LA SCARSITA' DELLA RISORSA IDRICA IN PERIODI DI CRISI CLIMATICA:
PROBLEMATICHE ESPERIENZE E PROPOSTE DI INTERVENTI DI MITIGAZIONE

Dip.to di Fisica, Aula Magna "Tullio Regge", Via P. Giuria, 1 - TORINO
29 Giugno 2023

PROGETTAZIONE ED ESERCIZIO DEGLI IMPIANTI DI RICARICA DELLE FALDE IN CONDIZIONI CONTROLLATE AI SENSI DEL DM 100/2016

Rudy Rossetto

Crop Science Research Center

Managed Aquifer Recharge

Intentional recharge of an aquifer

A process to intentionally increase the volume ordinarily stored underground soil surface

Techniques mimicking/enhancing natural processes

(or, Bower (2002): *the main objective of artificial recharge techniques are to increase the available groundwater resources and to improve groundwater quality*)

This recharge is intentional (managed) in order to assure an adequate protection of human health and the environment.

This management makes this recharge different from non intentional recharge (i.e. excess irrigation), which may pose threath to the above.

Managed Aquifer Recharge

Not a novelty!

Highly developed from 1950.

(In Italy: Mario Canavari's Manuale di Geologia Tecnica, 1927)

Geoengineering schemes

Potential use and objectives:

- Increase groundwater availability;
- Compensate diminishing recharge due to human activities;
- Replenishment against overdrafting;
- Control of subsidence phenomena;
- Combat seawater intrusion;
- Sustain groundwater-dependant ecosystems;
- Improving groundwater quality.

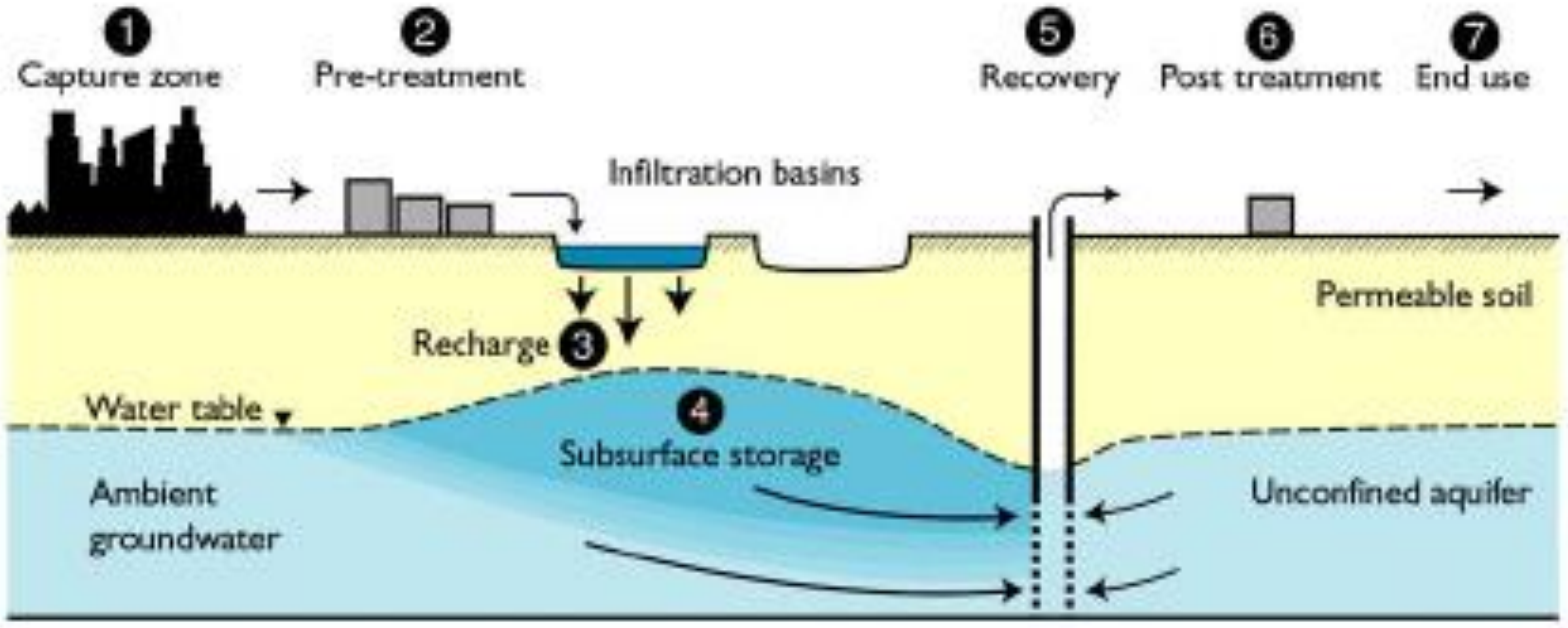
Video resource

Managed Aquifer Recharge
(CSIRO – Australia)

https://www.youtube.com/watch?v=9HyeGKYulwo

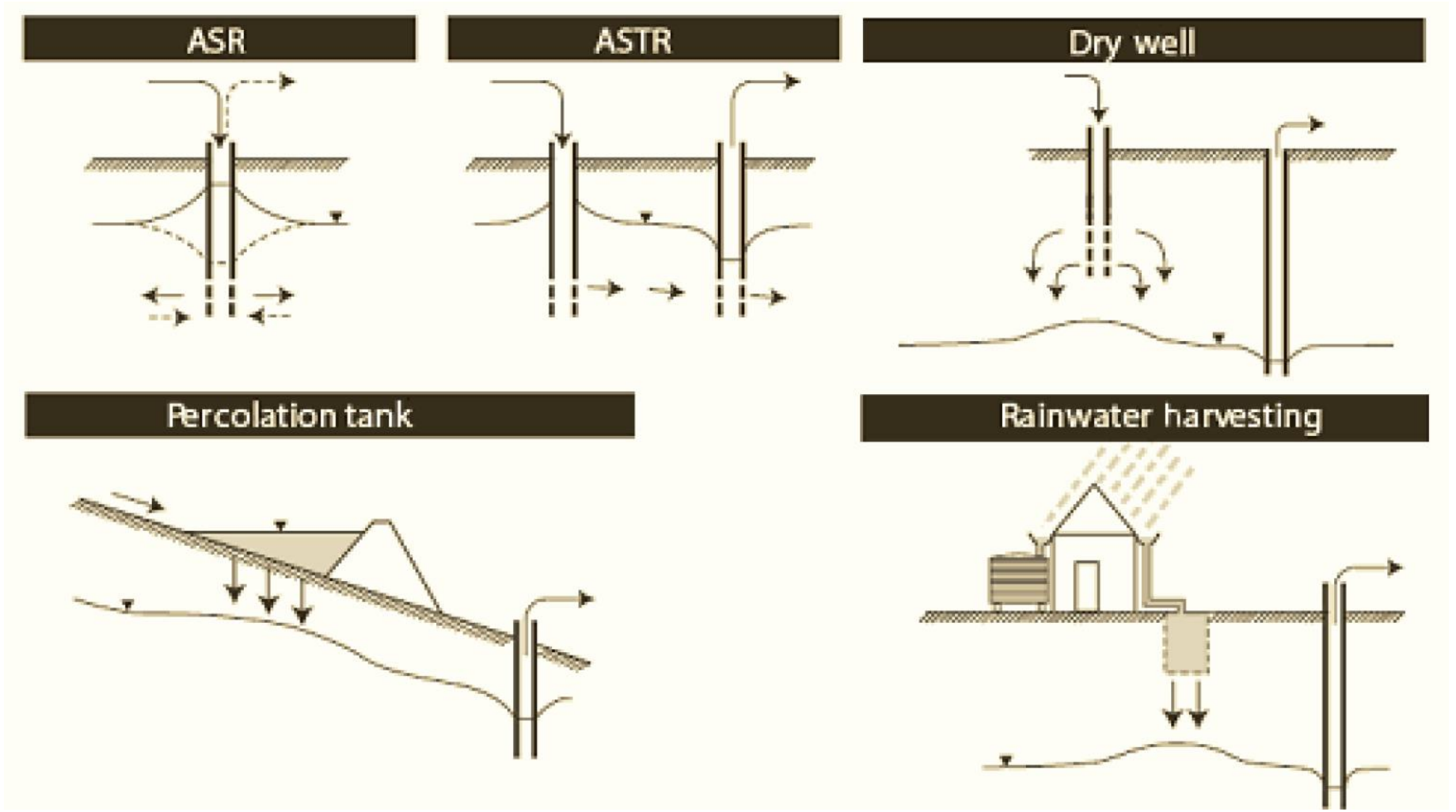
MAR components

1) Source
2) (if needed) pre-treatment
3) Recharge scheme
4) Aquifer
5) Pumping system
6) Post-treatment
7) Final users



Scientific resource
From: AUSTRALIAN GUIDELINES FOR WATER RECYCLING: MANAGING HEALTH AND ENVIRONMENTAL RISKS (PHASE 2)
Managed Aquifer Recharge
(Natural Resource Management Ministerial Council + Environment Protection and Heritage Council +National Health and Medical Research Council 2009)
https://www.waterquality.gov.au/sites/default/files/documents/water-recycling-guidelines-full-21.pdf

MAR types/1



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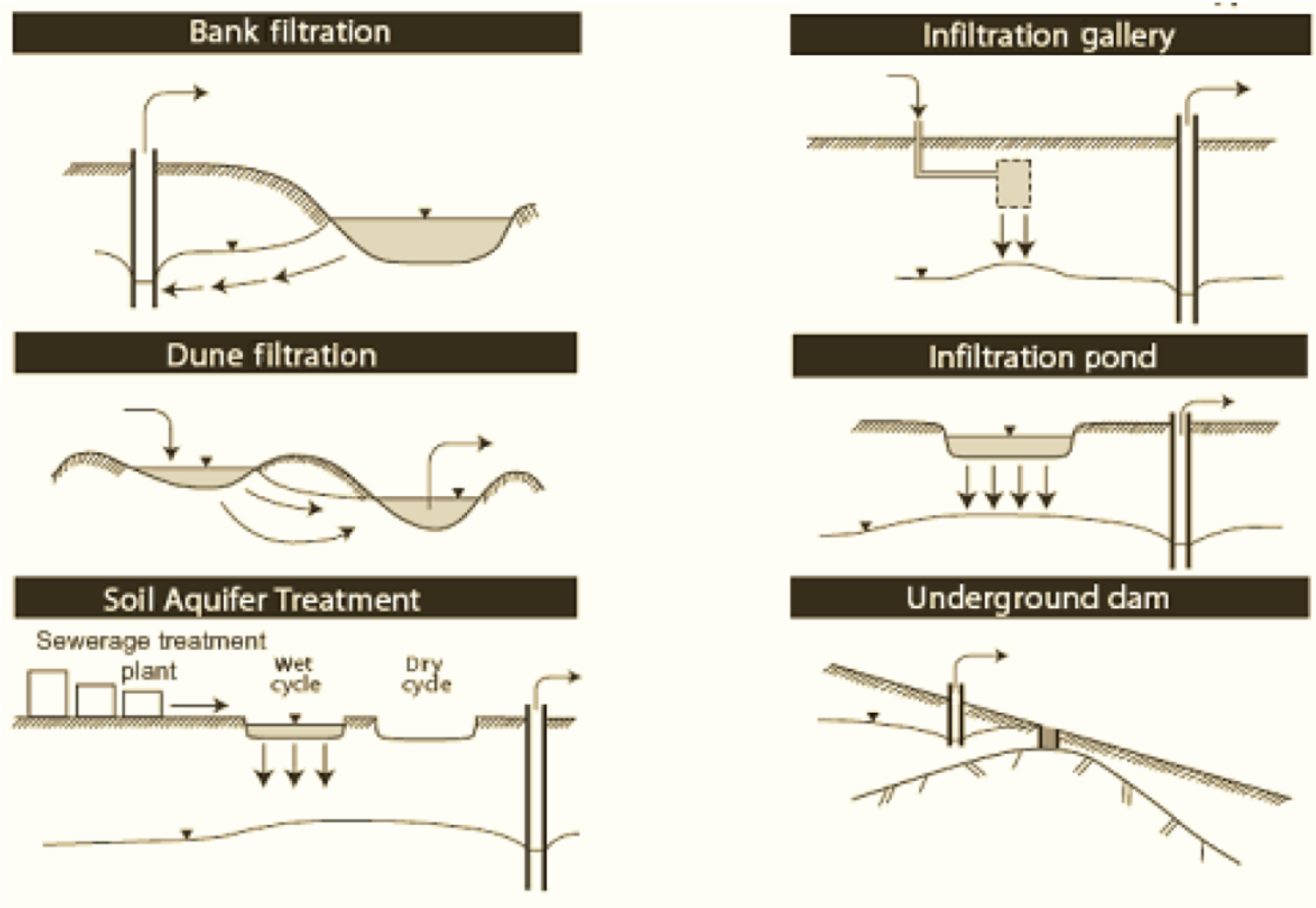
MAR types/2



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Managed Aquifer Recharge
(Natural Resource Management Ministerial Council + Environment Protection and Heritage Council +National Health and Medical Research Council 2009)

ARTIFICIAL AQUIFER RECHARGE IN ITALY

Vicenza:
7 dry wells
4 FIA's
Infiltration Pond
Infiltration Trench
Infiltration Channel
Infiltration Field

Padova:
FIA
IRBF

Treviso:
Infiltration Pond

Pordenone:
SAT

Udine:
Dry well
Infiltration Pond

Milano:
2 Infiltration Ponds

Ferrara:
Infiltration Pond

Rimini:
2 ASR's
2 Infiltration Ponds
IRBF

Ravenna:
Infiltration Pond

Prato:
IRBF

Pesaro Urbino:
ASR

Lucca:
IRBF

Livorno:
River scarification

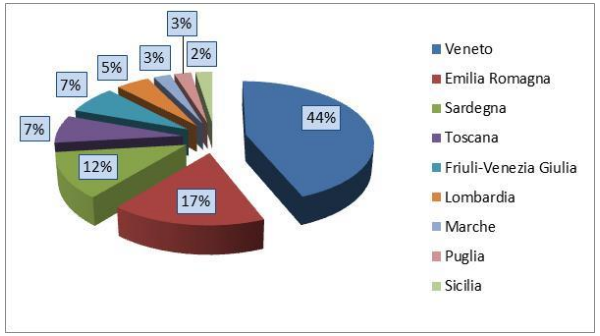
Bari:
ASTR

Carbonia – Iglesias:
ASR

Cagliari:
2 ASR's
Infiltration Trench
Infiltration Pond

Siracusa:
ASR

UNMONITORED



Credits: Silvia Di Bartolo – Alessio Barbagli

MAR in Italy

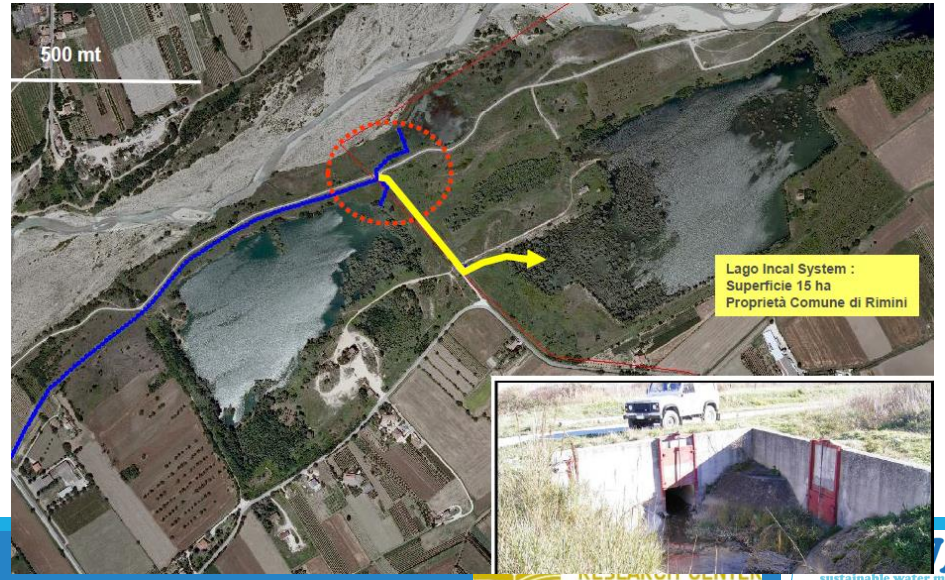
Some projects on aquifer recharge were co-financed by the European Commission mainly through the LIFE program.

- **TRUST** (*Tool for regional - scale assessment of groundwater storage improvement in adaptation to climate change*, LIFE07 ENV/IT/000475; Marsala 2014);

- **AQUOR** (*Implementation of a water saving and artificial recharging participated strategy for the quantitative groundwater layer rebalance of the upper Vicenza's plain* - LIFE 2010 ENV/IT/380; Mezzalira et al. 2014);

- **WARBO** (*Water re-born - artificial recharge: innovative technologies for the sustainable management of water resources*, LIFE10 ENV/IT/000394; 2014).

From TRUST



From TRUST

RECENT YEARS/3

Moving from an agriculture only impacting the water resources to the provision of agroecosystem services

Forested Areas

Infiltration

(Veneto, Italy)

DM 100/2016

Italian regulation for permitting managed aquifer recharge schemes set up and operation

LEGGI ED ALTRI ATTI NORMATIVI

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

DECRETO 2 maggio 2016, n. **100.**

Regolamento recante criteri per il rilascio dell'autorizzazione al ravvenamento o all'accrescimento artificiale dei corpi idrici sotterranei al fine del raggiungimento dell'obiettivo di qualità, ai sensi dell'articolo 104, comma 4-*bis*, del decreto legislativo 3 aprile 2006, n. 152.

IL MINISTRO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

Acquisita l'intesa della Conferenza permanente per i rapporti tra lo Stato, le Regioni e le Province Autonome di Trento e Bolzano repertorio n. 232/CSR nella seduta del 17 dicembre 2015;

Udito il parere del Consiglio di Stato n. 388/2016 espresso dalla Sezione consultiva per gli atti normativi nell'adunanza del 28 gennaio 2016;

Vista la comunicazione al Presidente del Consiglio dei ministri, ai sensi dell'articolo 17, comma 3, della legge 23 agosto 1988, n. 400, effettuata con nota 7680 del 6 aprile 2016;

ADOTTA
il seguente regolamento:

Regional authorities «may» define groundwater bodies suitable to recharge.

Key points of DM 100/2016: Annex 1

Annex 1 lists criteria to be respected for granting authorization to set up a MAR scheme.

The authorization is granted upon presentation of:

- a preliminary project (large area hydrological and hydrogeological characterization of the groundwater body and MAR type, source of water)
- an executive project (detailed area characterisation, type of MAR scheme, hydraulic and hydrochemical and socio-economic assessments).

The following must then be provided before full operation starts:

- **management plan**
- **monitoring plan**
- **emergency plan**

Key points of DM 100/2016: Annex 1

- A dedicated monitoring system is required:

  - discrete monthly monitoring for hydrodynamics and hydrochemistry

    during the design phase

  - *operational monitoring*, to evaluate:

    i. effectiveness of the scheme, and

    ii. detect potential deterioration

  - *high frequency* or continuous *first alert monitoring*

    - at the upstream recharge point,

    - to halt the recharge flow in case of source contamination events

The LIFE REWAT MAR plant in Suvereto

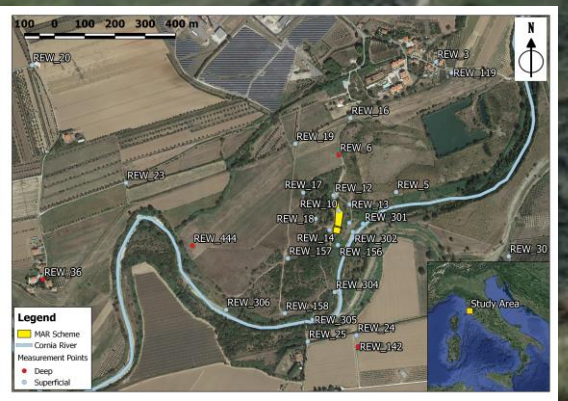
RENDERING VASCA DI SEDIMENTAZIONE E INFILTRAZIONE

Expected results

- Increase aquifer storage from 0.3 to 1.2 Mm^3/y
- Cost 350000 €
- From design to operation about 24 months
- Environmental purposes

REWAT
sustainable water management in the lower Cornia Valley
Life

REWAT
sustainable water management in the lower Cornia Valley



WORK TO BE DONE

Two-phases project design required following DM 100/2016

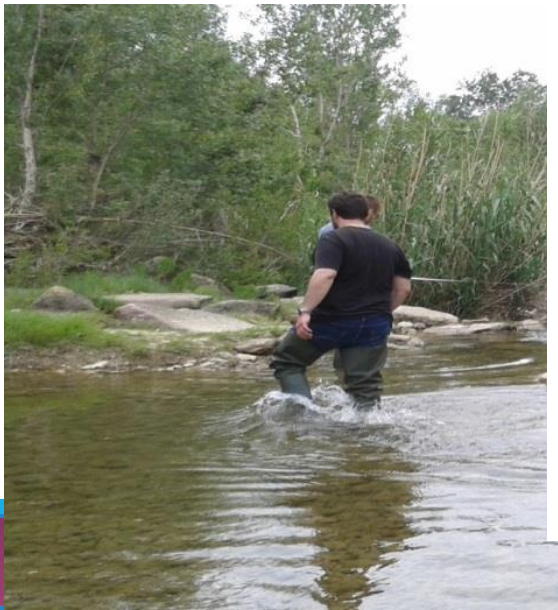
- ***Preliminary project***
- ***Executive project***

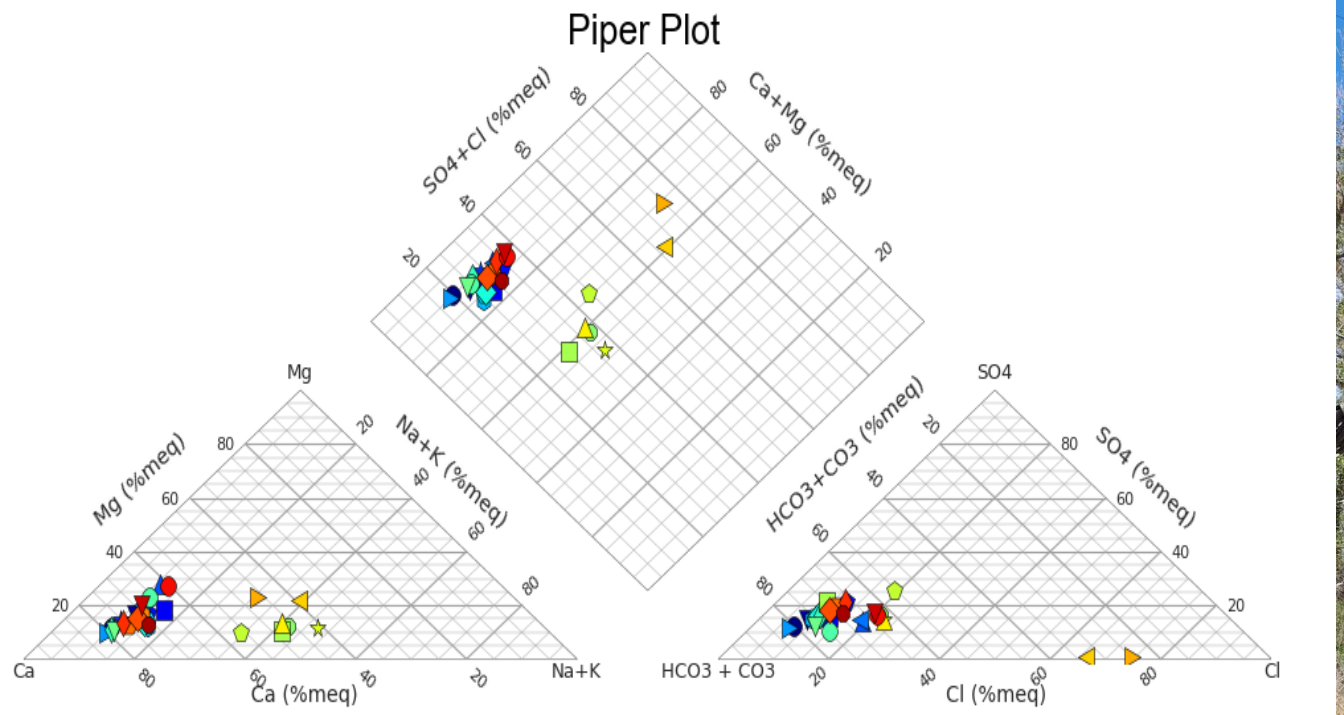
… but wasn't this a pilot???

Monthly monitoring required:

- ***Groundwater head***
- ***Discharge curve (river)***
- ***Chemical quality (ground- and surface-water)***

WORK DONE





- REW 5 (APRILE 2016)
- REW 5 (DICEMBRE 2016)
- REW 5 (GENNAIO 2017)
- REW 5 (FEBBRAIO 2017)
- REW 5 (MARZO 2017)
- REW 5 (APRILE 2017)
- REW 5 (MAGGIO 2017)
- REW 5 (giugno 2017)
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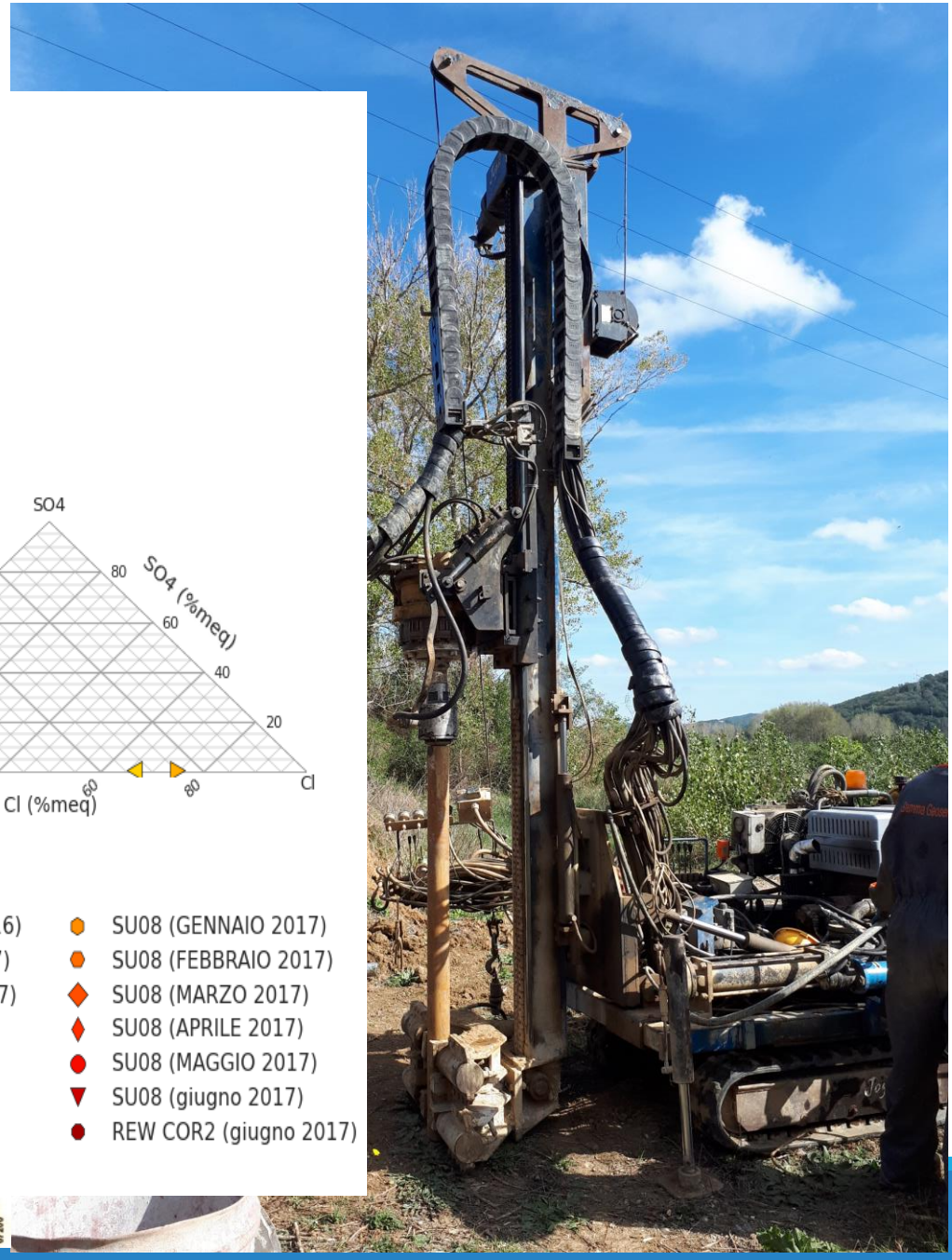
- REW 6 (GENNAIO 2017)
- REW 6 (FEBBRAIO 2017)
- REW 6 (MARZO 2017)
- REW 6 (APRILE 2017)
- REW 6 (MAGGIO 2017)
- REW 6 (giugno 2017)
- SU01 (DICEMBRE 2016)
- SU01 (GENNAIO 2017)
- SU01 (FEBBRAIO 2017)
- SU01 (MARZO 2017)
- SU01 (APRILE 2017)
- SU01 (MAGGIO 2017)
- SU01 (giugno 2017)
- SU08 (GENNAIO 2017)
- SU08 (FEBBRAIO 2017)
- SU08 (MARZO 2017)
- SU08 (APRILE 2017)
- SU08 (MAGGIO 2017)
- SU08 (giugno 2017)
- REW COR2 (giugno 2017)



The MAR scheme/1

The MAR scheme/2

The MAR scheme/3

The MAR scheme/4

The MAR scheme/5

The MAR scheme/6

hydrology

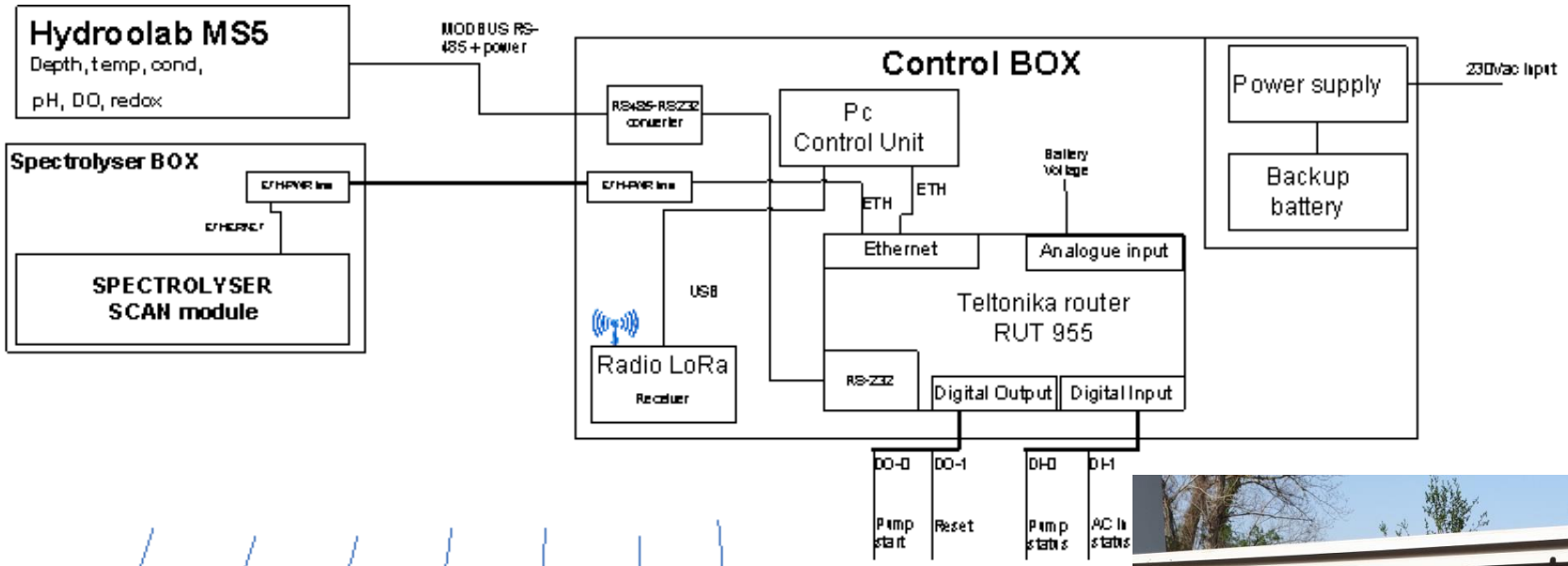
MDPI

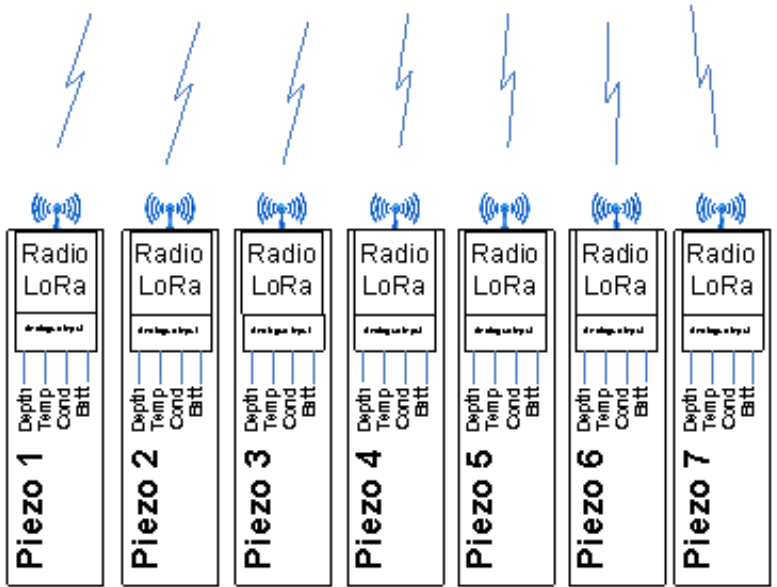
Article

Using Heat as a Tracer to Detect the Development of the Recharge Bulb in Managed Aquifer Recharge Schemes

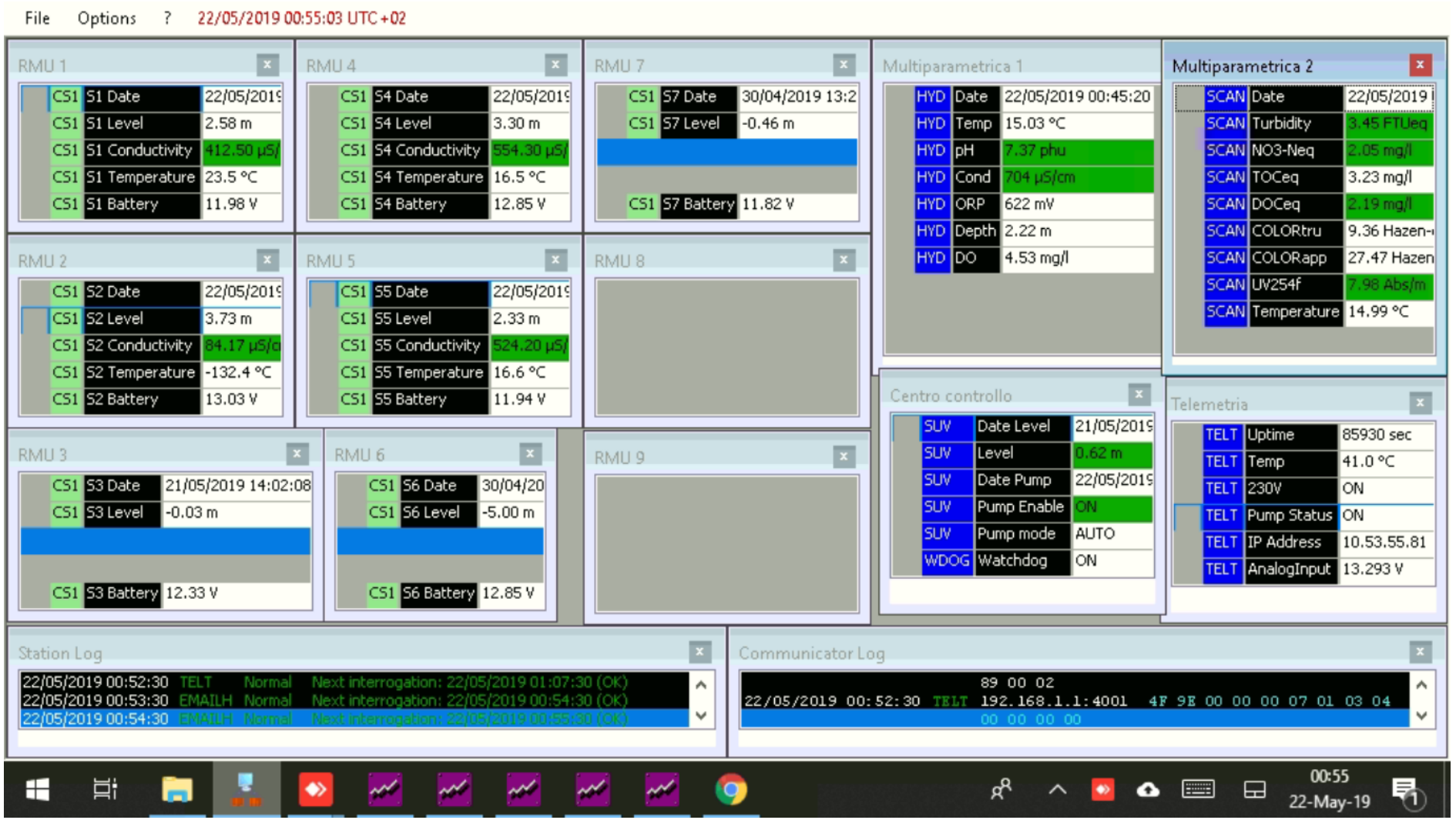
Esteban Caligaris, Margherita Agostini and Rudy Rossetto *

Automation and monitoring

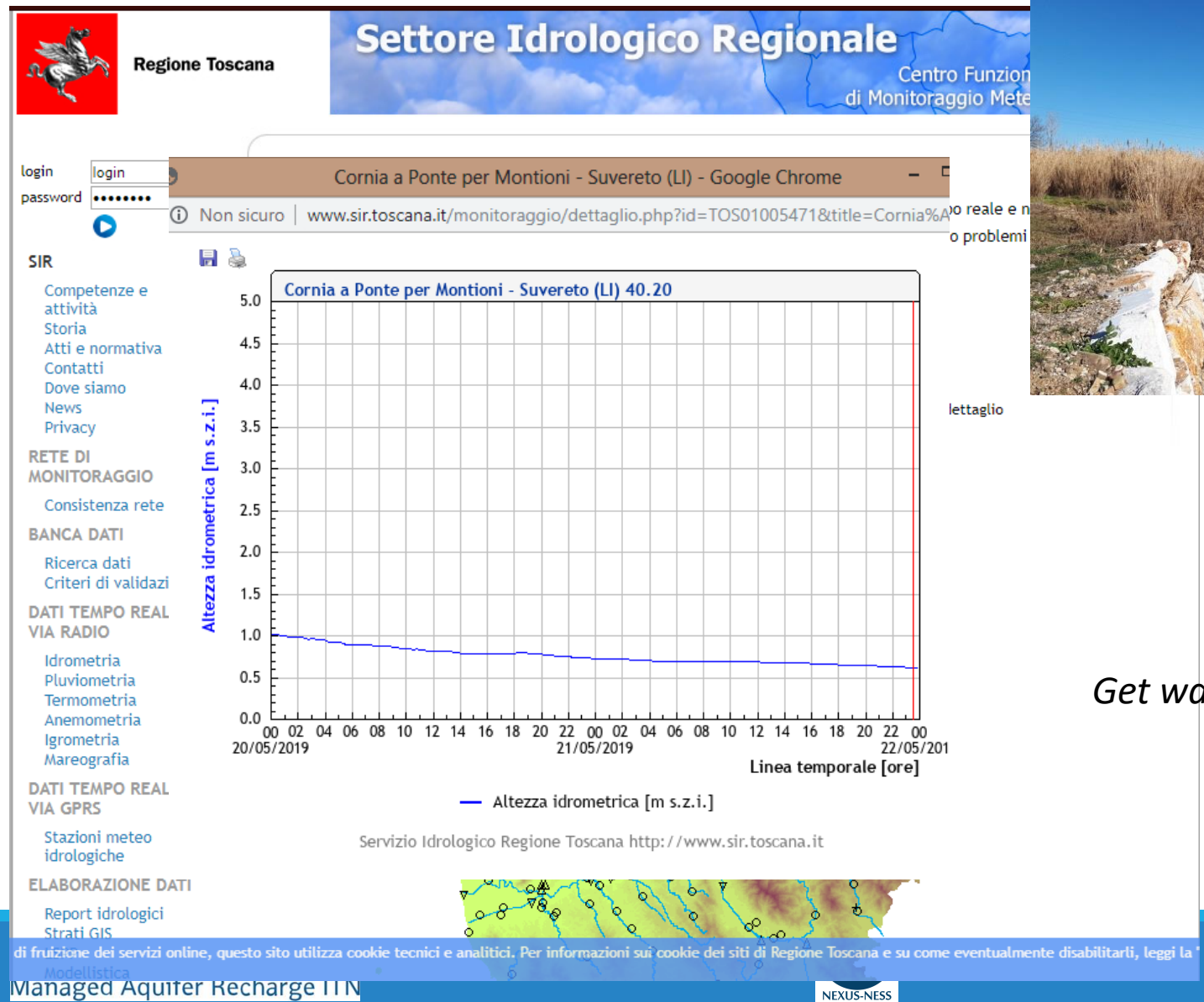




ICT infrastructure architecture



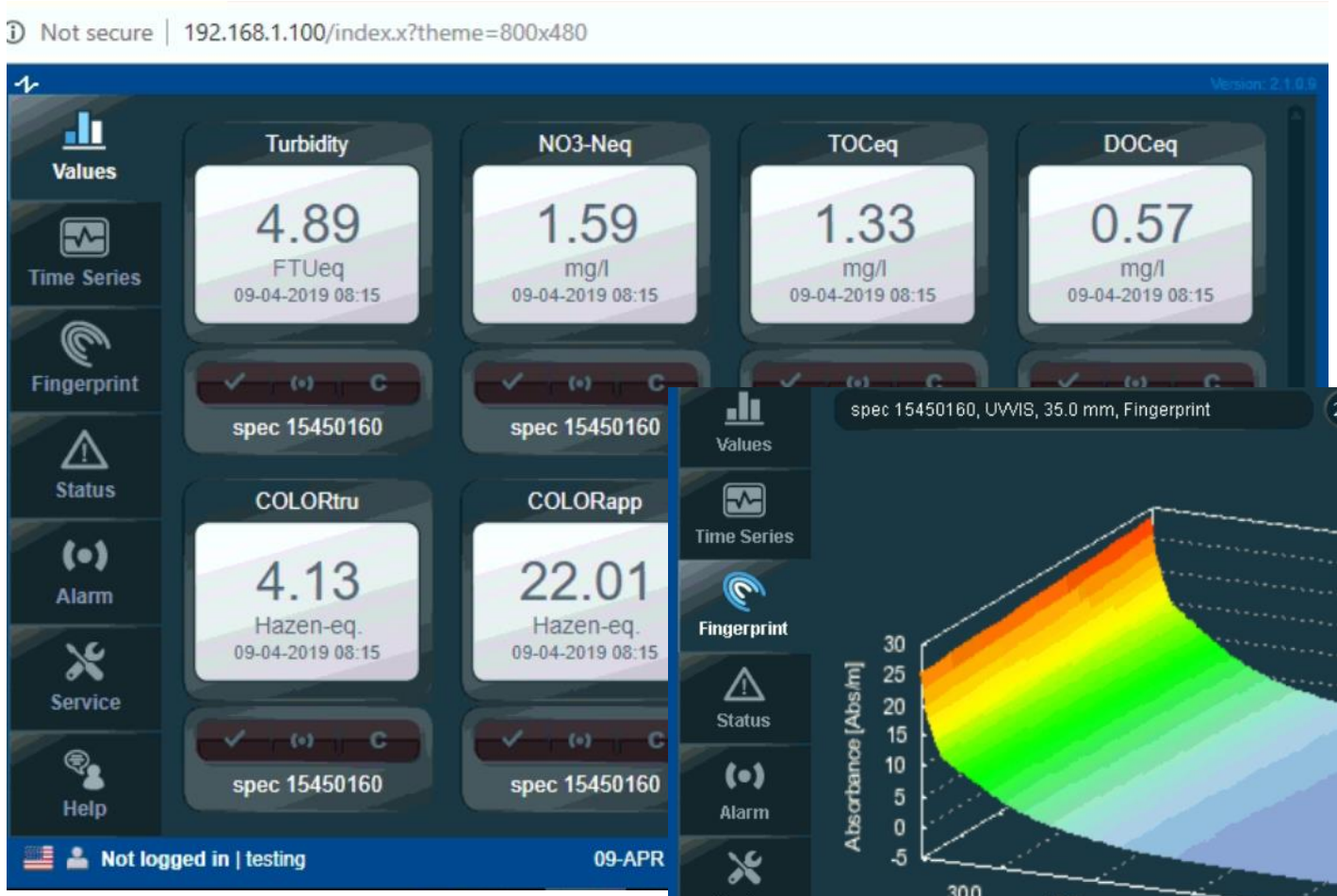
Operational monitoring

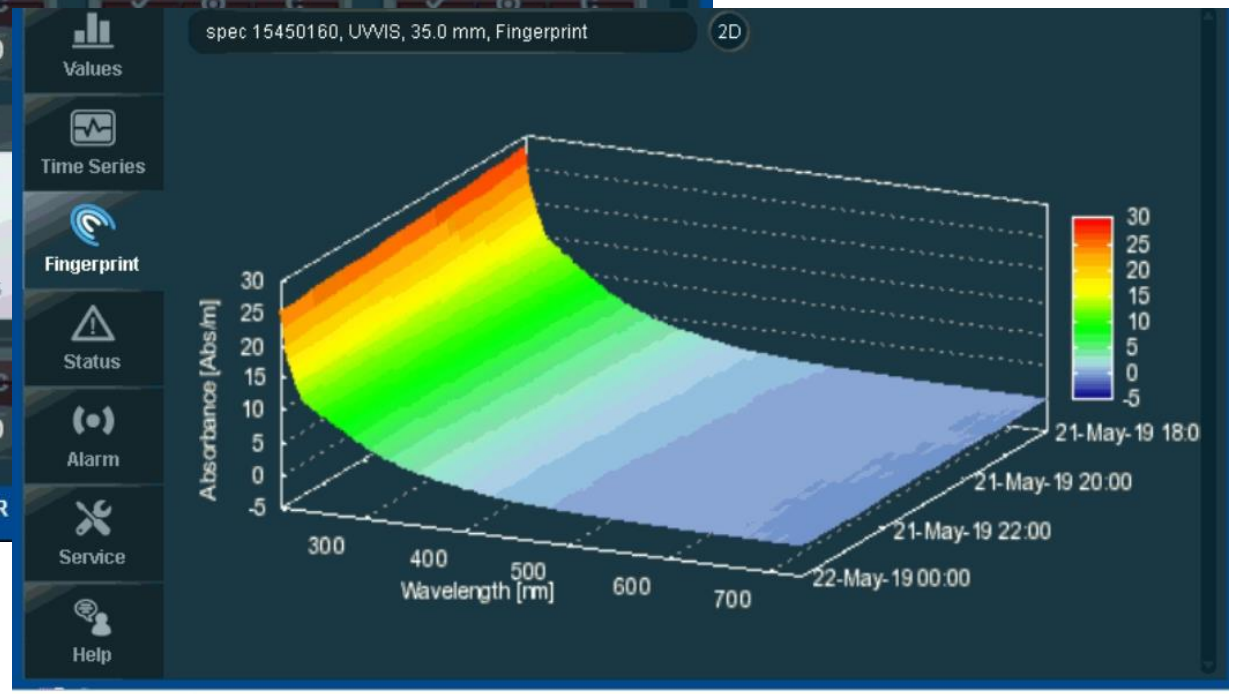


Get water for recharge only if

Q river > MEF

Operational monitoring/2





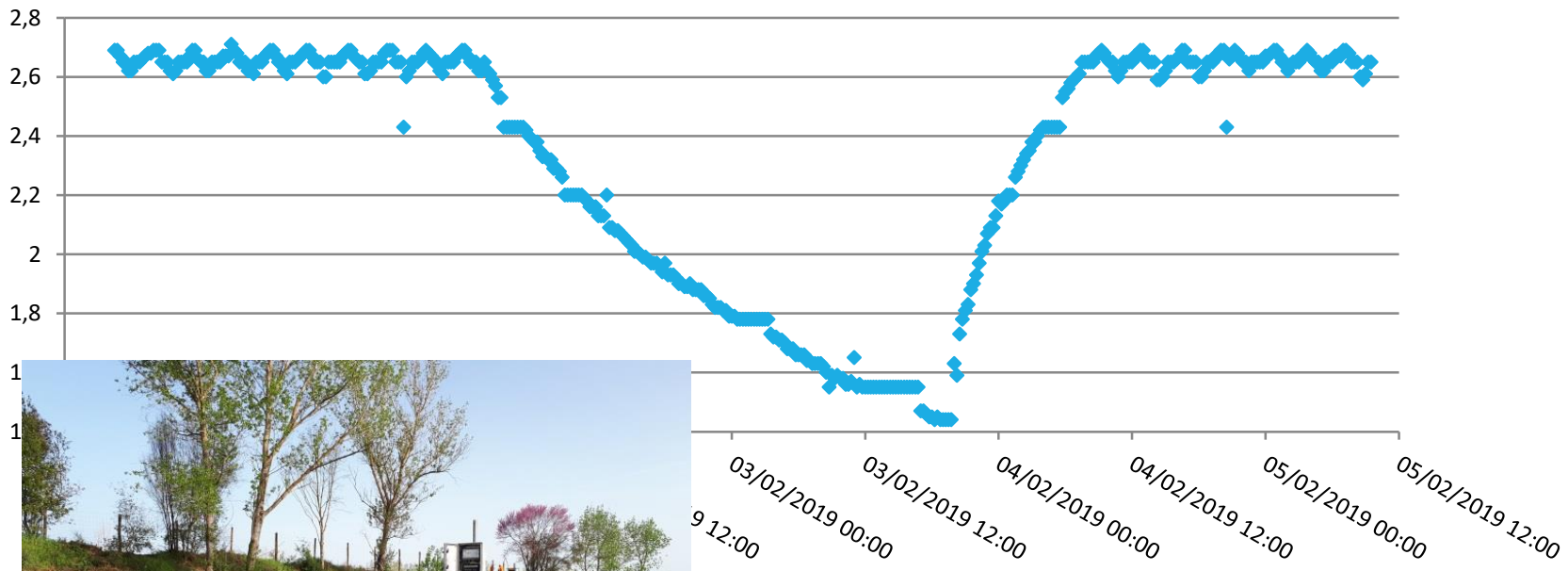
Get water for recharge only if

Standards are met

Operational monitoring/3

Basin filling: up to 2.69 m head over sensor --- then stop

Filling again from 2.64 m over sensor

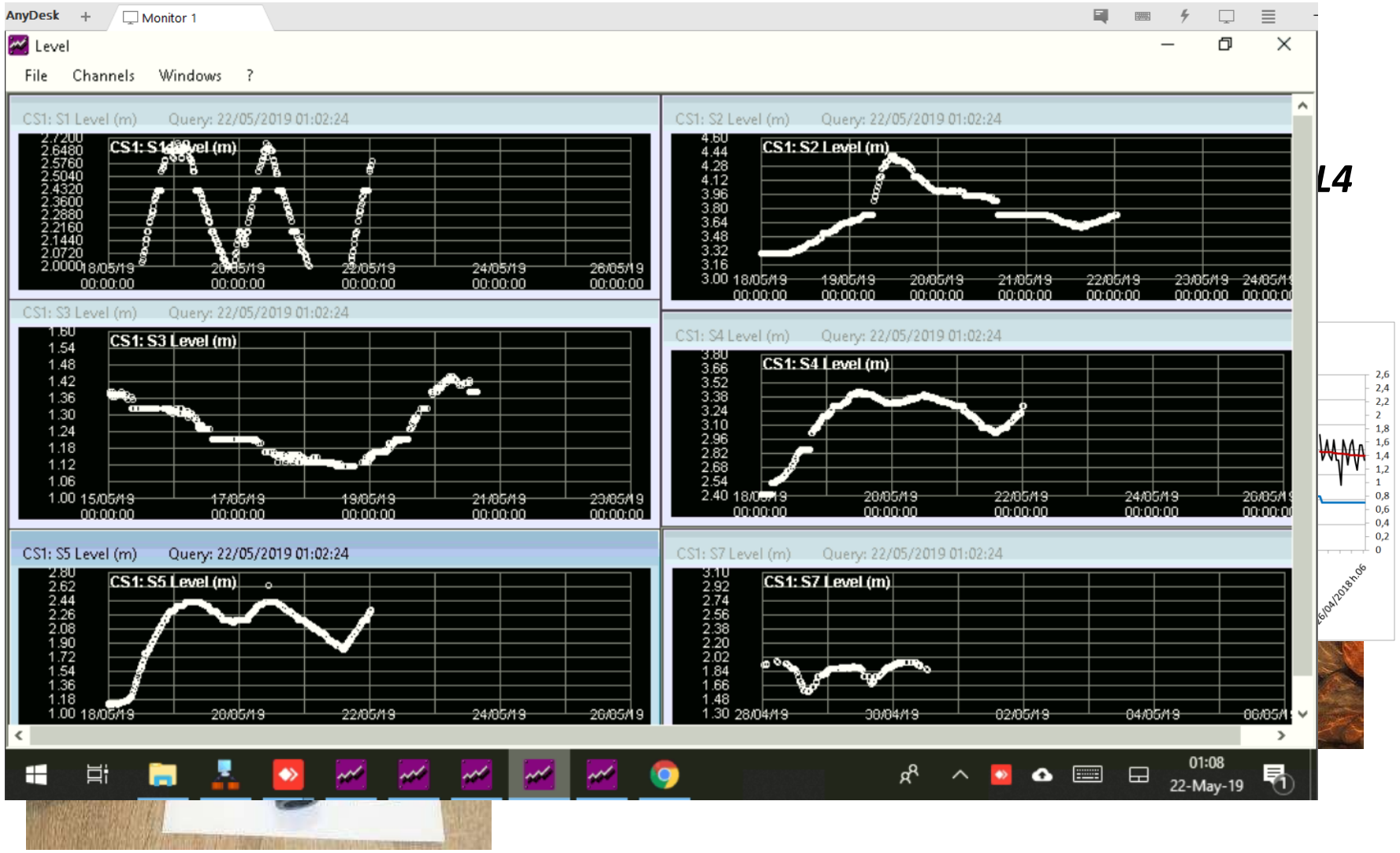


Recharge cycle from top:

about 1.15 h to go down

1.45 h to reach maximum

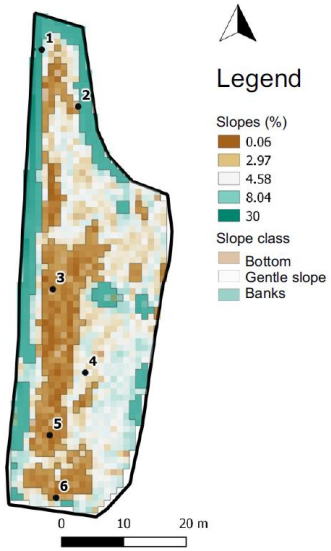
Monitoring changes in the aquifer



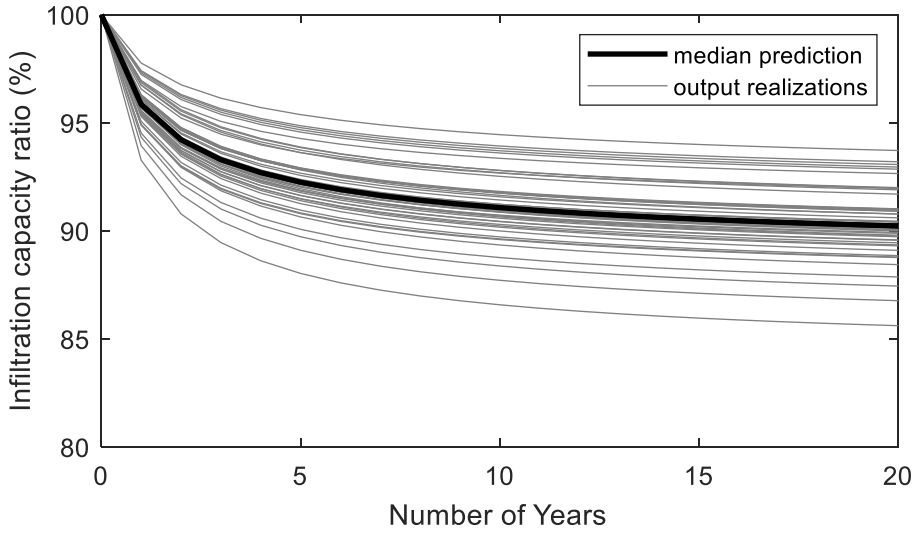
Clogging

Infiltration basins may be clogged because of fine depositions and other processes

Yearly-mainteinance is needed (basin ploughing) and recommended



Simulating potential clogging turnaround to get an idea during the basin lifetime could be a good idea



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journal homepage: www.elsevier.com/locate/advwatres

Understanding and predicting physical clogging at managed aquifer recharge systems: A field-based modeling approach

Maria Chiara Lippera [a,d,*], Ulrike Werban [d], Rudy Rossetto [c], Thomas Vienken [b,d]

[a] Technical University of Munich, TUM Campus Straubing for Biotechnology and Sustainability, Straubing, Germany
[b] Weihenstephan-Triesdorf University of Applied Sciences, TUM Campus Straubing for Biotechnology and Sustainability, Straubing, Germany
[c] Scuola Superiore Sant'Anna, Crop Science Research Center, Pisa, Italy
[d] UFZ - Helmholtz Centre for Environmental Research, Leipzig, Germany

We grow up!

Thanks to a small additional fund from Protezione Civile (100k €) a new basin was designed, built and set in operation

Construction started in December 2022 – inaugurated March 2023

Now, infiltration capacity is up to 2 Mm^3/y

Issues to be dealt with

- poor or unefficient design (i.e. poor knowledge of medium properties, etc.)
- poor quality of the water to be used (treatment trains to be designed and used)
- environmental impacts not duly evaluated (i.e. downstream of the MAR scheme)
- insufficient experience on real applications in several areas
- waterlogging (i.e. basement flooding in urban areas)
- socio- economical issues (problems with population not used to these new tech.)
- mainteinance not planned after the start of operations
- reduced functionality of the scheme (i.e. clogging with time)
- poor communication

MAR or not MAR?

- MAR is one of the tool for water management and planning
- when deciding for a solutions costs/benefits/waterworks values/efficiency should be thoroughly evaluated
- ------**viability studies should be done before deciding for**
  - **desalination/use of reclaimed water/MAR/dams …**

Or maybe all of the solutions!

Advantages

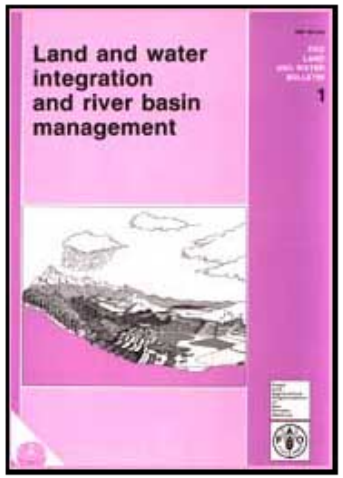
- ✓ low investment costs
- ✓ (+ economic among techniques for water supply – about 1/1.5 €/m^3 construction costs vs 5/6 €/m^3 surface water reservoirs);
- ✓ no or minimal land loss;
- ✓ potential use of salinised/brakish aquifers (*salinised groundwater displacement*)
- ✓ **attention to energy issues**

NEXUS-NESS

https://prima-nexus-ness.org/

Conjunctive use of surface and groundwater

Non sicuro | fao.org/3/v5400e/v5400e00.htm#Contents



Land and water integration and river basin management

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Proceedings of an FAO informal workshop
Rome, Italy
31 January - 2 February 1993

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Caracalla, 00100 Rome, Italy.

"surface water storage,

because of the large investments involved,

is often preferred because it offers a ***much higher political visibility***

and because ***high construction costs*** *give an opportunity for private profit and corruption, opening the way for improper influence on decision making"* (FAO, 1995)

CONCLUSIONS

The implementation of managed aquifer recharge requires:

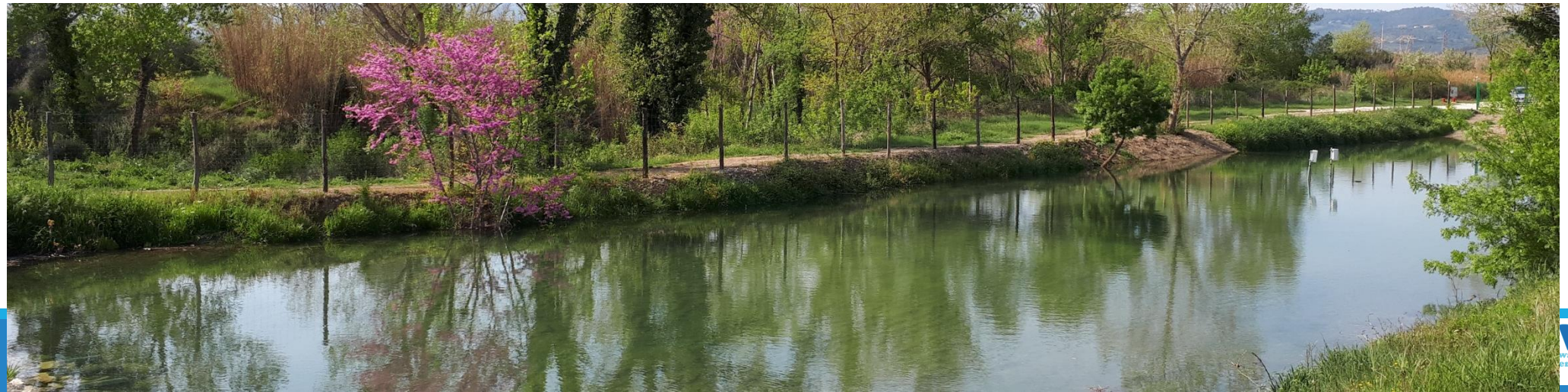
- careful planning and clear and sounding regulations;

- coordinated investments;

- monitoring of operations;

- creation of technical and managerial skills.

The environmental, energy, health and other consequences must be diligently considered while defining the potentials and limitations of these options.



CONCLUSIONS/2

MAR schemes can be a viable option to increase the supply of good quality groundwater and to restore unbalanced situations.

There is a growing interest on the use of this low-cost technique, which could move the water market also thanks to the potential interactions with agricultural policies.

The dissemination and promotion activities of MAR techniques and the results of scientific research, in the public and private sectors, are crucial for the exploitation of MAR techniques on a large global scale.

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