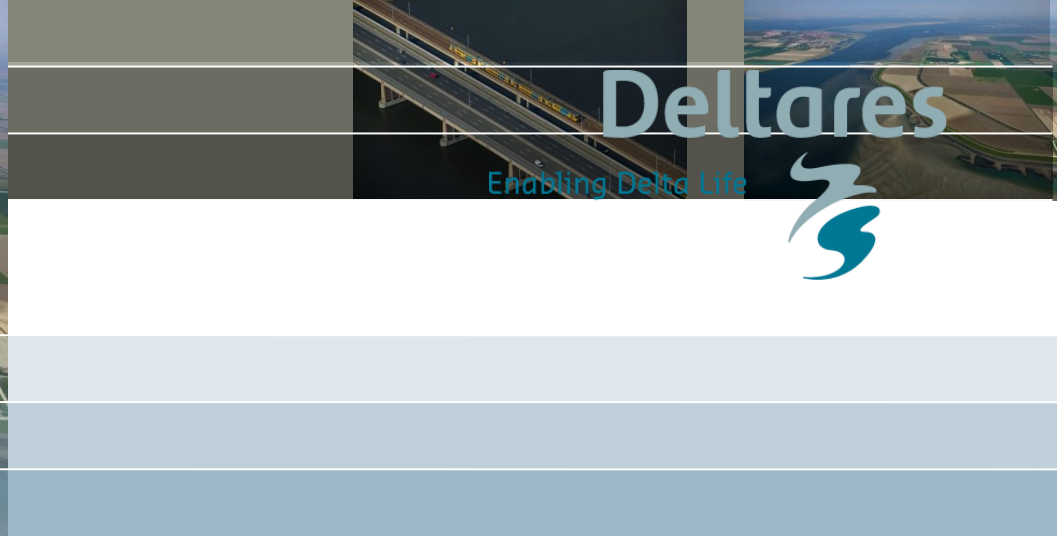
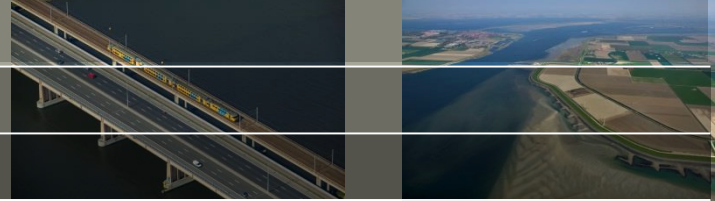




Constructed wetlands for soil remediation and groundwater management

GQ, Liege, September 2019

Nanne Hoekstra (Deltares), Paul Verhaagen (HMVT)



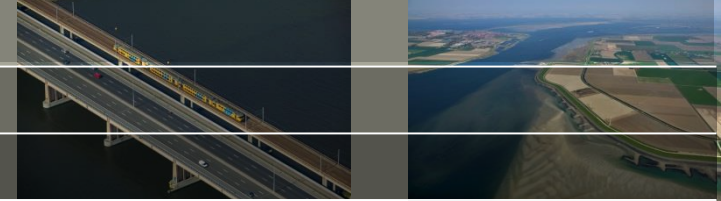
1. Constructed wetlands

- What is a constructed wetland?
- Building blocks: transport, treatment, biodegradation, energy.

2. Cases

- Amersfoort ; railway station
- Doorn ; large contamination plume from a drycleaner
- Zwolle ; interception of multiple plumes from downtown to protect the public drinking water source

Constructed wetlands



A constructed wetland (CW) is an artificial swamp in which polluted (ground-)water is purified

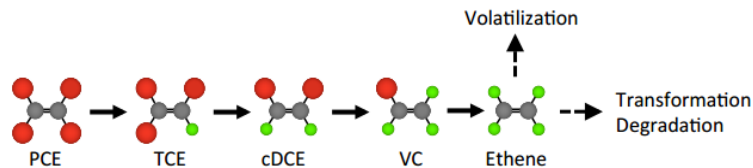
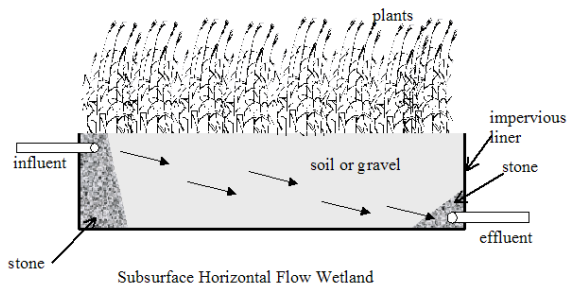
Advantages:

- optimal use of biological processes
- fully integrated in the landscape
- low operational costs
- energy-neutral

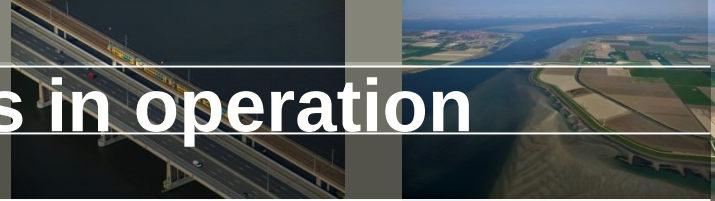


Building blocks for a constructed wetland

- **Transport** of contaminated water
- **Design** tailored to the specific contaminants
- **Biodegradation** of contaminants
- **Energy** supply (preferably green)

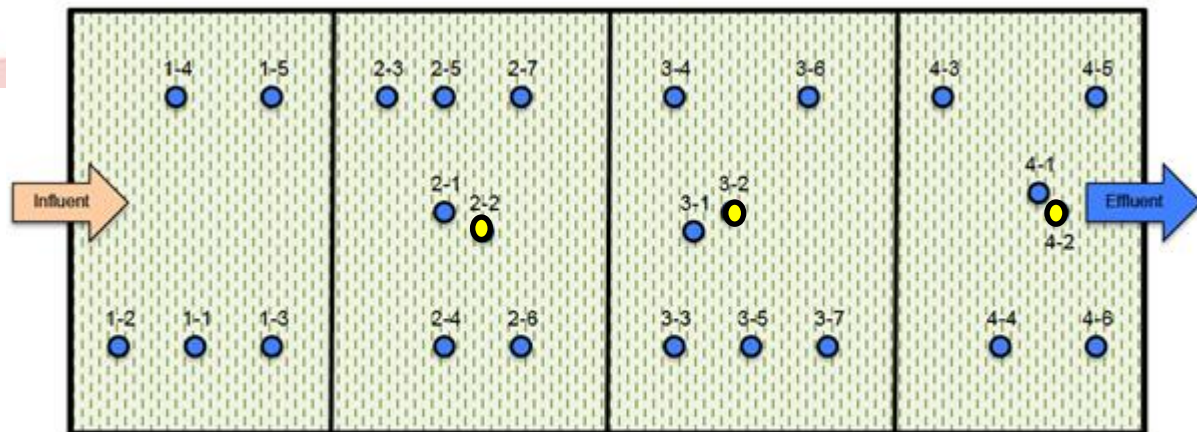
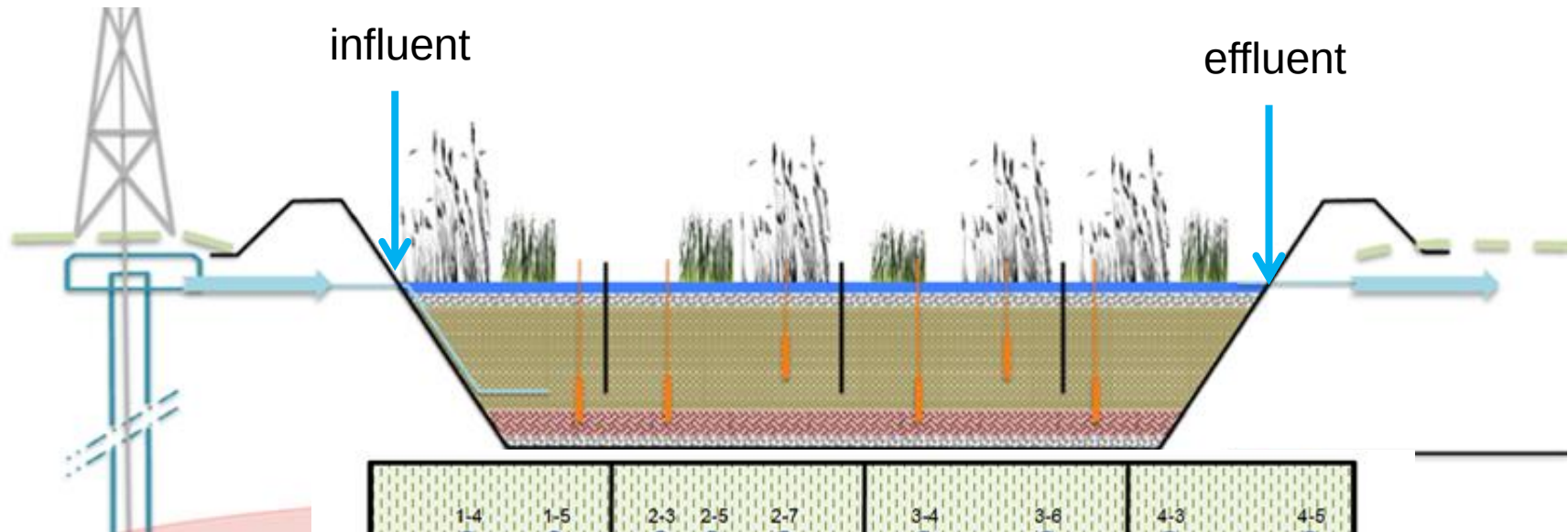
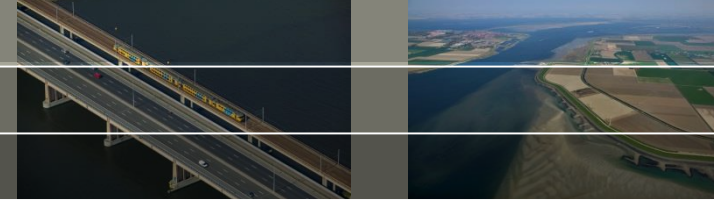


3 cases: constructed wetlands in operation



1. Amersfoort: railway station
2. Doorn: large contamination plume from a drycleaner
3. Zwolle: interception of multiple plumes to protect public drinking water source

Sampling locations



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

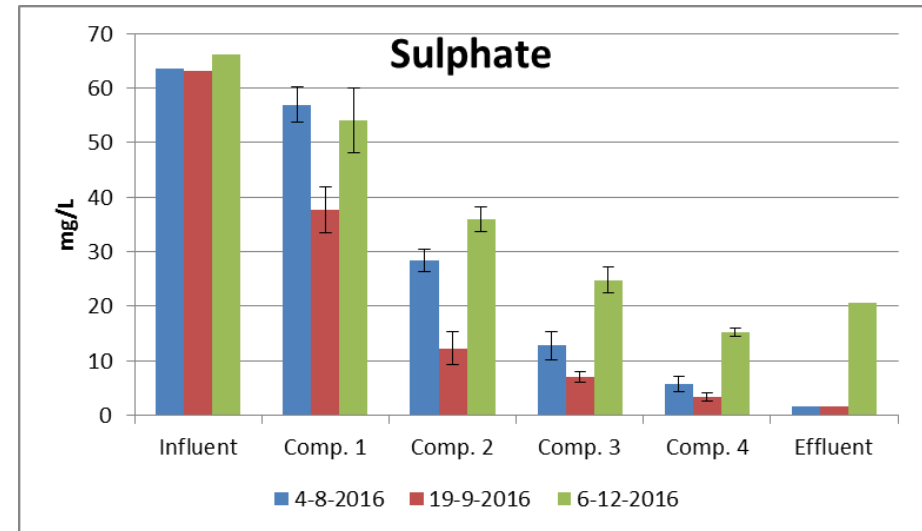
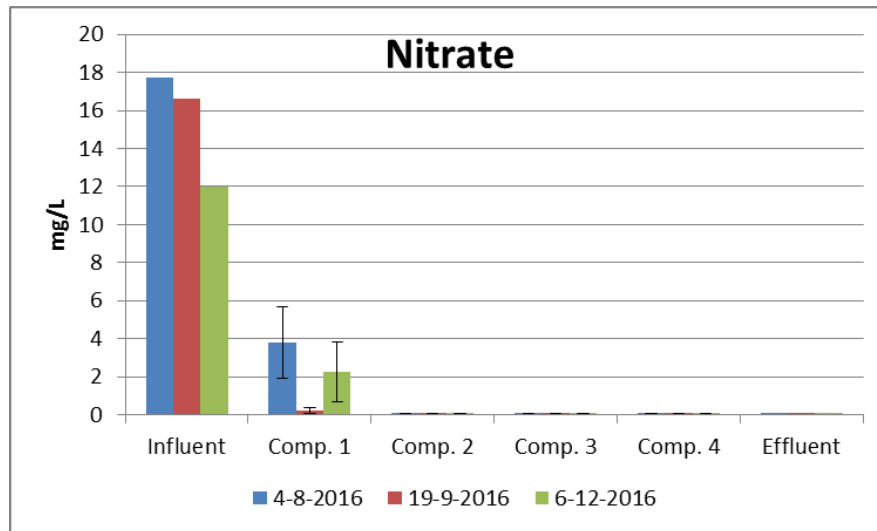
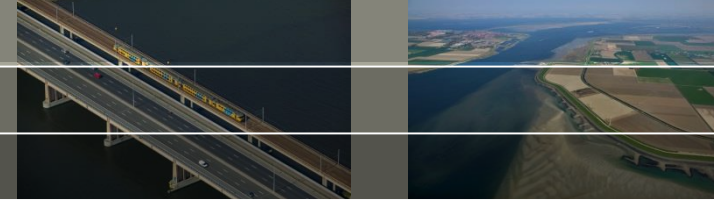
Construction wetland



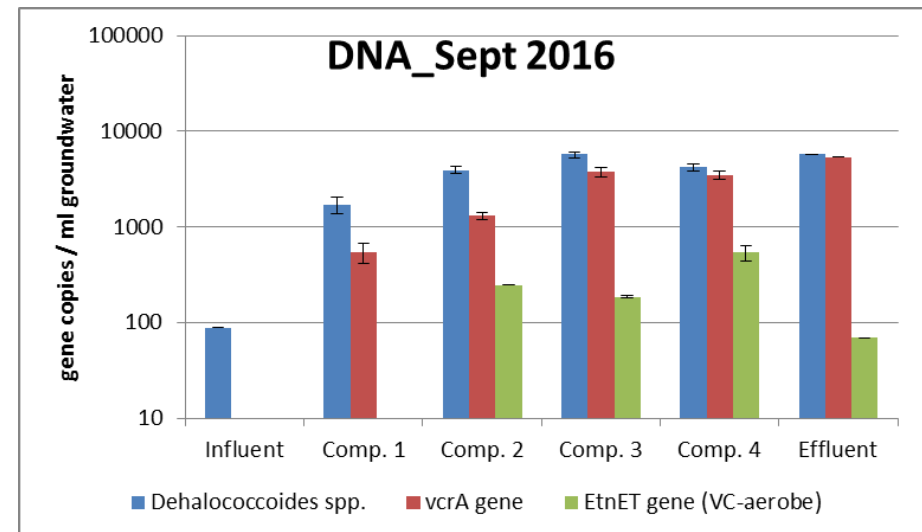
Field test



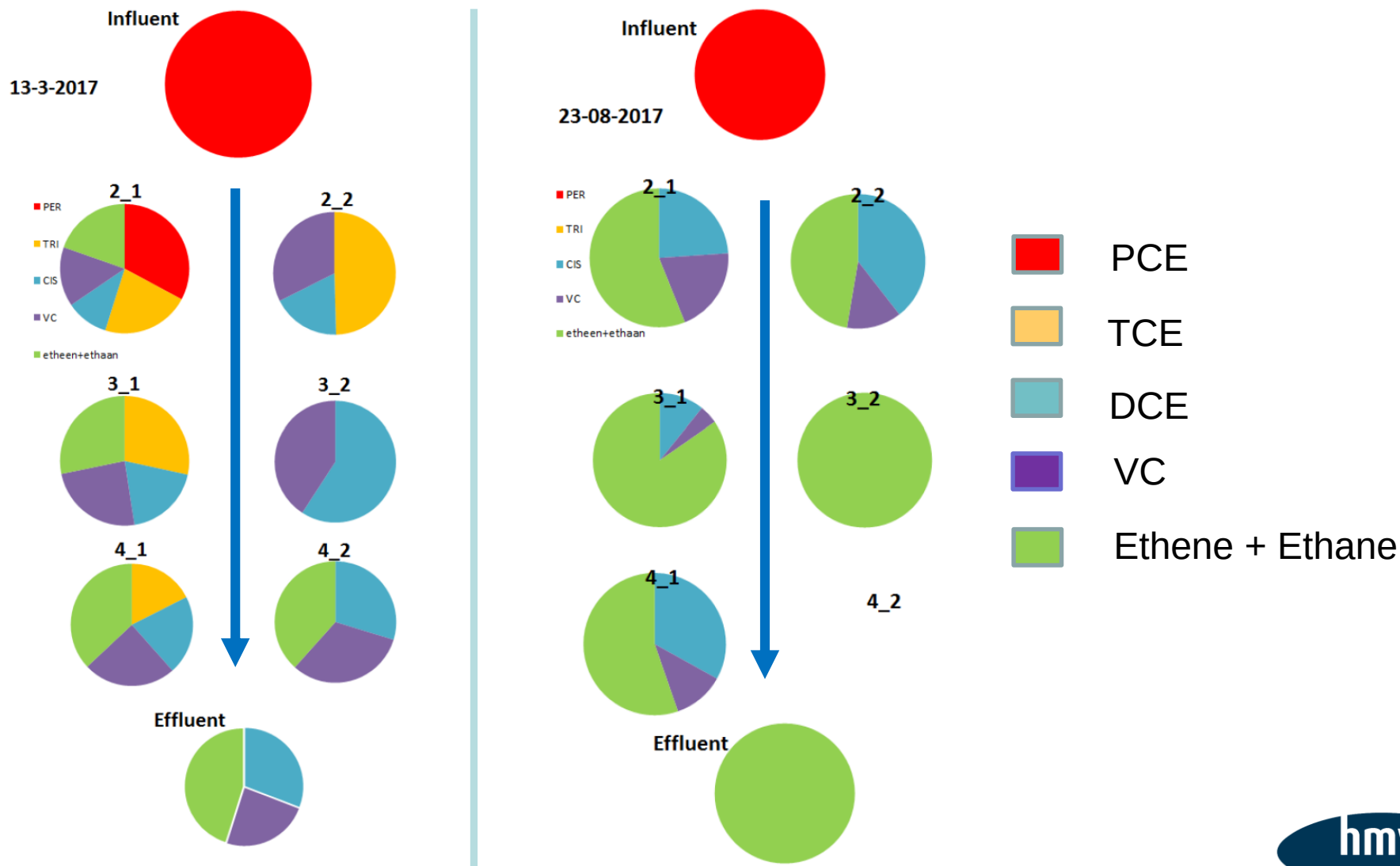
Biochemical conditions



- Over the flow path:
 - Redox conditions optimize
 - Both organisms capable of reductive dechlorination and VC-oxidation develop
- Conditions in winter less suitable



Relative degradation for PCE, in winter and summer



Conclusions Amersfoort Railway site

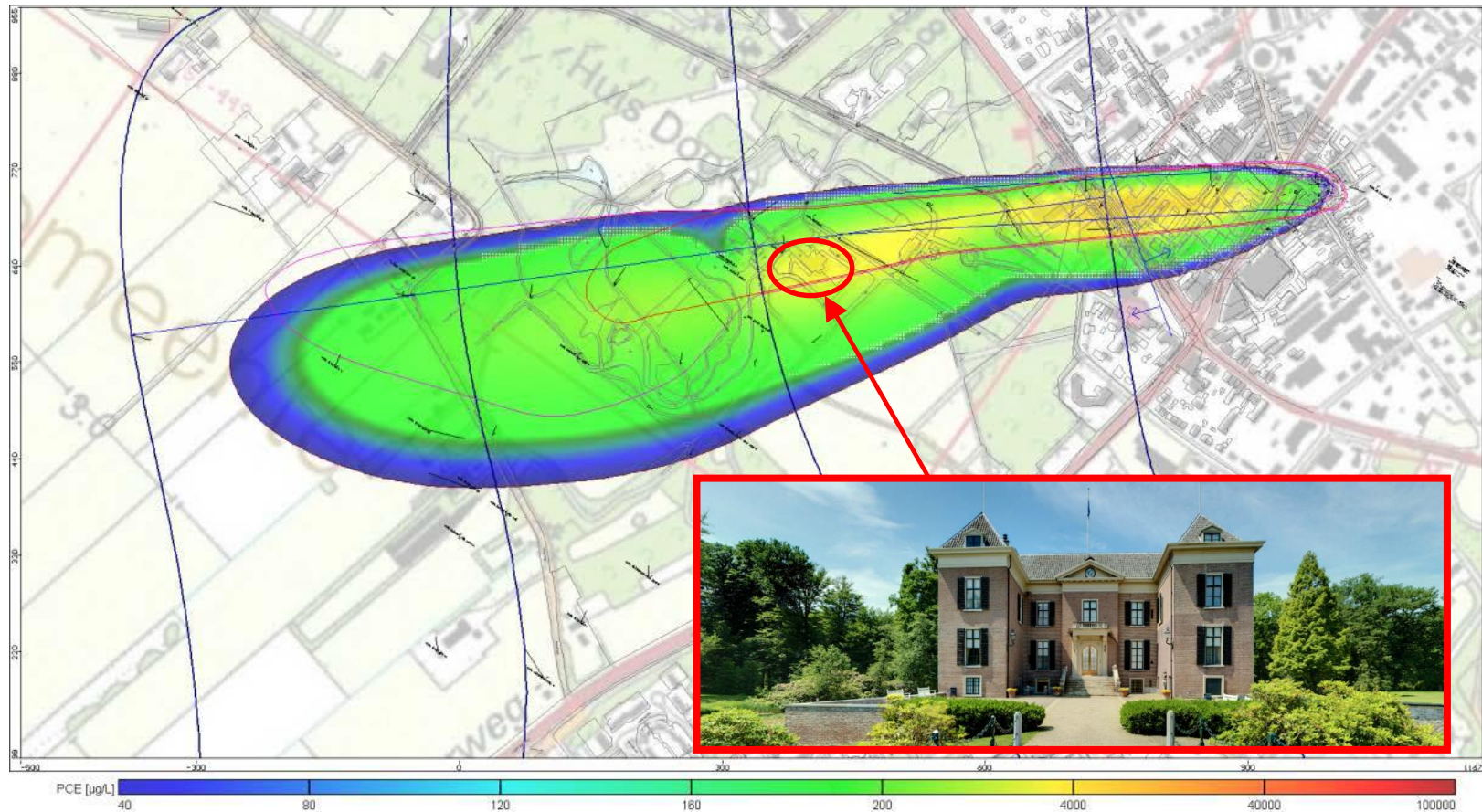
- Full PCE dechlorination in wind powered constructed wetland achieved
- Constructed wetland is self-sustaining
- Tailoring the design to local weather and subsurface conditions is important (*micro organisms; DOC, nitrate/sulphate, wind, temperature, contaminant concentrations, etc.*)
- Seasonal variation in wind and temperature affect the system, but treatment efficiency remains sufficient
- Constructed wetlands are economically attractive: lower investment costs, significant lower operational costs.

House Doorn : interception plume (Case 2)



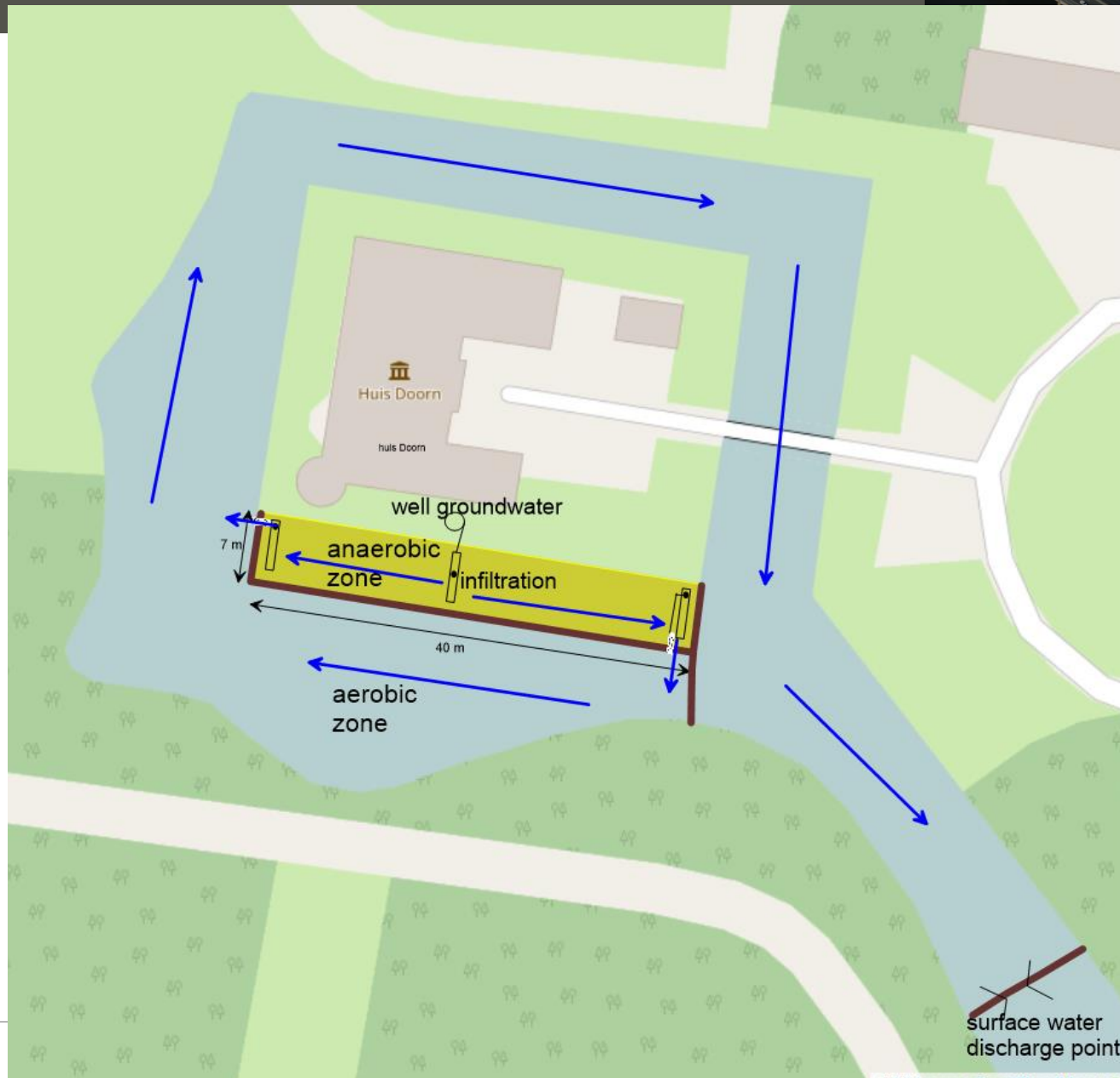
National Monument -Refuge where the German emperor Wilhelm II spent his last years after the First World War (1918-1941)

Plume originating from dry-cleaner is intercepted by feeding well for castle moat



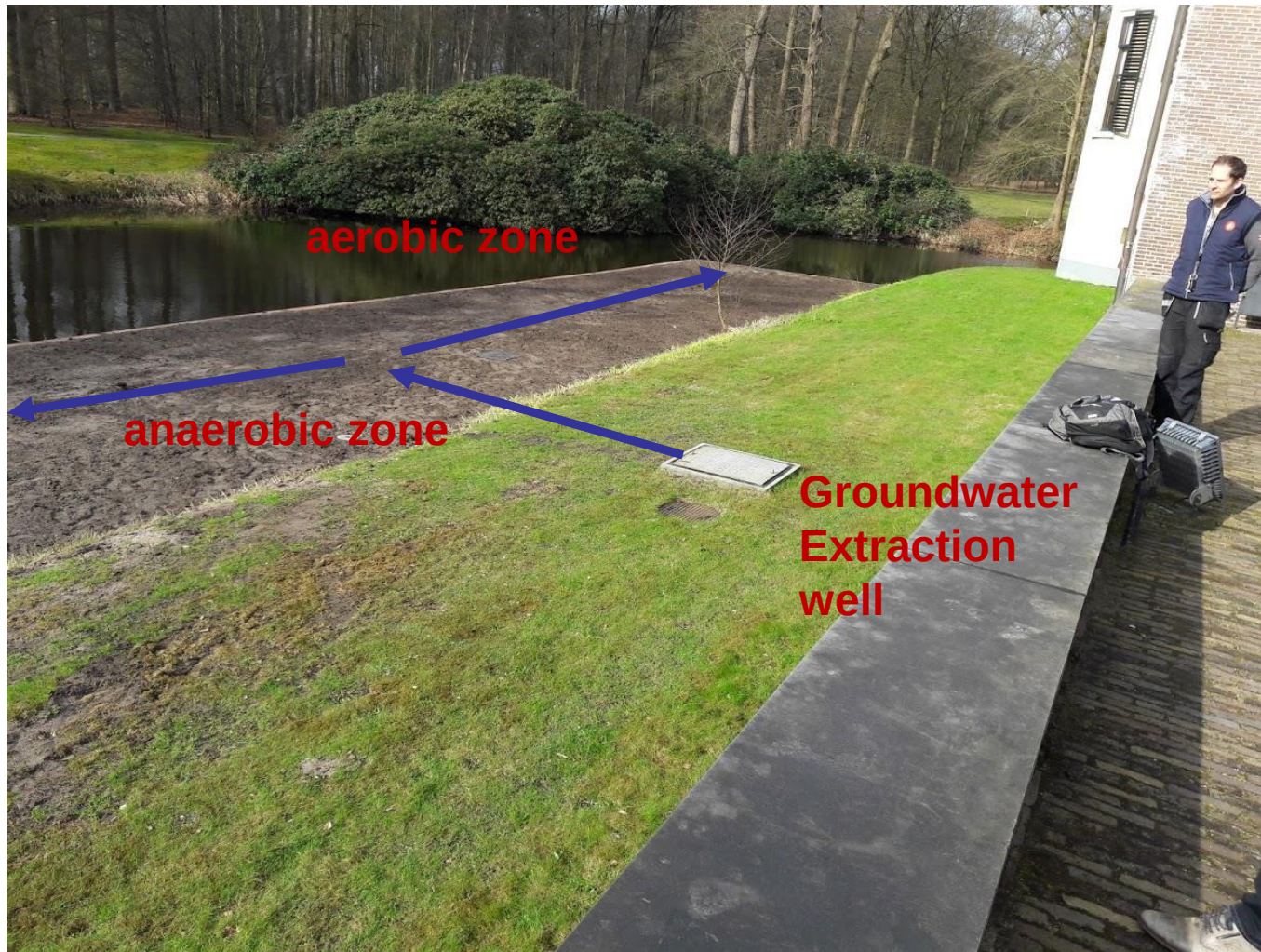
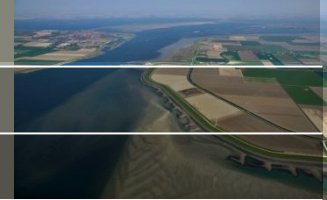
Groundwater contaminated with 2500 µg/l PCE

With purification plume remediation

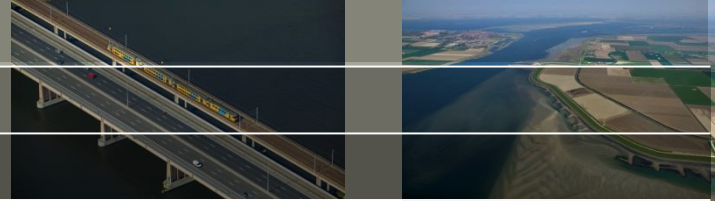


Topview

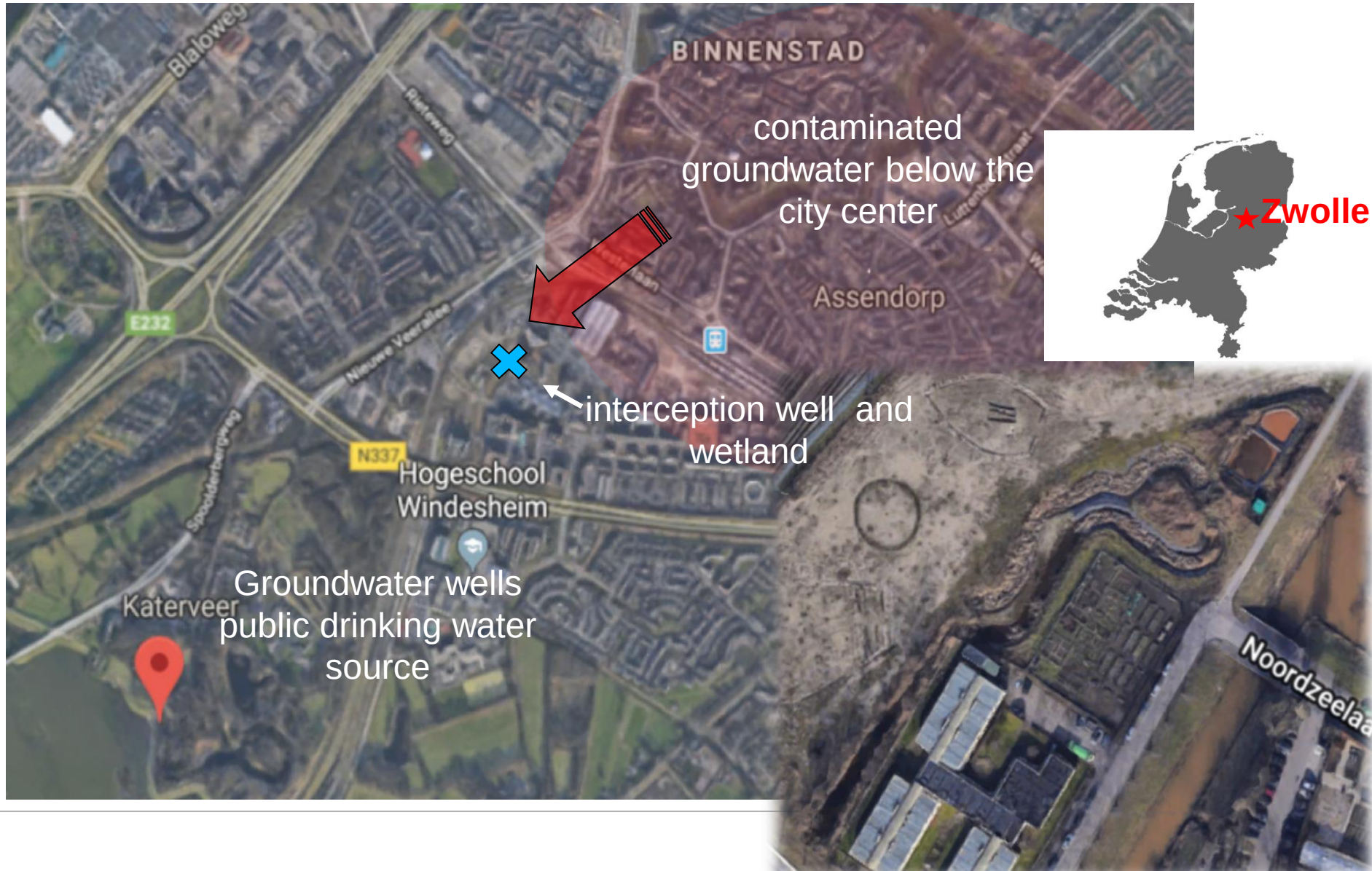
Construction works finished



current situation



Areal groundwater management Zwolle (case 3)



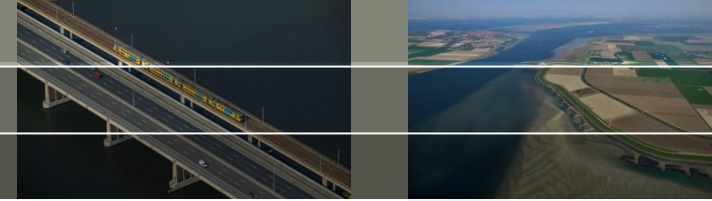


- ## Watertreatment

- ## energy saving and water saving

- extracted groundwater is used for cooling and heating a shelter for homeless people

Photo impressions



construction



apply sand



applying plants



renewable energy



purified water infiltration



impression



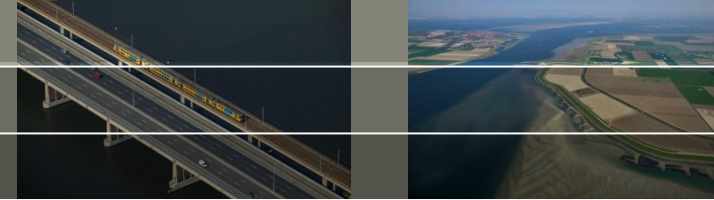
Conclusions / Lessons Learned

- Constructed wetlands are a robust solution to treat moderate concentrations of pollutants.
- Very low operational costs. Focus points:
 - when changing from anaerobic to aerobic: risk of iron precipitation
 - excessive plant growth: mow periodically
 - regular site maintenance: tree pruning, etc.
- Constructed wetlands provide a combination of functions. In addition to groundwater restoration:
 - local supply of heat / cold for buildings
 - public parks, more attractive urban environment
 - bringing natural cooling into an urban environment
- By combining functions you can have multiple sources of financing

Opportunities for CW in urban areas



Partners



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