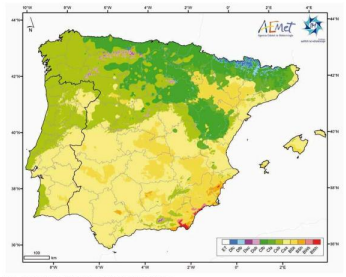
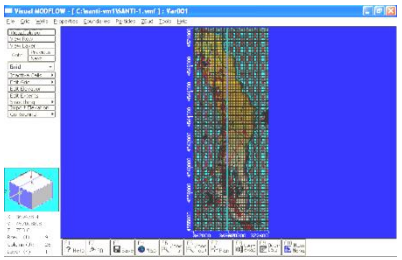
LA SCARSITA' DELLA RISORSA IDRICA IN PERIODI DI CRISI CLIMATICA:
PROBLEMATICHE ESPERIENZE E PROPOSTE DI INTERVENTI DI MITIGAZIONE

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







WATER SECURITY INCREASEMENT AND CLIMATE CHANGE ADAPTATION BY MEANS OF MANAGED AQUIFER RECHARGE IN SPAIN.

OVERVIEW OF DEMONSTRATIVE SITES, AND LESSONS LEARNED

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2023 June 29th

MARSoluT Managed Aquifer Recharge ITN

Tragsa GrupoTragsa

POLITÉCNICA

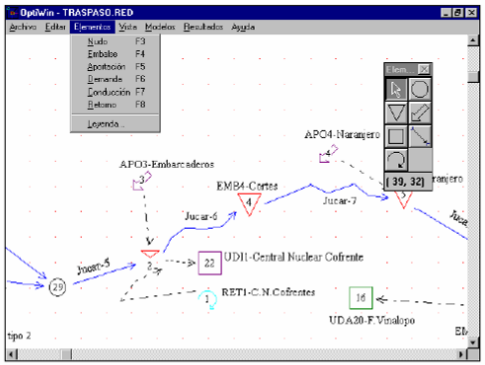
International Association of Hydrogeologists
the World-wide Groundwater Organisation
IAH Commission on Managed Aquifer Recharge

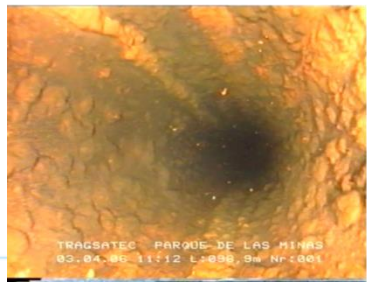
Introduction

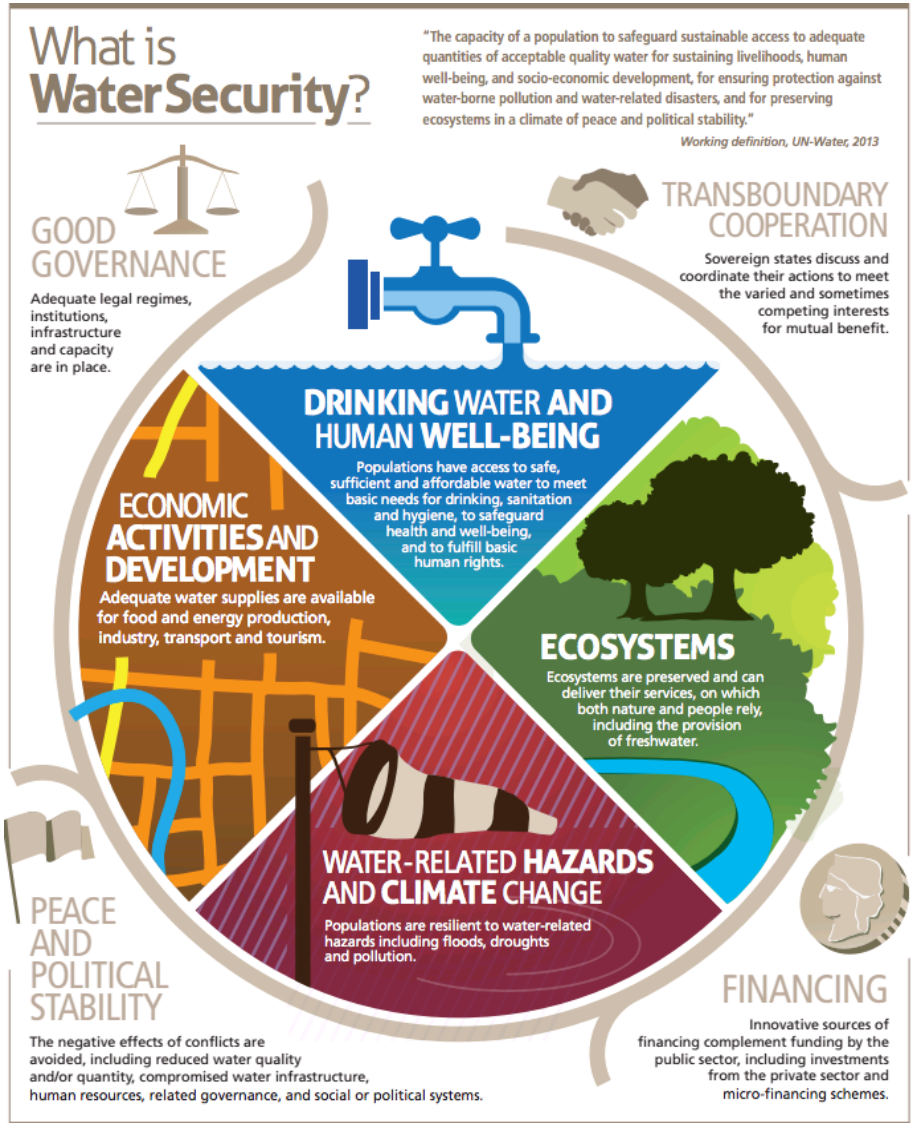
-Selected Spanish **MAR sites** have been studied, tracking some indicators´ evolution… **to check whether or not MAR is a key element** for human wellbeing, socio-economic development, …, food safety and public health

-Socio-economic success is dependent on water availability, water preservation and MAR (to a certain extent)

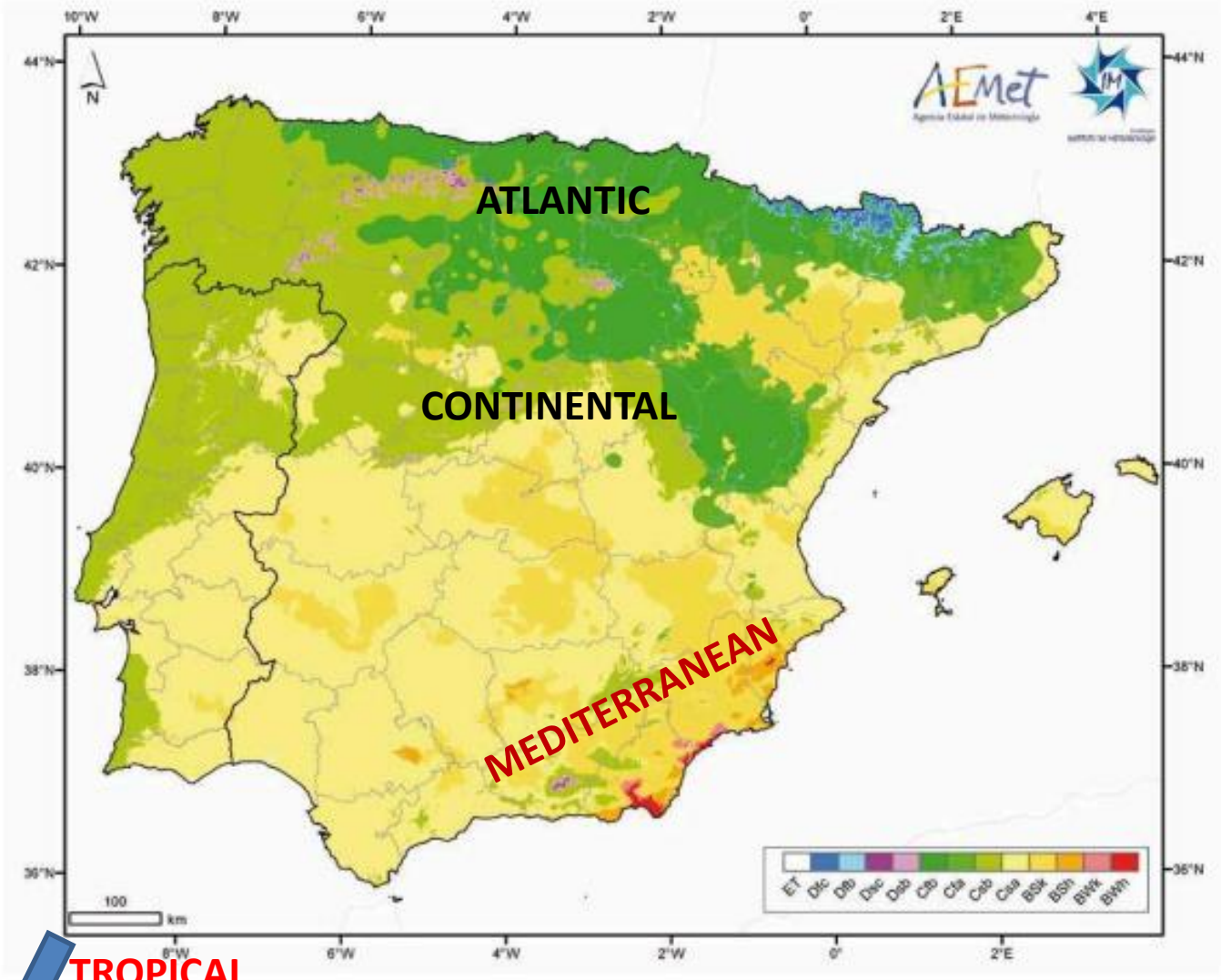
-The next selected areas have included **MAR in their IWRM schemes to increase their resilience & to improve their governance.**



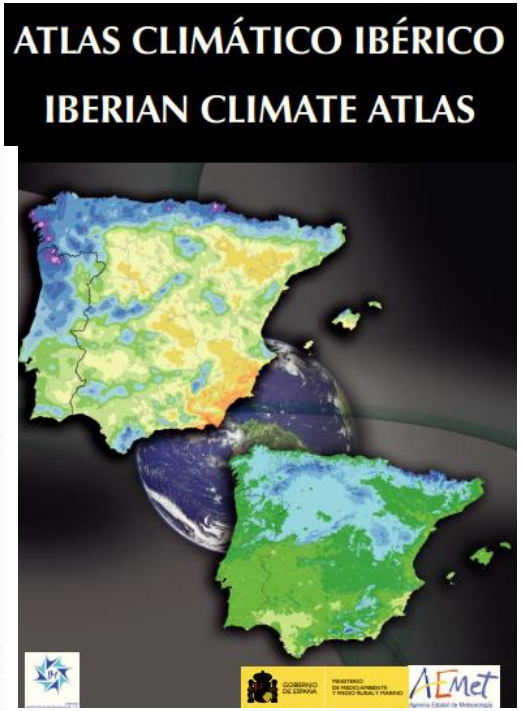




Climates in Spain



Clasificación climática de Köppen-Geiger en la Península Ibérica e Islas Baleares.

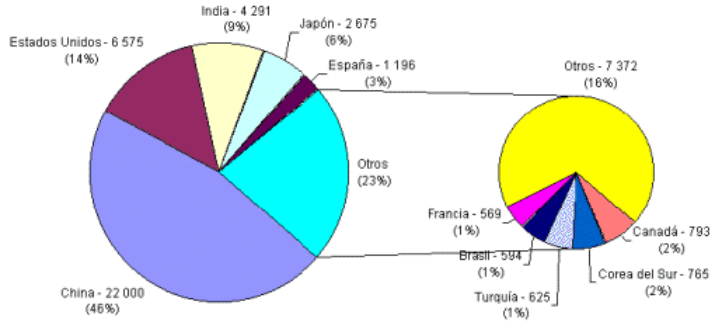


Mediterranean:
Palmer Index (2100):
-4 (extreme drought)

https://www.aemet.es/documentos/es/conocermas/recursos_en_linea/publicaciones_y_estudios/publicaciones/Atlas-climatologico/Atlas.pdf

IWRM in Spain

Spain is the 5th country all over the World in daming (IUCN, 2010).
Damed volume over **53.000 hm³** (2015).



Groundwater consumption is about **6.000 hm³/year. 80 %** for **irrigation**.

Volume of **wastewater treated**:
4.450 hm³/year (2008).

4th country in desalinated water production: from 0.01 to 0.25 **hm³/day**.
765 operative desalination plants > **550 hm³/year**

MAR in Spain: (hm³ /year)

50-60 (1994, LBAS)
350 (2000, LBAE)
380 (**2008**, DINA-MAR)

Water comsumption in Spain: >28.000 MMC/year

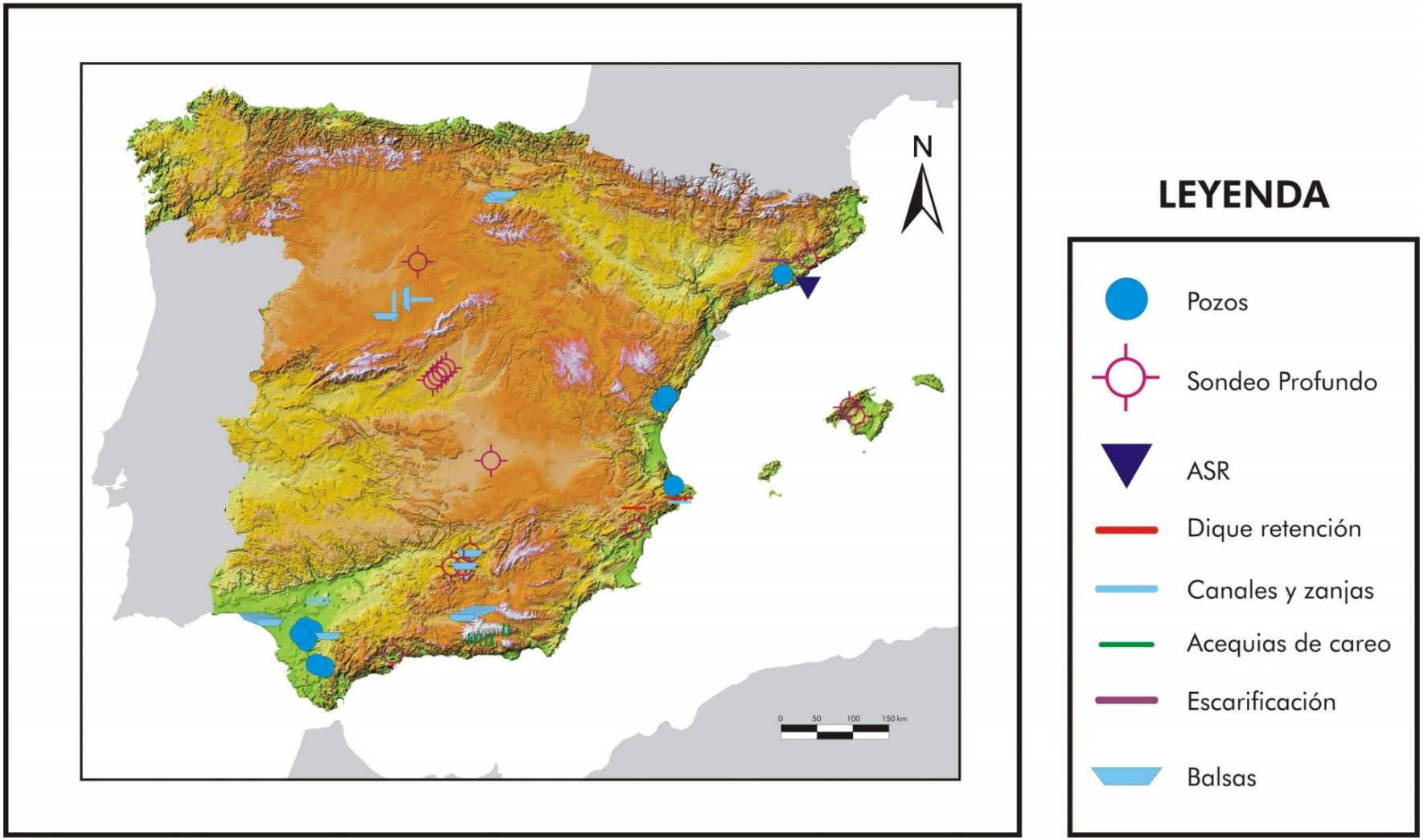
Figura 1. Demarcaciones Hidrográficas de España

POTENTIAL GROUNDWATER RESOURCES ABOUT 111.000 hm³/year

Including (un)Intentional MAR: about **800 hm³/year**

MAR devices in Spain

32 MAR sites (2011)

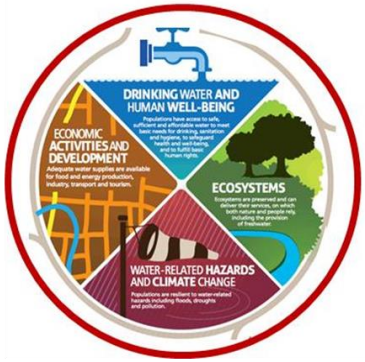


https://dinamar.tragsa.es/post/documentacion-tecnicanoticias

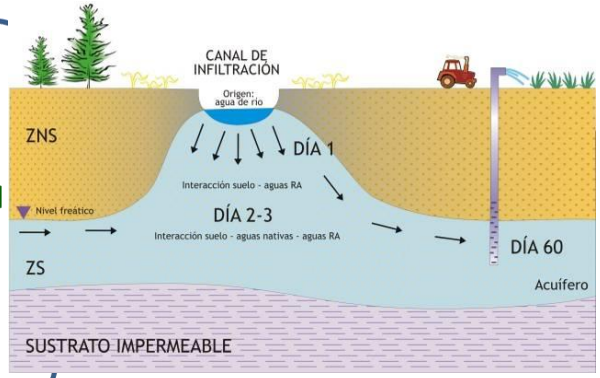
https://dinamar.tragsa.es/pdf/dina-mar-2007-2011-libro.pdf

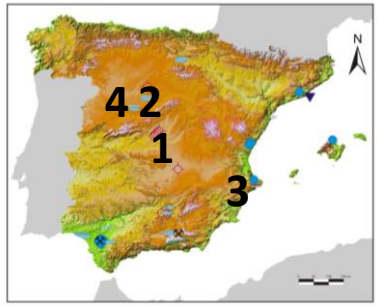
Water security and MAR

Industrial water security



Environmental water security





MAR (Intentional)

MAR as an IWRM component:

- -MAR guarantees environmental water security
- -MAR is a climate change adaptation measure
- -MAR in an irrigation area > contributes to food safety

Use-cases

1- Water security in urban cities. CYII, Madrid

2- Water security related to water quality evolution and measures for preservation (Valladolid)

3- MAR is used to decrease the flood´s devastation effect on crops and food production (Valencia)

4- MAR to reduce the disturbing presence of water in agricultural areas with drainage problems affecting food production (Salamanca).

1

2

3

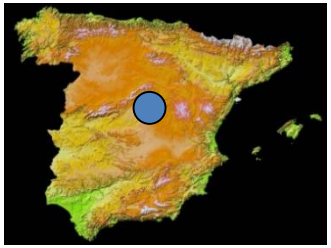
4

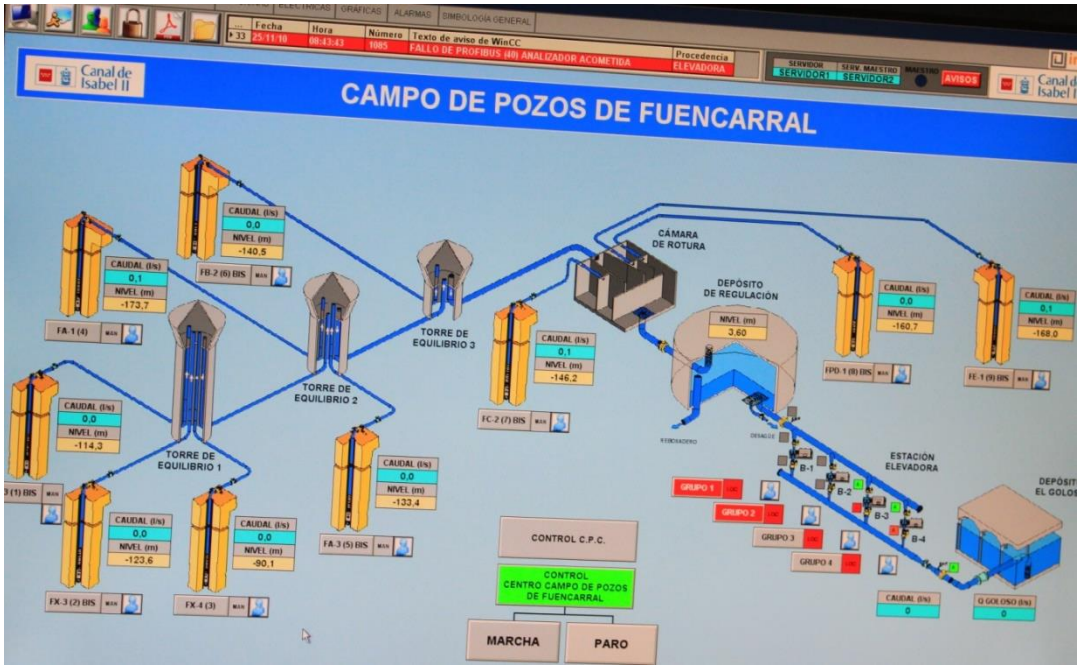
A- Urban supply water security

1- MAR to increase water supply guarantee. Madrid

Deep MAR by boreholes. CYII. Madrid

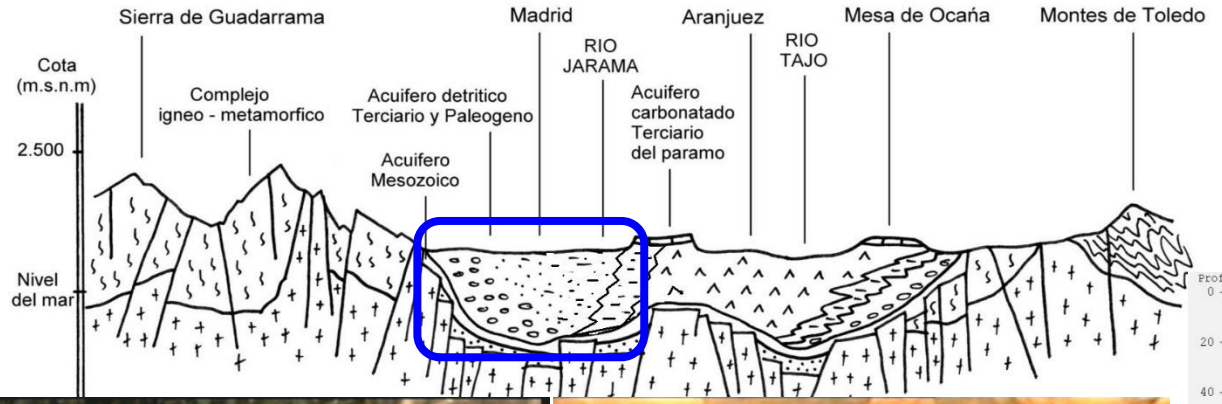
- 5 well fields
- Only for emergency situations
- Deep boreholes (until 650 m)
- Dual systems
- Advanced sensors
- Specific designs

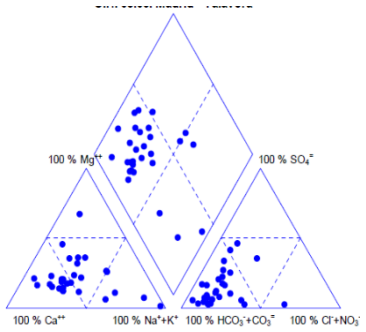


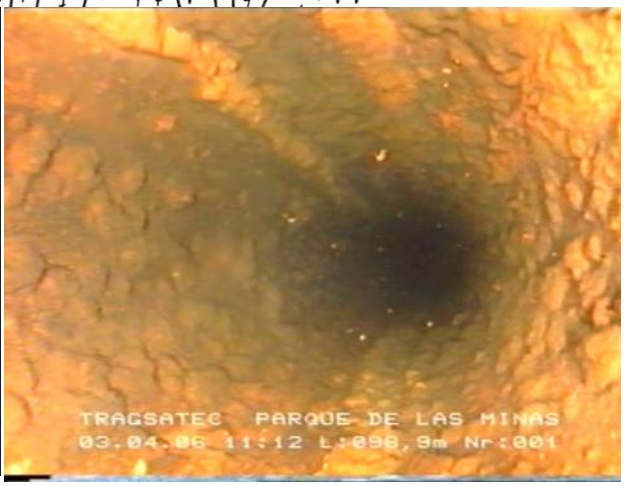


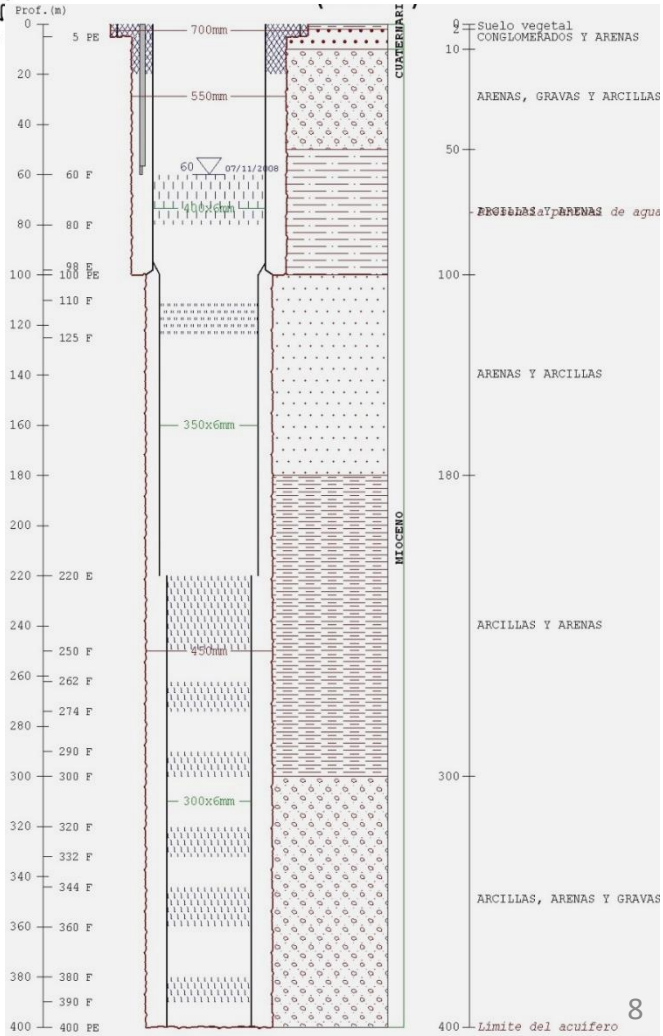
1- MAR to increase water supply guarantee. Madrid

Medio receptor. Madrid sedimentary basin







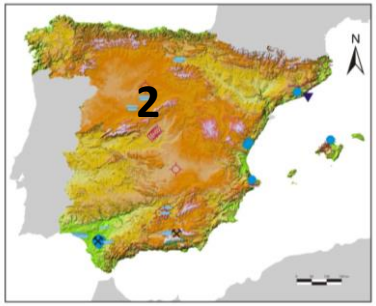


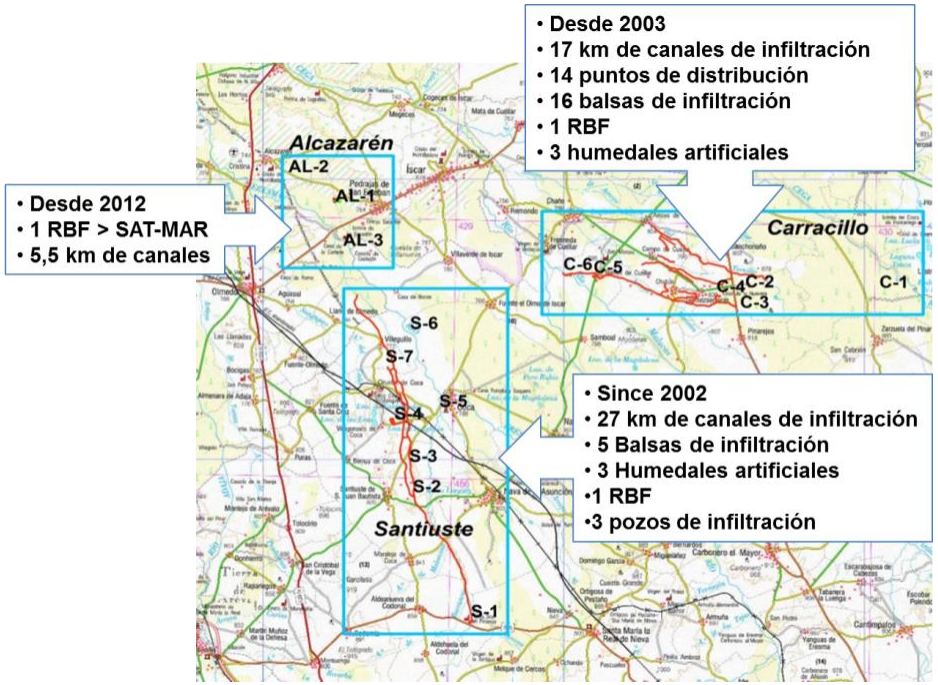
- **Tertiary aquitard**
- **Injection (high energy consumption)**
- **Permanent watching**

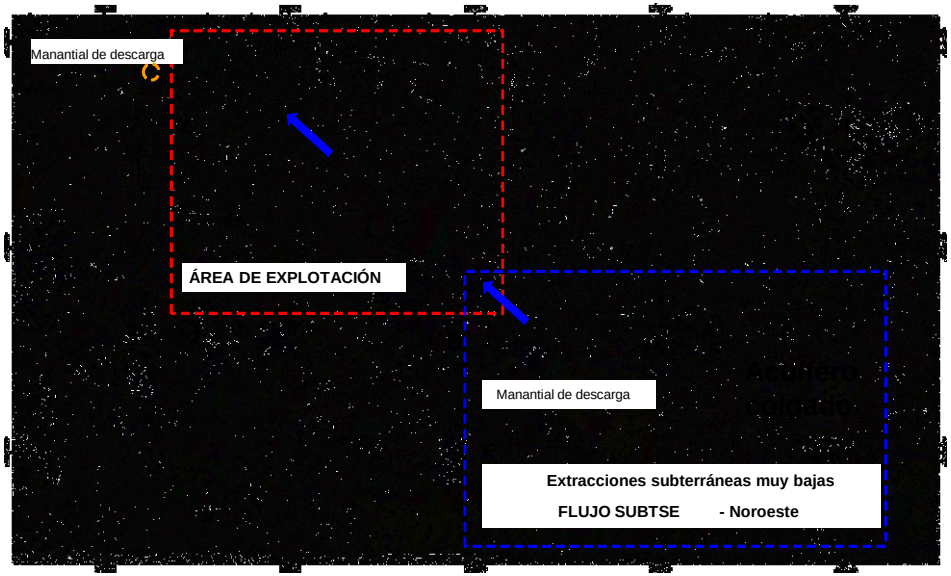
Guarantee excedes 95% during drought periods

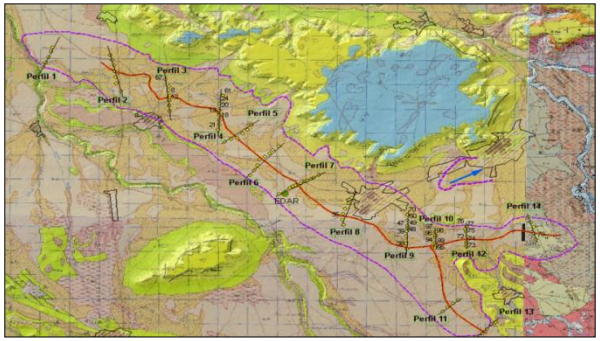
2-Water quality variations depending on the wise mixture of different origin water resources, with stakeholders´ intervention (Co-MAR)

Alcazarén-Pedrajas SAT-MAR (Los Arenales) Valladolid







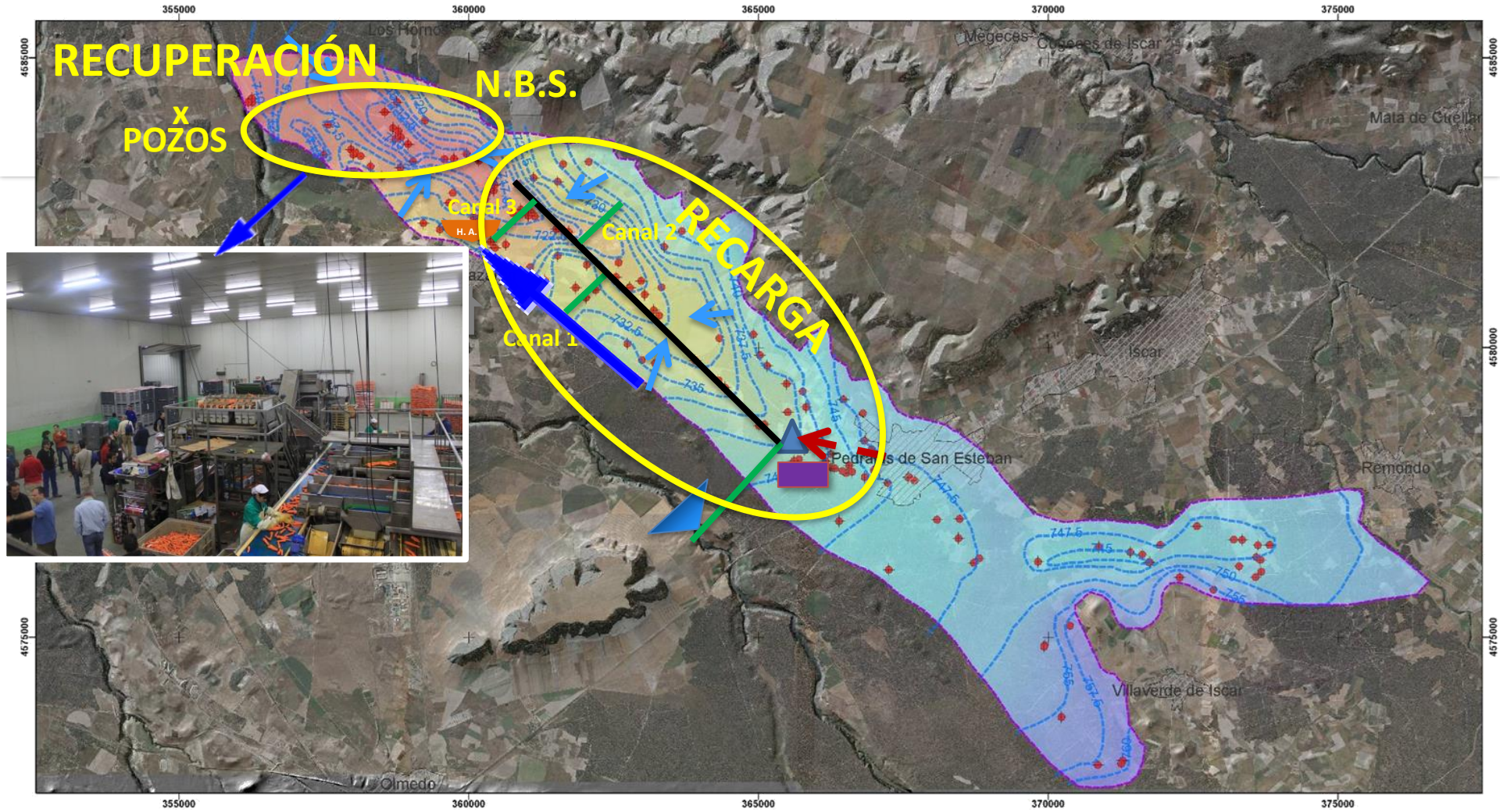


Aquifer area: 23 x 2.5 km²

PROBLEM: Intensive GW exploitation.
GW table declined 15 m in 30 years

SOLUTION: 2012 NEW (SAT-)MAR experience to guarantee **the aquifer sustainability, irrigation and agroindustry**

Alcazarén-Pedrajas SAT-MAR (Los Arenales)



HYDROGEOLOGICAL SCHEME

Water sources diversification

Novelty: Three different water sources for MAR

PIRÓN RIVER

PEDRAJAS VILLAGE RUNOFF ROOF-TOP WATER > > MAR CHANNEL

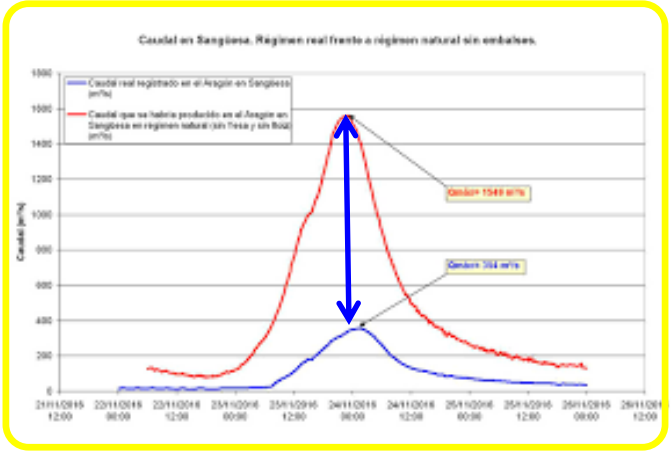
ADVANCED SECONDARY WWTP

- **Operativity independent from surpluses and allowances**
- ***"Dilution as a solution to pollution"***
- **Post-treatment actions (interactive filters)**
- ***Nature Based Solutions* (aquifer as purification element)**
- Natural, passive and economic actions
- **Reuse of water with security (circular economy)**
- **TOC increase > disinfection actions**
- **Long term applicable technologies.**

3- MAR to decrease the flood´s devastation effect on crops and food production, Lliria (Valencia)

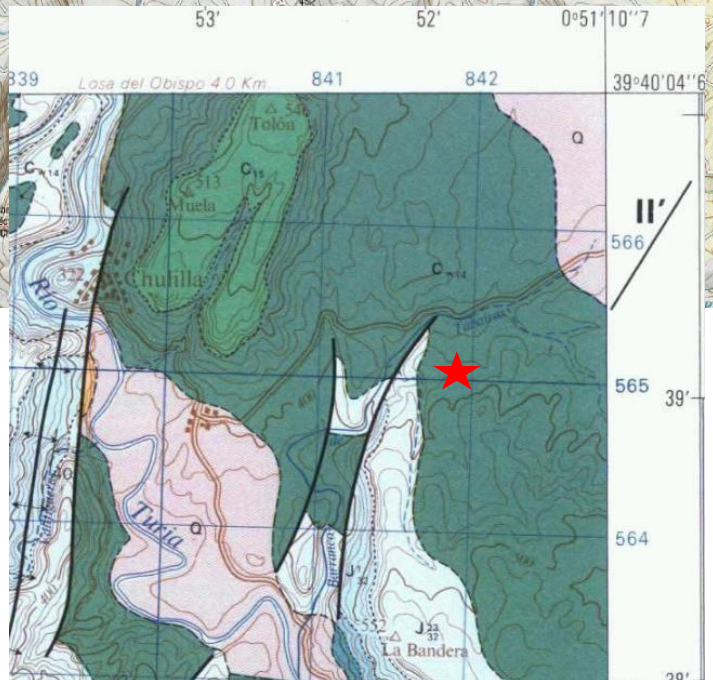
Deep MAR borehole from an irrigation pond (flood MAR and water security)

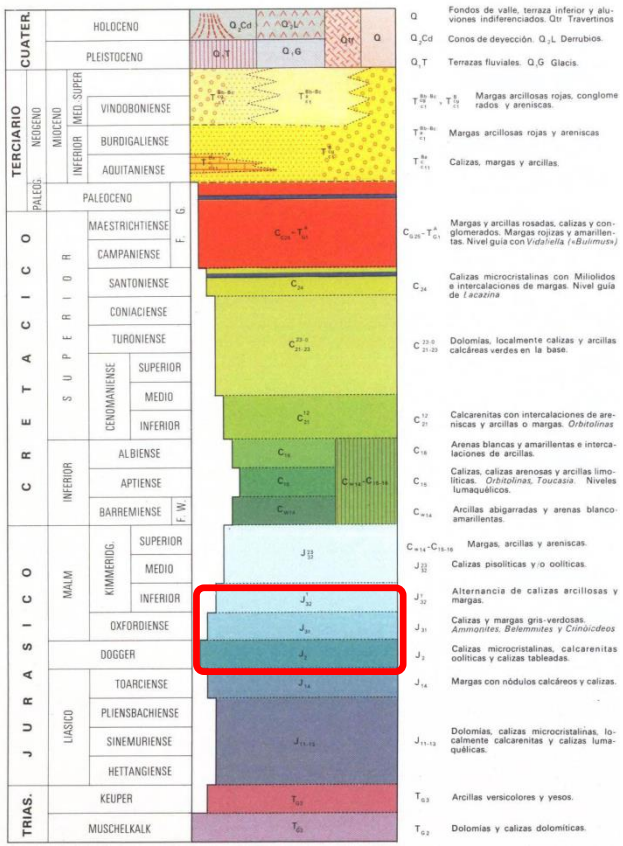
- MAR flow rate during a flood (>100 l /s)
- Flood peak reduction
- Devastation reduction *(divide et impera)*



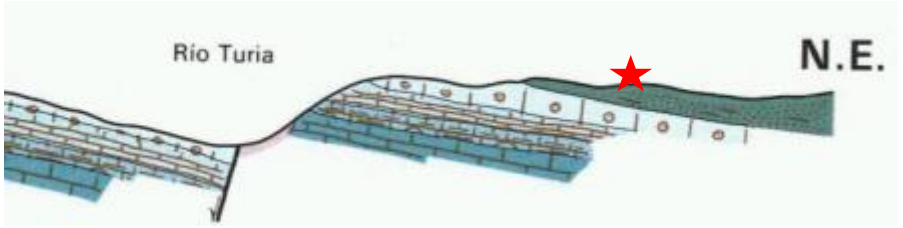
INDICATOR: Amount of water detracted from a flood and rapidly converted into groundwater (~ 0.05 MCM/event)

MAR to decrease the flood´s devastation effect on crops and food production (Valencia)



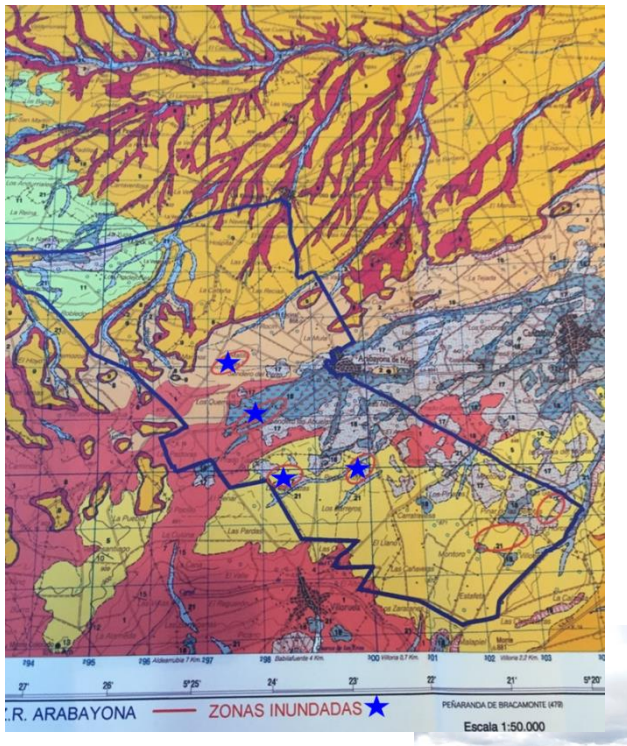


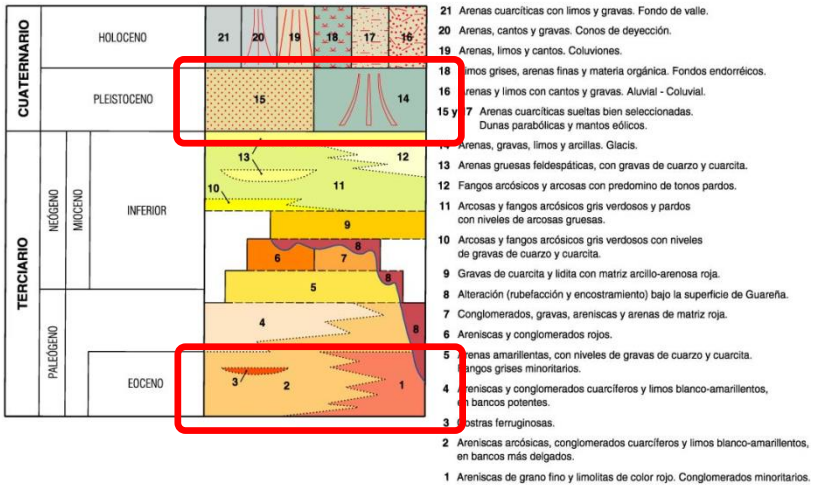
Geological context



Arabayona, Salamanca, Spain

4- MAR to reduce the disturbing presence of water in agricultural areas with drainage problems affecting food production





-Natural situation and MAR as a complementary technology for aquifer storage using a fraction of "nuisance" surface water

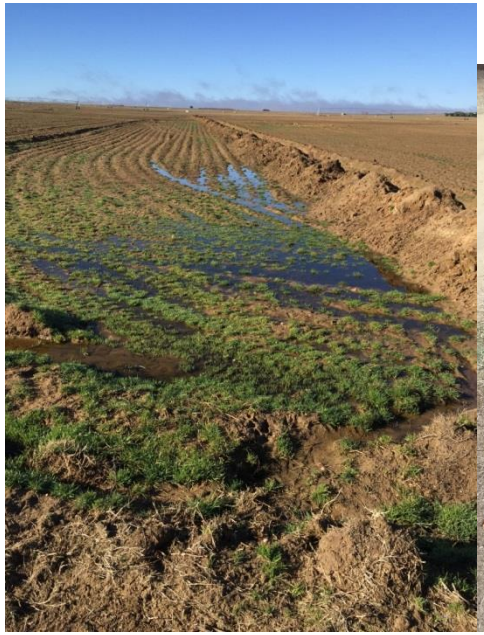
-Food production is resulting increased

-Nitrates impact

Indicator: balance surface water-GW storage

Arabayona, Salamanca, Spain

Food production is resulting increased



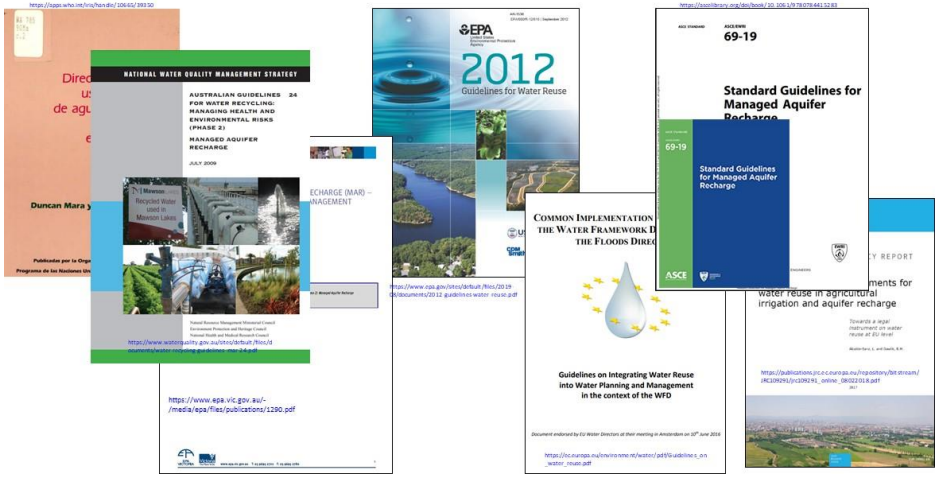
"nuisance" surface water

Location: https://www.google.es/maps/@41.0291389,-5.3322165,6573m/data=!3m1!1e3

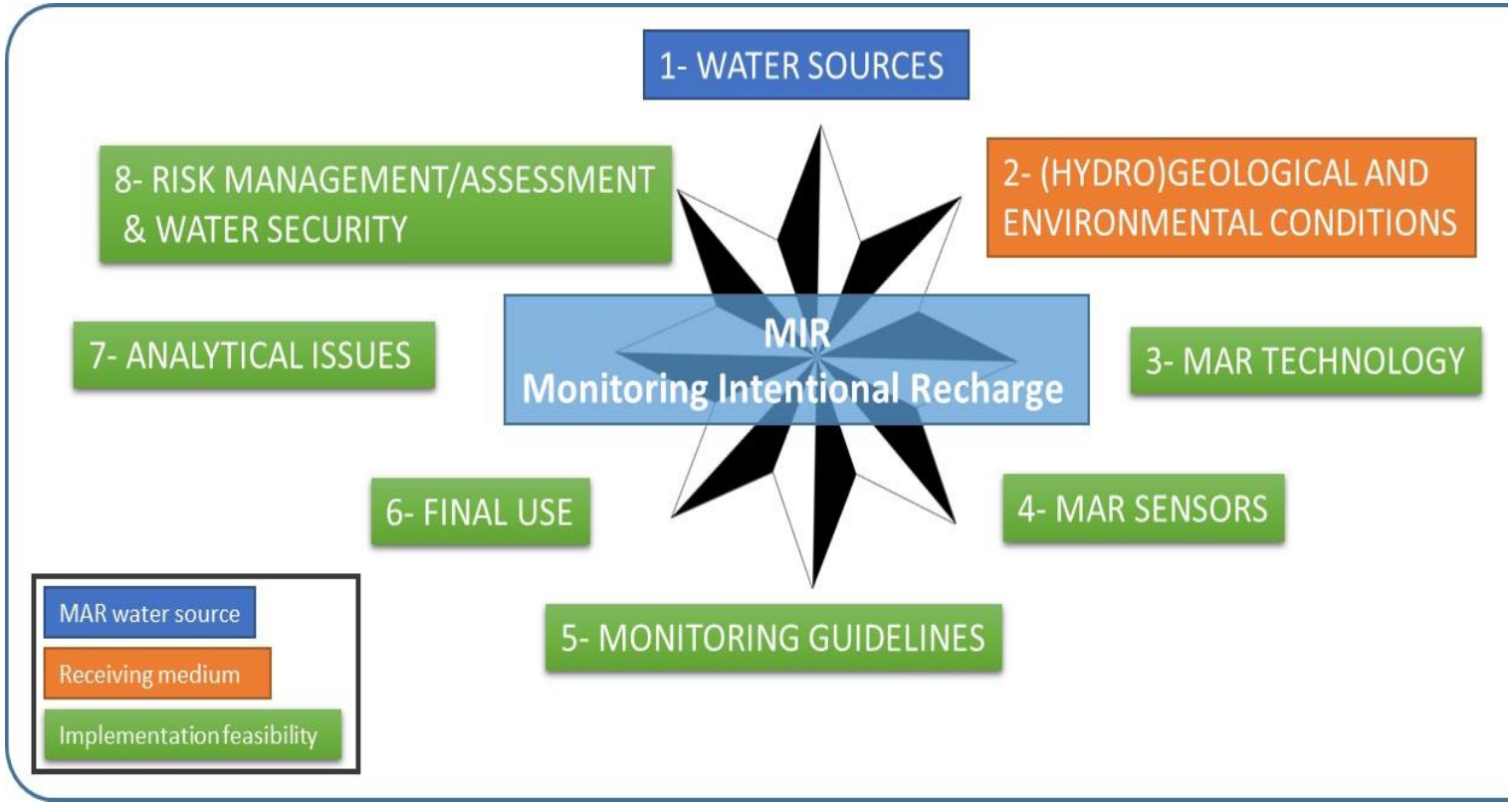
MAR in the neighbor "aquifer"

https://dinamar.tragsa.es/file.axd?file=/PDFS/P-ISMAR-11.pdf

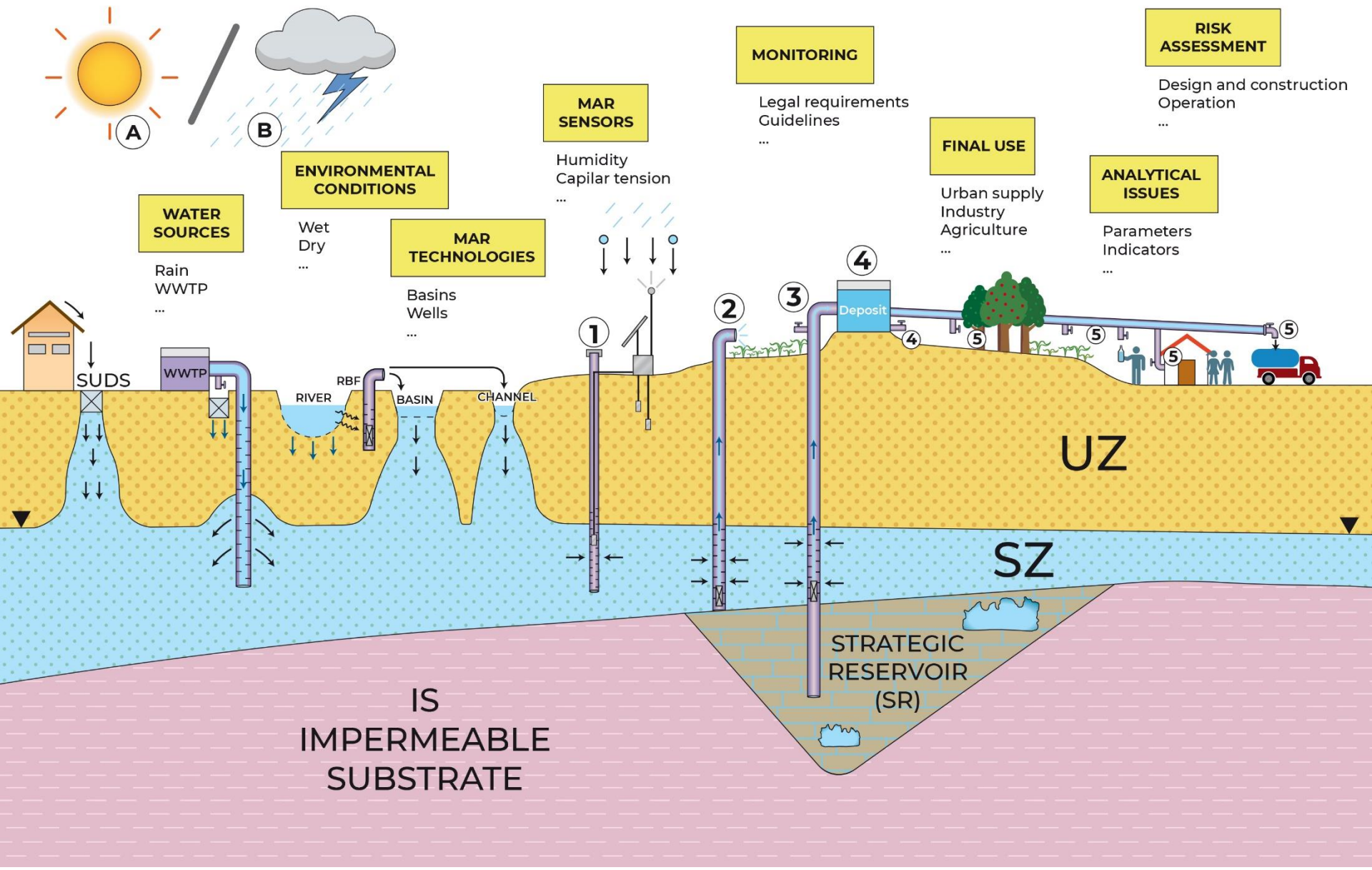
Integration of the different components of the MIR or Monitoring & Intentional Recharge concept



1. WATER SOURCES
2. (HYDRO)GEOLOGICAL AND ENVIRONMENTAL CONDITIONS
3. MAR TECHNOLOGY
4. SENSORIC FOR MAR
5. MONITORING GUIDELINES
6. END USE
7. ANALYTICAL ASPECTS
8. RISK ASSESSMENT



MONITORING INTENTIONAL RECHARGE (MIR) SOIL, AQUIFER AND WATER



https://www.mdpi.com/2073-4441/14/21/3405

MIR CONCEPT. GENERAL APPROACH

Methodological approach and recommendations to achieve a *"Monitored and Intentional Recharge"* (MIR)

WATER SOURCES:
- River
- Rainwater
- Urban runoff
- Waste Water Treatment Plant
- Wetland
- Inter-dunar site
- Desalination plant
- Water supply excess
- Irrigation return
- Drainages
- Others (...)

ENVIRONMENTAL CONDITIONS:
- Dry site
- Arid site
- Wet site
- Soil. Type and thickness
- Vegetal coverage
- Detritic aquifer
- Karst aquifer
- Hard rocks "aquifer"
- Self-purification capacity
  - -Unsaturated zone
  - -Saturated zone

...

MAR TECHNOLOGIES:
- Infiltration basins
- Canals
- In-channel modifications
- Flooding
- Dykes
- Wells (injection/ percolation)
- Boreholes
- Drainages
- Underground irrigation
- Combinations
- Leakages from pipelines (anti-MAR)*
- River Bank Filtration (RBF)*
- Urban drainage and SUDS*

...

MAR SENSORS:
- Water level
- Physical parameters soil/water
  - -Soil humidity
  - -Capilar tension/water potential
  - -Dielectric permittivity
  - -Vapor pressure
  - -Conductivity
  - -Temperature
  - -pH
  - -ORP
- Hydrochemical parameters
  - -Salinity
  - -TOD
  - -TDS/turbidity
- Flow rates
- Infiltration rates
- Meteo

...

FINAL USE:
- Irrigation
- Industrial water supply
- Urban water supply
- street cleaning & sweeping
- Strategic reservoirs (SR)

...

MONITORING GUIDELINES :
- Legal imperatives
- Preliminary guidelines
- Controls for prior authorisation
- Exact point/s for monitoring:
  - 1-Discharge point
    - -Unsaturated zone
    - -Saturated zone
  - 2-On site MAR piezometers
  - 3-Recovery point
  - 4-Post-treatment in itinere
  - 5-Post-treatment deposit
  - 6-End-use point (tap)
- Sampling frequency
- Data gathering:
  - -Remote
  - -On site
  - -Real-time
- Energetic monitoring

...

ANALYTICAL ISSUES:
- Parameters to be analyzed
  - -Unsaturated zone
  - -Saturated zone
    - -Unstable parameters
    - -Stable parameters
- Emergent pollutants´ indicators
- Cost of the analyses
- Stakeholders participation

...

RISK MANAGEMENT/ASSESSMENT & WATER SECURITY:
- Design and construction
  1-Non-technical constraints*
  - -Legal constraints
  - -Economic constraints
  - -Social unacceptance
  - -Governance

  2-Technical constraints
  - -Source water availability and right of access
  - -Water scarcity
  - -Hydrogeological assessment
  - -Lack of infrastructures
- Operation
  1-Non-technical constraints
  *Idem

  2-Technical constraints
  - -Structural damage
  - -Not enough water recharged
  - -Water scarcity
  - -Clogging
  - -Unacceptable quality of water at sensitive location
  - -Specific targets (operator level)

...

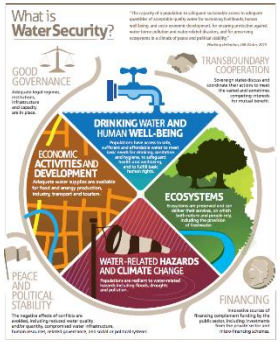
*Managed Aquifer Recharge (MAR)
*Sustainable Urban Drainage Systems (SUDS)
*River Bank Filtration (RBF)

MAR TECHNOLOGY:
1. Water spreading systems
2. Associated with rivers and canals
3. Targeted recharge: wells-boreholes percolation-injection
4. Filtration and infiltration
5. Runoff (SUDS)
6. Accidental recharge (unmanaged)

MARSoluT
Managed Aquifer Recharge ITN

MAR SYSTEM
1. WATER SPREADING SYSTEMS
2. ASSOCIATED WITH RIVERS AND CANALS: DETENTION-INFILTRATION AND RETENTION-INFILTRATION
3. TARGETED RECHARGE: WELLS-BOREHOLES PERCOLATION-INJECTION
4. FILTRATION AND INFILTRATION
5. RUNOFF (SUDS)
6. ACCIDENTAL RECHARGE (UNMANAGED)

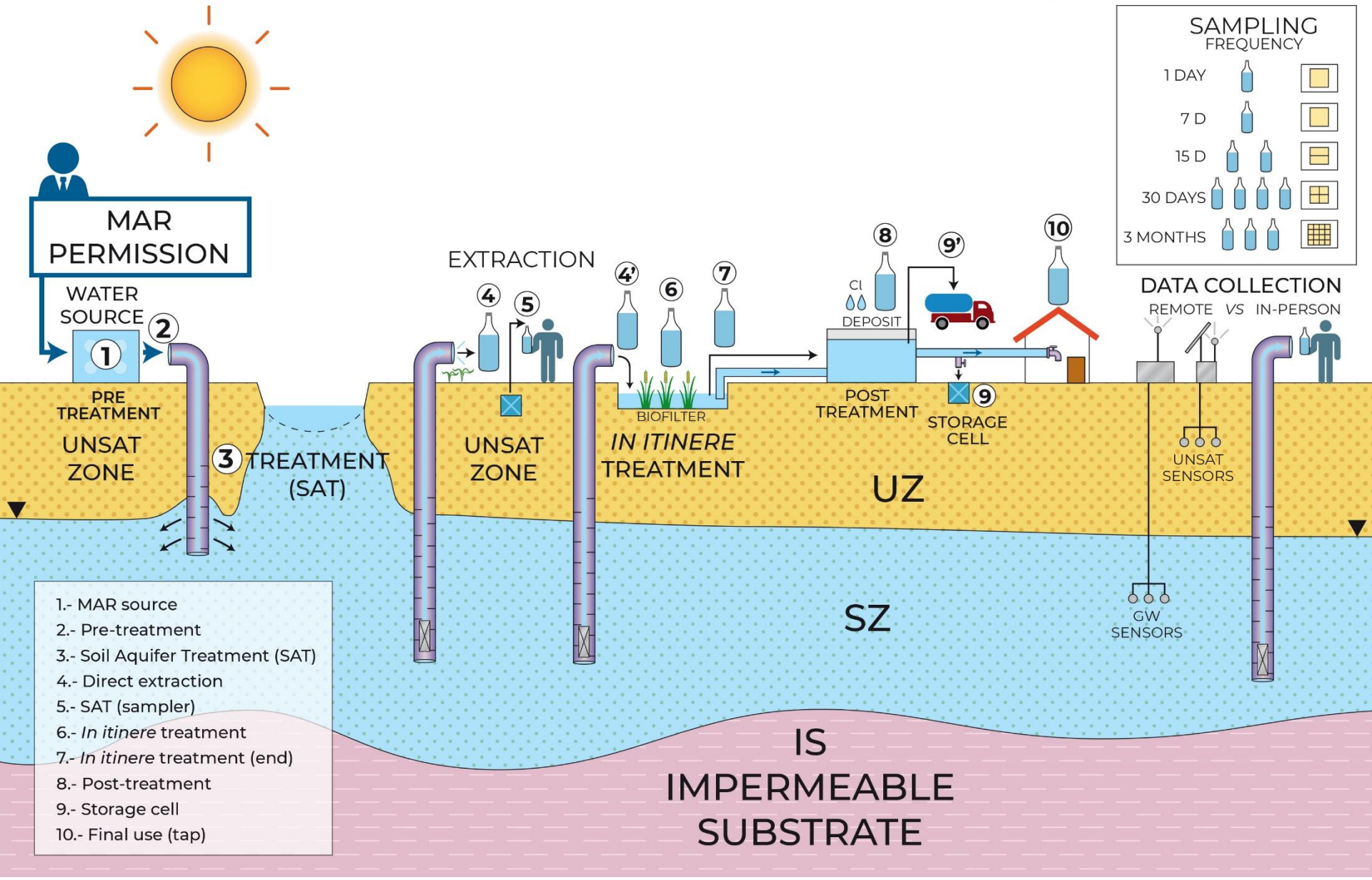
∑WS + MIR integration



∑

MIR
Monitoring Intentional Recharge

MONITORING GUIDELINES



Results

In general, the application of MAR technique in the selected IWRM schemes are:

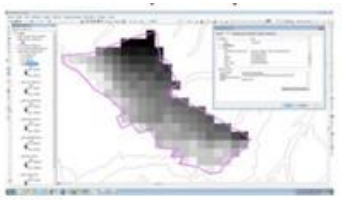
1- Water supply security over 95%

2- The reuse of water is key for food production (MAR & NBS are improving water quality in, at least, 17 parameters and GW availability)

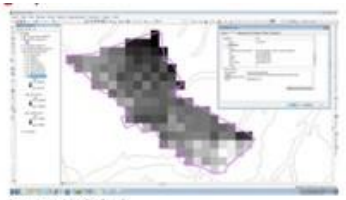
3- The amount of water detracted from floods is about 0.05 MMC in each event

4- Drainage areas with MAR present high nitrates concentration but food production is increased.

5- Water security requires guidelines which redaction might be based on the "MIR" concept



Suelos



Permeabilidad

Zonificación del medio receptor por Unidades homogéneas

Ensayos hidráulicos

Conclusions

1. MAR in IWRM schemes should prioritize urban water supply as main water security objective
2. Intermittent MAR systems cannot guarantee a permanent application of MAR, therefore water security has a higher degree of uncertainty
3. SAT-MAR cases (24-7 MAR) increase water security, but water quality evolution must be permanently monitored
4. Water security very often depends on (or is jeopardized by) economic interests
5. Regulation barriers and conflicts of interest hamper MAR
6. Multi-level governance, bottom-up DSSs, Co-Managed Aquifer Recharge (Co-MAR), People Public Private Partnerships (PPPP) and Monitoring Intentional Recharge (MIR) are improving IWRM, water security, food safety and public health.

IAH-MAR Managing Aquifer Recharge Commission

IAH Commission on
Managing Aquifer Recharge

International Association of Hydrogeologists

WELCOME | ABOUT THE COMMISSION | SYMPOSIA AND WORKSHOPS | WORKING GROUPS | COMMUNITIES | COLLABORATIONS | RESOURCES

Welcome

Attendees at ISMAR10, Madrid, May 2019 – the latest triennial symposium of IAH-MAR, UNESCO and ASCE

Welcome to the website of the International Association of Hydrogeologists Commission on Managing Aquifer Recharge (IAH-MAR). Here you can discover what our working groups are doing and contribute to their current projects, you can download resources on MAR, connect with people, get information on symposia coming up, and join our email list to stay informed of latest news. We also have sister sites in Spanish and Chinese.

Managed Aquifer Recharge

Managed aquifer recharge, also called groundwater replenishment, water banking and artificial recharge, is the purposeful recharge of water to aquifers for subsequent recovery or environmental benefit. It embraces methods such as riverbank filtration, stream bed weirs, infiltration ponds and injection wells, and uses natural water sources and appropriately treated urban stormwater, sewage and other waste waters to increase groundwater storage, protect and improve water quality,and secure drought and emergency supplies. Its growing scientific base supports its rapidly increasing use as a vital management tool in the sustainable use of the world's water resources.

Latest News

CURRENT PROJECTS THAT YOU CAN JOIN

- New working group: MAR in Conferences. Coordinator: Daniela Benedicto van Dalen
- New working group: Urban MAR. Coordinator: Niels Hartog
- LatinMAR Community of Practice – a new initiative to advance MAR in Latin America. Coordinator: Adriana Palma
- MAR Suitability Mapping Working Group. Coordinator: Jose Bonilla
- Contributions to a second monograph on clogging-focussing on its management – Clogging Working Group. Coordinator: Russell Martin
- Groundwater Solutions Initiative for Policy and Practice (GRIPP) – a Collaborative International Project, Coordinator: Karen Villholth

JOIN OUR MAILING LIST

Register with our large email group to share information, ideas and news concerning recharge enhancement.

Join IAH-MAR email community

Technical Forum
Sinergies

https://recharge.iah.org/

MARSoluT
Managed Aquifer Recharge ITN

Tragsa Grupo

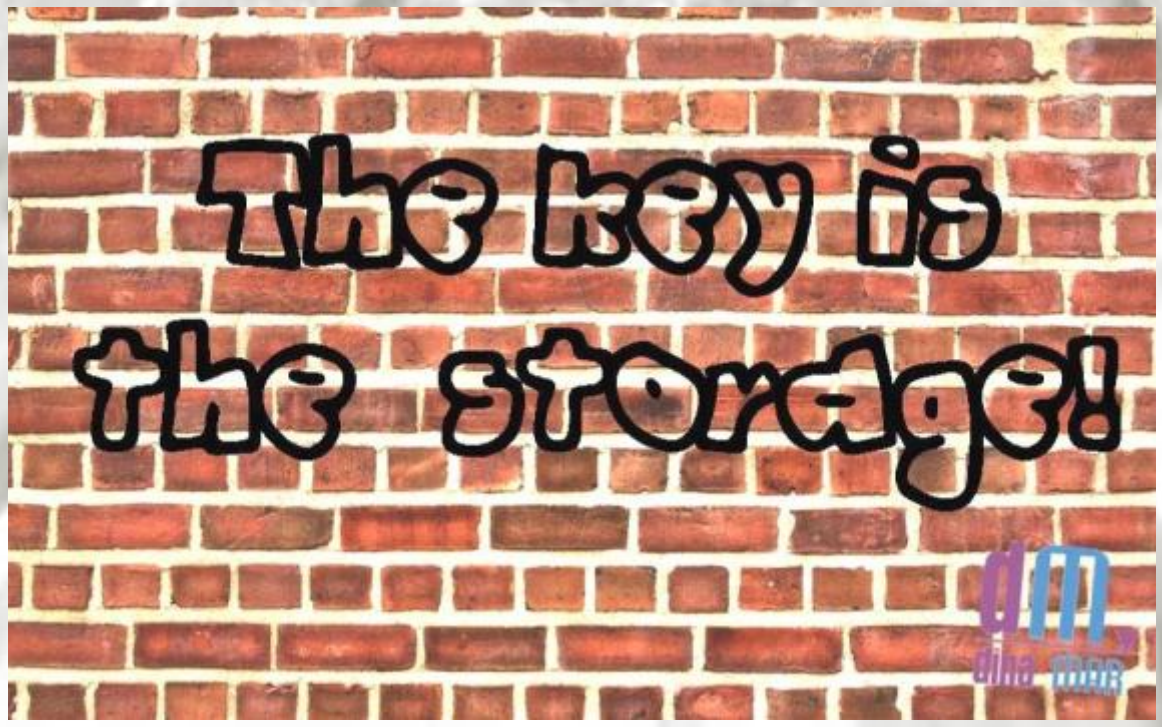
International Association of Hydrogeologists
Commission on Managing Aquifer Recharge

efernan6@tragsa.es

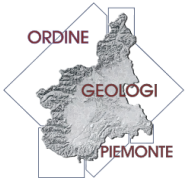
2023 June 29th

POLITÉCNICA

GRAZIE MILLE



DIPARTIMENTO DI SCIENZE DELLA TERRA, UNIVERSITA' DI TORINO



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