Including contaminant budget principles in the monitoring program for sediment remediation efforts in Oslo harbour, Norway

Amy M.P. Oen[1], Espen Eek[1], Arne Pettersen[1],
Gijs D. Breedveld[1] and Torild Jørgensen[2]

[1]NGI and [2]Oslo Port Authority

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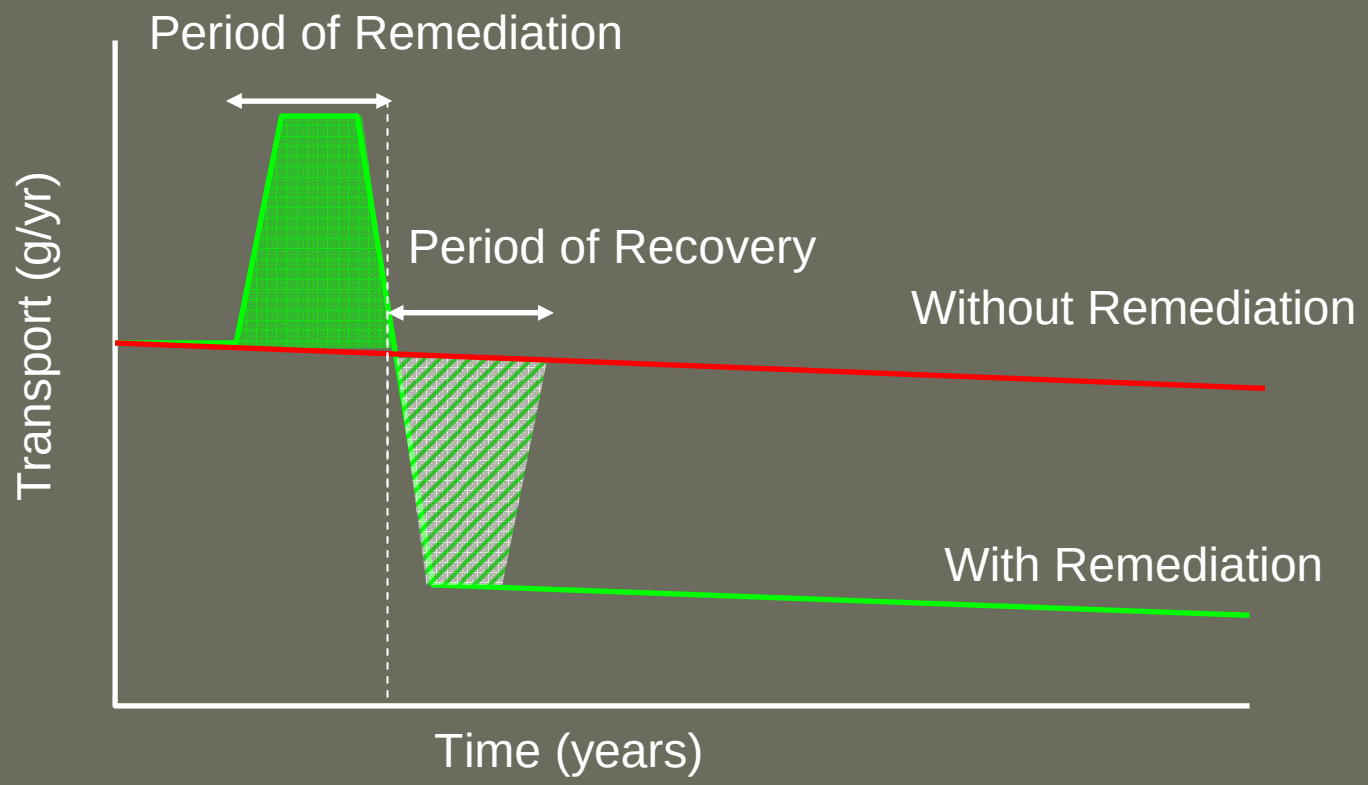
NGI


Oslo Harbour Remediation Project

Documenting environmental cost and benefit

- Contaminant budget
  - Established in design phase
  - Included in permit application
- Contaminant loads or “expenditures” included in monitoring program

Contaminant budget principles



Deep water disposal facility near Malmøykalven

Transport mechanisms identified for deep water disposal facility

- Prior to remediation
  - Diffusion from the seafloor sediments
- During remediation
  - Diffusion from seafloor sediments
  - Resuspension of sediments
  - Release of pore water
- After remediation
  - Diffusion through capping layer

Methods used for flux estimates

- Diffusion
  - Mesocosm studies conducted by NIVA at Solbergstrand
  - Lab scale diffusion chamber
- Resuspension
  - Mesocosm studies conducted by NIVA at Solbergstrand
- Advection
  - Pore water chemistry and consolidation data

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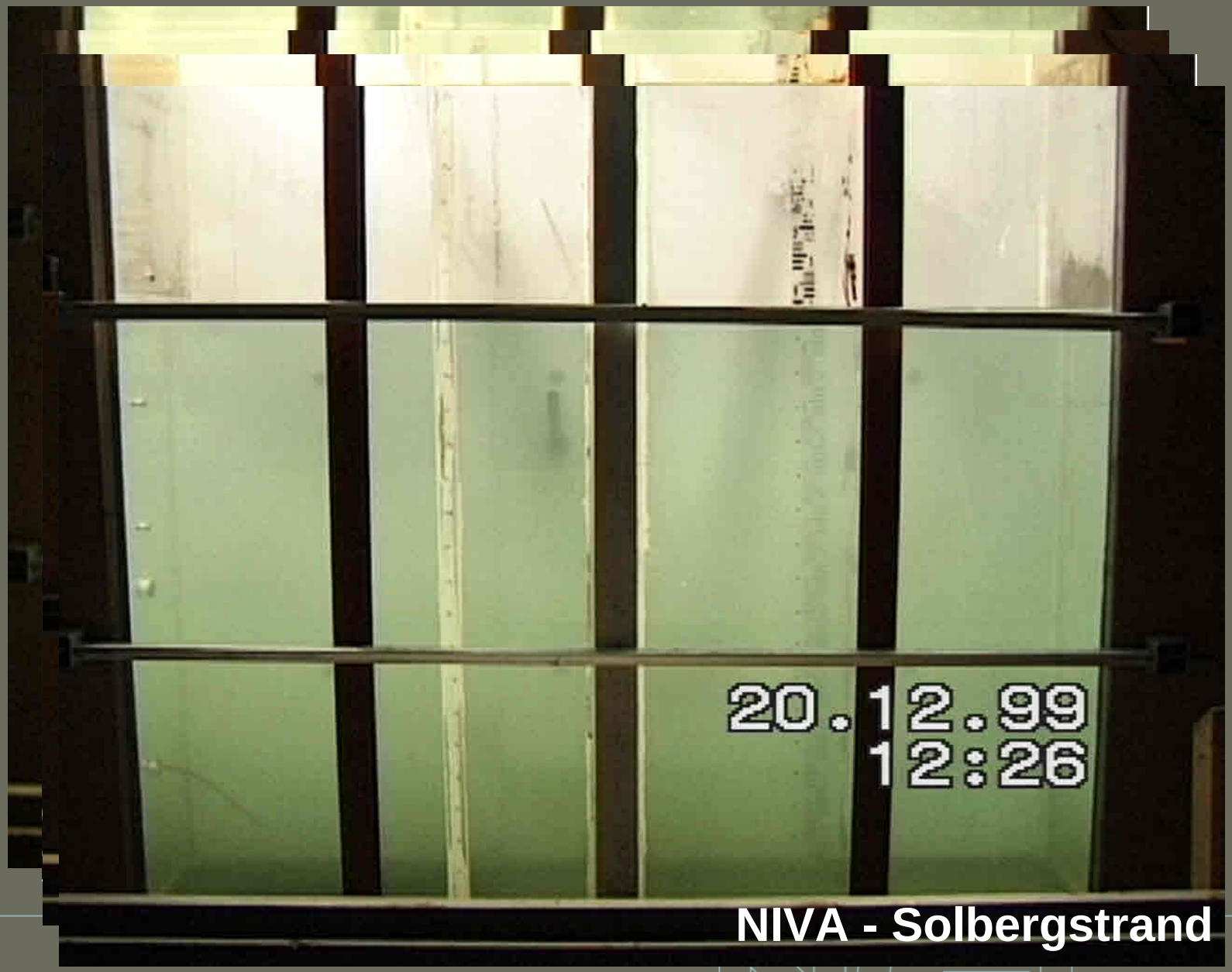
NIVA - Solbergstrand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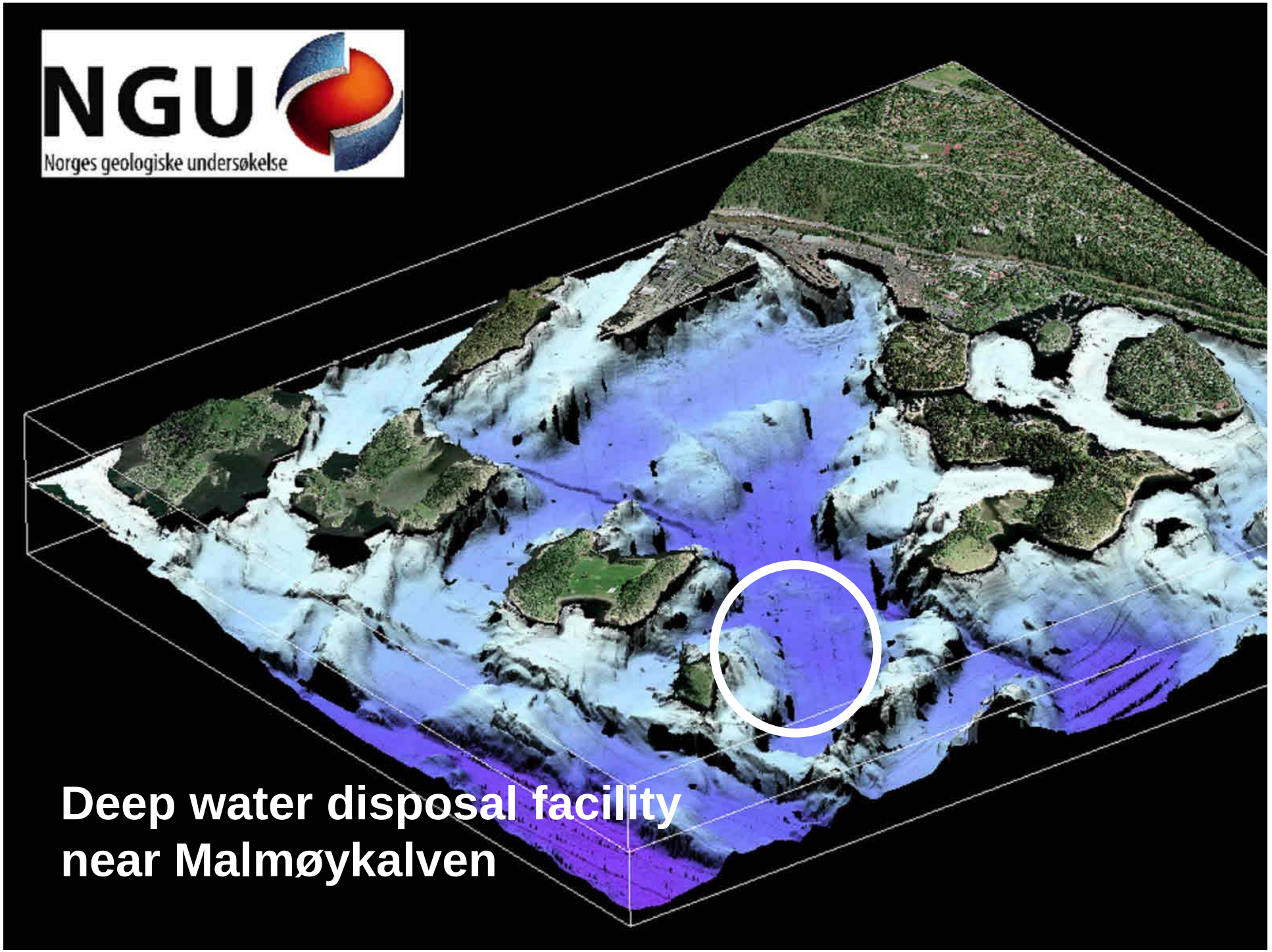
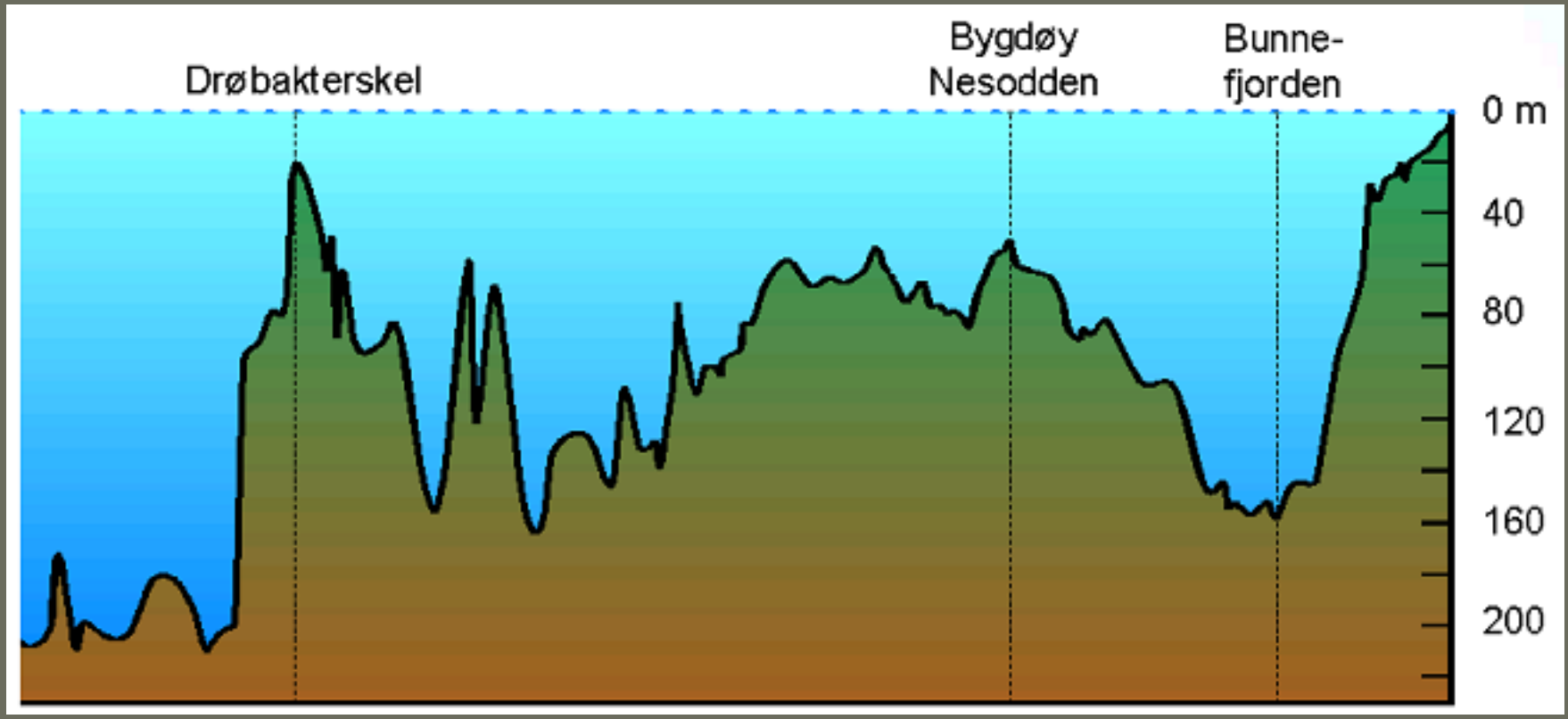
NIVA - Solbergstrand

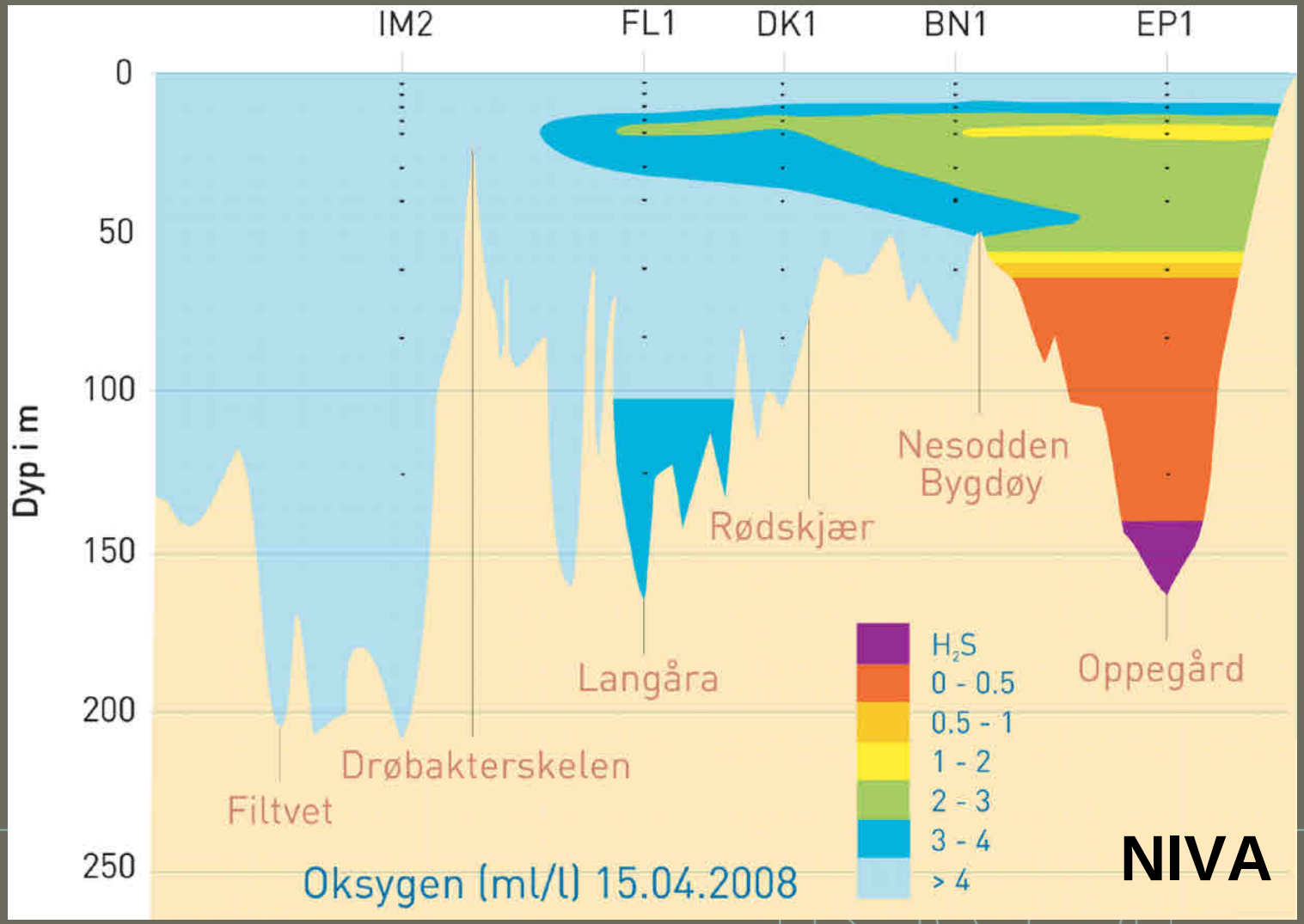

NGU
Norges geologiske undersøkelse
Deep water disposal facility
near Malmøykalven

Oslo Fjord depth profile

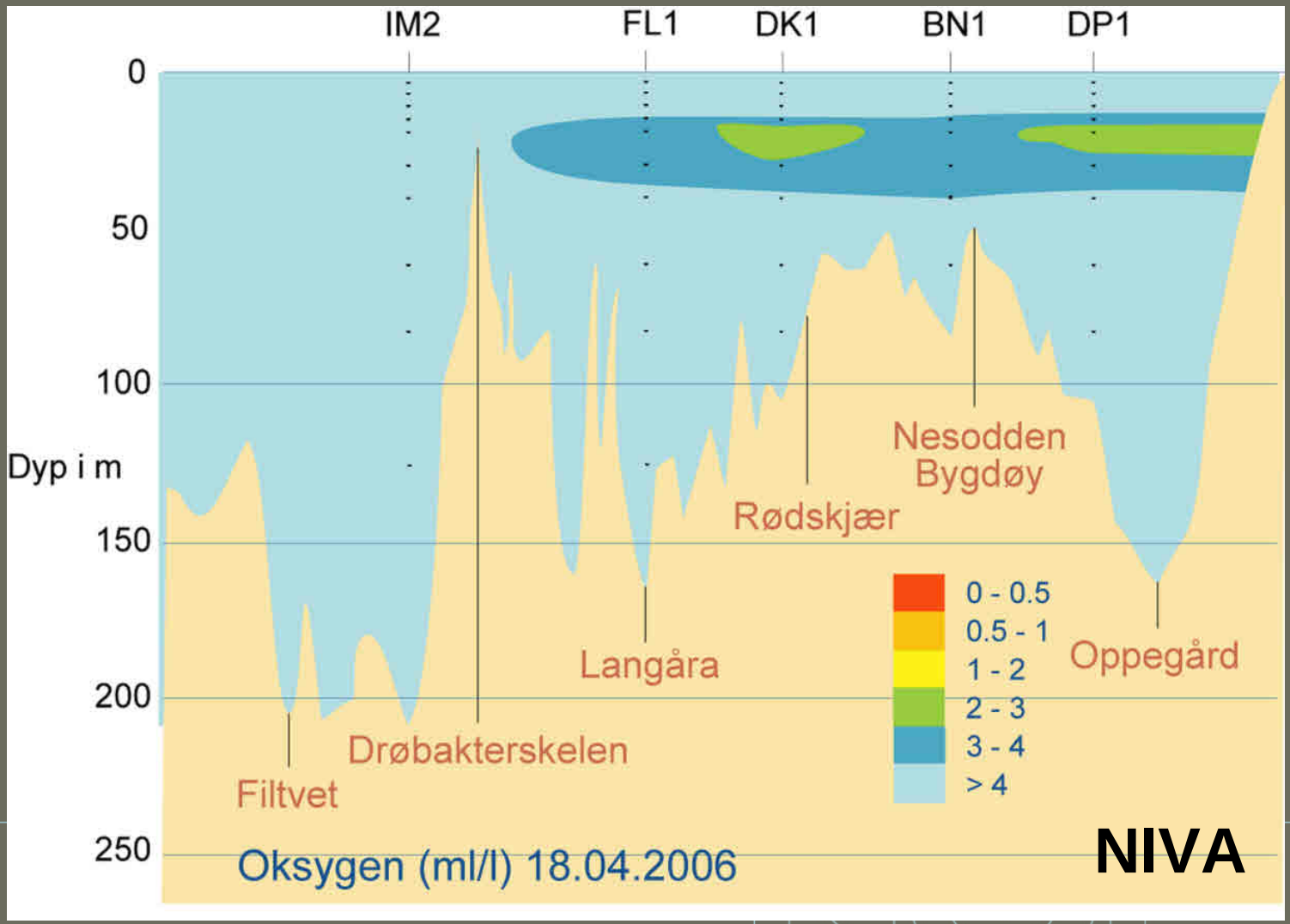


Threshold fjords result in limited water circulation forming deep anoxic basins

Limited water renewal in Oslo Fjord



Complete deep water renewal in Oslo Fjord



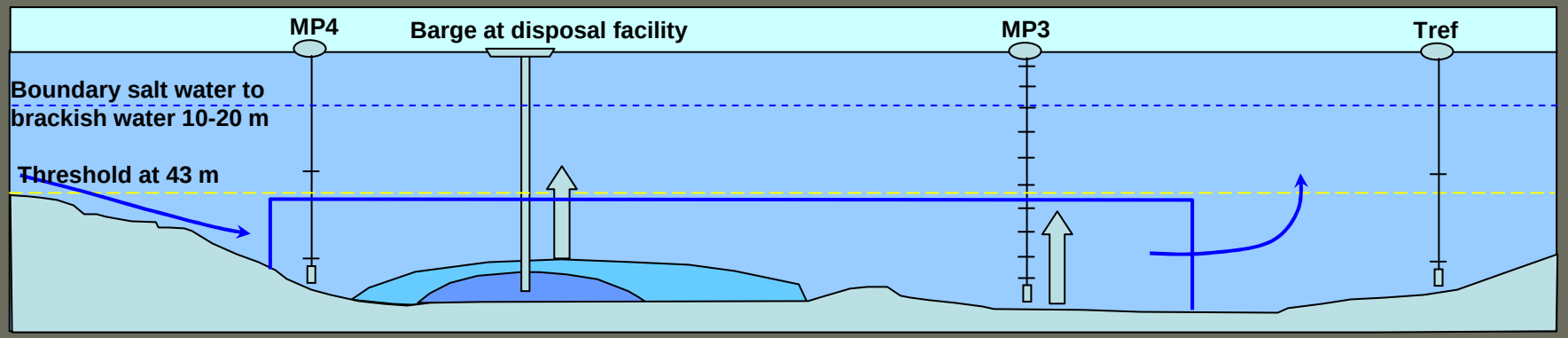
Deep water renewal in Oslo Fjord

- Not included in contaminant budget, alternative measures:
  - Monitoring of water current
  - Addition of salt to dredged sediments to avoid advection of “fresher” water
- Included in documentation of contaminant “expenditures”
  - Conservatism
  - Largest ever deep water renewal – winter 2006

Methods used for “expenditure” estimates

- Concentrations based on measured water samples
  - Input to characterize mass of water
- Divided into three scenarios
  - Turbulent diffusion acceptable turbidity
  - Turbulent diffusion unacceptable turbidity
  - Deep water renewal

Transport mechanisms for contaminant loads



Transport via turbulent diffusion

Transport via deep water renewal

Monitoring program – turbidity

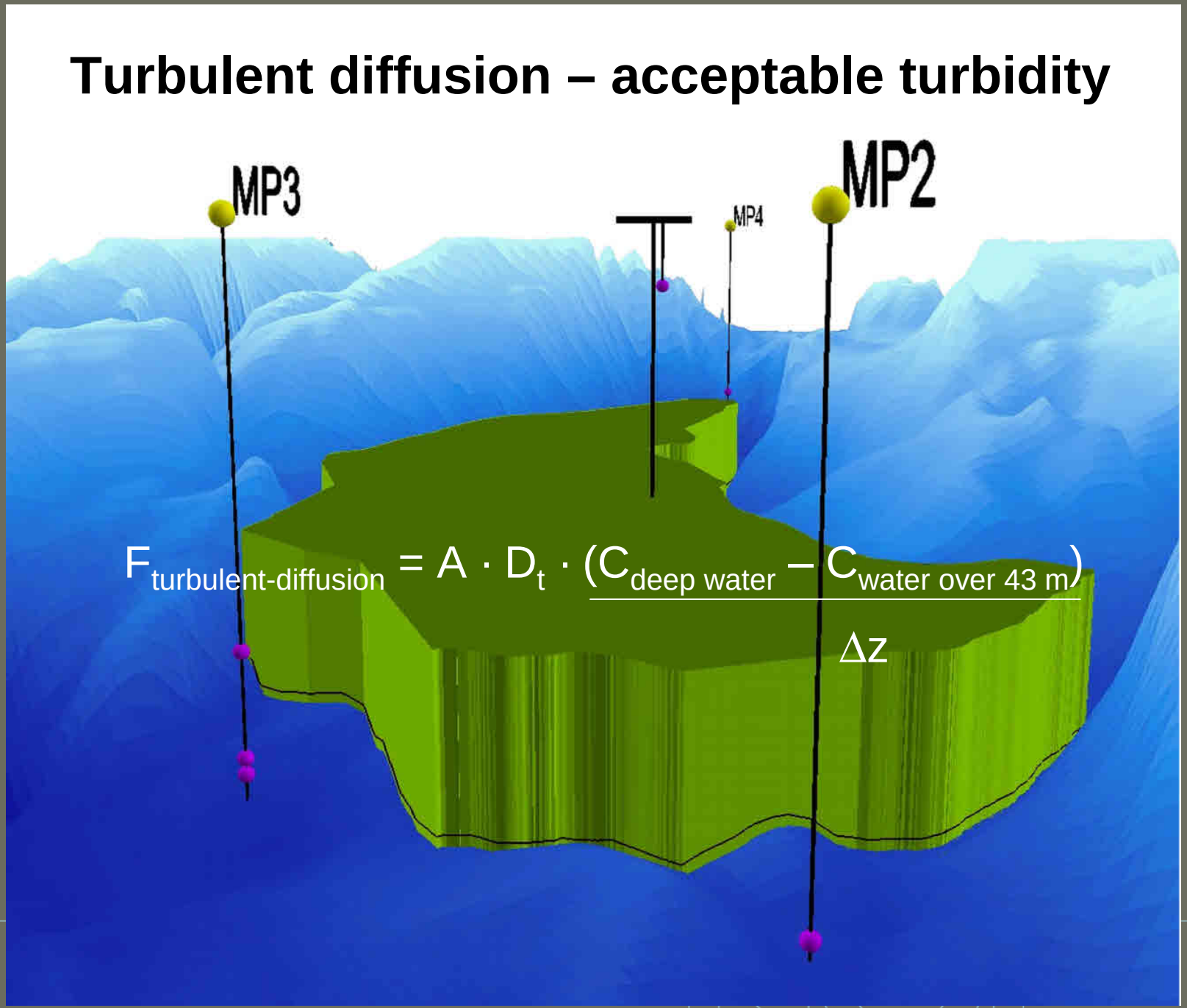
Water samples when turbidity > 6 NTU

Monitoring program includes:

- Water samples
  - 5 m
  - 40 m
  - 5 m over seafloo
- Passive samplers
  - POM 55 μm
  - Vertical profiles

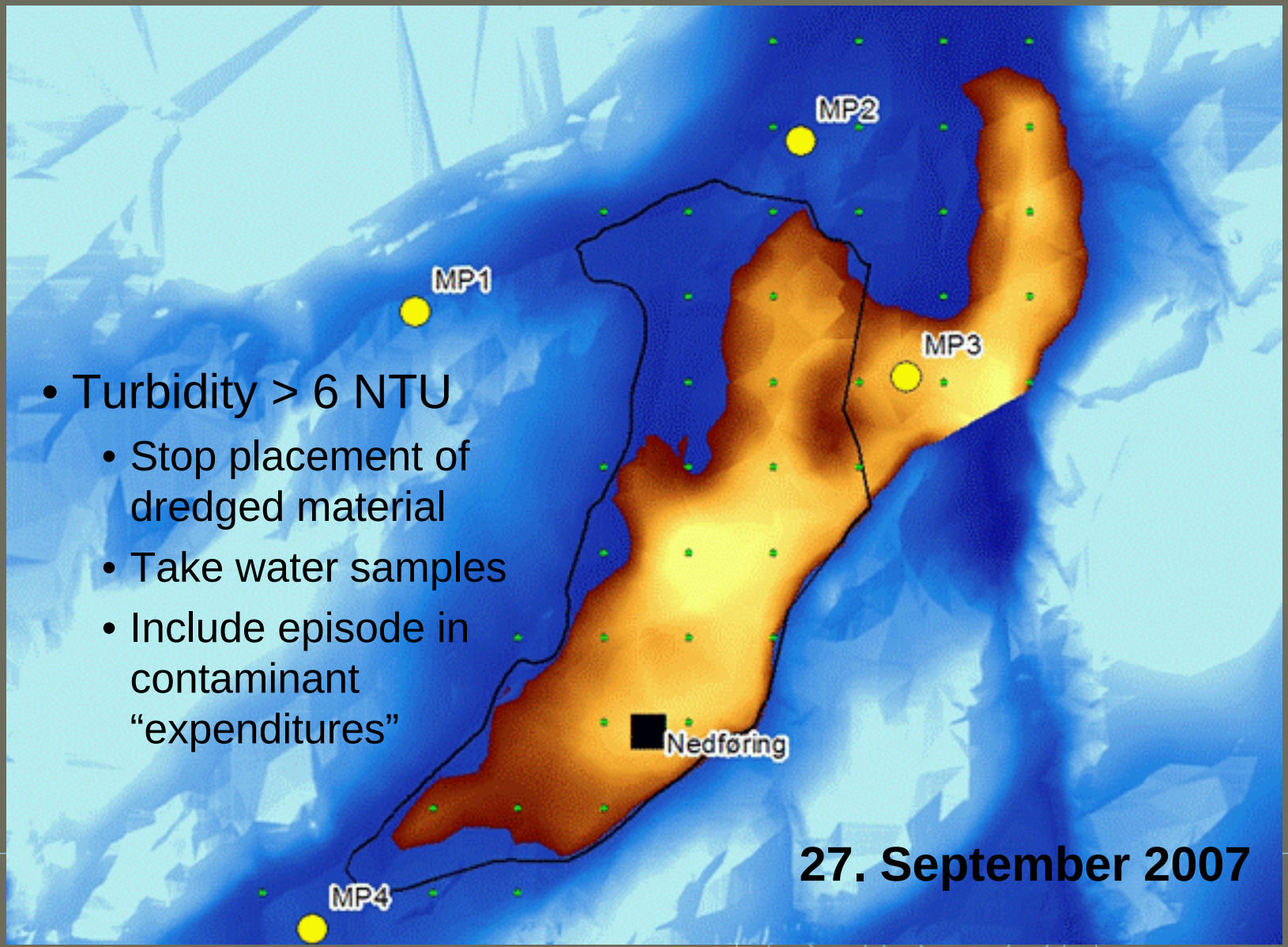
Several other methods are also used, although they are not directly utilized in the contaminant ”expenditure” estimates

Turbulent diffusion – acceptable turbidity



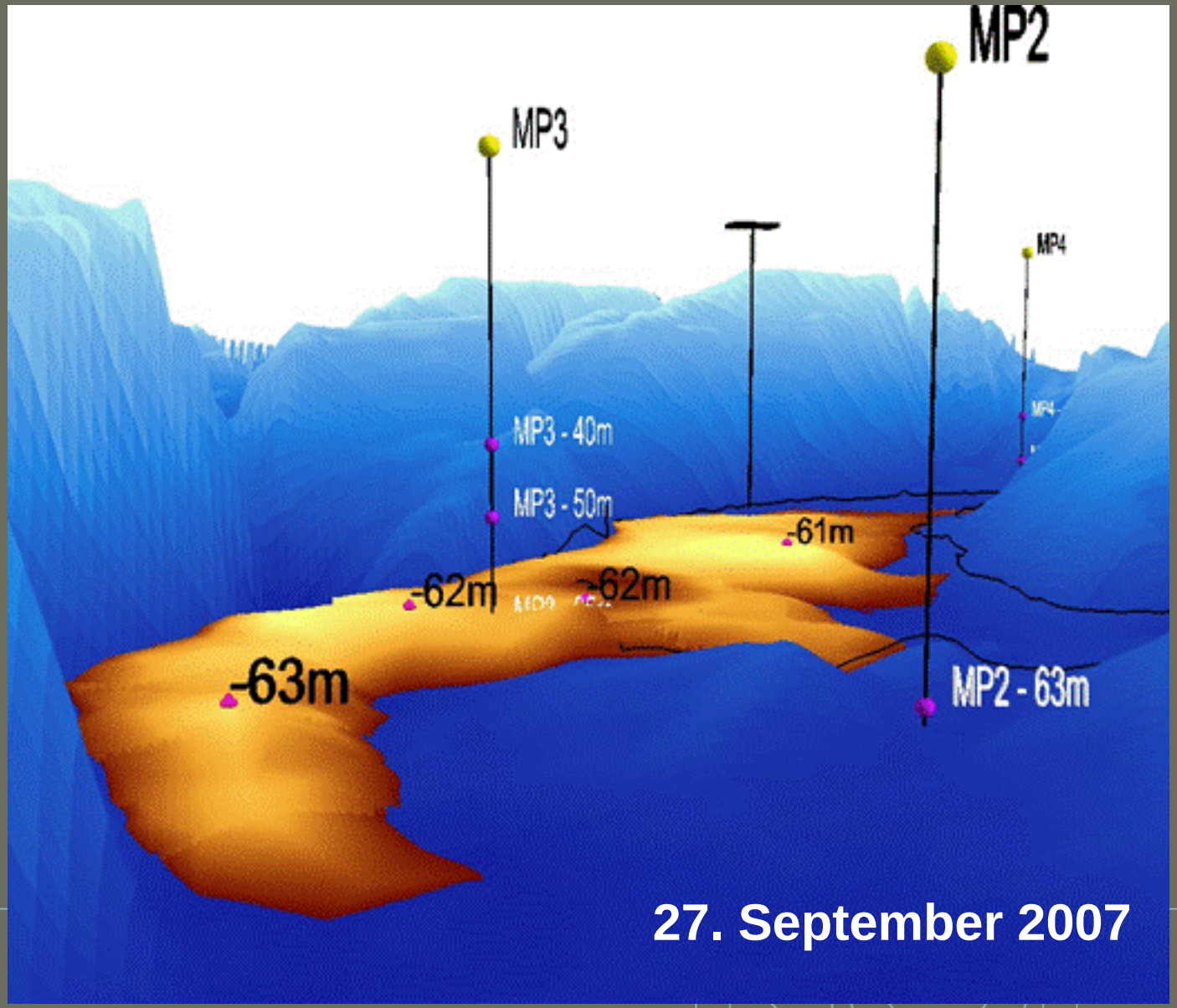
$$F_{\text{turbulent-diffusion}} = A \cdot D_t \cdot \frac{(C_{\text{deep water}} - C_{\text{water over 43 m}})}{\Delta z}$$

Turbulent diffusion – episodes of unacceptable turbidity

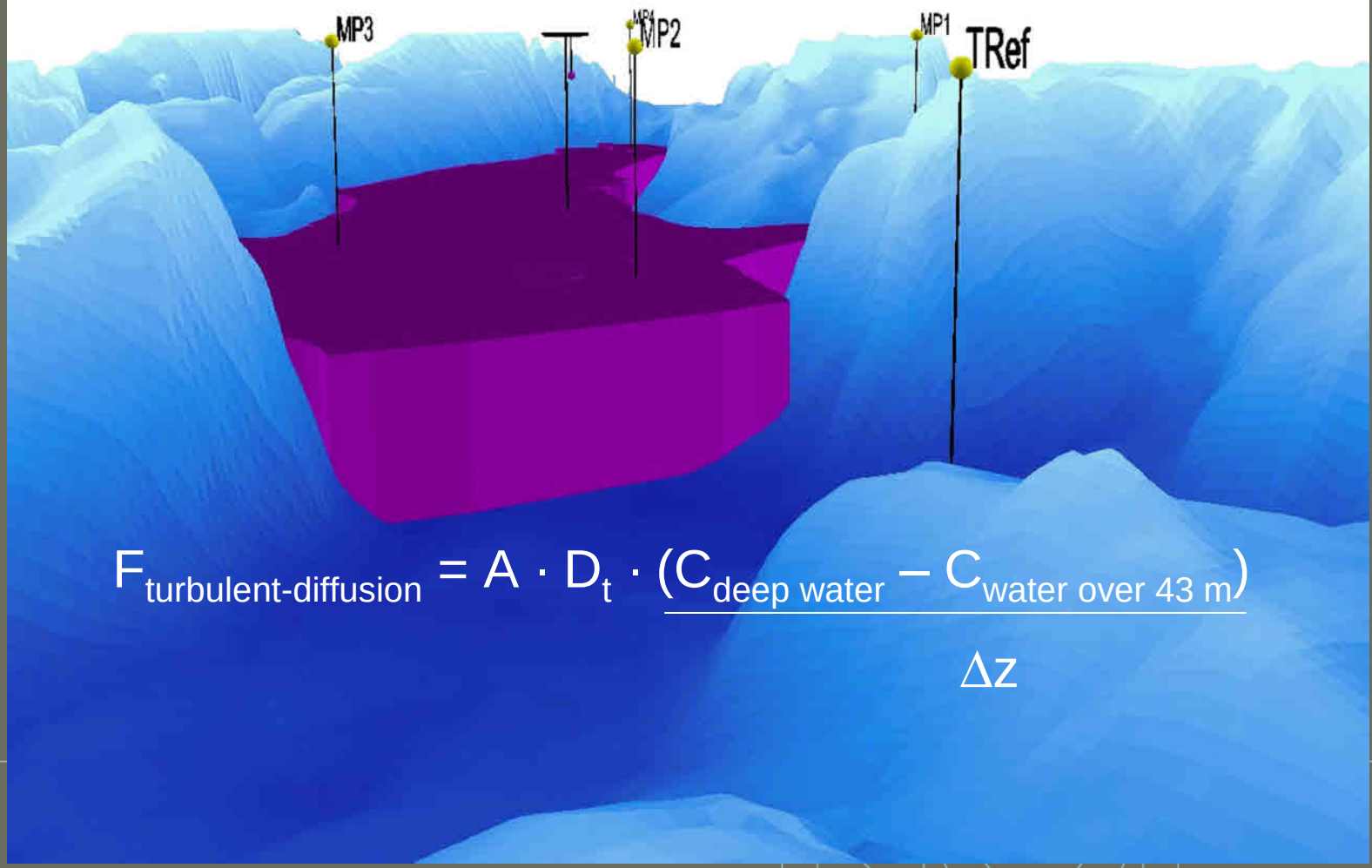


- Turbidity > 6 NTU
  - Stop placement of dredged material
  - Take water samples
  - Include episode in contaminant “expenditures”

Turbulent diffusion – episodes of unacceptable turbidity



Turbulent diffusion – unacceptable turbidity



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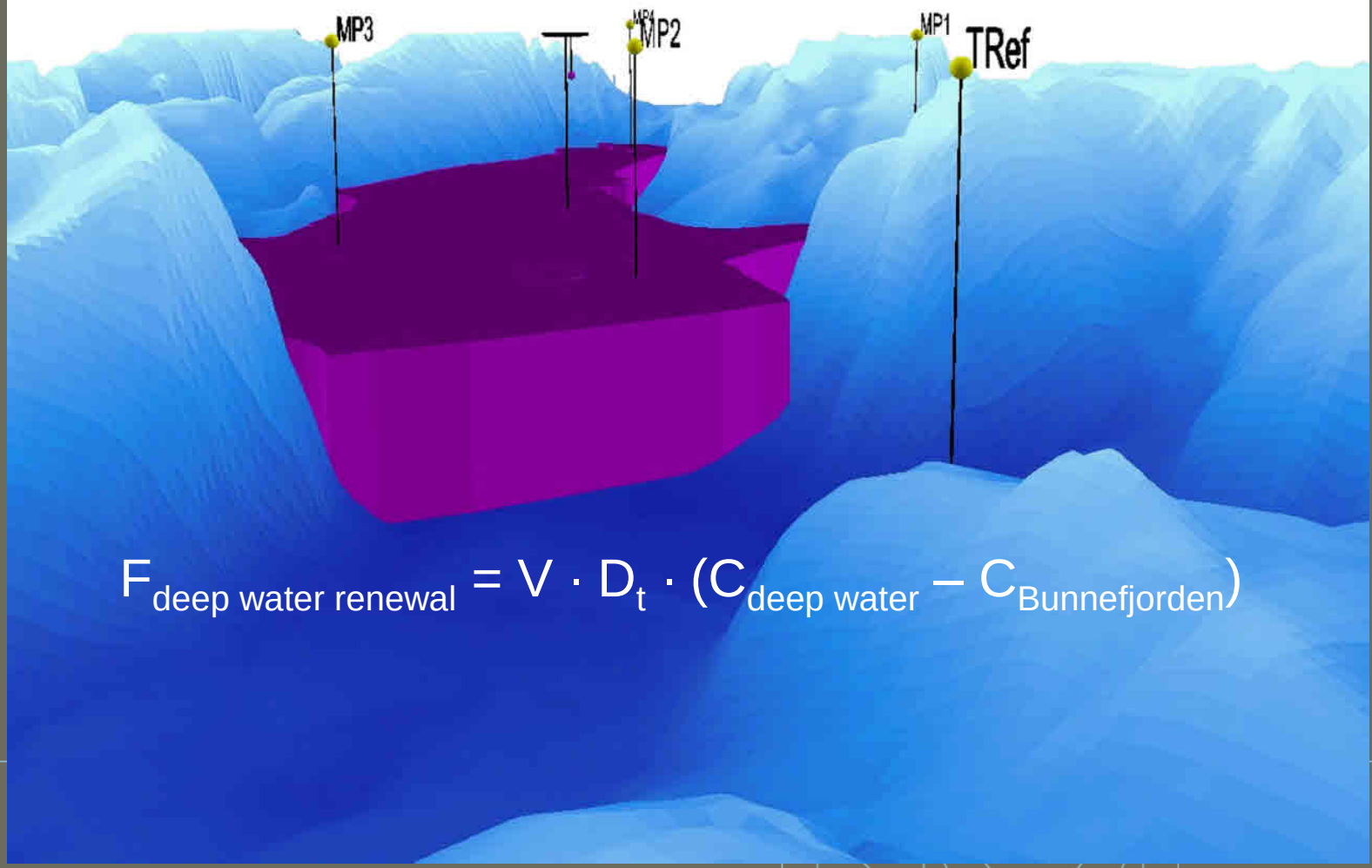
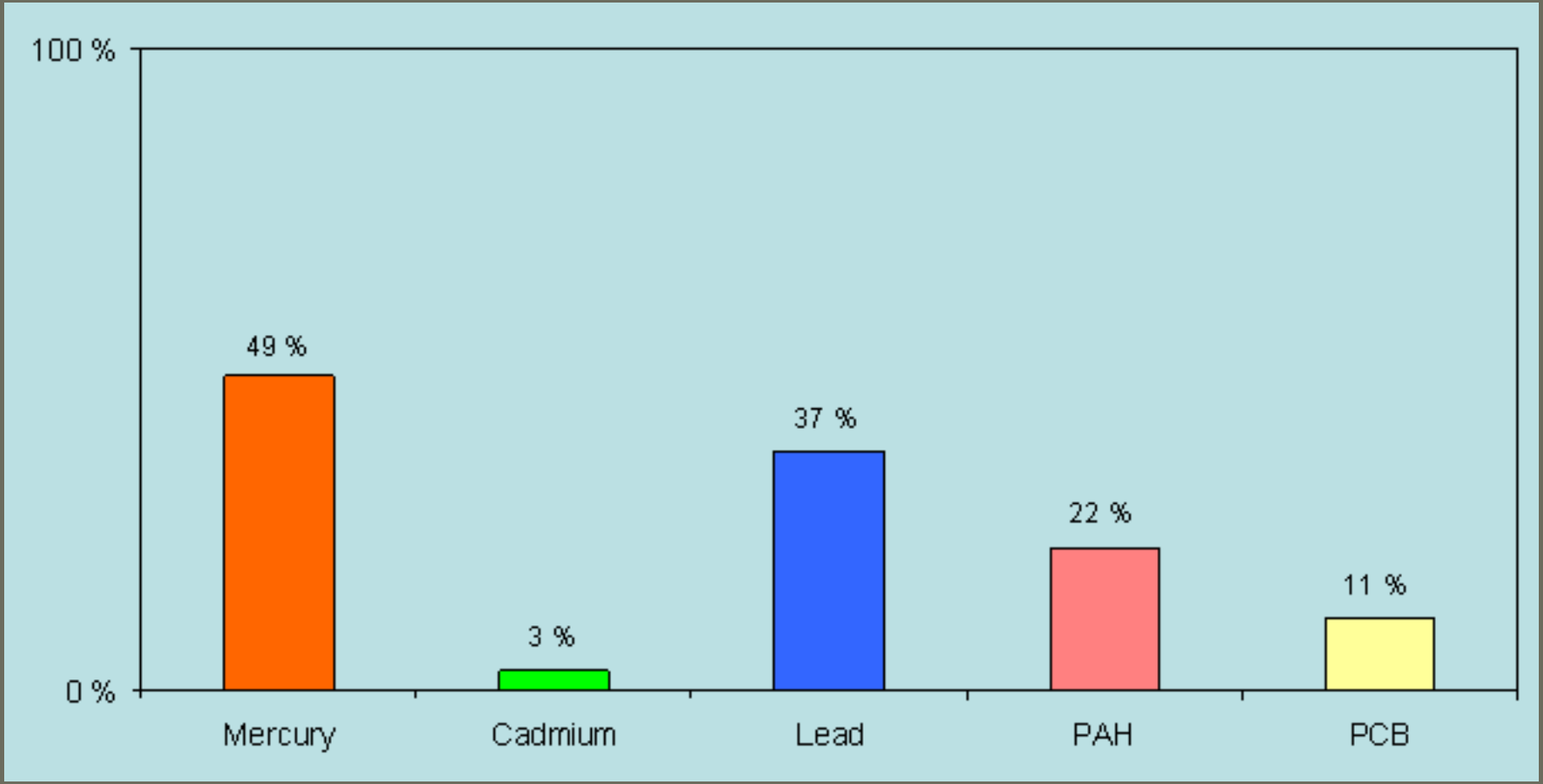
Deep water renewal

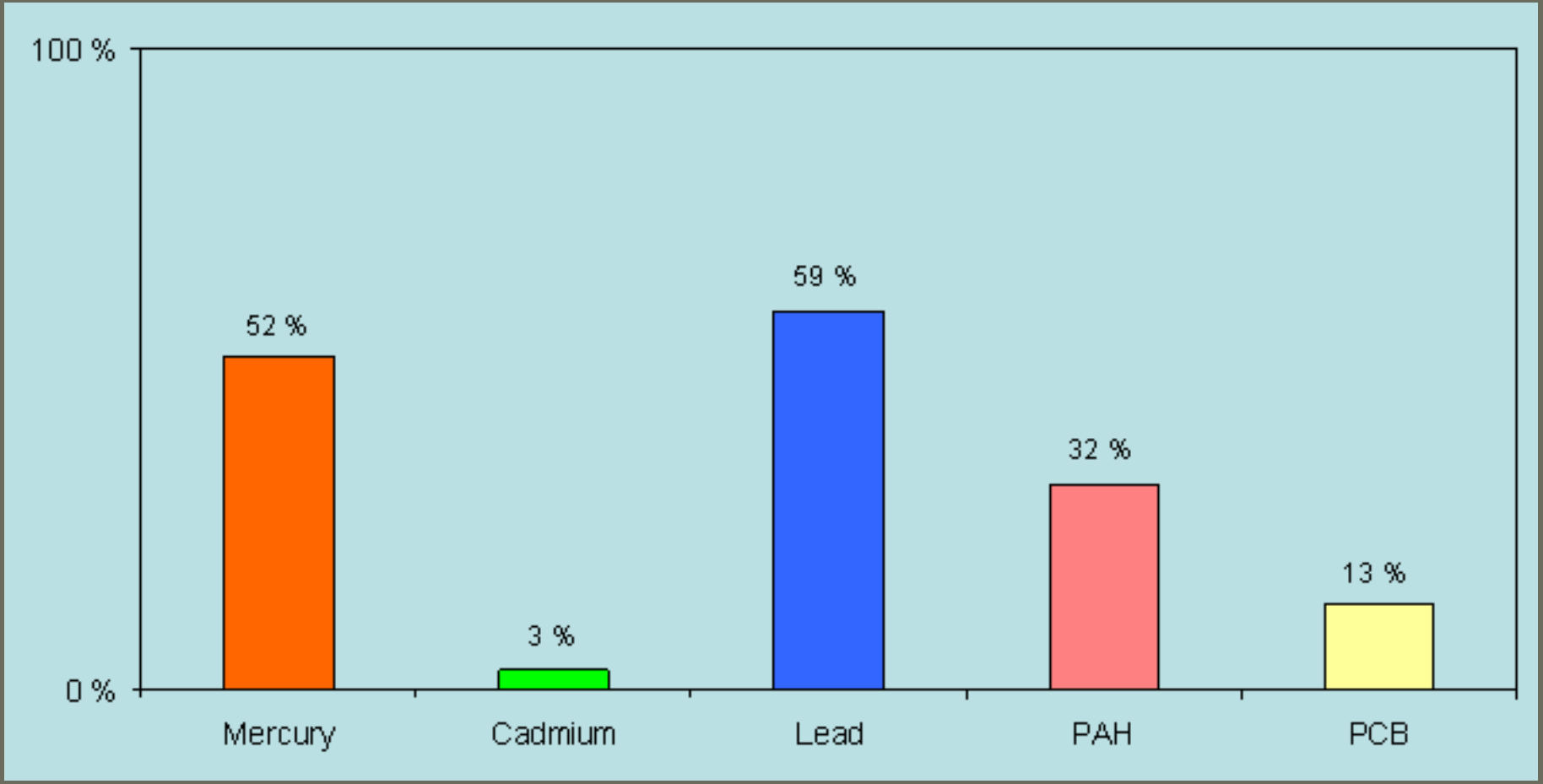


$$F_{\text{deep water renewal}} = V \cdot D_t \cdot (C_{\text{deep water}} - C_{\text{Bunnefjorden}})$$

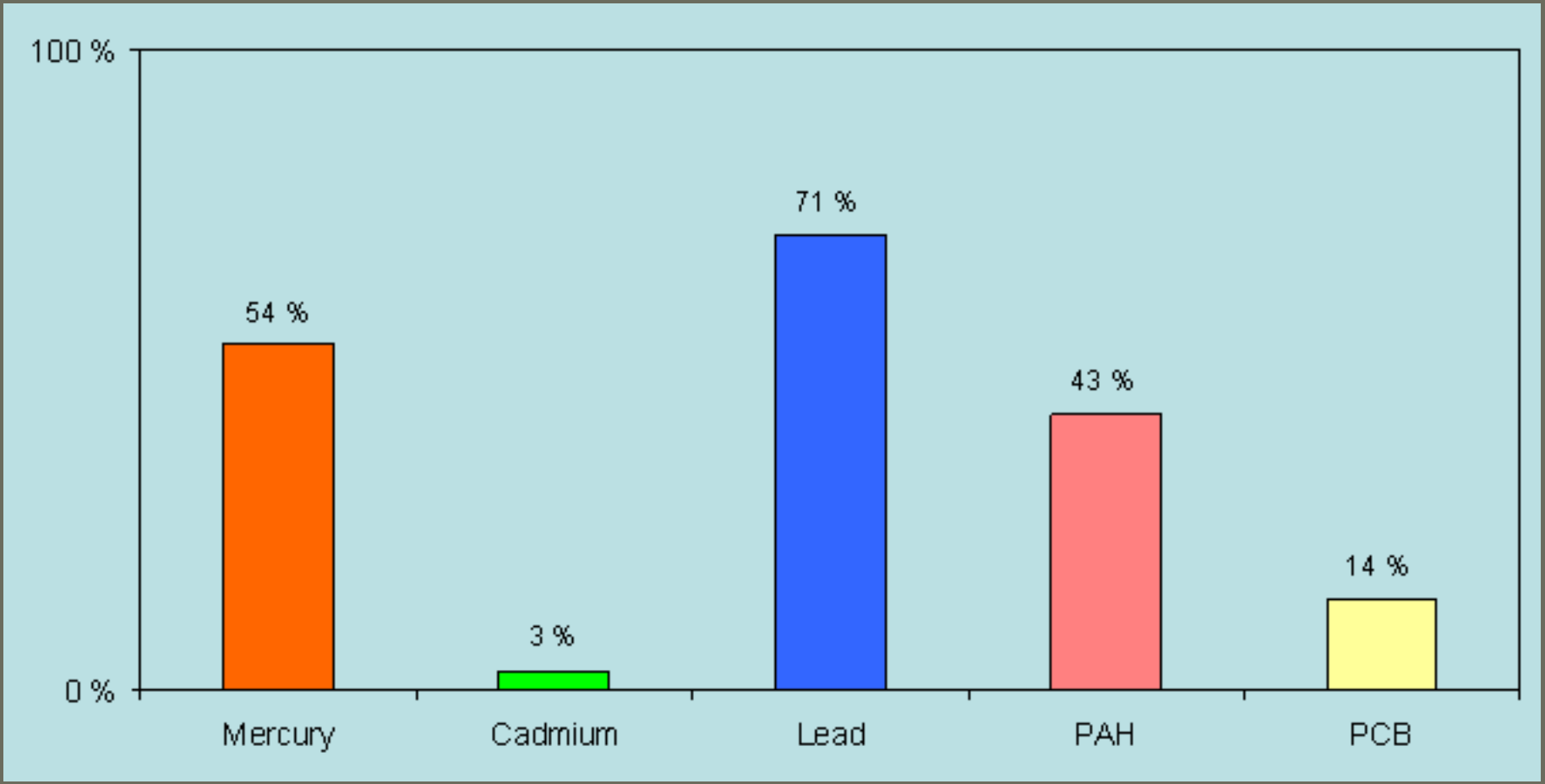
Contaminant balance as of December 2006



Contaminant balance as of June 2007



Contaminant balance as of December 2007



Advantages of the model

- Concept of budgets and “expenditures” is universal
- Defines realistic expectations of environmental benefit
- Provides feedback to improve monitoring program
- Can be useful for contaminant load predictions
- Method of communicating progress and status of activities

Thank you for your attention!