MAR SOL MANAGED AQUIFER RECHARGE SOLUTIONS

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION HORIZON 2020 FREEWAT

European Commission

EIP Water Online Market Place
Matchmaking for water Innovation

MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AG128)

The MARSOL Project – Impementation and Evaluation of Managed Aquifer Recharge Systems in Southern Europe

Christoph Schüth, TU Darmstadt

Joint International Workshop

EU FP7 MARSOL and EU HORIZON 2020 FREEWAT projects and EU EIP MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AG128)

Pisa - April 21st 2015

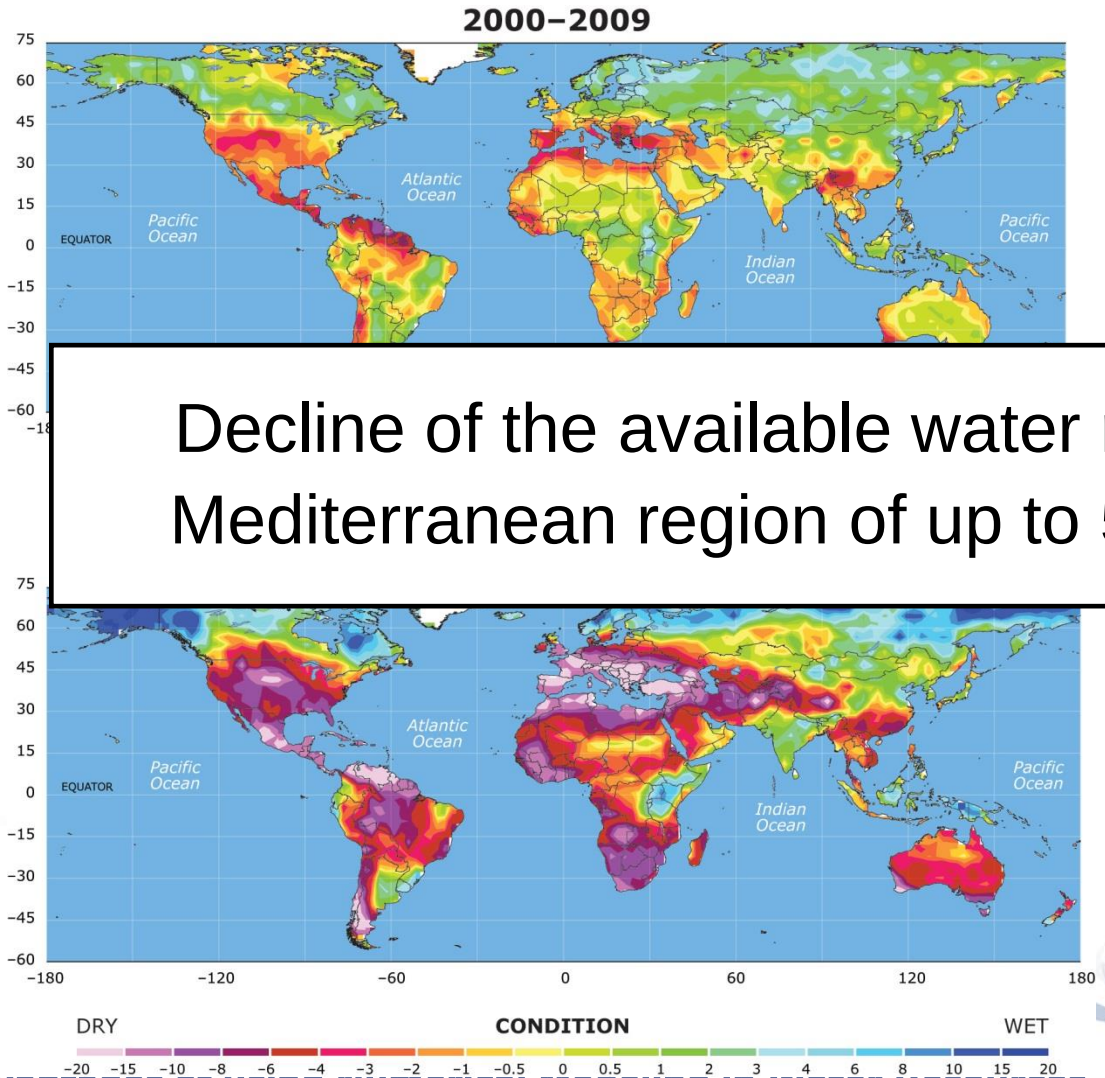
INSTITUTE OF LIFE SCIENCES
Scuola Superiore Sant'Anna

TEASISTEMI
ENERGY AND ENVIRONMENT TECHNOLOGIES

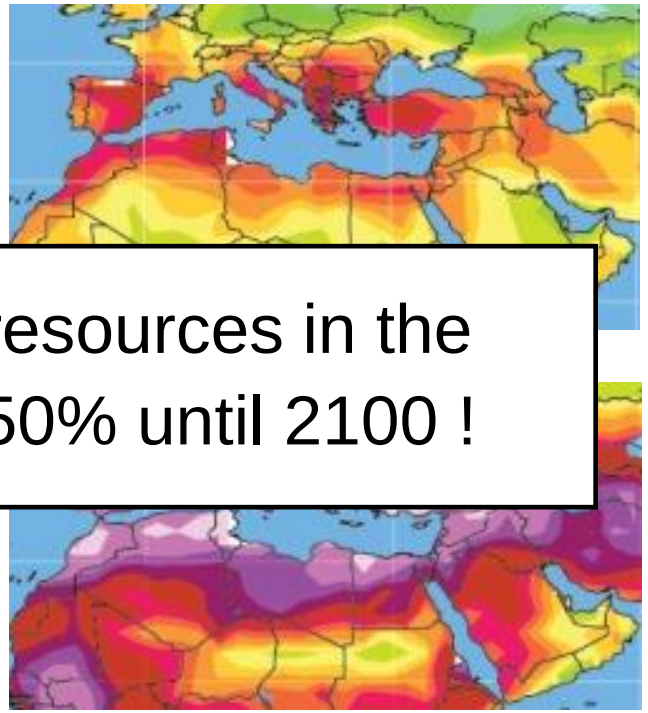
PROVINCIA di Lucca

iah aih
MAR Commission

Increasing number and intensity of dry periods (Palmer Drought Severity Index*)
Temporal variation



source: NCAR images, 2010



Decline of the available water resources in the Mediterranean region of up to 50% until 2100 !

* Determines aridity from precipitation and temperature information, especially for long-term prediction

< -4 = extreme drought

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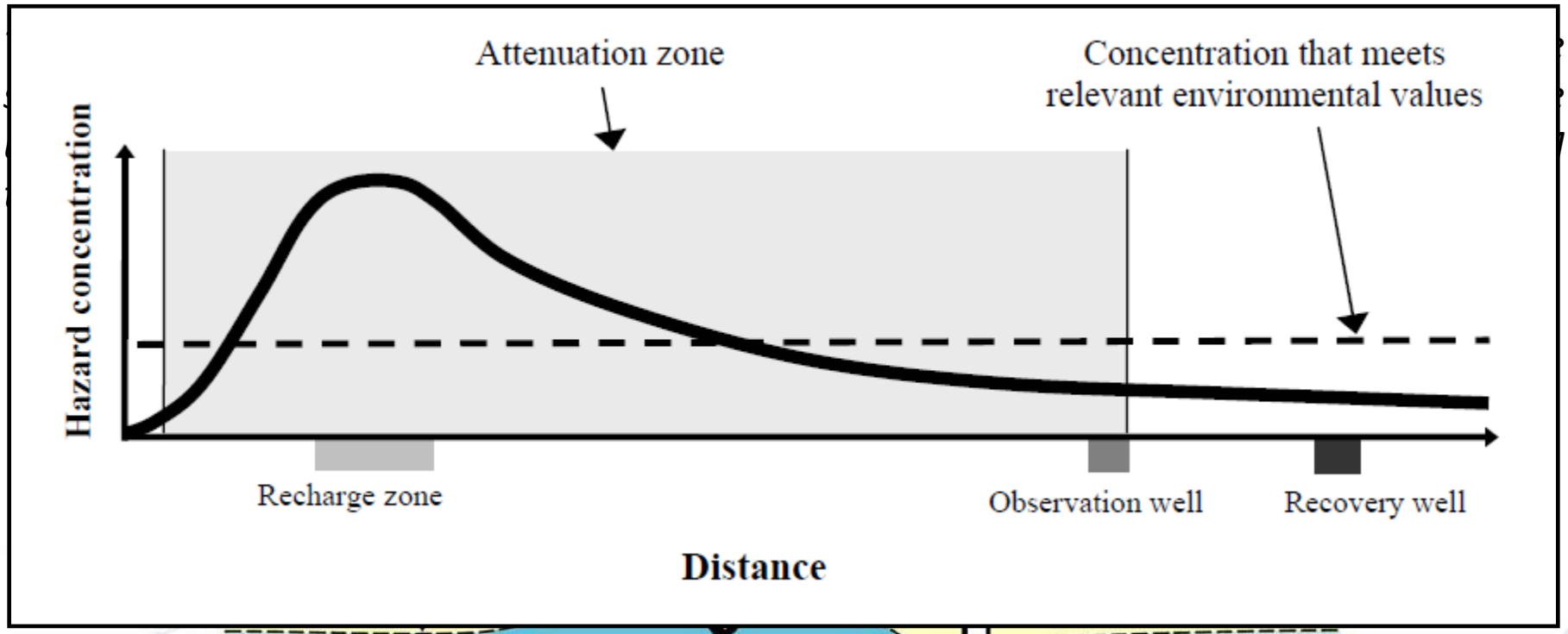
Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought (FP7-Env-2013-Water-Inno-Demo)

Start: 12.2013 **Duration: 3 years** **EU Contribution: 5.2 Mio €**



Australian guidelines for Water recycling, 24: Managed Aquifer Recharge (2009)

MARSOL Consortium

21 partners **7 countries** **8 field sites**

Public (Research) Institutions (5)

- LNEC – Laboratório Nacional de Engenharia Civil
- MRA – Malta Resources Authority
- Helmholtz Zentrum für Umweltforschung UFZ
- Autorità di Bacino
- Provincia di Lucca

Universities (6)

- Technische Universität Darmstadt
- UPC
- Scuola Superiore Sant'Anna di Studi Universitari e di Perfezionamento
- ICCS
- UAlg – Universidade do Algarve
- [unidentified]

Industry (4)

- Tragsa – TragsaGroup, Partners in excellence
- Mekorot – Development & Enterprise Ltd.
- EYΔAΠ
- 20 Years Water Services Corporation 1992 - 2012

SMEs (6)

- Τεχνολογικό Πολιτιστικό Πάρκο Λαυρίου
- SGI – life, first
- IWW
- TARH
- TEASISTEMI – Energy and Environment Technologies
- PARAGON Europe

Scientific Advisory Board

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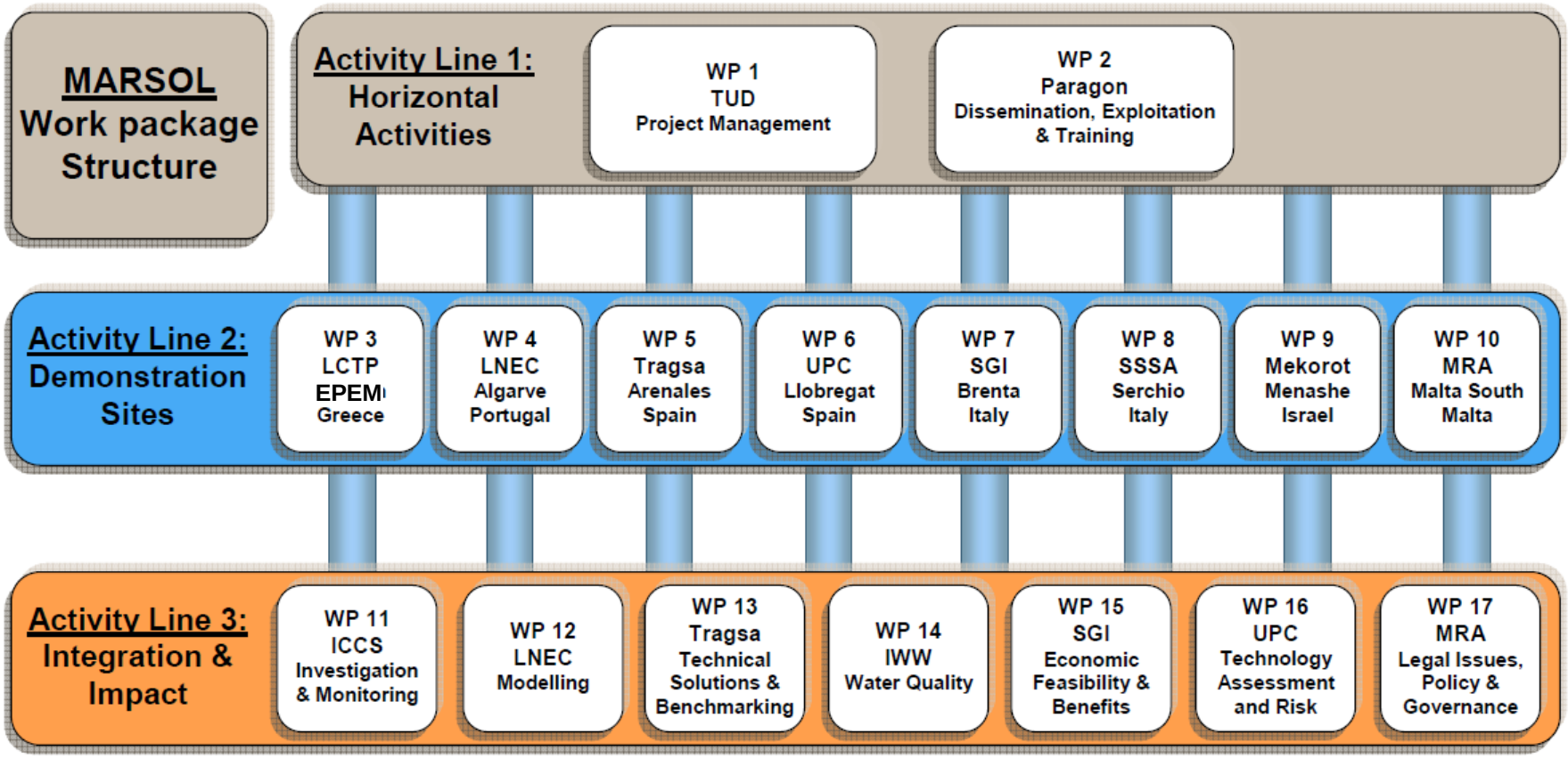
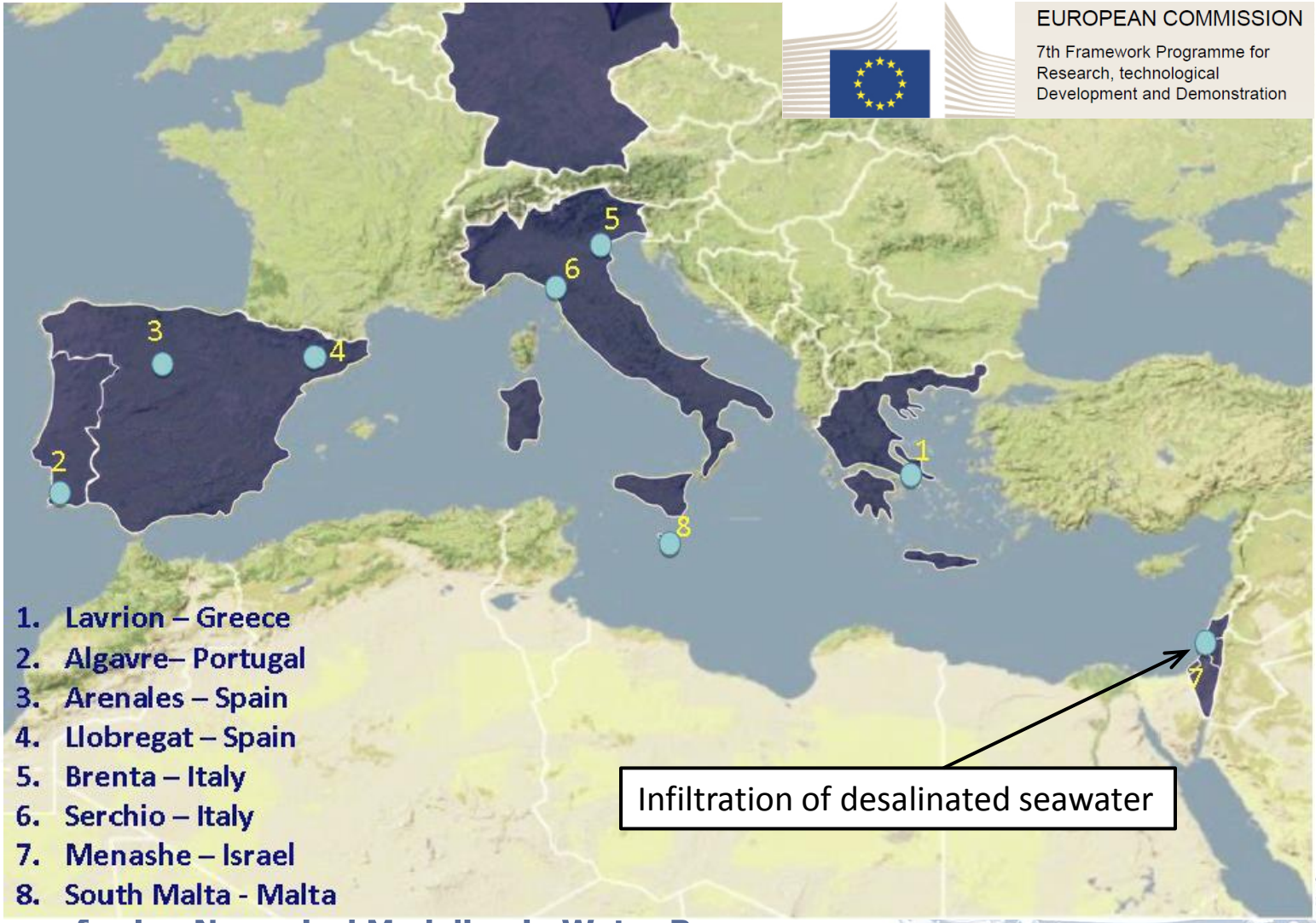
Worpackage structure



MARSOL Field sites

Various water sources and qualities - various technologies - various objectives



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Desalinated sea water – Israel (Daniel Kurtzman, Yossi Guttman et al.)

3 desalination plants currently operating, by 2015 two more will start operation

- Desalination plants built under build-operate-transfer (BOT) contracts
- Less dry periods during the last years

→ **Production of an increasing amount of excess water.**

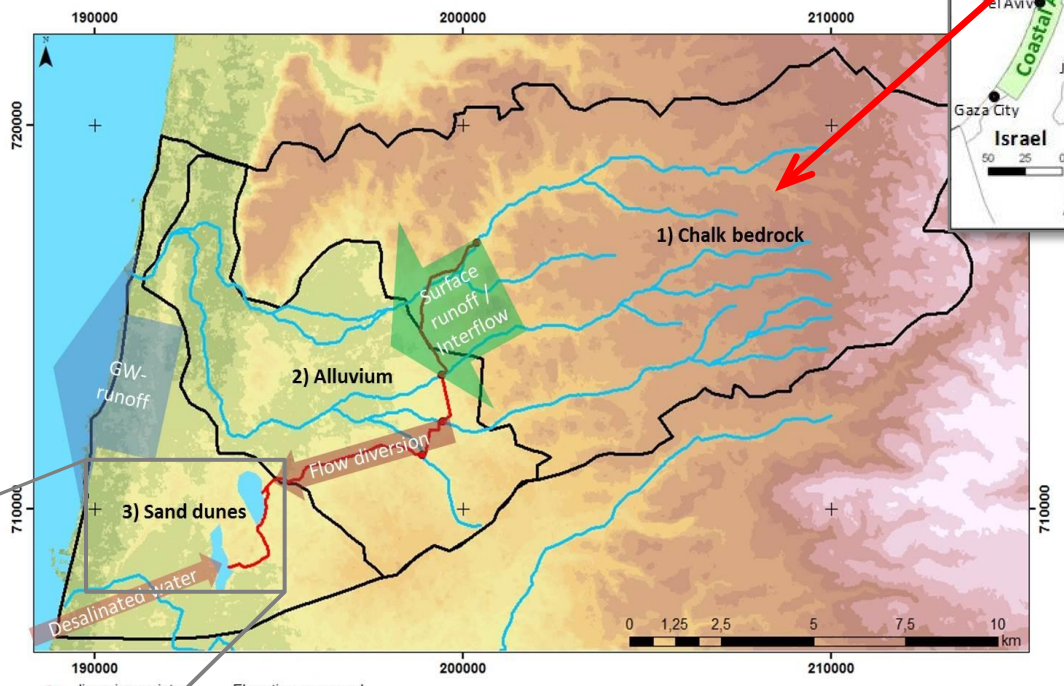
Water authorities aim at seasonal storage as well as aquifer storage recovery (ASR) of large volumes of these surpluses in the adjacent coastal aquifer via artificial recharge.

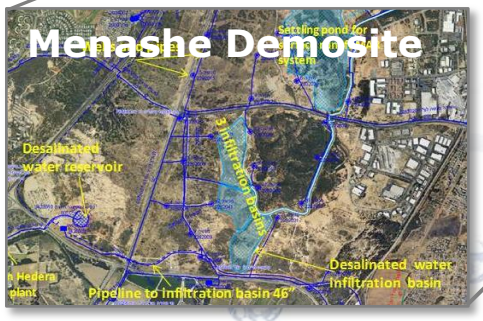
Techniques include infiltration ponds and injection wells

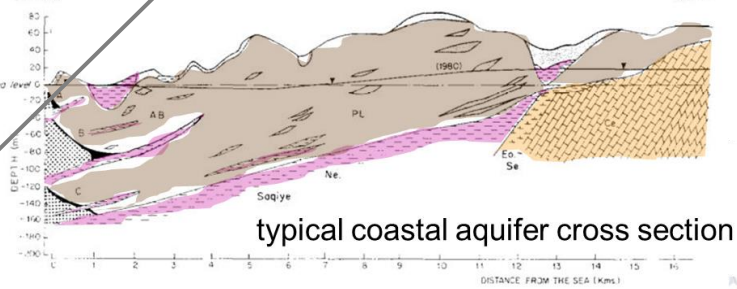
Nachalei Menashe Watershed

- watershed ~200 km²
- 4 main ephemeral streams

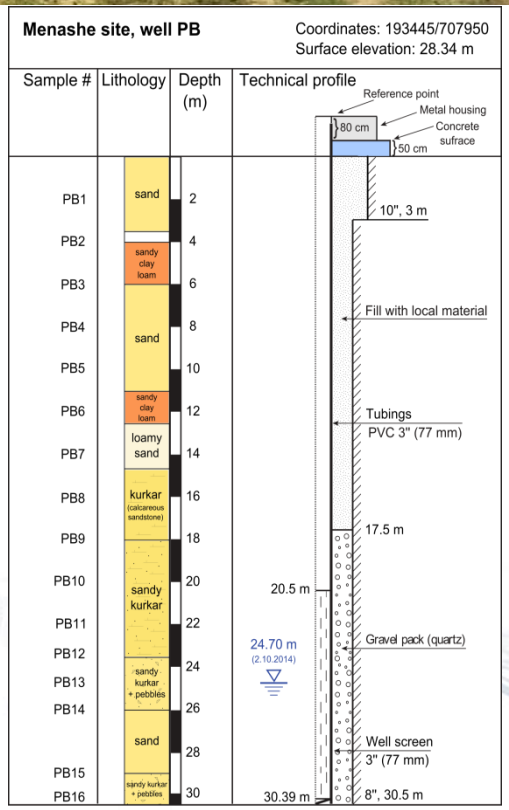
- stormwater collection since 1966
- 4 dams/ diversion points
- 16 km diversion channel
- 1 settlement basin
- 3 infiltration ponds

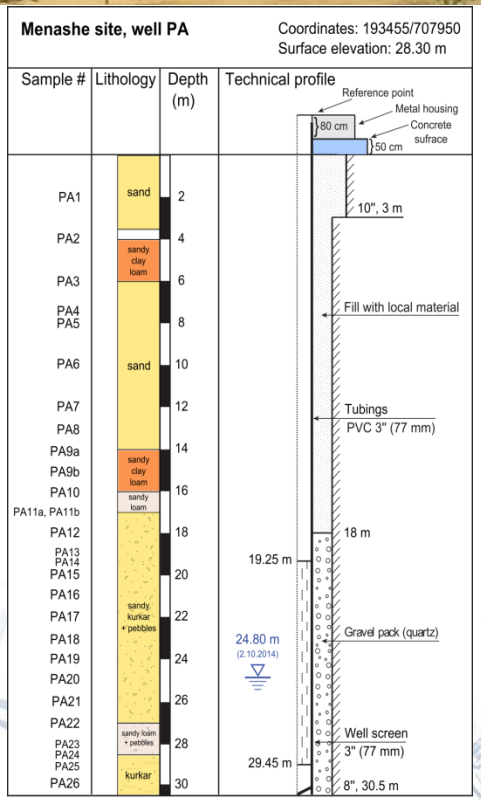


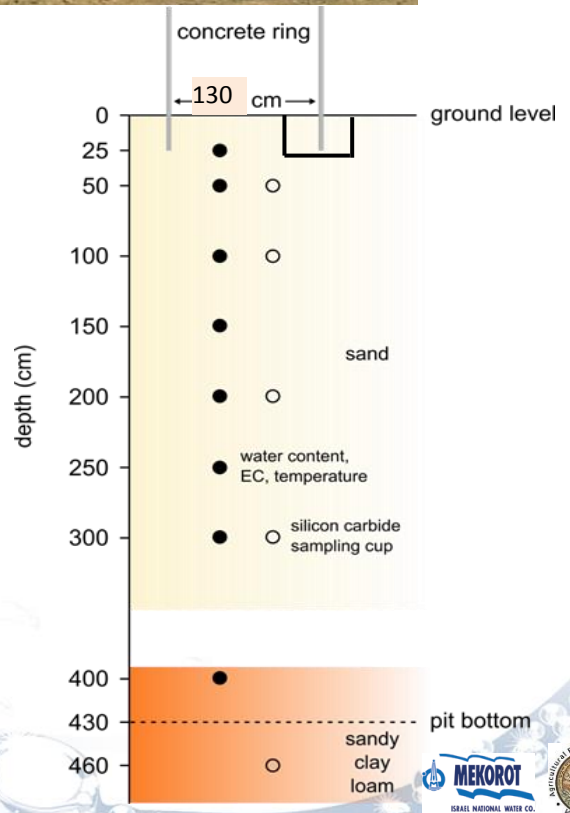




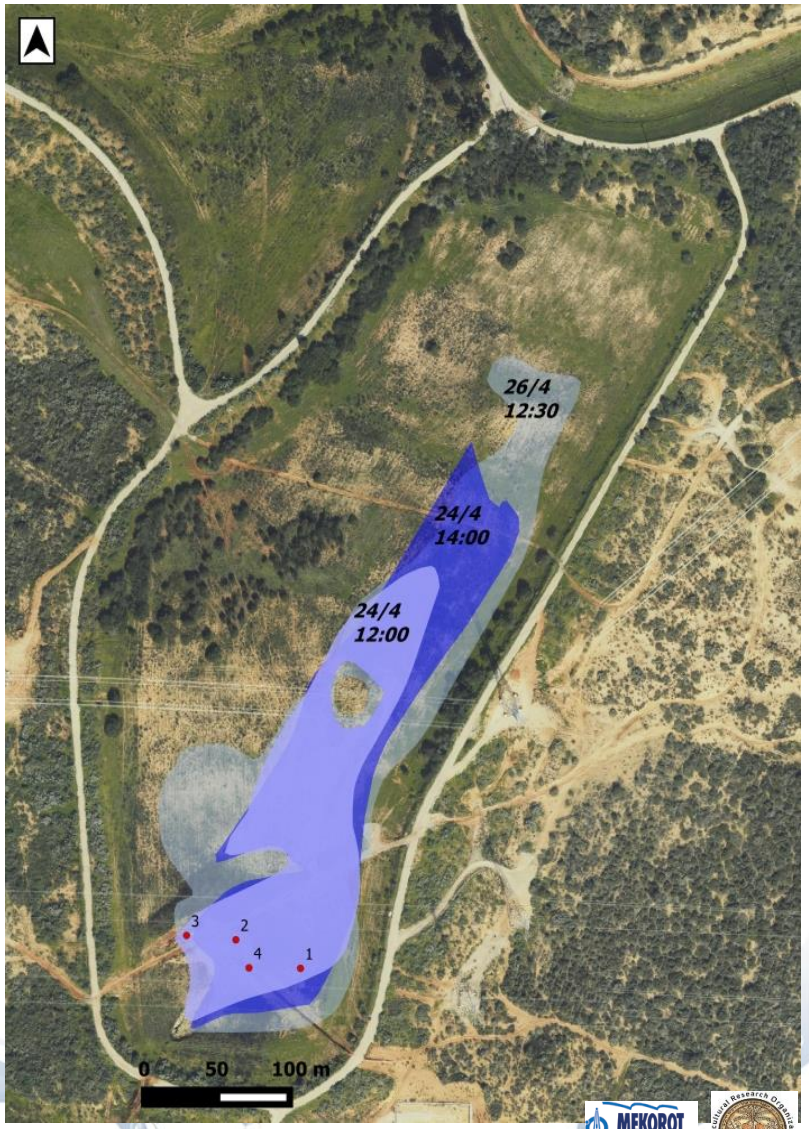
Setup of the field site





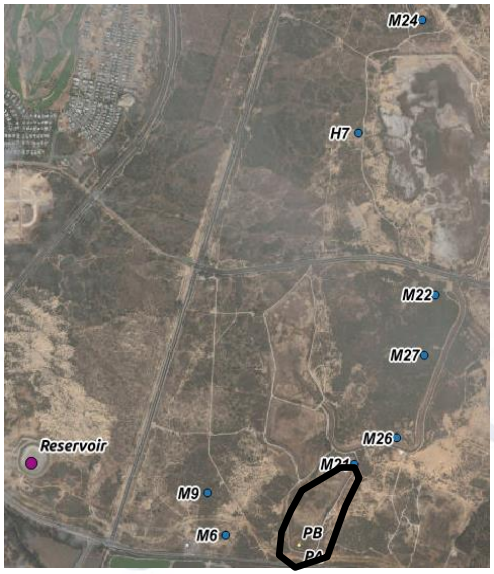


Monitoring an operational MAR event



Water chemistry

Sampling	Water type and source	Cl	Na	K	Ca	Mg	HCO3	SO4	NO3	B
01/06/14	Groundwater production well H7	79	42	2.0	85	11.1	205	27	19	0.03
01/06/14	Groundwater production well M24	54	25	1.0	60	11.7	186	22	23	0.01
01/06/14	Groundwater production well M6	74	36	1.6	100	11.9	267	35	37	0.03
01/06/14	Groundwater production well M9	70	33	1.4	93	9.7	253	34	23	0.03
01/06/14	Groundwater production well M21	61	40	1.8	99	11.2	254	32	24	0.03
01/06/14	Groundwater production well M22	80	34	1.1	81	13.4	230	29	25	0.02
01/06/14	Groundwater production well M26	67	33	1.6	88	14.4	246	28	28	0.02
01/06/14	Groundwater production well M27	86	43	2.0	96	16.7	249	25	31	0.02
01/06/14	Desalinated (Reservoir)	10	11	0.5	40	0.1	107	8	<0.3	0.24
24/02/14	Desalinated (MAR event)	20	19	0.5	27	<1	97	17	<0.3	
05/10/14	Shallow groundwater below pond PA	15	23	0.8	48	3.6	202	16	0.5	
02/10/14	Shallow groundwater below pond PB	13	24	0.8	51	3.7	215	16	0.8	

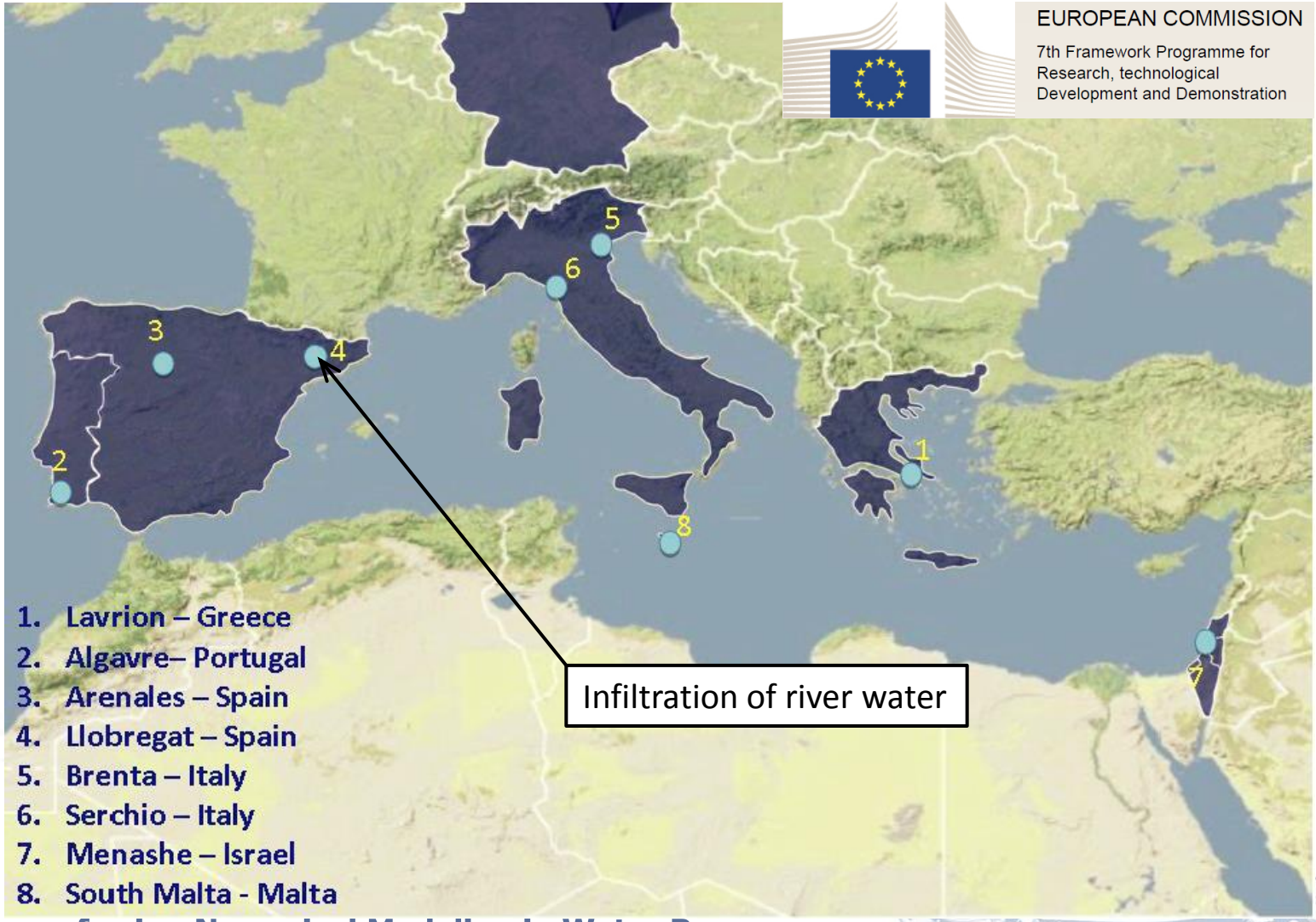


$$CaCO_{3(s)} + CO_2 + H_2O \leftrightarrow Ca^{2+} + 2HCO_3^-$$

Assuming remineralization through MAR will lead to concentrations similar to the production wells and an operational cost of 0.03 EUR/m^3 for discharging and pumping, we can get remineralization at 0.01 EUR/m^3 and get a little Mg^{2+} as a bonus.

MARSOL Field sites

Various water sources and qualities - various technologies - various objectives



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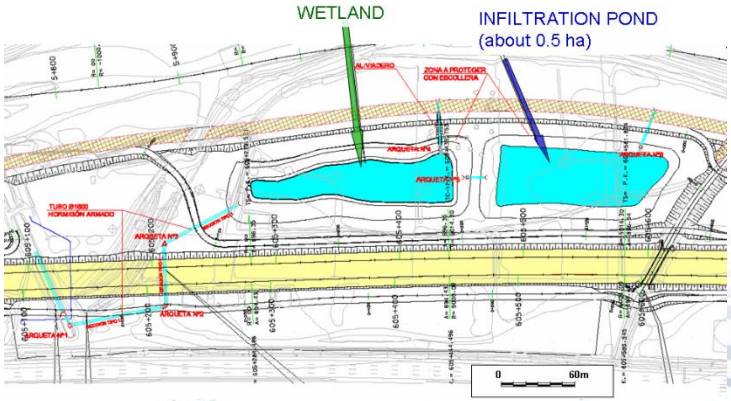
Diverted river water – Spain (Albert Folch, Xavier Sanches-Villa et al.)

Artificial aquifer recharge through infiltration ponds. The site includes a sedimentation and an infiltration pond. Water for recharge is diverted from the Llobregat River. Recovery is done by extraction wells downgradient.

Major goals

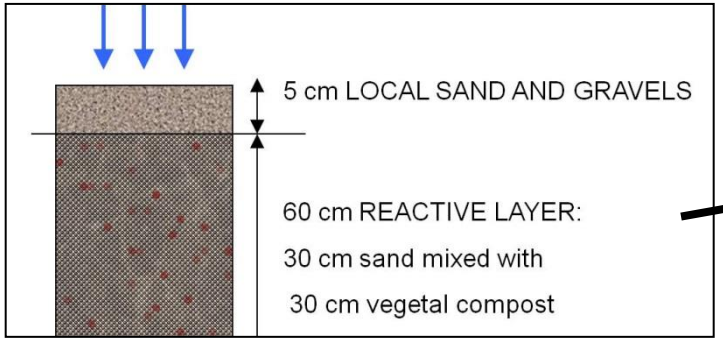
(i) increase the strategic groundwater reserves in the Llobregat aquifer in order to supply water to Barcelona

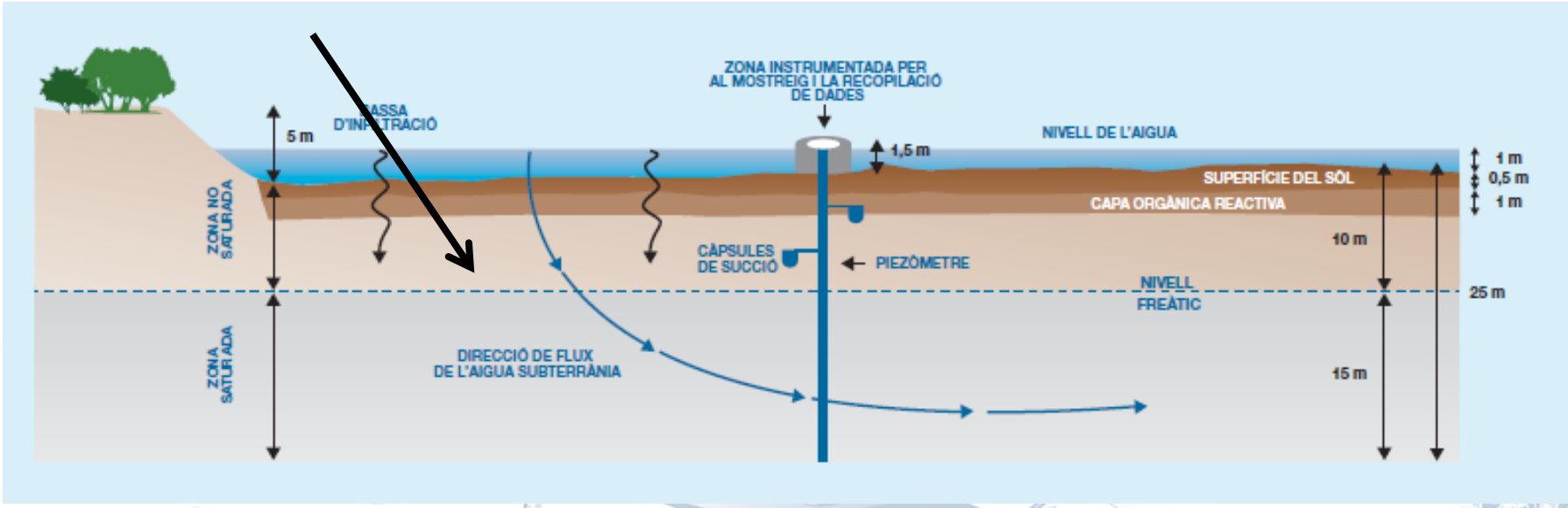
(ii) improve the groundwater quality



Infiltration of water from Llobregat river

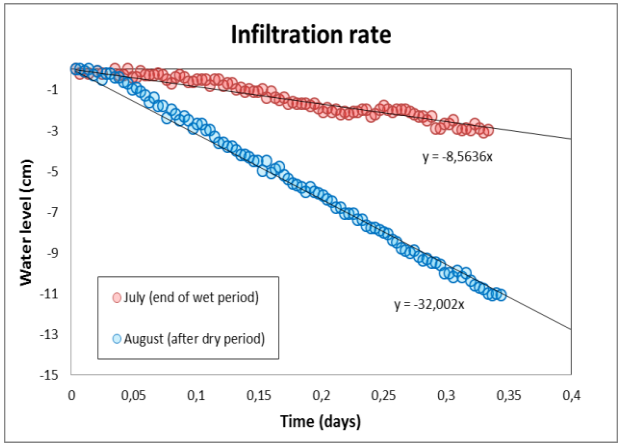
An active layer located at the bottom of an infiltration pond to enhance the degradation of certain contaminants.

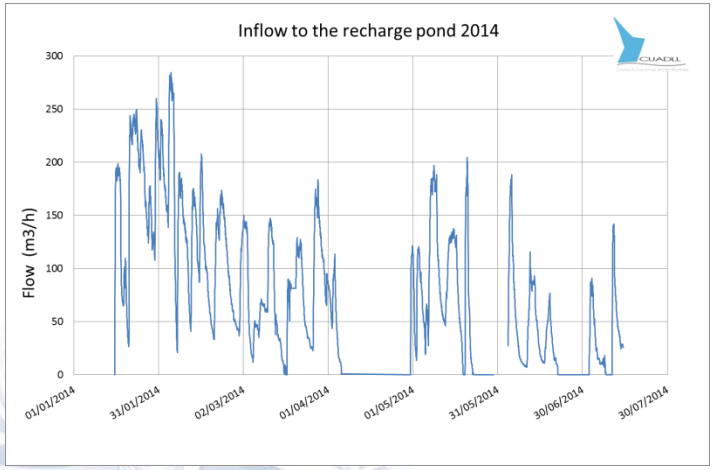




Work in progress – Infiltration dynamics

Change of the infiltration rates





Work in progress - microbyology

Degradation processes

Biodegradation

(Bio)clogging

What kind of bacteria we find and where?

How are they affected by environmental conditions (T, sal, …)?

Sampling
(with Microbiologists)

Soil

Water

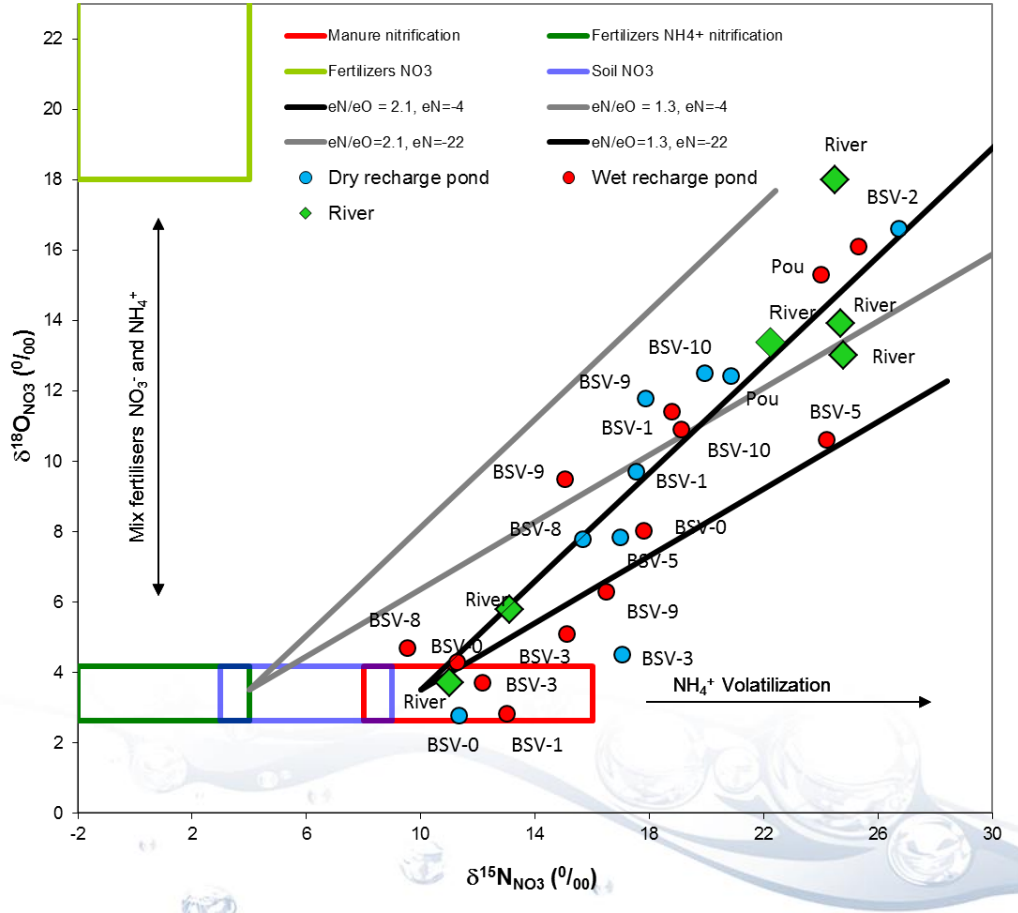
July 2014

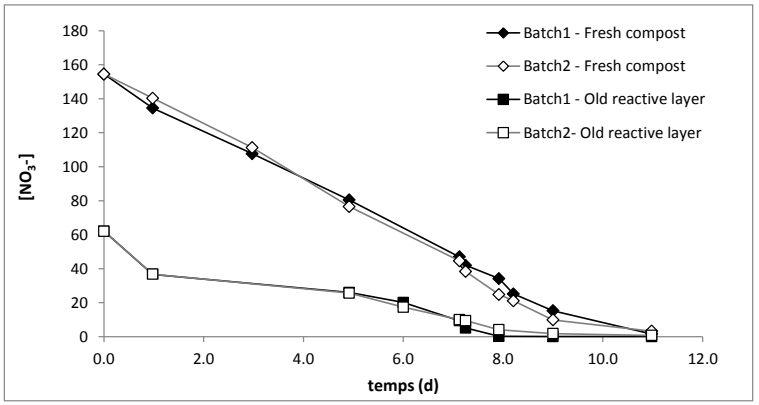
In the Future Biotrap with local material ➩ Fixed biomass

Work in progress - denitrification

Induced denitrification during MAR

In collaboration with MAIMA group (University of Barcelona) with the project WADISMAR

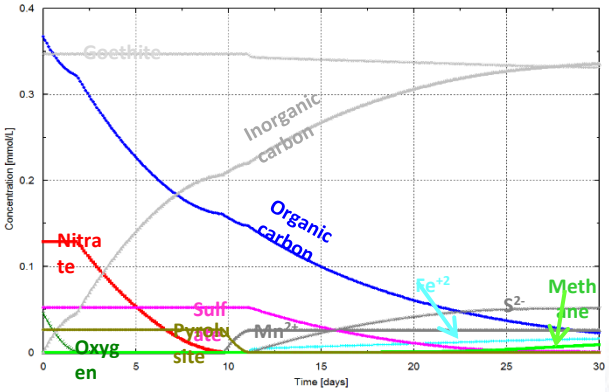




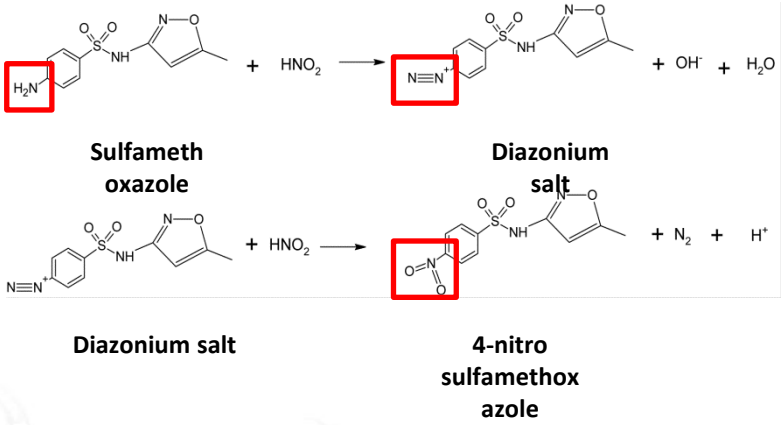
Batch experiments indicate that the reactive layer can induce denitrification even three years after installation

Work in progress – Pollutant degradation

- How to enhance natural attenuation of emerging pollutants in MAR applying engineering injection-extraction→ Montecarlo simulations.
- Understanding degradation mechanism of antibiotics: sulfamethoxazole and diclofenac.
- Evaluating change of hydraulic properties in different materials of reactive layers in MAR (Univ. Barcelona, WADISMAR).



Modeling organic matter degradation of reactive layer during MAR



Mechanism degradation of SMX under denitrifying conditions

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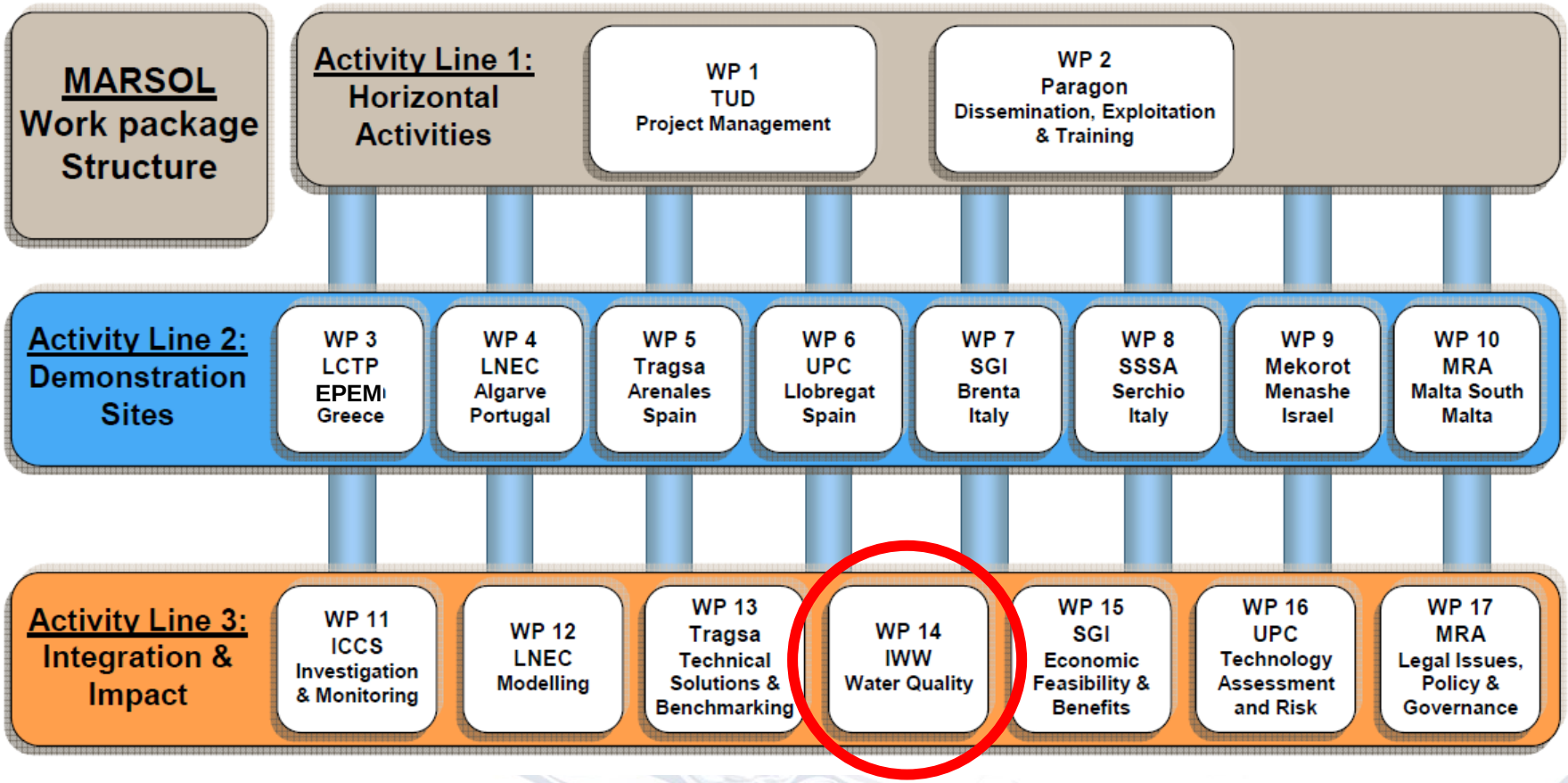
Worpackage structure



Water quality (Axel Bergmann, Christine Kübeck)

- Water constituents (Task 14.1, IWW)
  - Identification of anthropogenic substances in the infiltrated waters and percolates at the DEMO sites

➢ Create a consistent data base

- Human pharmaceuticals (Diclofenac, Ibuprofen…)
- Antibiotics (Doxycycline, Sulfamethazole…)
- Beta blocker (Bisoprolol, Satalol…)
- X-ray contrast agents (Iomeprole…)
- Surfactants
- Complexing agents (EDTA)
- Sweetener (Acesulfam…)
- Nonylphenole
- Xenobiotics (Atracine, DET…)

- Inorganic parameter (tww: COD, BOD etc.)

Water quality (Axel Bergmann, Christine Kübeck)

- Accompanying column experiments

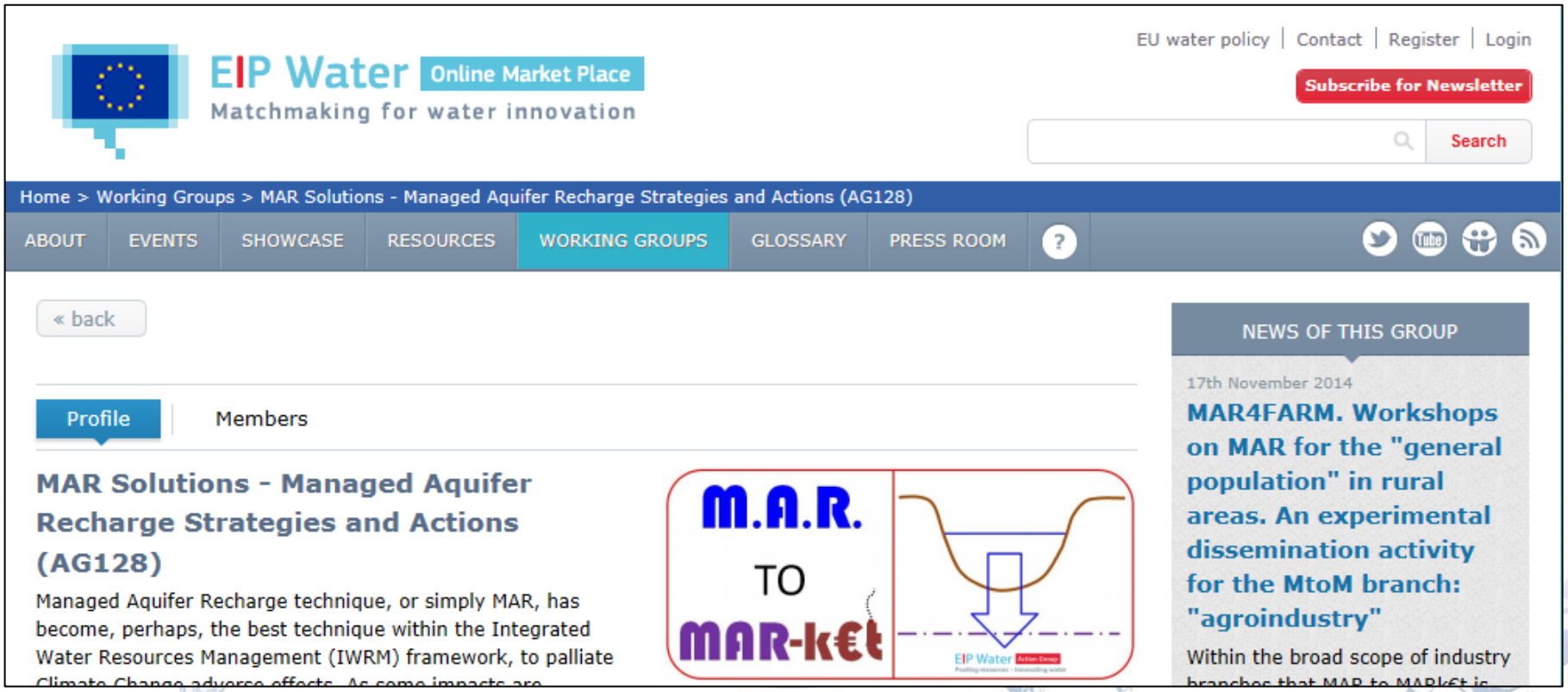
Demo site			AIM	Conditions	Status
Campina de Faro, Portugal	LNEC	Wastewater un-/treated (enrich EC)	Soil capacity for retaining specific pollutants	➢ *saturated, steady flow*	*First exp. finished*
				➢ *saturated, steady flow* ➢ *un-/saturated, flush*	*First exp. finished*
				➢ *saturated, steady flow*	*First exp. finished*
				➢ *saturated, steady flow*	*Planned*
				➢ *saturated, steady flow* ➢ *un-/saturated, flush*	*Started*

MAR to MARKET

Action Group, European Innovation Partnership (EIP)

The aim is to speed up innovations that contribute to solving societal challenges, enhance Europe's competitiveness and contribute to job creation and economic growth. EIPs help to pool expertise and resources by bringing together public and private actors at EU, national and regional level, combining supply- and demand-side measures.

Coordinated by LNEC and TRAGSA (Joao-Paulo, Enrique), 36 Partners



MARSOL Webpage

www.marsol.eu ***Info:*** **marsol@tu-darmstadt.de**