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Flood mitigation by hydropower in Norway

IEA Hydropower – Joint Annex IX and XII Workshop
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Hydropower and flood mitigation

Hydropower may decrease flood risk by technical structures

- Reservoirs can store water and reduce flood peaks
- Divertion/Bypass structures (tunnels, canals, …)

The operation of structures is important

- Operation need to consider two or more objectives
- Energy production
- Flood damage
- Other uses (Irrigation, transport, tourism, …)
- Who will pay and who will benefit?

How to balanse between these objectives?

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Hydropower system – Dam safety

Hydropower may also increase flood risk –
Always consider Dam safety

Roppa dambreak May 1976

Possible Case studies Flood/Hydropower in Norway

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- Nea-Nidelv river (Large reservoirs – flood volume)

- Gaula (Small reservoirs, sharp flood peaks)

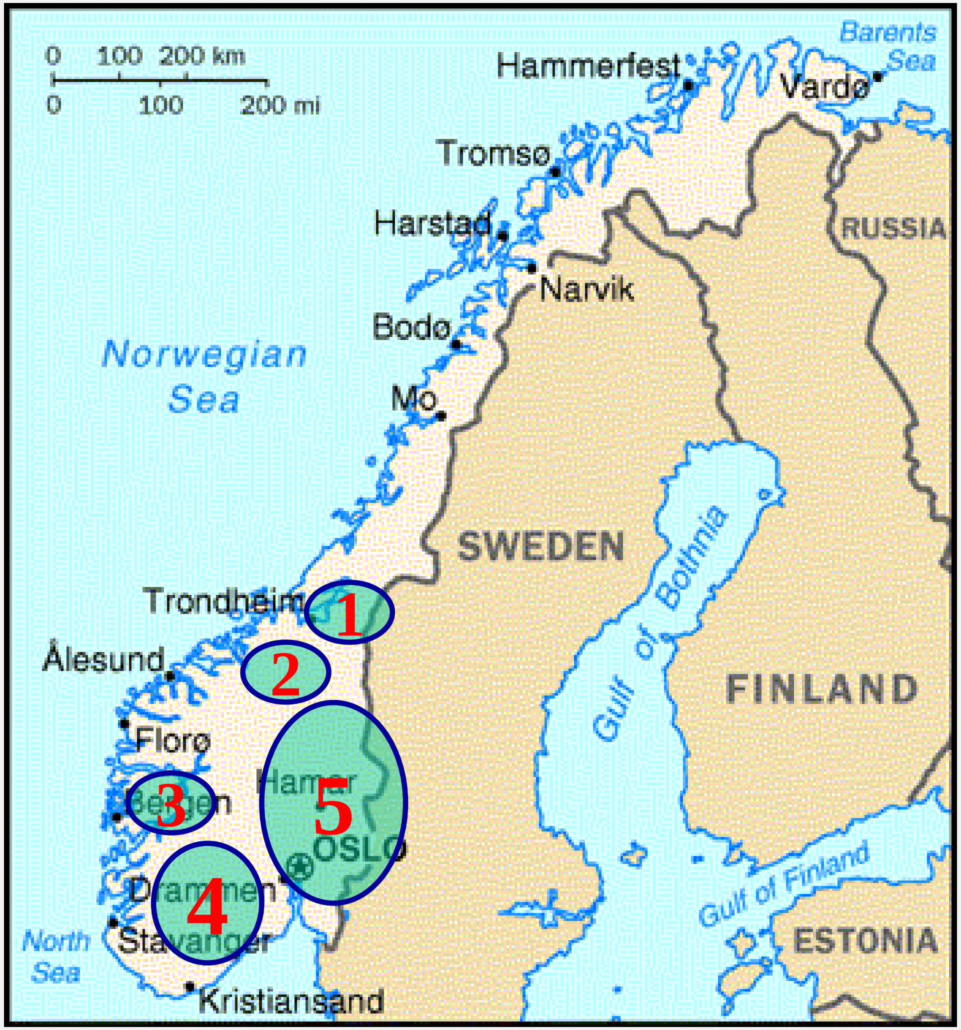
- Vosso – (Diverting flood by hydro tunnels)

- Telemark (Complex hydro system, forecast model)

- Glomma (Three major floods, Land use and Hydro)

Potential case studies in Norway - Locations

- *(1) Nea-Nidelv river*
- *(2) Gaula*
- *(3) Vosso*
- *(4) Telemark*
- *(5) Glomma*



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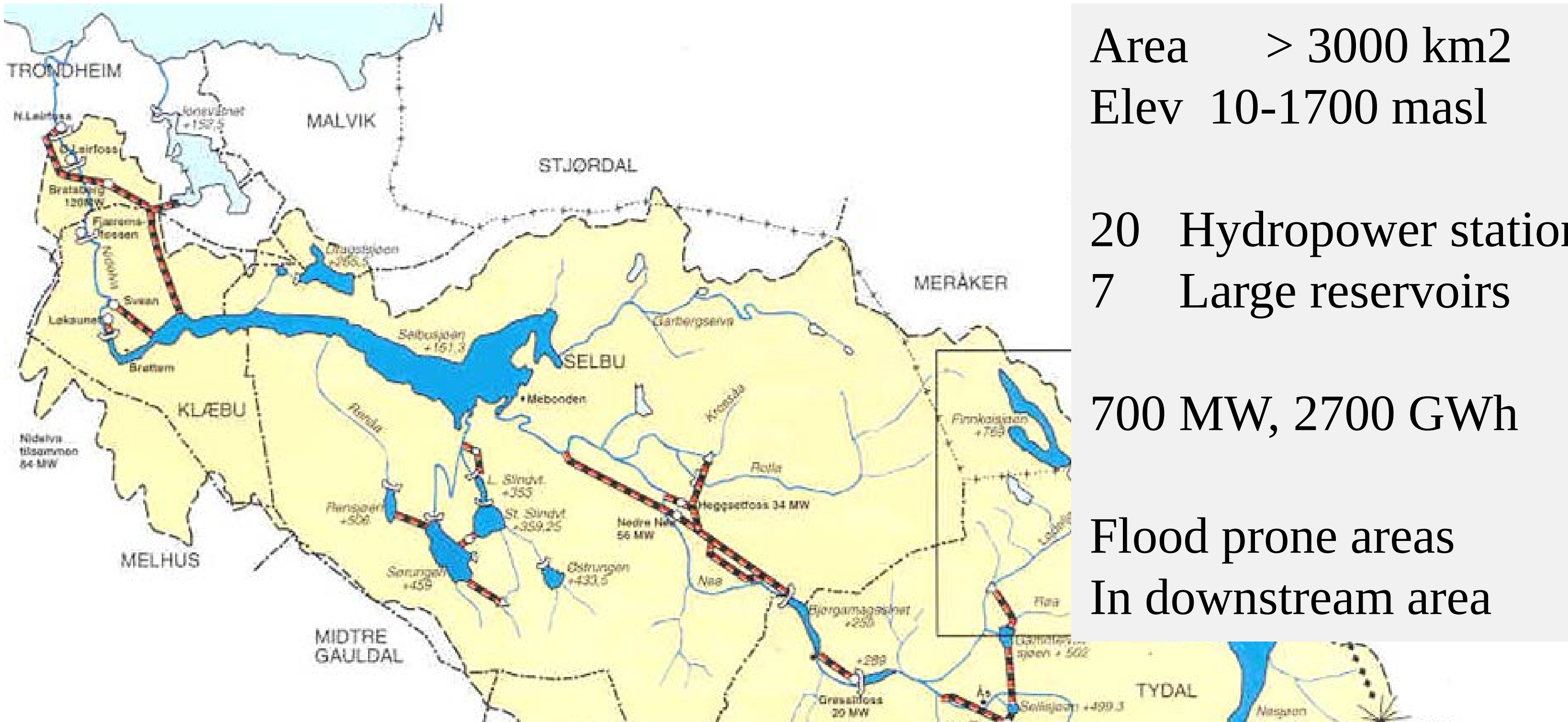
Nea-Nidelv catchment and hydropower system




Area > 3000 km2
Elev 10-1700 masl

20 Hydropower stations
7 Large reservoirs

700 MW, 2700 GWh

Flood prone areas
In downstream area

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From Nea-Nidelv catchment

Nea-Nidelv Floods - Summary

- Large reservoirs for hydropower
- Snowmelt floods most important
- Long term optimization (seasonal) needed for reservoirs
- First flood forecasts by models issued in 1976
- Very significant flood reduction observed – due to reservoirs
- Well documented case

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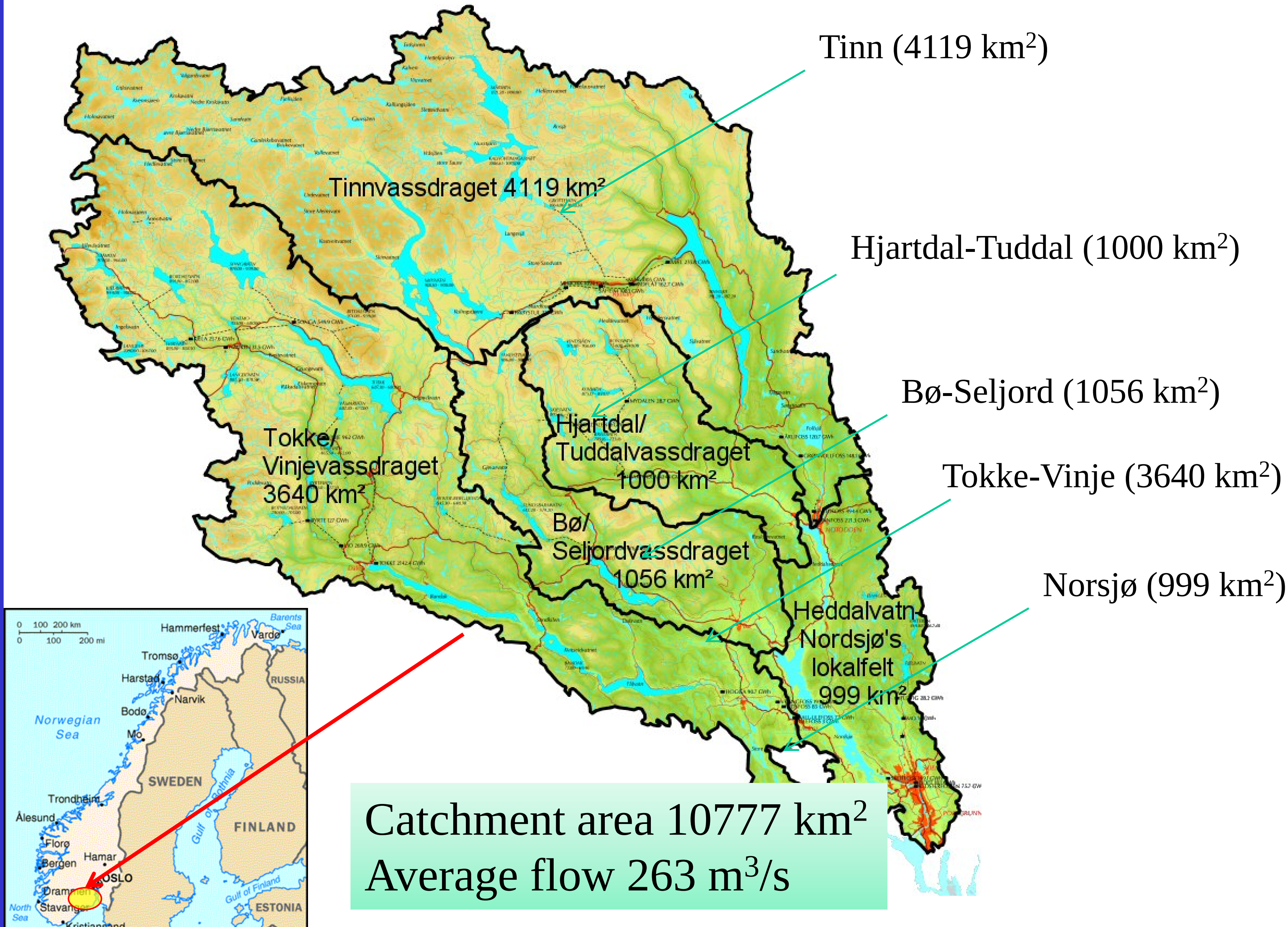
Telemark river system

Telemark – major river basins



Catchment area 10777 km^2

Average flow 263 m^3/s

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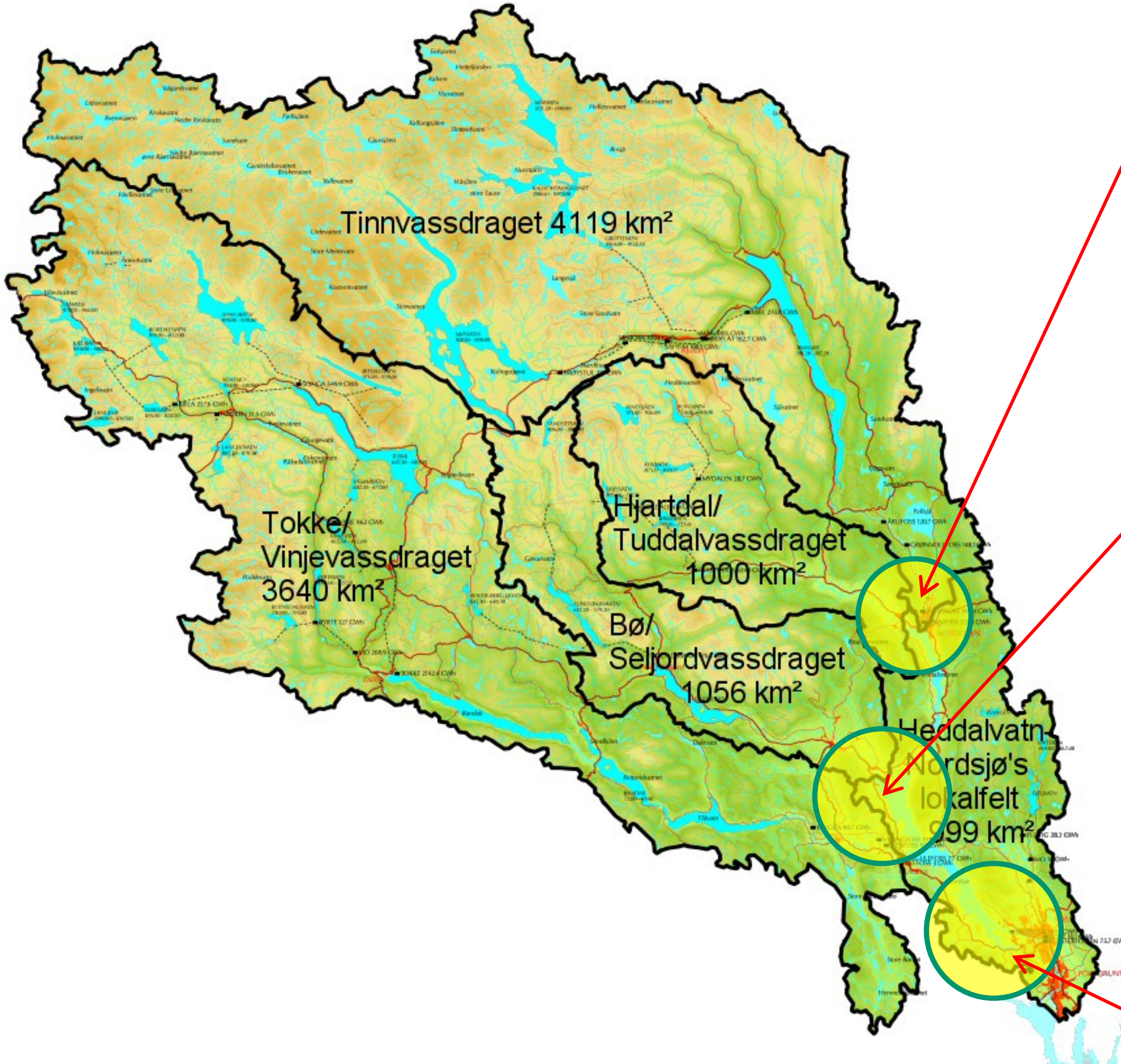
Telemark – the most flood prone areas



Notodden

Norsjø

Skien Hjellevatn

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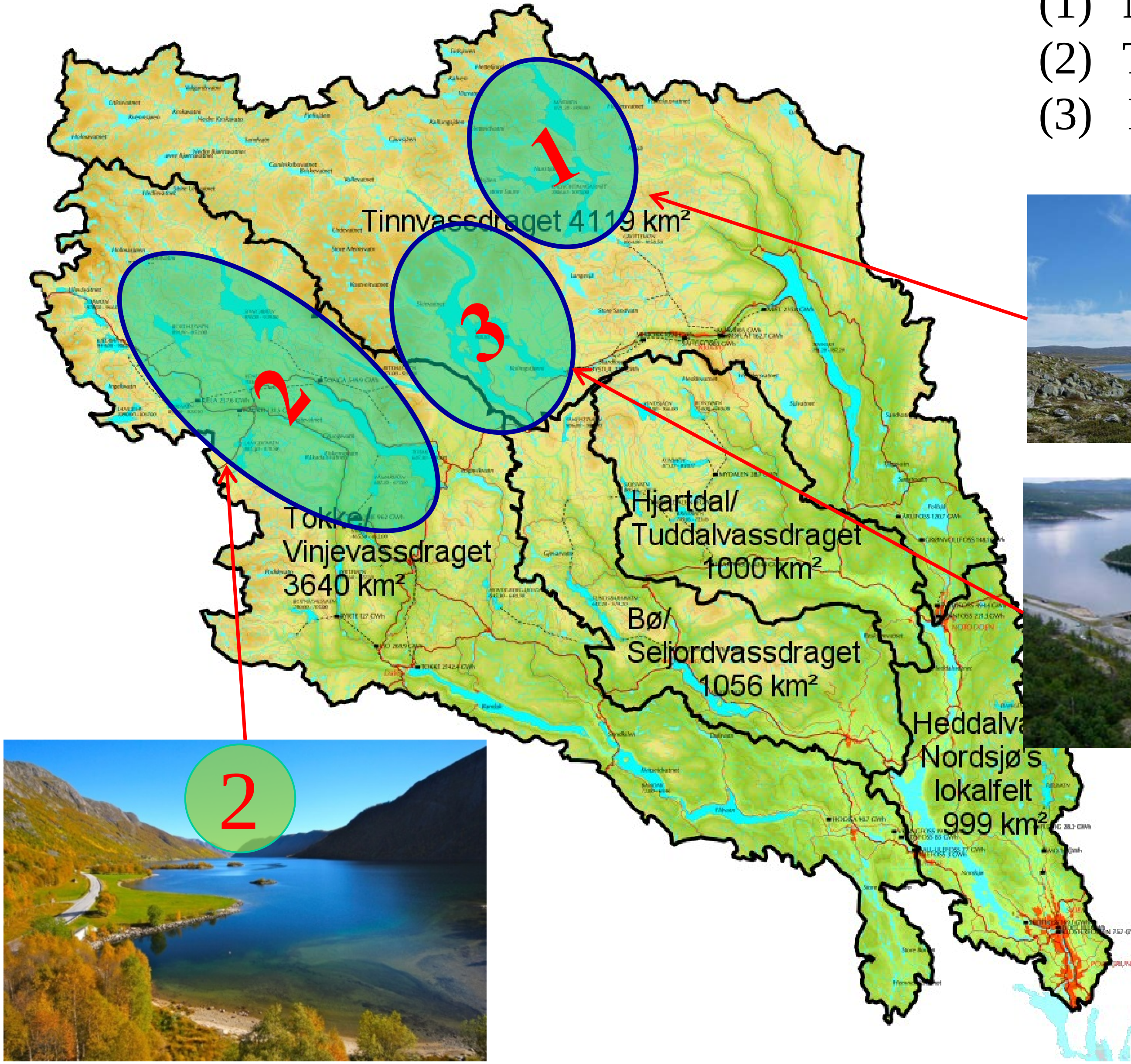
Telemark- Main hydropower reservoir areas

(1) Mår,
(2) Tokke-Vinje,
(3) Møsvatn



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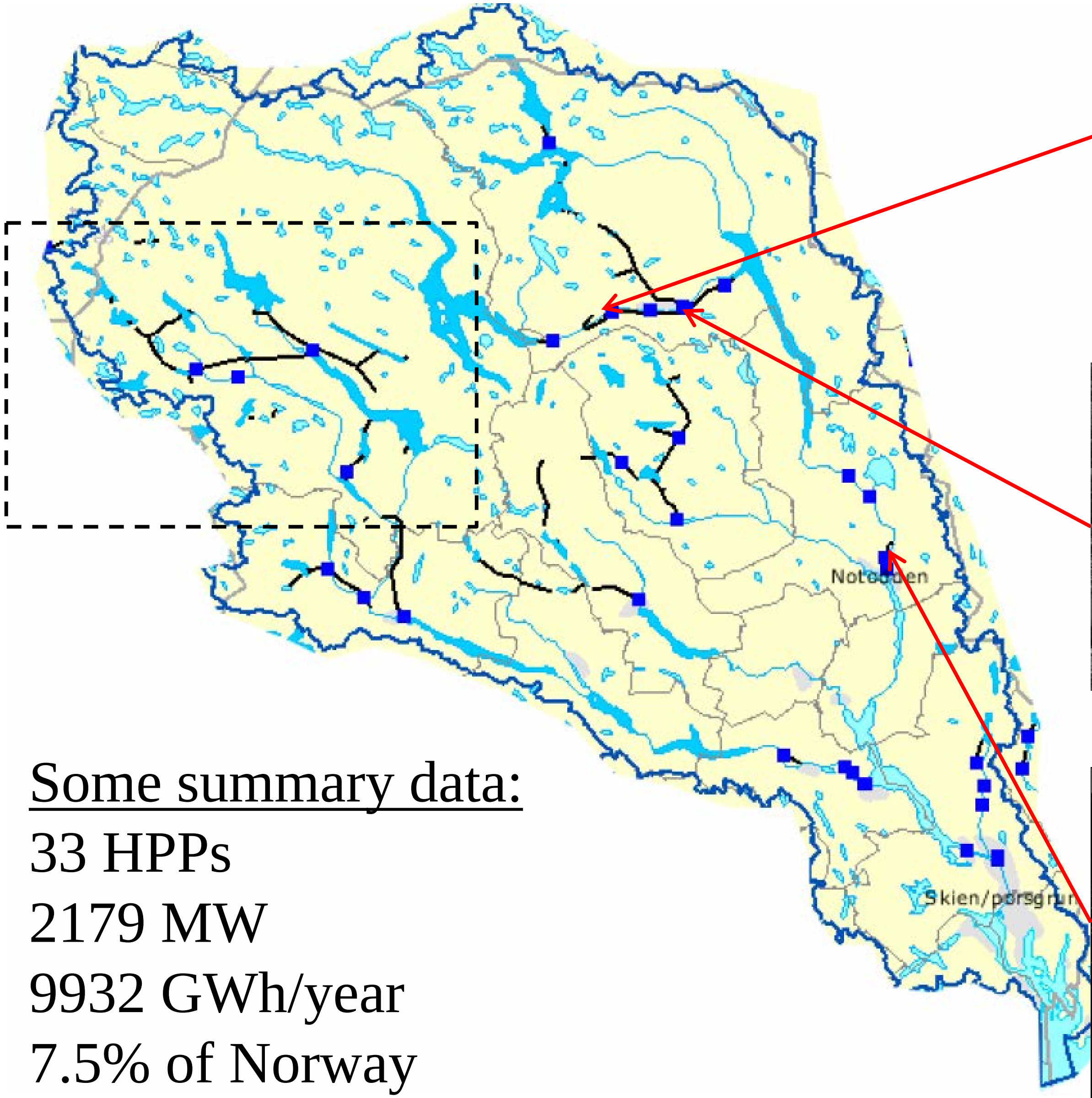
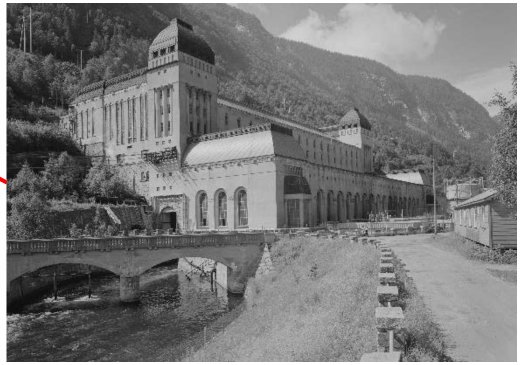
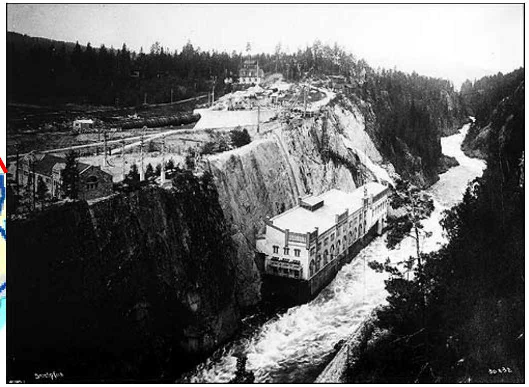
Telemark – Extensive hydropower system



Vemork 1911



Såheim 1916



Svelgfoss 1907

Some summary data:

33 HPPs

2179 MW

9932 GWh/year

7.5% of Norway

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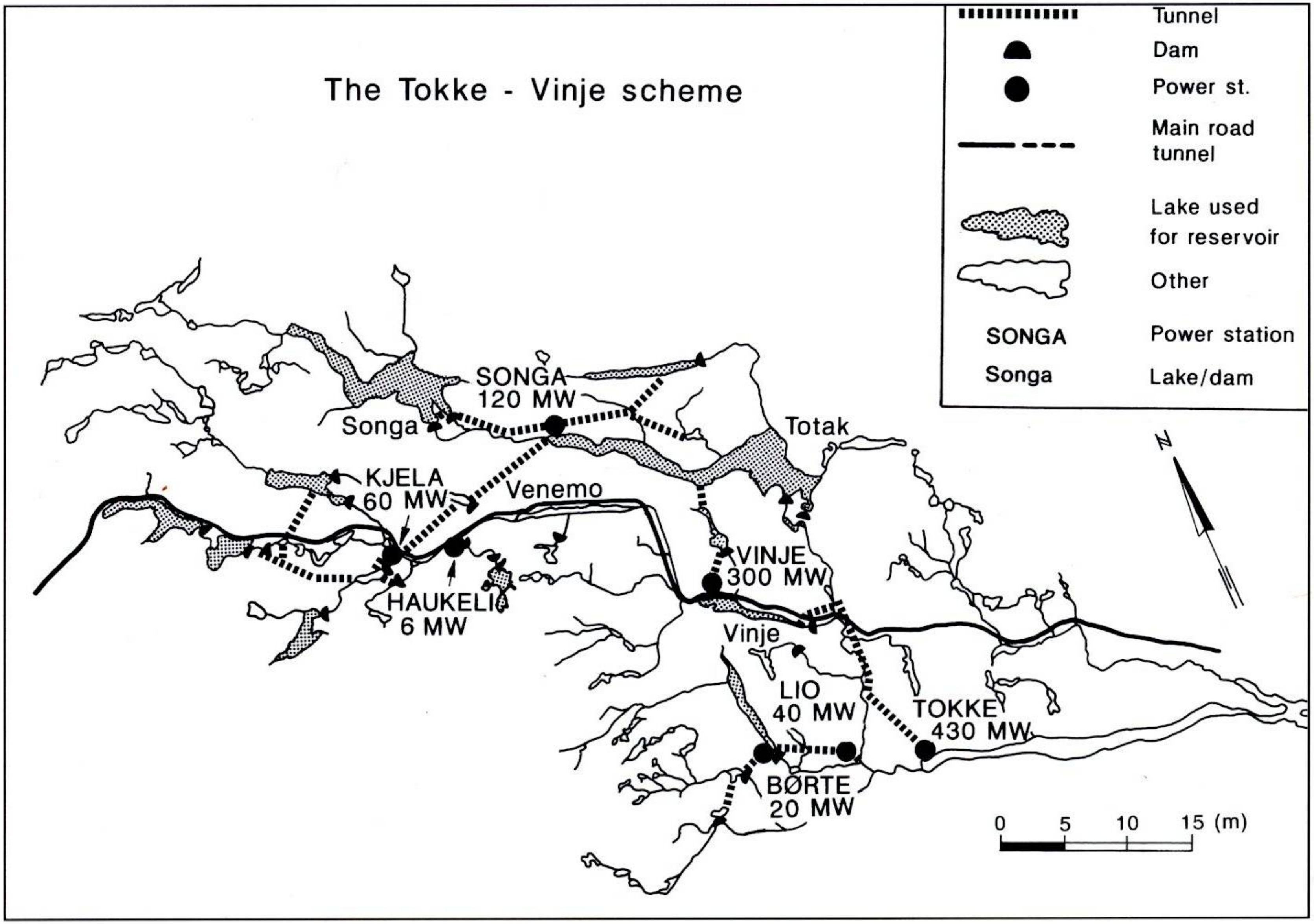
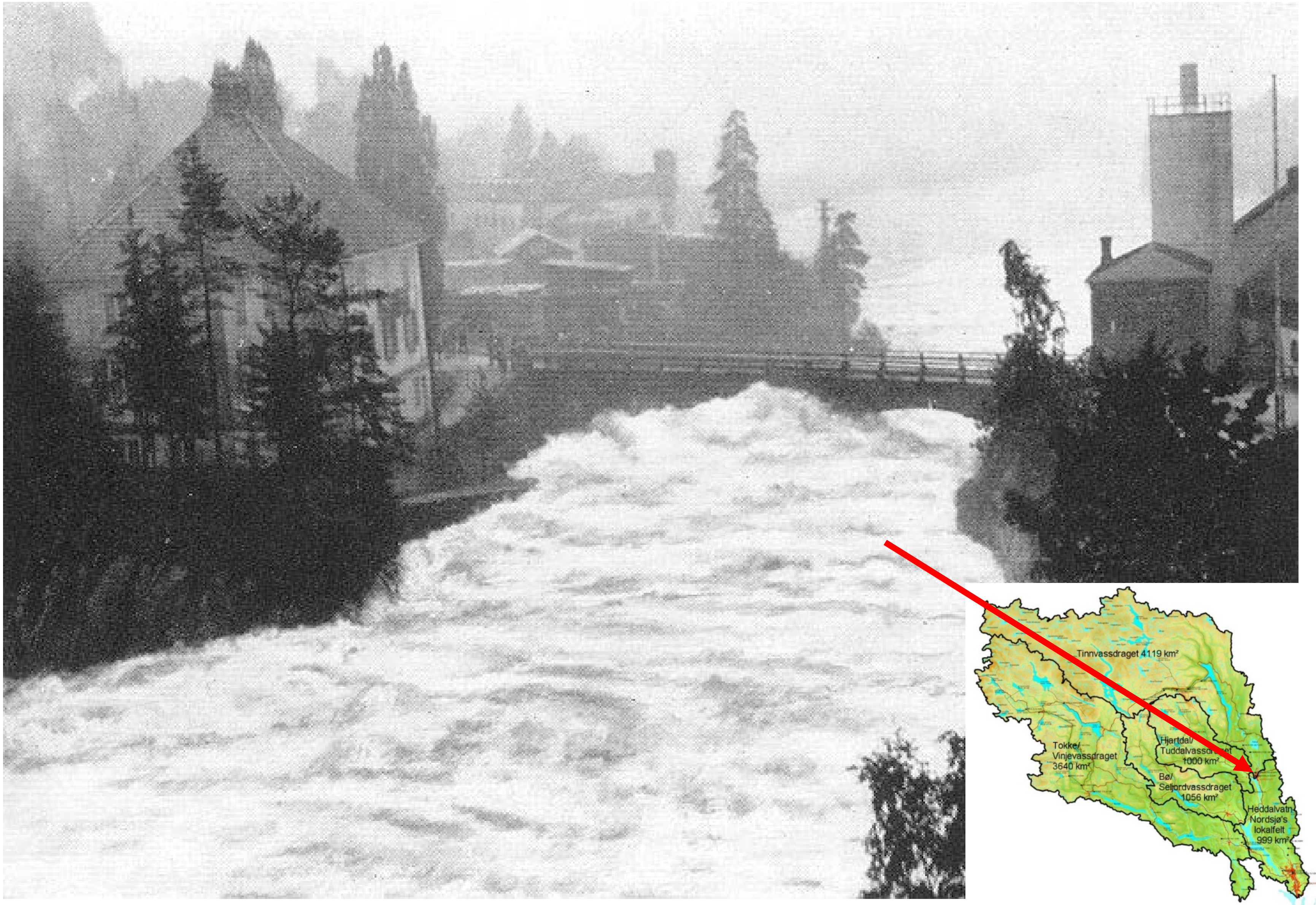
A complex hydropower system



Tinnelva – Major flood in 1927



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Rjukan - Flood and landslides in 1927

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Hjartdøla (close to Notodden) – Flood in 2015

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Skien – Flood in 2015

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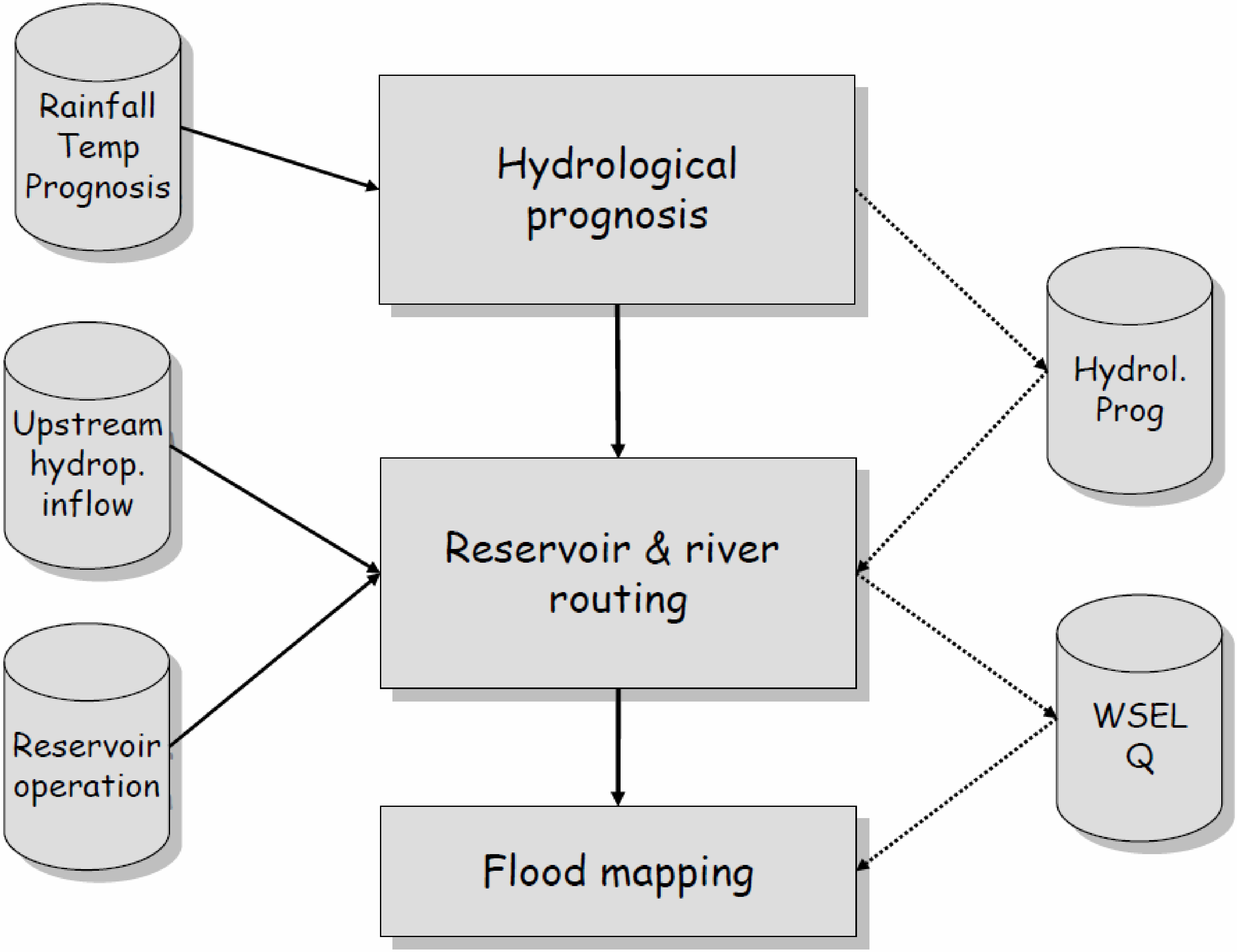
Telemark flood forecasting model system



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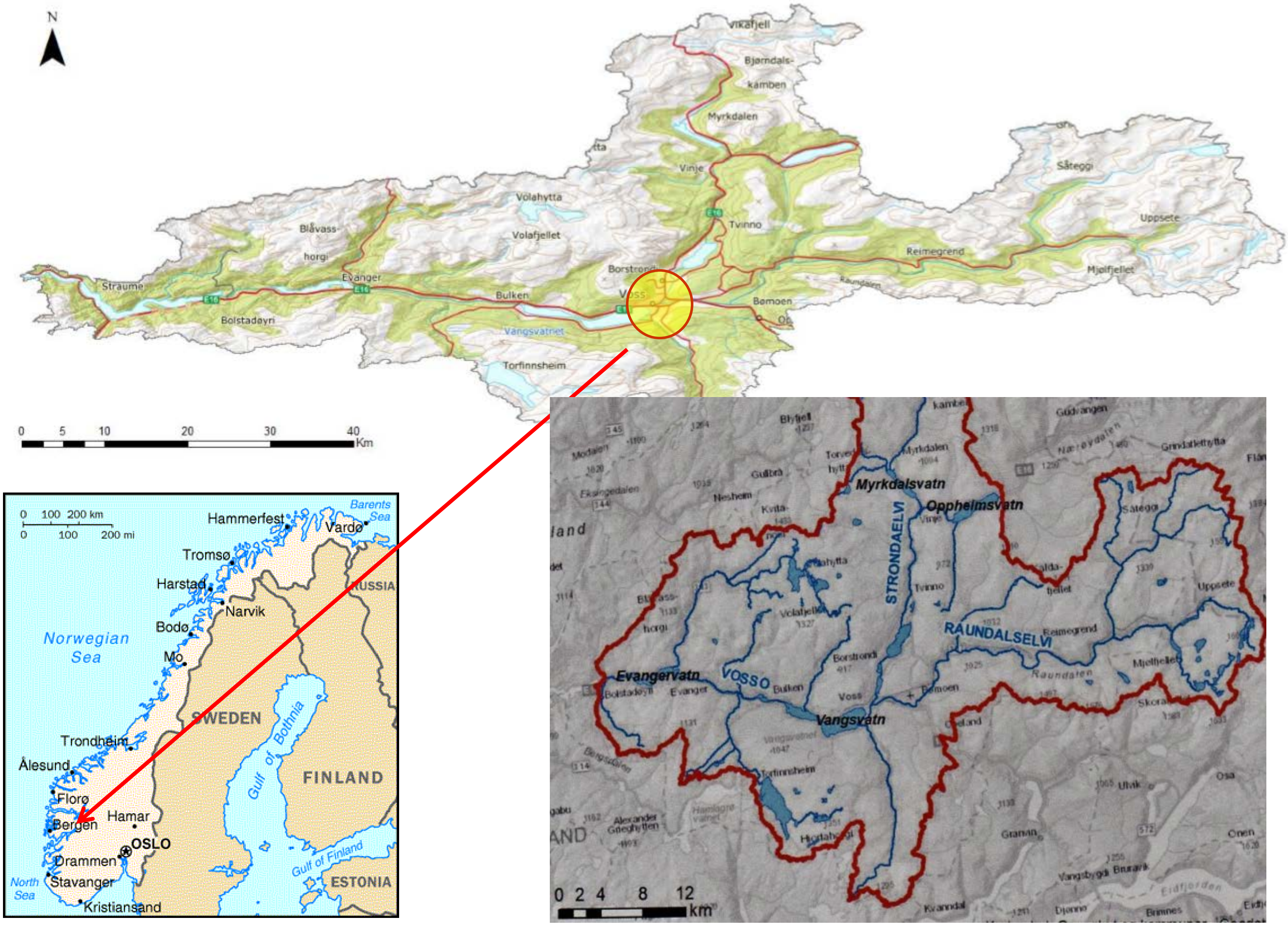
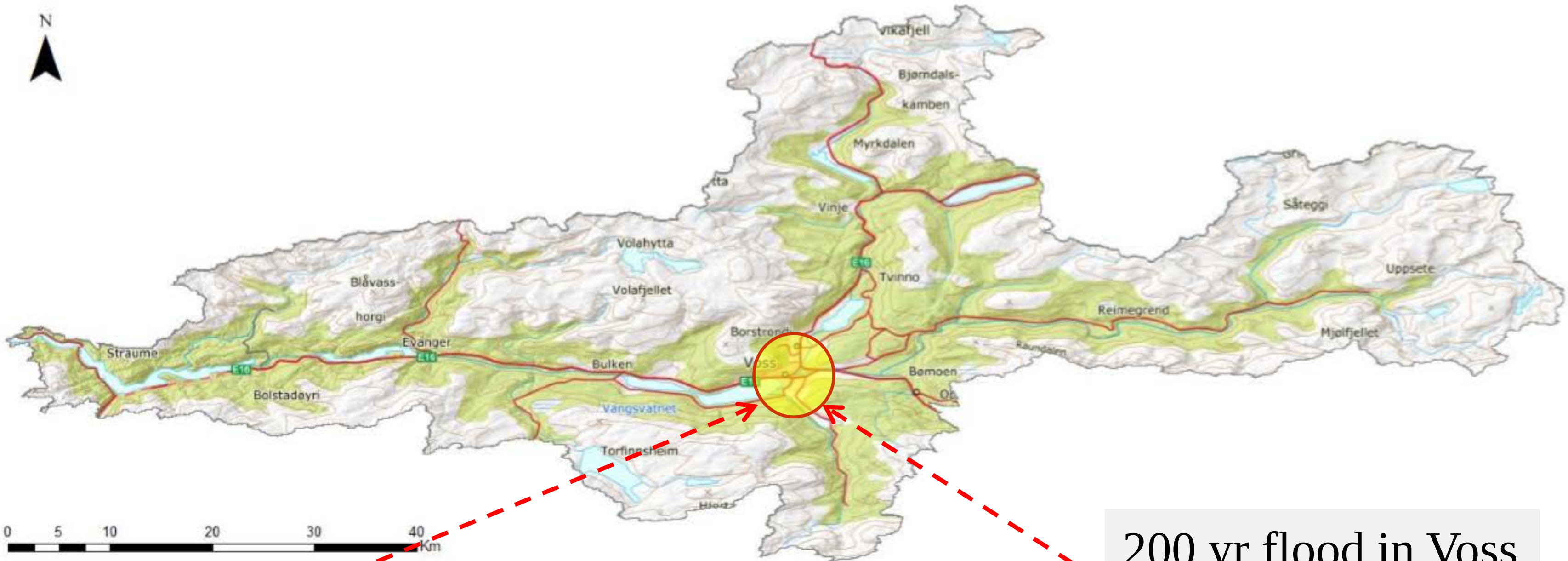
Summary – Telemark flood model

- Significant flood risk in the river basin in downstream areas
- Many large flood events recently – high media focus
- Flood damage can be mitigated by hydropower reservoirs
- Conflicts between flood mitigation and power generation
- Difficult to find optimal operation for reservoirs
- The Telemark flood model was developed as a tool
- Tested during several years of operation since 2008
- «Acid test» during the 2015 flood «Petra»

Vosso river system



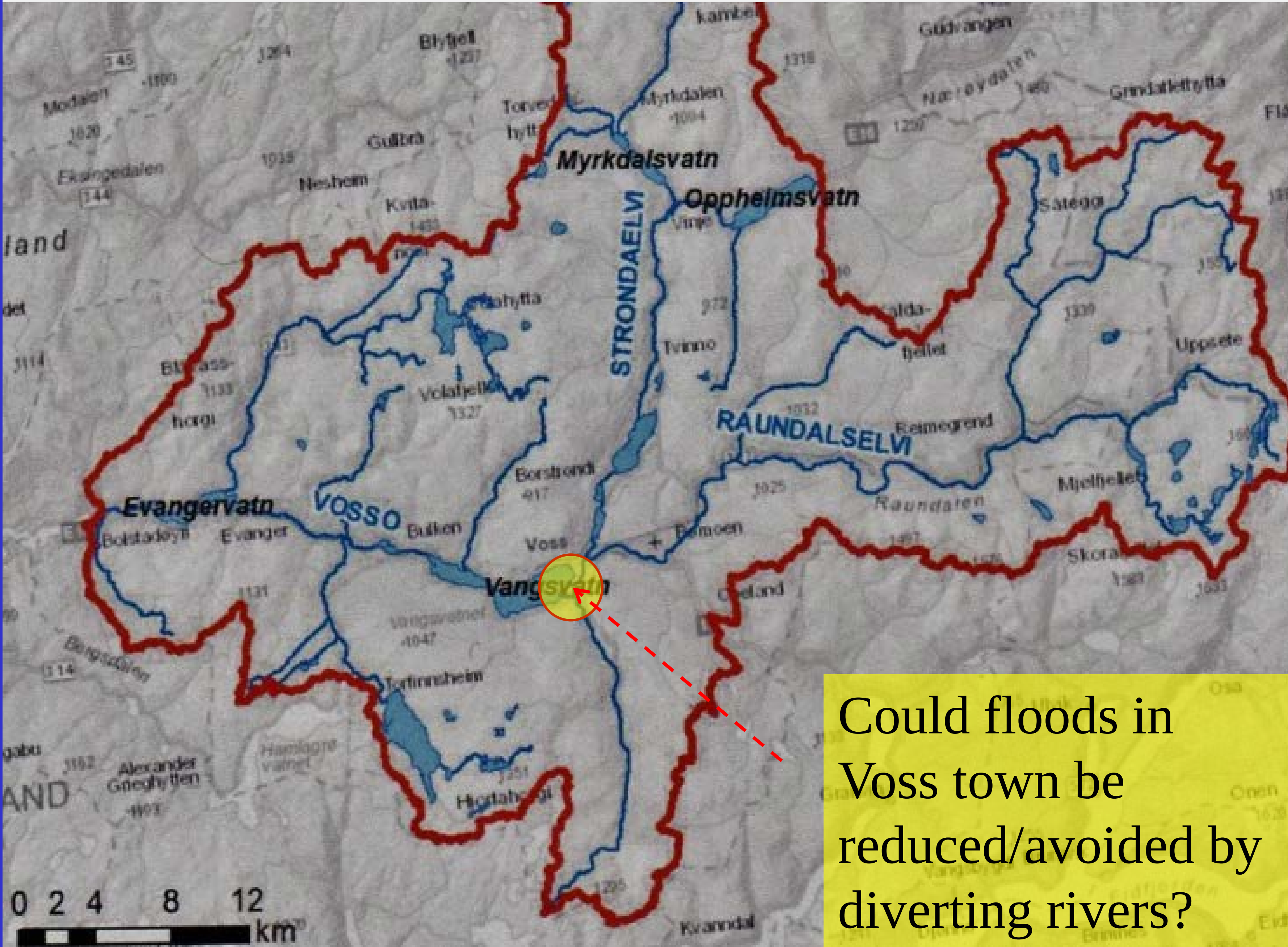
Vosso river system – Flood risk in Voss town



200 yr flood in Voss

2014 Flood in Voss

Flood risk in Voss town – can inflow be diverted?



Could floods in Voss town be reduced/avoided by diverting rivers?

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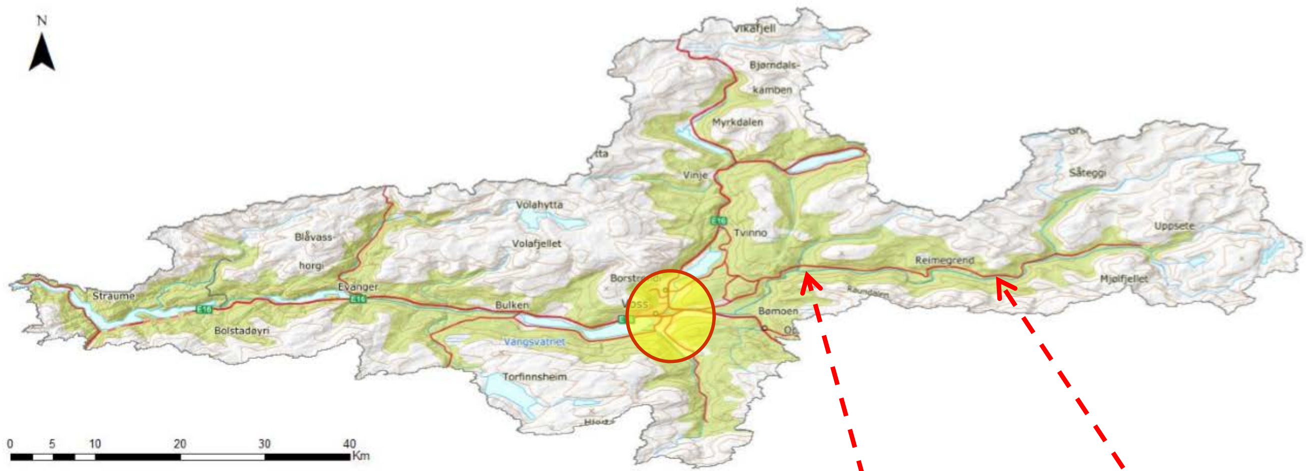
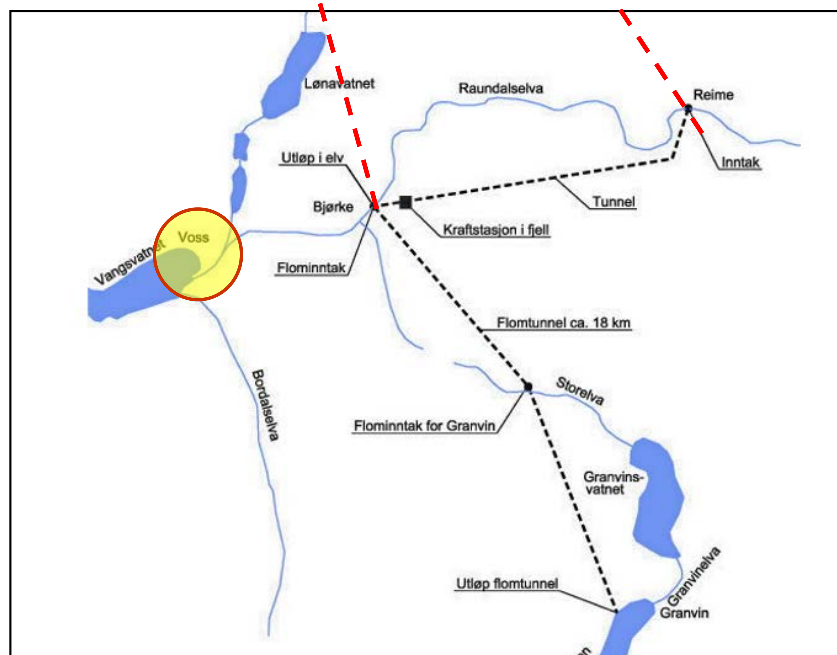
Combined flood tunnel and hydropower possible



Rivers could be diverted through tunnels to nearby fjord at Granvin.

Hydropower plants in the tunnels could pay for the tunneling cost (500 GWh/yr)…



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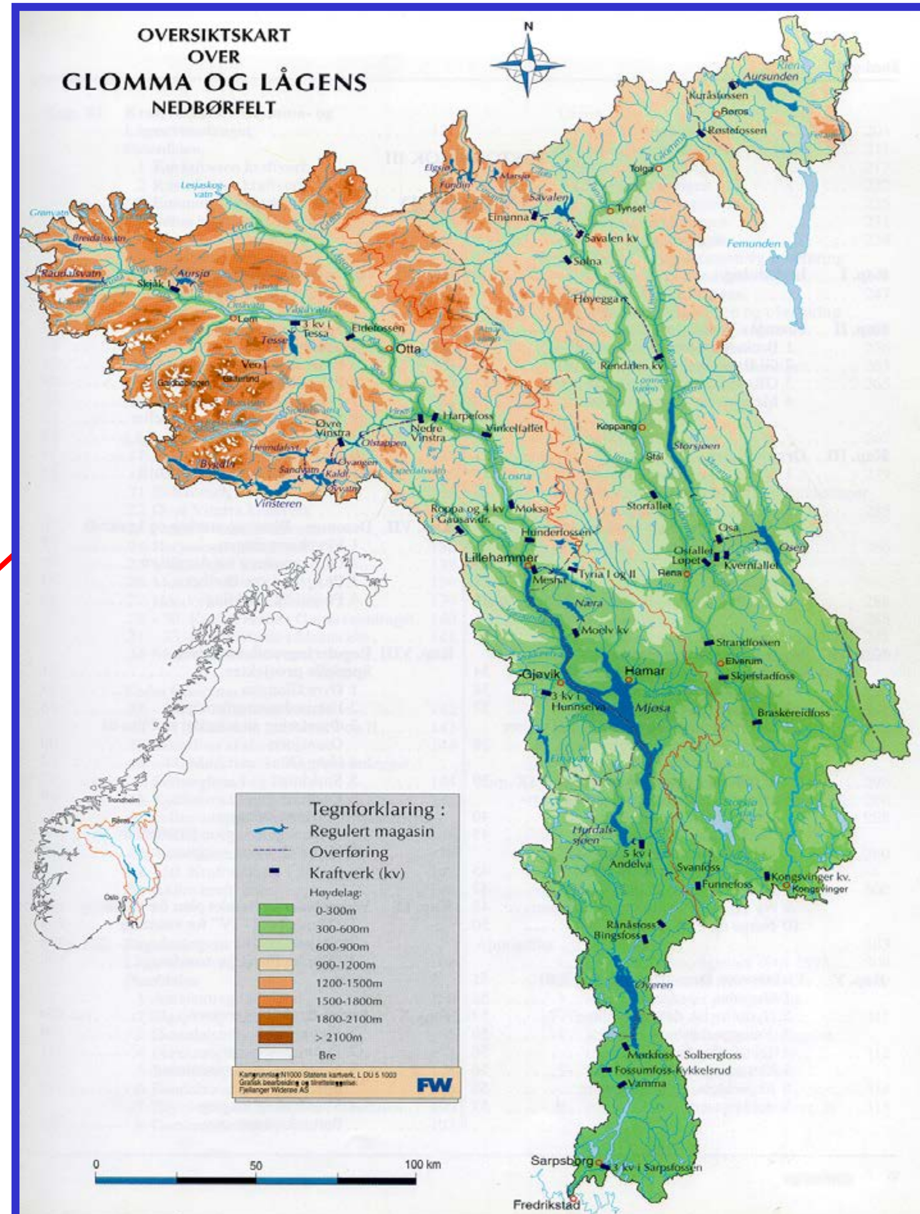
Glomma river system

Area 40 000 km^2
Avg flow 600 m^3/s

Max flood > 4000 m^3/s

Hydropower:
2500 MW, 12300 GWh



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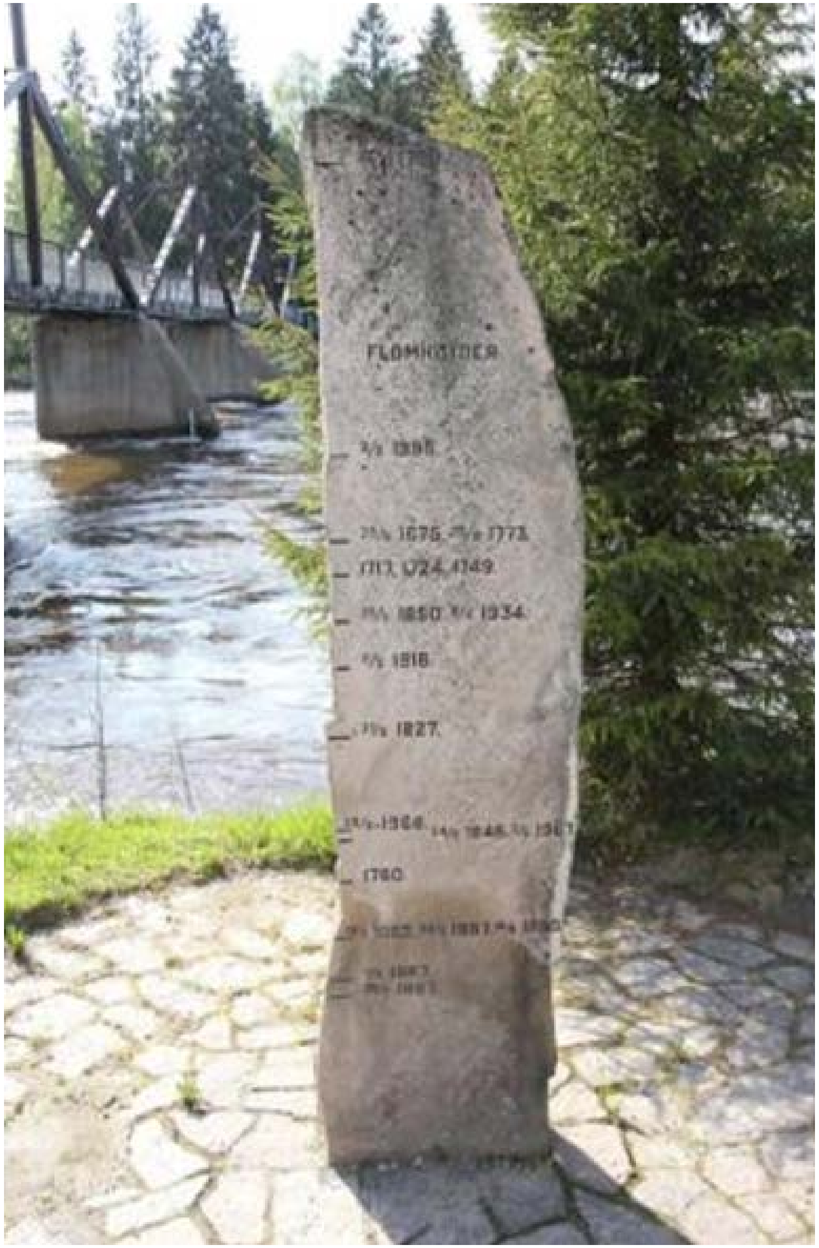
Glomma river system – Flood in 1995

In 1995 the biggest floods in this century occurred in Norway, in a two week period from May 27th to June 10th.

This flood created damage in the order of 1800 Mill. NOK, equivalent to 300 Mill US $.

The flood was caused by a combination of large initial snowpack, a delayed spring and unusual but not extreme precipitation in combination with high air temperature during the flood event.



The HYDRA research program

A large research program called HYDRA was initiated as one of the measures taken by the government to be better prepared to meet possible future floods.

The main research topics in this program were:

- To understand combined effects on flood of land use changes in the catchment
- To improve flood forecasting methods
- To improve methods to reduce damage in flood prone areas
- To make optimal use of hydropower reservoirs during floods

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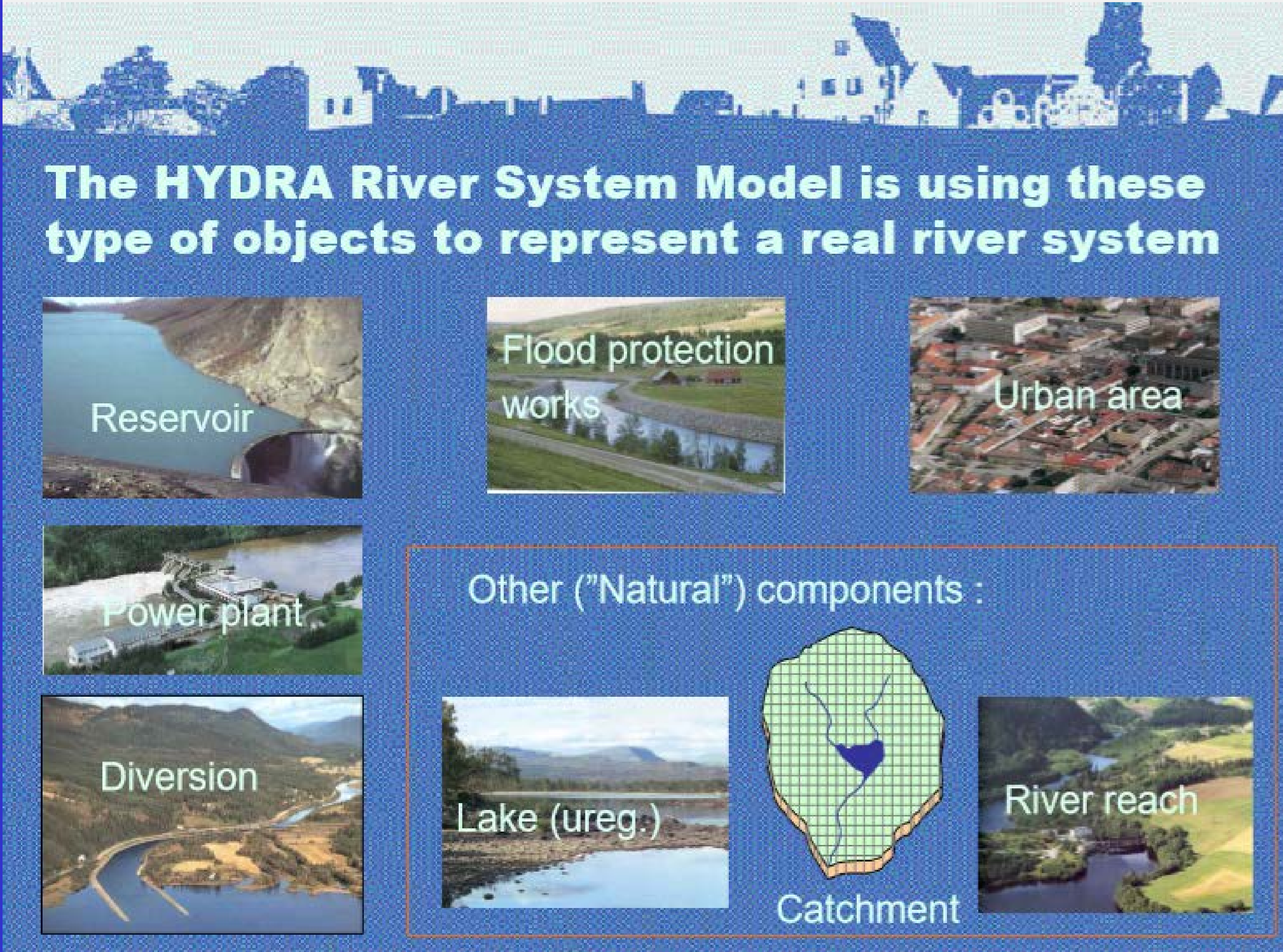
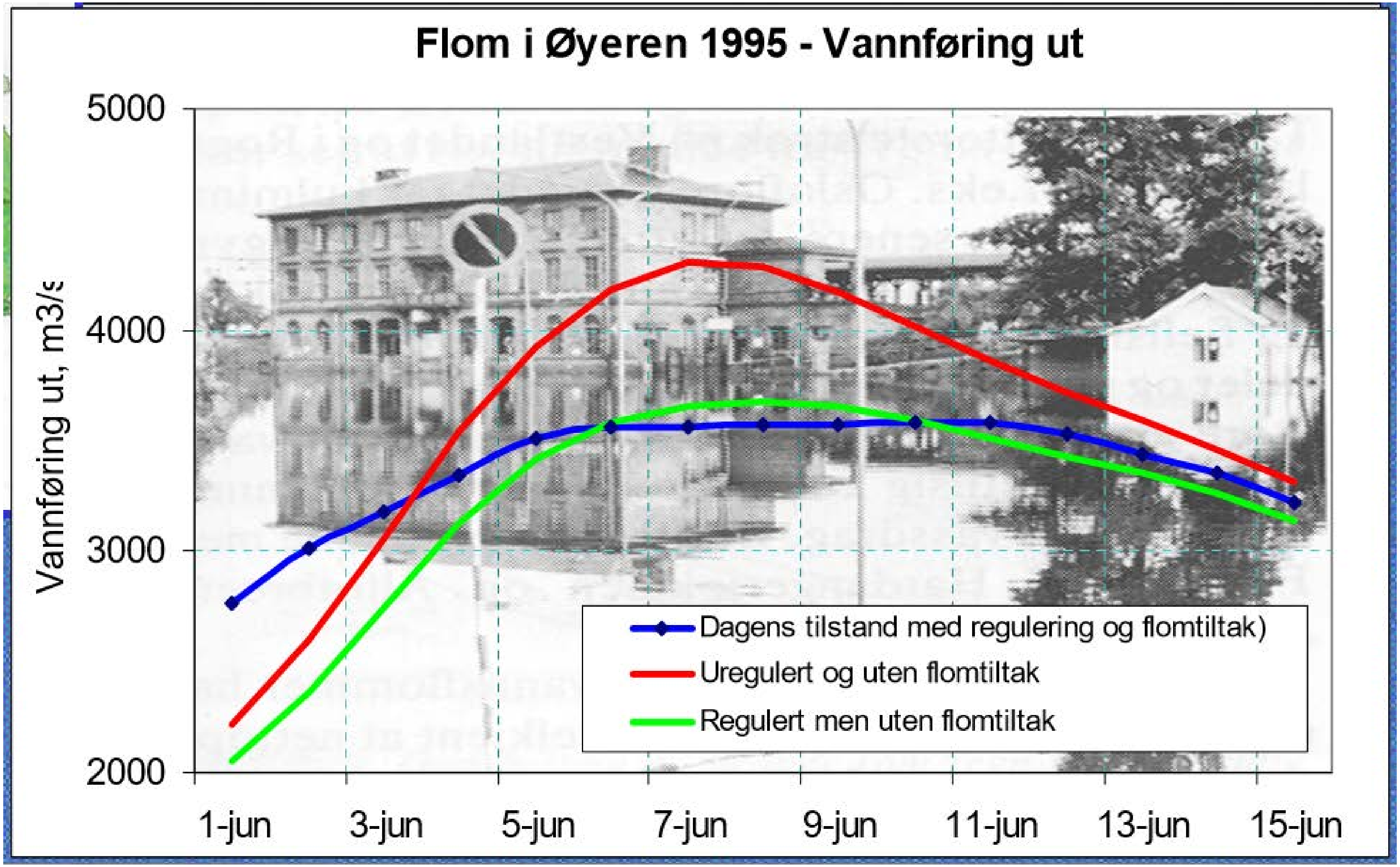
The HYDRA flood model



Hydropower structures - Impact on 1995 - flood



HYDRA - Some conclusions

- Floods in Glomma have been affected by anthropogenic influence from 1900 to 1990
- This has led to a flood reduction, not larger floods, practically everywhere in the river
- **The major part of the flood reduction is caused by hydropower regulation reservoirs**
- Urbanization may lead to increasing floods, but the effect is only visible locally in small catchments and have no detectable effects in the main rivers
- The greatest potential for further reduction in floods is probably to improve the operation of regulating reservoirs and if possible to build new reservoirs

Hydropower and flood mitigation - Summary

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Hydropower may decrease flood risk by technical structures

- Reservoirs storing flood peaks
- Diverting flood water through tunnels/canals/pipes

Optimal operation of flood/hydropower reservoirs is challenging

- Operation need to consider multiple objectives
- Energy production require reservoirs as full as possible
- Flood mitigation requires reservoirs as empty as possible
- Other uses (Irrigation, transport, tourism, …) mostly full?
- Reservoirs should be lowered just before flood arrives
- With «perfect» forecasts this may be possible (not always)
- Still – generation will usually be reduced (and money lost)
- Who will pay the cost and who will benefit?

Key question: How to balanse between these objectives?

Thank you!
Questions?

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