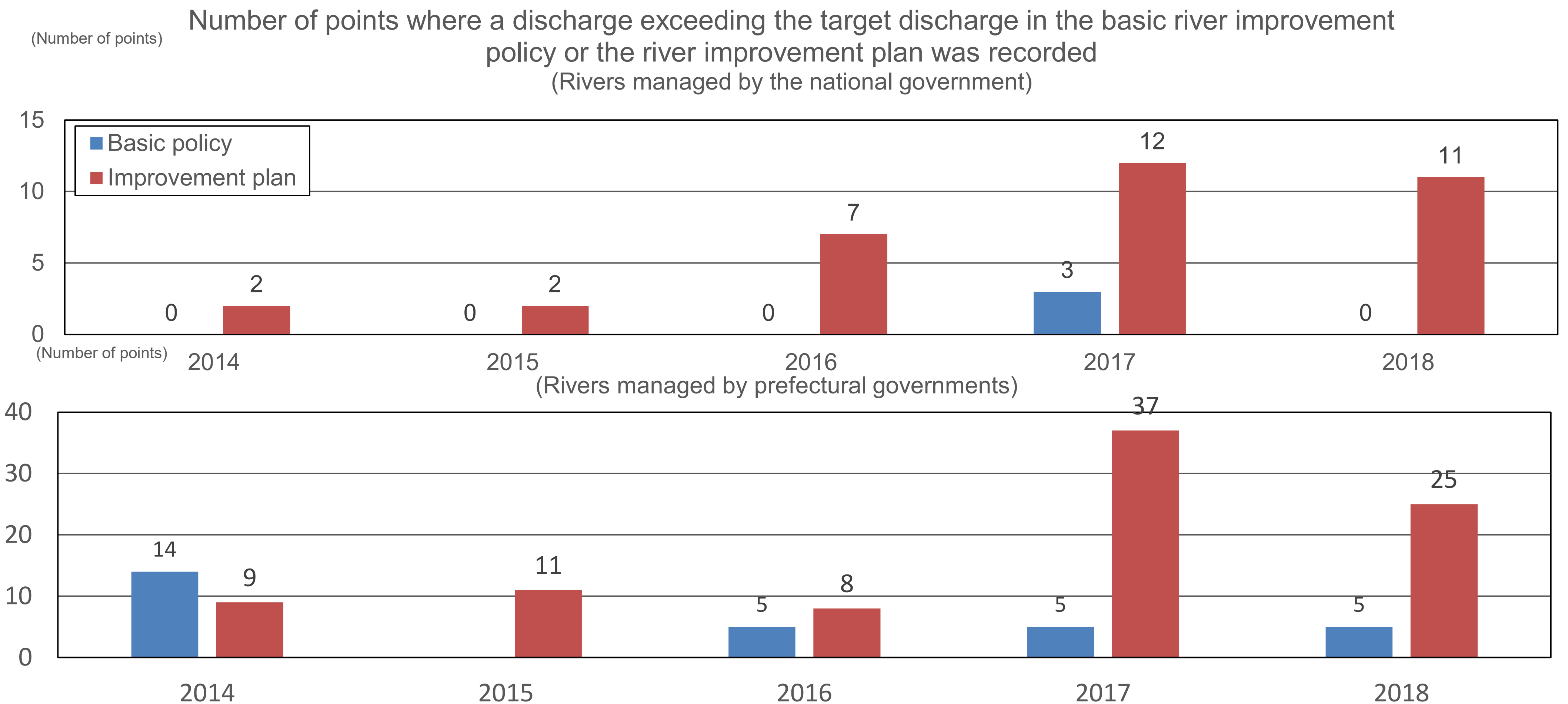
○ Owing to the increase in heavy rains due to climate change, etc., relative safety levels may be declining.
○ Through dams and retarding basins or river channel dredging, measures to lower river levels are systematically implemented, but the number of points where floods exceed the flood danger water level (water level at which a river may flood) has tended to increase.



*According to disaster information announced by the Ministry of Land, Infrastructure, Transport and Tourism (posted on the MLIT website)

Intensification of disasters due to climate change, etc. (Number of floods exceeding the design scale)

○ The increasing trend of heavy rains due to climate change, etc. has become obvious, and the number of points whe floods exceeding the design scale have occurred (in the basic river improvement policy and river improvement plans have tended to increase in both rivers managed by the national government and rivers managed by prefectural governments.



* Basic policy: Number of points where the estimated high-water discharges at main points in the basic river improvement policy were exceeded

** Improvement plan: Number of points where the target discharges at main points in the river improvement plan were exceeded

*** Data for 2018 are preliminary figures up to the end of October.

**** The number of rivers for which improvement plans are formulated has been increasing over time.

ange in the amount of rainfall and frequency of flooding due to climate change

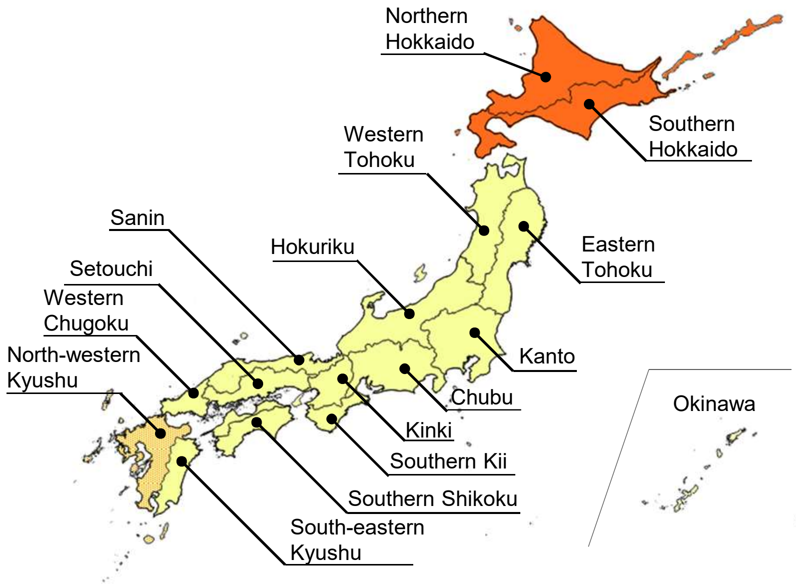
The future rainfall change rate is calculated for each region with similar rainfall characteristics, and the rainfall change rate is se based on an evaluation of the breadth of the future sea surface temperature distribution and average values etc.

The rainfall change rate for a rise of 2˚C is 1.15 times for Hokkaido and 1.1 times for other areas (including Okinawa), and the precipitation change rate for a rise of 4˚C is 1.4 times for Hokkaido and North-western Kyushu and 1.2 times for other areas (including Okinawa).

When temperatures rise by 4˚C, there is a significant impact on small basins and short-term rainfall, so change of rainfall rate is separately.

Rainfall change rate for each region>

Area classification	2˚C rise	4˚C rise	
			Short time
Northern and Southern Hokkaido	1.15	1.4	1.5
North-western Kyushu	1.1	1.4	1.5
Other areas (including Okinawa)	1.1	1.2	1.3



Reference> National average changes in flow rate and flood frequency in class A river systems, calculated based on rainfall change rate

Climate change scenario	Rainfall	Flow rate	Flood frequency
Rise of 2˚C	Approx. 1.1 times	Approx. 1.2 times	Approx. 2 times
Rise of 4˚C	Approx. 1.3 times	Approx. 1.4 times	Approx. 4 times

2. River Basin Disaster Resilience and Sustainability by All

Direction of River Basin Disaster Resilience and Sustainability by All

- Comprehensive and Multi-layered Water-related Disaster Risk Reduction Considering Climate Change -

- Shift to mainstream disaster prevention and mitigation for society
- Promote the transition to River Basin Disaster Resilience and Sustainability by All, including businesses and households

Conventional Measures

- Rebuilding Flood-Conscious Societies
- Combination of Structural and Non-structural Measures

Changes

Impacts of Climate Change	Social Trends	Technological Innovation
Need to enhance measures for early improvement of safety	Need to achieve safe and secure Compact Plus Network urban planning	Need to utilize 5G, AI, Big Data, and IT technologies in disaster risk reduction

Important Perspectives for Measures

Resilience | Inclusion | Sustainability

Future Measures

Revise plans considering climate change

Transition to **River Basin Disaster Resilience and Sustainability by All**

Revising Plans to Consider Climate Change

- Revise plans considering the future impacts of climate change

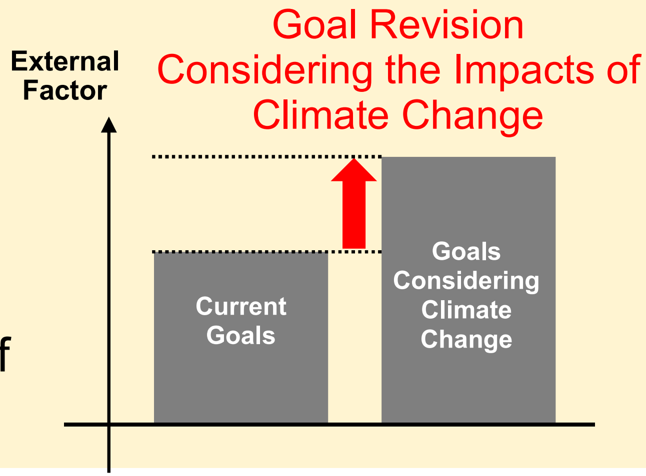
Plan Revision

The current defense plans against floods, inland floods, landslides, storm surges, and high tides were developed based on **past records of precipitation and tide levels**

However,
they may not be able to secure safety considering the impacts of climate change, such as increased rainfall and rising sea levels

For the future,
revise plans to **consider the impacts of climate change such as increased rainfall* and rising sea levels**

* In the scenario, hold global average temperature increase to well below 2°C (the target scenario of the Paris Agreement on Climate Change), precipitation is likely to increase by a factor of 1.1



Transition to River Basin Disaster Resilience and Sustainability by All

- Having continued to rebuild a Flood-Conscious Society by raising awareness of possible floods beyond facility capacity
- Driving this further, promote the transition to River Basin Disaster Resilience and Sustainability by All

Rebuilding a Flood-Conscious Society

A Society Where Disaster Prevention/Mitigation Is Mainstream

Measures with clear role allocation

Structural measures mainly by the administrators of rivers, sewage, erosion and sediment control, and coasts

Conventional Flood Control

Measures mainly for river areas

Implement measures in river areas and floodplains

Climate Change
Changes in Social Trends
(such as population decline and Society 5.0)

Revise Flood Control Measures

Measures to be implemented with the cooperation of all stakeholders

Flood control measures implemented by all stakeholders around basins including the national government, prefectures, municipalities, private enterprises, and residents

River Basin Disaster Resilience and Sustainability by All

Measures to be implemented in any kind of place around basins

Measures implemented around basins including not only river areas and floodplains but also catchments

Image of River Basin Disaster Resilience and Sustainability by All

- Transition to River Basin Disaster Resilience and Sustainability for All, a new concept of flood management with the cooperation of all stakeholders around basins
- Upgrade flood management plans with consideration for the impact of climate change
- Promote the following integrated and multilayered measures: 1) Flood Prevention, 2) Exposure Reduction, and 3) Disaster Resilience

1) Flood Prevention

Catchments

- Improve rainwater storage functions

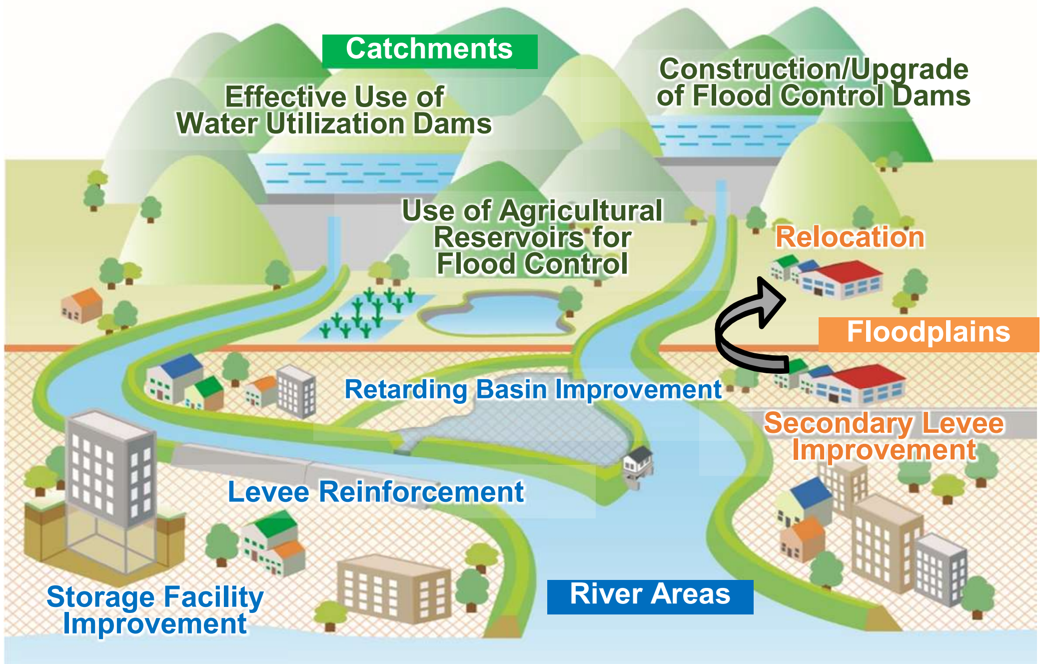
River Areas

- Store flowing water through construction/ upgrades/effective use of dams, etc.
- Ensure and improve the discharge capacity of river channels
- Reduce overflow

2) Exposure Reduction

Floodplains

- Guide residents to lower risk areas
- Promote safer ways of living
- Localize inundation areas



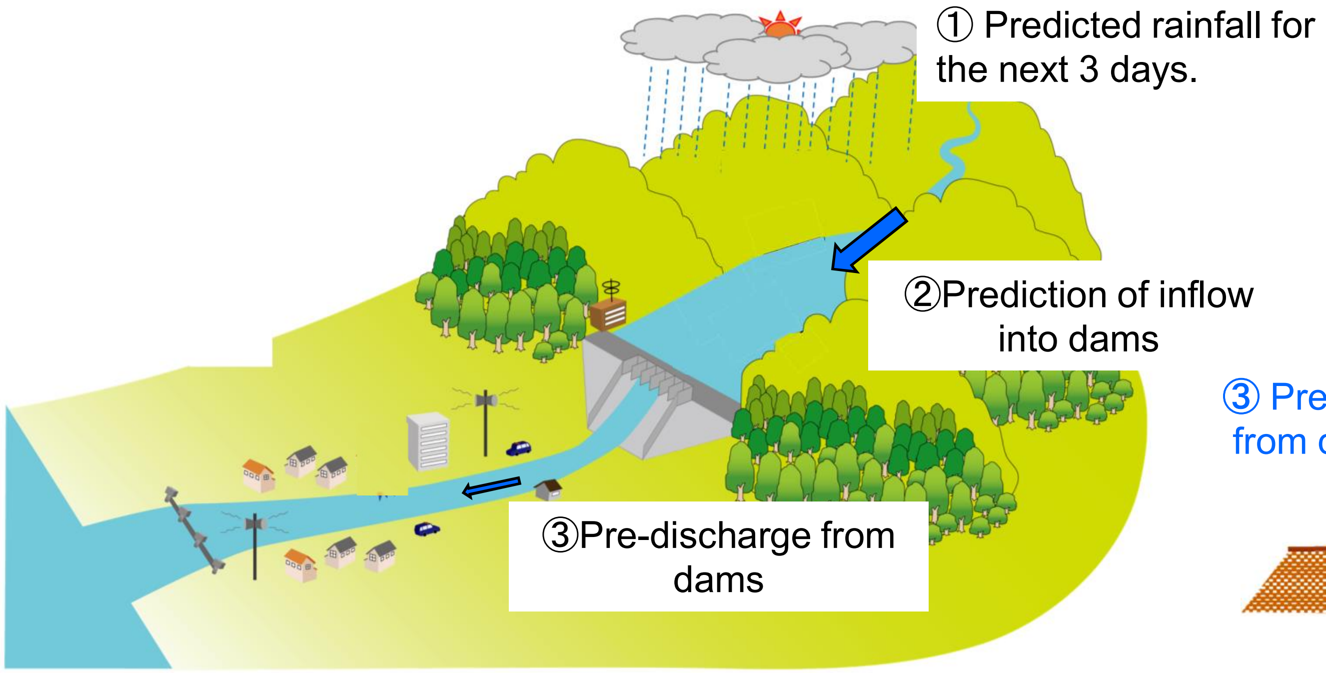
3) Disaster Resilience

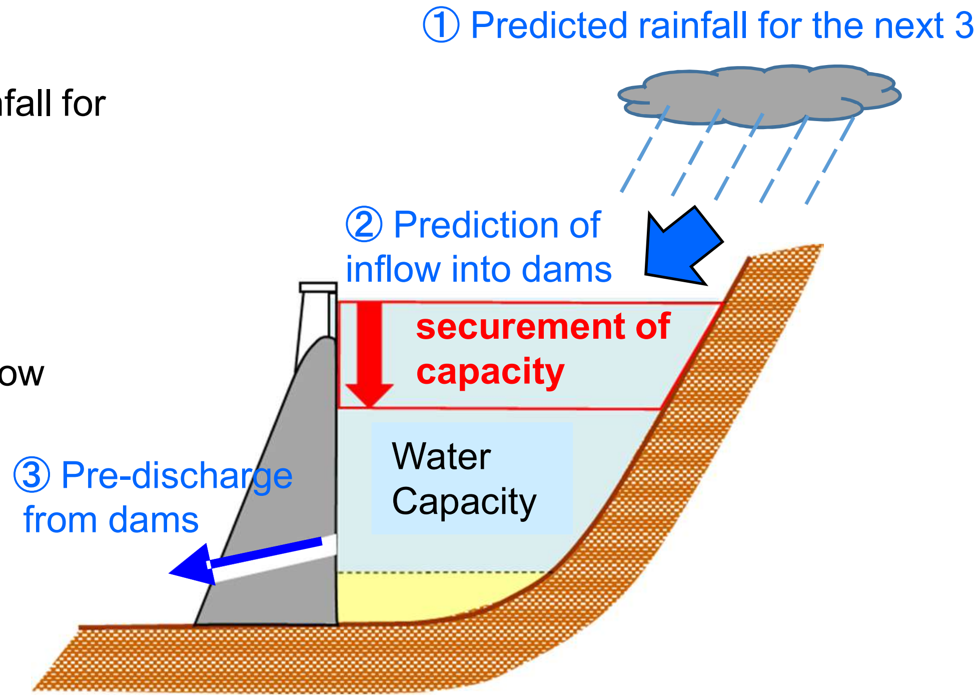
Floodplains

- Improve land risk information
- Reinforce evacuation systems
- Minimize economic damages
- Promote safer ways of living
- Improve support systems for affected local governments
- Eliminate inundation promptly

① Flood Prevention～upgrades/effective use of dams～

- There are approximately 570 dams for flood control purposes, and approximately 900 dams exclusively for water use, such as power and agricultural water.
- With the cooperation of water users, pre-discharges of water storage for water use are released in advance t temporarily provide capacity for flood control.



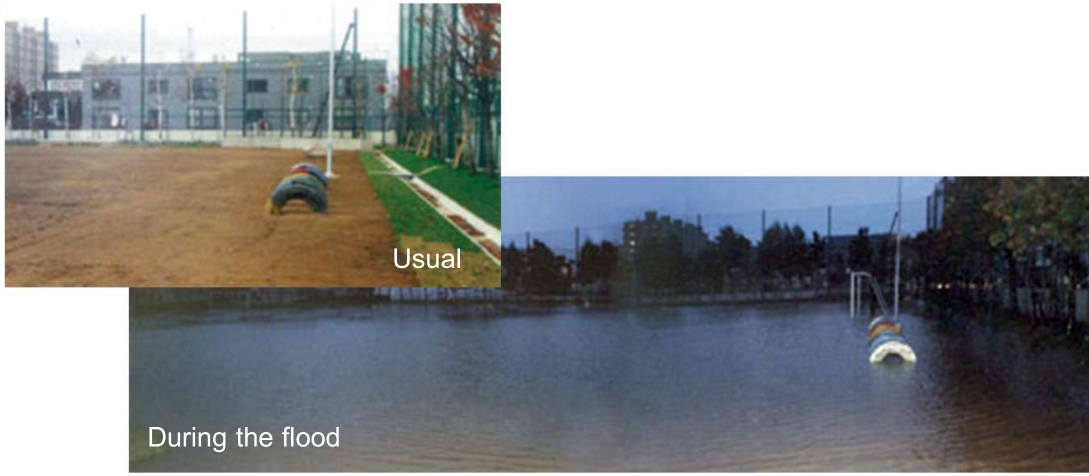


① Flood Prevention ～Development of storage facilities～

・Runoff control measures using existing stock to temporarily store rainwater during flooding.

Reservoir

Schoolyard storage



Pond

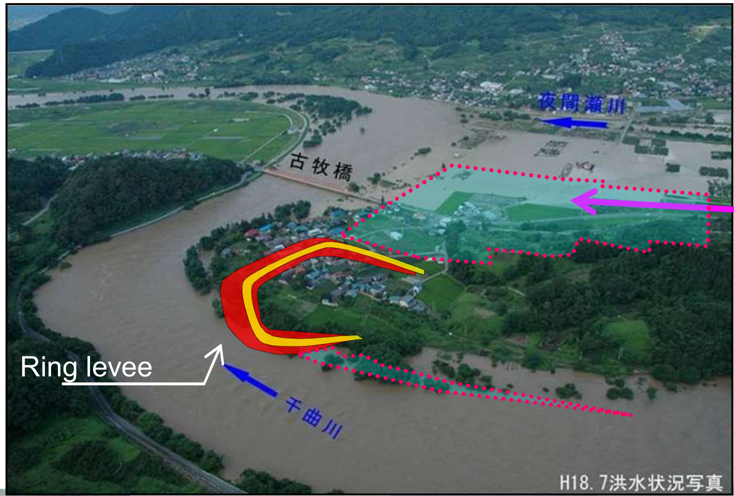
Paddy field

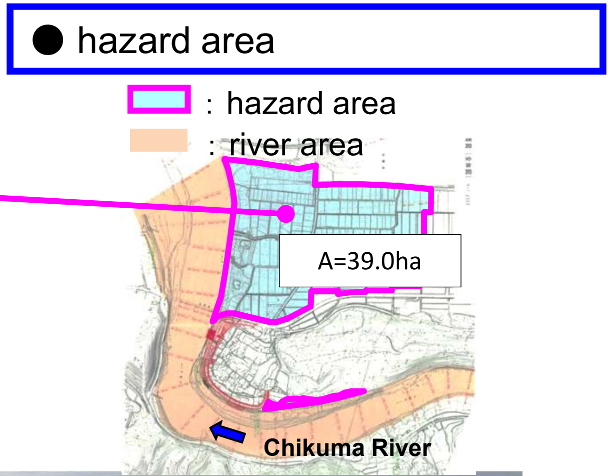
Infiltration trout and pipes

②Exposure Reduction～Promote safer ways of living～

○ Effective flood control measures are implemented by building a ring levee that allows flooding in some areas, taking into account land use conditions, rather than building a continuous levee.

＜Elimination of house flooding damage caused by a ring levee in Nagano Prefecture (Chikuma River).＞





② Exposure Reduction ～Guide residents to lower risk areas～

○ Take comprehensive measures for safe community development, such as controlling development in disaster hazard areas, promoting relocation, and strengthening the linkage between site optimization plans and disaster prevention.

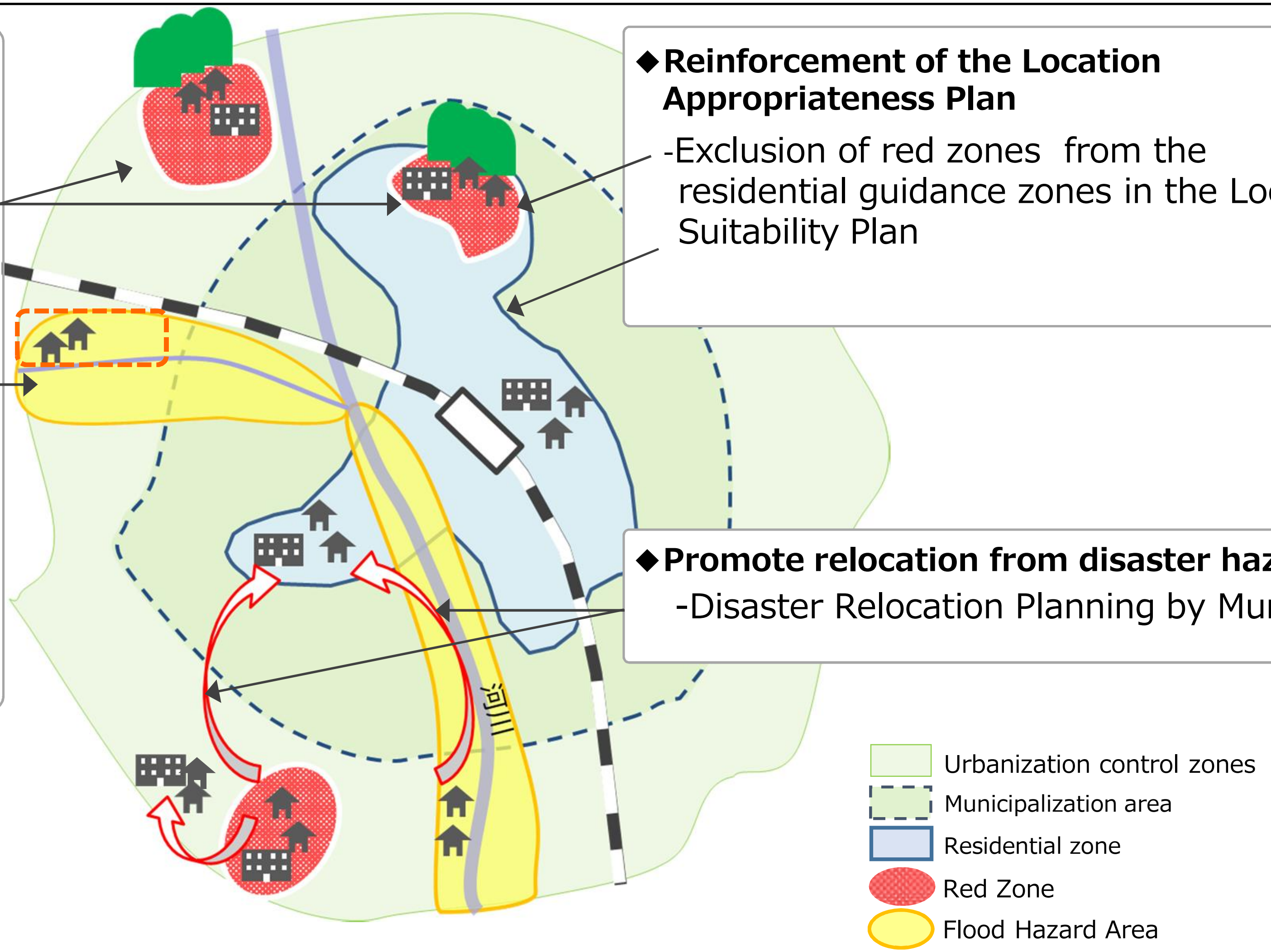
Development control in disaster hazard areas

< Red Zone >

-Development of residences and private business facilities (stores, hospitals, social welfare facilities, inns/hotels, factories, etc.) are prohibited throughout the entire city planning area.

<Flood Hazard Area>

-Stricter development permits for housing in urbanization control zones (permits will be granted if safety and evacuation measures are taken).



◆Reinforcement of the Location Appropriateness Plan

-Exclusion of red zones from the residential guidance zones in the Locati
Suitability Plan

◆Promote relocation from disaster hazard

-Disaster Relocation Planning by Munici

③Disaster Resilience～Create My Timeline～

○ My Timeline is a personal disaster preparedness action plan that includes a timeline of "when" and "what" to do advance, depending on the approach of a typhoon

○ My Timeline is an initiative that is expected to increase the effectiveness of evacuation by making each resident aw of local flood risks through the use of flood hazard maps

Image of My Timeline

Municipalities

住 民 等

3 days ago

Pay attention to the weather forecast

Check evacuation centers on hazard maps

Prepare an emergency bag

Check the river level on the Internet

Evacuation preparation information → Started evacuation with grandfather

Evacuation advisory → evacuation completed

氾濫発生

In the process of reviewing My Timeline.

「Recognize risk 」 Realizing

・ My house will be flooded.

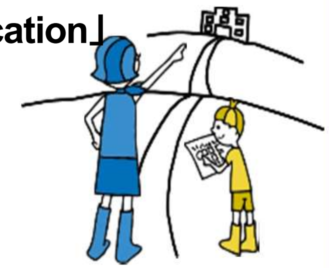
「Know when to run away」 Consider

・When will you run away?

・Who are you running away with?

「Expanding the circle of communication」

・Get to know each other through exchanges of ideas, etc.



Workshop

Disaster prevention educatio

③Disaster Resilience～ TEC-FORCE ～

What Is TEC-FORCE?

* TEC-FORCE (**T**echnical **E**mergency **C**ontrol **FORCE**)

○In preparation for large-scale natural disasters, MLIT set up TEC-FORCE in April 2008, with the objective of promptly supporting local public bodies and other organizations. Based on directions from the chief and other managers of the task force for disaster prevention, the staff members at regional development bureaus across Japan carry out activities.

○When a large-scale natural disaster or the like occurs, TEC-FORCE determines the extent of disaster investigated by the municipalities in the disaster area, prevents the damage from spreading, and smoothly and promptly provides technical support for early rehabilitation and the like in the disaster area

TEC-FORCE's activities

*Ku-SAT: Satellite-based compact picture-transmission system

➢ Investigation of damage using disaster response helicopters

➢ **Ku-SAT* ensures a supervisory system.**

➢ **Identifying extent of disaster**

➢ **Dispatching liaisons to municipalities**

➢ **Technical advice for search operations**

➢ **Urgent water discharging using pumpers**

➢ **Technical advice for municipalities**

Sharing an Overview of River Basin Disaster Resilience and Sustainability by All

eed to present an overall image of measures by preparing projects and plans for cooperation for all akeholders while conducting emergency response measures

Emergency Flood Control Projects for the seven river systems affected by the 2019 Typhoon Hagibis and accelerate the implementation of preliminary disaster prevention measures for those major river systems through the "River Basin Disa Resilience and Sustainability for All" Project

Transition to New Flood Management that can handle climate change (Reconsider the basic policy and implementation

1st

Respond to major recent floods

- Emergency Flood Control Projects for the seven river systems, affected by the 2019 Typhoon Hagibis
- "River Basin Disaster Resilience and Sustainability for All" Project for all 109 major river systems in Japan

lain measures

- River Excavation and Strengthening Levees

＋

- Effective Use of Water Utilization Dams and Retarding Basins
- Urban Planning Considering Flood Risks, etc.

2nd

Avoid catastrophic damage by severe floods intensified by climate change

- Promote flood measures adapting to climate change by revising the basis of flood control plans from past rainfall data to increased rainfall due to climate change

Main measures

- New Retarding Basins and Upgrade Existing Dams
- Rainwater Storage Facilities

＋

- Land Use Planning Considering Risks, etc.

Start uickly

Review basic river management policy/ river implementation plan considering climate change

3. Basin flood control related laws

Background and need for legislation

Impact of Climate Change

Prompt response

○ Promptly implement "River Basin Disaster Resilience and Sustainability by All projects" which clarify the overall structural and non-structural measures of national, prefectural and municipal governments to respond to intensifying flood disasters
(Formulated for all 109 Class A water systems in FY 2020)

[Respond to inland flood damage from recorded maximum scale rainfall in urban function consolidation areas for the largest floods since WWII in nationally managed rivers]

Review flood control plans in anticipation of future climate change (increased rainfall etc.)

Further response in anticipation of climate change

○ To cope with more rainfall (external force) than current plans, further expand River Basin Disaster Resilience and Sustainability by All by related parties with an overall perspective of the upstream and downstream, and main/branch river basins, including enhancing river measures

Need to develop a framework for a "Bill for River Basin Disaster Resilience and Sustainability by All "

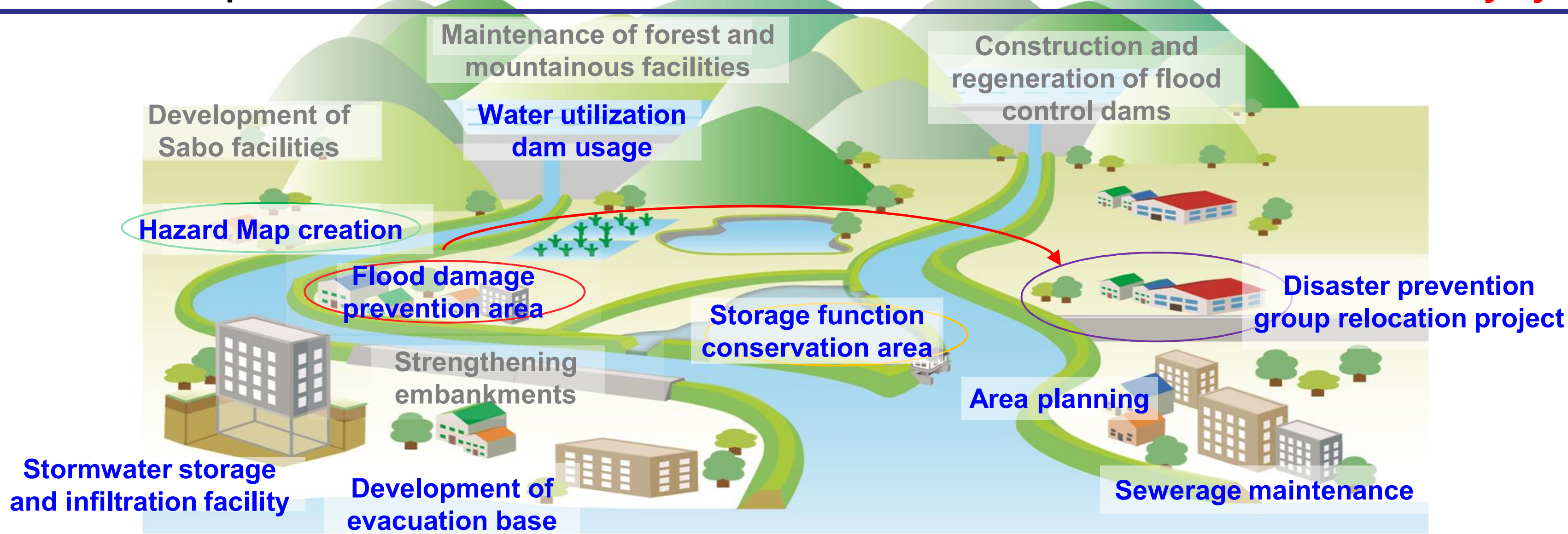


Illustration of River Basin Disaster Resilience and Sustainability by All

ct for the Partial Revision of Specified Urban River Inundation Control Law (Act No. 31 of 2021

tline of the Act

rengthening flood control plans and systems

pansion of rivers utilizing basin flood control plans

lded rivers that are difficult to improve due to natural conditions to rivers are difficult to prevent damage due to the progress of urbanization panded to rivers nationwide)

tablishment of Basin Flood Control Councils and ncement of plans

elevant parties from the national, prefectural and municipal governments her together to discuss land use in inundation areas to strengthen public private measures of rainwater storage and infiltration

a result of discussion, positioning and reliable implementation for basin d control plans

easures to mitigate inundation

rengthening measures for rivers and sewers

tablishment of a council (with participation by river managers and water users as electric power companies etc.) to plan the expansion of prior flow for water ation dams (*budget and tax system)

osition target rainfall to prevent flood damage in sewers within plans and elerate improvements

andatory formulation of operating rules for sewer sluices to reliably prevent kflow from rivers to urban areas

rengthening measures for stormwater storage in basins

stablish storage functions in conservation areas and secure land for water ntion and retarding basin functions along rivers

onserve urban green spaces and use as green infrastructure with storage and ration functions

pport the development of municipal/private sector rainwater storage and ration facilities with certification system, assistance and special tax system

3. Measures to reduce the targets of damage

◆ **Cooperation of urban development and living methods flood disaster prevention**

— Create inundation damage prevention areas and confirm the safe homes and facilities for people requiring special care (Permission systen

— Promote relocation from dangerous areas due to the expansion of requirements for disaster prevention group relocation promotion projects

— Strengthen urban safety with development of bases for evacuation si the event of a disaster, and measures against flooding in each district

4. Measures for damage mitigation and early recovery and reconstruction

— Expand the creation of food hazard maps to small and medium-sized rivers to eliminate risk information gaps

— Ensure effective evacuations with the advice and recommendations of municipalities for evacuation plans and drills for facilities for people requiring special care

— Expand the targets of authority agency from MLIT and remove earth and sand accumulated from disasters and add provisional class rivers

Illustration of River Bas Disaster Resilience an Sustainability by All

Taiwan International Water Week 2022
Flood Prevention and Adaptation Strategies under Climate Change

Risk-Based Floodplain Meanagement
: Experience in Shiga, Japan
for the Eco-DRR Implementation

October 13th, 2022

Kentaro Taki, P.E.jp, Dr.eng
Associate Professor
School of Environmental Science
The University of Shiga Prefecture

K. Taki, T. Matsuda, E. Ukai, T. Nishijima, S. Egashira (2013) Method for evaluating flood disaster reduction measures in alluvial plains, Journal of Flood Risk Management 6(3) pp.210-218

Photos by Kentaro Taki (2012)

Eco-DRR oriented approach

Integrated Flood Risk Management in Shiga Prefecture

In 2014, the SPG launched a new regulation to conserve wetland.
Wetlands usually have not only high flood risk but rich ecosystem.

Wetlands store flood water and lower the downstream water level.
The SPG designed a new risk-based floodplain regulation system.

Zone A (h ≥ 0.5m by 10-year flood)

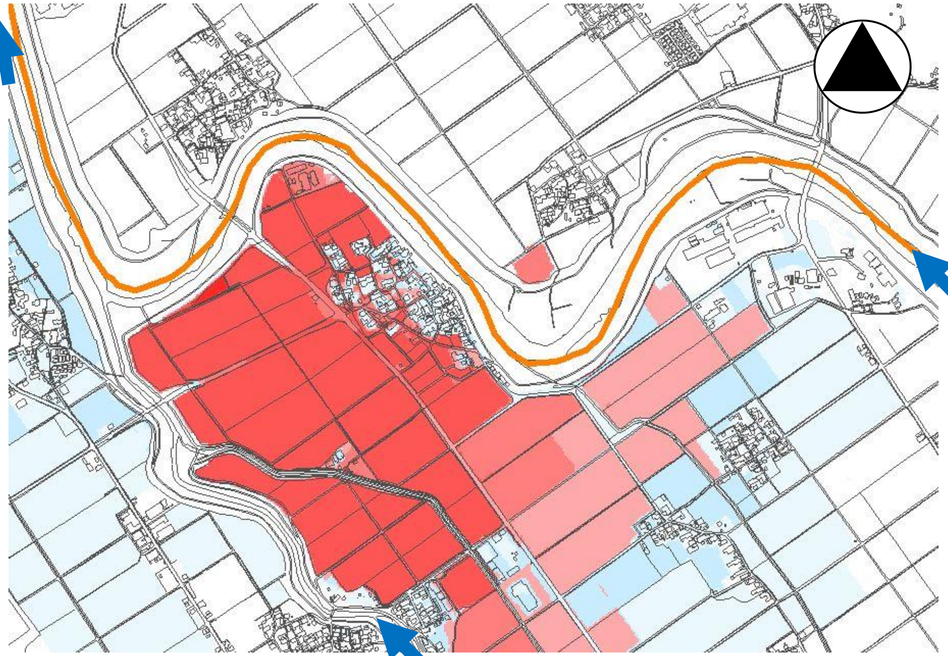
Frequent damage

No one can expand
the urbanization promotion area
without elevating land over the flood level.

Zone B (h ≥3.0m by 200-year flood)

Severe damage

No one can build houses
without a shelter over the flood level at least.



Zone B (Red) on the flood risk map

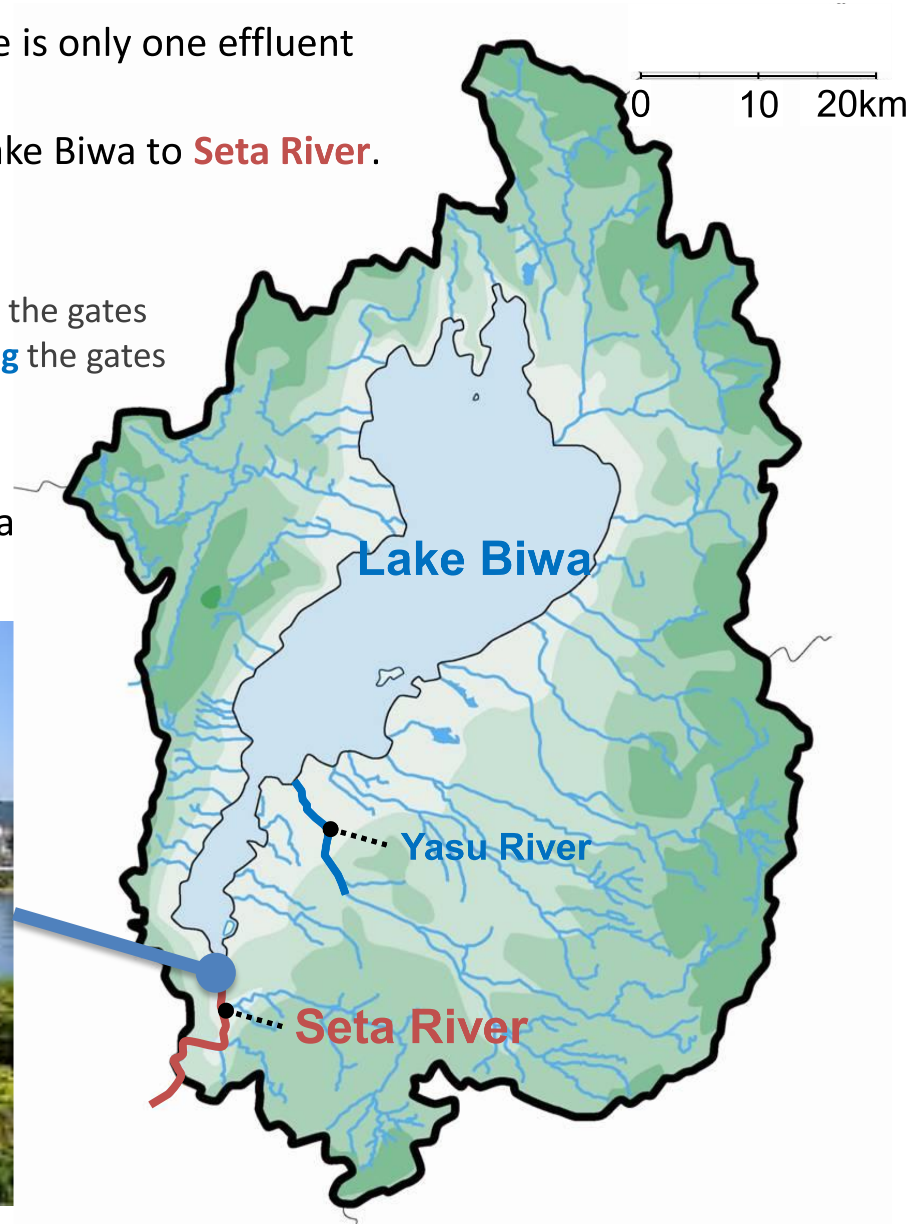
Geography
～Shiga Prefecture, Japan～

Lake Biwa

– Lake Biwa : 240ml^2 (670km^2)
– the biggest lake in Japan
– 4 million years old (the 3rd oldest lake in the world)
– Providing drinking water for 14 million people in Osaka, Kyoto and Hyogo
– Rich Ecosystem - 1000 species, including more than 50 native species

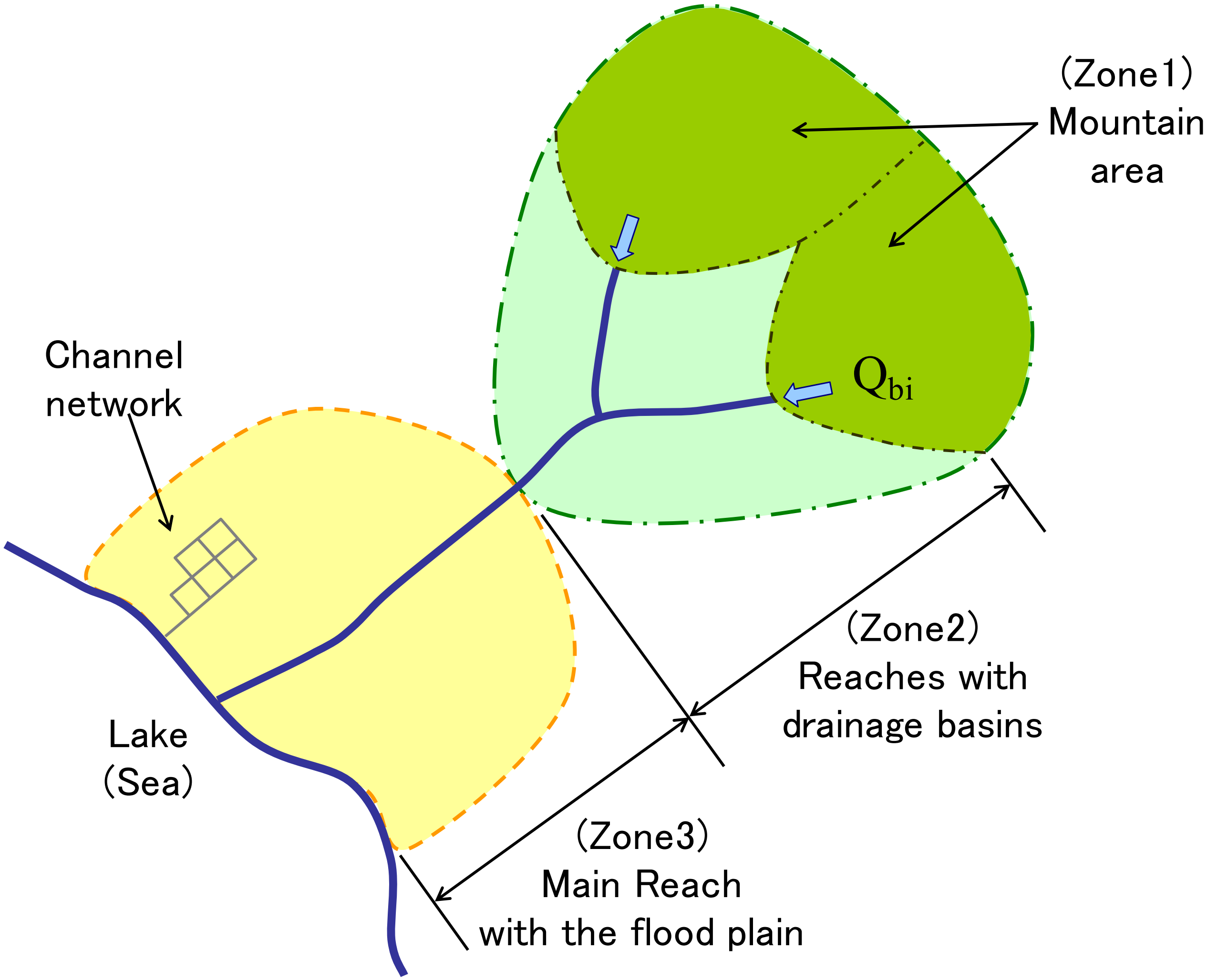
River Administration
～Shiga Prefecture, Japan～

- Nearly **460** rivers flow into Lake Biwa, but there is only one effluent stream, the **Seta River**.
- The **Seta River** Weir controls the outflow from Lake Biwa to **Seta River**. Its purposes are:
  1) To provide water to downstream – $40m^3/s$
  2) To avoid flooding downstream – **closing** the gates
  3) To avoid flooding around Lake Biwa – **opening** the gates
- MLIT administrates only two rivers in Shiga, **Seta River** and **Yasu River** (down stream)
  SPG manages the other rivers including Lake Biwa instead of MLIT.



Numerical Model for Flood Risk Analysis

Schematic of drainage basin

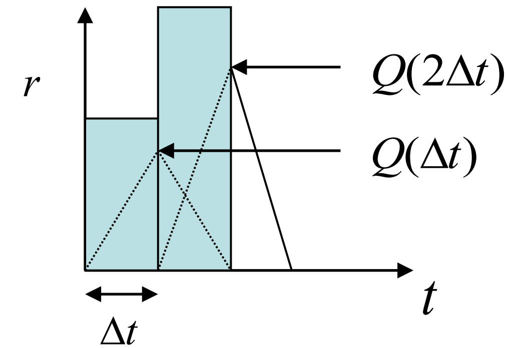


K. Taki, T. Matsuda, E. Ukai, T. Nishijima, S. Egashira (2013) Method for evaluating flood disaster reduction measures in alluvial plains, Journal of Flood Risk Management 6(3) pp.210-218

Numerical Model for Flood Risk Analysis
Rainfall runoff & River flood flow (1D)

Rainfall run-off

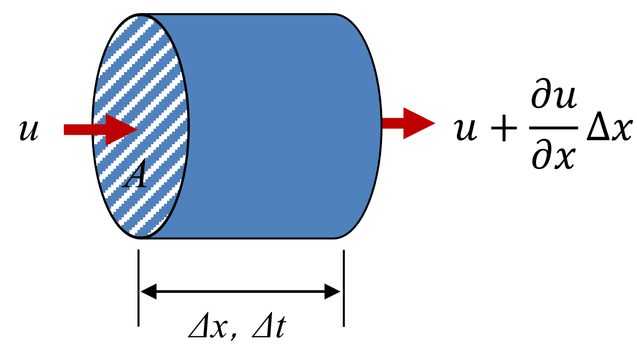
Hydrograph
- Integrated rational formulas



River flow

Continuity

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} - q = 0$$



Momentum Conservation

$$\underbrace{\frac{1}{g}\frac{\partial u}{\partial t} + \frac{u}{g}\frac{\partial u}{\partial x}}_{\text{Kinematic Energy}} + \underbrace{\frac{\partial H}{\partial x}}_{\text{Potential Energy}} + \underbrace{\frac{n^2 u|u|}{R^{4/3}}}_{\text{Friction Resistance}} = 0$$

Where,

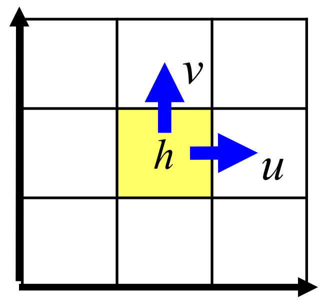
x: Axis, t: time, g: acceleration of gravity,
A: Cross-section area, Q: Flow rate,
q: Lateral Discharge, u: velocity, H: water level,
n: roughness coefficient, R: hydraulic radius

Numerical Model for Flood Risk Analysis
~Alluvial plain Flood Flow (2D)~

Flood flow on the alluvial plain

Continuity

$$\frac{\partial h}{\partial t} + \frac{\partial uh}{\partial x} + \frac{\partial vh}{\partial y} = r$$



Grid size: 50m x 50m

u: velocity, x-axis direction
v: velocity, y-axis direction
h: depth
H: water level
n: roughness coefficient
K: extinction coefficient

Momentum Conservation

$$\frac{\partial uh}{\partial t} + \frac{\partial}{\partial x}(u^2h) + \frac{\partial}{\partial y}(uvh) = -gh\frac{\partial H}{\partial x} - \frac{gn^2u\sqrt{u^2+v^2}}{h^{1/3}} - \frac{guh\sqrt{u^2+v^2}}{K^2} + \frac{\partial}{\partial x}\left(\varepsilon\frac{\partial uh}{\partial x}\right) + \frac{\partial}{\partial y}\left(\varepsilon\frac{\partial uh}{\partial y}\right)$$

$$\frac{\partial vh}{\partial t} + \frac{\partial}{\partial x}(uvh) + \frac{\partial}{\partial y}(v^2h) = -gh\frac{\partial H}{\partial x} - \frac{gn^2v\sqrt{u^2+v^2}}{h^{1/3}} - \frac{gvh\sqrt{u^2+v^2}}{K^2} + \frac{\partial}{\partial x}\left(\varepsilon\frac{\partial vh}{\partial x}\right) + \frac{\partial}{\partial y}\left(\varepsilon\frac{\partial vh}{\partial y}\right)$$

Kinematic energy | Potential energy | Frictional resistance | Vegetation resistance | Shearing resistance

Kinematic viscosity coefficient

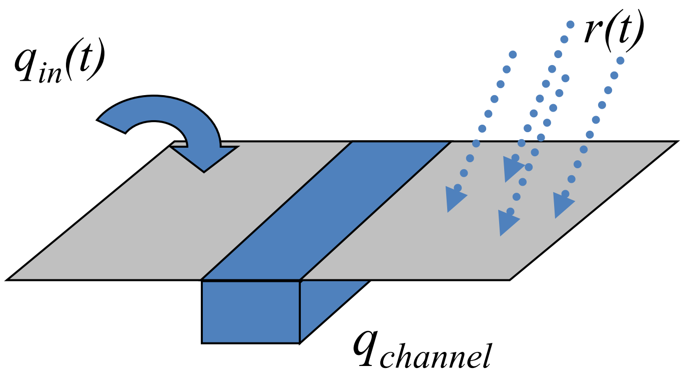
$$\varepsilon = \frac{\kappa}{6}u_*h$$

(κ: Kalman coefficient (=0.4), u_*: Friction velocity)

Small Channel Flow Modeling

～stream, agricultural waterway, a rainwater drain～

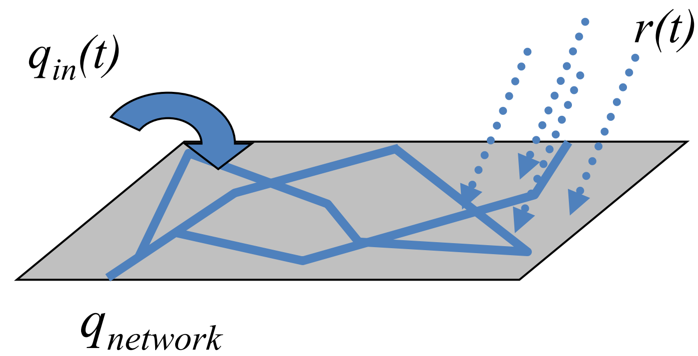
Stream channel flow



$$Q_{in} = A \cdot r(t) + q_{in}(t) - q_{channel}$$

$A \cdot r(t)$	Inflow by rainfall to the cell
$q_{in}(t)$	Inflow from the neighboring cells
$q_{channel}$	Discharge calculated by Equi-flow calculation

Small channel network



$$Q_{in} = A \cdot r(t) + q_{in}(t) - q_{network}$$

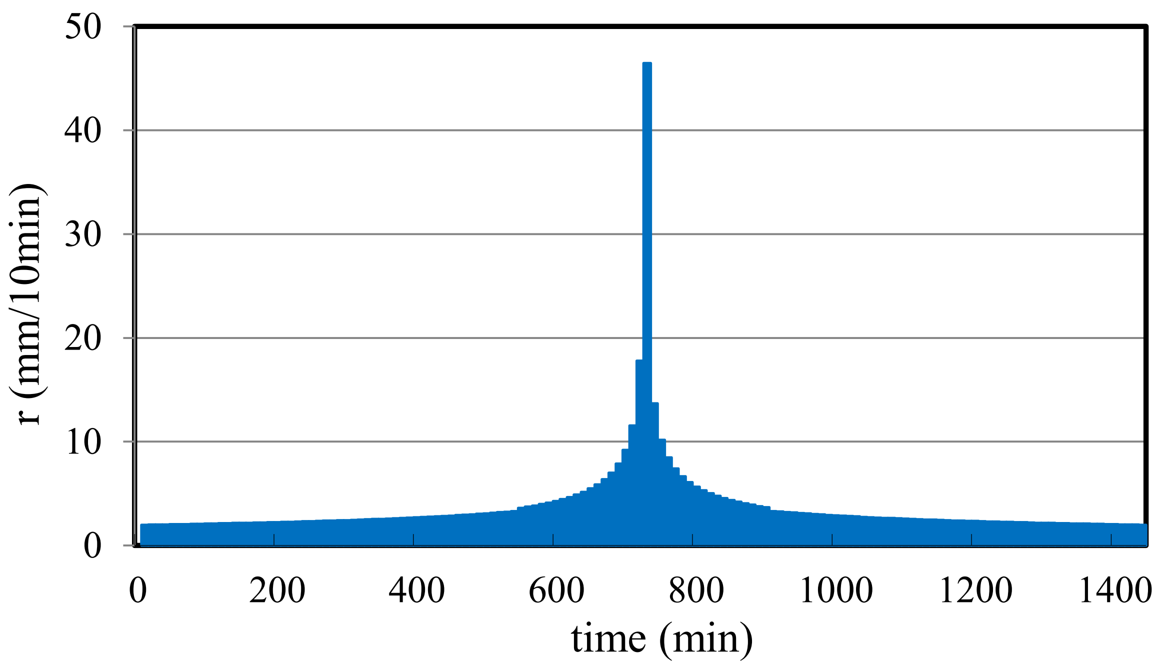
$A \cdot r(t)$	Inflow by rainfall to the cell
$q_{in}(t)$	Inflow from the neighboring cells
$q_{netwoek}$	Discharge designed in the drainage plans of the urban area or agricultural area.

Numerical Model for Flood Risk Analysis

Design Rainfall
～Alternating Block Method (ABM) ～

Shiga's probable rainfall intensity-duration curve（Shiga Prefectural Government（2007））

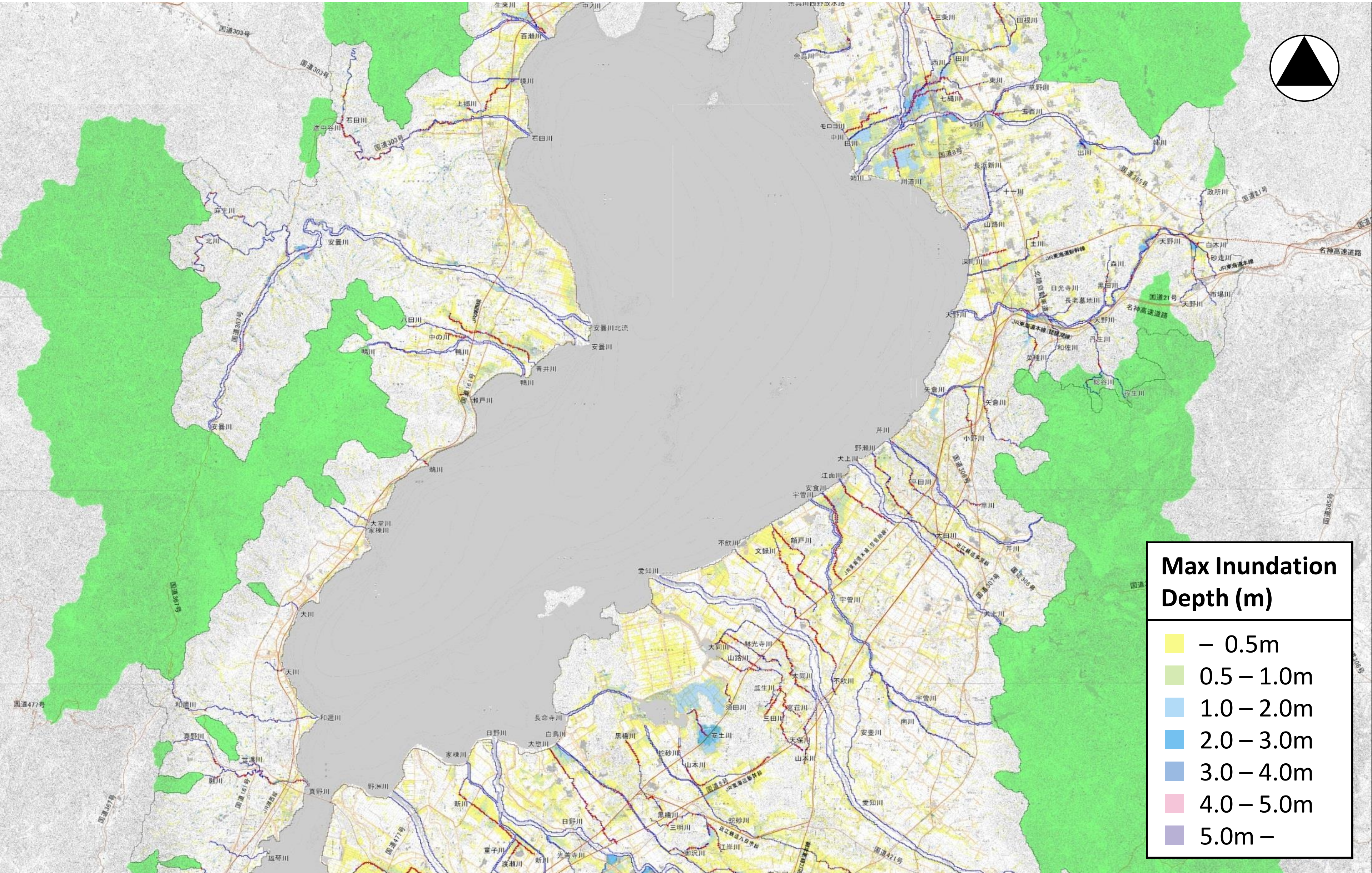
Return Period T = 2, 10, 30, 50, 100, 200, 500, 1000 years



Designed Rainfall (Hyetograph)　T = 100 years

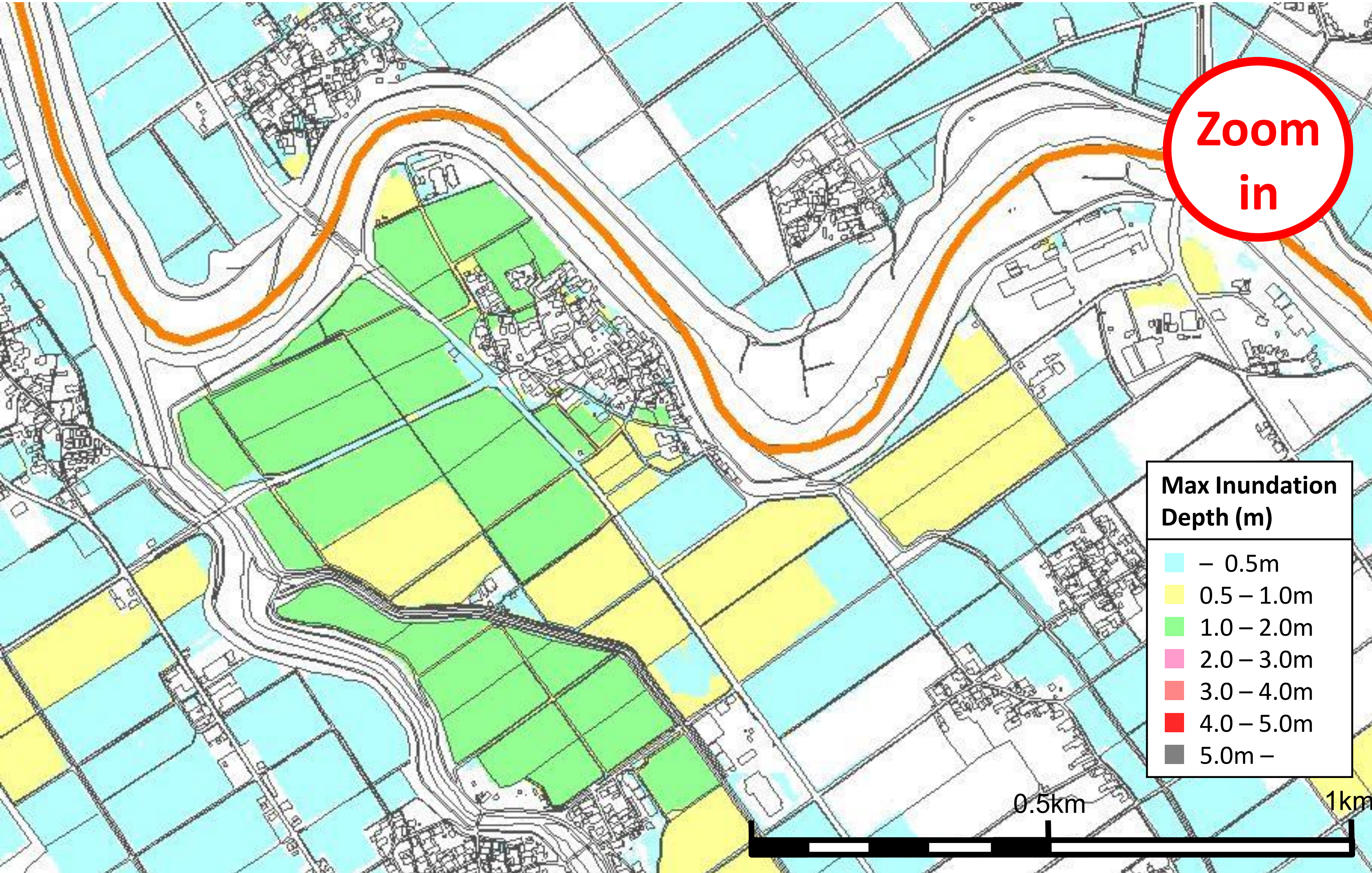
Flood Disaster Risk Analysis

Max inundation depth（10 year flood）～ corresponds to r=50mm/h（High frequency）



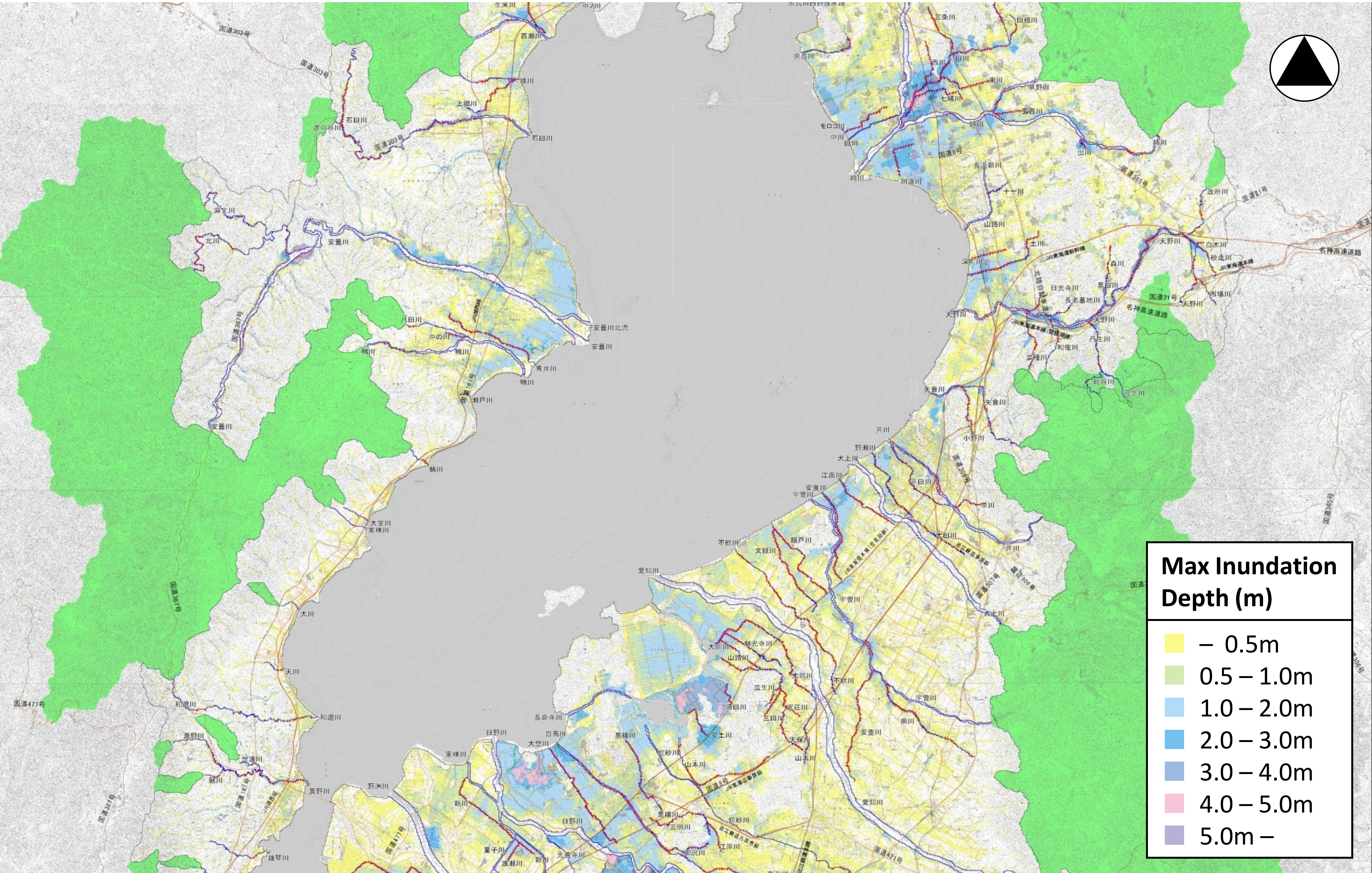
Flood Disaster Risk Analysis

Max inundation depth（10 year flood）～ corresponds to r=50mm/h（High frequency）



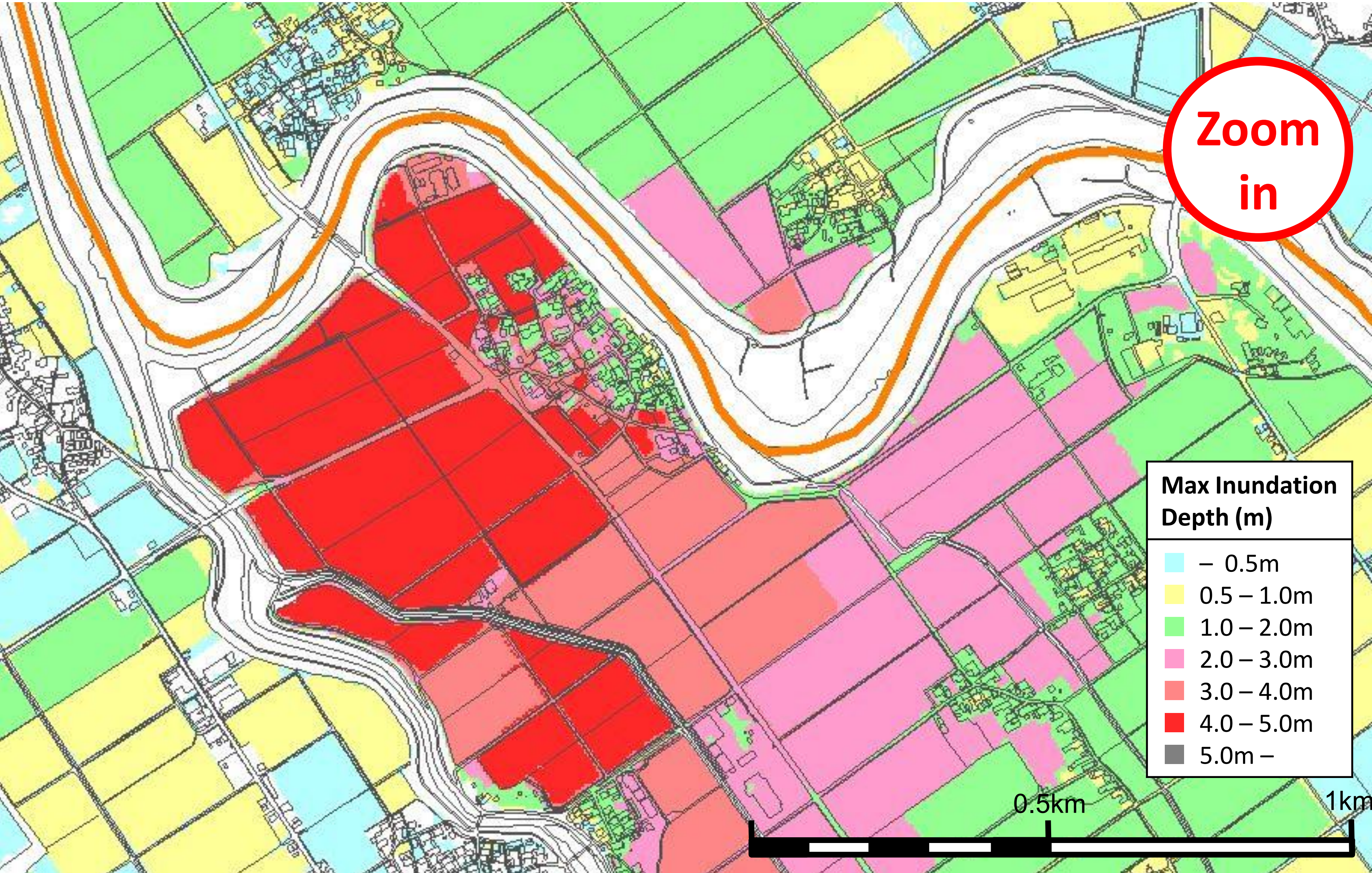
Flood Disaster Risk Analysis

Max inundation depth（100 year flood）～ corresponds to r=109mm/h（Lower frequency）



Flood Disaster Risk Analysis

Max inundation depth（100 year flood）～ corresponds to r=109mm/h（Lower frequency）



Objective evidence
Assessment indicators

"Safety of Site Frontage" gave us the objective evidence to manage the alluvial plain.

Basic policy for the flood management in Shiga Prefecture

Shiga Prefectural Government (2012) P.12-13

- In order to promote "**measures outside the river**" as well as "**measures inside the river**" and promote flood control of the basin which comprehensively conducts both **structural** and **non-structural measures** with the combination of **self-help, mutual assistance,** and **public assistance**, it is necessary for the residents in the basin, including administrative bodies commonly aware of the risk of flood disasters in the entire basin.
- In Shiga Prefecture, in order to share the disaster risks and steadily promote the flood control of the basin, **we study the degree of safety at each point in the basin (hereafter the "safety of site frontage"), where the residents are living and use this as basic information,** instead of the degree of safety of each flood control facility. To make the "safety of site frontage" measurable, estimated external force is set widely from small-scale, which does not cause damage, to large-scale, which is beyond the level of the maintenance of flood control facilities.
- **The "safety of site frontage"** shall be **expressed as the yearly probability for a typical house on a point to be exposed to the risk such as**

Level.4	washing-out of the house	($u^2h \geq 2.5\ m^3/s^2$)
Level.3	submersion of the house	($h \geq 3.0m$)
Level.2	inundation above the floor level	($h \geq 0.5m$)
Level.1	inundation below the floor level	($h \geq 0.1m$)

as well as expressed as hydrological elements (inundation height, flow rate, etc.) by event probability at each point.

How to express the “site frontage safety”

■ The “Safety of each site frontage” is expressed by the “Risk Matrix”

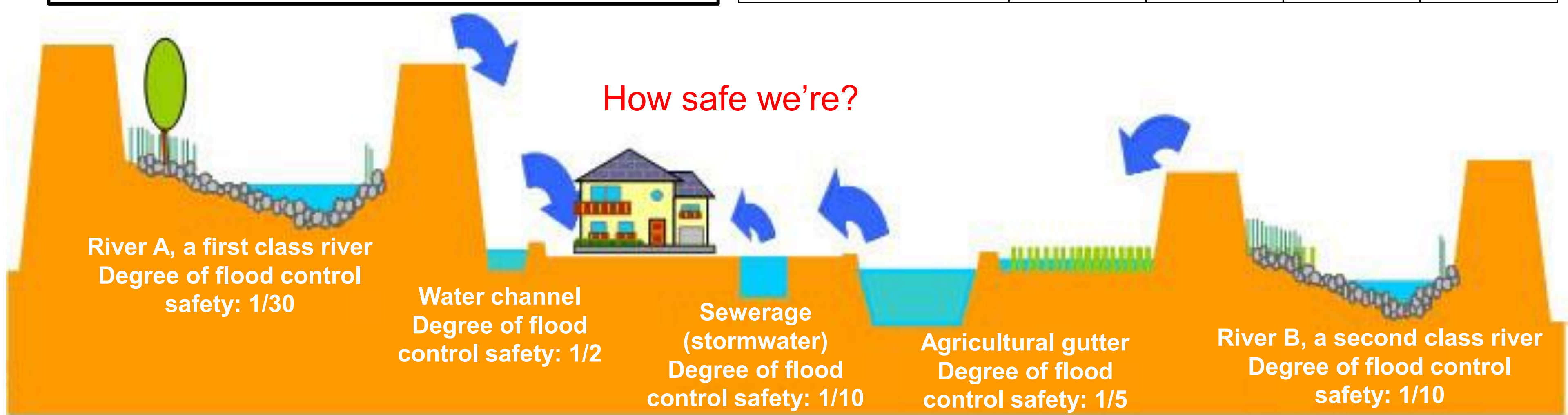
The figure on the right shows:
If a typical Japanese house is located on a point, the building will

(1) be washed out approx. once every 200 years,
(2) be submerged approx. once every 200 years,
(3) experience inundation above floor level approx. once every 50 years,
(4) experience inundation below floor level approx. once every 10 years.

This corresponds to the
“flood disaster risk”
to be prepared for at each place

Yearly event probability		Inundation below floor level $0.1\text{m} < h < 0.5\text{ m}$	Inundation above floor level $0.5\text{ m} \leq h < 3.0\text{ m}$	Submersion of the house $h \geq 3\text{ m}$	Washig-out of the house $u^2 h \geq 2.5\text{ m}^3/\text{s}^2$
1/ 2	(0.500)				
1/ 10	(0.100)	(4)			
1/ 30	(0.033)				
1/ 50	(0.020)		(3)		
1/100	(0.010)				
1/200	(0.005)			(2)	(1)
…					

Damage category (inundation hight/fluid force)



Flood Disaster Risk Analysis

Occurrence probability of the damage (at each mesh) P_{D_i}

$$P_D = \int_{\varepsilon}^{1} d_i(p)\,dp$$

$$\left(i = \begin{cases} \text{Level.4 washing-out of the house} & (u^2h \geq 2.5\ \mathrm{m^3/s^2}) \\ \text{Level.3 submersion of the house} & (h \geq 3.0\mathrm{m}) \\ \text{Level.2 inundation above the floor level} & (h \geq 0.5\mathrm{m}) \\ \text{Level.1 inundation below the floor level} & (h \geq 0.1\mathrm{m}) \end{cases} \right)$$

$d_i(p) = 1$ when the damage is expected at the mesh

$= 0$ no damage

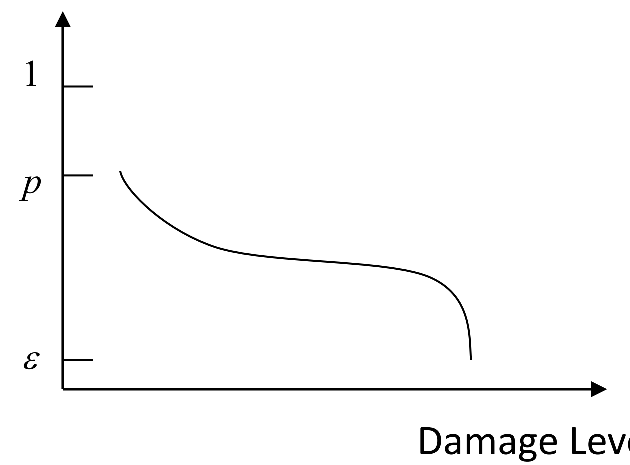
Annual Average Damage (at each mesh) D_m

$$D_m = \int_{\varepsilon}^{1} f(p)\,dp$$

p: Occurrence probability

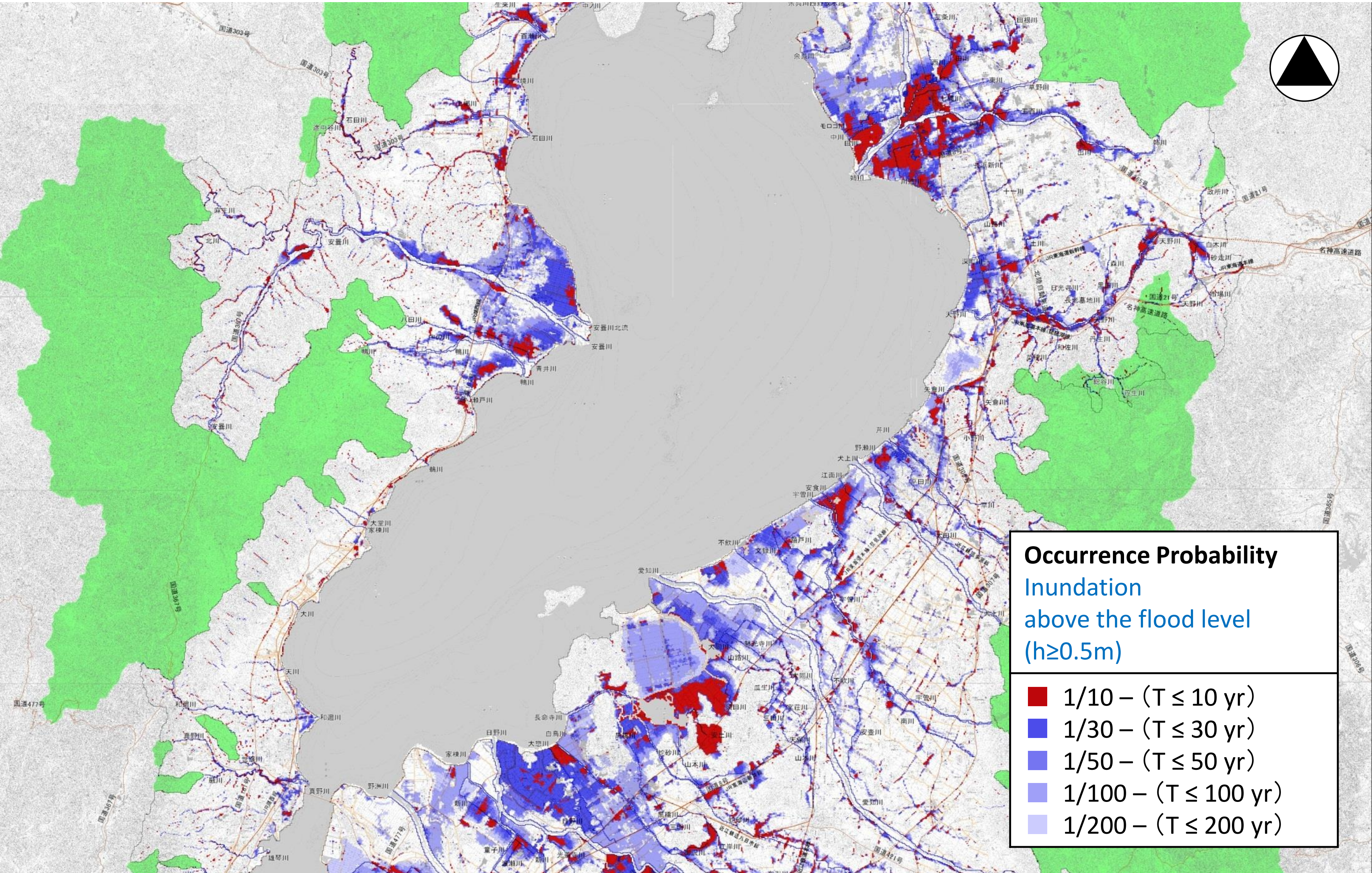
D_m: Damage Level

$f(p)$: Damage – Probability function



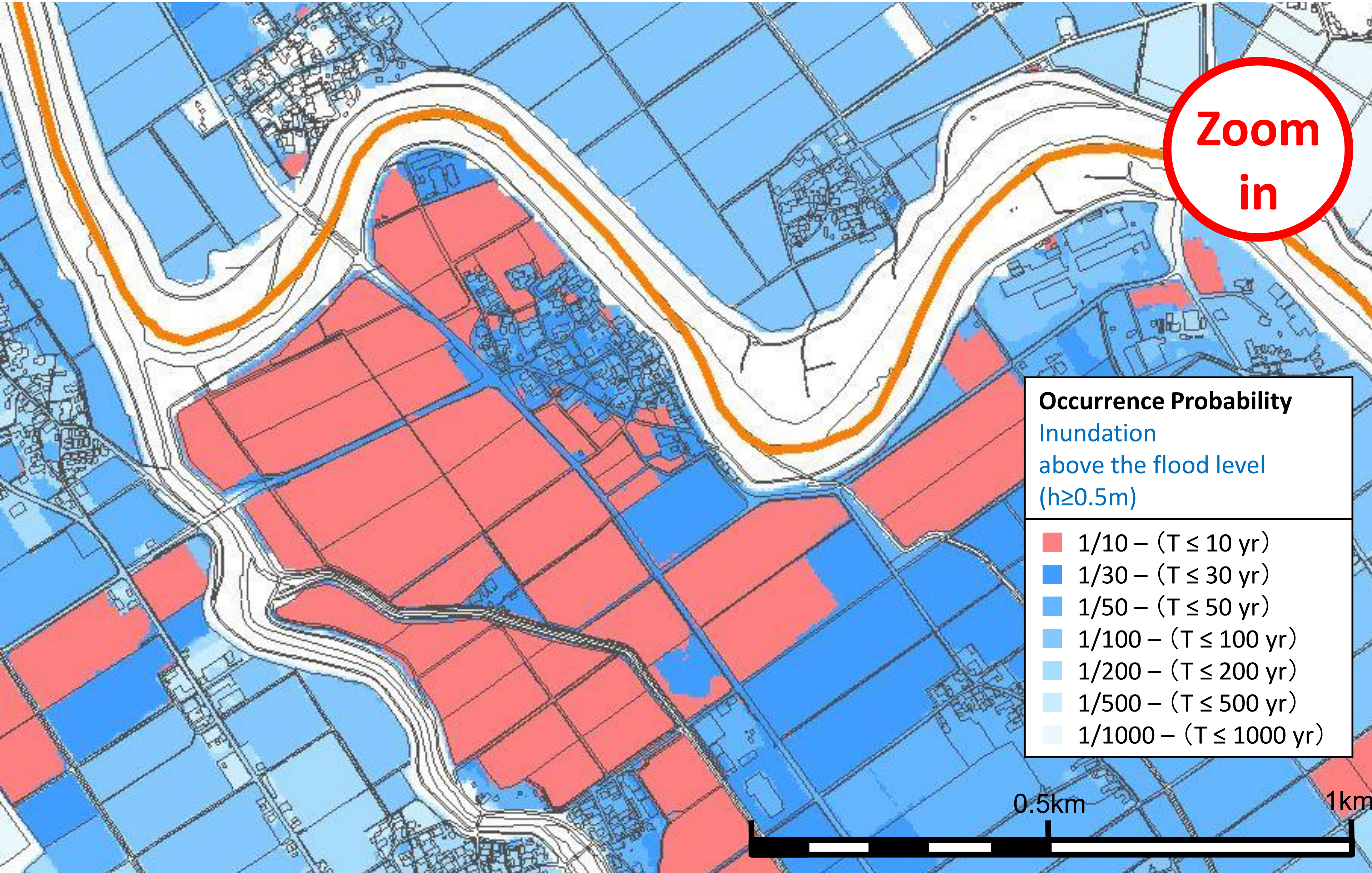
Flood Disaster Risk Analysis

The frequency of the inundation above the floor level（≥50cm）



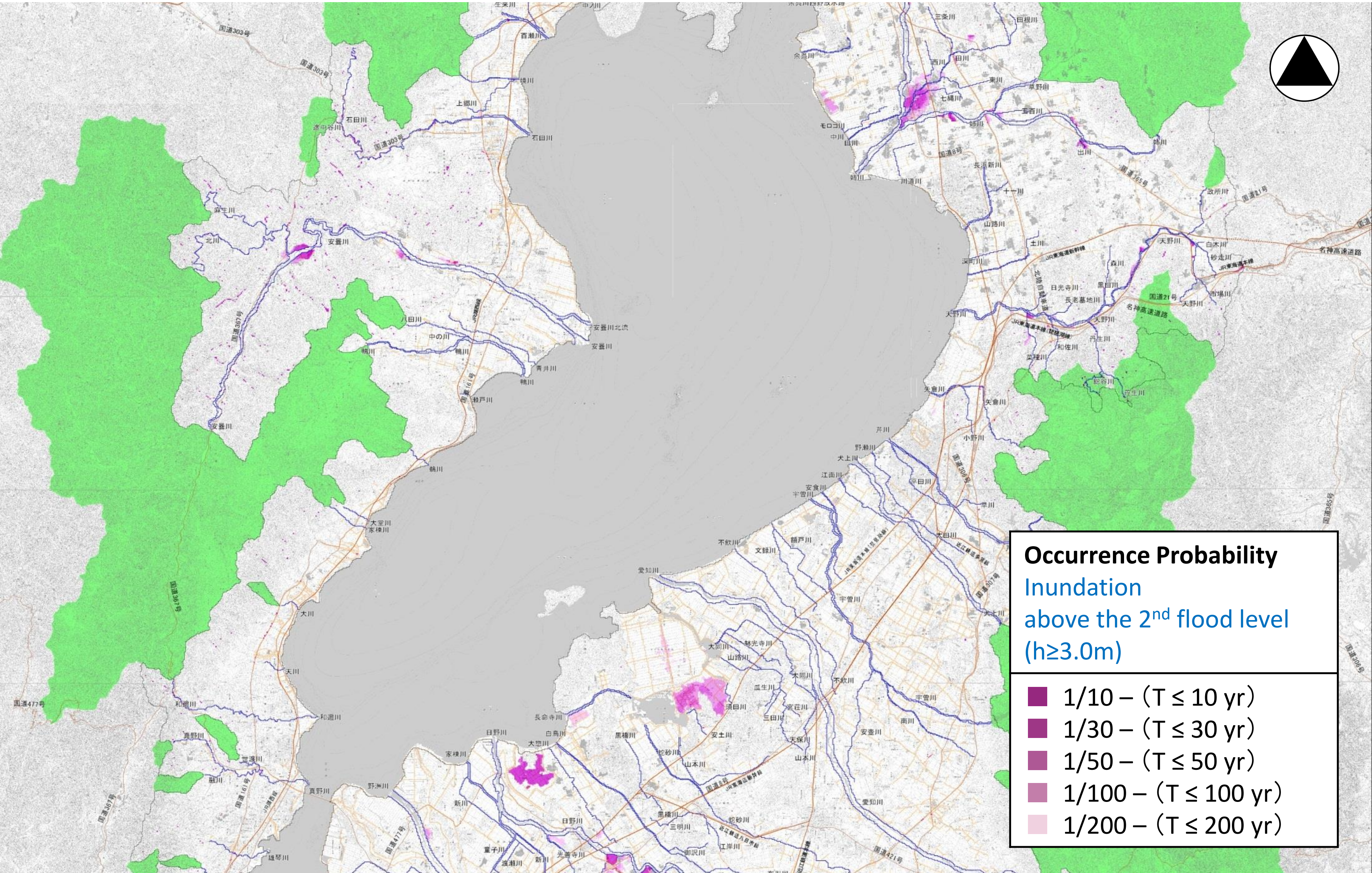
Flood Disaster Risk Analysis

The frequency of the inundation above the floor level（≥50cm）



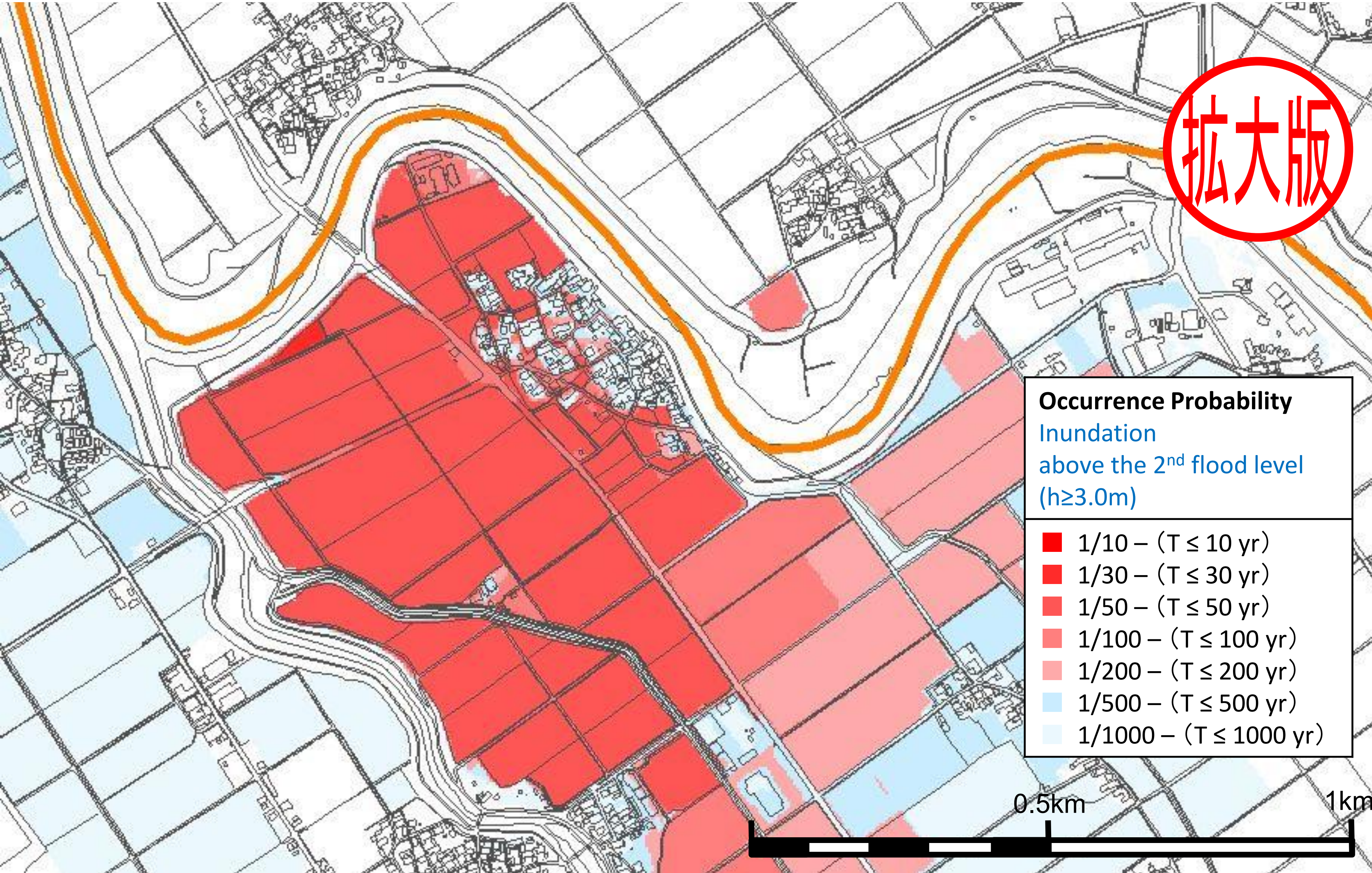
Flood Disaster Risk Analysis

The frequency of the inundation above the 2nd floor level（= 300cm）



Flood Disaster Risk Analysis

The frequency of the inundation above the 2nd floor level（≥ 300cm）

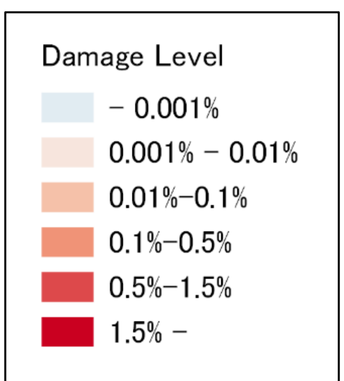


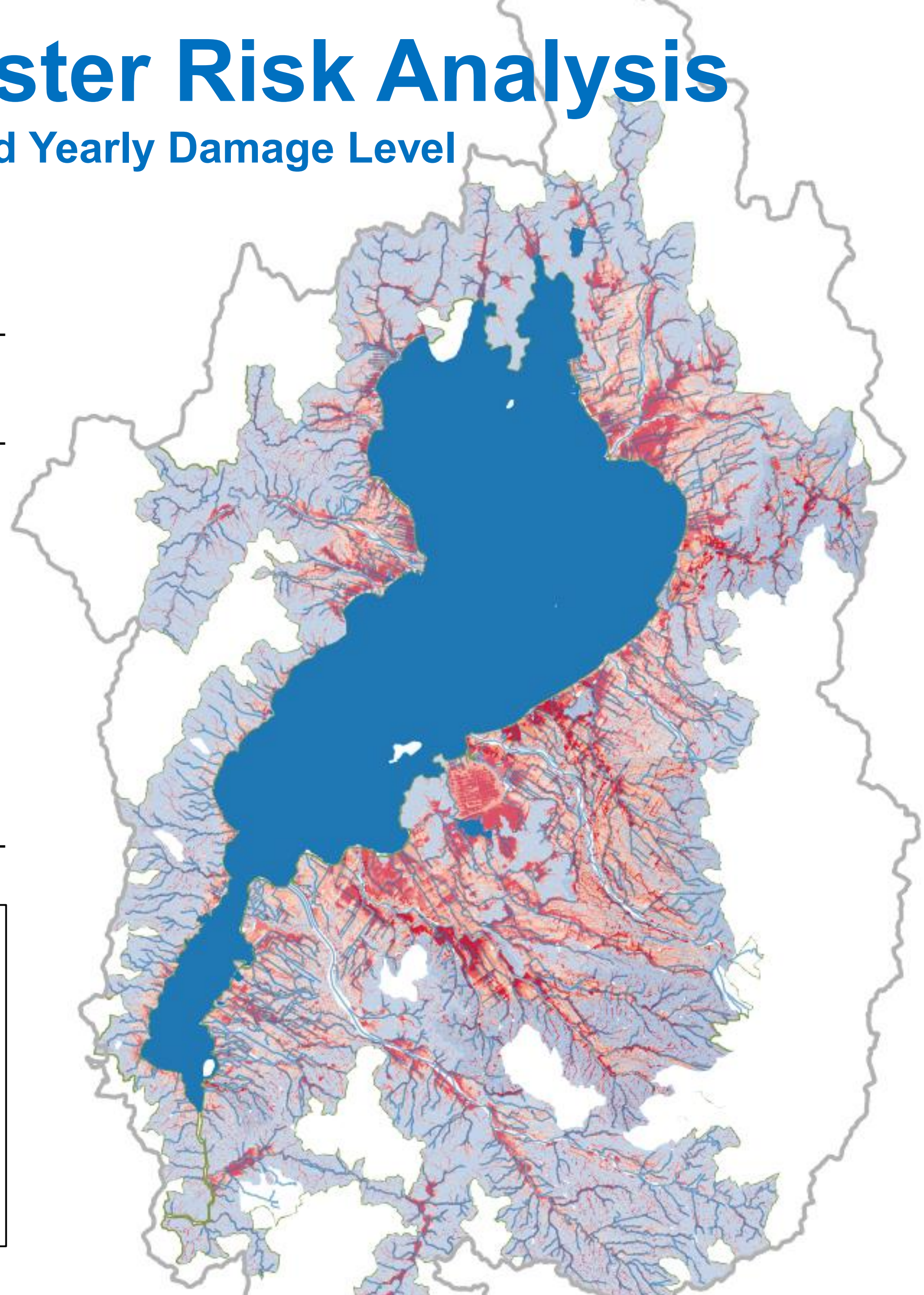
Flood Disaster Risk Analysis

Expected Yearly Damage Level

Table: Relationship b/w Inundation Depth and Damage Level

Depth (m)	Damage Level (%)
0.10-0.50	0.044
0.50-1.00	0.176
1.00-2.00	0.343
2.00-3.00	0.647
3.00-	0.870





Building and Land use regulations

■ Risk matrix (in the case of a residential area)

Event probability (Yearly)		No damage	Inundation below floor level	Inundation above floor level	Submersion of the house	Washig-out of the house
1/ 2	(0.500)				Higher Risk	
1/ 10	(0.100)					
1/ 30	(0.033)					
1/ 50	(0.020)					
1/100	(0.010)					
1/200	(0.005)					
…		Lower Risk				
Damage level (Inundation height/fluid force)		$h < 0.1$ m	0.1m $< h < 0.5$ m	0.5m $>= h < 3.0$ m	$h >= 3$ m	$u^2h >= 2.5\ m^3/s^2$

Risk ＝(Event probability) × (Damage level)

Building regulation
(Permitted if measures are done)

Event probability (Yearly)		No damage	Inundation below floor level	Inundation above floor level	Submersion of the house	Washig-out of the house
1/ 2	(0.500)				A	A
1/ 10	(0.100)				A	A
1/ 30	(0.033)				A	A
1/ 50	(0.020)				A	A
1/100	(0.010)				A	A
1/200	(0.005)				A	A
…						
Damage level (Inundation height/fluid force)		$h < 0.1$ m	0.1m $< h < 0.5$ m	0.5m $>= h < 3.0$ m	$h >= 3$ m	$u^2h >= 2.5\ m^3/s^2$

Article 39, Building Standard Acts

Prohibition of new incorporations into the urbanization promoting area
(Permitted if measures are done)

Event probability (Yearly)		No damage	Inundation below floor level	Inundation above floor level	Submersion of the house	Washig-out of the house
1/ 2	(0.500)			B	B	B
1/ 10	(0.100)			B	B	B
1/ 30	(0.033)					
1/ 50	(0.020)					
1/100	(0.010)					
1/200	(0.005)					
…						
Damage level (Inundation height/fluid force)		$h < 0.1$ m	0.1m $< h < 0.5$ m	0.5m $>= h < 3.0$ m	$h >= 3$ m	$u^2h >= 2.5\ m^3/s^2$

Article 7, City Planning Act

How about the existing houses ??

Realization of the development of safe local communities through subsidies instead of penalties.

Estimated number of houses which need measures: About 1,800 (estimated)

Important Administrative Document

Area division of urbanization promoting area and urbanization control area by the City Planning Act, and policy on adjustment measures, etc., with flood control projects

(Official notice from chiefs of the city bureau and the river bureau to the prefectural governor)

1970

Areas which fall into any of the following items […] are considered as "areas at a risk of disaster caused by overflow, inundation, tsunami, storm surges, etc." […] and in principle, not included in urbanization promoting areas.

- [Omitted] with targeting at rainfall with 60-min rainfall intensity of around 50 mm, flooded areas of the river where river channels are not developed and areas where inundation higher than 0.5 m is expected
- Areas which do not fall under the preceding items but are expected to have a large risk of disaster caused by overflow, inundation, tsunami, storm surge, sediment discharge, landslides, etc.

Prevention of damage to buildings by wind and flood damage
(Official notice from the vice-minister of construction to the prefectural governor)

October 27, 1959

3. To actively designate a disaster hazard area, especially in lowlands, based on Article 39 of the Building Standard Acts, strengthen the structures of the buildings in the area, and improve evacuation facilities.

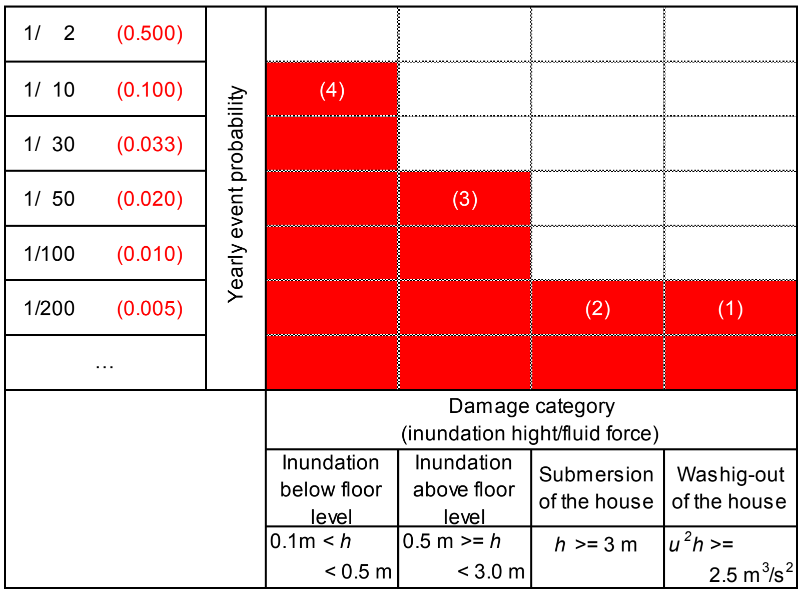
Details:

1. For the range of designated areas, the following areas should be mainly considered.
   (1) Areas with a significant risk to human life in which the level of overflowed water caused by storm surges, torrential rain, etc., exceeds the floor of the ground floor.
   (2) Areas with a risk that soil and sediment directly wash out, collapse, or causes serious damage to the building due to tsunami, surges, floods, landslides, etc.
2. The contents of the restriction should be roughly as follows, with an emphasis on the evacuation at the time of flooding and the preservation of the building. Note that the restriction should be set in consideration of special circumstances in the local area and its surroundings.
   (1) Area described in 1-(1)
      (II) Buildings for housing should be governed by the following items.
         (i) Raise the ground up to the estimated flooding level, or build the room (at least the part of the floor which is needed for the evacuation) at the estimated flooding level or higher.
         (ii) The structures below the estimated wetting surface should fall under one of the following items.
            a Major pillars or bearing walls that are made of reinforced concrete, reinforced concrete blocks, steel frames, etc., with water resistant structures.
            b The base has continuous footing and the framework is made of wood that is specially reinforced.

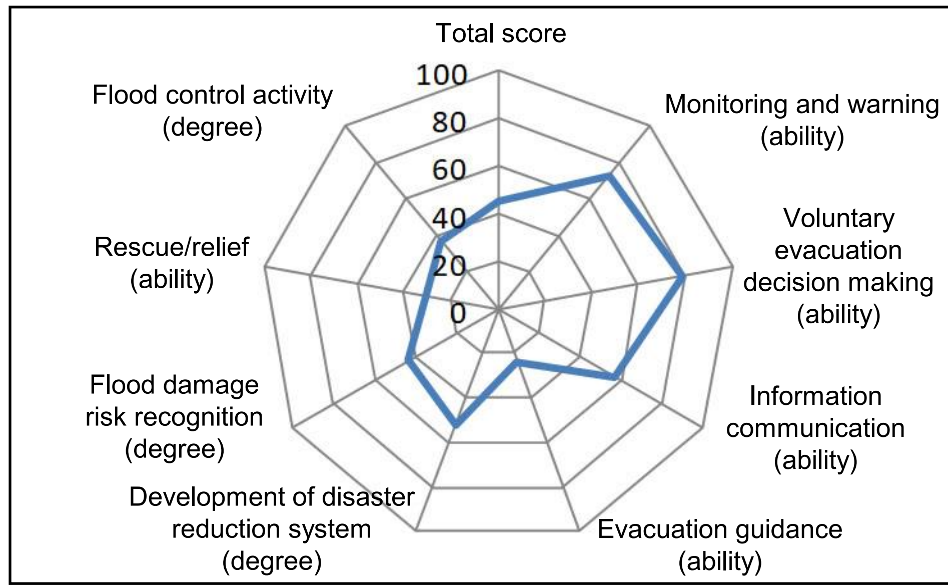
Information for
the Self-DRR Residents' Associations

As an opportunity of spontaneous self-help/mutual assistance-

- "**Safety of Site-frontage**" and "**Local Disaster Reduction Ability**" are available to every self-DRR Residents' Association and individuals.
- "Local Disaster Reduction Ability" of all residents' associations in Shiga Prefecture were surveyed in 2009 and 2016/2018



Degree of safety of site frontage

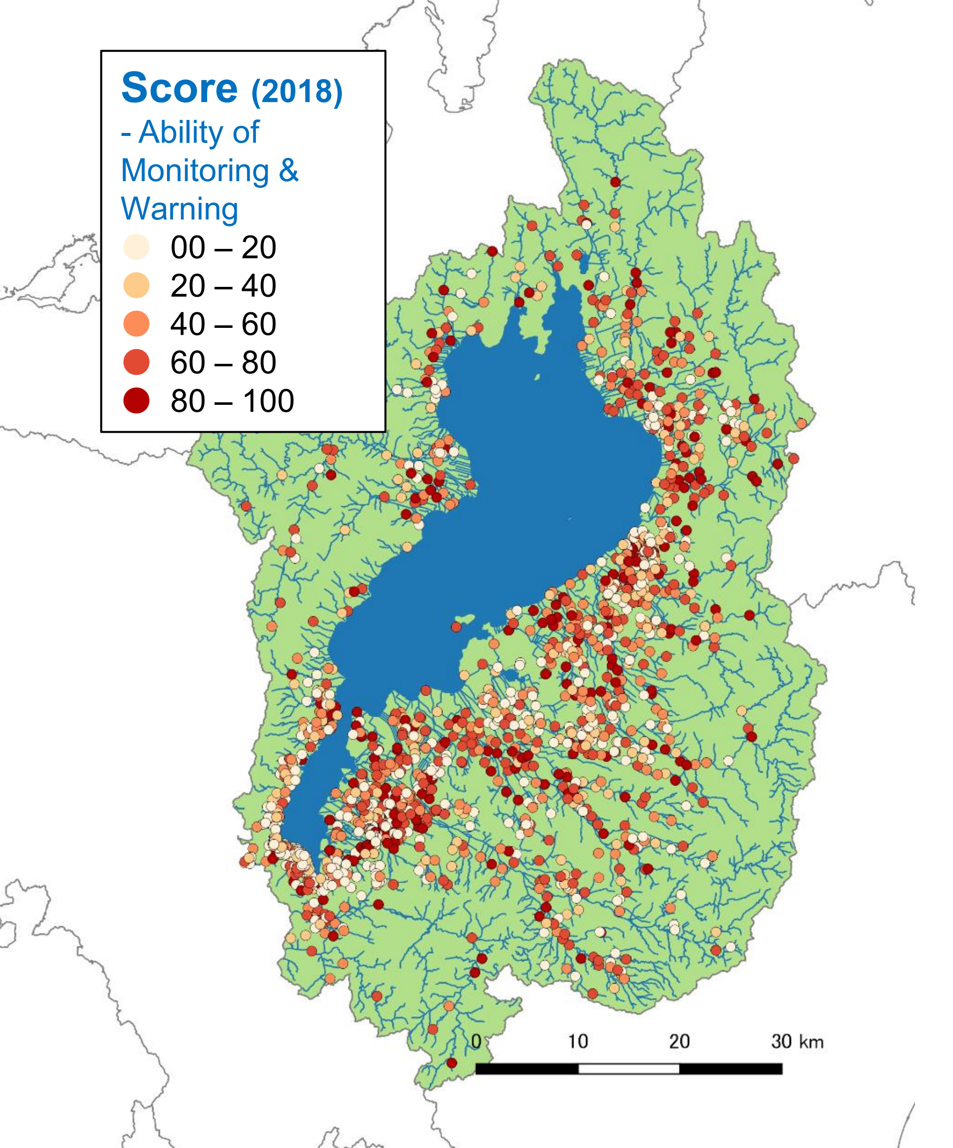


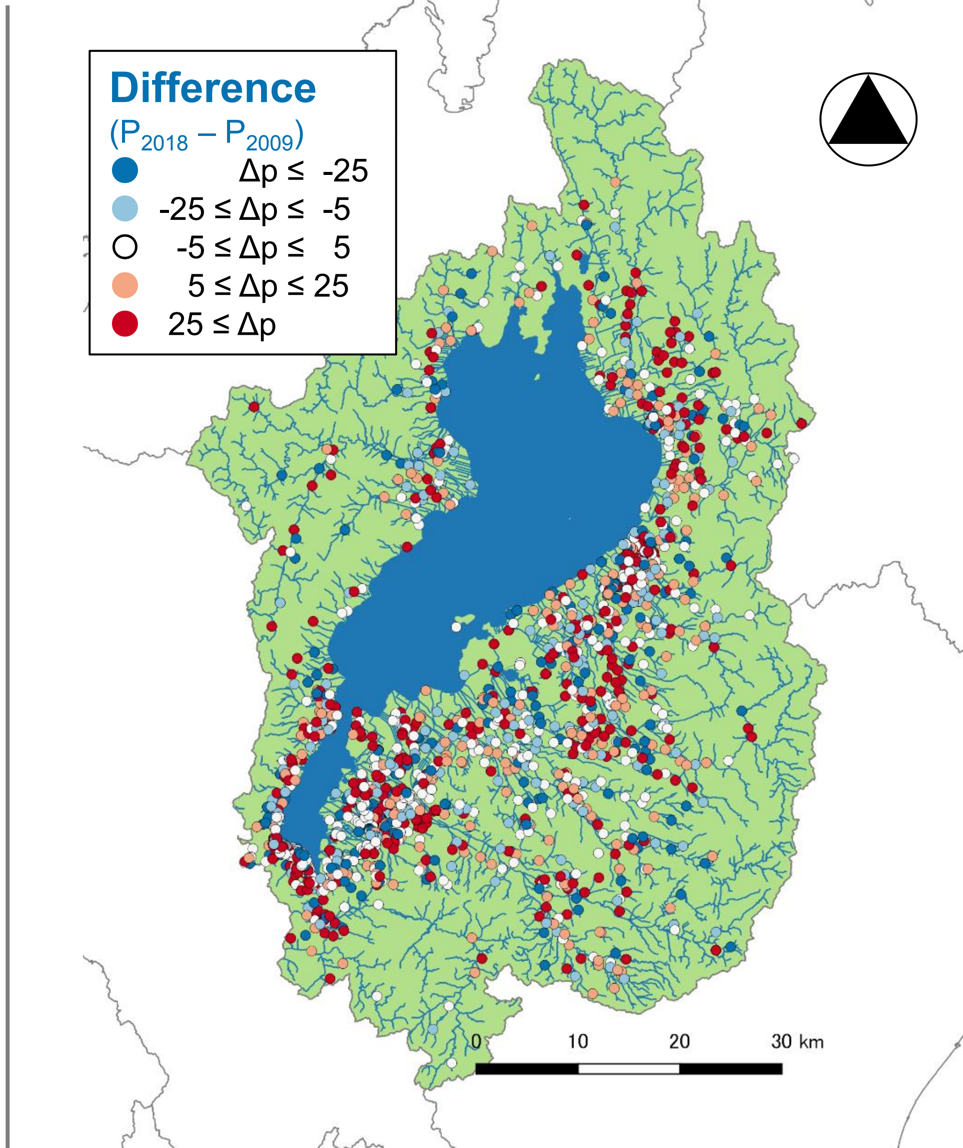
Local disaster reduction ability

By presenting the "degree of safety of site frontage" and "local disaster prevention ability" of self-government association and clarifying the issues,
it will be possible to discuss **the better measures spontaneously.**

Local Disaster Reduce Ability Survey

2009 and 2016/18





Cabinet Office provides the self-detection system on http://www.bousai.go.jp/fusuigai/sonota/shindan/index.html

For floodplain administration

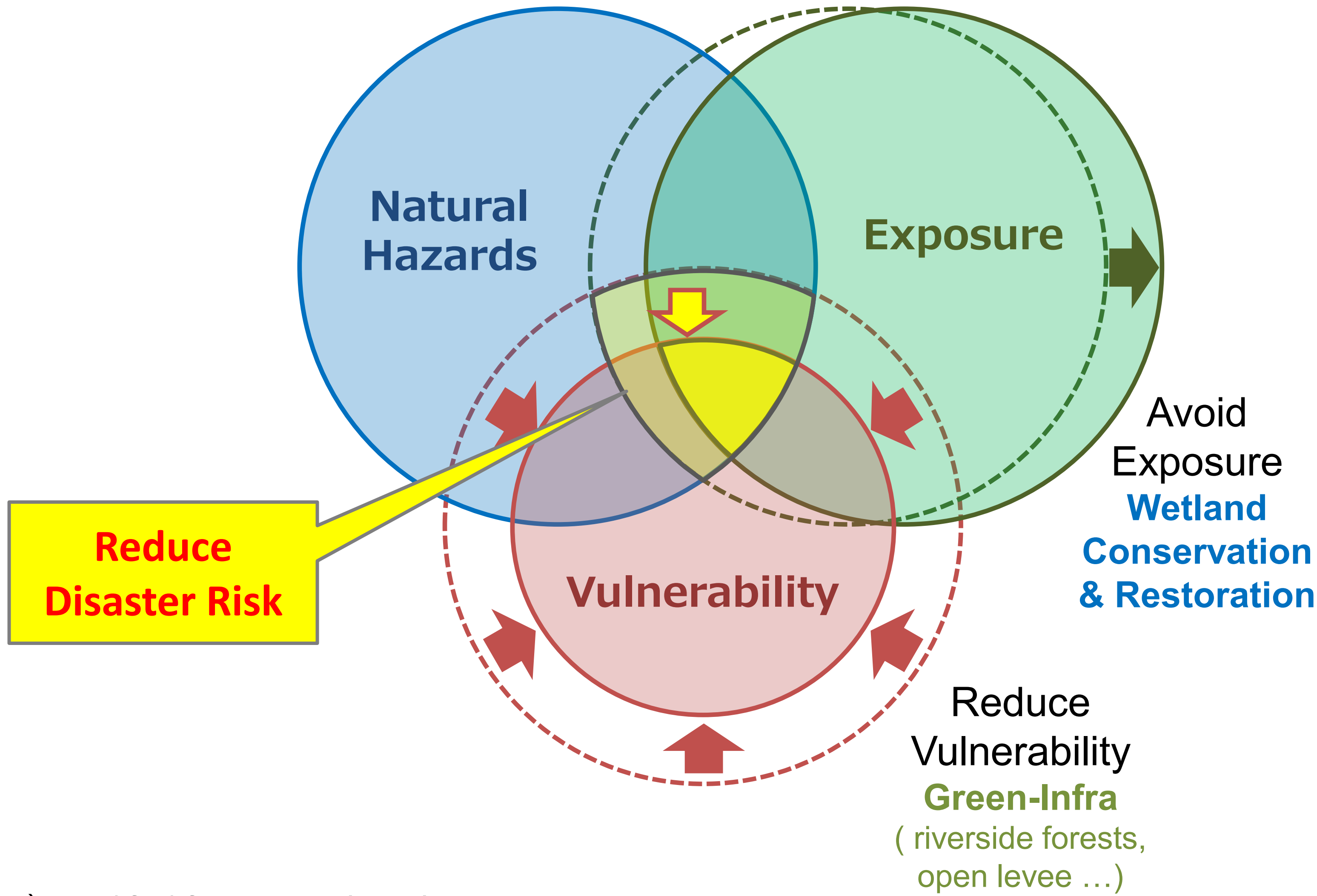
Obtain “Risk distribution in alluvial plain”

Local government becomes to conducting robust floodplain management based on risk-level.

- **Performance estimate for planning flood control facilities**
  - Performance of river admiration facilities ー dikes, reservoirs et al.
  - Performance of measures for excessive flood in alluvial plain ー riparian forests, open levees, and secondary dikes et al.
  - Affection of close type embanking – road, railroad et al.
- **Criterion judgment for non-construal measure**
  - Zoning for land use and building regulations
  - Trigger of evacuation in each place
  - Decision for buying a house and water damage insurance

Concept of Disaster Risk Reduction

Avoid Exposure & Reduce Vulnerability



Source） Modified from ADRC (2005)
Nature Conservation Bureau, Ministry of the Environment (2016) Ecosystem-based Disaster Risk Reduction in Japan：A handbook for practitioners

Reference

K. Taki, T. Matsuda, E. Ukai, T. Nishijima, S. Egashira (2013)
Method for evaluating flood disaster reduction measures in alluvial plains,
Journal of Flood Risk Management 6(3) pp.210-218

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Satoru Ichidate, Mitsuhiro Tsuji, **Kentaro Taki**, Hitoshi Nakamura (2016)
The Risk-Based Floodplain Regulation of Shiga Prefecture in Japan
3rd European Conference on Flood Risk Management 7

https://doi.org/10.1051/e3sconf/20160713008

Kentaro Taki (2022)
Flood Management Policy in Shiga Prefecture, Japan
: Implementation Approach of a Risk-Based Flood Management System at Catchment Scale
Green Infrastructure and Climate Change Adaptation pp 43–59, Springer

https://link.springer.com/chapter/10.1007/978-981-16-6791-6_4


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FOUNDED 1897

An Approach to Hydro-Reality -The Integration of FAST and IOW

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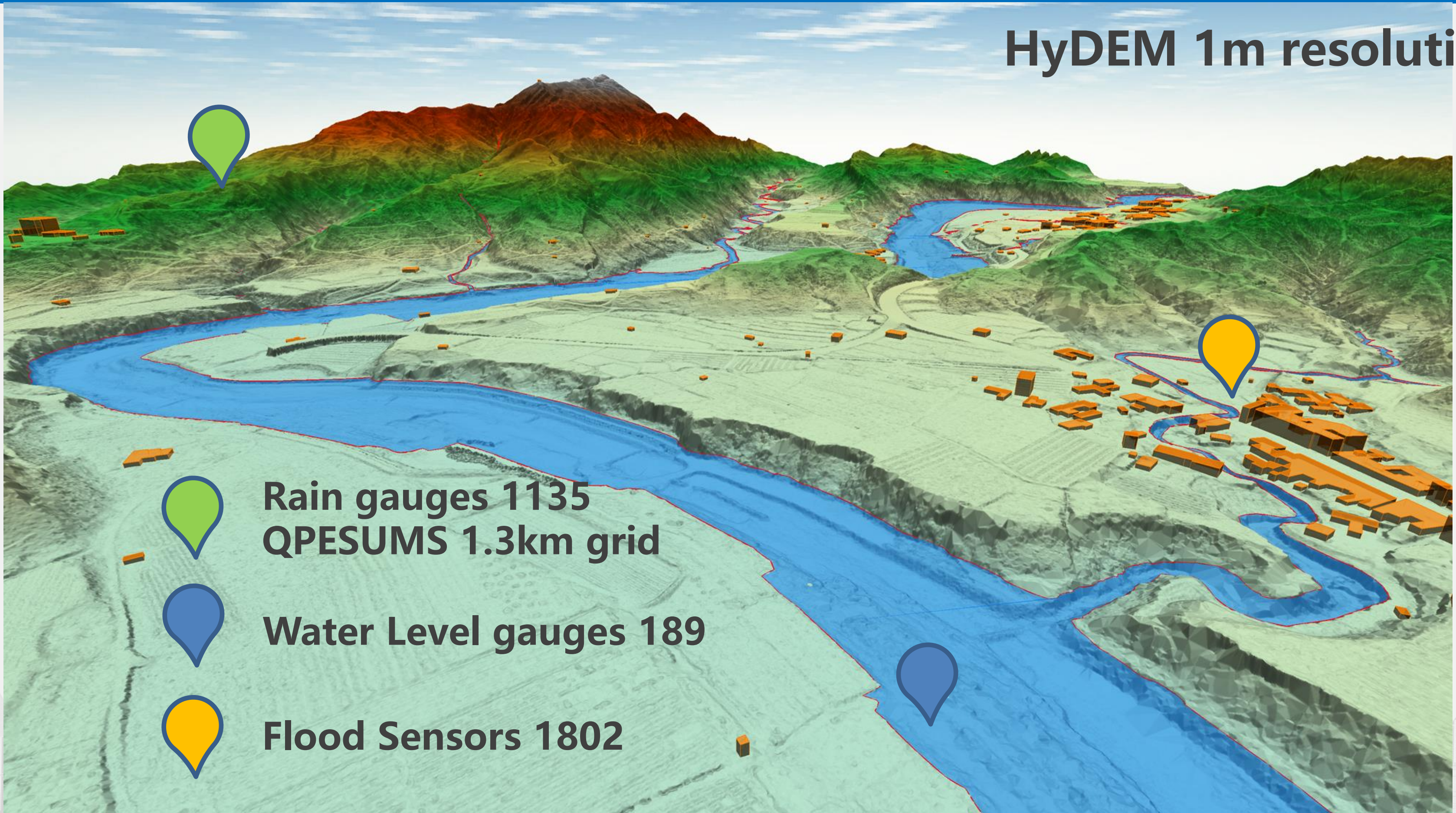
Professor, Civil Eng. Dept., NTUT
TIWW 2022/10/13

Content

01

Analysis Ready Data

Analysis Ready Data, ARD



Digital Governance

ARD V0

Are We Ready for ARD?

Spatial

- 1m high Resolution Terrain
- 3m channel width
- Dike and flood wall for coastal, rivers, and drainages

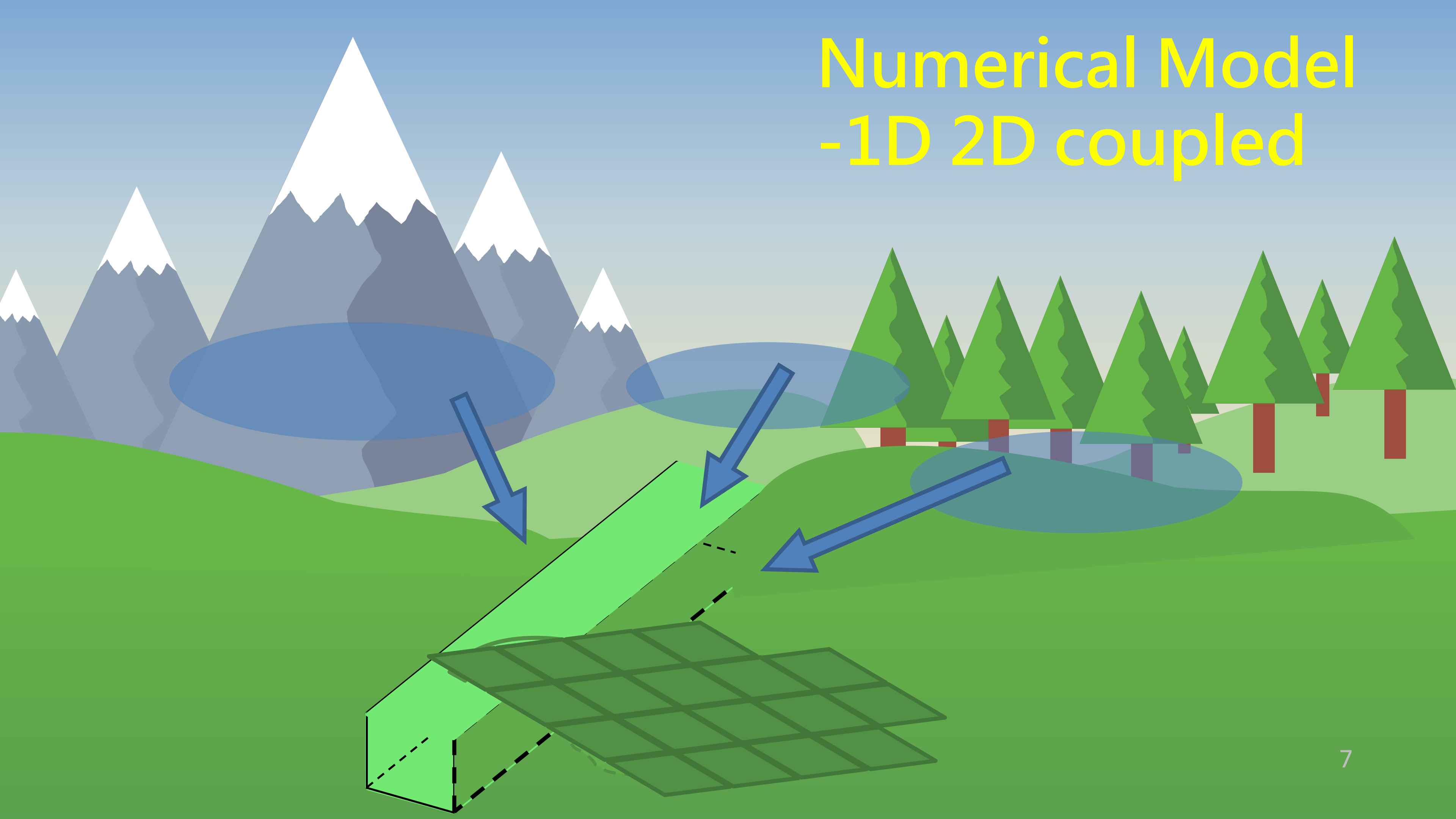
Temporal

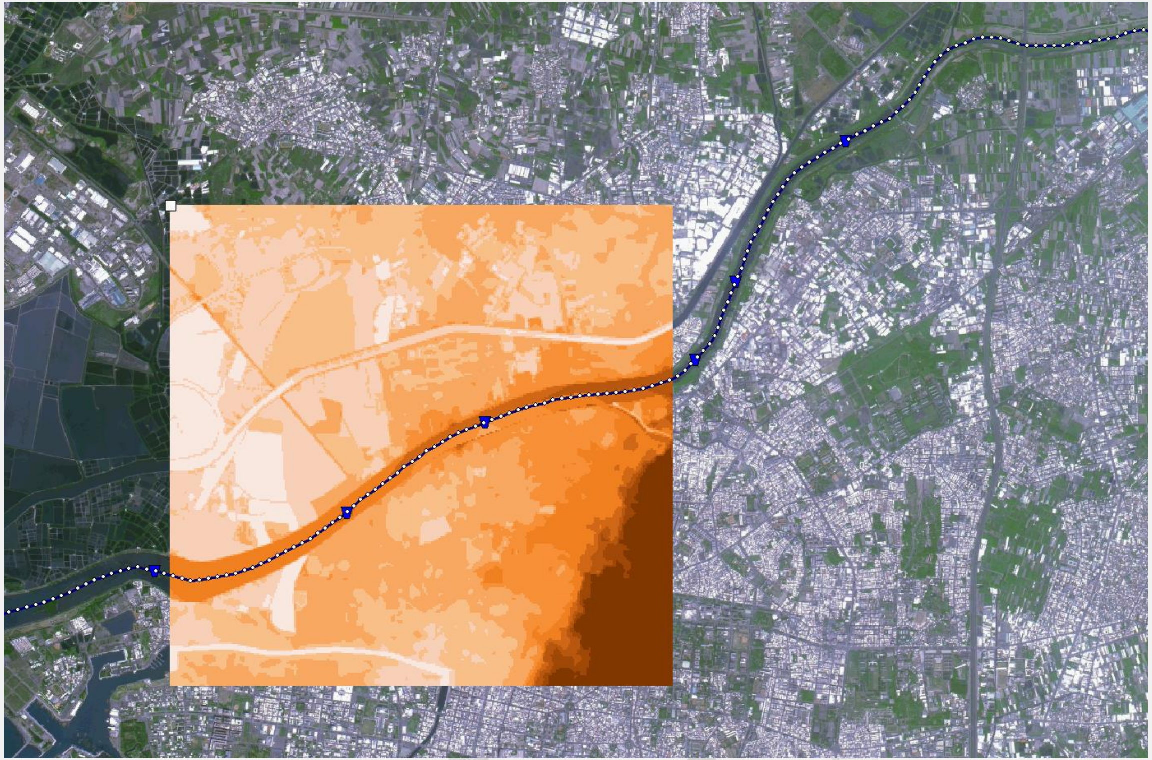
- Precipitation 10mins，1.3km *1.3km
- Water levels in rivers, drainages, and sewers
- Flood depth in urban area

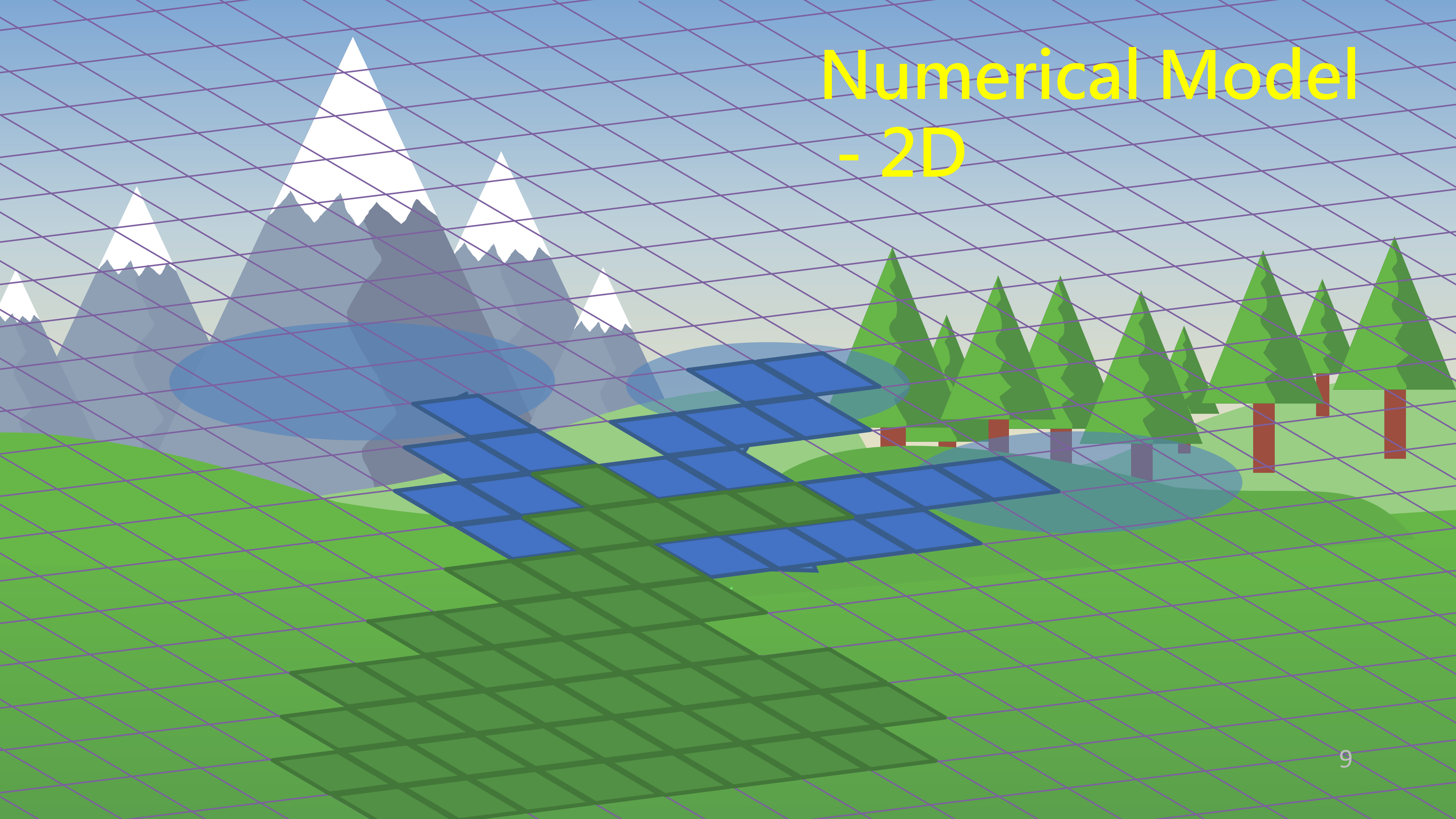
Hydraulic Model

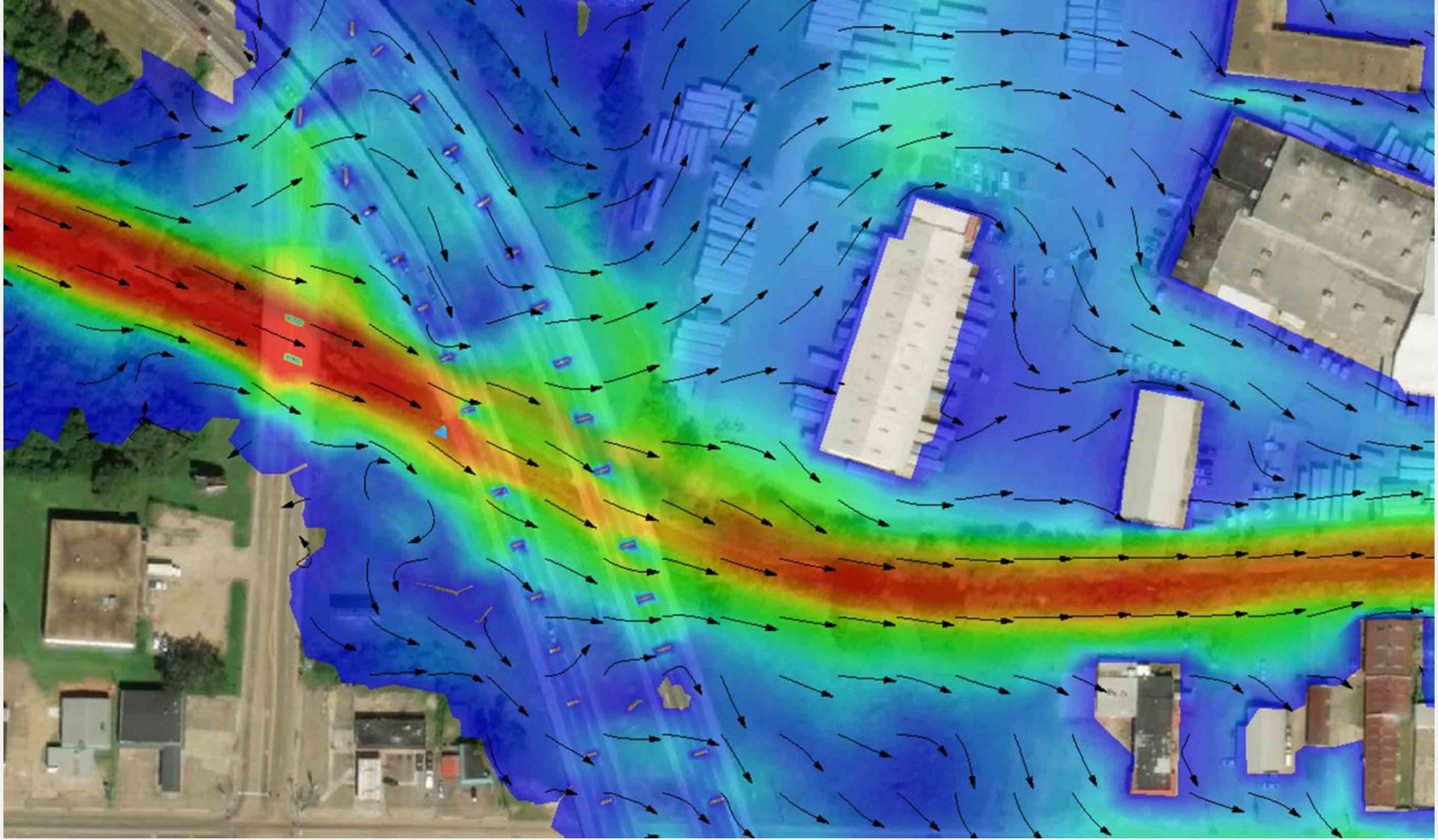
https://www.youtube.com/watch?v=fuHS0NfBgFk&t=75s

Numerical Model
-1D 2D coupled






Numerical Model
- 2D



https://www.stantec.com/en/ideas/completing-the-picture-the-future-of-hydraulic-modeling-is-two-dimensional

02

FAST, Flood Aware Simulation - Taiwan

Flood Potential Map Update

01

1st Gen.
1999-2001

NCDR
DEM 200m
150, 300, 450, 600mm/24 hrs

02

2nd Gen.
2007-2009

WRA
DEM 40m
200, 350, 450, 600mm/24 hrs
Return Period 1.1, 2, 5, 10, 20, 25, 50, 100, 200, 500 yr

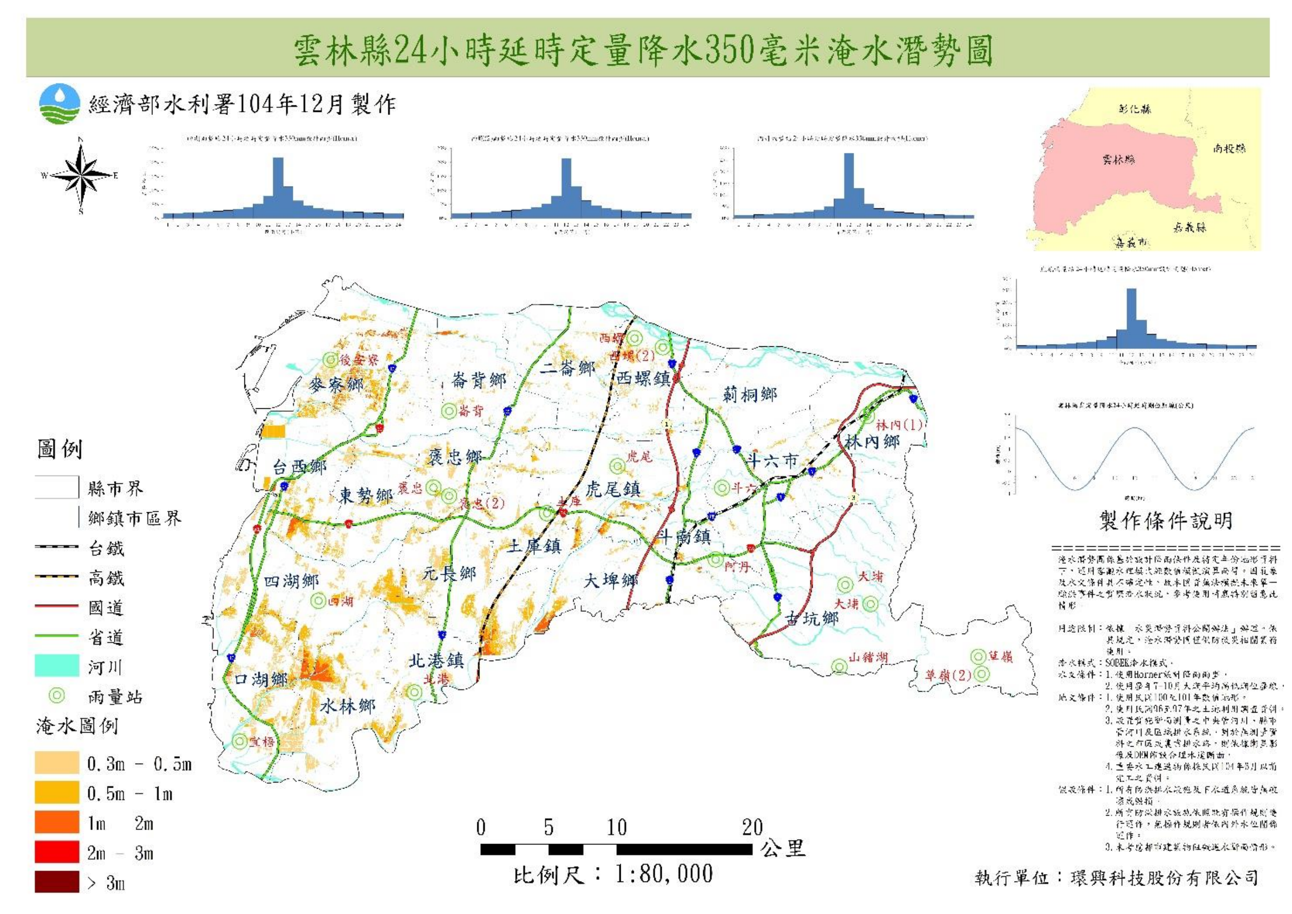
03

3rd Gen.
2014-2016

WRA
DEM <= 40m
150, 250, 350mm/6 hrs
200, 300, 400, 600mm/12 hrs
200, 350, 500, 650mm/24 hrs
Drainages and Sewers

http://103.253.146.123/wra/riskmap-dev/

3rd Gen.

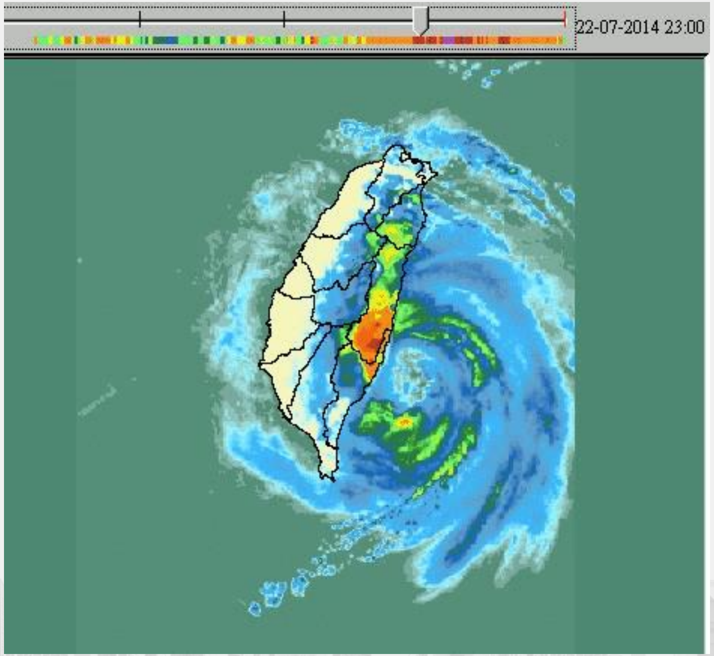


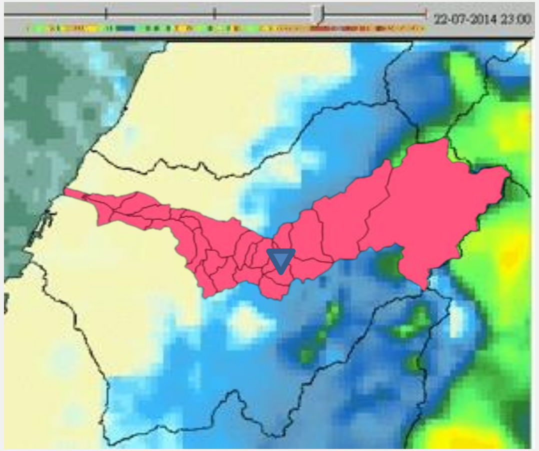
http://103.253.146.123/wra/riskmap-dev/flood

FAST, Flood Aware Simulation - Taiwan

FEWS_Taiwan 2014 MATMO

1.3km QPESUMS



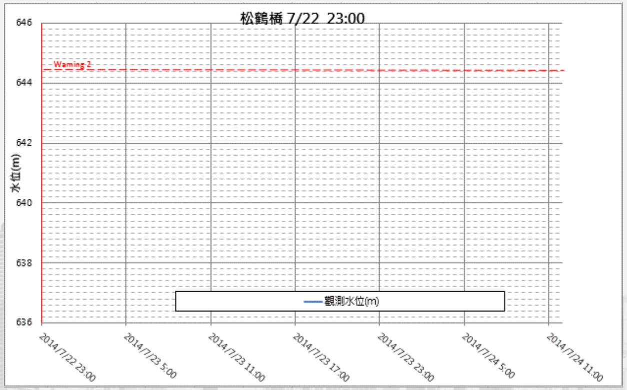


Numerical Model

大甲溪 SOBEK

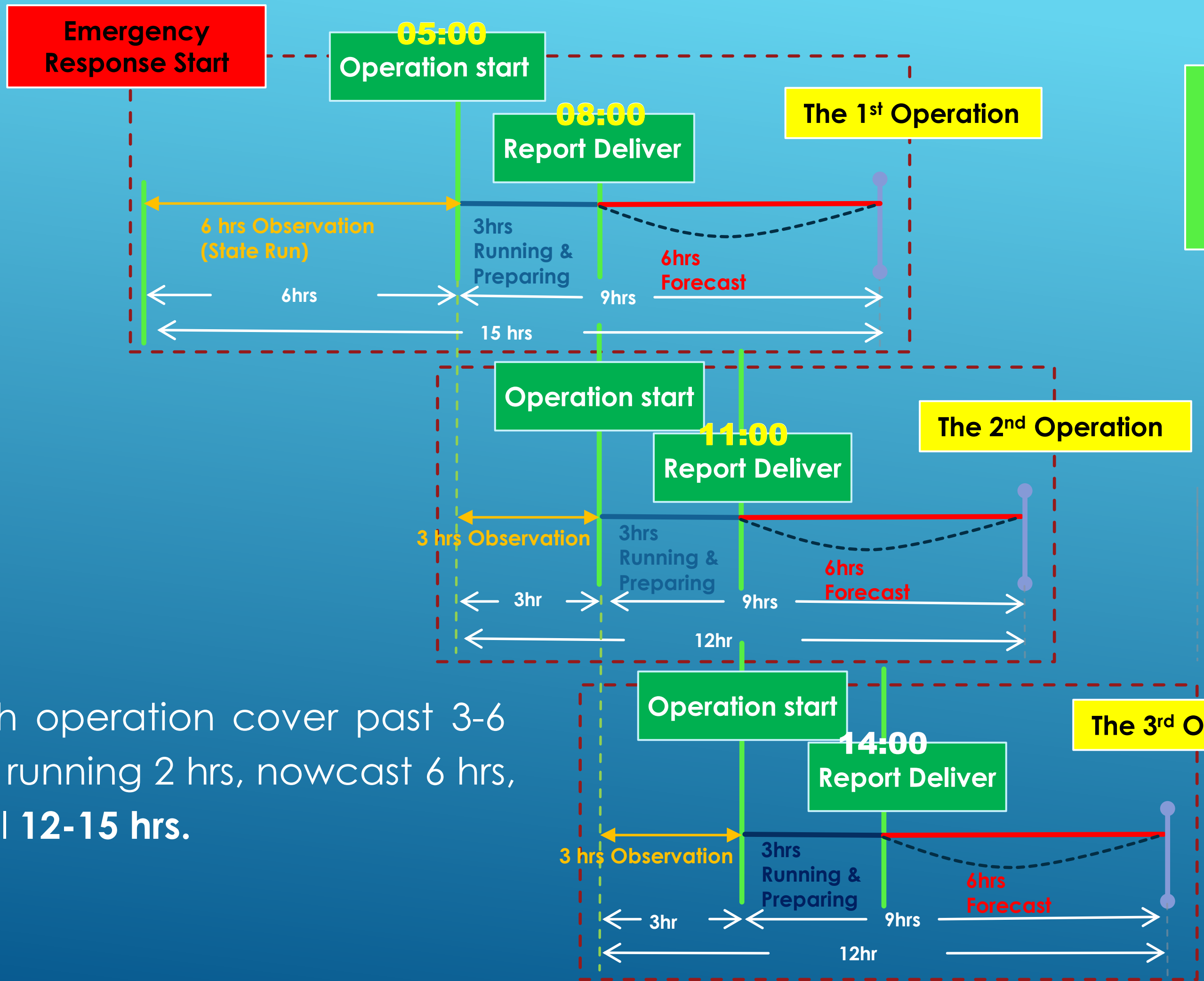
Observation and Nowcast

松鶴橋 water level



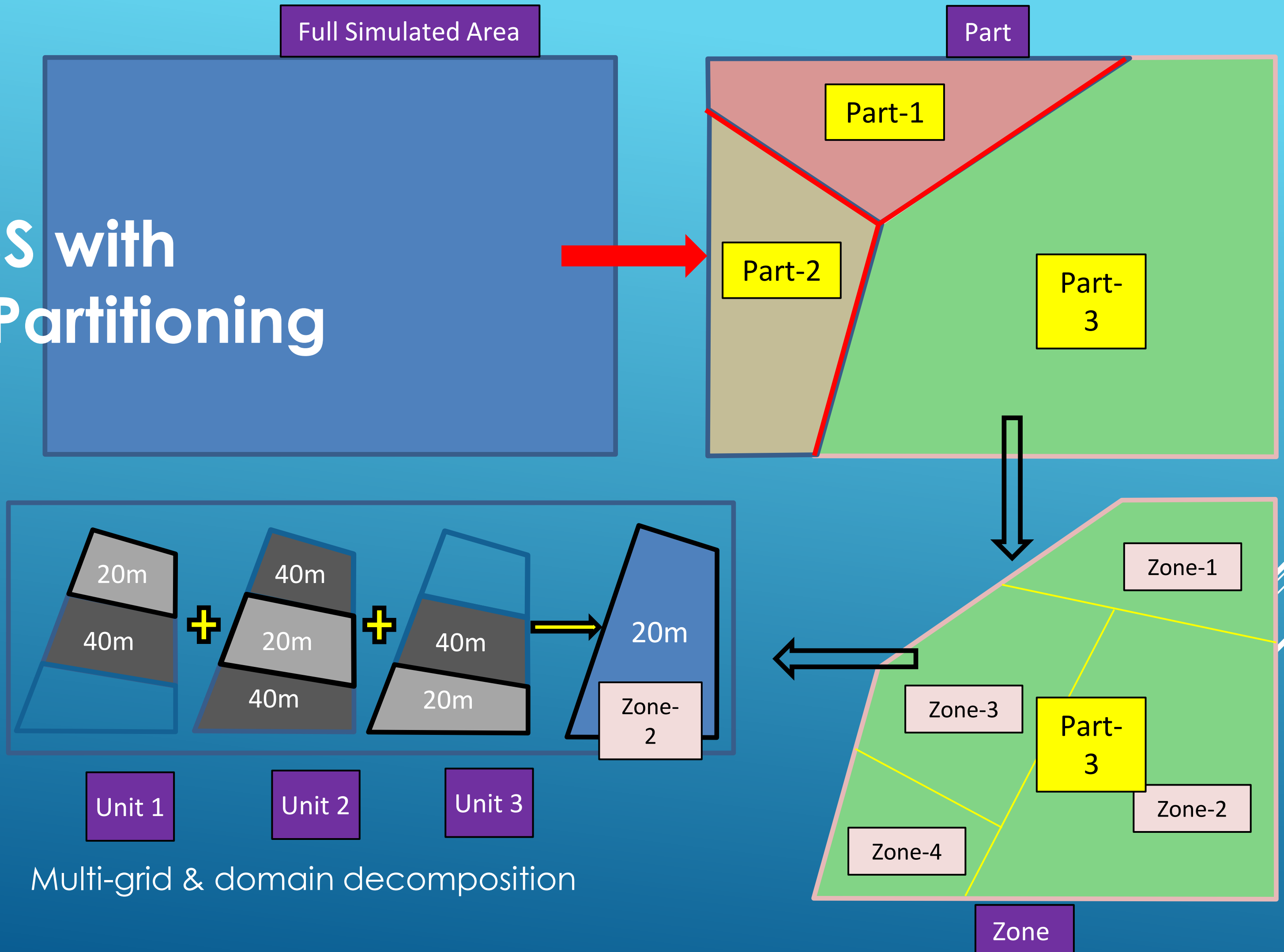
Operational System:

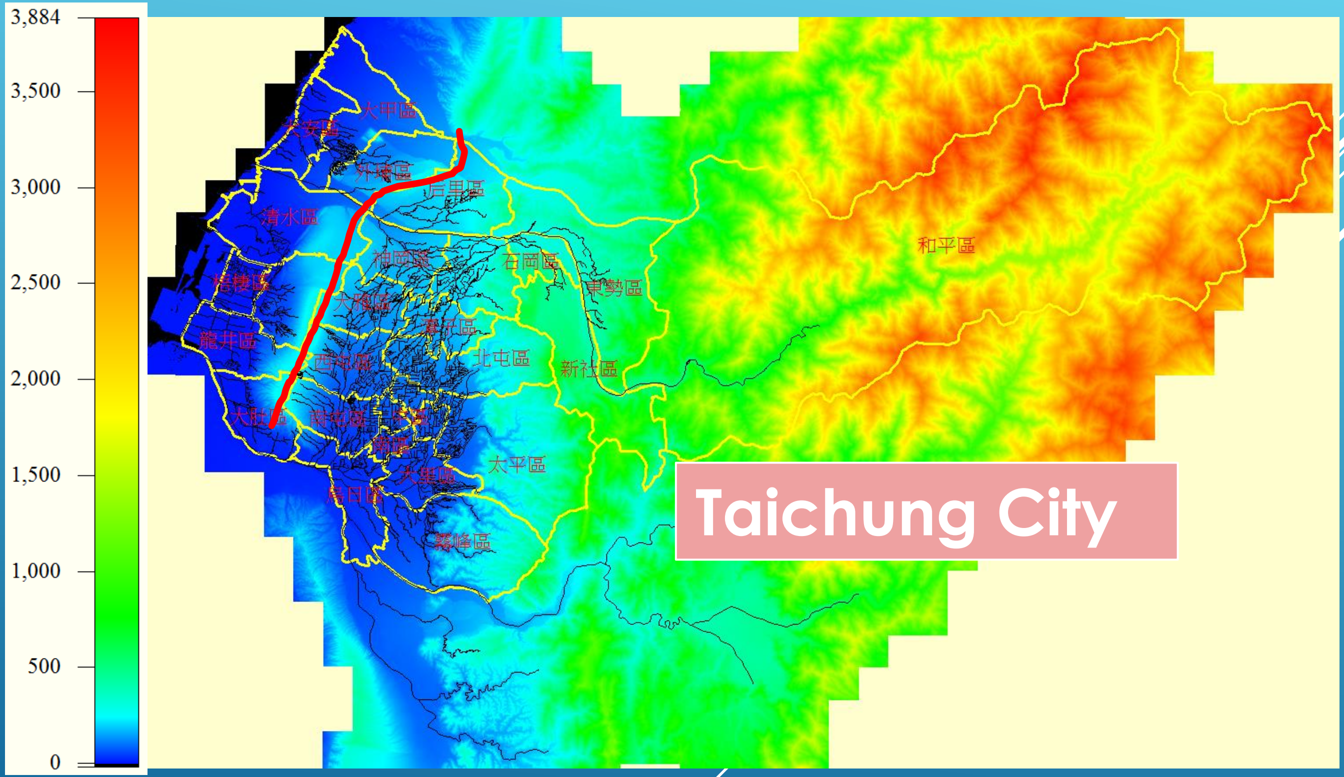
Scheduling of 8 operations in 24 hours



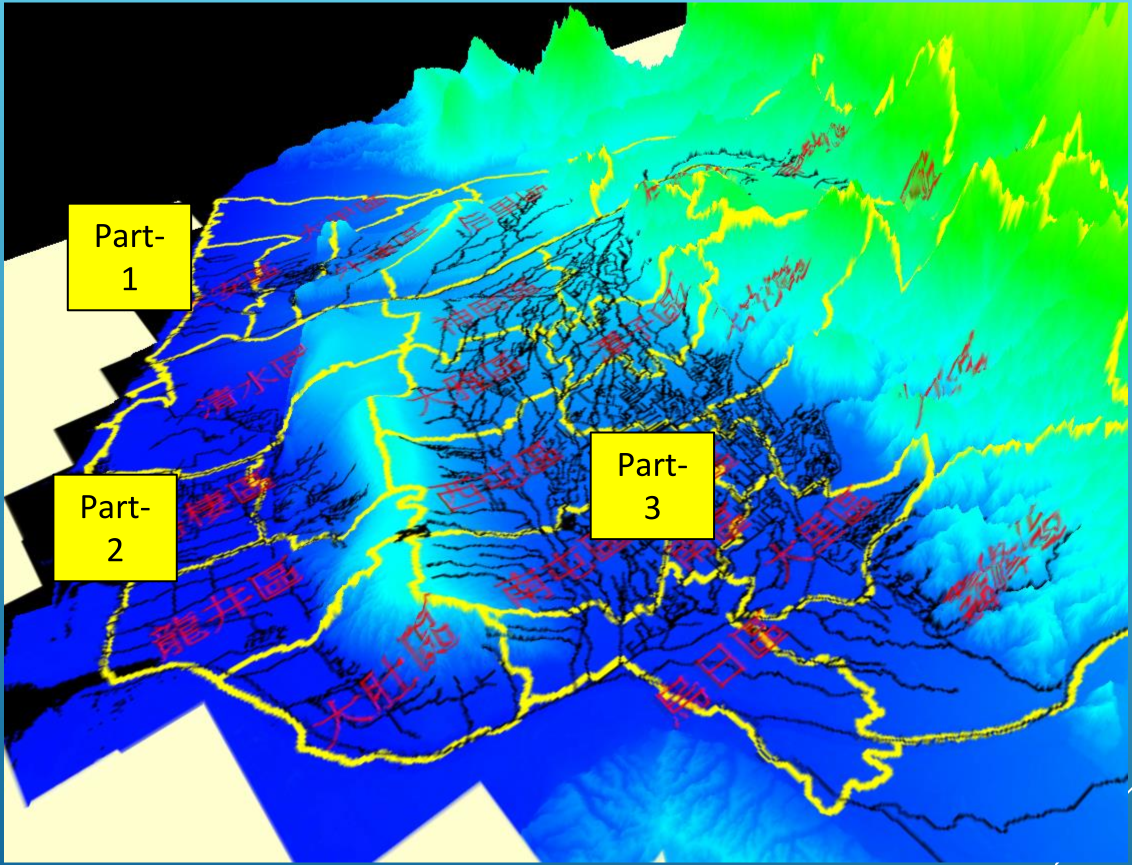
Each operation cover past 3-6 hrs, running 2 hrs, nowcast 6 hrs, total **12-15 hrs.**

MC+FSS with Smart Partitioning

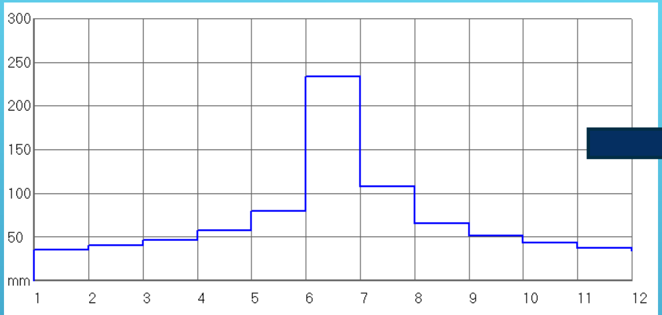




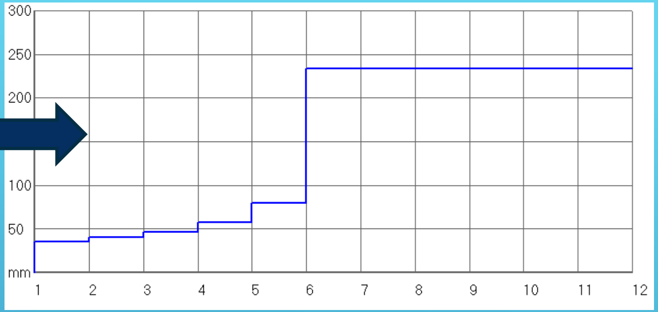
3,884
3,500
3,000
2,500
2,000
1,500
1,000
500
0
大甲區
大安區
清水區
梧棲區
龍井區
大肚區
神岡區
大雅區
潭子區
西屯區
北屯區
石岡區
東勢區
新社區
和平區
太平區
大里區
烏日區
霧峰區
南區
Taichung City


Part-1
Part-2
Part-3
清水區
龍井區
大肚區

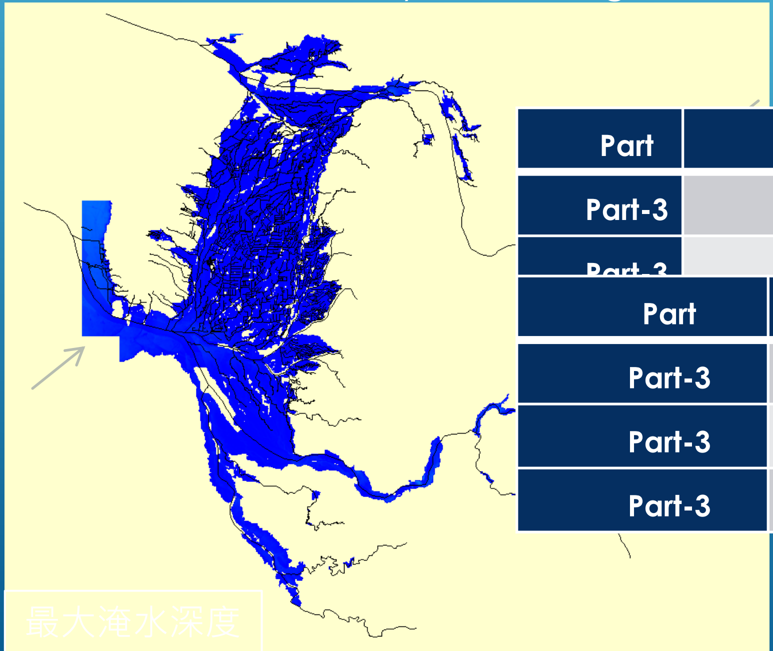
Part-3



500 yr 12hr design event



Increase rainfall intensity

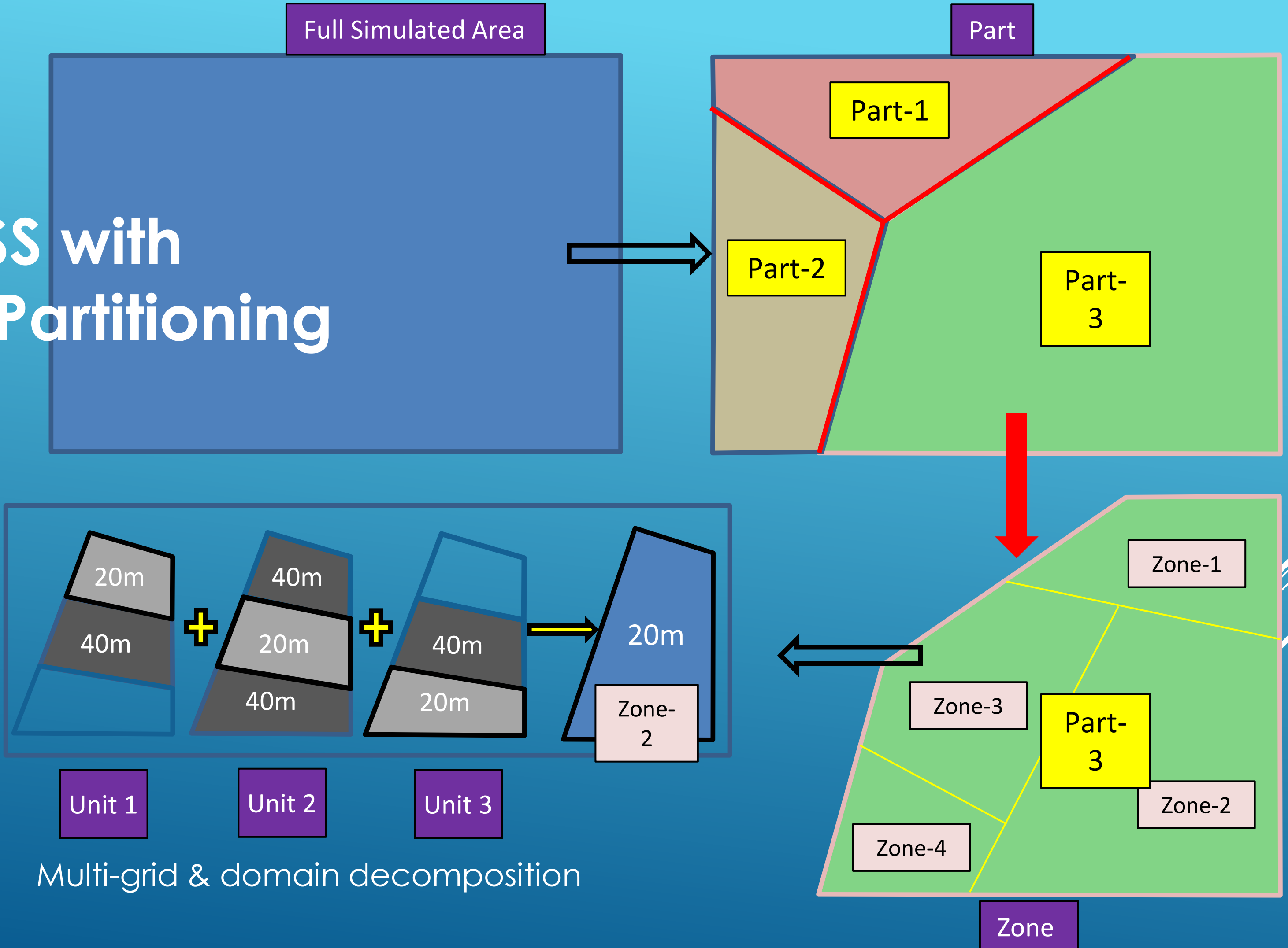


Part	Grid Type	10m	20m	40m	80m
Part-3	Active cell	3,857,964	884,925	221,224	59,264
Part-3	Total cell	17,579,598	4,081,515	1,021,416	255,672

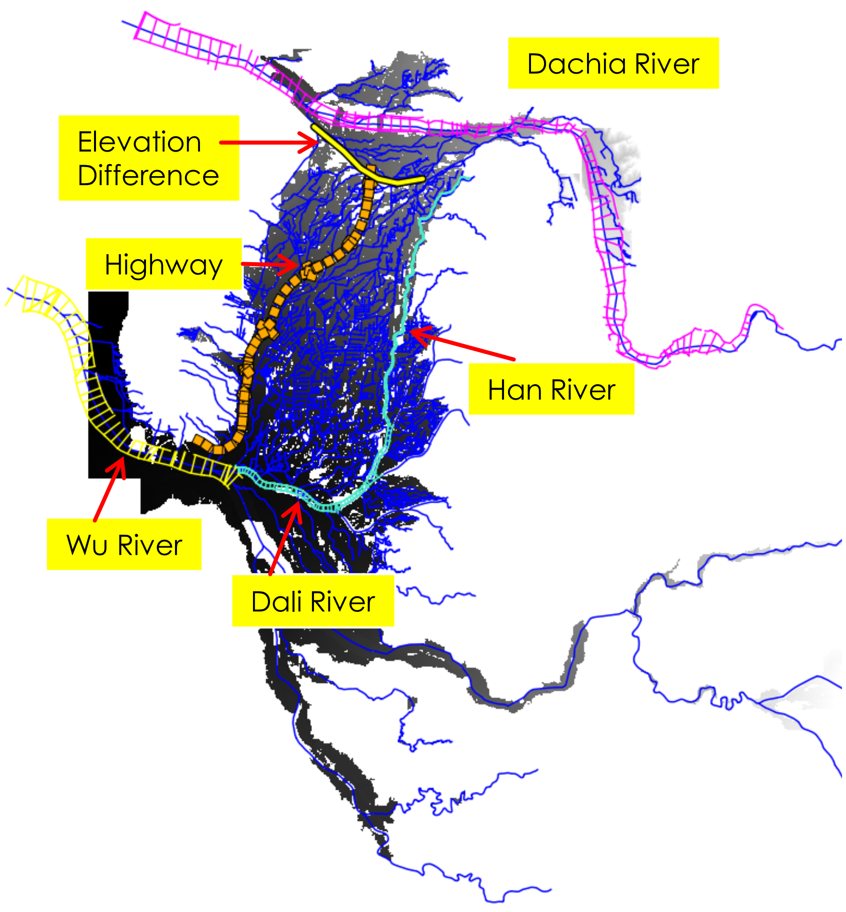
Part	Resolution	CPU time (sec)	Area of Max Flood (km²)
Part-3	20m	32,816 (>9hrs)	140.81
Part-3	40m	11,529 (>3hrs)	168.81
Part-3	80m	3,644 (1hr)	178.17

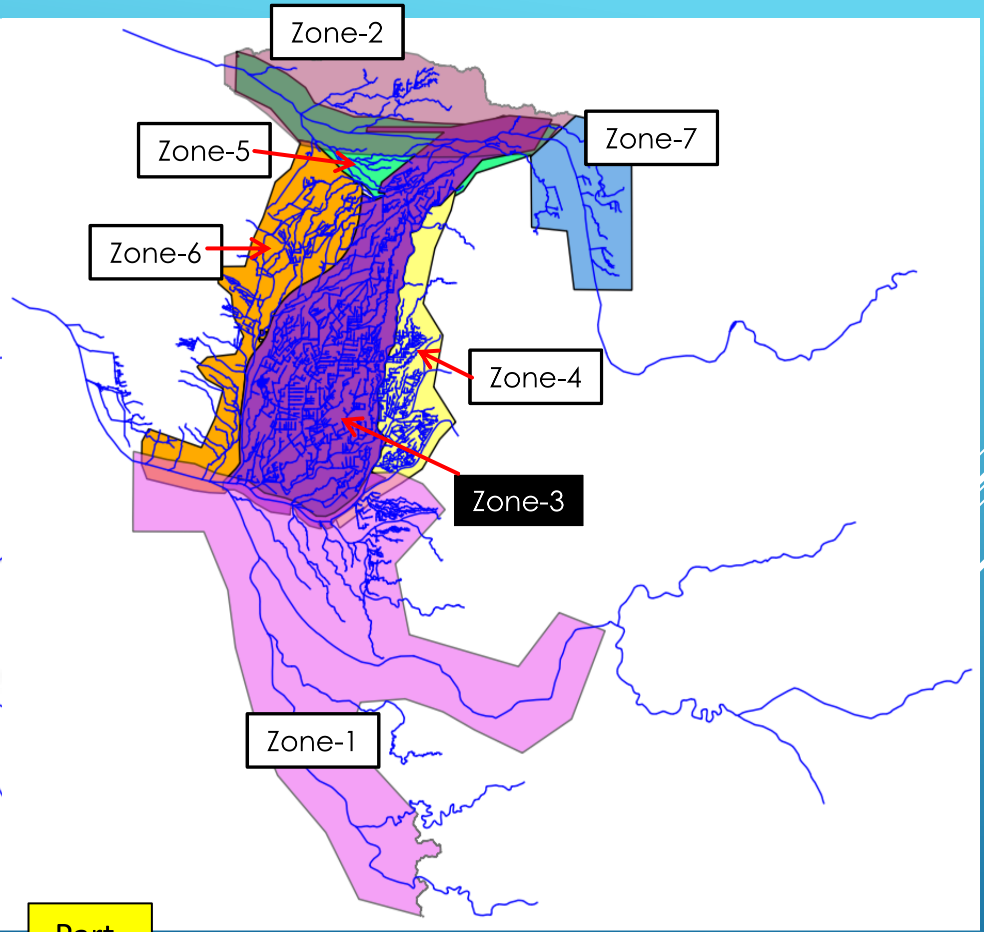
Intel® Core™ i7-3770K CPU @ 3.50GHz

MC+FSS with Smart Partitioning



Multi-grid & domain decomposition


Dachia River
Elevation Difference
Highway
Han River
Wu River
Dali River


Zone-2
Zone-5
Zone-7
Zone-6
Zone-4
Zone-3
Zone-1

Part-3

Zone	Compare with	Flood Area Correct Coefficient	Flood Depth Error (m)
Zone-1 (20m)	Part-3 (20m)	0.9361	0.0174
Zone-2 (20m)	Part-3 (20m)	0.9496	0.0114
Zone-3 (20m)	Part-3 (20m)	0.9682	0.0201
Zone-4 (20m)	Part-3 (20m)	0.9233	0.0261
Zone-5 (20m)	Part-3 (20m)	0.9999	0.0002
Zone-6 (20m)	Part-3 (20m)	0.9776	0.0163
Zone-7 (20m)	Part-3 (20m)	0.9990	0.0000

Flood Area Correct Coefficient

$$A_a = \frac{A_c}{A_f + A_o - A_c}$$

A_f : Simulation of total Part 3 as reference, A_o: Zone simulation, A_c:intersection of A_f and A_o ,

Flood Depth Error

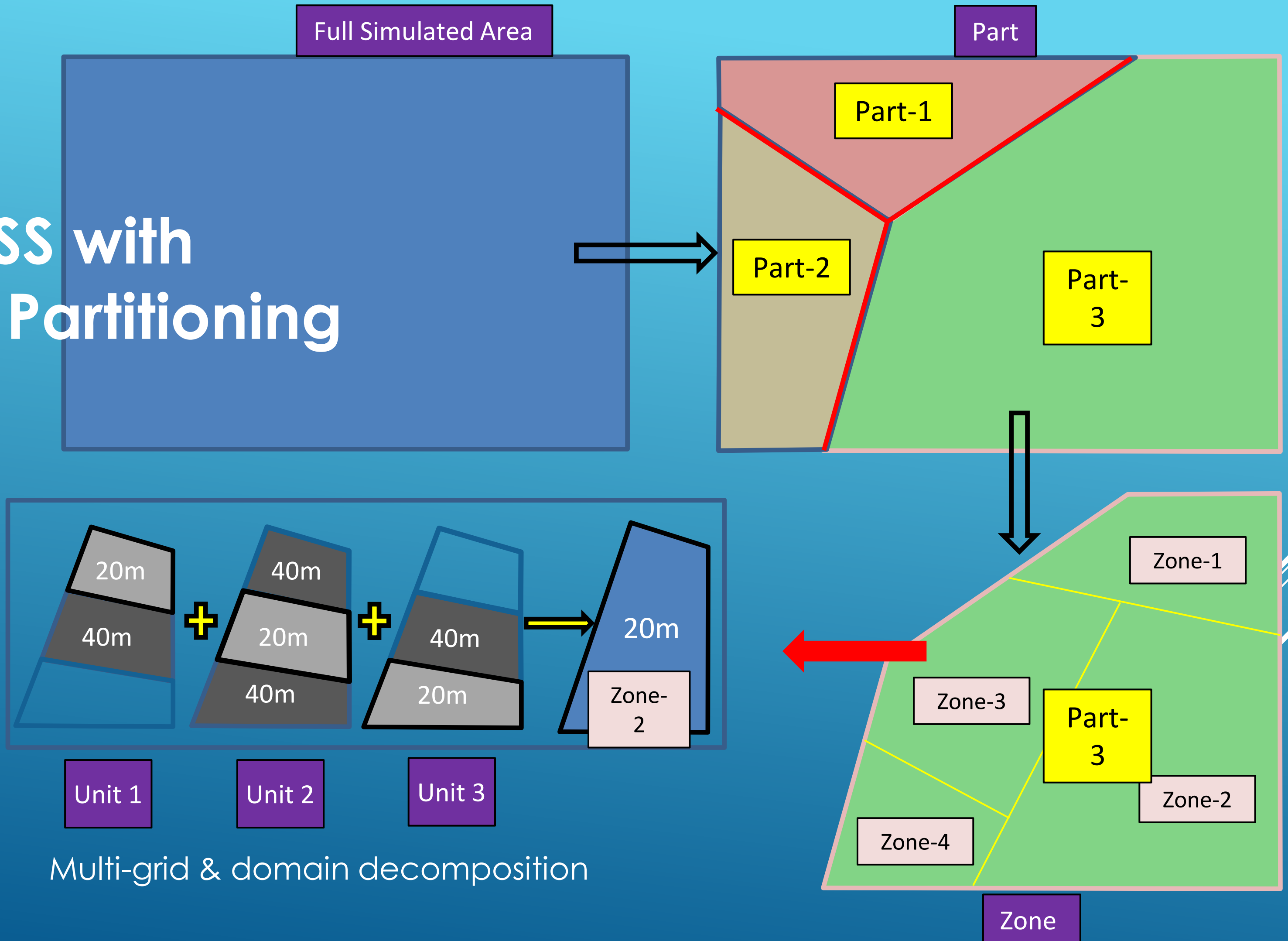
$$D_a = \frac{\sum_{i=1}^{n} |D_o(i) - D_f(i)| * A_i}{\sum_{i=1}^{n} A_i}$$

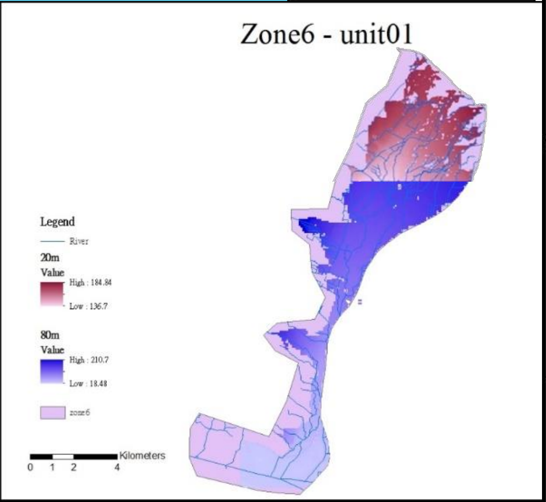
D_f: Simulation of total Part 3 as reference ； D_o: Zone simulation ； A_i:area

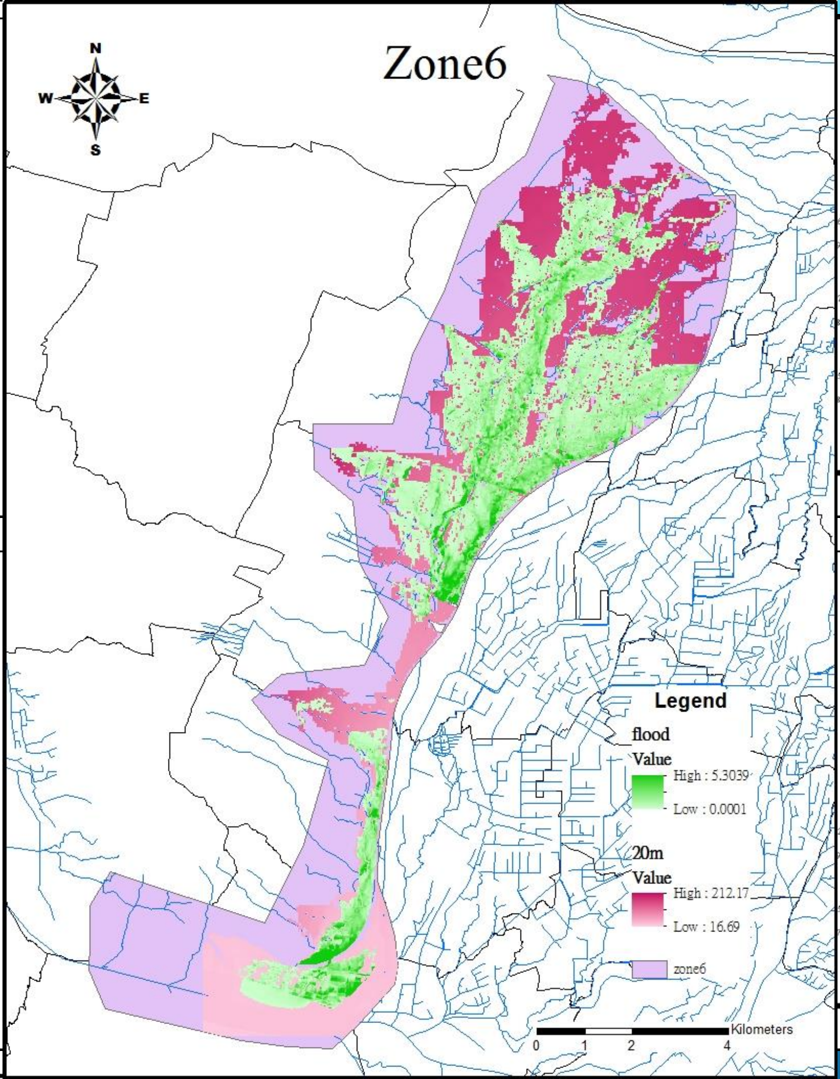
	Resolution (m)	CPU Time (sec)	Active cell	Total cell
Zone-1	20	8,572 (>2 hrs)	298,326	1,629,450
Zone-2	20	3,819 (>1 hrs)	78,115	252,510
Zone-3	20	13,773 (>3 hrs)	318,070	1,164,240
Zone-4	20	3,500 (1 hrs)	50,513	359,074
Zone-5	20	3,847 (>1 hrs)	89,762	423,508
Zone-6	20	6,688 (>1.5 hrs)	114,932	549,328
Zone-7	20	2,424 (>0.5 hrs)	58,843	94,240

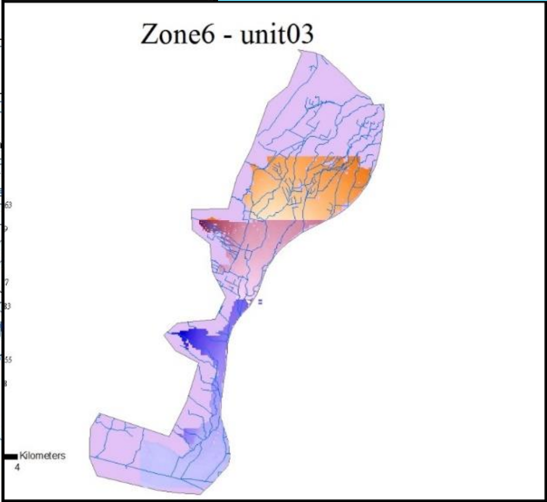
Intel® Core™ i7-3770K CPU @ 3.50GHz

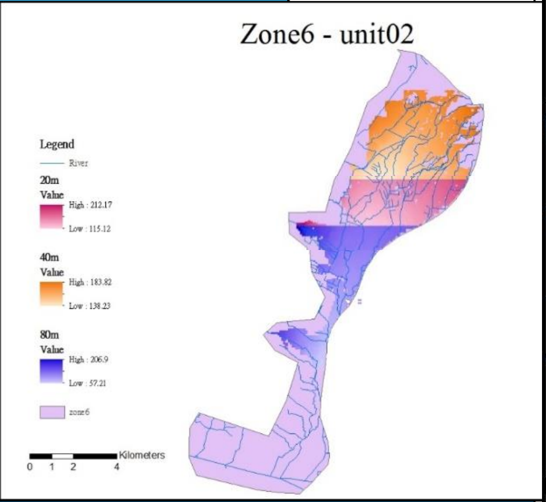
MC+FSS with Smart Partitioning

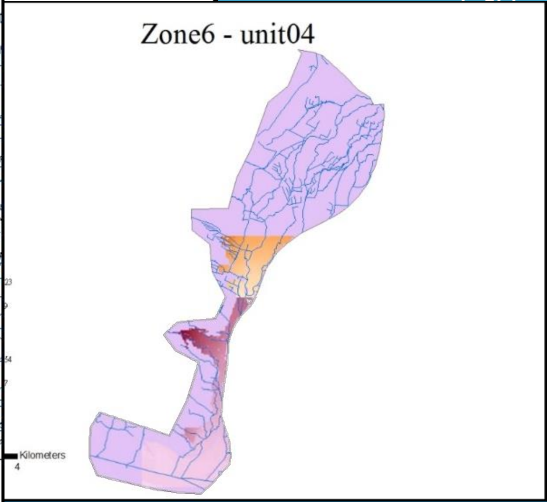



Zone6 - unit01
Legend
River
20m
Value
High : 184.84
Low : 136.7
80m
Value
High : 210.7
Low : 18.48
zone6
Kilometers
0 1 2 4

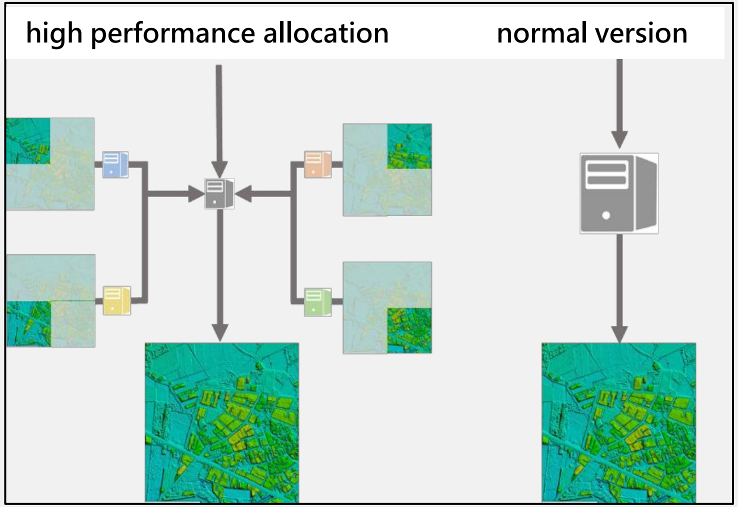

Zone6
N
S
W
E
Legend
flood
Value
High : 5.3039
Low : 0.0001
20m
Value
High : 212.17
Low : 16.69
zone6
Kilometers
0 1 2 4

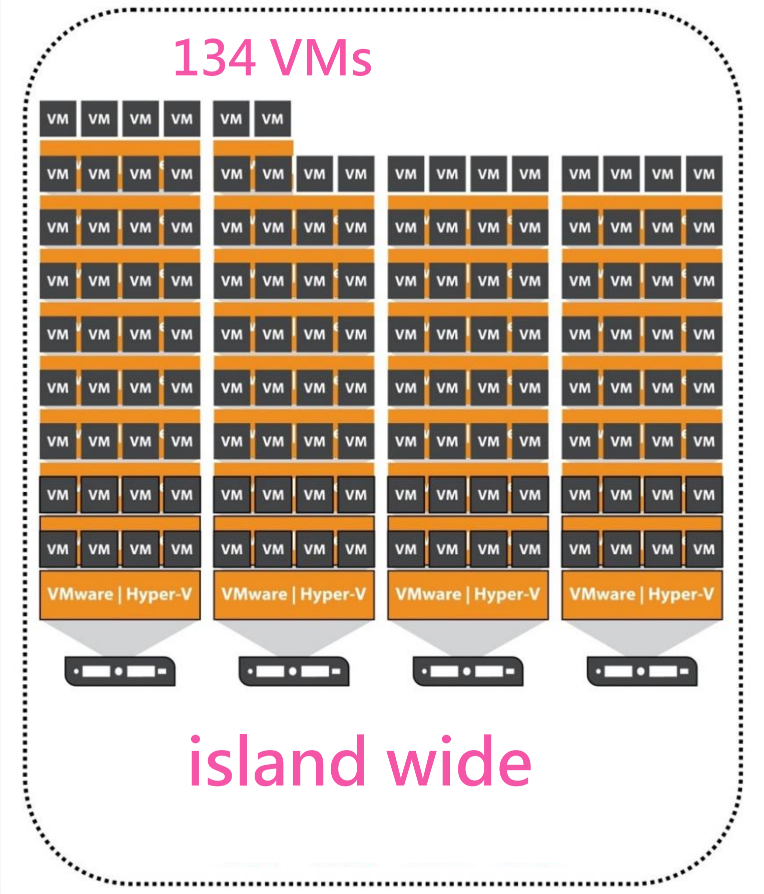

Zone6 - unit03
Kilometers
4


Zone6 - unit02
Legend
River
20m
Value
High : 212.17
Low : 115.12
40m
Value
High : 183.82
Low : 138.23
80m
Value
High : 206.9
Low : 57.21
zone6
Kilometers
0 1 2 4


Zone6 - unit04
Kilometers
4

FAST, Flood Aware Simulation - Taiwan





A Case Study for the Application of an Operational Two-Dimensional Real-Time Flooding Forecasting System and Smart Water Level Gauges on Roads in Tainan City, Taiwan. Water, Apr., 2018, 10(5),574.

Improving the Computational Performance of an Operational Two-Dimensional Real-Time Flooding Forecasting System by Active-Cell and Multi-Grid Methods in Taichung City, Taiwan., Water, Mar., 2018, 10(3),319.

03

IoW

Sensor-based Water Resources Operating Platform with Internet of Things

Flood Sensors


吉城
黃金
珠寶
五金
百貨
文具
玩具
禮品
美容
金吉城黃金珠寶銀樓
10
元の店
大苑子
鮮茶


Lalu Island
Lalu Island
Lane 516, Sec 2, Yi
1
Sec 2, Yi An Rd.
1
Sec 2, Yi An Rd.
Tong An Rd.
Sec 1, An Jhong Rd.
安中站
An-Jhong Station
Alley 6, La
1
Tong An Rd.
Lane 387, Tong An Rd.
Sec 1, An
bing
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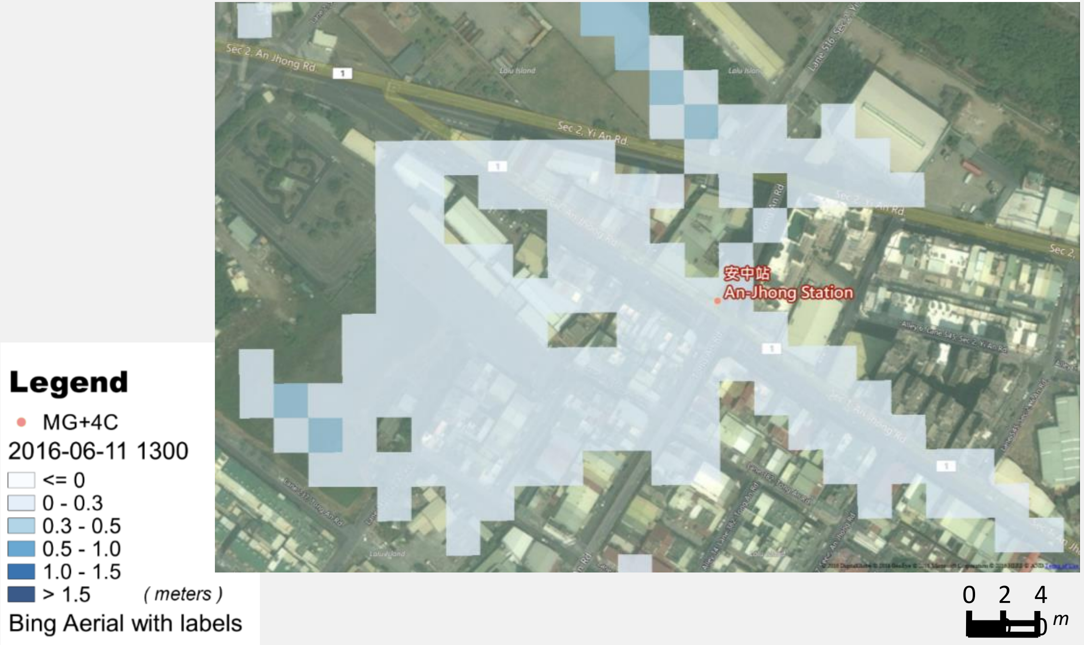
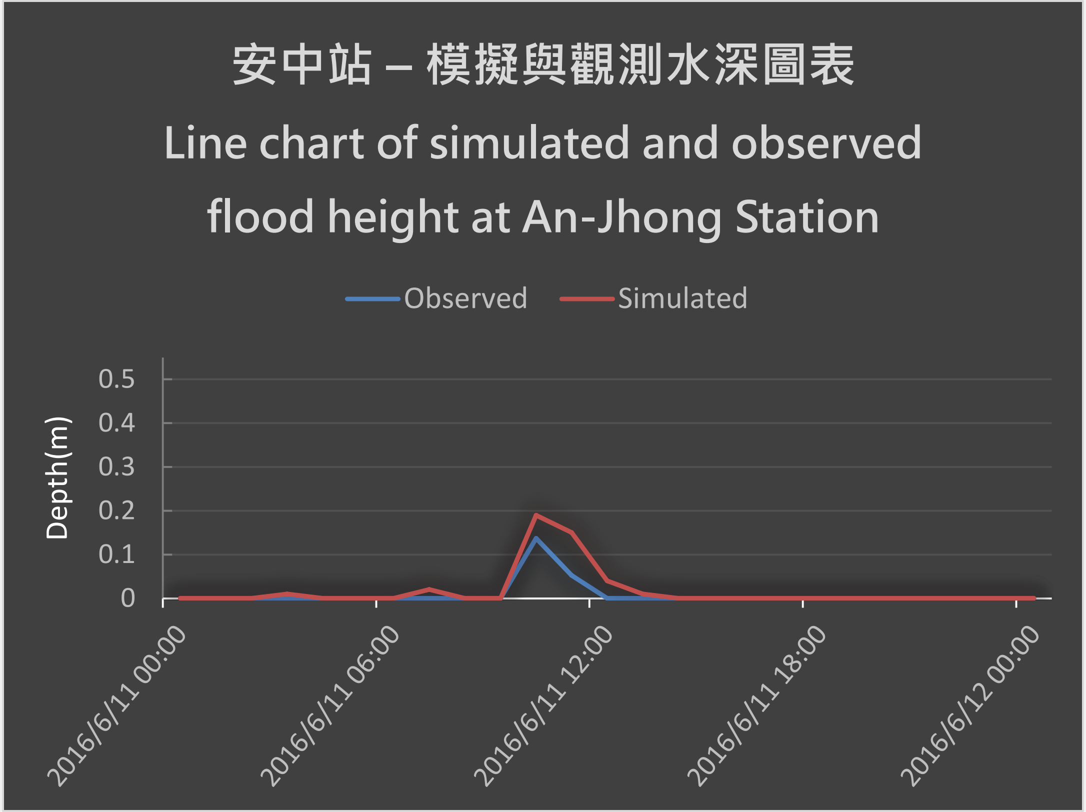
安中站淹水範圍套疊
Flood Grid at An-Jhong Station




安中站 – 模擬與觀測水深圖表
Line chart of simulated and observed flood height at An-Jhong Station
Observed
Simulated
Depth(m)
0.5
0.4
0.3
0.2
0.1
0
2016/6/11 00:00
2016/6/11 06:00
2016/6/11 12:00
2016/6/11 18:00
2016/6/12 00:00


朝皇宮站
Chao-Huang-Gong Station
Hai Jhong St.
Lane 101, Hai Jhong St.
Lalu Island
Lalu Island
Lane 483, Sec 2, Hai Dian Rd.
Alley 57, Lane 32, Hai Huan St.
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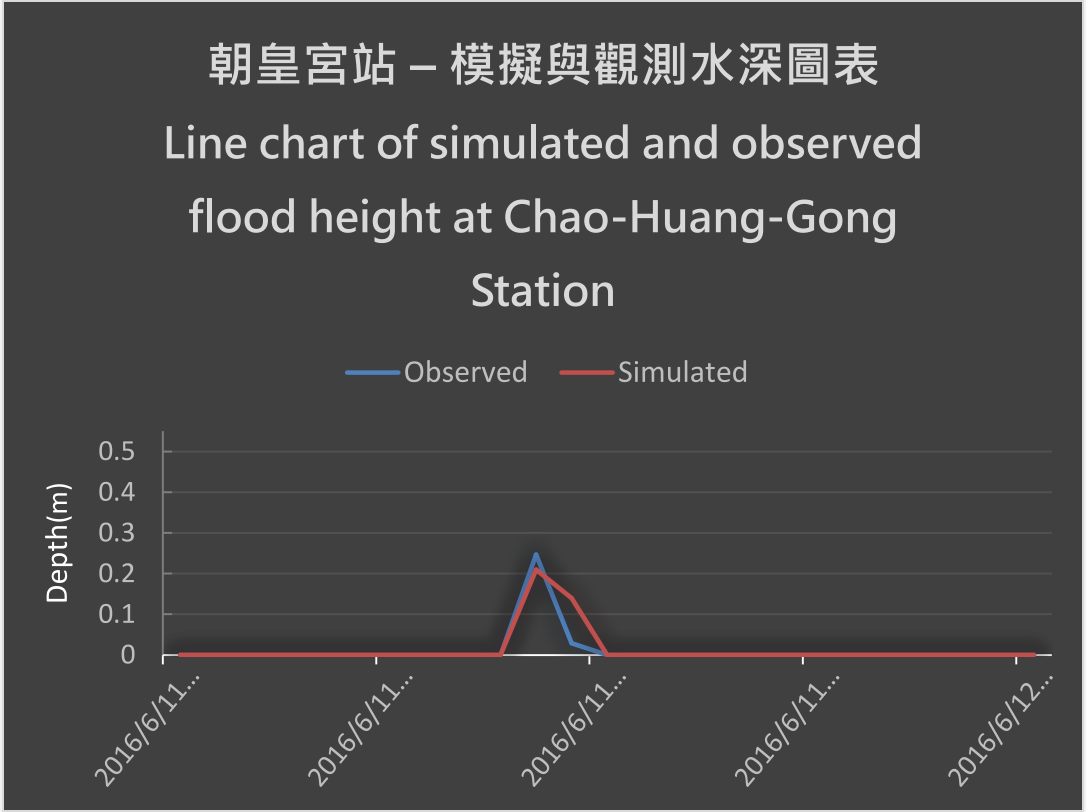
朝皇宮站淹水範圍套疊
Flood Grid at Chao-Huang-Gong Station


朝皇宮站 – 模擬與觀測水深圖表
Line chart of simulated and observed flood height at Chao-Huang-Gong Station
Observed
Simulated
Depth(m)
0.5
0.4
0.3
0.2
0.1
0
2016/6/11...
2016/6/11...
2016/6/11...
2016/6/11...
2016/6/12...

20160611 event

16 gauges，12 in operation

8 matched

20160611 event	SOBEK	Observation
長和二站	X	X
龍金站	X	N/A
安和站	X	N/A
溪頂寮站	X	●
媚儷站	X	X
頂安站	X	●
安中站	●	●
海佃豪宅站	●	X
朝皇宮站	●	●
海佃三段站	●	X
公學站	X	N/A
總頭里站	X	X
海佃四站	●	●
金格站	X	X
安中五站	X	X
安中六站	X	N/A

X 為實際無淹水情況發生；● 為實際淹水發生

2016 Typhoon Megi (09/27-09/28)

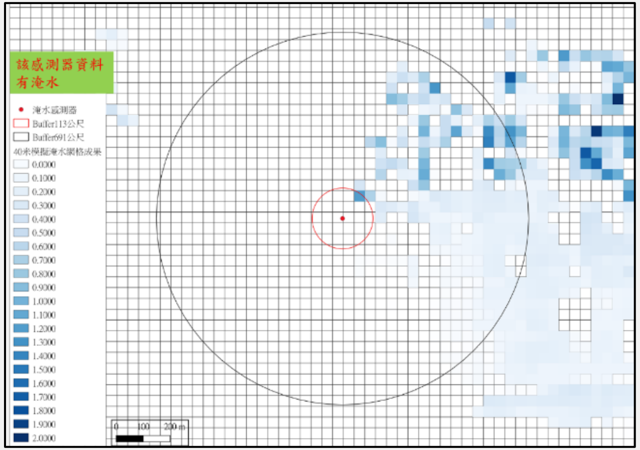
16 gauges，6 in operation

6 matched

2016 Typhoon Megi	SOBEK	Observation
長和二站	●	N/A
龍金站	●	●
安和站	X	N/A
溪頂寮站	●	N/A
媚儷站	●	N/A
頂安站	●	●
安中站	●	●
海佃豪宅站	●	N/A
朝皇宮站	●	N/A
海佃三段站	●	●
公學站	X	N/A
總頭里站	●	●
海佃四站	●	N/A
金格站	●	N/A
安中五站	●	●
安中六站	●	N/A

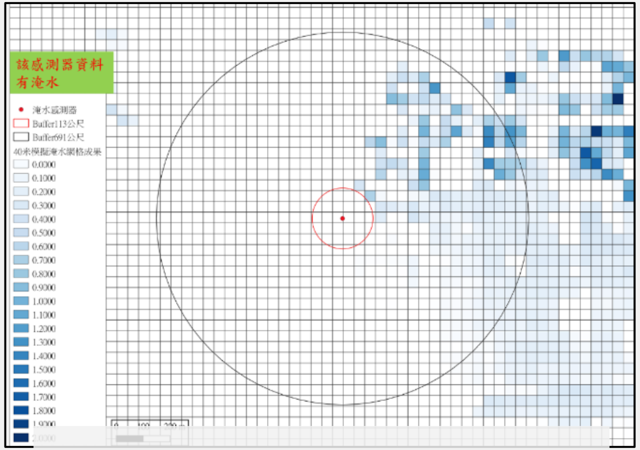
Scale of Spatial Unit

Community Level 118m



Hit in Community Level

Village Level 691m



Hit in Village Level

2021- hit rate in village level

	City/County	Hit Rate
0604 event	彰化縣	60%
	雲林縣	36%
	嘉義縣	0%
	台南市	74%
	高雄市	70%
	屏東縣	80%

2021- hit rate in village level

	City/County	Hit Rate
0730 event	彰化縣	64%
	雲林縣	82%
	嘉義縣	70%
	台南市	79%
	高雄市	50%
	屏東縣	88%

2021- hit rate in village level

	City/County	Hit Rate
0805 Typhoon Lupit	彰化縣	41%
	雲林縣	83%
	嘉義縣	78%
	台南市	67%
	高雄市	67%
	屏東縣	88%

Singnal Detection Theory

	Flood simulated	Non-flood simulated
Flood observed	Q1 (Hit)	Q2 (Miss)
Non-flood observed	Q3 (False Alarm)	Q4 (Correct Rejection)
Hit rate: (Q1/Q1+Q2)		
False Alarm rate: (Q3/Q3+Q4)		
Correct rate: (Q1+Q4/Q1+Q2+Q3+Q4))		

04

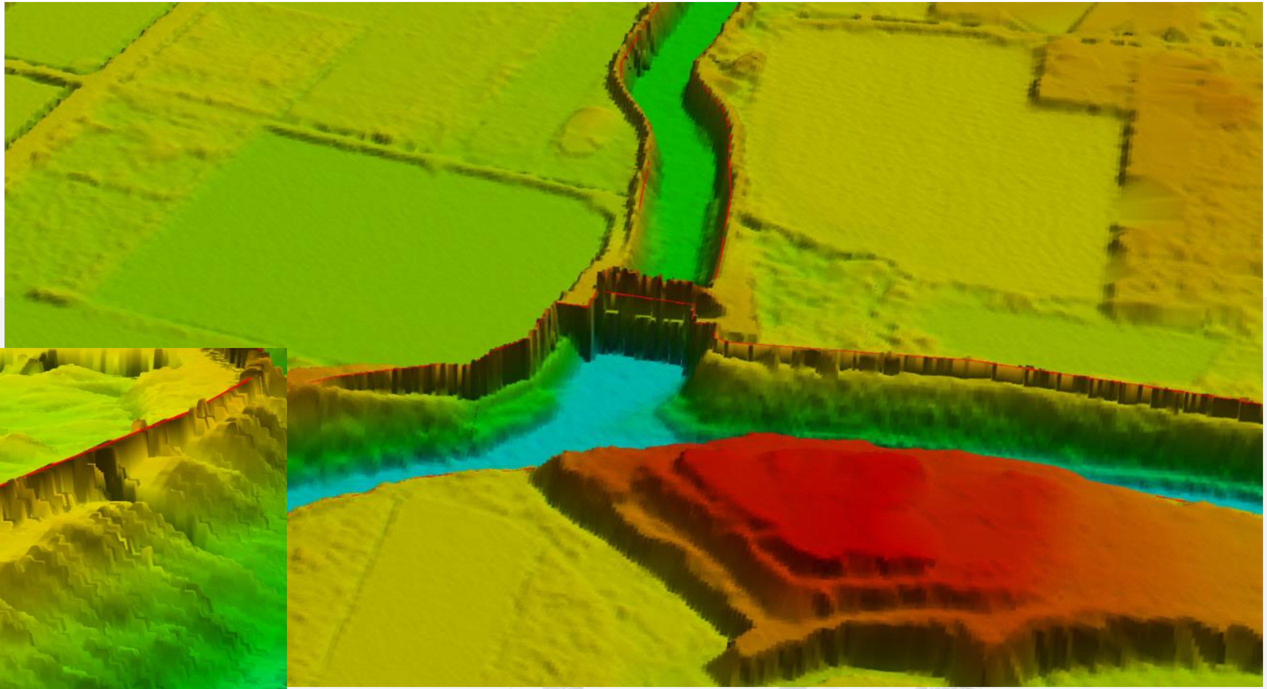
HyDEM

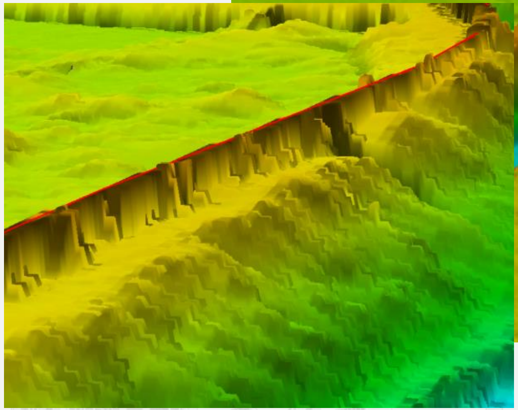
HyDEM

水利數值地形資料應用於細緻化淹水模擬之研究 2016

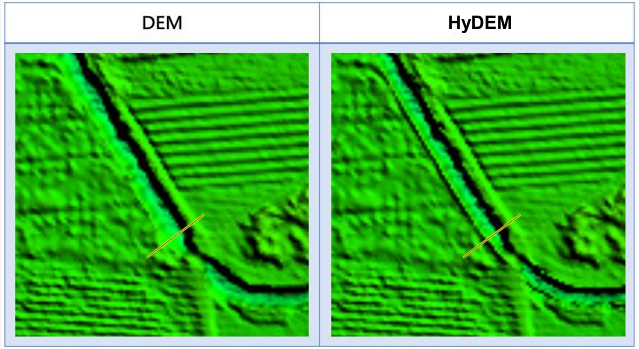
地文資料對區域淹水模擬之影響評估 2017

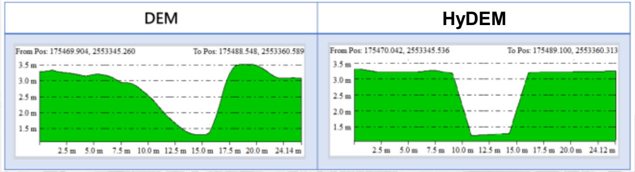
WRPI, Water Resources Planning Institute

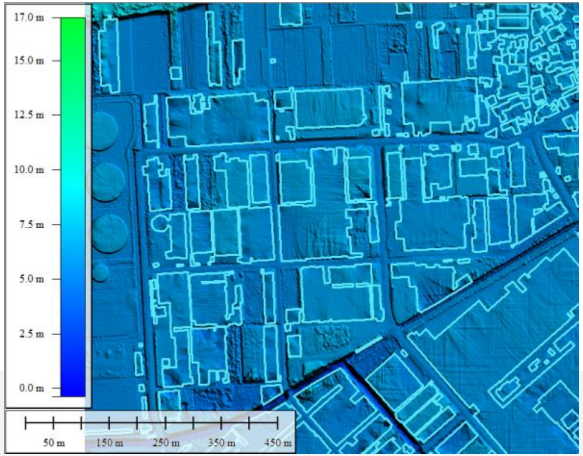


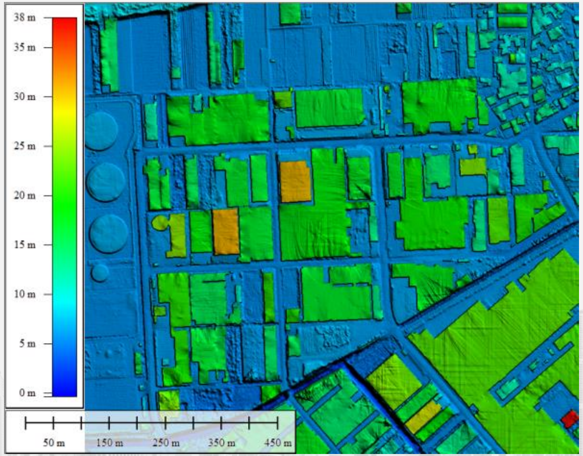


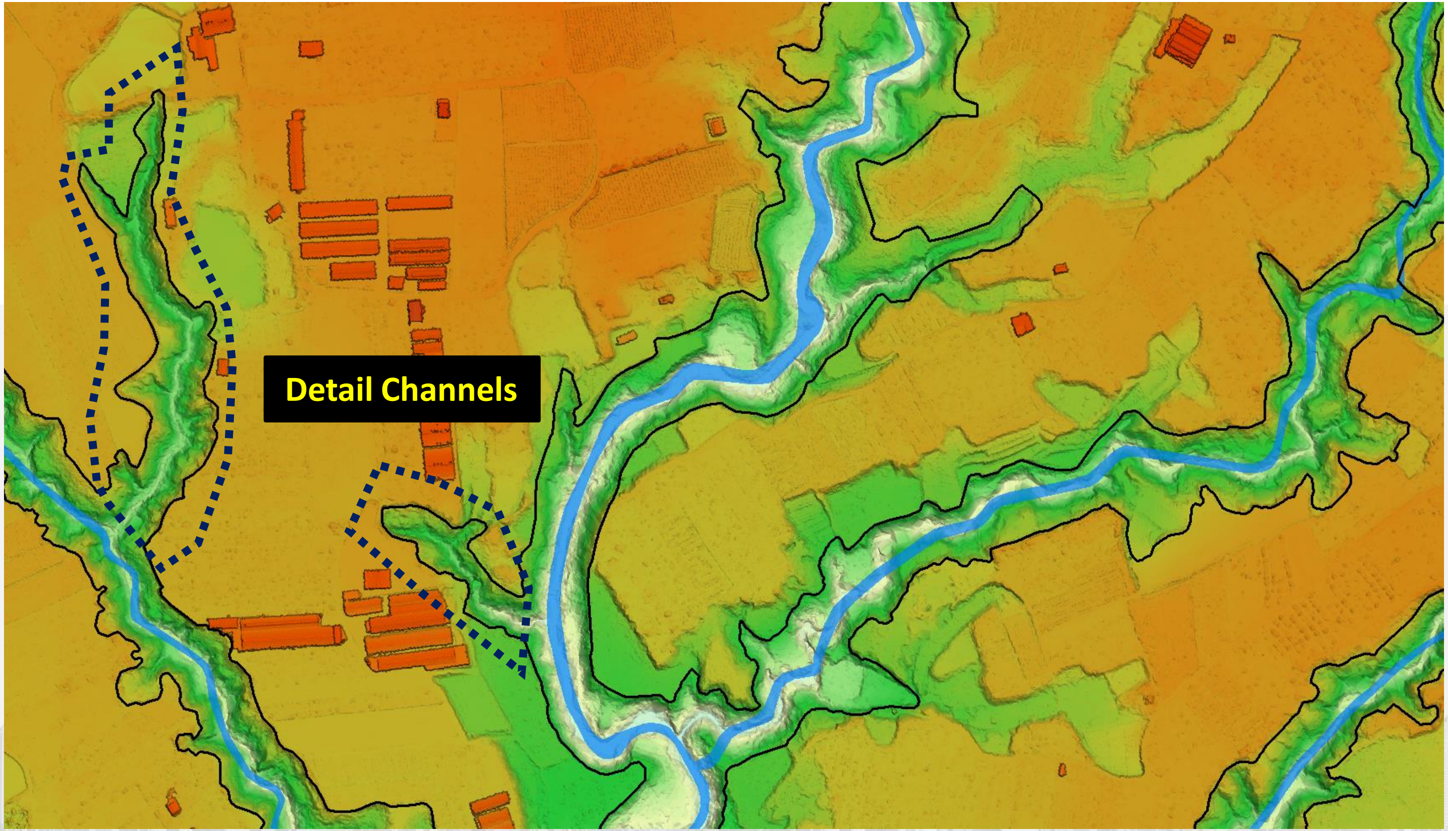
HyDEM - 3D Vectors for Multiple Spatial Resolution



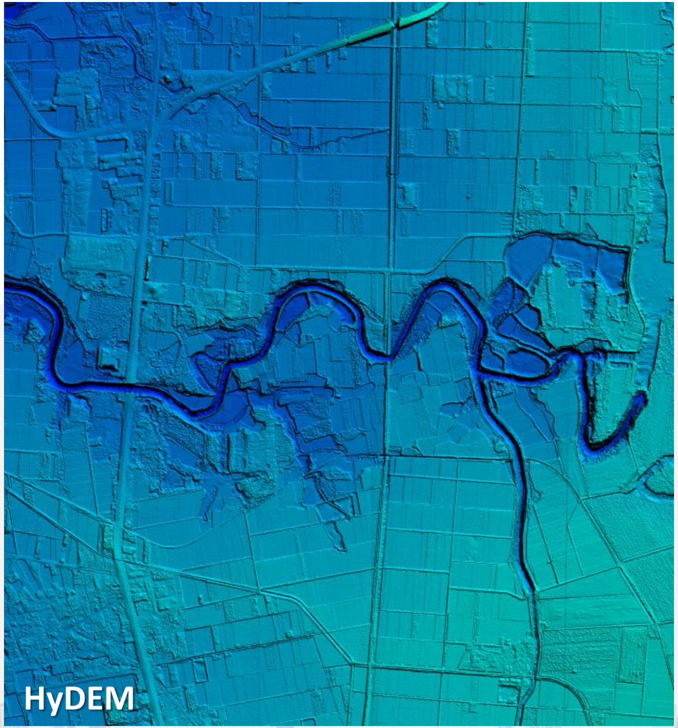


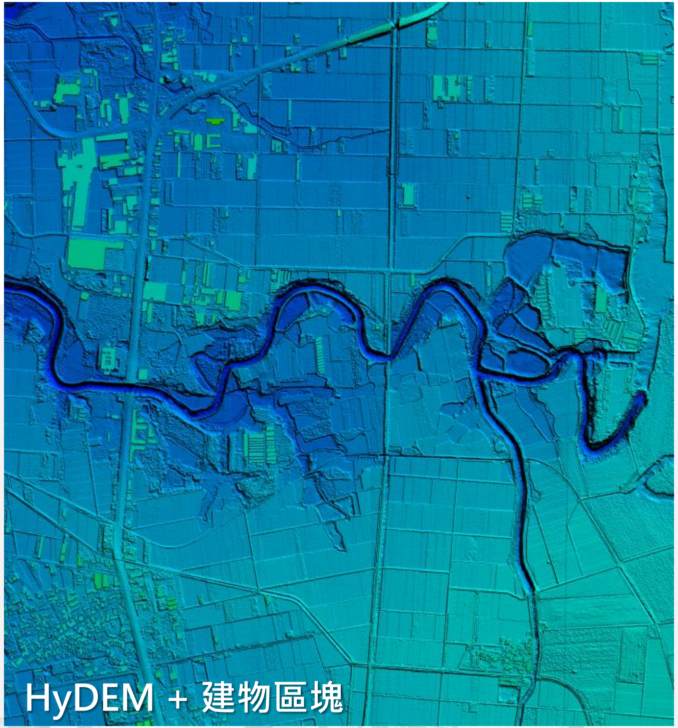





Detail Channels

HyDEM 109年度水利數值地形資料測製與檢核工作案 2020
DLA, Dept. of Land Administration





Detail Channel System Defined

Channel total length

鹽水溪 watershed

Before 533 km (2019 update 43%)

After 574km (2020 update 7.6%)

將軍溪 watershed

Before 180 km

After 788km (2020 update 337%)

二仁溪 watershed

港尾溝 drainage (part of 二仁溪 only)

Before 219 km

After 237km (2020年update 8.2%)

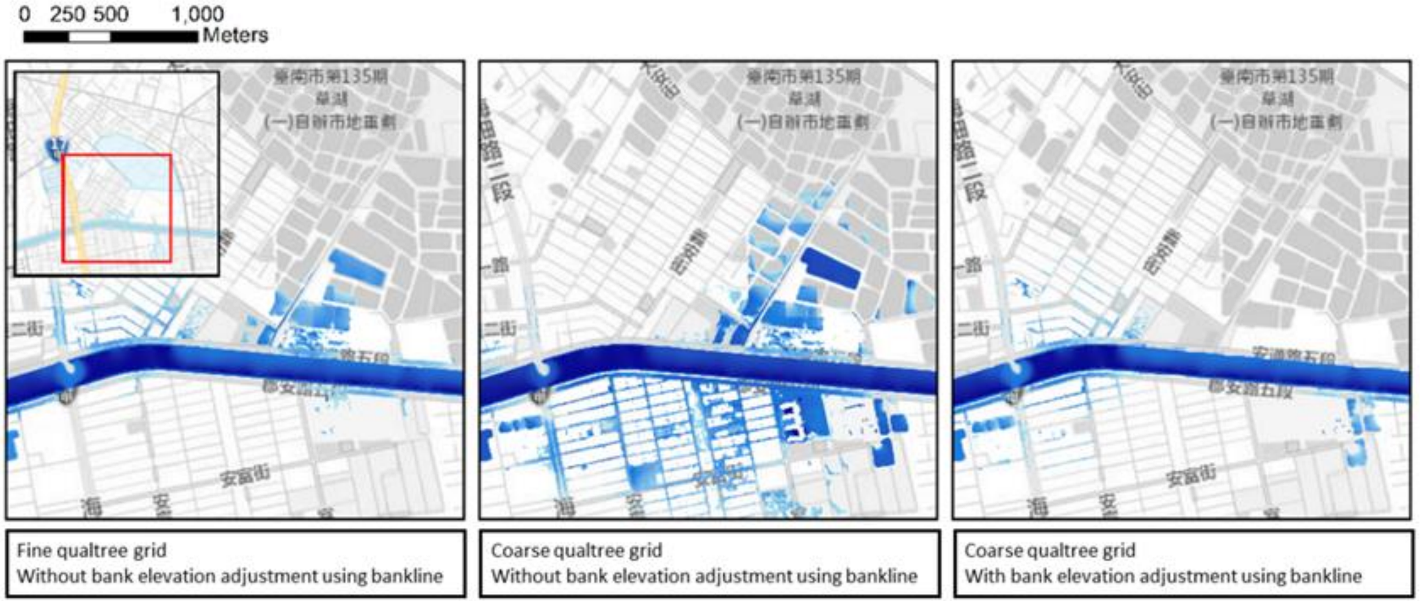
HyDEM 110年度水利數值地形資料檢核與監審工作採購案 2021

NLSC, National Land Surveying and Mapping Center

Cross Section Underwater Integrated

A Balance Performance

- High Resolution Terrain and Less Simulation Time Together



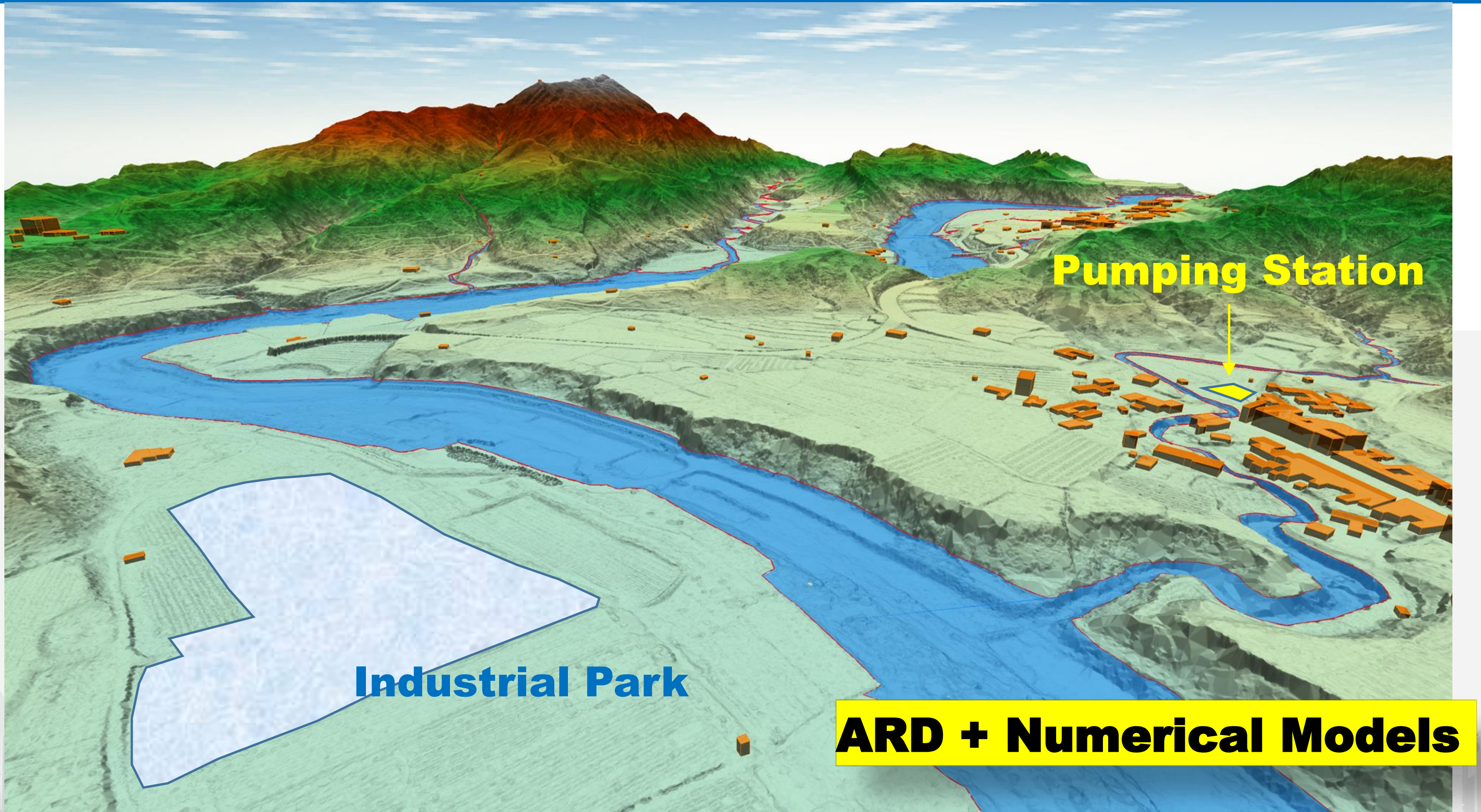
No. of Grids	21,593	: 2,949	(7:1)
Simulation Time	4’30”	: 30”	(9:1)

Hydrological Topography Data Set (HTD)—The Data Set for High Resolution 2D Urban Flood Modeling, Photogrammetric Engineering & Remote Sensing Vol. 88, No. 7, July 2022, pp. 439–450.

05

Hydro-Reality

Hydro-Reality



Digital Governance

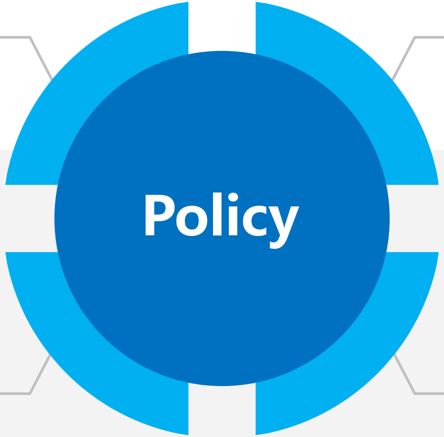
Set up Data Governance Ecosystem

- IoW
- HyDEM

Smart Public Service

- DRD Decision Ready Data

Mitigation, Preparedness, Response, Recovery- Engineering Planning, Design, and Water Resources Distribution



Complete Digital Foundation

- Hydrology and Hydraulics Models
- Interoperation between Organizations
- Analysis Ready Data

Civic Engagement

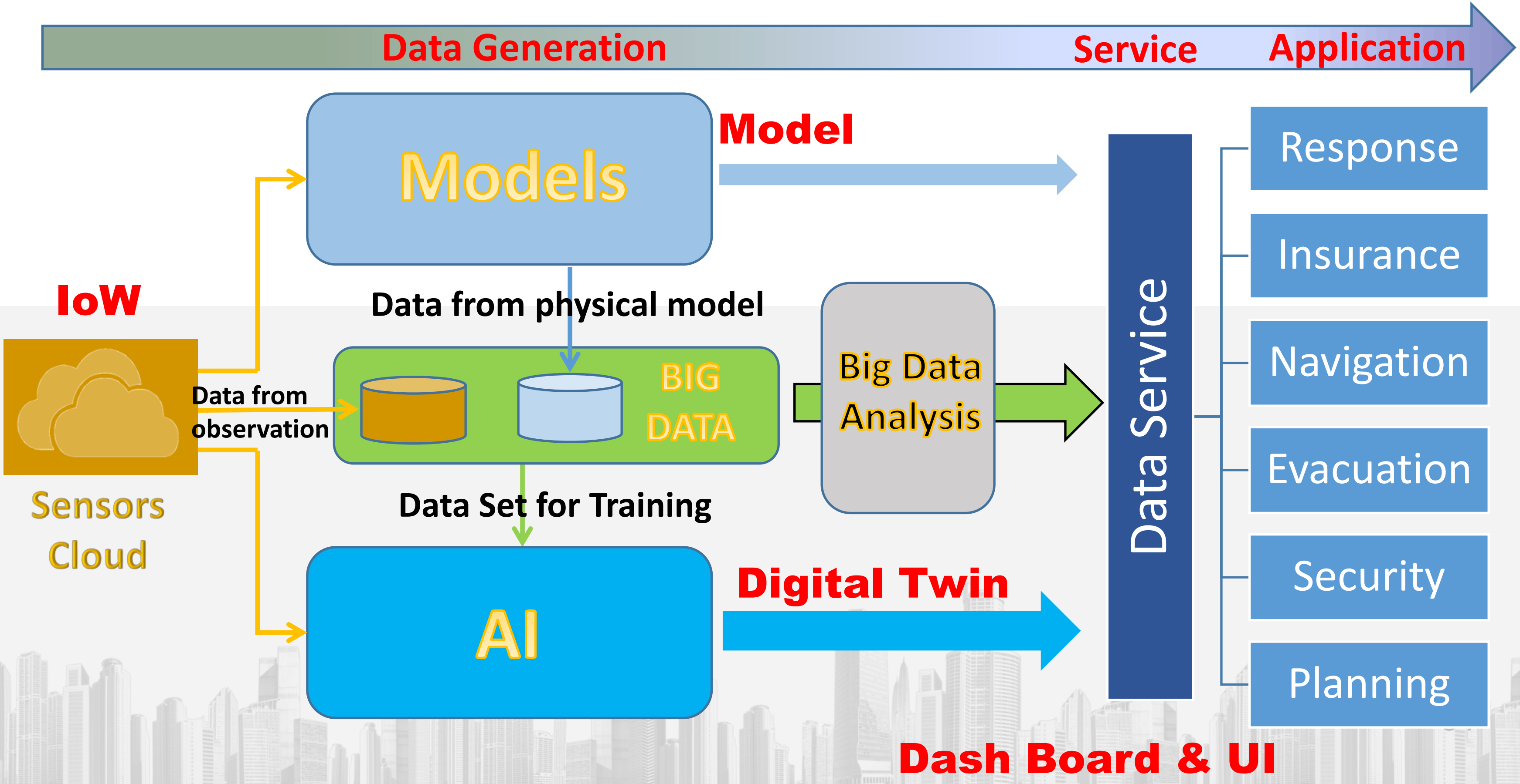
- Volunteer、Public-Private Partnership, Open data and Application

Key Issue

Currently Available

Future Goals

Concept and Planning for Hydro-Reality



謝謝

Thank you