

SWIBANGLA



Groundwater monitoring

An introduction

Contents

- Introduction to monitoring
 - Why monitoring groundwater
 - Monitoring networks
 - Monitoring techniques
- Information management and monitoring responsibilities - Example of the Netherlands
- Monitoring of groundwater in Bangladesh
 - Existing monitoring networks
 - Monitoring responsibility
- Recommendations and discussion

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Why monitoring groundwater?

51676

Deep Wells and Prudence:

Towards Pragmatic Action for
Addressing Groundwater
Overexploitation in India

you cannot manage What you don't know:

Understanding Realities Under

and Above the Ground

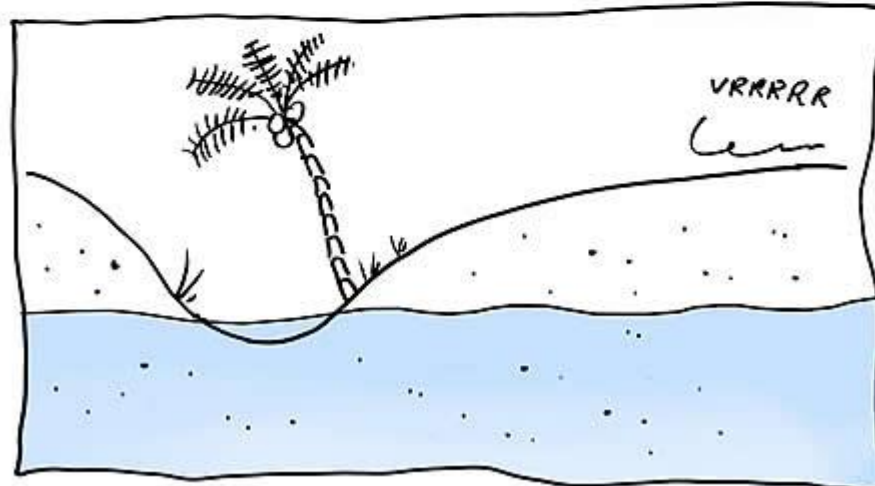
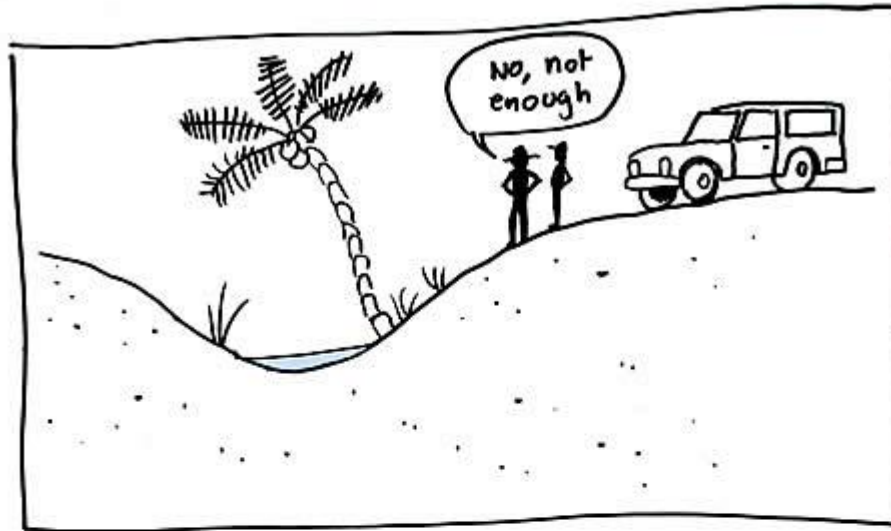
Monitoring before & after understanding



The World Bank

SWIRANGI A

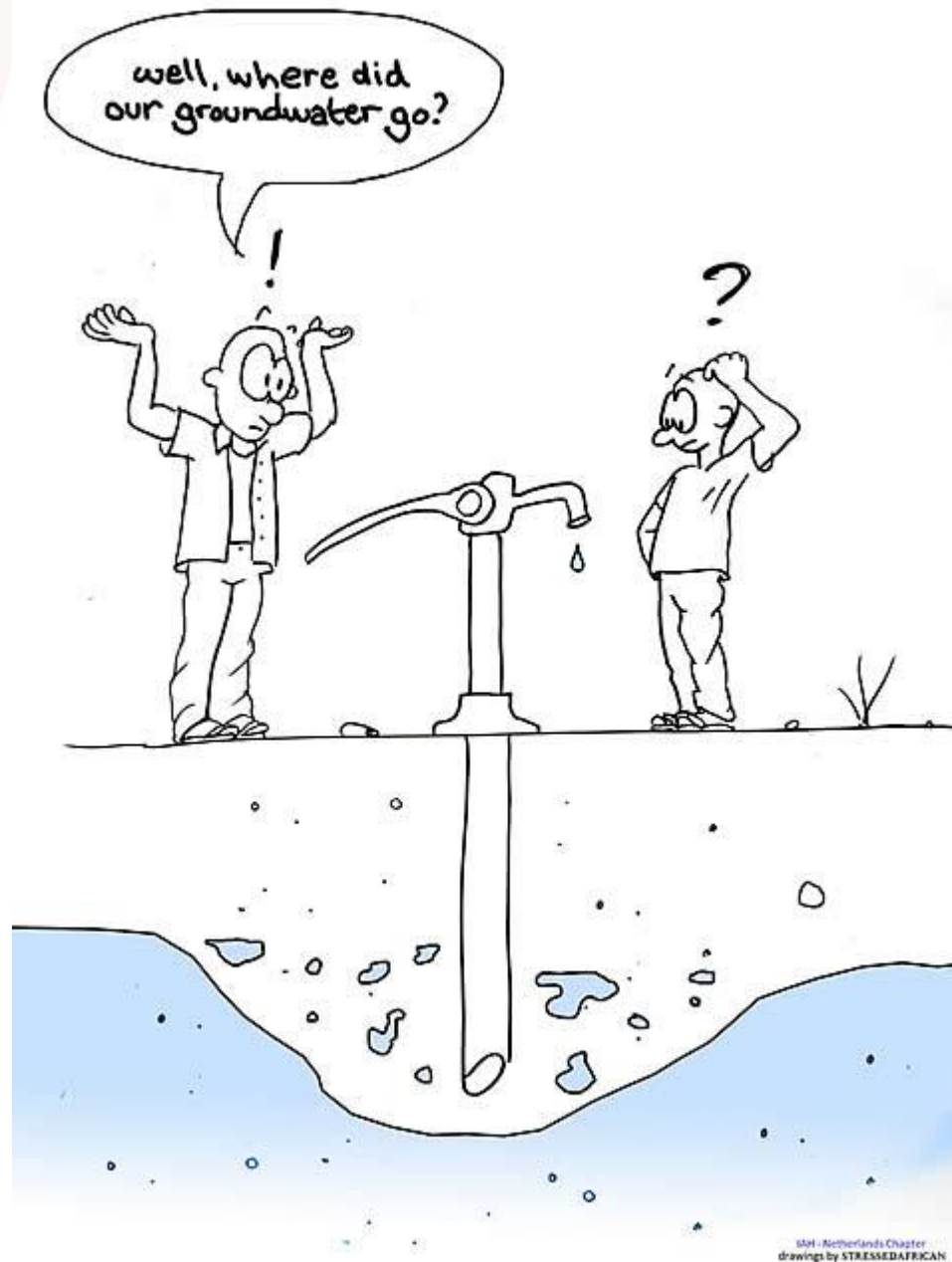




ISE - Netherlands Chapter
drawings by STRENEAFRICAN

SW

ILA



SIH - Netherlands Chapter
drawings by STRESSED AFRICAN

SWIDANICLA



UW²-Netherlands Chapter
drawings by STRESSED AFRICAN

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Monitoring networks

Different objectives → different monitoring networks, but combinations when possible

Groundwater monitoring:

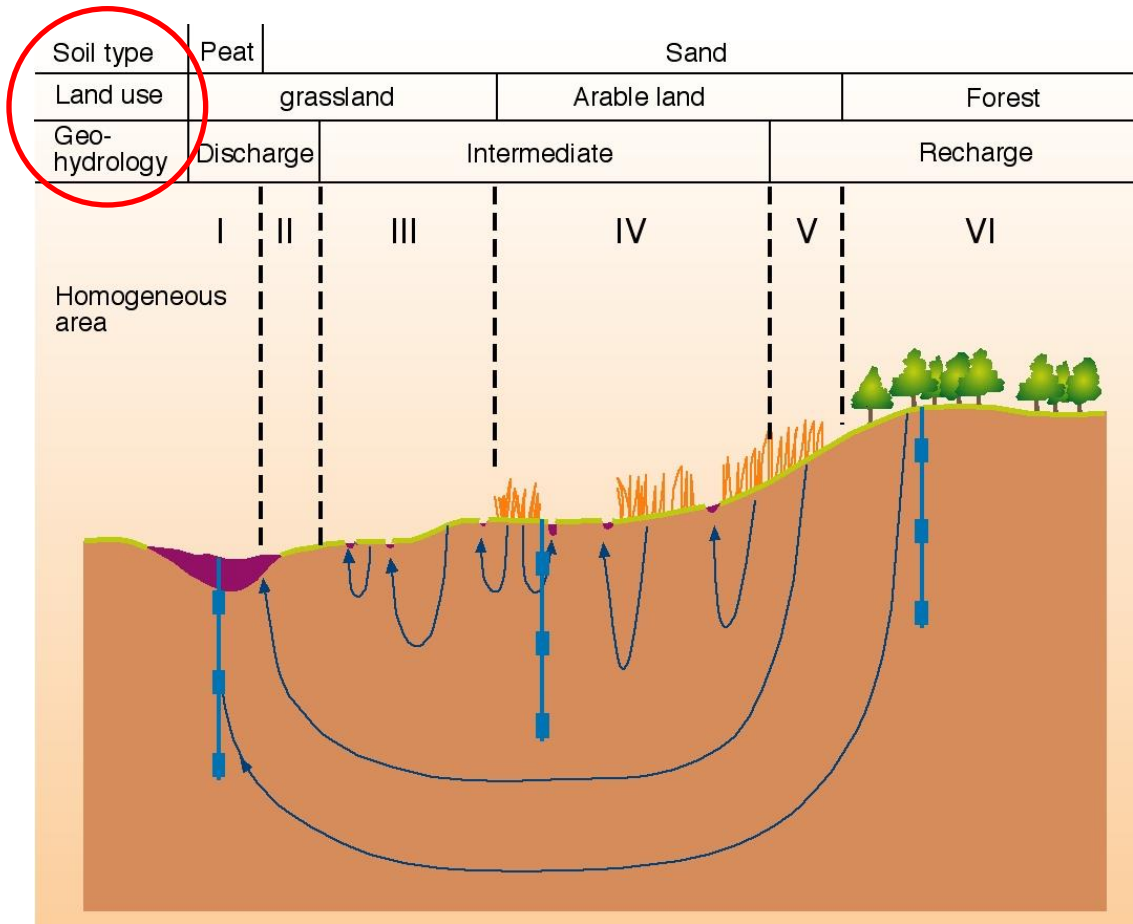
- Groundwater quality
 - Volume groundwater body
 - Nature/wetlands
1. Primary networks (hydraulic heads)
 2. Secondary networks (drinking water supply)
 3. Tertiary networks (nature, gasoline stations etc.)
 4. Groundwater quality networks
 5. Urban groundwater networks
 6. Project monitoring networks

Monitoring objectives

1. Understanding storage capacity of the soil (unsaturated zone)
2. Understanding ground water level – subsidence interaction
3. Understanding drainage canal surface water – ground water interaction
4. Understanding water level impact on river bank area
5. Understanding relation street infrastructure & groundwater levels
6. Determination of ground water flow
7. Controlling potential salinization risk
8. Controlling urban ground water quality
9. Controlling ecohydrological factors of wetlands and open water.

Example: monitoring network design in practice

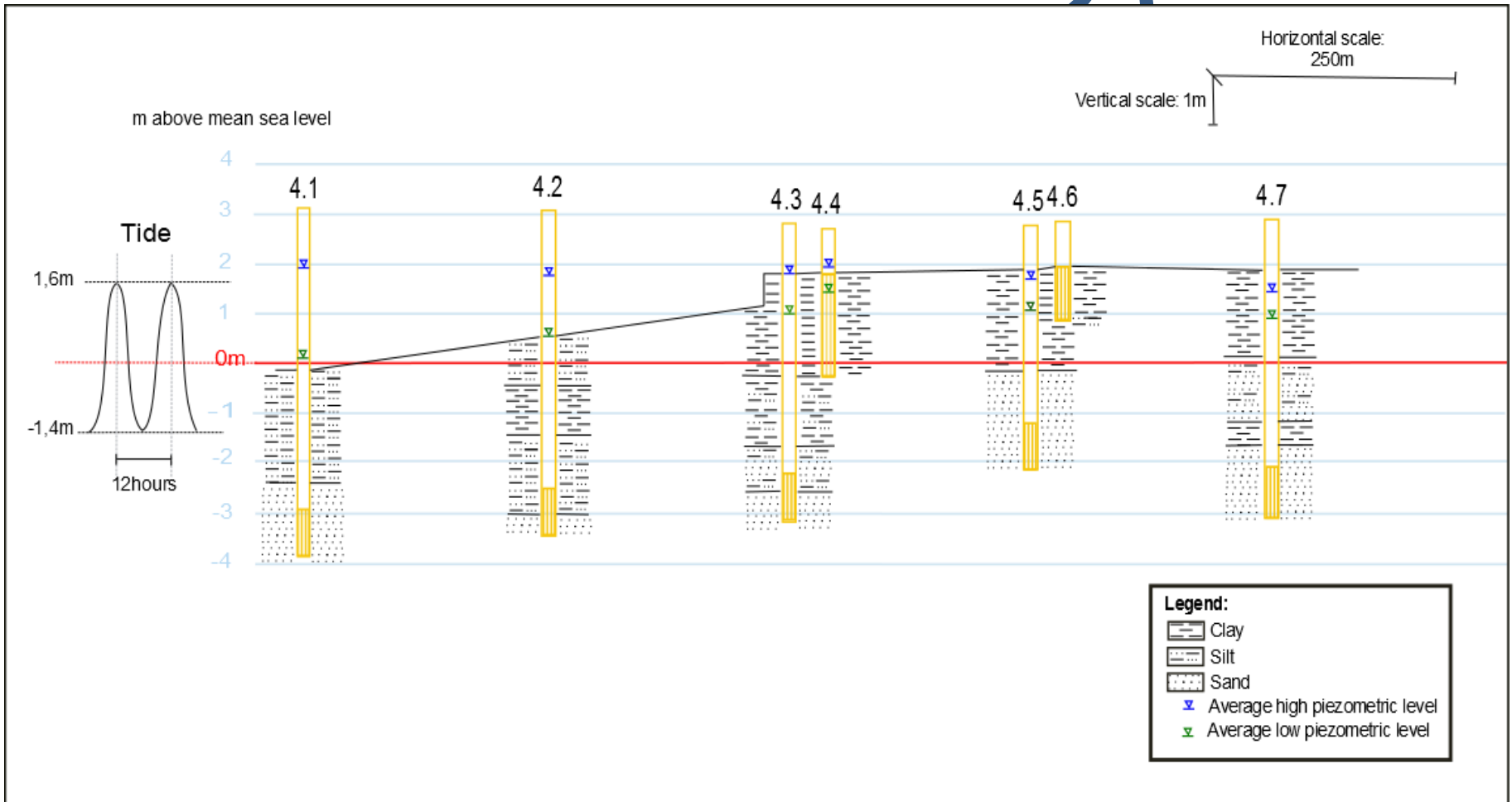
Example of the Netherlands



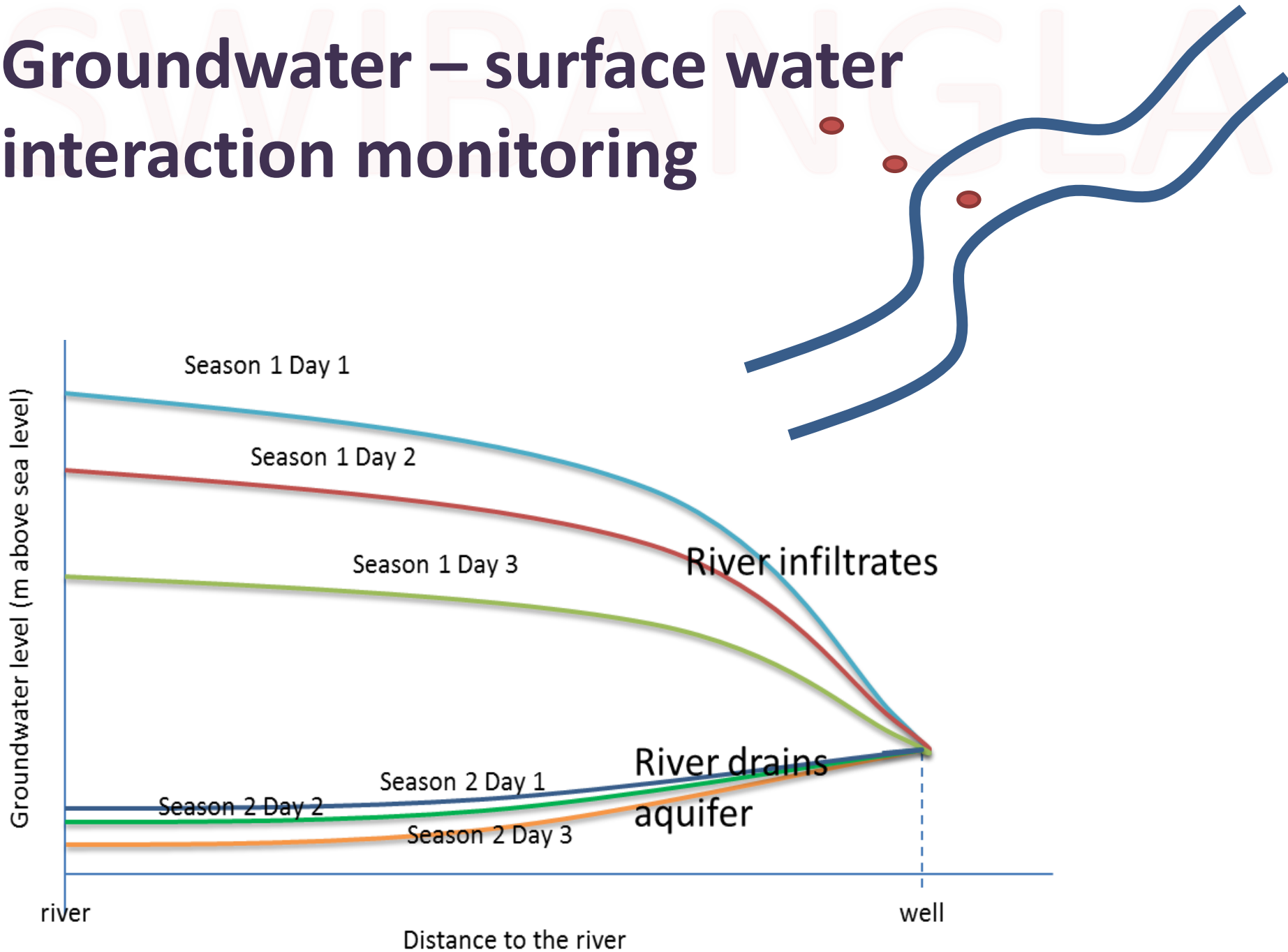
Conceptual model:
Homogeneous areas

**Homogeneous areas type approach:
screens at 10, 15 and 25 m depth below surface**

Groundwater – surface water interaction monitoring



Groundwater – surface water interaction monitoring



Combination of monitoring networks with different objectives



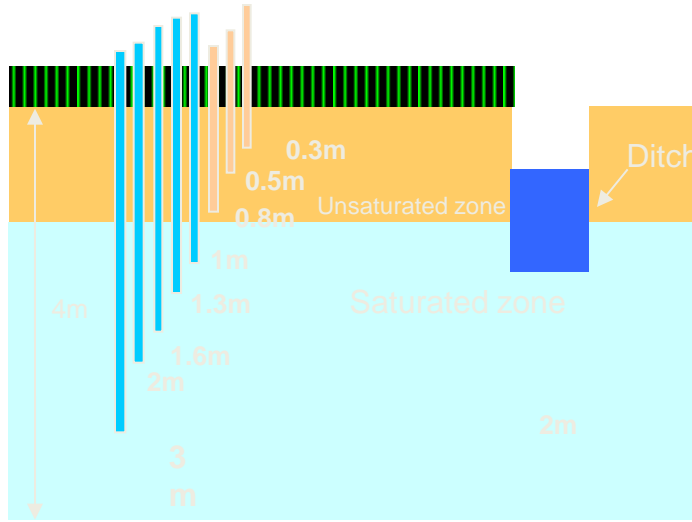
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Monitoring techniques for salinity

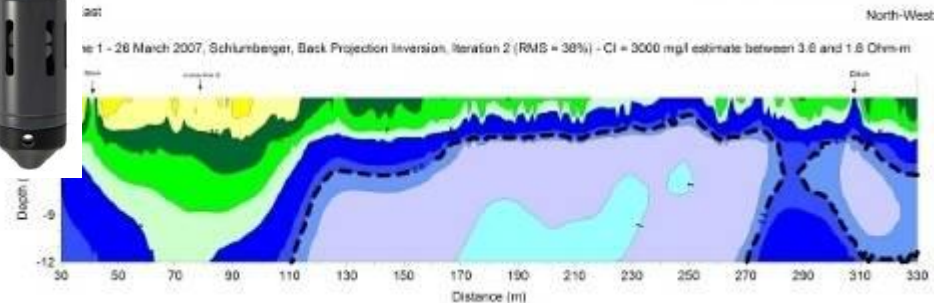
Monitoring techniques for salinity

- Conventional Sampling and Laboratory Analysis
- Measure Electrical conductivity of the water with EC meters (field tool kits)
- Automated measurements with EC Divers
- Crowd-sourcing measurements with ECApp
- Geophysical methods
 - Electrical Cone Penetration Test
 - Borehole logging
 - Electrical Vertical Sounding
 - Electromagnetic techniques
 - EM31
 - EM34
 - EM39
 - Slimflex
 - Airborne

Monitoring techniques



11 - Renesse

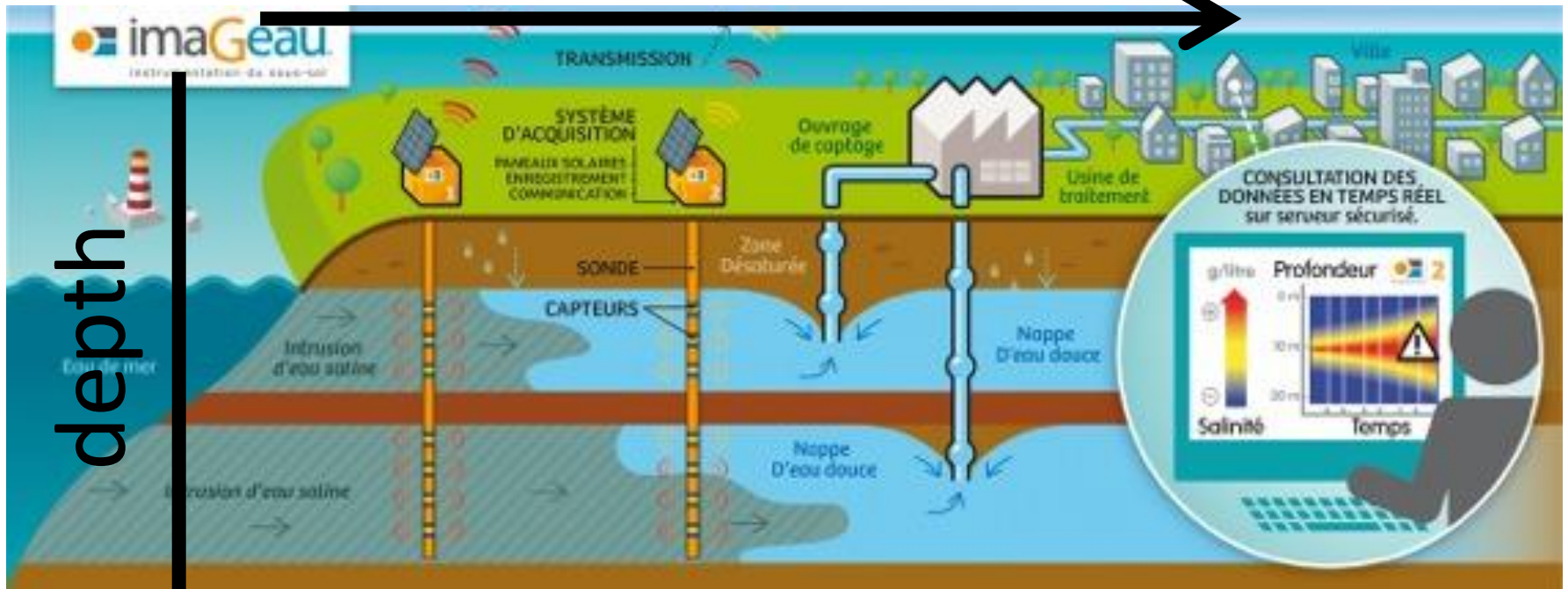


Monitoring techniques – Water quality monitoring kit



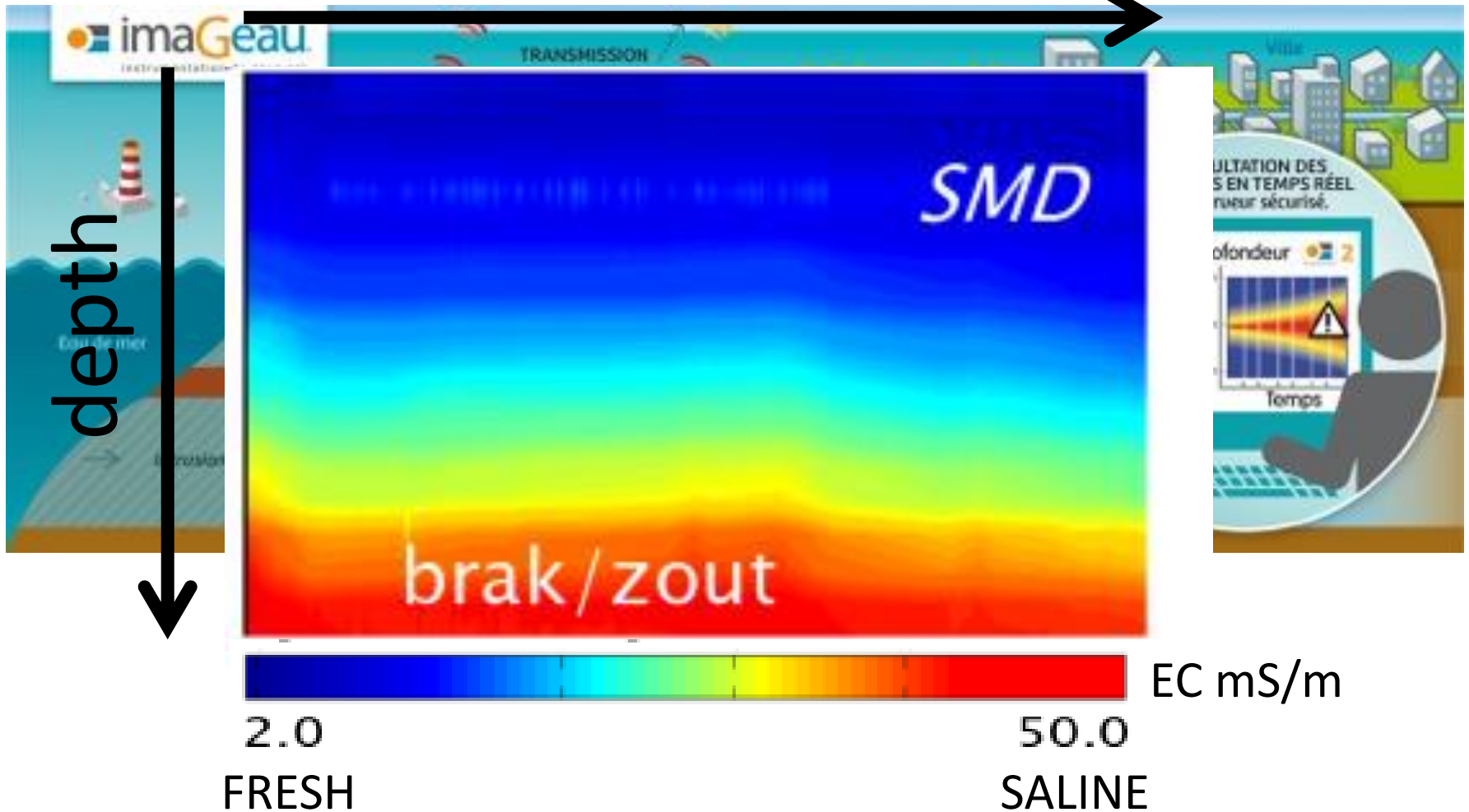
Electromagnetic Techniques - SMD

time



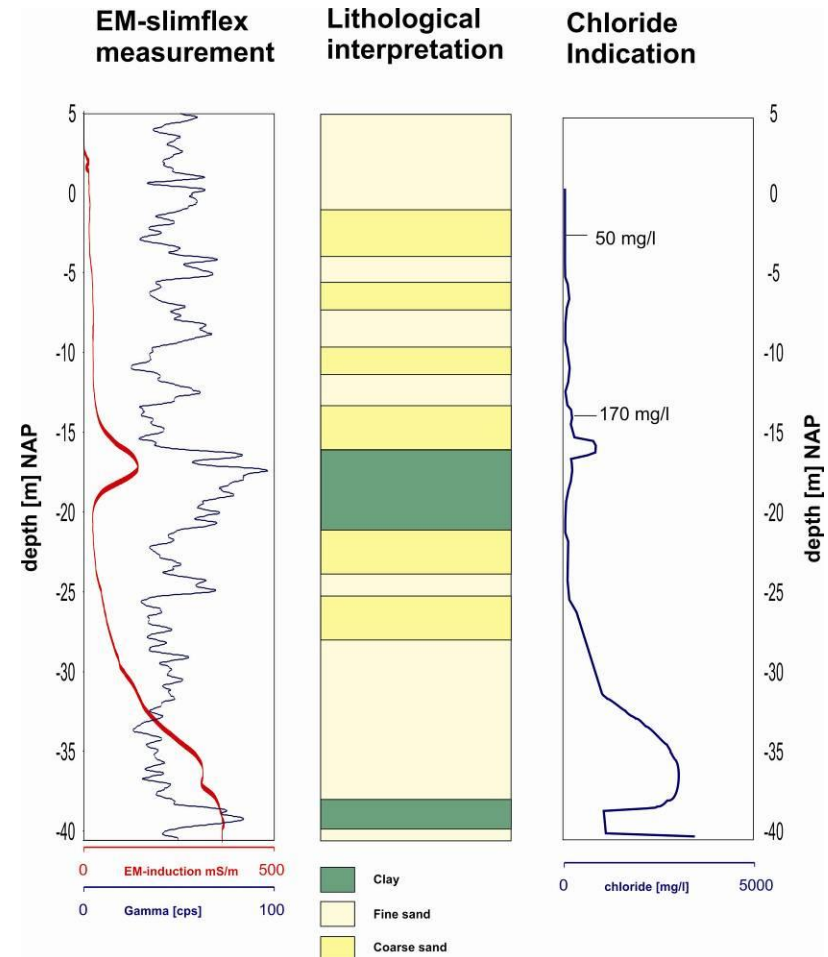
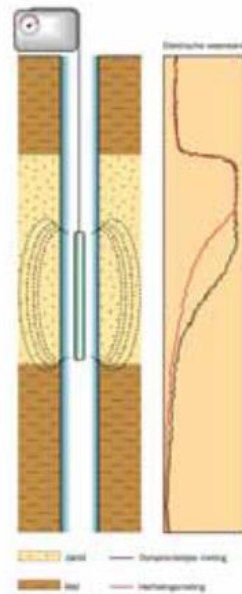
Electromagnetic Techniques - SMD

time

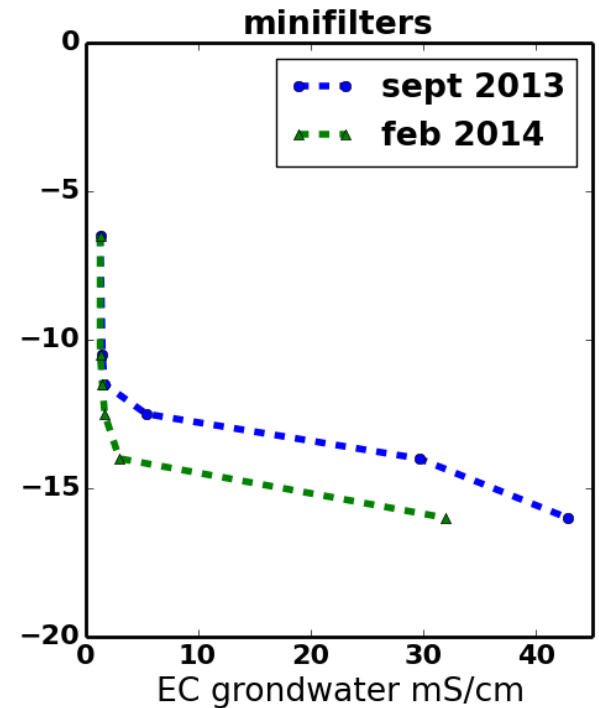
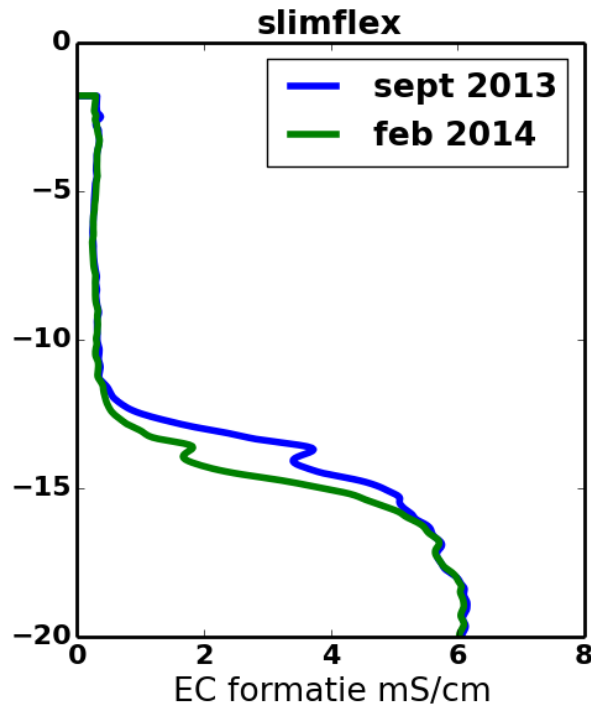
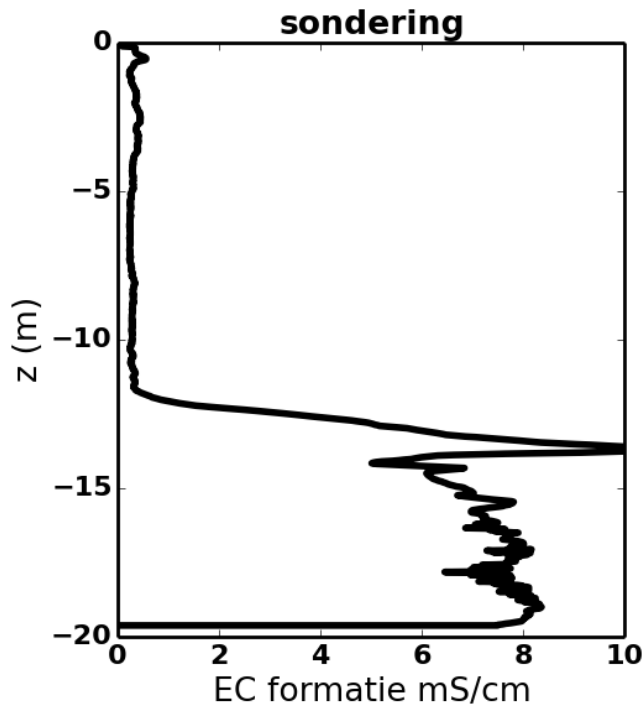


Electromagnetic Techniques - SLIMFLEX

- Slim and flexible
- High resolution data
- More data points
- Easy to handle



Electromagnetic Techniques - SLIMFLEX



Electromagnetic Techniques - EM

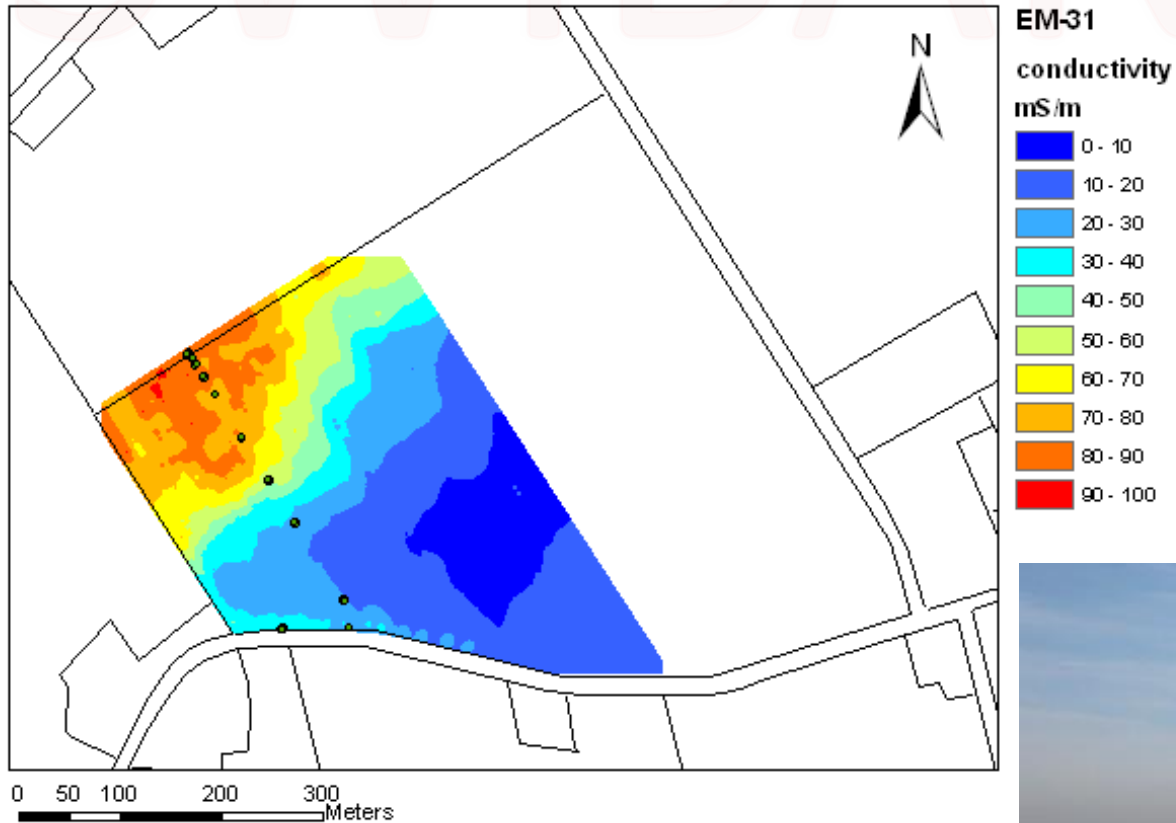
- EM34
generally used for lateral variations in subsurface conductivity



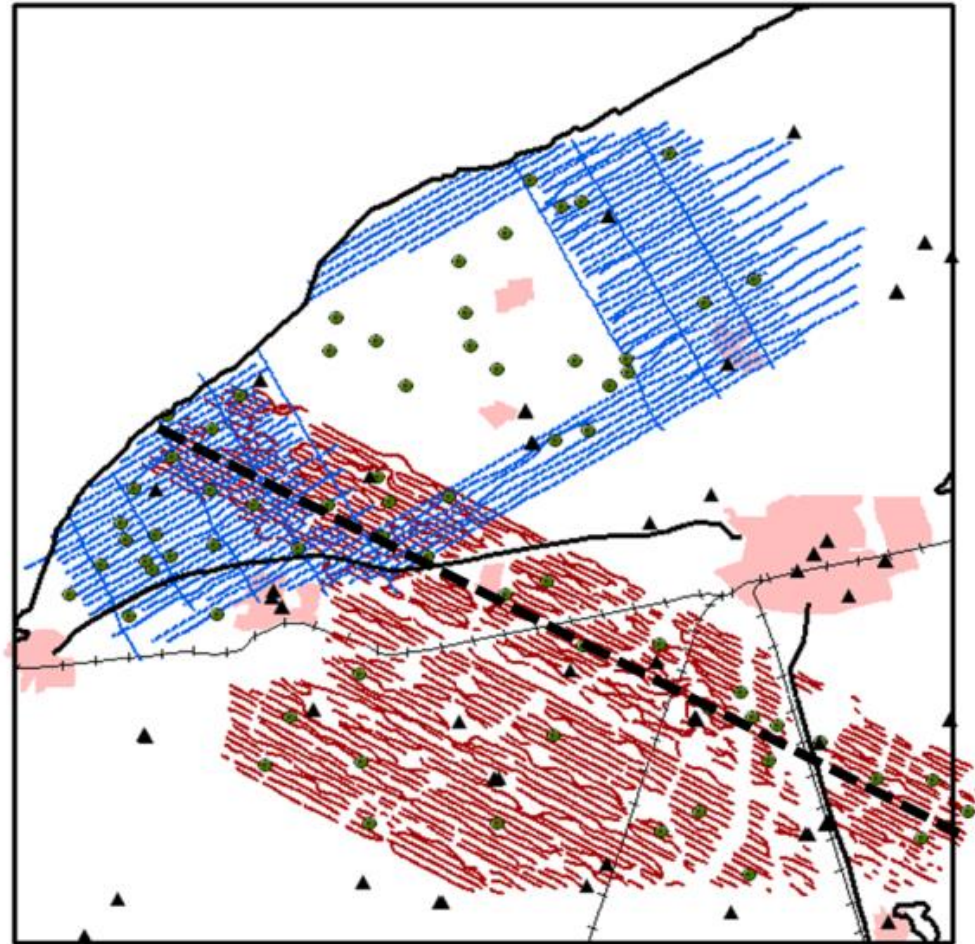
- EM39
~EM31/34, but in borehole



EM31: lateral variability of the subsurface bulk conductivity



Electromagnetic techniques – Airborne Electromagnetics (AEM)



Legend

- ECPT
- ▲ CI measurements
- HEM
- skyTEM
- Geological cross-section

0 1.5 3 6 9 12 Kilometers

Compare Airborne EM with ECPT

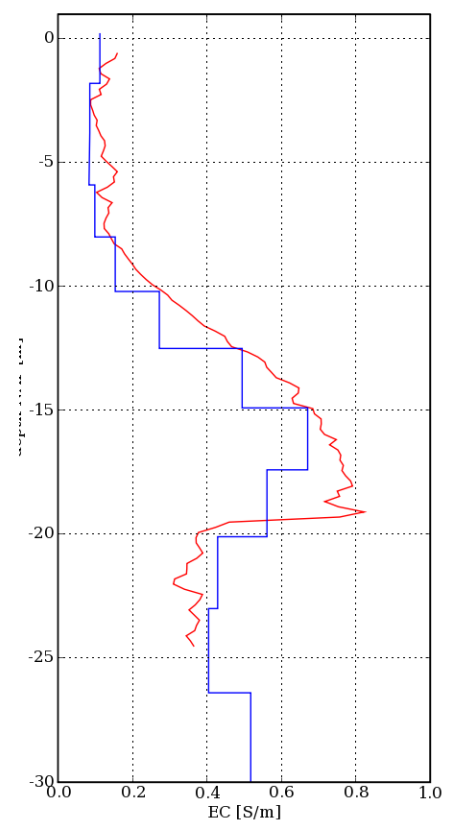
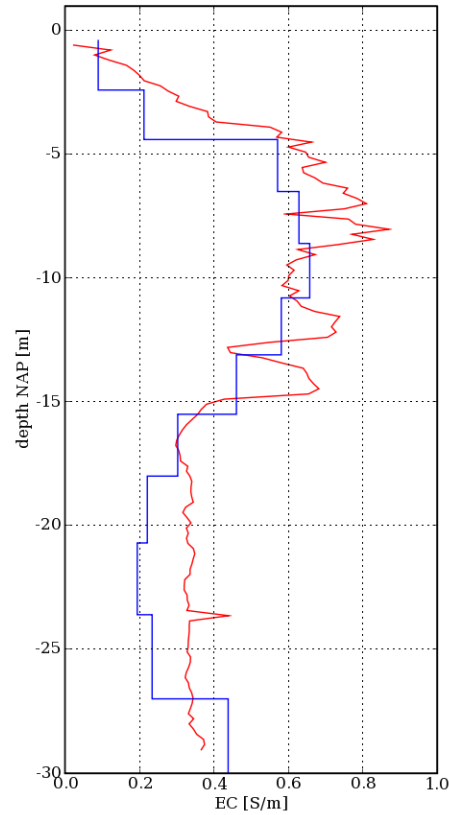
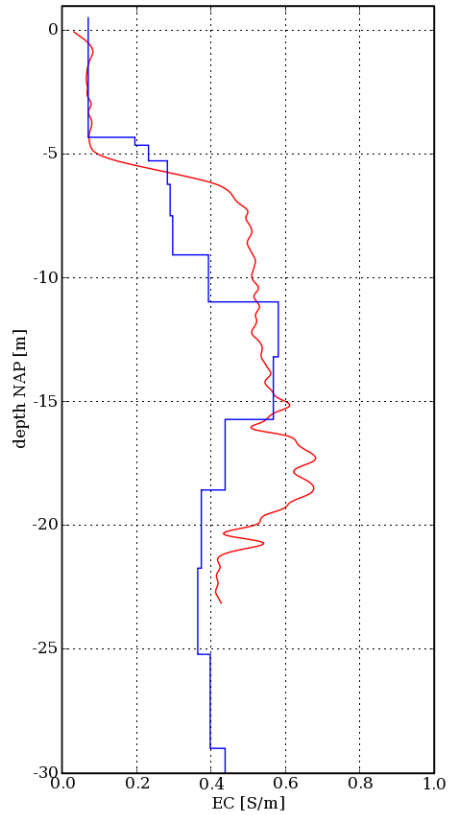
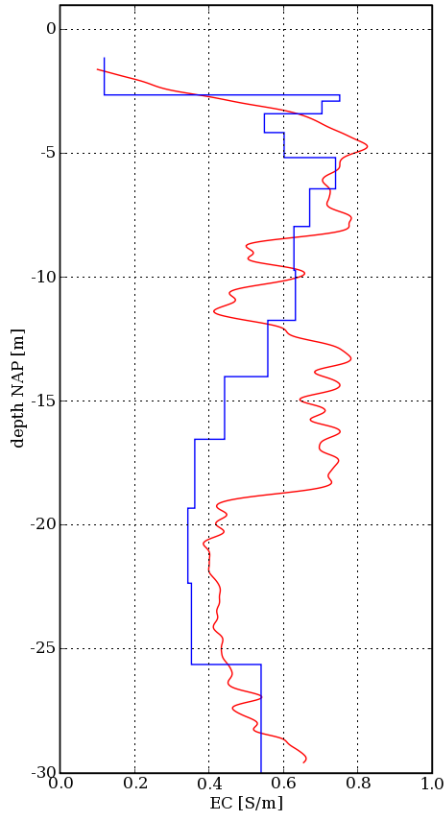
Case Wetterskip Fryslân

ECPT: S05G00615
HEM-id: 161304.021_579176.305
distance: 35.0 m

ECPT: S05G00610
HEM-id: 160478.403_580431.629
distance: 17.0 m

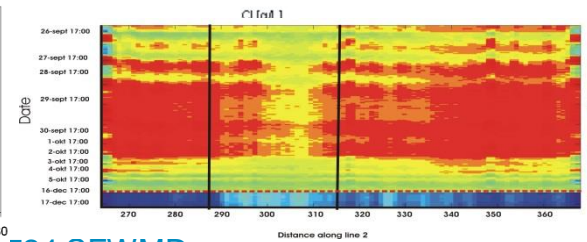
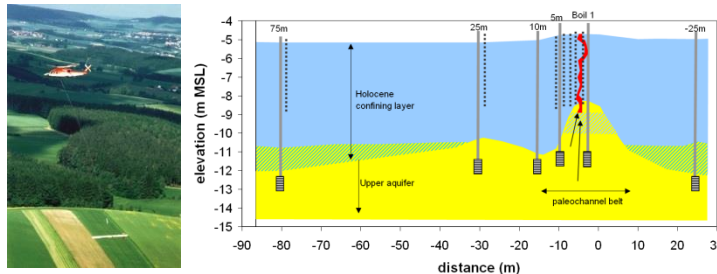
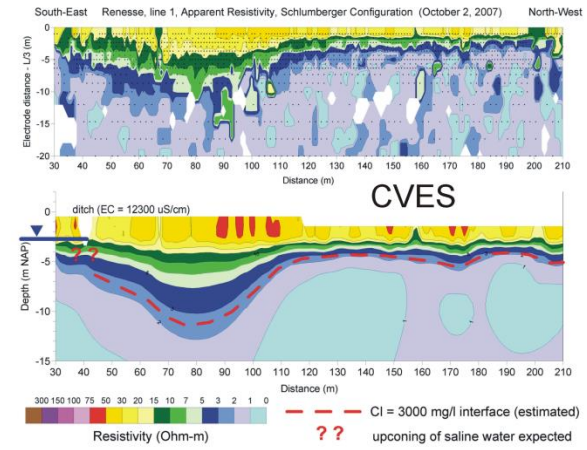
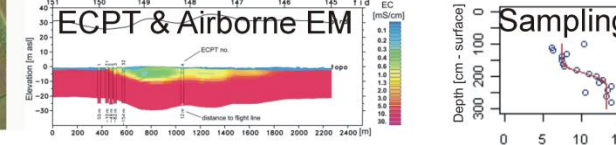
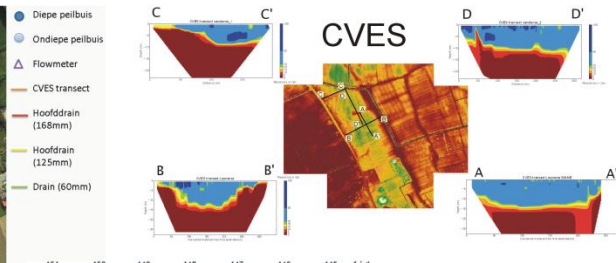
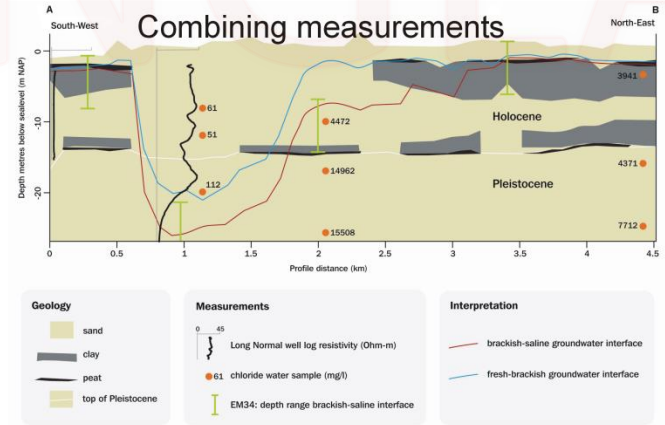
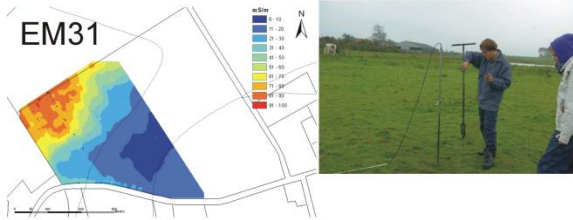
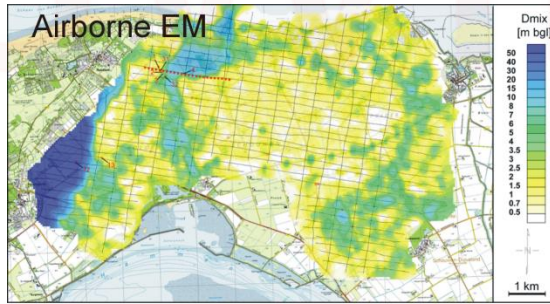
ECPT: S10F00073
skyTEM-id: 19392
distance: 23.0 m

ECPT: S10F00072
skyTEM-id: 10487
distance: 31.0 m

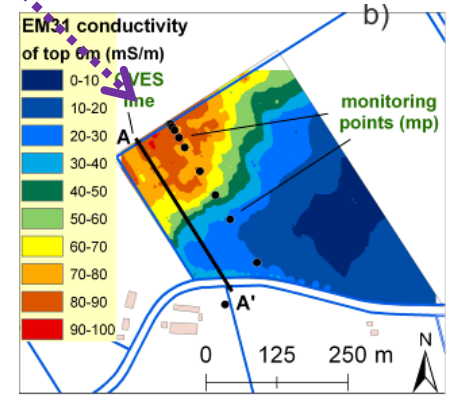
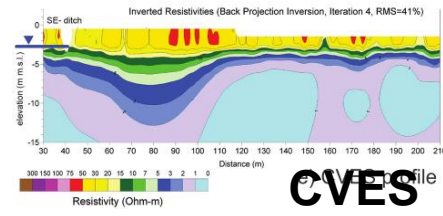
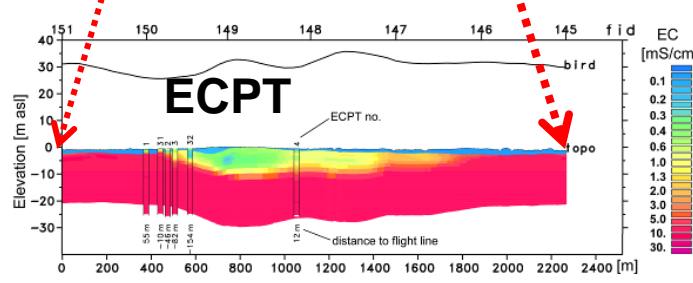
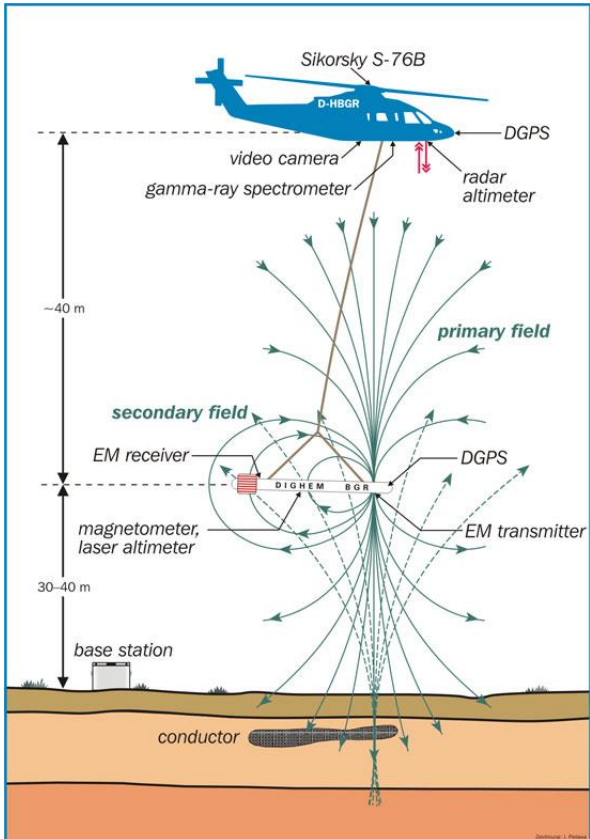
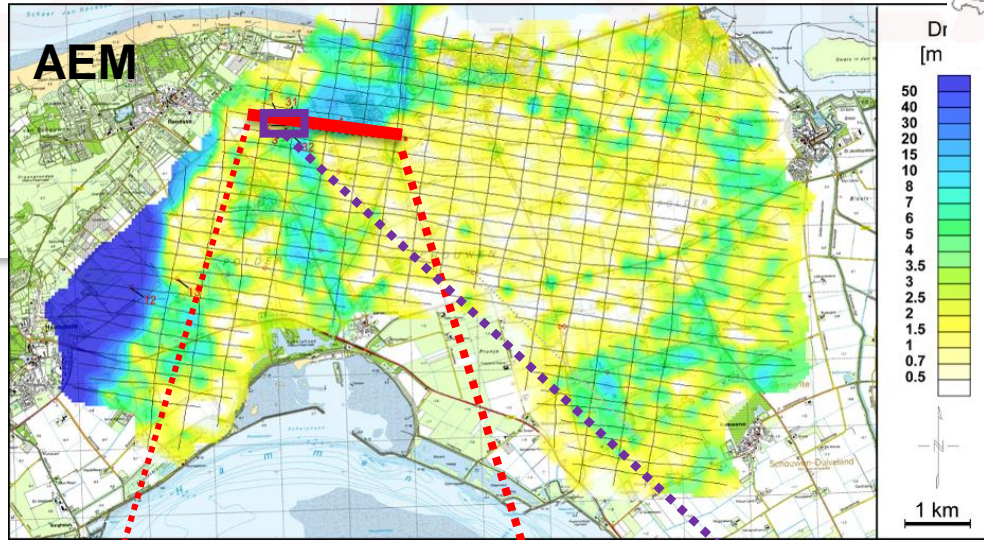


— EC from ECPT
— EC from inversion

Combining monitoring techniques



Case Schouwen-Duiveland

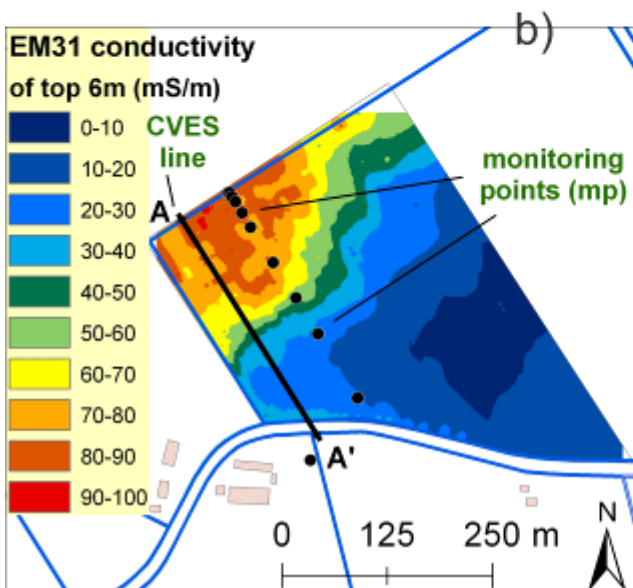
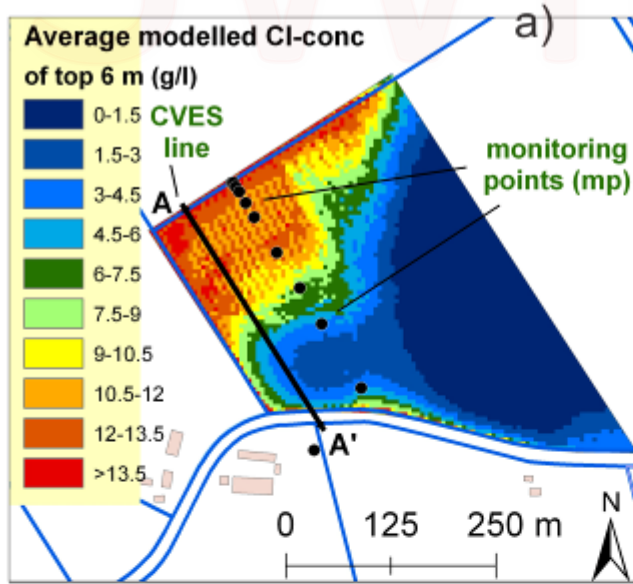


EM31

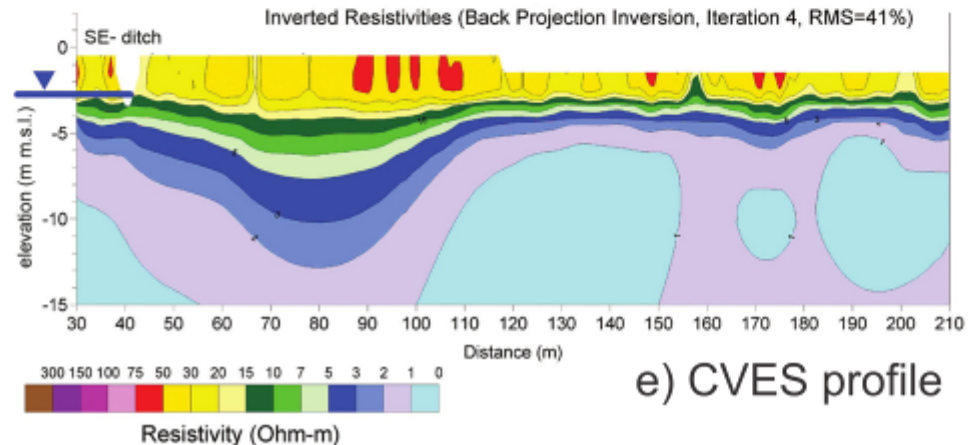
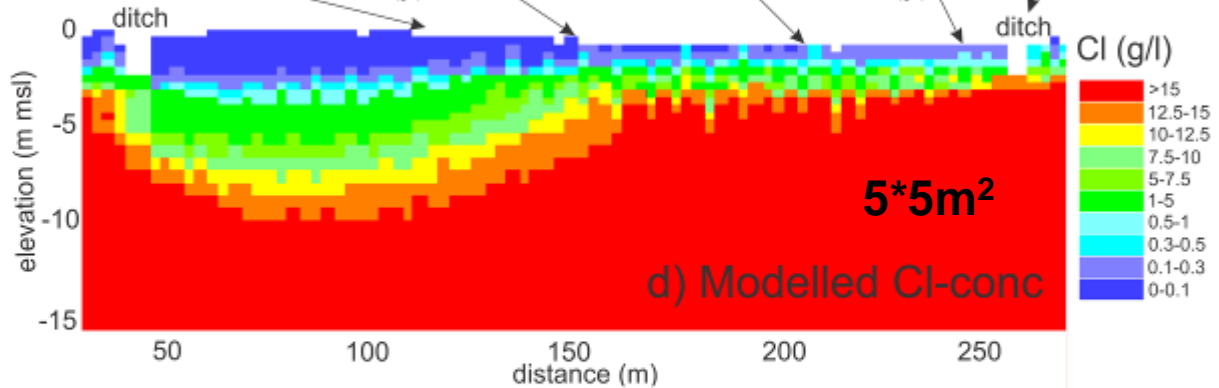
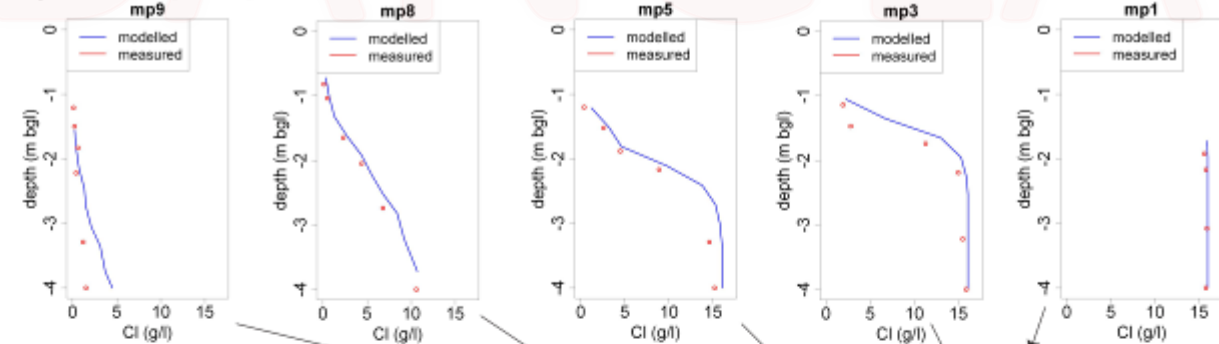
CVES

conventional monitoring techniques

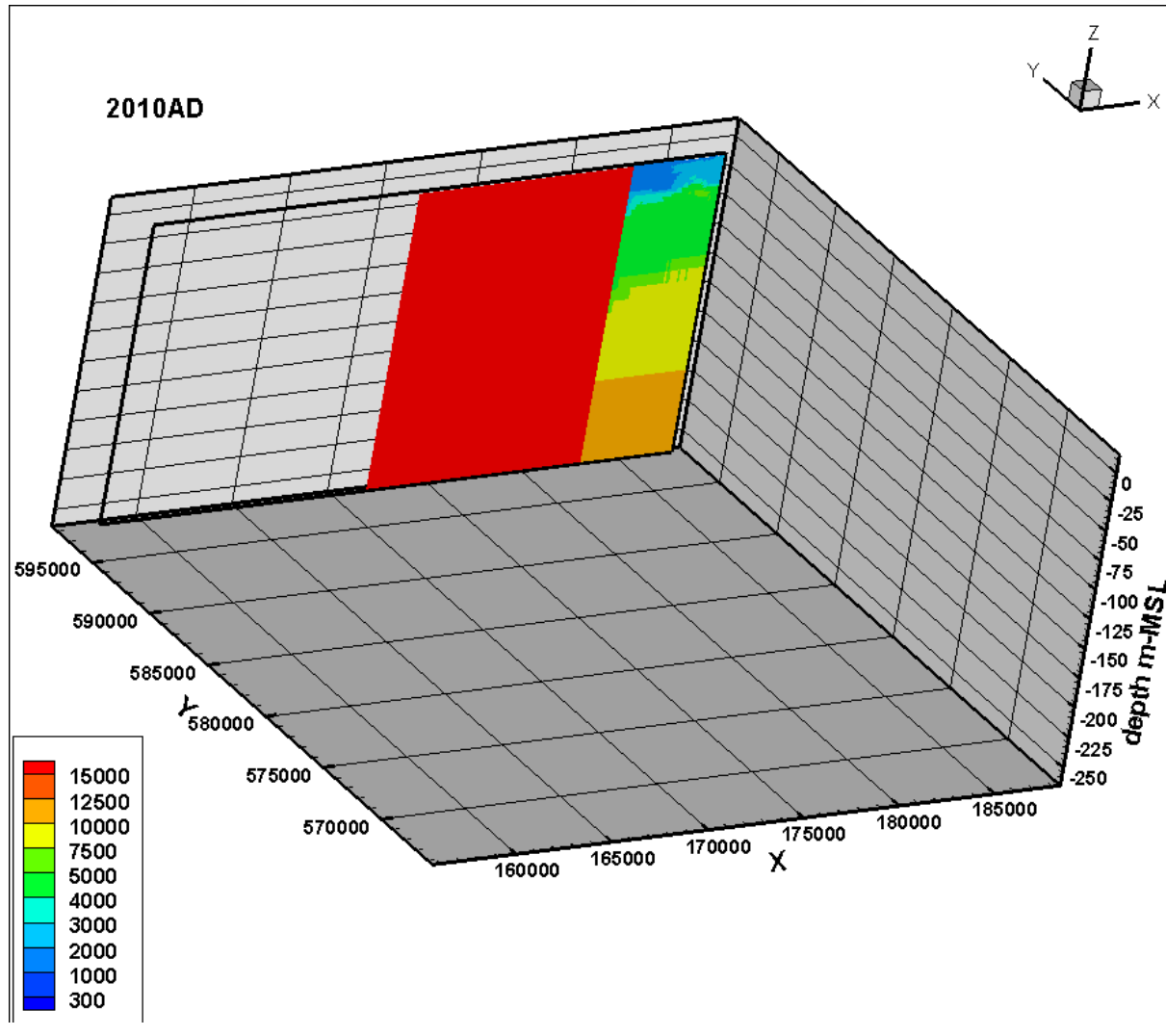
Comparison monitoring data with model results



c) Cl-depth profiles



3D fresh-brackish-salt from AEM



Information Management and Monitoring responsibility

Example of The Netherlands

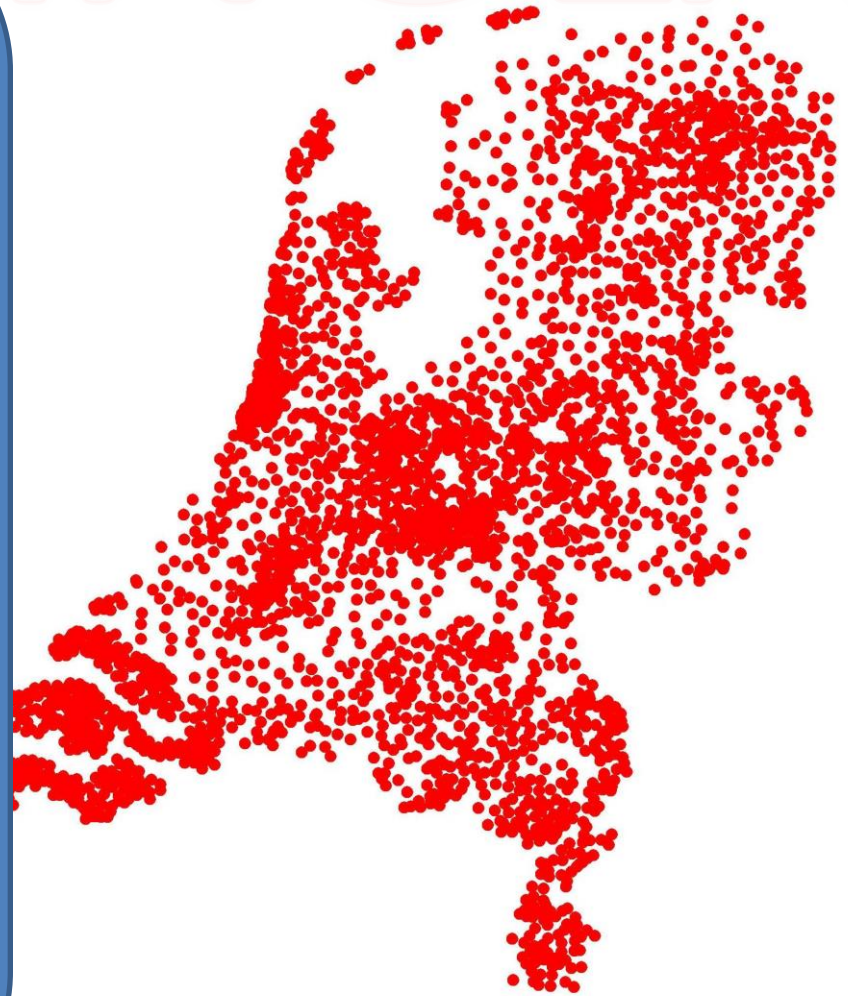
Information Management and Monitoring responsibility – Example of The Netherlands

› **Monitoring networks**

- National level: Ministry of Infrastructure and Environment
- Regional level: provincial authorities, water boards, nature conservation
- Local level: municipalities and water supply companies

Primary groundwater level monitoring network

- Developed and maintained by all 12 provinces;
- Deepest 800 meter – s.l.;
- Started after 1970;
- Designed to create a regional picture of the spatial distribution of hydraulic head (per aquifer);
- Very good information but dated!;
- Old interval 14 days, now 1 hour, using “divers”;



Monitoring networks in the Netherlands:

(1) groundwater level monitoring

Groundwater level monitoring	No. of sites	max. freq.	design	operation & database	data analysis
Primary networks					
11 provincial networks	± 1000	1/14 days	TNO	TNO	TNO
Secondary networks					
obligatory networks drinking water well fields	± 1000	1/14 days	TNO, cons.	TNO	TNO, cons.
Tertiary networks					
Ad hoc networks water boards		1/14 days	TNO, cons	TNO, owners	TNO, cons.
Nature reserves networks		1/14 days	TNO, cons.	TNO, owners	TNO, cons

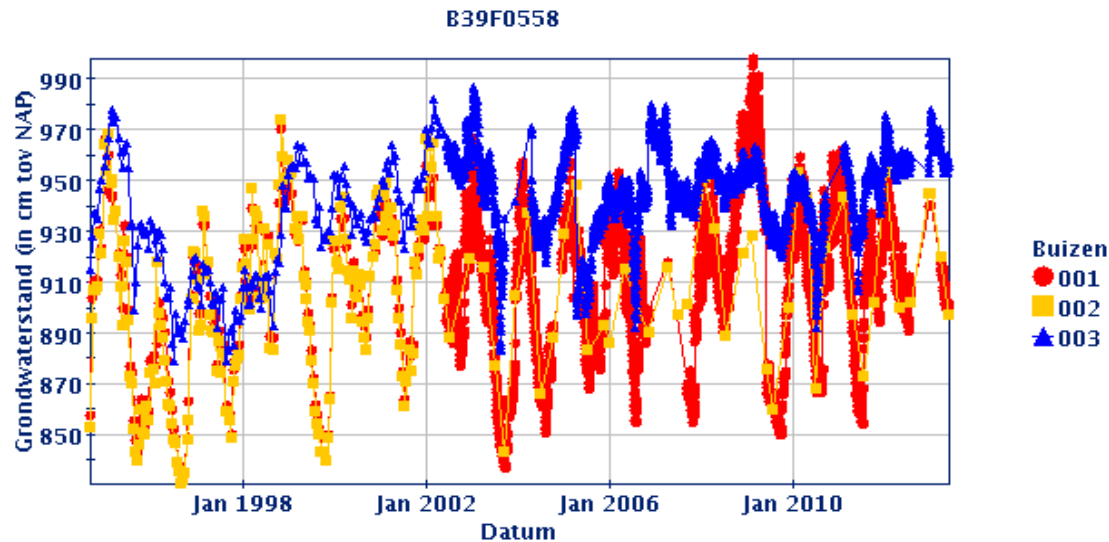
Monitoring networks in the Netherlands:

(2) groundwater quality monitoring

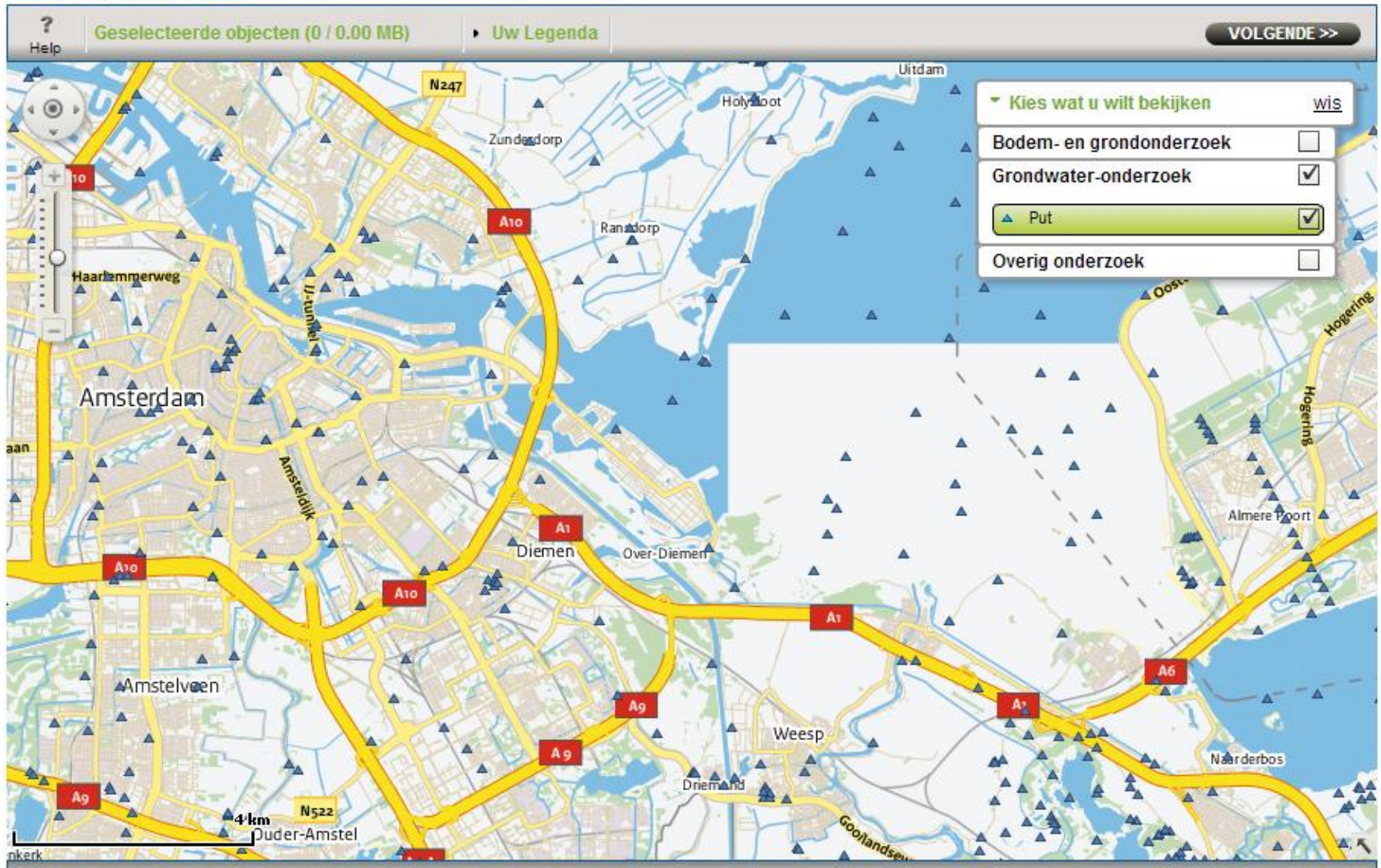
Groundwater quality monitoring	No. of sites	max. freq.	design	operation & database	data analysis
Groundwater 5-30 m depth					
National network	400	1/yr	RIVM	TNO	RIVM
Provincial networks	500 extra	1/yr	TNO, cons.	TNO	TNO, cons.
Networks around well fields	1000	1/yr	cons.	owner	cons.
Groundwater < 5 m depth					
National soil quality network	280	1/7 yrs	RIVM	TNO	RIVM
Provincial soil quality	600	1/yr	TNO, cons.	TNO, cons.	TNO, cons.
National "Manure" network	160	1/yr	RIVM	RIVM	RIVM

DINO Groundwater Database:

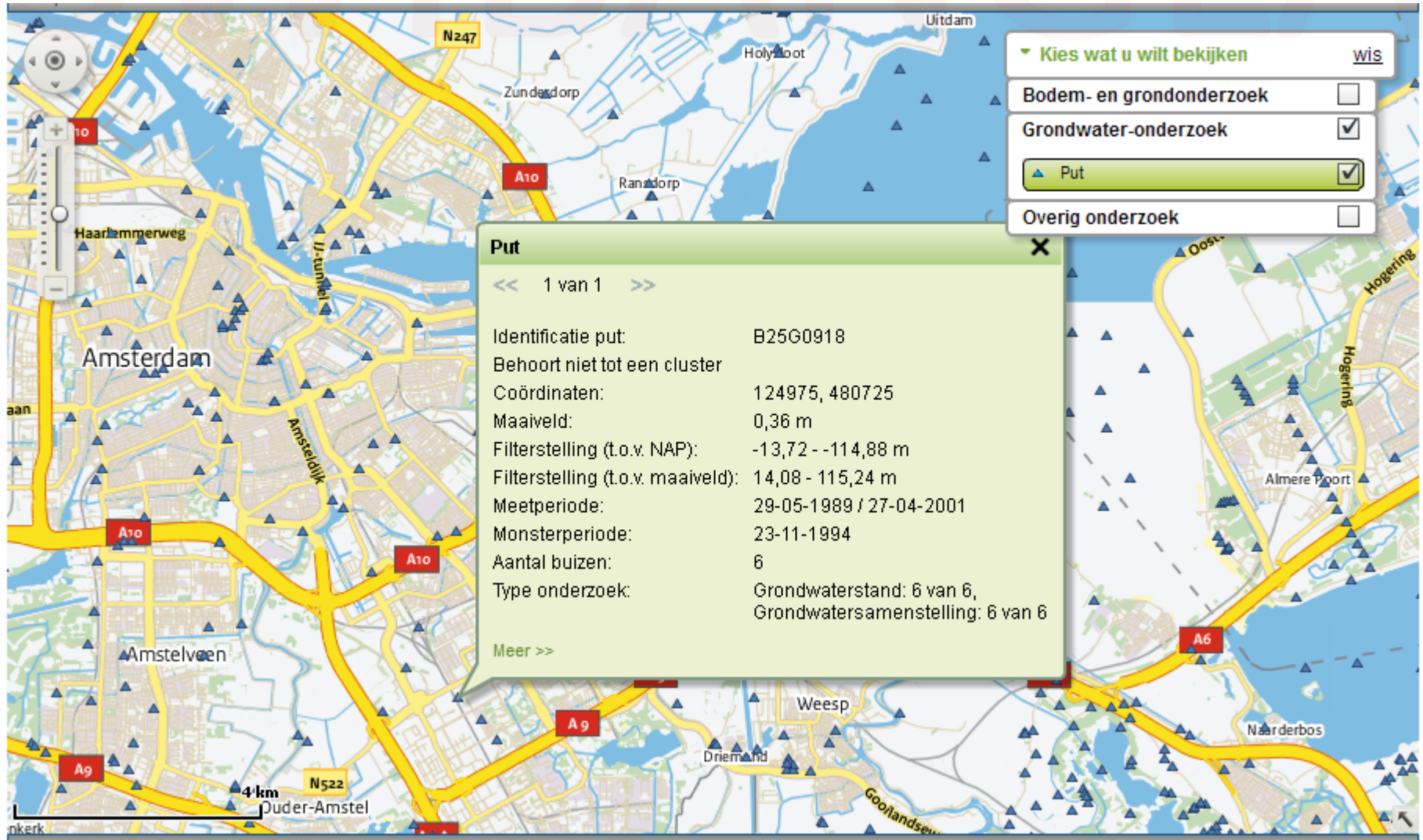
- › 1997: 31,000 monitoring locations; 15 million groundwater levels/heads
- › Present: 49,000 monitoring locations; 74,000 piezometers, 130 million groundwater levels/heads



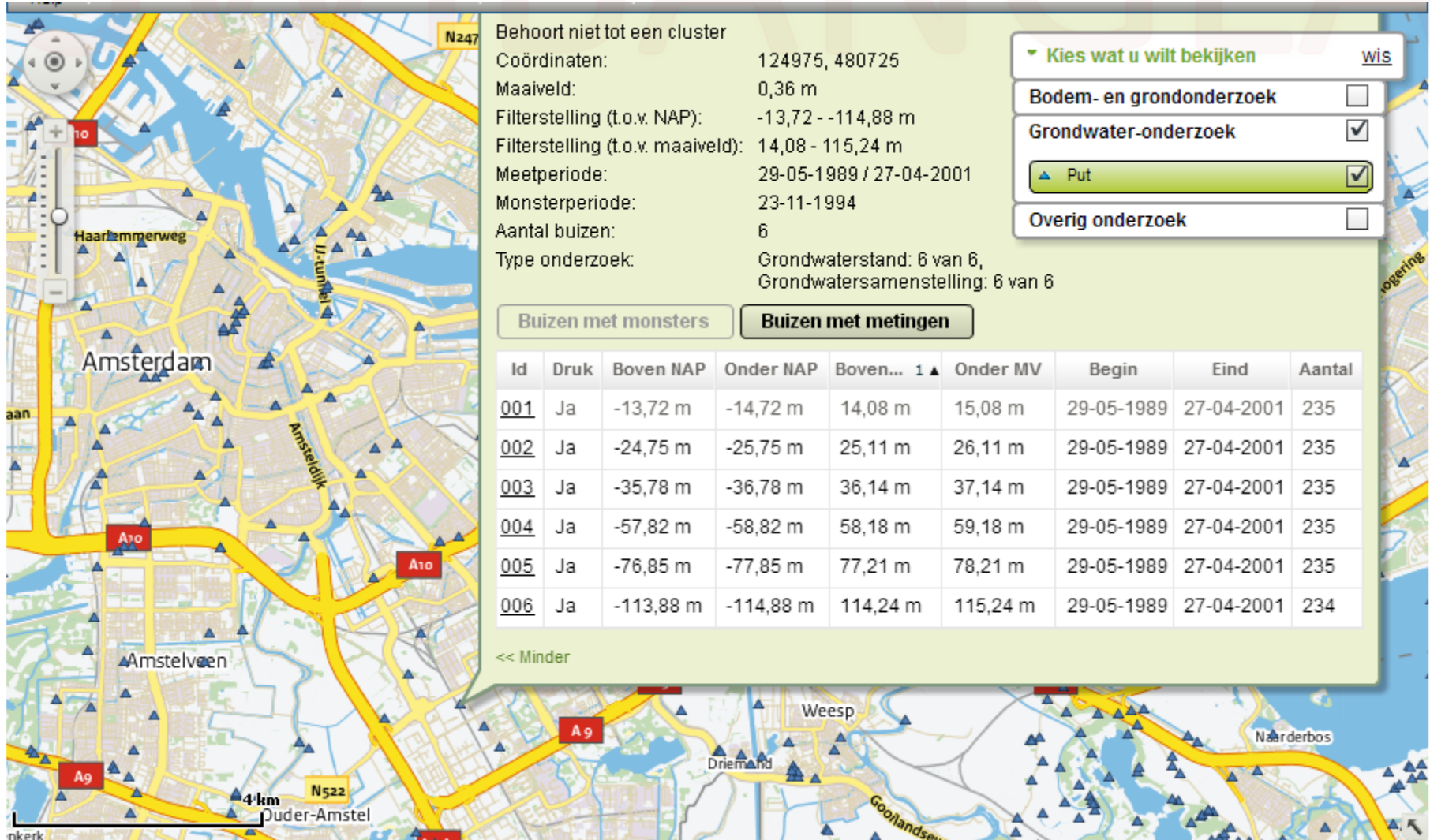
WWW.DINOLOKET.NL

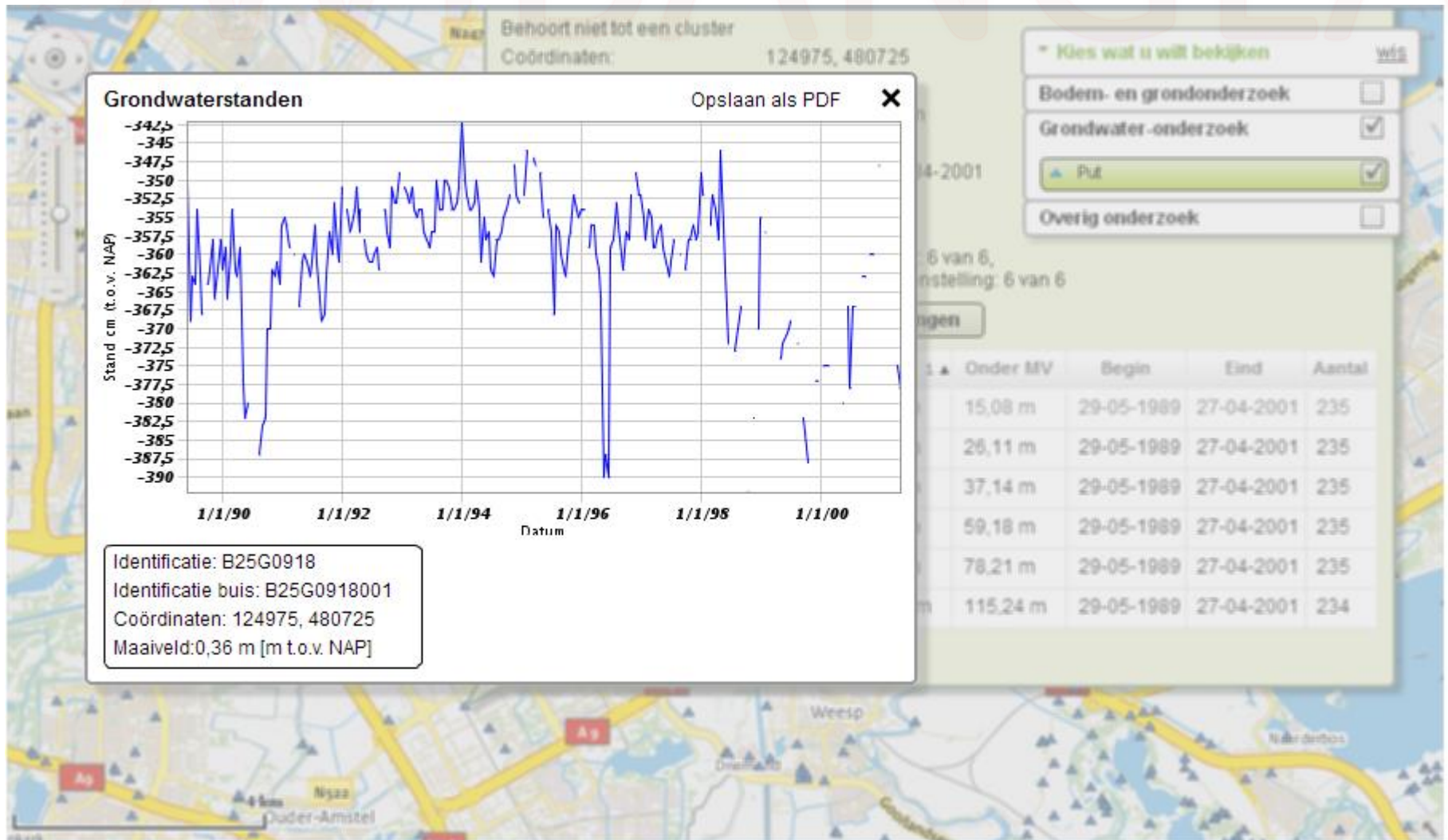


WWW.DINOLOKET.NL



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Monitoring of groundwater salinity in Bangladesh

Groundwater salinity measurements

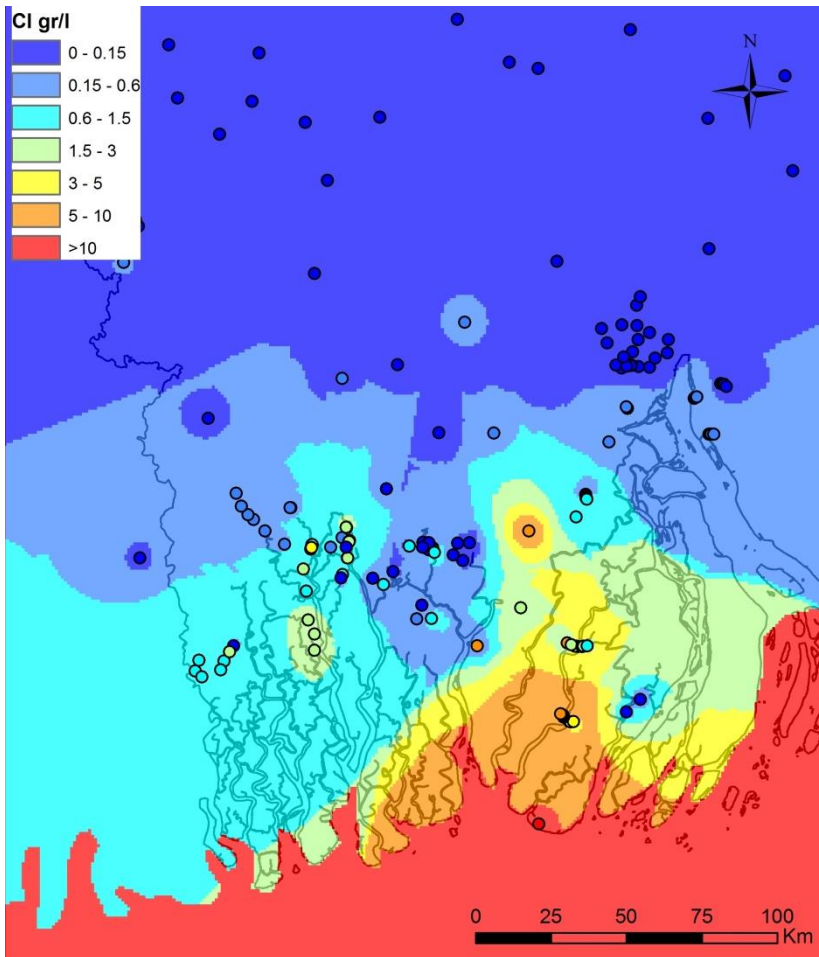
Collected data from:

- BRAC
- DPHE
- BWDB

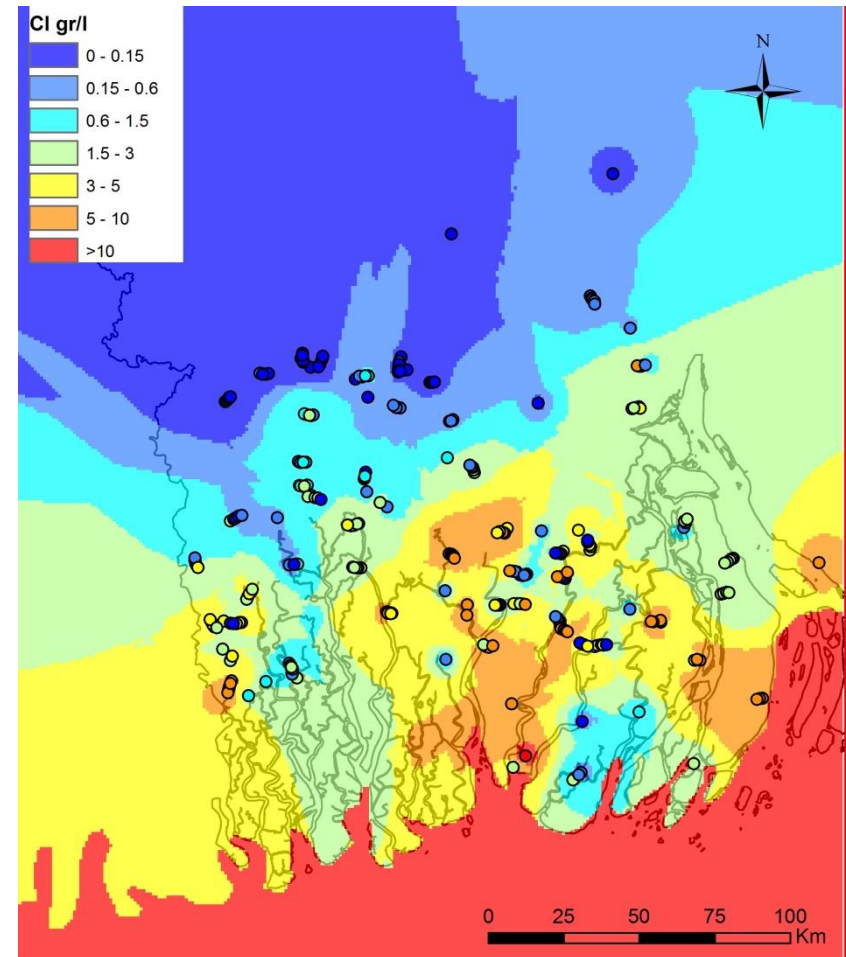
Types of measurements:

- Chloride laboratory samples
- EC field kit measurements

Groundwater salinity measurements

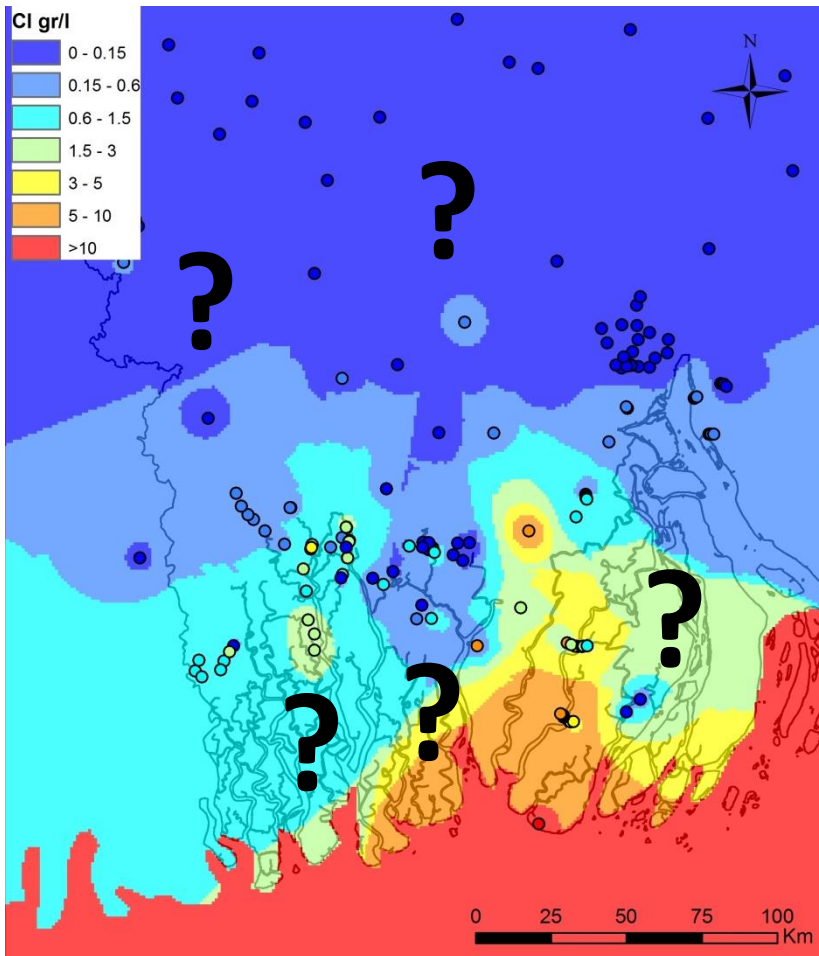


0-50m

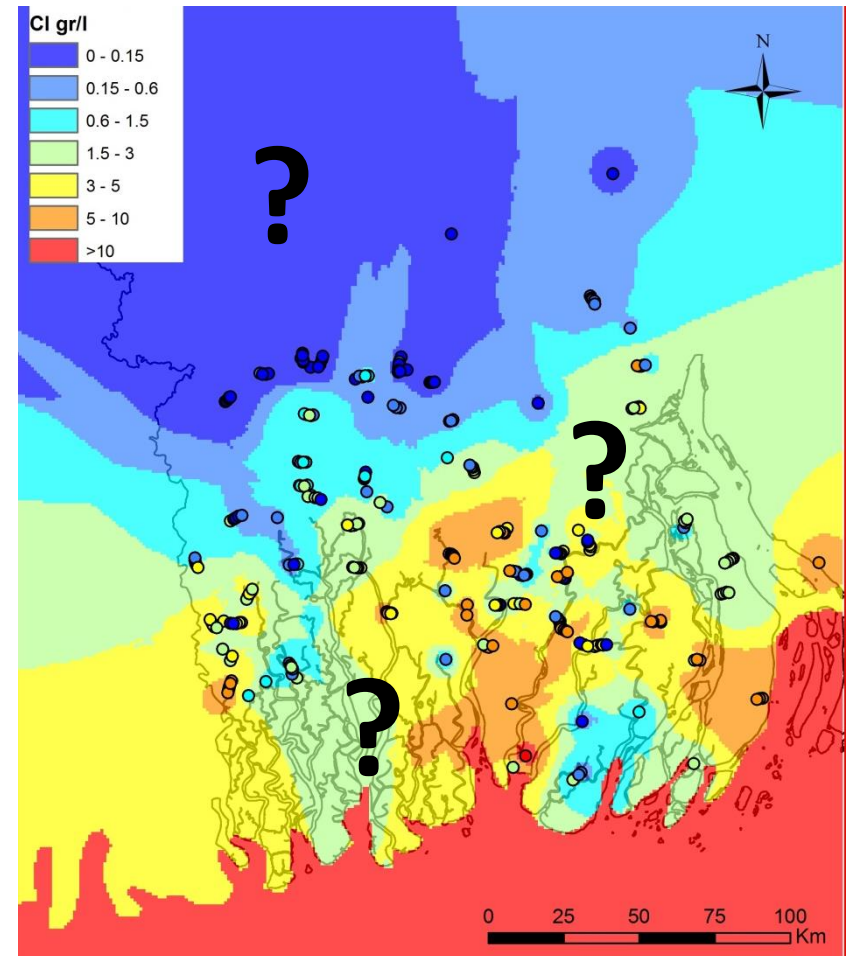


50-100m

Groundwater salinity measurements

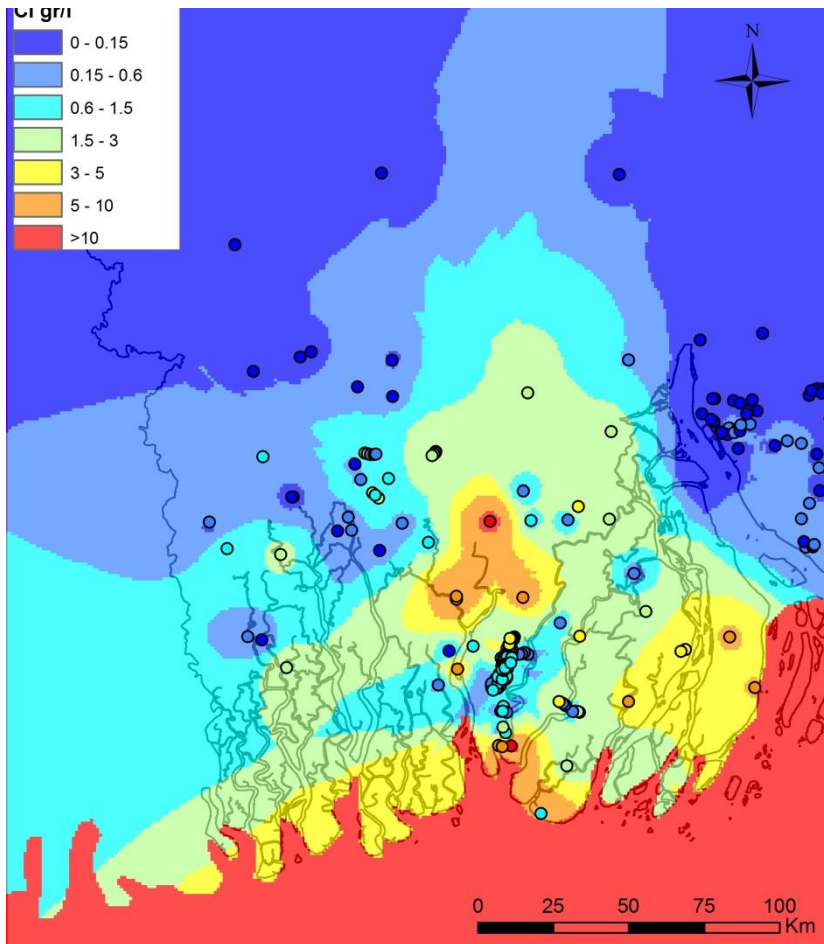


0-50m

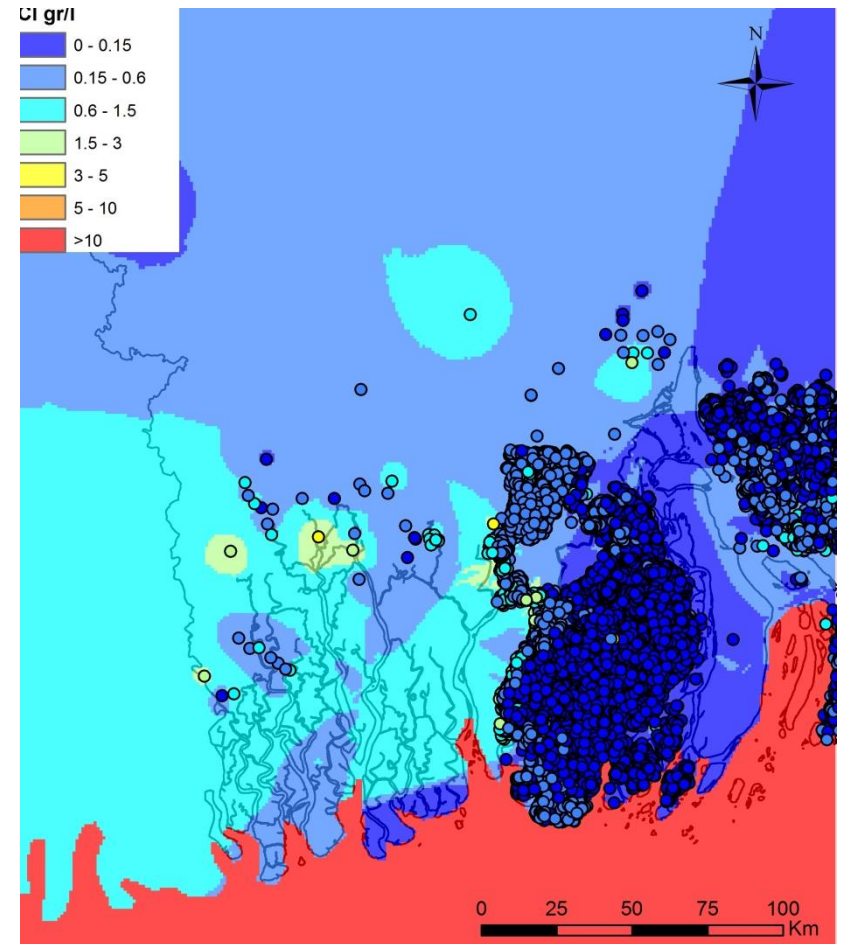


50-100m

Groundwater salinity measurements

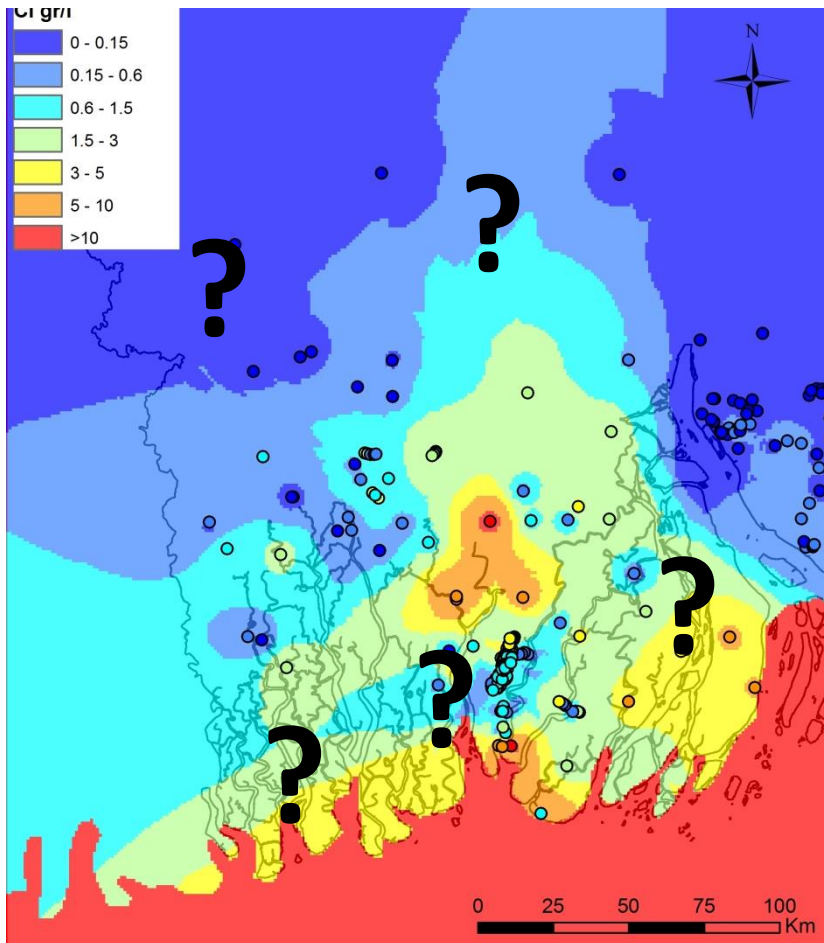


100-200m

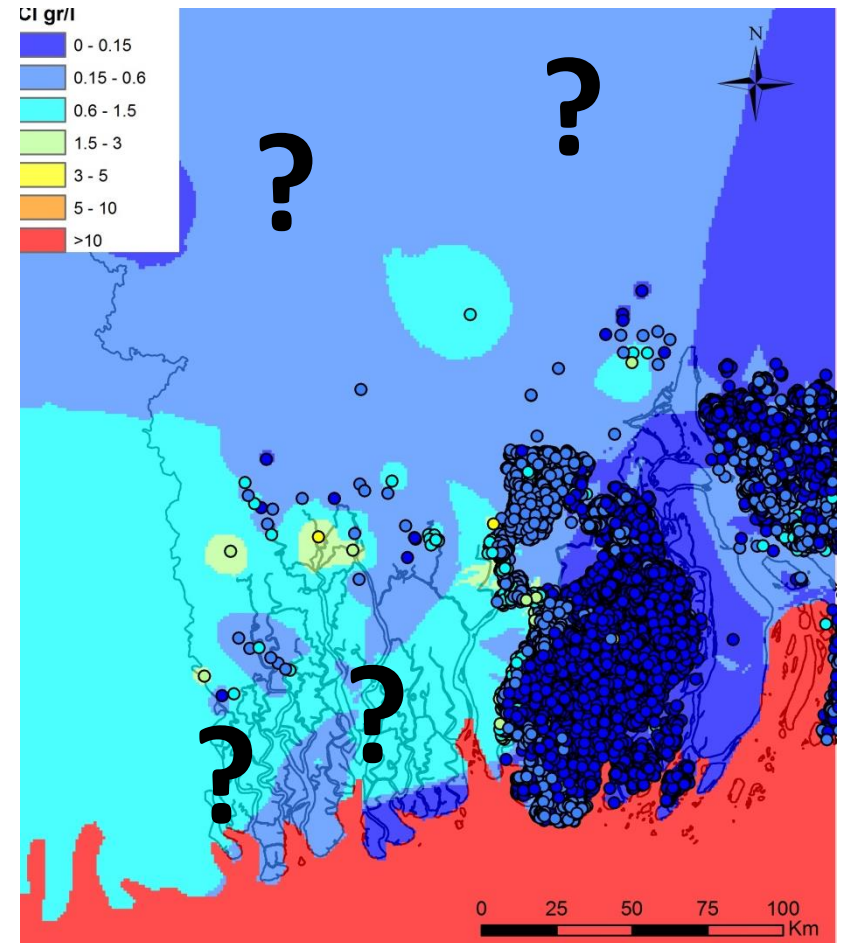


>200m

Groundwater salinity measurements



100-200m



>200m

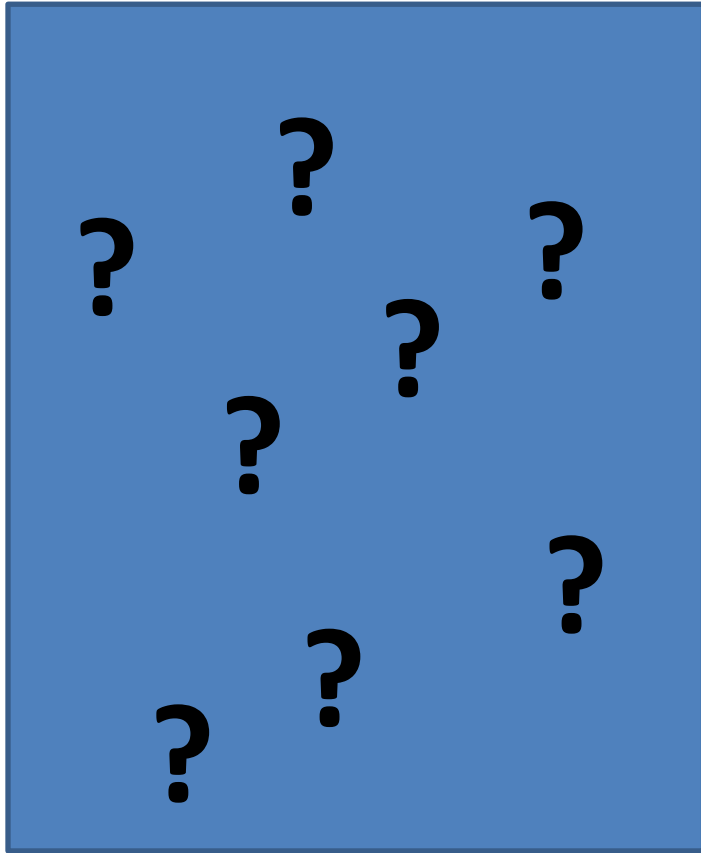
Groundwater salinity measurements

No information beneath
350m

Crucial information to know
if the drinking water wells
in the deep aquifer will get
salinized

>350m

Groundwater salinity measurements

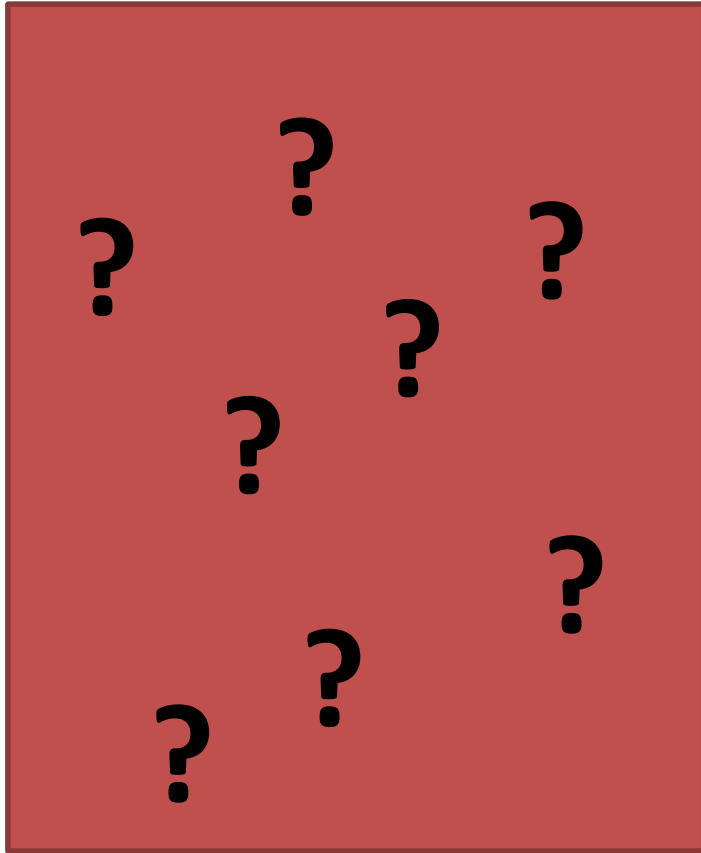


No information beneath
350m

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>350m

Groundwater salinity measurements



No information beneath
350m

Crucial information to know
if the drinking water wells
in the deep aquifer will get
salinized

>350m

Monitoring of groundwater in Bangladesh

Organisation	Surface water				Ground water			
	Policy and Planning	Research/ Assessment	Data collection and Monitoring	Service delivery	Policy and Planning	Research/ Assessment	Data collection and Monitoring	Service delivery
WARPO	◆	◆			◆	◆		
BWDB	◆		◆	◆	◆		◆	◆
JRC	◆	◆	◆					
BHWDB	◆	◆		◆				
RRI		◆				◆		
DPHE					◆	◆	◆	◆
LGED	◆	◆	◆	◆	◆	◆	◆	◆
DWASA and CWASA		◆		◆		◆		◆
BIWTA	◆		◆	◆				
BADC		◆		◆		◆	◆	◆
BARC		◆		◆		◆		◆
BARI		◆		◆		◆		◆
DAE		◆		◆		◆		◆
BMDA		◆		◆		◆	◆	◆
CEGIS	◆	◆			◆	◆		
IWM		◆				◆		
Private sector / NGOs		◆		◆		◆		◆

Monitoring of groundwater in Bangladesh

Monitoring of groundwater in Bangladesh

A lot of data

Monitoring of groundwater in Bangladesh

A lot of data

But...

Monitoring of groundwater in Bangladesh

A lot of data

But...

still not enough due to complex geology

Monitoring of groundwater in Bangladesh

A lot of data

But...

still not enough due to complex geology

no easy access (no central database)

Monitoring of groundwater in Bangladesh

A lot of data

But...

still not enough due to complex geology

no easy access (no central database)

And some of it...

Monitoring of groundwater in Bangladesh

A lot of data

But...

still not enough due to complex geology

no easy access (no central database)

And some of it...

missing georeference

Monitoring of groundwater in Bangladesh

A lot of data

But...

still not enough due to complex geology

no easy access (no central database)

And some of it...

missing georeference

missing measurement date

Monitoring of groundwater in Bangladesh

A lot of data

But...

still not enough due to complex geology
no easy access (no central database)

And some of it...

missing georeference

missing measurement date

missing depth of measurement

Some questions for reflection...

Some questions for reflection...

Is Bangladesh using the most efficient monitoring techniques given the geology and hydrogeology?

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Is Bangladesh using the most efficient monitoring techniques given the geology and hydrogeology?

Is Bangladesh combining networks to profit from integrated data analysis?

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Is Bangladesh combining networks to profit from integrated data analysis?

Is Bangladesh monitoring towards understanding and data assimilation for forecasting and support decision systems?

Some questions for reflection...

Is Bangladesh using the most efficient monitoring techniques given the geology and hydrogeology?

Is Bangladesh combining networks to profit from integrated data analysis?

Is Bangladesh monitoring towards understanding and data assimilation for forecasting and support decision systems?

Is Bangladesh well organized regarding data management?

Recommendations Bangladesh groundwater monitoring

1. Determine clear monitoring objectives
2. Determine what kind of results you want. Design the type of graphs etc. (“think backwards”)
3. Every objective has his own design criteria, in space and in time
Often different objective monitoring networks can be combined
4. Collect and store all monitoring data in 1 central database
5. Produce clear graphs, maps etc. to show the monitoring results on a public website
6. Determine in advance what you decide to do with results, passing thresholds (“the red dot method is no solution”)
7. Evaluate existing monitoring networks
8. Bring all monitoring stake holders together in one network (at least one meeting/year)

Towards a central, public database for geohydrological data in Bangladesh?

Gijs Janssen

Roelof Stuurman

Unit Soil and Groundwater Systems

Background

- Identifying, tackling and managing the groundwater issues of Bangladesh relies on a sound comprehension of the physical processes involved
- Such system understanding relies, in turn, on the availability of data
- Many organizations are involved in the collection of data
- However, coordination is lacking

Why a central, publicly accessible database?

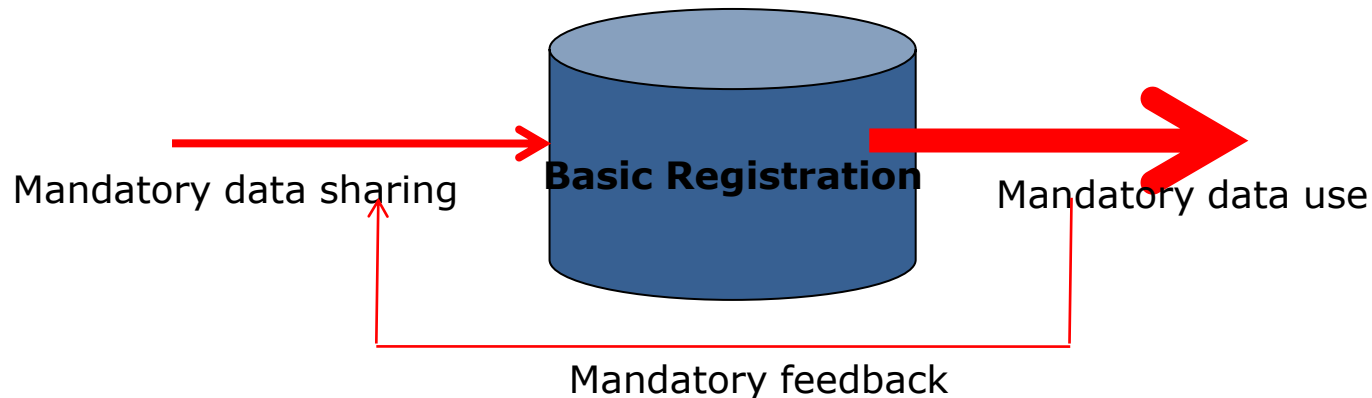
- 1 A better data availability for all stakeholders, allowing a scientifically more sound basis for research and consultancy projects, thereby increasing the success level and rate of these projects.
- 2 A more efficient use of the available data, as the data can be easily retrieved in the database, and can be used and reused infinitely by everyone interested;

Why a central, publicly accessible database?

- 3** A better focus and coordination of new measurement and monitoring efforts: a more complete picture of what has already been or is already being measured/monitored can prevent “double work”;
- 4** Increased business in the field of geohydrology: the more data there are, the more that can be done with it, spiralling new research ideas and insights, and promoting the level and expertise of geohydrologists in Bangladesh;
- 5** Greatly enhanced possibilities for data quality management: data that do not meet set standards can be denied from the database through clear and scientifically sound decision rules.

Example from The Netherlands: BRS and DINO

- BRS = “Basic Registration Subsurface”
- Governmental organisations are obliged by law to supply TNO with their data
- TNO is obliged by law to provide public access to the data.
- DINOloket enables everyone to download data of the Dutch subsurface to use them for example in analyses www.dinoloket.nl



Discussion

- Do you support the idea of a publicly accessible, central database?
- Do you support the idea of (mandatory) data sharing by governmental bodies?
- Will non-governmental organizations also share their data?
- Do you support the idea of measurement protocols?
- What are the main obstacles for putting such a database in place?
- What are the first steps to be taken now?