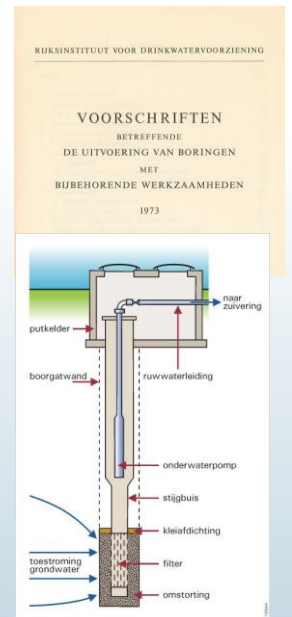


1. Introduction

Wells in the Netherlands

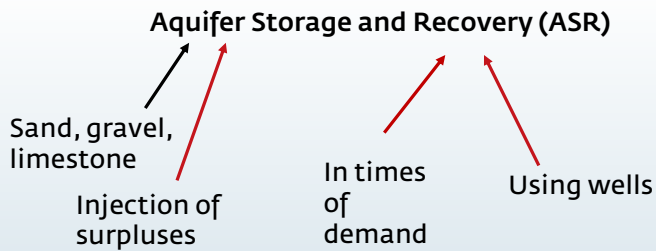
- Groundwater is the main source for drinking water
- 3500-4000 pumping wells
- Est. value 500-1000 M€ (incl. measurement and control, pipes, etc..)
- Large variation in depth, extracted volume, used materials
- Mostly 'simple' vertical wells!



Sophisticated well configurations to enable aquifer storage and recovery (ASR) in coastal aquifers

1. Introduction

Aquifer storage and recovery (ASR)

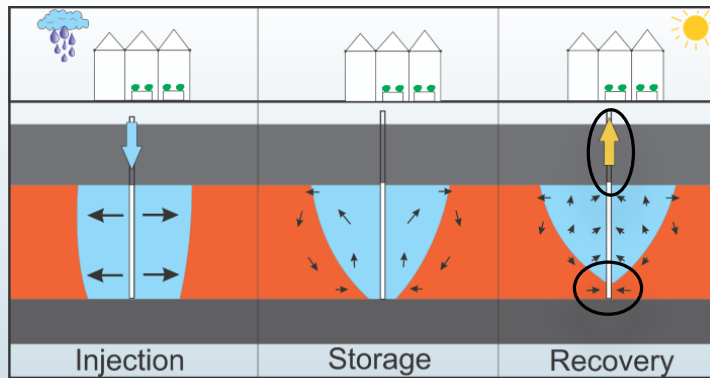


- Large capacity;
- Protected from surface contamination;
- Not claiming area aboveground.

Sophisticated well configurations to enable aquifer storage and recovery (ASR) in coastal aquifers

1. Introduction

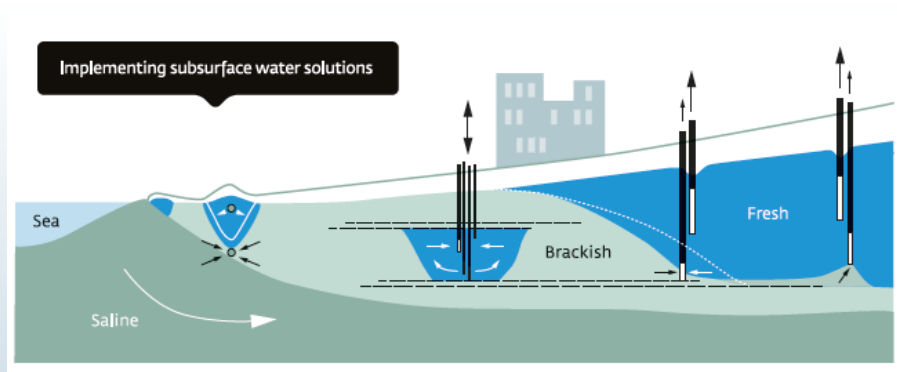
Aquifer storage and recovery (ASR) in coastal aquifers



Sophisticated well configurations to enable aquifer storage and recovery (ASR) in coastal aquifers

1. Introduction

Sophisticated well configurations

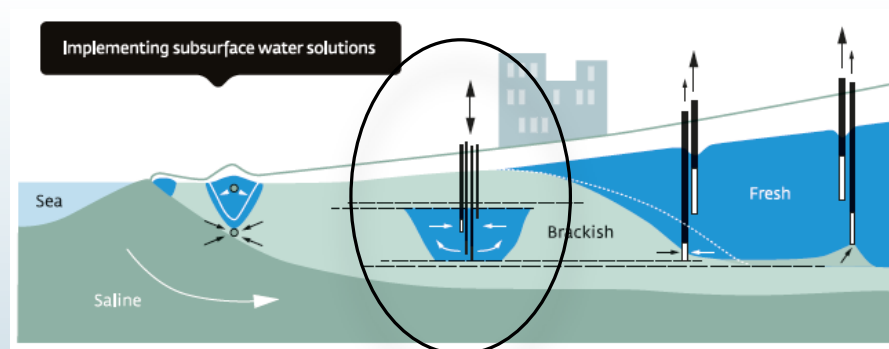


Can sophisticated well configurations be a practical, cost-efficient solution for ASR in coastal aquifers??

KWR Watercycle Research Institute

2. The approach: sophisticated well configurations

ASR-coastal

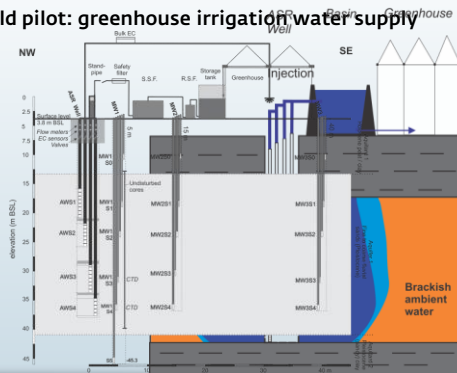


KWR Watercycle Research Institute

2. The approach: sophisticated well configurations

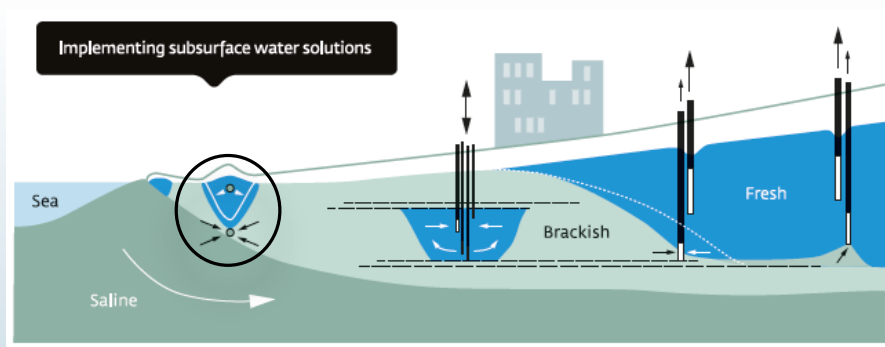
ASR-coastal

1. Store excess (rain)water in confined brackish and saline aquifers
2. Multiple Partially Penetrating Wells (MPPW)
3. Field pilot: greenhouse irrigation water supply



2. The approach: sophisticated well configurations

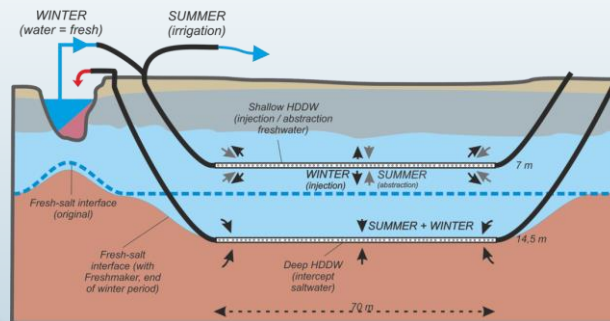
The Freshmaker



2. The approach: sophisticated well configurations

The Freshmaker

1. Horizontal directional drilled wells (HDDWs)
2. Shallow HDDW infiltration and recovery of freshwater surpluses ('ASR well')
3. Deep HDDW to remove saltwater and prevent upconing
4. Field tested for irrigation water supply at fruit grower



KWR Watercycle Research Institute

2. The approach: sophisticated well configurations

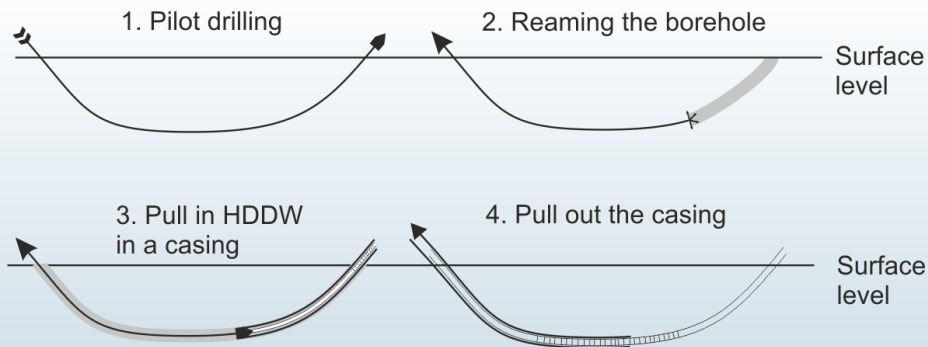
The Freshmaker



KWR Watercycle Research Institute

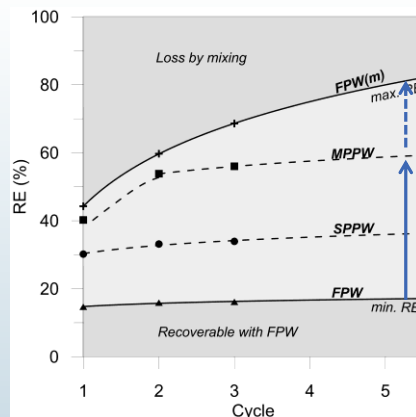
2. The approach: sophisticated well configurations

The Freshmaker



3. The results: increased freshwater recovery

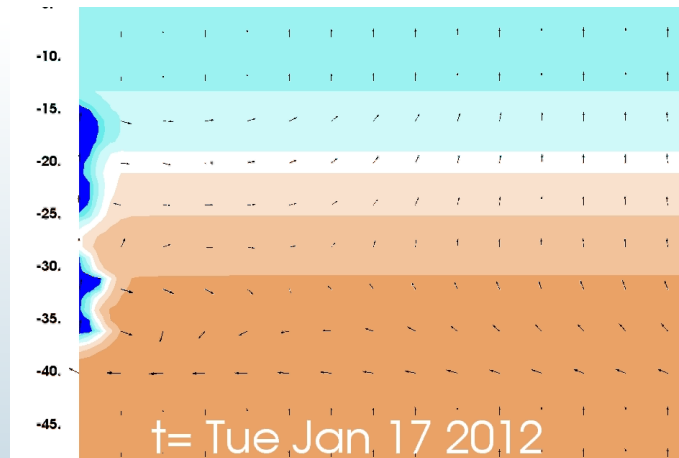
ASR-coastal



1. Comparison with conventional ASR set-up
2. Significant increase in freshwater recovery
3. > Sufficient for greenhouse owner
4. No elimination of freshwater loss by buoyancy
5. Competing cost price per m³

3. The results: increased freshwater recovery

ASR-coastal



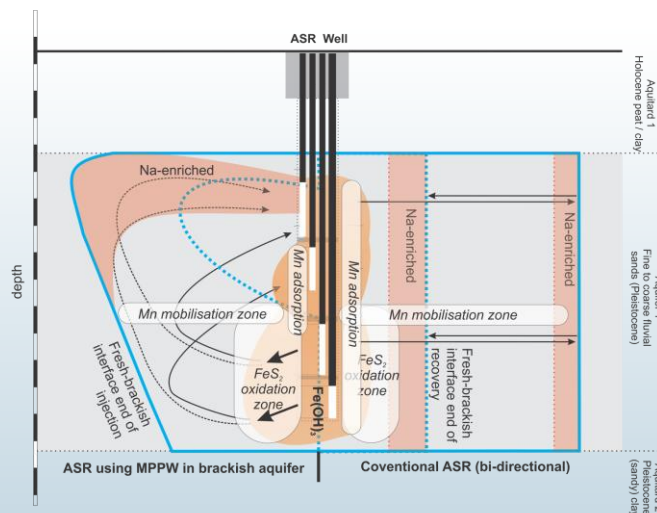
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3. The results: increased freshwater recovery

ASR-coastal

Mind you:

- Different from conventional, bi-directional ASR
- Na release from cation exchange
- Water travel vertically through reactive zones

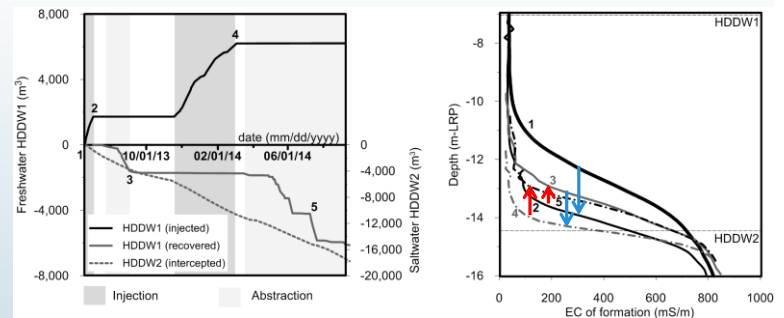


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3. The results: increased freshwater recovery

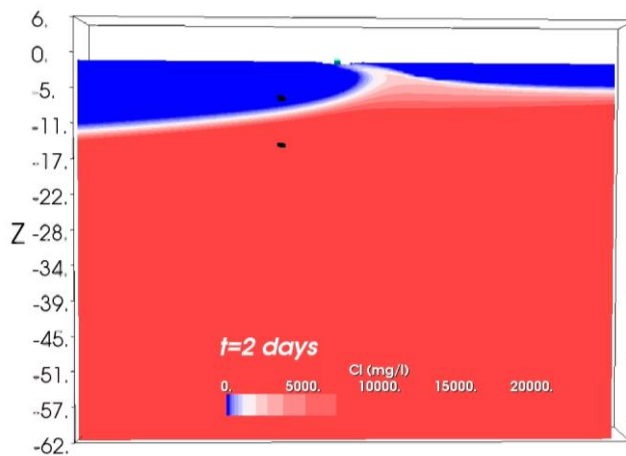
The Freshmaker

1. 2 test cycles: recovering 1,700 and 4,500 m³
2. Active management of freshwater-saltwater interface
3. HDDWs demonstrate their efficiency for MAR in coastal zones
4. Estimated cost price: 0.35 €/m³



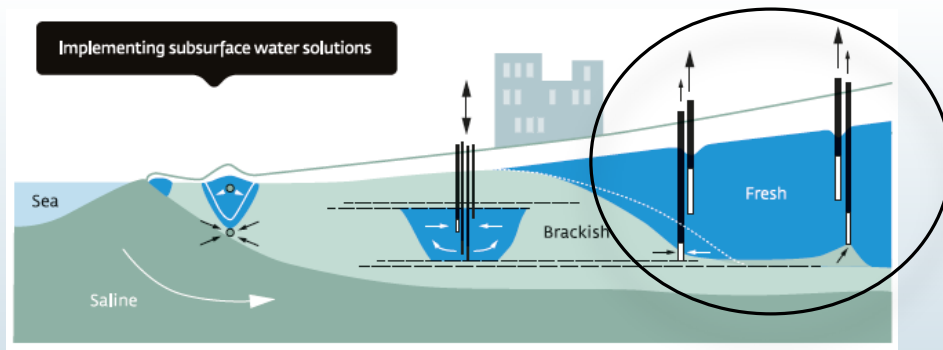
3. The results: increased freshwater recovery

The Freshmaker



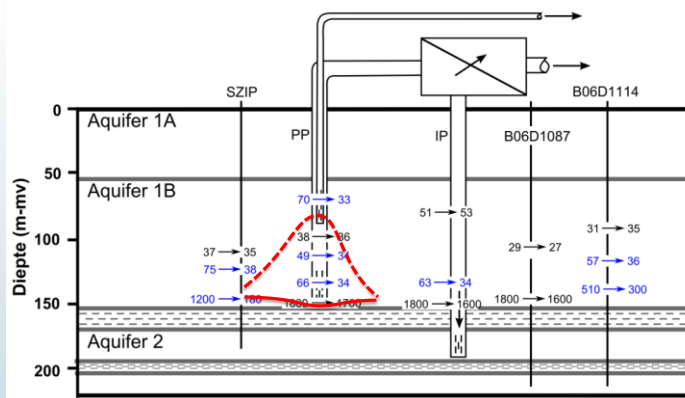
3. The results: increased freshwater recovery

Without injection of freshwater: Freshkeeper



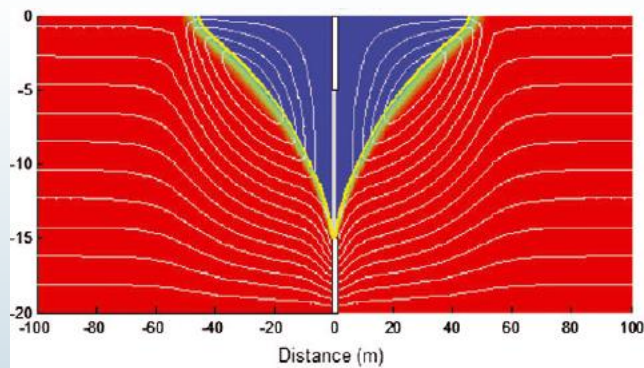
3. The results: increased freshwater recovery

Freshkeeper



3. The results: increased freshwater recovery

Combination ASR - Freshkeeper



Van Ginkel, M., Olsthoorn, T.N. and Bakker, M., 2014. A New Operational Paradigm for Small-Scale ASR in Saline Aquifers. *Groundwater*, 52(5): 685-693.

Sophisticated well configurations to enable aquifer storage and recovery (ASR) in coastal aquifers

*Can sophisticated well configurations be a **practical, cost-efficient** solution for ASR in coastal aquifers??*

4. The conclusions

The value of sophisticated well configurations

1. Sophisticated well configurations have transformed from idea to proven-technology in the past 5 years.
2. Groundwater modeling and field operation + monitoring of three examples (ASR-Coastal, Freshkeeper, Freshmaker) underline that they can protect, enlarge, and utilize freshwater resources.
3. Coastal aquifers have become interesting water resources and water storage media.
4. Local natural freshwater sources can be utilized without claiming large areas aboveground, reducing the stress on other, less sustainable freshwater sources (e.g., piped water, desalinated water).
5. Additional 'complexity' in the set-up (MPPWs, HDDWs, saltwater interception) compared to 'conventional set-ups' does not lead to unviable business cases.

Future?

Hardest part is yet to come...

Valorisation

Optimisation

Replication

Automisation

Regulation

Sharing knowledge

...

27 Deltas in times of climate change

More information?

www.kwrwater.nl


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