2011 SWAT

Integrated surface-groundwater analysis on groundwater dam effect in Ssangcheon watershed in South Korea

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- Introduction
- Integrated SW-GW Modelling
- Results of simulation
- Conclusion

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Drought in Sokcho

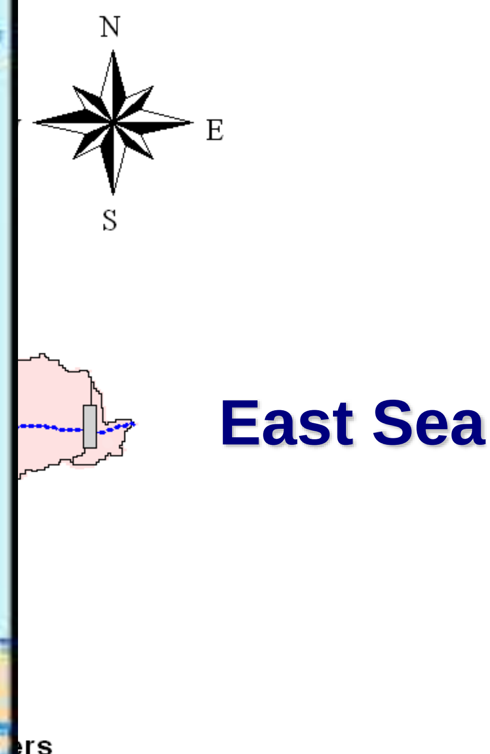
Enhancement of water supply was needed

- As Sorak Nat'l Mountain Park and East Coast resorts locate in this area, additional water supply was needed.
- Surface water resources was insufficient for water supply
  - Rainfall is concentrated from June to September
  - Water resources management is very hard
- For this purpose, the GW(groundwater) dam was built in 1998.


Sorak Nat'l Mountain Park & East Coast Beach

INTRODUCTION

eather station



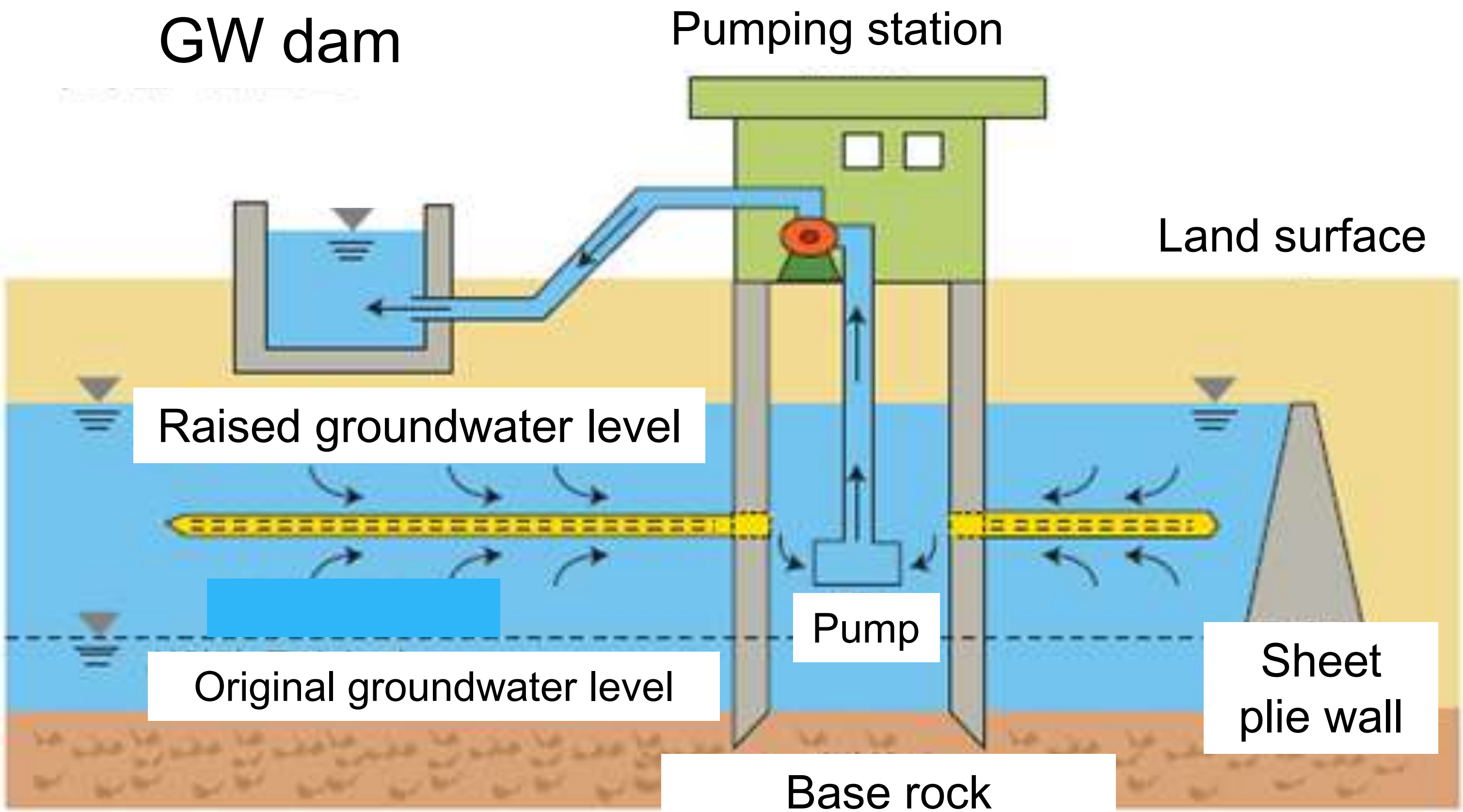
INTRODUCTION

- ✓ Watershed area is 65.3km^2
- ✓ Annual rainfall is 1,310mm
- ✓ Groundwater recharge rate is 22% of annual rainfall
- ✓ Streamflow runs to the east sea
  -Basin slope is steep, flow velocity in stream is fast
  -Usual stream condition is dry

Groundwater dam

- Groundwater dam is a structure that intercept the natural GW flow and provide storage for water underground.
- It is needed where flows of groundwater vary considerably during the course of the year, from very high flows following rainfall to negligible flows during the dry season.
- The basic principle of the groundwater dam is that instead of storing the water in surface reservoirs, water is stored underground.
- The reservoir is recharged during the monsoon period and the stored water can be used during the dry season.

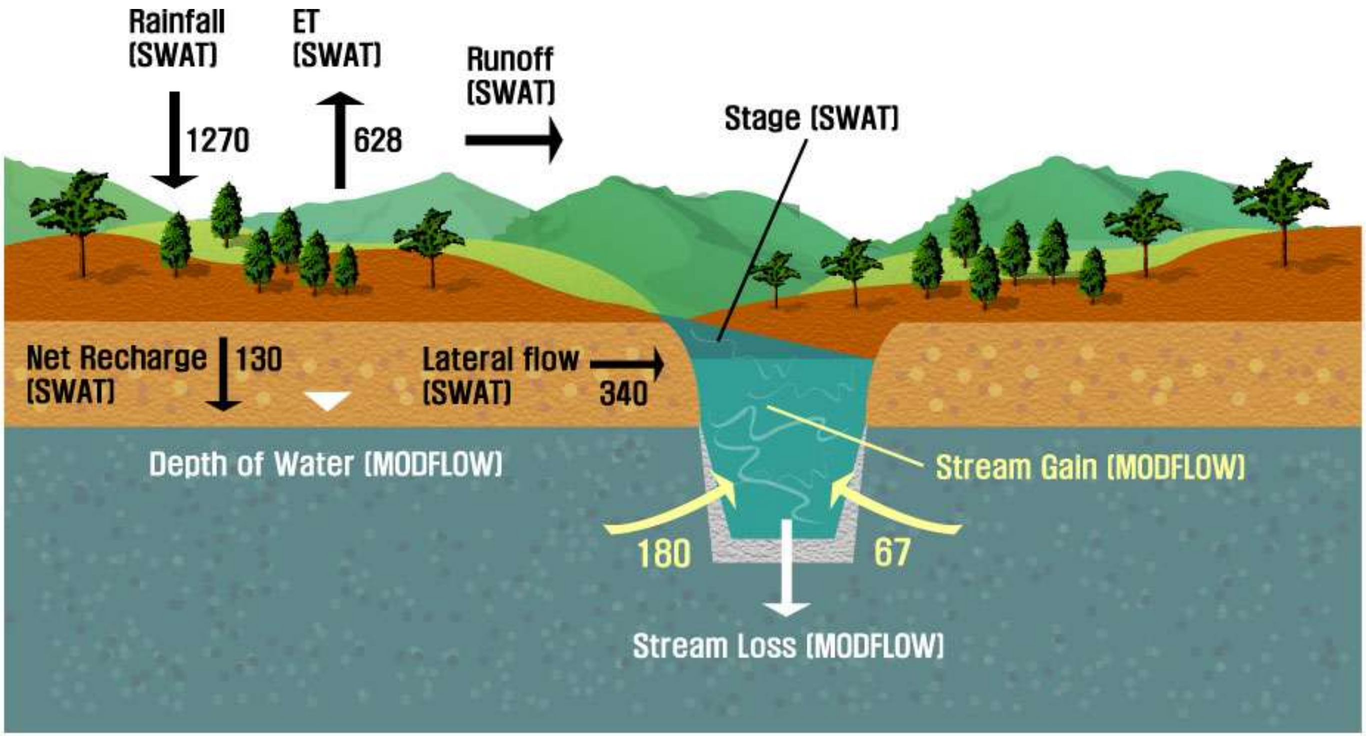
Cross section of GW dam



Integrated SWAT-MODFLOW model

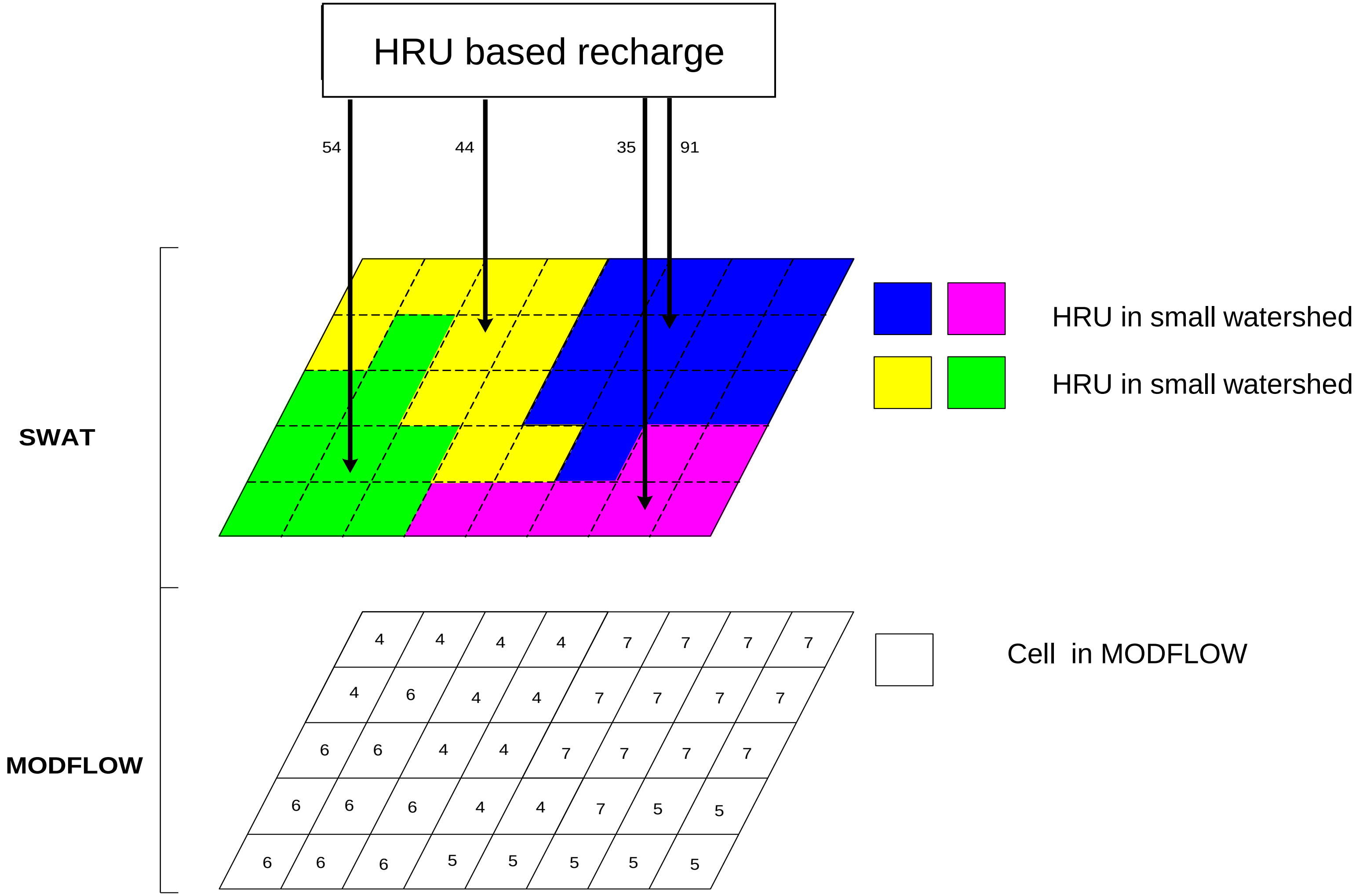
- To understand water balance in this area the integrated surface-groundwater analysis is carried out
- SWAT-MODFLOW (Kim et al., 2008) is capable of simulating spatial-temporal GW recharge and stream-aquifer interactions
- Groundwater module in SWAT has been replaced by MODFLOW (MODFLOW is embedded as subroutines)
- Characteristics between HRU(Hydrologic Response Unit) of SWAT and CELL of MODFLOW can be exchanged(e.g., grid based recharge)

Schematic diagram

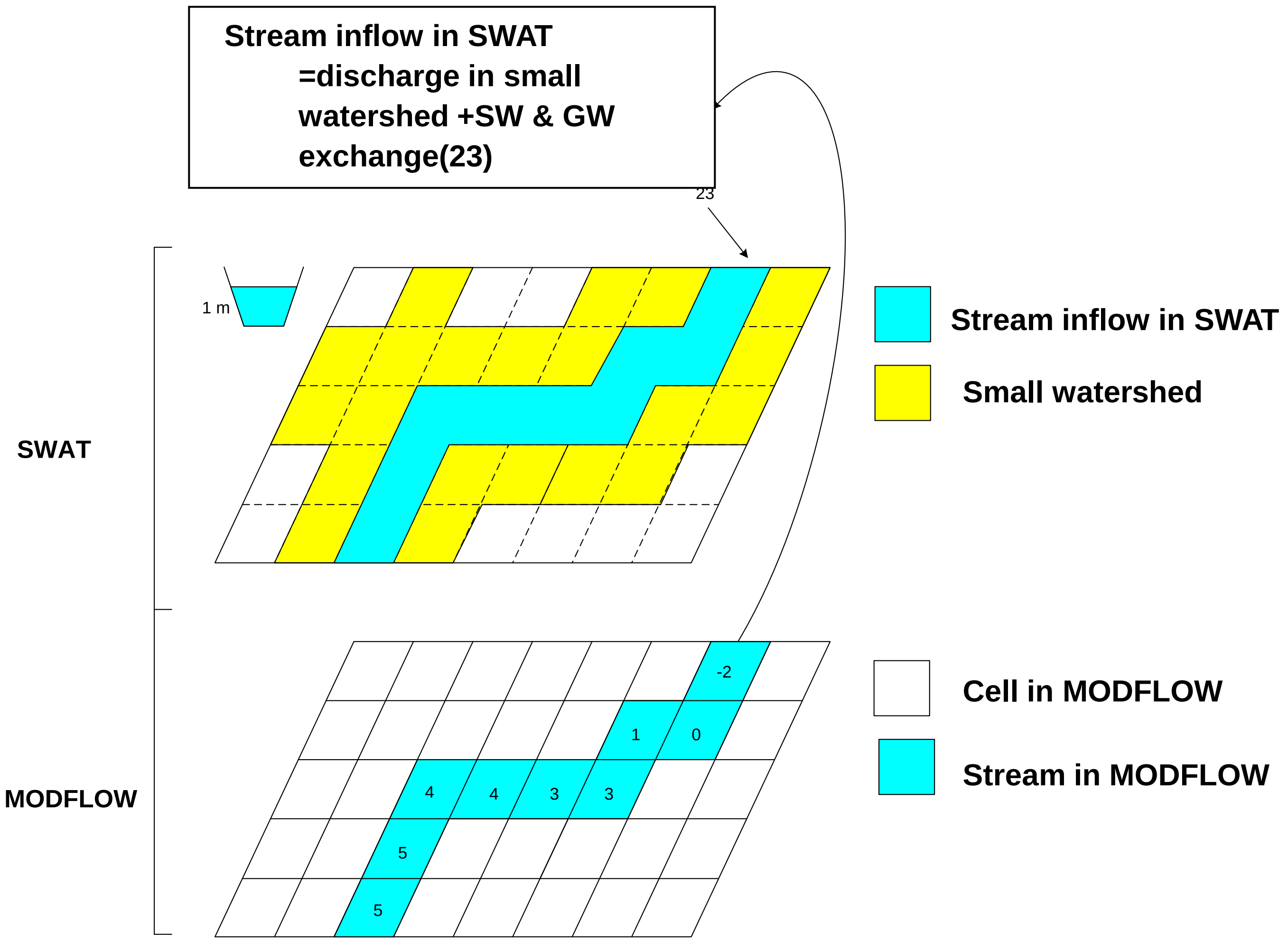


- Development and application of the integrated SWAT-MODFLOW model (J. of Hydrology, 2008)

■ Linking RECHARGE in MODFLOW with SWAT

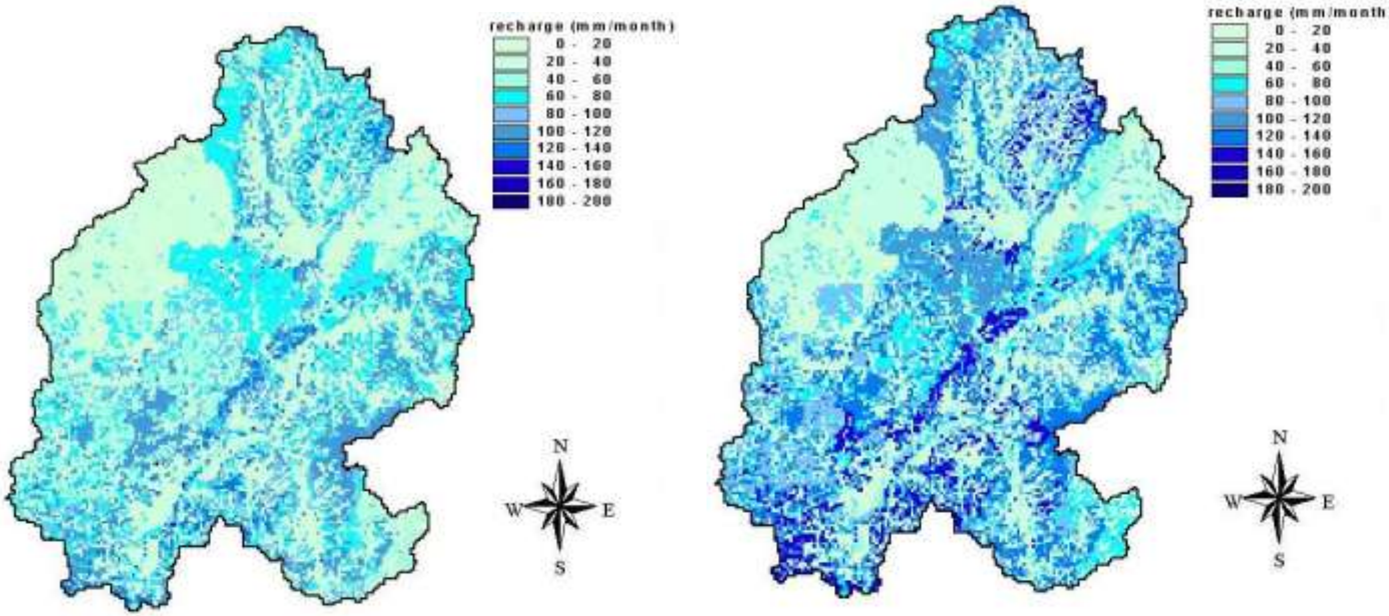


■ Linking RIVER in MODFLOW with SWAT



SWAT-MODFLOW

- Distribution of average monthly recharge (Mihocheon, S. Korea)



- Assessing distributed groundwater recharge rate using integrated surface water-groundwater modelling: Application to Mihocheon watershed, South Korea (Hydrogeology Journal, 2010)

Simulation Separation of SW / GW(Jeju Island, S. Korea)

(a) upstream

- Integrated surface-groundwater analysis for the Pyoseon region, Jeju Island in Korea (Applied Engineering in Agriculture, in revision)

▪ Input data

✓Daily precipitation for Sokcho gauging station

✓Daily values of weather data (maximum and minimum temperatures, solar radiation, wind speed, and relative humidity) from KMA

✓Land use digital data(1:25,000)

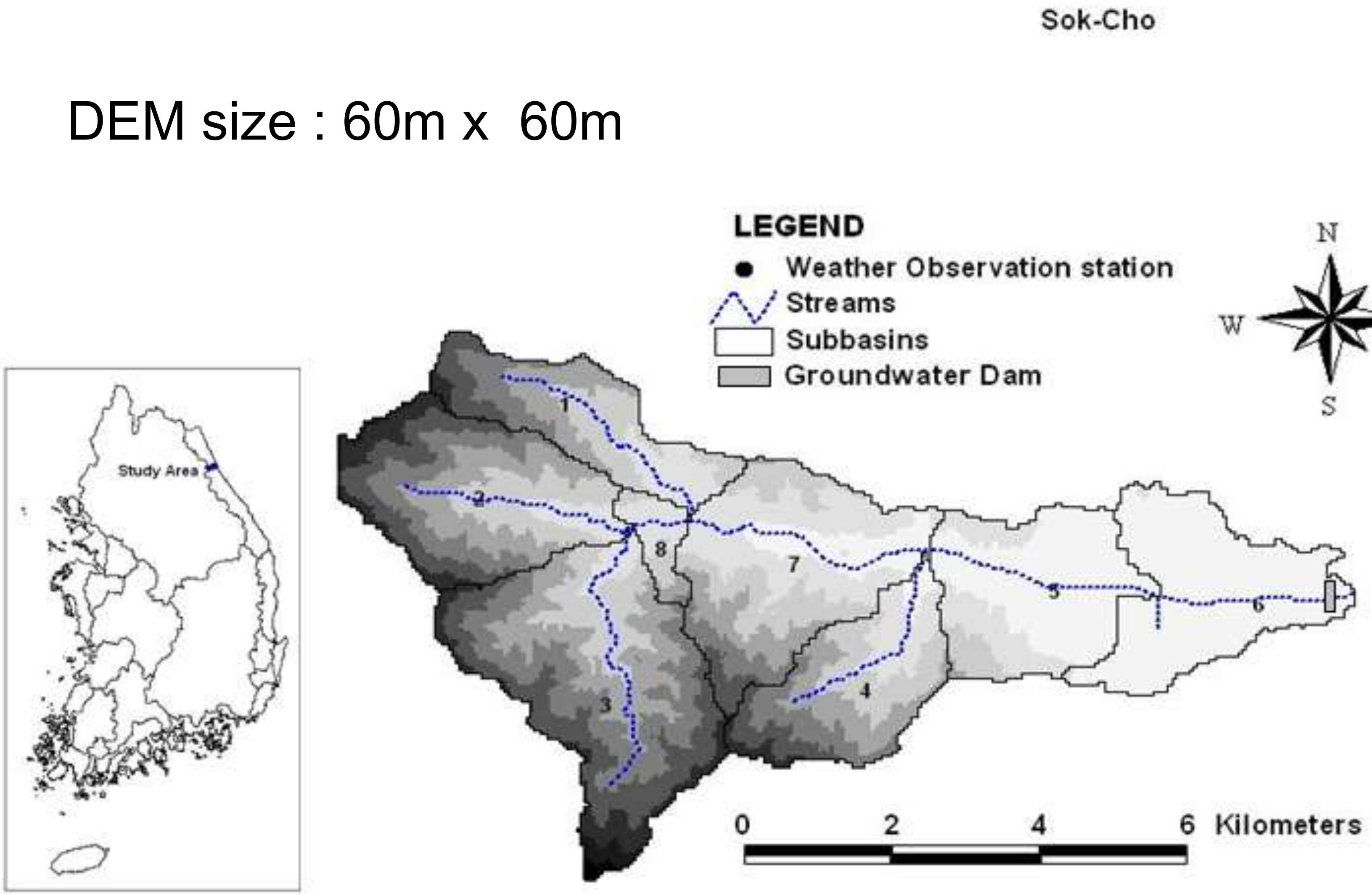
✓The detailed soil association map(1:25,000) was used for selection of soil attributes. 23 hydrologic soil groups within basin were used.

✓Related soil physical properties such as texture, bulk density, available water capacity, saturated hydraulic conductivity, soil albedo and some additional factors were obtained from the Agricultural Soil Information System (http://asis.rda.go.kr)

✓ Aquifers are represented as two layers. GW information from GIMS(http://gims.go.kr) was used

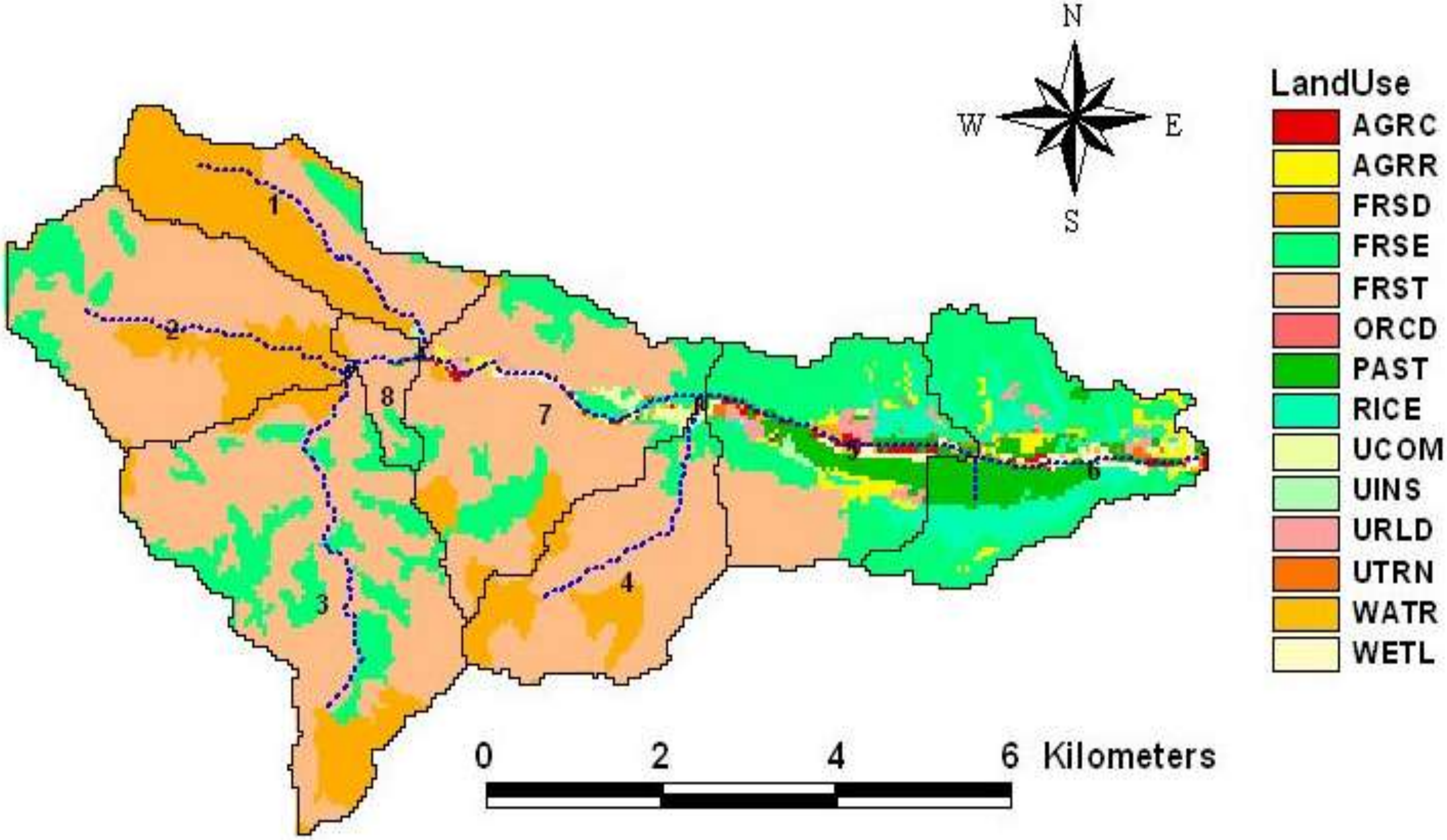
SSANGCHEON WATERSHED

DEM size : 60m x 60m



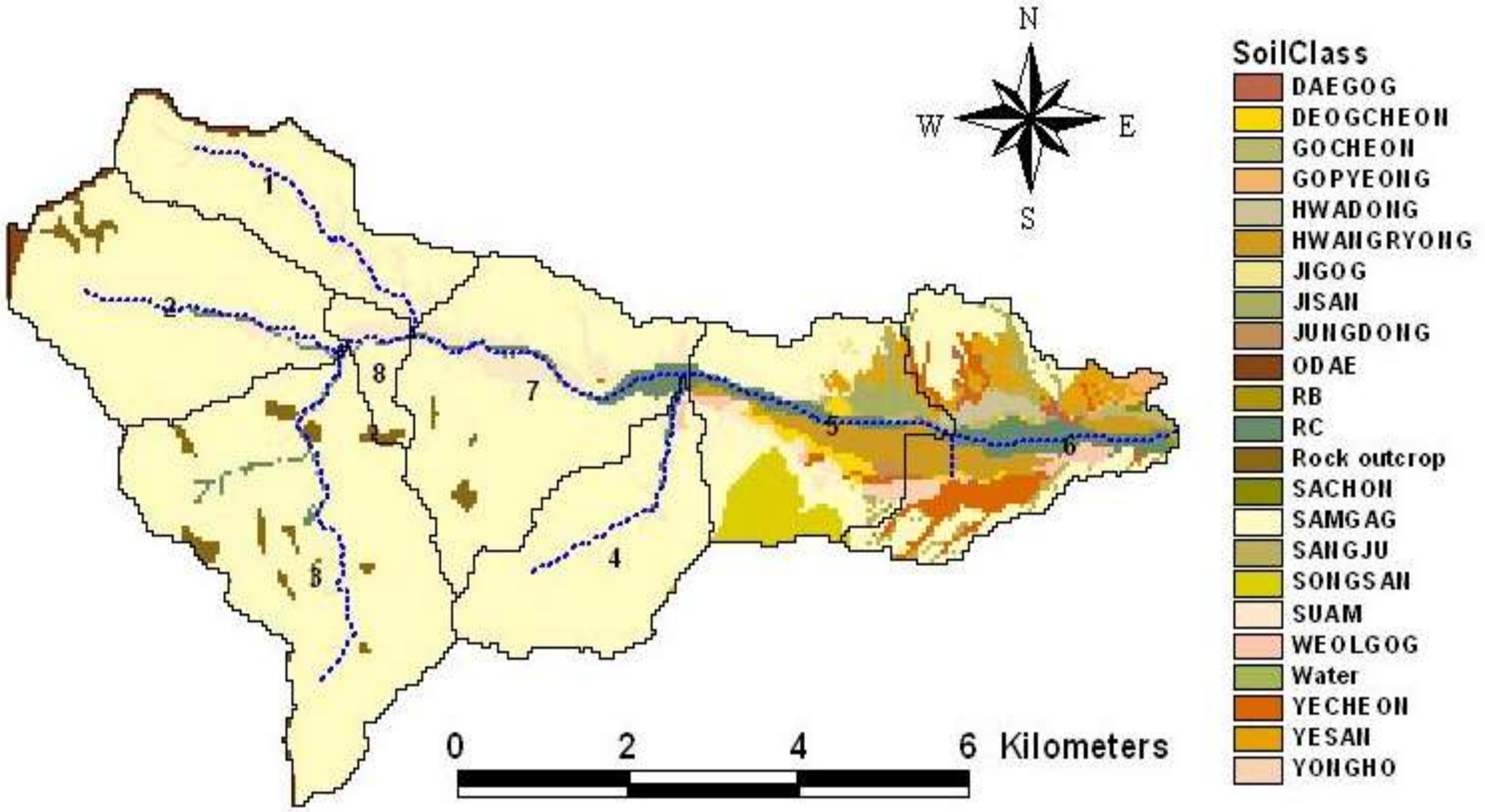
SSANGCHEON WATERSHED

- **Land Use :** About 90% is Forest Area, 5% is Agricultural area including rice paddy field



SSANGCHEON WATERSHED

- Spatial information : 23 Soil groups



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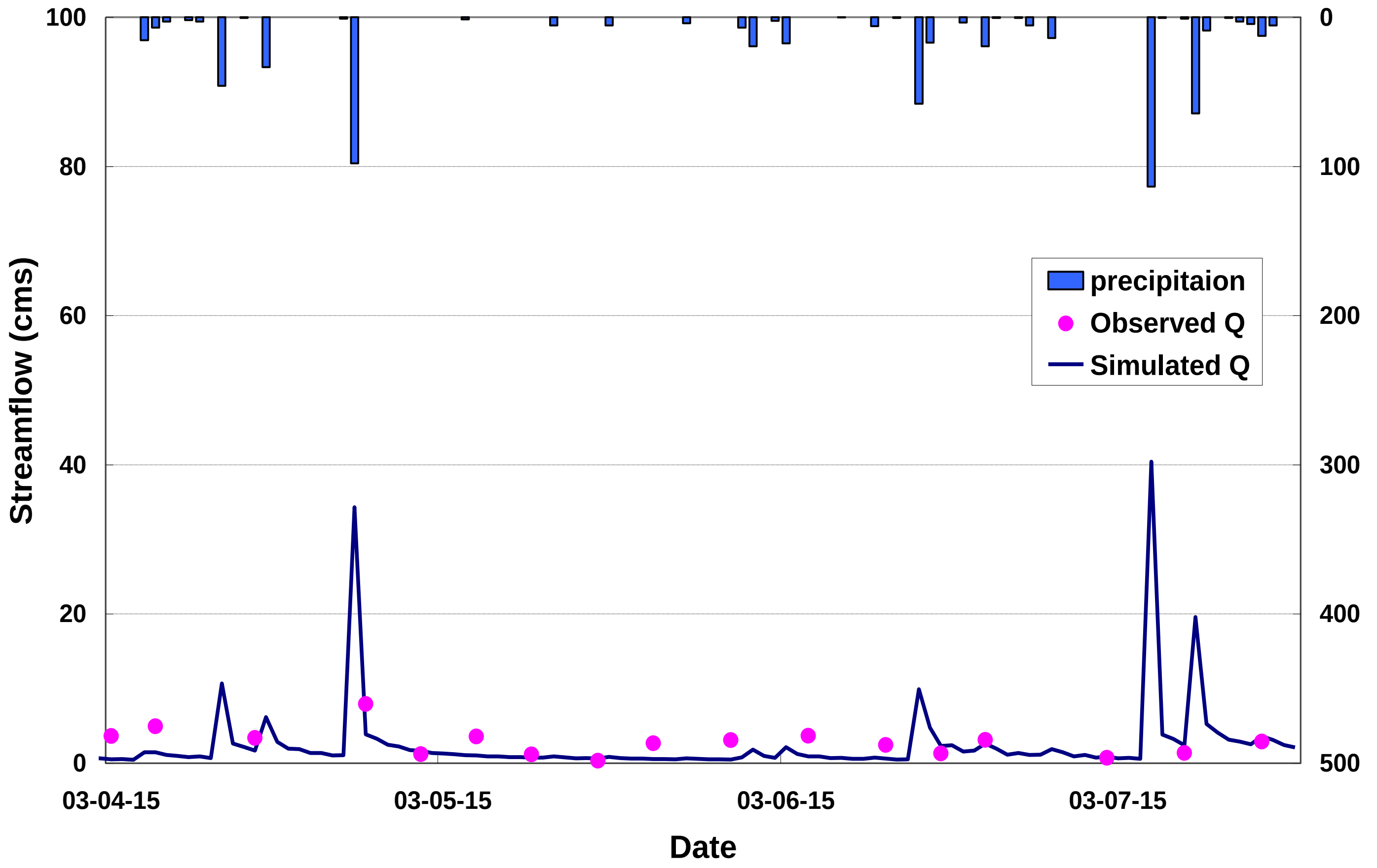
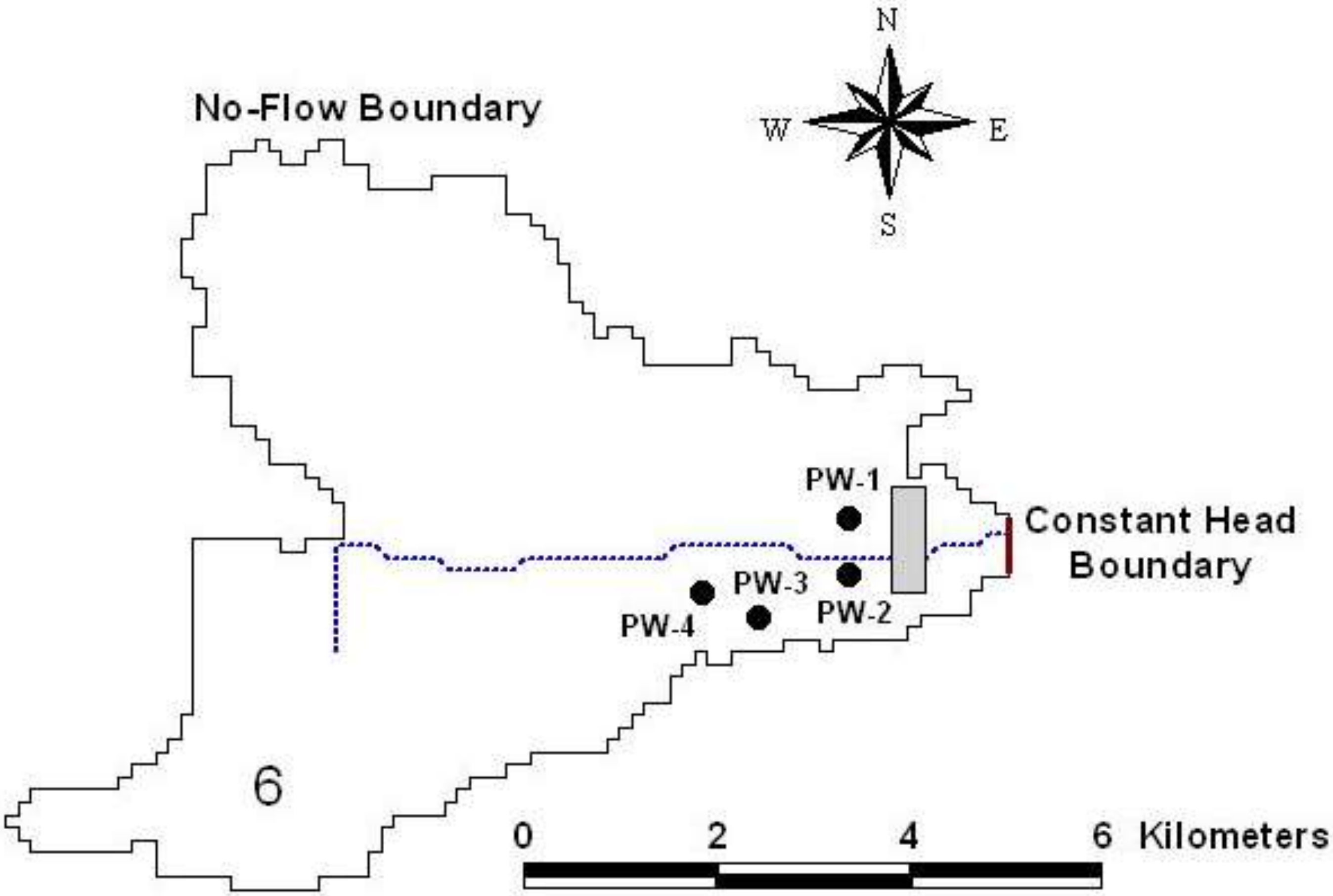
RUNOFF SIMULATION

- **Model Calibration (2003/4/15 - 2003/7/28) : R^2=0.68**



Measured and simulated runoff for studied basin during 2003.

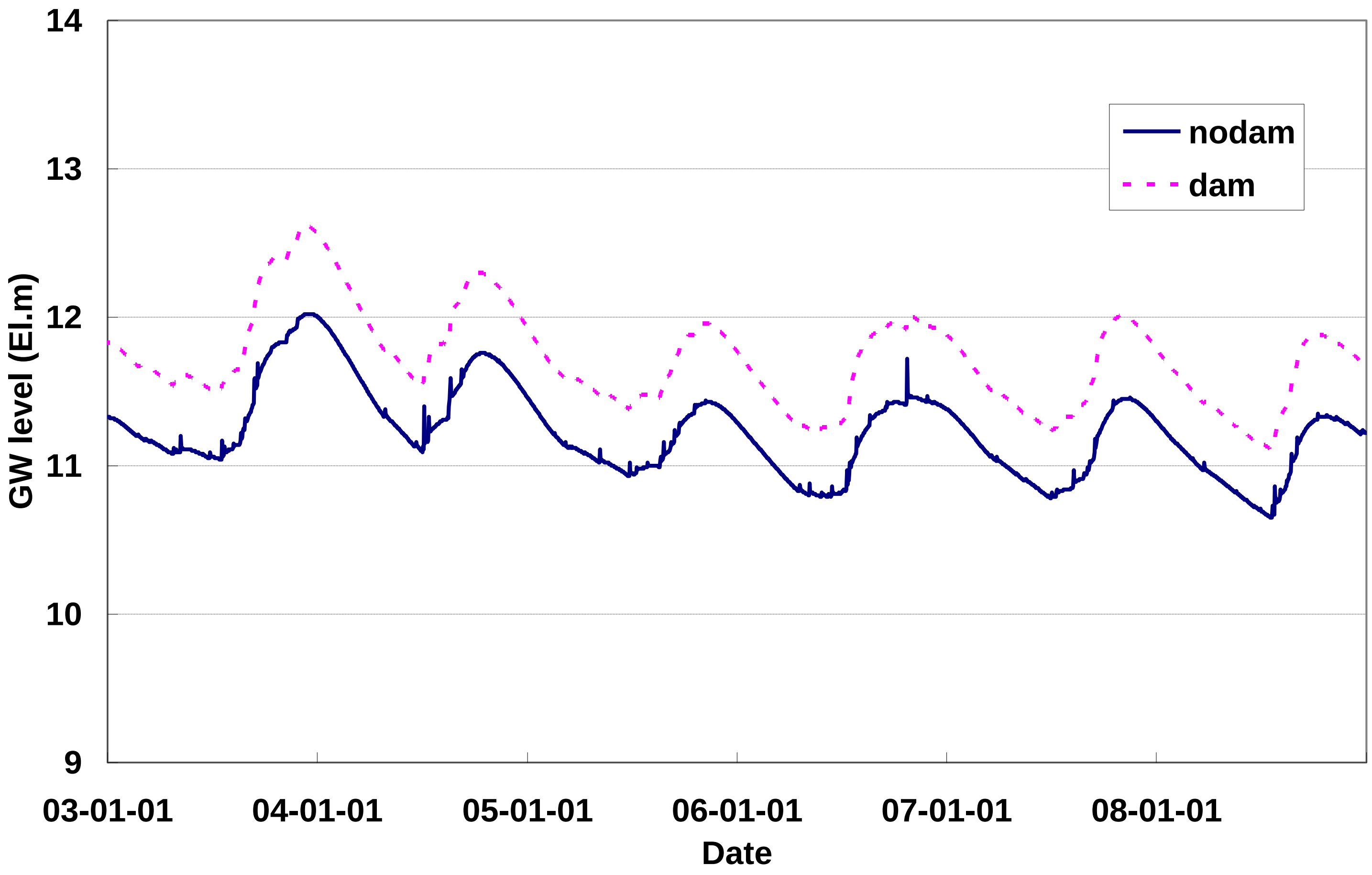
GW FLOW SIMULATION



Pumping wells (#6 basin)

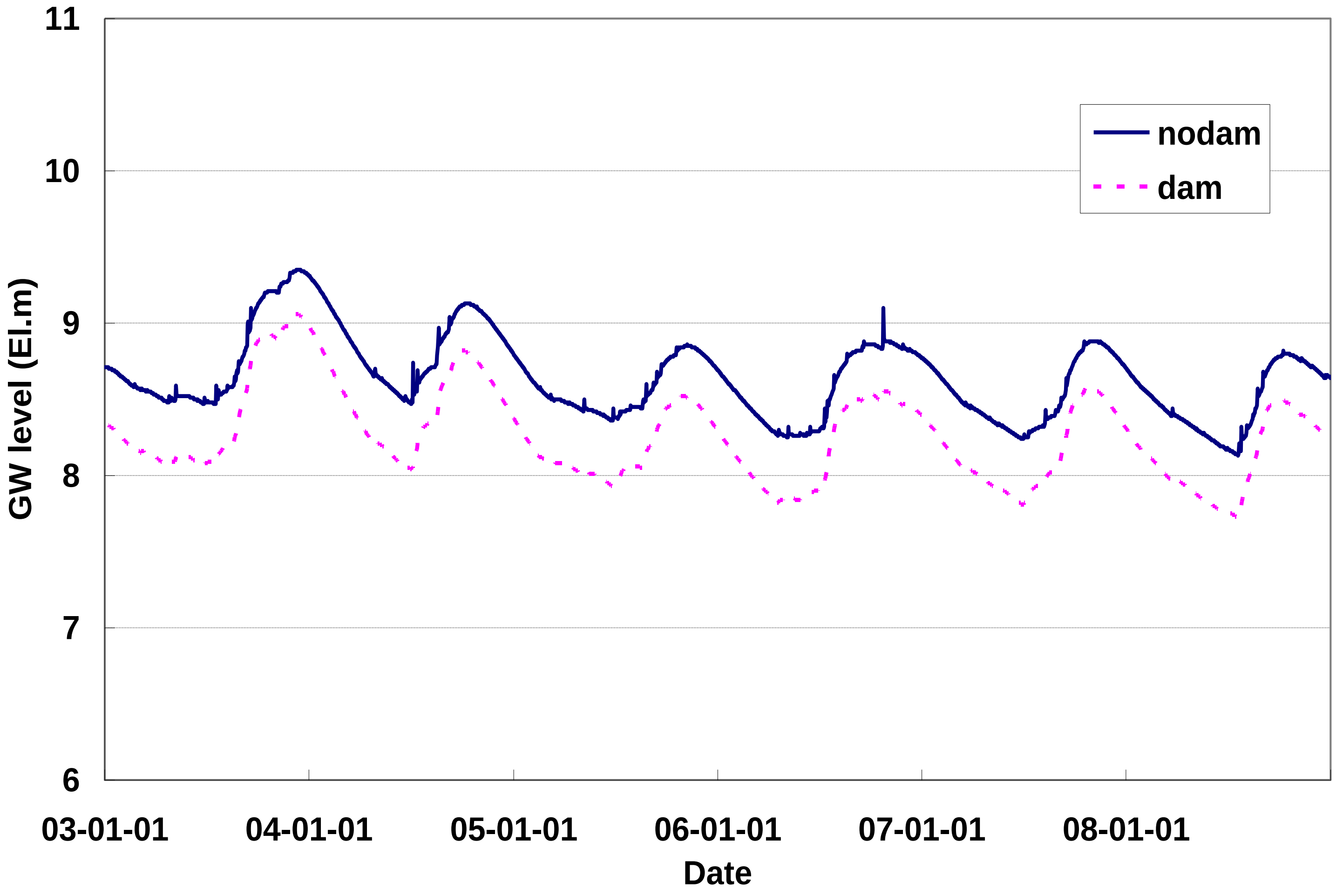
Input	data
Hydraulic conductivity(m/day) Layer-1	0.24
Hydraulic conductivity(m/day) Layer-2	0.076
Pumping rate pw-1	7,000m^3/day~10,000m^3/day
Pumping rate pw-2	2,000m^3/day~5,000m^3/day
Pumping rate pw-3	2,000m^3/day~5,000m^3/day
Pumping rate pw-4	2,000m^3/day~5,000m^3/day

RESULT OF **SIMULATION**



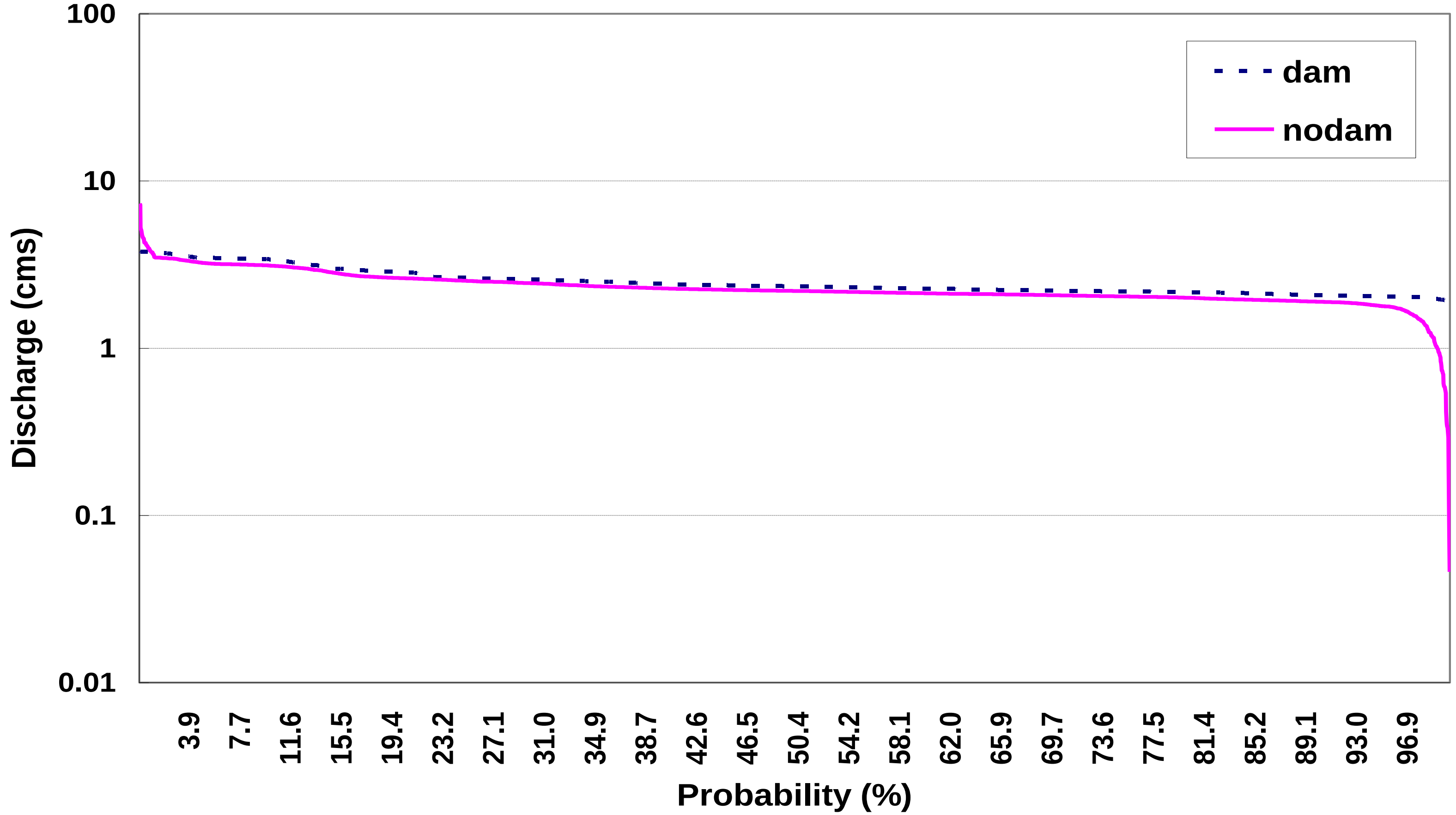
GW level variation(+0.5m) in upstream area of GW dam

RESULT OF SIMULATION



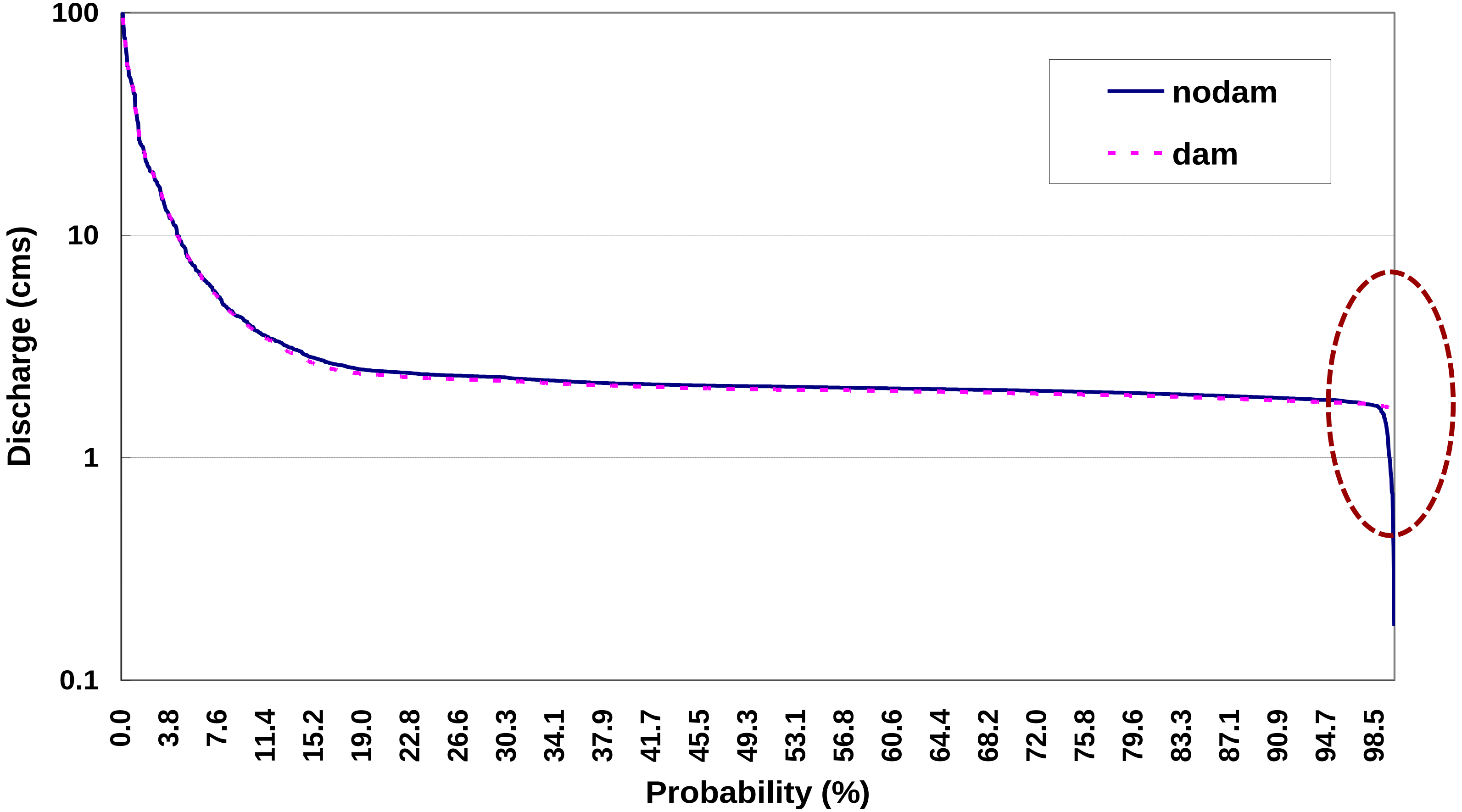
GW level variation(-0.39m) in downstream area of GW dam

RESULT OF SIMULATION



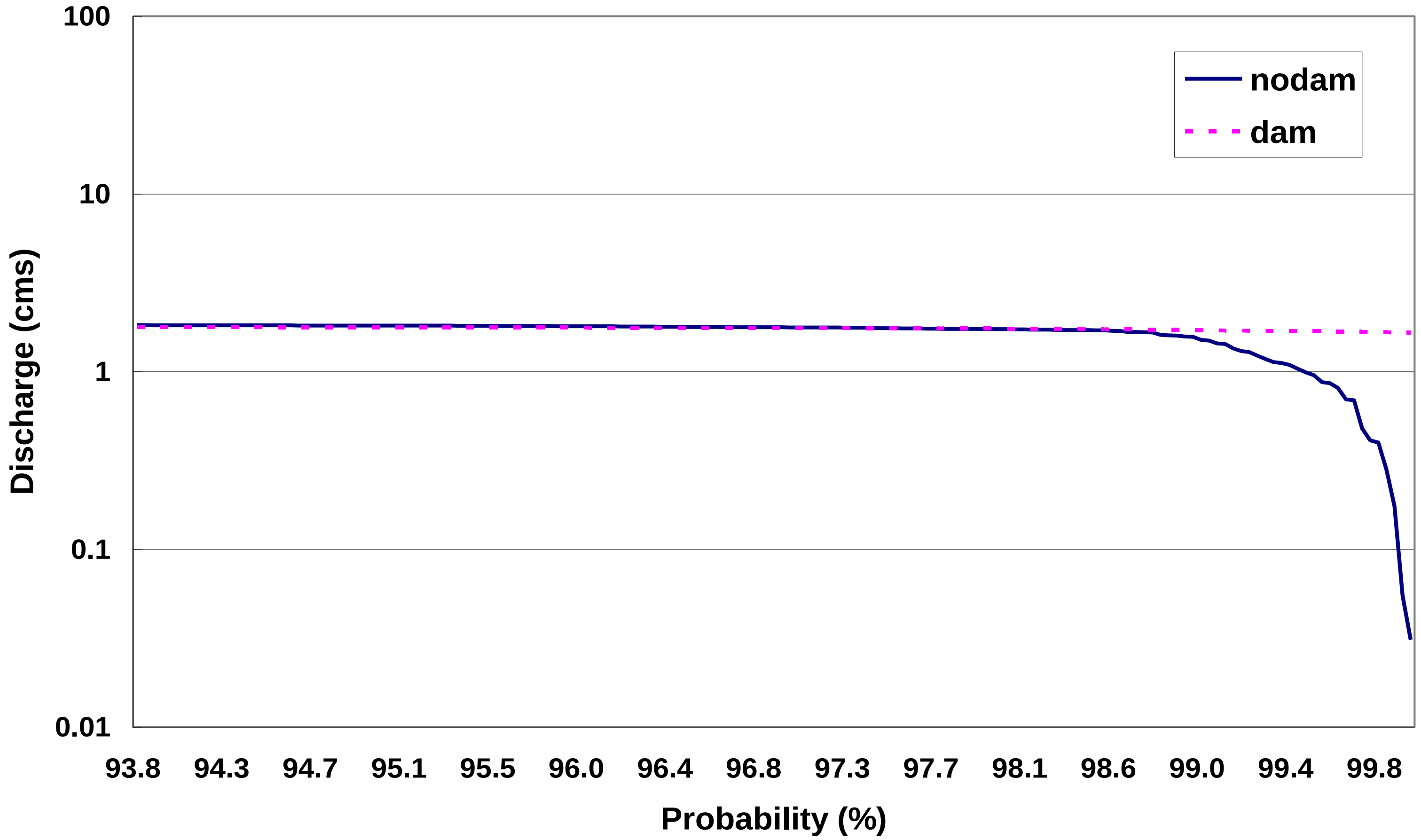
Flow duration curves in upstream watershed
(before / after dam construction)

RESULT OF SIMULATION



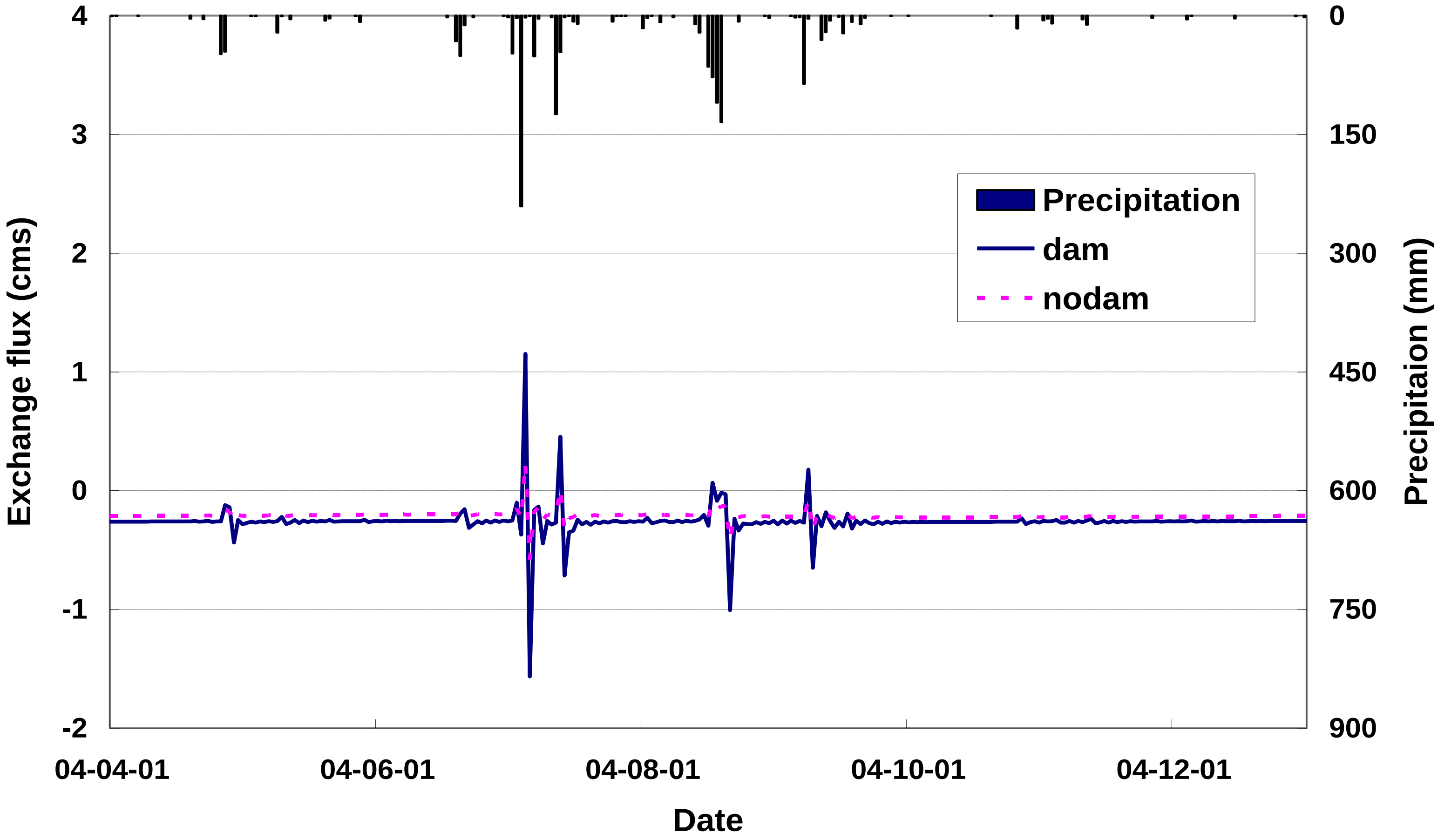
Flow duration curves for entire watershed
(before / after dam construction)

RESULT OF SIMULATION



Flow duration curves in dry period for entire watershed
(before / after dam construction)

RESULT OF SIMULATION



SW-GW Flow exchange (upstream watershed)

CONCLUSION

1. Groundwater dam in Ssangcheon watershed has been played a important role in sustainable water supply in Sokcho region after having been built in 1998.

2. After construction the groundwater level has been raised in upstream area of groundwater dam while been lowered in downstream area.

3. The exchange rate of river-aquifer interactions has increased in the upper area of the dam. It means that baseflow in dry season became large according to the raised groundwater level

CONCLUSION

4. Since the storage in the aquifer has largely increased in the upper area of the dam, the exploitable groundwater could be greater as much.

5. These examples demonstrated that groundwater dams may be very useful instrument to increase the available storage in the aquifers as well as to protect sea water intrusion.

6. It is also demonstrated that the SWAT-MODFLOW is useful tool for analysis on planning and operation of the groundwater dams.

: Thank you :

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