TWO DAYS TRAINING ON THE OPERATION AND MANAGEMENT OF WWTPS

9-10 September, Murcia

Managing Reclaimed Water

Presented by: Dr. Francisco Pedrero Salcedo

Introduction to agricultural use of reclaimed water

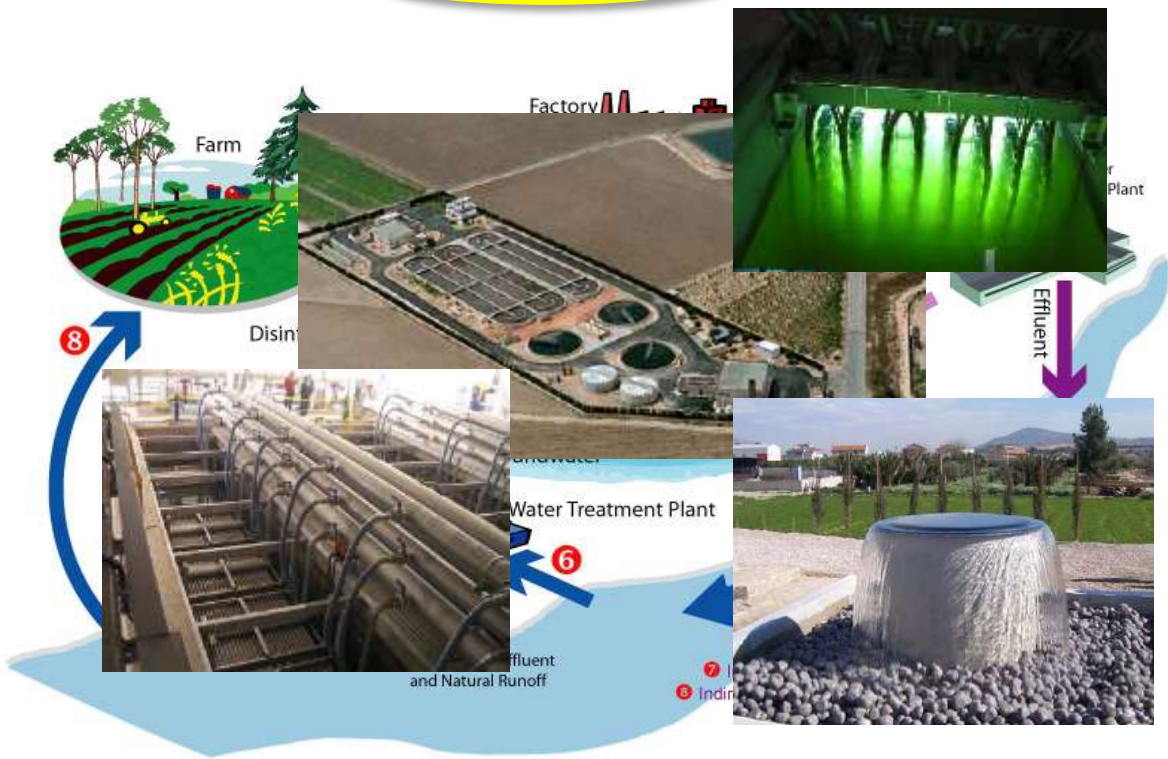
IRRIGATION WATER **DEMAND** MANAGEMENT

WATER SAVINGS

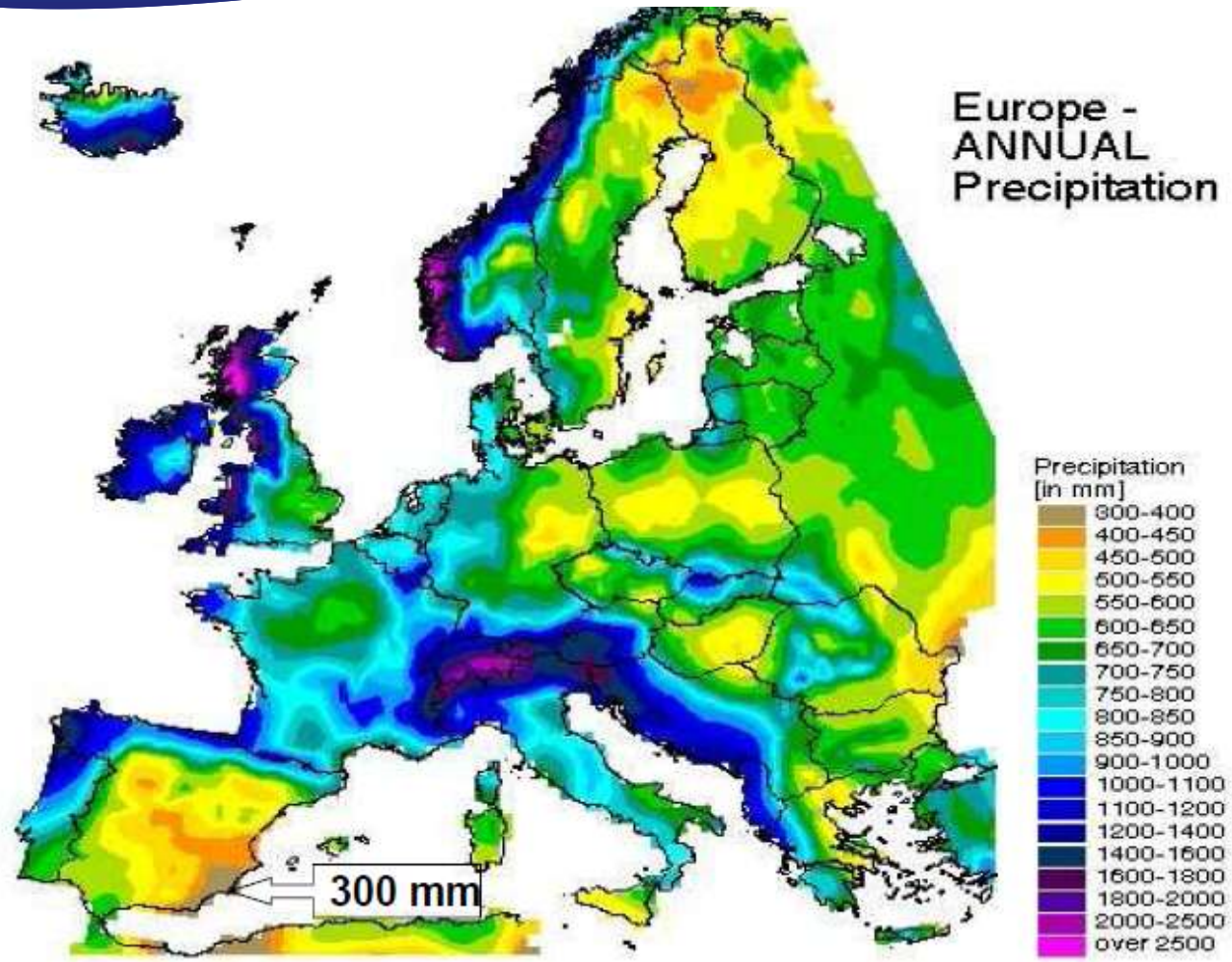
- ✓Cropping pattern
- ✓Efficient water application
- ✓Precise irrigation scheduling (..GIS)
- ✓Deficit irrigation strategies
  - *Sustained water deficit*
  - *Partial root zone drying*
  - *Regulated deficit irrigation*
  - *Supplemental irrigation*

NON CONVENTIONAL WATER RESOURCES

- ✓Sea water
- ✓Drainage water
- ✓Harvested precipitations
- ✓Reclaimed water



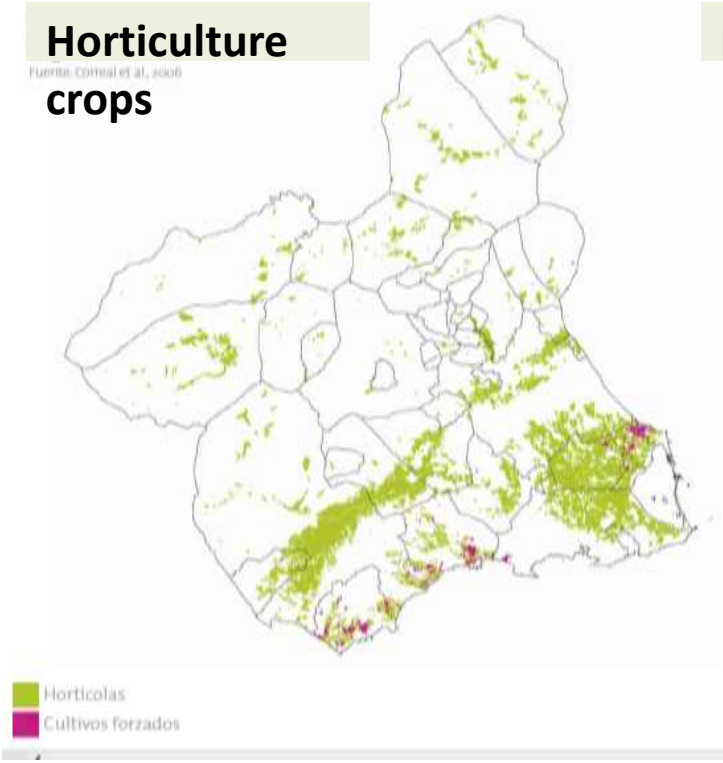
Rainfall


Europe -
ANNUAL
Precipitation
Precipitation
[in mm]
300-400
400-450
450-500
500-550
550-600
600-650
650-700
700-750
750-800
800-850
850-900
900-1000
1000-1100
1100-1200
1200-1400
1400-1600
1600-1800
1800-2000
2000-2500
over 2500
300 mm

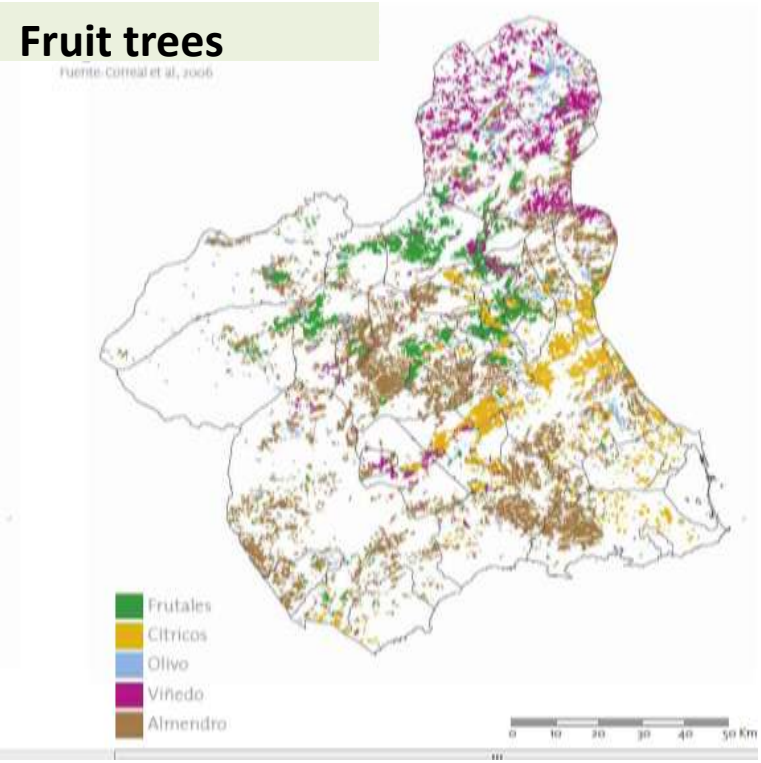
Agriculture in Murcia

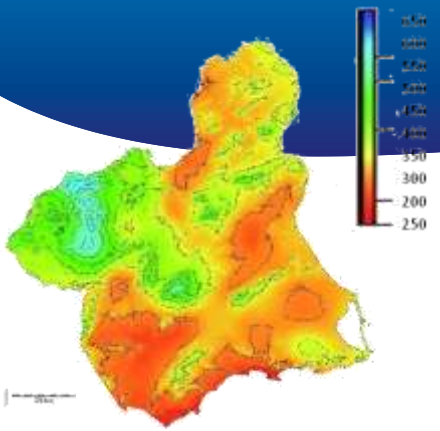
- 336.000 cropped ha (122.000 vegetables – 214.000 fruit trees)
- 170.000 irrigated (85% drip irrigation)

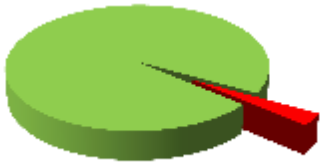
Horticulture crops



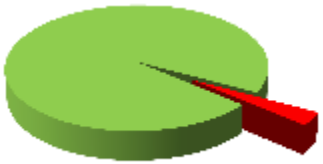
Fruit trees







3,1 %



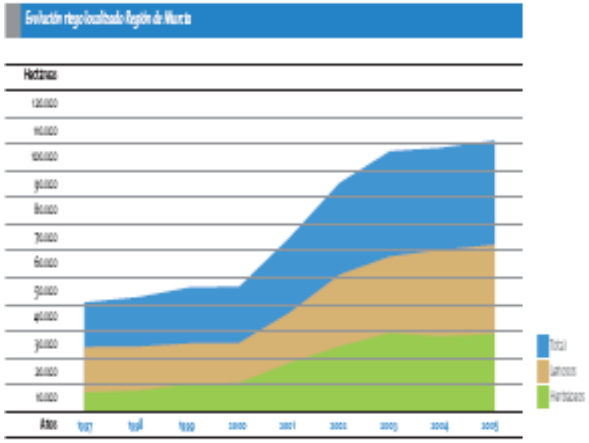
3,3 %

Vegetables and fruit export

20,0 %

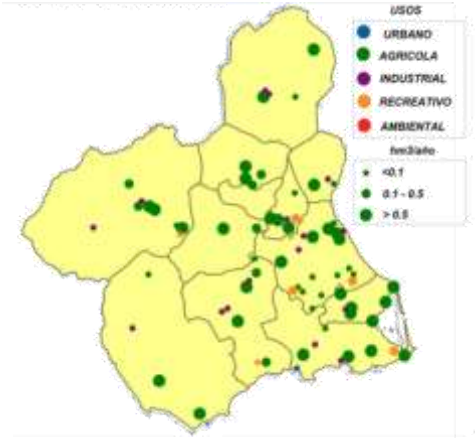
Modernization

80-90 %



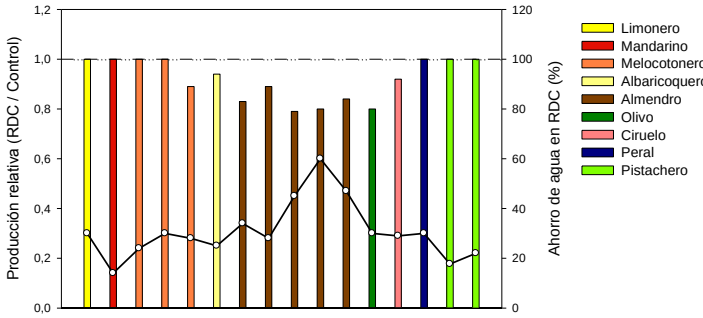
Reuse

92 WWTP- 102 Hm³/year



Deficit management

Regulated deficit irrigation



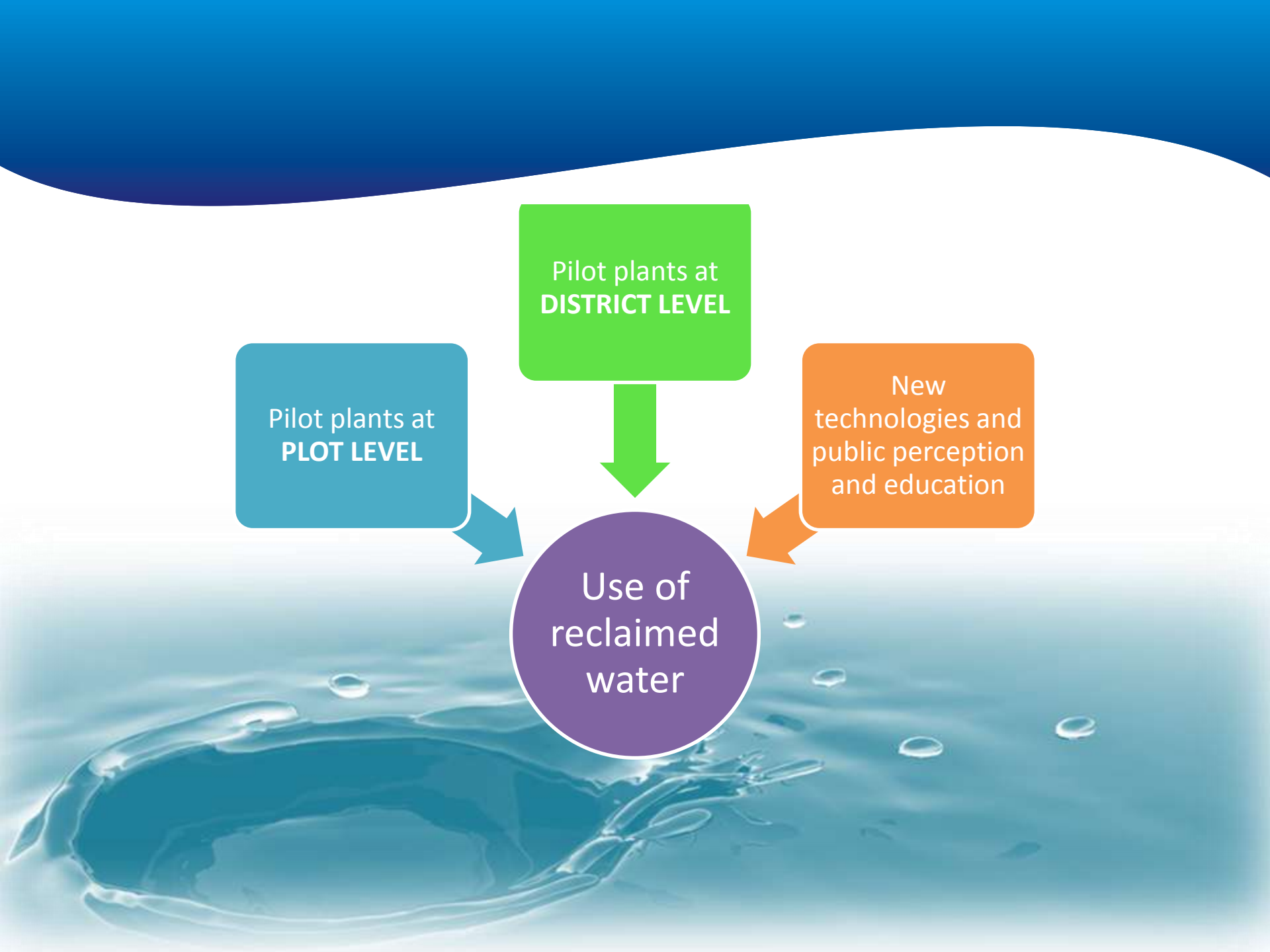
Accumulation/concentration salt??

Characteristic features of irrigation in the Mediterranean Region

-Predominance of smallholdings

- Wide variety of crops grown in one single irrigation zone

- Presence of irrigation channels and drainage ditches where the reclaimed water is mixed with other sources


Pilot plants at **DISTRICT LEVEL**
Pilot plants at **PLOT LEVEL**
New technologies and public perception and education
Use of reclaimed water

Pilot plants at plot level

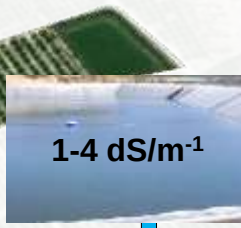
-A network of experimental plots in different Mediterranean locations and different types of reclaimed water and crops.

-The effect of using reclaimed water on tree physiology, performance, quality and safety of crops

- Effects on the long and medium term effect on soil salt accumulation, unsaturated area and groundwater pollution.

Orchard : Lo Montero
Province : Campotejar-Murcia

Irrigators association



WWTP

Tajo-Segura

Experimental plots

Grapegruit

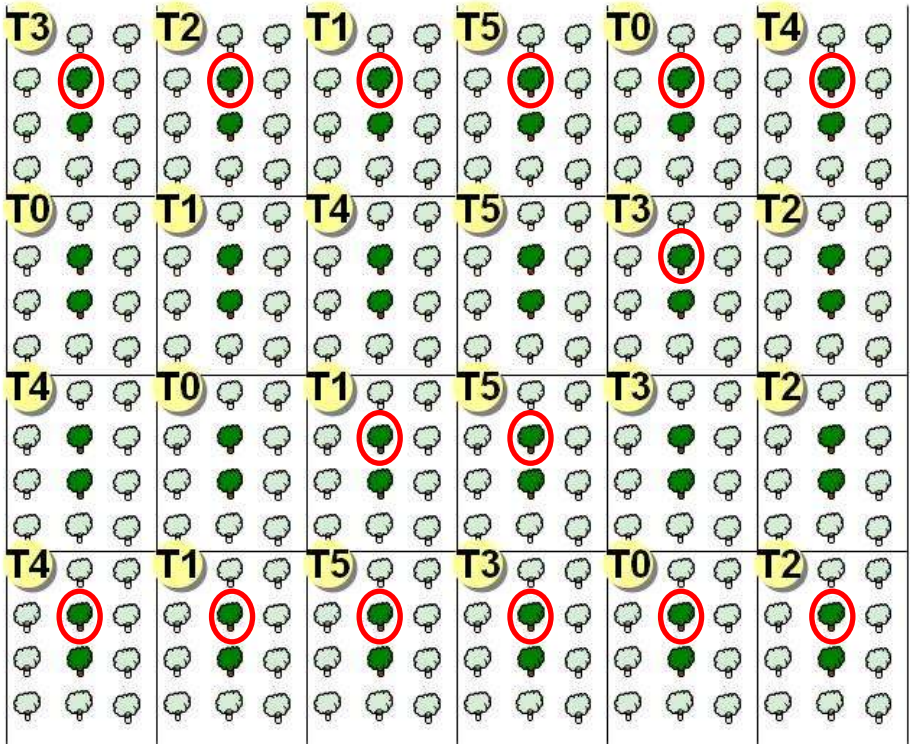
Mandarin

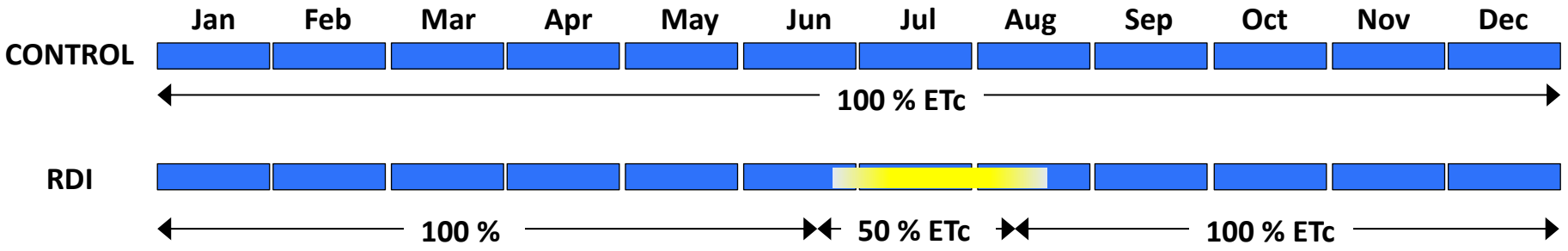
Variety	: Star Ruby	: Orogrande
Rootstock	: Macrophyla	: Carrizo
Age	: 6 years (2007)	: 10 years (2007)
Plant spacing	: 6 * 4 m	: 3.5 * 5 m

Experimental design

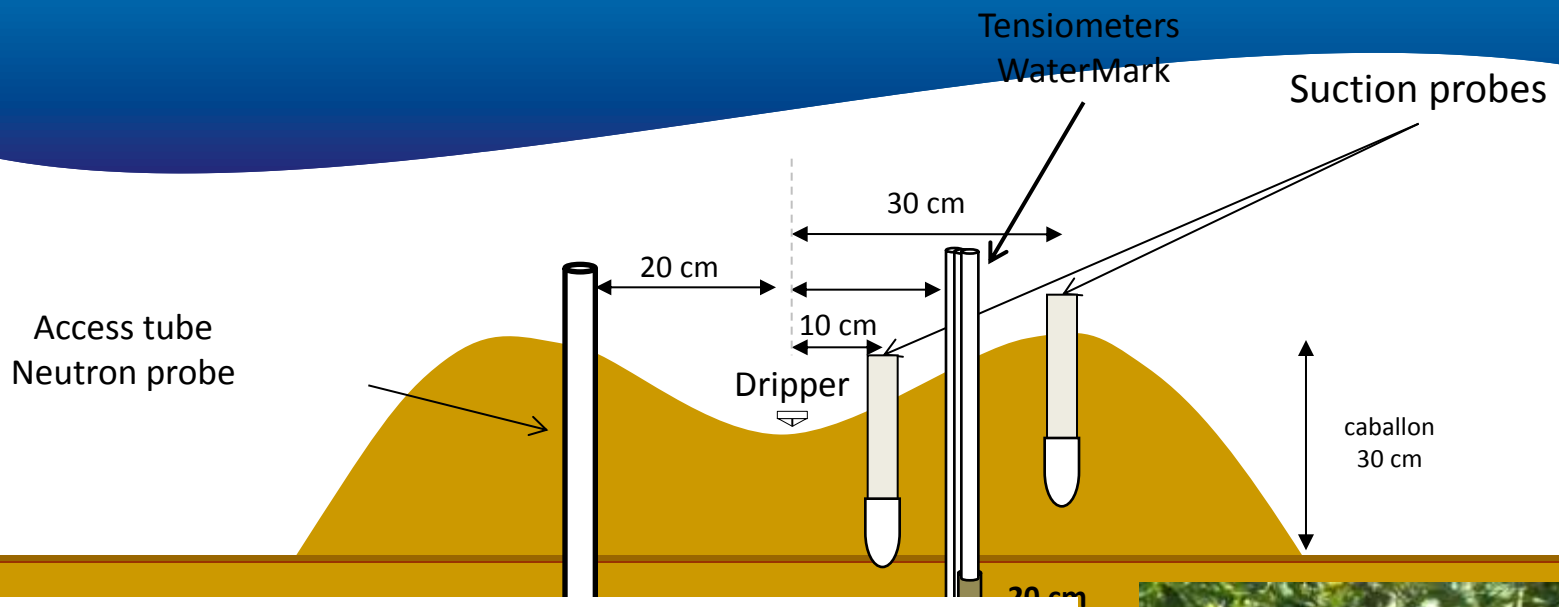
Irrigation Treatments

- **Transfer water**
  - TW-**C**
  - TW-**RDI**
- **Reclaimed water**
  - RW-**C**
  - RW-**RDI**





Equipment and soil measurements



15 days

- Soil water content
- Matric soil water potential
- Soil solution water quality

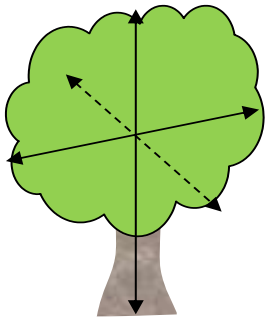
Periodic measurements

- Salts accumulations at different depths
- Leaf mineral status

Equipment and plant measurements

Periodic plant measurements

Tree
Canopy



Fruit
Diameter, fruit set

Stem water potential

Leaf gas exchange

Harvest

Yield assessment

Production
(kg.tree^{-1})

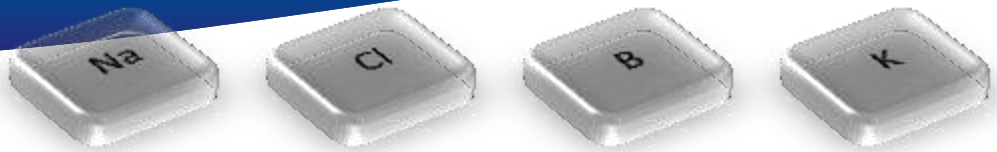
Diameter distribution

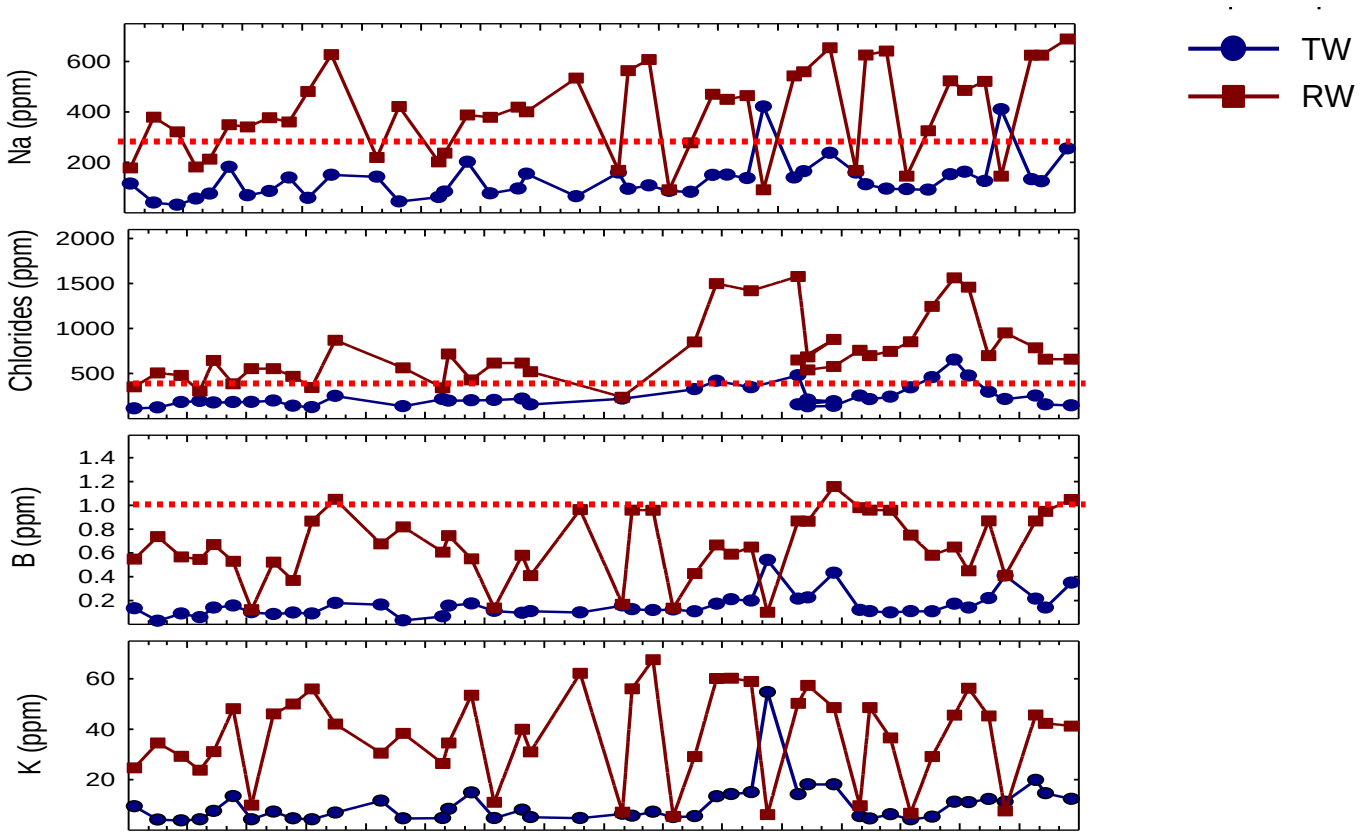
Quality indexes

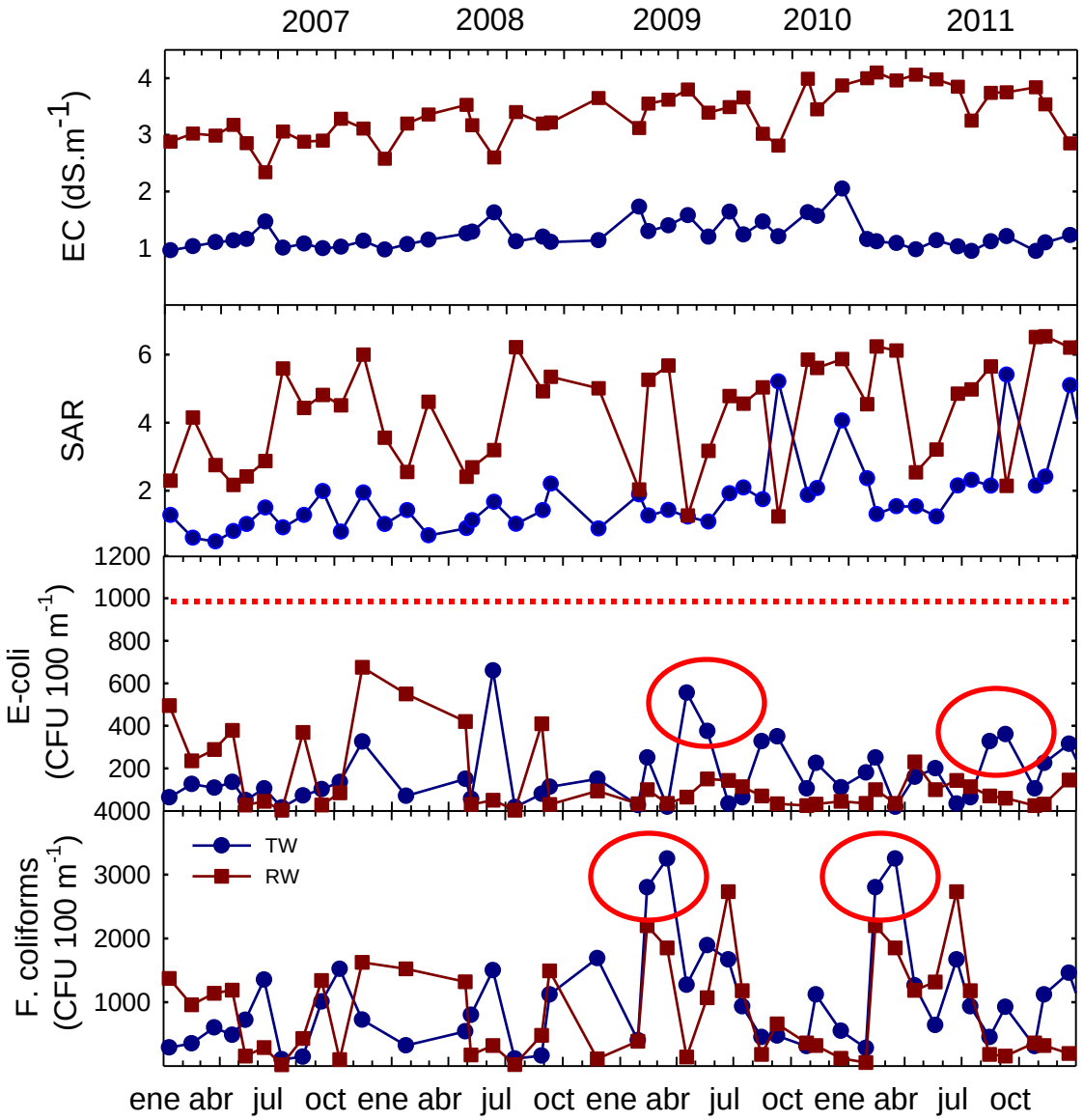
- ❑ TA
- ❑ pH
- ❑ SSC
- ❑ Vitamin C

Fruit safety

Results. Irrigation water quality





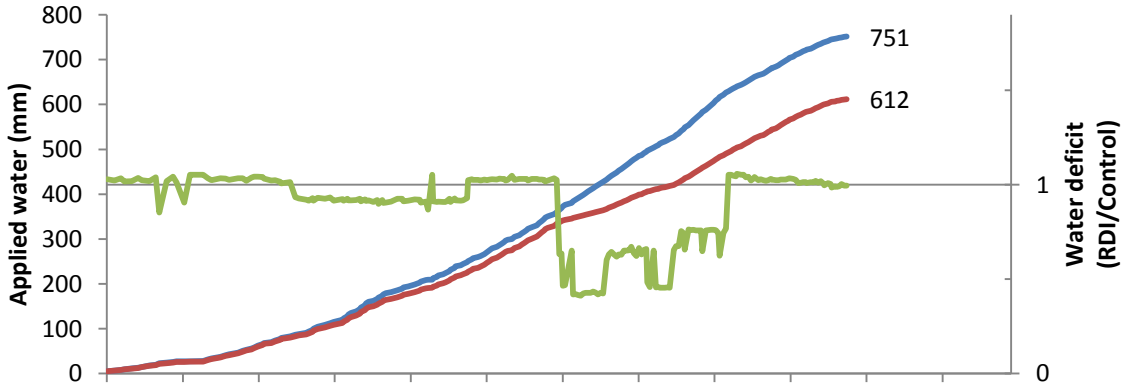

2007
2008
2009
2010
2011
EC (dS.m-1)
SAR
E-coli (CFU 100 m-1)
F. coliforms (CFU 100 m-1)
TW
RW
ene abr jul oct ene abr jul oct ene abr jul oct ene abr jul oct

RD 1620/2007

Water needs and saving

Mandarin

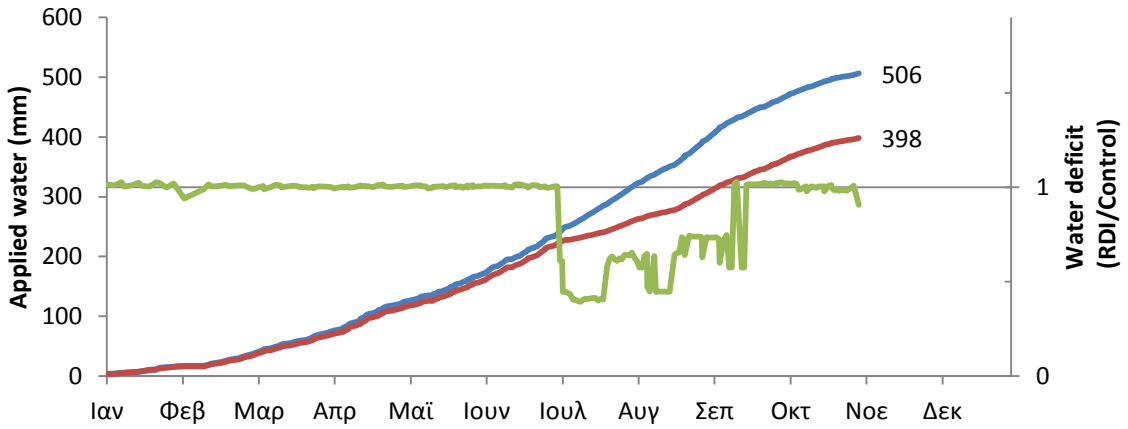
Save 19 %



Grapefruit

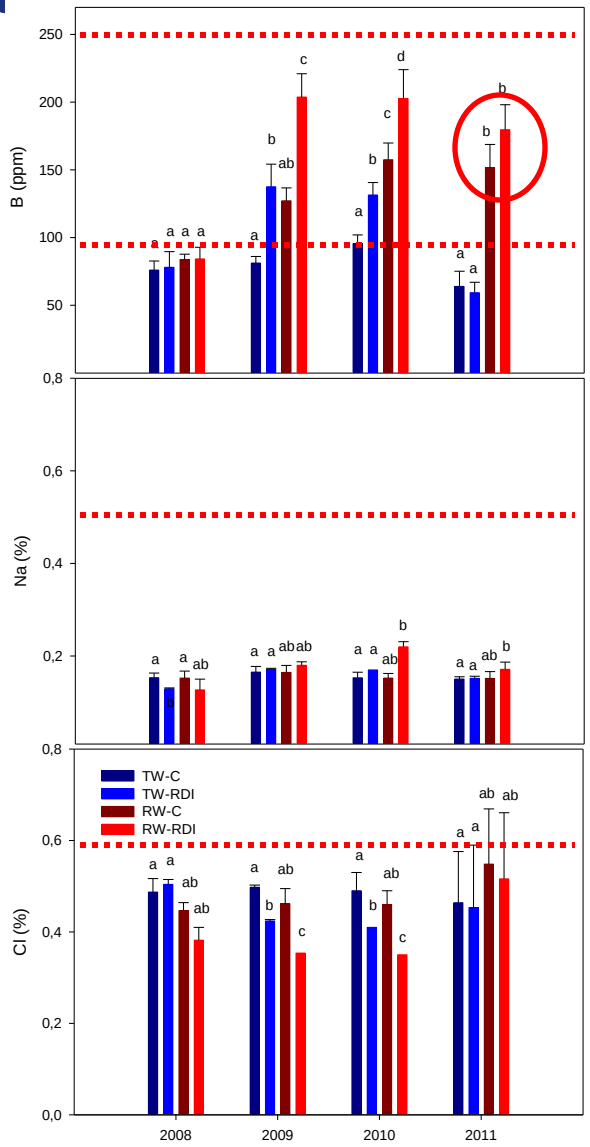
Save 21 %

(≈1000 $m^3.ha^{-1}$)

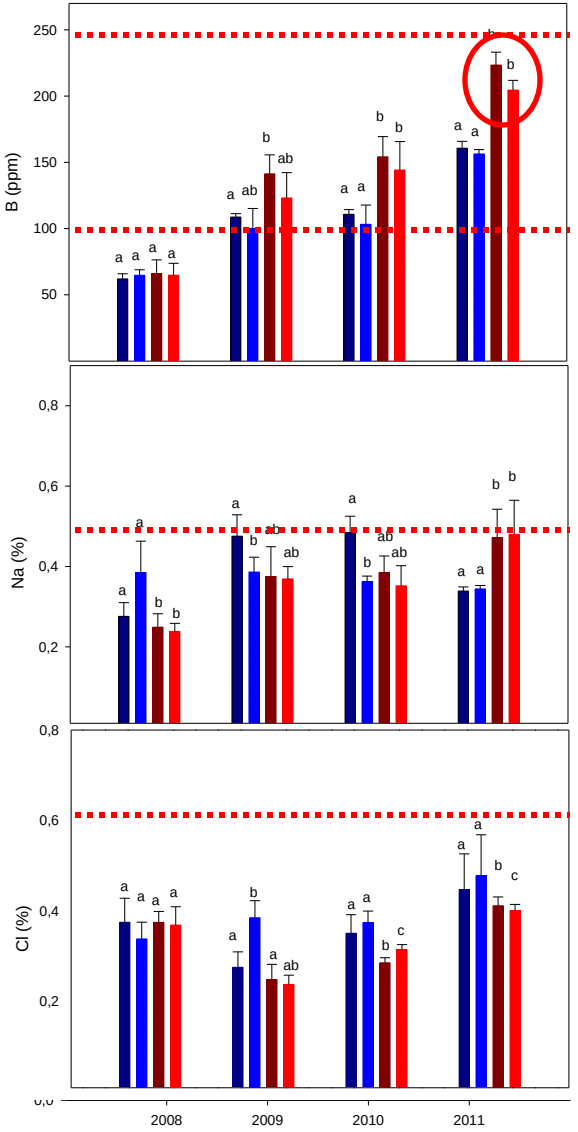


Leaf mineral status

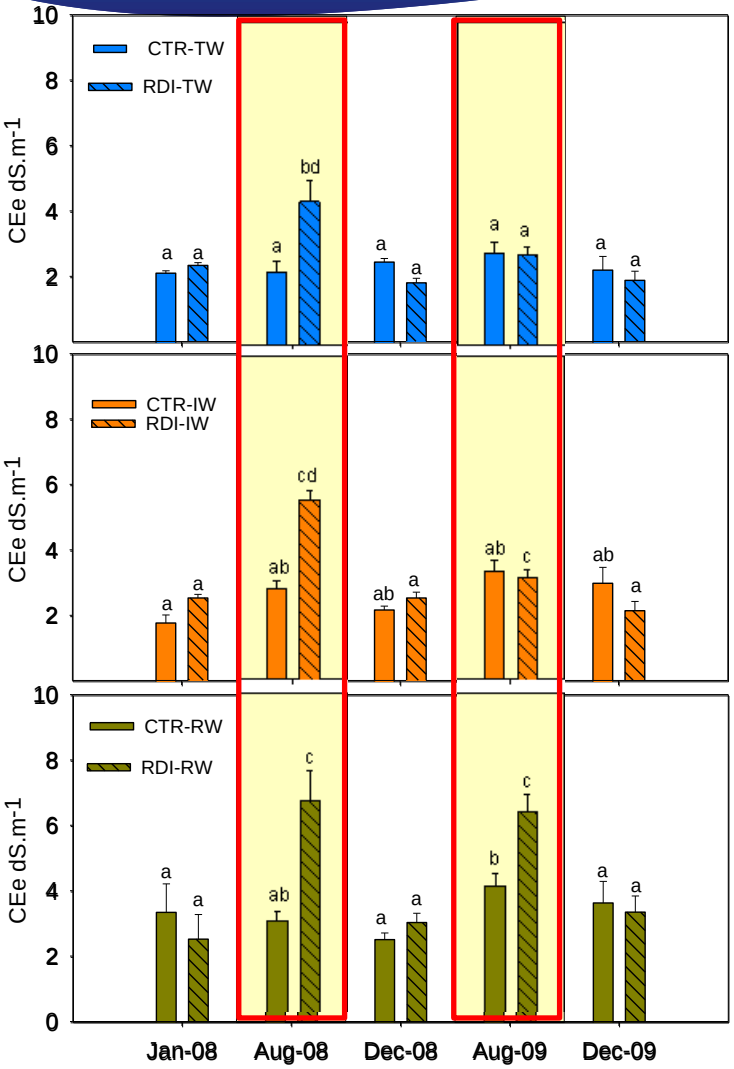
Mandarin

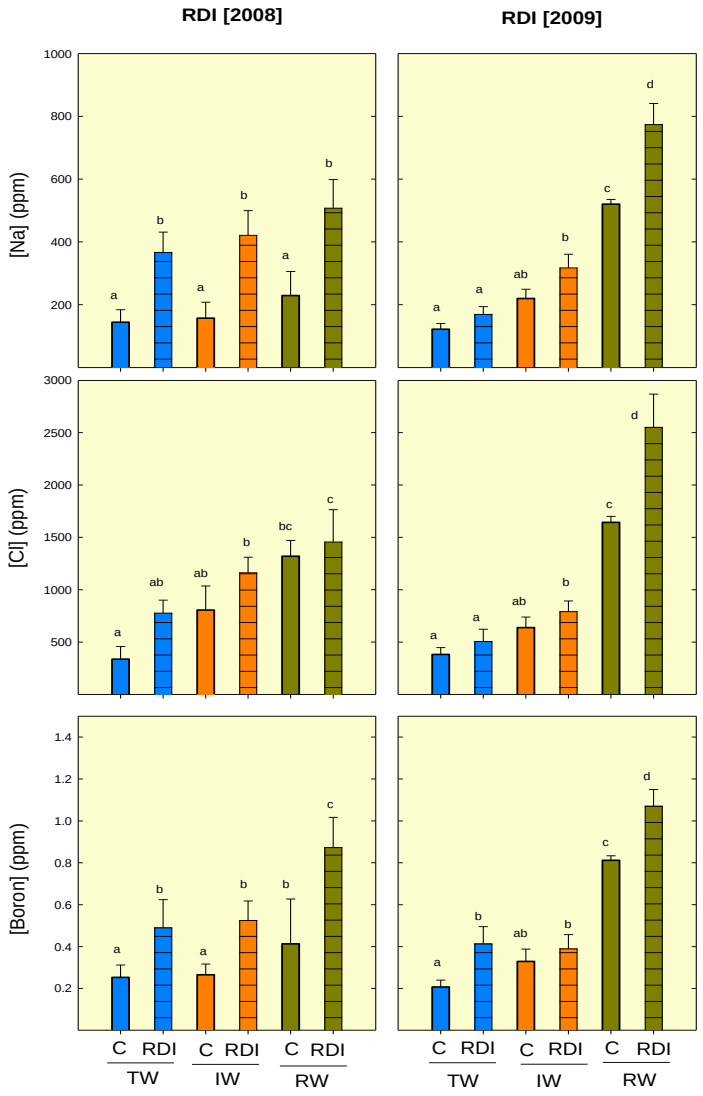


Grapefruit



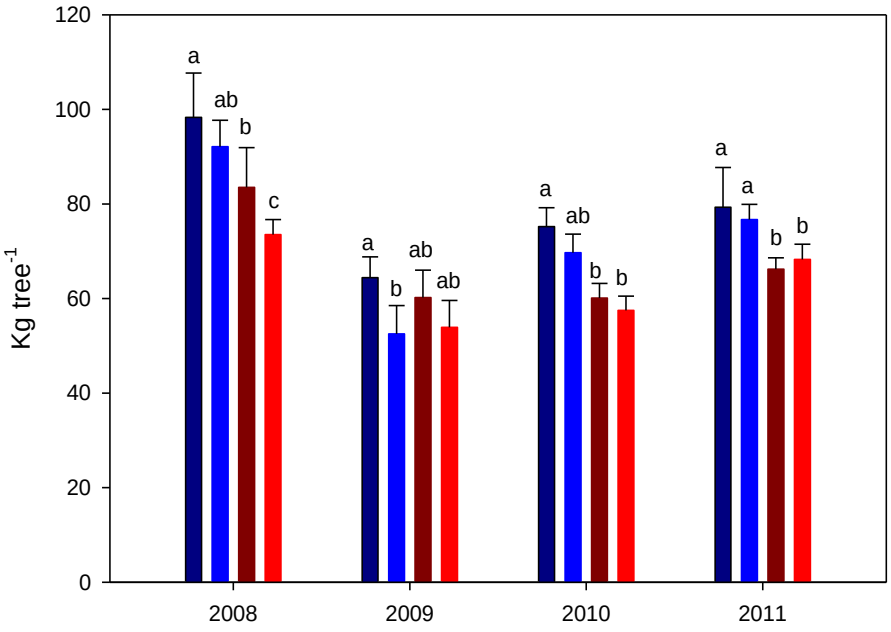
EC (dS.m^{-1}) of the soil saturated paste extract & the soil solution



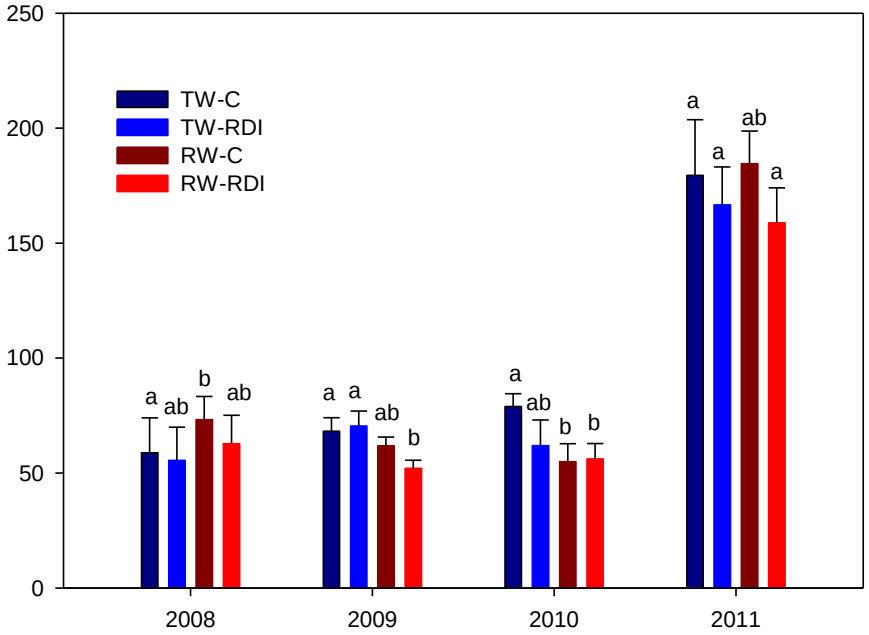


Yield

Mandarin



Grapefruit



Fruit quality parameters

Treatment	Peel thickness (mm)	Juice volume (ml)	º Brix	pH	Total Acidity	Maturity Index	Vitamin C
TW-CTR	2,52 ± 0,75a	53,00 ± 13,05a	11.6 ±0.7a	3.6 ±0.1a	0,9 ±0.1a	12,8 ±1.5a	8,5 ±0.6a
TW-RDI	2,20 ± 0,44a	53,80 ± 14,81a	12.0 ±0.4a	3.7 ±0.0a	0,9 ±0.0a	13,8 ±0.6a	11,0 ±0.4b
RW-CTR	2,43 ± 0,43a	61,33 ± 14,32a	12.2 ±0.9a	3.7 ±0.1a	1,0 ±0.1a	11,9 ±0.8a	13,8 ±1.1ab
RW-RDI	2,57 ± 0,48a	57,53 ± 12,71a	12.7 ±1.0a	3.6 ±0.1a	1,1 ±0.1a	11,8 ±0.6a	17,7 ±0.6c

LONG TERM EFFECTS?

ON THE OTHER HAND…

Conclusions

General

- A tendency to **reduce the number of fruits** was detected under **RW treatments**. This reduction was more pronounced under regulated deficit irrigation (RW-RDI treatment).
- Combined effects of RDI strategies and reclaimed water **increased some fruit quality parameters** on mandarin trees. [**Vit.C**] RDI-RW > RDI > Control treatments.
- RW is **safe resource** for irrigation of fruit trees.

✓ Sustainability concerns and technological advances are continuously **augmenting the volume of reclaimed water**.

✓ **Increasing demand and water shortage** conditions are pushing forward using **reclaimed water** for irrigation in modern agriculture.

✓ **[Na], [B] and [Cl] exceeded the phyto-toxic levels** in reclaimed irrigation-water. Although no toxic problems have been detected during the experiment, some mild toxicity symptoms started appearing during the last year and therefore long term effects could be more pronounced.

- Irrigation with reclaimed water tends to **accumulate salts** within the plant root zone. Therefore, **careful monitoring** is needed to avoid possible reduction in the soil agronomic properties.

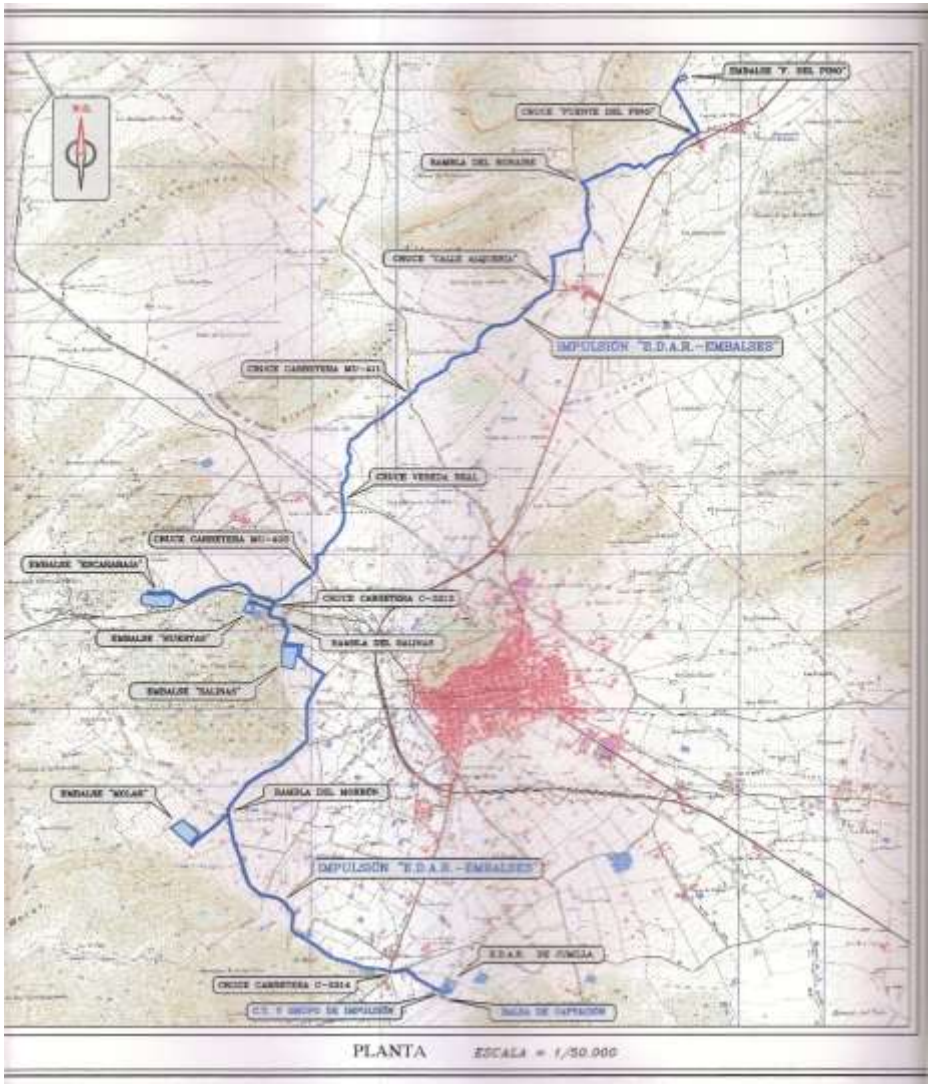
Pilot plants irrigation at district level

- Associated with irrigation districts, often organized around **irrigators associations** with concessions for use reclaimed water

- Continuously assess the **quality of irrigation water** used.

- Assessing the **effects of reclaimed water on plant and soil**, but also estimating how the reservoirs, water pipes systems and all the associated infrastructures with the distribution could affect.

Miraflores irrigation comunity



crop	% surface
Pear	45
Peach	32
Grapefruit	2
apricot	12
Olive	5
almold	1
plum	3

- 967 irrigators
- Irrigation surface = 1329 Ha

Miraflores Irrigators Community

Feasibility study of using reclaimed water from the WWTP of Jumilla in the Miraflores Irrigators Community

ETSIa Escuela Técnica Superior de Ingeniería Agronómica

Universidad Politécnica de Cartagena

CSIC

Región de Murcia

cajamar

CAJAMURCIA

Banesto

Study of reclaimed irrigation water on soils, aquifers and crops (2011-2016)

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Grupo Tragsa

Objetives

4. Evaluate the effects of using reclaimed water on plant physiology, yield and fruit quality and safety

Knowledge about plant water and nutritional status.

Yield of the most representatives species in two plots

Effects on fruit quality and safety

Pilot plots

INCA

Olives trees v. Picual – SON CATIU (well water and reclaimed water)

Pilot plots

INCA

Horticulture crops

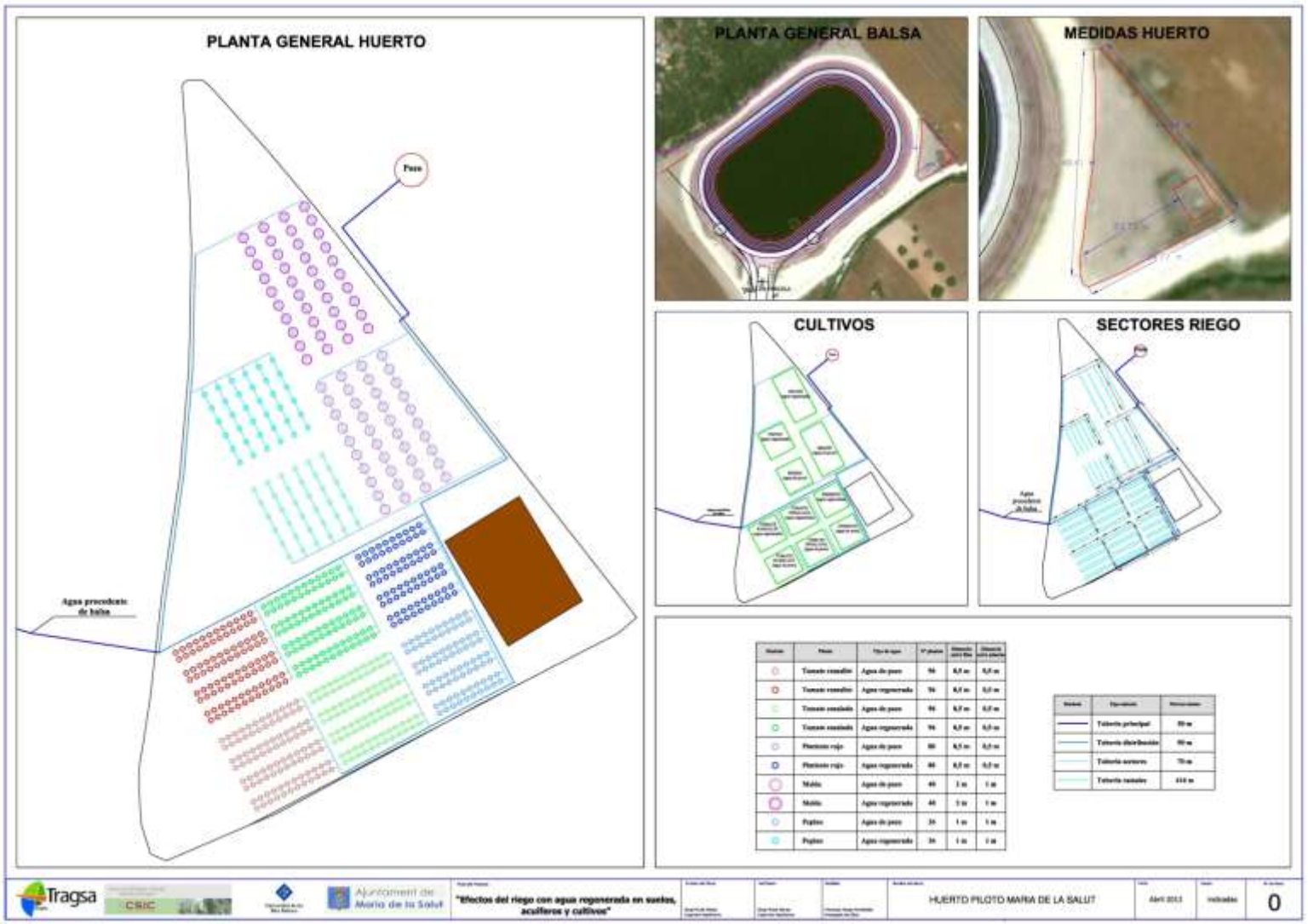
ANGEL WINERY (well water and reclaimed water)

Vinegrapes

Pilot plots

MARÍA DE LA SALUD

Horticulture crops (well water and reclaimed water)



Public acceptance and education of reclaimed water use

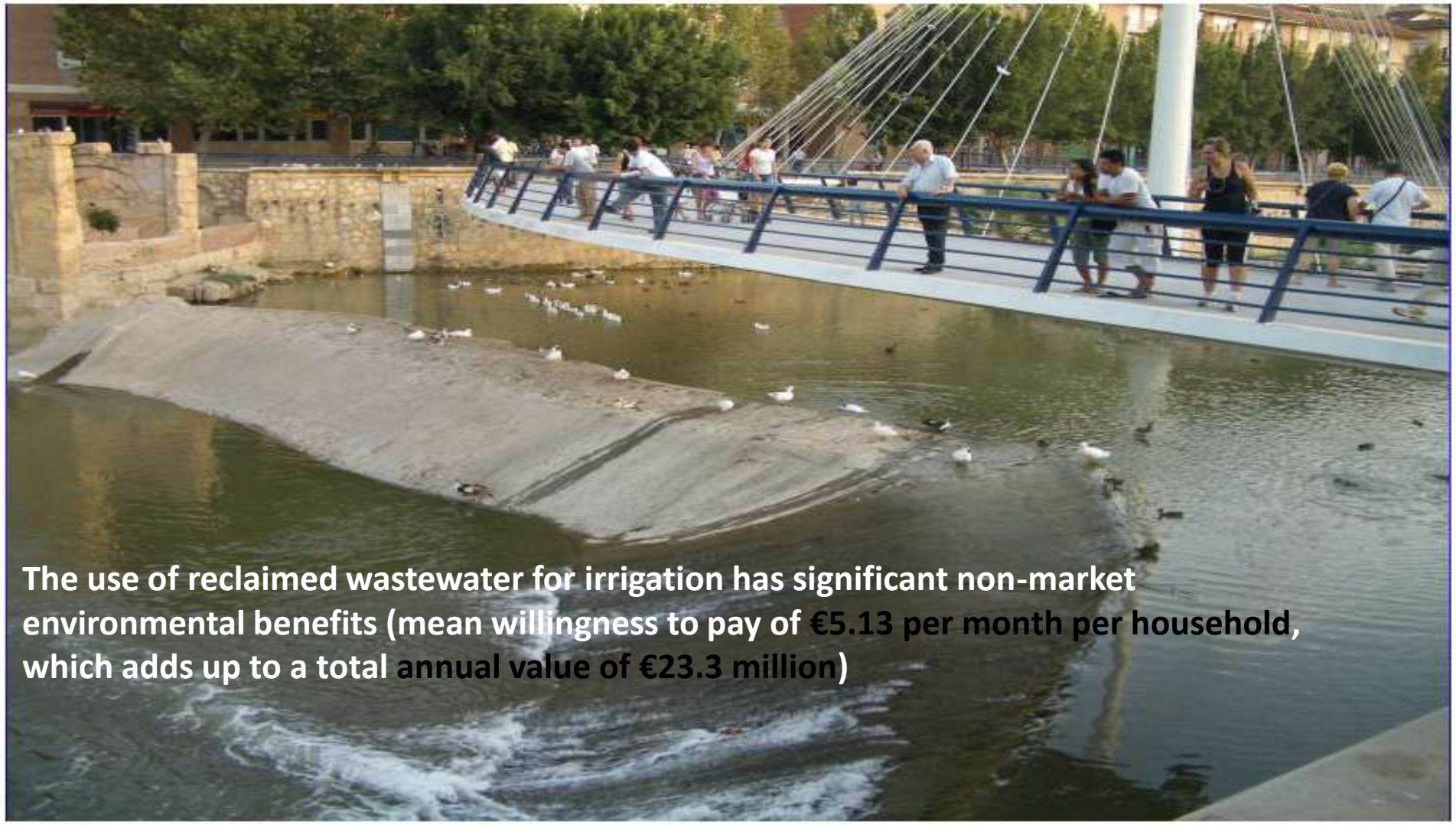
-Conferences must be training at all levels, both users and generators of such waters, to raise awareness of the importance of it.

-Economic analysis. Within this economic assessment all environmental benefits – including non-market benefits – should be included.

-To estimate the non-market benefits that society attaches to the use of reclaimed water for agricultural purposes


a
b
c
6
Mejora
EcoHidro

The non-market value of reclaimed wastewater for use in agriculture: a contingent valuation approach



The use of reclaimed wastewater for irrigation has significant non-market environmental benefits (mean willingness to pay of €5.13 per month per household, which adds up to a total annual value of €23.3 million)

Local users, local experiences

Public information

• The most successful projects have been promoted by users, under water scarcity conditions

• Acceptable risks (microbiological and chemical= varies with the socio-economical and cultural conditions

• Demostration projects generate a very positive public perception and promote public acceptance

• Demostration projects offer an excellent opportunity for manufactures and operators to study and reseacrh process performance

• Public participation is critical in project´s planning , implementation and operation.

TWO DAYS TRAINING ON THE OPERATION AND MANAGEMENT OF WWTPS

9-10 September, Murcia

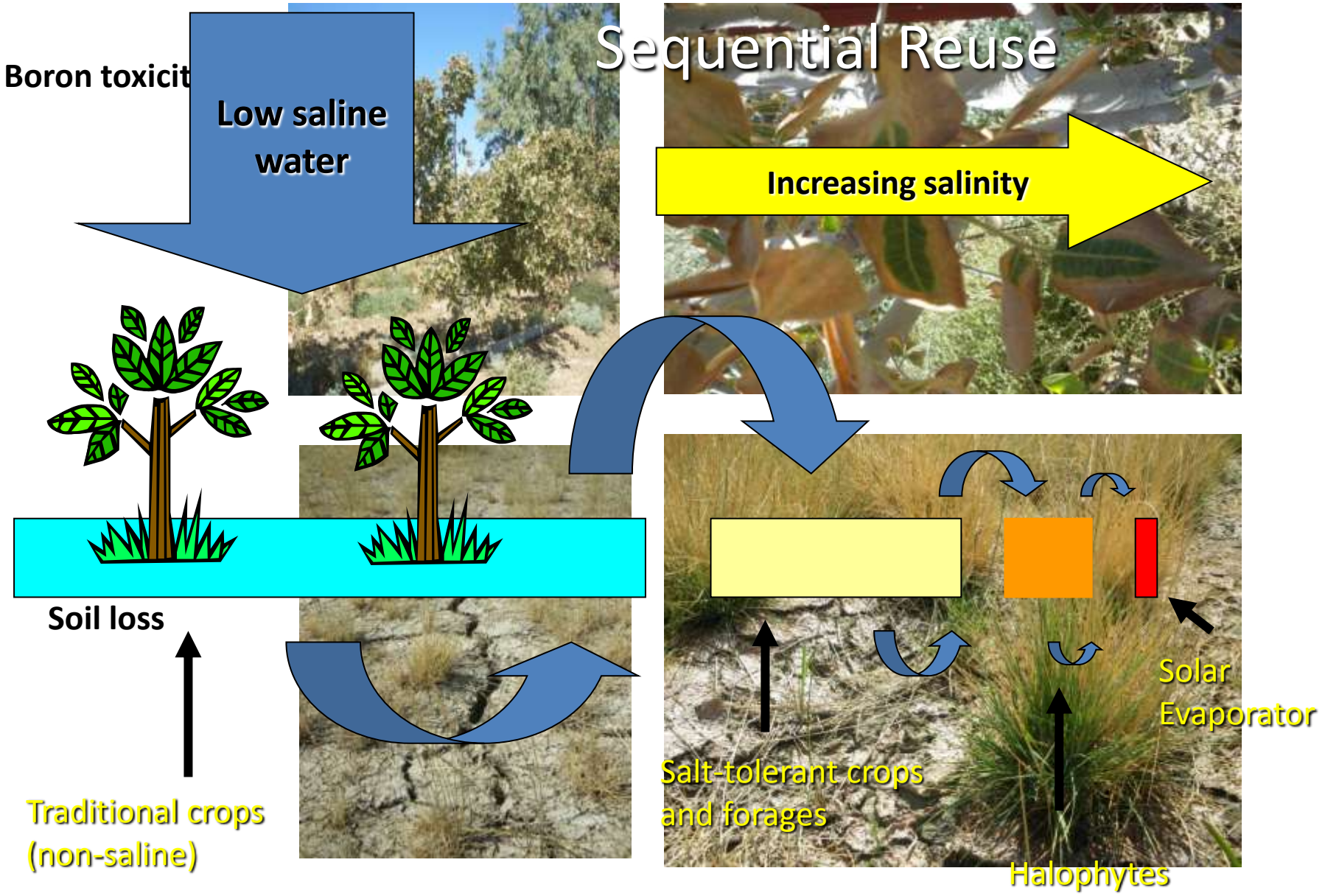
Future Trends in Water Reuse

Presented by: Dr. Francisco Pedrero Salcedo

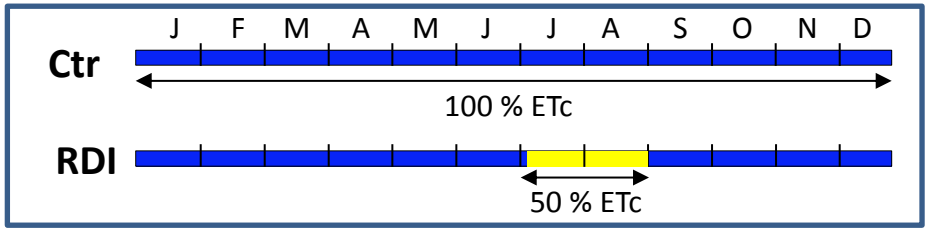
Although research on water reuse in agriculture has been done over the years, new research is needed to identify gaps in data such as salt tolerances of plants, new or unknown threats, best management practices for production and processing, and identifying the right water for certain crops. Additional funding should be dedicated to meet these research needs.

(Dobrowolski, J., et al, 2008) Opportunities and challenges in agricultural water reuse: Final report.(USDA-CSREES)

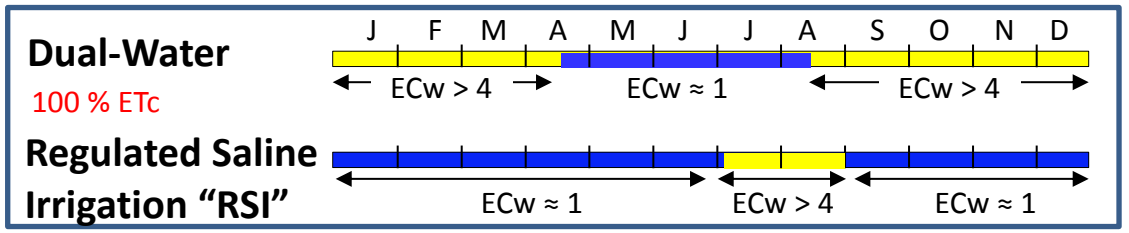
PROJECT IN FRESNO (CALIFORNIA)



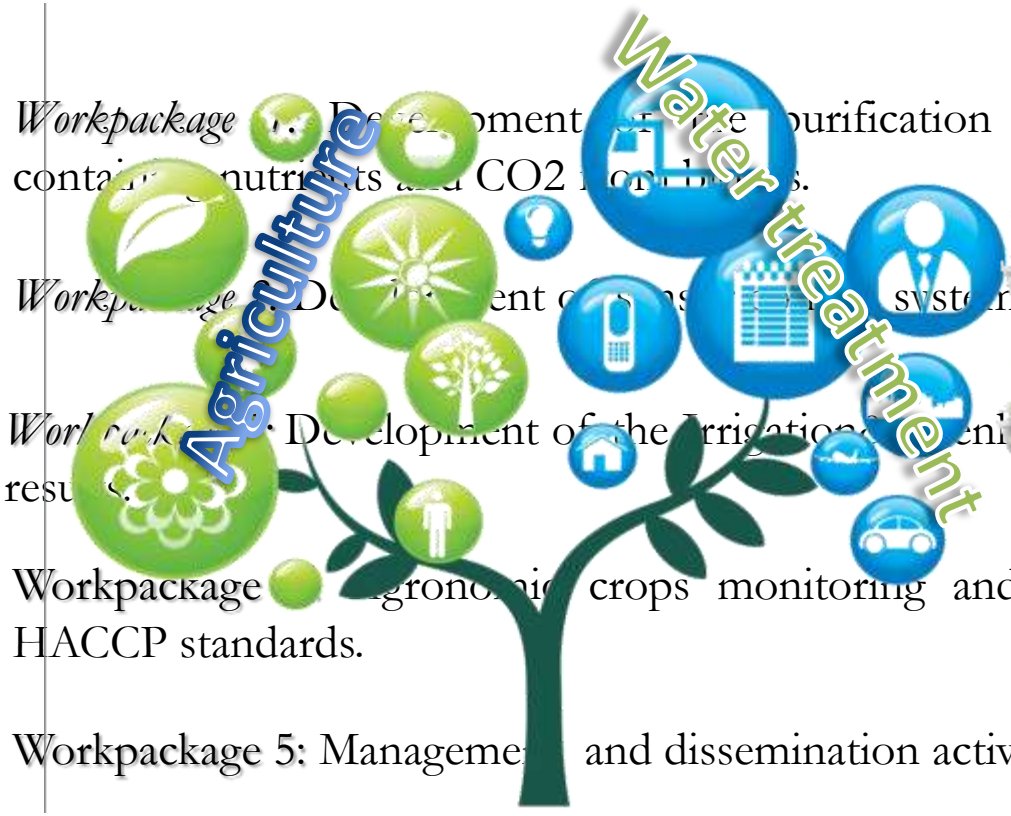
Good quality, Tajo-Segura canal : **TW**
(EC = 1 dS.m^{-1})
Reduced quality, reclaimed water : **RW**
(EC > 3 dS.m^{-1})

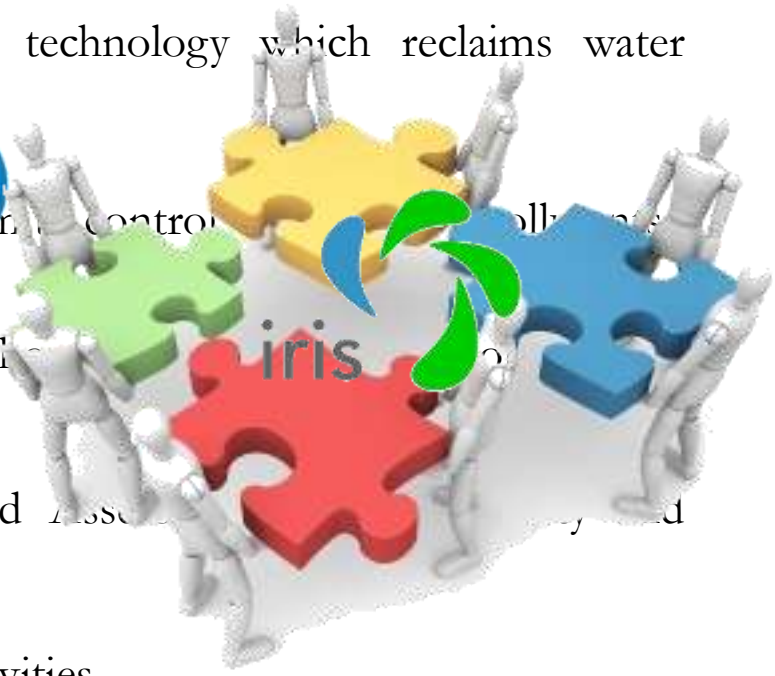


New treatments



The objective is to develop a water treatment system which **reclaims water** and **utilizes nutrients** from municipal wastewater for irrigation purposes. The system will treat domestic wastewater from small villages. It will connect waste to food production with modern technology.





Workpackage [illegible]: Development of the purification technology which reclaims water contai[illegible] nutrients and CO2 [illegible].

Workpackage [illegible]: Development of [illegible] system [illegible] control [illegible].

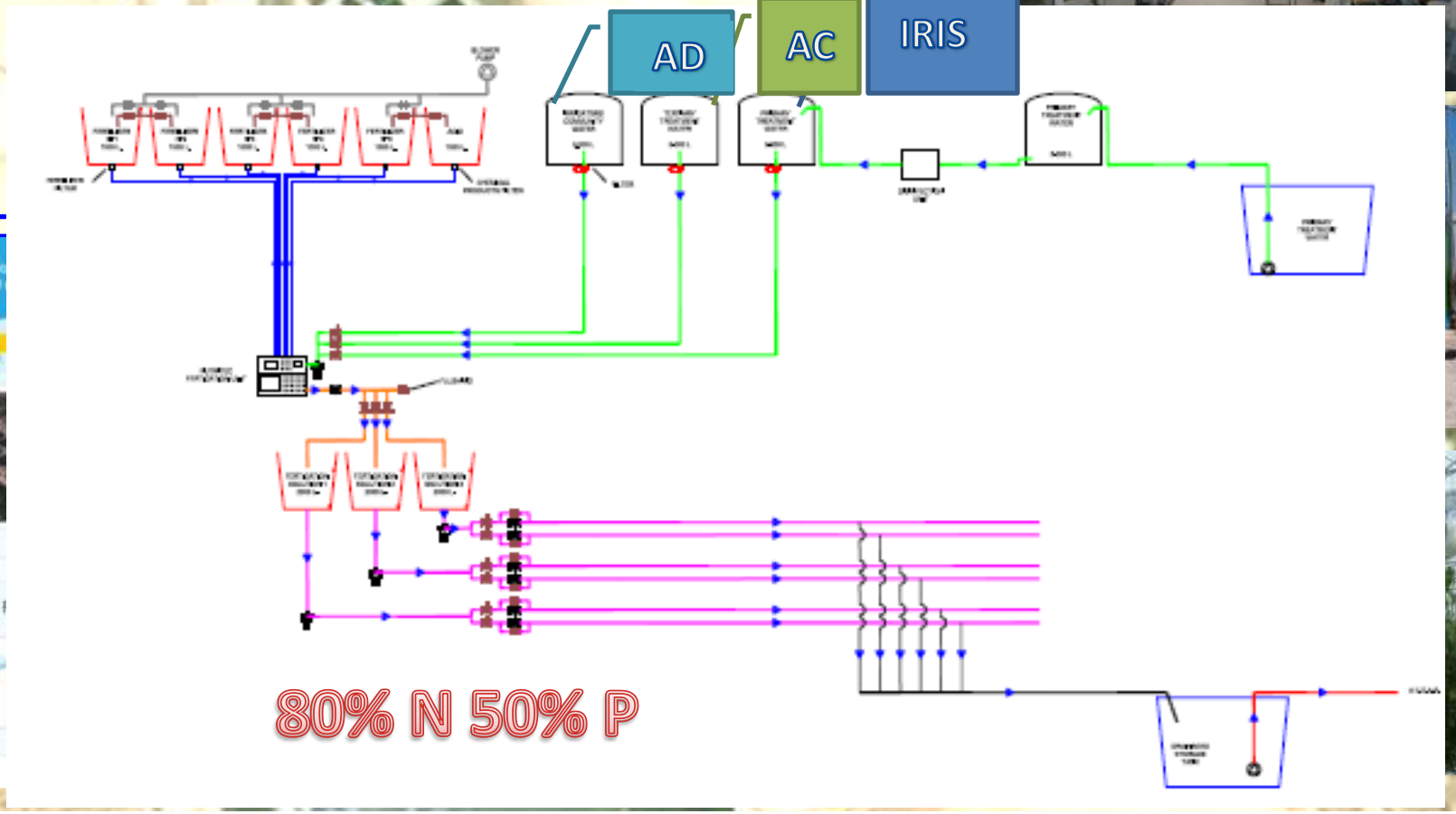
Workpackage [illegible]: Development of the Irrigation [illegible] results.

Workpackage [illegible]: agronomic crops monitoring and [illegible] and HACCP standards.

Workpackage 5: Management and dissemination activities.

iris

eurostars™



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HELLEBREKERS
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RUFEPA
www.rufepa.com

IRIS

Intelligent Reclaim Irrigation System

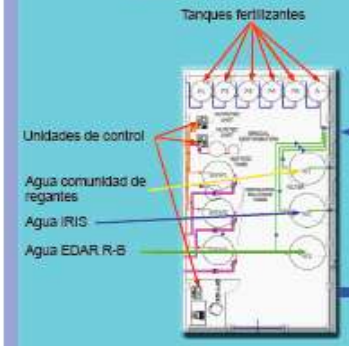
www.iris-project.eu

Intelligent

Sistema de control agroclimático

Unidad de fertirrigación

Esquema de funcionamiento

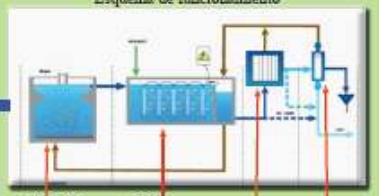


Reclaim

Sistema de control EDAR IRIS

Prototipo EDAR IRIS

Esquema de funcionamiento



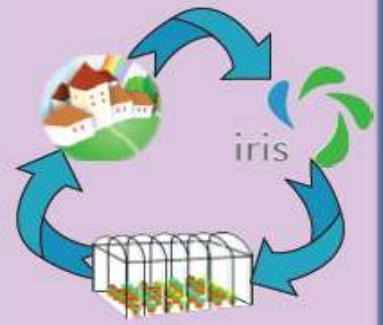
Irrigation

Interior invernadero

Exterior invernadero

Agua IRIS
Agua Depuradora R-B
Agua Comunidad de regantes
Sustrato Fibra de Coco
Sustrato Lana de Roca

System



Objetivos del proyecto:

-Reutilización de agua y nutrientes.

-Optimizar producción agronómica.

-Tratamiento aguas residuales pequeños núcleos.

-Obtención producto comercializable©

esamur

RITEC

CAPILIX

HELLEBREKERS TECHNIEKEN

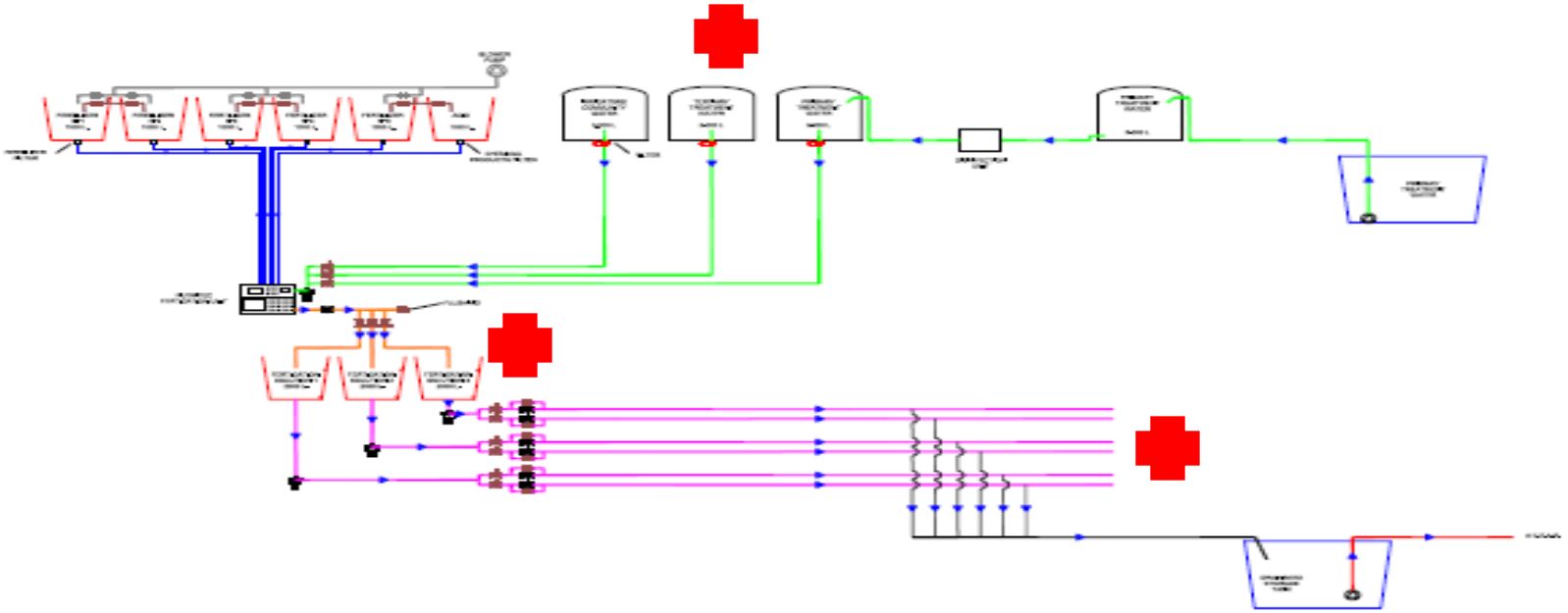
KUPEPA

CSIC

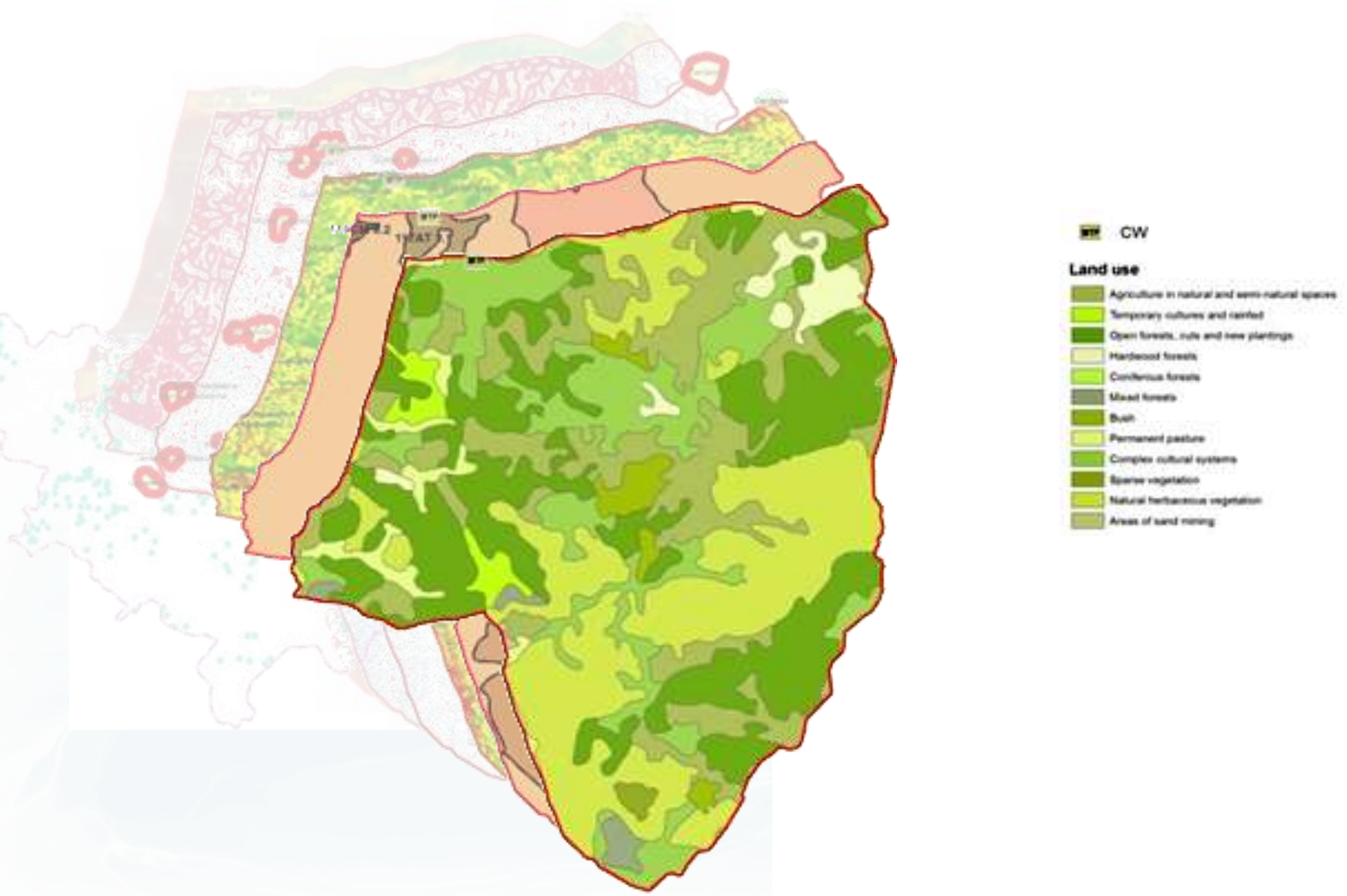
Influence of irrigation water in hidroponic tomate microbiology safety

Presence and concentration of:

-Escherichia coli
-Escherichia coli VTEC (identification of 5 patogens)
-Salmonella spp
-Listeria monocytogenes

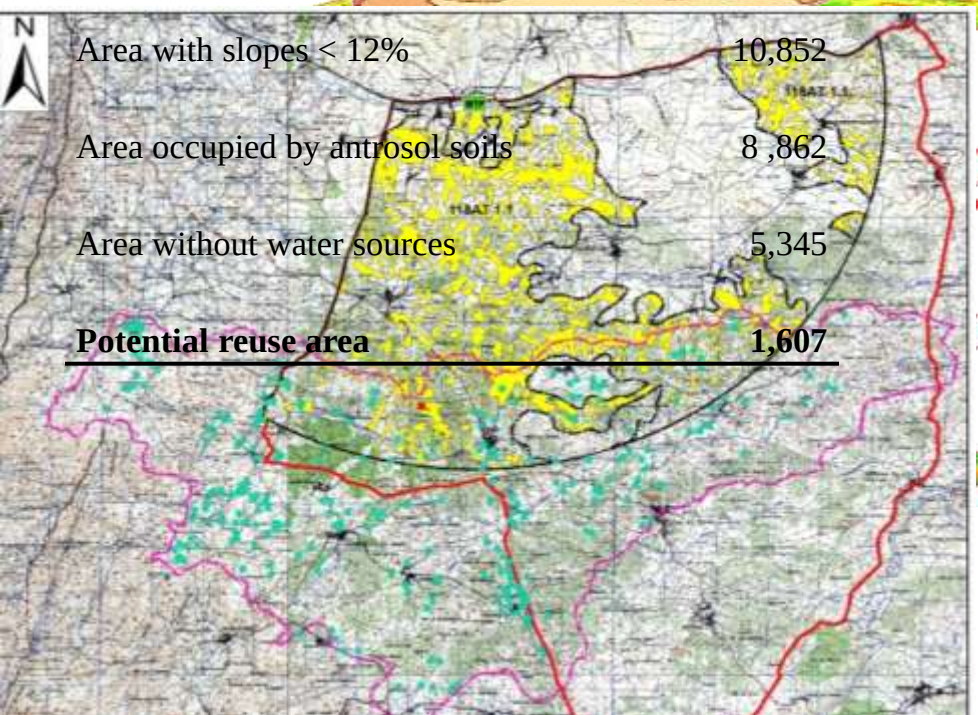


Potential use of reclaimed water with GIS based on multicriteria analysis

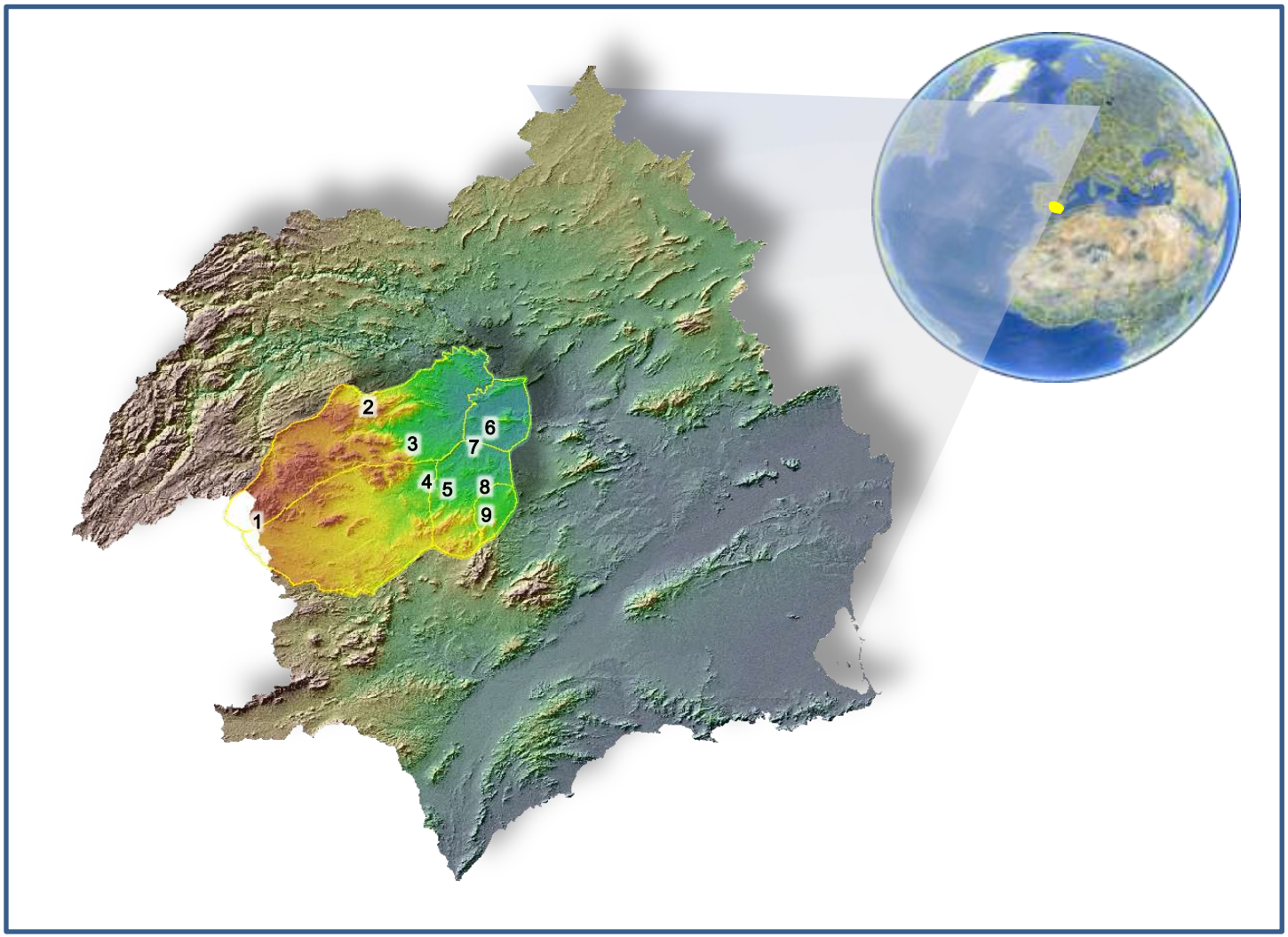


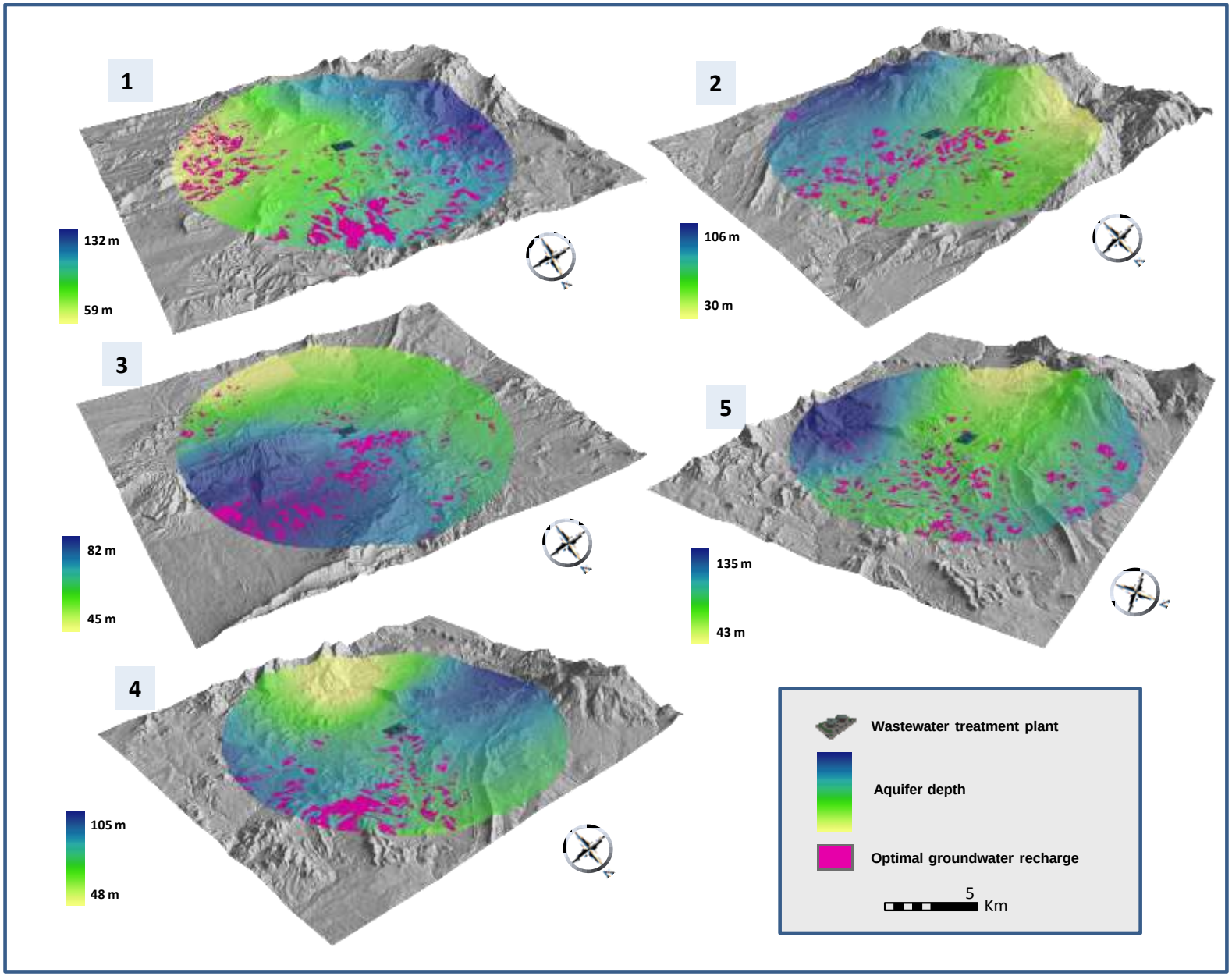
Results

Parameters	Area (ha)
Studied area	13,944
Area without population agglomerates	12,445
Economic restriction area	7,805
Area with slopes < 12%	10,852
Area occupied by antrosol soils	8 ,862
Area without water sources	5,345
Potential reuse area	**1,607**



Reclaimed water use optimization under Mediterranean conditions through GIS




1
132 m
59 m
2
106 m
30 m
3
82 m
45 m
4
105 m
48 m
5
135 m
43 m
Wastewater treatment plant
Aquifer depth
Optimal groundwater recharge
5
Km

Covered storage ponds

CFU / 100ml	Discovered	Covered	Reduction
Fecal coliforms	1680,8	279	83,4%
E-coli	52,37	5,03	90,4%

Future perspectives

- ✓ Update and establish **new agronomic thresholds** to properly assess the suitability of reclaimed water for irrigation.
- ✓ Develop new tools and sustainable management strategies that save water and profit the **potential nutritive value** of reclaimed water.
- ✓ Introduce new criteria in the **GIS-techniques** as a tool to assess the proper extension of RW use.

Future challenges

- Advances in water integrated management

  - Institutional: Water Cycle Agencies
  -Urban and agricultural users
  -Economic and finantional aspects

- Appropiate terminology

- Development suitable regulation

- Study and research in demostration projects

- Promote public information and outreach

- Ensure the viability and sustainability

Recommendations for the Mediterranean regulation on reclaimed water use

- Microbiological parameters selected must have incidence in present-day Mediterranean countries.

- User can't be responsable for providing treatment and for quality. The concept must be precisely explained (i.e., algae growing in reclaimed water storage ponds).

- Reclaimed water use regulation needs to be harmonized with other regulations (drinking waters, bathing waters, Legionella).

- Must have rational emphasis on control, regardless on the intenstity of treatment and the use of the facility.

- Traditional analytical methods must be accepted.

TWO DAYS TRAINING ON THE OPERATION AND MANAGEMENT OF WWTPS

9-10 September, Murcia

Case Studies in Wastewater Reuse

Presented by: Dr. Francisco Pedrero Salcedo

Bigest projects on reclaimed water use in irrigation

- **1156 Hm^3, Australian agriculture**
- **937 Hm^3, Californian agriculture**
- **355 Hm^3, Japan**
- **310 Hm^3, Florida agriculture**
- **246.841 residences in Florida.**
- **794 parks in Florida.**
- **477 golf courses in Florida.**
- **272 schools in Florida.**
- **More than 4000 has in Italia.**
- **Más de 3640 has de bosque, viñedos, olivos, alfalfa, frutales y otros cultivos, Argentina.**
- **70% de toda la producción de alcachofas, Estados Unidos.**
- **10% del suministro nacional total de agua y cerca del 20% del suministro total de agua utilizado para riego.**

Planned reclaimed water use projects history

1912	The first water reuse system was for irrigation in **Golden Gate Park (San Francisco**, EEUU)
1965	**Israel** start to use reclaimed water for irrigation
1966	**Florida** introduce reclaimed water in the Tallahassee farm builtding.
1977	**St.Petersburg** city built the first urban water reuse system in the EEUU
1984	**Tokio** start to use reclaimed water from Ochiai WWTP, for the use of toilets in buildings in the distric of Shinjuku.
1985	**Water Conserv II**, the biggest water reuse proyect, combine agriculture irrigation with aquifer recharge through infiltration (**Orlando, Florida)**
1989	**Spain** start to use relaimed water in golf courses from the Consorci Costa Brava WWTPs.
1998	**Monterrey Council, California**, start to use reclaimed water in 4800 has of vegetables. At present, they continue irrigating.
1999	**Virginia Pipeline project** , the biggest water reuse project in **Australia**, irrigate diferent types of crops with reclaimed water from the Bolivar WWTP
2005	Inform from the **Departament of Environment protection in Florida** entitle “Use of reclaimed water: perspectives about regulation and security", reported that reclaimed water has been used in Florida during 40 years without no illness.

Agricultural reuse projects in the Mediterranean

Spain

Region	Volume of wastewater for reuse (hm3/yr)
Comunidad Valenciana	128.0
Comunidad de Murcia	106.0
Islas Canarias	47.5
Islas Baleares	40.0
Cataluña	33.0
Coast of Andaluzia	11.5
Vitoria-Gatzei	12.5
Madrid	8.0

Thank you for your attention