Mitigation of the Negative Impacts of Impoundments

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Typical impacts of dams/reservoirs

- Change in quality of impounded water (seasonal)
- Water loss due to evaporation (seasonal)
- Downstream effects in terms of decreased (and more-uniform) flows
- Changes in saltwater patterns and changes in estuarine fisheries
- Changes in local groundwater level and quality
- In-reservoir landslides and/or increased seismic activity due to water pressure
- Changes in microclimate of area (more wind, humidity, and/or precipitation)
- Inundation of mineral resources and/or historic sites
- Changes in number and types of fish
- Preclusion of movement of migratory fish
- Fish destruction in turbines and pumps

And more …

- Increased areas for breeding of mosquitoes and related insects (public health implications)
- Promote growth of aquatic weeds (e.g. water hyacinths)
- Changes to habitat due to inundated area and wildlife associated with habitat (such migratory birds)
- Changes to waterfowl habitat from shallow, flowing habitat to deeper reservoirs
- Impacts on endangered and/or unique species
- Decrease in waste assimilative capacity of water
- People relocation-resettlement
- Influx of construction workers and associated impacts
- Downstream impacts on floodplain cultivation
- Reduced flood delivery of nutrients to downstream agriculture fields
- Development in the catchment area resulting from roads and from other associated increases in sediment

Selection of Mitigation Measures for Impoundments

- Because of the wide range of:
  - potential environmental impacts; and,
  - possible measures to mitigate these;

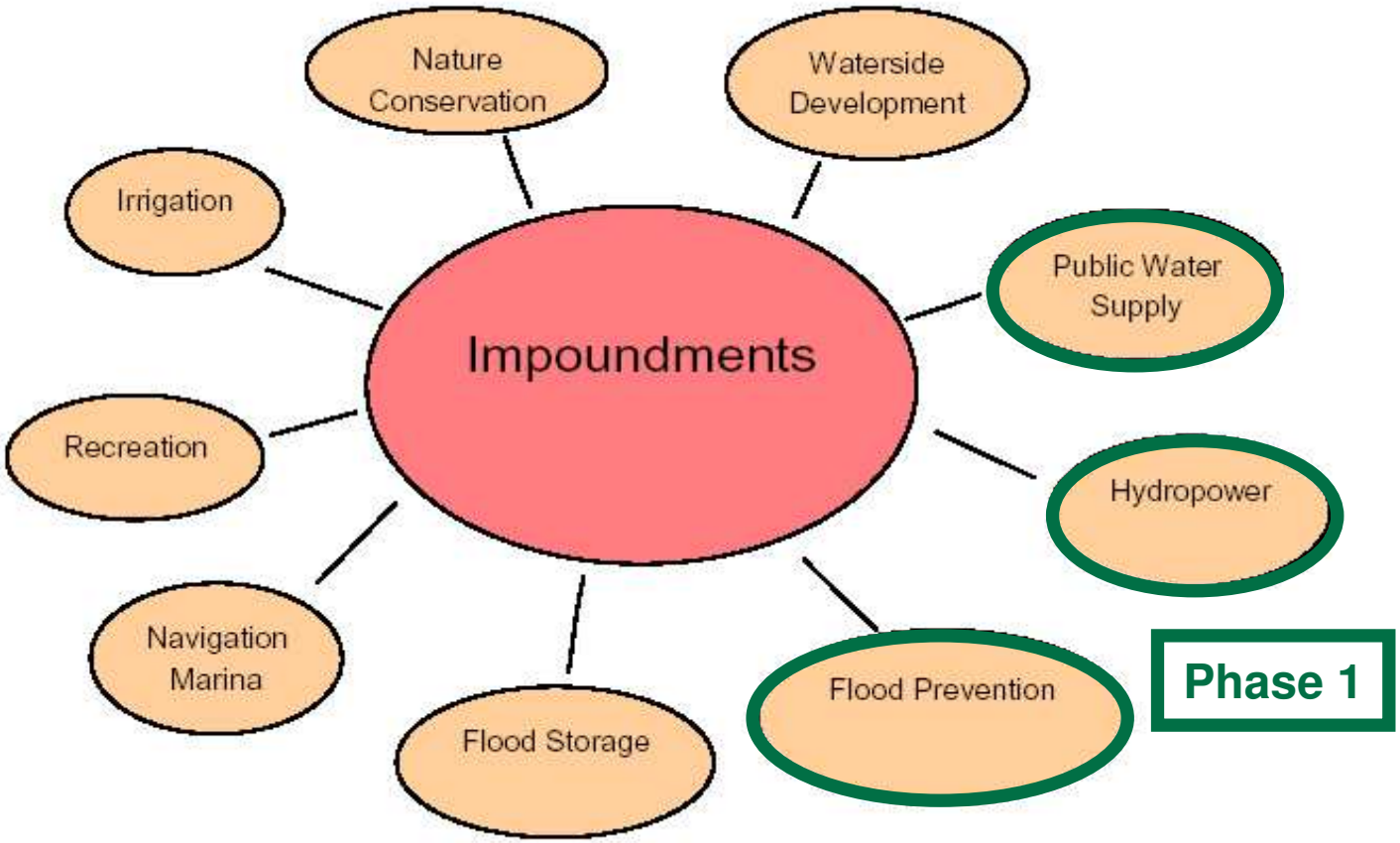
  we need a systematic method for identifying the most cost effective set of measures for any impoundment.

- These measures must aim to achieve Good Ecological Potential (GEP)

Developing a methodology

- A method for selecting the most cost-effective mitigation measures has been developed through a research project.
- This is a UK project managed by SEPA and co-sponsored by EA and EHS.
- Phase 1 of the project is complete and available on the SNIFFER website.
- Phase 2 is about to commence.

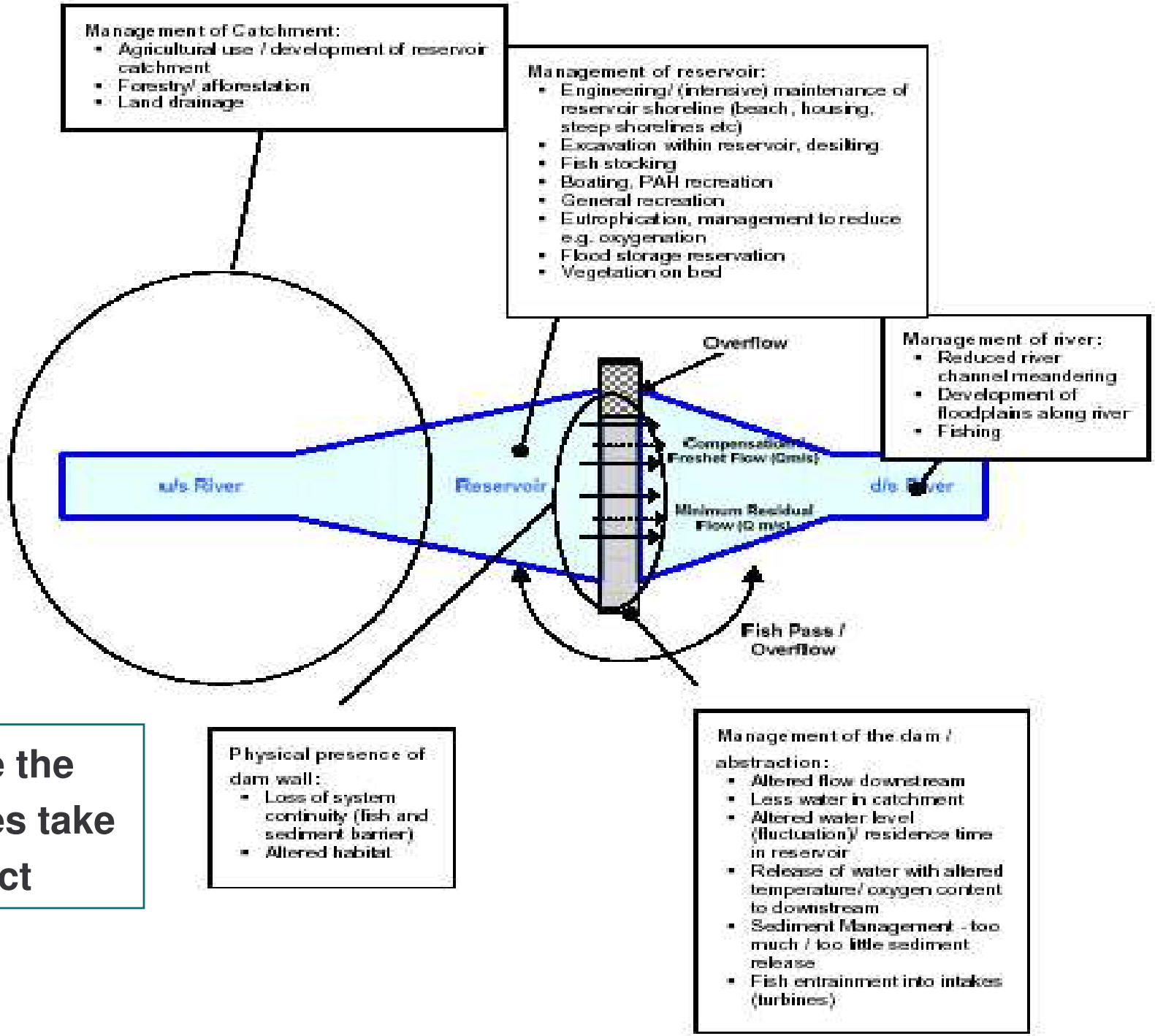
Impoundment Types



Identifying Mitigation Measures

- The project reviewed international best practice to identify:
  - well over 100 specific mitigation measures that have been applied;
  - the environmental impacts that these were attempting to mitigate;
  - the effectiveness of these measures.
- The project reviewed these measures to:
  - categorise where the benefits would take effect;
  - assess how soon the benefits would follow;
  - assess which biological quality elements they would be likely to affect (+ve and –ve).

Where the measures take effect



The Effectiveness of Mitigation Measures

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However, in many cases the improvements are difficult to predict or quantify because:

- water bodies have different characteristics and so the scale of improvement will often vary;
- effects are often only visible in the medium and long term;
- lack of follow up monitoring makes it difficult to quantify the effectiveness of measures;
- combined effects are often greater than effect of a single measure.

Effectiveness of measures

Therefore, effects of measures are given a score of their likely effect.

Category	Effect	Representation
1	strong positive effect	+++
2	moderate positive effect	++
3	limited positive effect	+
4	no effect	
5	limited negative effect	-
6	moderate negative effect	--
7	strong negative effect	---

Potential Measures

Mitigation measure	Effectiveness per biological element				Period for improvement
	Phyto-plankton	Macrophytes and phytobenthos	Benthic invertebrates	Fish fauna	
Introduce fish pass for movement downstream (9)	–	–	–	+	+++
Basic compensation flow (17)		+	+	+	+++
Provide freshets to mimic minor natural floods and encourage upstream migration of fish (also used for recreational river use) (19)	++	++	++	++	+++
Environmentally acceptable flow rates (21)	~	++	++	++	+++
Draw off water at a number of pre-determined levels through use of a multi-level intake structure (39)	~	++	++	++	++
Design / retrofit turbines to inject atmospheric oxygen into releases (48)	?	?	?	?	++
Provide and regulate a *spatial* zoning system to balance recreation and wildlife needs (designate areas as 'no entry' to boats) (90)	~	+	+	++	+
Nutrient control (110)	+++	++	++	++	++

Assessing Combinations of Measures

Combination	Mitigation measures	Effectiveness	Period for improvement	Chance of realising WFD aim
C1	9, 17, 39,110	limited positive effect	Before 2015	+
C2	9,19,21,110	moderate positive effect	Between 2015 and 2021	++
C3	9,21,48,90,110	moderate positive effect	Between 2015 and 2021	++
C4	9,19,21,39,48,90,110	strong positive effect	Between 2015 and 2021	+++

Assessing Financial Costs and Other Effects

Nr.	Combination of measures	Net Present Value	Other socio-economic effects
C1	9, 17, 39,110	£ 150,000	Reduction in farming activities
C2	9,19,21,110	£ 170,000	Reduction in farming activities
C3	9,21,48,90,110	£ 220,000	Reduction in farming activities Impacts on recreation
C4	9,19,21,39,48,90,110	£ 400,000	Reduction in farming activities Impacts on recreation

Selecting Combination of Measures to meet GEP

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Selecting the most cost-effective combination of measures							
Nr.	Combin-ation of measures	Likelihood of reaching WFD target			Net Present Value	Other socio-economic effects	Ranking of measures based on cost-effectiveness
		Effect	Period	Chance to reach WFD-aim in 2015			
C1	Combination of M9, M17, M39, M110	limited positive effect	Before 2015	+	£ 150,000	Reduction in farming activities	3
C2	Combination of M9, M19, M21, M110	modera te positive effect	Betwee n 2015 and 2021	++	£ 170,000	Reduction in farming activities	1
C3	Combination of M9, M21, M48, M90, M110	modera te positive effect	Betwee n 2015 and 2021	++	£ 220,000	Reduction in farming activities Impacts on recreation	2
C4	Combination of M9, M19, M21, M39, M48, 90, M110	strong positive effect	Betwee n 2015 and 2021	+++	£ 400,000	Reduction in farming activities Impacts on recreation	4

The principle of Good Ecological Potential

- MEP is defined by WFD as:

  *The values of the relevant **biological quality elements reflect** …. those associated with the **closest comparable surface water body type**, given the …. artificial or heavily modified characteristics of the water body.*

- GEP is defined as:

  *There are **slight changes** in the values of the relevant **biological quality elements** as compared to the values found at maximum ecological potential.*

  'The hydro-morphological elements' are ***consistent with the achievement of the …. biological quality elements***.

Achieving Good Ecological Potential in Practice

- In most cases it will not be possible to give an accurate, quantified prediction of ecological status in advance of implementing mitigation measures.
- GEP is therefore the ecological state that results from applying all the mitigation measures that are not disproportionately costly.
- Environmental monitoring will then determine how close this state compares to GES for the closest comparable surface water body.
- If monitoring identifies that problems remain then additional measures can be considered in subsequent RBMP.

Summary

- The methodology (WFD29 Project) comprises a structured Cost-Effectiveness selection of mitigation measures for large impoundments
- Some expert judgement is needed to arrive at best selection of measures but method gives a structured and auditable framework.
- The phase 1 project report is available in the SNIFFER website.
- Phase 2 is about to get underway.