Lessons learned from MAR experiences in Flanders (Belgium)

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International Association of Hydrogeologists
the World-wide Groundwater Organisation
IAH Commission on Managing Aquifer Recharge

Online MAR Seminars
#11. Long-standing experience in MAR
Wednesday, 2 September 2026, 15:30 – 17:00 PM CEST

1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997

University Ghent Investigating alternatives for dune water extraction (with prof. Dr. W. De Breuck and prof. Dr. L. Lebbe)
Artificial recharge (MAR) was the proposed option

Hired by IWVA, now Aquaduin, to implement MAR

First test with membranes on groundwater from RBF

Membranes tested for effluent treatment

1st infiltration test performed in the dunes

2nd infiltration test performed in the dunes

Test performed with River Bank Filtration (RBF) in polder area (Avekapelle)

1998 → 1999 → 2000 → 2001 → 2002 → 2003 → 2004

Membranes tested for effluent treatment

Construction of water reuse facility and infiltration infrastructure

Start of water reuse (WPC Torreele) combined to MAR (dunes of St-André) IPR (Indirect Potable Reuse)

2006 → 2010 → 2014 → 2018 → 2022 → 2026

Test with Aquifer Storage and Recovery (ASR) in deeper aquifer (Landeniaan)

Research on temperature effects in MAR system

Subsurface infiltration implemented in MAR system

Nature Based Solution (NBS) implemented for the treatment of concentrate (brine) of reverse osmosis

Interreg 2 Seas Mers Zeeën FRESH4Cs

Test performed with RBF in polder area (Koksijde), FRESHMAN project

Life Freshman project

Why was MAR combined to water reuse?

- Proximity of wastewater treatment plant
- Best water source available all year long in this region (*compared to brackish water in polder area (lowlands)*)
- Availability of effluent in accordance with drinking-water demand (*more in summer compared to winter*)

The project : Torreele / St.-André

- By integration of water-reuse at the nearby WWTP Wulpen, water could be recharged in the existing dune water catchment of St.-André with limited impact for nature

  - Enabling decrease of natural groundwater extraction

- Ecological management of the dunes implemented

The project : Torreele / St.-André

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RESEARCH ARTICLE

WILEY

Seasonal variation of infiltration rates through pond bed in a managed aquifer recharge system in St-André, Belgium

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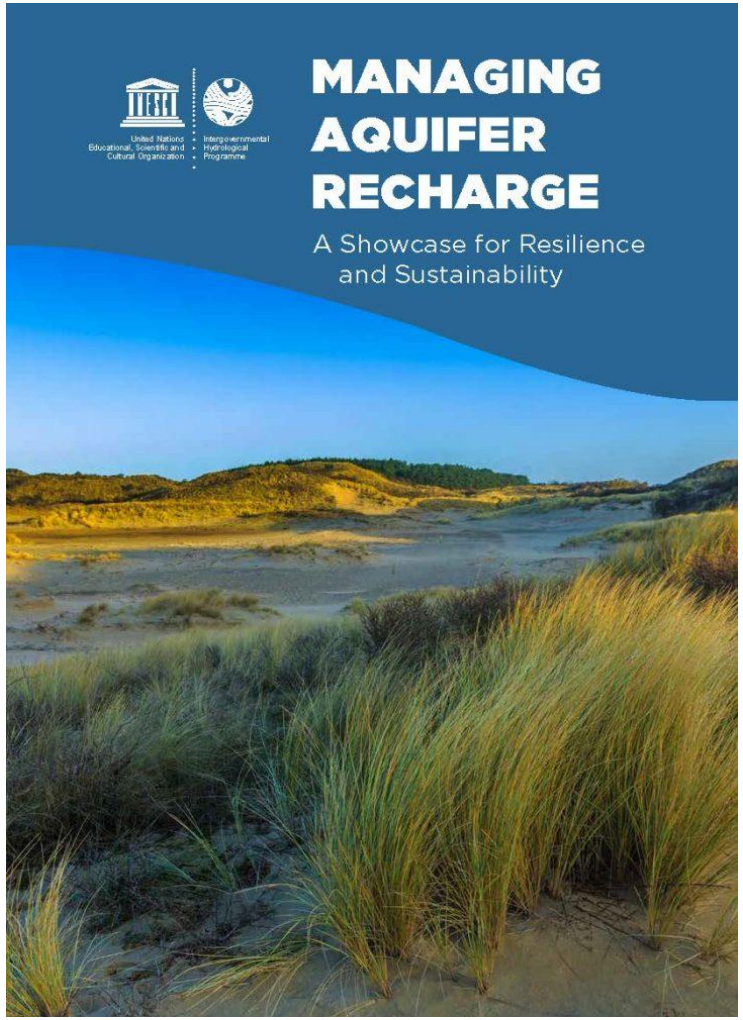
Abstract

In Belgium, IWVA uses managed aquifer recharge (MAR) to recharge the aquifer with treated wastewater generated from the communities to sustain the potable water supply on the Belgian coast. This MAR facility is faced with a challenge of reduced infiltration rates during the winter season when pond water temperatures near 4°C. This study involves the identification of the predominant factor influencing the rate



Lessons learned from the early years

- Good knowledge of the hydrogeology and hydrochemistry of the area where MAR will be developed is mandatory; take every opportunity to perform tests as you will learn a lot from them;
- Develop a MAR project in consultation with the relevant stakeholders; they should be involved from the start; especially environmental issues, including ecology, need to be tackled;
- Be patient: it can take a decade between the first idea and the start-up of the full-scale

A continuous lesson when developing (new) concepts

- As a MAR specialist you might be the only knowledgeable person about MAR in the organization. But it might be that someone feels he is smarter and knows better and counters your concept or ideas.
  - Always defend what you think is the best option; open discussions can be valuable/positive and result in better solutions;
  - Use (scientific) arguments in this defence;
  - Keep calm and polite

What is the best way to infiltrate?

Open water

Or

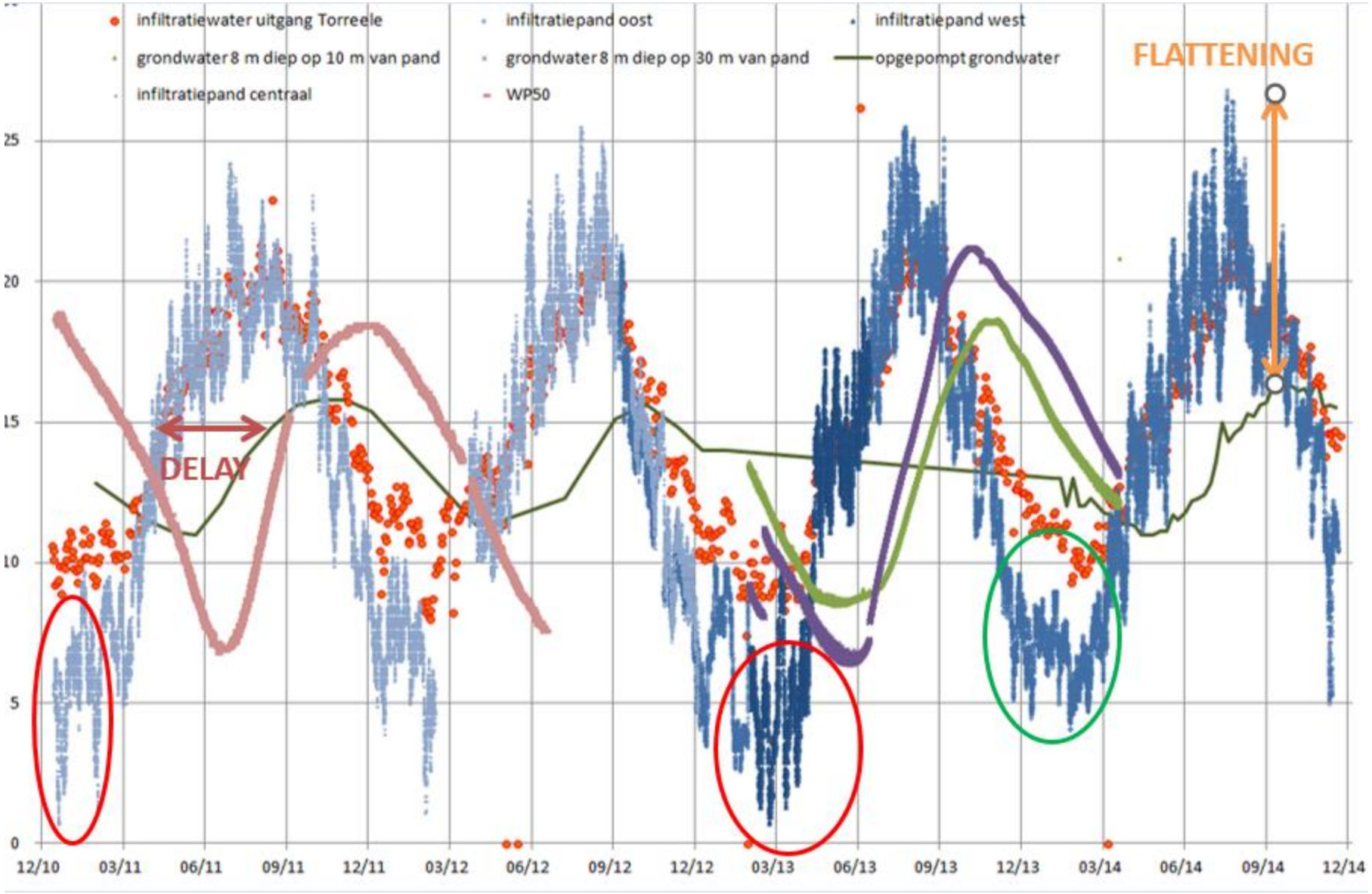
Subsurface infiltration

What is the best way to infiltrate?

Depends on local conditions:

- ***geology;***
- ***climate (temperature);***
- ***availability of space***

Temperature plays a crucial role in MAR processes: with lower temperatures the viscosity of the water decreases and the permeability of the aquifer decreases



Observations in the open pond:

Decreased temperatures in winter;

Extra cooling of water in open pond in colder winters

Open pond

DISADVANTAGES :

- Clogging effects and recontamination; maintenance will be necessary;
- Loss of water by evapotranspiration;
- Temperature affected by season: warming-up in summer and thus more microbiology and cooling down in winter decreasing infiltration capacity

ADVANTAGES :

- Moderate investment;
- Easy cleaning and monitoring;
- Infiltration water stabilizes in open air

Subsurface infiltration

ADVANTAGES :

- No clogging and no recontamination resulting in no or limited maintenance
- No evapotranspiration;
- More stable temperatures : warmer in winter, thus higher infiltration rate and more moderate in summer

DISADVANTAGES :

- Investment is more expensive

COMBINATION of OPEN POND and SUBSURFACE INFILTRATION GIVES MORE FLEXIBILITY

Some tips for the concept:

Try to work in compartments, feed and extraction:

In case of maintenance or calamities a certain capacity could be maintained

The length of the system is the most important item; not the total surface area

Some tips for the concept:

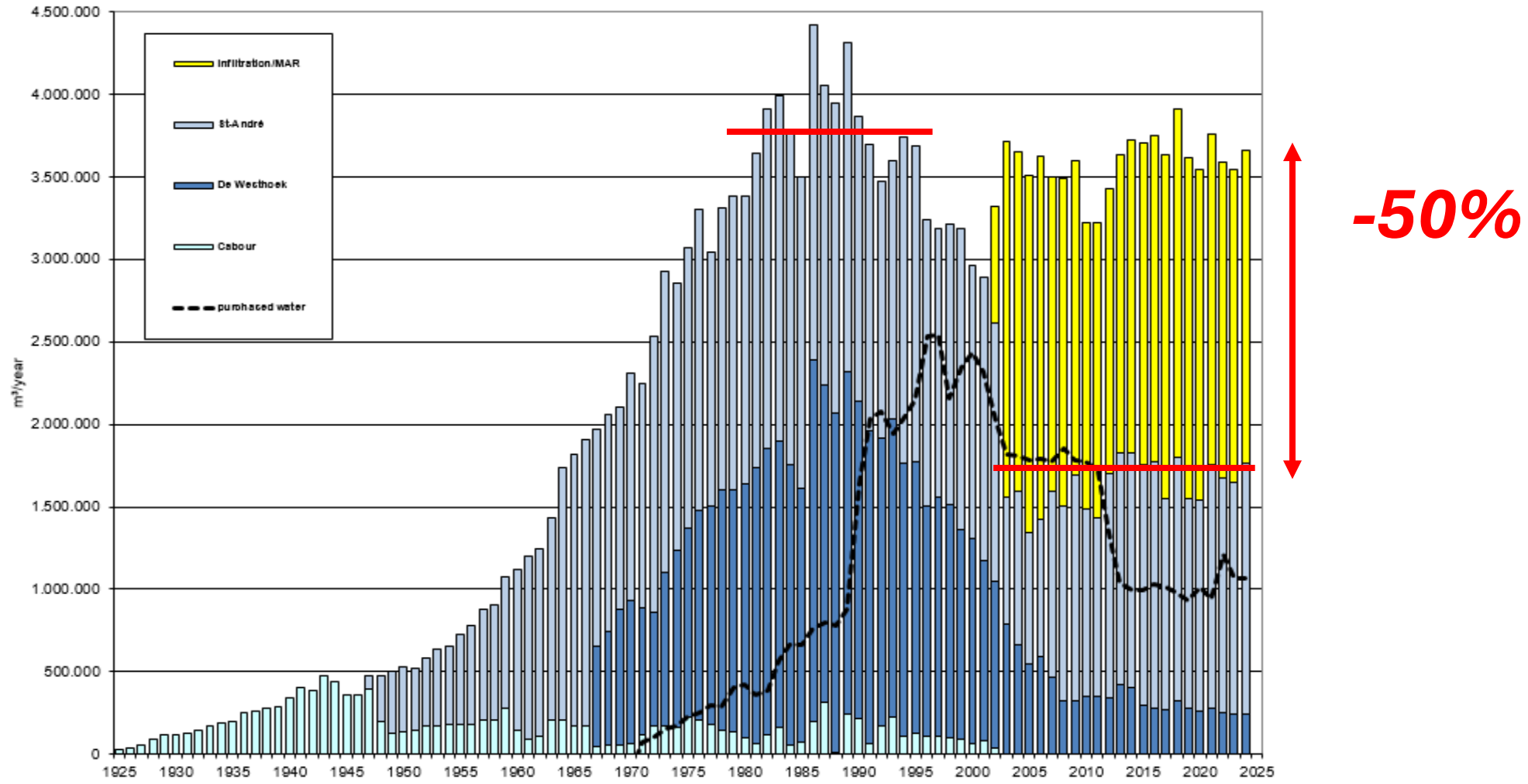
Monitoring is mandatory:

- ***Infiltrating flow*** *(to each compartment)****;***
- ***Extracted flow*** *(as detailed as possible)****;***
- ***Level and temperature measurements in pond and groundwater;***
- ***Quality control on periodic basis.***

After a certain time the periodicity of quality control can be reduced.

Experiences of MAR

MAR is a method to REDUCE GROUNDWATER EXTRACTION



Experience of MAR

Decreased groundwater extraction resulted in higher Groundwater levels: ADAPTIVE to climate change

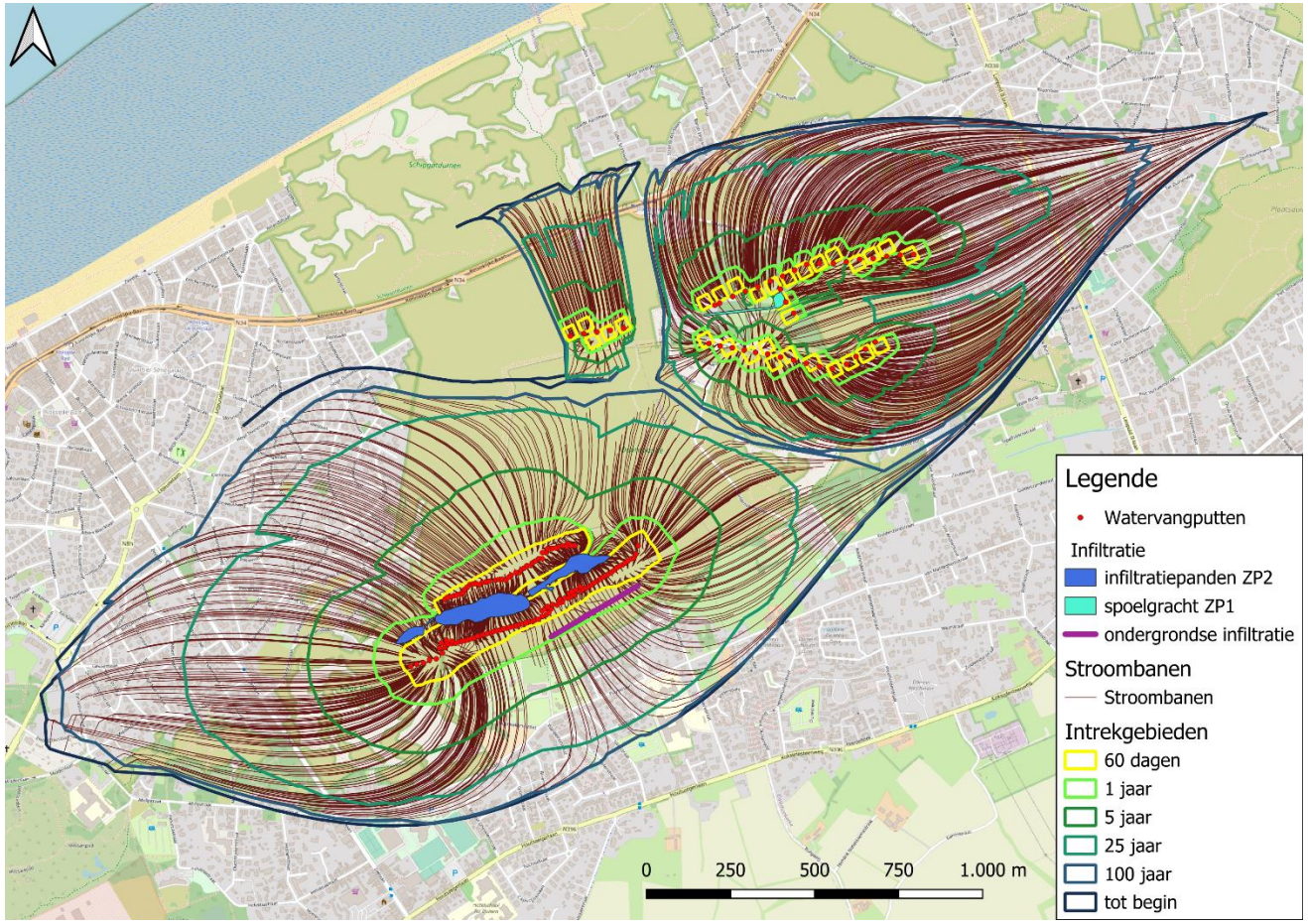
Expected sealevel rise –
higher groundwater levels

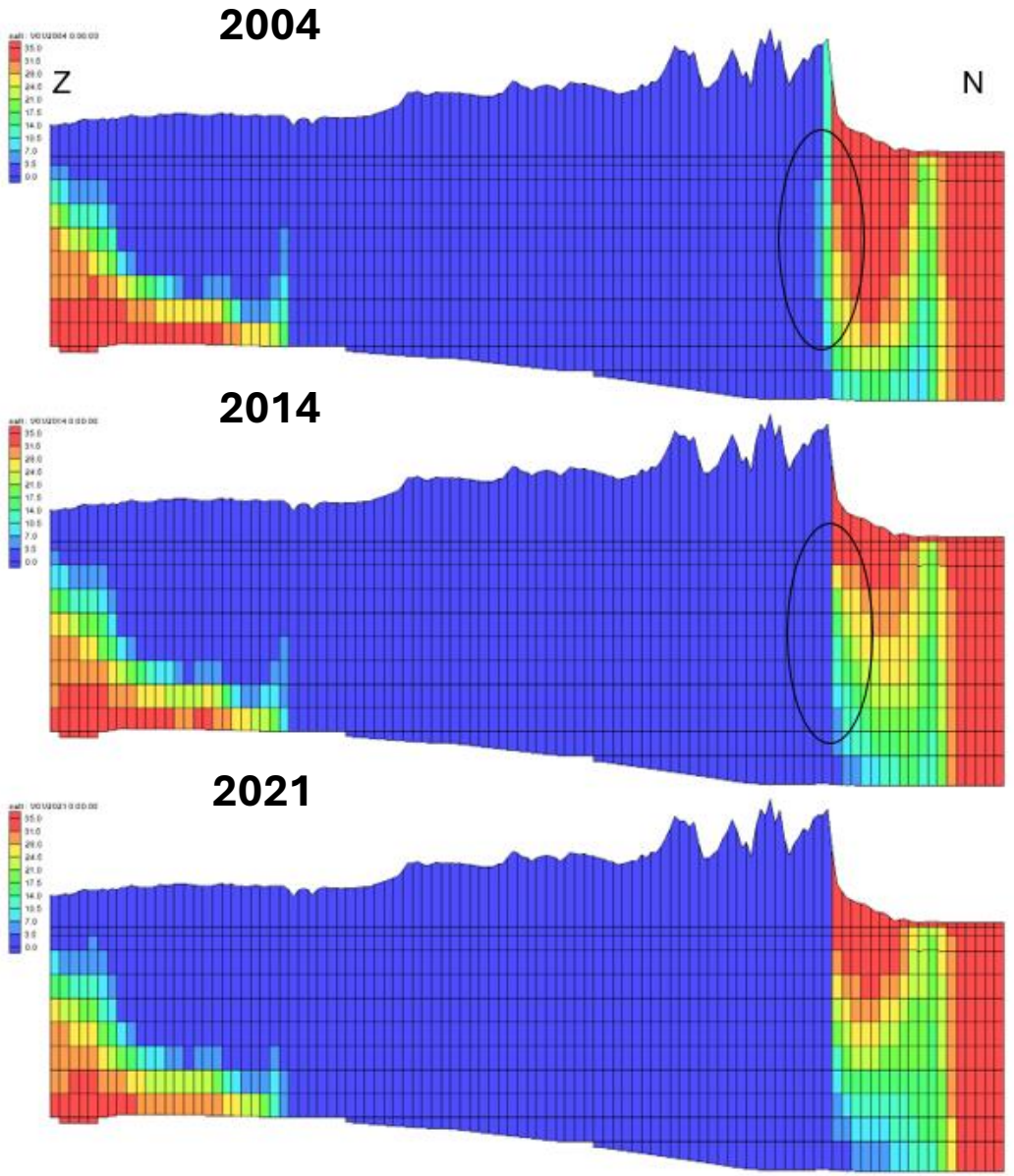
Dryer summers and more
periods of heat –
increased infiltratio
will be possible due to higher
temperatures;
this will follow demand

During drought of recent years water reuse / MAR scheme was more robust compared to conventional drinking-water production schemes.

Experiences of MAR

LESS RISK OF SALINE INTRUSION





Experiences of MAR

These higher groundwater levels also resulted in HIGHER ECOLOGICAL VALUES

MONITORING OF ECOLOGICAL VALUES IS OF GREAT IMPORTANCE

Experiences of REUSE/MAR combination

WATER SAFETY IS OF ULTIMATE IMPORTANCE

1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022 2024

Control program based on critical points including online and manual measurements

HACCP study performed

Regular screening of emerging pollutants

Tracer tests

WATER SAFETY PLAN

DW standards = Standard IW

Tracer tests

MULTIPLE BARRIER APPROACH

More emerging pollutants of concern

Hormones were the HOT issue

PFAS

1,2,4 triazole

Lower LOQ's

Experiences of REUSE/MAR combination

Costs

- **costs of a project vary according to volumes, local circumstances, … and are difficult to compare;**
- **keep track of the costs from the start-up of a new project**

Paper in preparation

The costs of managed aquifer recharge: drilling down

Andrew Ross[a], Aki Artimo[b], Emmanuel Van Houtte[c], Mohamed Shamrukh[d].

Risk mitigation in MAR

It is important to monitor the most relevant micropollutants periodically both in infiltration water, groundwater and recaptured water. It helps you to understand risks:

- **amount of removal of micropollutants during soil passage;**
- **the effect of the native groundwater and thus the dilution effect of these micropollutants.**

Keep yourself informed about potential issues with new pollutants. Regularly new issues will appear.

Risk mitigation in MAR

Varying distances from extraction wells to the infiltration pond

Result in variation of residence time

Be aware of potential reactions during the MAR process.

Some uncertainties

What is the effect of clogging?
What is the best period for cleaning/maintenance?

This is why you need data on flow, temperature and levels.



Ideas for improvement

In 2022 a Nature Based Solution based on willows was introduced for concentrate treatment

Introduction of a similar system into MAR could enhance the performance of MAR.
On the other hand MAR can in some cases be considered as a Nature Based Solution.

Think 'out of the box'

Do not be afraid if people laugh about 'new' ideas. When you follow the rules few chances you will innovate.

Innovation cannot be the purpose on its own but in case of severe problems innovation will be needed.

I will give you 2 examples of 'strange' ideas.

Think 'out of the box' (1)

The tram line is situated alongside the coastline from west to east.

A lot of accidents (with crossing cars) and incidents (with sand) occur resulting in a lot of down-time.

Think 'out of the box' (1)

Proposal: invest in a monorail to replace existing trams.

Most of the tram track from west to east could be used to infiltrate storm water.

Think 'out of the box' (1)

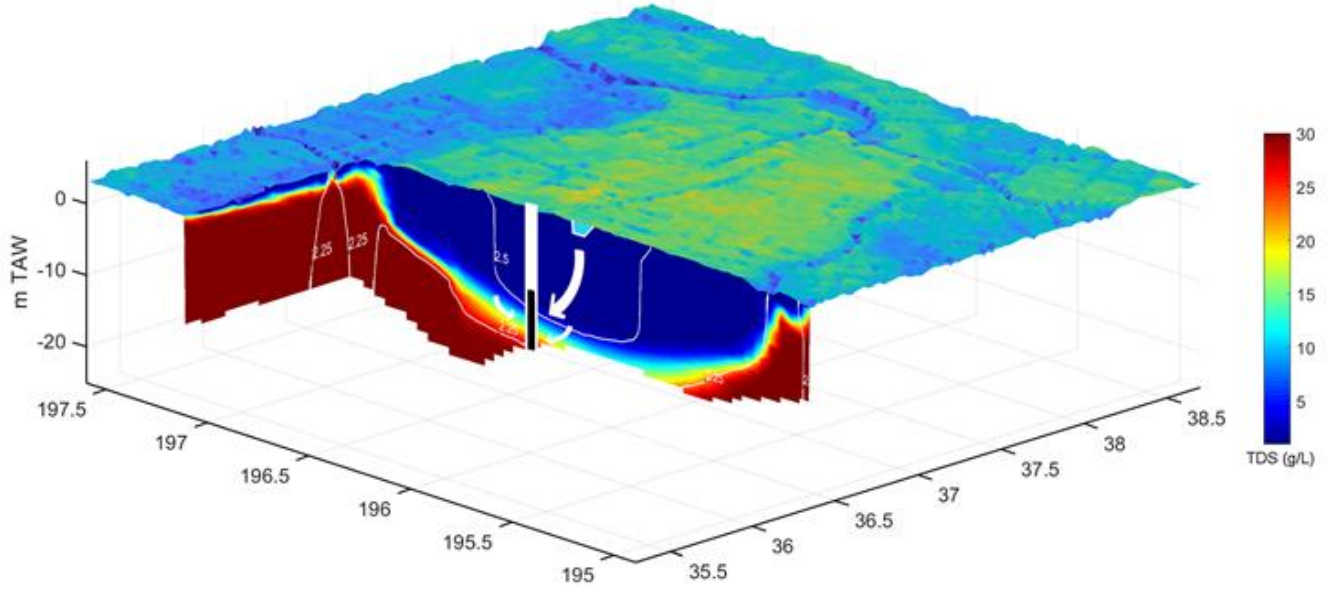
Advantages:

- **Sustainable economic investment;**
- **No accidents with other cars and less incidents during storm events resulting in less down-time in the future.**

- **Creates a fresh water buffer, results in higher groundwater levels and thus a preventive measure against sea level rise;**
- **Creates locally a green belt favouring biodiversity;**
- **Wastewater treatment plant will perform better as less rainwater dilutes the wastewater.**-

Think 'out of the box' (2)

In the Flemish polder (lowlands) the drainage is achieved (in winter) using canals. This results in drainage of fresh water.



If we should extract the brackish (to salt water) from the bottom of the aquifer in winter, more fresh water could infiltrate replacing brackish and salt water. The extracted water could be treated (e.g. with membranes) and as salinity would drop in the future the cost would go down.

General conclusion of REUSE/MAR experience

- A preventive method to **adapt to** the consequences of **climate change** (droughts, sea level rise, ….)

- With a safe design (multiple barrier, risk spreading in pond and wells) and stringent control system at place (both online and manual) the **quality of the drinking-water is safe** and stable, both chemically and microbiologically

- It enhances the **ecological value** of the dune area


Thanks for listening