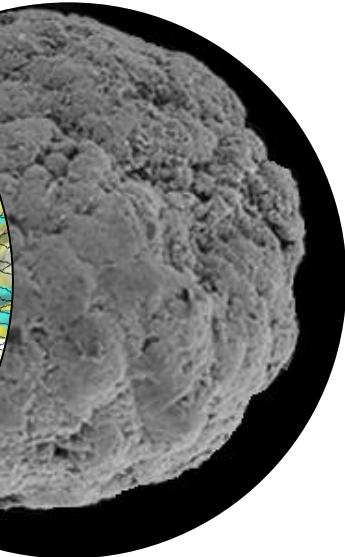
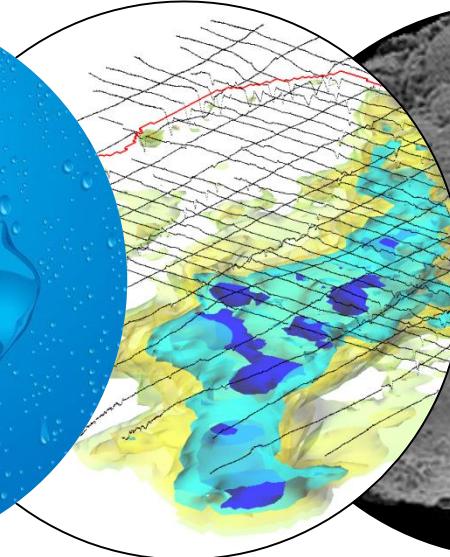
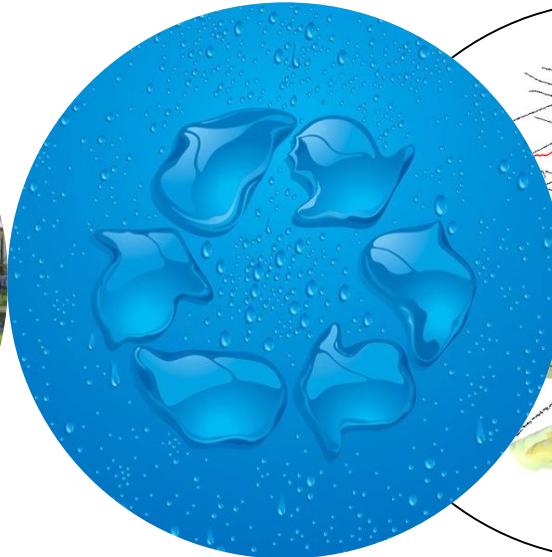


Climate Change and Engineering Coastal Water Resources

FRESH4Cs symposium Bruges, Belgium; September 2019

Huub Rijnarts



Prognosis Coastal Flooding: National Geographic



Salt water intrusion: climate change driven sea level rise: underground seepage, flooding

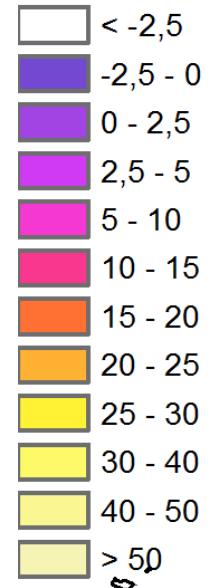
Coastal saltwater intrusion in groundwater in Europe

Deltares, NL

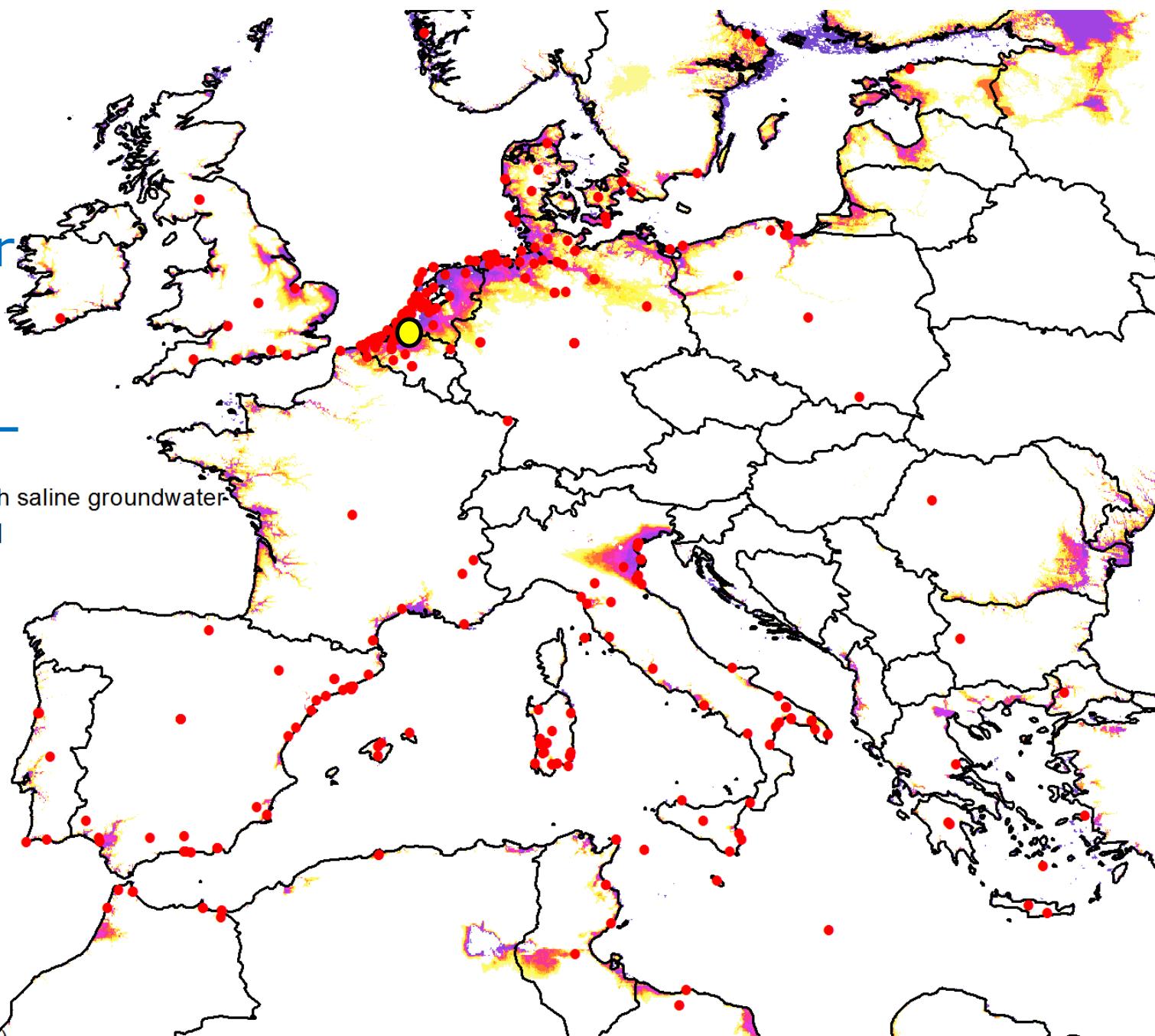
Legend

- Registered issues with saline groundwater

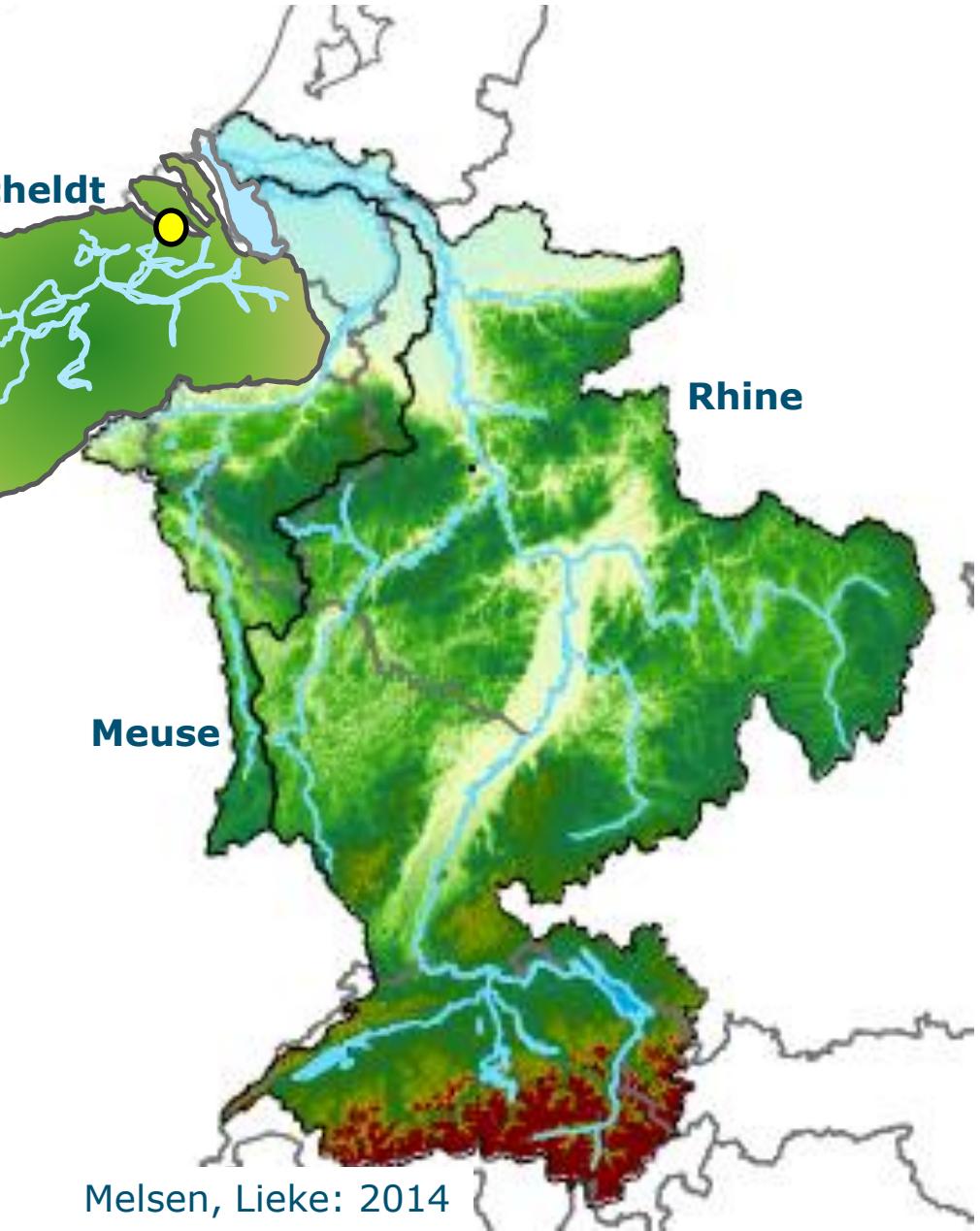
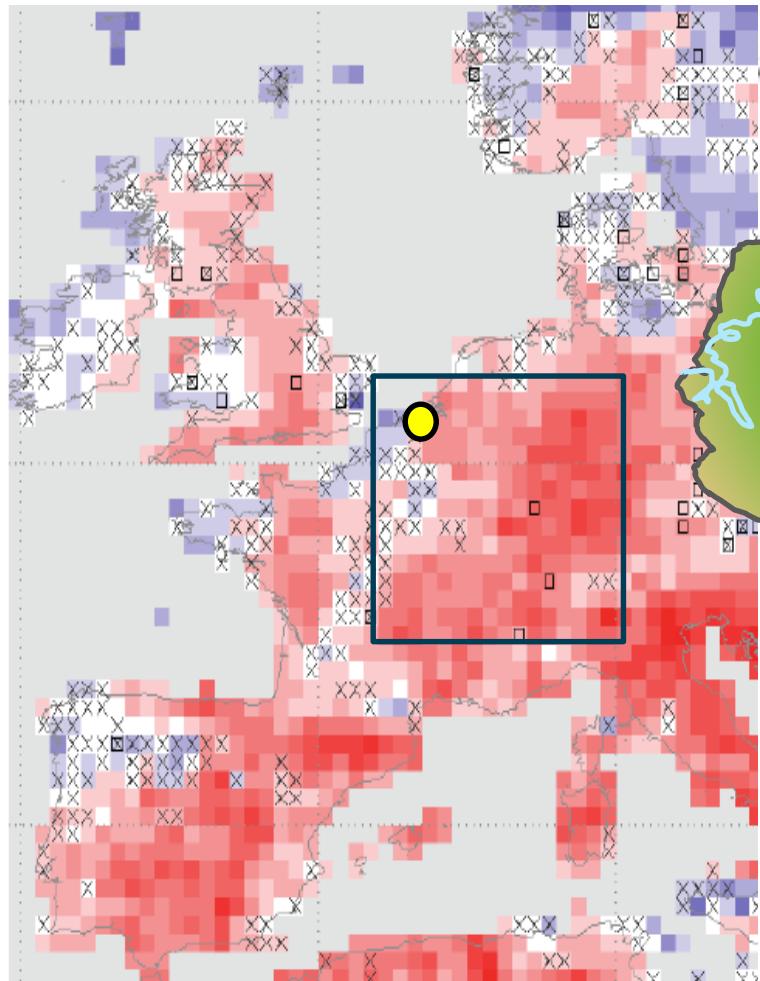
Digital Elevation Model [m MSL]



Source: Deltares (Oude Essink)



Droughts: regionally & in river basin hinterlands



Dr. Stahl et al.; van Lanen, H.A: 2012

Dow Bernelux Terneuzen, The Netherlands



Our future agro/industrial and economic development
in Delta's depends on adequate water provision

What do we NEED?

- Long-term sustainable water supply
- Through Integrated water management: connecting local, regional, continental scale
 - Good knowledge on water demand and supply
 - Good technologies
 - Good concepts

Integral Solution
for water
scarcity problems



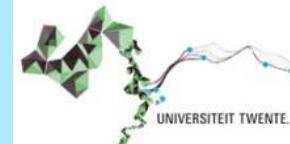
Saline when possible
Fresh when needed



Ministerie van Infrastructuur
en Waterstaat



Toegepaste en
Technische Wetenschappen

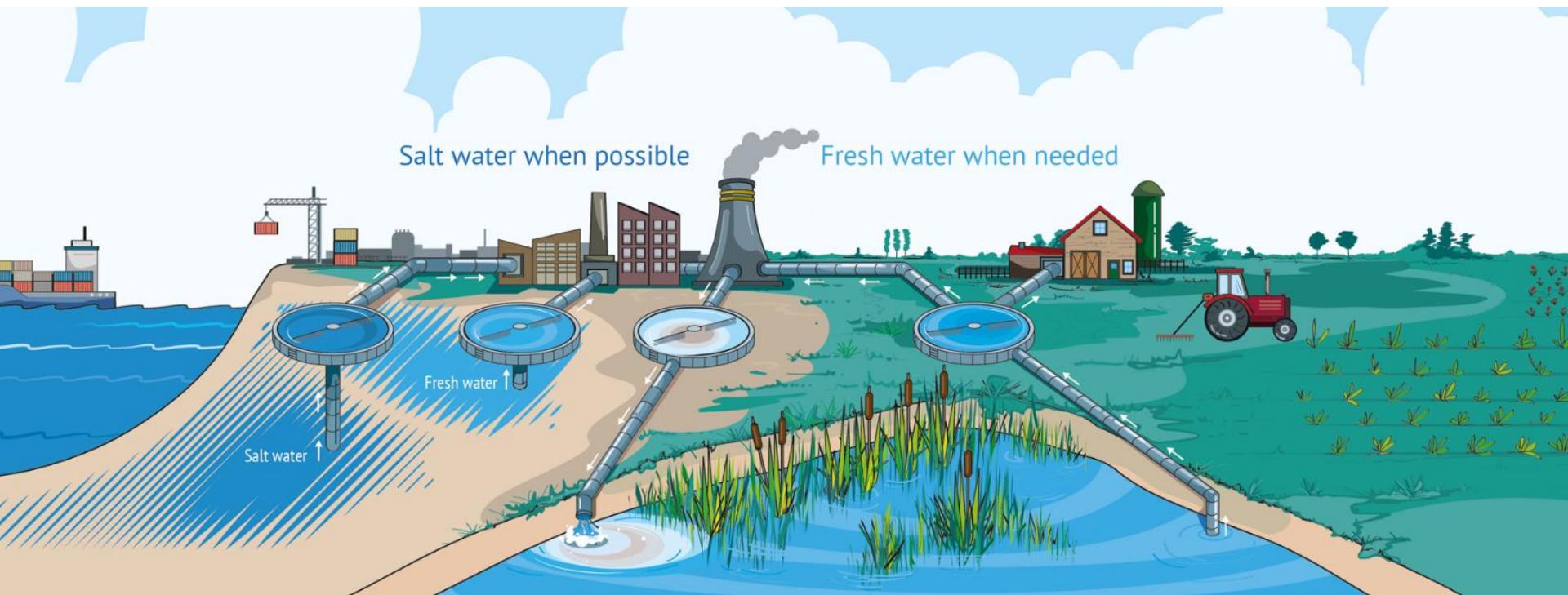


Water Nexus Consortium

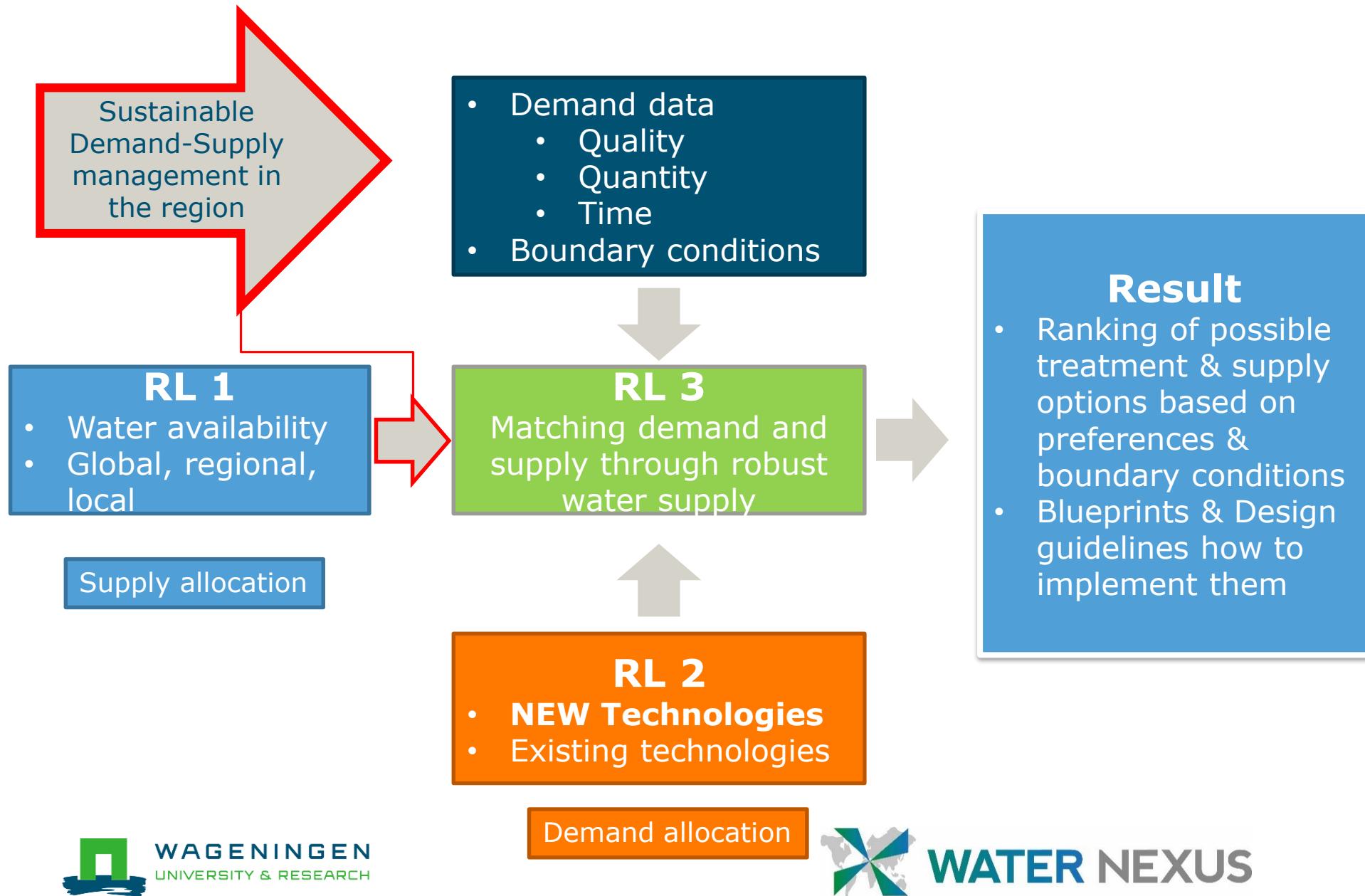
End goals

- Make (agro) industrialised regions water self sufficient using green infrastructure
- Saline when possible, Fresh when needed
- Used & salt (including brackish) water as an indispensable resource
- Regional Integration; Industrial demonstration

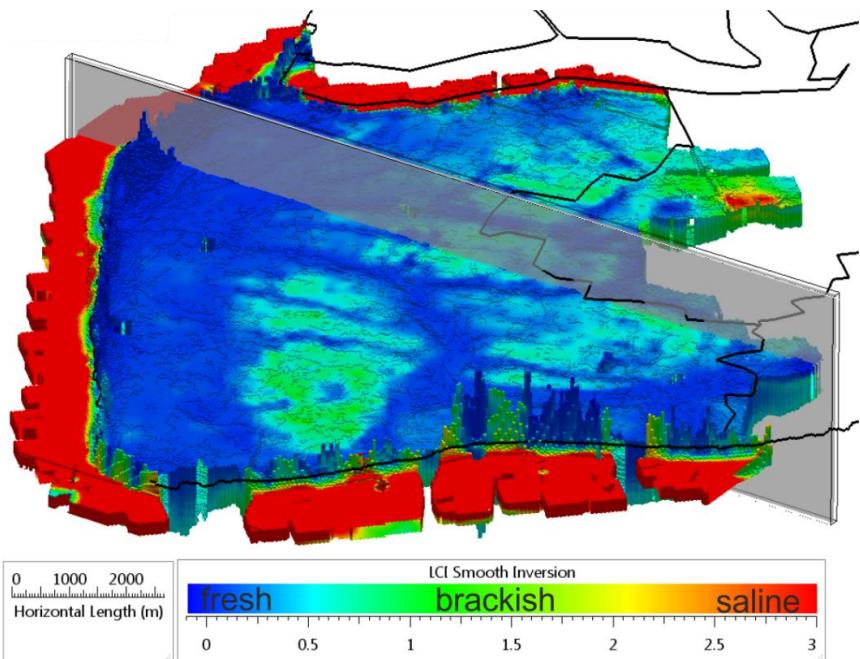
Water Nexus: water provision through local network and treatments enabling reuse



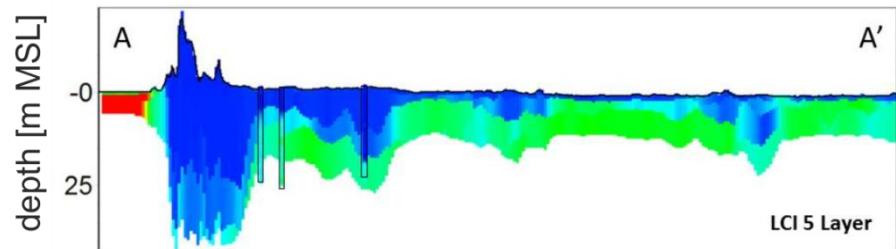
Three research lines



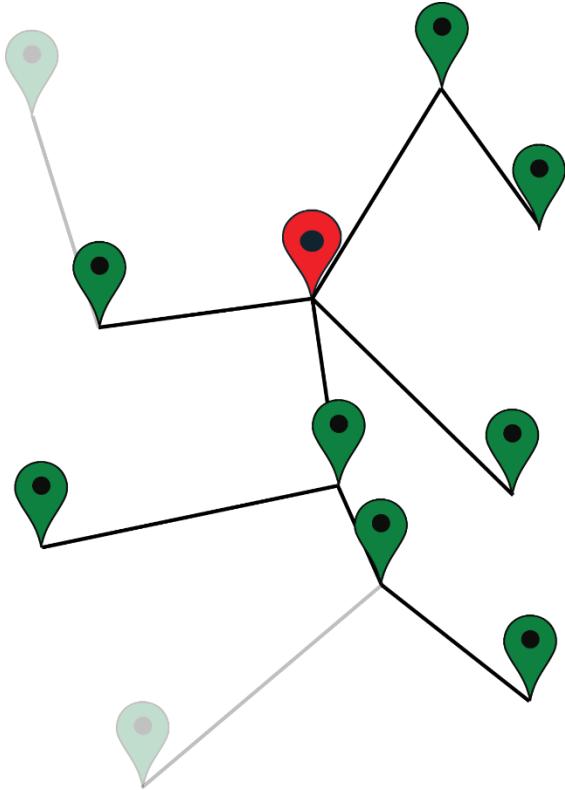
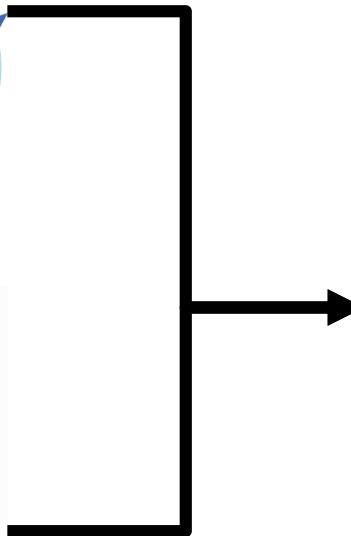
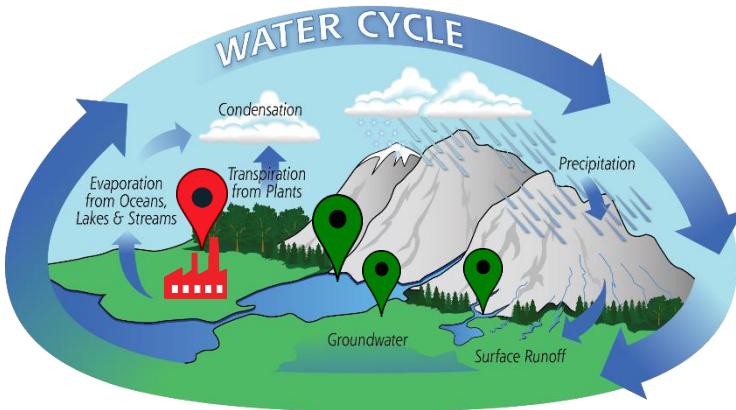
Line 1. Finding fresh and brackish GW resources using geophysical techniques



COASTAR – Deltares/KWR
Artificial Recharge in
Coastal Aquifers



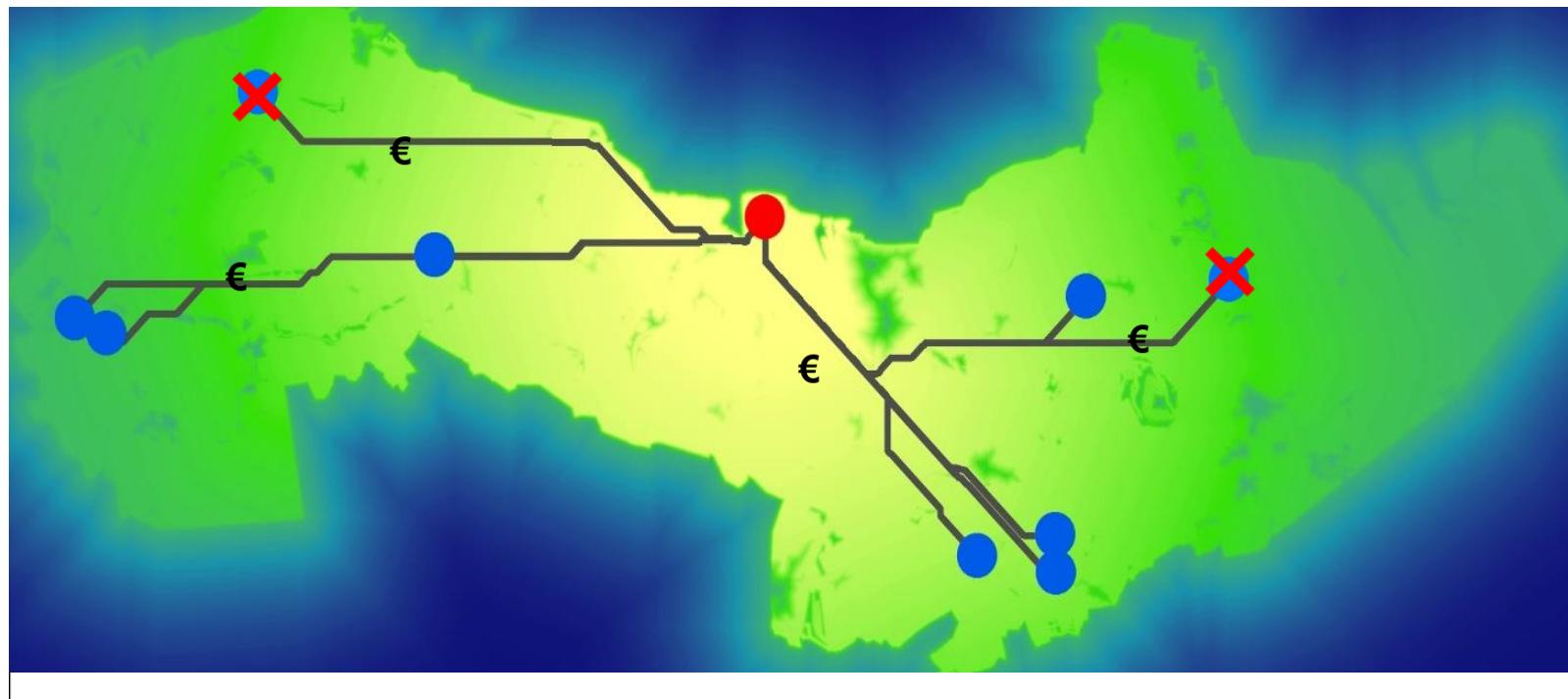
Line 3. Matching demand and supply by infra network connecting ground-, surface-, and waste water resources to demand



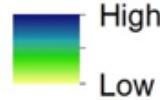
Network model matching demand and supply

>> SMART WATER GRIDS

Landscape elements determine costs infra: best route?



Supply location



High
Low

Demand location
Costs of infrastructure

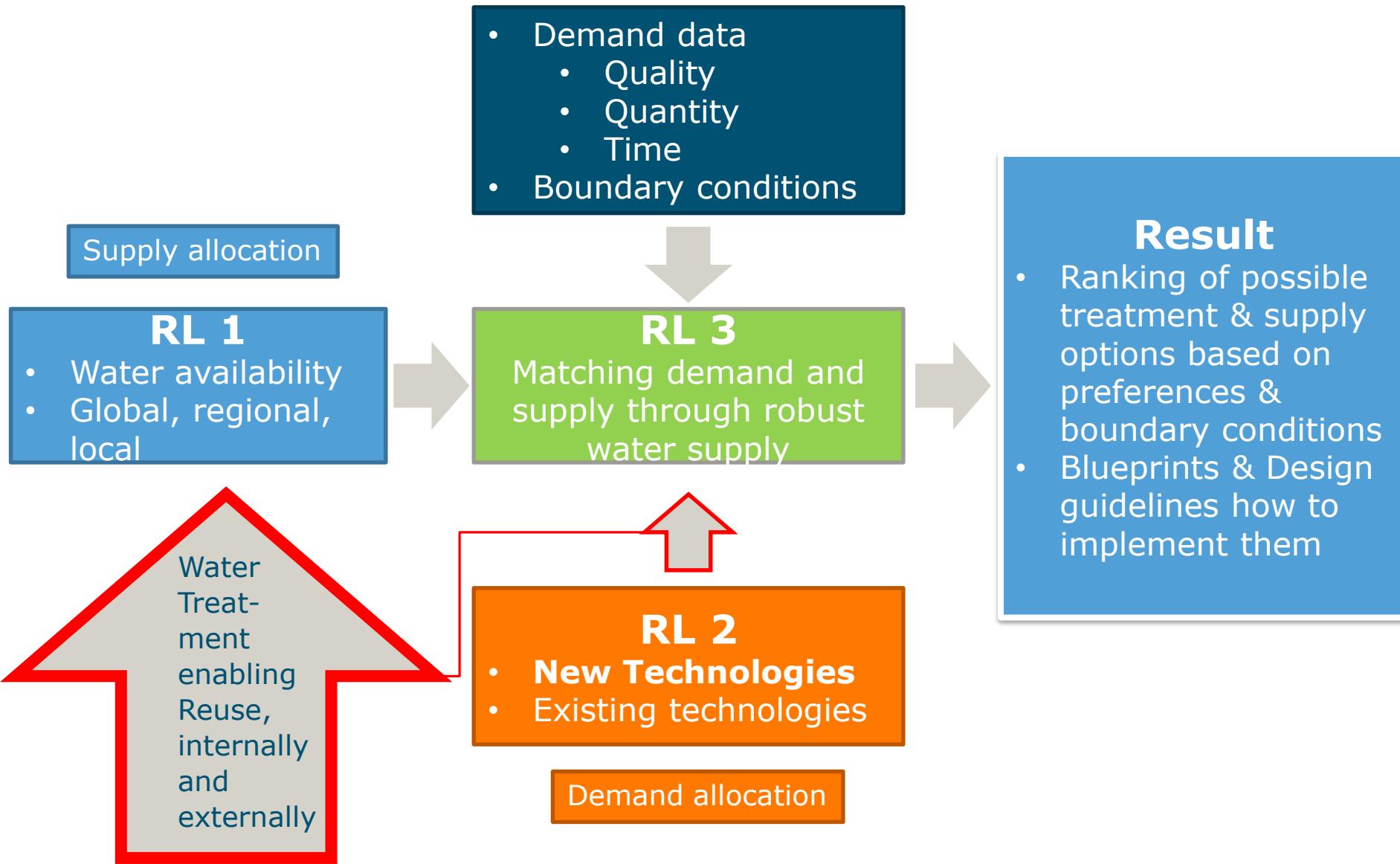
0

5

10

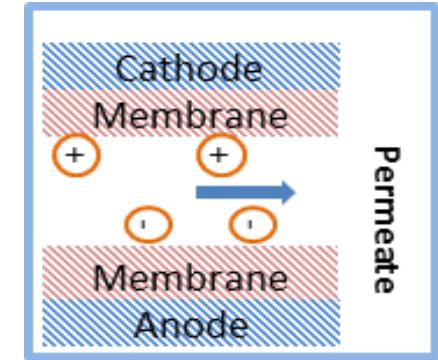
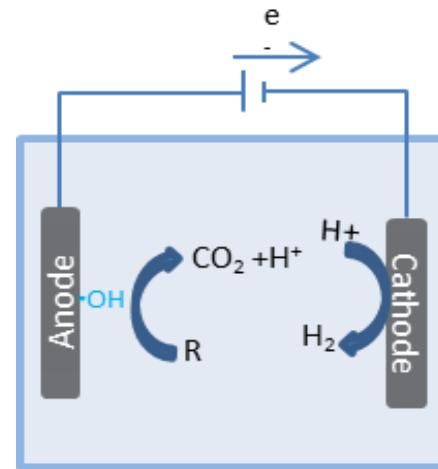
20 Kilometers

Three research lines



Line 2. Water Nexus: technologies enabling WW reuse

■ Biological, electrochemical, membranes



NEW. High COD WW. Anaerobic sludge (and aerobic) granulation at high salt concentrations



**Salt concentration
20 g Na/L
(sea water
8 g Na/L)**

**Day 45
Fully formed
granular sludge
bed**

Line 2. Cooling tower water treatment

- In 2010, 67 billion m³ water was used for cooling in EU power plants
- Cooling tower blowdown (CTBD) contains :
 - Low COD but recalcitrant and
 - Biocides, Corrosion inhibitors, Scale Inhibitors & Salts
- Desalination of CTBD failed due to membrane fouling

.....Electrochemical oxidation could be a potential organic pollutants removal technology

Line 2. Electrochemical oxidation of organics in CTBD

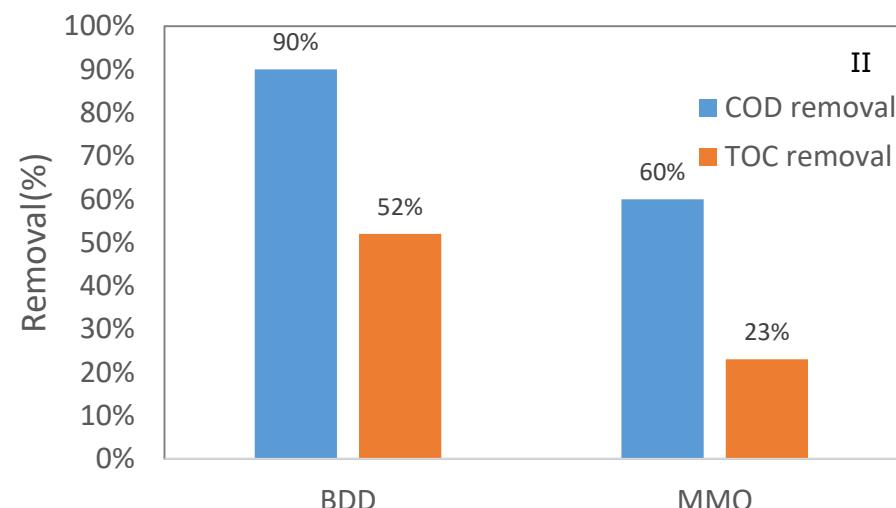
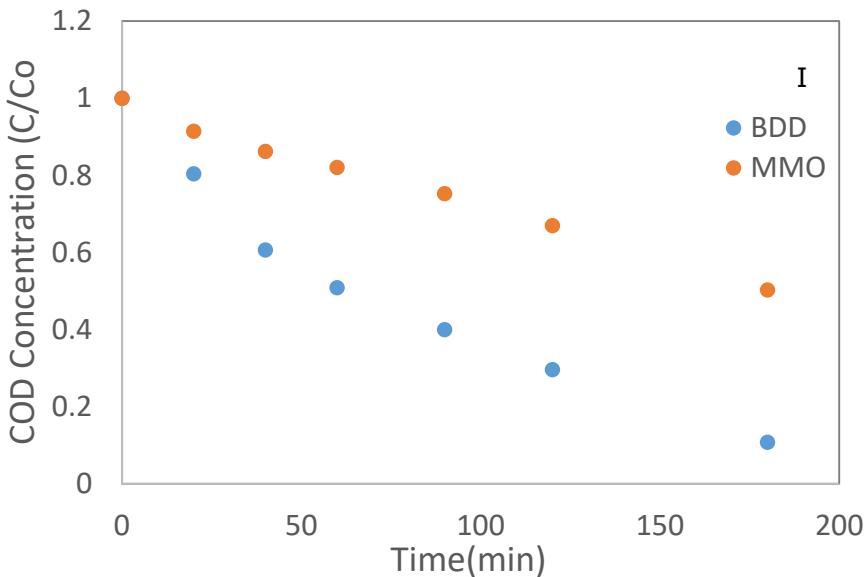


Figure: I) the evolution of COD and II) TOC & COD removal, during electrochemical treatment of CTBD effluent on

boron-doped diamond (BDD) and

mixed metal oxide (MMO) anodes

at 9mA/cm^2 current densities, $T=21-$

23°C , Conductivity = $3.7\text{mS/cm}/$; pH = 6.9

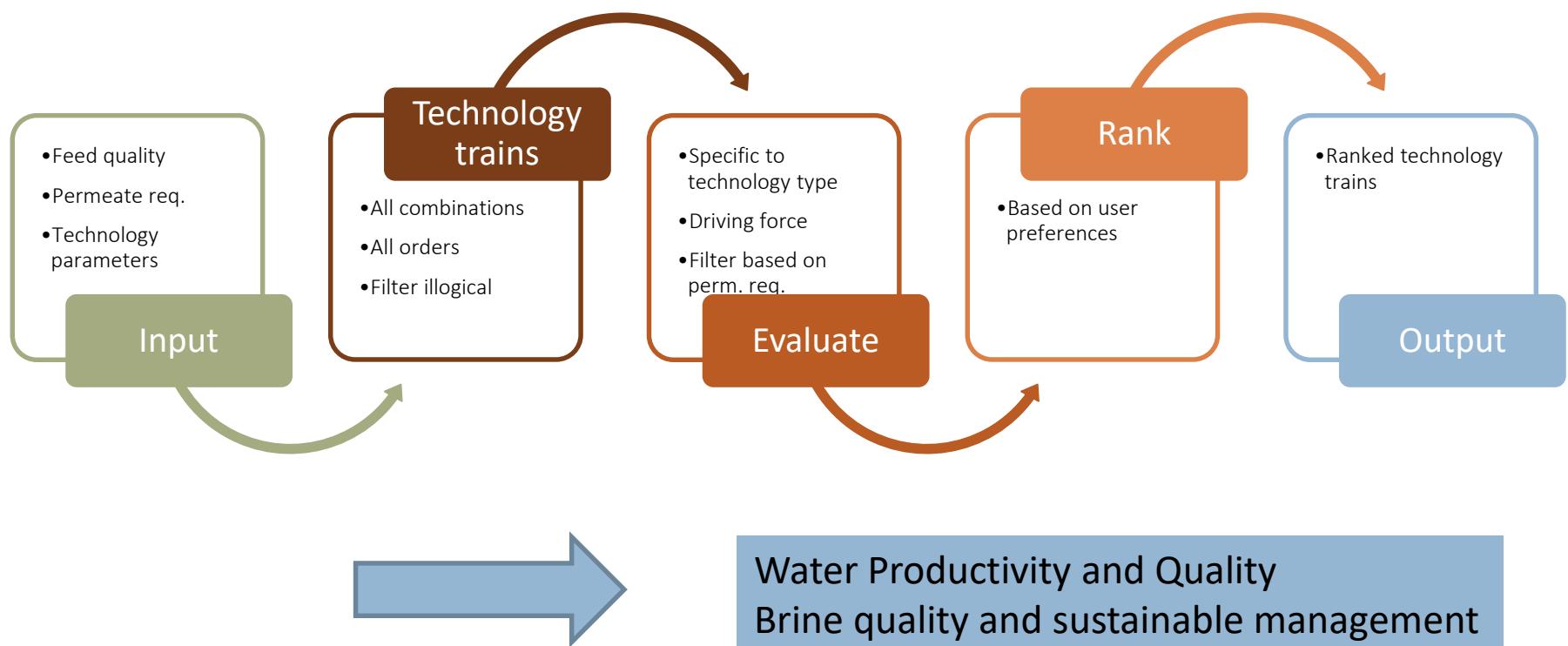
Line 3. Cooling tower blow down water treatment in constructed wetlands



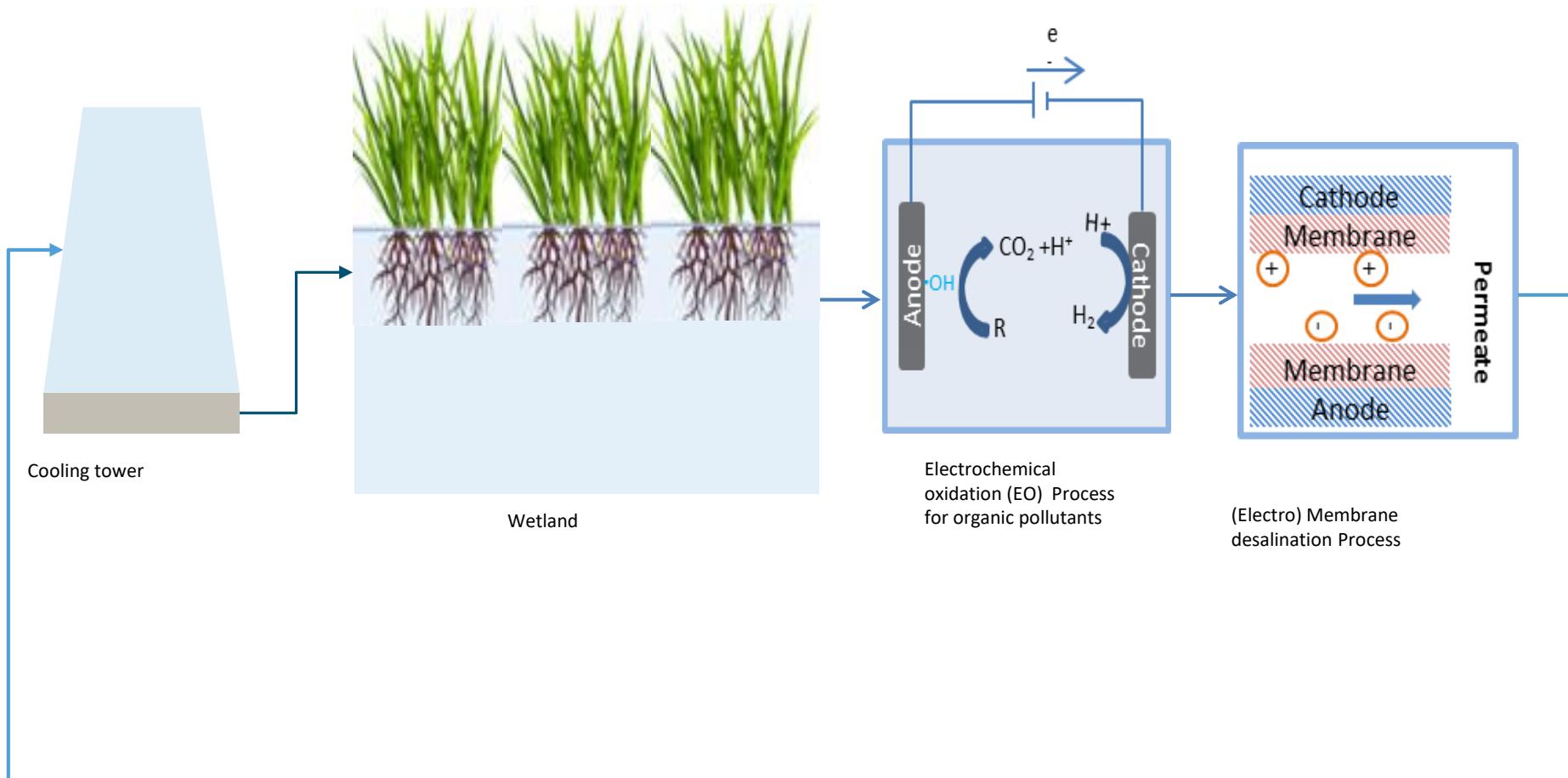
Studies completed end 2019

Very effective for most chemical Additives but add on technologies needed for TOC and salt

Modelling optimal technology trains



Line 2 and 3: Proposed technology train for cooling tower wastewater treatment

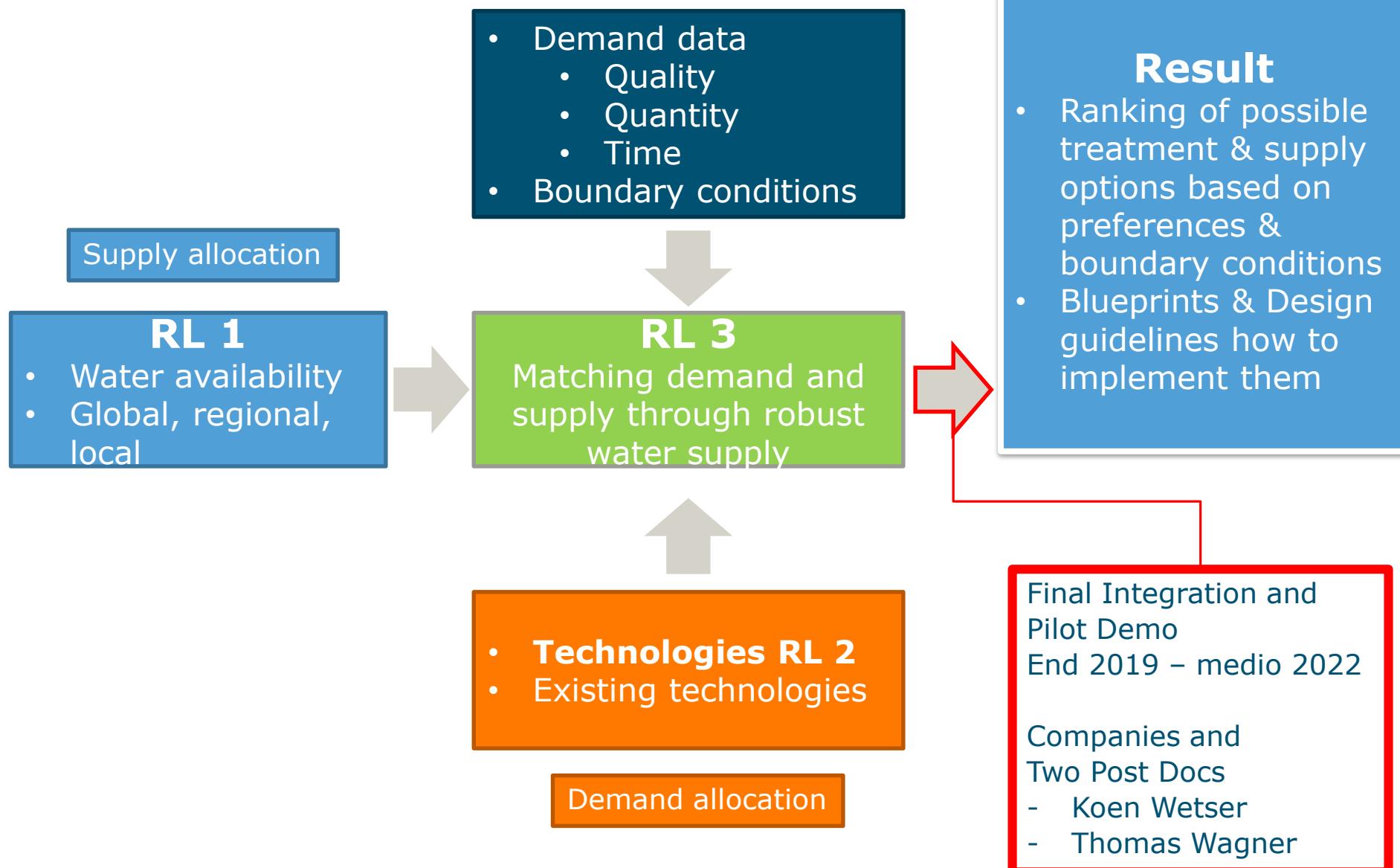


Pilot Demonstration end 2019 - mid 2021



**Wetland part of PILOT
with seedlings > start
end 2019**

Three research lines



Line 3. Scale up and involvement stakeholders



- Robust water system
DOW + Zeeuws Vlaanderen
- Production DOW guaranteed

- Stakeholders needed:
 - Gemeente Terneuzen
 - Provincie Zeeland
 - RWS
 - WS Scheldestromen
 - Evides



Roll-out other locations in region and globally

Global Collaborations



Prognosis Coastal Flooding:
National Geographic



WATER NEXUS

ENTIRE Project: ENabling susTainable Industrial development in Vietnamese delta's: REducing, recycling and multi-sourcing industrial water



Climate Change and Engineering Coastal Water Resources >> local water grids

