Closing the water cycle for sustainable groundwater management
The Torreele/St-André project

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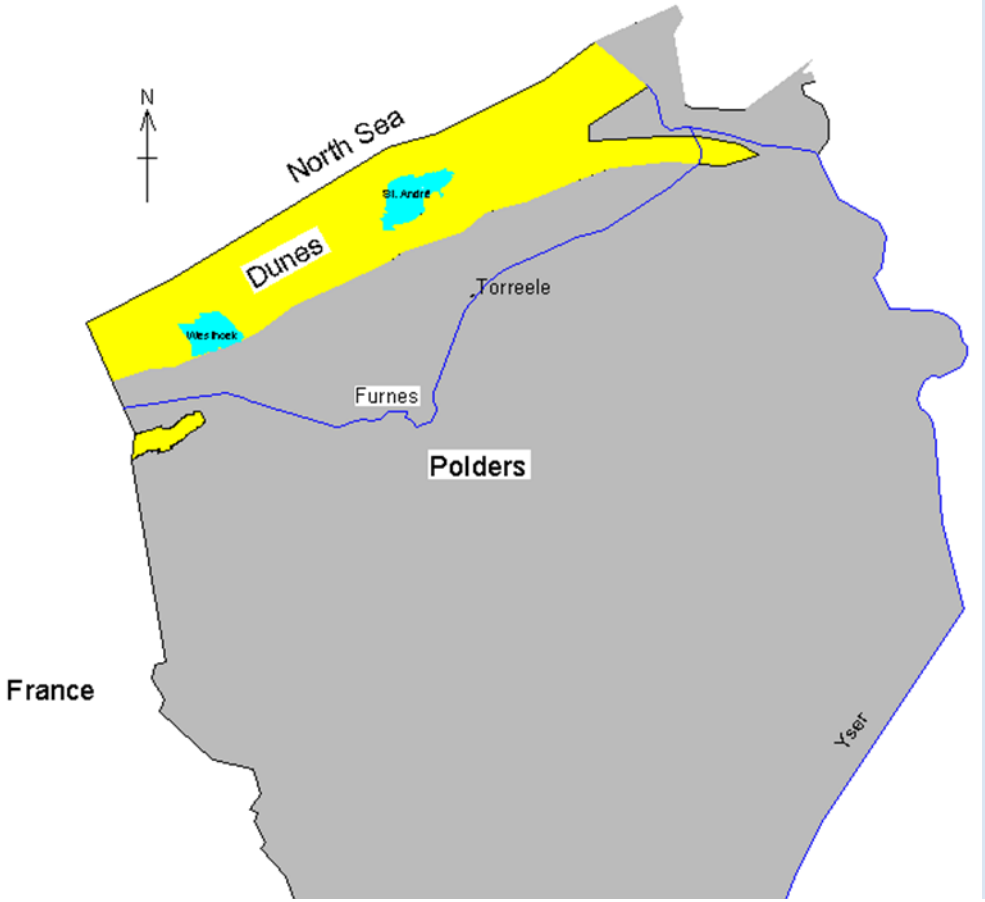
Hydrogeology Workshop

EUROPEAN FEDERATION OF GEOLOGISTS WORKSHOP

European water policy: challenges for Hydrogeologists

Brussels, 22-23 November 2013



Production of potable water

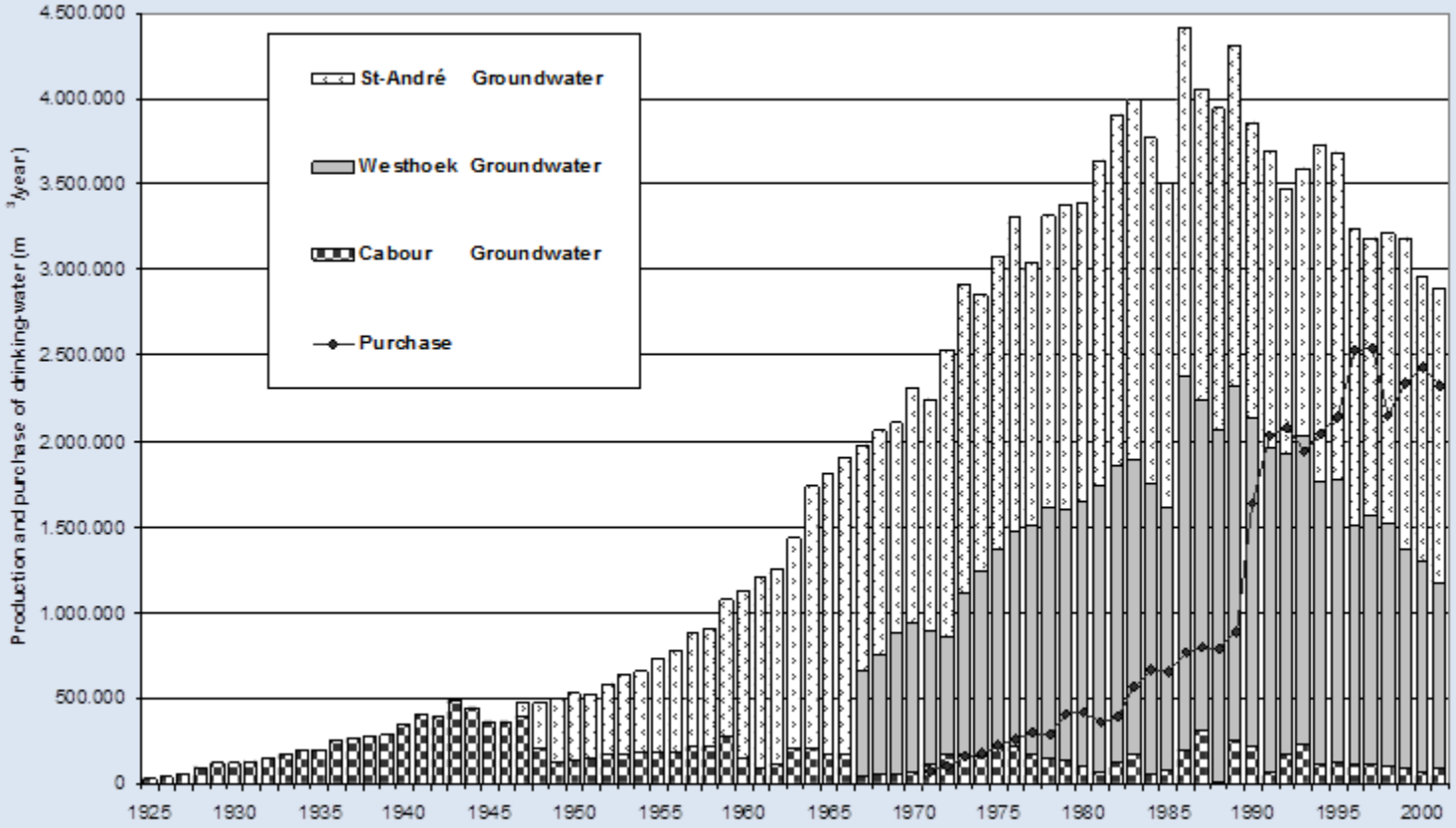
Sandy unconfined dune aquifer :
- the natural groundwater is of excellent quality;
- easy to exploit;
- limited treatment : areation and sand filtration

Distribution of potable water

- Distributed to 60,000 permanent residents in the area;
- TOURISM : increased demand in vacation periods

Increasing demand for potable water

- Growing population;
- More comfort;
- Explosion of tourism



The early solution

- Increased demand was first fulfilled taking other dune areas in use;
- In 1970's IWVA started purchasing potable water at neighbouring companies

The I.W.V.A. - problem

- Groundwater levels depleted with loss of natural values and risk of saline intrusion on the longer term;
- Growing interest for nature;
- Ever increasing demand and catchments reached maximum capacity.

The I.W.V.A. - solution

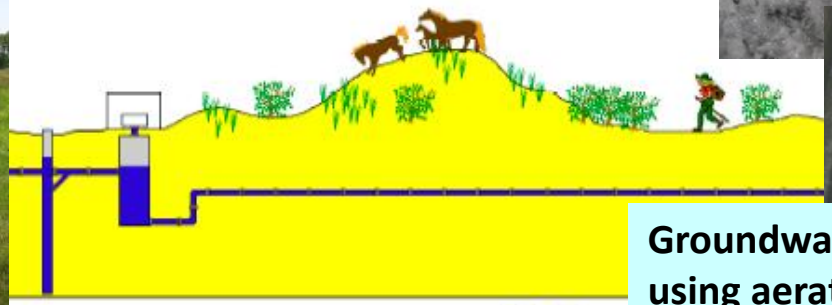
A study of the University of Ghent recommended to recharge the groundwater at St-André.

SELECTED ALTERNATIVE

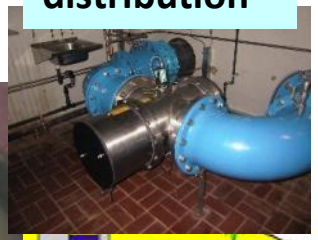
Groundwater recharge combined to water reuse

- Natural groundwater extraction reduced
- Implemented into ecological management of dunes
- Maximum use of existing infrastructure
- Wastewater treatment plant nearby
- Effluent available all year and of acceptable quality

Recharge of dune aquifer
Minimum residence time 30 days



UV prior to distribution



Groundwater treatment using aeration and sand filtration

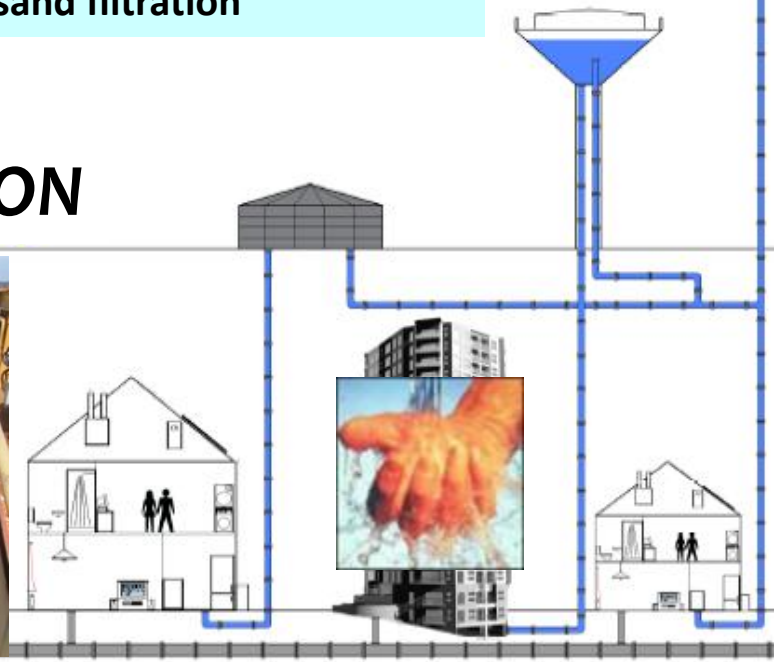
SUSTAINABLE

DRINKING-WATER PRODUCTION

UF

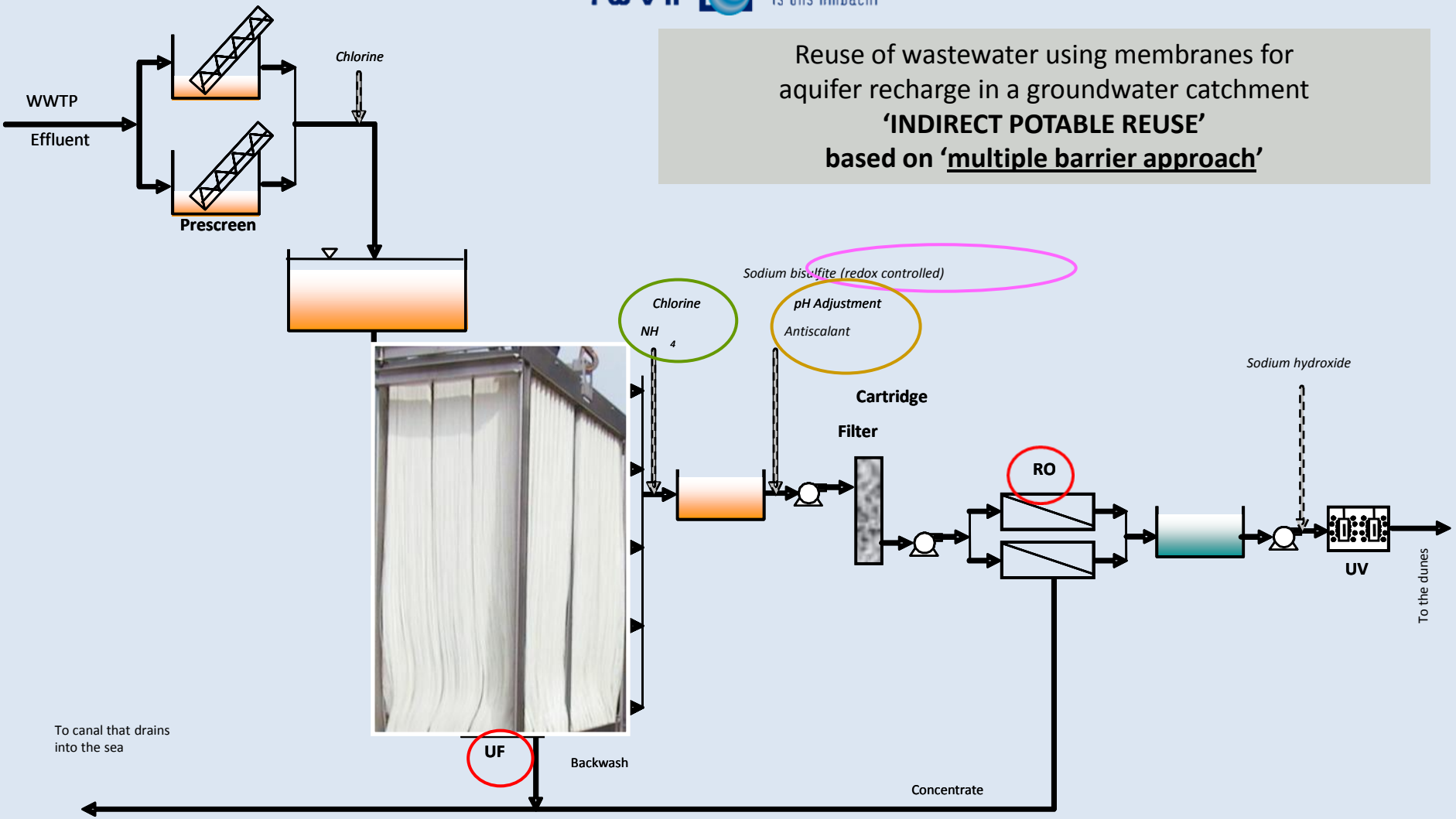
RO

WWTP Wulpen
Conventional treatment of domestic ww



After use or consumption the water is collected and flows back to WWTP

Reuse of wastewater using membranes for aquifer recharge in a groundwater catchment
'INDIRECT POTABLE REUSE'
based on '<u>multiple barrier approach</u>'



<u>Multiple barrier</u> approach for microbiological safety

+ biofouling prevention by dosing of monochloramines

+ redox controlled dosing of bisulfite to protect membranes against chlorine

+ scaling prevention dosing sulfuric acid (pH correction) and anti-scalant

Torreele – experience

- **UF proves to be a good pretreatement for RO**
as bacteria and suspended solids are totally removed

quality can be controlled by turbidity

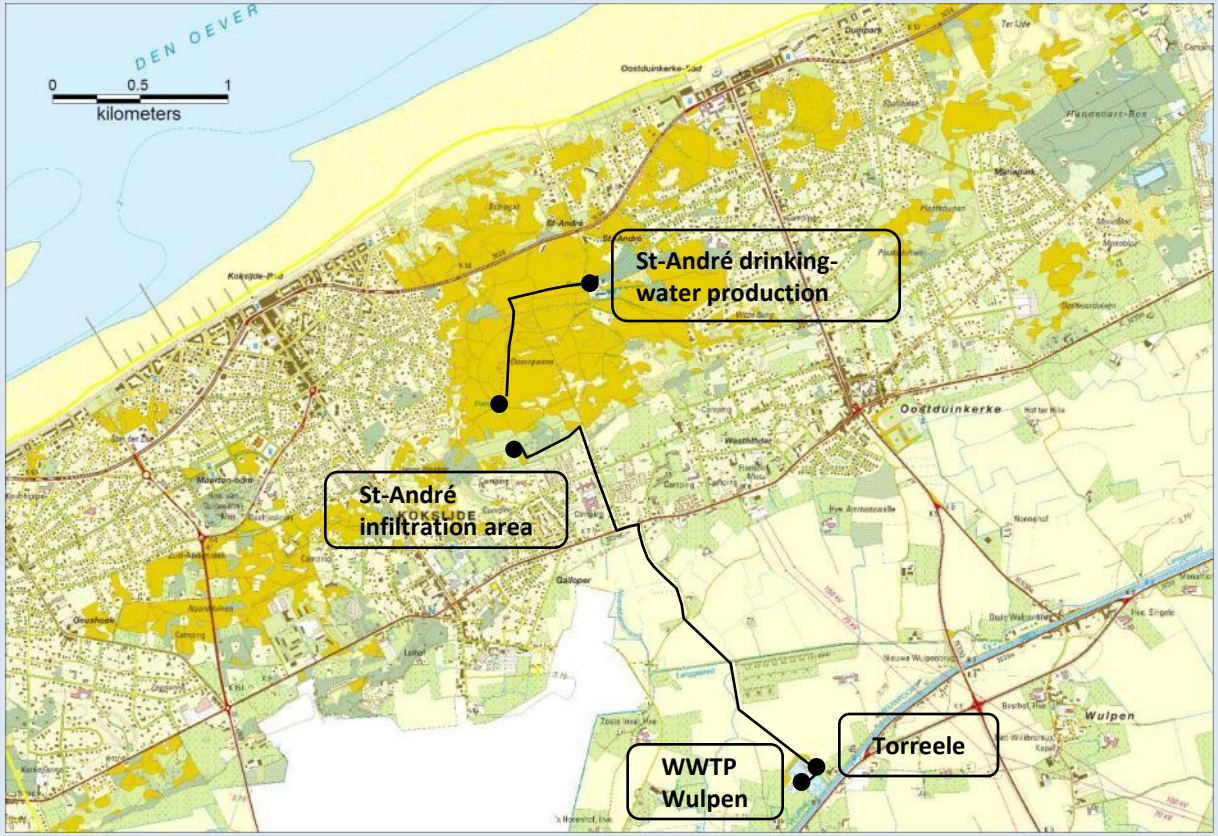
- **RO removes salt, nutrients, hardness, bacteria, viruses, small organic substances (pesticides, pharmaceuticals)**

performance/quality easy to control with conductivity

Infiltration water is of excellent quality

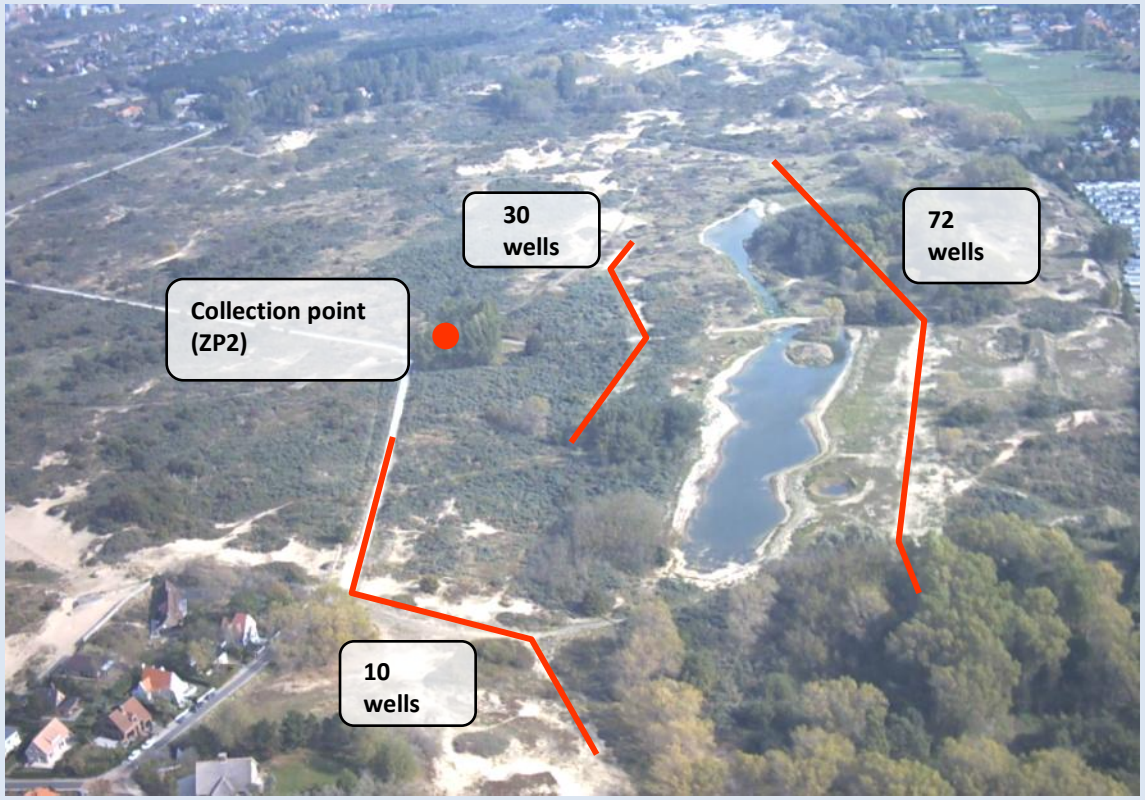
Continuous monitoring of different parameters e.g. conductivity, pressures, turbidity, chlorine content

Integration of wastewater reuse into existing drinking-water production scheme by managed aquifer recharge

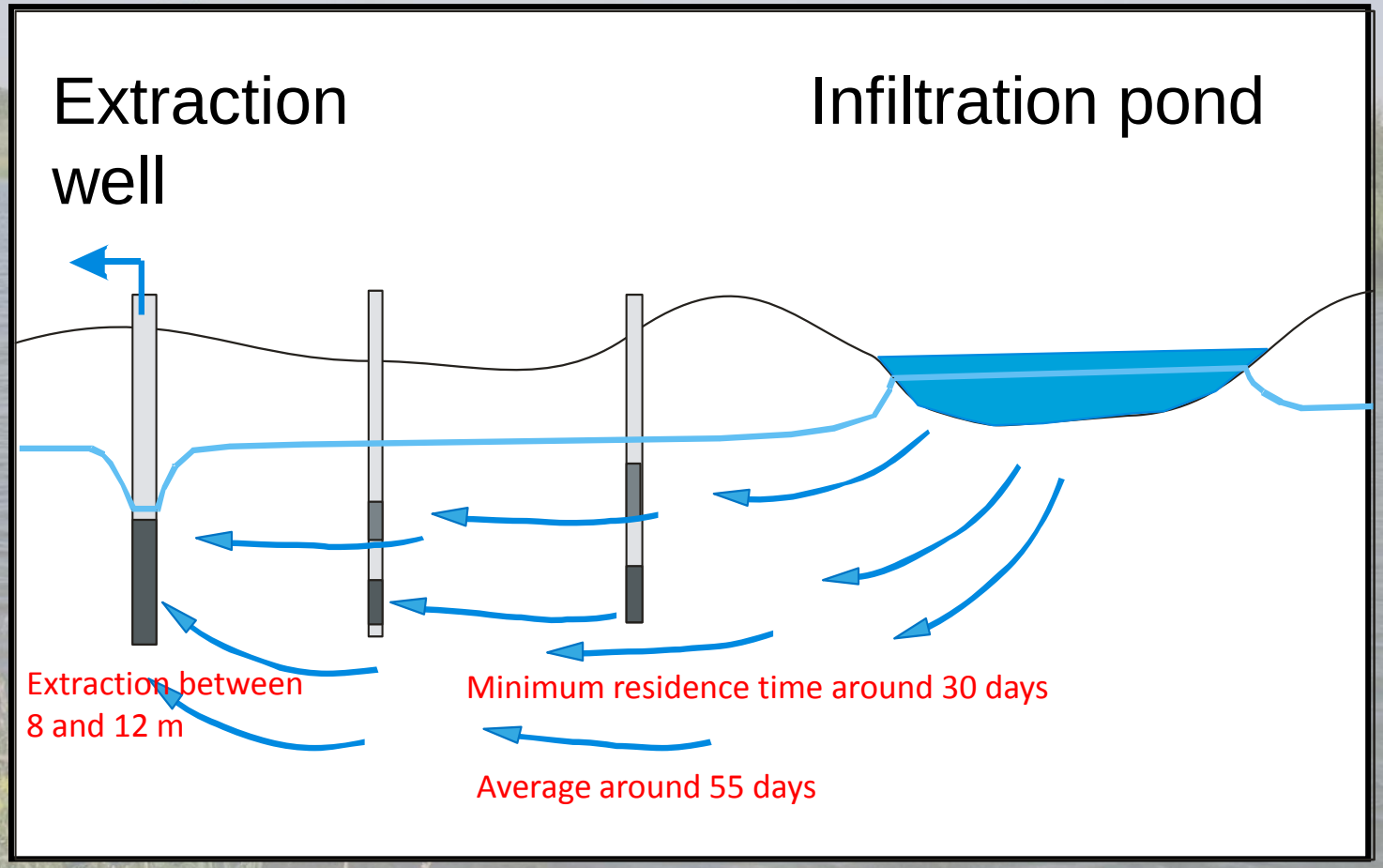


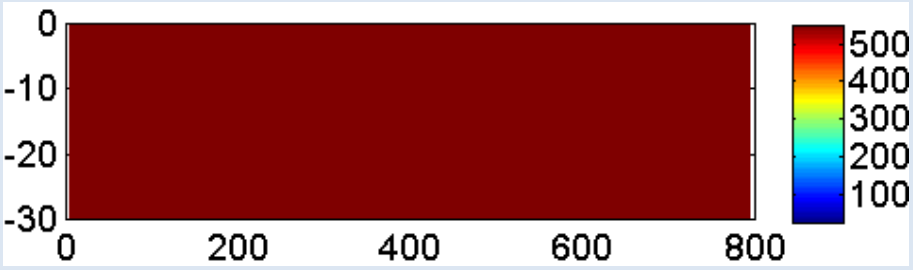
St-André – Managed Aquifer recharge

- Infiltration pond (18.200 m²) with variation
- Minimum impact on nature
- Extraction of all infiltrated water by installing wells north and south of pond

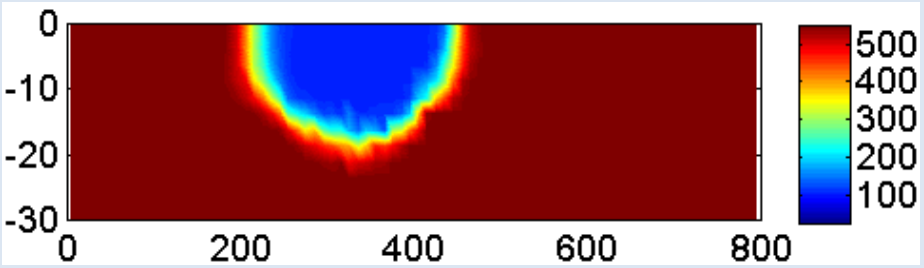


Managed Aquifer recharge

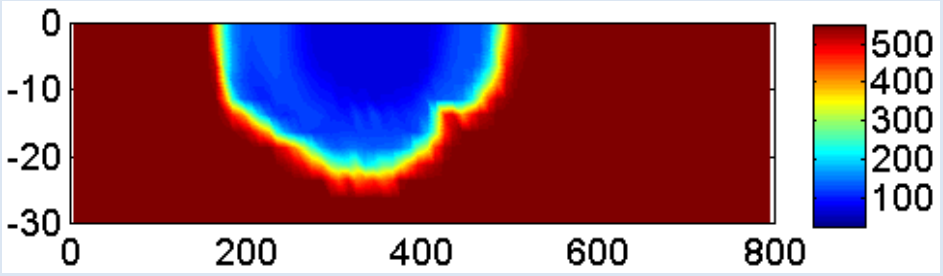




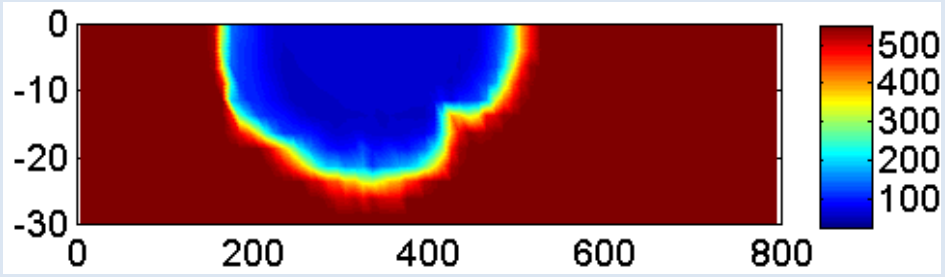
June 2002



February 2003

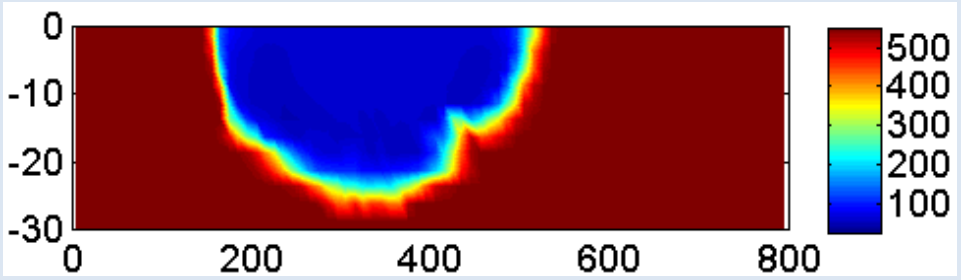


December 2003

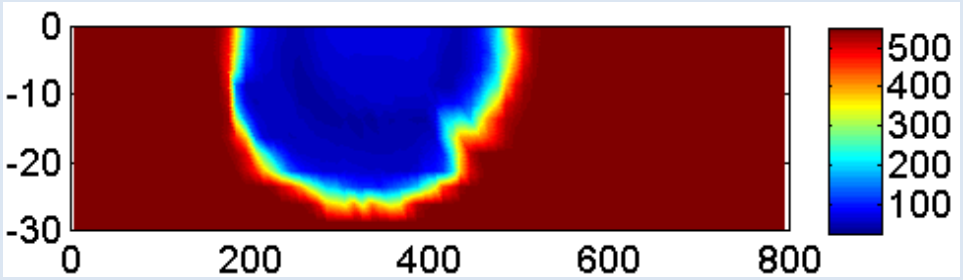


October 2004

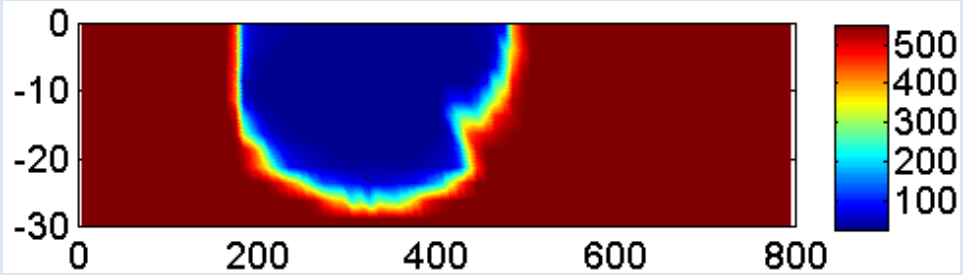
Simulation by Vasiliki Pantoula



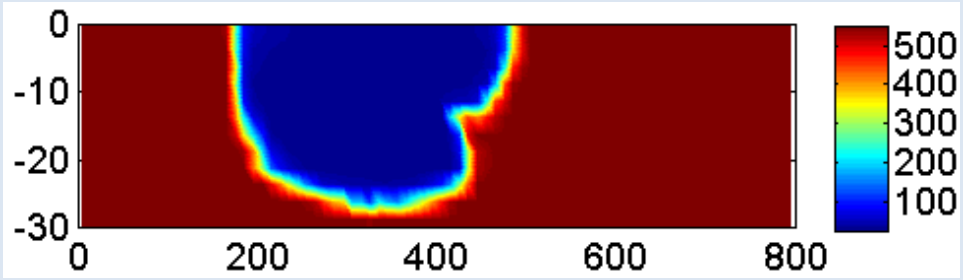
August 2005



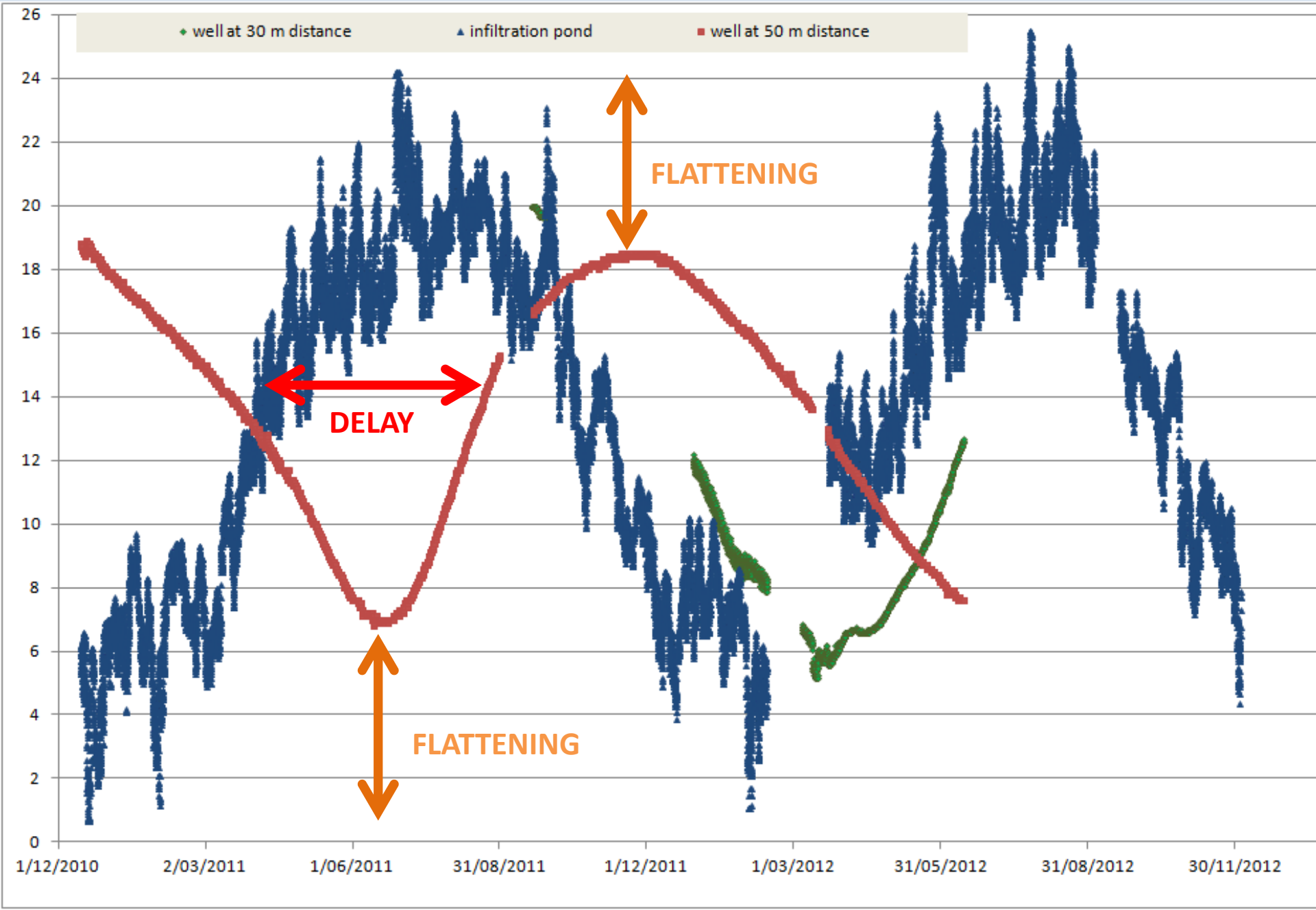
April 2007



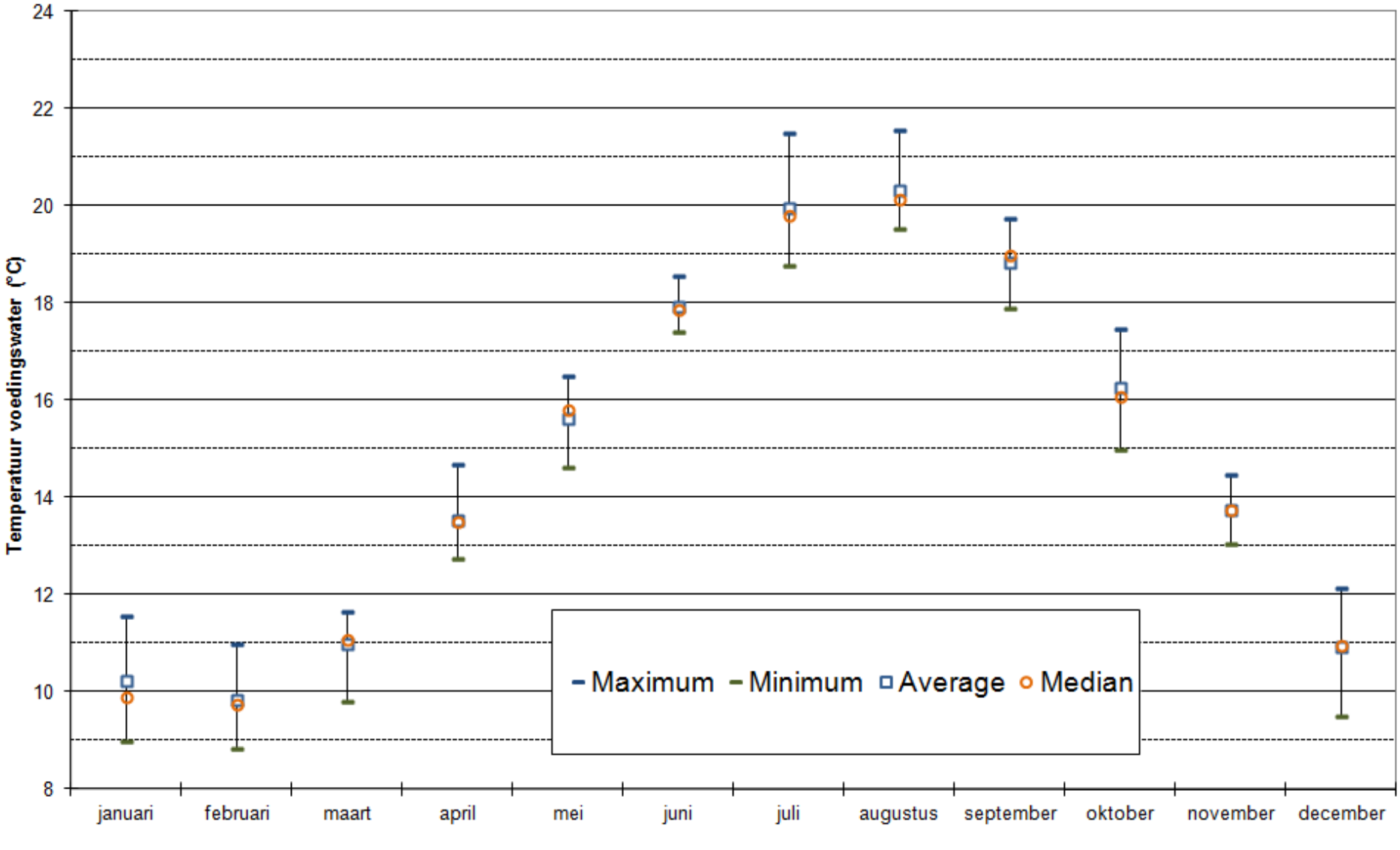
December 2008



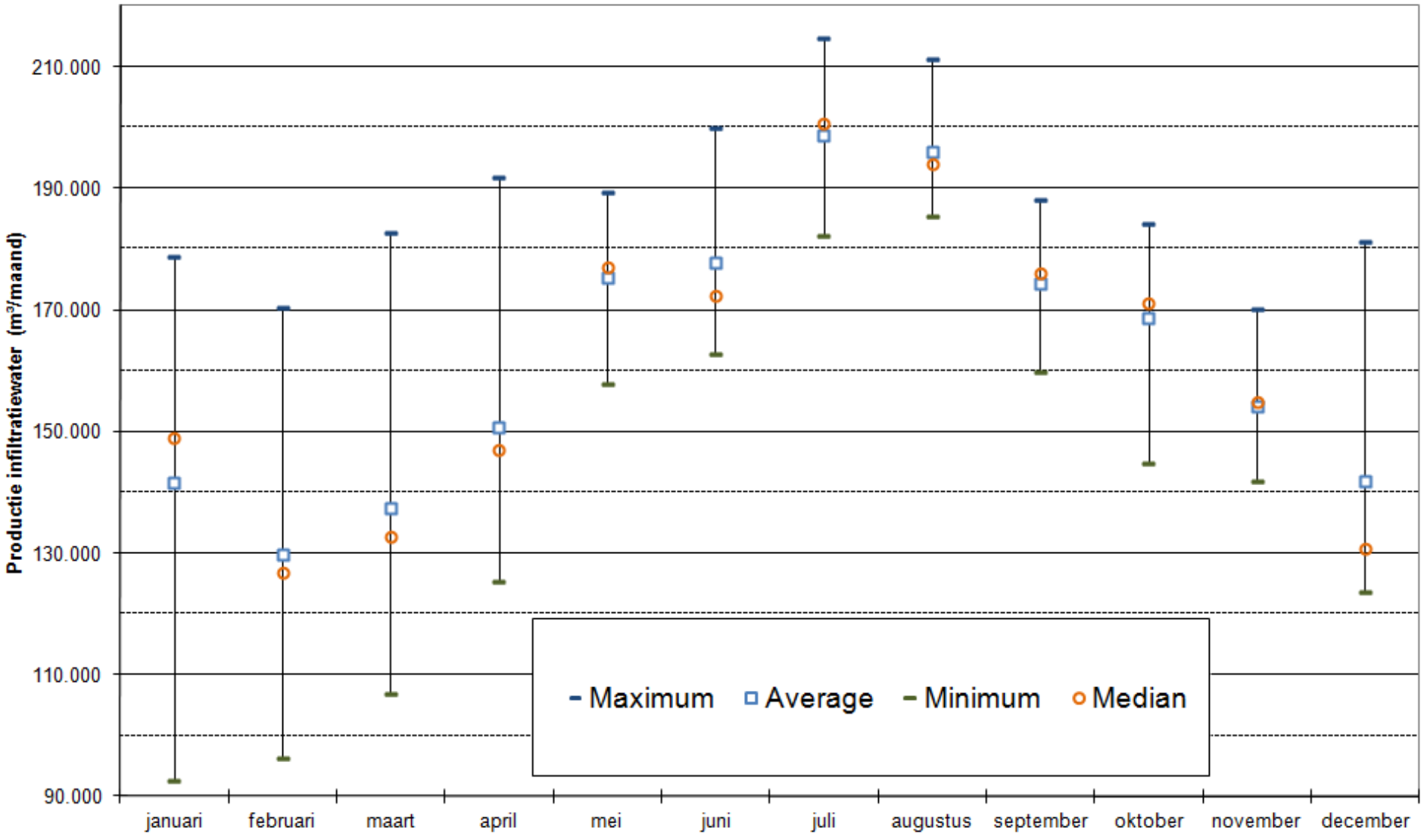
December 2011


well at 30 m distance
infiltration pond
well at 50 m distance
FLATTENING
DELAY
FLATTENING
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1/12/2010
2/03/2011
1/06/2011
31/08/2011
1/12/2011
1/03/2012
31/05/2012
31/08/2012
30/11/2012

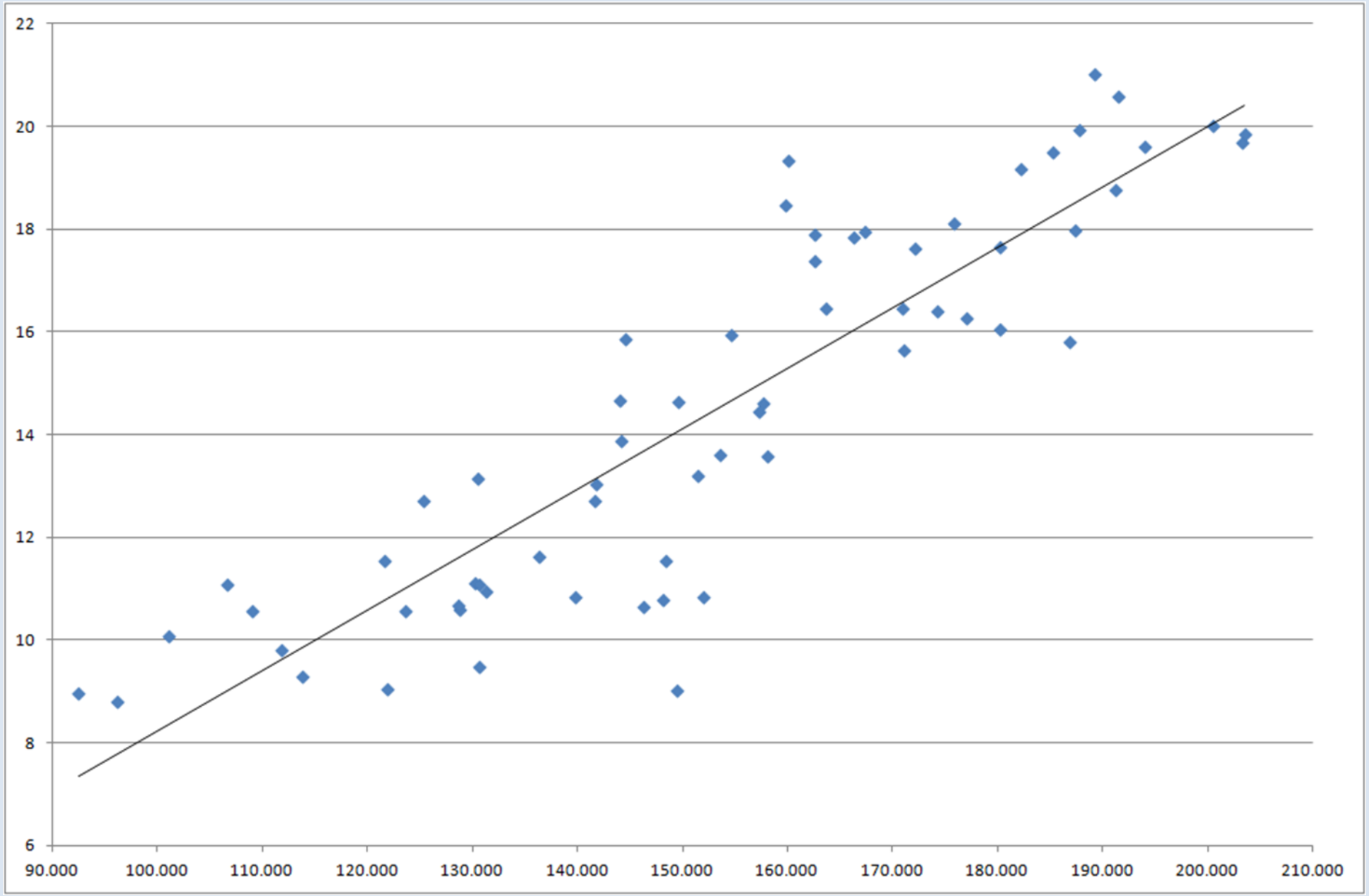
Temperature (°C) of infiltration water coming out of Torreele

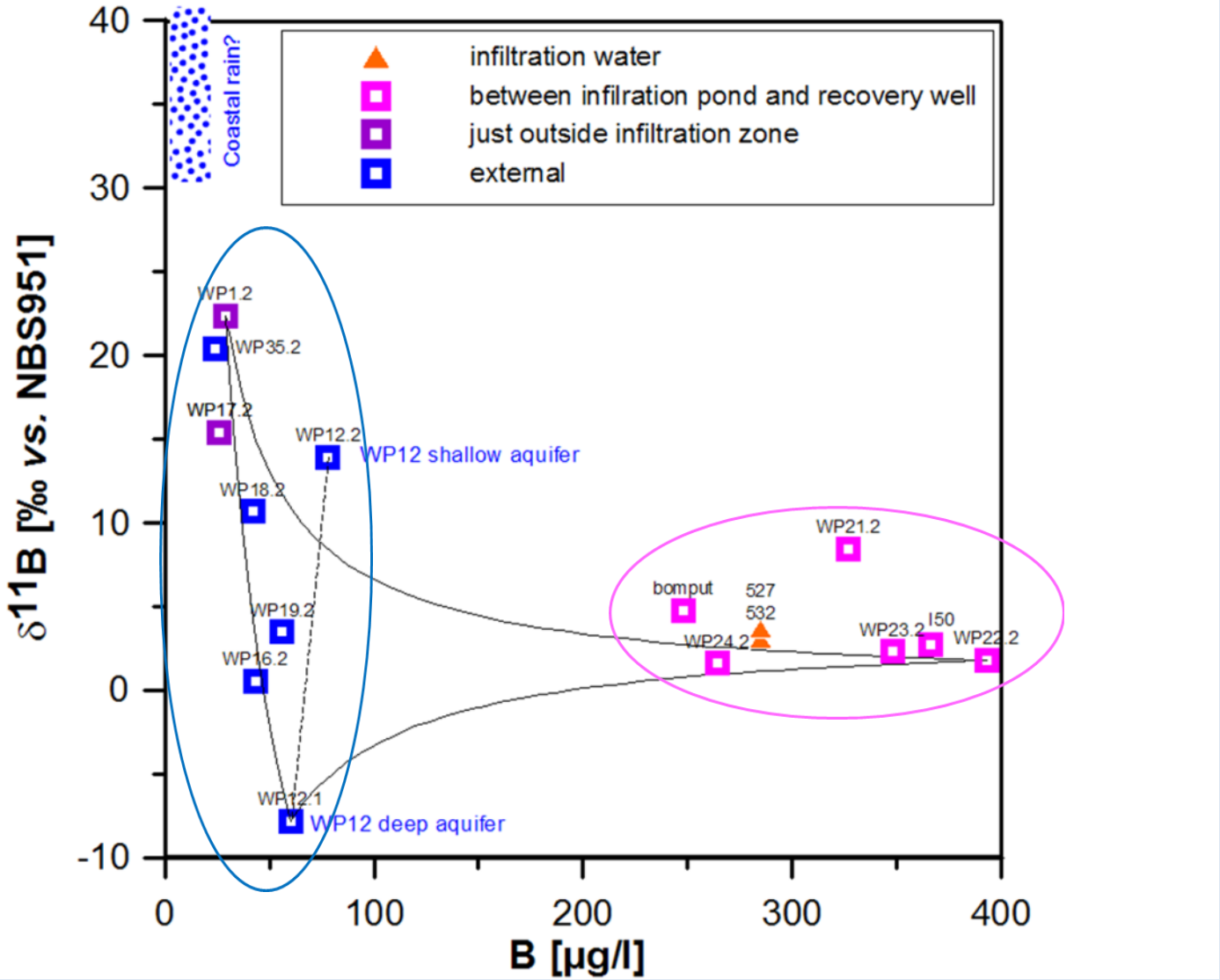


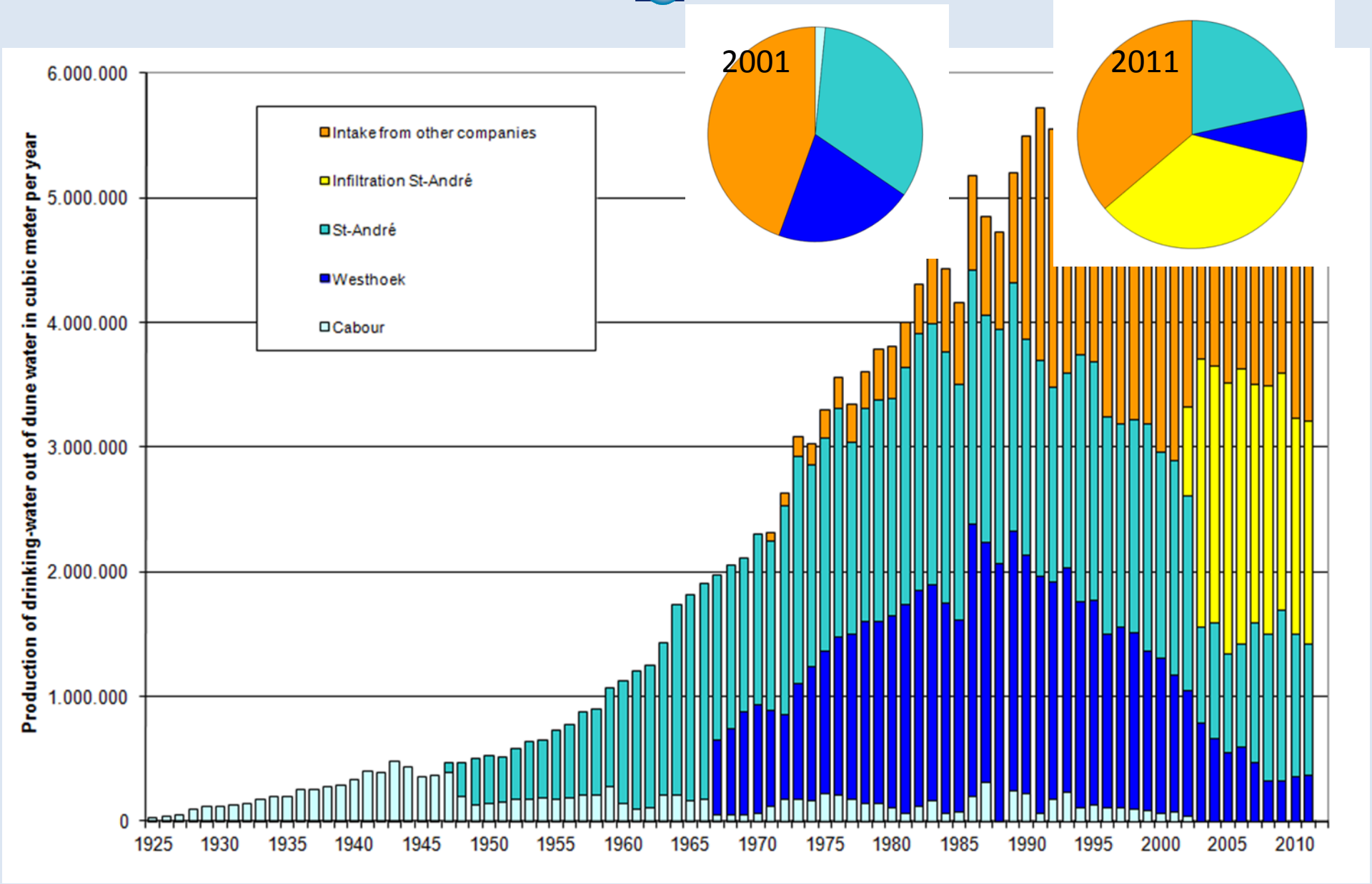
Infiltration in m³/month



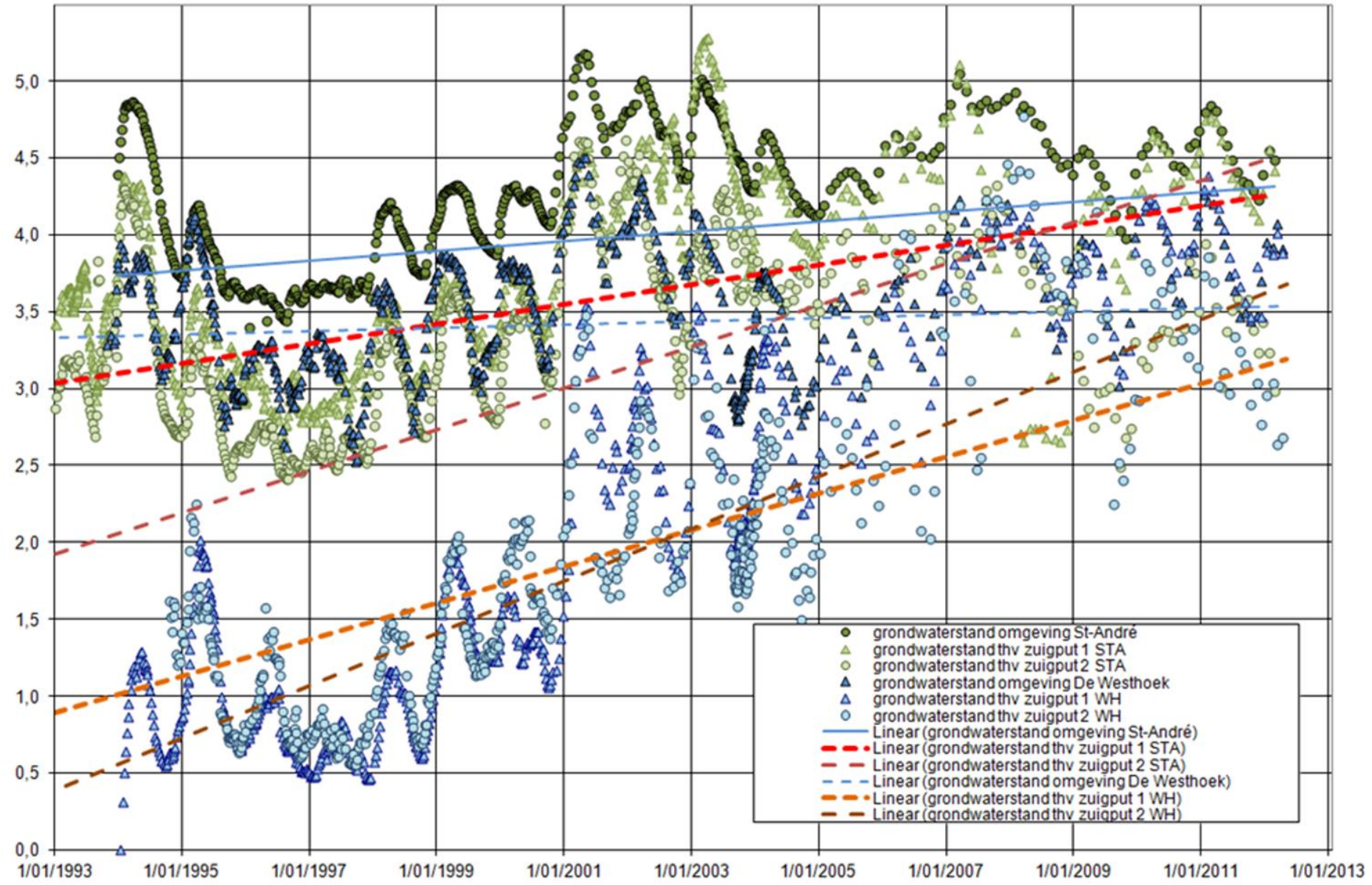
Infiltration capacity depends on temperature




Coastal rain?
infiltration water
between infiltration pond and recovery well
just outside infiltration zone
external
WP1.2
WP35.2
WP17.2
WP12.2
WP12 shallow aquifer
WP18.2
WP19.2
WP16.2
WP12.1
WP12 deep aquifer
WP21.2
bomput
527
532
WP24.2
WP23.2
I50
WP22.2
δ11B [‰ vs. NBS951]
B [µg/l]
40
30
20
10
0
-10
0
100
200
300
400



Since 2002 infiltration water replaced ‘natural’ groubndwater substantially


5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
1/01/1993
1/01/1995
1/01/1997
1/01/1999
1/01/2001
1/01/2003
1/01/2005
1/01/2007
1/01/2009
1/01/2011
1/01/2013
grondwaterstand omgeving St-André
grondwaterstand thv zuigput 1 STA
grondwaterstand thv zuigput 2 STA
grondwaterstand omgeving De Westhoek
grondwaterstand thv zuigput 1 WH
grondwaterstand thv zuigput 2 WH
Linear (grondwaterstand omgeving St-André)
Linear (grondwaterstand thv zuigput 1 STA)
Linear (grondwaterstand thv zuigput 2 STA)
Linear (grondwaterstand omgeving De Westhoek)
Linear (grondwaterstand thv zuigput 1 WH)
Linear (grondwaterstand thv zuigput 2 WH)

Quality of drinking-water produced at St-André

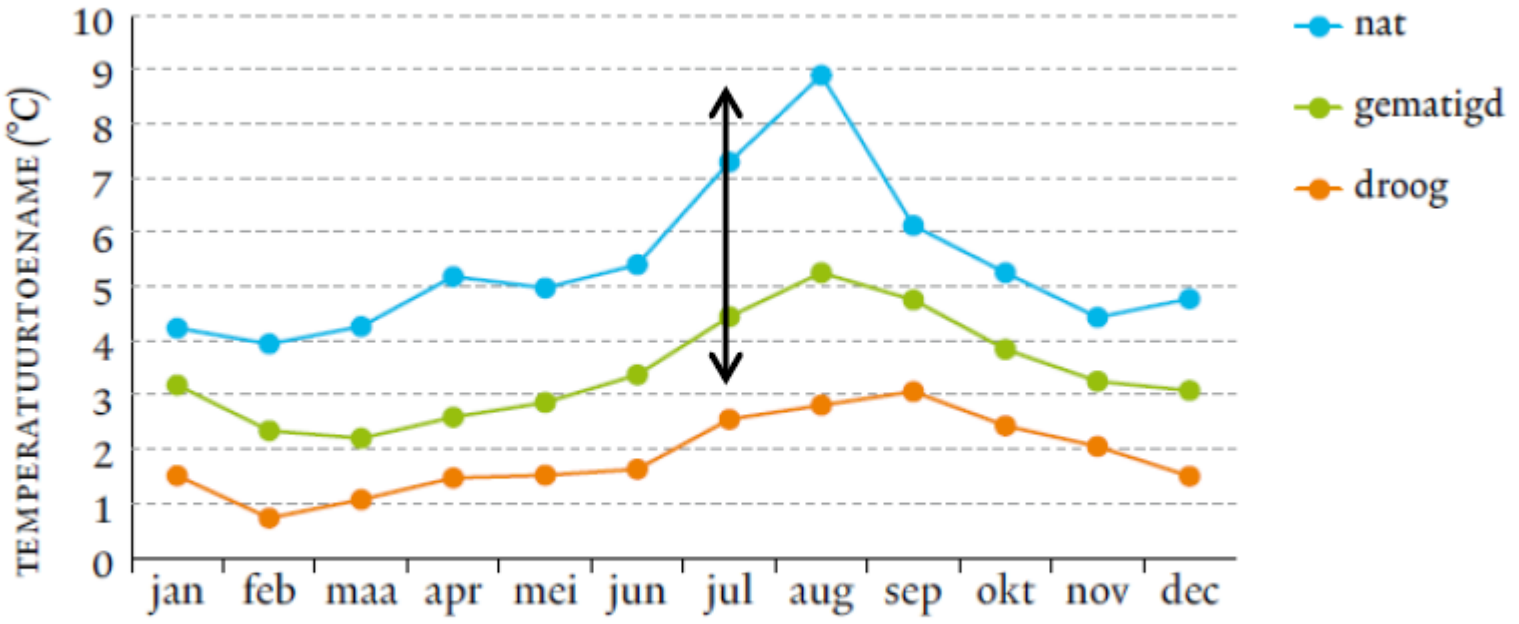
	2001	2008
	100% natural groundwater	41% natural groundwater 59% 're-extracted' infiltration water
pH	7.02 – 7.89	7.66 – 7.80
Conductivity (µS/cm)	697	365
Chlorides (mg Cl/l)	87	26.3
Sulfates (mg SO_4/l)	91	27.2
Sodium (mg Na/l)	45	24.1
Total hardhness (°F)	32.7	14.0
Nitrates (mg NO_3/l)	<6	3,7
Ammonia (mg NH_4/l)	<0.4	0.03
Total phosphorous (mg P/l)	± 0.1	<0.1
Total Organic Carbon (mg C/l)	± 5	2.1
Total coliform bacteria	Absent	Absent
Heavy metals	<DL	<DL
Pesticides	<0.01	<0.01
Temperature	12.6	13.2

Lower hardness means more comfort to customer and is better for the environment

Water is brighter

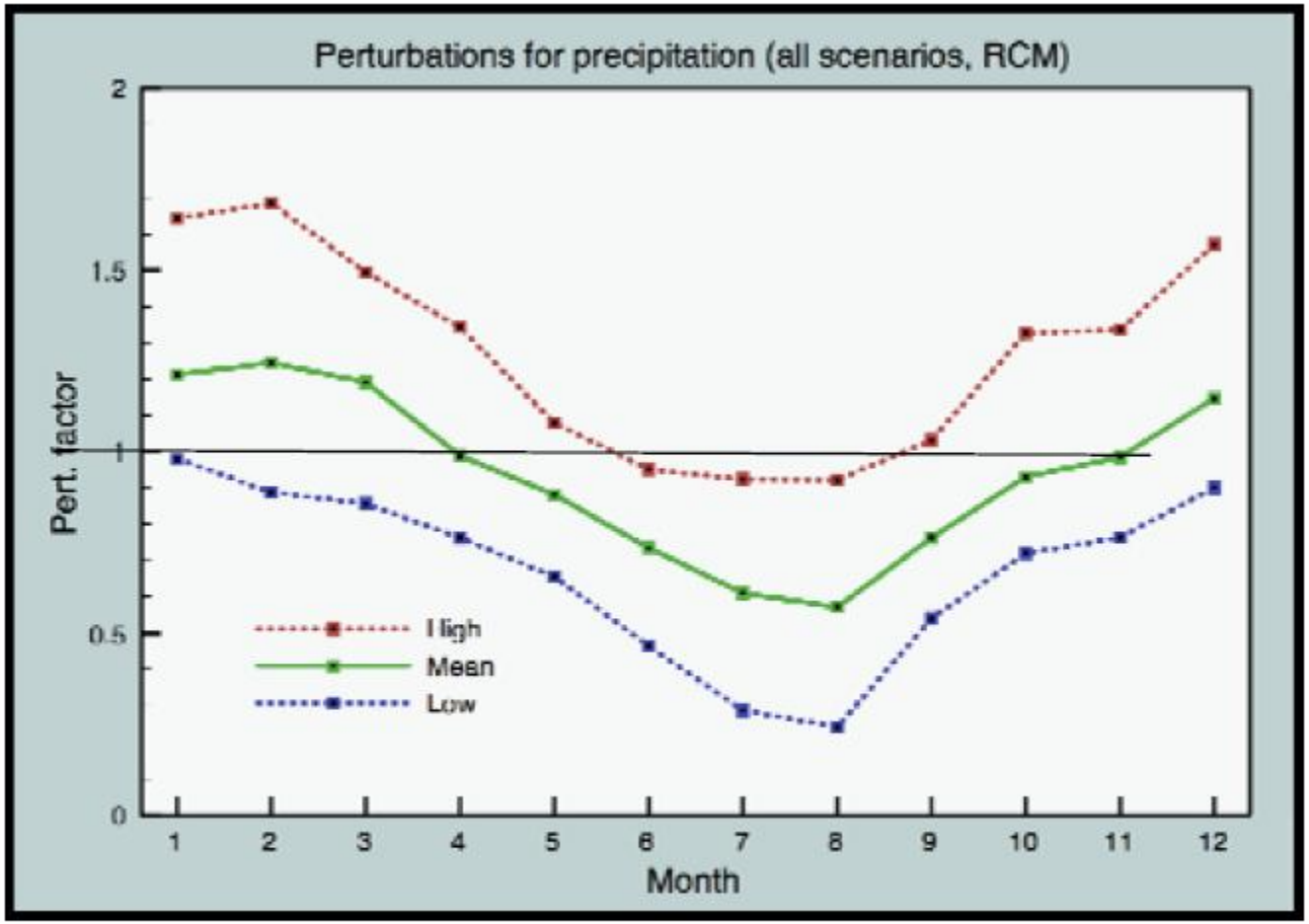
COMBINATION REUSE/RECHARGE
PEVENTIVE ACTION TOWARDS CLIMATE CHANGE

Temperatures will increase especially during summer – expected increased demand for drinking-water

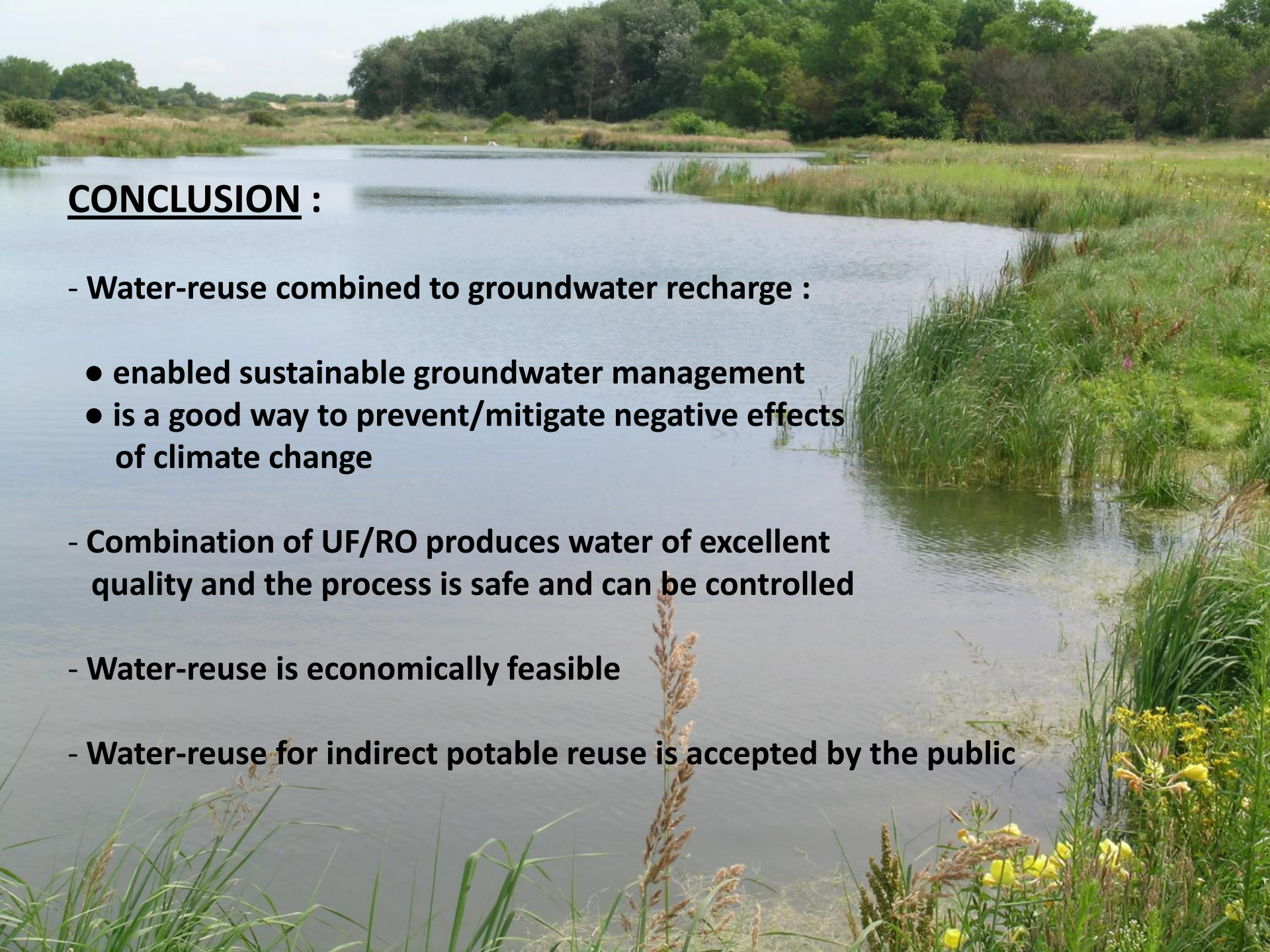


Figuur 3-3 Toename in maandgemiddelde temperatuur te Ukkel volgens de 3 CCI-HYDR klimaatscenario's voor de scenarioperiode 2071-2100 (Brouwers et al, 2009; Willems et al, 2009)

Amount of rain will drop during summers



Figuur 3-6 Perturbatiefactor (-) voor de maandgemiddelde neerslag in Ukkel volgens de 3 CCI-HYDR klimaatscenario's, referentieperiode 1961-1990 tot scenarioperiode 2071-2100 (Willems et al., 2009)



CONCLUSION :

- Water-reuse combined to groundwater recharge :

  - enabled sustainable groundwater management
  - is a good way to prevent/mitigate negative effects of climate change

- Combination of UF/RO produces water of excellent quality and the process is safe and can be controlled

- Water-reuse is economically feasible

- Water-reuse for indirect potable reuse is accepted by the public