
Interreg
EUROPEAN UNION
2 Seas Mers Zeeën
European Regional Development Fund
FRESH4Cs
closing conference
Live from Ipswich, UK
February 3rd 2023

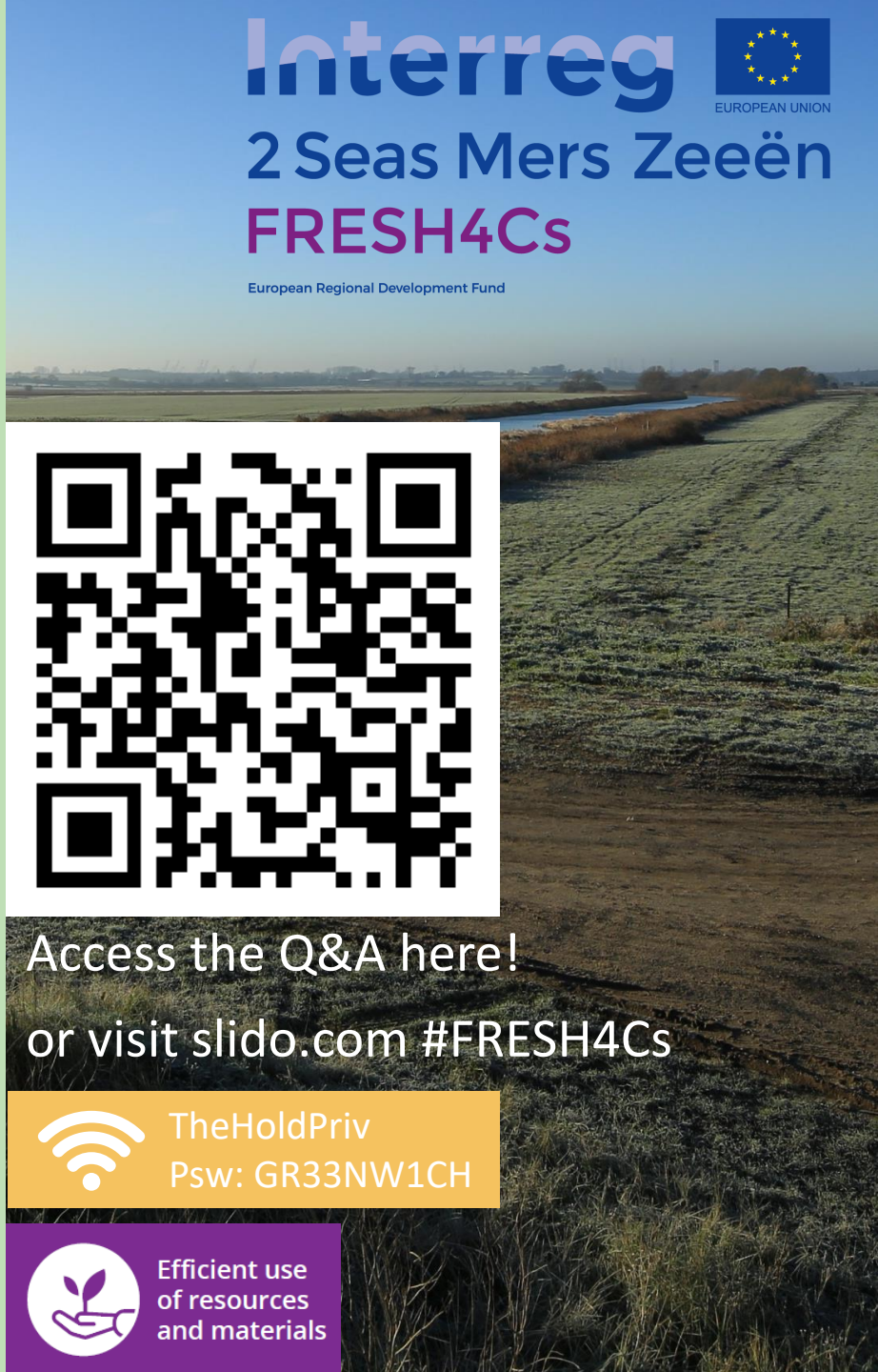
Welcome!

Matt Hullis

Head of Environment Strategy

Suffolk County Council

Matt.Hullis@suffolk.gov.uk



Conference Programme

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European Regional Development Fund

- **9h45: Opening remarks**
  Cllr Richard Rout, Suffolk County Council

- **9h55: Keynote *Tackling water scarcity***
  Daniel Johns, Water Resources East

- **10h25: FRESH4Cs demo cases**
  - Feasibility and demonstration of creek ridge infiltration by Dow
  - Water storage in Kwetshage by Vlaamse Landmaatschappij
  - Treating water for reuse in agriculture by Lamb Weston / Meijer
  - Q&A

11h30-13h: Lunch break

Efficient use of resources and materials

Conference Programme

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- **13h: Managed aquifer recharge as a solution for sustainable freshwater scarcity?**
  Ane Wiersma, Deltares

- **13h30: FRESH4Cs demo cases**
  - Treating concentrate with a willow marsh: a nature-based solution, Aquaduin
  - Providing Felixtowe farmers with sustainable freshwater, Felixstowe Hydrocycle
  - Managed Aquifer Recharge: farmers and the regulator, EA and Felixstowe Hydrocycle
  - Q&A

- **14h40 Break**

Efficient use of resources and materials

Conference Programme

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- **15h: Stakeholder participation and integral value by HZ University**
- **15h15: Round table discussion**
  moderated by Matt Hullis
- **15h45: Networking drinks**

Efficient use of resources and materials

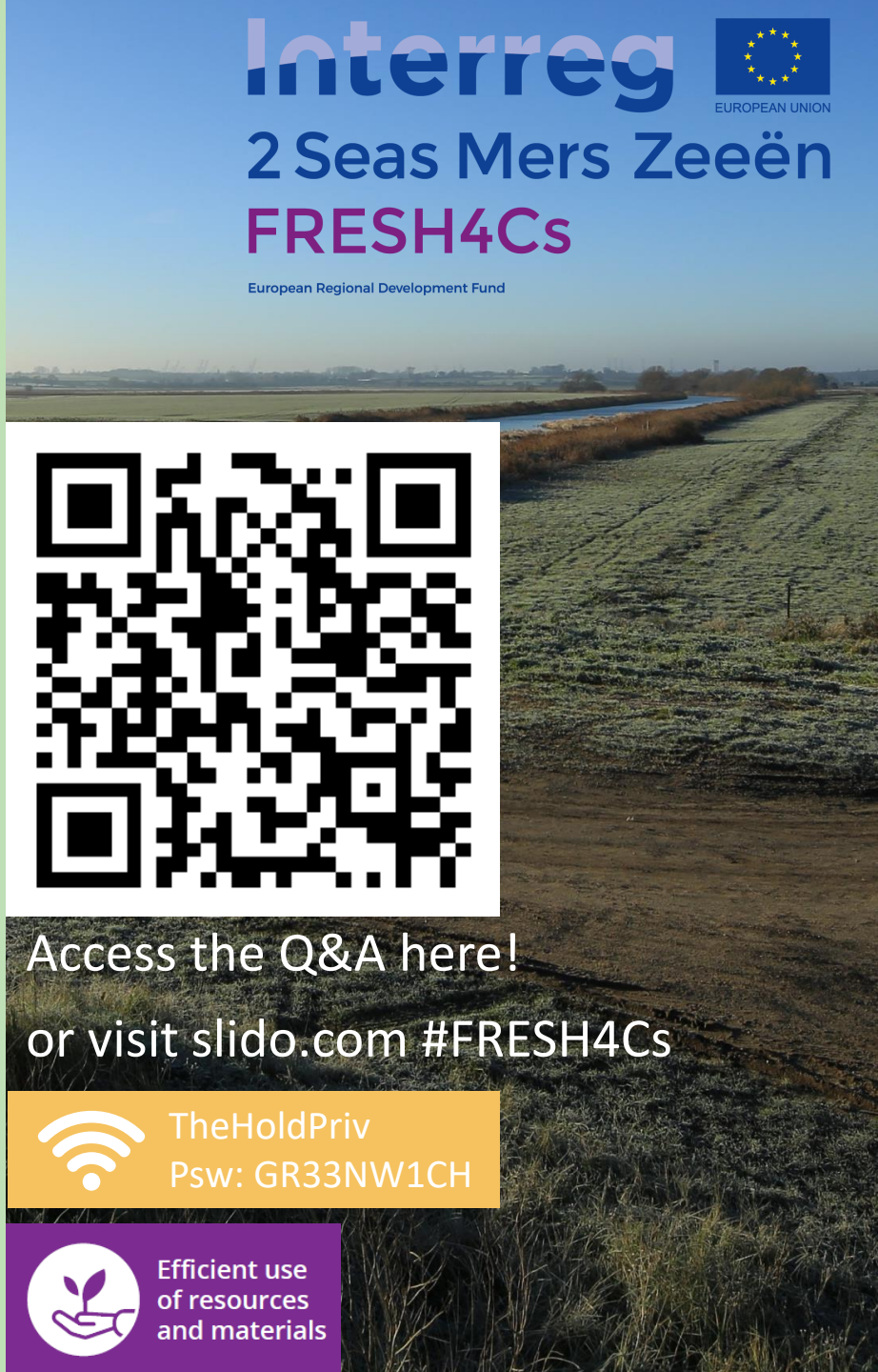
About the project

Bastiaan Notebaert

Water Innovator

vito

bn@vlakwa.be



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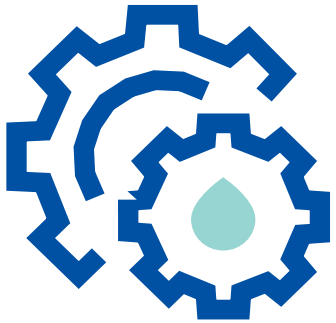
FRESH4Cs

Freshwater resources for coastal regions

agriculture



industry

nature

drinking water

Recovering water drained to sea

- Felixstowe (UK) piping network

Recovering effluent (concentrate)

- Koksijde (BE) concentrate treatment with willow marsh
- Kruiningen (NL) industrial effluent for agriculture

Recovering water through above ground and underground storage

- Felixstowe (UK) MAR
- Braakman South (NL) kreekruginfiltratie
- Kwetshage (BE)

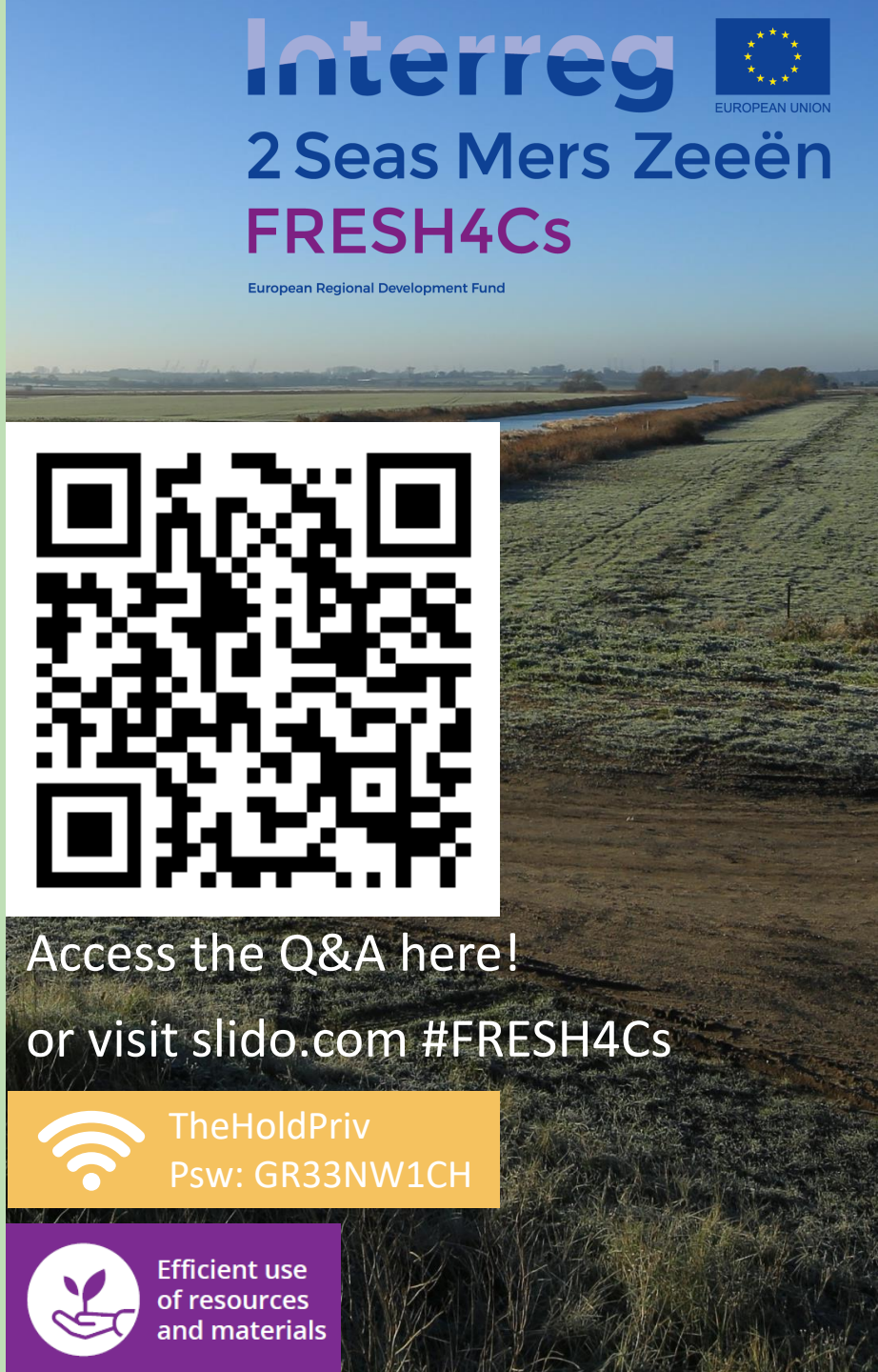
Click here to watch the project animation video

Opening remarks

Cllr Richard Rout

Deputy Leader and Cabinet Member for Finance and Environment

Suffolk County Council



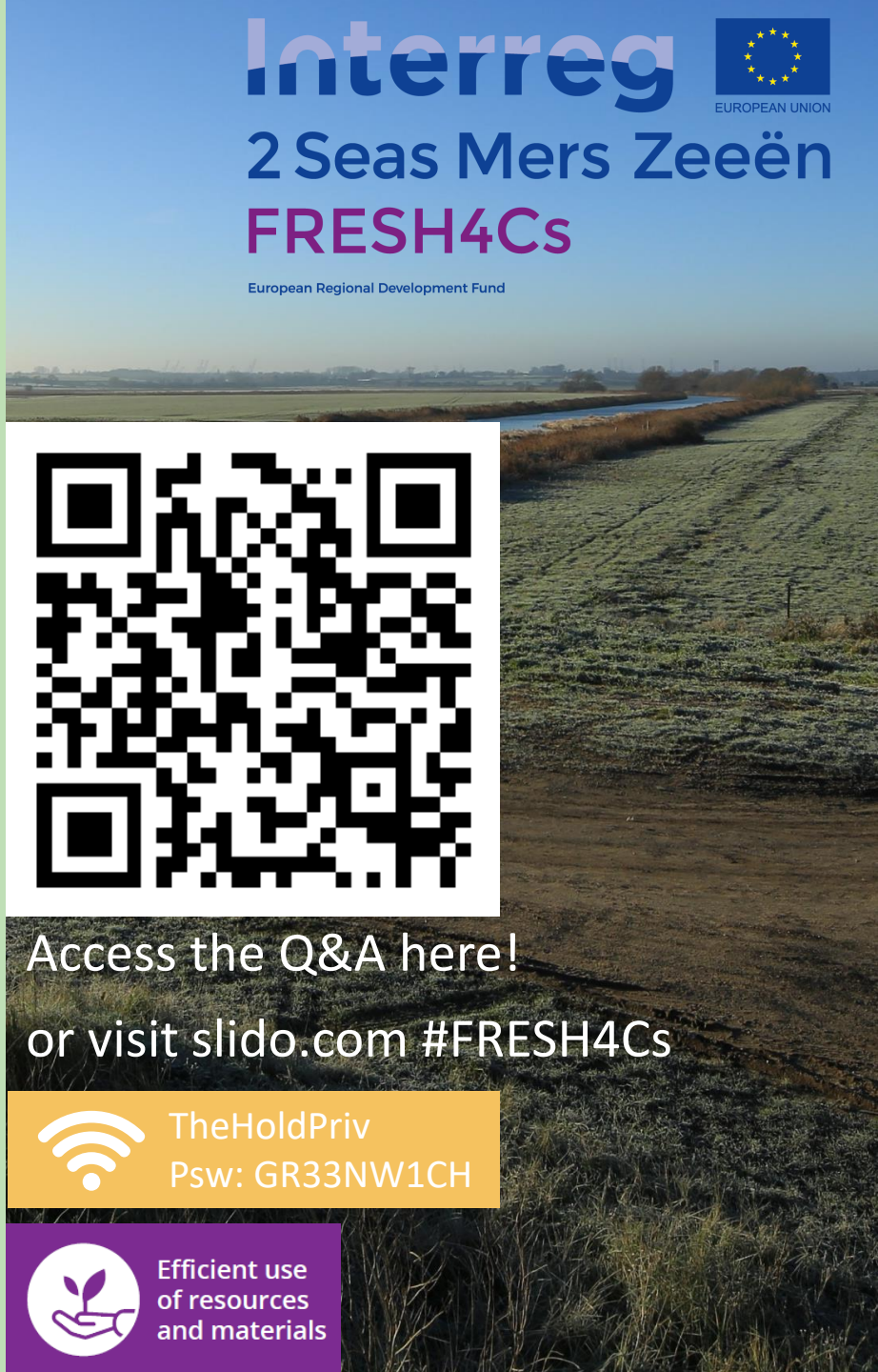
Tackling water scarcity: projections and solutions

Daniel Johns

Managing Director

WRE
WATER RESOURCES EAST

danieljohns@wre.org.uk



WRE's board members and funders

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FRESH4Cs
European Regional Development Fund

love every drop
anglianwater
Affinity Water
CAMBRIDGESHIRE & PETERBOROUGH COMBINED AUTHORITY
Norfolk County Council
ESSEX&SUFFOLK WATER living water
Suffolk County Council
CAMBRIDGE WATER COMPANY
NFU
Broads Authority
Essex County Council
ada Representing Drainage Water Level & Flood Risk Management Authorities
The Rivers Trust
RWE
Wildlife and Countryside LINK

WRE's operating costs are funded by membership fees:
70% water companies, 30% other organisations


SEMLEP
South East Midlands Local Enterprise Partnership
BritishSugar
An AB Sugar company
The Stamford Canal Society
Carter Jonas
RHS
Biomation
Urban&Civic plc
CAMBRIDGE AHEAD
Natural Cambridgeshire
Ely Group of Internal Drainage Boards
WRE
WATER RESOURCES EAST
the Environment Bank
Essex County Council
Cambridgeshire County Council
Nene Park
THE JOCKEY CLUB
love every drop
anglianwater
CAMBRIDGE WATER COMPANY
Affinity Water
Your local supply, on tap
Lincolnshire COUNTY COUNCIL
Suffolk County Council
INLAND WATERWAYS ASSOCIATION
NORTH NORFOLK DISTRICT COUNCIL
Norfolk County Council
ESSEX & SUFFOLK WATER
Natural Cambridgeshire
Borough Council of King's Lynn & West Norfolk
Breckland Council
SEVERN TRENT
Broads Authority
Energy UK
East Suffolk Drainage Board
South Holland Drainage Board
RWE
NEWANGLIA
Local Enterprise Partnership for Norfolk and Suffolk
University of Suffolk
Suffolk New College
EDF ENERGY
BRCC
bmk Waterway Park
ada
Representing Drainage Water Level & Flood Risk Management Authorities
Norfolk Rivers Drainage Board
UNIVERSITY OF LINCOLN
UEA
University of East Anglia
Cambridgeshire ACRE
Working to strengthen local communities
Broads Drainage Board
Water Management Alliance
Cranfield University
CAN
Community Action Norfolk
CPRE
Campaign to Protect Rural England
Standing up for your countryside
Black Sluice Internal Drainage Board
NORTH LEVEL DISTRICT INTERNAL DRAINAGE BOARD
King's Lynn Drainage Board
NFU
CLA
The Nature Conservancy
WildAnglia
Nature is our business
rspb
H & J Nevile & Son
IRRIGATION IN UK
BAWAG
T.W. Page & Son ltd
East Suffolk Water Abstractors Group (ESWAG)
SOMELCO
ANGLING TRUST
FISH LEGAL
NORFOLK RIVERS TRUST
NORFOLK FWAG
Essex and Suffolk Rivers Trust
FeCRA – The Federation of Cambridge Residents' Associations
BROWN&CO
WOODLAND TRUST
BIODIVERSIFY
Voluntary CENTRE Services
Helping everyone to make a difference
Drip UK
waterwise
RWC TITTLESHALL LIMITED
BEDFORD GROUP OF INTERNAL DRAINAGE BOARDS
Managers of the local water environment
Bedfordshire
Cambridgeshire
Northamptonshire
Sustainable Water Solutions
Dr Jilly Hall
Supporting the People who Support Nature
Better Together
Cavs
Stantec
Essex Wildlife Trust
RCCE
RURAL COMMUNITY COUNCIL OF ESSEX
National Trust
CVF
CAMBRIDGE CITY COUNCIL
South Cambridgeshire District Council
Sustainable Direction Ltd
WILLMOTT DIXON
SINCE 1852
Lincolnshire Wildlife Trust
REVIVE
Cam Valley Forum
Protecting and enhancing the environment of the river Cam and its tributaries
Uttlesford District Council
Fenland CAMBRIDGESHIRE
Fenland District Council
Broadland District Council
Community at heart
South Norfolk COUNCIL
COSTAIN
ES INTERNATIONAL
The River Lark Catchment Partnership
Lark Abstractors Group
Consultation Group
Department for Environment Food & Rural Affairs
NATURAL ENGLAND
Environment Agency
dwi
Forestry Commission
CCW
RAPID
Ofwat
Wash Frontage Group
Norfolk Farm Management Limited
GREAT GLEMHAM FARMS
The land app
SOMERLEYTON
SPAINS HALL ESTATE
ROYAL ESTATE Sandringham
Nature Friendly Farming Network
Wilson Wraight
Thelveton Farms

River Witham, Boston

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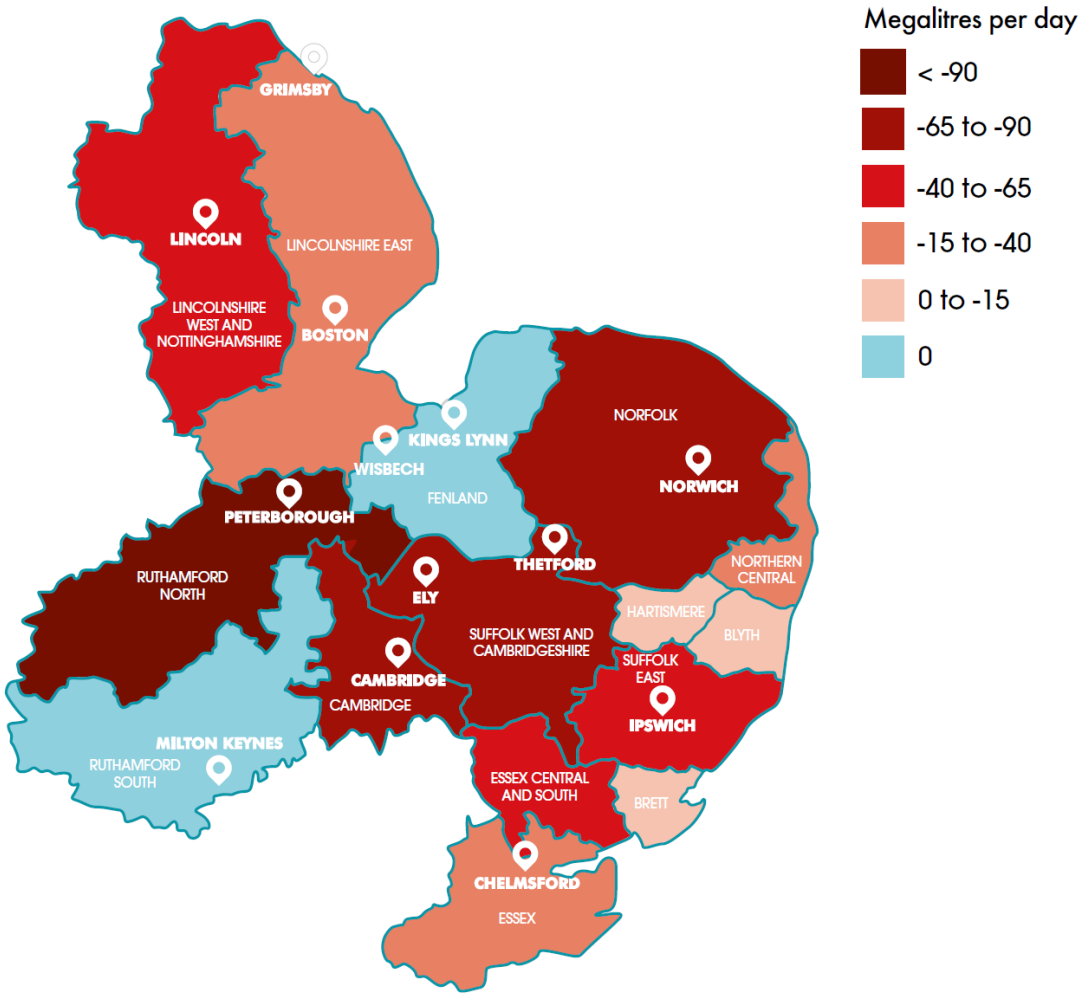
Draft Regional Water Resources Plan for Eastern England

Urgent action needed by all sectors to manage the region's scarce water resources



Projected supply-demand deficits in 2050 (Public Water Supply only)

- Whole of Eastern England is classified as 'seriously water stressed' by the Environment Agency
- 92% of rivers and other waterbodies fall short of 'good' ecological status
- A deficit of 640 million litres of water per day (Ml/d) projected for 2050
- Unless action taken, increasing water scarcity will:
  - constrain agricultural production
  - curtail economic and housing development
  - endanger the East's iconic chalk rivers, peatlands and wetlands

300Ml/day more water needed by 2050

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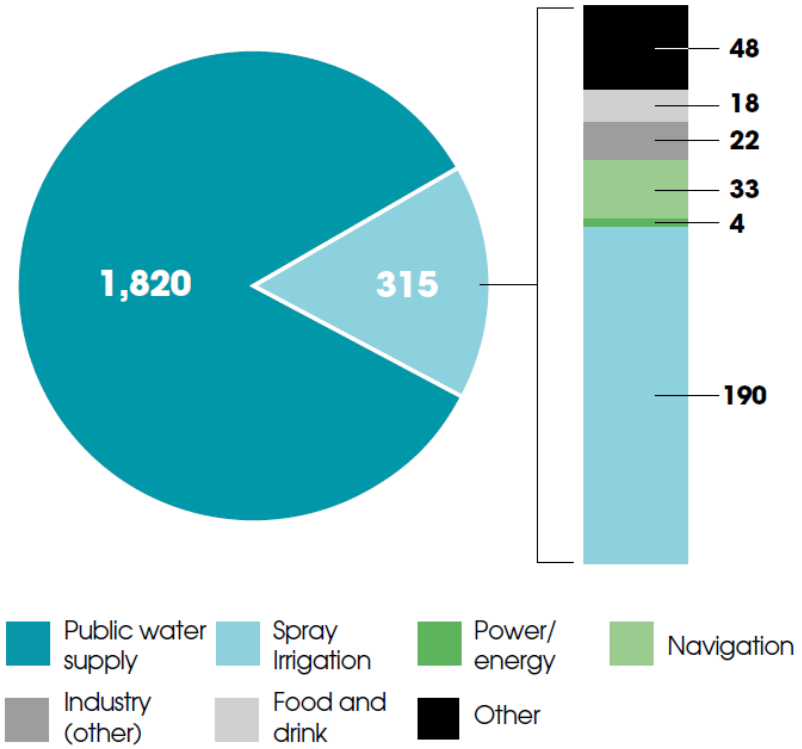
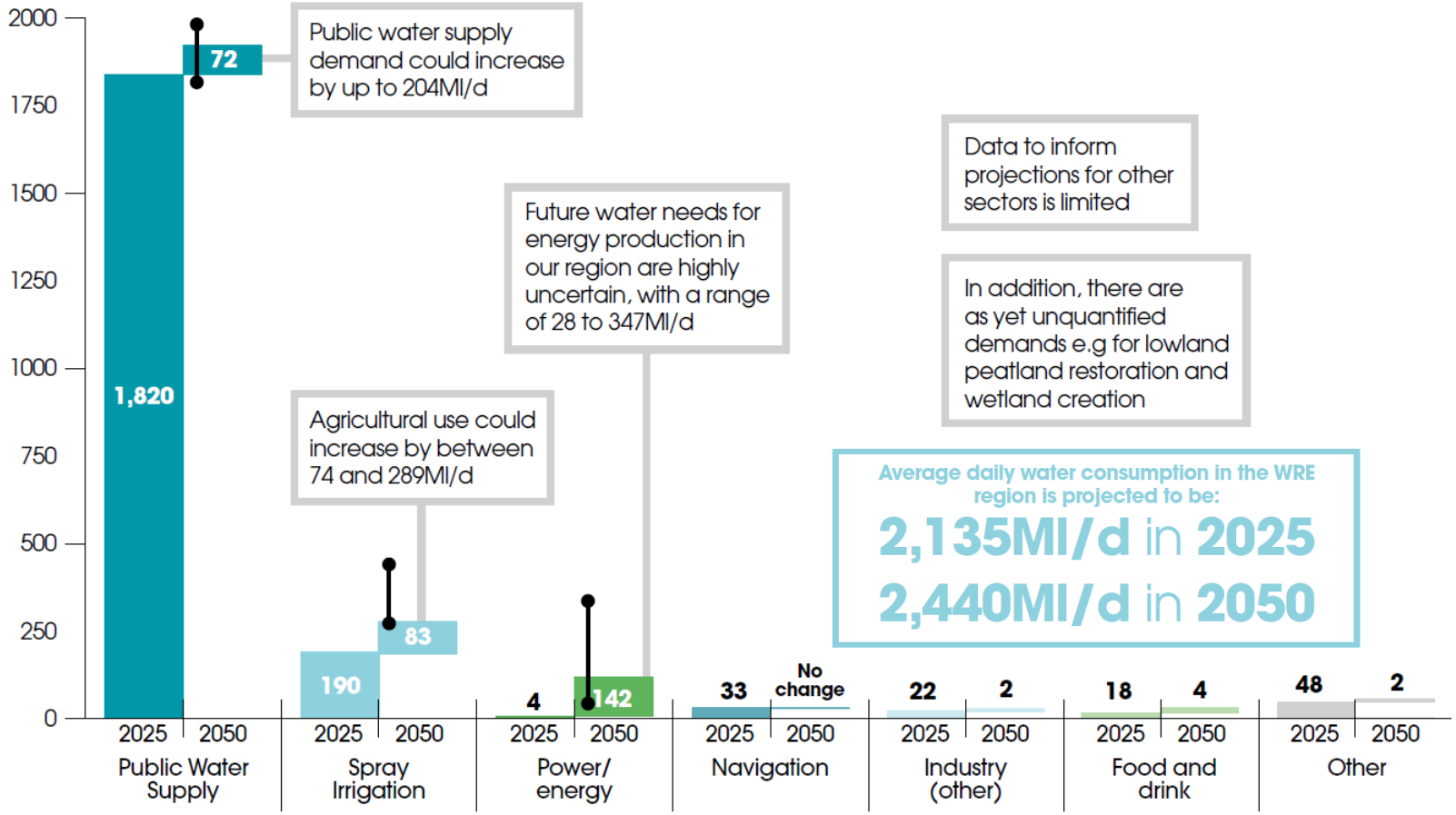


Baseline water demand in 2025



Projections and uncertainties in future water demand

Water available from existing sources will fall

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WATER RESOURCES EAST

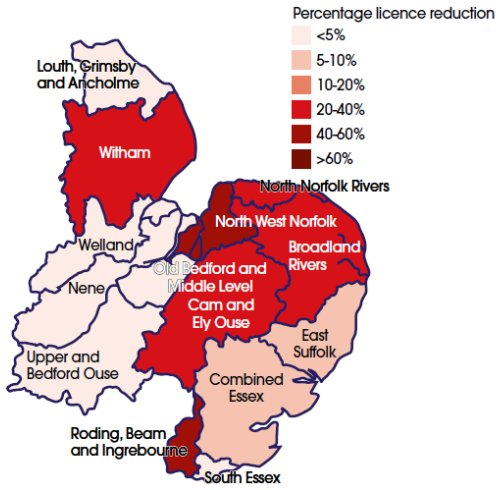
	Capping licences to protect habitats To meet 'no deterioration' legal requirement	**Drought resilience** A regulatory requirement to deliver 1:500 year drought resilience by 2040	**Climate change** An uncertain, progressive reduction in available water	**Environmental Destination** Achieving flows that support good ecological status by 2050
	By 2035	**By 2040**	**By 2050**	**By 2050**
Public Water Supply	**148Ml/d** **8%**	**85Ml/d** **5%***	**23Ml/d** **1%***	**337Ml/d** **19%***
Agriculture	**Further work with Environment Agency needed**	**n/a**	**Further work needed**	**59Ml/d** **22%****
Other Sectors		**n/a**		**22Ml/d** **8%****



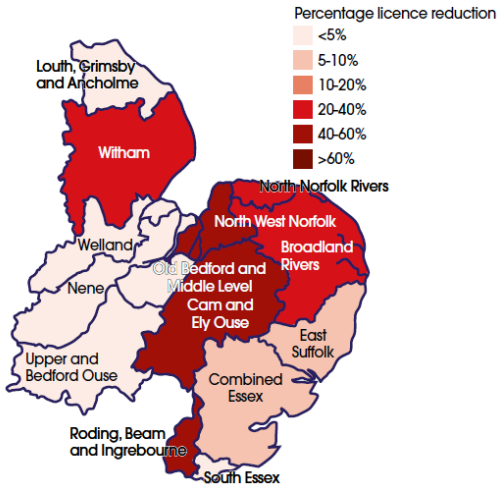

Shorter-term challenge → **Longer-term challenge**

Some areas could lose 60%+ of licenced volumes

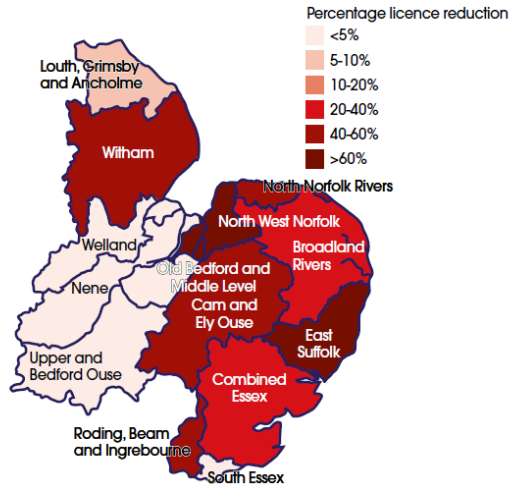
Public water supply: Recover (BAU)



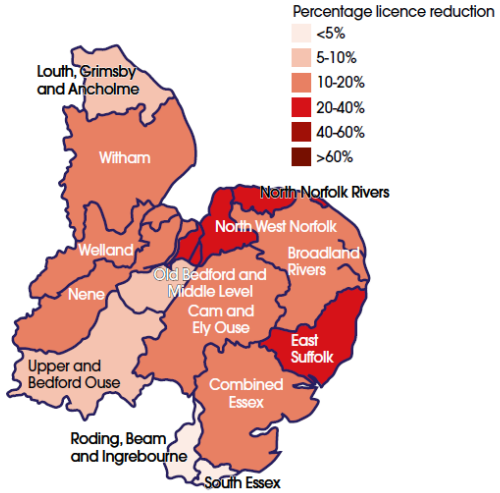
Public water supply: Resilience (BAU+)



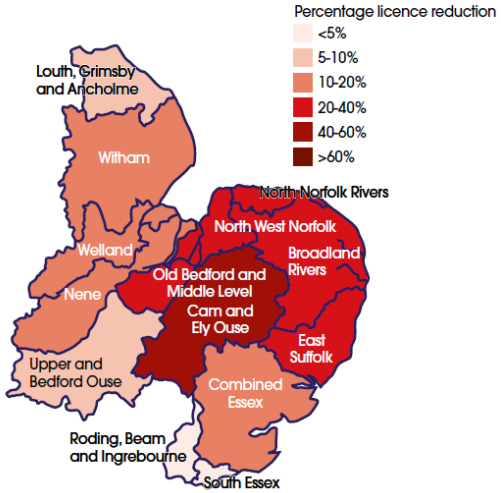
Public water supply: Enhance



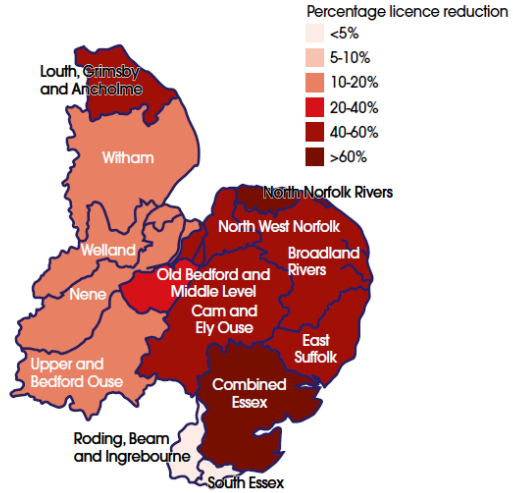
Agriculture: Recover (BAU)



Agriculture: Resilience (BAU+)



Agriculture: Enhance



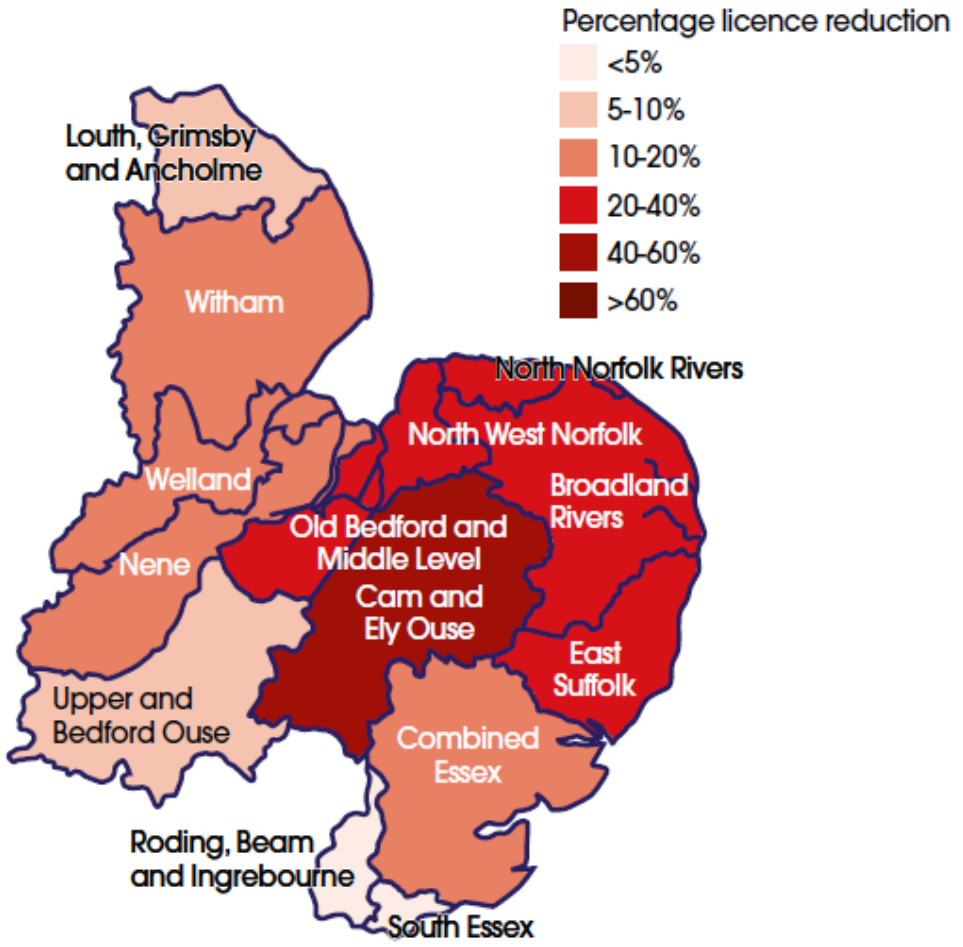
Potential returns of water to the environment for Public Water Supply (*top row*) and agriculture (*bottom row*) by 2050:

- **'Business As Usual':** to meet existing legal requirements, excluding 'uneconomic' waterbodies
- **BAU+:** extra protection for internationally designated habitats
- **Enhance:** including 'uneconomic' waterbodies plus extra protection for UK designated habitats, chalk rivers, headwaters and wetlands

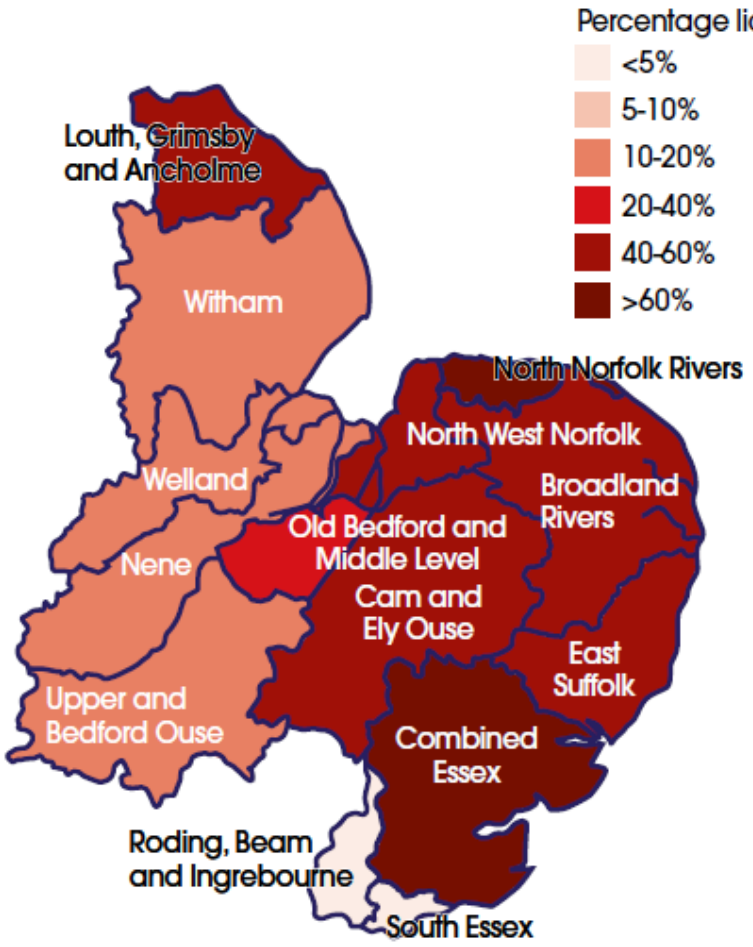
Some areas could lose 60%+ of licenced volumes

WATER RESOURCES EAST

Agriculture: Resilience (BAU+)



Agriculture: Enhance



Potential returns of water to the environment for by 2050:

- **'Business As Usual':** to meet existing legal requirements, excluding 'uneconomic' waterbodies
- **BAU+:** extra protection for internationally designated habitats
- **Enhance:** includes 'uneconomic' waterbodies plus extra protection for UK designated habitats, chalk rivers, headwaters and wetlands

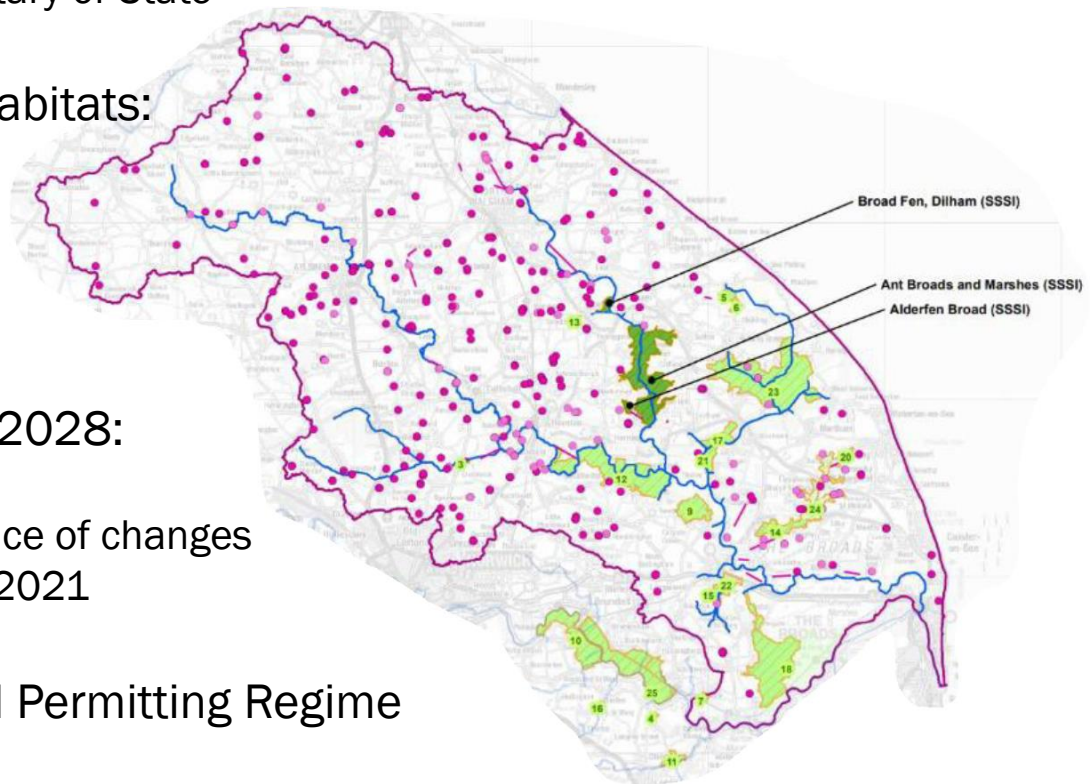
Proposed abstraction reforms

- Time-limited licences were reviewed by Environment Agency in 2018 to avoid deterioration in waterbody health. Further reductions are needed to restore healthy flows:
  - Licenced volumes were reduced to 'Max Peak' usage based on a reference period (2000-2015)
  - Could be reduced again in 31 March 2024 – approach to be announced by EA in next six months
  - Scope is 277 irrigation licences in East Anglia catchments
  - 28 days to appeal once notice served, final decisions rest with Secretary of State

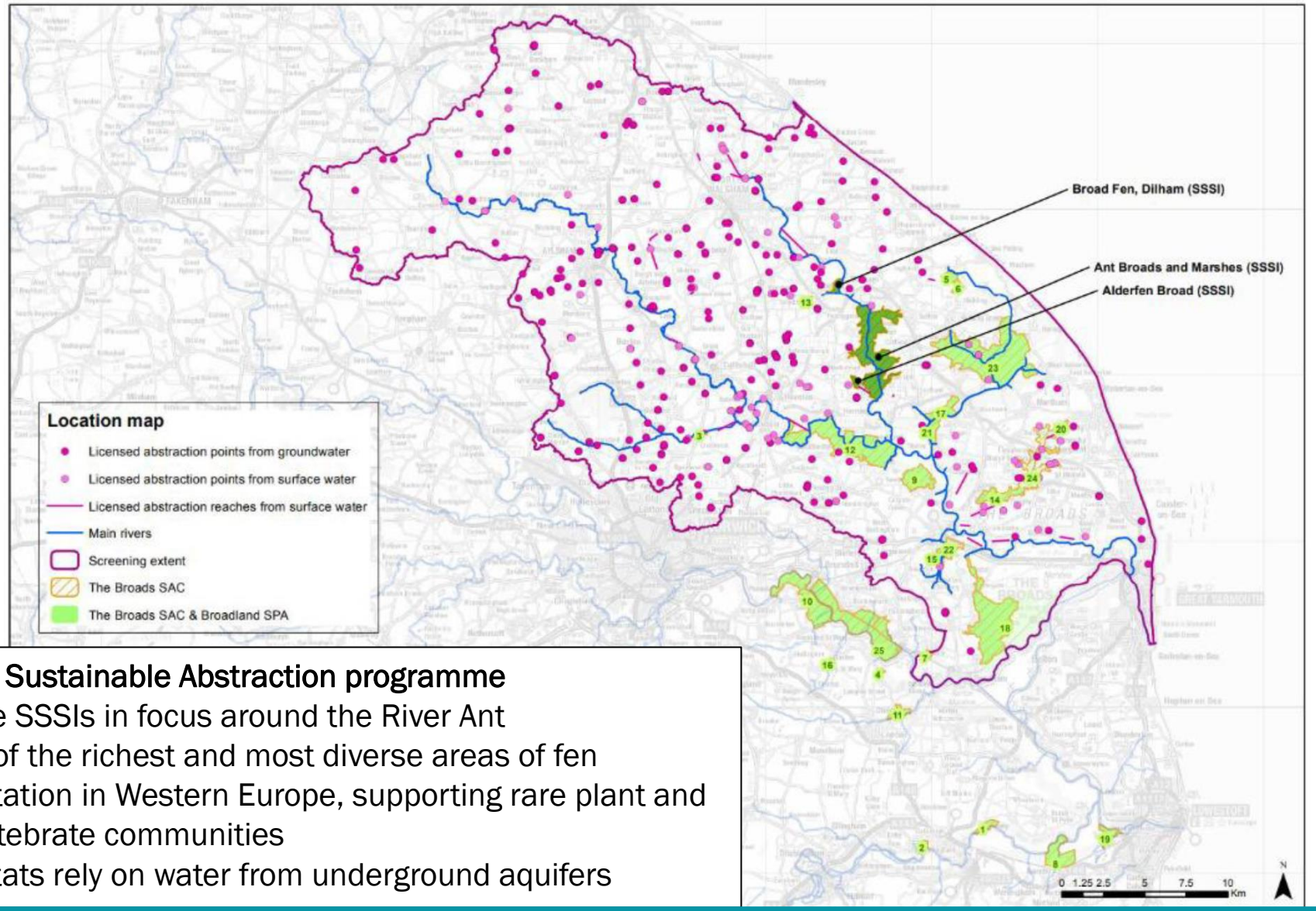
- Permanent licences not immune where they harm designated habitats:
  - Could result in licences being heavily constrained or withdrawn
  - For example, changes to 17 permanent licences affecting Ant Valley SSSIs now confirmed for 1 October 2024
  - EA widening scope to entire Broads SAC, following judicial review

- All permanent licences to be reviewed and changes made from 2028:
  - Thousands of permanent licences potentially in scope
  - Licence holders contacted in 2023 – EA aim to provide six years' notice of changes
  - No compensation will be paid, as per Section 88 of Environment Act 2021

- EA propose all licences to become permits under Environmental Permitting Regime



Ant Valley Water Resources Strategy Group



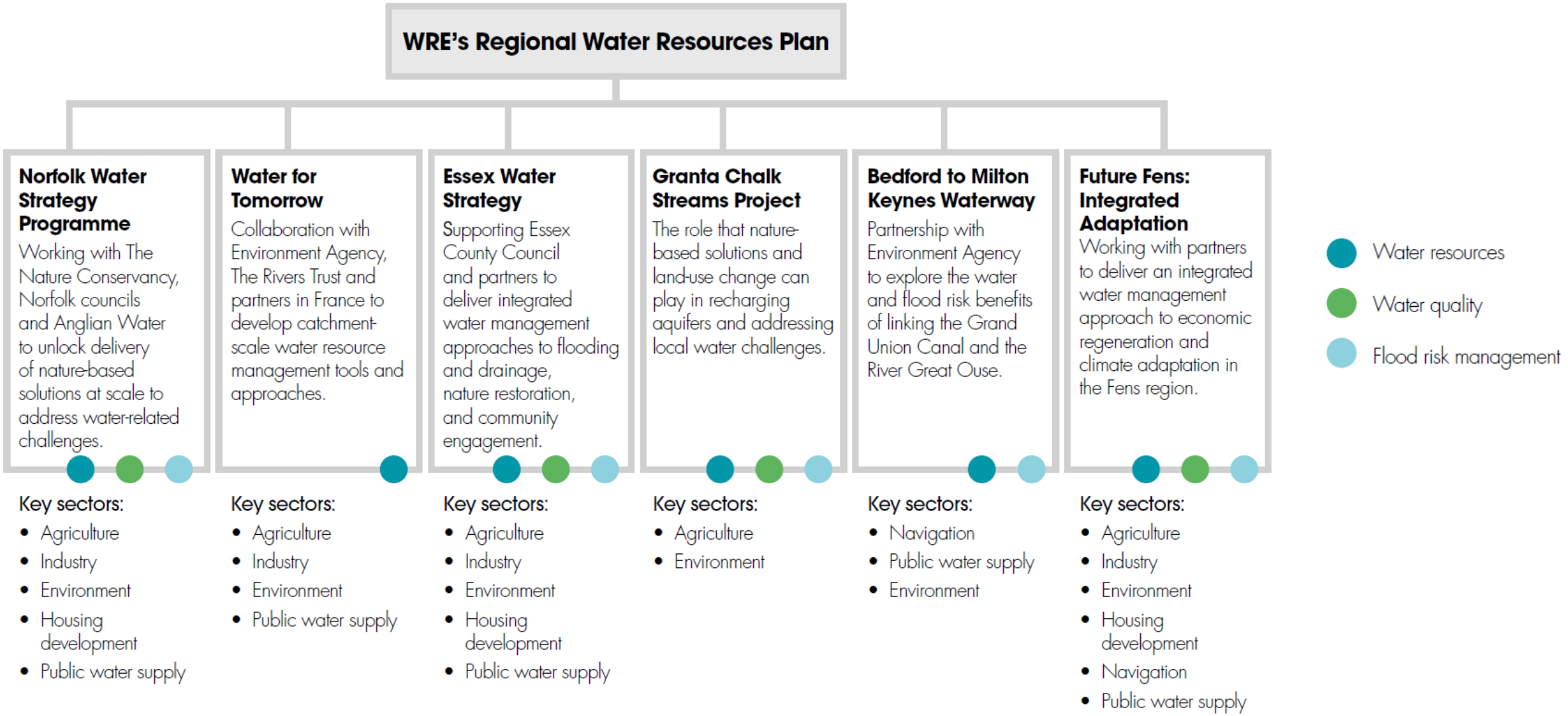
Restoring Sustainable Abstraction programme

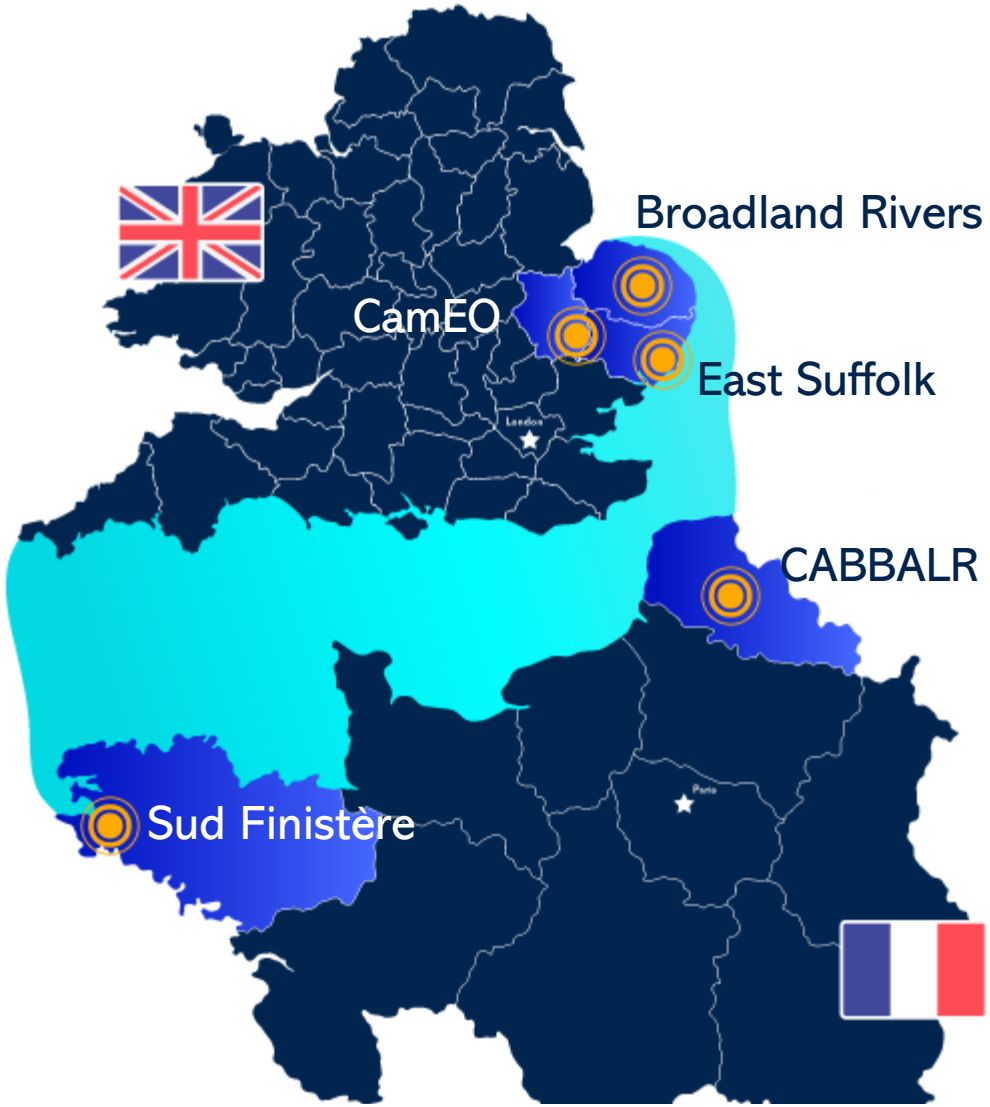
- Three SSSIs in focus around the River Ant
- One of the richest and most diverse areas of fen vegetation in Western Europe, supporting rare plant and invertebrate communities
- Habitats rely on water from underground aquifers

- 17 licences being curtailed/revoked on 1 October 2024
- Impacting public water supply, agriculture, food processing
- **Ant Valley Water Resources Strategy Group** and Delivery Group has been formed, chaired by WRE:
  - EA & NE
  - NFU
  - BAWAG
  - Anglian Water
  - LPAs
- Proposal to extend scope of group to entire Broads SAC

Toward multi-sector, catchment scale planning

WATER RESOURCES EAST





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Water For Tomorrow
European Regional Development Fund

Water for Tomorrow

https://water-for-tomorrow.com

The Rivers Trust

Communauté d'Agglomération Béthune-Bruay Artois Lys Romane

Environment Agency

Géosciences pour une Terre durable brgm

WRE WATER RESOURCES EAST

Developing local water resource plans

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Water For Tomorrow
European Regional Development Fund

What is the scale of the problem?

Hydrological modelling at a detailed local scale (sub catchments based on CAMS Assessment Points)

Testing different climate and environmental scenarios

What local options might be available?

Unconstrained list, for example:

- Demand management
- Rainwater harvesting
- Nature-based solutions
- Winter storage reservoirs
- Licence trading
- Licence sharing

How are the options likely to perform given future uncertainty?

Assessment of costs, water availability and supply resilience in a variety of future scenarios, examining trade-offs

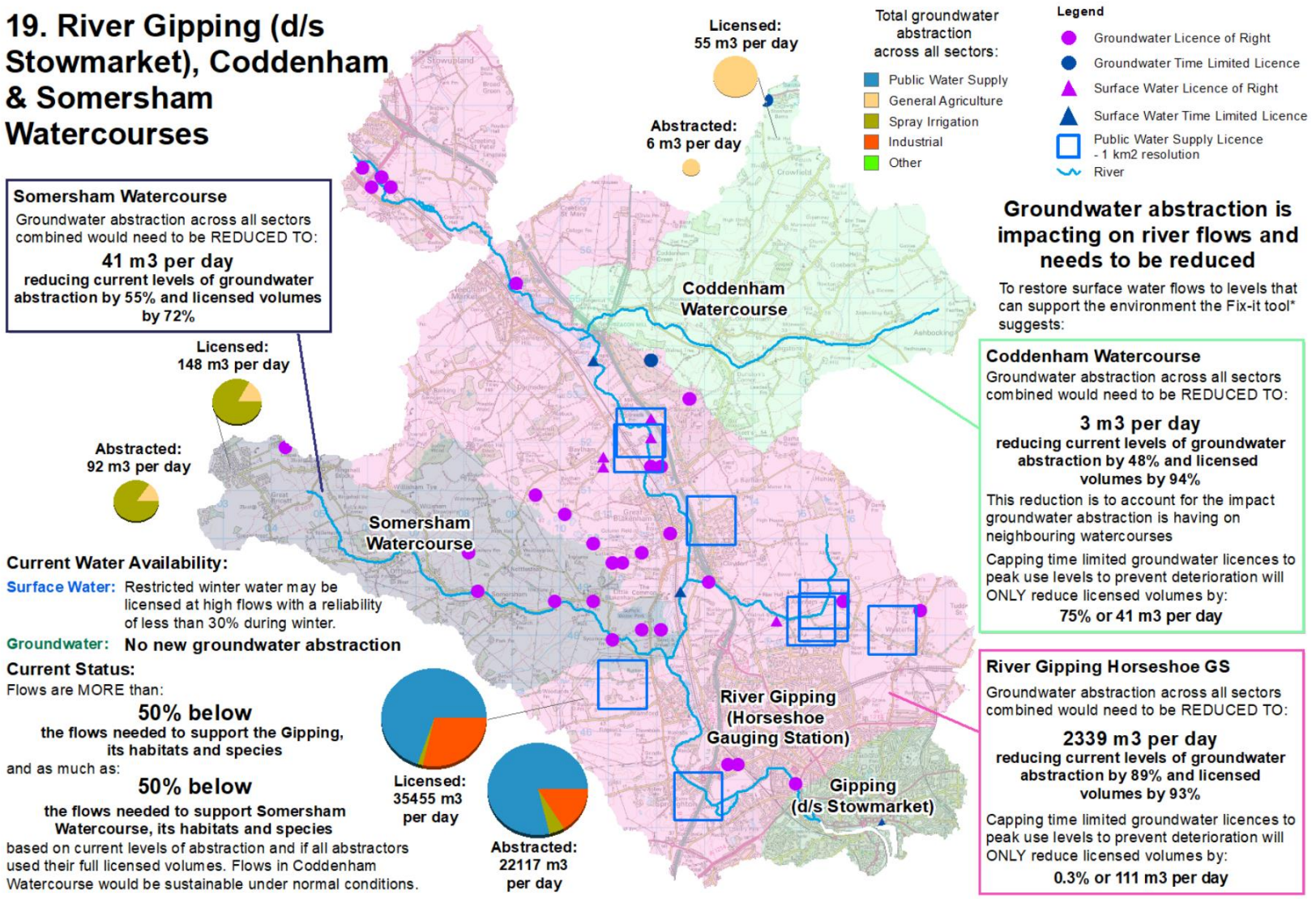
Create a portfolio that balances needs.

Catchment Management System

Allows non-technical users to run and visualise 'What if?' scenarios, based on combinations of:

- Selected water resource options and approaches
- Growth in water needs
- Extent of environmental returns necessary
- Severity of climate change impacts

Understanding the scale of the challenge



Environment Agency groundwater abstraction maps:

- Is there scope for new abstraction licences to be granted?
- How much might groundwater abstraction licences need to be reduced by to protect the environment?
- Will capping time-limited licences to ‘max peak’ historic usage be sufficient?

See: https://water-for-tomorrow.com/abstraction-map-gallery/

Exploring options in a range of future scenarios

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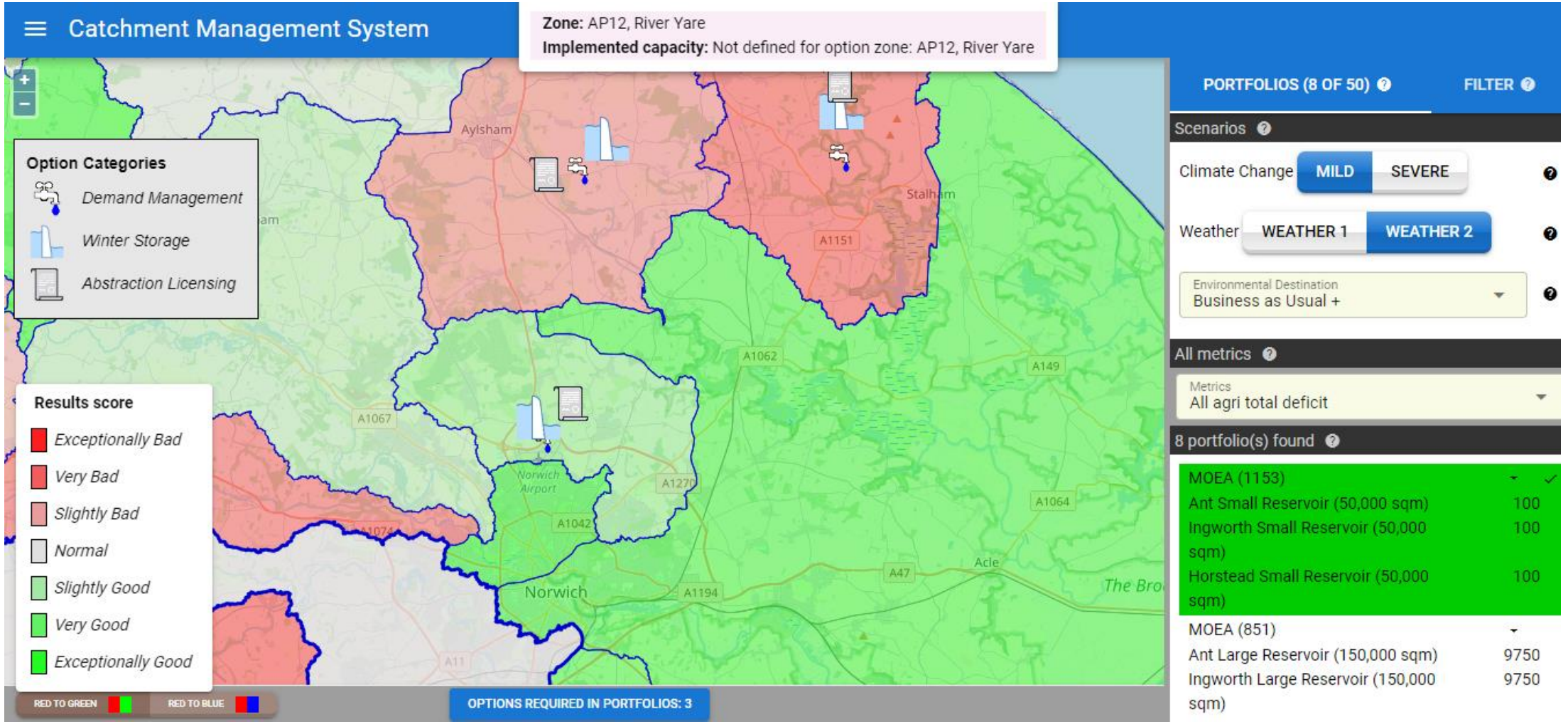
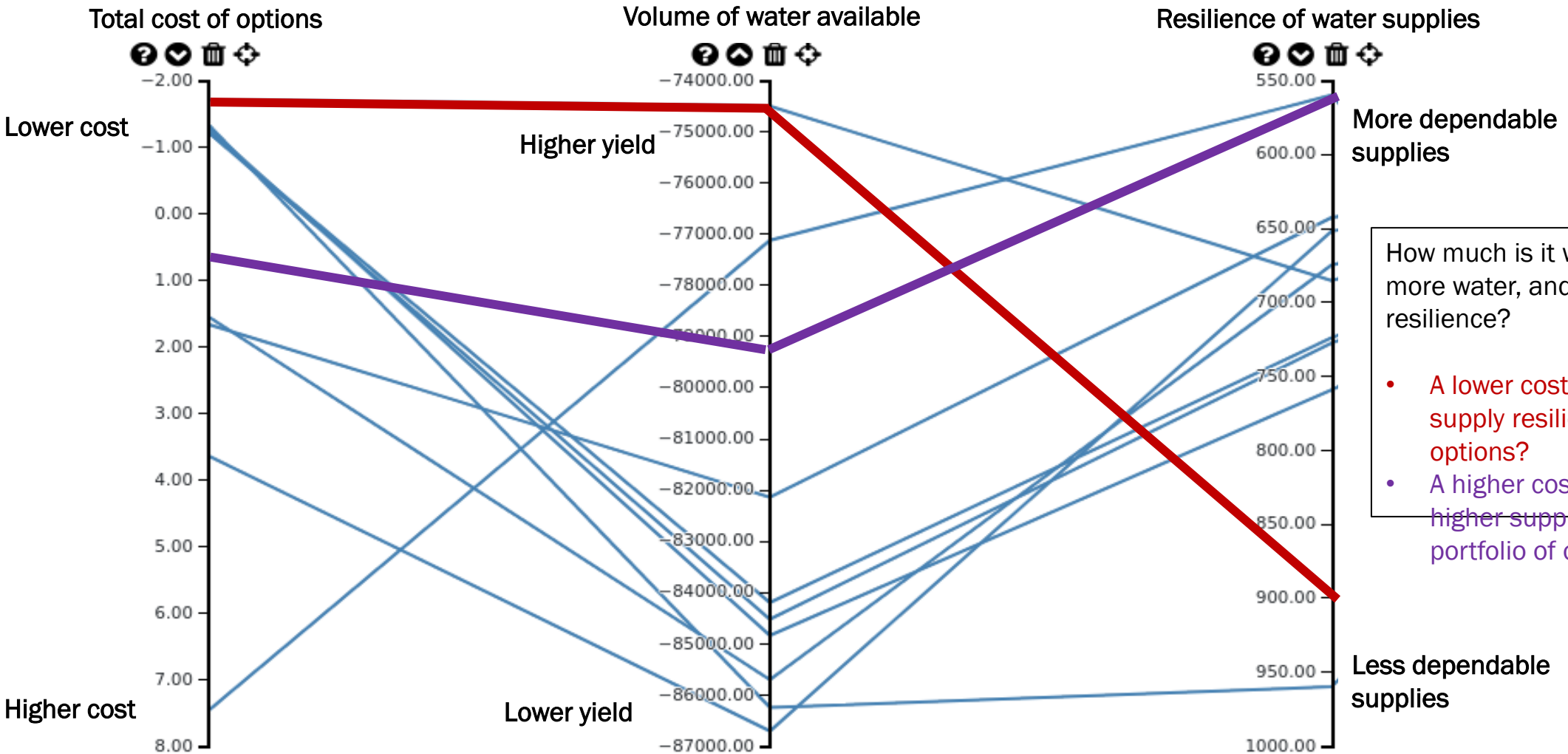
Water For Tomorrow
European Regional Development Fund



Beta website: https://fe.cms.hydra.org.uk/#/wft

Considering trade-offs between costs and supplies



How much is it worth investing for more water, and greater supply resilience?

- A lower cost, high yield but low supply resilience portfolio of options?
- A higher cost, lower yield, but higher supply resilience portfolio of options?

WRE's Regional Plan: headline recommendations

- **Commit now to a second round of regional planning** so that the five regional groups do not lose momentum. Otherwise, key skills and knowledge, and multi-sector support and ambition, will be lost as staff inevitably move on.
- **Accelerate the timetable for new government policy on demand management,** including tighter building regulations for water efficient new homes and the proposed mandatory water efficiency label on white goods, taps, toilets etc.
- **Fund the regional groups so that they can fulfil their remit on a multi-sector basis from mid-2023**. At present, WRE's Technical Programme is entirely funded by our water company members, who are prevented from using customer income to pay for studies that benefit other sectors.
- **Create more long-term certainty for all abstractors over the impact of forthcoming licence reforms.** The Catchment Based Approach (CaBA) national working group on Abstraction and Water Resources could extend its remit with WRE to navigate through licence reduction challenges and escalate strategic issues to decision makers, including, where appropriate, to ministers.
- **Establish a single, integrated approach to planning for environmental improvement for all sectors,** that clarifies through joint investigations the necessary returns of water to the environment in the short, medium and long-term. This should consider water quality aspects alongside quantity requirements so that a joined-up, efficient and effective approach is achieved.

Sector-based recommendations

WATER RESOURCES EAST

Farmers and growers:

- Long-term security of abstraction licences to allow multi-year farm planning and investment in new supplies.
- Funding to develop and grow local abstractor groups.
- Streamlining of agriculture reservoir consent processes for both planning and abstraction licensing.

Energy generation:

- Ensure licence caps do not compromise investment in energy generation to meet the UK's net-zero commitment.
- Ensure that hydrogen projects have access to the water needed to contribute toward decarbonising the UK.

Regional economy:

- Stronger support by government and regulators for action to reduce non-household consumption.
- Building Regulations for water efficiency should promote rainwater harvesting and grey water recycling.

Internal Drainage Boards:

- Give IDBs wider powers and functions to allow them to take a bigger role in water resources management and carbon sequestration as part of integrated approaches to water management in the landscape.

Thank you

How to respond to the Regional Plan consultation:

Online:
web-based response form

By email:
contact@wre.org.uk

By post:
Water Resources East,
The Enterprise Centre,
University of East Anglia,
Norwich, NR4 7TJ

Consultation closes on 20th February 2023

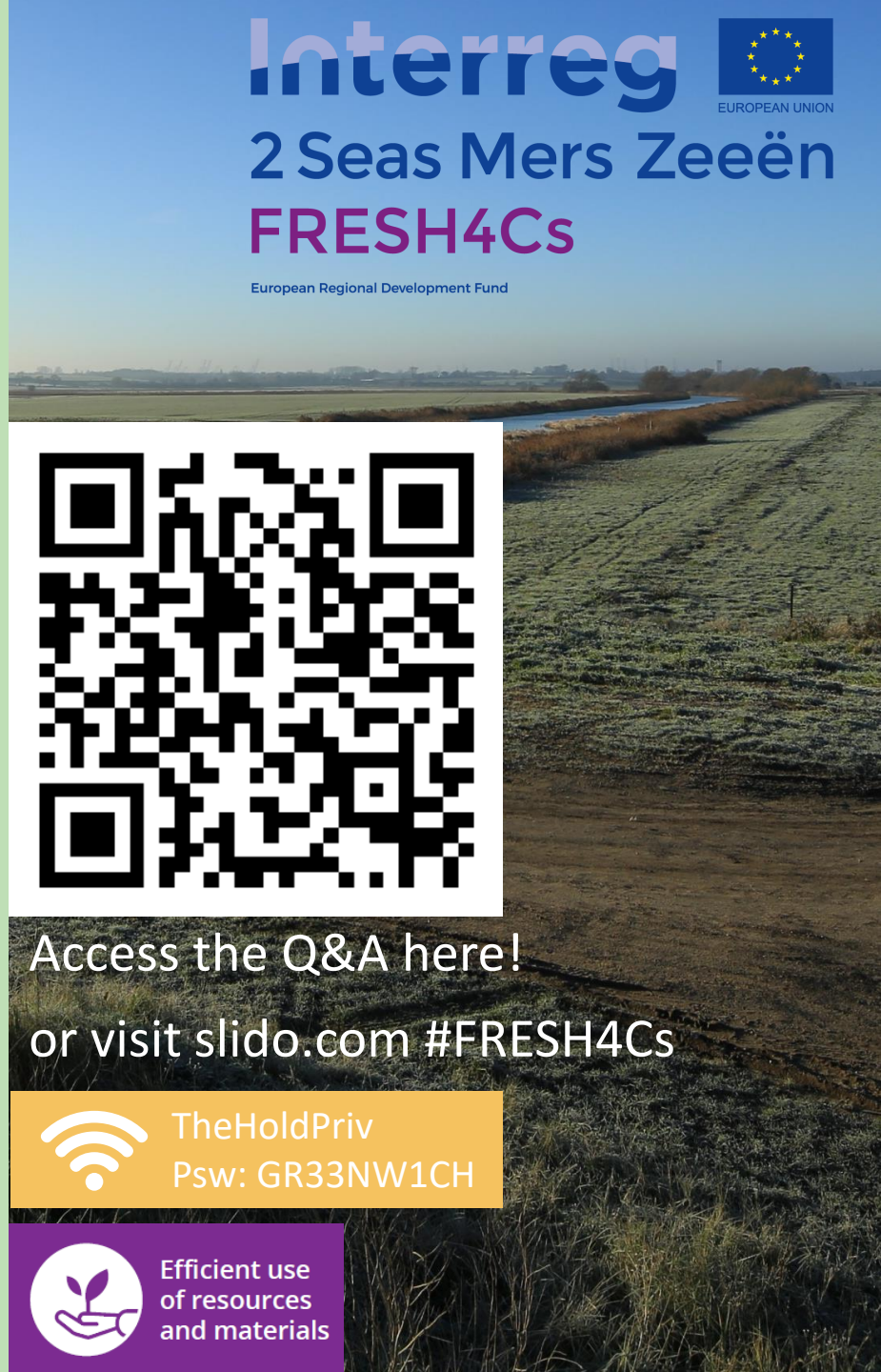
www.wre.org.uk
@DanielJ88 / @WaterREast
Water Resources East

Feasibility and demonstration of creek ridge infiltration in Braakman South

Niels Groot

Environmental Expert

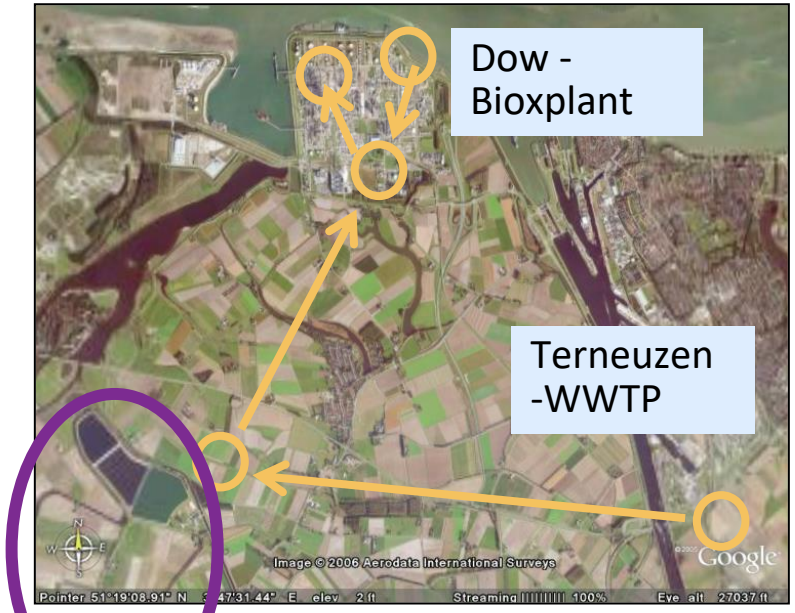
ckgroot@dow.com

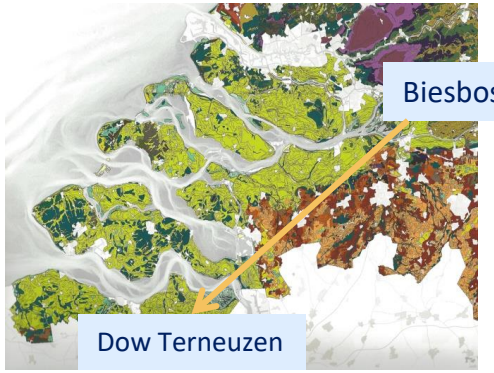


Click here to watch the Dow case video

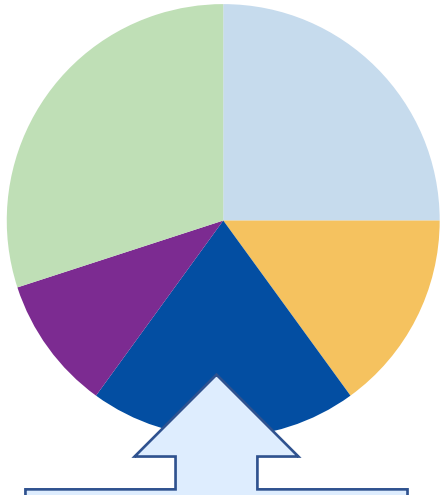
Dow's water management

- Water usage is ~ 20 million m³/y (70% of regional demand)
- Dow's objective –> minimize use of virgin freshwater (Biesboschwater)





Freshwater supply – 120 km



Replace virgin freshwater source by:
- process water
- rainwater
- wastewater

Sources of freshwater

- Surface Water
- Dow wastewater
- Biesbosch water
- Municipal wastewater
- Intern reuse (condensate)

Efficient use of resources and materials

FRESH4Cs case study objective

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Provide back-up freshwater source thru Creek Ridge Infiltration

- Drought periods
- Use by industry and local farmers

Regional feasibility for large scale subsurface storage

Demo site to establish design criteria for full scale

Project organization

- **Project partners**: Dow, HZ University of Applied Sciences
- **Observer partners**: Evides Industriewater (EIW), Waterboard, Province of Zeeland, Municipality of Terneuzen, ZLTO (farmers)
- **Expert knowledge**: Deltares

Demonstration site

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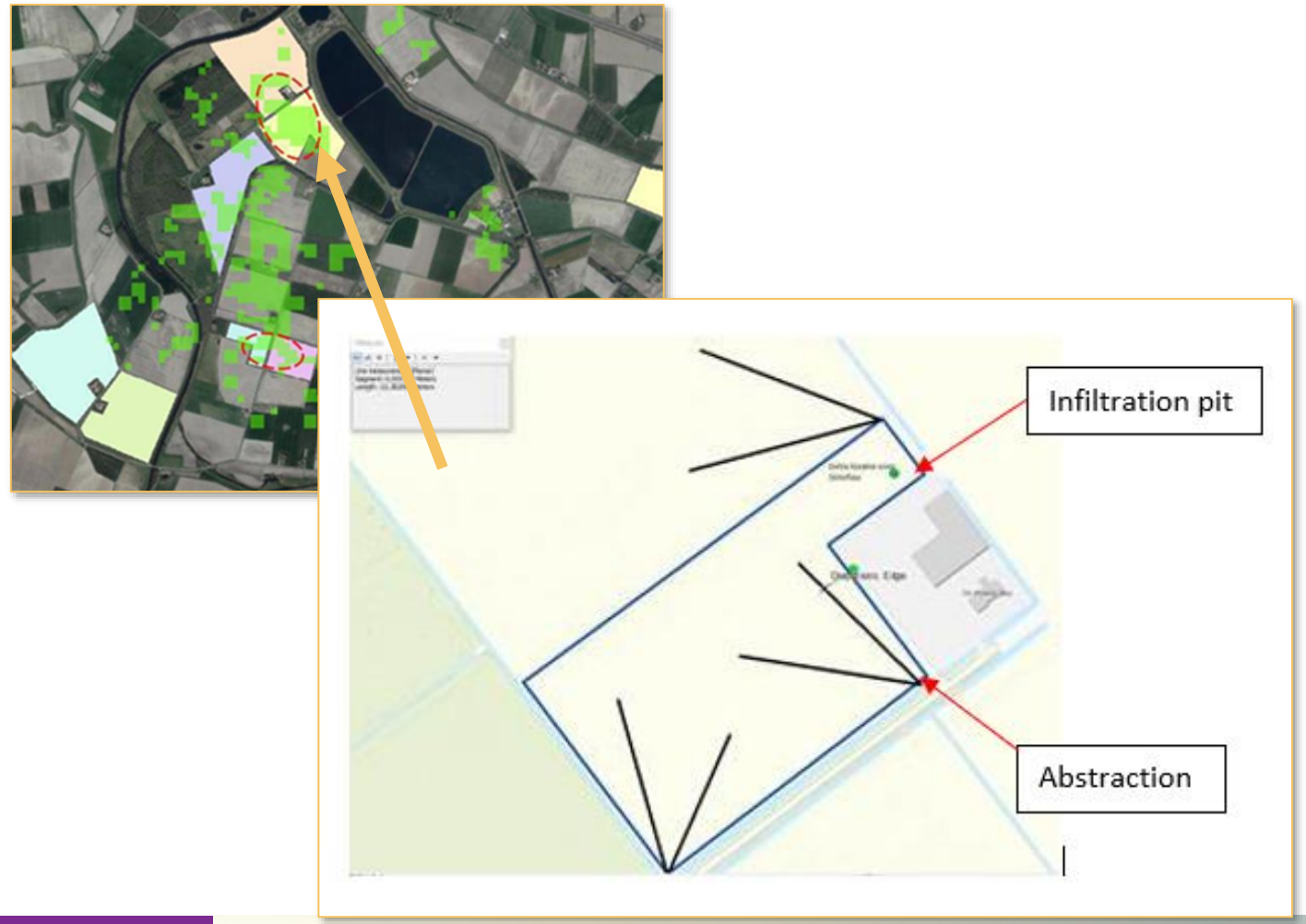

Dimensions

- 35,000 m² (3.5 ha)
- 3000 m³/ha infiltration
- 50% recovery
- Natural infiltration at -0.5m
- Withdrawal from deep drains at -5m

Efficient use of resources and materials

Demonstration site

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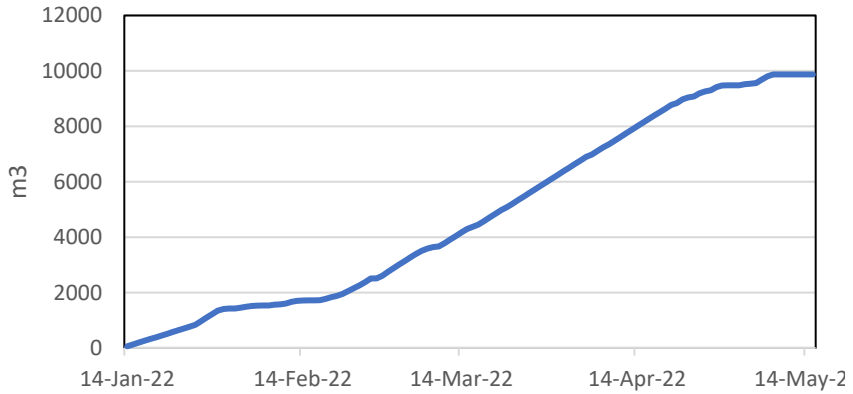
Monitoring

- Water quality
- Groundwater level
- Salinity gradient

Results

- 50% withdrawal feasible
- Raw water did not always meet criteria for infiltration
- Area likely too small to allow lens growth

Infiltrated water 2022



Efficient use of resources and materials

Raw water sourcing

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Full scale potential

Three nearby sources:

1. Isabella canal (too saline most of the year)
2. Leopold canal (fresh, but high in contaminants)
3. **Belgian polders**
   - Fresh and moderate in contaminants, e.g. pesticides and heavy metals
   - Quantity sufficient in most years
   - Allowed for infiltration by Waterboard
   - Possible use of Evides' infrastructure

Outlook for large scale implementation

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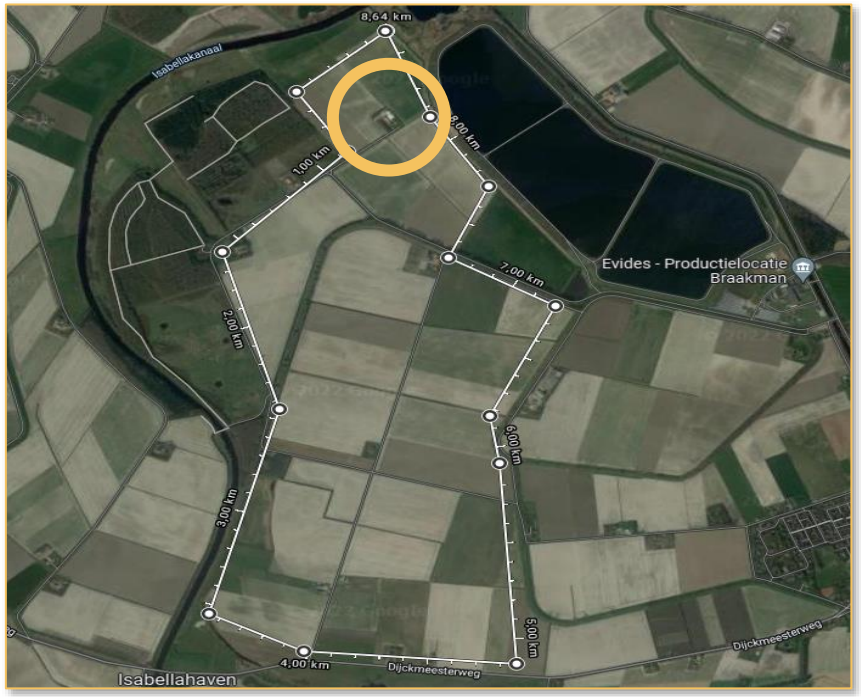
Full-Scale development

1 million m³/y storage (300 ha)

0.5 million m³/y abstraction for industry and farmers

- Use of excess water from Belgian polders
- Pre-treatment to meet infiltration criteria
- Use Evides' infrastructure
- Install infiltration, abstraction drainage, pumping equipment and instrumentation



Feasibility

Range 0.35 – 0.50 Euro/m³

Collaboration model (socio-economic aspects) to be developed further

Lessons learned:
Workshop with local authorities to create a simpler legislative roadmap for such techniques

Summary

Concept for large scale CRI and reuse seems **feasible and affordable**

Evides Basins

Winter

Pre-treatment

Creek Ridge Infiltration

Summer

Water storage in Kwetshage

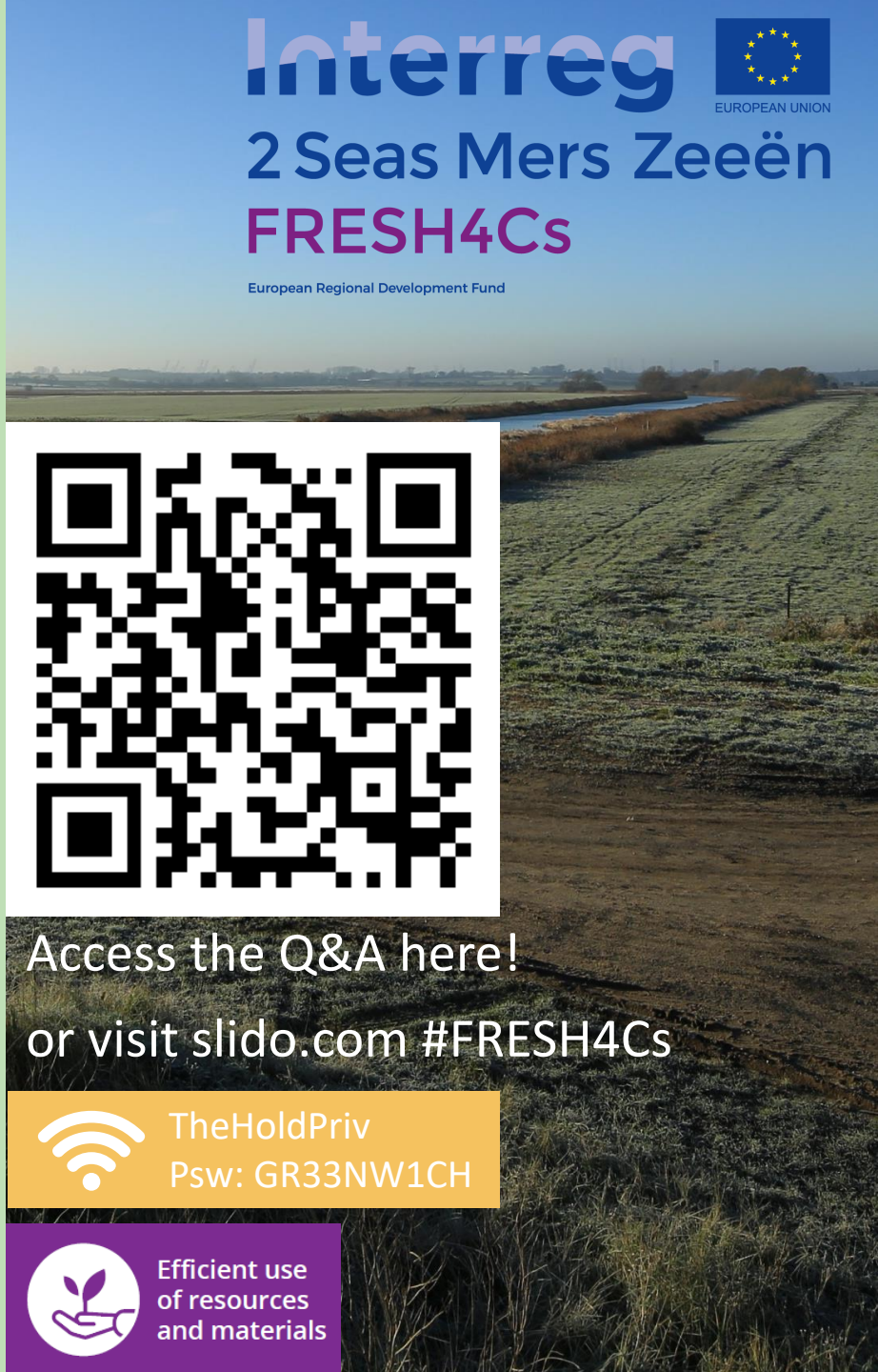
Edgard Daemen

Project Manager / Ecologist

VLAAMSE LAND MAATSCHAPPIJ

Vlaanderen is open ruimte

edgard.daemen@vlm.be



Kwetshage

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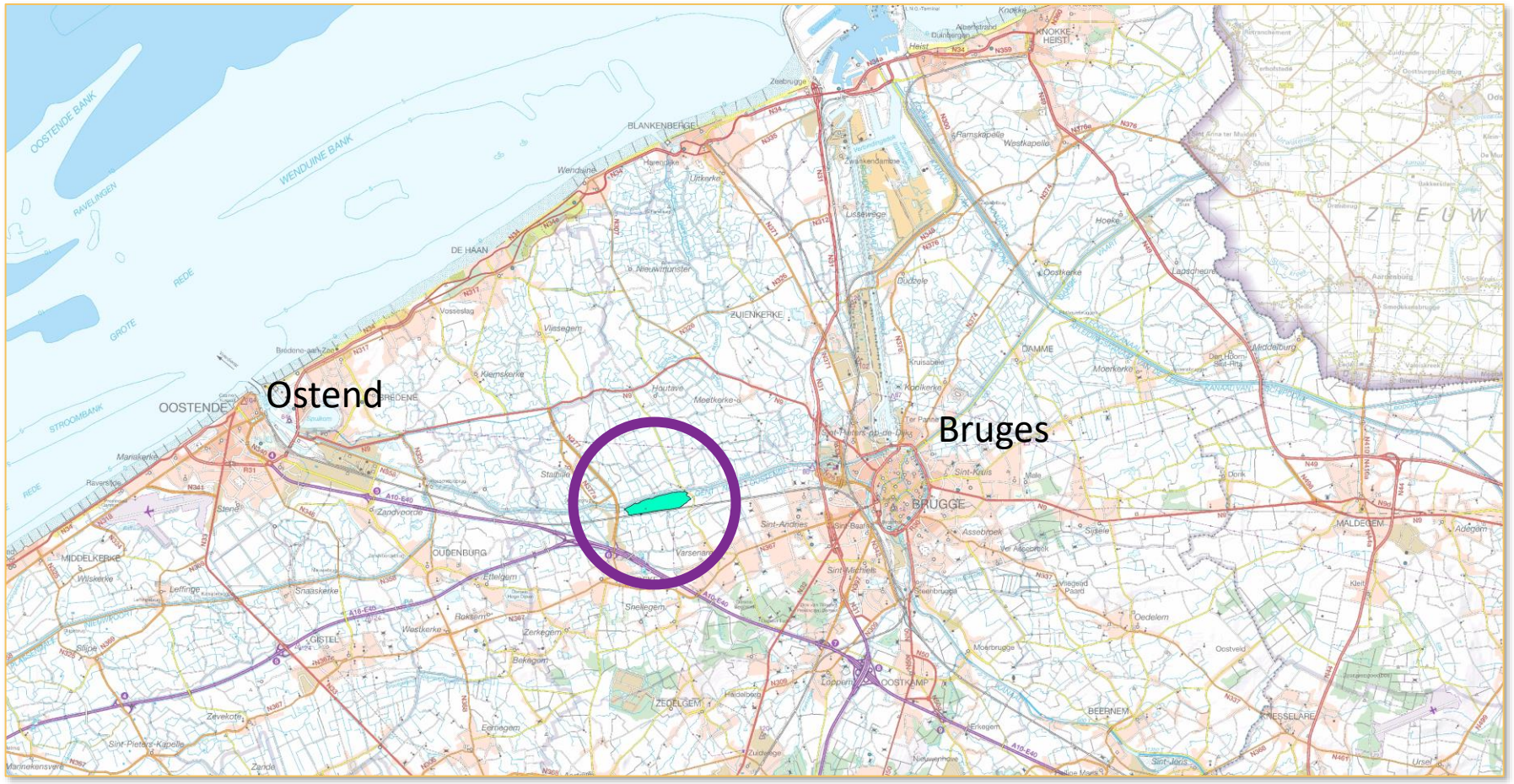

Efficient use of resources and materials

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Efficient use of resources and materials

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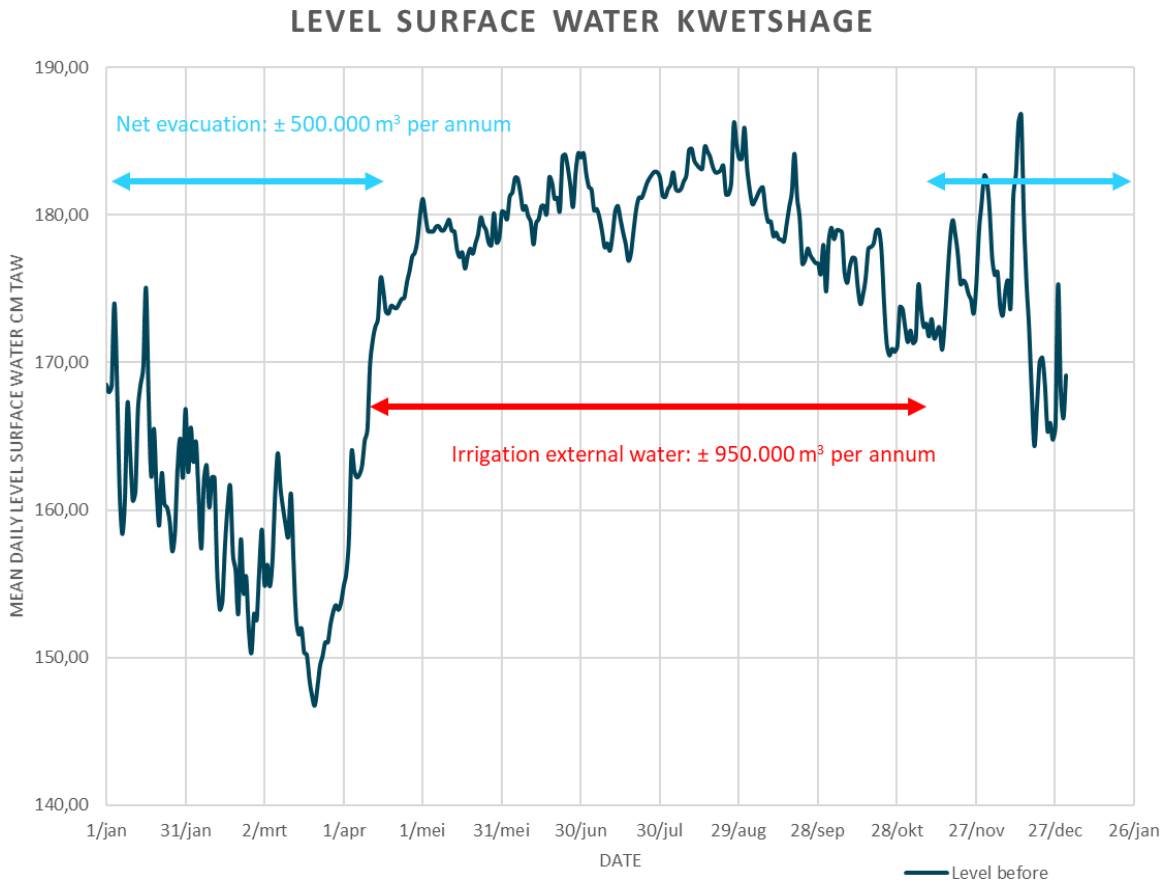
+2.3 m TAW: average sea level



Efficient use of resources and materials

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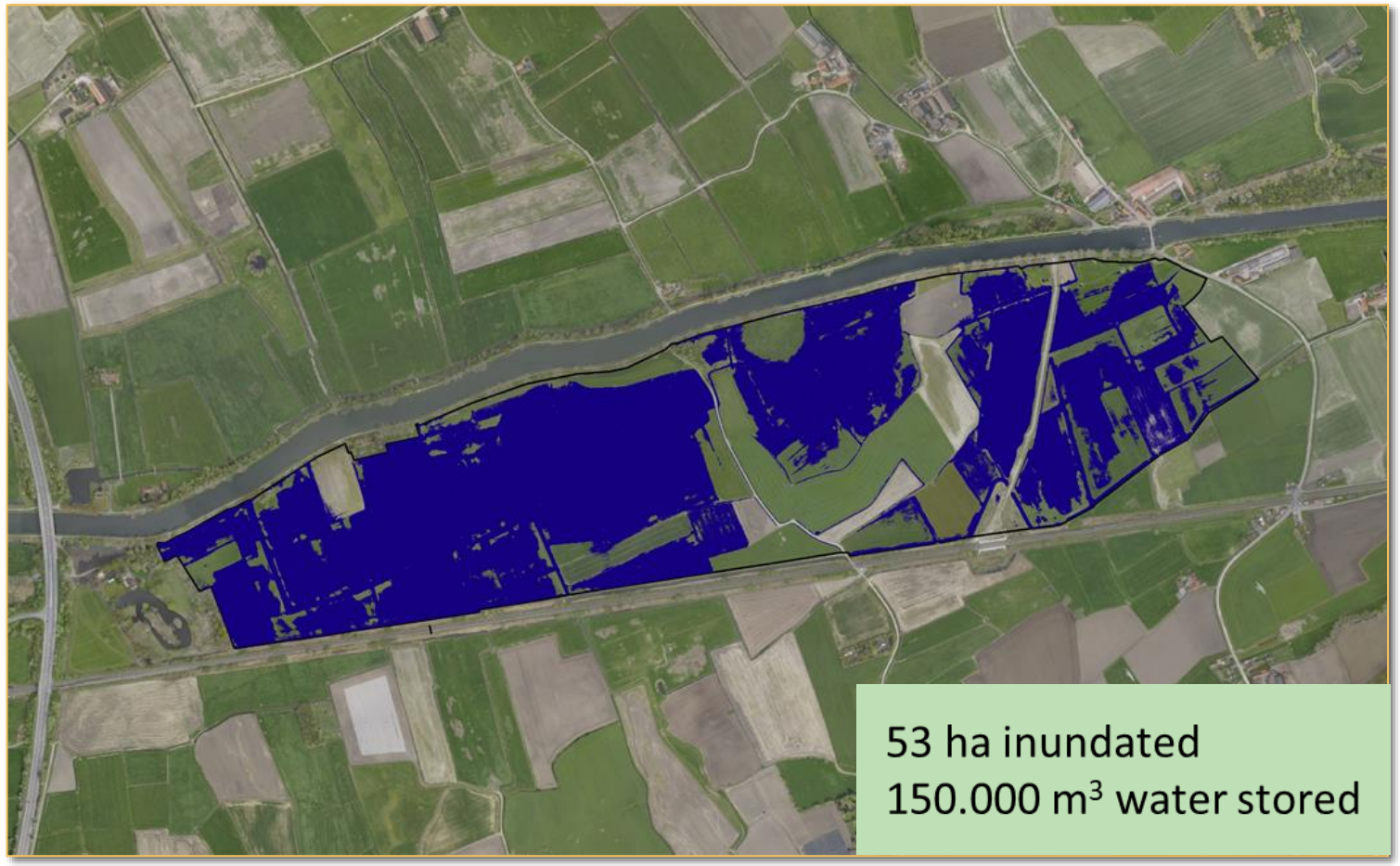

Efficient use of resources and materials

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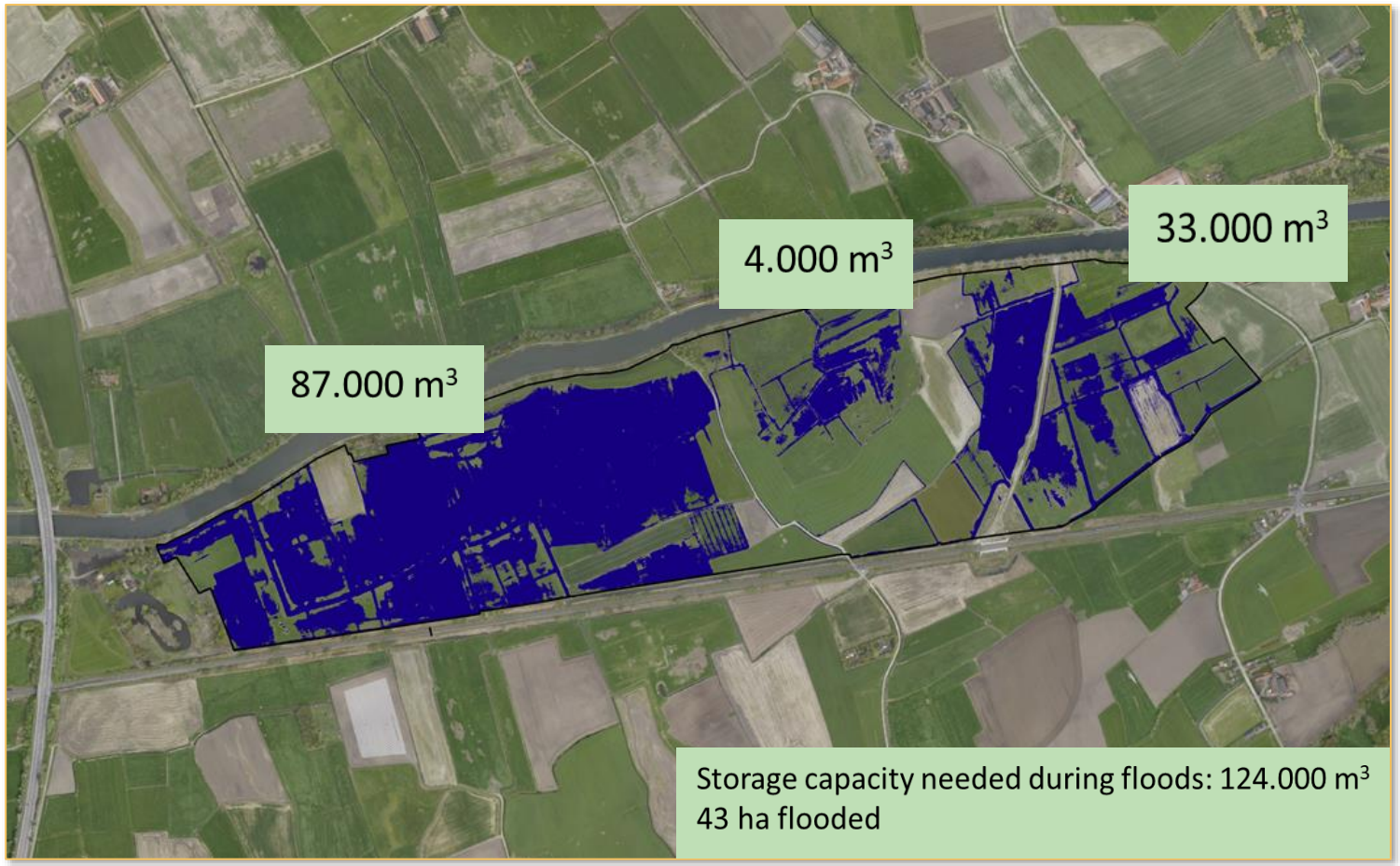

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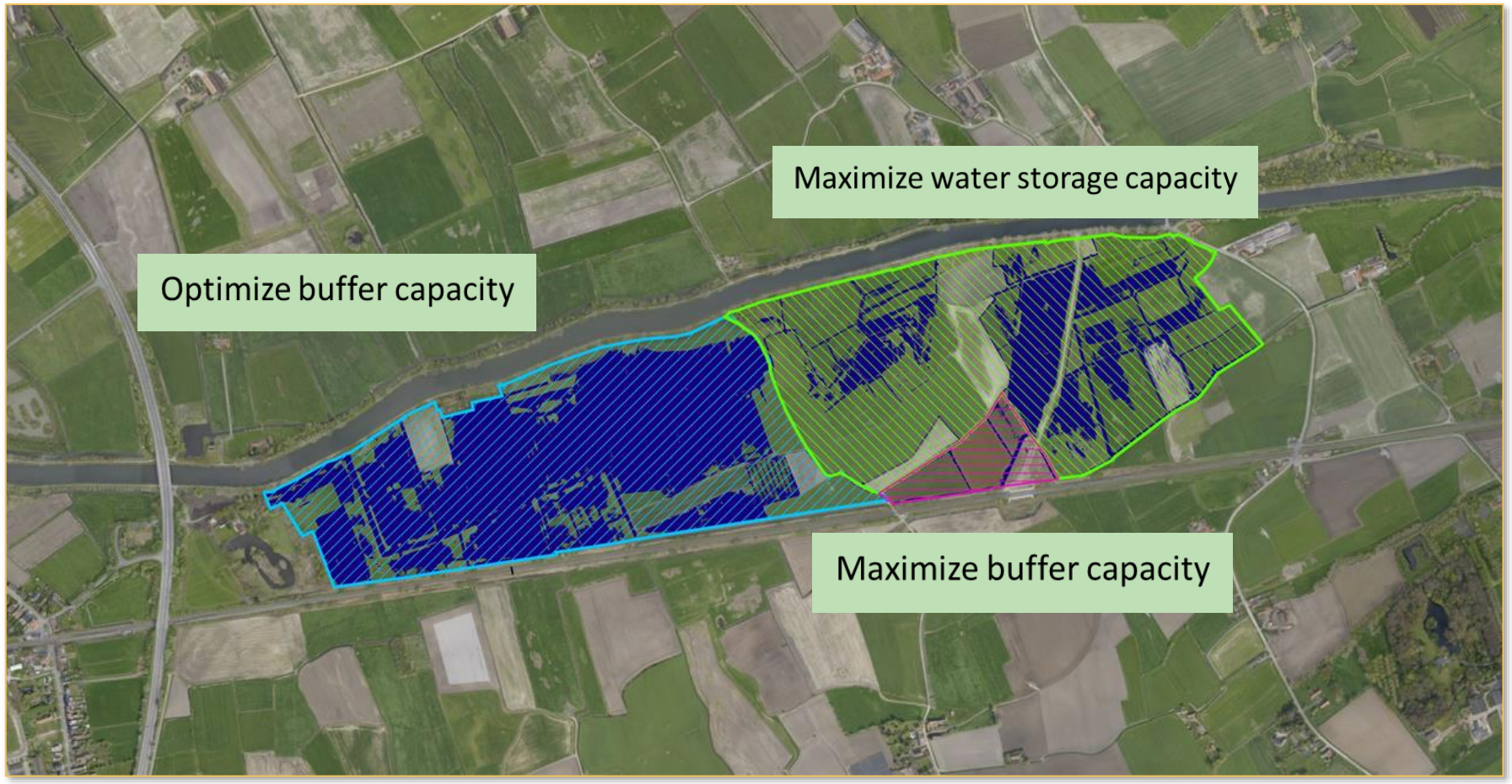

Efficient use of resources and materials

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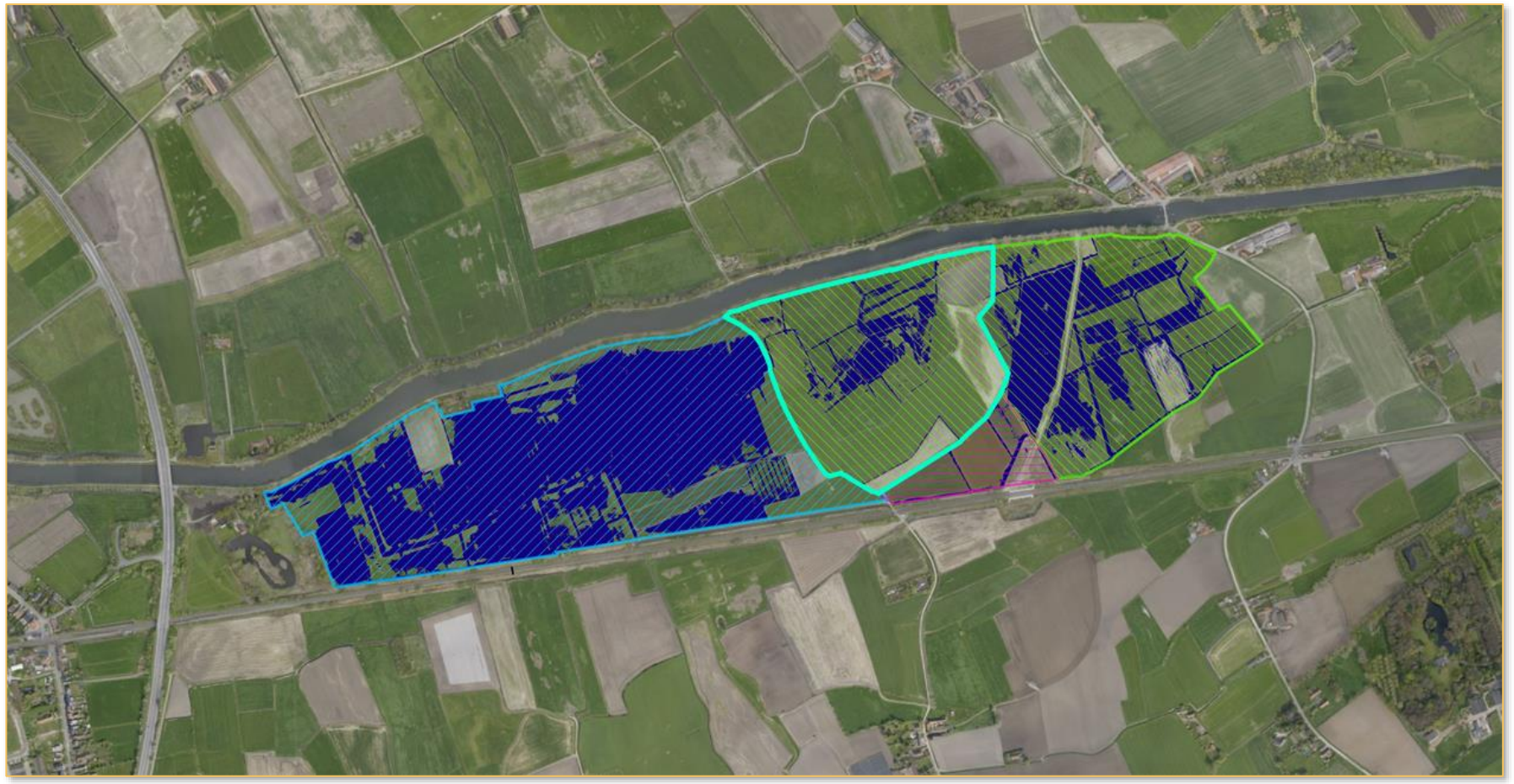

Efficient use of resources and materials

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Objectives demo FRESH4Cs

- Maximising water retention in winter
  - Surface water
  - Infiltration
    - Inundated area
    - Creek ridge
- Retain (~~increase~~) buffer capacity during floods (overall project)

Kwetshage

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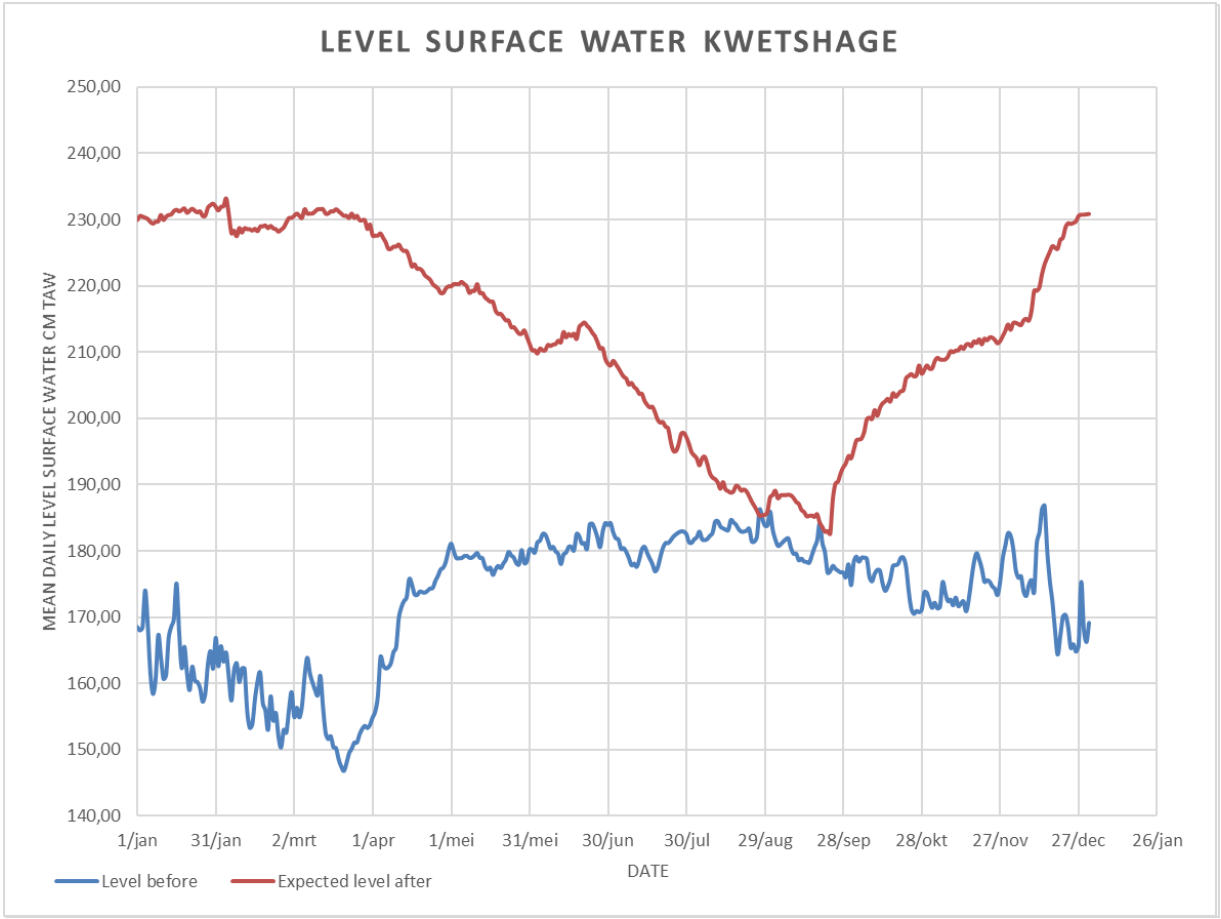
Winter: + 70 cm

Summer: + 10 cm



Efficient use of resources and materials

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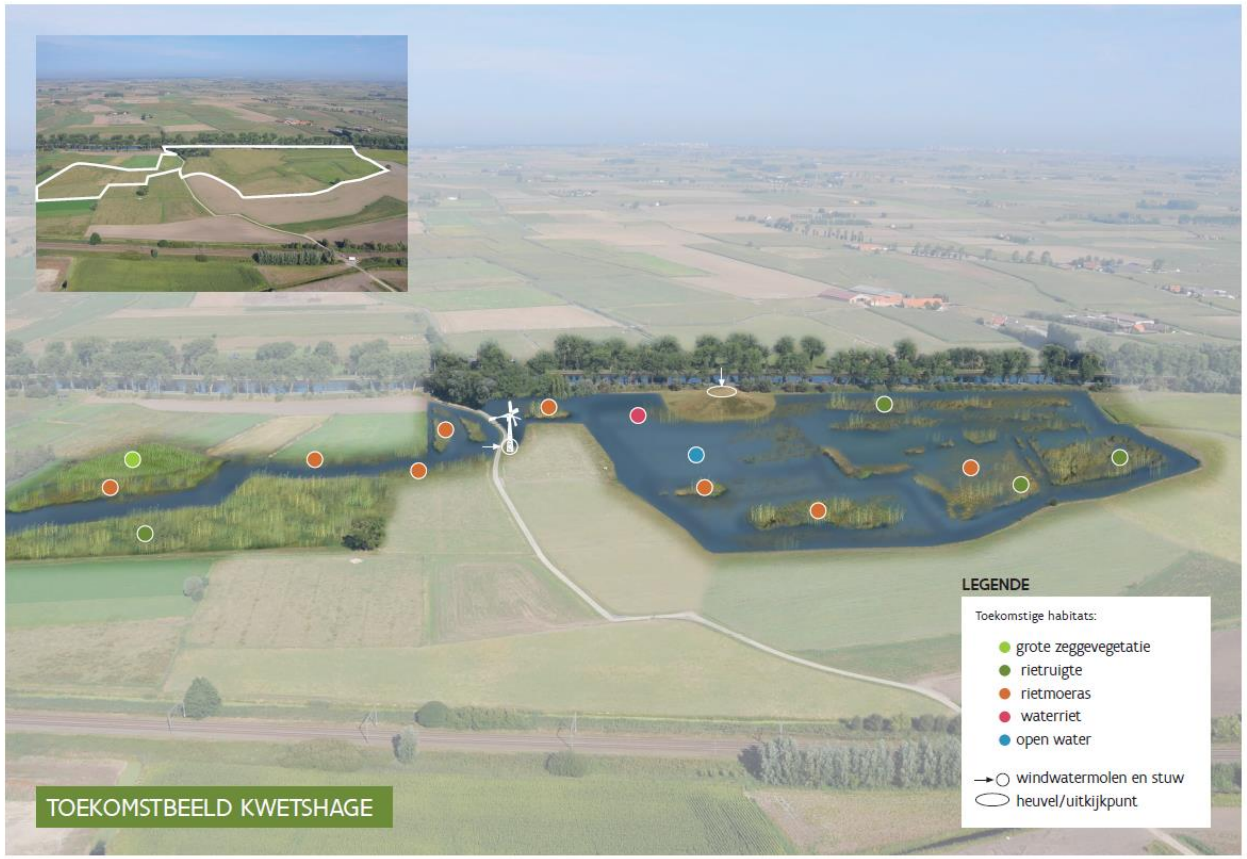
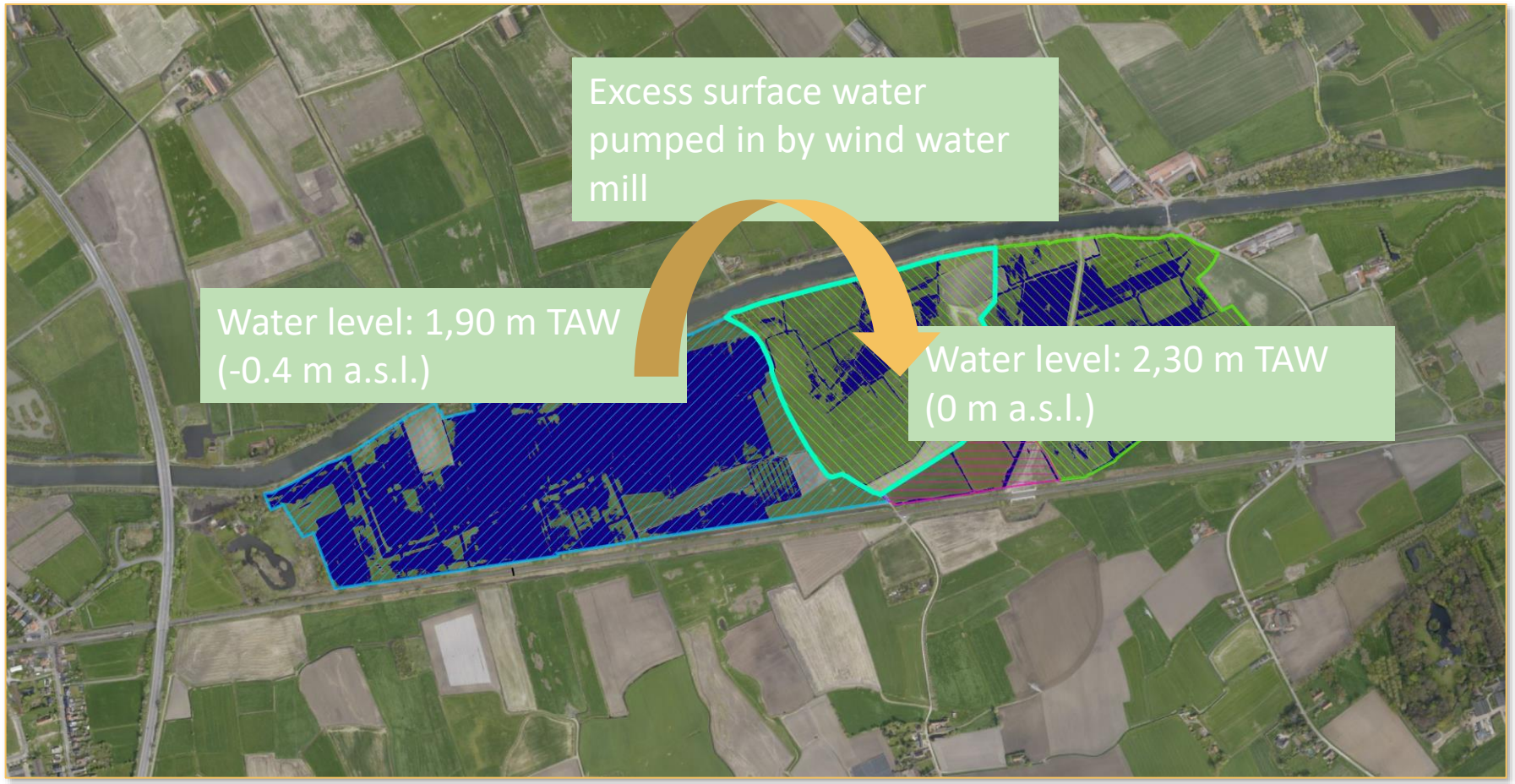


Efficient use of resources and materials


Excess surface water pumped in by wind water mill
Water level: 1,90 m TAW (-0.4 m a.s.l.)
Water level: 2,30 m TAW (0 m a.s.l.)

Kwetshage

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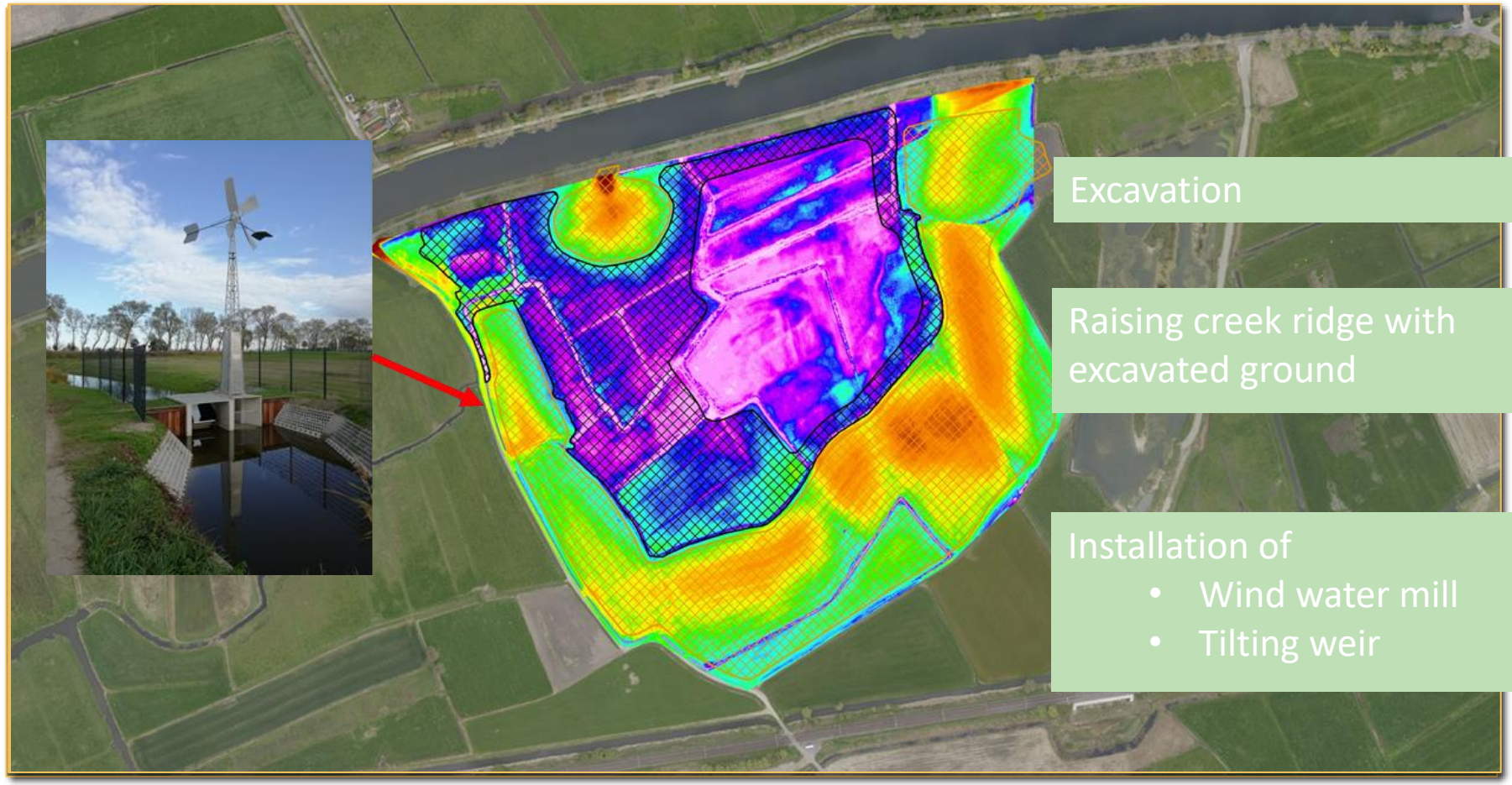

Excavation

Raising creek ridge with excavated ground

Installation of
- Wind water mill
- Tilting weir

Efficient use of resources and materials

Kwetshage

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Efficient use of resources and materials

Kwetshage

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Efficient use of resources and materials

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Performance

- Pumping capacity water mill: ± 750 m^3 / day
- Maximum storage capacity: 42.500 m^3
- Effective storage capacity (minimum level 1,90 m TAW): 36.000 m^3
- Time to fill the full capacity: 50 to 60 days
- Infiltration estimated 140 m^3 /day

Kwetshage

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Conclusion

- An effective storage capacity of 36.000 m^3 has been generated (maximum 42.000 m^3)
- Infiltration to groundwater is estimated at 20.000 m^3/year (55% of storage capacity)
- Overall gain of 15.000 m^3 of buffer capacity during floods

Efficient use of resources and materials

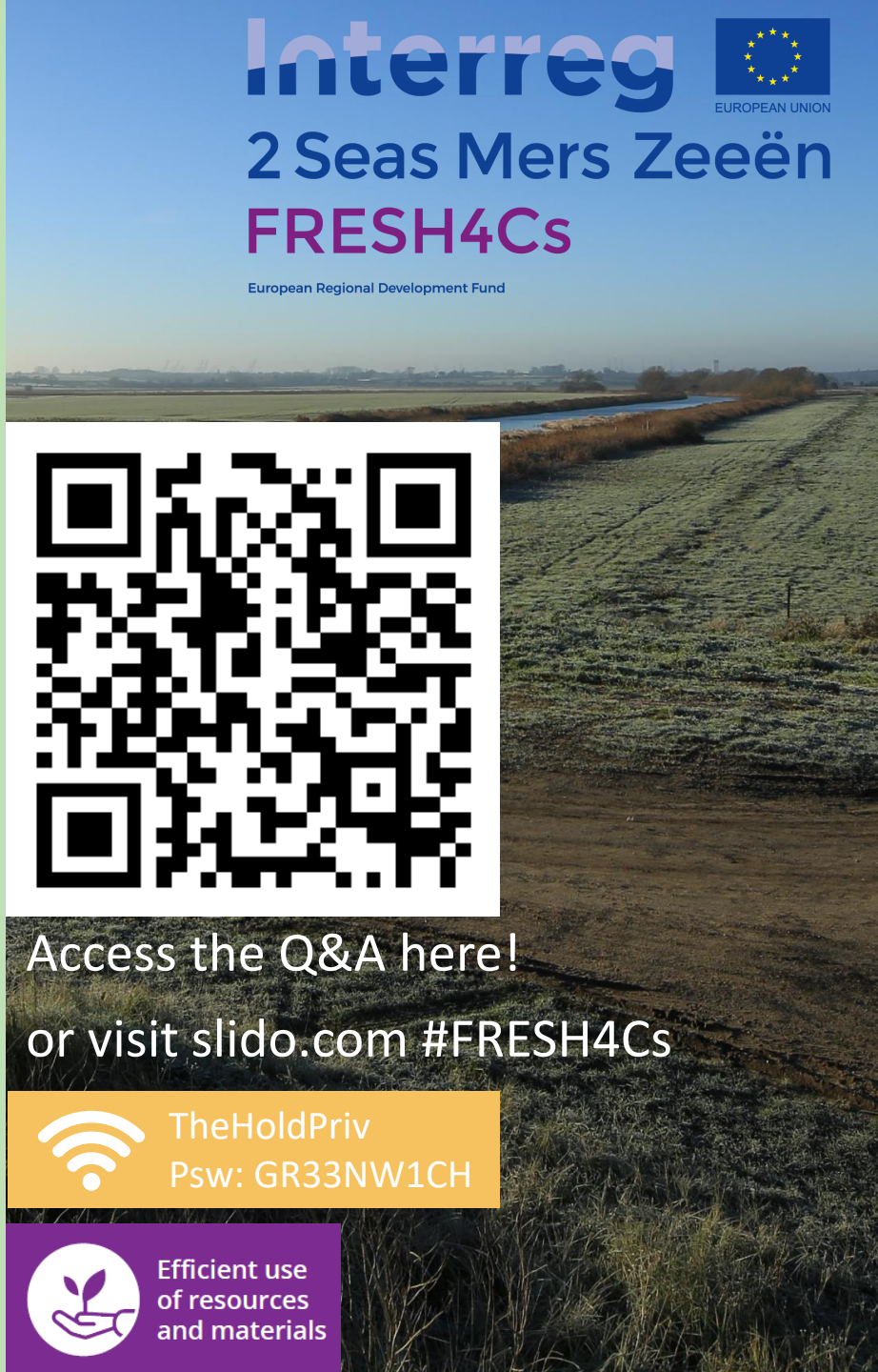
Treating water for reuse in agriculture

Mariska van Dalen

Sustainability by Design Manager

LambWeston
SEEING POSSIBILITIES IN POTATOES

mariskavandalen@lambweston.eu



About Lamb Weston

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European Regional Development Fund

6 factories in Europe

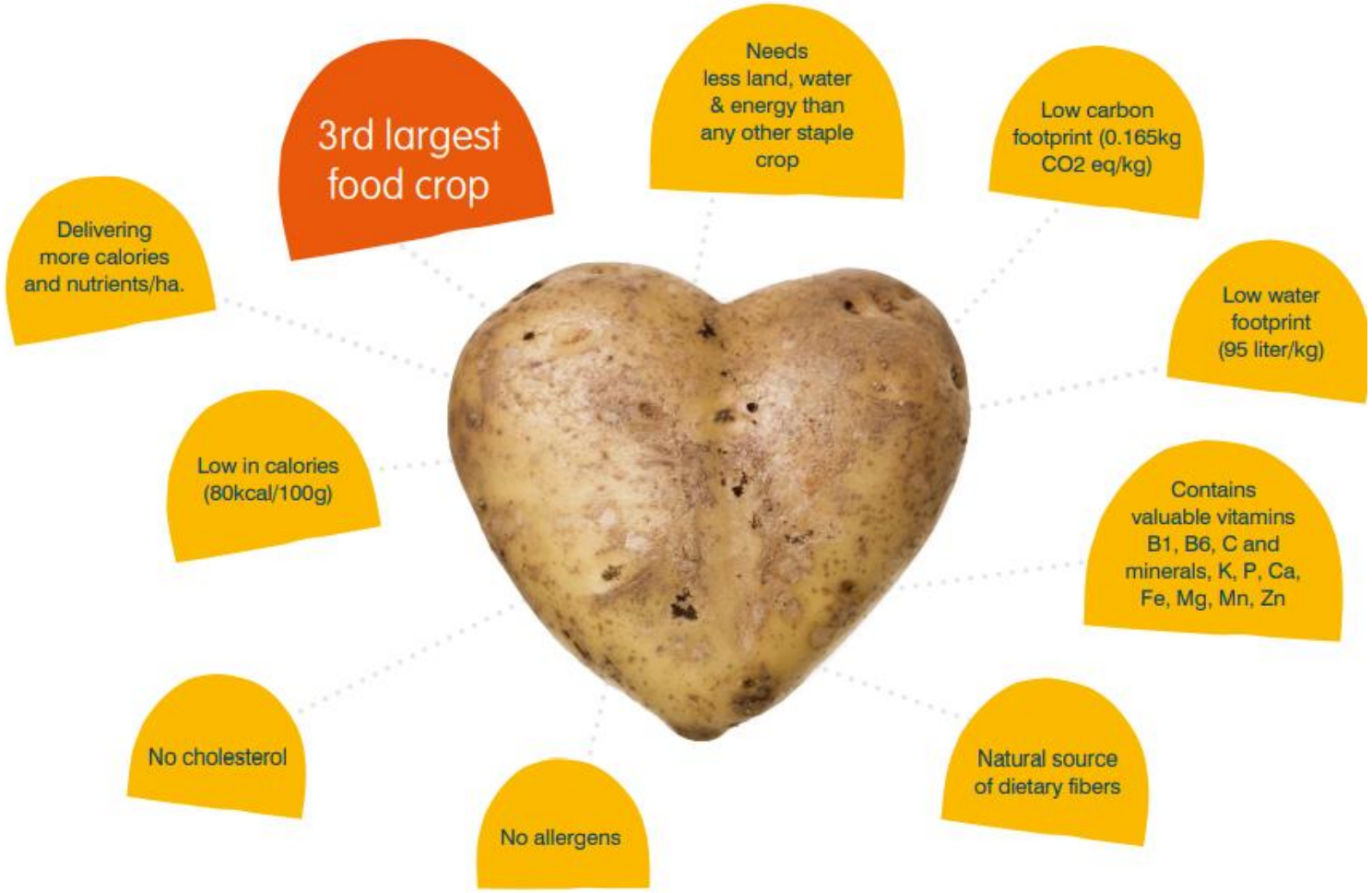
900 thousand tons produced in Europe

1.6 million tons of potatoes used in Europe

- 0.5 million m^3 water evaporated in processing
- 4.3 million m^3 wastewater discharged, cleaned onsite

Efficient use of resources and materials

32,000 ha farm land



Value of water

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Efficient use of resources and materials

Redesign for local reuse

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Removal P and N?

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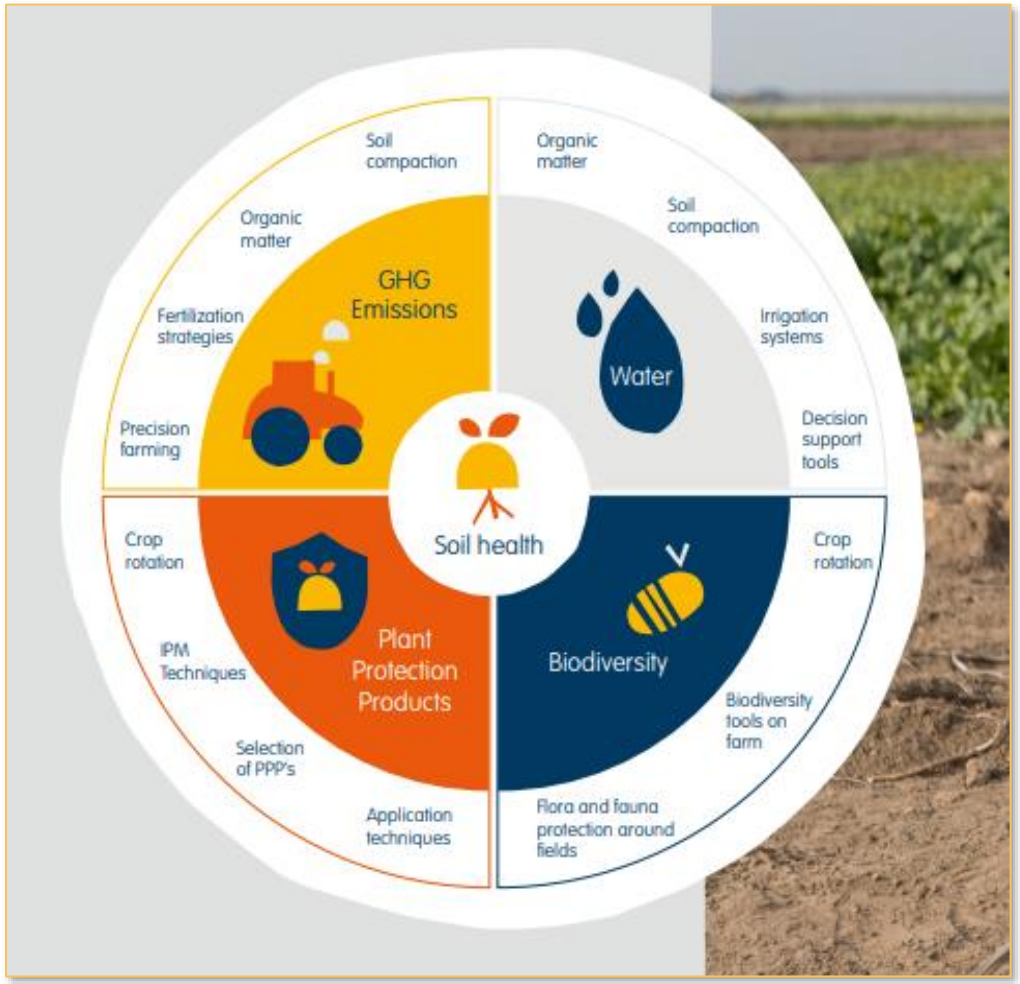

How to transport our water?

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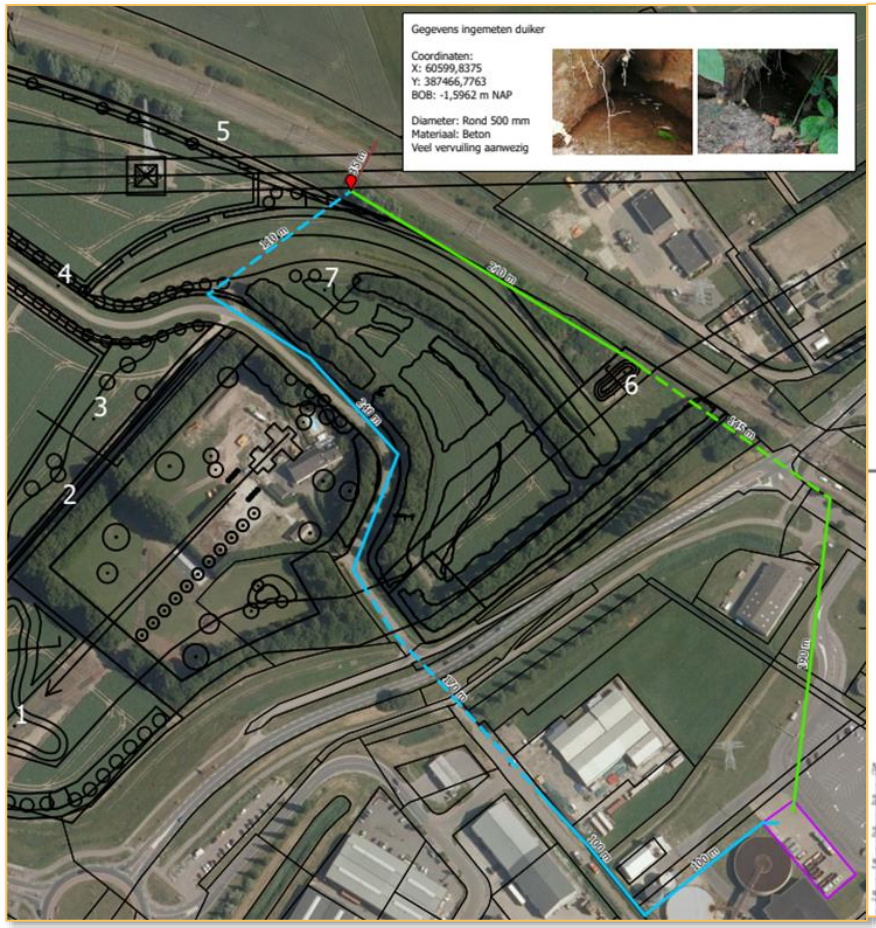

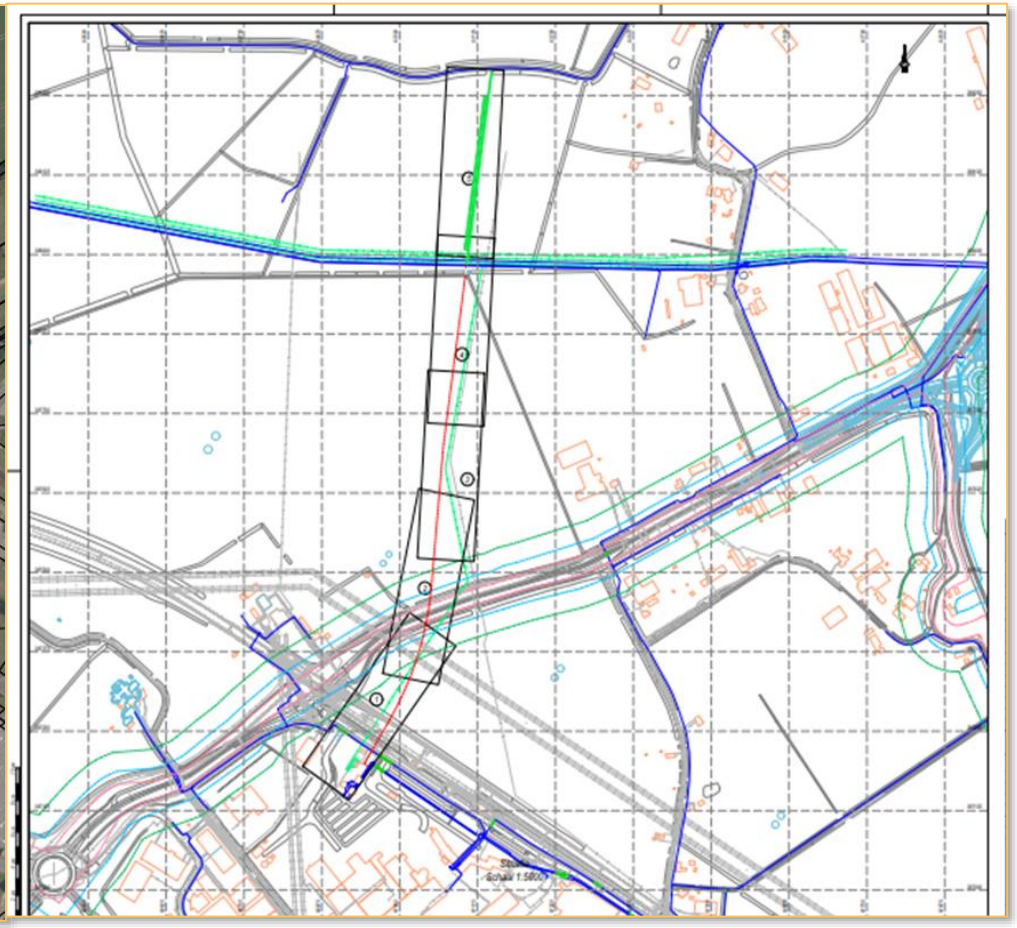

Efficient use of resources and materials

Creek ridge infiltration?

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Efficient use of resources and materials

Q&A

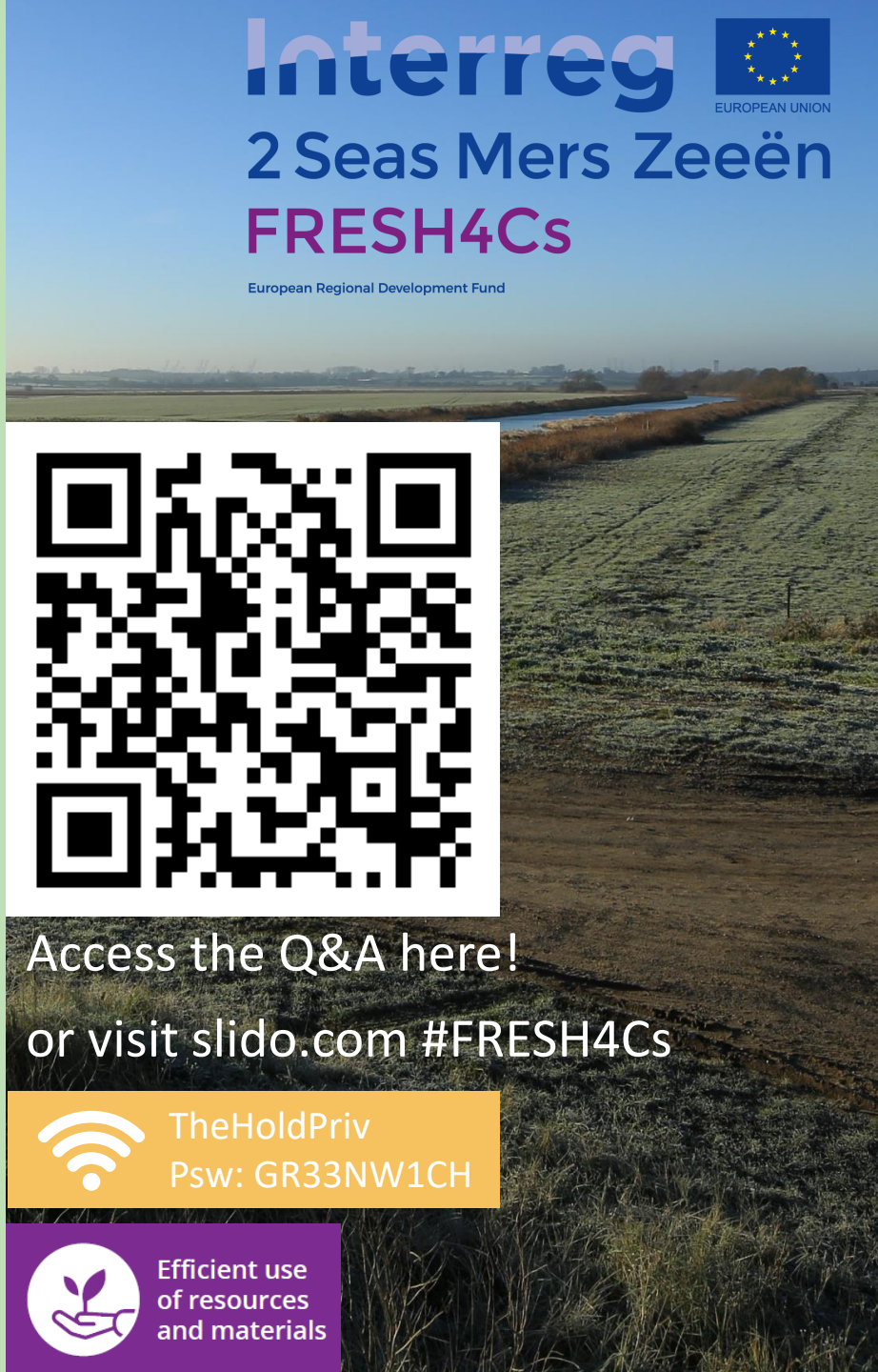
Lamb Weston
SEEING POSSIBILITIES IN POTATOES

WRE
WATER RESOURCES EAST

VLAAMSE LAND MAATSCHAPPIJ

Vlaanderen
is open ruimte

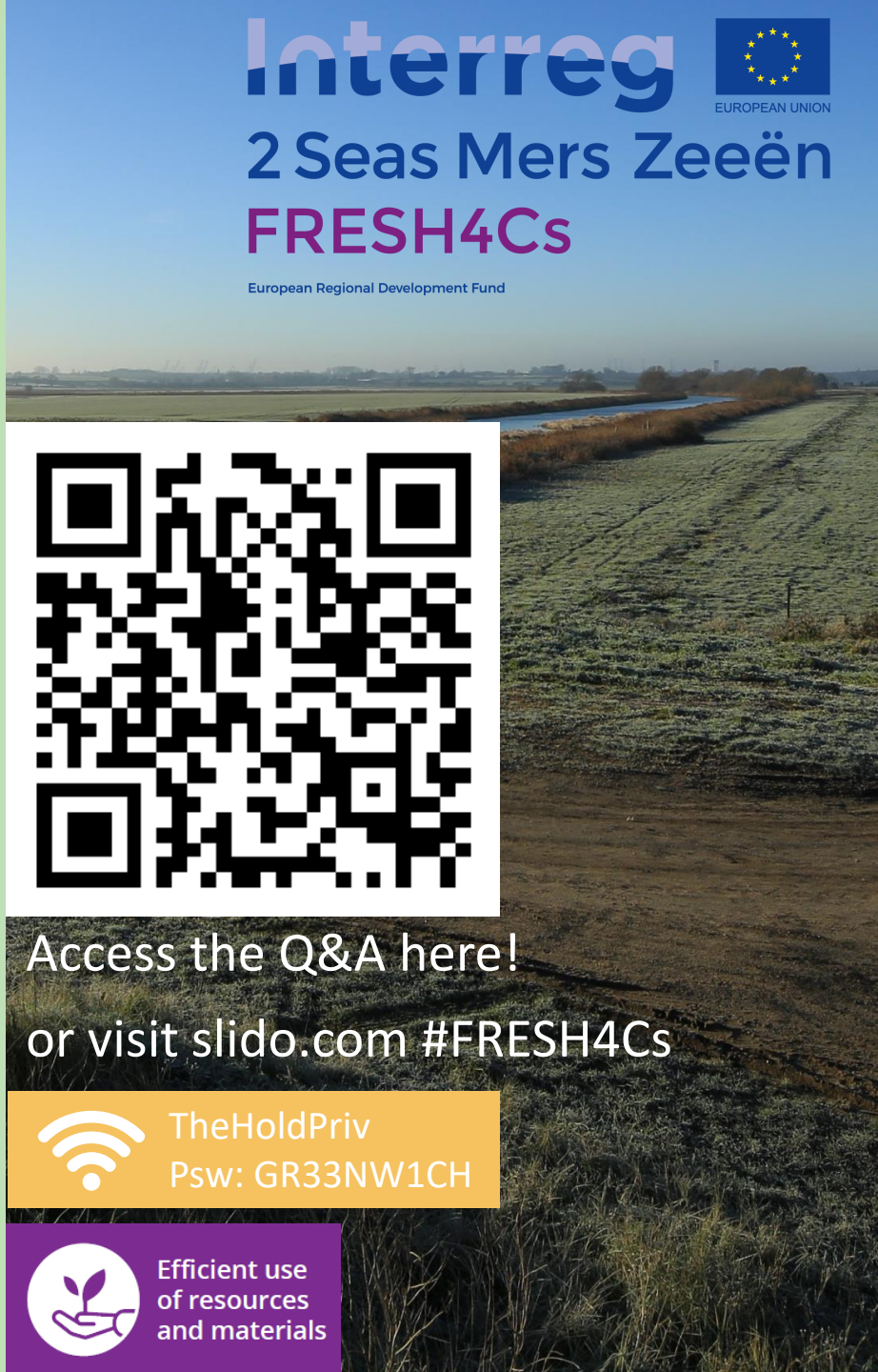
DOW



Lunch break

We'll be back at 1 PM! (UK)

We'll be back at 14:00! (BE, NL)



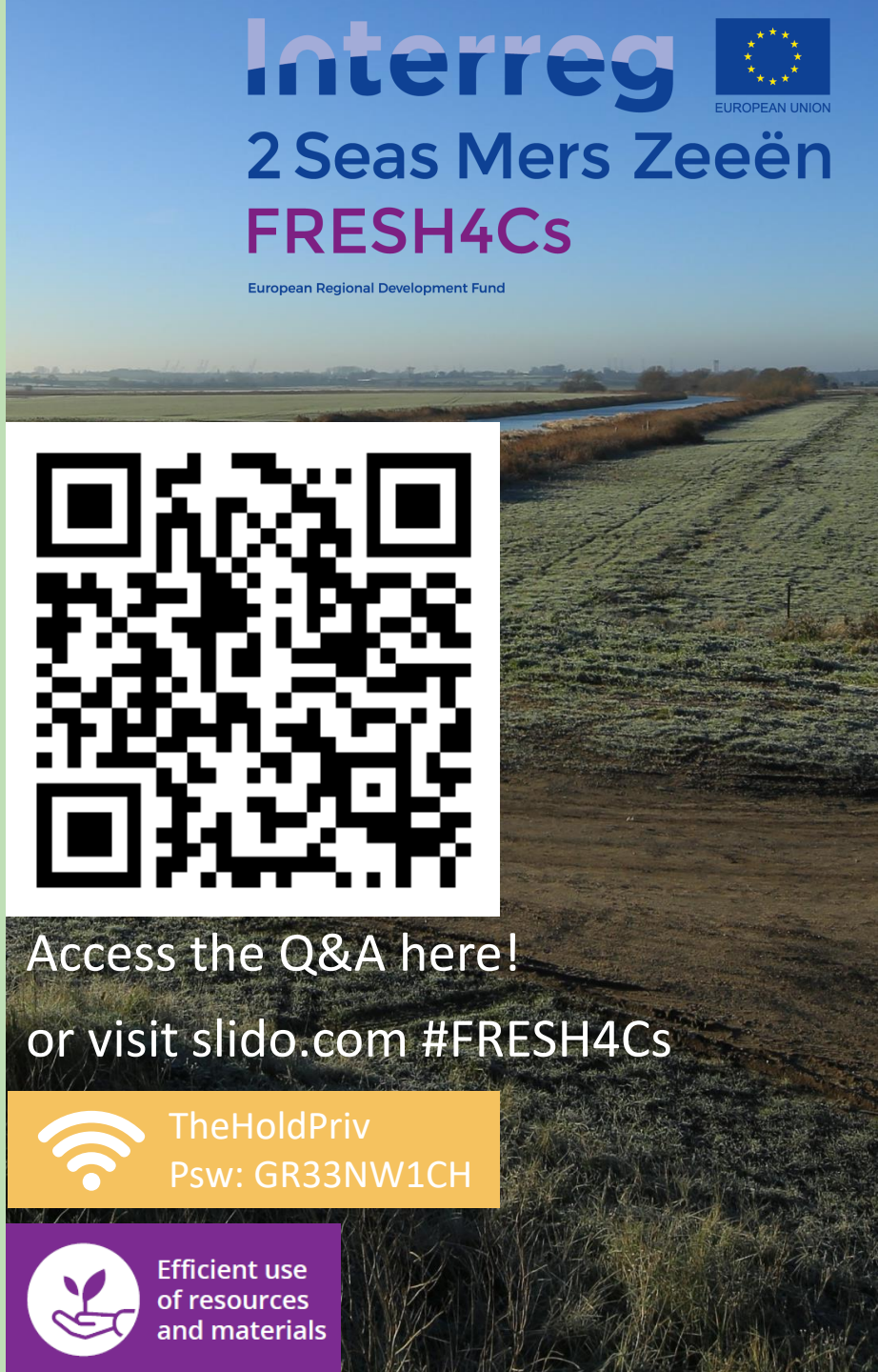
Managed aquifer recharge and creek ridge infiltration

Ane Wiersma

Senior Researcher

Deltares

Ane.Wiersma@deltares.nl



Deltares

enabling delta life

Deltares

Managed aquifer recharge as the solution to freshwater scarcity?

Ane Wiersma

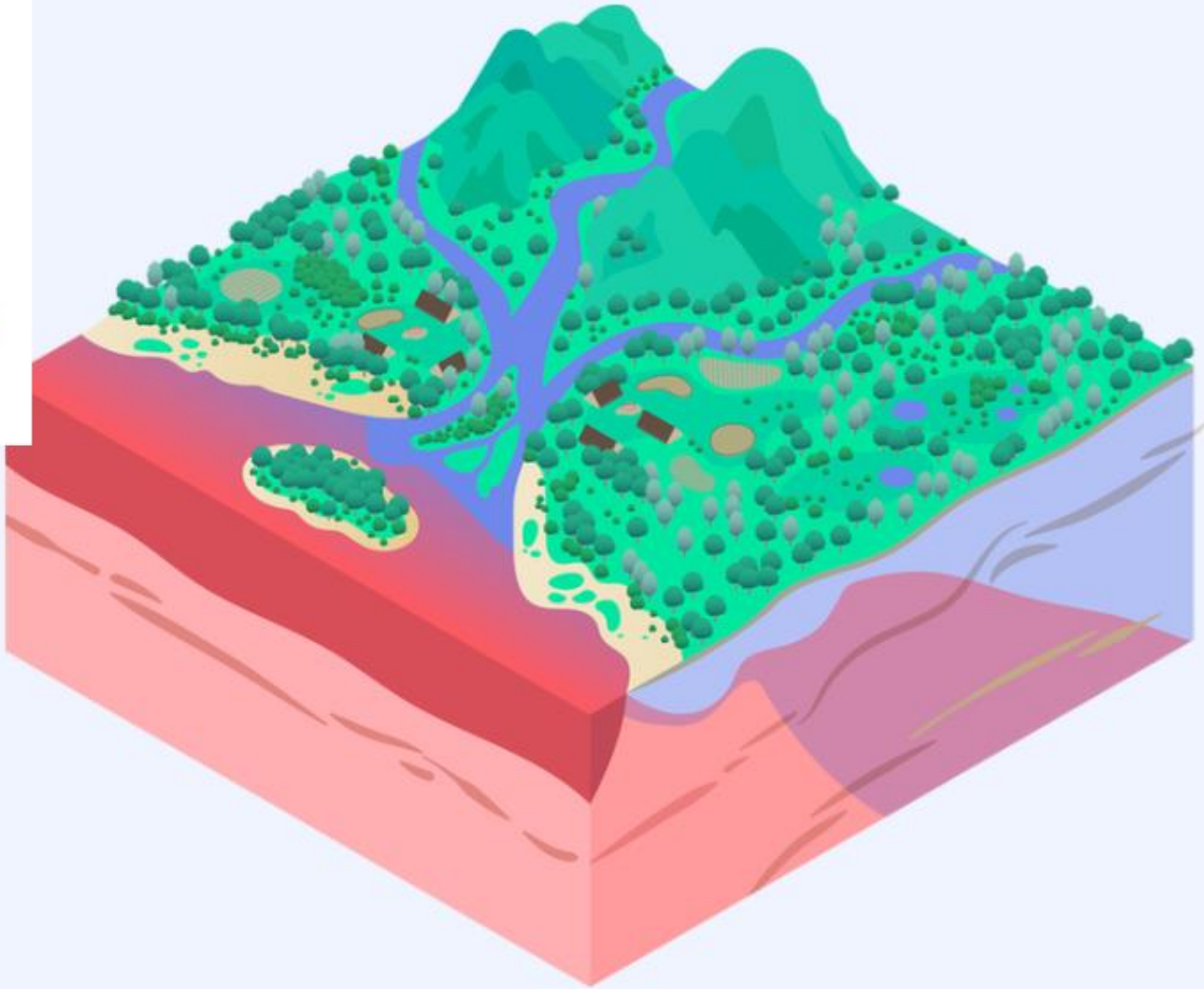
Subsurface and groundwater systems

3 February 2023

Salinisation of the land in time

The past

In the distant past barely any humans permanently lived in delta areas, mostly due to the hunter-gatherer's nomadic lifestyles. This slowly changed as they began to grow their food and spend more time in once place.

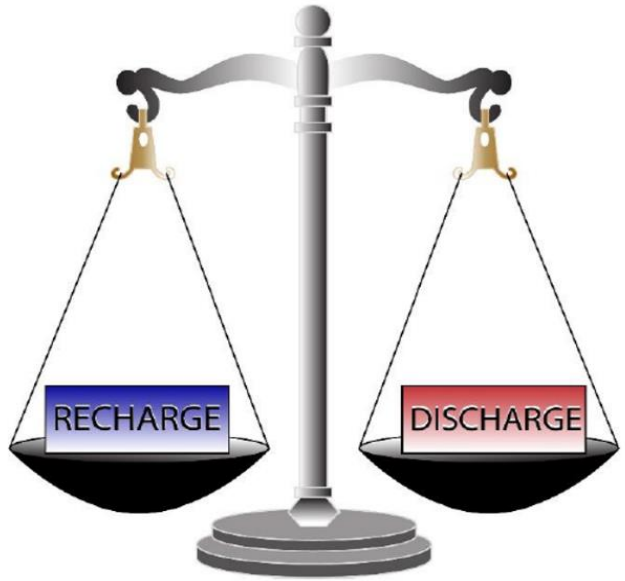


Legend

- Salt water
- Fresh water
- Brackish water

Past | Present | Future

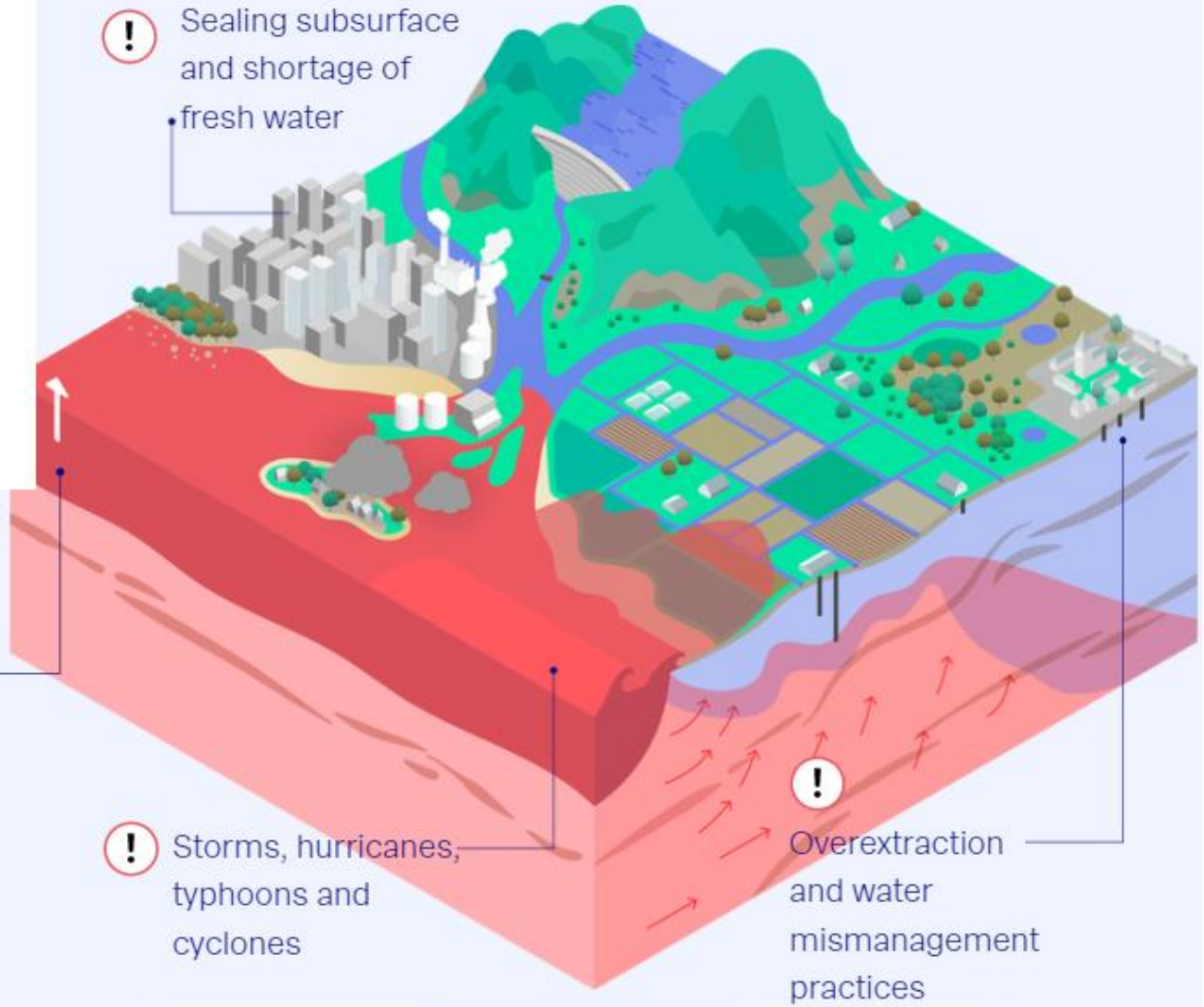
a) Prior to development



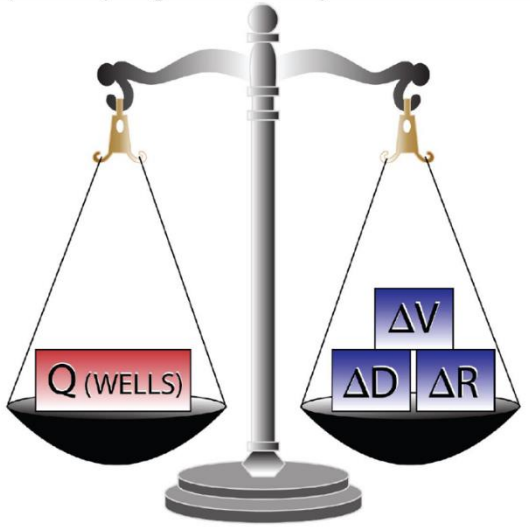
Today deltas are increasingly populated. This is due to the economic advantages, good soil for agriculture and sufficient water, water management, and because we are equipped to handle the threats posed by flooding.

Salinisation of the land in time

The present



b) Developed groundwater system

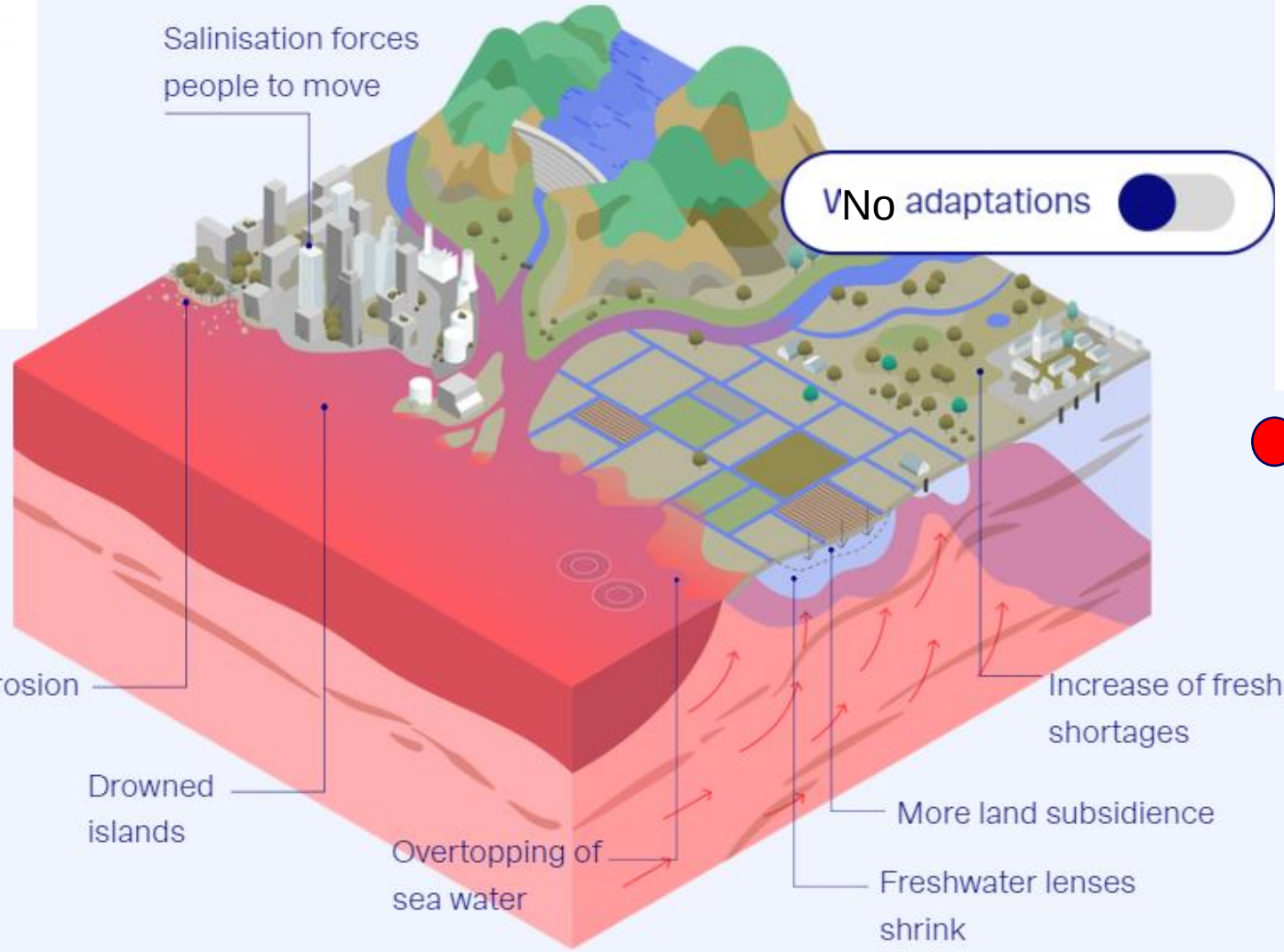


- Q = discharge wells
- ΔV = change storage
- ΔD = change discharge
- ΔR = change recharge

The future

In order to safeguard our current standard of living and safety, we must adapt to the new situation.

Will we be able to make the change in time?



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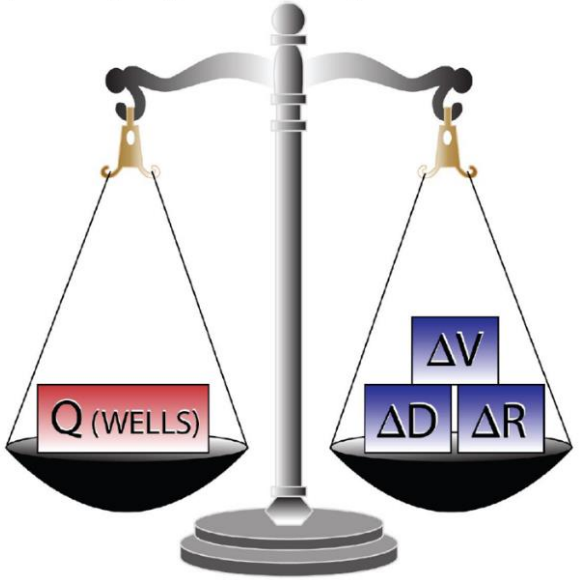

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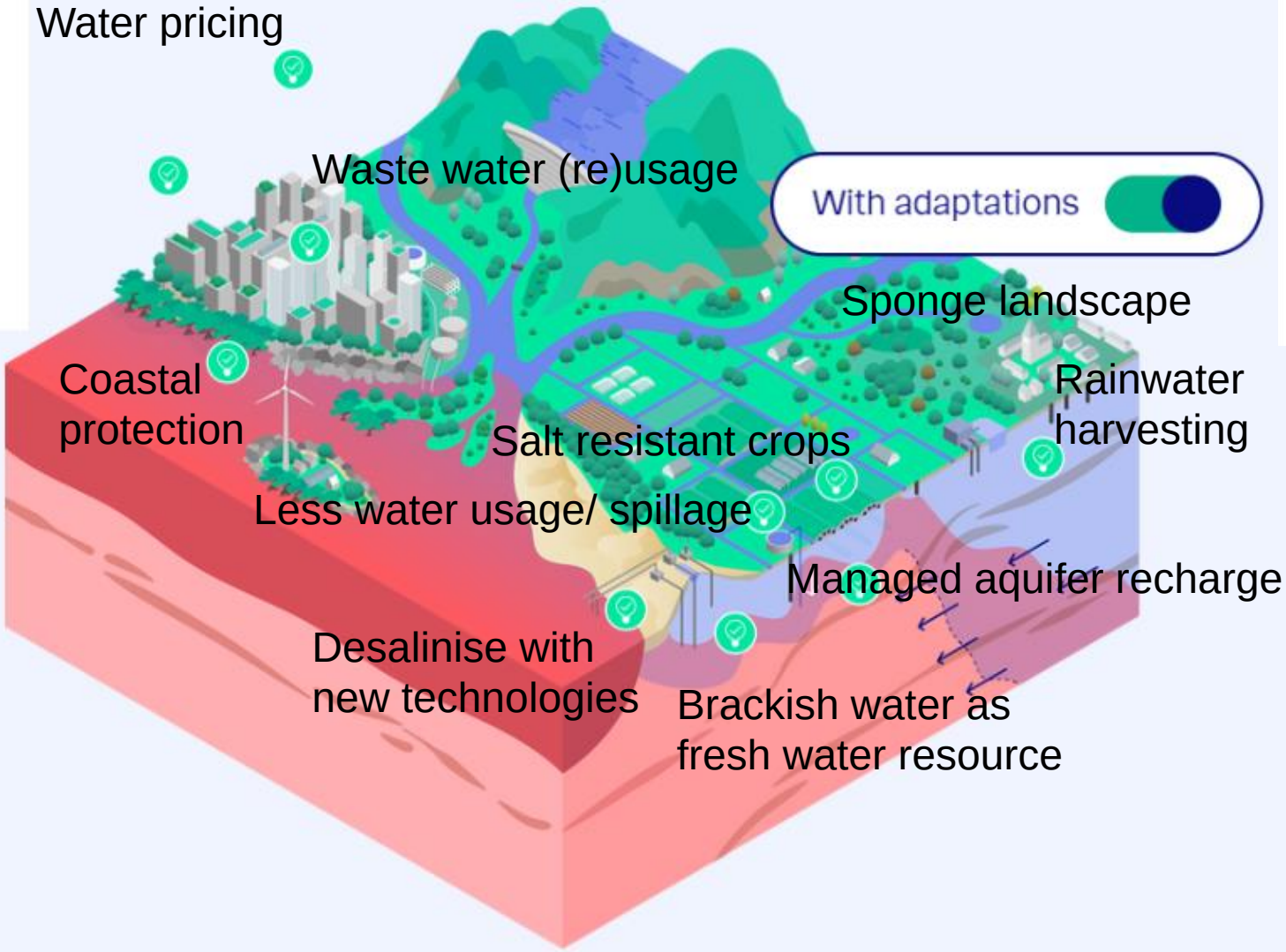
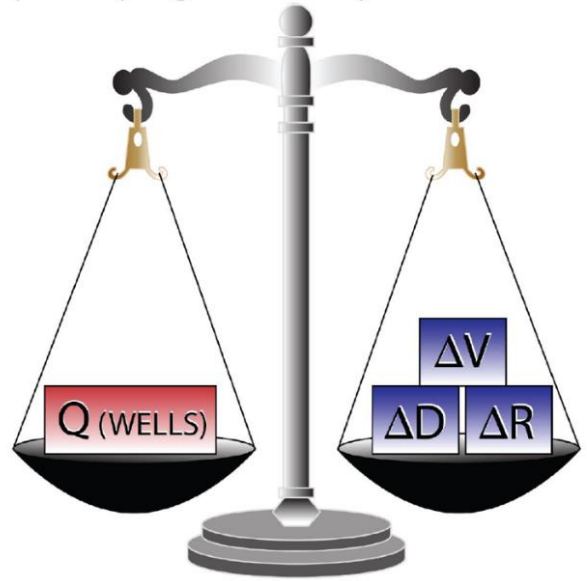
Salinisation of the land in time

The future



b) Developed groundwater system



- Q = discharge wells
  ΔV = change storage
  ΔD = change discharge
- ΔR = change recharge + MAR

Managed aquifer recharge

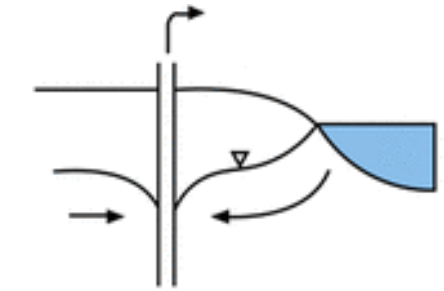
“The purposeful recharge of water to aquifers for subsequent recovery or environmental benefit”

Advantages:

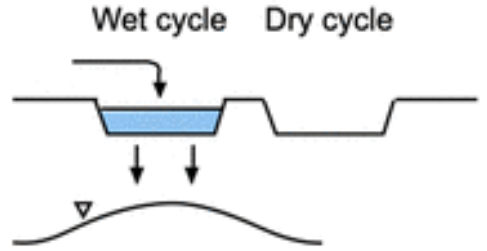
- Small surface footprint
- No evaporation
- Natural treatment capacity

Need:

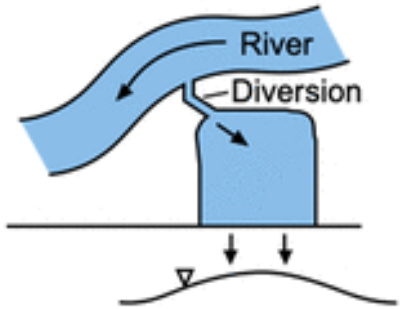
- Groundwater overextraction



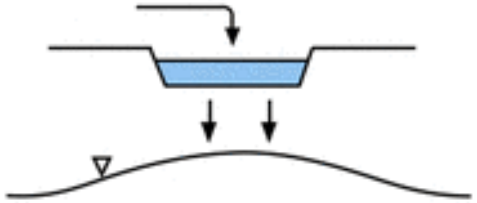
Riverbank filtration (RBF)



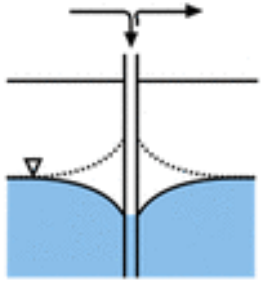
Soil aquifer treatment (SAT)



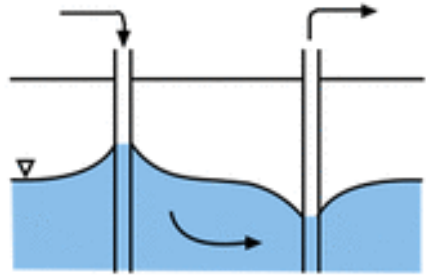
Surface water spreading



Infiltration basin



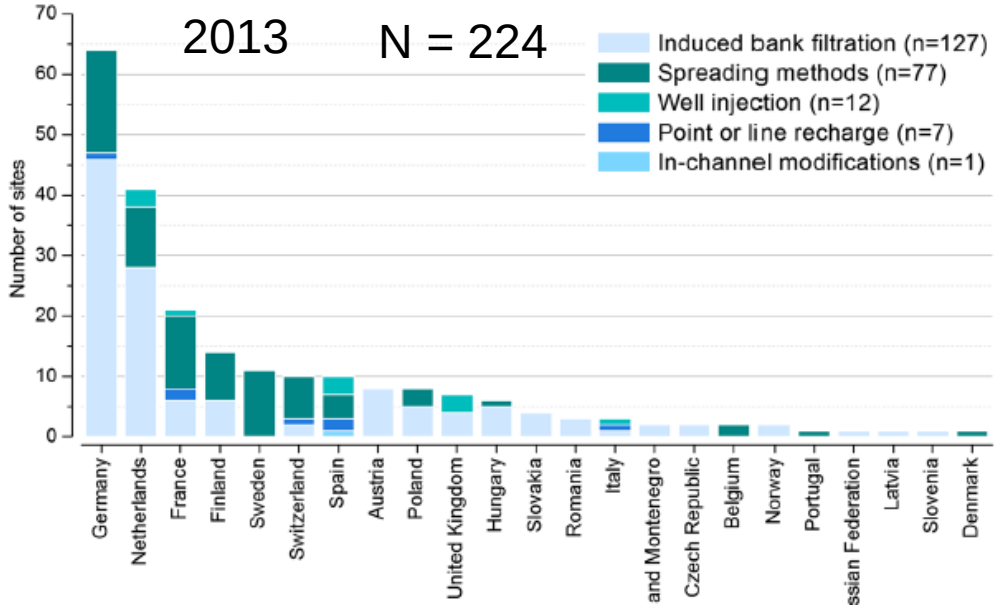
Aquifer storage and recovery (ASR)

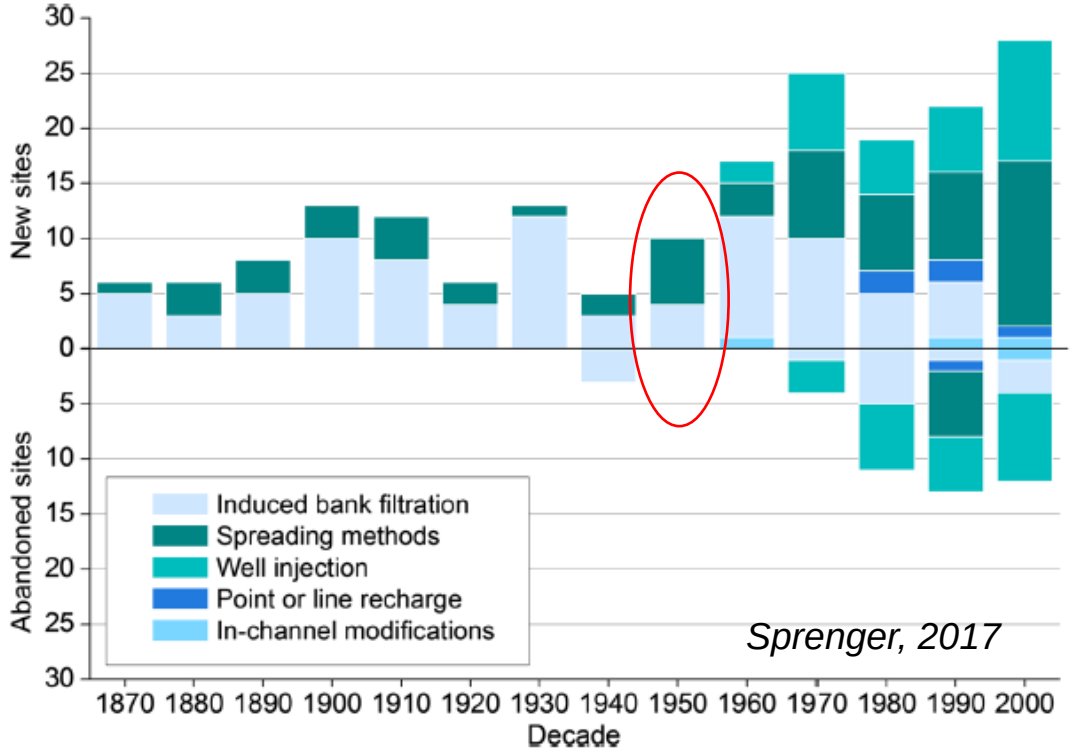


Aquifer storage transfer and recovery (ASTR)

History of MAR

- UK birth ground of MAR!
- Initially mostly river bank filtration
- Later spreading methods etc.
- Challenges: clogging!
  - Mechanical
  - (bio)Chemical

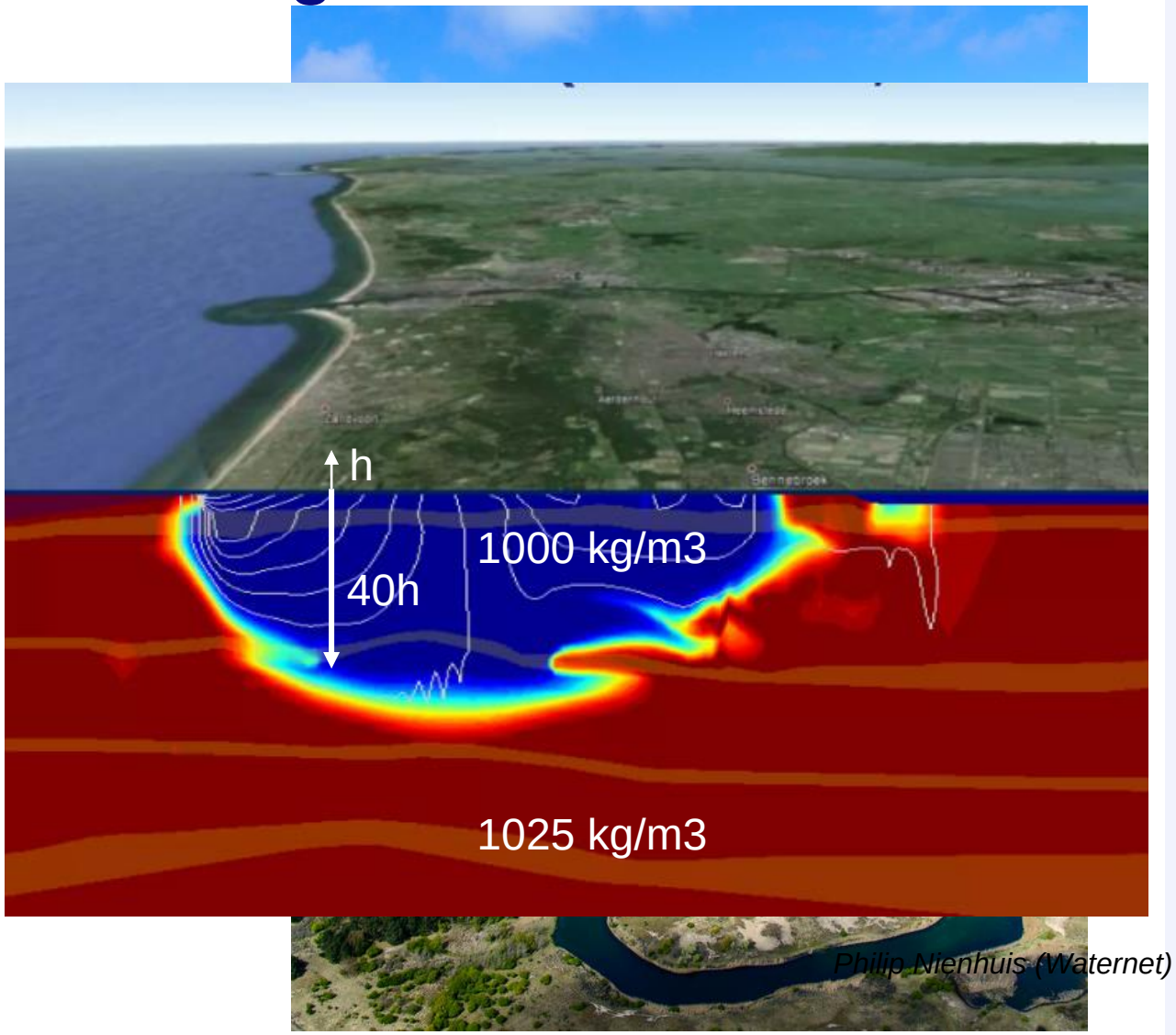




Deltares

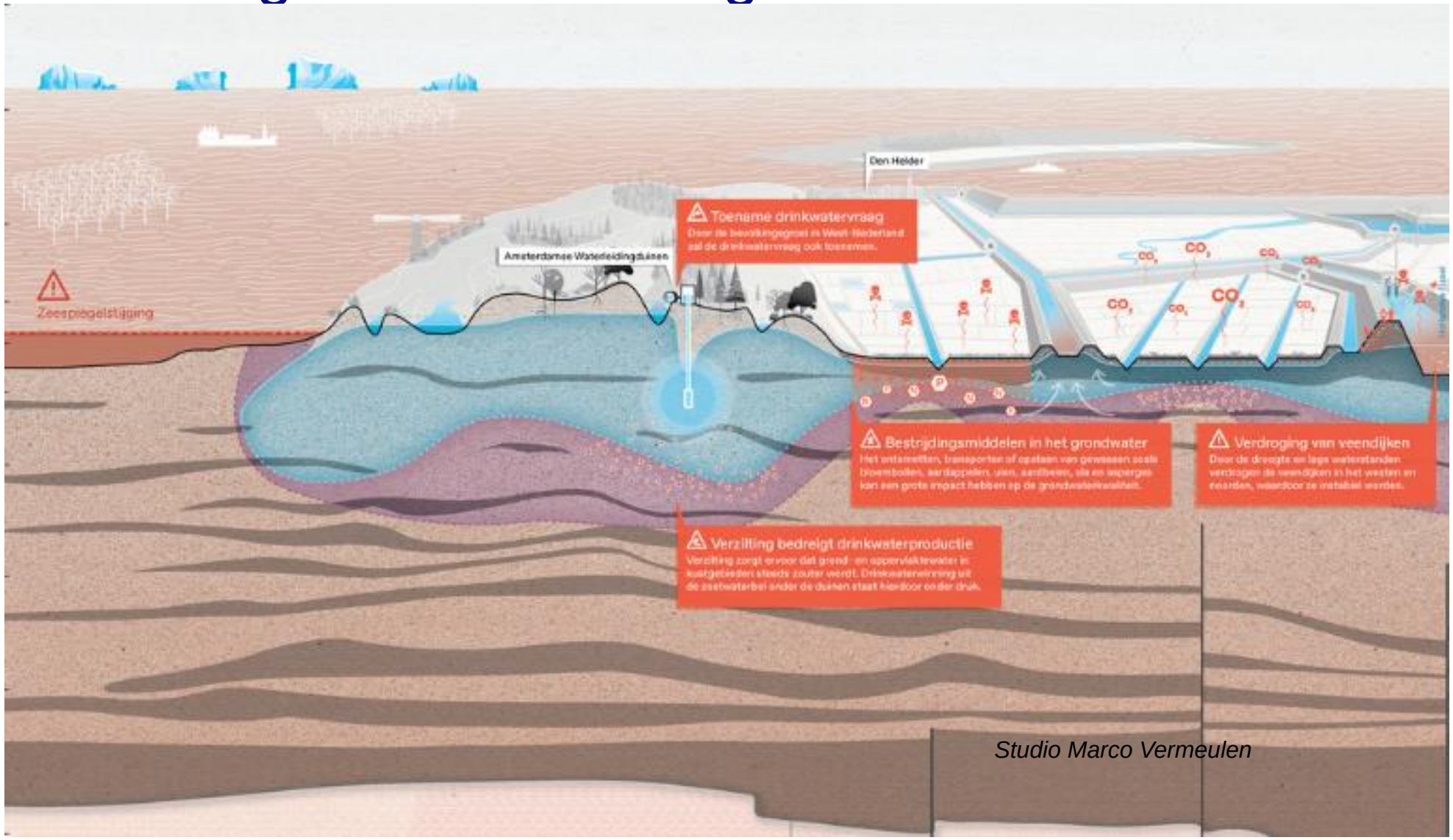
Story of Amsterdamse waterleidingduinen

- <1850: major drinking water quality issues
- 1850: first pipe line from dunes to Amsterdam
- 1950's: infiltration ponds
  - Rhine water
  - Reverse depletion
  - Filtration / treatment
  - Buffer for drought, calamities
- > 2023: time for new measures?



Philip Nienhuis (Waternet)

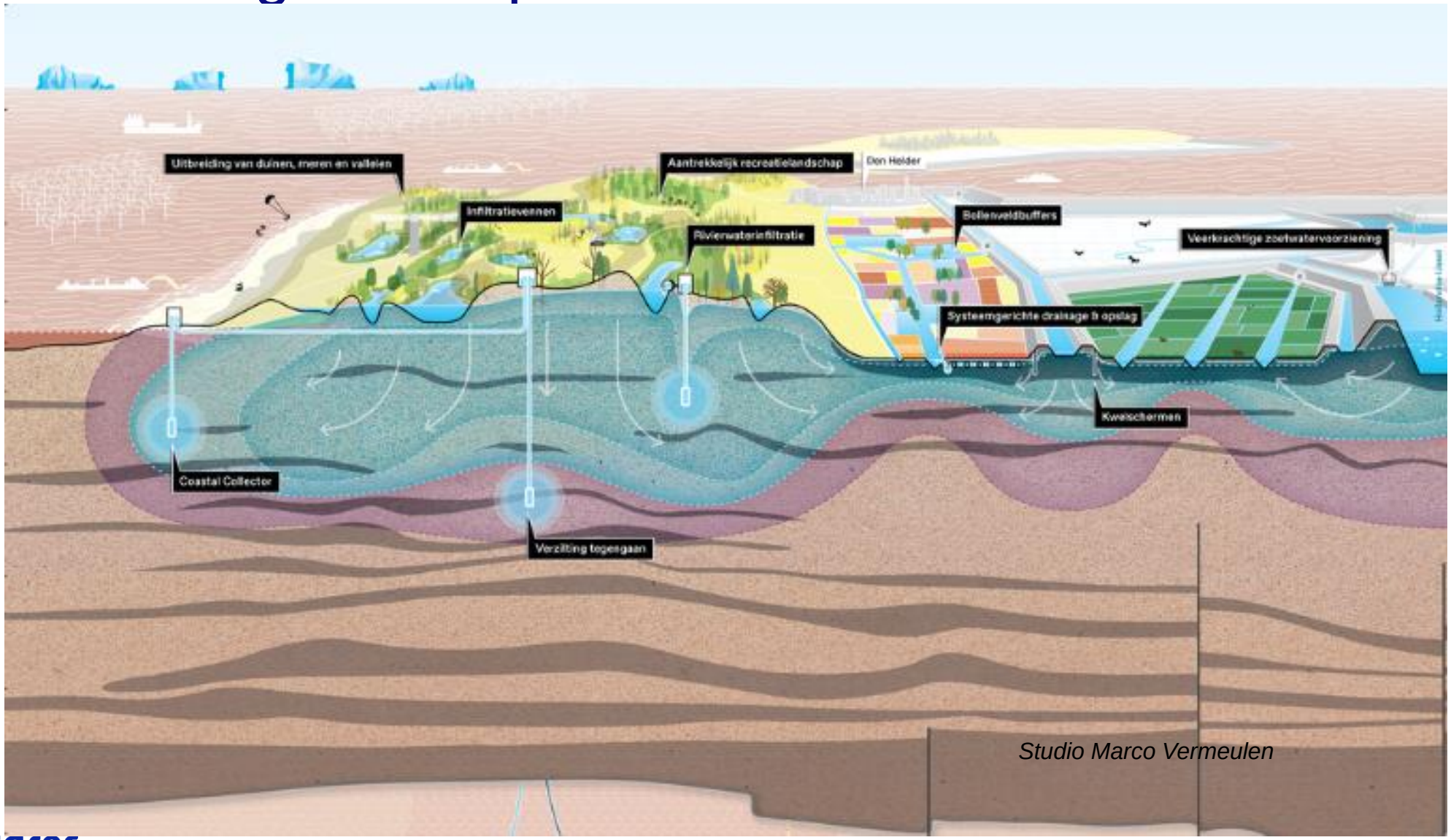
Waterleidingduinen challenges



Studio Marco Vermeulen

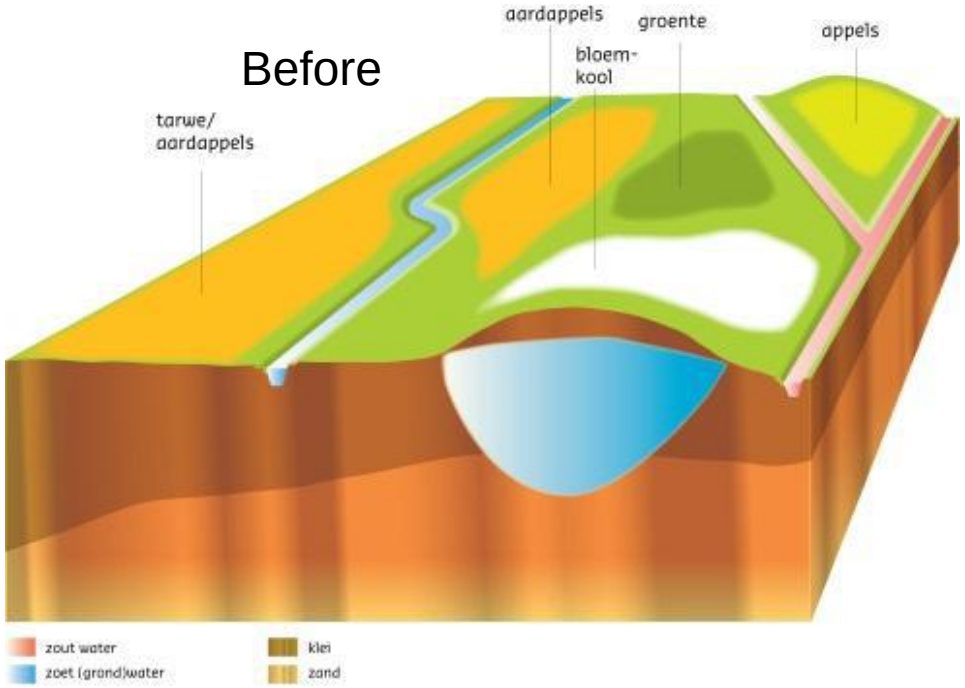
Deltares

Waterleidingduinen potential solutions: MAR 2.0

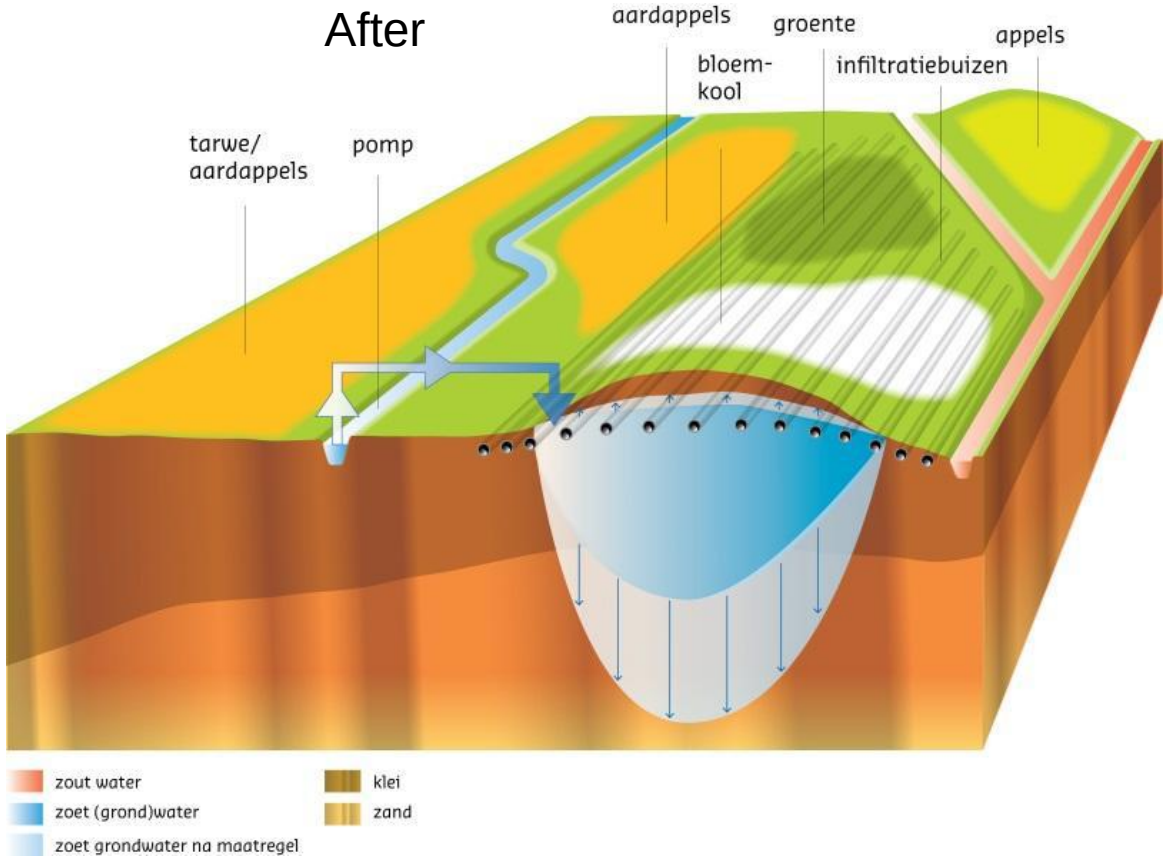


Creek ridge infiltration

Before



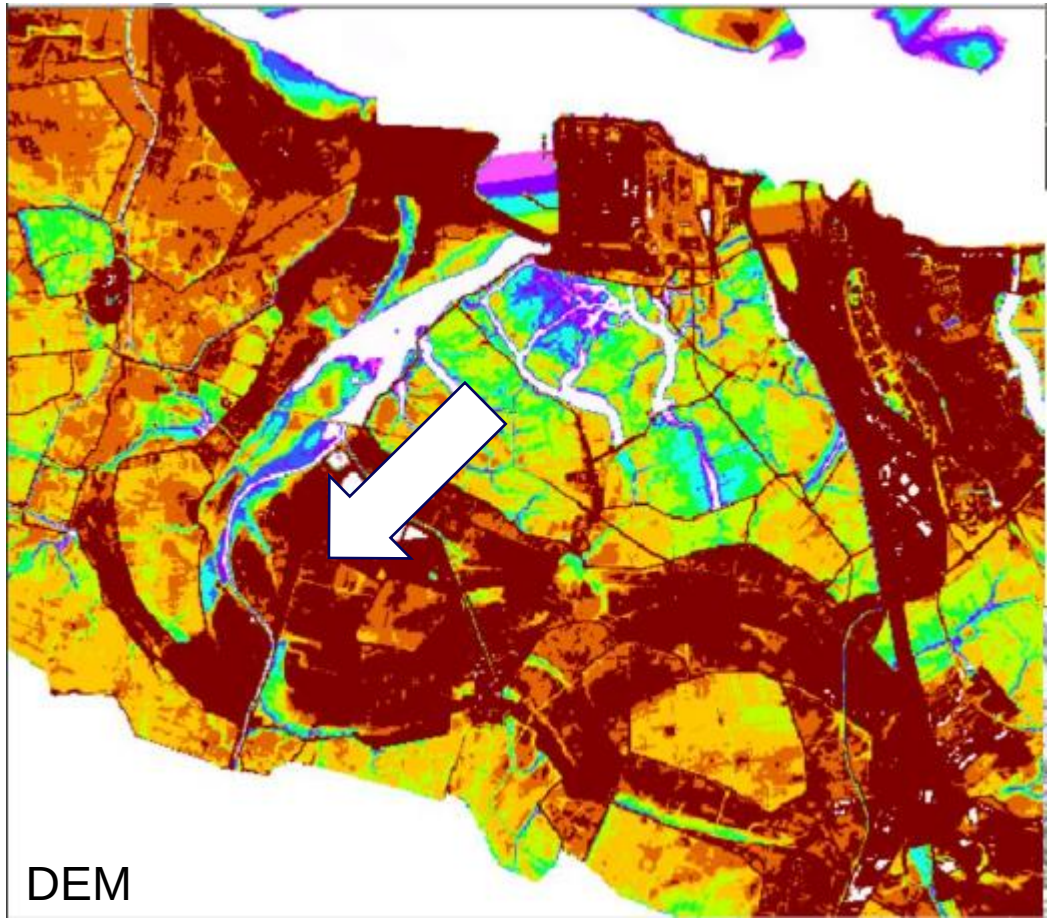
After

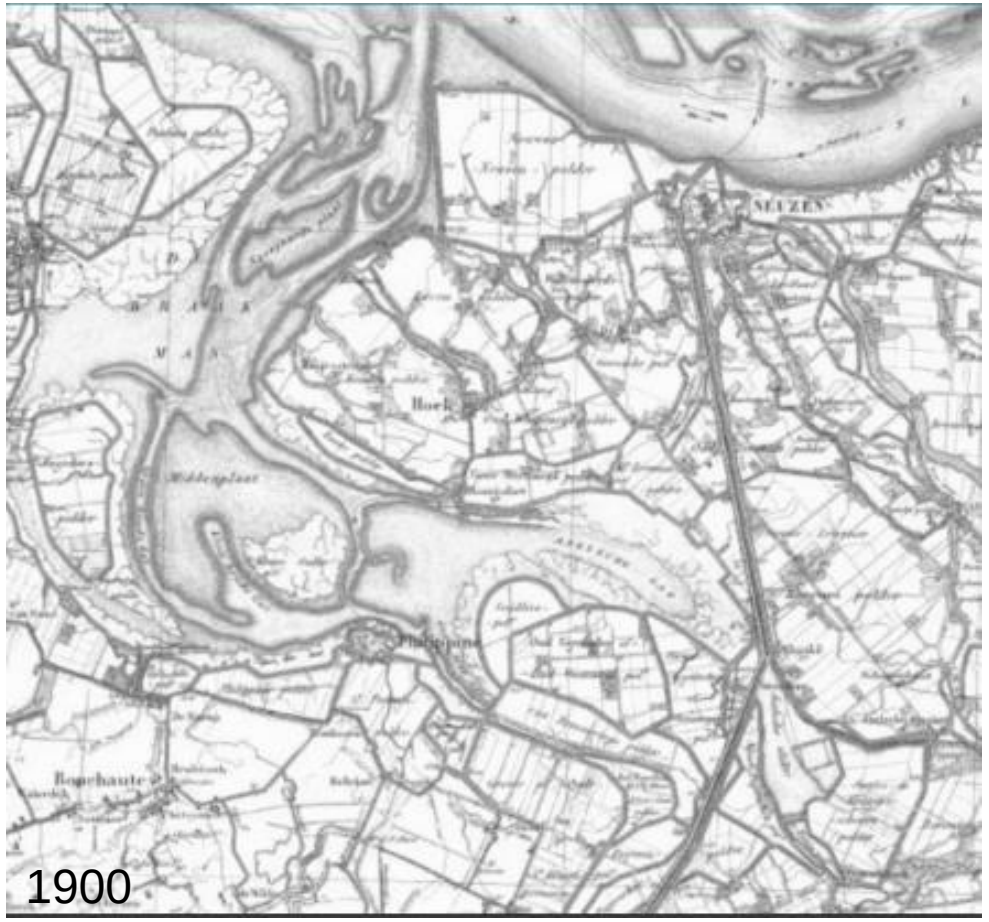


GO-FRESH

Deltares

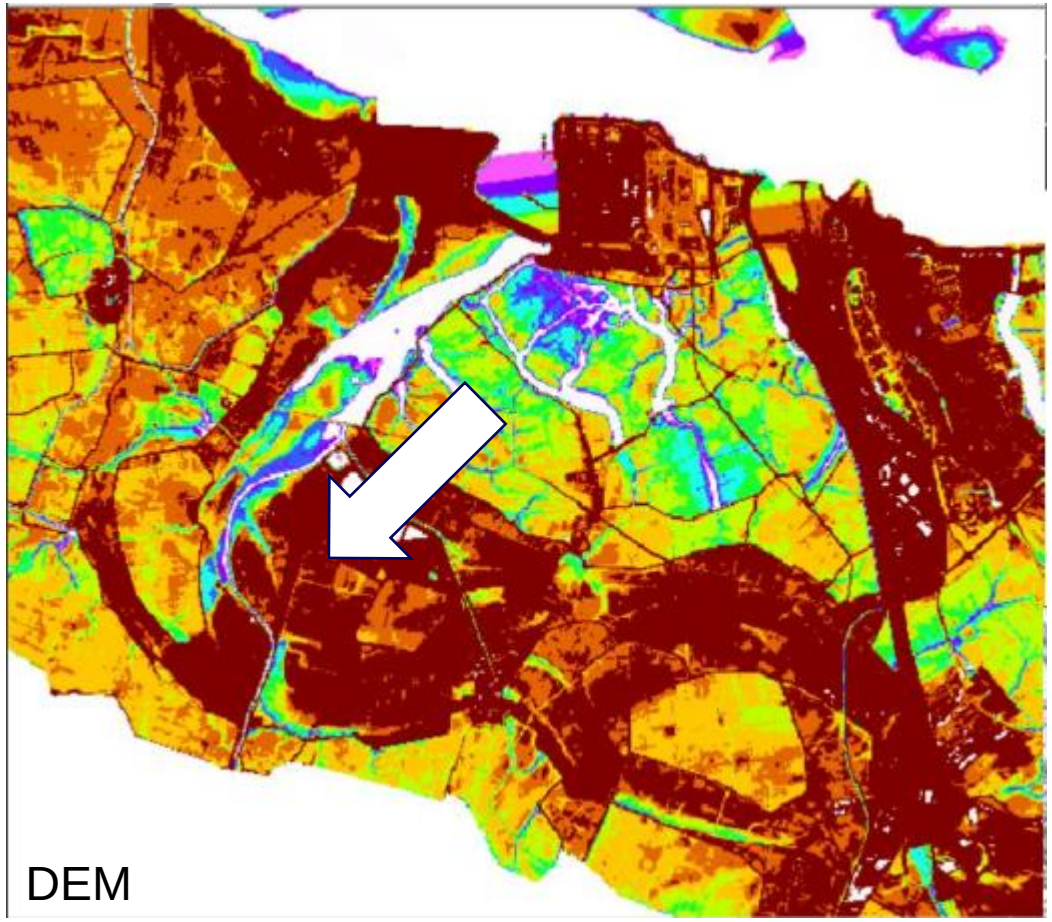
De Braakman Creek ridge

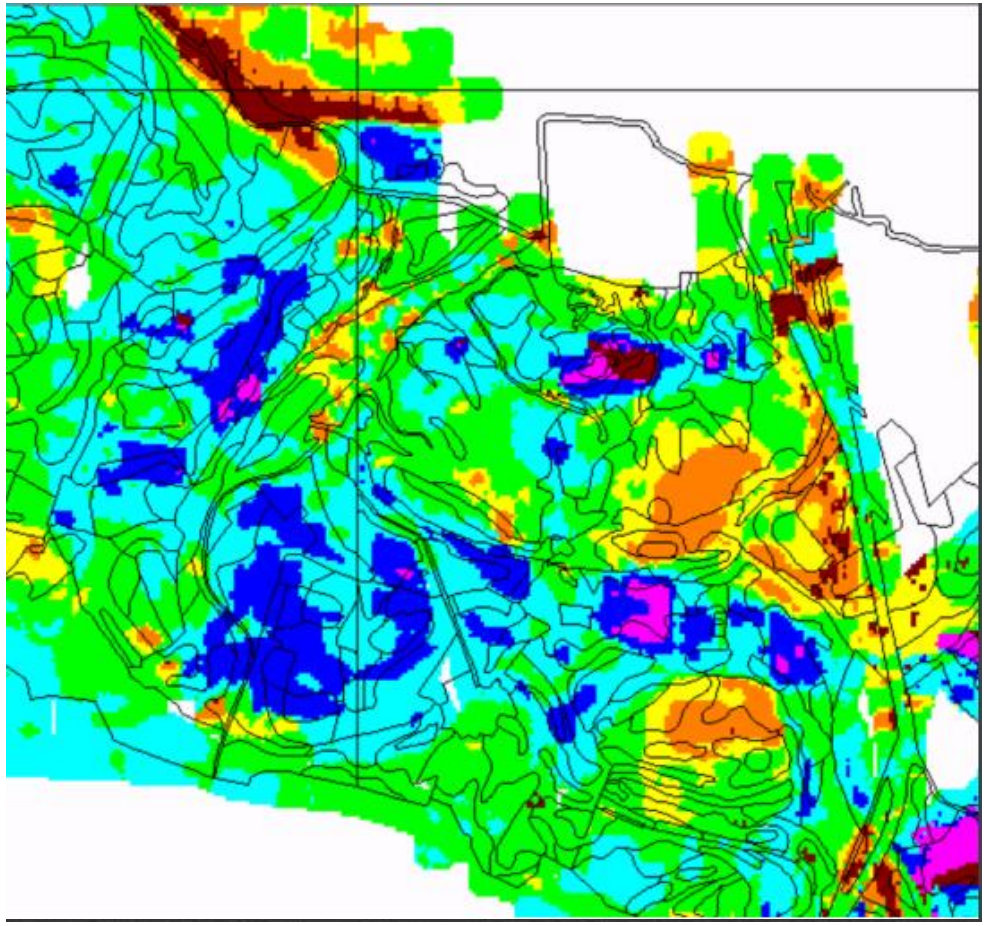




Deltares

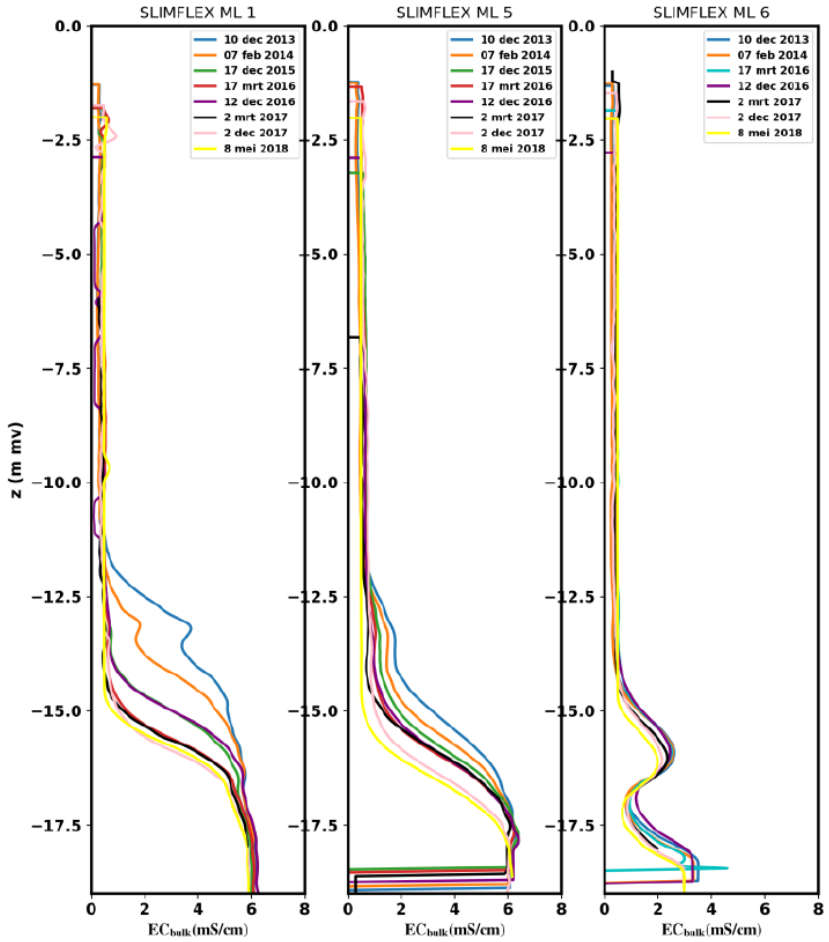
De Braakman Creek ridge: freshwater lens thickness

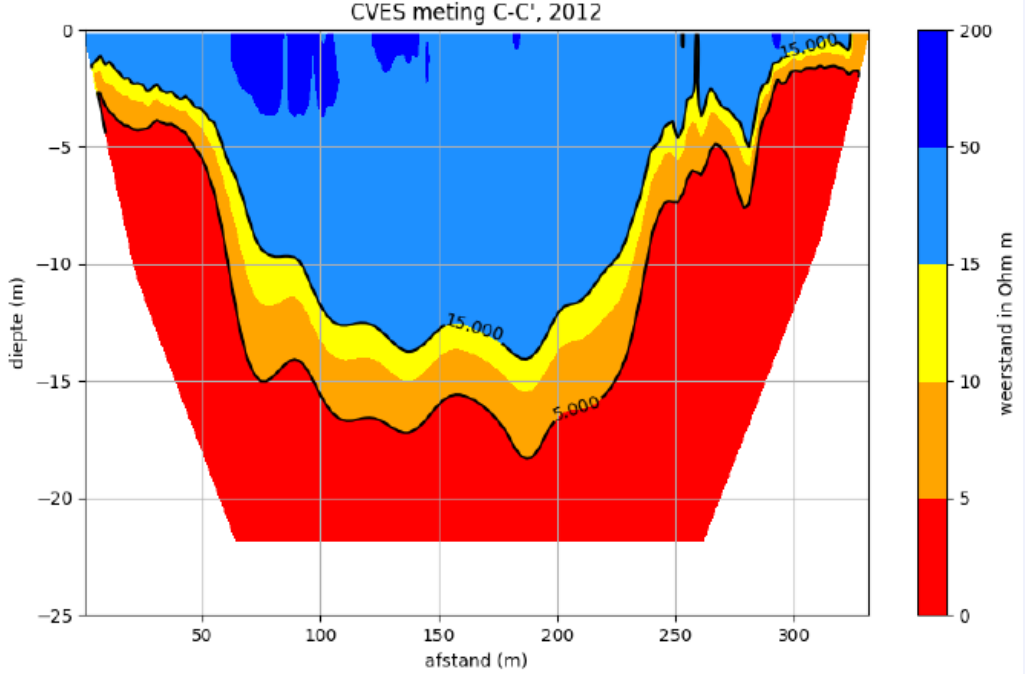


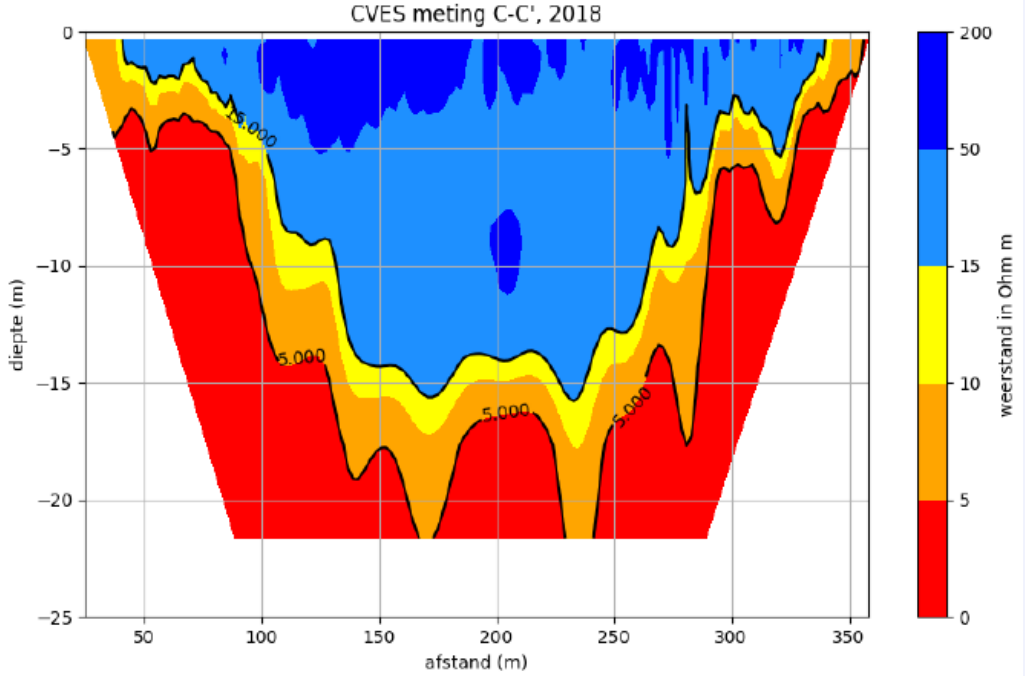


Creek “Ridge”

Experience from Serooskerke: Freshwater lens thickness







GO-FRESH

Deltares

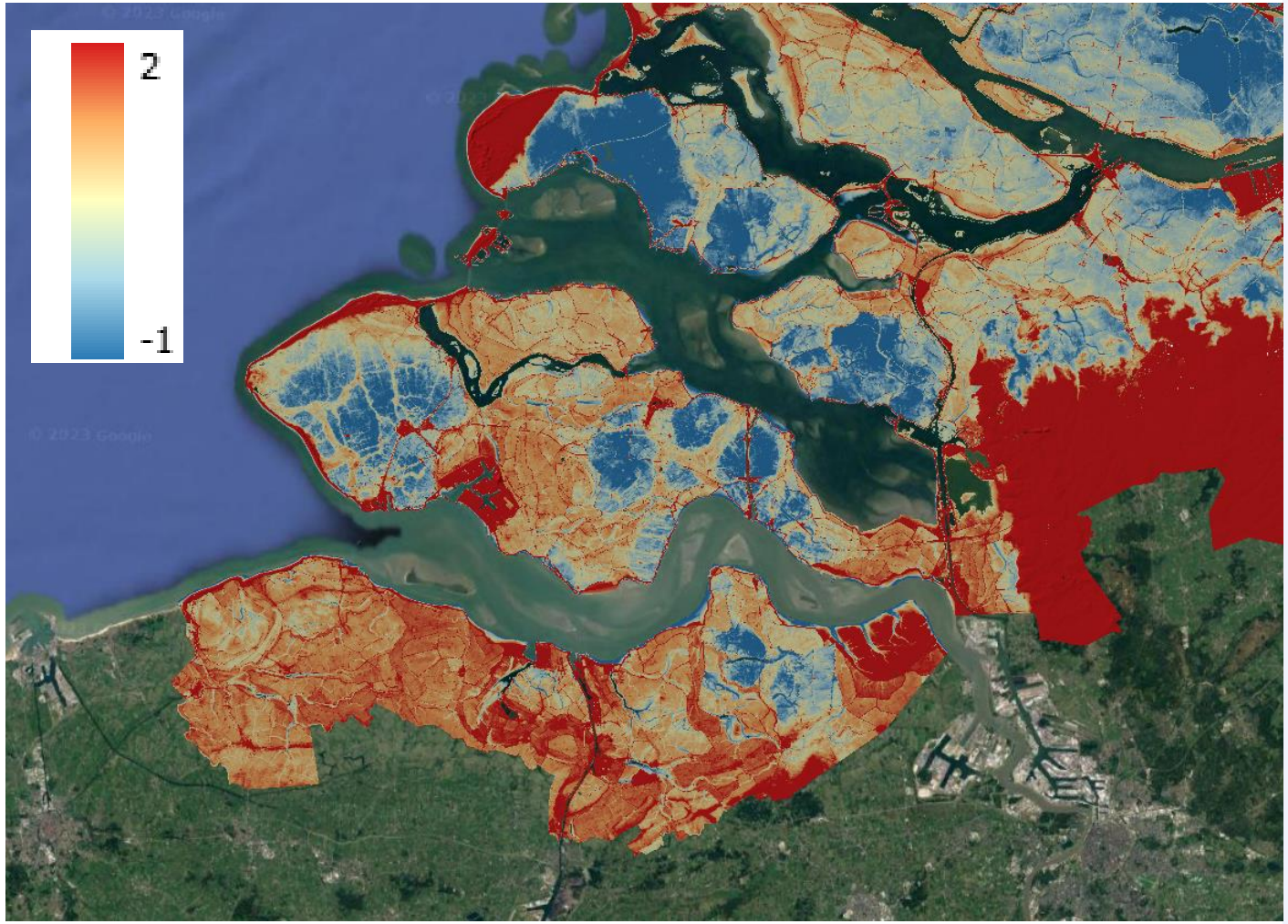
Voettekst van de presentatie

Zeeland: suitability for CRI

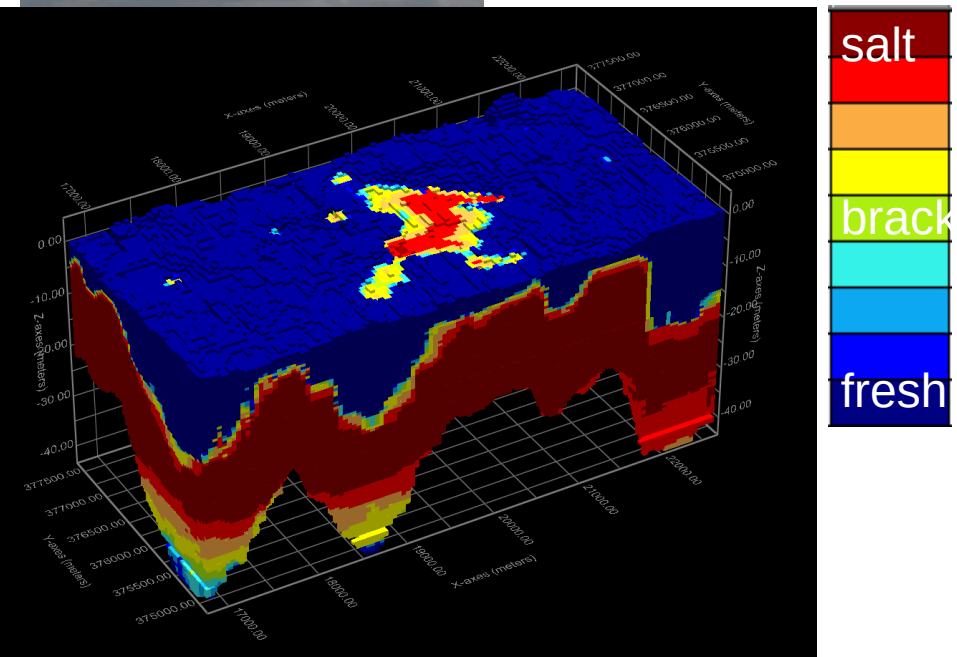
Deltares

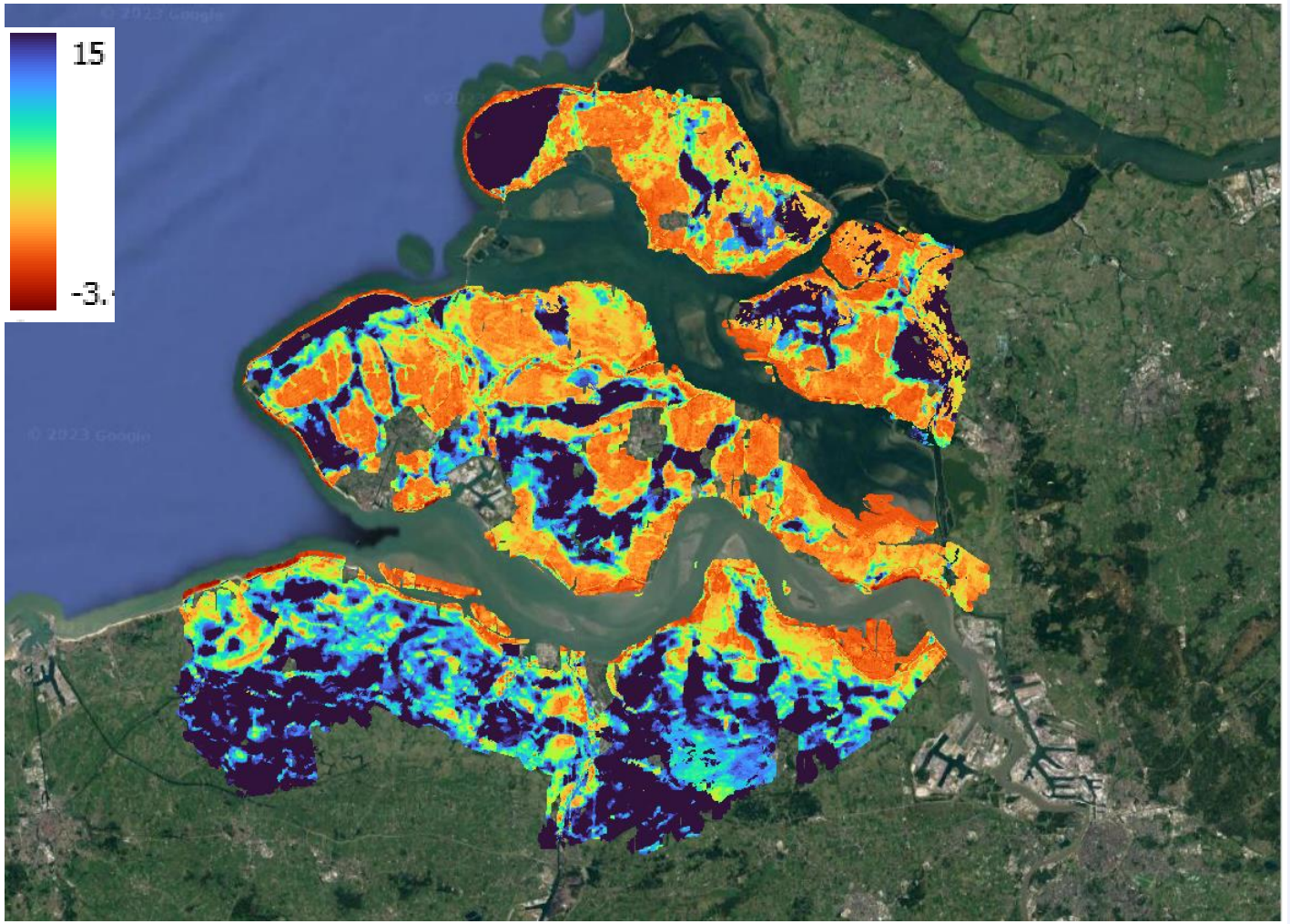
Zeeland: surface elevation

- Old islands below sea-level
- Dunes and tidal creek ridges high



Zeeland: Freshwater lens thickness

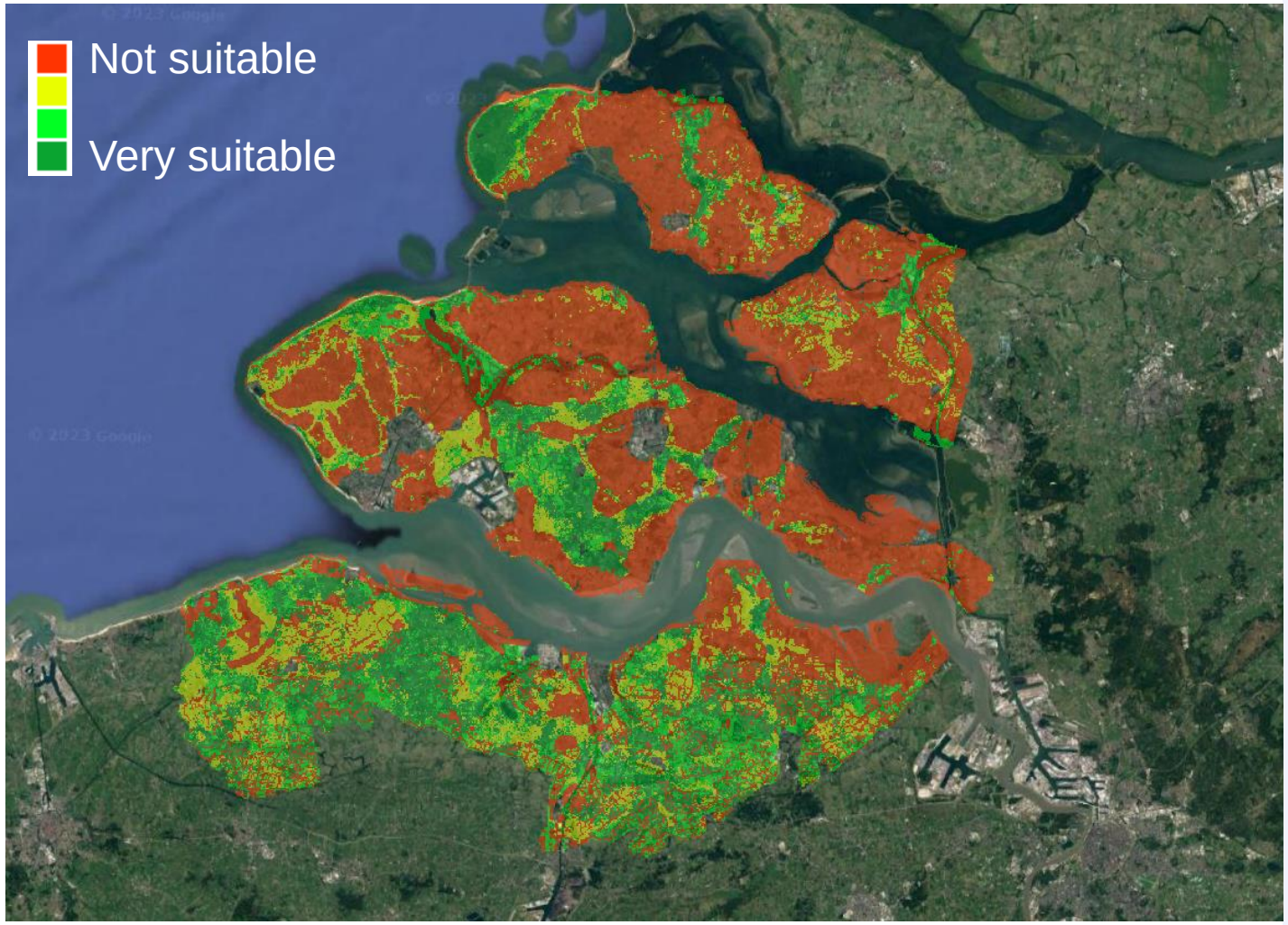




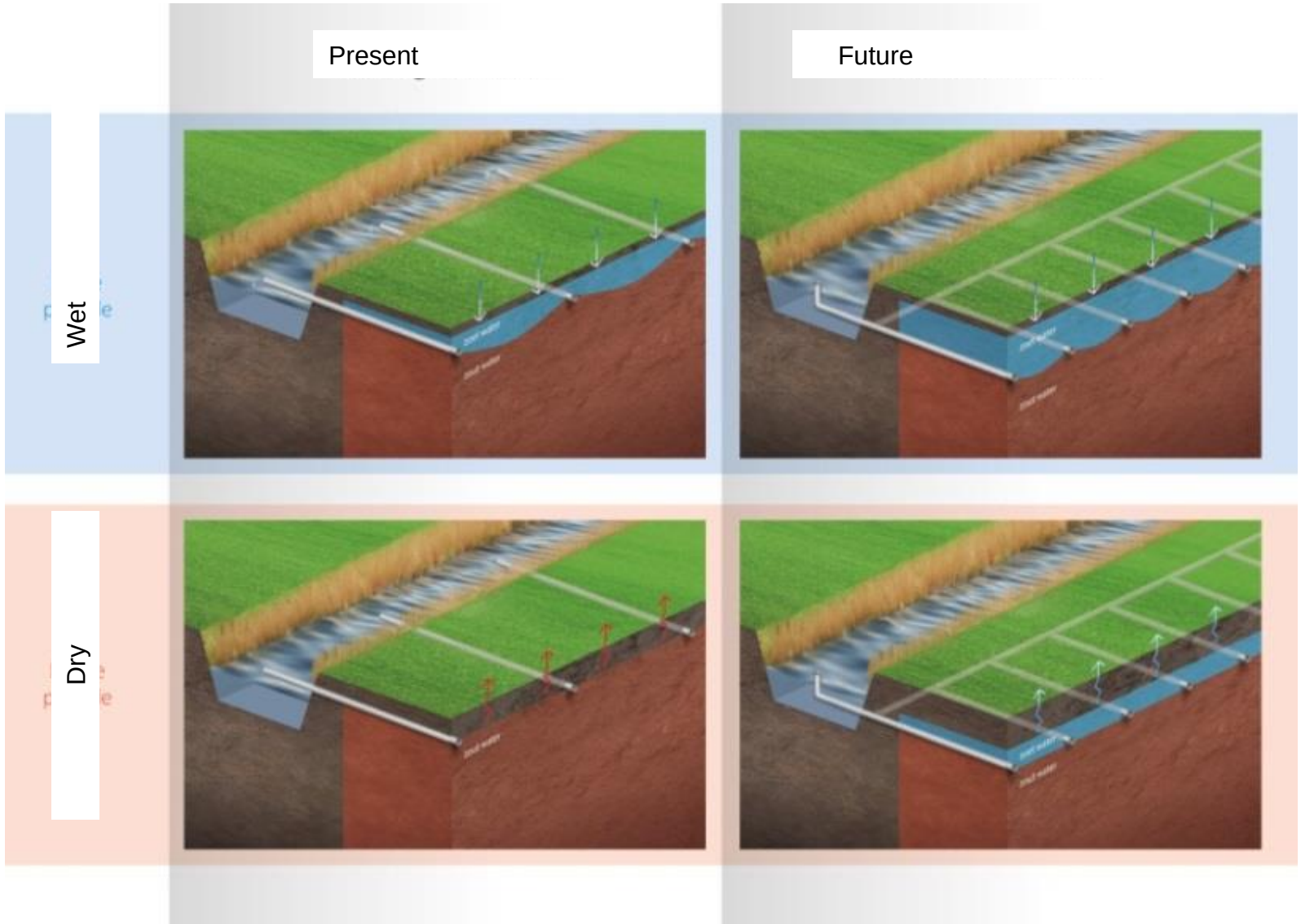
FreshEM

Suitability for CRI

- Sand below freshwater lens
- Not too permeable, not too much resistance
- Space above groundwater table
- Water available for infiltration



Drain2Buffer

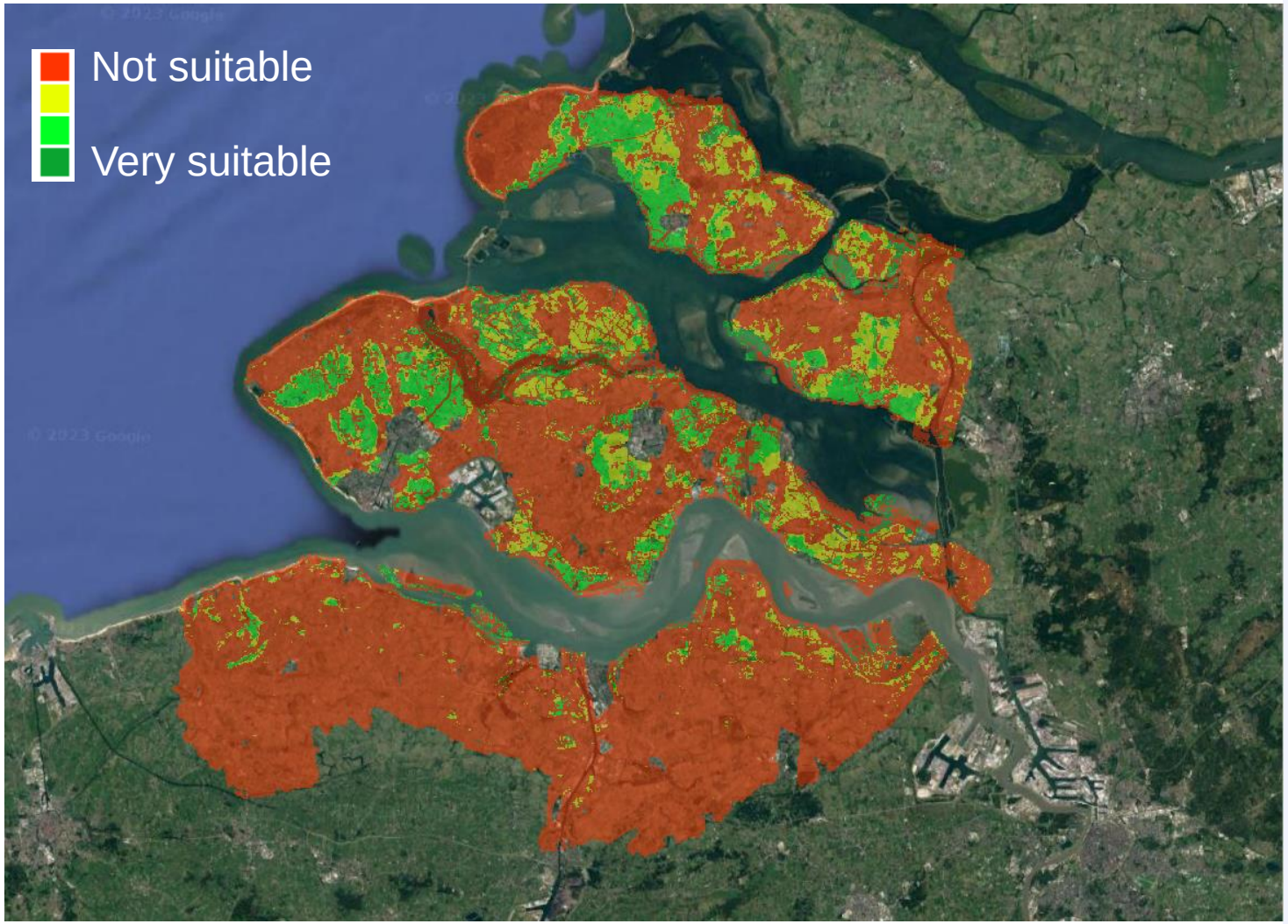


Deltares

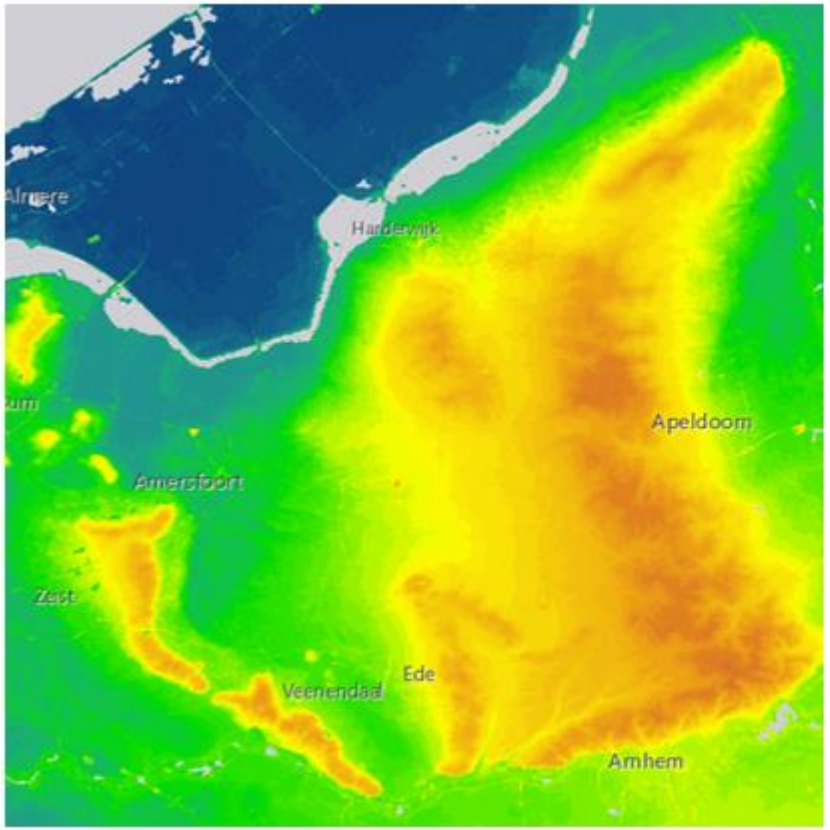
GO-FRESH

Suitability map drains2buffer

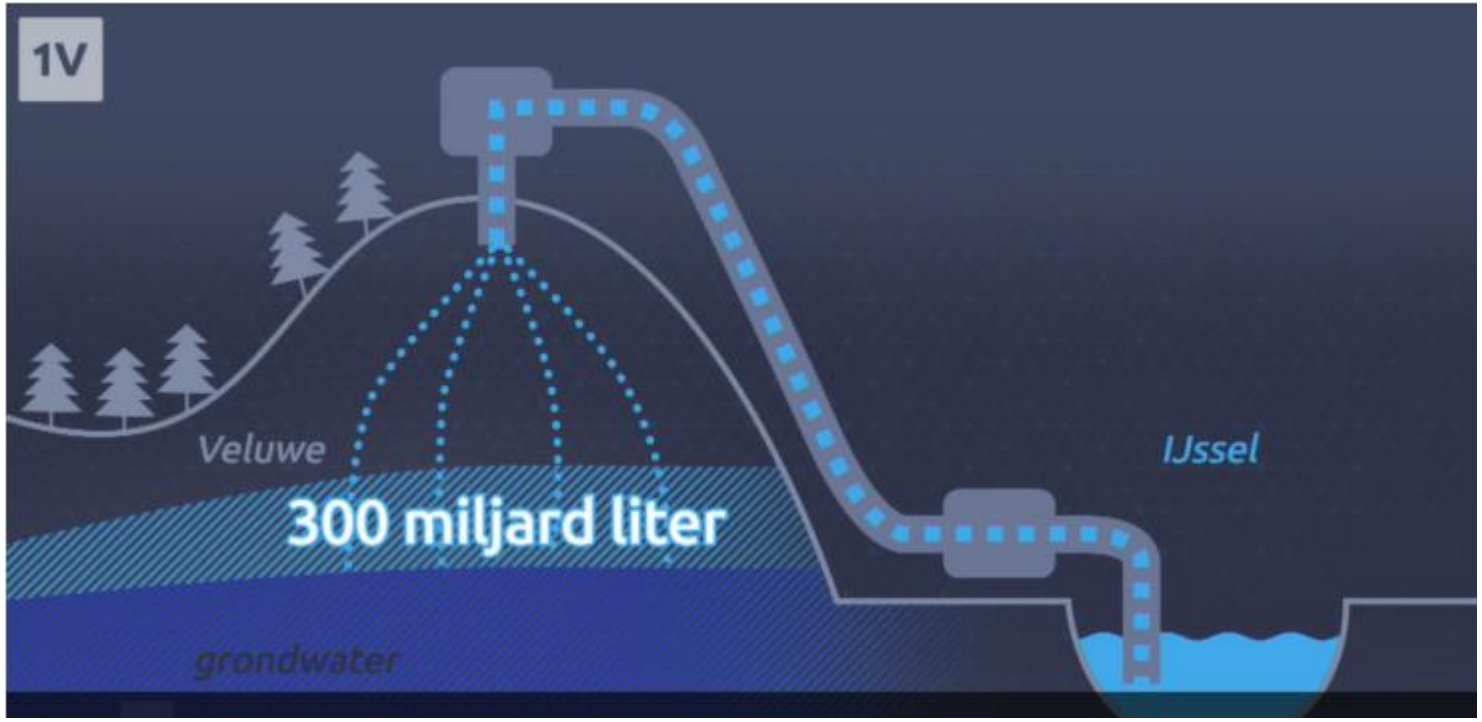
- Not too peaty or clayey
- Seepage
- Thin freshwater lens



National Watering Can



National Watering Can

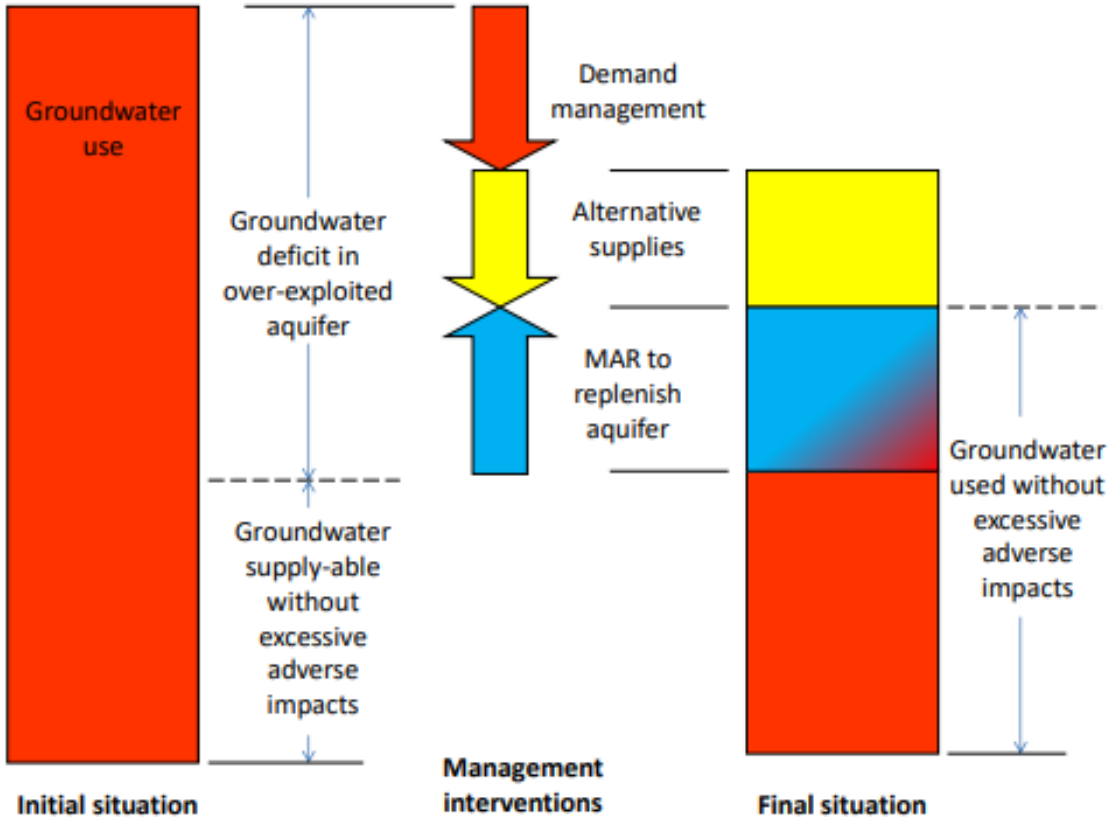


Sponge landscape

Deltares

Conclusions

- Increasing pressure on (ground)water system
- MAR can be a **partial** solution
- Very successful measure for specific local challenges
- MAR solution specific for each setting
- High tech options available
- Small scale and large scale options available
- Low tech options: Using the landscape as a sponge
- Still long way to go to be significant in global groundwater depletion!



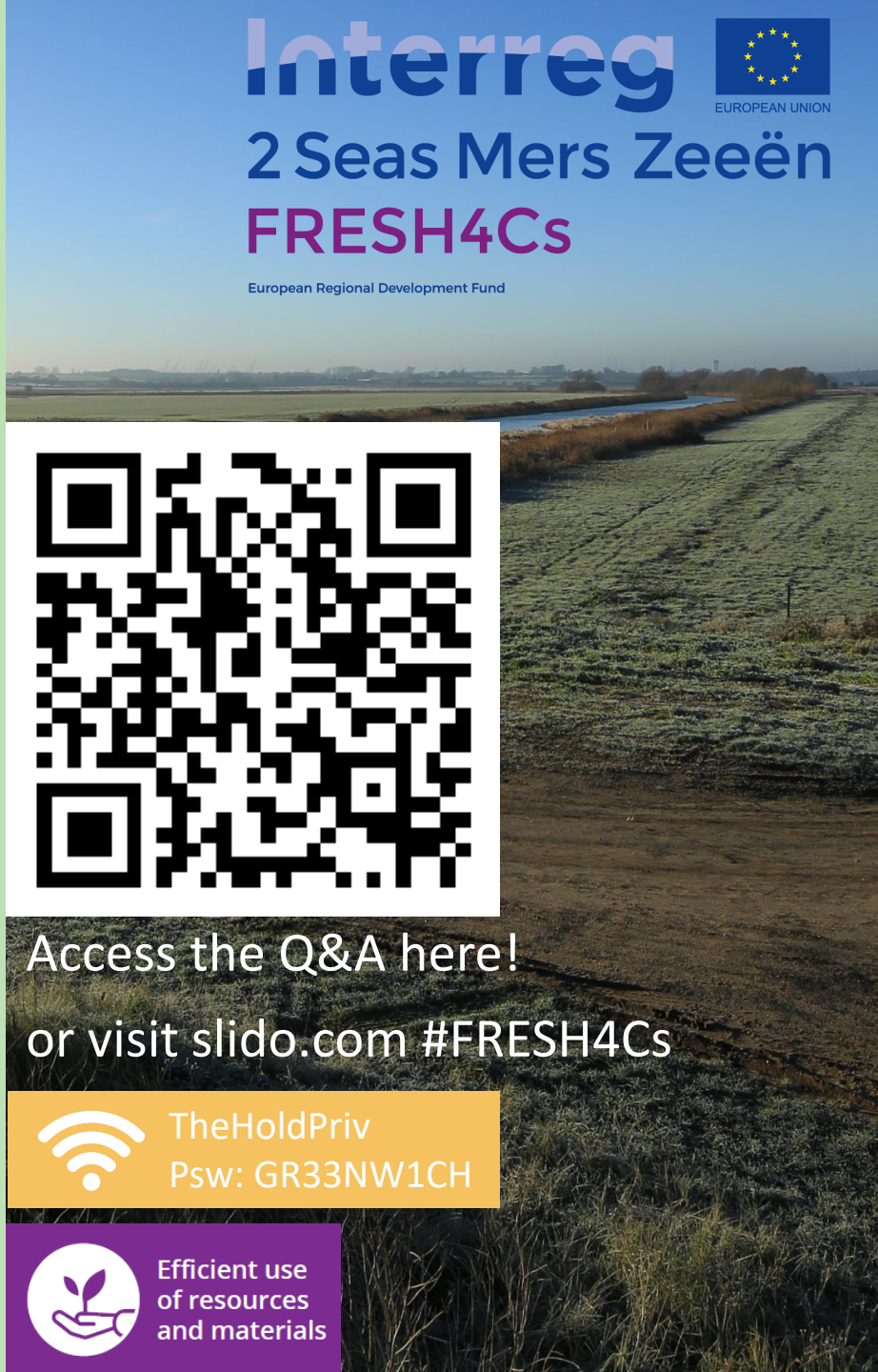
Treating concentrate with a willow marsh: a nature-based solution

Emmanuel Van Houtte

Director Quality & Environment

aquaduin
lekker kraanwater,
duurzaam gewonnen

emmanuel.van.houtte@aquaduin.be



About Aquaduin

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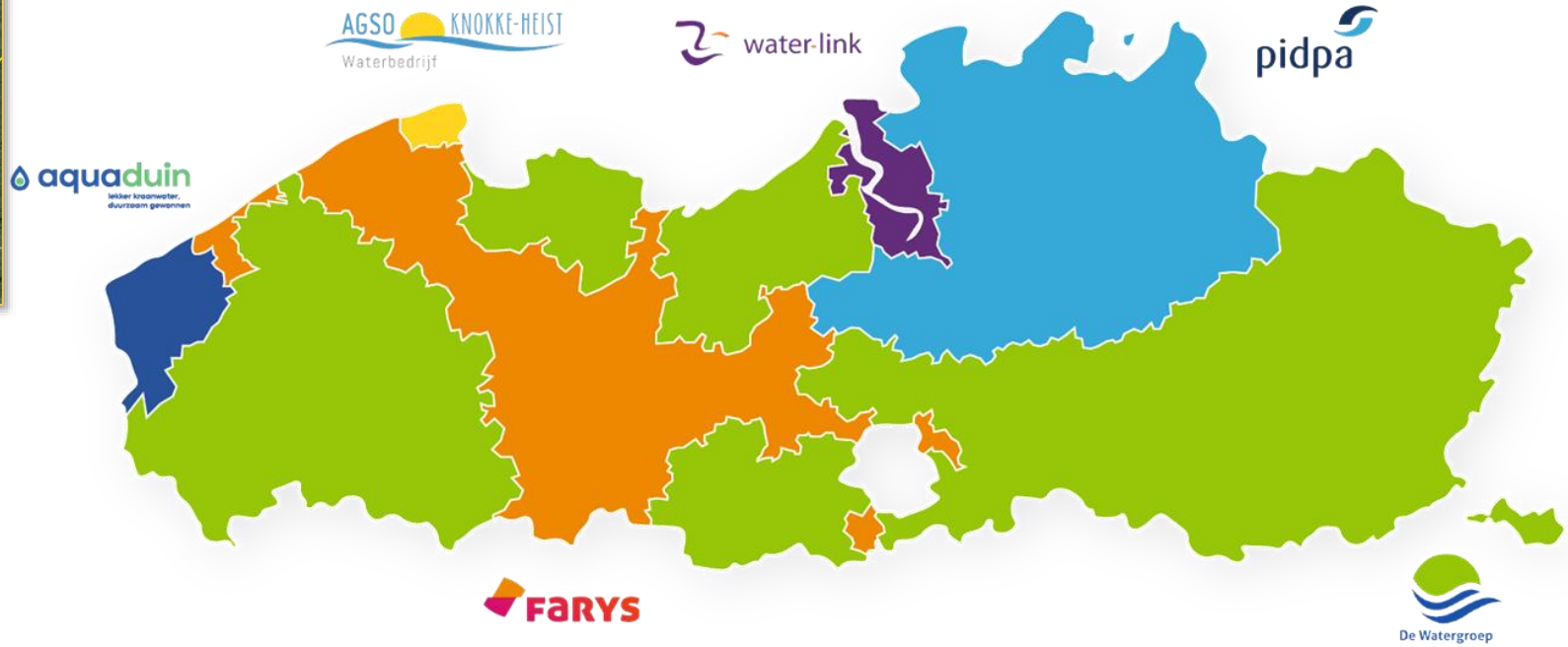

Figures 2022

63.000 permanent residents;
4,5 million m³ drinking-water dsitributed
2,28 million m³ infiltration water produced
1.005 km of distribution network

Efficient use of resources and materials

Water reuse combined with MAR

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Since 2002 Aquaduin reuses the effluent from the local sewage plant using membranes. The treated water is infiltrated in the dunes.

Efficient use of resources and materials

WPC Torreele

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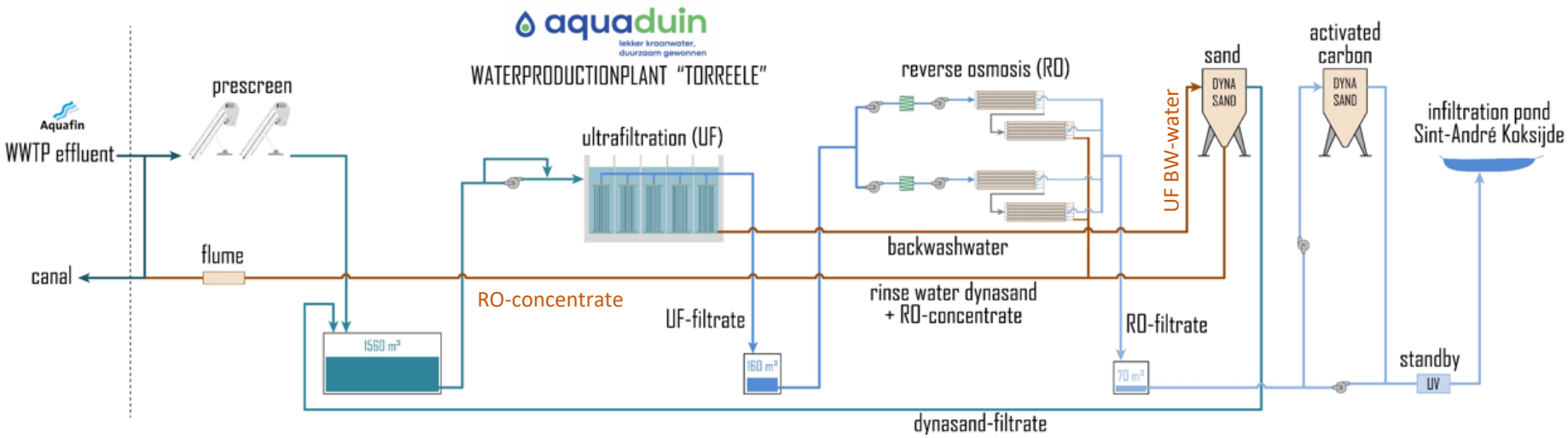
Production of infiltration water



COMBINATION OF WATER REUSE AND MANAGED AQUIFER RECHARGE (MAR) AT AQUADUIN IS BASED ON MULTIPLE BARRIER CONCEPT

NO CONCESSIONS: QUALITY IS OF PARAMOUNT IMPORTANCE

Efficient use of resources and materials

A solution for the RO concentrate?

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Research with natural systems at Aquaduin

2003-2009 : conventional wetland

2010: box test with willow species

2011-2016: pilot with willows

Efficient use of resources and materials

A solution for the RO concentrate?

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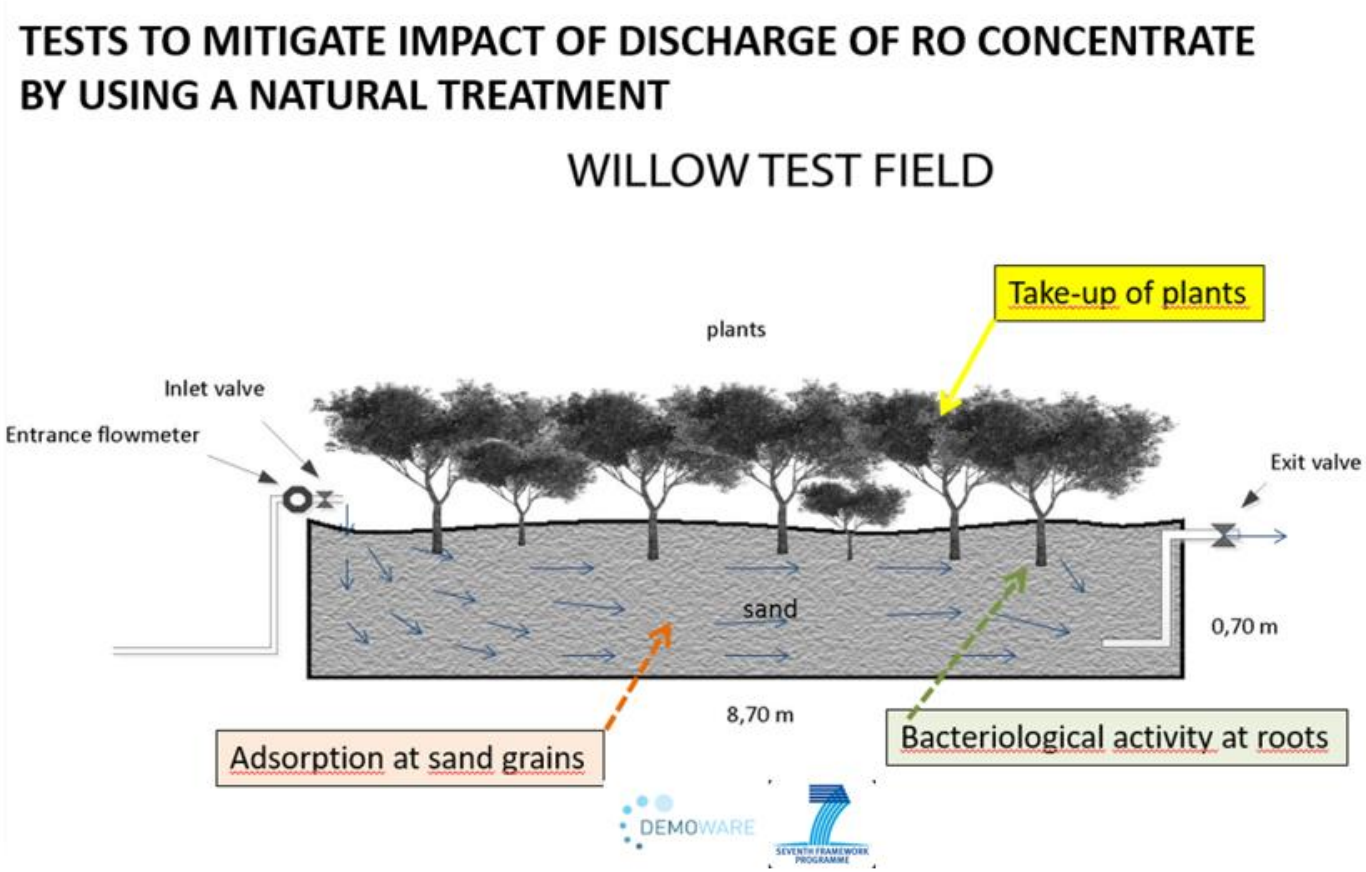

14 LIFE BELOW WATER

15 LIFE ON LAND

Small pilot (2011-2016)

part of the DEMOWARE project

objective was to investigate salt tolerance of plants and removal capacity of nutrients

Efficient use of resources and materials

A solution for the RO concentrate?

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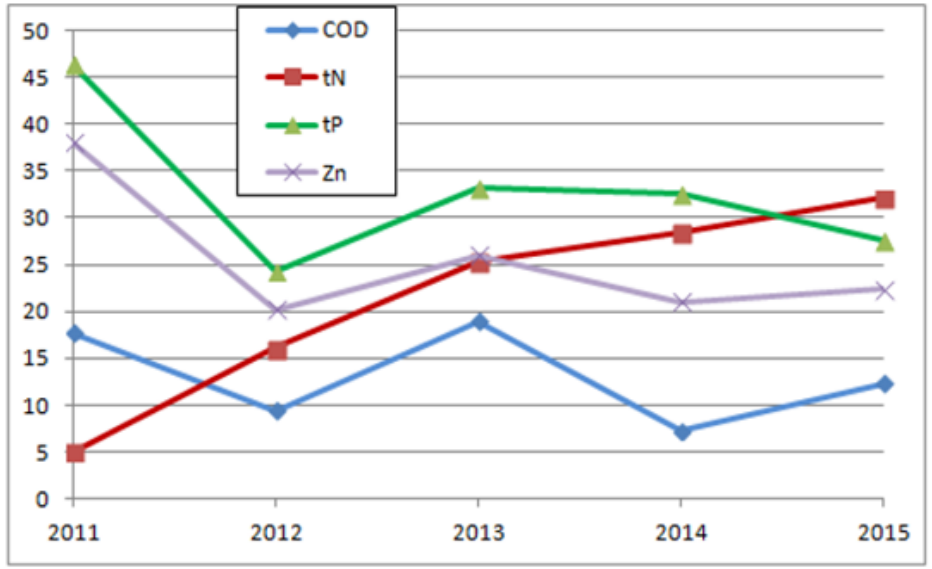
EUROPEAN UNION



Average removal throughout the years :

- **Improved for nitrogen : >30% in 2015;**
- **Phosphorous and zinc removal better in 1st year and stable since then :**
  - **around 30% for phosphorous and 20 to 25% for Zn;**
- **COD removal between 10 to 20%.**

DEMOWARE

Willow marsh

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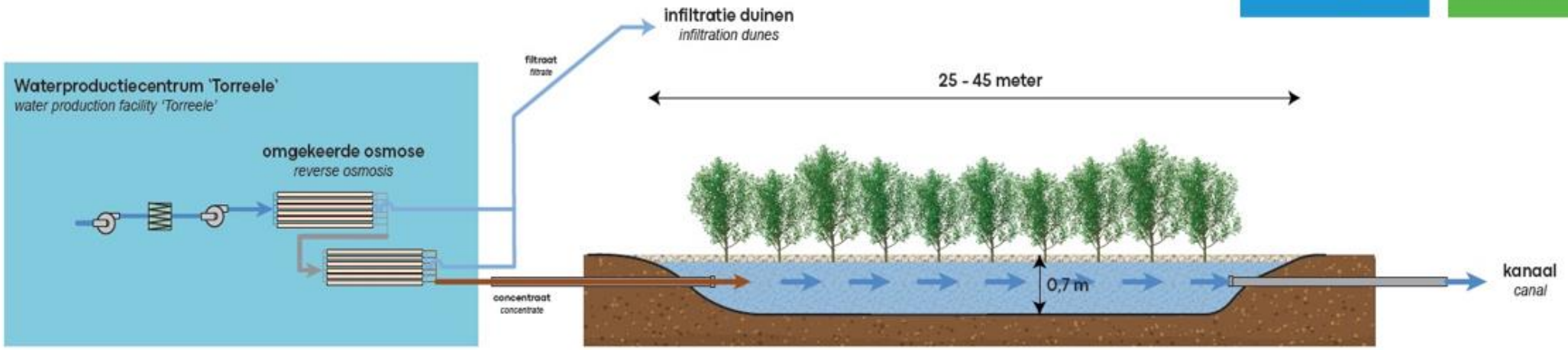
A willow marsh was constructed in 2021 near WPC Torreele (Wulpen, Koksijde) for the treatment of the reverse osmosis concentrate.

First tests started at the end of December 2021.

Fully operational since January 10th, 2022.



Efficient use of resources and materials

Willow marsh

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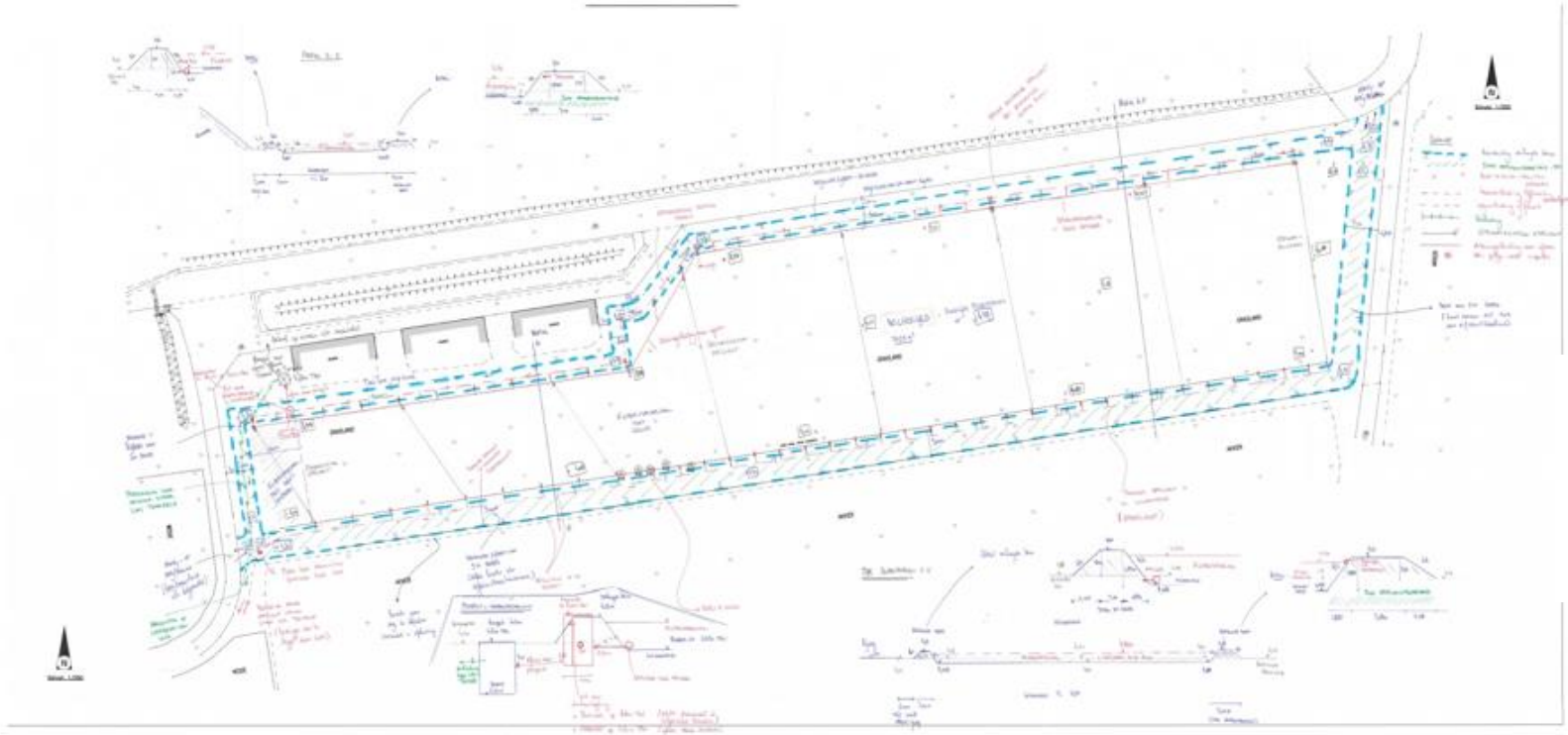
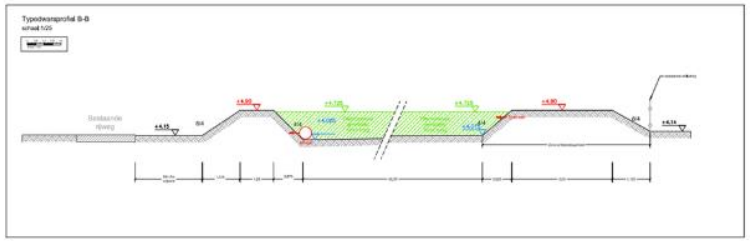
Drawing plans





Efficient use of resources and materials

Willow marsh

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Efficient use of resources and materials

Willow marsh

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Installation: 2021

Efficient use of resources and materials

Willow marsh

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Installation: 2021

Efficient use of resources and materials

Willow marsh

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Installation: 2021

Efficient use of resources and materials

Willow marsh

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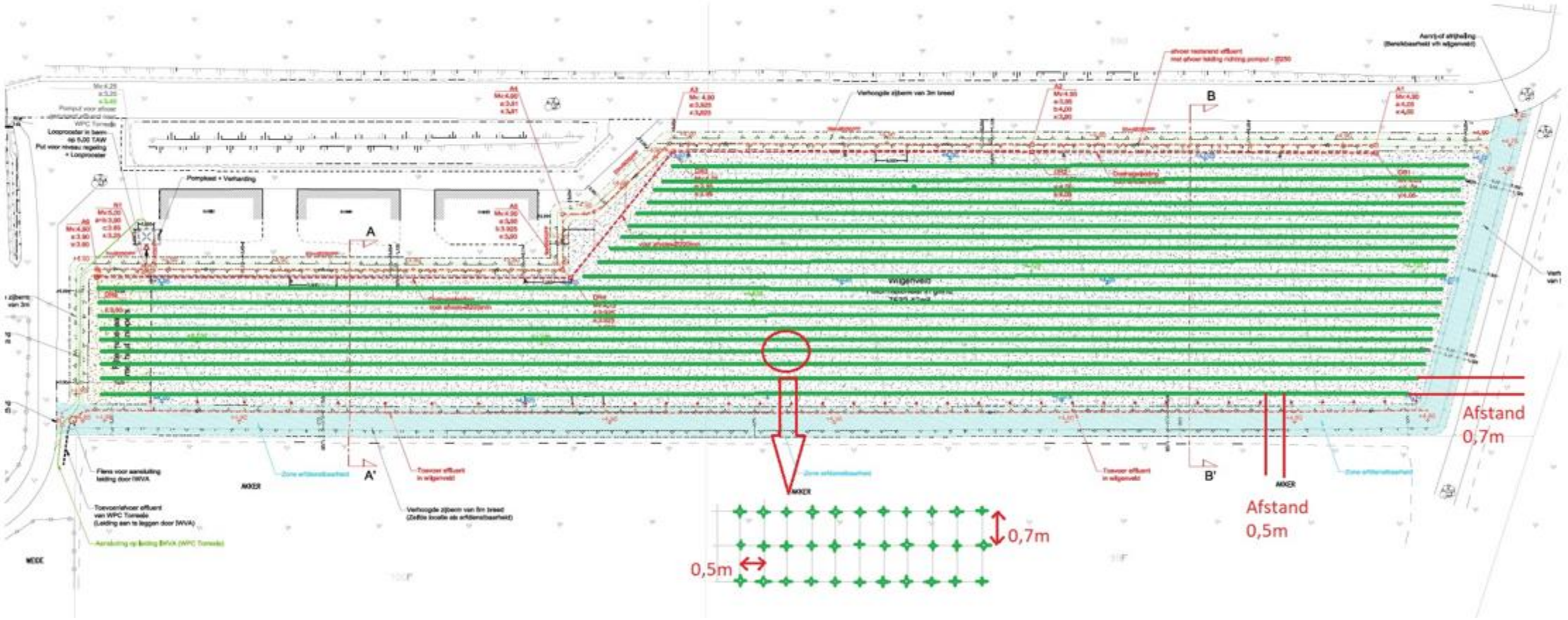
Installation: 2021



Efficient use of resources and materials

Willow marsh

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Start up: end 2021

Efficient use of resources and materials

Willow marsh - results

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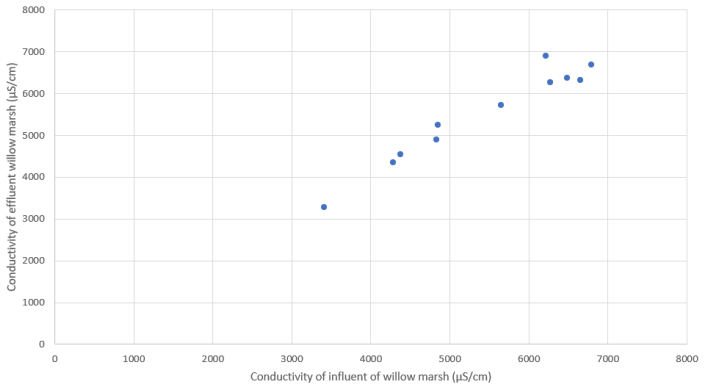
RESULTS FOR TOTAL NITROGEN

DATE	INFLUENT WILLOW MARSH (mgN/l)	DATE	EFFLUENT WILLOW MARSH (mgN/l)	REMOVAL RATE (%)
3/03/2022	19,5	4/03/2022	16,5	15,4%
12/04/2022	16,1	13/04/2022	13,4	16,8%
3/05/2022	13,8	4/05/2022	9,8	29,2%
12/07/2022	16,5	13/07/2022	10,4	37,0%
8/08/2022	14,4	9/08/2022	8,2	43,1%
9/08/2022	12,4	10/08/2022	7,2	41,9%
10/08/2022	12,5	11/08/2022	6,7	46,4%
11/08/2022	11,8	12/08/2022	6,7	43,2%
16/08/2022	13,0	17/08/2022	10,2	21,5%
6/09/2022	14,9	7/09/2022	8,9	40,4%
15/11/2022	21,1	16/11/2022	15,5	26,5%
6/12/2022	13,4	7/12/2022	11,7	12,7%
3/01/2023	18,0	4/01/2023	12,4	31,1%

RESULTS FOR TOTAL PHOSPHOROUS

DATE	INFLUENT WILLOW MARSH (mgP/l)	DATE	EFFLUENT WILLOW MARSH (mgP/l)	REMOVAL RATE (%)
3/03/2022	1,1	4/03/2022	1,0	10,9%
8/03/2022	1,3	9/03/2022	1,0	23,8%
12/04/2022	1,4	13/04/2022	1,2	14,3%
3/05/2022	1,6	4/05/2022	1,4	12,5%
12/07/2022	2,5	13/07/2022	2,0	20,0%
8/08/2022	4,1	9/08/2022	4,4	-6,1%
9/08/2022	5,7	10/08/2022	4,4	23,4%
10/08/2022	5,8	11/08/2022	4,0	32,1%
11/08/2022	5,4	12/08/2022	4,0	27,4%
16/08/2022	6,0	17/08/2022	3,8	36,9%
6/09/2022	7,5	7/09/2022	6,6	12,0%
15/11/2022	1,5	16/11/2022	2,1	-40,0%
6/12/2022	1,0	7/12/2022	1,3	-30,0%
3/01/2023	2,0	4/01/2023	1,7	15,0%

Relation between conductivity of influent at DAY 1 to effluent of DAY 1+1



Efficient use of resources and materials

Willow marsh - results

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RESULTS FOR CHEMICAL OXYGEN DEMAND

DATE	INFLUENT WILLOW MARSH (mgO2/l)	DATE	EFFLUENT WILLOW MARSH (mgO2/l)	REMOVAL RATE (%)
3/03/2022	111	4/03/2022	109	1,8%
8/03/2022	135	9/03/2022	124	8,1%
12/04/2022	129	13/04/2022	129	0,0%
3/05/2022	139	4/05/2022	147	-5,8%
16/08/2022	151	17/08/2022	129	14,6%
6/09/2022	159	7/09/2022	144	9,4%
15/11/2022	126	16/11/2022	120	4,8%
6/12/2022	119	7/12/2022	111	6,7%
27/12/2022	112	28/12/2022	102	8,9%
3/01/2023	99	4/01/2023	86	13,6%

RESULTS FOR BIOLOGICAL OXYGEN DEMAND

DATE	INFLUENT WILLOW MARSH (mgO2/l)	DATE	EFFLUENT WILLOW MARSH (mgO2/l)	REMOVAL RATE (%)
3/03/2022	5	4/03/2022	4	30,0%
8/03/2022	46	9/03/2022	0	100,0%
12/04/2022	3	13/04/2022	4	-18,2%
3/05/2022	6	4/05/2022	4	32,1%
12/07/2022	5	13/07/2022	3	35,3%
16/08/2022	11	17/08/2022	0	100,0%
6/09/2022	5	7/09/2022	0	100,0%
15/11/2022	3	16/11/2022	0	100,0%
6/12/2022	0	7/12/2022	0	
3/01/2023	0	4/01/2023	0	

Surface area willow-marsh appr. 7.500 m²

Efficient use of resources and materials

Willow marsh - results

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RESULTS FOR ZINC

DATE	INFLUENT WILLOW MARSH (µgZn/l)	DATE	EFFLUENT WILLOW MARSH (µgZn/l)	REMOVAL RATE (%)
3/03/2022	100	4/03/2022	220	-120,0%
8/03/2022	100	9/03/2022	93	7,0%
12/04/2022	97	13/04/2022	87	10,3%
3/05/2022	120	4/05/2022	100	16,7%
12/07/2022	100	13/07/2022	130	-30,0%
8/08/2022	92	9/08/2022	85	7,6%
9/08/2022	0	10/08/2022	86	
10/08/2022	111	11/08/2022	87	21,6%
11/08/2022	112	12/08/2022	87	22,3%
6/09/2022	130	7/09/2022	100	23,1%
15/11/2022	130	16/11/2022	120	7,7%
6/12/2022	120	7/12/2022	120	0,0%
3/01/2023	130	4/01/2023	91	30,0%

RESULTS FOR Absorbable Organic Halogens (AOX)

DATE	INFLUENT WILLOW MARSH (µg/l)	DATE	EFFLUENT WILLOW MARSH (µg/l)	REMOVAL RATE (%)
8/03/2022	500	9/03/2022	590	-18,0%
12/04/2022	540	13/04/2022	430	20,4%
3/05/2022	690	4/05/2022	500	27,5%
16/08/2022	760	17/08/2022	610	19,7%
6/09/2022	830	7/09/2022	620	25,3%
15/11/2022	380	16/11/2022	110	71,1%
6/12/2022	750	7/12/2022	660	12,0%
3/01/2023	370	4/01/2023	370	0,0%

In 2022 a total volume of 538.446 m³ was treated by the willow marsh and this is 85% of the total volume of RO concentrate produced.

Efficient use of resources and materials

Willow marsh - improvements

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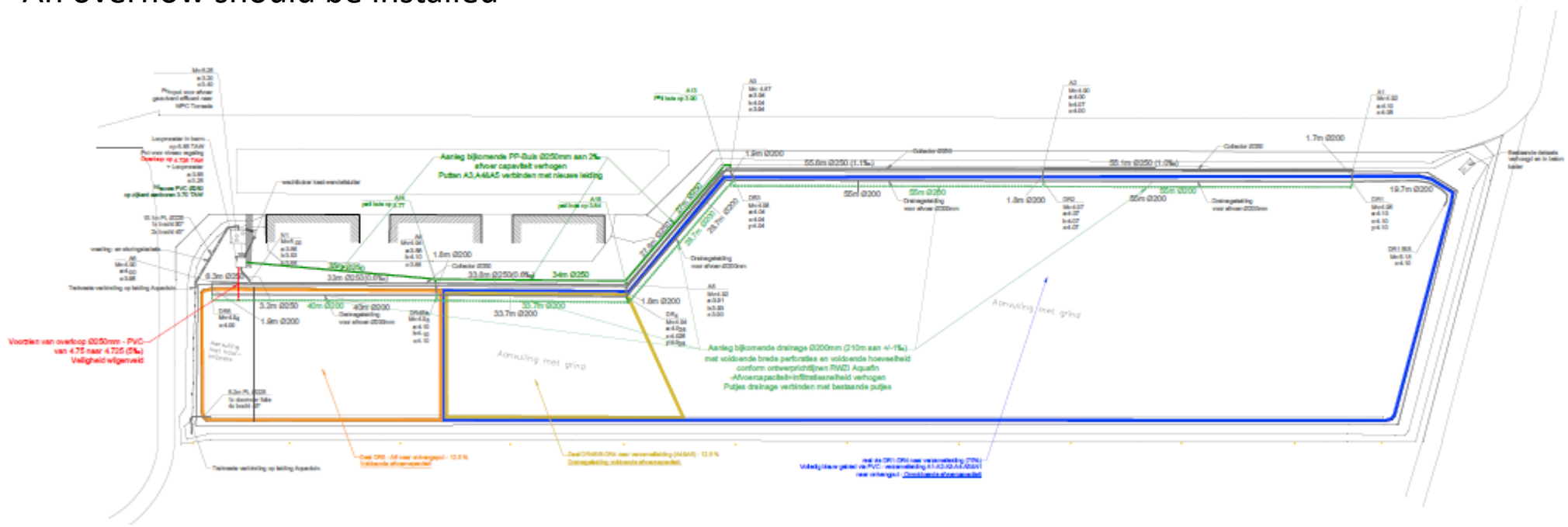
The hydraulic capacity was recalculated and it was decided that:

- Part of the drain pipe should be doubled
- Part of the collection pipe should be doubled
- An overflow should be installed



Efficient use of resources and materials

Willow-marsh – award winner

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European Regional Development Fund

CERTIFICATE

This certificate is issued to:

Aquaduin

In the capacity of winner of the:

Blue Innovation Captain Award 2022

with the project:

Afvalwaterbehandeling met wilgen:
een nature-based solution

Blue Innovation Awards 2022

With our sincerest congratulations:

Marc Nuytemans,
CEO of Blue Cluster

Certificate issued on: **16.12.2022**

Blue Innovation Awards 2022

Efficient use of resources and materials

Willow marsh - conclusions

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- Improvement of the **RO-concentrate**: water to be discharged as expected based on preliminary research
- System could be implemented as a **green buffer zone** and it offers a cooler area

What is possible when harvesting the willows?

- **Wood chips** could be used for heating or to improve soil in agricultural areas;
- **Willow branches** could also be used for construction of mats for flood protection or even for making baskets or chairs as was done up to the 1950's.

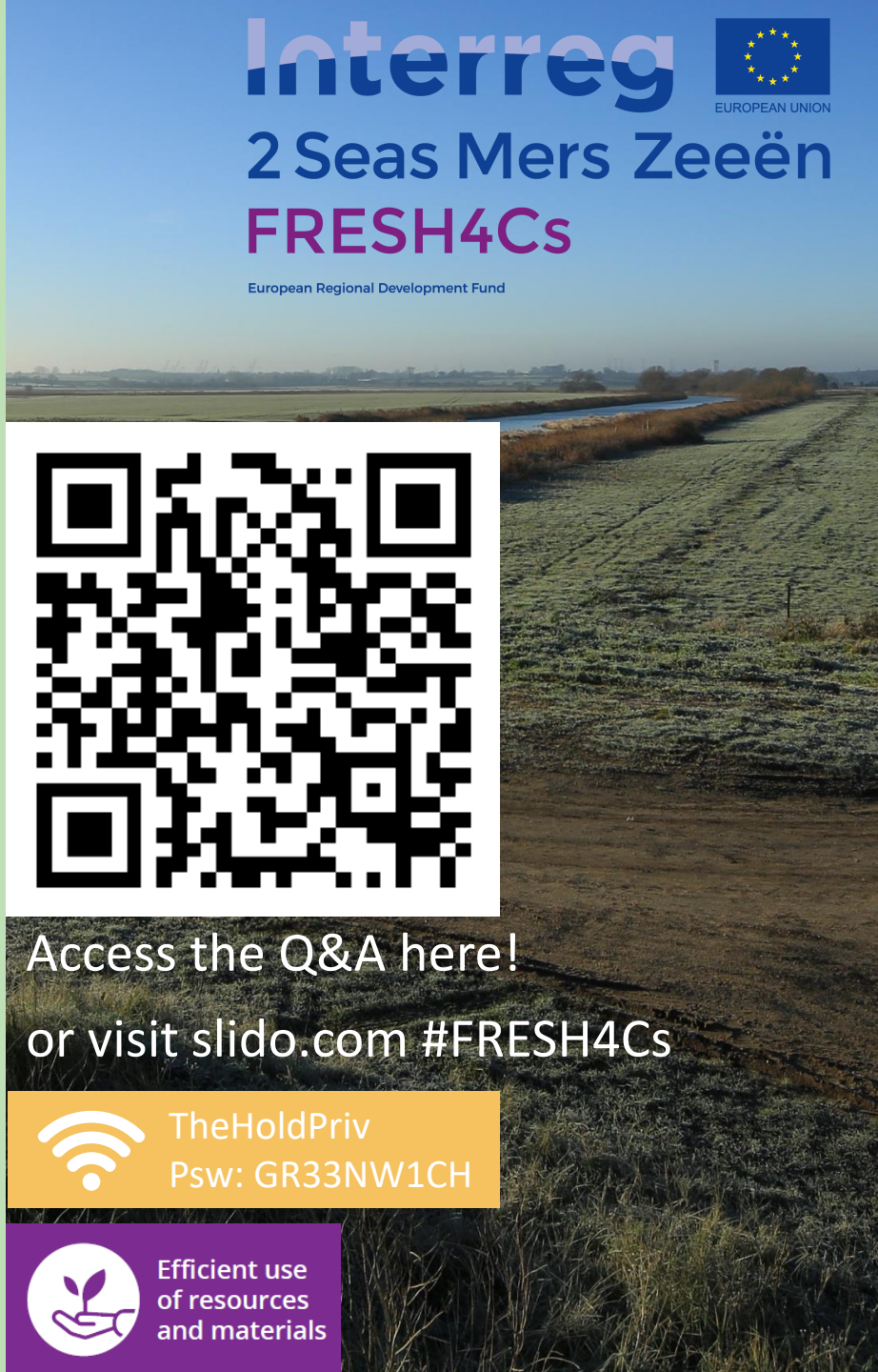
Providing Felixtowe farmers with sustainable freshwater

John Patrick

Project Manager

Felixstowe HYDROCYCLE

john@felixstowehydrocycle.com



Water flows

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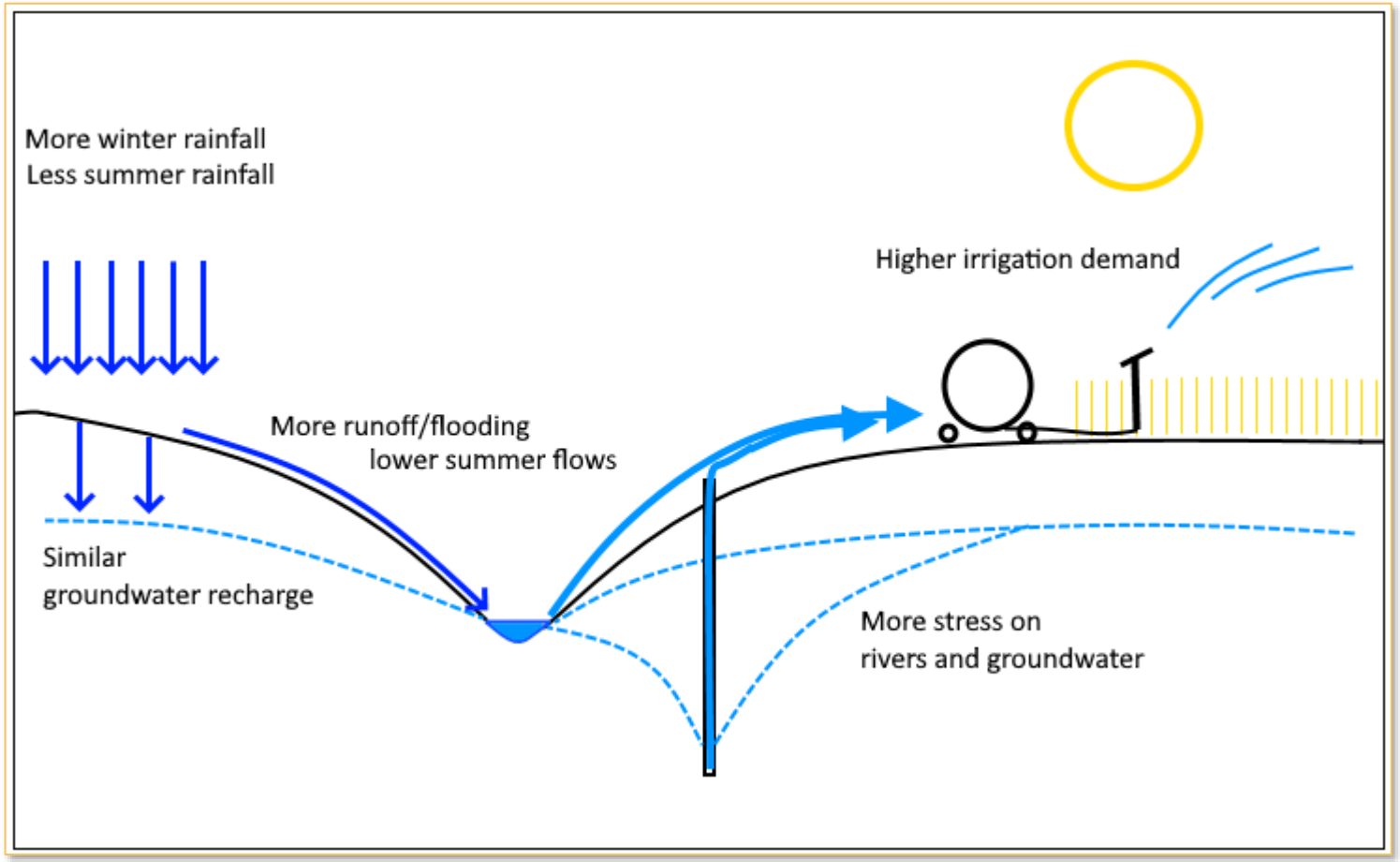

Climate change by 2050

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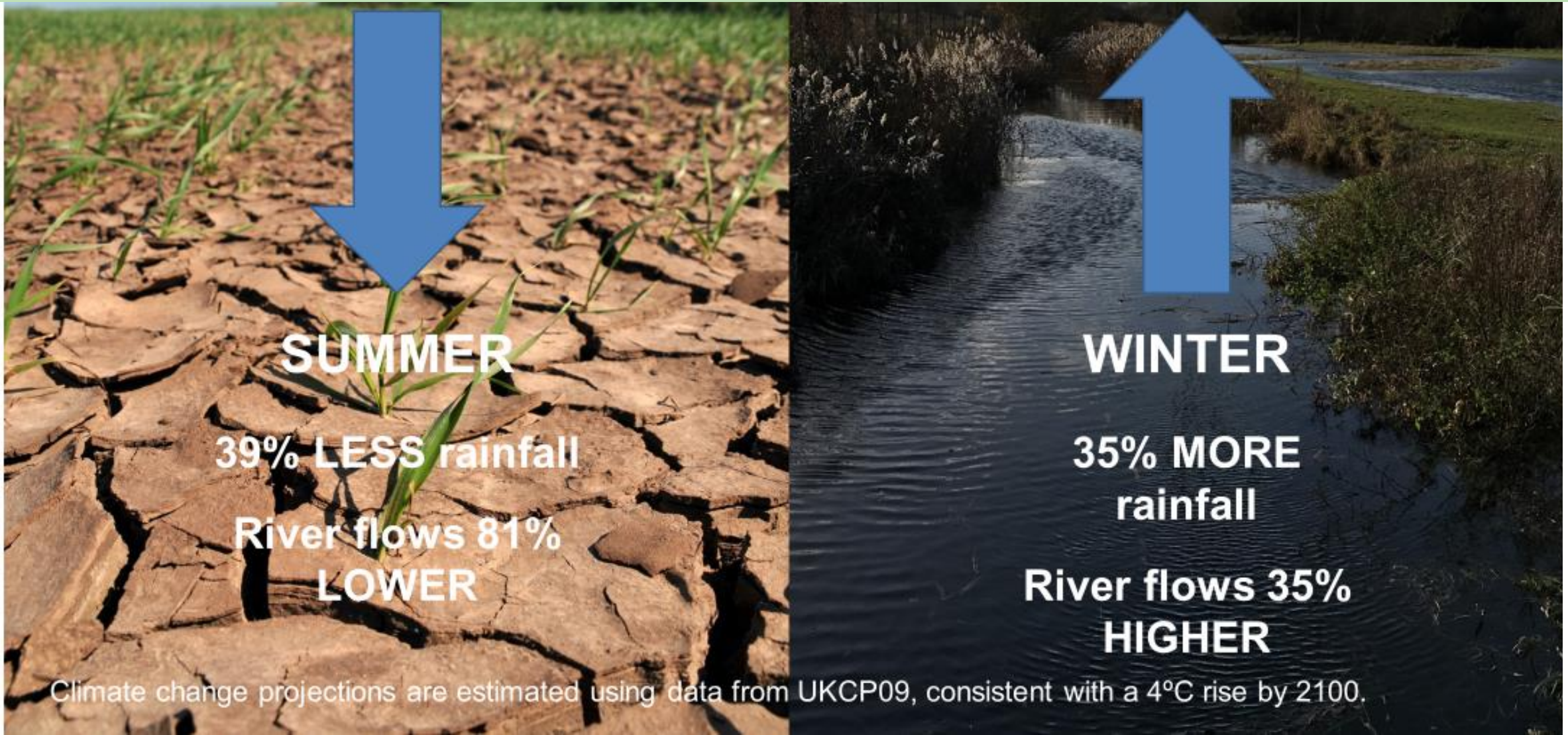


Eastern England is...

Driest region in the UK

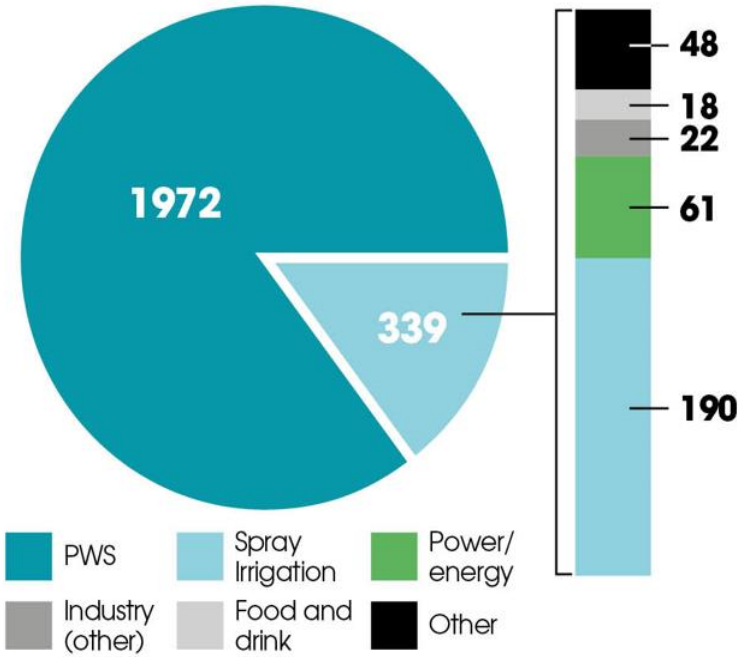
Seriously water stressed

Highest forecast growth outside London

Leading agricultural producer

Internationally important environments

How water is used in Eastern England today



Average daily water consumption in our region is currently estimated at

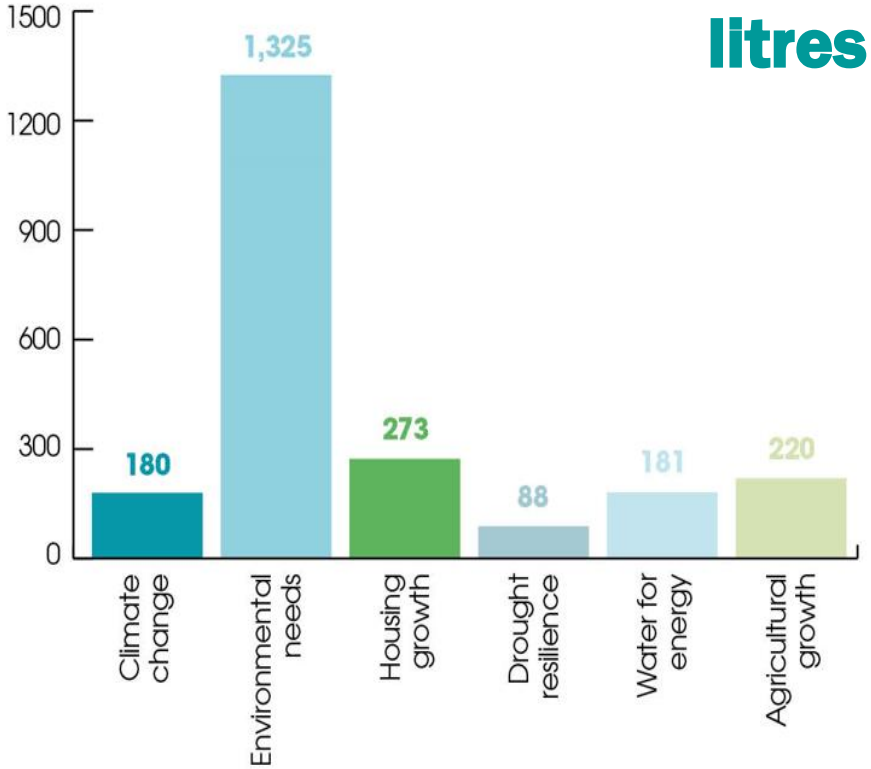
2,311 million litres

WRE

WATER RESOURCES EAST

Potential additional water needs in 2050

2,267 million litres



WRE's Proposed Supply Options

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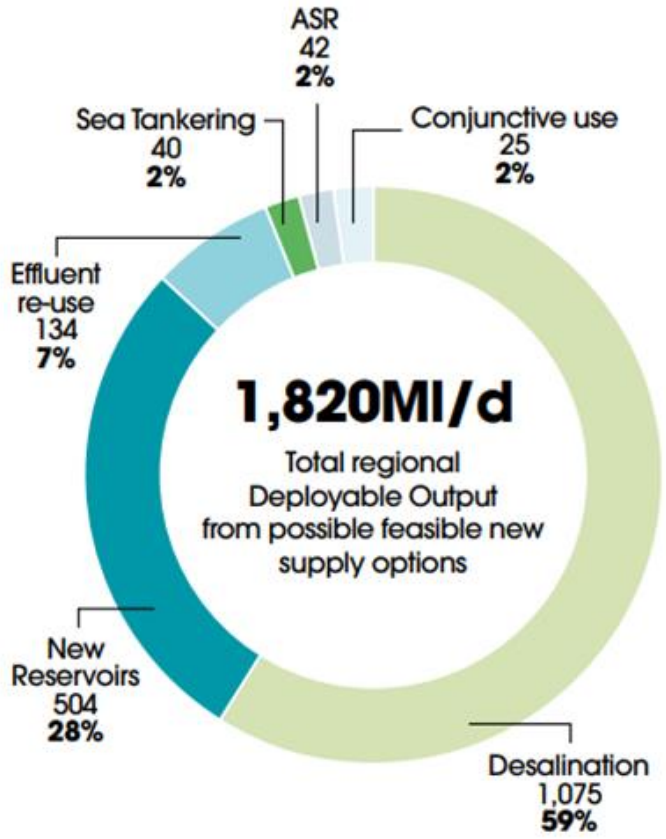

Efficient use of resources and materials

Possible Abstraction Licensing Timescales

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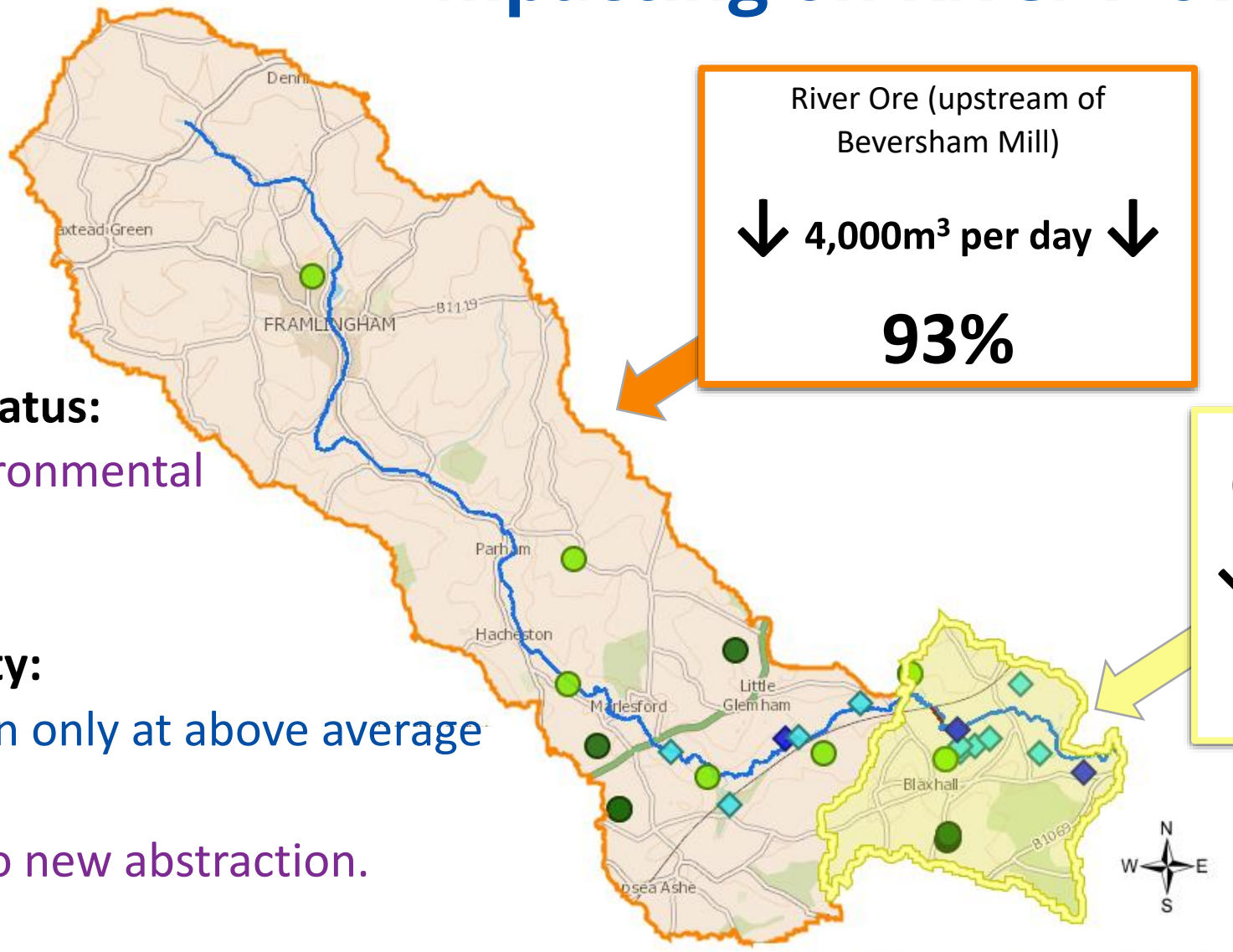
Date	Regulation/Policy	Licences affected	Likely modification
2018 ongoing	Revocation of unused licences	Unused or low uptake	'Voluntary' reductions
2021 ongoing	Trading and variation policy	Trades and variations (groundwater)	Reduction to average uptake
2026	Time limited licence review	Time limited licences (E Suffolk)	Reduction to recent max uptake
2028	Environment Act Removal of compensation	Unsustainable non-time limited licences	Reduction to sustainable levels
>2028		All licences	Reduction to sustainable levels

River Ore & the confluence with the Alde

Groundwater Abstraction is Impacting on River Flows



River Ore (upstream of Beversham Mill)

↓ 4,000m³ per day ↓

93%

Alde-Ore confluence (Beversham Mill to Snape)

↓ 700m³ per day ↓

64%

Current River Status:

50% below environmental flow threshold

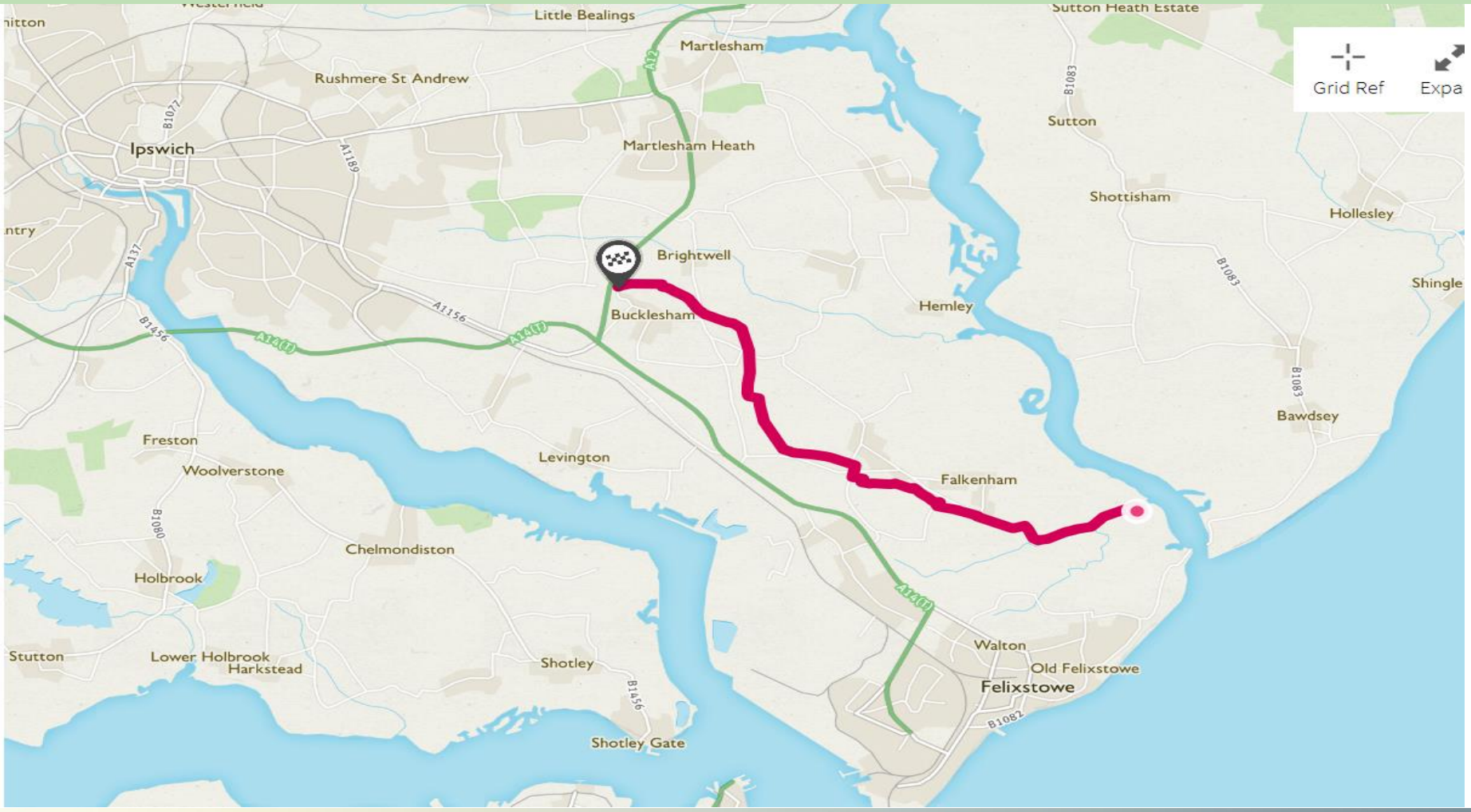
Water Availability:

River: Abstraction only at above average flows (winter)

Groundwater: No new abstraction.

What are we going to do about it?

- Change our behaviour!
- Provide examples of what behaviour change can look like
- Realism, speed and adaptability from policy makers. DEFRA / EA
- Understand the rules of the game for the next 25 years
- Support agriculture as we do Public Water Supply



Efficient use of resources and materials

Environmental impact

- Pumping of high volumes of drainage water into North Sea , 1,500,000 m3 p.a
- Causes damage to valuable saltmarsh
- Working closely with IDB , this volume and associated damage now reduced
- Lower and less intense pumped volumes are still discharged to sea to provide freshwater in the estuary, to support wading birds and scenting for fish/eels

Efficient use of resources and materials

Funding

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- 6 co-operating farmers, formed a limited company
- 50% EU grant for capital FRESH4C's
- 50% Match funding loans from members proportional to usage
- Members pay 20p/m3 for water delivered to their reservoir. This covers the running costs and also repays their loans in 14 years

Efficient use of resources and materials

Pumping

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- 2x eel friendly riverscreen pumps
- 2x 45 kW booster pumps operating at 12 bar
- Flow rates of 236 m3/hr
- Remote control

Efficient use of resources and materials

Pipeline

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- Avoids sensitive archaeology and environmental sites
- 2x 200mm pvc pipelines in a common trench
- Supplying 9 different reservoirs up to 14 km inland
- Crossing 10 different land holdings

Efficient use of resources and materials

Managed Aquifer Recharge: farmers and the regulator

Paul Bradford

Project Manager

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Felixstowe HYDROCYCLE

Jonathan Thompson

Groundwater & Contaminated Land Team Leader East Anglia

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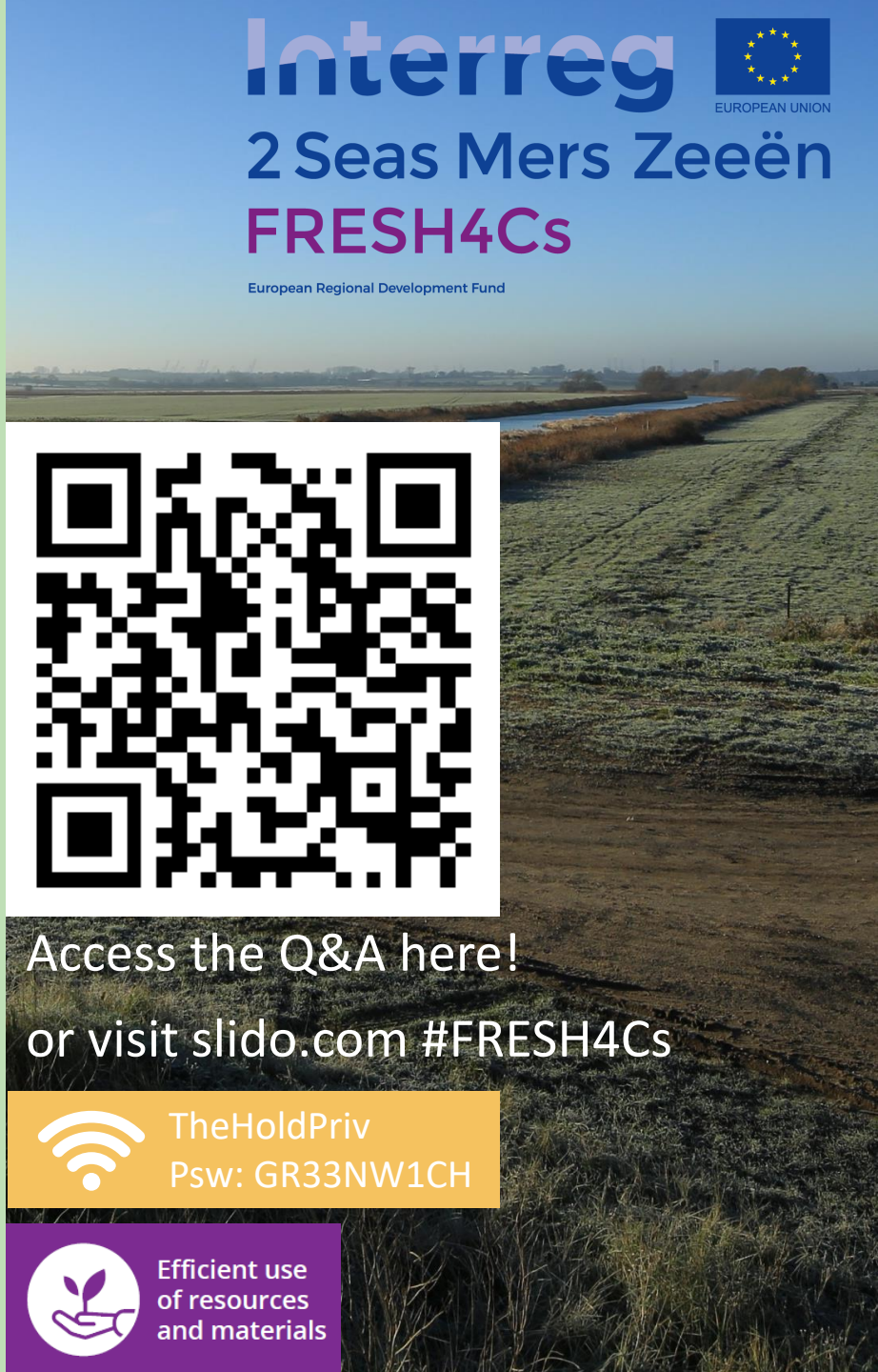

Managed Aquifer Recharge (MAR) Trial

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The aim: to evaluate MAR as an alternative to reservoir storage

Purpose: To use natural underground aquifer storage, rather than build reservoirs

Challenges:

- Source water quality suitable to meet the standards required by EA
- Getting the water into the ground/aquifer
- Proving that the water stays there
- Getting the water out of the again

Outcome:

- To demonstrate a fully operational system that the EA can licence
- To provide a “road map” to help develop commercial MAR schemes in the future

Permits Required for MAR

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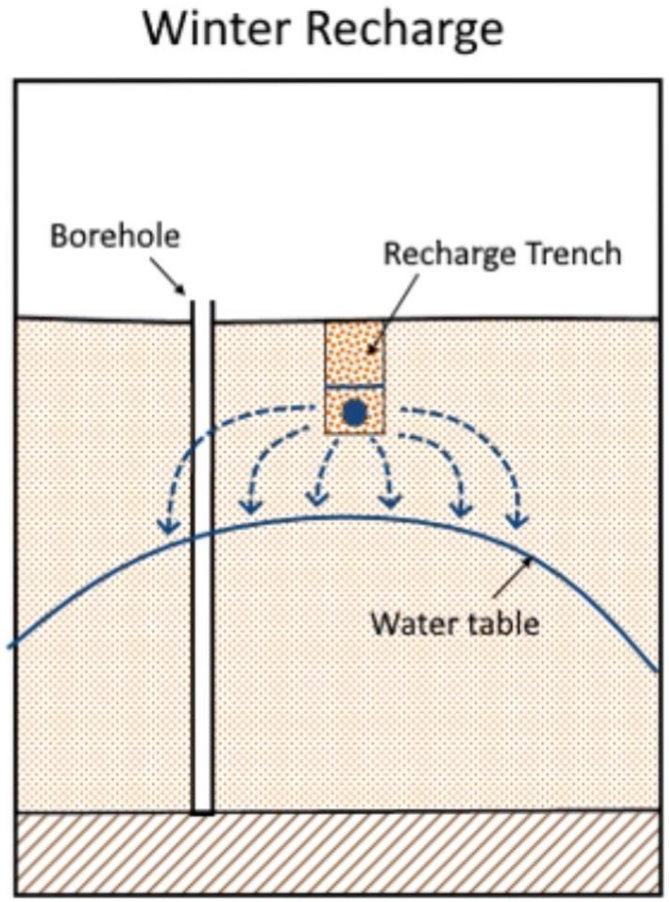
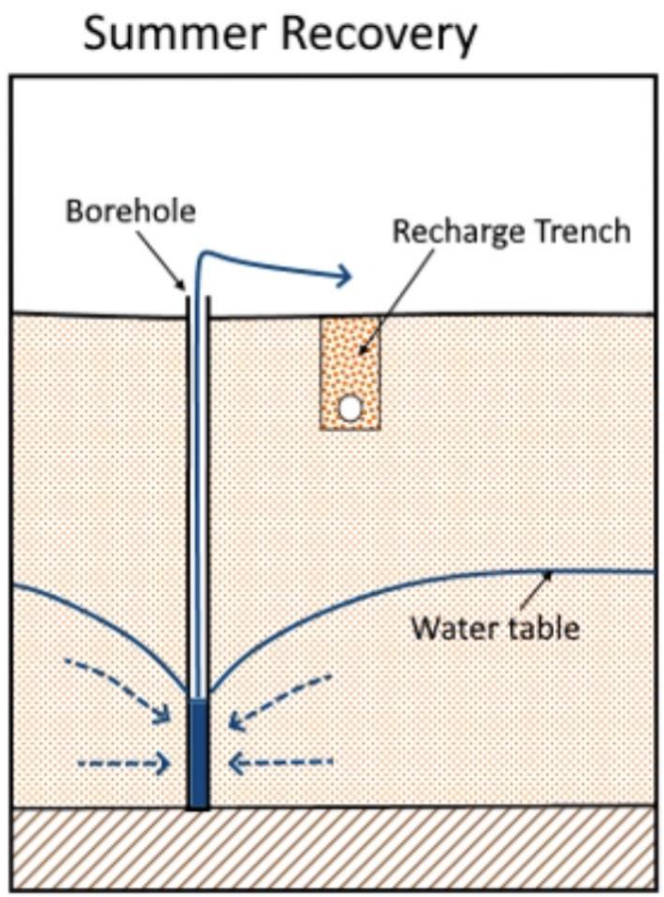
Investigations

- Groundwater Investigation Consent

Operation

- Discharge Consent
- (Water Quality) Abstraction Licence (Water Quantity)





Supporting Information

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Water quality

- Monthly analysis of source water (590 compounds x 13 samples)
- Major ions (20 samples)
- EC realtime monitoring 5 boreholes

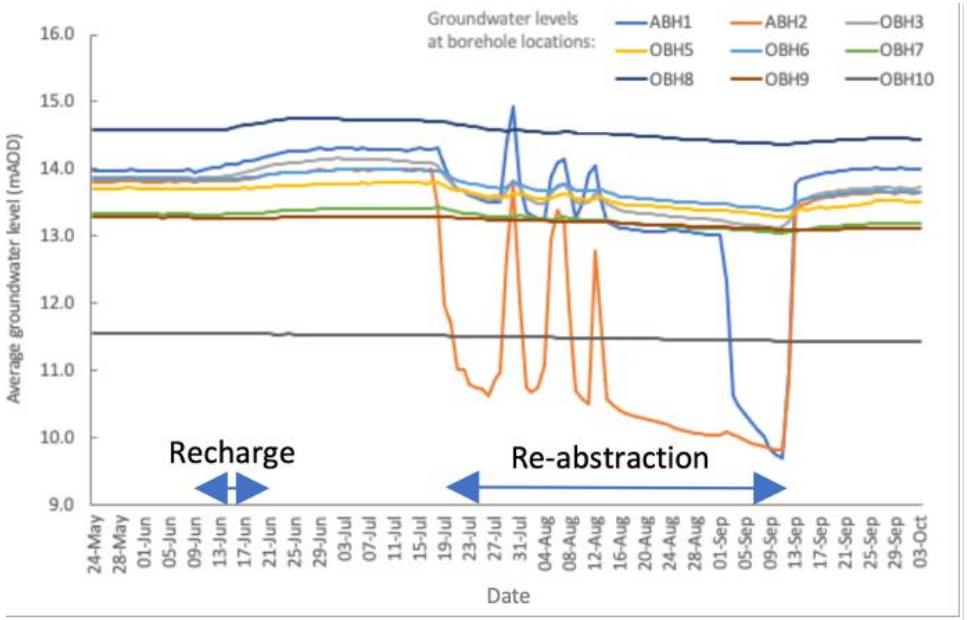
Water resources

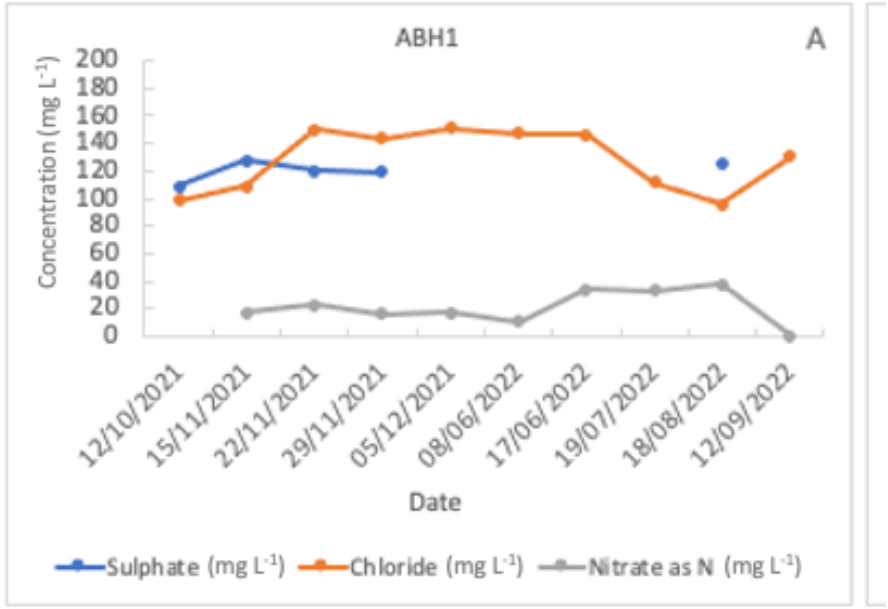
- Volume meters
- Groundwater levels (11 boreholes)
- Streamflow monitoring
- Rainfall, Soil moisture, etc.

Total monitoring and permit costs

- £63,000 excl. labour costs

Results





- Abstraction licence issued with groundwater level monitoring
- Discharge consent issued with water quality monitoring
  - Realtime NO_3 and Cl^- alarms and cut off thresholds
  - Full analysis before and after recharge

Efficient use of resources and materials

Risk perception

Financial

- Farmer input
- Project finances
- Project timelines

Environmental

- Site specific
- Precedent setting
- Legislative framework

When is there enough information?

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- Water quality
- Water resources
- Local environs
- Investment decisions
- Long term legacy

Discussion points

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Farmer

- Monitoring appears to be very precautionary
- High costs impact on commercial viability and replicability

Regulator

- How much information is enough?
- Risk based decision making

Lessons

- Communication
- Standing in each other’s shoes
- Clarity on expectations from day one

Efficient use of resources and materials

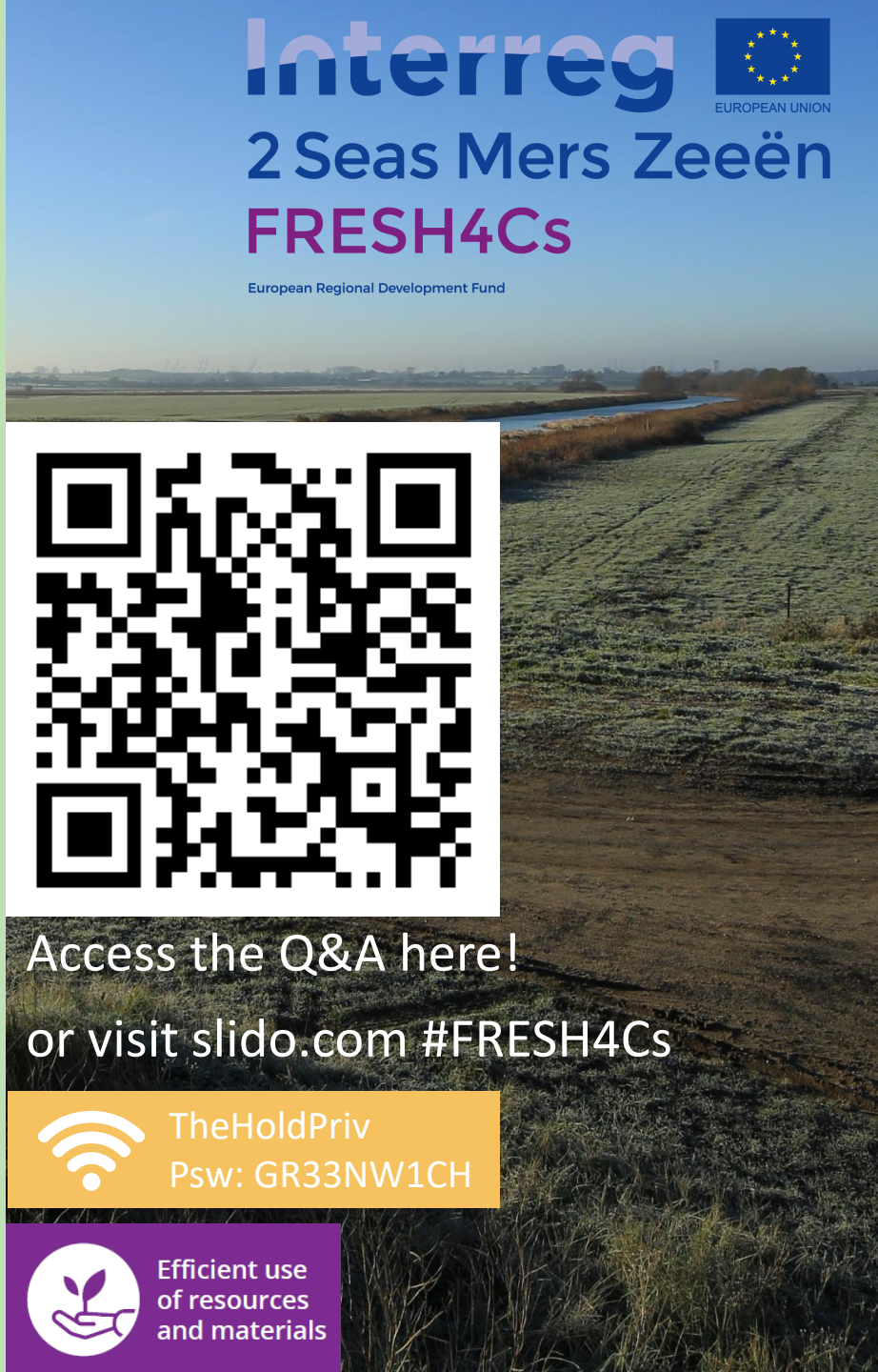
Q&A

Deltares

aquaduin
lekker kraanwater, duurzaam gewonnen

Felixstowe HYDROCYCLE

Environment Agency



Stakeholder participation and integral value

Ageeth van Maldegem

Director of Research Innovation Management and Entrepreneurship

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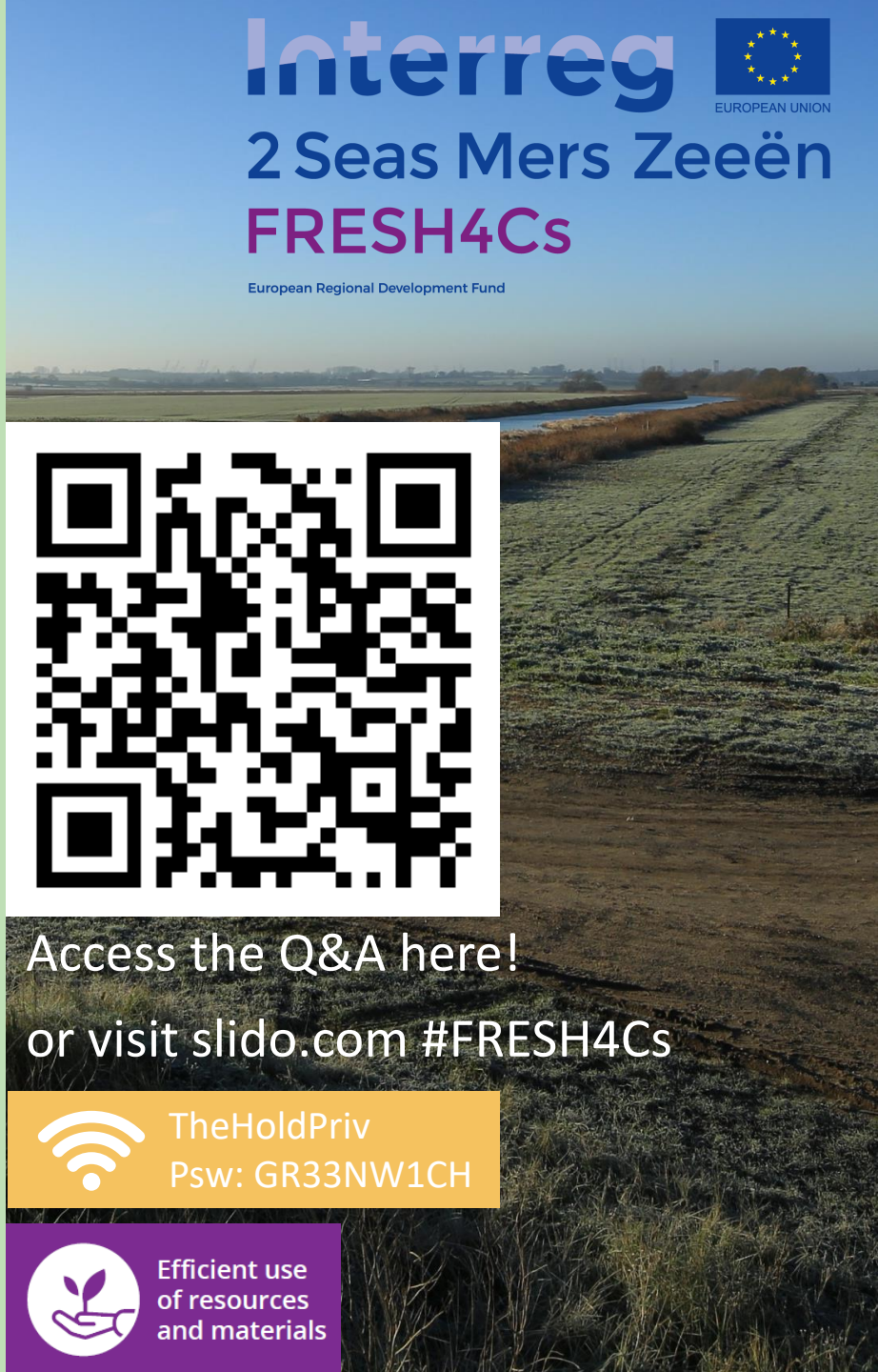


Stakeholder interaction
Key recommendations

Stakeholder interaction

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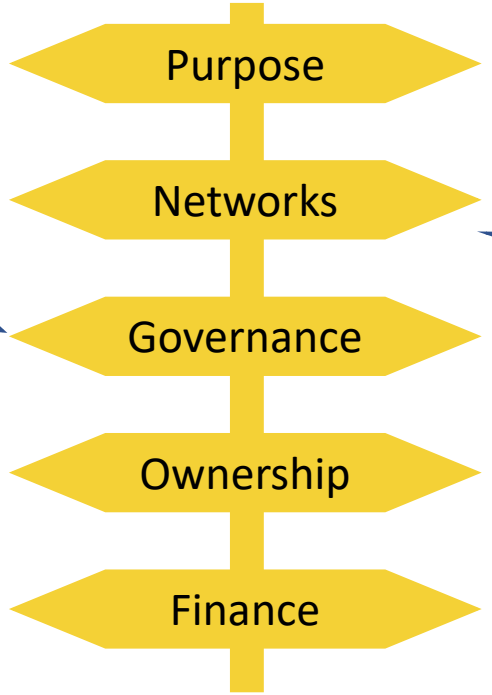
Effective freshwater management is a complex process. It poses technical challenges, but also substantial socio-economic challenges. This is due to:

- the many stakeholders, their interdependencies and conflicts of interest
- the high level of uncertainty and dynamics with regard to climate conditions and water availability

It therefore requires a system view



How can we benefit from alternative freshwater management systems

Source: https://doughnuteconomics.org/about-doughnut-economics, extracted 18-01-2023

Stakeholder interaction

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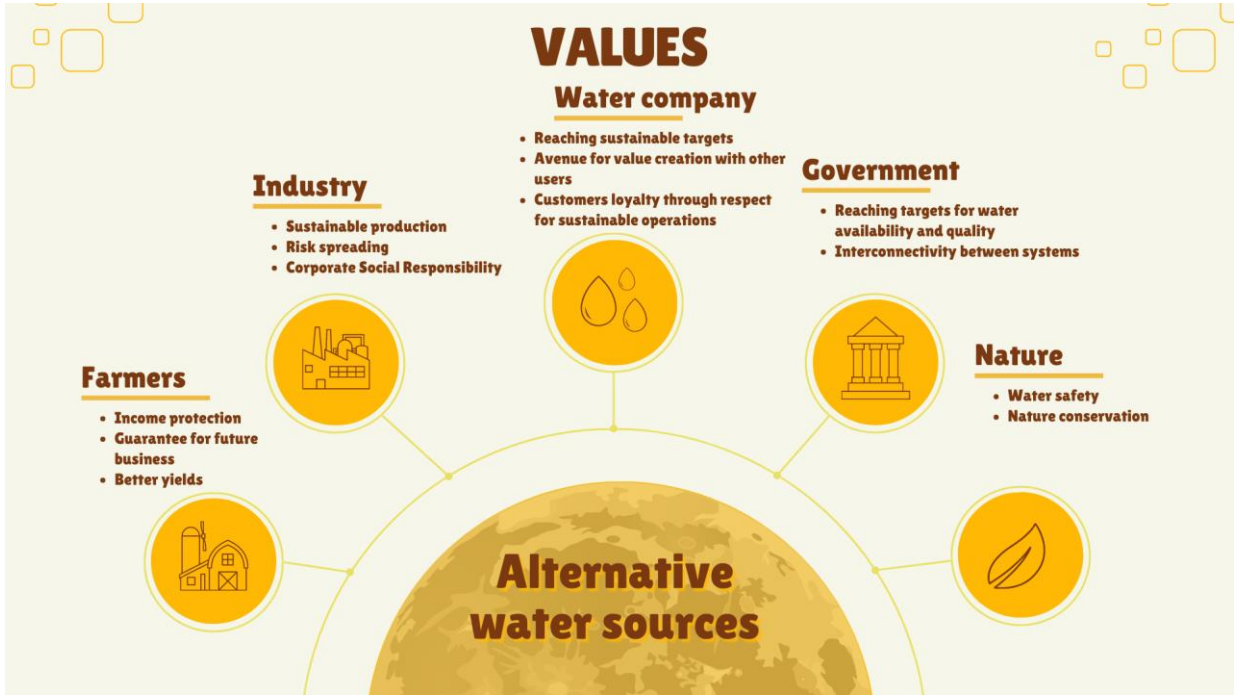
Purpose

SYSTEM CHANGE THRIVES WITH INTRINSICALLY MOTIVATED ENTREPRENEURS WILLING TO INNOVATE



Not all parties want to innovate, due to previous investments, perceptions of vested rights

Efficient use of resources and materials

Stakeholder interaction

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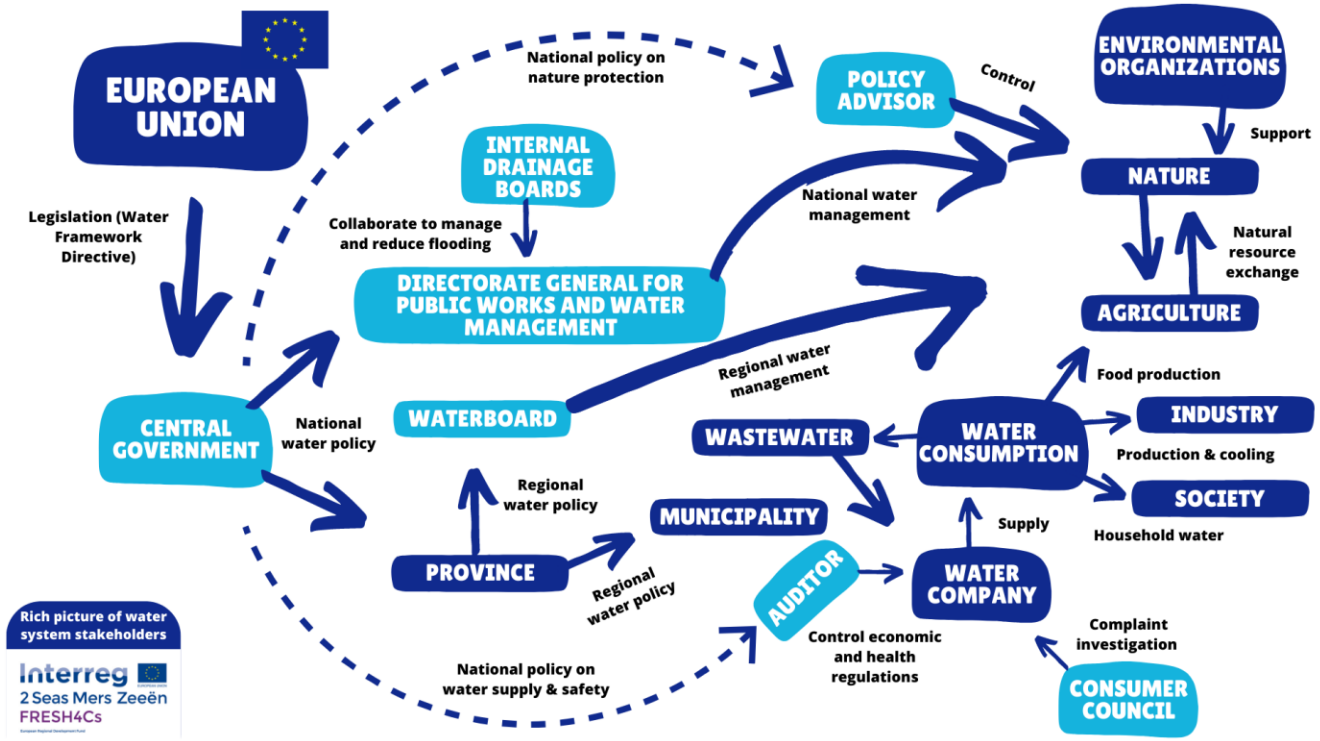
Networks

INNOVATIVE SOLUTIONS REQUIRE NEW PARTNERSSHIPS, NEW COALITIONS COMING FROM A CAREFULLY SELECTED AND EXTENSIVE NETWORK



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Stakeholder interaction

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Networks

INNOVATIVE SOLUTIONS REQUIRE NEW PARTNERSSHIPS, NEW COALITIONS COMING FROM A CAREFULLY SELECTED AND EXTENSIVE NETWORK

	Farmers	Industry	Water company	Government	Nature
Felixstowe (UK)	x			x	
Felixstowe MAR (UK)	x				
Koksijde (BE)			x	x	x
Kwetshage (BE)	x			x	x
Terneuzen (NL)	x	x	x		
Kruiningen (NL)	x	x			

Not all parties are present. Project owner decides who is at the table.

- Mostly near-by or close at hand network
- New networks, outside current business are difficult to find.
- Roles of others are not always clear
- **Carefully selected?**

Stakeholder interaction

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Governance

DYNAMIC SYSTEMS REQUIRE A DEMOCRATIC PROCESS INVOLVING ALL ACTORS FROM THE EARLY PHASE ON TO DEVELOP A SHARED VISION

Fragmented	Aligned	Coordinated	Integrated
Separation	Corresponding	Coherent	Inherent
Single value (either/or)	Combined value	Balanced value	Added value
			
Values are achieved separate. Division in time: first one then the other/ Division of tasks: we do this, you do that.	Values are added as an extra objective to existing ambitions and are then trade-off amongst each other. There are always winners and losers.	Values are combined, do not get in each other's way significantly so that each value reaches at least a basic standard.	Added value is achieved when the integration of values leads to enhanced value for each objective within the integration.

Source: Kuittert, L. and Van Buuren, A. (n.d.), Page 7

Efficient use of resources and materials

Stakeholder interaction

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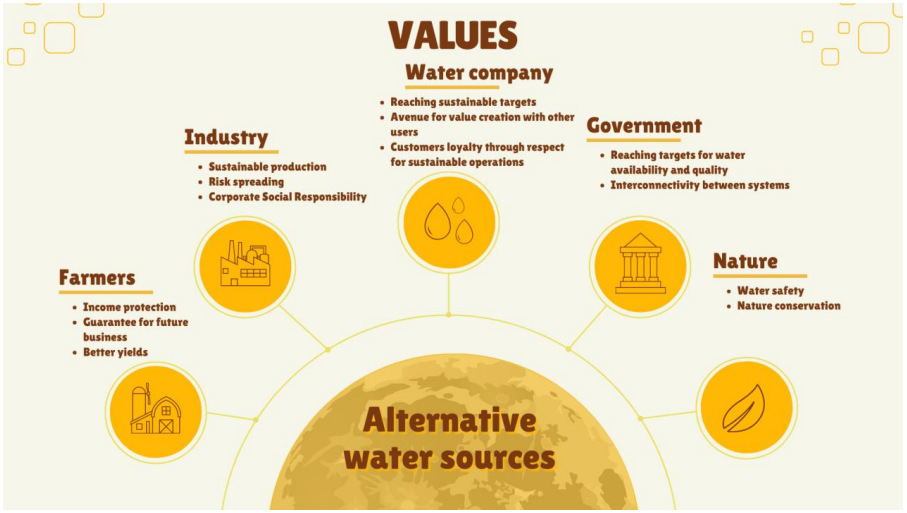
Governance

DYNAMIC SYSTEMS REQUIRE A DEMOCRATIC PROCESS INVOLVING ALL ACTORS FROM THE EARLY PHASE ON TO DEVELOP A SHARED VISION

- **Timing of involvement**
  - Involvement generally starts late, vision development is done at project proposal and inspired by lead partners.
  - Within the UK we found some examples of early involvement
  - No holistic value on all values



Efficient use of resources and materials

Stakeholder interaction

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Ownership

DYNAMIC SYSTEMS REQUIRE CLARITY ON ROLES AND A LEAD TEAM CAPABLE TO CREATE TRUST AND SENSE OF OWNERSHIP AMONG ALL PARTIES

Role of government is traditionally legitimized by market failures. However, we also noted system failure and transformation failure, which is itself a kind of government failure (Stam, 2021).

Mission-driven innovation view that all government bodies are part of the systems and need to take ownership (Mazzucato, 2018)

Market failures

Underinvestment in new technologies
Access to sufficient water of the right quality is location-based

System failures

Prices of plots
Value need to be redistributed

Transformation failures

Coordination across borders e.g. water quality
Inefficient monitoring

Efficient use of resources and materials

Stakeholder interaction

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Ownership

DYNAMIC SYSTEMS REQUIRE CLARITY ON ROLES AND A LEAD TEAM CAPABLE TO CREATE TRUST AND SENSE OF OWNERSHIP AMONG ALL PARTIES

- Questions are raised on efficacy of role played of the government
- Governmental bodies itself struggle. Fixing instead of creation
  - Just decide on permits OR seek other solutions ?
  - prevent flooding – prevent drought ?
  - water quality – water quantity
  - Should governments get involved in commercial activities

- Governments not playing expected role affect ownership and pro-activeness
- Ownership is related to size and power of parties and relates to trust
- Both horizontal and vertical linkages need to be present.

Efficient use of resources and materials

Stakeholder interaction

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Finance

FINANCE MECHANISMS SHOULD TAKE INTO ACCOUNT INTEGRAL VALUE

Return	Value bucket[1]
Financial Return	1. Higher income from farming[2]
	2. Higher income from forestry / hunting[3]
	3. Higher income from (eco-)tourism
	4. Higher income from new economic activity
	5. Increase in land value (other than farmland / Natural Zone)
Natural Return	6. Lower green house gas emissions
	7. Better N/P balance
Social Return	8. Direct / indirect jobs within the region
	9. Increased safety
	10. Health benefits

Source: Commonland, 2021, Page 29

- We should measure value for all stakeholders -> Move away from short-term financial value
- We need a common metric that is accepted by all and that can quantify all values
- The metric is a basis to redistribute value to those who lose

"Correctly aligned subsidies have the potential to redistribute value: they compensate the losing stakeholders in situations where the gains of an action is positive to all" (Commonland, 2021)

Efficient use of resources and materials

Stakeholder interaction

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Finance

FINANCE MECHANISMS SHOULD TAKE INTO ACCOUNT INTEGRAL VALUE

- Innovation in freshwater systems is not beneficial to all
- Cashflow mismatch: investments first, returns later.
- Mindset is on short-term financial value
- Stakeholder-specific estimations of future price of water, vary from 0,12 € to 3 €, dependent on:
  - Current prices vs price of not having water
  - Risk assessment and risk-taking profile
  - Information position
  - Cashflow situation
- Not all cost are included in the current price of water
- Little attention for non-financial gains and overall public value
- **A common metric for the value of water is not available but more than needed**

Efficient use of resources and materials

KEY RECOMMENDATIONS

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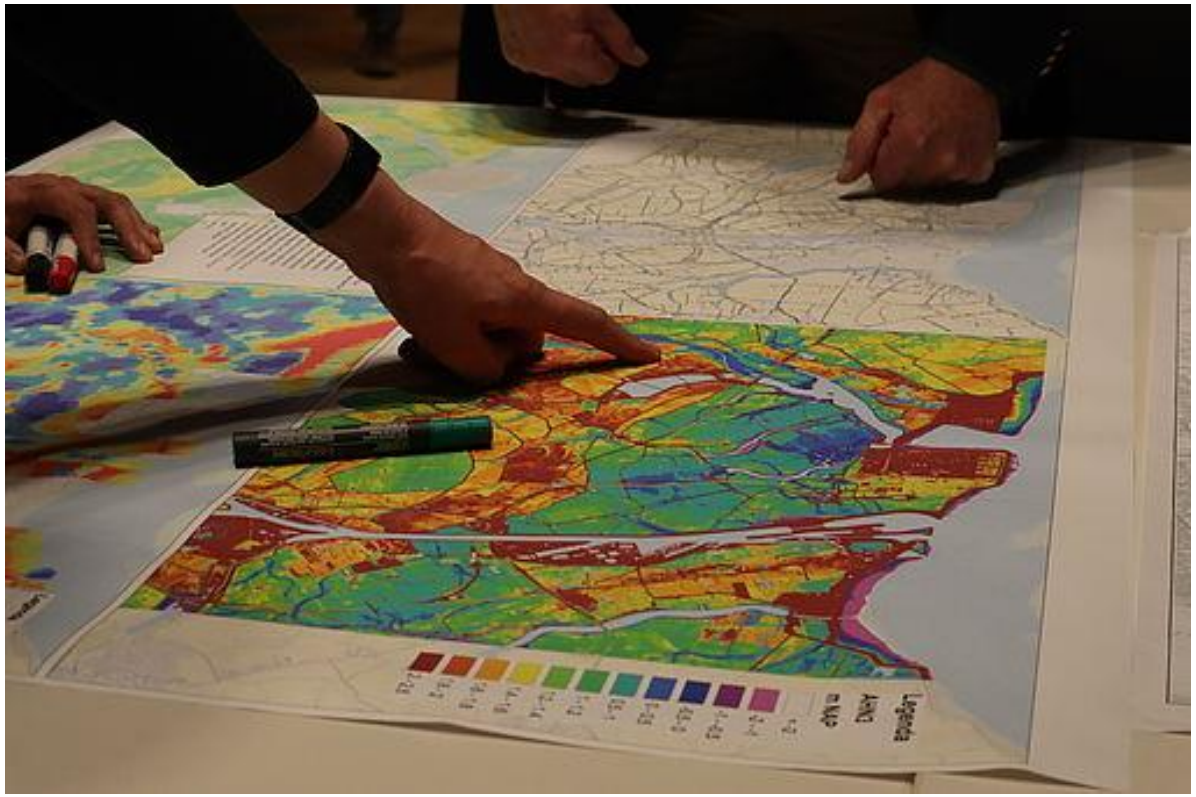
Start organizing for integral value

- Freshwater is a mission
- Strategic and bottom-up involvement
- More time needed for a shared vision, and long-term goals and values
- Develop a common and accepted metric for measuring all returns.
- Assess stakeholder-specific impacts, costs, value and dependencies
- Choose the right regional scope
- Clear views on roles and how to create trust and sense of ownership among all actors



Efficient use of resources and materials

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Round table

Moderated by Matt Hullis

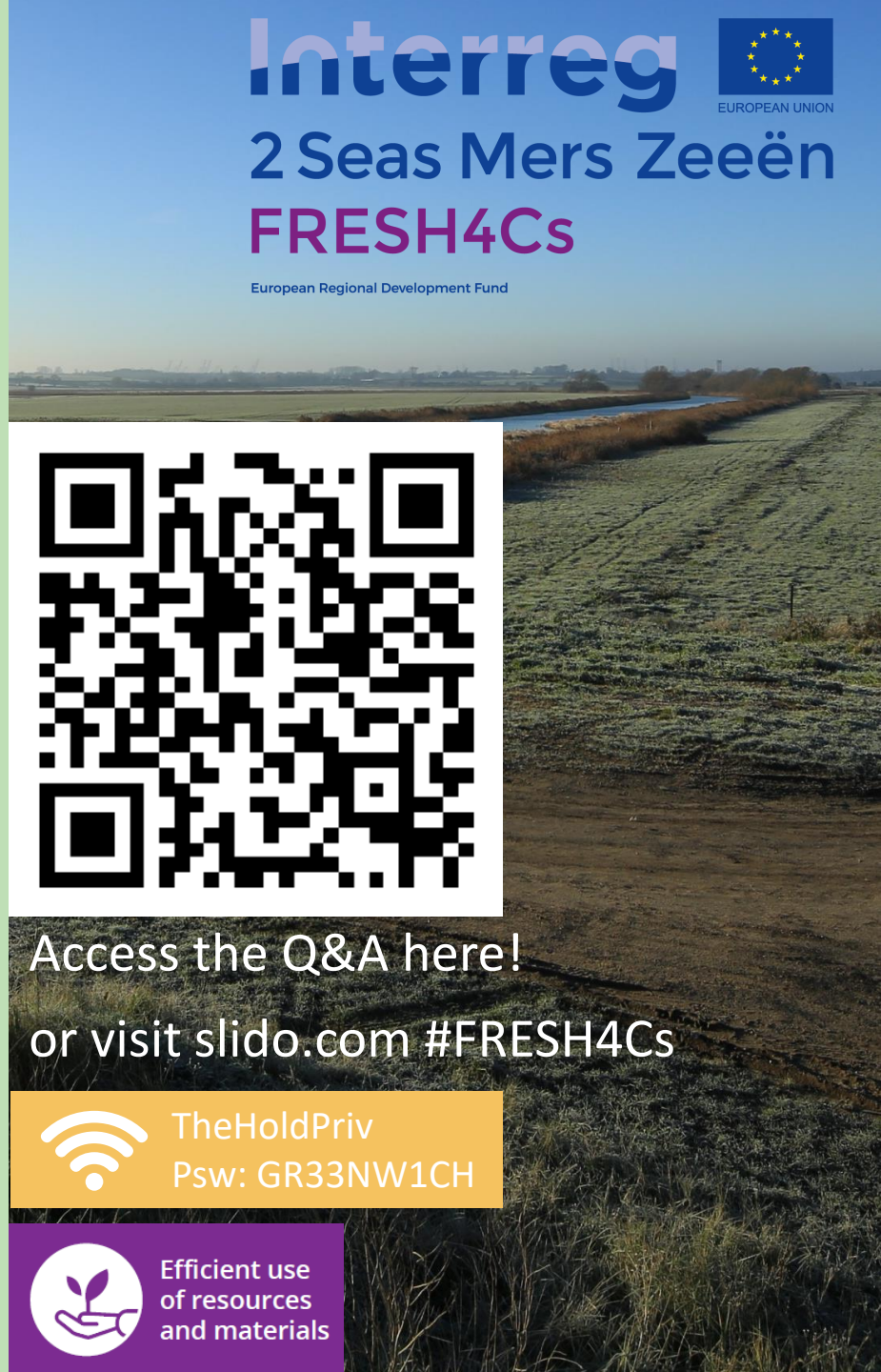
Bastiaan Notebaert

Emma McAteer

Stef Bleyenberg

John Patrick

Mariska Van Dalen



Thank you!

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