Deltares
Enabling Delta Life

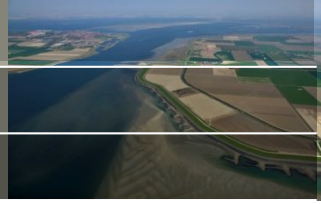
Wind powered constructed wetland for PCE dechlorination

Miami, Battelle bioremediation symposium 2017

By Jasperien de Weert, Johan van Leeuwen, Bas van der Zaan, Jan Gerritse and Nanne Hoekstra

25th of May 2017

Outline



- Historical contamination
- Clean up efforts
- Design: Ecological engineered wind powered wetland concept Field test & data
- Conclusions
- Recommendations & future work

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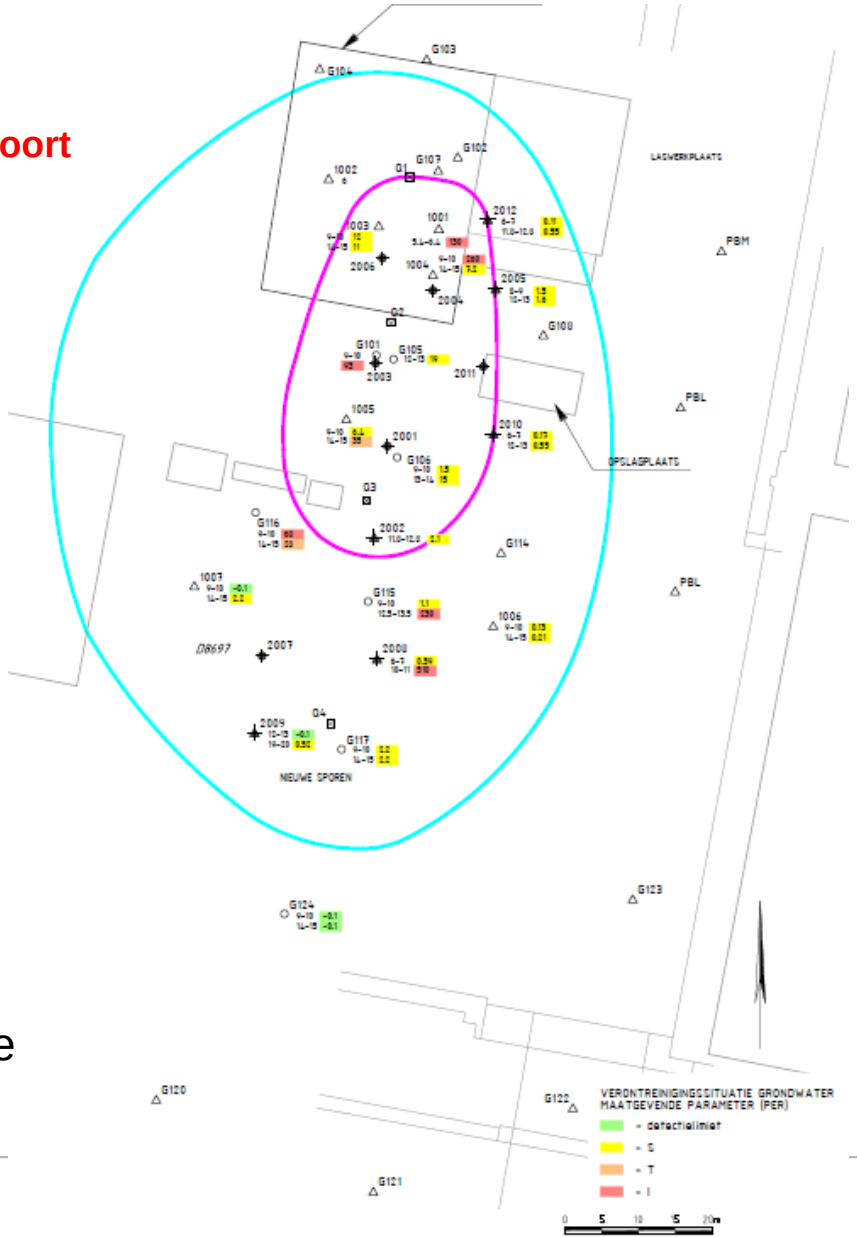
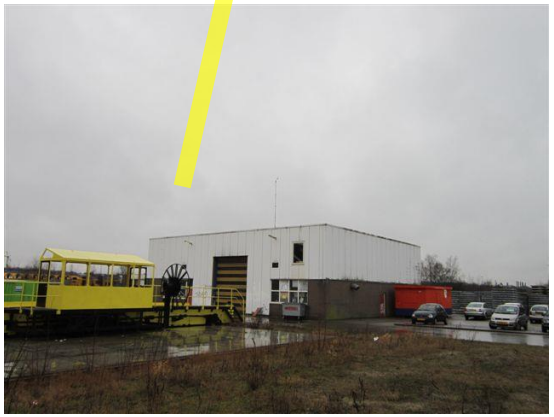
Site history



Contamination ground and groundwater with perchloroethylene (PCE)

Birdsview of railyard



Former welding workshop from Dutch rail

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Clean up effort(s)

Soil excavation in 2007

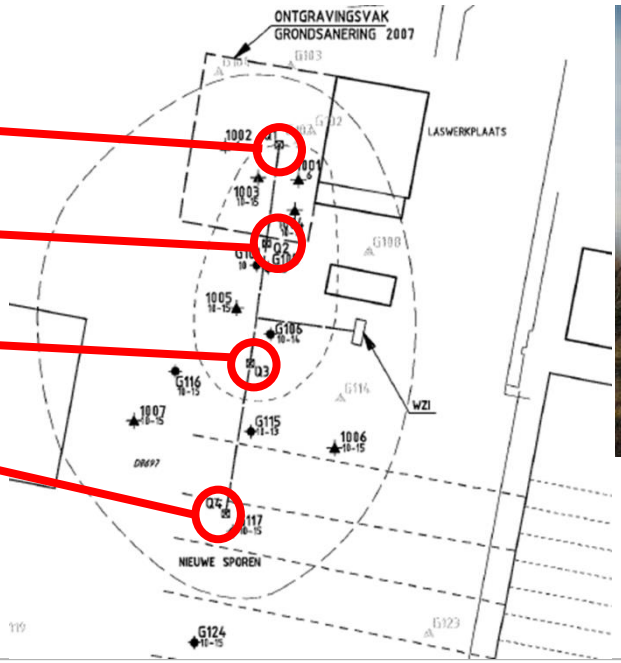
Pump & treat (PAT)
over period 2009-2011

Deepwells & pump volumes

Q1 8 -16 m –mv, 2 m3/hour
Q2 6 -16 m –mv, 2 m3/hour

Q3 6 -16 m –mv, 2 m3/hour

Q4 6 -16 m –mv, 8 m3/hour



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Excavation → PAT → constructed wetland

- After contaminated soil excavation, contaminated soil remained underneath the dugout pit
- After 6 months of pump and treat influent concentrations dropped below cost effective contaminant removal
- After 2 years of PAT decided to stop and design and construct a more extensive green remediation concept

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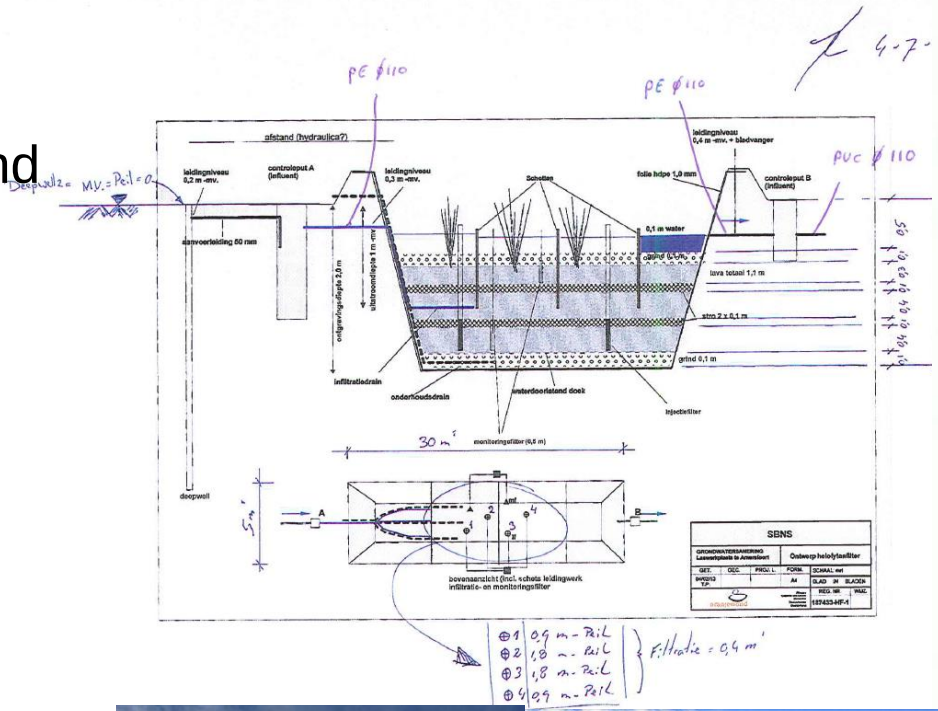
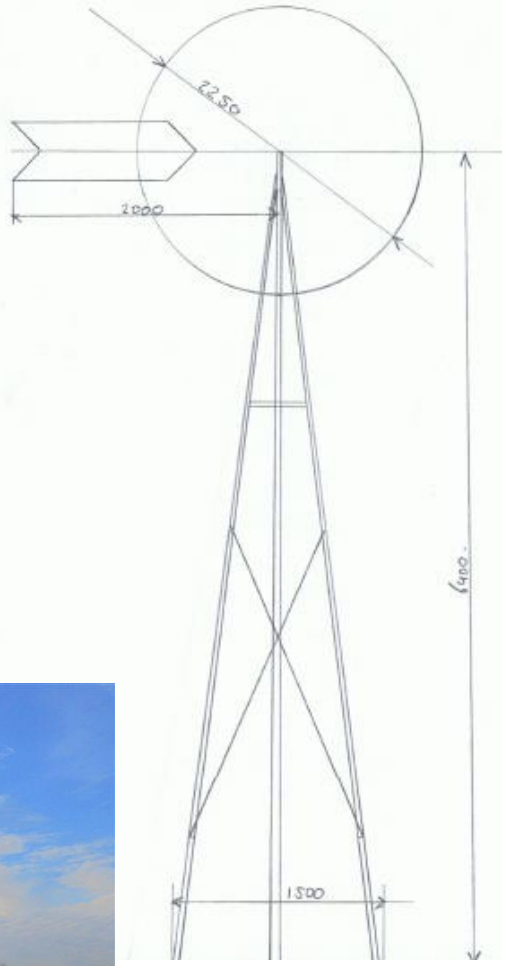
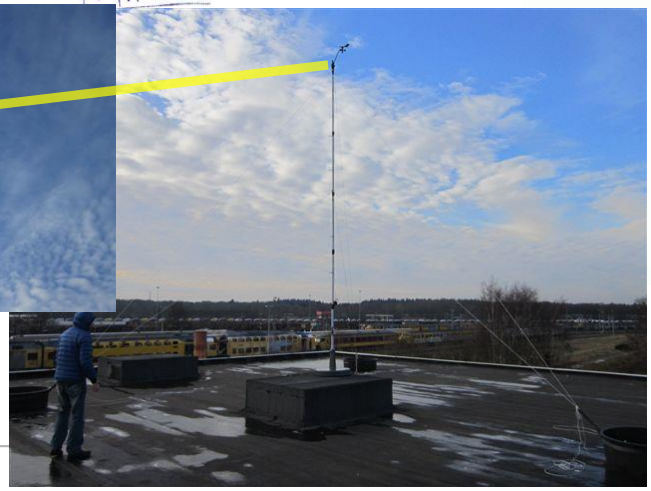
Design ecological engineered concept

Design wetland and windpump





Wind testing for local circumstances



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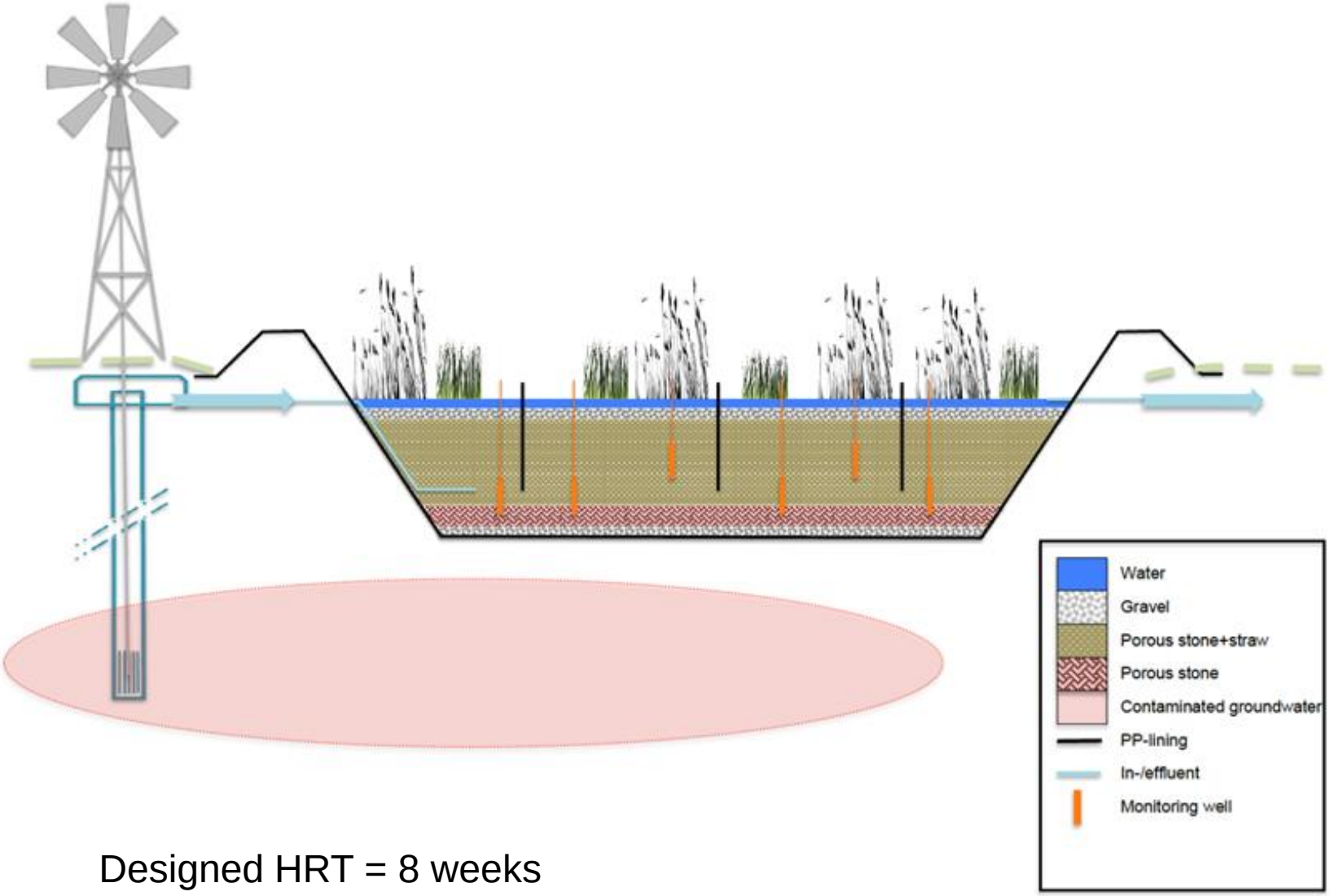
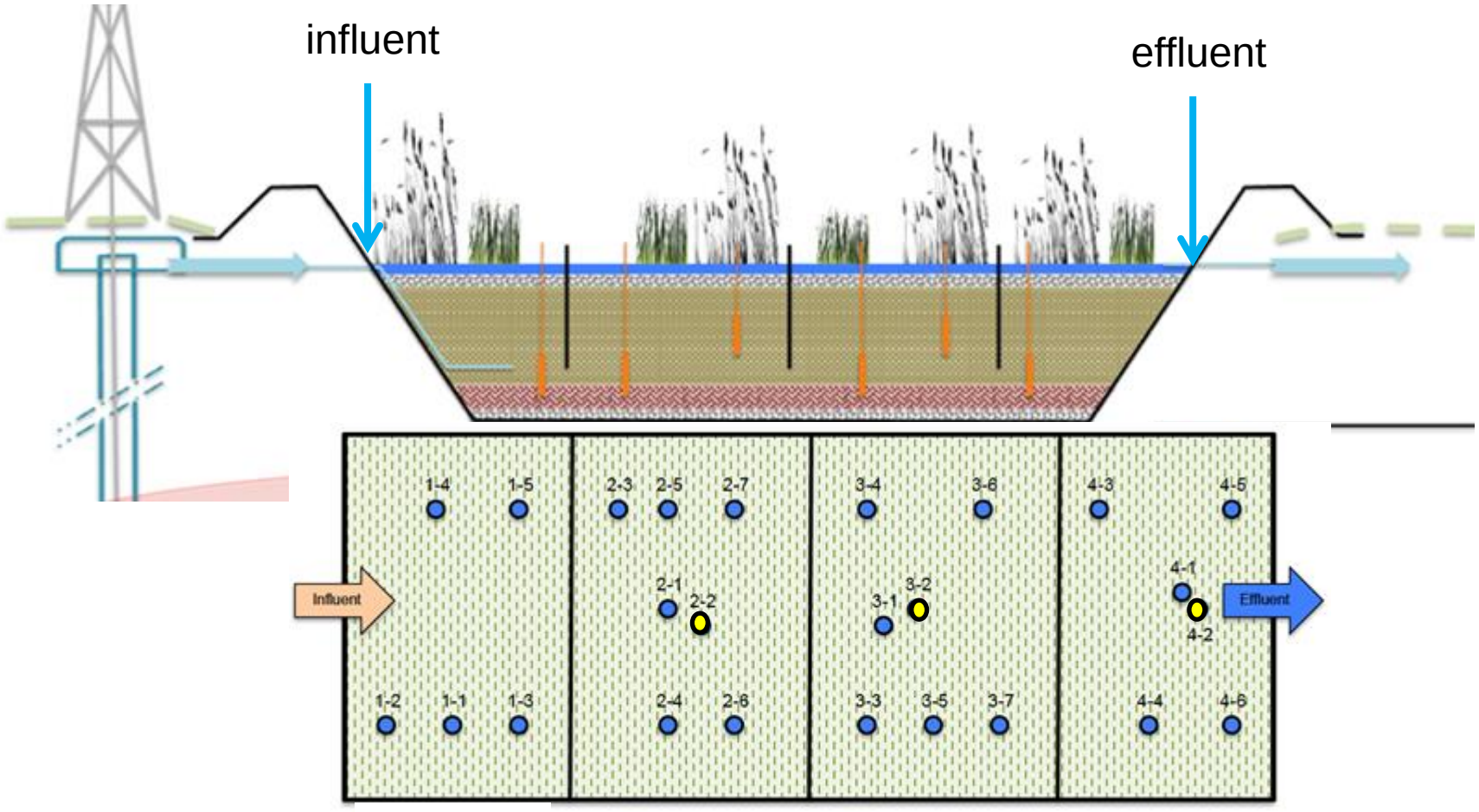
Final design



Designed HRT = 8 weeks

Sampling locations



- = monitoring well 1.2 – 1.35 m
- = monitoring well 1.7 - 2.1 m

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Construction wetland

Placing liner and maintenance drain


Building wetland with scoria & straw


Finished wetland with gravel on top


Helofytes planted 10 pcs/m^2

Field test

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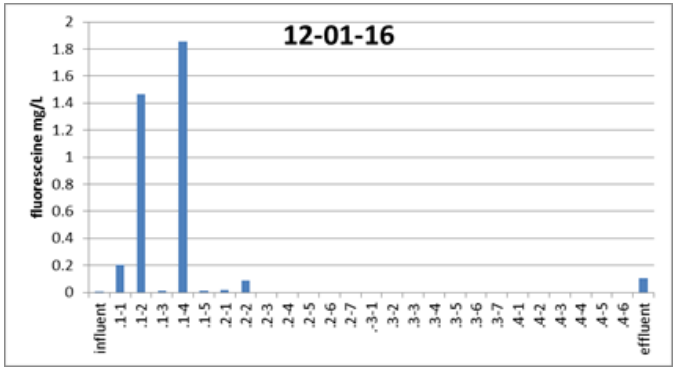
Flow conditions test

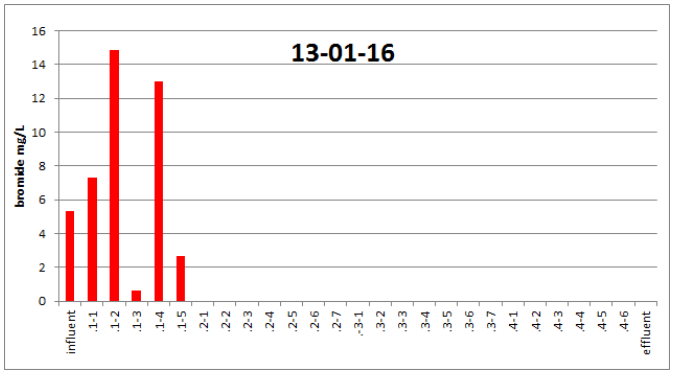
Tracer test at different positions

Fluorescein concentrations

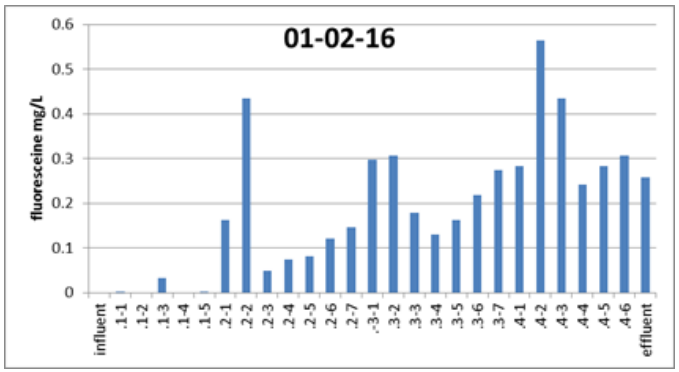
Bromide concentrations

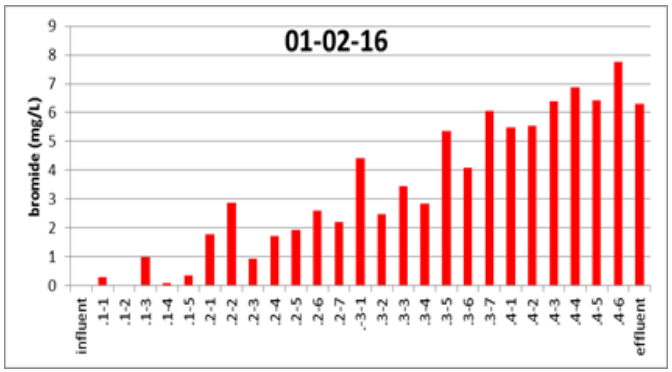
Start or one day after start





After 19 days





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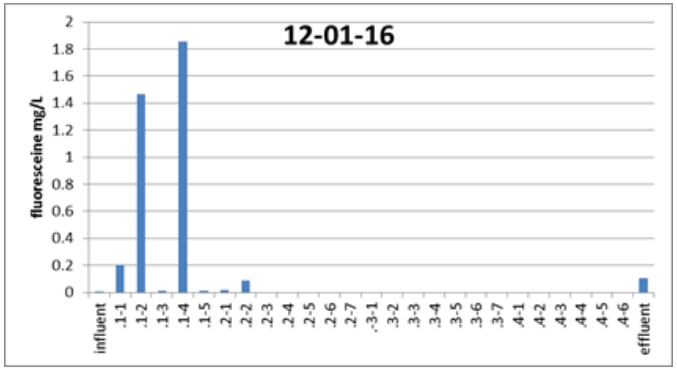

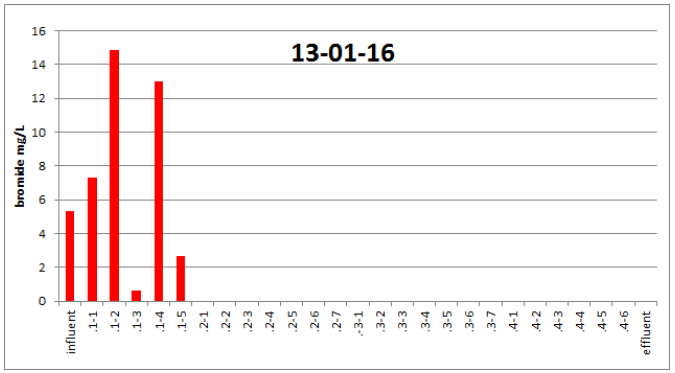

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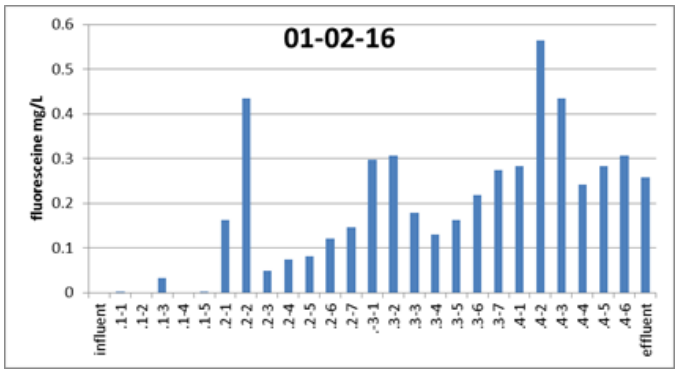

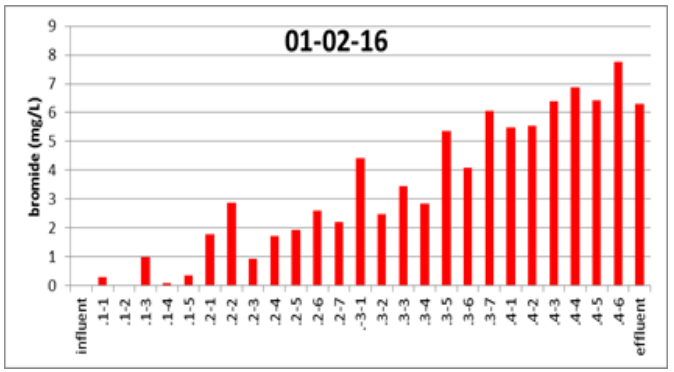

HRT based on flow rate = 4 weeks

Tracers break though in 14 days → preferential flow paths

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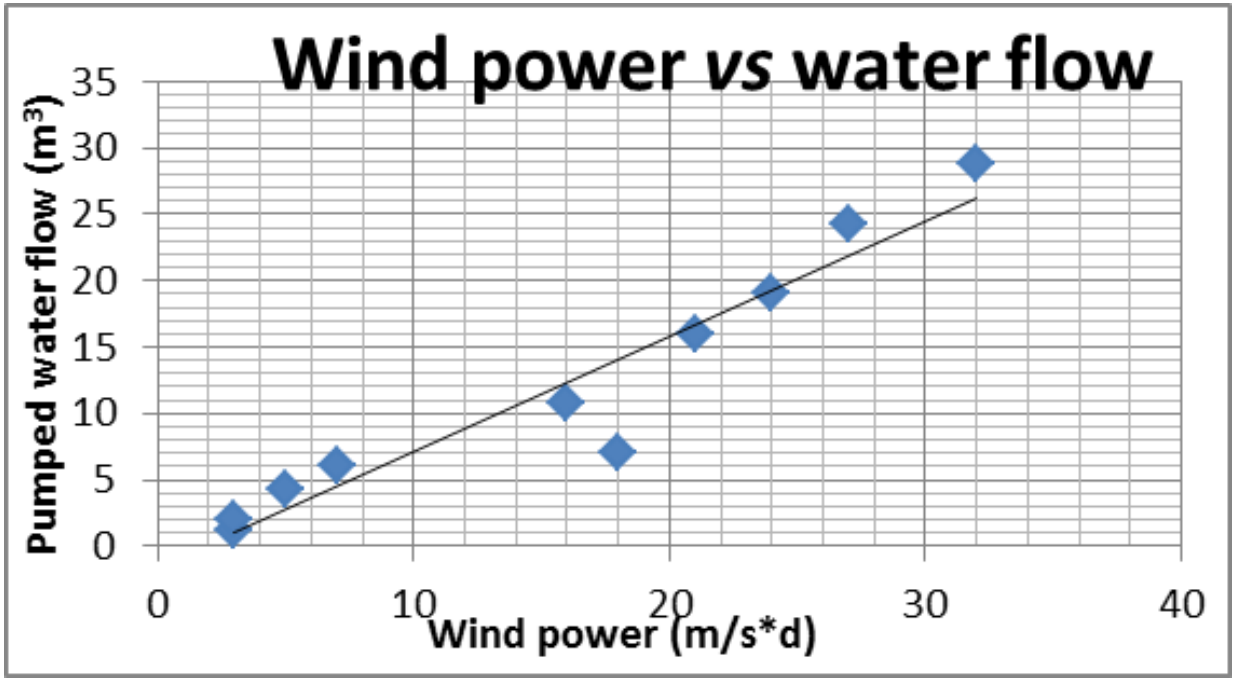
Wind in relation to water flow



- Influent ranged from 52 to 1198 L/hr. (1.2 - 28.7 m3/day)
- Influent Average = 125 L/hr. (over a period of 19 days)
- Flow and residence time are directly coupled to local wind speed over time → important to know local weather circumstances

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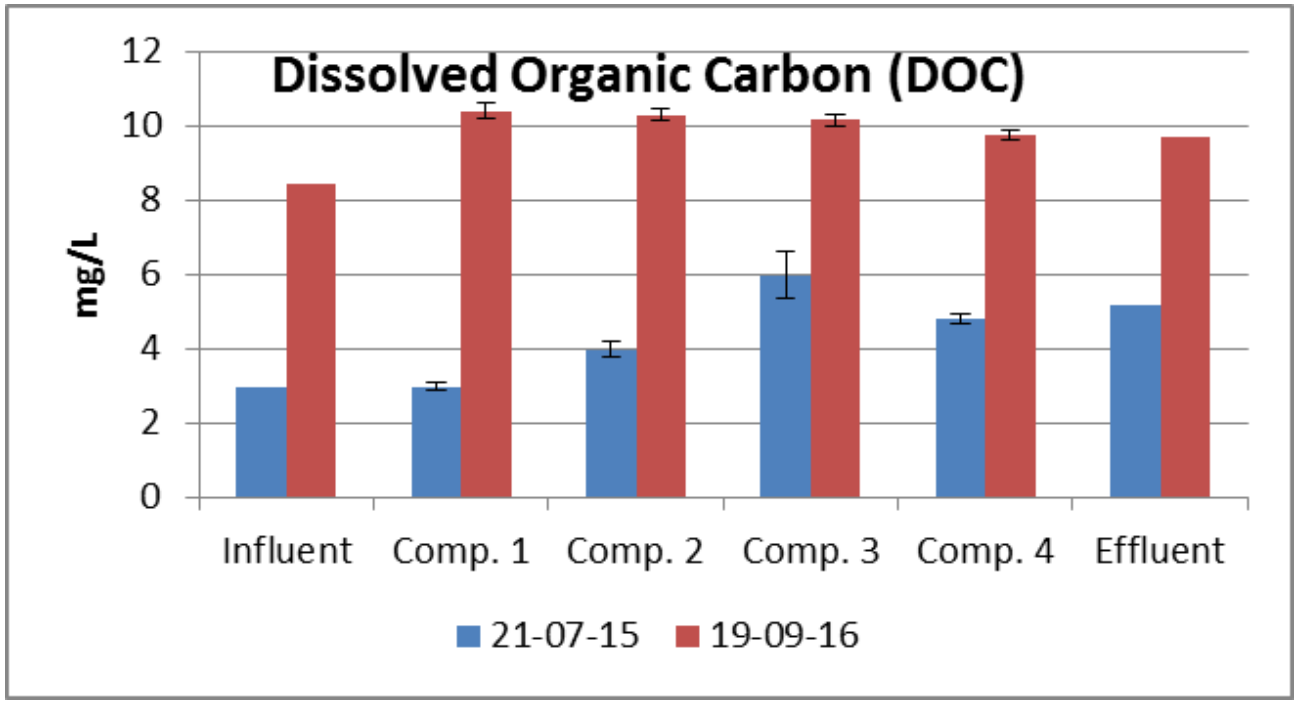
DOC

DOC at start and after 14 months



DOC is higher than at start or in influent reflecting DOC release from helophytes and slow release compound (straw)

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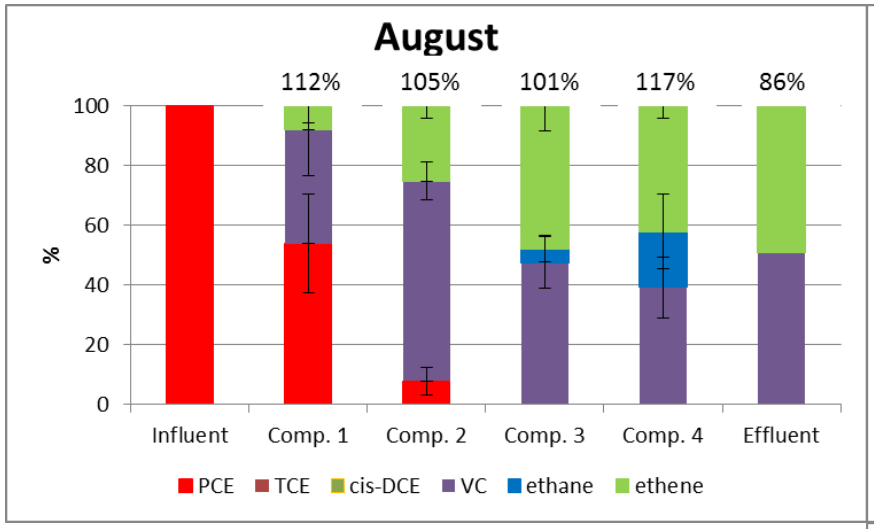
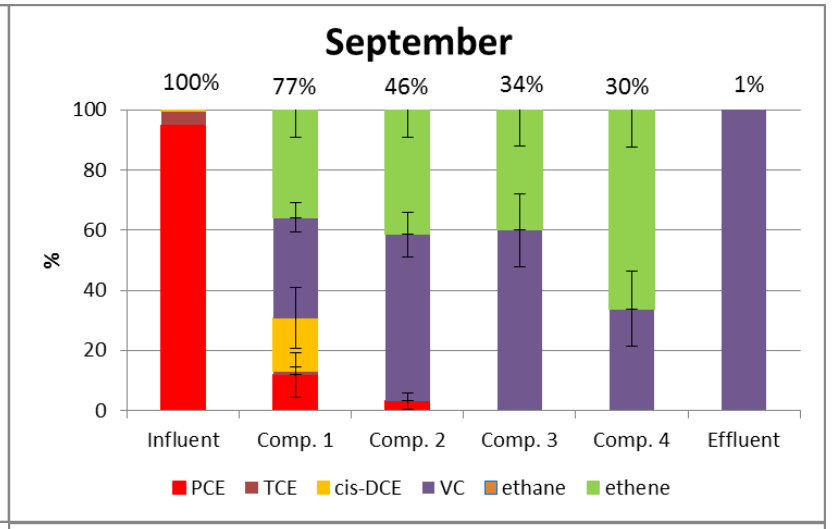
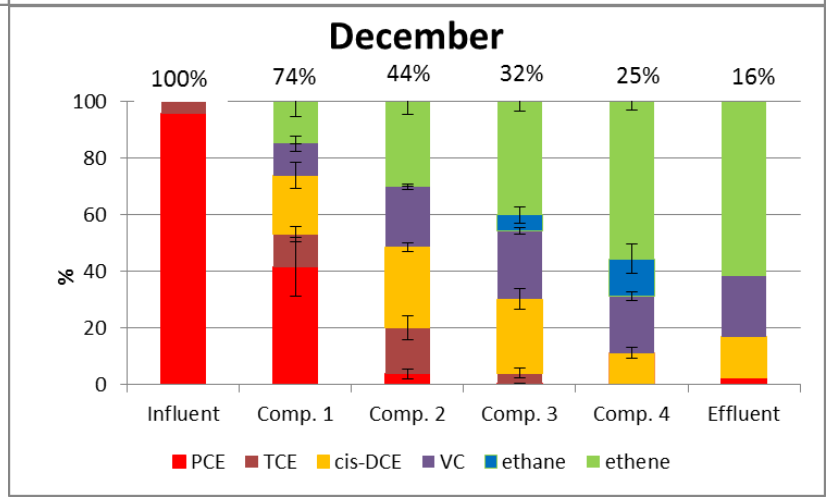
Relative degradation for PCE







- Relative amount of PCE and intermediates. Percentages are relative to sum of the PCE, TCE, cis-DCE, VC, ethene & ethane

(error bars represent 6-7 wells per compartment)

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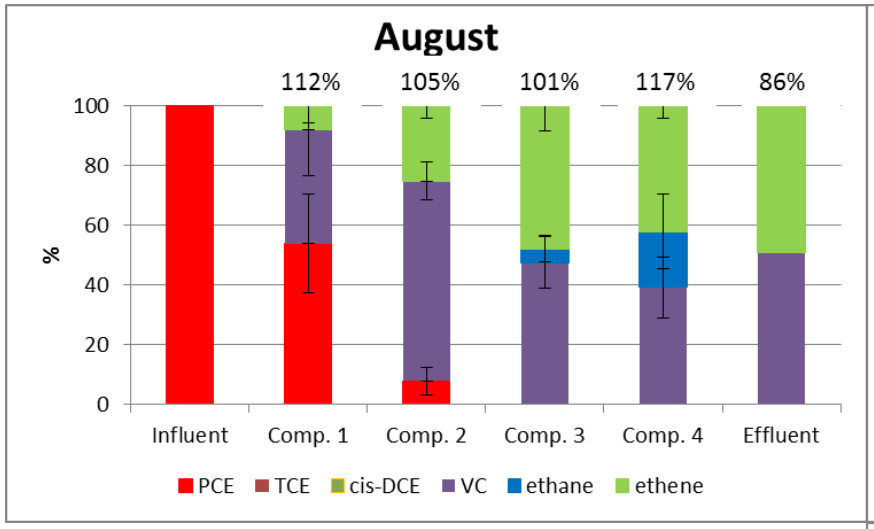
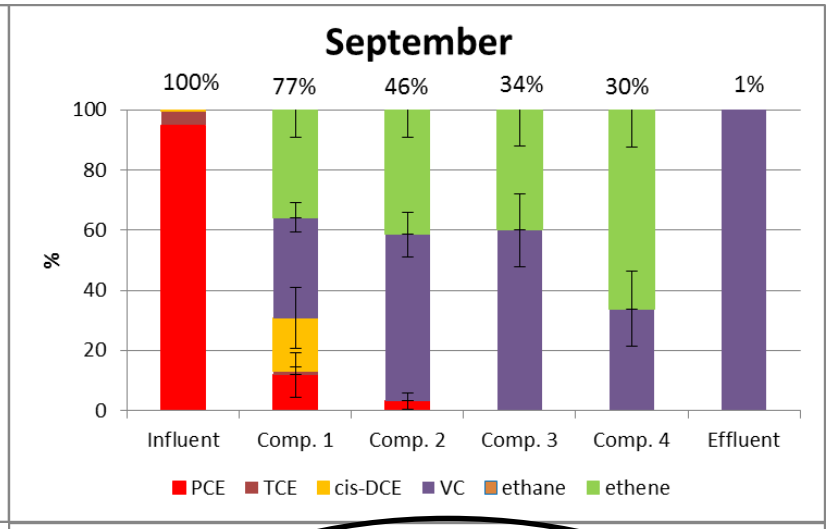
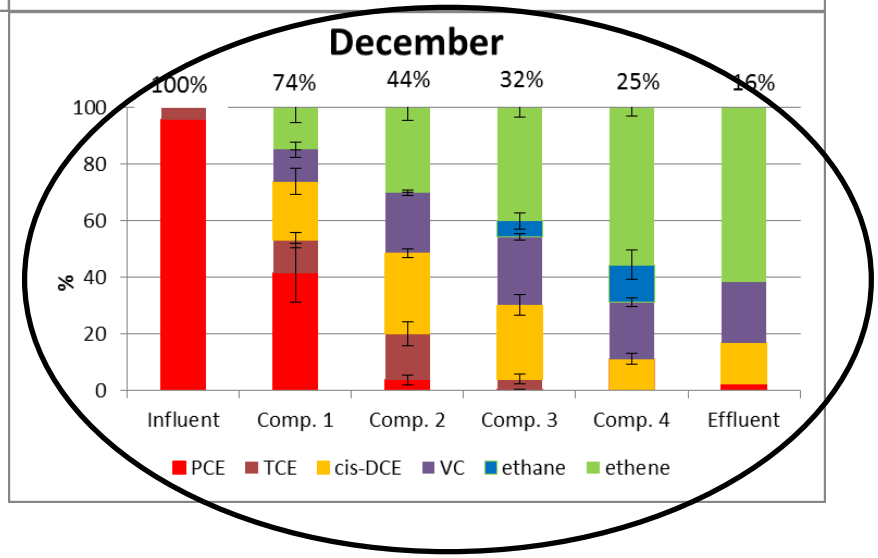
Relative degradation for PCE







More wind, more pumped water →
too low HRT for complete degradation.

Also lower temperatures →
lower degradation rates

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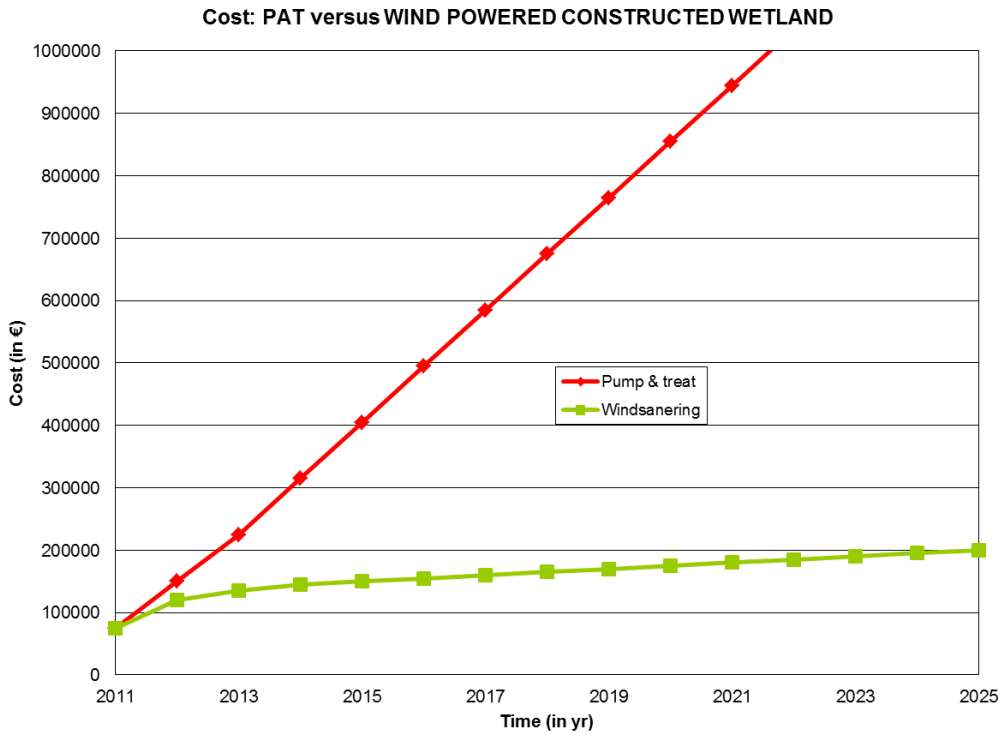
Costs

- Design of wind powered wetland: €15.000,-
- Construction of wetland €35.000,-
- Monitoring & research: €37.500,-
- Maintenance cost: €2.500,-
- Conventional monitoring: €10.000,-



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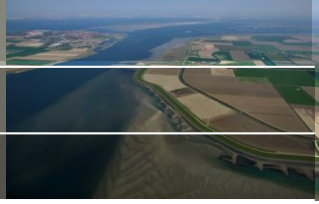
Conclusions

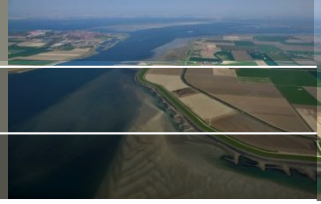


- Full PCE dechlorination in wind powered constructed wetland
- Ecological designed concept is self-sustaining
- Seasonal variation in wind and temperature effect the system, but remains sufficient
- Added straw as slow release compound provided sufficient dissolved organic carbon
- Tailoring the design to local weather and subsurface conditions is important *(micro organisms; DOC, nitrate/sulphate, wind, temperature, contaminant concentrations; etc)*

Recommendations & future work

- Optimizing flow paths within the wetland, to decrease its footprint
- Explore possibilities to evolve the concept for application with other contaminants
- Optimization of the dimensions of the system for local wind conditions
- Applying different possible carbon release compounds in addition to straw such as wood chips, saw dust or compost
- Re-inject effluent water within the contaminated zone to stimulate in-situ degradation

Partners



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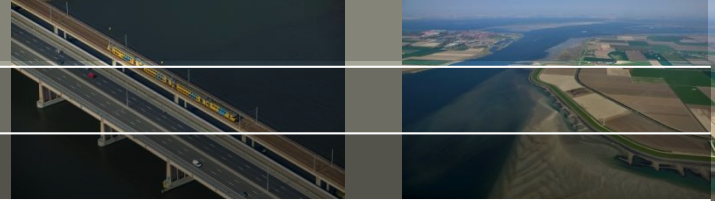
antea group

Aveco de Bondt
ingenieursbedrijf

WINDKRACHT
ONDERHOUD & REPARATIE



Thanks for your attention
Questions?