THE INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON HYDROPOWER

IEA Hydropower

Annex IX and XII Joint Workshop, Rio 3-5 Dec 2019

Hydropower providing flood and drought control

Atle Harby, SINTEF Energy Research and Operating Agent

Glomma, Norway

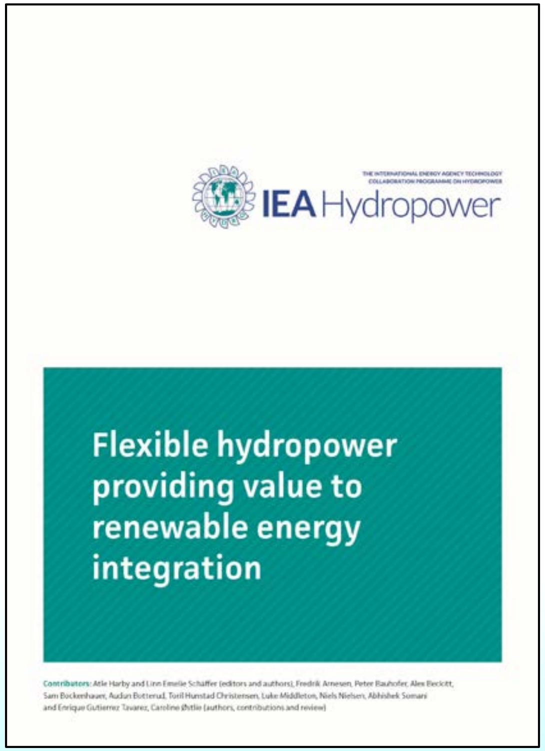
Owens Lake, California

ANNEX IX -Valuing Hydropower Services

- How will hydropower be valued in
  - future electricity market scenarios?
  - providing climate change adaptation services?







Outcome:

- Collecting information, analysing and documenting
- Informing industry, authorities and policy makers
- Hydropower Balancing and Flexibility Roadmap

ANNEX IX -Valuing Hydropower Services


Task 1. Energy, Grid Services and Flexibility:

The future role and value of hydropower in energy markets and electricity systems. The final outcome of this task is a Hydropower Balancing and Flexibility Roadmap


Task 2. Climate Change Services Adaptation:

The role and value of hydropower in minimising or mitigating risks associated with a changing climate

Hydropower Services and Climate Change workshop:

Adaptation, Resilience and Valuation of Climate Change Services

- Challenge:
  Climate change leads to increased risk for floods and droughts
- Scope of work - produce discussion and documentation:
  Reservoir hydropower can mitigate increased risks
- Objectives:
  - How to operate hydropower to provide flood and drought control
  - What are the value hydropower provide in minimizing or mitigating risks associated with a changing climate?

Joint ANNEX IX and XII Workshop
3-5 December 2019, CEPEL, Rio de Janeiro, Brazil

Climate Change Services and Adaptation – Annex IX objectives

Three task objectives:

2.1 Understanding the role of hydropower in minimising or mitigating risks associated with a changing climate with focus on flood and drought control

2.2 Assessing the value that hydropower provides in minimising or mitigating risks associated with a changing climate

2.3 Disseminate results and findings in conferences, meetings, workshops and through relevant media

Work plan

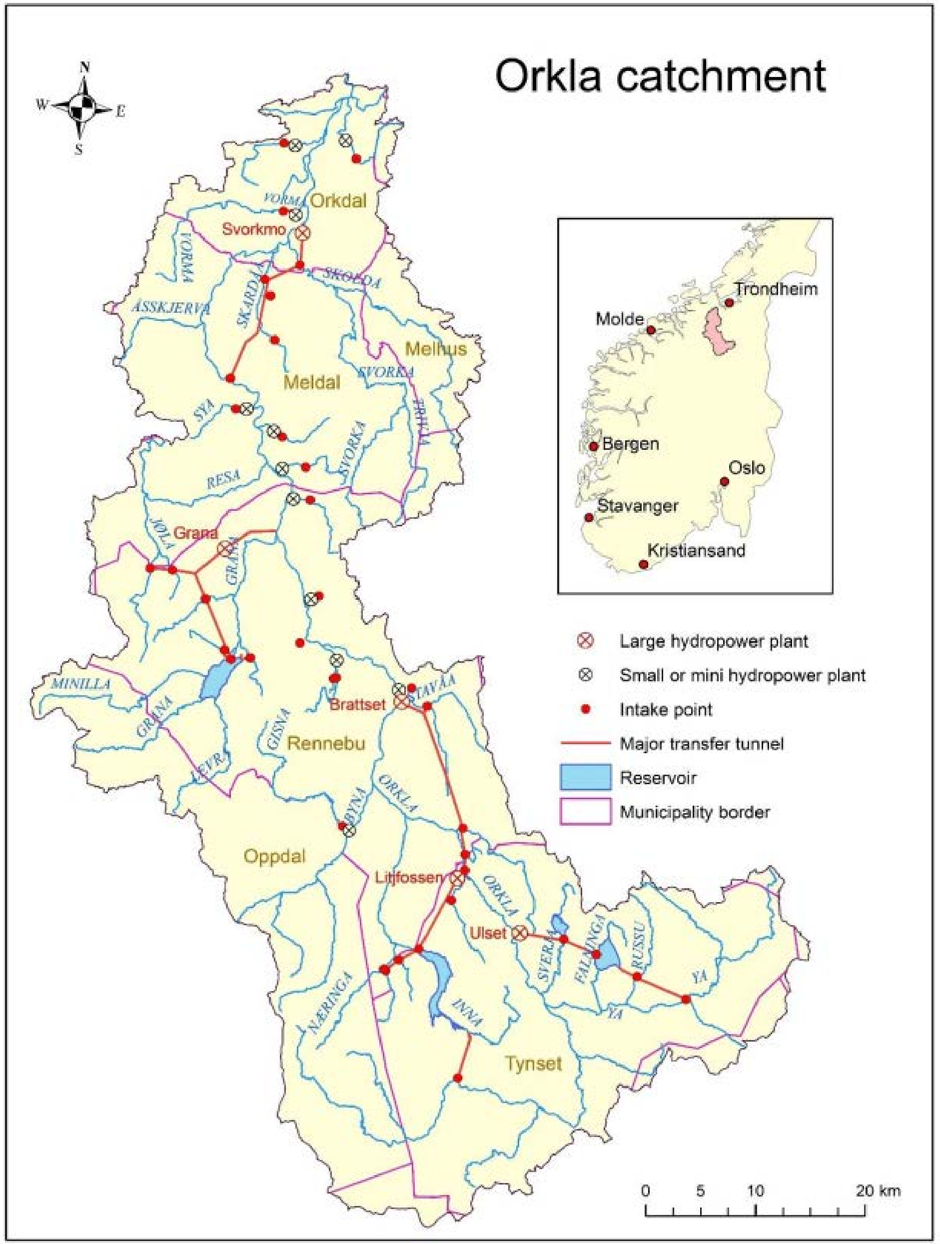
Activity	When	Who
Task 2. Climate Change Services Adaptation		
A2.0 Organise kick-off workshop	Dec 2020	Operating Agents of Annex IX and XII
A2.1.1 Understanding and documenting how various countries approach managing water resources under climate change scenarios		
A2.1.2 Investigating the role of hydropower in minimising or mitigating risks associated with a changing climate		
A2.2.1 Assessing the value that hydropower provides in minimising or mitigating risks associated with a changing climate		

Orkla case study

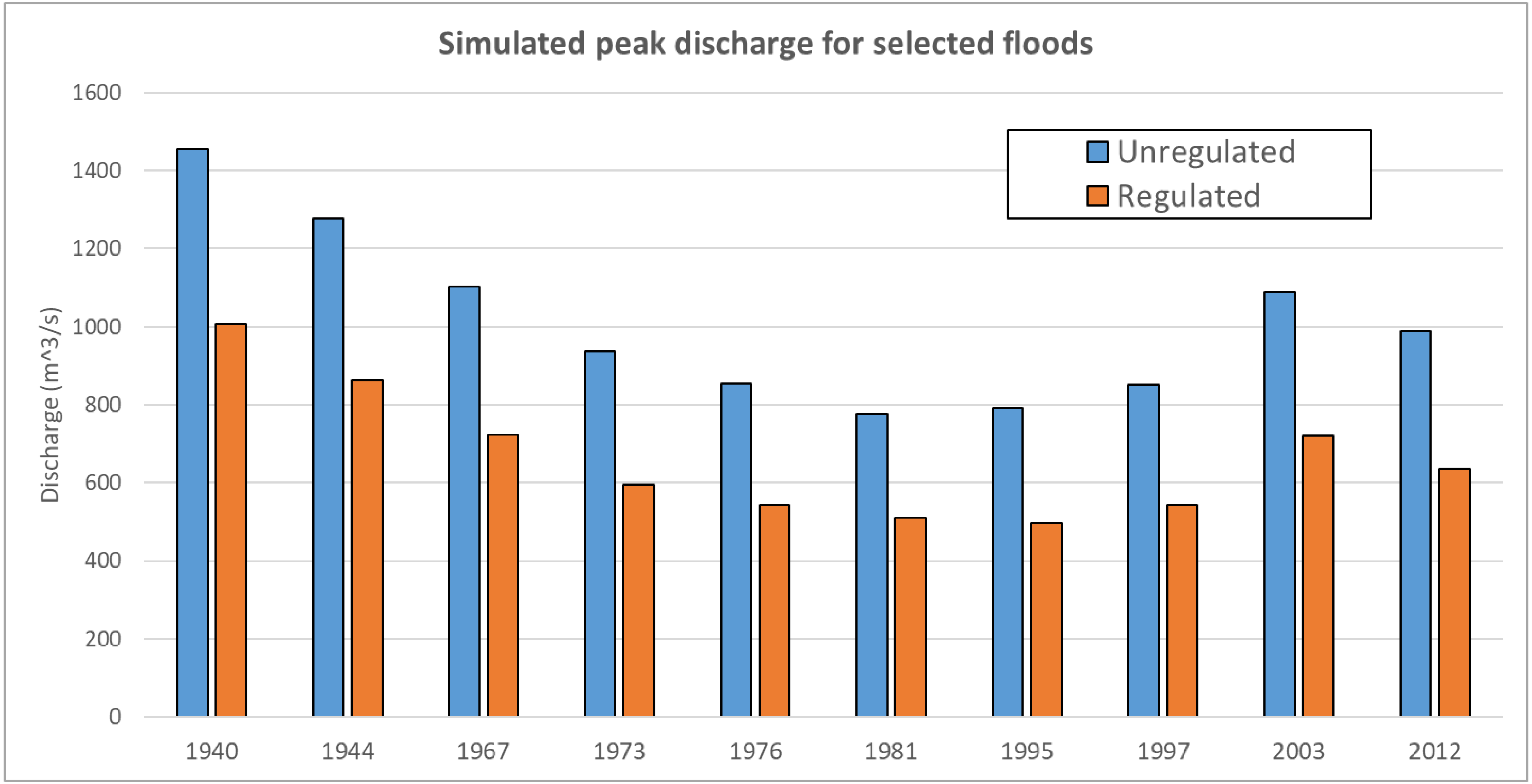
Bendik Hansen
SINTEF Energy Research

Orkla case study, Norway

- Semi-distributed HBV hydrological model calibrated for runoff
- WEAP model used to simulate flood events
- Simulation of historical flood events in Orkla catchments with and without existing dams and hydropower assets
- Investigated importance of
  - Inititial conditions prior to flood events
  - Capacity to turbine water in advance
  - The importance of inter-basin transfer



Orkla case study: Main results



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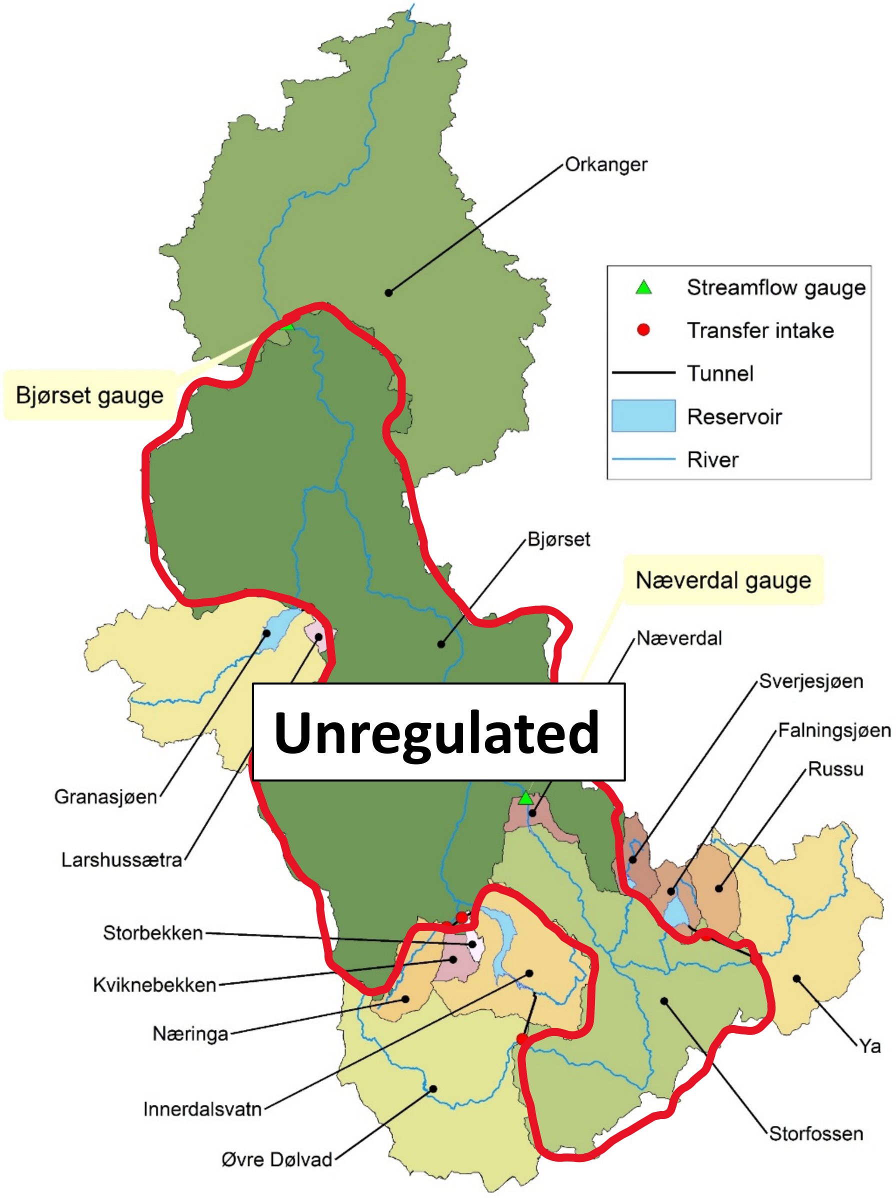
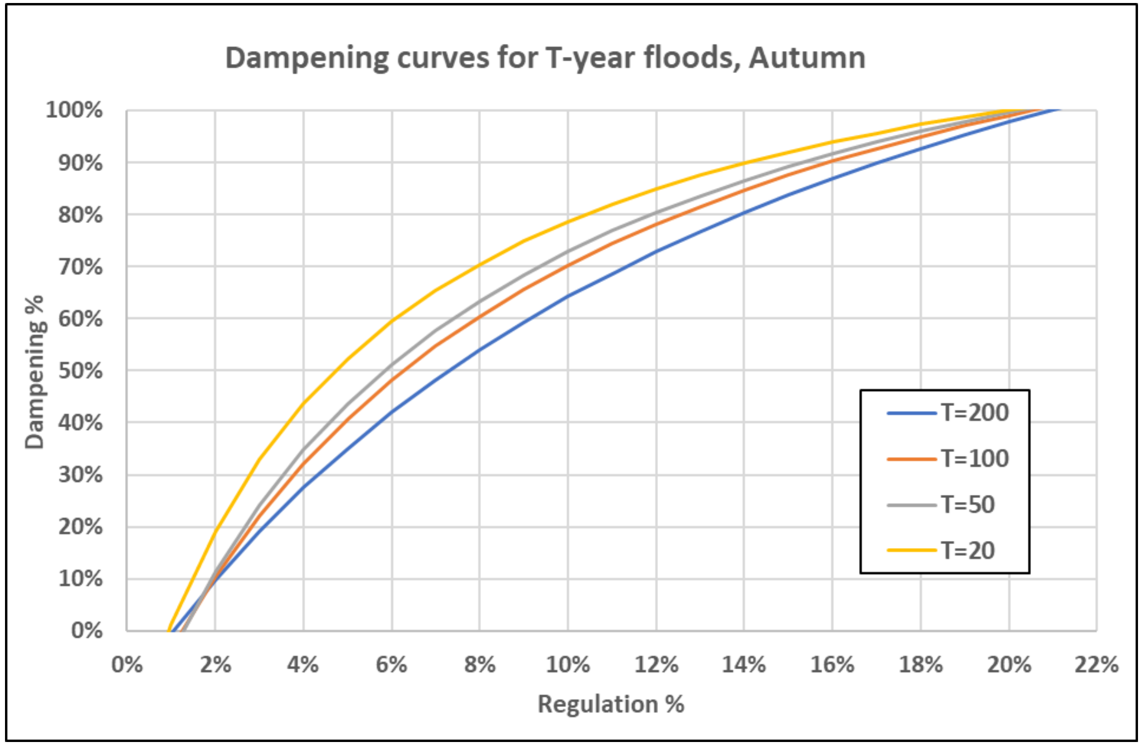
Orkla case study: Conclusions

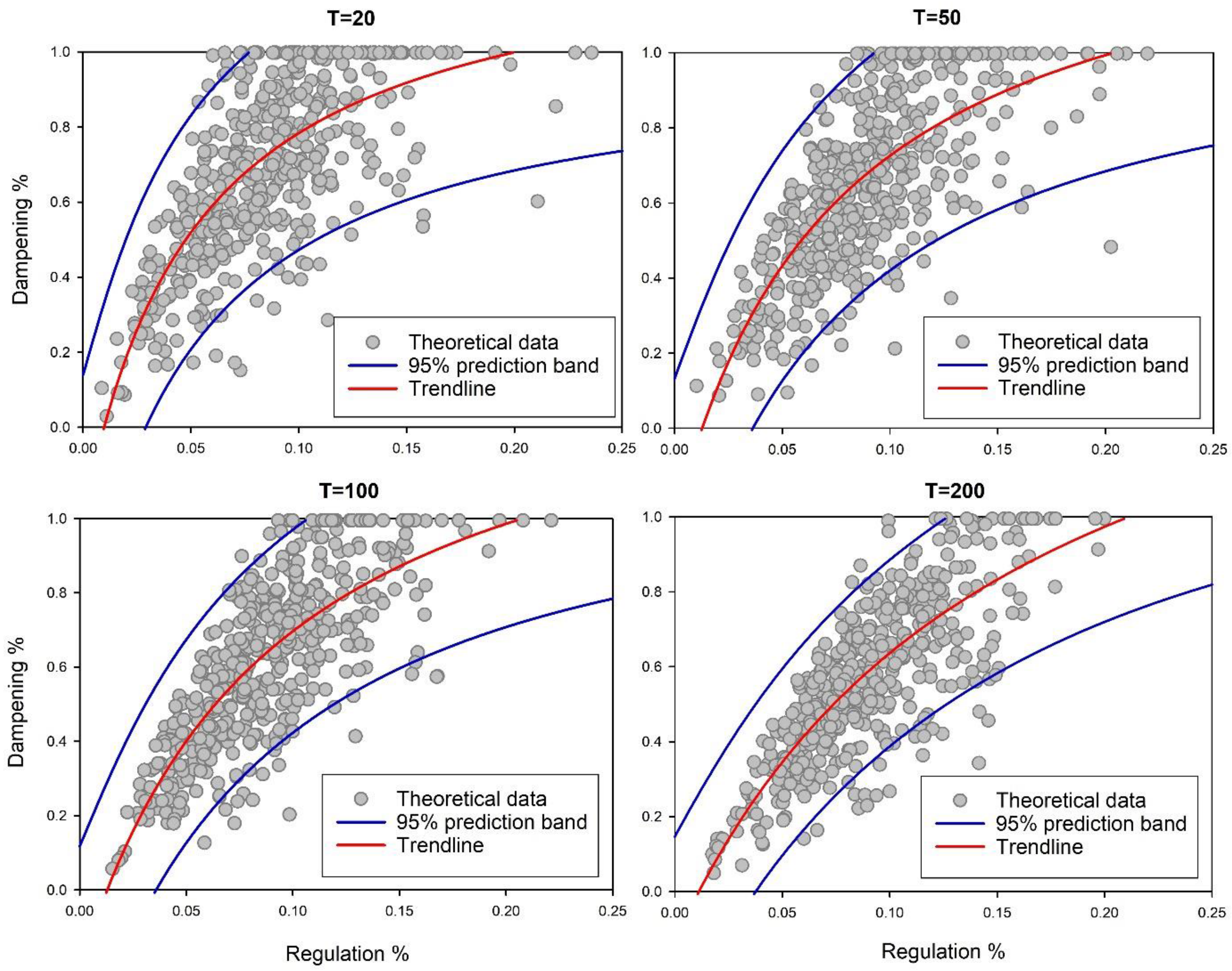
- Important reduction in peak flood
- Limitation in flood control capacity due to the large share of unregulated catchment
- Reservoirs were never spilling when initial state were 20 % full for spring an 85 % full for autumn (typical for the site)
- Higher initial state (for instance 95 % full), would reduce the flood control capacity



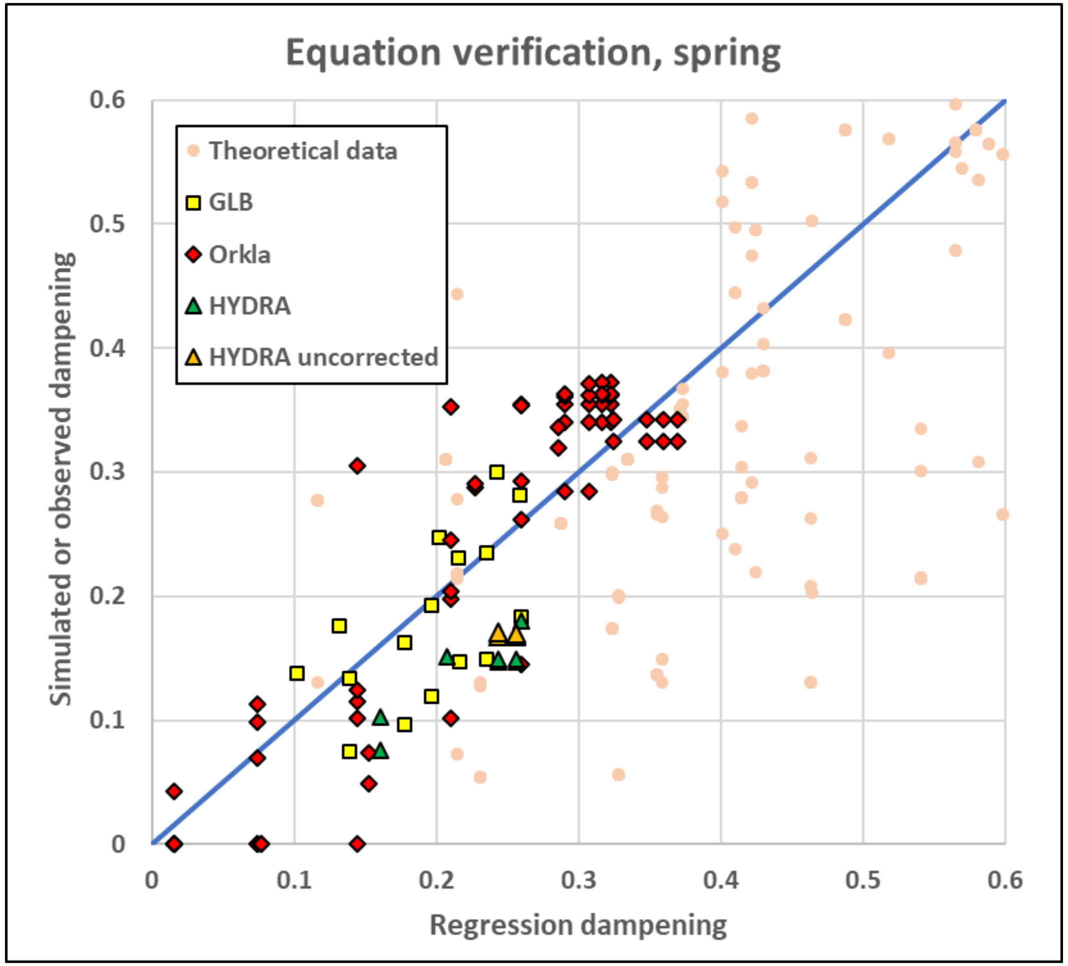
Imortant for flood control capacity: Degree of regulation = Total reservoir volume/total annual inflow

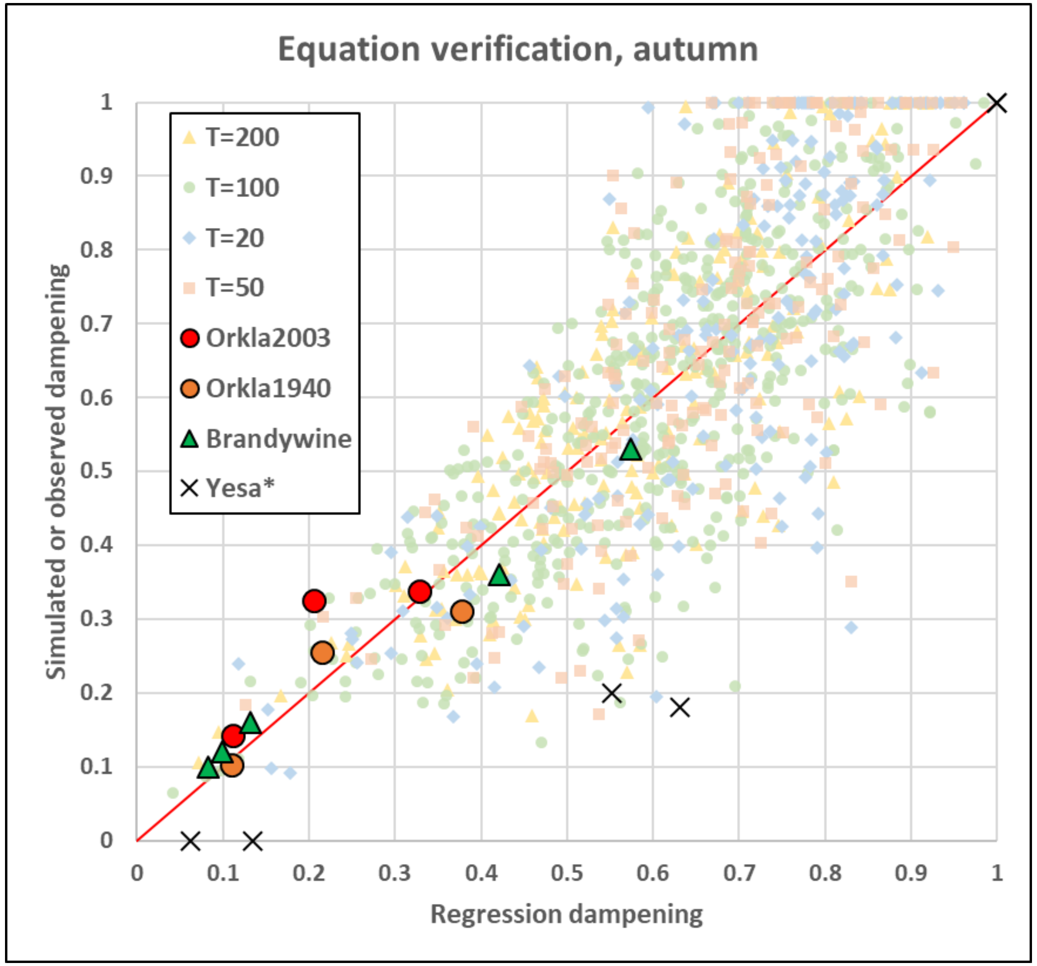
Regressions



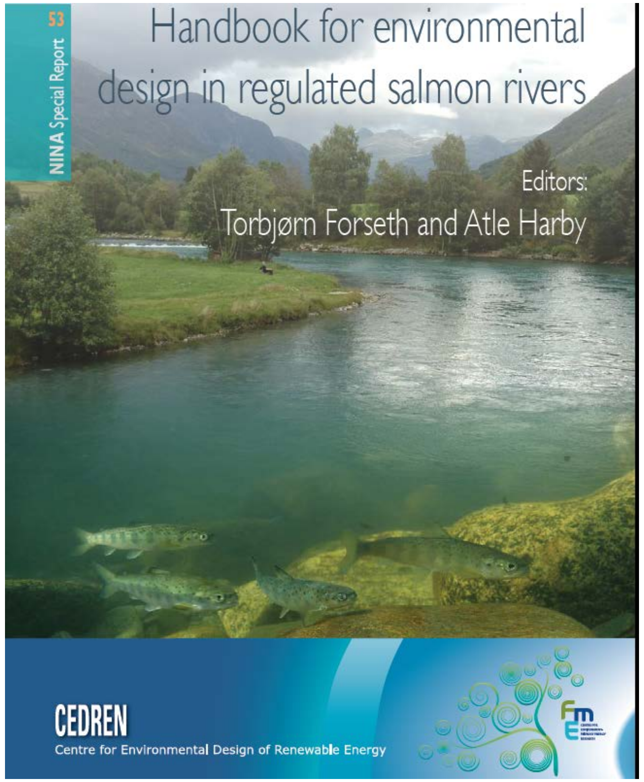


Test and verification





Environmental design of regulated rivers



Download free copy:
www.cedren.no

- Guidance developed for salmon rivers in Norway
  The format is a handbook with tables and instructions for the user - simplistic
- Methods suitable for other species and end users
  → Further development in HydroCen centre
- Including services and user interests:
  - Providing flexibility to the energy system
  - Flood control
  - Biodiversity (more than salmon fish)
  - Recreation and aesthetics
- Look-up tables and simplistic instructions

Degree of regulation

Factor	Code	Description	Quantitative description
5		Major capability/importance	>1
4		High capability/importance	0.5-1
3		Moderate capability/importance	0.3-0.5
2		Some capability/importance	0.1-0.3
1		Low/no capability/importance	<0.1

Data requirements/calculations:

- Inflow to reservoir under consideration
- Storage volume of reservoir (between HRWL and LRWL)

Degree of regulation

Spring (snowmelt) floods			
Factor	**Code**	**Capability**	**Available degree of regulation**
5		Major	>30%
4		High	20-30%
3		Moderate	15-20%
2		Low	10-15%
1		None	<10%

Data requirements/calculations:

- Inflow to reservoir under consideration
- Storage volume of reservoir (between HRWL and LRWL)

The role of the specific reservoir in the river basin as a whole

SPRING		Basin available degree of regulation (including reservoir in question)				
		<10%	10-30%	30-50%	50-70%	>70%
Relative (%) contribution to total regulation from assessed reservoir	<10%	None	Low	None	None	None
	10-30%	None	Moderate	Low	None	None
	30-50%	Low	High	High	None	None
	50-70%	Low	High	Major	High	Low
	70%+	Low	High	Major	Major	Major

Data requirements/calculations:

- Storage volume of reservoir (between HRWL and LRWL)
- Total storage volume of reservoirs in the basin
- Runoff data from the whole basin

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The role of the specific reservoir in the river basin as a whole

AUTUMN (T=200)		Basin available degree of regulation (including reservoir in question)				
		<3%	3-9%	9-15%	15-21%	>21%
Relative (%) contribution to total regulation from assessed reservoir	<10%	None	None	None	None	None
	10-30%	Low	Low	Low	None	None
	30-50%	Moderate	High	Moderate	Low	None
	50-70%	Moderate	High	High	High	Low
	70%+	Moderate	Major	Major	Major	Major

Data requirements/calculations:

- Storage volume of reservoir (between HRWL and LRWL)
- Total storage volume of reservoirs in the basin
- Runoff data from the whole basin

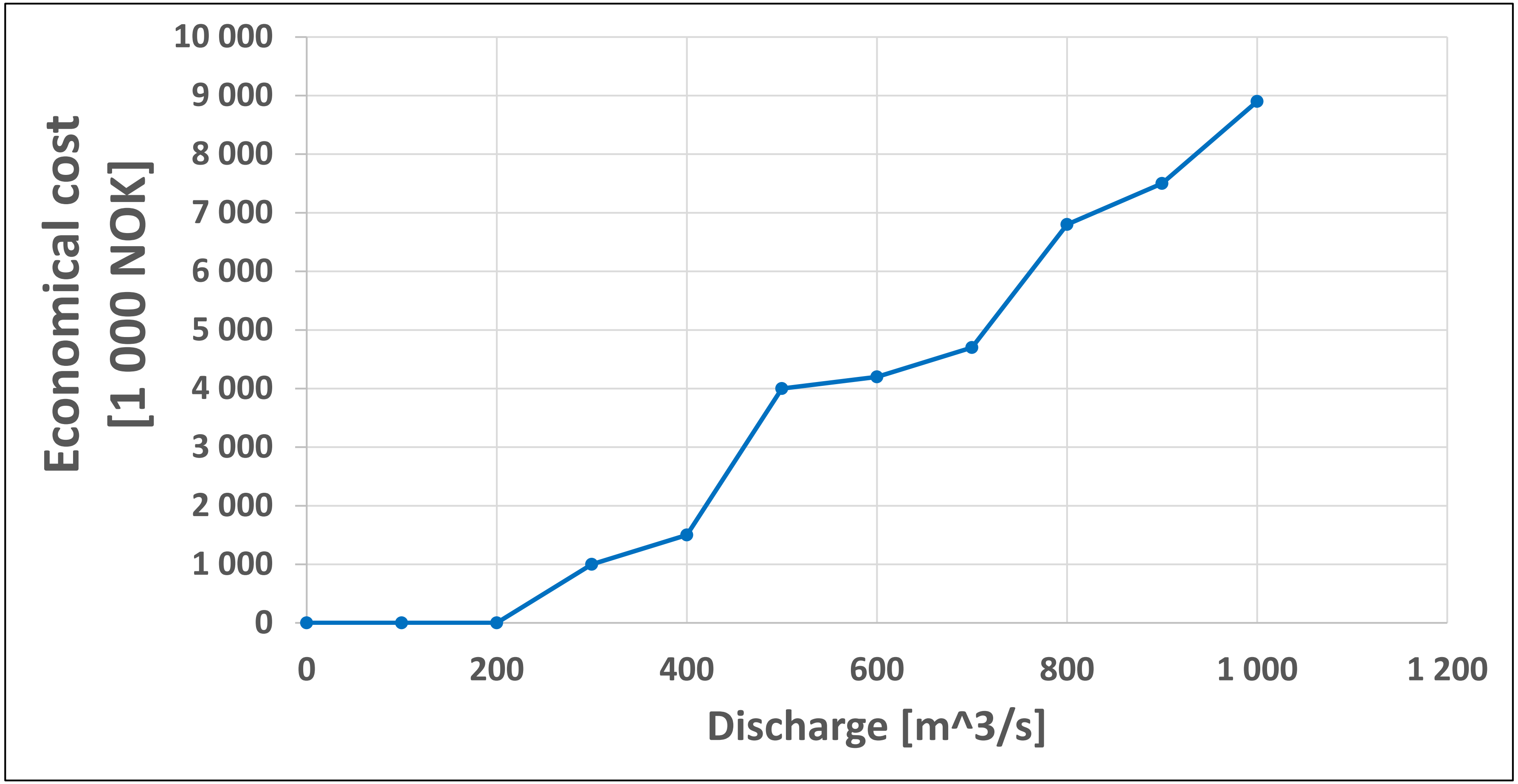
Potential impacts of damage from flood

Factor	Code	Impact	No. of house-equivalents flooded
5		Major	>50
4		High	25-50
3		Moderate	10-25
2		Low	5-10
1		None	<5

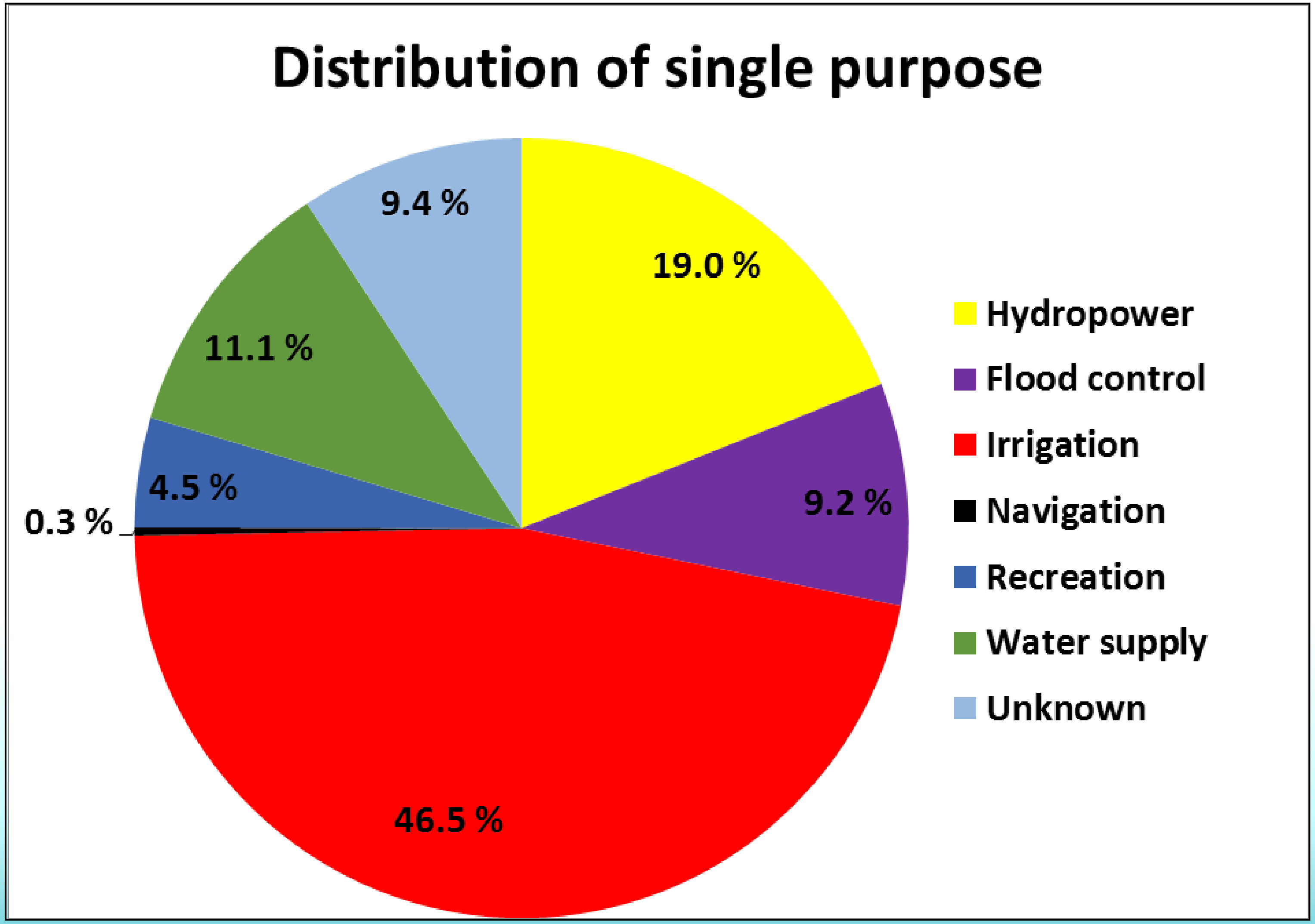
Data requirements/calculations:

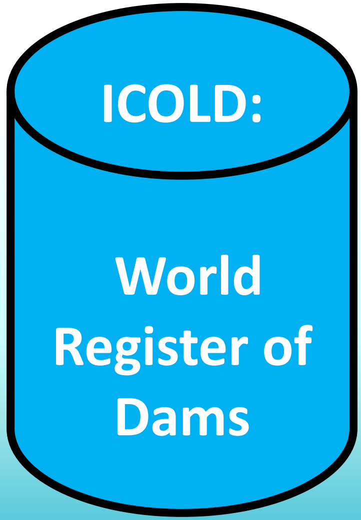
- Flood zone maps (200 years return period)
- Map layer of houses/infrastructure

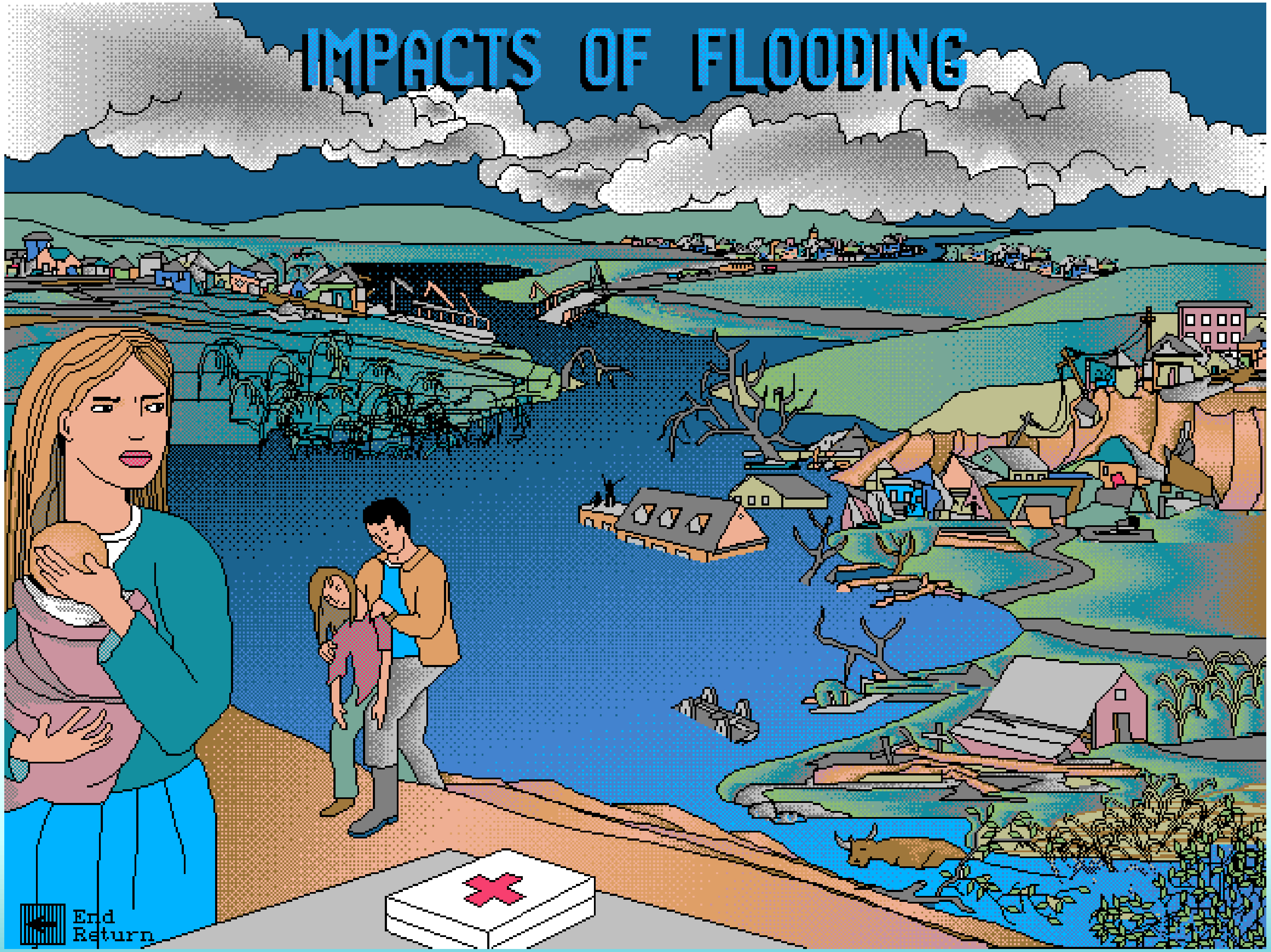
Discharge – cost curve (example)



World dams


Distribution of single purpose
9.4 %
19.0 %
11.1 %
4.5 %
0.3 %
9.2 %
46.5 %
Hydropower
Flood control
Irrigation
Navigation
Recreation
Water supply
Unknown


ICOLD:
World Register of Dams



System boundary

- Material damage
- Health
- Lives
- Infrastructure
- Industry
- Jobs
- Indirect damage
- …..

Thank you for your attention!