Water Resources Research Center
YEUNGNAM University, Daegu, KOREA

INTEGRATED FLOOD RISK MANAGEMENT

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- FLOOD CHARACTERISTICS
- FLOOD RISK FACTORS
- INTEGRATED FLOOD RISK MANAGEMENT METHODOLOGIES
- INTEGRATED FLOOD RISK MANAGEMENT MEASURES
- BASINWIDE INTEGRATED FLOOD MANAGEMENT PLAN

FLOOD CHARACTERISTICS

➢ Korean River Basin Characteristics

Characteristics of the Rivers in Korea(1/2)

☐ The river reaches are relatively short and channel slopes are relatively steep.

- The river reaches are short and drainage areas are small in Korea compared with other major continental rivers.

- The channel slopes are relatively steep upstream because of steep mountains and deep valleys in the uplands.

☐ Floods occur quickly and peak flood discharges are enormous.

- Due to the topographical conditions and torrential rainfalls, the hydrographs of rivers in Korea are very sharp and peak flood discharges are enormous compared with other comparable rivers in the continent.

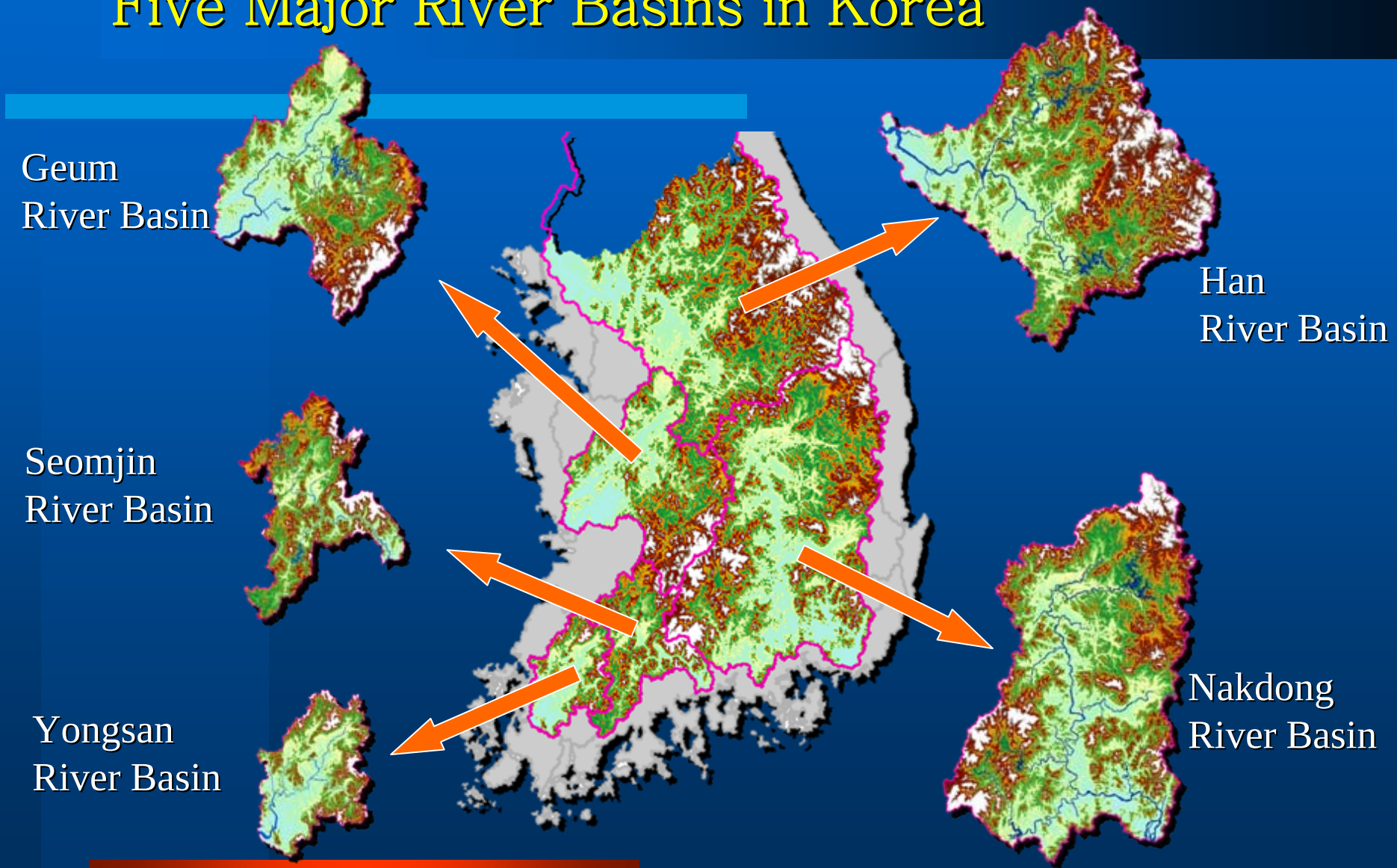
Characteristics of the Rivers in Korea(2/2)

☐ Flow variations are high.

- The coefficients of the river regime, expressed by maximum discharge over minimum discharge for rivers in Korea usually range from 100 up to 700.

- This large variation in the flow discharge causes serious problems in river management concerning flood control and water use.

Five Major River Basins in Korea



➢ Korean River Basin Characteristics

Meteorological Background(1/3)

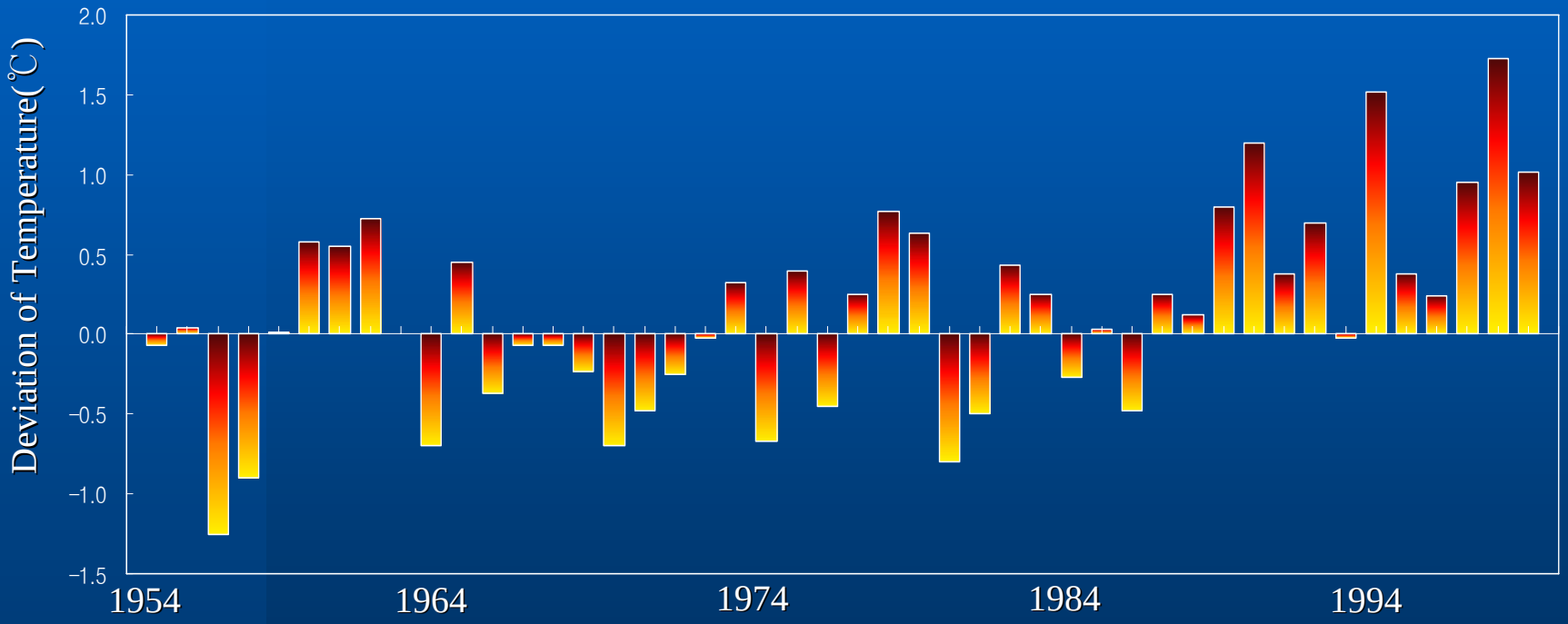
☐ The main typhoon season, which affects Korea, normally runs between June and September. Korea is normally hit directly by 1 to 3 heavy typhoon storms per year with most events occurring in August.

Monthly Variation of Korean Typhoons

Month	Number of Events(1950-2002)	Percentage of Total
June	5	7.5%
July	24	35.8%
August	26	38.8%
September	10	14.9%
October	2	3.0%

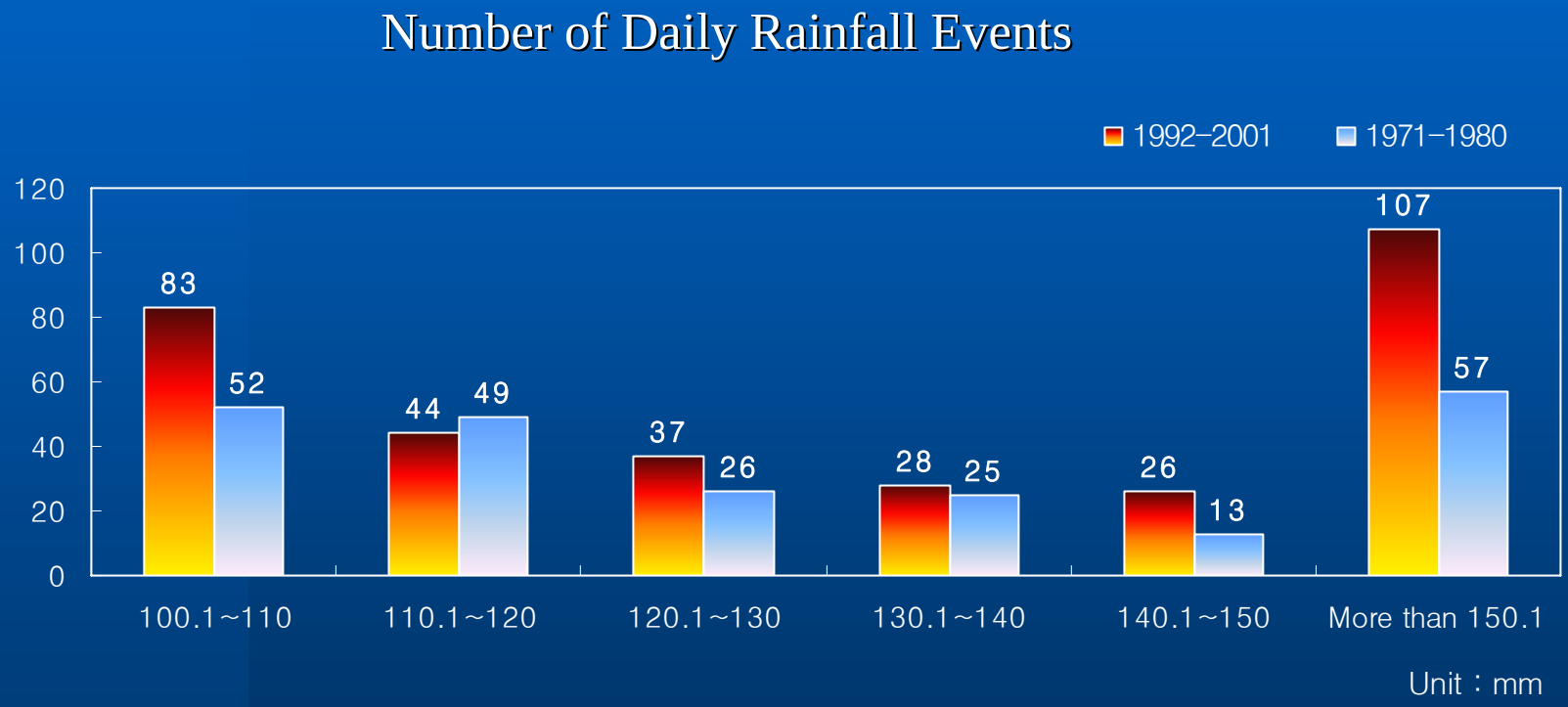
Meteorological Background(2/3)

Over Annual Average Air Temperature



Since late 1980's air temperature has risen significantly, higher than global average.

Meteorological Background(3/3)



Rainfall Intensity has been increased significantly, especially for higher intensity events.

Typhoon Rusa(1/3)

□ Typhoon Rusa Track and Characteristics

- Typhoon Rusa formed in the west Pacific Ocean on 22 August 2002 and strengthened into a typhoon on 24 August while tracking northwest.

- The cyclone tracked northwest toward Okinawa for approximately 8 days before turning toward the Korean Peninsula and subsequently made landfall at approximately 0630Z 31 August near the city of Goheung, Korea, with maximum sustained winds of 65 knots, gusting to 80 knots.

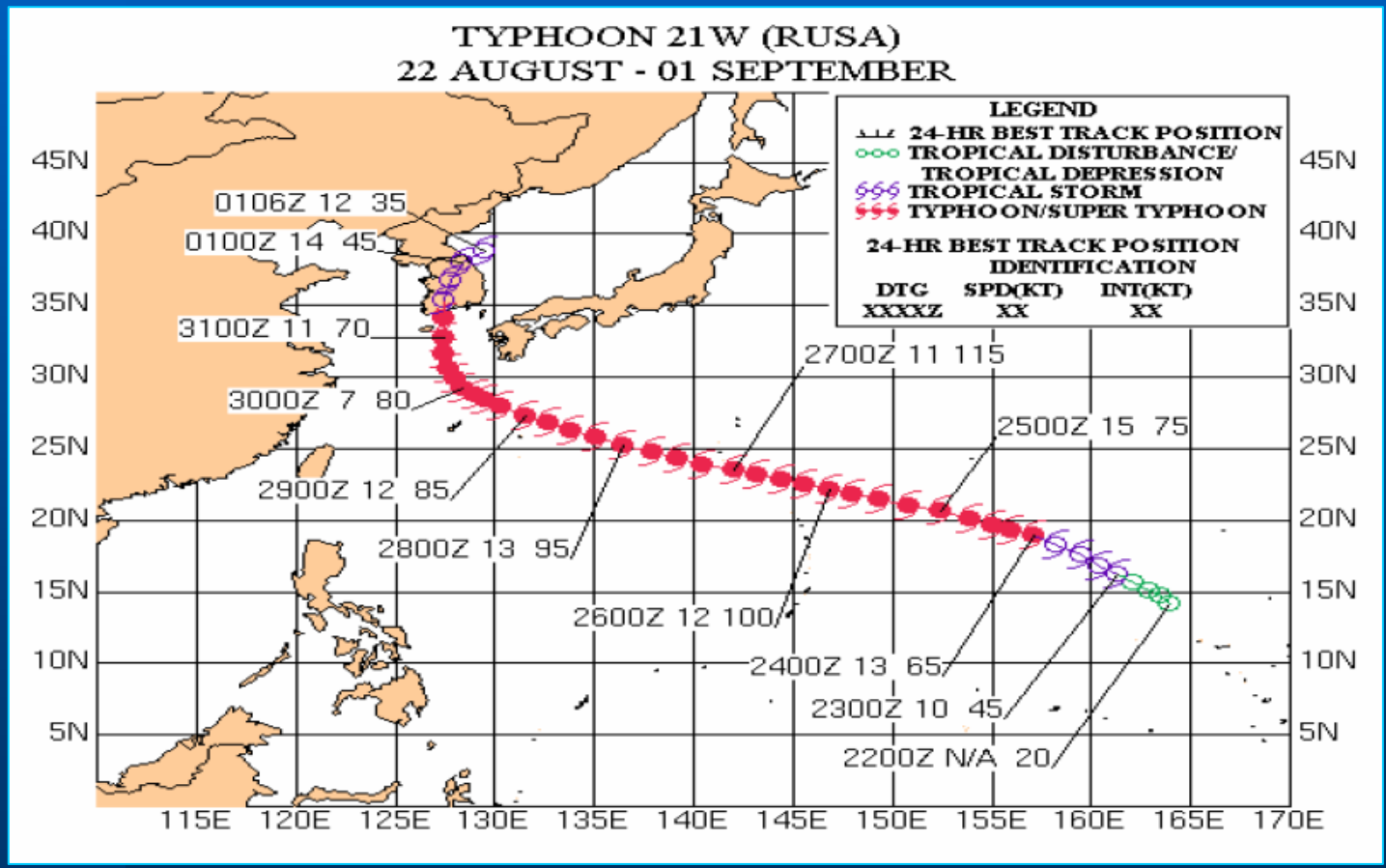
- Rusa reached a peak intensity of 115 knots on 26 August 2002 near the Bonin Islands and maintained this intensity for 24 hours before beginning a slow weakening trend until landfall in Korea.

- During the Rusa, atmospheric pressure maintained at 950hPa and Rusa poured 1.7 times of maximum heavy storms across Korean peninsula.

- Typhoon Rusa caused the death of around 246 people and generated more than USD 5,000 million damage losses with more than 60,000 people

Typhoon Rusa(2/3)

Path of Typhoon Rusa



Typhoon Rusa(3/3)

Maximum Rainfall for Given Durations

Storm Period	Maximum		Second	
	Station	Rainfall(mm)	Station	Rainfall(mm)
Duration 6hr 08/31 20~	Yangyang-kun	403.0	Kangleung	274.5
Duration 12hr 08/31 12~	Kangleung	576.0	Samcheok City Miro-myeon	529.0
Duration 24hr 08/31 01~	Kangleung	880.0	Daekwanryung	739.0
Duration 48hr 08/30 05~	Kangleung	897.5	Daekwanryung	758.8

Flood Damage Pictures by Typhoon Rusa (1/5)

Flooded Urban Area(Hallim-myeon, Gimhae-si, Gyeongsangnam-do)

Flood Damage Pictures by Typhoon Rusa (2/5)

Town and View of Farmland
(Hallim-myeon, Kimhae-si, Kyeongsangnam-do)

Flood Damage Pictures by Typhoon Rusa (3/5)

Broken Levee in Nam River
(Beobsu-myeon, Haman-gun, Kyeongsangnam-do)

Flood Damage Pictures by Typhoon Rusa (4/5)

Destroyed Spillway
(Gangneung-si, Gangwon-do)

Flood Damage Pictures by Typhoon Rusa (5/5)

Broken Gamcheon Railway Bridge
(Gimcheon-si, Kyeongsangbuk-do)

Super Typhoon Maemi(1/3)

□ Track and Characteristics of Super Typhoon Maemi

- Super Typhoon Maemi formed as a tropical depression near Guam, east of the Philippines on 5 September and as it approached the southern Japanese islands of Okinawa, it developed into a super typhoon(Saffir-Simpson scale 5).

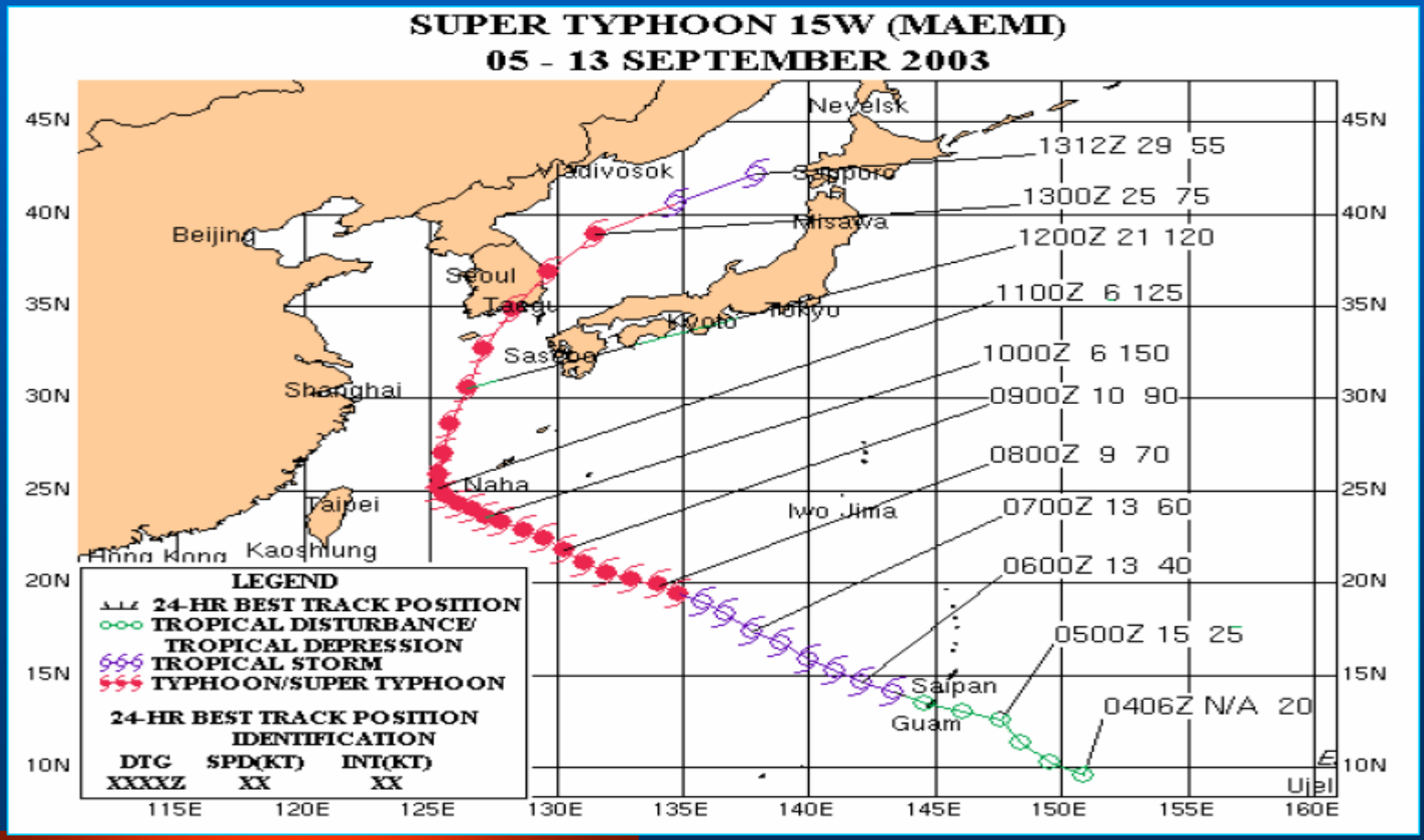
- It struck the southern coast of Korea during the night of September 12 with wind gusts reaching 216 kph and rainfall of up to 450 mm.

- According to the Korea's official weather service, Maemi was the most powerful typhoon to strike the country since records began in 1904 (KMA, 2003).

- Super Typhoon Maemi caused the death of around 120 people and generated more than USD 500 million in insurance-related losses. The typhoon also left more than 25,000 people homeless.

Super Typhoon Maemi(2/3)

Path of Super Typhoon Maemi



Super Typhoon Maemi(3/3)

History of Maximum Wind Velocity(unit : m/s)

Flood Damage Pictures by Typhoon Maemi(1/4)

Broken Micheonje Levee
(Uiseong-gun, Gyeongsangbuk-do)

Flood Damage Pictures by Typhoon Maemi(2/4)

Flooded Inland Punping Station in Lowland
(Uiseong-gun, Gyeongsangbuk-do)

Flood Damage Pictures by Typhoon Maemi(3/4)

Broken Hoecheonje Levee
(Goryeong-gun Gyeongsangbuk-do)

Flood Damage Pictures by Typhoon Maemi(4/4)

Broken Crane
(Busan Metropolitan City)

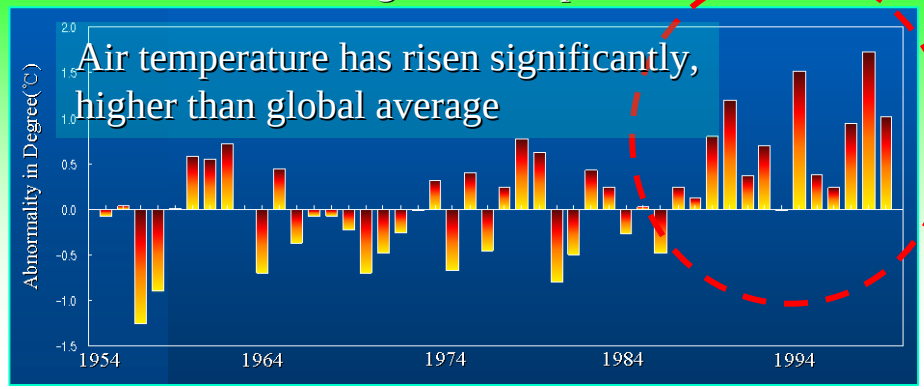
FLOOD RISK FACTORS

Risk Factors(1/5)

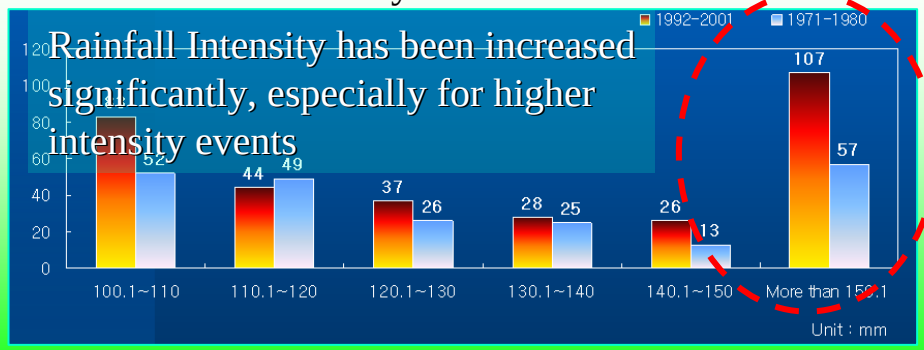
- Abnormal weather events due to global warming
- Rapid urbanization and industrialization
- Insufficient infrastructure for flood defense
- Lack of social systems, cooperation between sectors and public participation

Risk Factors(2/5)

Annual Average Air Temperature



Number of Daily Rainfall Events



Risk Factors(3/5)

Social System Indices

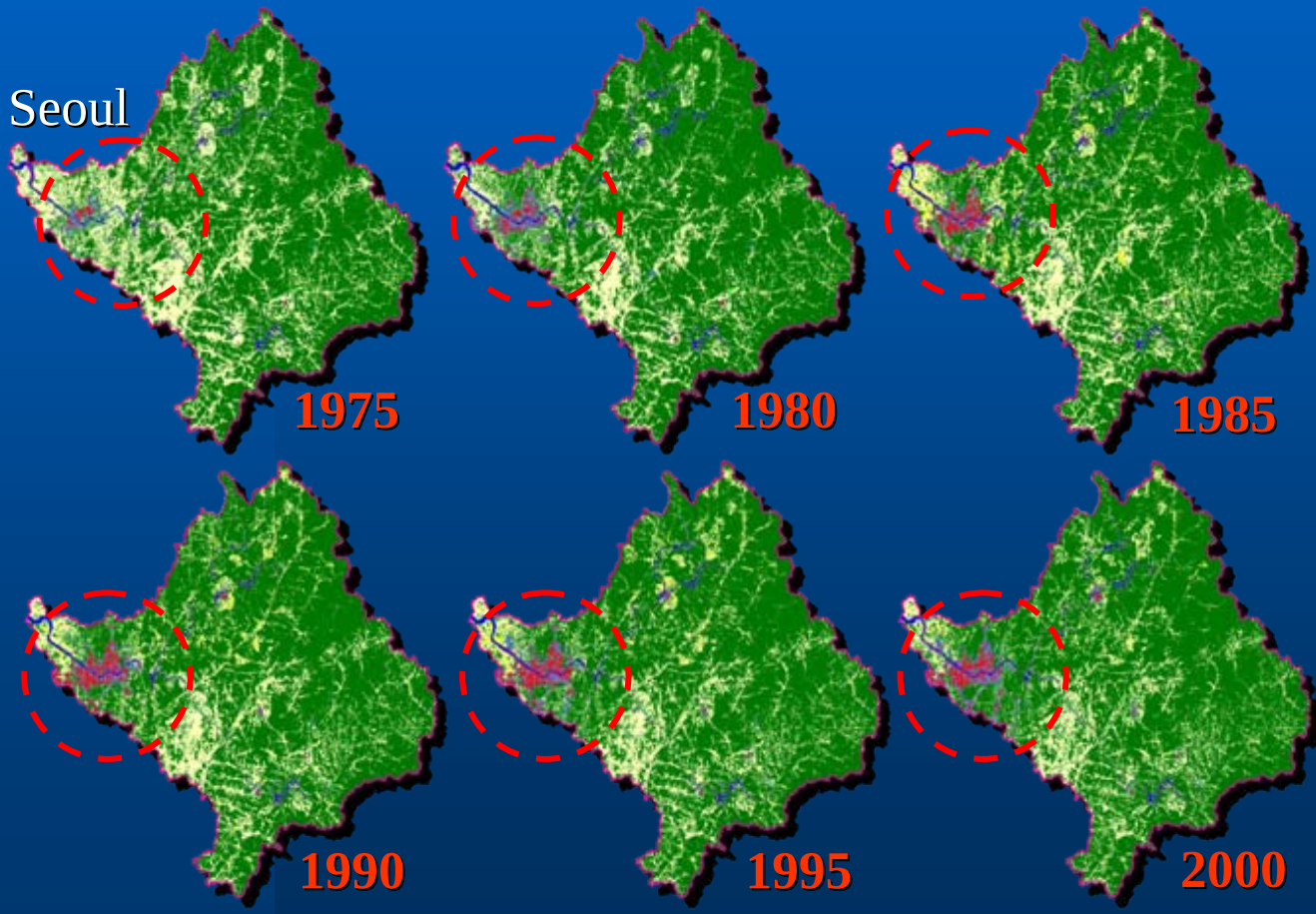
Index / Year	Area(km^2)	Population (thousand)	GDP (trill. Won)	Urban Ratio(%)	Average Life(year)
1960	98,222	24,990	0.2	39.1	52.4
1970	98,222	31,470	2.8	50.1	63.2
1980	98,992	37,440	37.8	68.7	65.8
1990	99,274	43,410	178.8	81.9	70.2
1999	99,800	47,360	483.8	87.6	74.4

For the last four decades, population increase two times; GDP increased 2,500 times; and urban ratio increased more than two times.

→ Rapid urbanization and industrialization

Risk Factors(4/5)

☐ Change of Land Cover in Han River Basin



Risk Factors(5/5)

Insufficient infrastructure for flood defense

- ☐ Lack of fund for flood control
- ☐ Difficulty in securing investment funds for middle and small-sized streams
- ☐ Insufficient flood control facilities in urban areas
- ☐ Deficient improvement of stream management system
- ☐ Deterioration of stream functions

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INTEGRATED FLOOD RISK MANAGEMENT METHODOLOGIES

Integrated Flood Risk Management Methodologies(1/2)

Flood Forecasting and Warning

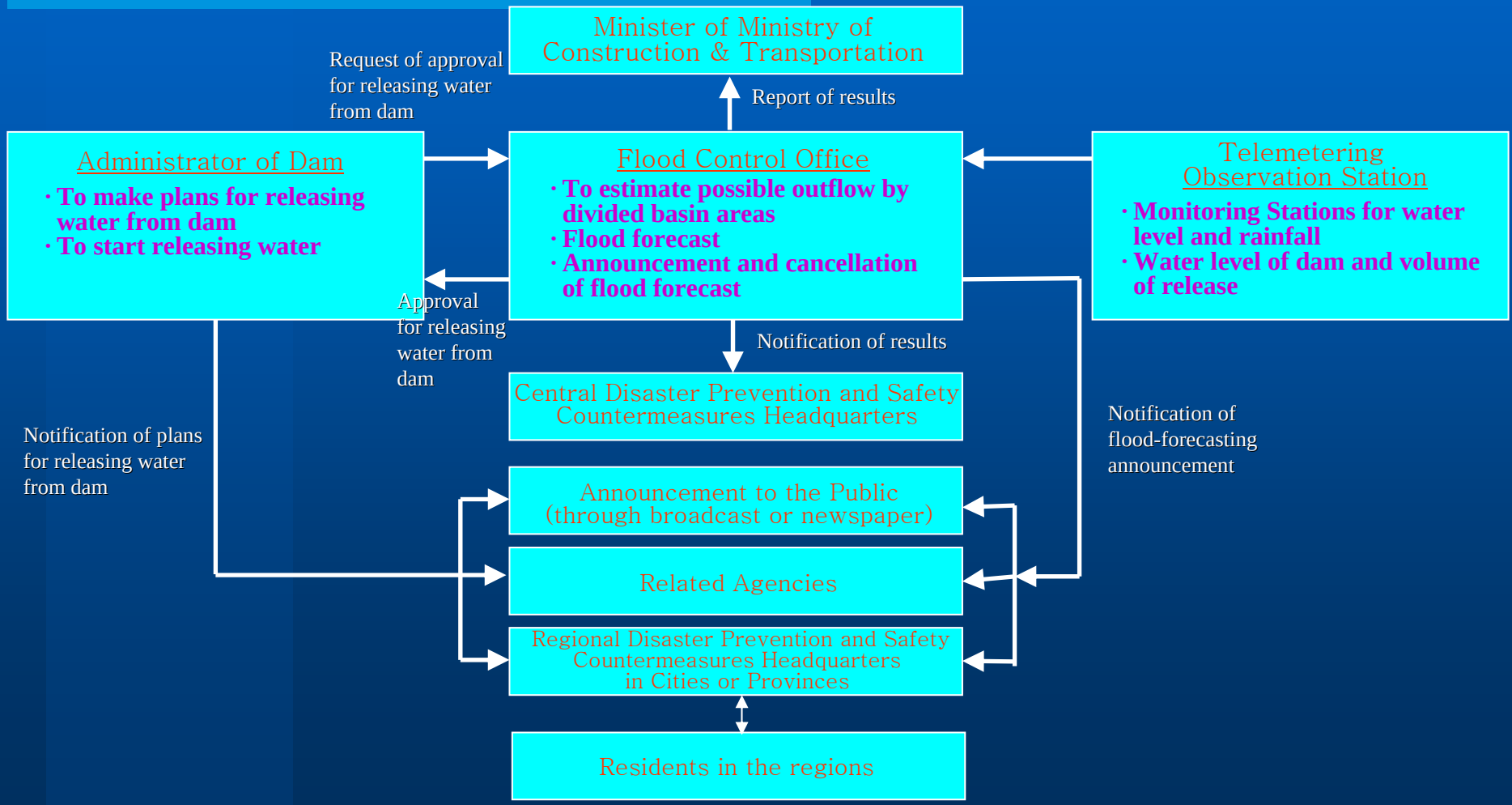
☐ Concept of Flood Forecasting and Warning

- Storm monitoring and forecasting

- Flood information monitoring and transmitting

Flood Risk Management Methodologies(2/2)

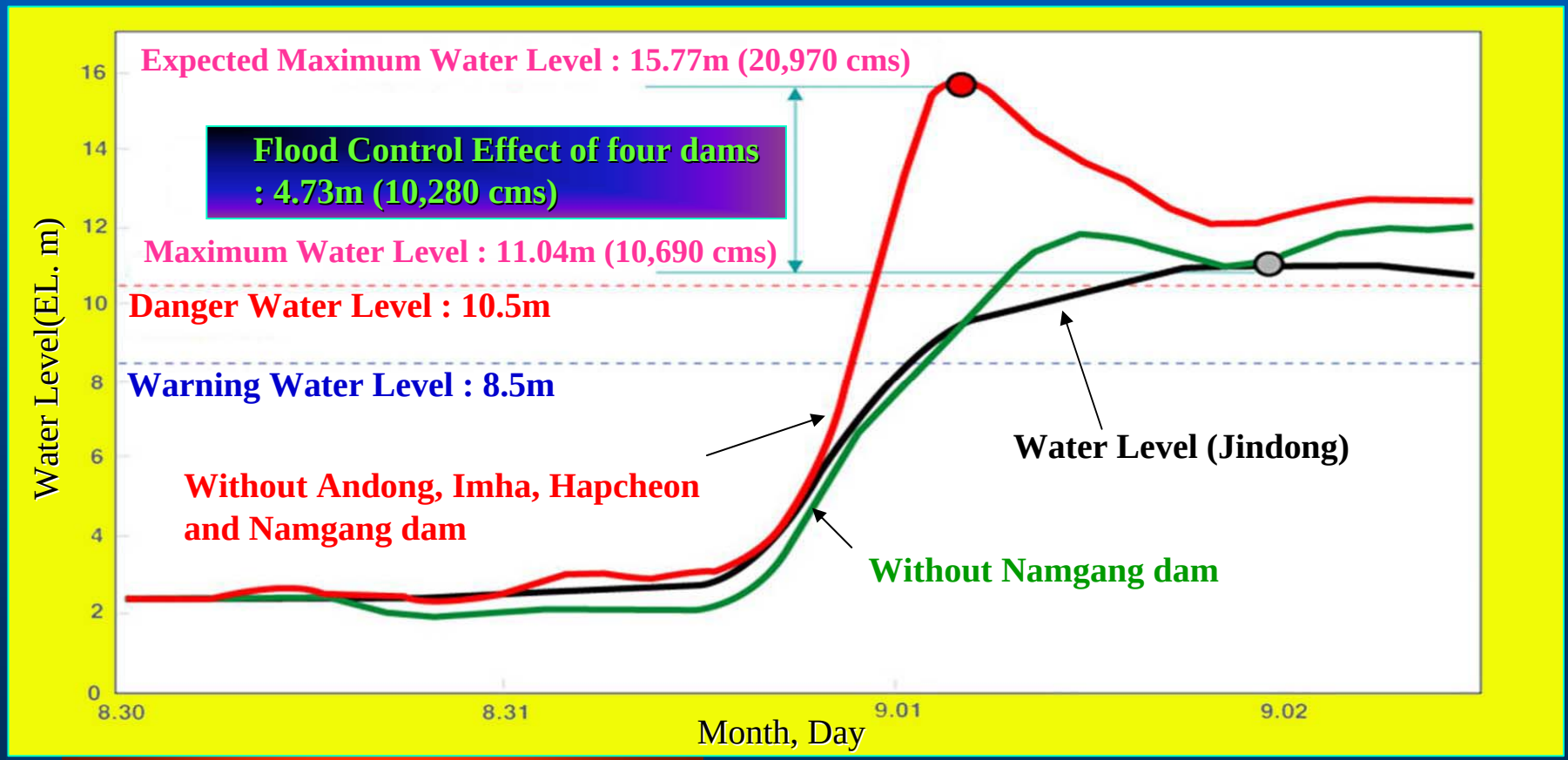
Flood Forecasting and Warning



Flood Risk Management Methodologies(1/3)

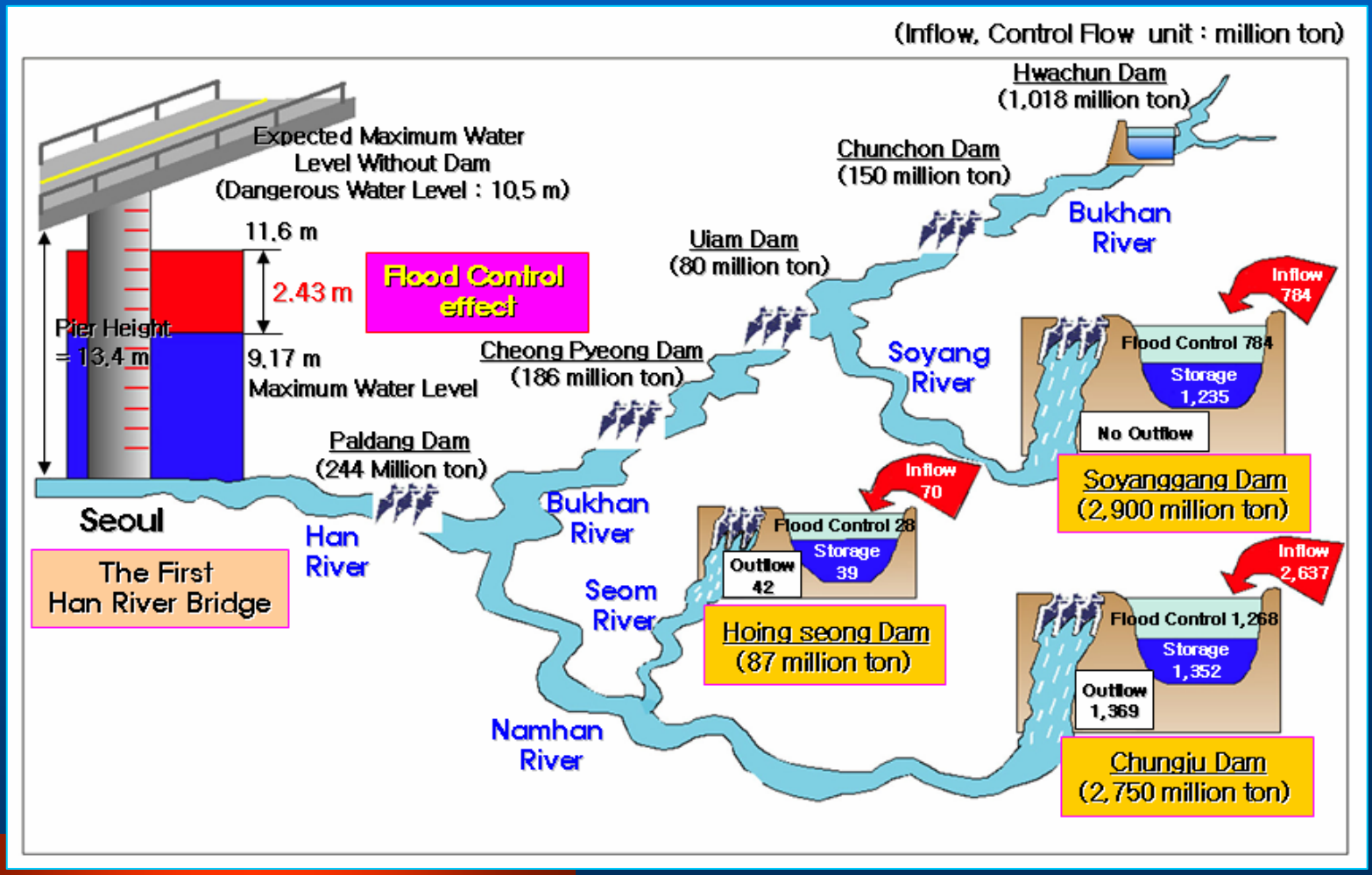
Flood Control

Flood Control Effect of Multipurpose Dam in Nakdong River System (at Jindong)
(Flood Period : 2002. 8. 30 ~ 9. 2)



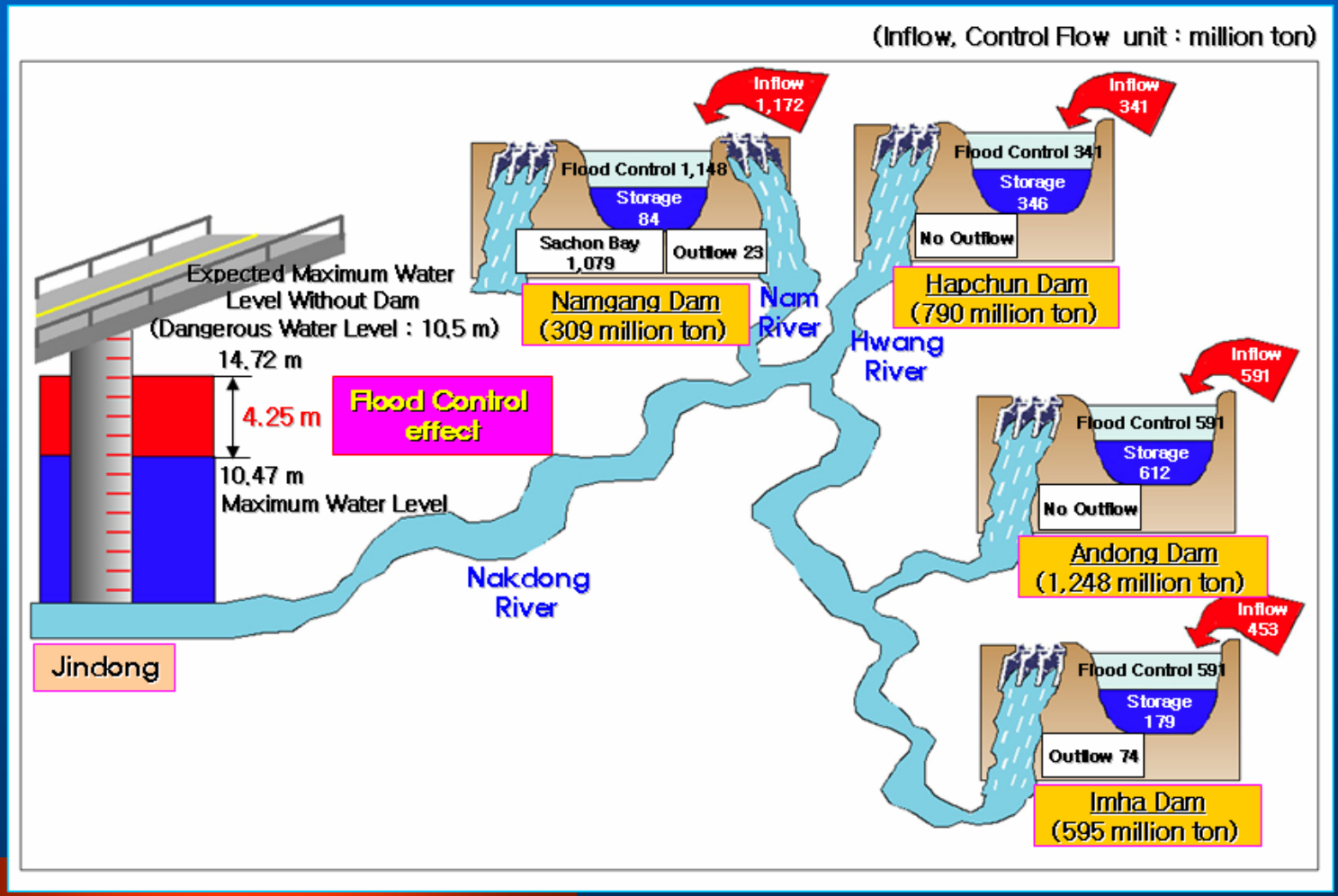
Flood Risk Management Methodologies(2/3)

Flood Control – Han River



Flood Risk Management Methodologies(3/3)

Flood Control – Nakdong River



Flood Risk Management Methodologies(1/4)

Flood Hazard Map

☐ Flood Hazard Map : A map that provides with geographical information that is essential for local residents to conduct “safe & smooth evacuation”

☐ The purposes of producing Flood Hazard Map

- For local residents:
  To promote proper and prompt evacuation actions by providing them with prior information of flood risk and evacuation

- For local municipalities:
  to promptly and smoothly accomplish evacuation of residents using Flood Hazard Map to reduce human losses

Flood Risk Management Methodologies(2/4)

Flood Hazard Map

☐ Effectiveness of Flood Hazard Map

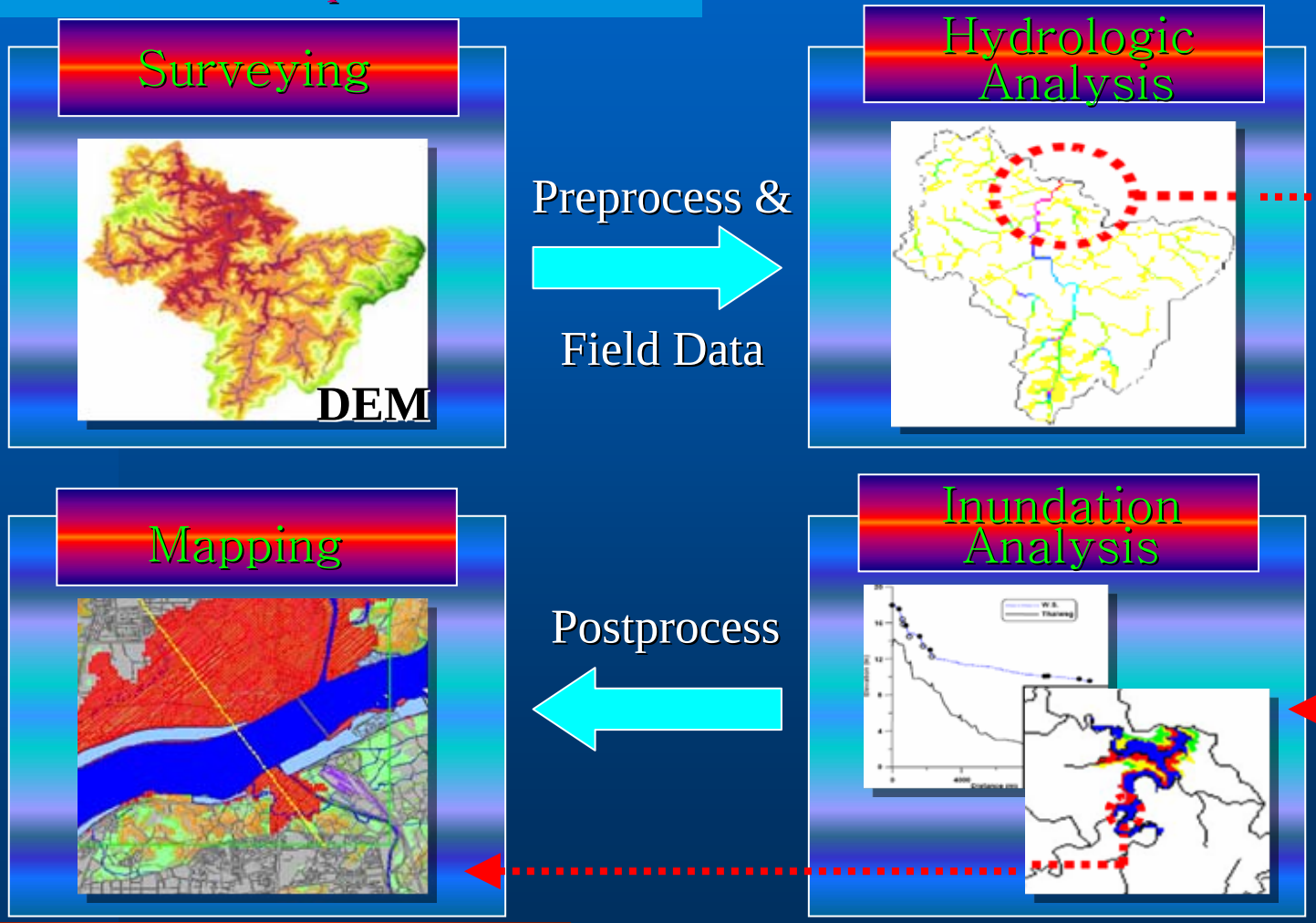
- Quicker evacuation
- Higher evacuation ratio
- Correct direction to evacuate

☐ Guidance to Flood Hazard Map

- Flooding mechanism
- Topographic features and flooding types
- Real danger of flood, Predicted extent of damage
- Meteorological information
- Past flood records (rainfall, inundation, and damage)
- Rules to follow in cases of flood
- Explanation and direction to use Flood Hazard Map
- Preparedness against flood

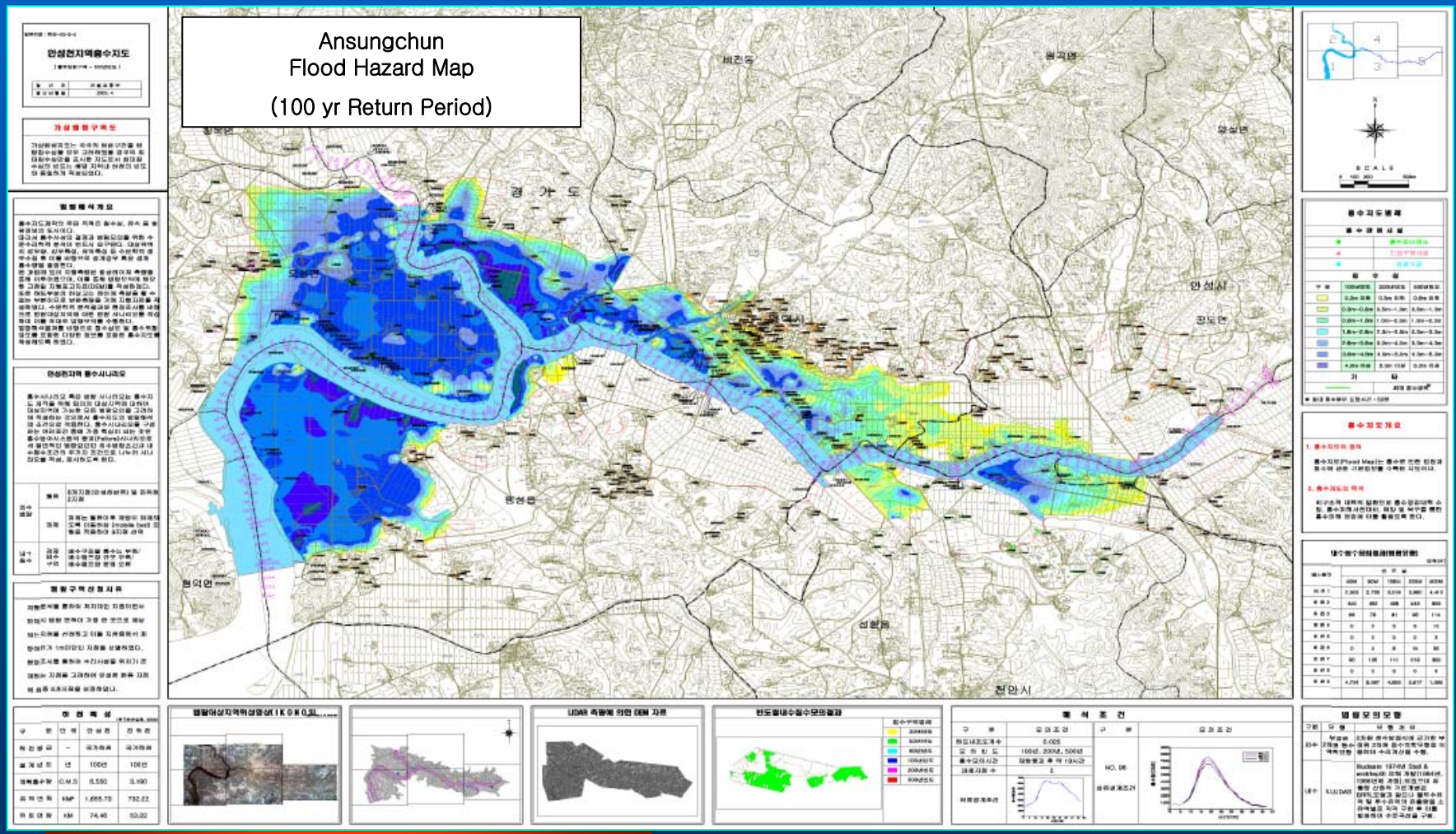
Flood Risk Management Methodologies(3/4)

Flood Hazard Map



Flood Risk Management Methodologies(4/4)

Flood Hazard Map



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INTEGRATED FLOOD RISK MANAGEMENT MEASURES

Flood Risk Management Measures(1/6)

- New planning of comprehensive and integrated flood disaster prevention and management on the basis of basinwide
- Early elimination of uncertain factors
- Improving the management and operation of dams and river structures
- Updating the guidelines for river works and implementation of them
- New legislation for the effective flood damage mitigation
- Adopting more non-structural measures and improving the recovery system
- Drawing more public awareness and participation

Flood Risk Management Measures(2/6)

Basinwide Integrated Flood Management Plans

Flood Risk Management Measures(3/6)

Basinwide Integrated Flood Management Plans

Objectives

By 2007, completing the Basinwide Integrated Flood Management Plans for the 13 river basins in the nation to defend the flood from the extreme rainfall;

- Upgrade the flood management paradigm for the abnormal climate change
- Overcome the deficiency of flood control capacities due to the limitation of dam construction and river flood protection facilities
- Raise the storage capacities of flood in the basin
- Establish the measures for the urban population and properties in the flood prone areas
- Establish the integrated optimal operation system of dams and flood control facilities in each basin

Flood Risk Management Measures(4/6)

Basinwide Integrated Flood Management Plans

Main contents (Basic direction) (1/2)

- Distributing flood control functions into both river channel and basin for the present and future flood flow by changing the flood control policy.

- Increasing the flood storage capacities in upstream areas by the construction of riverside detention reservoirs or by using floodplain areas, and accordingly, increasing the safety level of flood management in whole river basin and decreasing the flood control volume in downstream channel reach.

- Spatial and master planning for the flood control including storages, rainwater capture systems, levees, pumping stations and landuse plan for their construction and share of flood flow.

Flood Risk Management Measures(5/6)

Basinwide Integrated Flood Management Plans

Main contents (Basic direction) (2/2)

- Planning, development and maintenance of optimal integrated operation system for the flood control

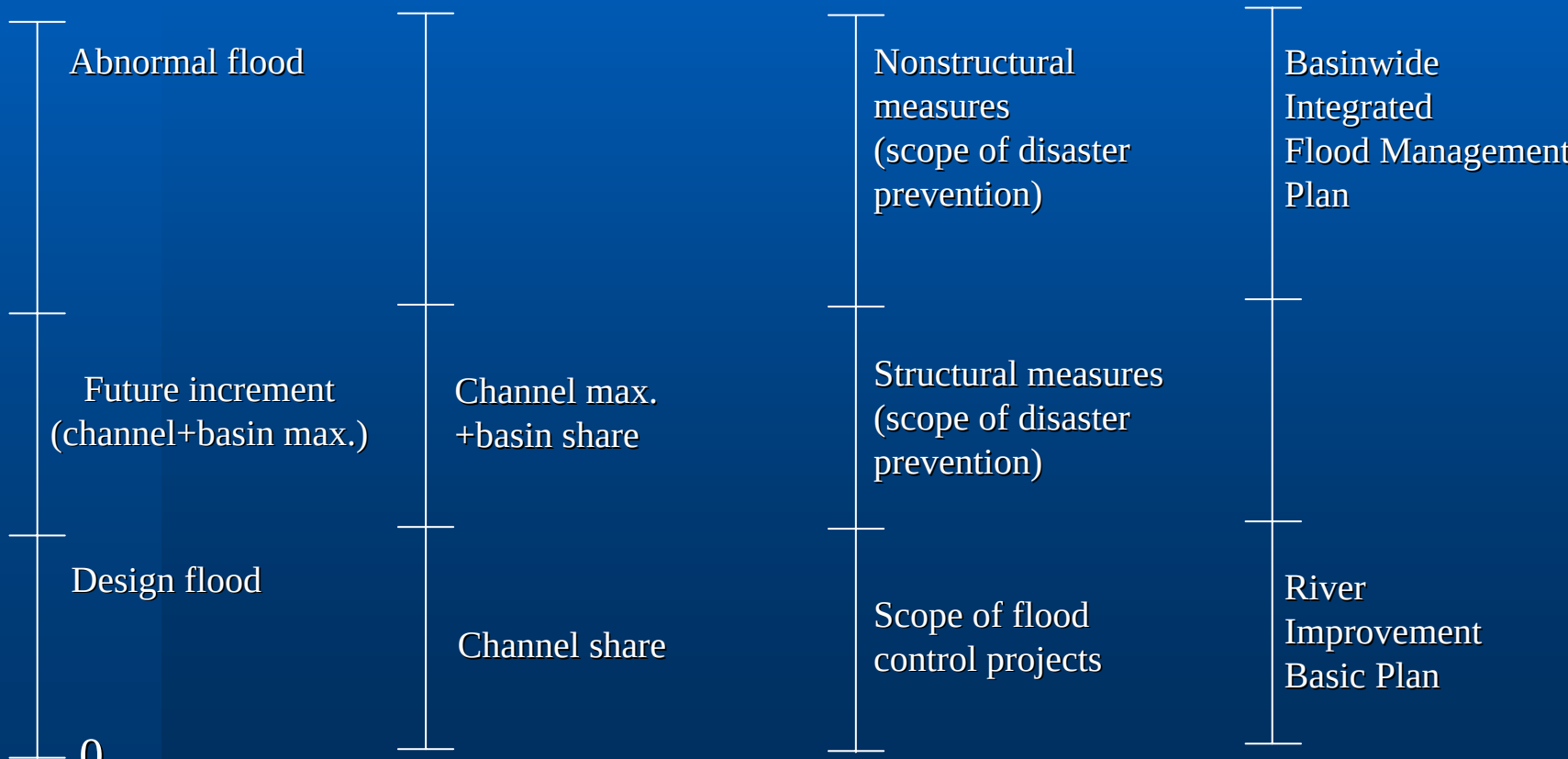
- Building flood control plans of both structural and nonstructural measures appropriate to the regional characteristics

- Examining the links with higher level or other related plans as well as the links of the facilities with other infrastructures such as railways, roads and bridges

Flood Risk Management Measures(6/6)

Basinwide Integrated Flood Management Plans

Classification by the variation of flood discharge and the scope of plan



Structural and Nonstructural Measures

Remark		Scope of Plan	Plan	Measures
Structural Measures	Channel Reach	Design Flood	River Improvement Basic Plan	Channel Improvement, Levees, Drainage Facilities
		Above Design Flood Channel Acceptable Maximum Value	Basinwide Integrated Flood Management Plan	Retarding Reservoir, Riverside Detention Reservoir, Temporary Storage in Agricultural Land, Bypass, Flood Control Reservoir
	River Basin	Future Urban Increment Excess of Channel Share		
Nonstructural Measures		Abnormal Storm Excess of Basin Share Emergencies due to Levee Break etc.		Flood Forecasting and Warning System, Flood Hazard Map, Flood Insurance System
Others Basin Measures		System Improvement, Roof Storage, School Ground Storage, Underground Storage of Roads, Parking Lot and Park etc.		

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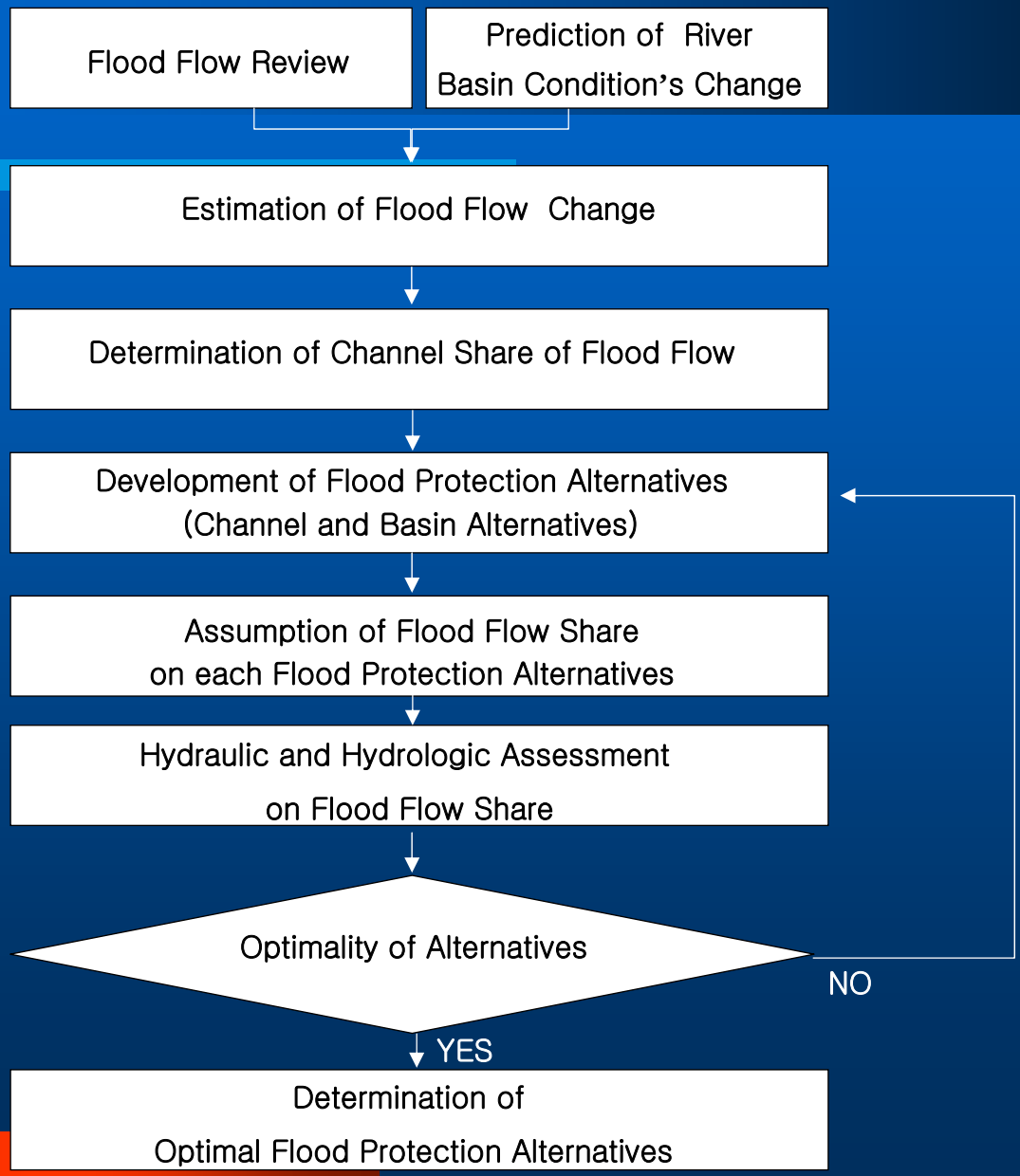
BASINWIDE INTERGRATED FLOOD MANAGEMENT PLAN

– NAKDONG RIVER BASIN –

Flood Flow Distribution Plan

- Increased flood flow by recent abnormal climate change (19,400cms to 22,000cms)
- Basinwide Integrated Management Plan established.
  - River improvement works by 2011
  - Reinforcement of existing flood protection facilities by 2016
  - In channel reach, additional share of flood flow of 300~1,000cms by enlargement of estuary barrage, improvement of low-flow channel and narrow channel.
  - In basin share, establishing the flood protection plan for the excess of channel share by further construction of storage facilities such as flood control reservoir, riverside detention reservoirs and short-cut channel..

Assessment Procedure



Proposed Plans (Alternatives) (1/2)

Plan - Ⅰ	**River Channel + New Dams + Redeveloped Existing Dams+ Riverside Detention Reservoir + Flood Control Reservoir + Short-Cut Channel**
	• Channel shares another 900cms by enlargement of estuary barrage and sedimentation removal out of increased flood flow of 2,600cms. • Basin shares 1,700cms by 4 new dams, redevelopment of 4 existing dams, 20 riverside detention reservoirs, 1 flood control reservoir and 1 short-cut channel.
Plan - Ⅱ	**River Channel + Levee Heightening + New Dams + Redeveloped Existing Dams + Riverside Detention Reservoirs + Flood Control Reservoirs**
	• In case of no short-cut channel, basin shares 700cms and channel shares 1,900cms by 4 new dams, redevelopment of 4 existing dams, 75 riverside detention reservoirs, 2 flood control reservoirs and levee heightening.

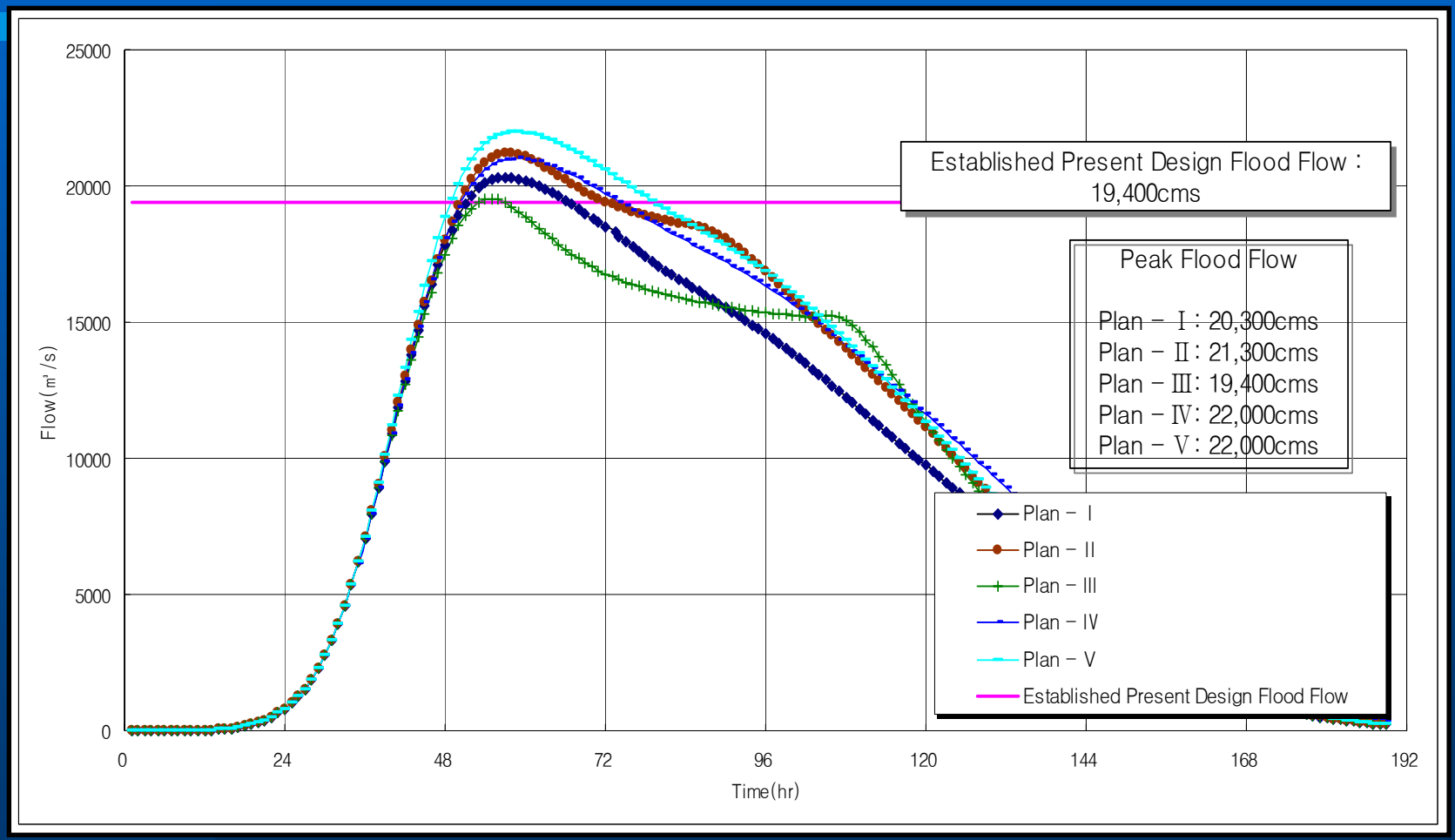
Proposed Plans (Alternatives) (2/2)

Plan - Ⅲ	New Dams + Redeveloped Existing Dams + Riverside Detention Reservoirs + Flood Control Reservoir + Short-Cut Channel
	• This plan maintains the legally designated present design flood 19,400cms in the channel but the excessive flood flow 2,600cms is managed by 4 new dams, redevelopment of 4 existing dams, 75 riverside detention reservoirs, 1 flood control reservoir and 1 short-cut channel.
Plan – Ⅳ	River Channel + Diversion Channel + New Dams + Redeveloped Existing Dams + Riverside Detention Reservoirs + Flood Control Reservoir
	• Using the diversion channel and existing river channel, flood flow is managed at the estuary.
Plan - Ⅴ	River Channel + New Dams + Redeveloped Existing Dams + Levee Heightening
	• The excessive flood flow 2,600cms is shared and managed by the river channel with the levee heightening.

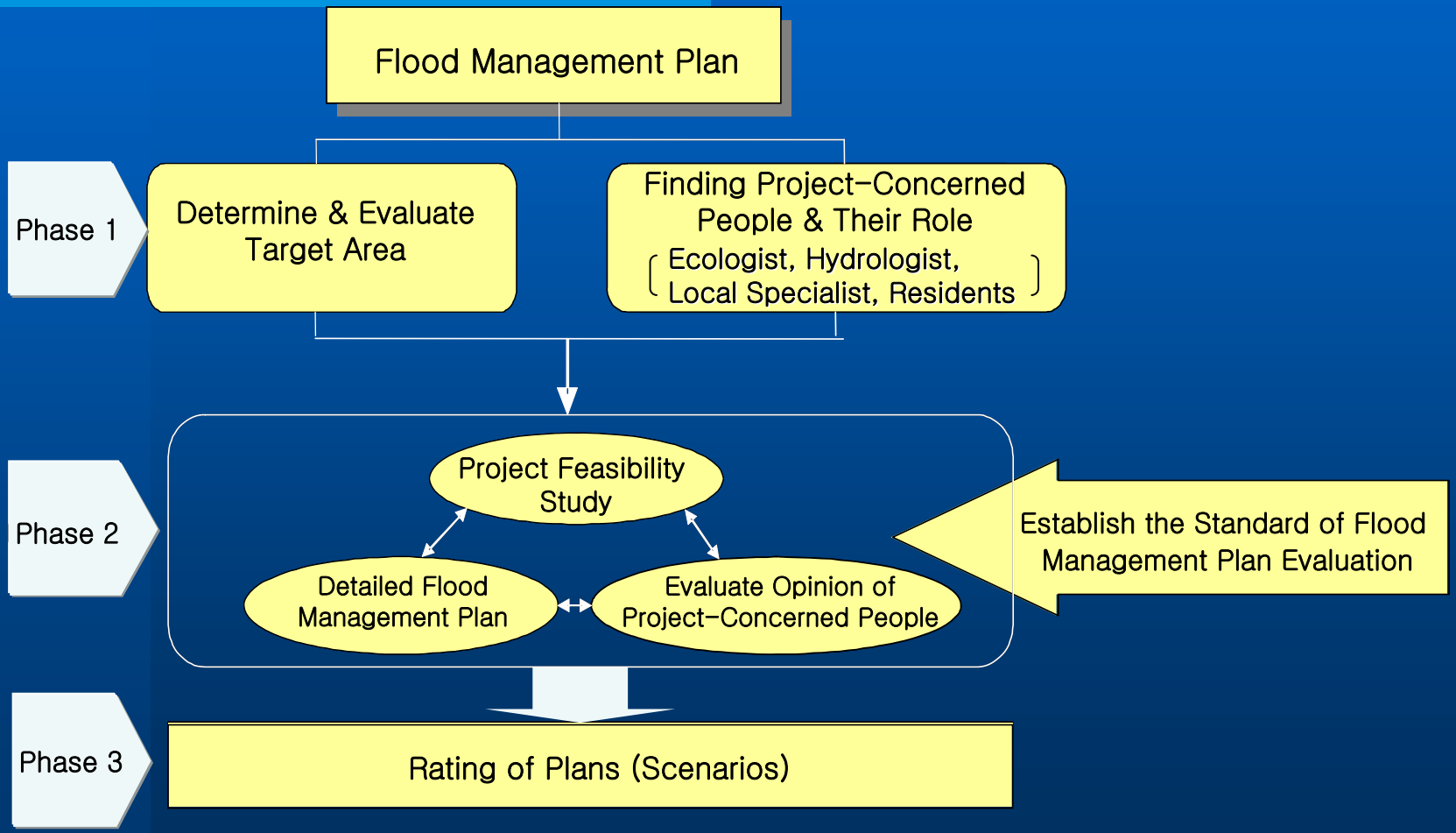
Flood Management Plans (Alternatives)
- Summary and Comparison -

Plans	Plan - Ⅰ	Plan - Ⅱ	Plan - Ⅲ	Plan - Ⅳ	Plan - Ⅴ
Plan Outline	Channel + Basin Share	Channel + Basin Share	Basin share Only	Channel share Only	Channel Share Only
Share Plan	Channel : 900cms Basin : 1,700cms	Channel : 1,900cms Basin : 700cms	Basin:2,600cms	Channel: 2,600cms	Channel:2,600cms
Project Details	Channel Project (900cms) - Sedimentation removal & River channel improvement - Enlargement of estuary barrage Basin Project (1,700cms) - 4 New dams - 4 Existing dams redevelopment - 20 Riverside detention reservoirs - 1 Flood control reservoir - 1 Short-cut channel : L=35 km	Channel Project (1,900cms) - Sedimentation removal & River Channel improvement - Enlargement of estuary barrage - Levee heightening Basin Project (700cms) - 4 New dams - 4 Existing dams redevelopment - 75 Riverside detention reservoirs - 2 Flood control reservoirs	Basin Project (2,600cms) - 4 New dams - 4 Existing dams redevelopment - 75 Riverside detention reservoirs - 2 Flood control reservoirs - 1 Short-cut channel : L=35 km	Channel Project (2,600cms) - Sedimentation removal & River channel improvement - Enlargement of estuary barrage - Diversion channel : L=64km Basin Project - 4 New dams - 4 Existing dams redevelopment - 20 Riverside detention reservoirs - 1 Flood control reservoir	Channel Project (2,600cms) - Sedimentation removal & River channel improvement - Enlargement of estuary barrage - Levee heightening Basin Project - 4 New dams - 4 Existing dams redevelopment

Hydrograph at Nakdong River Estuary



Means of Analysis



THANK YOU

FOR

YOUR ATTENTION