The development of a remediation action plan for a contaminated fjord in Norway, hosting a biological important submerged macrophyte meadow

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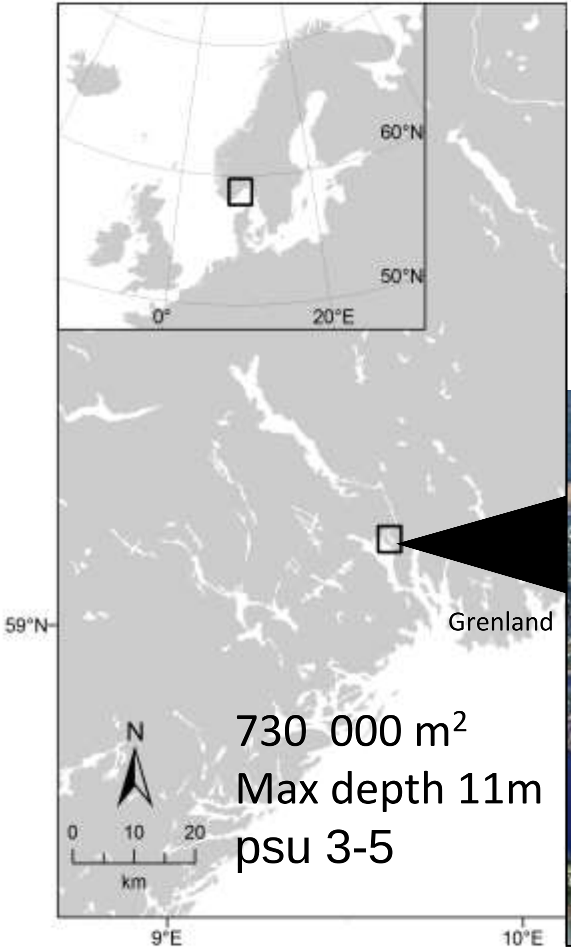
or…

Implementing activated carbon amendment in a full-scale remediation of contaminated sediment

Gunneklevfjorden, Norway

Discharges of dioxins and other chlorinated compunds

Discharges of 60-80 tonnes of Hg from a chlor-alkalie plant (1947-1987)



730 000 m^2
Max depth 11m
psu 3-5

70 000 m^2
Permanently submerged meadow of macrophytes

Chemical status Hg

		EQS TotHg	Tot-Hg	MeHg	
Water		0.07 µg L^{-1}	0.005	0.00003	(mean over all depths)
Biota	Benthos	-			
	Fish	20 µg k[illegible] ww	2058	1368	(max of all samples)

		EQS TotHg	Outside meadow Tot-Hg	Outside meadow MeHg µg kg^{-1} dw	Within meadow Tot-Hg	Within meadow MeHg µg kg^{-1} dw
Sediment	0-2 cm	-	9.5	2.0	2.7	1.5
	[illegible] cm	-	16.6	5.8	4.5	8.9
	0-10 cm	0.52 mg kg^{-1} dw	46.8	5.9	6.9	8.5

Consumption: 500 µg kg^{-1} ww

Natural recovery is in progress

(Ref: M-608/2016)

M-608/2016:

(Norwegian guidelines: Quality standards for water, sediment and biota)

«Environmental quality standards in sediments are not absolute. In case of exceedances of environmental quality standards in sediments, site-specific investigations and risk assessments should be carried out……… to assess whether the sediment poses a risk to humans and the environment and to spreading to the environment before assessing measures”.

Step 1: Sediment concentrations vs Environmental Quality Standards

↓

Step 2: Risk to humans, environment and for spreading

↓

Step 3: Site specific risk

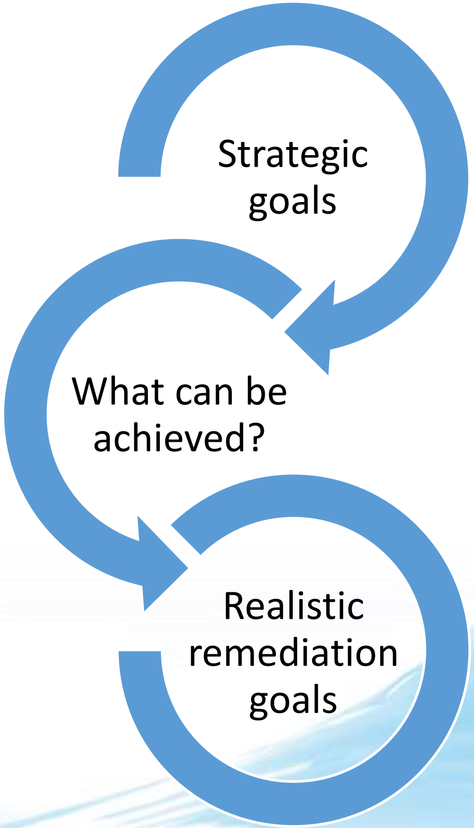
Defining environmental goals for remediation:

EQS

or

Site specific risk based approach (Step 3)?

→ relevant to consider what different measures actually achieve, including the possible negative effects



Risk to humans =

oral intake of either sediment or fish

- The fjord is presently not used for swimming or fishing
- Consumption standards (500 µg kg^{-1} ww) are met for fish below ~20 cm

→ Bioavailbility of Hg should be reduced

Risk to the environment =

uptake of the toxic and bioavailable MeHg in food webs

- The meadow is the most biologically important area
- MeHg production is enhanced within the meadow, contributing >30 % of MeHg from sediment to waters in <10% of the total fjord area
- MeHg uptake into food web occurs mainly within the meadow

→ Bioavailbility of Hg and flux from sediment to water should be reduced

Risk of spreading =

flux from sediment to water and transport out of the fjord to adjacent areas

- Flux from sediment is a minor contribution to the transport out of the fjord (10 g/year)
- Annual transport out of the fjord to adjacent areas = 0.5 kg (resuspended material?)
- Annual transport by the River Skienselva (into the same recipient) = 3.2 kg

→ Flux and resuspension should be reduced

Reaching the strategic goals

Dredging and/or capping

Reduced concentrations
Reduced risk to humans and environment
Reduced risk of spreading

WFD - EQS

Capping, with/without AC

Reduced concentrations
Reduced risk to humans and environment
Reduced risk of spreading
Reduced bioavai ility with AC

WFD - EQS

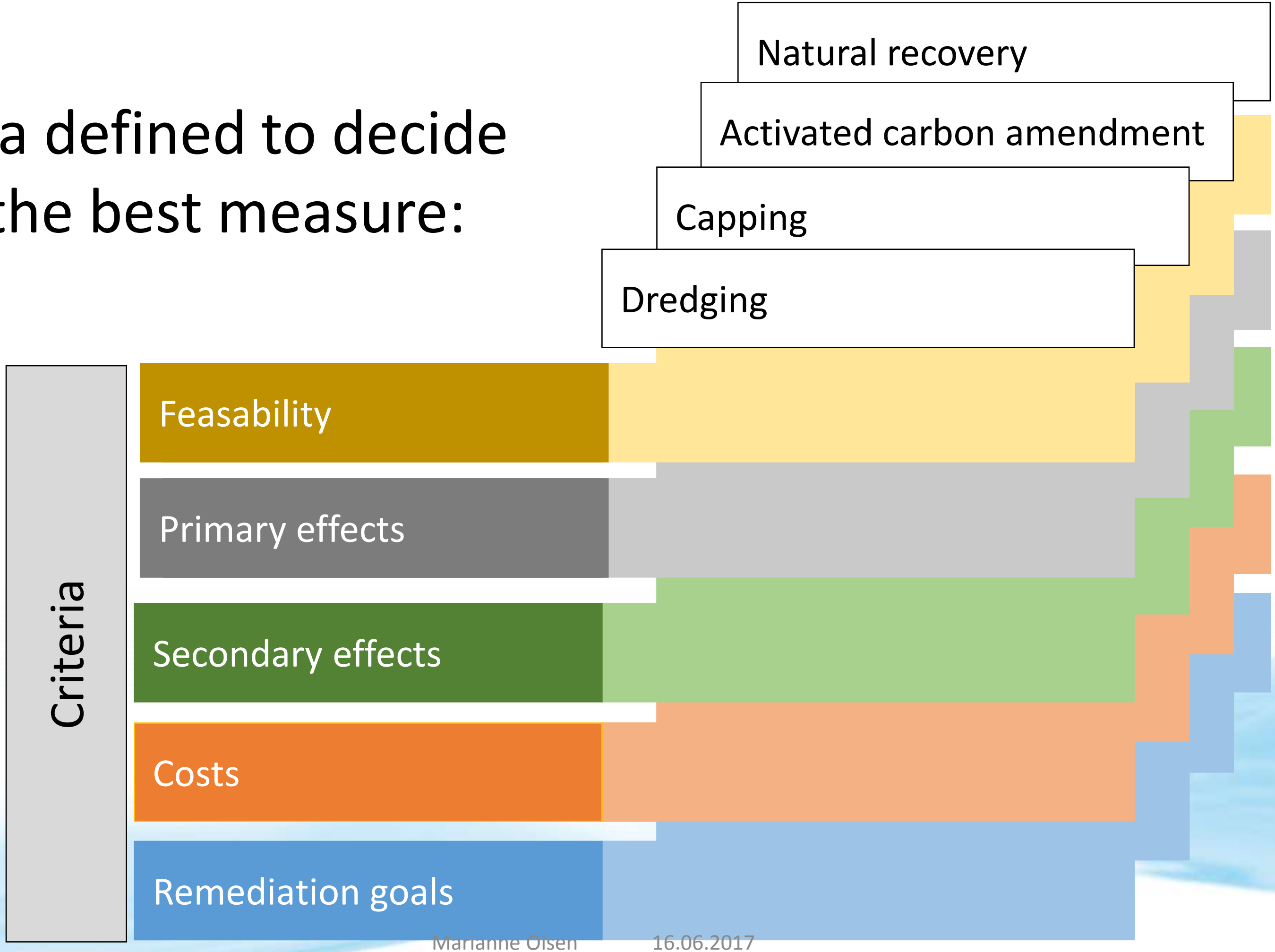
AC amendment

Reduced bioavailbility:
Reduced risk to humans and environment
duced risk of spreading;
nded particles
als by AC

~~WFD -~~

Reduced bioavailability

Criteria defined to decide upon the best measure:



Criteria

Criteria	
Feasability	Dredging and isolation capping not feasable due to high water content and unstable sediments. Thin-layer capping and AC amendment possible. AC duration?
Primary effects	Dredging and capping reduces sediment concentrations. AC amendment reduces bioavailability and flux of MeHg
Secondary effects	Dredging and capping reduces biodiversity short-term. AC amendent has low impact but may have negative impact on certain benthic organisms. User restrictions ?
Costs	Dredging and isolation capping high costs, thin-layer capping and AC amendment low(er) costs Natural remediation = monitoring costs
Remediation goals	Dredging and capping = EQS. Recolonisation? AC amendment = risk reduction due to reduced bioavailability. Good ecological status.

Consultants:

AC without/with thin-layer capping (max 5 cm in each capping operation; leave for 1-3 years for consolidation between capping layers)

Reduce bioavailability, minimize secondary effects and reduce costs

Industry:

AC amendment

Reduce bioavailability, minimize secondary effects and reduce costs

Authorities' order to industry:

20 cm capping with/ without AC, before 2021

Reduce sediment concentrations and bioavailability, reduce potential for spreading, support future good ecological status

External consultant for the authorities:
AC + sand possible: 14-19 cm capping. Consolidation?

Thank you for the attention!

Norwegian Institute for Water Research

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