Linking the issues surrounding hydropower needs, WFD and fish passage from a commercial and EU policy perspective

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Outline

- Hydropower today
- Influence of environmental legislation (WFD & RED) on hydropower
- Hydropower tomorrow
- Fish passage needs
- Conclusions

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Hydropower today (global)

Hydropower …

- is a proven and well advanced technology with several centuries of experience;
- is still the most efficient form of energy generation (η_{net}=65-88%);
- is produced in at least 150 countries;
- is largest source of renewable energy in the world & represents more than 92 % of all renewable energy generated;
- use reached 16.1% (3,427 TWh) of global electricity consumption by end of 2010 *(Worldwatch Institute, 2011)*.

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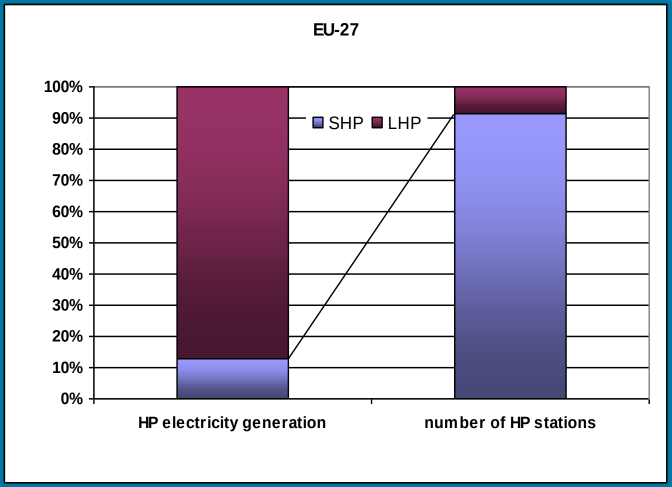
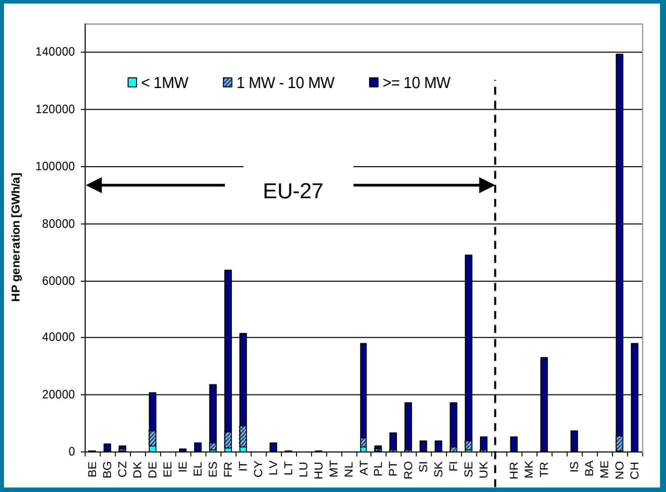
Hydropower today (EU)

- EU-27 (2008): 16.6% gross electricity consumption covered by renewable energies. HP covered ~60% of the renewable electricity production.
- EU-27 (2008): ~23,000 HP stations with installed capacity of 103 GW *(sources: SHERPA, ENTSOE, EURELECTRIC)*
- about 10 times more small (P < 10 MW) than large HP plants ($P \geq 10$ MW)
- **but**: generation of small HP only amounts to 13% of the total generation of large HP stations



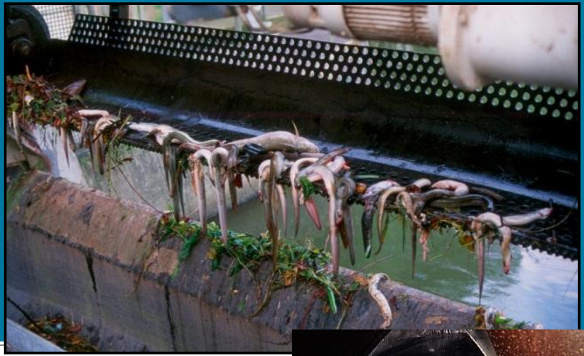
Hydropower generation in EU-27 and in candidate & associated States

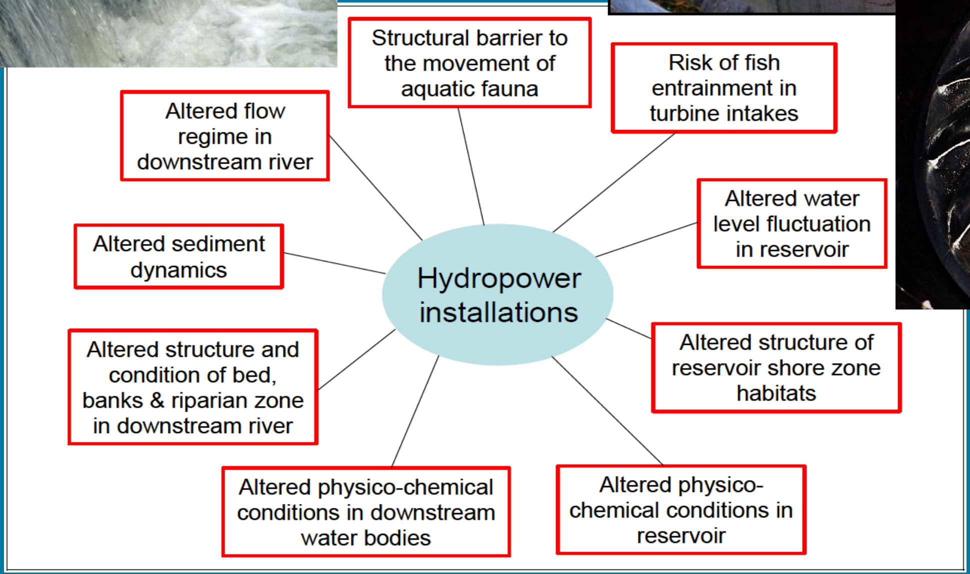


Hydropower today

Environmental impacts of HP:

Range of possible alterations typically associated with hydropower *(CIS, 2006)*





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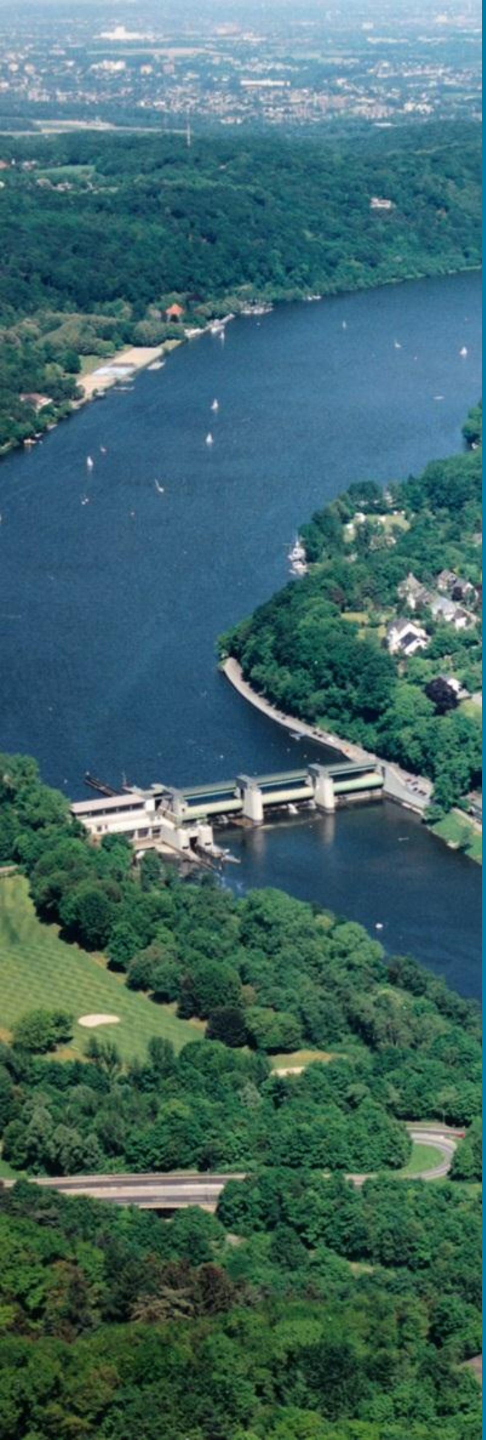
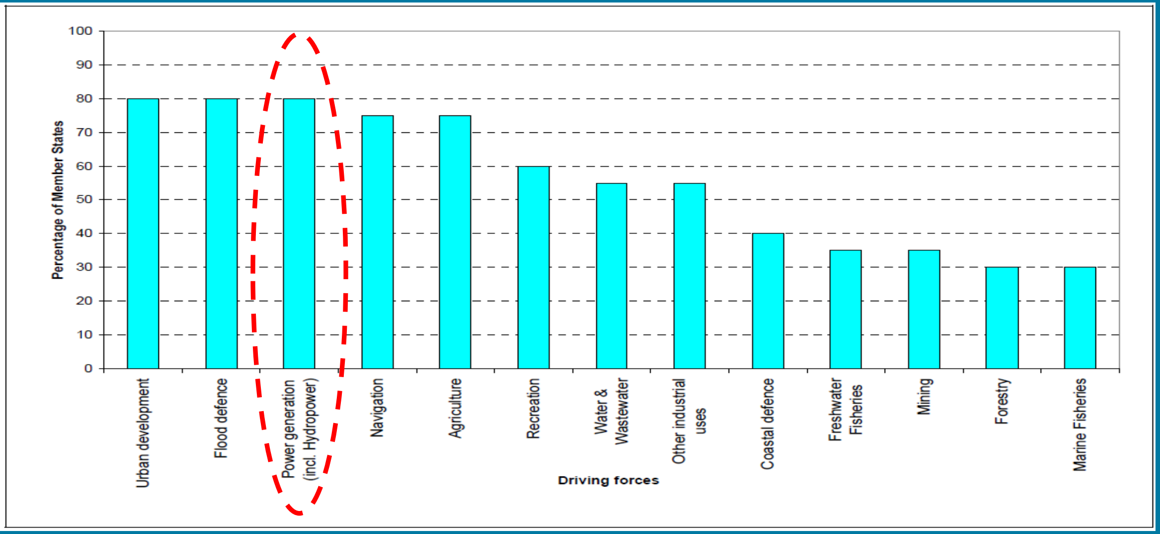


Influence of env. legislation (WFD) on hydropower

- Hydromorphological alterations & associated impacts are amongst top pressures emerging from WFD analysis. Hydropower & dams are amongst main drivers causing degradations.

Percentage of 20 Member States indicating a driving force related to hydromorphological pressures as significant *(EC, 2007)*



- MS have designated selected surface water bodies as HMWB (20%) or AWB (4.5%) (⟹ GEP criteria)

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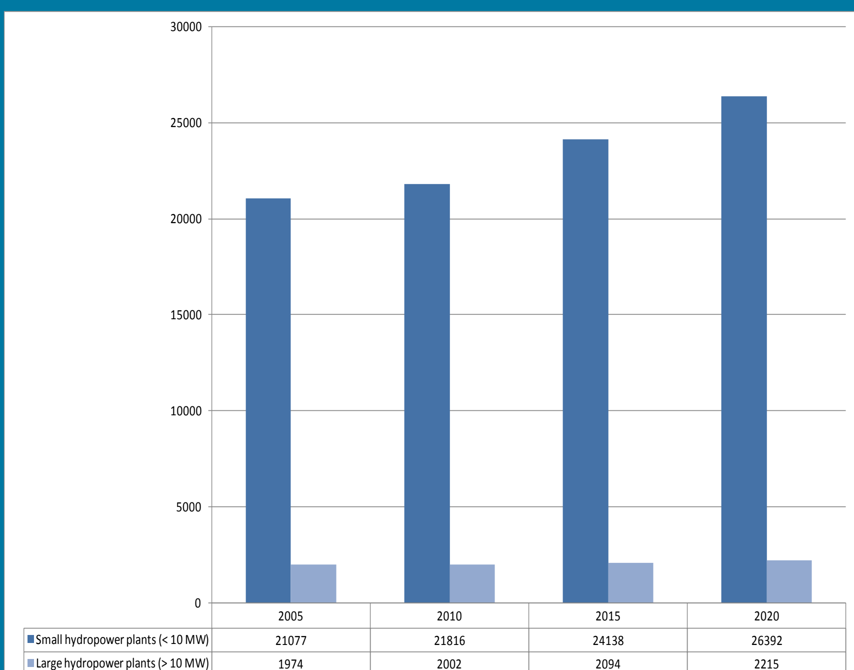
Influence of env. legislation (RED) on HP

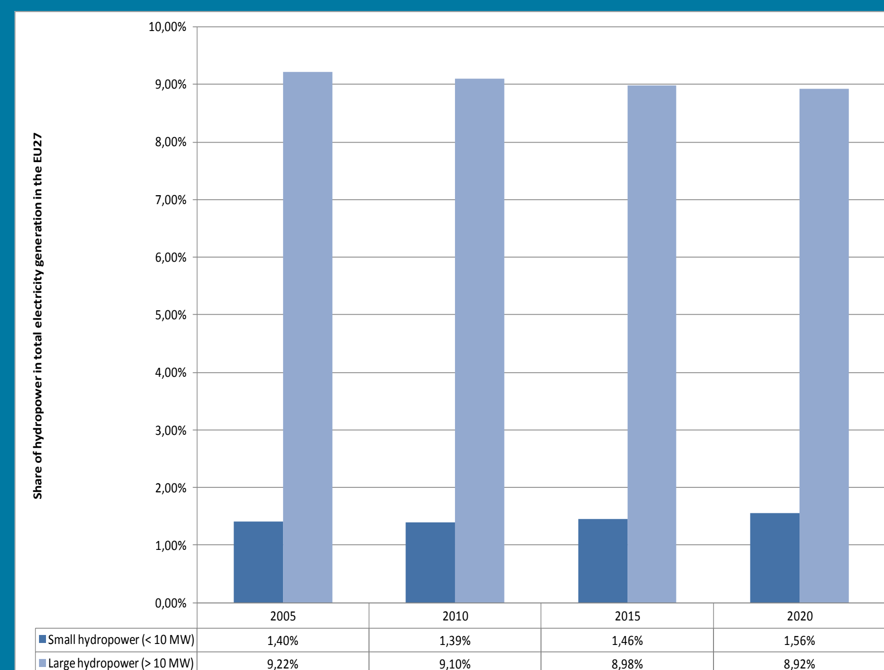
- EU climate and energy package (2009): "20-20-20" targets for 2020
  a) 20% reduction in EU greenhouse gas emissions from 1990 levels
  b) 20% improvement in the EU's energy efficiency
  c) raising share of EU energy consumption produced from renewable resources to 20% (currently 10%)
- Directive 2009/28/EC on promotion of use of energy from renewable sources
- Renewable Energy Action Plans (NREAPs) with national targets (notified in 2010)

$\Rightarrow$ Number of HP plants, installed capacity & electricity generation will increase, but share of hydropower electricity generation will decrease until 2020.

Expected development of number of small and large HP plants as specified in the NREAPs



Expected development of contribution of small and large HP to the total electricity generation in the EU27 as specified in the NREAPs



Hydropower tomorrow

- Contradictions between WFD and RED due to conflicting goals

MEASURES	EFFECTS ON HP PLANT
new construction or upgrading of existing fish pass and/or fish protection & bypass systems	additional investment cost
reduction of trash rack bar spacing/ installation of fish screen	additional investment cost and/ or decrease in energy production
installation of fish-friendly turbines	additional investment cost
provision of fish pass & bypass flow, and/or environmental flow	decrease in energy production

- Challenge: Best balance the site-specific characteristics and ecological quality of HP plants in an economically and technologically feasible way
- Significant effects of WFD requirements (i.e. integrated water management, environmental objective ('good status/ potential'), quality requirements, and monitoring) on hydropower:
  - policy level (EC policy, CIS …)
  - national & river basin level (broad strategies)
  - site-specific level (licensing new HPP, (re-)powering existing barriers & impoundments, re-licensing existing HPP, upgrading/ modernization existing HPP)

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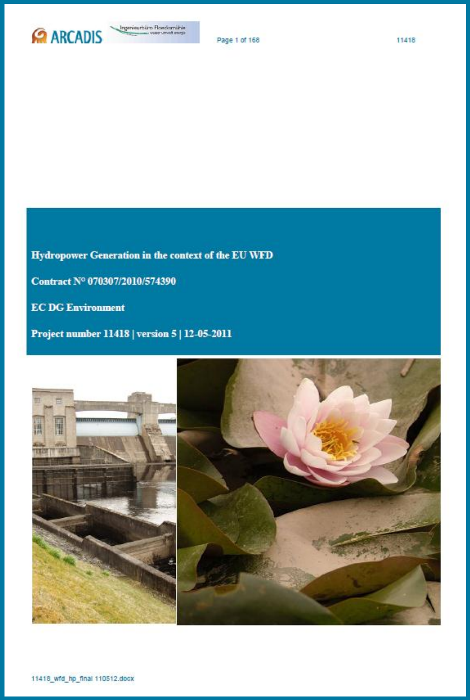
Hydropower tomorrow

Policy level:

- EC: collaboration between DG Environment and DG Energy
- ARCADIS & Floecksmühle (2011) “Hydropower generation in the context of the WFD” for DG Env

  http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/implementation_conventio/hydropower_september/11418_110516pdf/_EN_1.0_&a=d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Hydropower Generation in the context of the EU WFD

Contract N° 070307/2010/574390

EC DG Environment

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- Stakeholder participation:
  CIS-Workshops “Water Management, Water Framework Directive and Hydropower” in 2006 and 2011

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Hydropower tomorrow

Policy level (cont'd):

- Feed-in tariff systems. Example Germany:
  - initiated in 1991 (Renewable Energy Sources Act, REA)
  - copied in 18 EU member states and 40+ countries worldwide
  - REA amendments in 2004 and 2009: significant changes to hydropower feed-in tariff models as a result of WFD requirements (now: incentive to compensate costs for ecological measures & generation losses)
  - To qualify: new or modernized HP plants must achieve "good ecological status" of water body or improve ecological status considerably by:
    - reduction of <u>hydro-peaking</u>
    - restoration of <u>fish passage</u> (upstream & downstream)
    - <u>minimum environmental flows</u>
    - restoration/ improvement of <u>sediment transport</u>
    - restoration/ improvement of <u>riverine environment</u>
  - Experience: Remuneration insufficient to finance measures in <u>all</u> fields. Current focus on fish passage & minimum flows.

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Hydropower tomorrow

National & river basin level:

- Rules/ framework for HP developments, i.e. "go- & no-go areas":
  - SAC (e.g. in "Opportunity and environmental sensitivity mapping for hydropower in England and Wales", 2010)
  - France & Lithuania : Water Acts and RBMPs specify rivers in which new hydropower installations are prohibited
  - Austria: Stakeholder participation to determine framework for hydropower developments in Tyrol. Development of guideline & catalogue of env. criteria for sustainable hydropower developments, and implementation of hydropower committee.
- Specific principles & regulations for dams & HP plants:
  - Germany: Federal Water Act (2010) includes RBM principles and requirements for min. flow, upstream fish passage & fish protection
  - Germany: Criteria for hydropower developments (only at existing barriers, P_{el} > 200 kW) in State of Northrhine-Westfalia

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Hydropower tomorrow

Site-specific level:

- Compulsory standards for mitigation measures
- Best practice guidelines

Fish passage needs


Mülheim fish and eel passes in 1920
© Ruhrfischereigenossenschaft

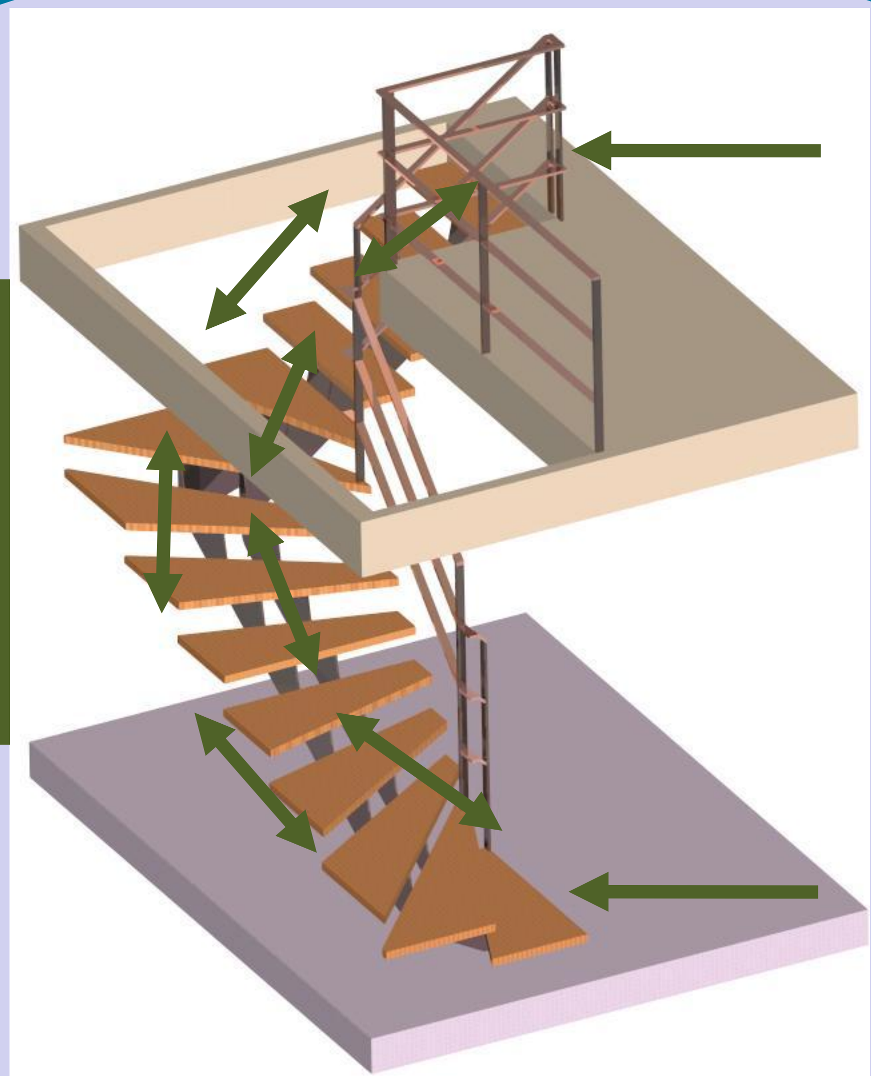
Translated from GERHARDT, P. (1912):

The correct design and implementation of fish facilities requires to be perfectly acquainted with the habits of fish. There are numerous complaints of poorly constructed fishways that have either entirely failed to meet their objective or proved to be too costly. Unfortunately those complaints are mostly valid. On most occasions the Engineer performed his work without any knowledge of the natural history of the fishes. He missed the fact that the design of a fish facility may never be based on the structure itself, or a preference for a certain design, but needs to be adjusted to the site-specific conditions and consider the fish and their habits. The design must be based on the fish one intends to guide. This requires to study its habits and the local conditions. A fishway may then be designed based on those findings.

Fish passage needs

Project-

Passability
- migration corridor
- geometry:
  Water depth,
  pool size,
  size of slot/ orifice
- hydraulics:
  velocity, turbulence



Operation time
- ≥ 300 d/a
  (min. between Q_{30} and Q_{330})

and site-specific

Attractivity
- location
- entrance position
- attraction flow

conditions

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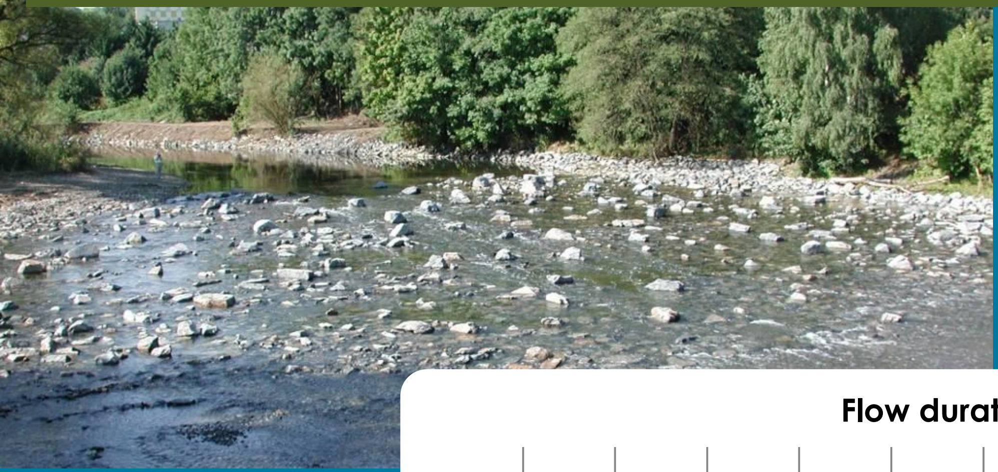
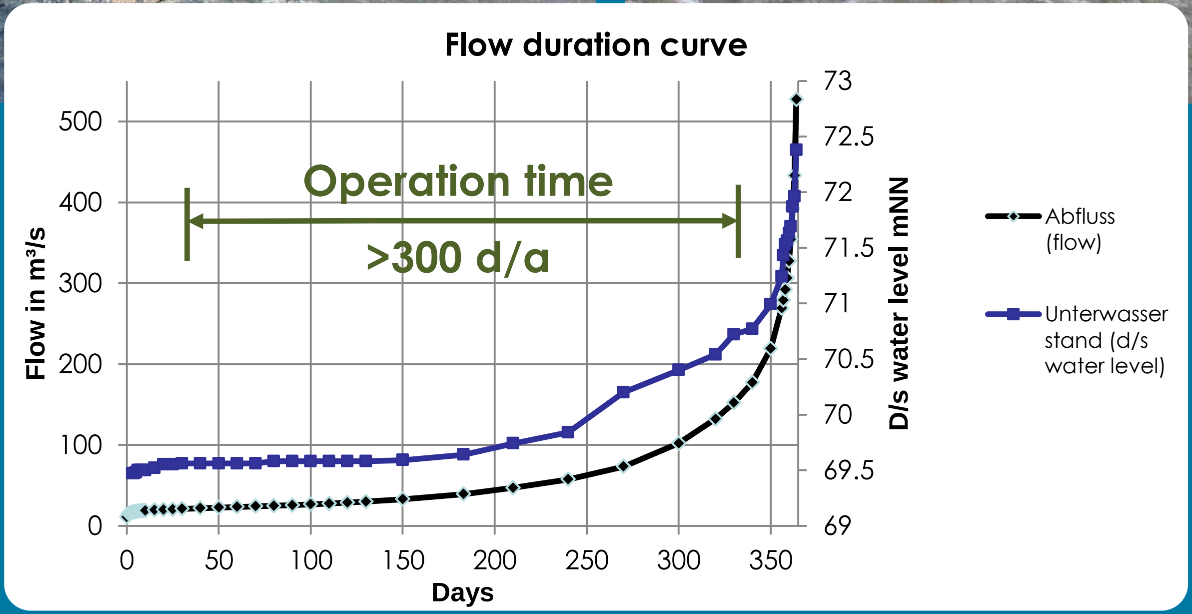
Fish passage needs (operation time)

Fish passage requirements (DWA-M 509 acc. *Clay* and *Thorncraft & Harris*):

Fishway is a water passage designed to be found, and to provide hydraulic conditions suitable for all site-specific fish to pass obstruction almost all-year round without undue stress, delay or injury.





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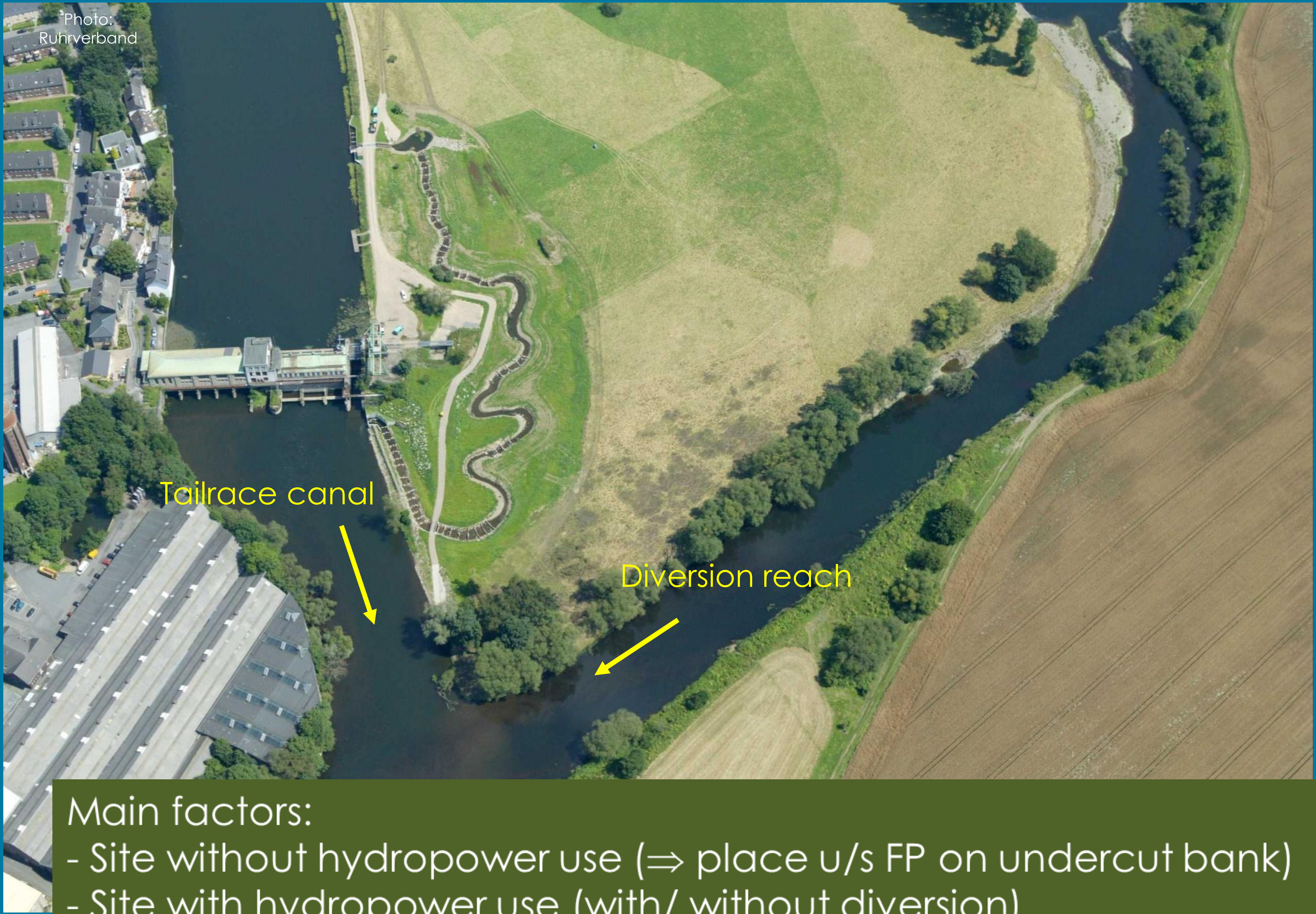
Fish passage needs (location)



Main factors:
- Site without hydropower use (⇒ place u/s FP on undercut bank)
- Site with hydropower use (with/ without diversion)

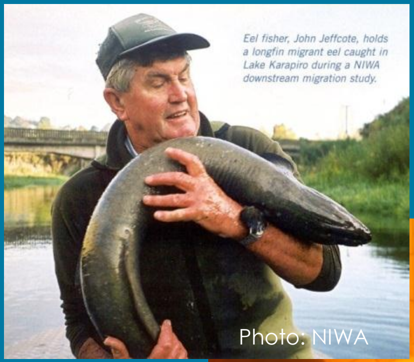
Fish passage needs (entrance & attraction flow)

(right at migration barrier)

Fish passage needs (entrance & attraction flow)

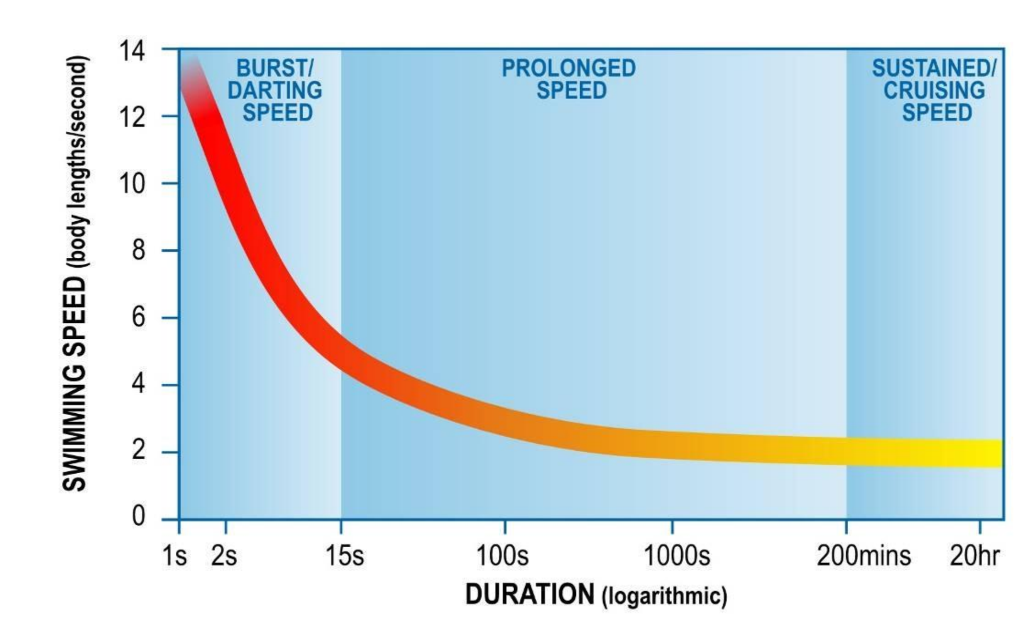
Fish passage needs (geometry & hydraulics)

- Continuous migration corridor of sufficient space (water depth, width and slot/ orifice size) to allow fish to manoeuvre upstream
- Migration corridor must be based on body size of largest prevailing migratory species



- Hydraulic conditions in migration corridor must suit weakest species

  - **Burst / darting speed**
    - maximum speed fish can achieve
    - extremely short (0-15 sec.) high-speed motion
    - fish may require up to 24 hrs to regenerate
  - **Prolonged speed**
    - performance reduces notably within the first 10 sec of burst
    - can be maintained for up to around 200 min
  - **Sustained / cruising speed**
    - 'normal' swimming speed
    - can be maintained indefinite ly without exhaustion



Fish passage needs (geometry & hydraulics)

Screening criteria for selected species acc. body size and swimming ability (DWA, 2005)

Table 5.4: Limit values of the permissible clear width of impassable mechanical barriers in dependence on the target species

species	relevant length [mm]	proportions		permissible clear width [mm]	
	L_{fish}	K_{high}	K_{thick}	d_{M+L}	d_{st}
salmon smolt	> 120	0.17	0.10	20	12
silver eel (♀)	> 500	0.05	0.03	25	15
silver eel (♂)	> 300	0.05	0.03	15	9

Table 5.1: Permissible approach velocities at almost vertical, rectangular to the flow arranged mechanical barriers (α = 80 - 90°, β = 90°)

target species	without bypass	with well traceable bypass
general	□ $V_{duration} = L_{fish}/s$	$V_{duration}$ to $V_{sustained}$ = 2 to 5 L_{fish}/s
salmon smolts	total length 12 - 15 cm: 0.25 m/s total length 15 - 20 cm: 0.30 m/s	0.5 - 0.6 m/s
silver eel	0.5 m/s	

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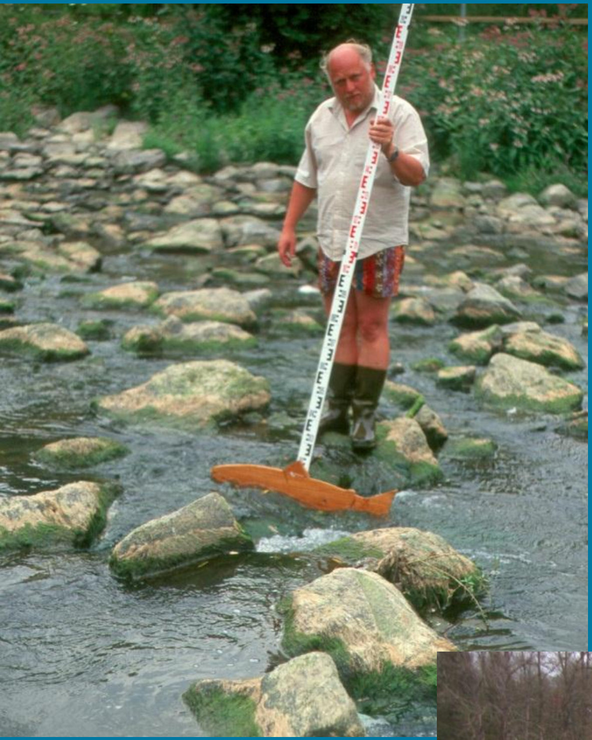
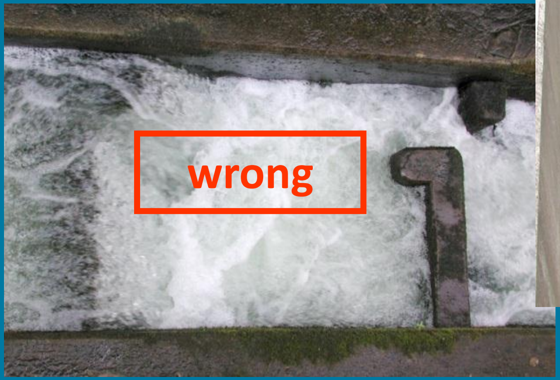
Fish passage needs (geometry)



Fish passage needs (hydraulics)

Max. flow velocity & drop heights

Energy dissipation / turbulence



Europe

0.09 - 0.22 m (species/ river reach dependant)

0.2 - 0.3 m (Salmonidae only)

< 2 m/s and 2,5 m/s resp. (species/ river reach dependant)

Europe

P = 100 - 250 W/m³ (species/ river reach dependant)

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Conclusions

- WFD has changed the way of dealing with and managing hydropower (strategy, licencing, operation…), but also industry's self-image and internal discussions
- RED has resulted in a (small) hydropower "revival"
- Inherent contradiction between RED targets and WFD goals calls for rules (e.g. policies, regulations, self-imposed codes of conduct), guidance (e.g. best practice that achieve WFD goals) and incentives (e.g. feed-in tariffs, extended term of permits, public subsidies)
- Broad & complex topic requires open & honest interdisciplinary discussions

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Conclusions

- Upstream fish passage: issues comparatively well understood; similar design criteria worldwide, broad range of solutions available, need consistent enforcement
- Downstream passage: need to improve knowledge (fish behaviour & swimming performance) and intensify research. Way forward: determine (preliminary) design parameters based on agreed criteria (e.g. fish conservation objectives) and commit to on-going review and improvement process.

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Imagine the result

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