Advanced Monitoring and Investigation Technologies for Managed Aquifer Recharge

Grupo Tragsa

MARSOL Technologies – Demonstration

12:00 - 13:30	**Demo site visit 1: MARSOL Developed Technologies**
13:30 - 15:00	*Lunch Break*

MARSOL Demo Sites – Presentations

15:00 - 15:20	*DEMO Site 2*: Algarve and Alentejo, South Portugal *Tiago Carvalho (TARH)*
15:20 - 15:40	*DEMO Site 3*: Los Arenales Aquifer, Castile and León, Spain *Enrique Fernández Escalante (Tragsa)*
15:40 - 16:00	*DEMO Site 4*: Llobregat River Infiltration Basins, Sant Vicenç dels Horts, Catalonia, Spain *Albert Folch, Xavier Sanchez-Vila (UPC)*
16:00 - 16:20	*DEMO Site 5*: River Brenta Catchment, Vicenza, Italy *Vincenzo Marsala (SGI)*
16:20 - 17:00	*Coffee Break*
17:00 - 17:20	*DEMO Site 6*: Serchio River Well Field, Tuscany, Italy *Rudy Rossetto (SSSA)*
17:20 - 17:40	*DEMO Site 7*: Menashe Infiltration Basin, Hadera, Israel

WP-5

INVESTIGATION AND MONITORING TECHNIQUES APPLIED AT *LOS ARENALES* AQUIFER

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MANAGED AQUIFER RECHARGE SOLUTIONS

*http://www.marsol.eu

M.A.R. TO MAR-KET

WIRE Water & Irrigated agriculture Resilient Europe
EIP Water Action Group Pooling resources – Innovating water

dm dina-MAR

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SEPI

Advanced Monitoring and Investigation Technologies for Managed Aquifer Recharge

INDEX

Arenales aquifer (Castille and Leon, Spain)

MAR SOL MANAGED AQUIFER RECHARGE SOLUTIONS

M.A.R. TO MAR-k€t

1- INTRODUCTION

Monitoring:

***"To observe, by means of special equipment, the development of one or more parameters in order to detect unexpected situations "* (RAE).**

-Technique helpful to control any situation
-Process of listening, analyzing and quantify/ qualify the information from digital devices
-Benefits:
- **-To prevent future undesirable occurrences**
- **-To set alerts in real time**
- **-To identify patterns of behavior**

Some advantages of historical data:

-Data-sets saved systematically over time
-Historical data sources
-Benefits:
- **-Statistics**
- **-To detect current behaviour patterns**

INTRODUCTION (2)

At Los Arenales aquifer, six monitoring networks are tracked, **collecting data-sets of**:

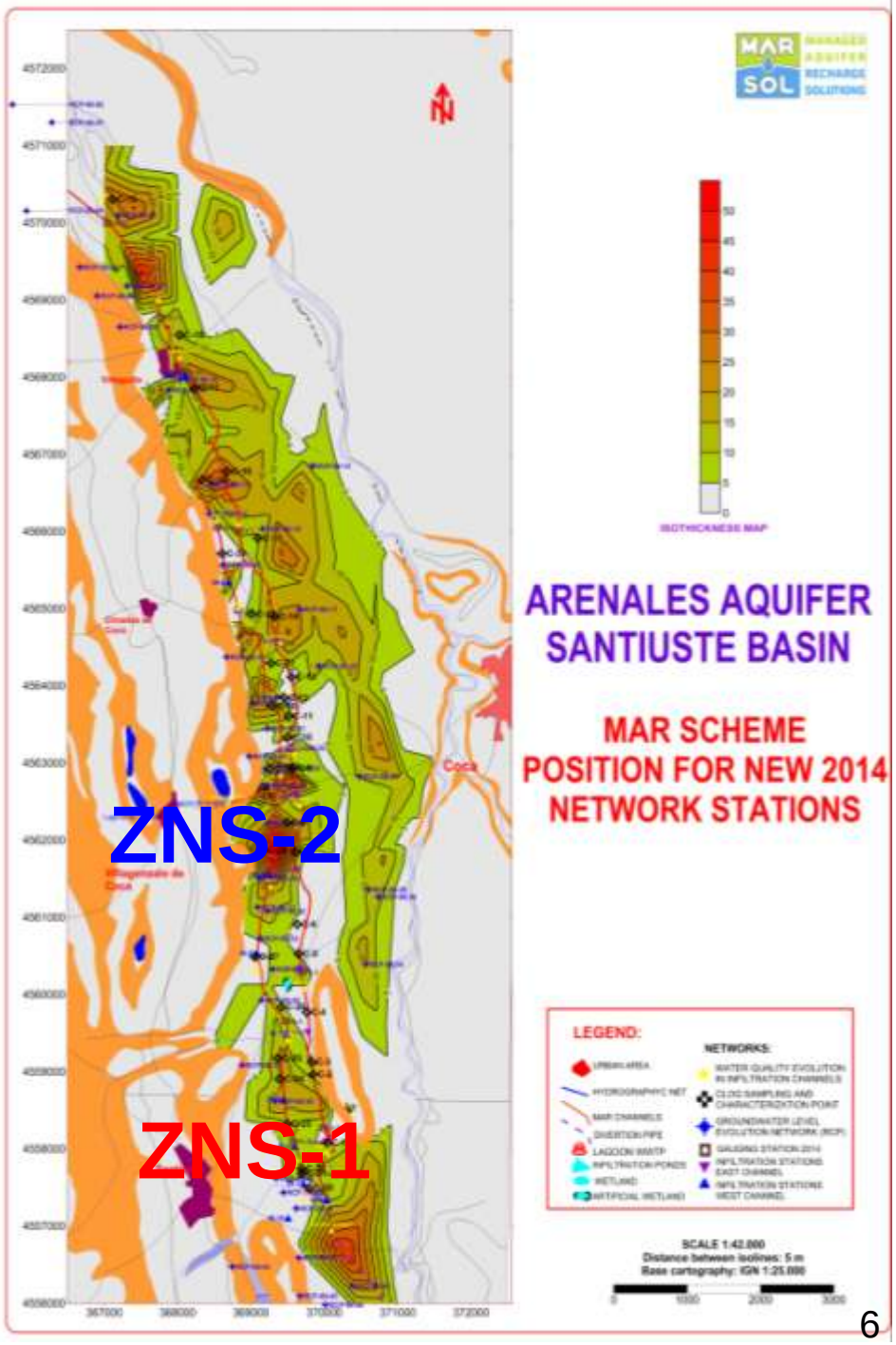
1. **GW table** evolution (54 points of water)
2. **GW and canals water quality** (45 + 15 points)
3. **Clogging** sampling stations (34 points)
4. **Gauging stations** along the MAR canals (20)
5. **Infiltration** test stations (20)
6. **UNSATURATED ZONE PARAMETERS RELATED TO MAR:** Three new stations to study U.Z. & gas clogging:
   - •ZNS-1 at Santiuste (Santiuste basin)
   - •ZNS-2 at Coca (Santiuste basin)
   - •ZNS-3 at Gomezserracín, Carracillo County.

E.G. SANTIUSTE BASIN

MONITORING NETWORKS:

1. WATER QUALITY EVOLUTION ALONG INFILTRATION CHANNELS
2. CLOG SAMPLING AND CHARACTERIZATION
3. GROUNDWATER LEVEL EVOLUTION (54 water points)
4. GAUGING STATIONS
5. INFILTRATION STATIONS
6. ZNS STATIONS

MAR SOL MANAGED AQUIFER RECHARGE SOLUTIONS



INTRODUCTION (3)

MOST RELEVANT DEVICES/SENSORS:

Measurements *in situ*

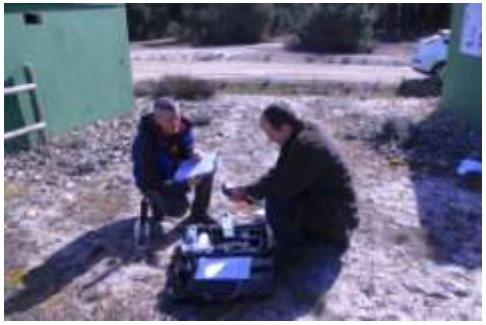
Hydro-level

Water layer thickness

Surface termometer

Microterm

Tensiometers



HI 9829 multiparametric meter

GW table, EC, Tª sensor

Off site

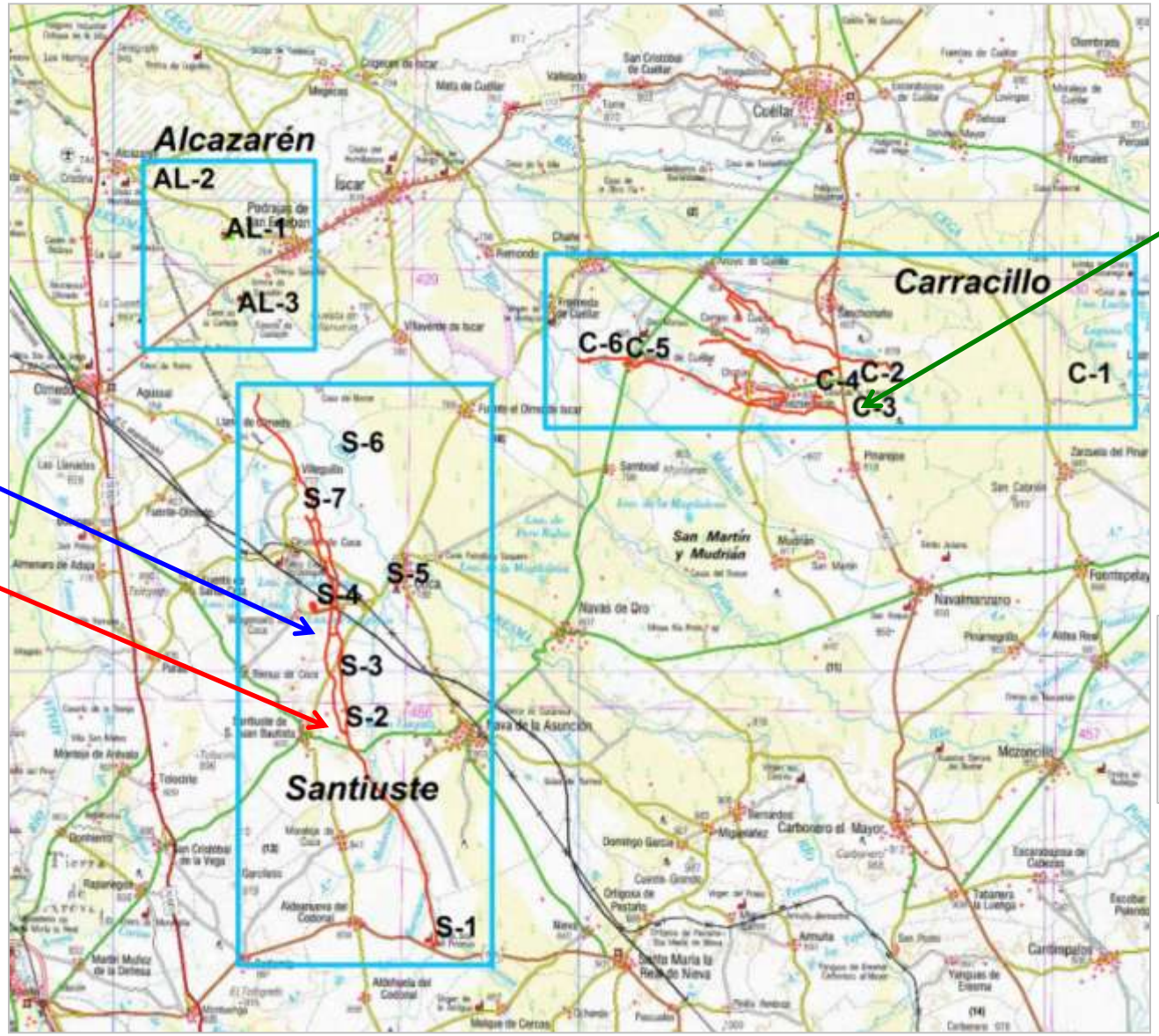
Tensiometers

Humidimeter/ Termometer

2- MARSOL ZNS STATIONS in the demo-site

ZNS-2

ZNS-1

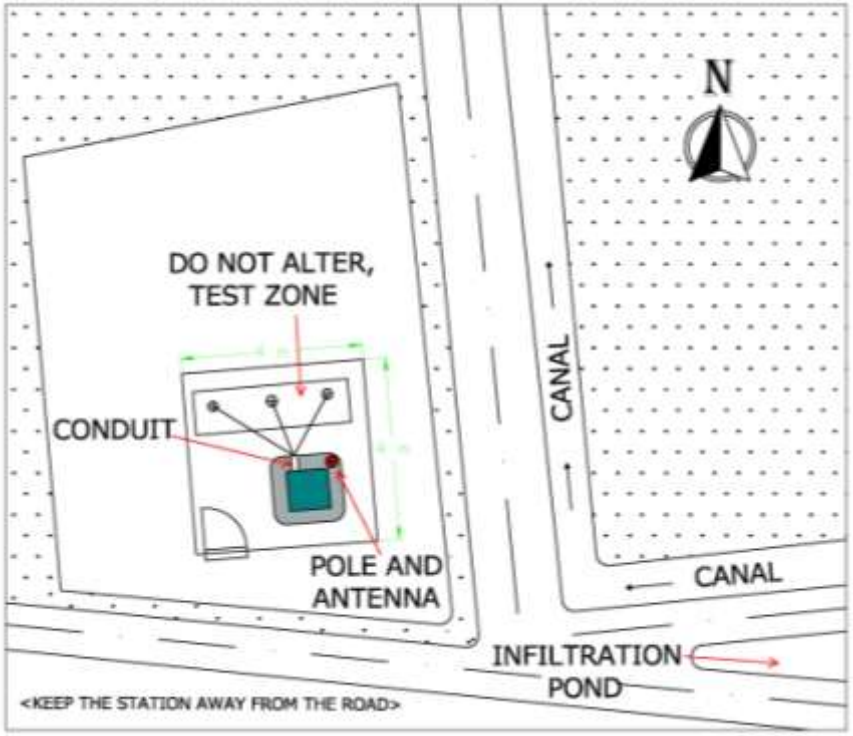


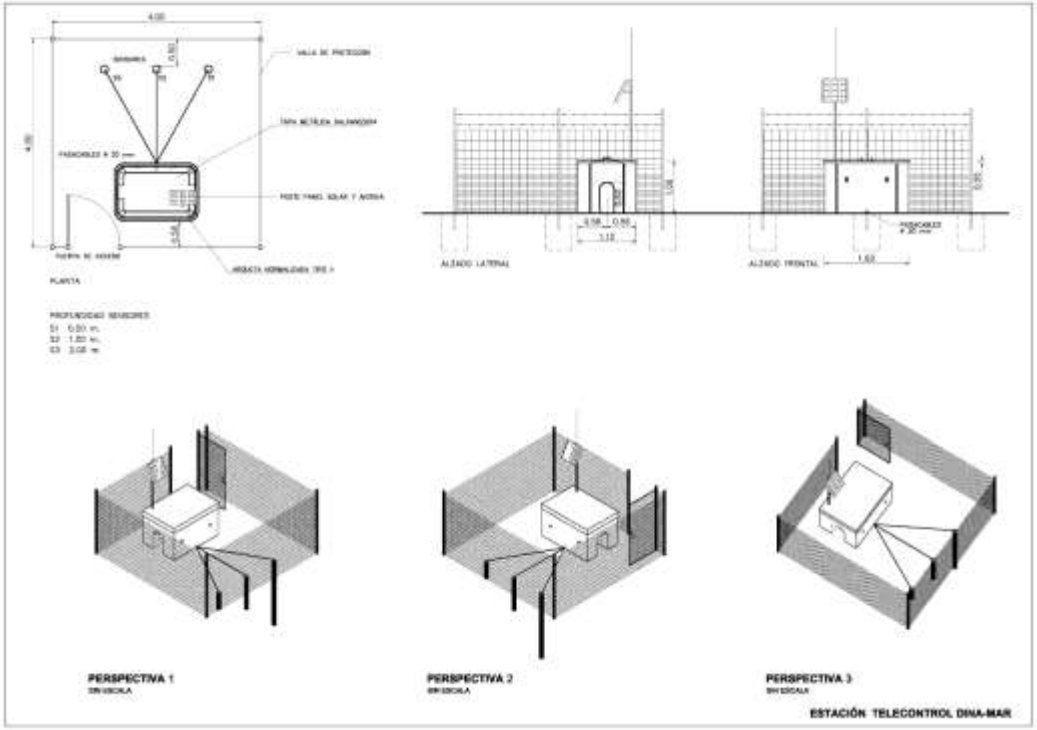
ZNS-3

2- MARSOL ZNS STATIONS
Foreseen use & targets

1. To study and determine the humidification bulb morphology and expansion from infiltration points (pond/canal)
2. To find out the influence of the humidification bulb on the unsaturated zone parameters as a key to design the best Soil &(SATs) Aquifer Treatment practices
3. To obtain accurate hydraulic parameters values as permeability (horizontal and vertical), transmissivity and their evolution along the year.
4. Effect of the fluid and its properties (density, viscosity, humidity, soil structure, water table depth, temperature of the soil, vegetation coverage, slope…) in the hydrogeological behaviour of water along MAR stages
5. To estimate the air volume trapped into the aquifer along MAR activities and its latter Lisse effect
6. Test the results of applying classical equations related to the unsaturated zone and changes in these formulae for this type of aquifer
7. To assess an accurate infiltration rate in order to solve the water balance equation
8. To have a test site under "over-controled" conditions to get trustable results, etc.

MARSOL ZNS-1 STATION





SCHEMES FOR THE MARSOL ZNS -1 STATION, NEXT TO SANTIUSTE VILLAGE

MARSOL ZNS-1 STATION (2)

Built close to the west canal in the heading of Santiuste basin
Sensors:

-2 IMKO 64 humidimeters-thermometers emplaced at 0.90 and 2.10 m depth

-1 SDEC SR1000 tensiometer with the capsule at 120 cm depth

- Campbell C-800 Data logger

-5 piezometers around.

TRIME-PICO is an intelligent soil moisture sensor with internal TDR-electronics for in situ monitoring of volumetric moisture in soils and other porous materials,
It measures 3 important parameters every 15 minutes:
-Water Content
-Temperature
-Electrical Conductivity (EC) and Salt Content

SDEC SR1000 is a ceramic tensiometer with a Bourdon type manometer and electronic capture.

ESTACIONES MARSOL ZNS PARA EL ESTUDIO DE LA ZONA NO SATURADA EN DISPOSITIVOS DE RECARGA GESTIONADA DE ACUÍFEROS

MARSOL MANAGED AQUIFER RECHARGE SOLUTIONS

Tragsa

DEFINICIÓN DE ZONA NO SATURADA (ZNS)

Está situada entre la superficie del suelo y el acuífero. Sirve como base para la vida terrestre, como soporte físico, para el crecimiento vegetal y el microbiano. Es el almacén de sustancias potencialmente contaminantes. En ella tienen lugar procesos físicos, químicos y biológicos.

En su estudio hay que tener en cuenta: Las transferencias de materia y energía que intercambian con la atmósfera, los acuíferos y los usos del suelo.

Más información en
http://www.marsol.eu
http://www.dina-mar.es

INSTRUMENTACIÓN

La instrumentación con la que cuenta cada estación de medida de la ZNS es:

- HUMIDÍMETRO: Utilizado para medir la humedad del suelo y el contenido en agua, basándose en la medición de la permitividad eléctrica.
- TERMÓMETRO: Utilizado para medir la temperatura del suelo a diferentes profundidades.
- TENSIÓMETRO: Mide el potencial hídrico en suelos (estado de humedad) o cantidad de agua útil que hay en el terreno. Consta de un tubo alargado que finaliza en una cápsula porosa, que permite el intercambio de humedad entre la tierra y el interior del tubo.

Fotofrafía de uno de los humidímetros.

Detalle de la extensión que posee el humidímetro.

Fotografía de uno de los tensiómetros.

Detalle del medidor que posee el tensiómetro.

Fotografía de la estación MARSOL ZNS-1.

Ortofoto en la que se muestra el emplazamiento de la Estación MARSOL ZNS-1.

DESCRIPCIÓN

Las estaciones MARSOL ZNS se encuentran en las inmediaciones del canal de recarga artificial y han comenzado a estar operativas en noviembre de 2014.

Registran datos en tiempo real de la tensión capilar, temperatura y humedad in situ.

Cada estación consta de un tensiómetro y dos humidímetros instalados entre 0,5 y 2 metros, que registran en continuo 5 parámetros. Están dispuestos de tal modo que detectan y cuantifican el avance del bulbo de humidificación, permitiendo conocer su morfología, hasta la saturación.

El estudio de la variación de agua almacenada en el acuífero se está realizando a partir de la medición de una Red de Control de la Piezometría (RCP).

Fotografías de la Estación MARSOL ZNS-2.

Ortofoto en la que se muestra el emplazamiento de la Estación MARSOL ZNS-2 y parcelario dentro del que queda ubicada.

OBJETIVOS

Las estaciones han sido construidas en el marco del proyecto de gestión de la recarga de acuíferos MARSOL, que financia el Grupo Tragsa y la Comunidad Europea, con los siguientes objetivos:

- Conocer mejor la morfología del bulbo de humidificación desde los canales de recarga gestionada.
- Conocer cómo influye el bulbo de humidificación en los parámetros de la ZNS, factores determinantes de las técnicas de Tratamiento de Suelo y Acuífero (SATs) a adoptar.
- Cuantificación de la tasa de avance (H y V) del agua de AR.
- Influencia de la capilaridad en el flujo (tensión superficial, densidad del agua, viscosidad del fluido, gravedad, humedad, estructura del suelo, profundidad del nivel del agua, temperatura del suelo, cultivo, pendiente, etc.).
- Estimación del aire entrampado en el acuífero durante la recarga artificial (efecto *Lisse*).
- Comprobación de los resultados de aplicar ecuaciones clásicas del estudio de la ZNS y formulación de una expresión especifica para este tipo de acuíferos.
- Conocer mejor la tasa de infiltración para el cierre del balance hídrico.

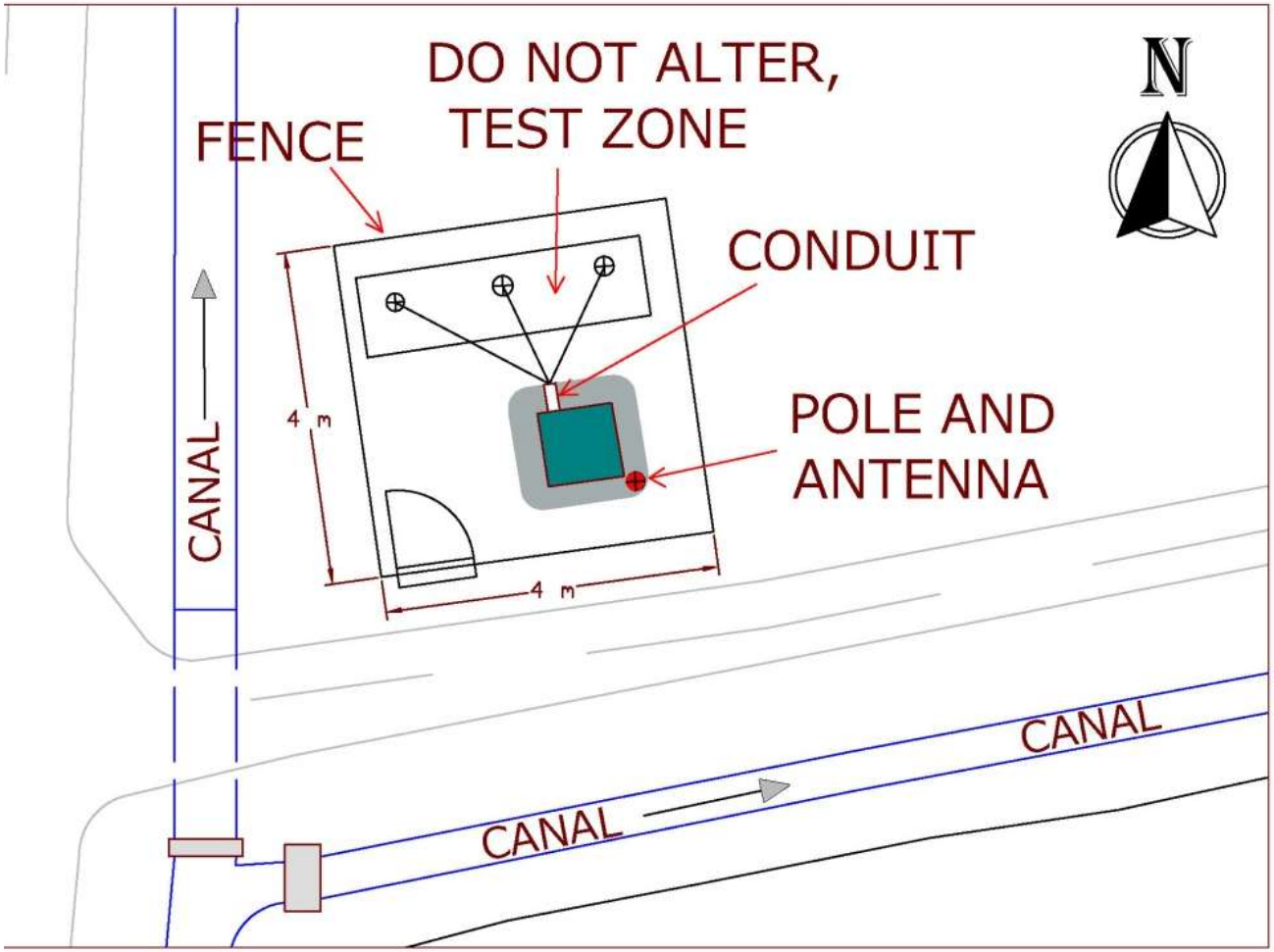
Detalle del aspecto que presenta el humidímetro, una vez que está colocado.

Instrumento que, conectado al humidímetro, nos informa sobre la permitividad y la temperatura de la ZNS.

This initiative takes place in the framework of "FP7-ENV-2013 MARSOL (GA 619.120). Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought (WPS)"d3 with the support of the European Commission, however it reflects the views only of the authors, and the Commission cannot be held responsible of any use which may be made of the information contained therein. http://www.marsol.eu

European Commission

MARSOL ZNS-2 STATION



SCHEME FOR THE MARSOL ZNS -2 STATION, NEXT TO COCA VILLAGE

MARSOL ZNS-2 STATION

Twin of ZNS-1 and built in a canal cross

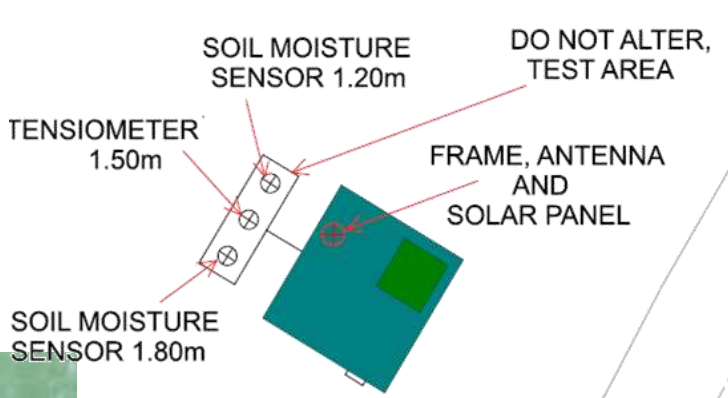
It is composed by the following sensors:

-2 IMKO 64 humidimeters-thermometers emplaced at 0.75 and 1.75 m depth
-1 SDEC SR1000 tensiometer
-Campbell C-800Data logger
-3 closed piezometers

MARSOL ZNS-3 STATION

Components MARSOL ZNS-3 station (first stage):

-2 IMKO 64 humidimeters-thermometers at 0.80 and 1.80 m depth.
-1 Eijkelkamp T4 tensiometer.
- Campbell 800 Data logger (IP connection).
-10 piezometers around.



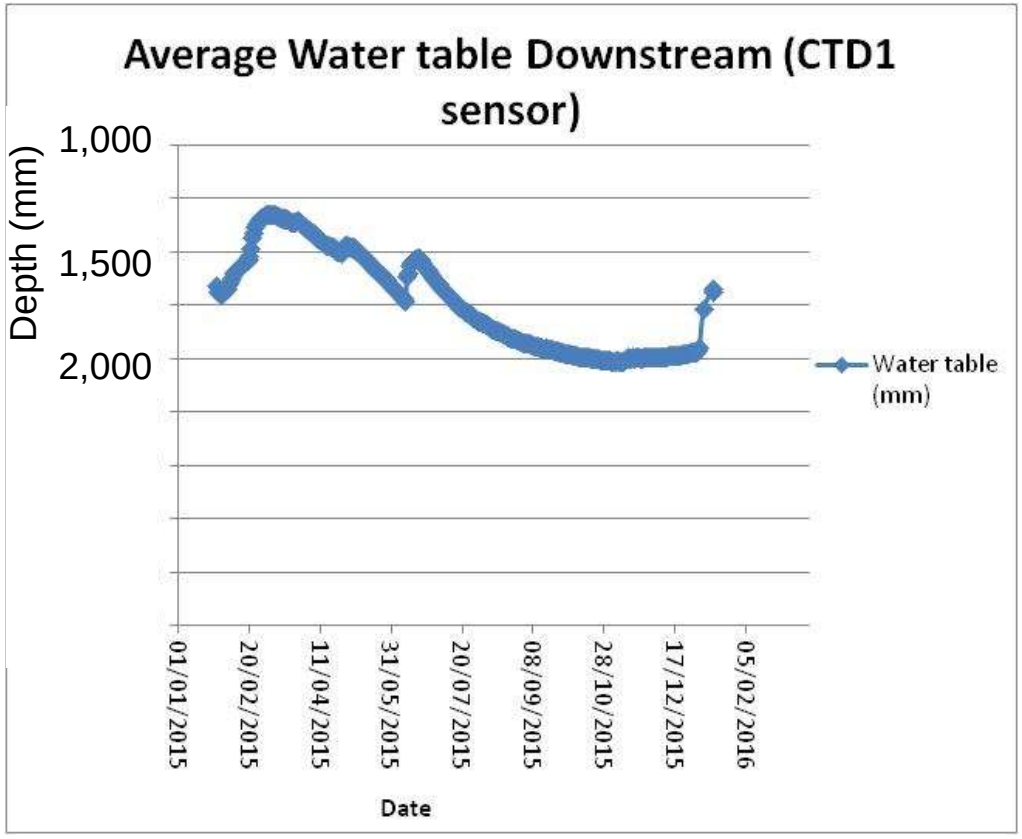
MARSOL ZNS3 STATION (2)

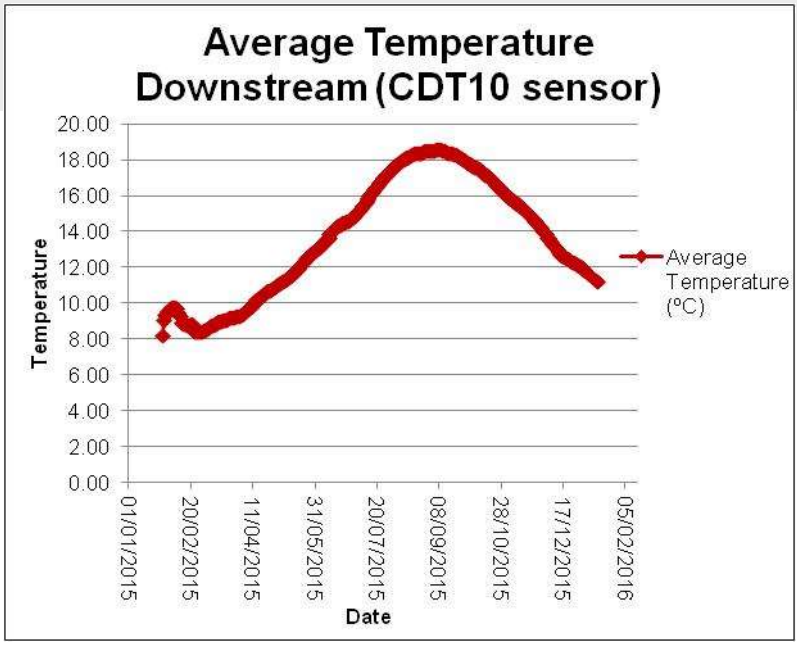
Second stage:

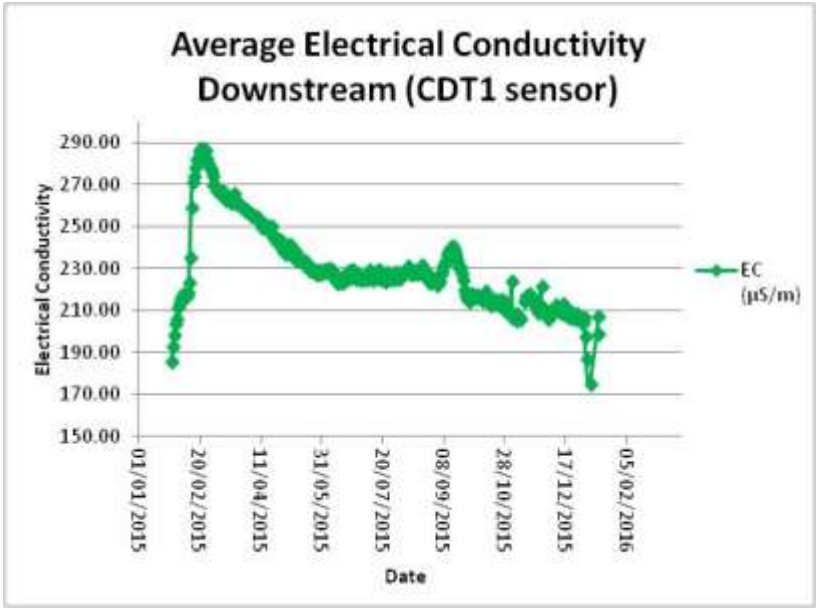
-2 Sensor Downstream (CTD-10 Decagon)
up and down GW flow to measure GW depth evolution, EC and T[a]

SCHEME FOR THE MARSOL ZNS -3 STATION, NEXT TO GOMEZSERRACÍN VILLAGE

MARSOL ZNS3 STATION (3)







ZNS-3 Station – Sensor Downstream (Decagon CTD-10)

SOME RESULTS UP TO DATE FROM ZNS DATASETS

- **Temperature keeps an inverse correlation with humidity variations**
- **Generally speaking, any climate incident is easy to detect in charts**
- **The sensors and the piezometers measures confirm the assimetric morphology of the humidification bulb and its convex-concave profile**
- **According to the advance of the bulb, Kh values are about 4 - 5 m/d & transmissivity 1,200-1,400 m^2/d (in the upper limit of the interval referenced in MAPA, 2005)**
- **Infiltration rates are smaller to those measured by other methodologies (about 15 m/d for K_h and 0.5 for K_v (MAPA, 2005)**
- **Natural recharge is slightly smaller than the HELP model s results reported in MAPA and in Fdez. Escalante, 2005**
- **The input stream and residual hidraulic charge obtained from Ernst and Kraijenhoff van de Leur equations are not satisfactory in both cases. Radial resistance is excessive for Ernst equation and K_h is about a half of direct real measures for Kraijenhoff van de Leur equation**
- **About gas clogging and Lisse effect, sensors detect declines in the humidity previous to saturation. This fact is interpreted as a push of the trapped bubbles as the bulb expands.**

3- PROBLEMS AND SOLUTIONS

PROBLEMS

- **Data** from **different formats and origins**
- Failures of **telecommunications coverage**
- Field conditions require **robust** sensors
- **Vandalism**, this is one of the biggest problem in monitoring
- **No alerts**

SOLUTIONS

- **Establish early warning** and response **systems**
- Identify **patterns of behaviour**
- Devices **protection**: fences, padlocks, surveillance cameras, etc.

- **Interoperability**
- **Internet of Things**: Digital connection of daily objects, anytime-anywhere.

ICT SOLUTIONS

INTEROPERABILITY

Hability of two or more systems of heterogeneous components: to

- **exchange information and use the exchanged information (IEEE).**
- **interact each-other without restrictions**
- **interconnect independently of the way they work**
- **read the information in the same way**

TO GUARANTEE INTEROPERABILITY → STANDARIZATION

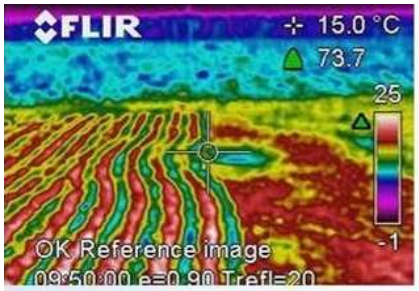
ICT SOLUTIONS

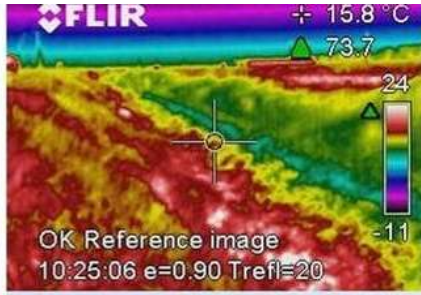
INTERNET OF THINGS (IoT)

- **Digital Interconnection of objects daily through Internet**
- **At any time-anywhere**
- **Any object identified interacts with others**
- **Any object to be able to register, process, store and transfer data**
- **Deployers: Manufacturers, application developers, managers social network operators, users, MARSOL PARTNERS…**
- **Infrastructure: Sensor, fixed, mobile networks, integrated systems**

4- ONGOING LINES OF ACTION

- **Tests and interchange of developments with alternative low cost sensors/storage devices to replace expensive data-loggers…**
- **Use of metal bars as antennas against vandalism (double use)**
- **Integrated applications: Big Data, Internet of Things and governance**
- **Common measurement system and INTEROPERABLE language for the WHOLE CONSORTIUM**
- **A final equation to relate gas clogging and tensiometer measures is about to be exposed**
- **Thermography advances.**





5- CONCLUSIONS

- The **datasets** are a really **important component of MARSOL** project, but "***not so easy to obtain***"
- It is important **to establish** a **common measurement procedure** for the whole consortium: **automatization + interoperable elements**
- At Los Arenales, the knowledge on humidification bulb shape and gas clogging evolution has increased lately but there **remain some steps to walk**
- The selections of **low cost and robust sensors are making** monitoring easier
- **ICT solutions** contribute to achieve a **greater water management efficiency**
- Detailed description of the ZNS stations at www.dina-mar.es

ISMAR 10
INTERNATIONAL SYMPOSIUM OF
MANAGED AQUIFER RECHARGE
MADRID, 2019 MAY

6- LAST *REMARKS*

ISMAR 10 PAN-EUROPEAN NETWORK

+Saphani

6- LAST *REMARKS*

Even donkeys are interested in M.A.R.!!!

Tragsa
GrupoTragsa

MAR SOL
MANAGED AQUIFER RECHARGE SOLUTIONS

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Thank you!

2016 March

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Pooling resources – Innovating water

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