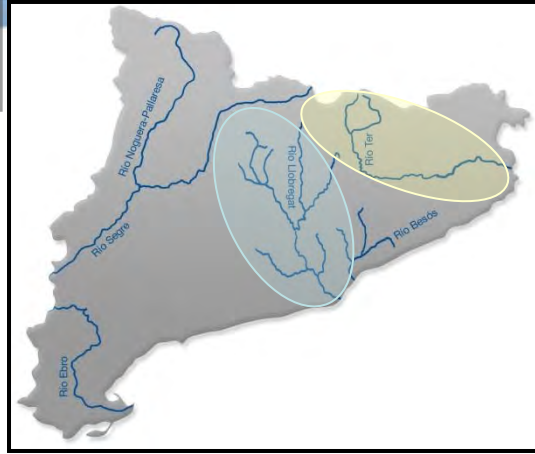


Drinking water treatment development in Barcelona

Torino, 8th November 2013

José Luis Armenter

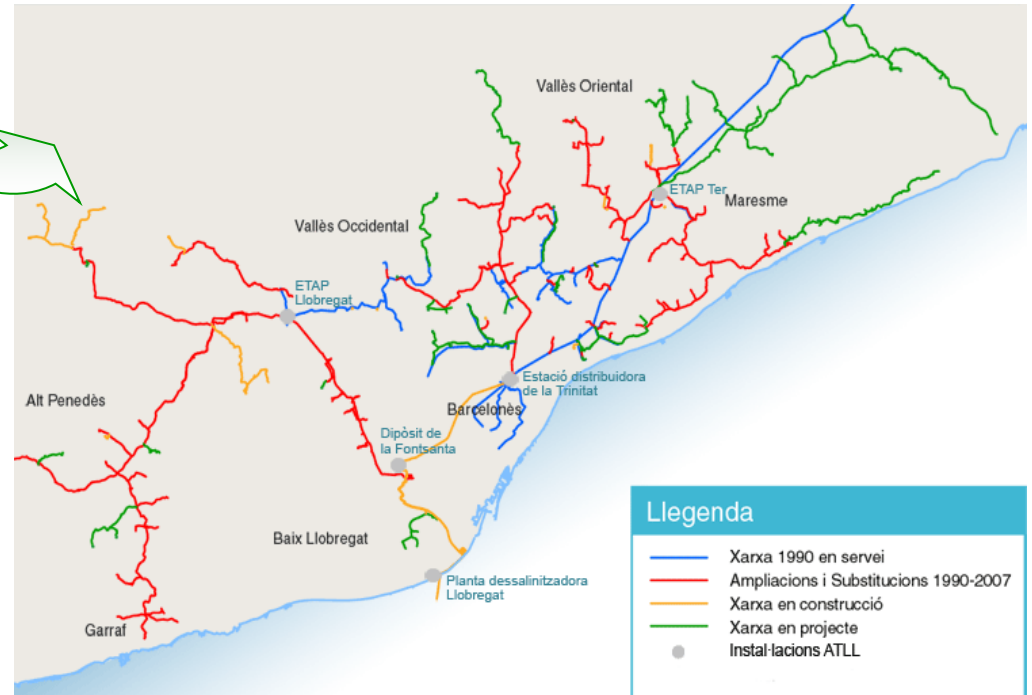
Ter-Llobregat System



The Ter-Llobregat System supplies drinking water to more than 100 municipalities of Barcelona and Girona provinces.

The Ter-Llobregat System has a complex set of facilities of catchment, DWTPs, tanks, pumping stations and distribution network that allows the water coming from Ter and Llobregat rivers to reach all municipalities with optimum quality for human consumption.

> 5,5 million inhabitants served



Ter-Llobregat System



Ter-Llobregat System



Ter-Llobregat System



Ter-Llobregat System

Water reservoirs capacity

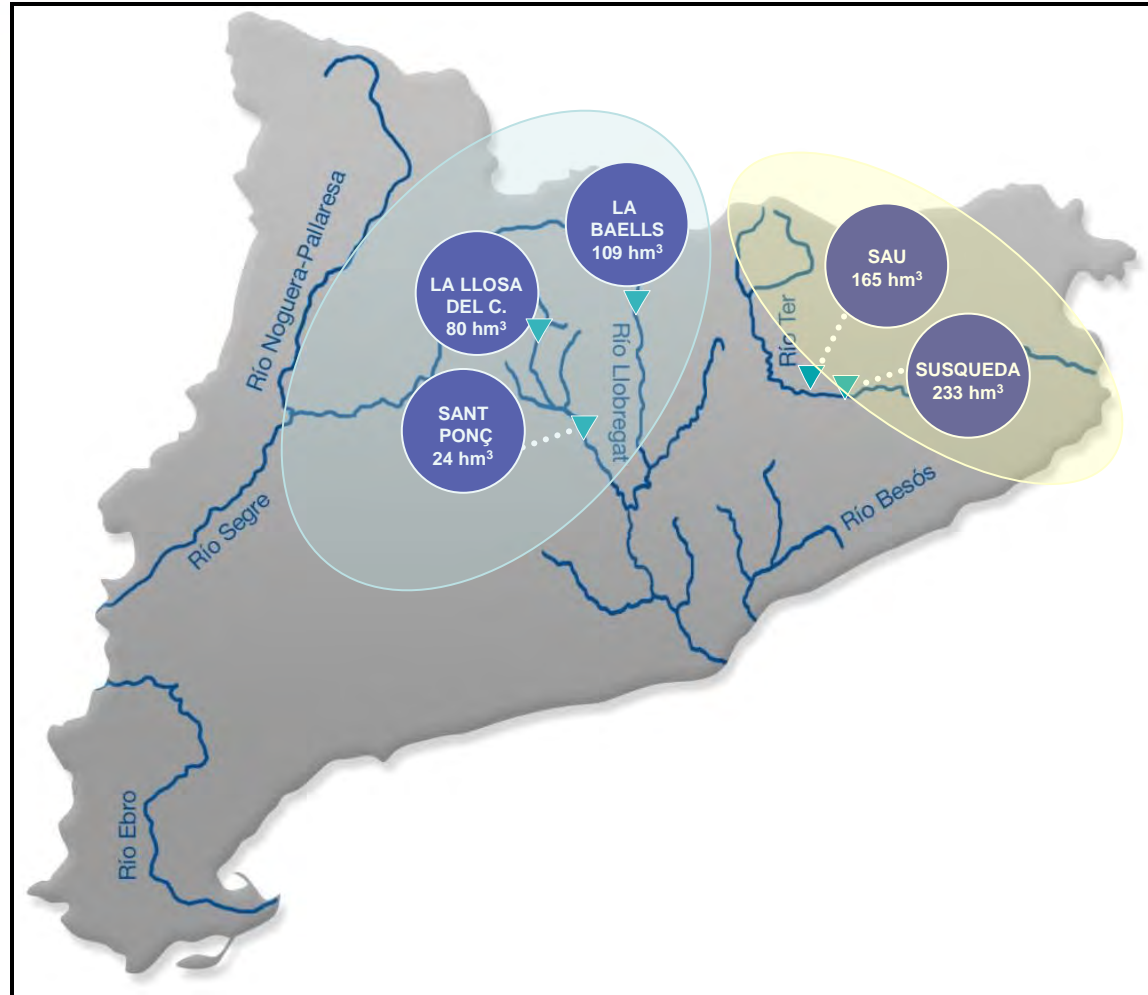
River Llobregat:	214
River Ter:	398

Ter - Llobregat **612 hm³**

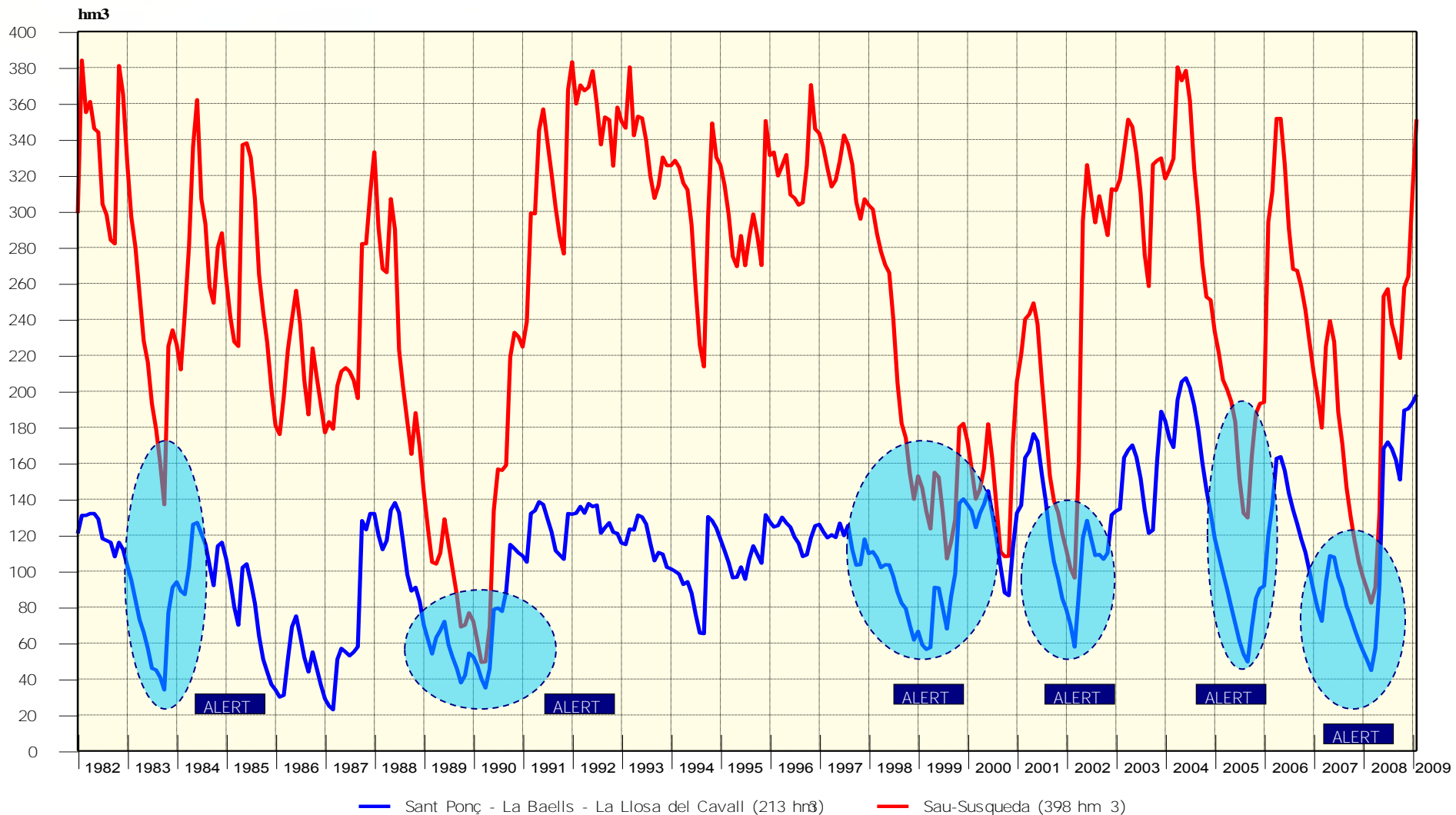
Yearly demand

Water demand:	330
Irrigation:	170
Environmental flow:	100

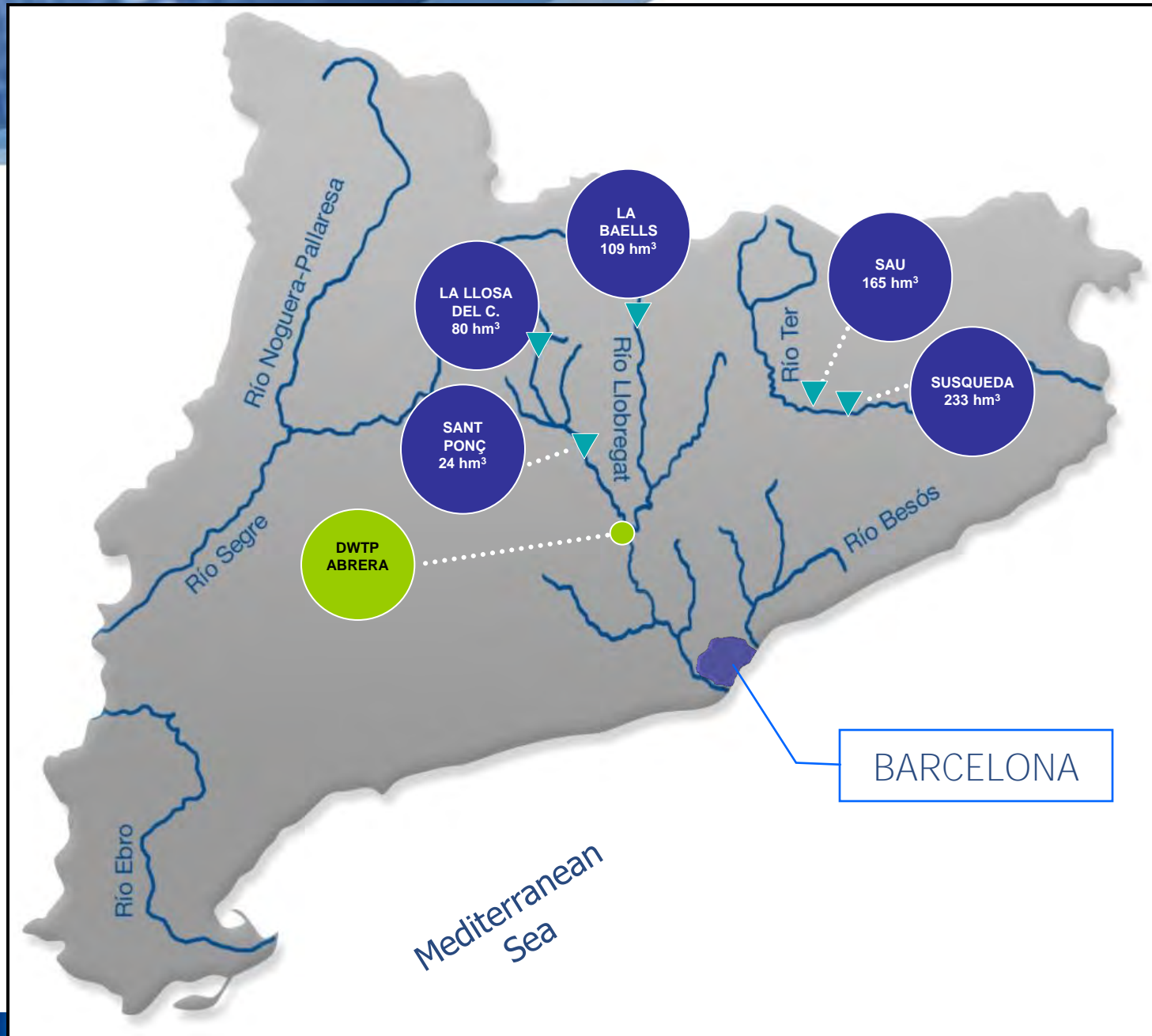
Total demand **600 hm³**



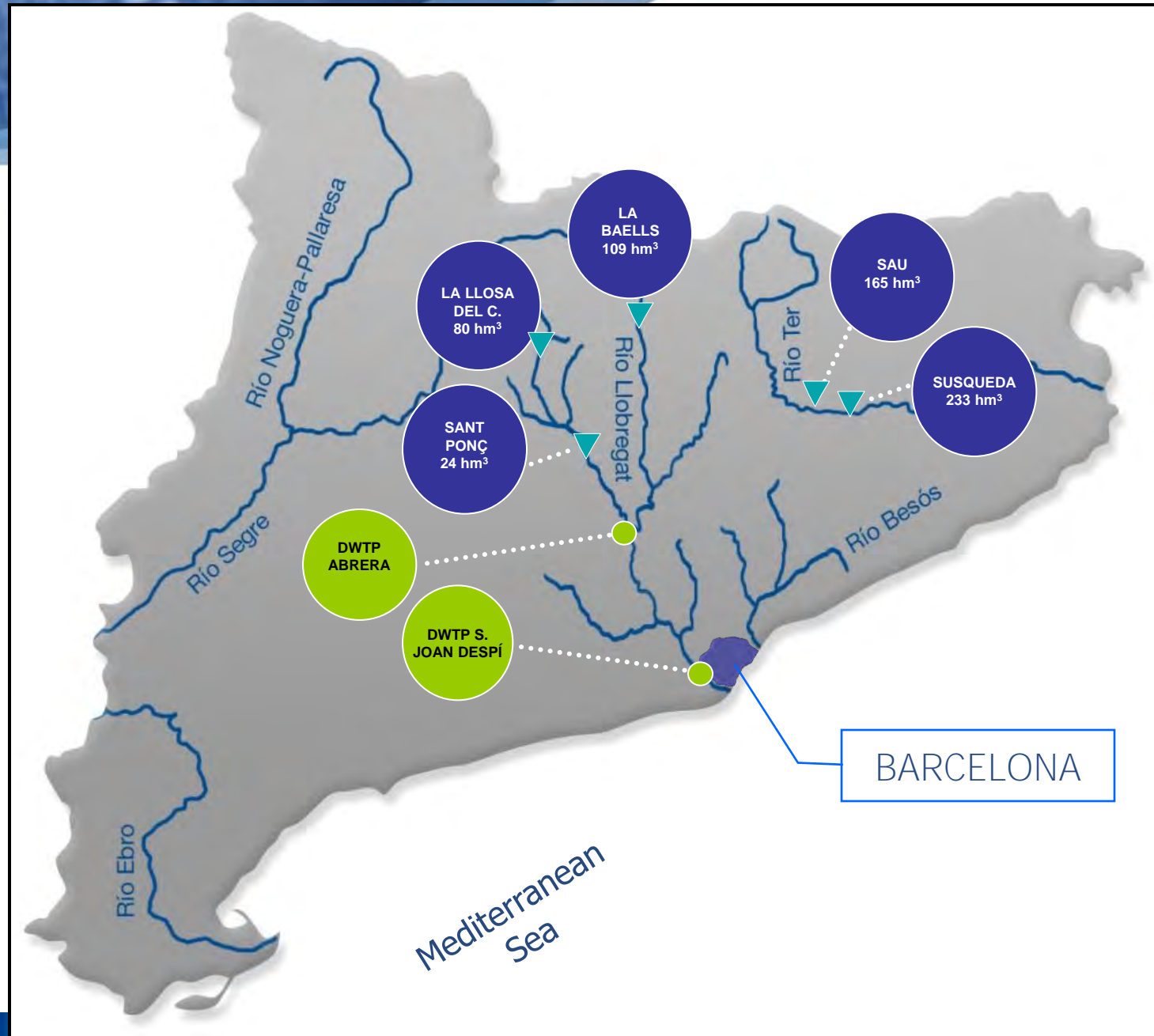
Evolution of the dam reserves in the Ter-Llobregat System



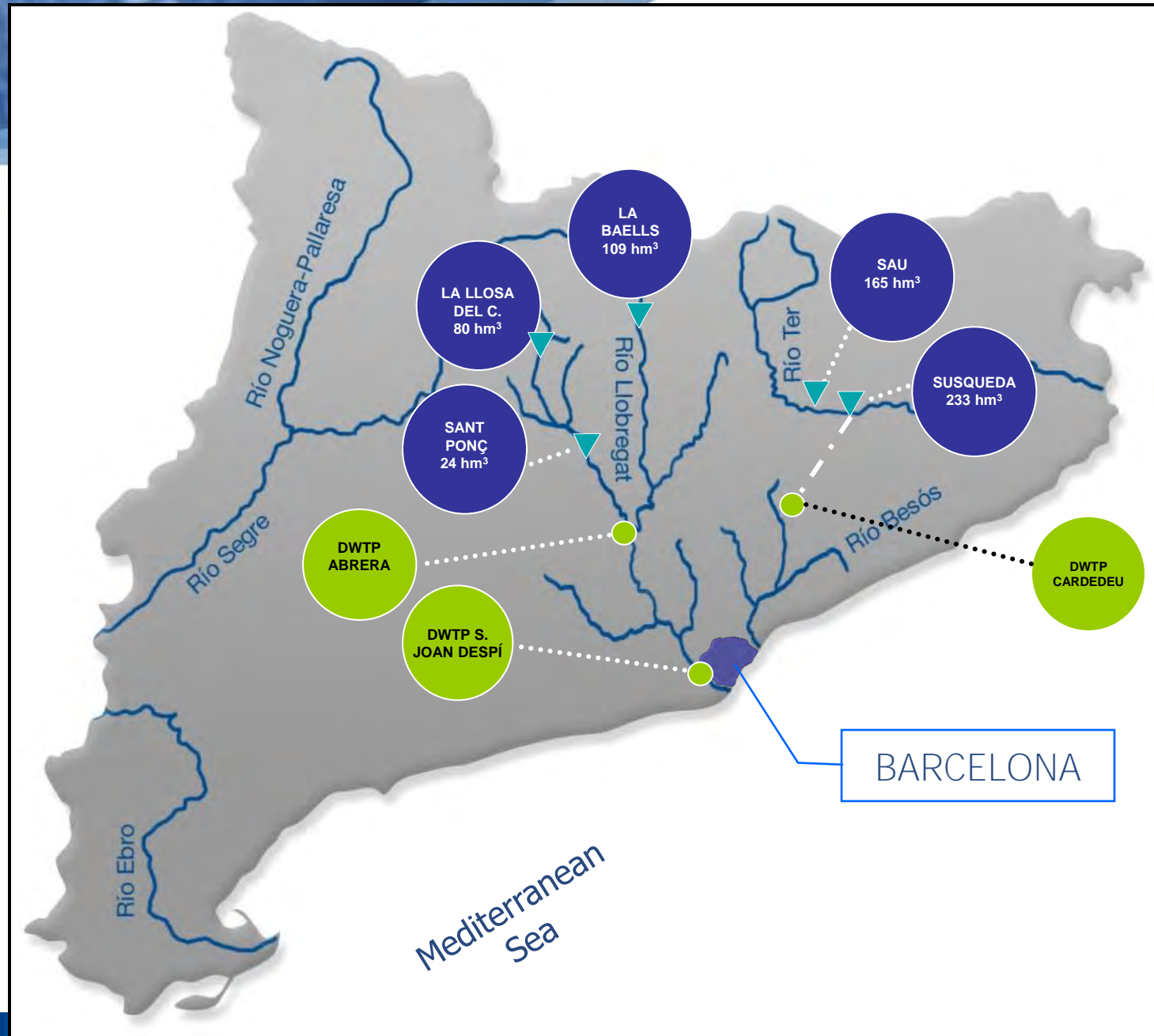
Ter-Llobregat System



Ter-Llobregat System



Ter-Llobregat System



Ter-Llobregat System



Ter-Llobregat System



Ter-Llobregat System



Ter-Llobregat System



The Llobregat, a salinized river



Pollution episodes



Sant Joan Despí DWTP Catchment area



Scarcity (June 1999)

Floodings (13th September 2006)





Sant Joan Despí DWTP (400,000 m³/d)



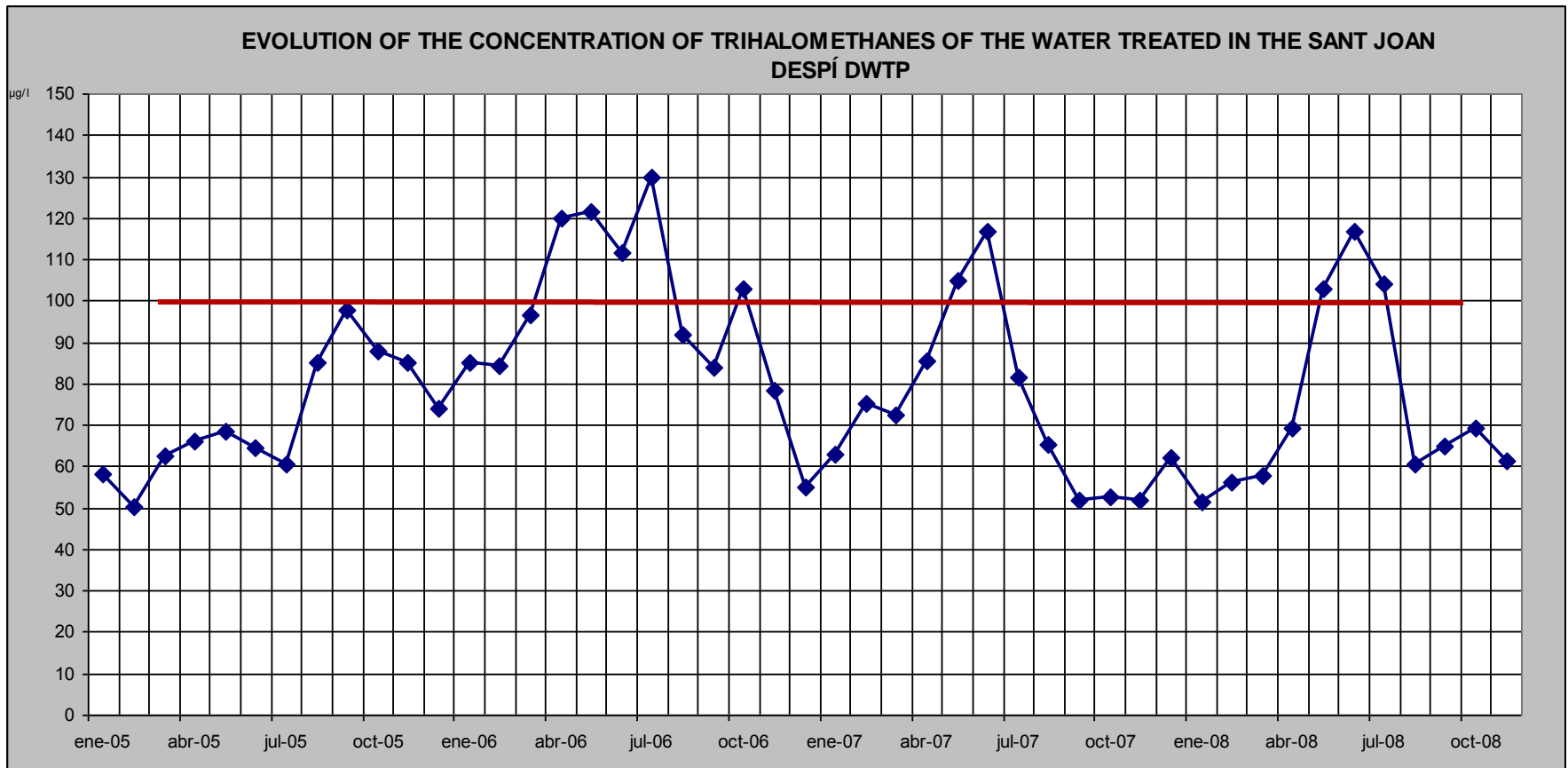
Sant Joan Despí DWTP

- 110,000,000 m³ of water treated yearly (60% of the water consumed in Barcelona), coming from river Llobregat and its aquifer.
- Despite the modifications introduced into the treatment in recent years, there was no guarantee to compliance with the parametric value of **THM's** fixed by the legislation since January 2009 (Directive 98/83).
- At that time, the treatment was not sufficient to achieve the organoleptic improvement required by customers.

Characteristics of the surface water

		Minimum	Average value	Maximum
Ammonium	mg NH₃/l	0.03	1.63	15.05
TOC	mg C/l	3.30	6.60	32.00
Conductivity	µS/cm	450	1651	4021
pH	pH units	7.10	7.98	8.77
Hardness	mg CaCO₃/l	150	410	573

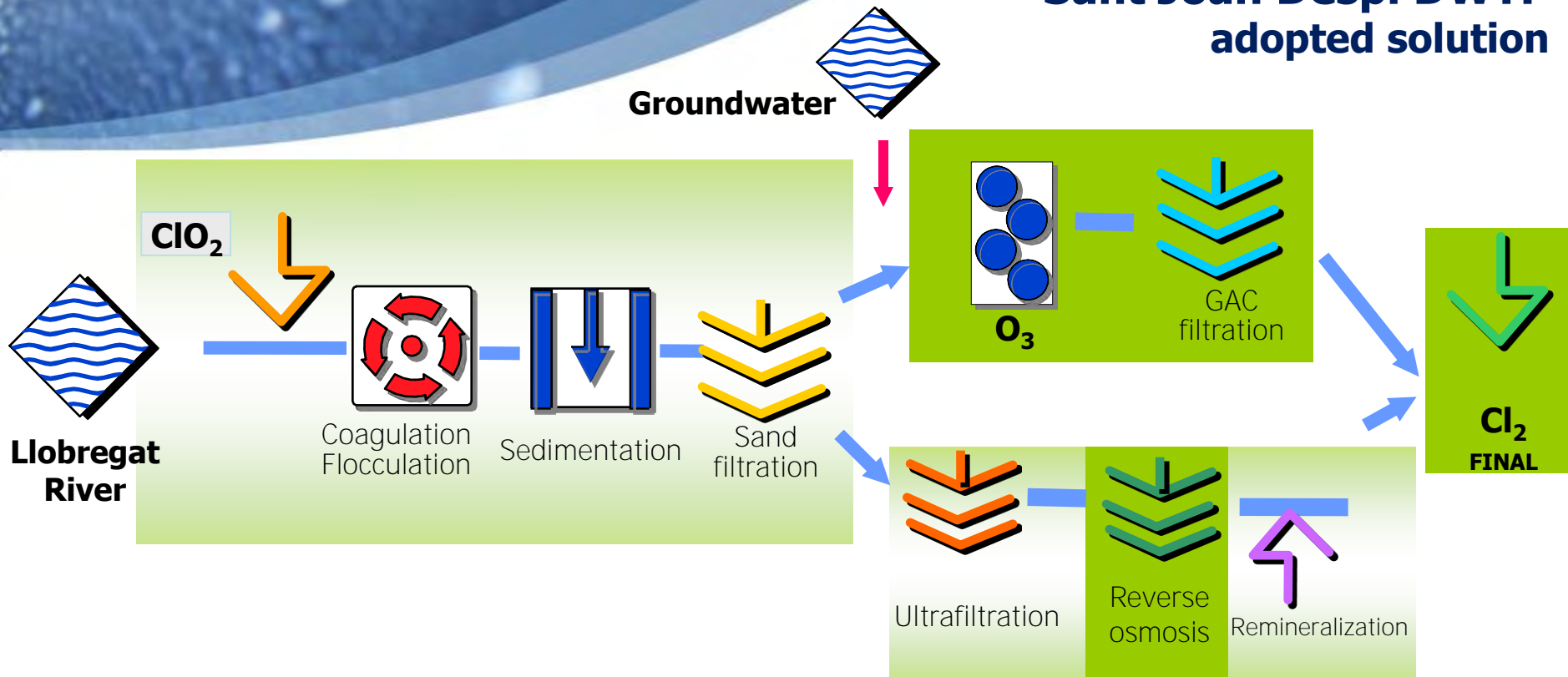
WATER QUALITY PROBLEMS



NEW TREATMENT OBJECTIVES

- To comply with Directive 98/83 (THM's < 100 µg/l at points of consumption).
- To eliminate salts and dissolved organic compounds.
- To obtain similar organoleptic quality independently from the source (Llobregat River or Ter River).
- To have a treatment with future possibilities.
- To maximize the use of the existing resources.

Sant Joan Despí DWTP adopted solution



- Conventional pre-treatment with static settlers + sand filters for 100% of the volume.
- Variable distribution of volumes in the post-treatment between the conventional line and a new membrane treatment line.
- Conventional post-treatment line composed by an ozonation stage and a second carbon filtration stage (maximum capacity of 5.3 m³/s).
- New membrane treatment line composed of UF pre-treatment and RO stage (maximum capacity of 2.4 m³/s).

TECHNICAL DATA

- 9 trains of 8 cassettes per train and 57 modules per cassette. Model ZW 1000 by Zenon.
- Total membrane surface area: 228,757 m².
- Net design flow: 41.7 l/m²/h.



Sant Joan Despí DWTP

RO pretreatment stage

TECHNICAL DATA

UV DISINFECTION

- 5 lines of 530 l/s with high intensity and low pressure lamps, with units before and after the cartridge filters.

CARTRIDGE FILTERS

- 5 RO protection filters equipped with wound cartridges with selectivity of 5 μm .



Sant Joan Despí DWTP

RO stage

TECHNICAL DATA

Treatment volume: 2.65 m³/s

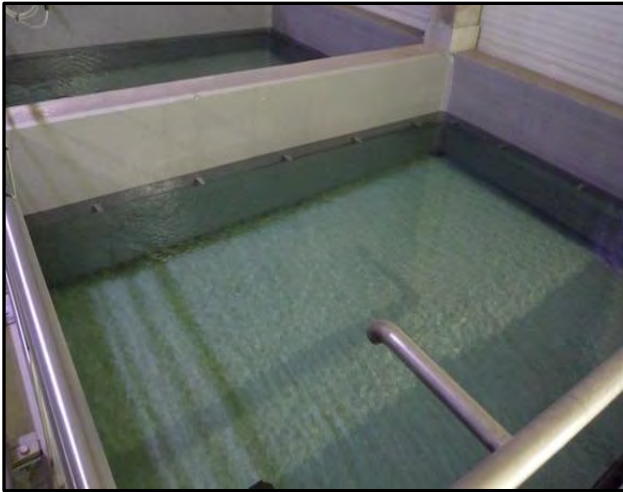
- Volume produced: 2.39 m³/s
- Number of racks: 10
- Recovery: 90%
- Configuration: 1 step, 3 stages
- Tubes per rack:
 - 90 tubes of 7 membranes 1st stage
 - 40 tubes of 7 membranes 2nd stage
 - 28 tubes of 7 membranes 3rd stage
- 1,106 membranes per frame, brackish water type,
size 8"x40", spiral winding, Filmtec LE 440-i
- Booster pump needed between 2 and 3 stage
- Supply pressure: between 8 and 16 kg/cm²



Sant Joan Despí DWTP

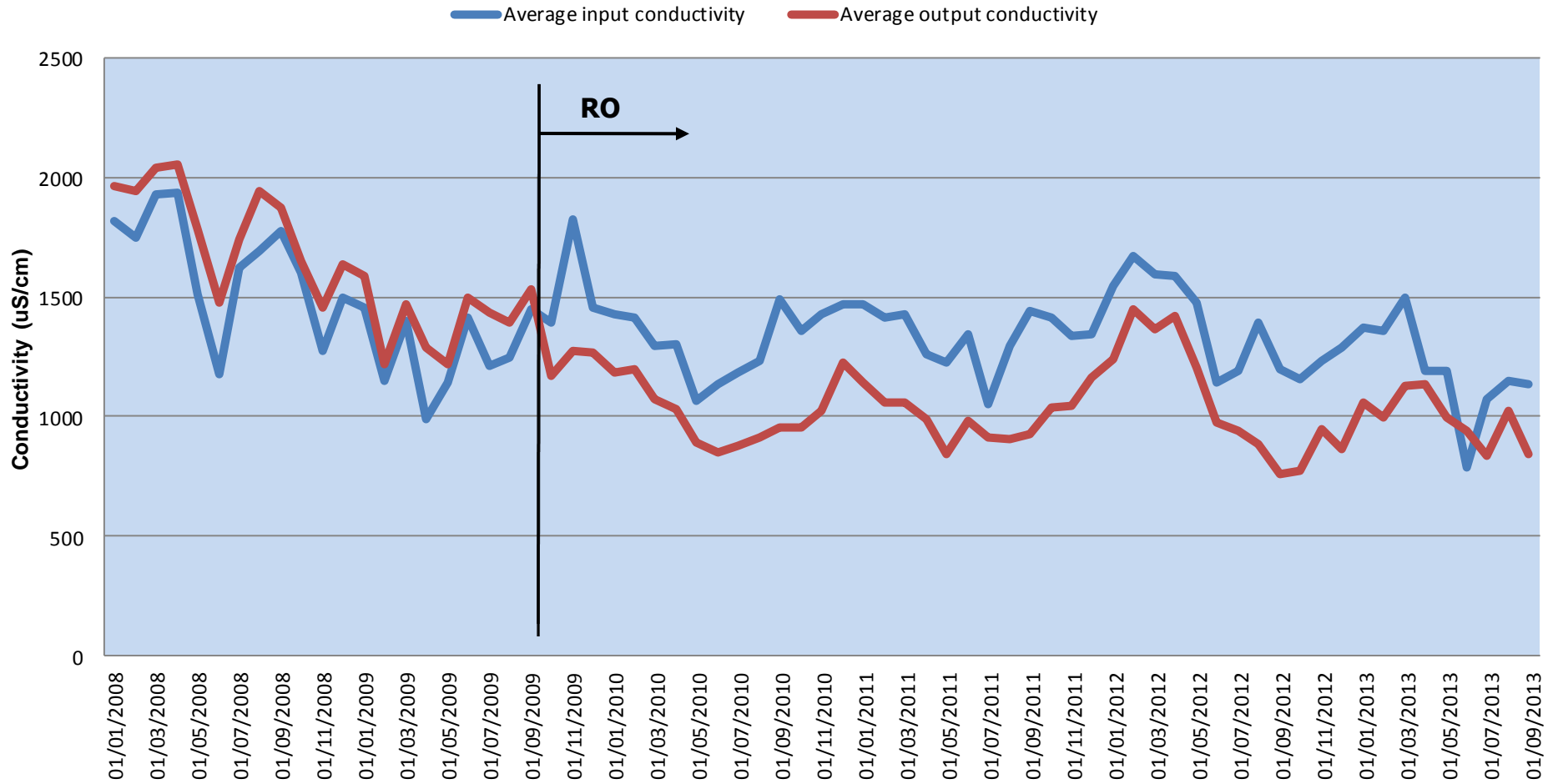
Remineralization stage

TECHNICAL DATA



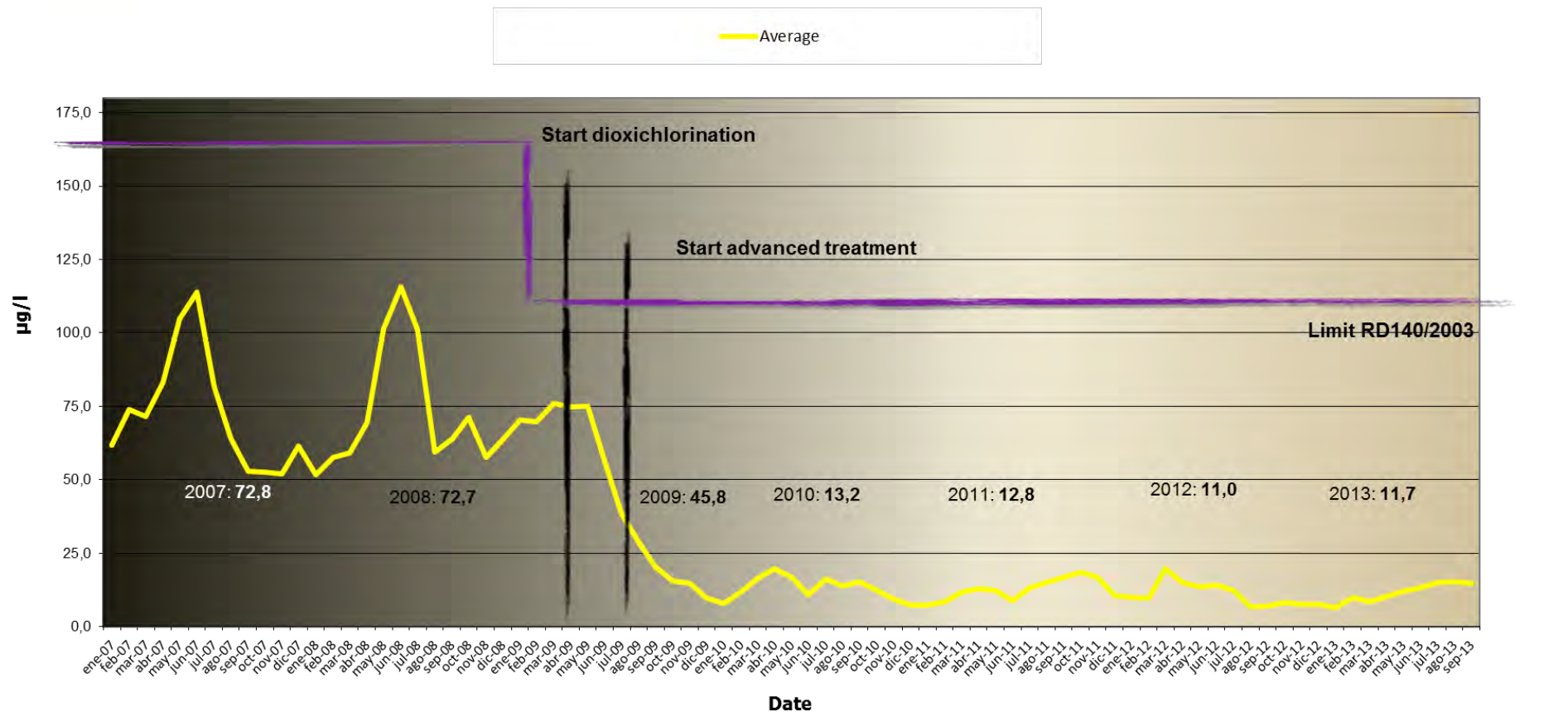
- Dosage of CO₂:
 - Storage tank 50 m³
- Calcite beds:
 - Downflow
 - 24 filters of 6x4 m²
 - Height of calcite between 2.5 and 3 m
 - Speed of the water: 14.91 m/h
 - Contact time 11.4 min
 - With aeration system to clean the calcite filter
- Blend with ozonized water and filtered by granular activated carbon
- Disinfection with chlorine gas

Sant Joan Despí DWTP Improvements: Conductivity

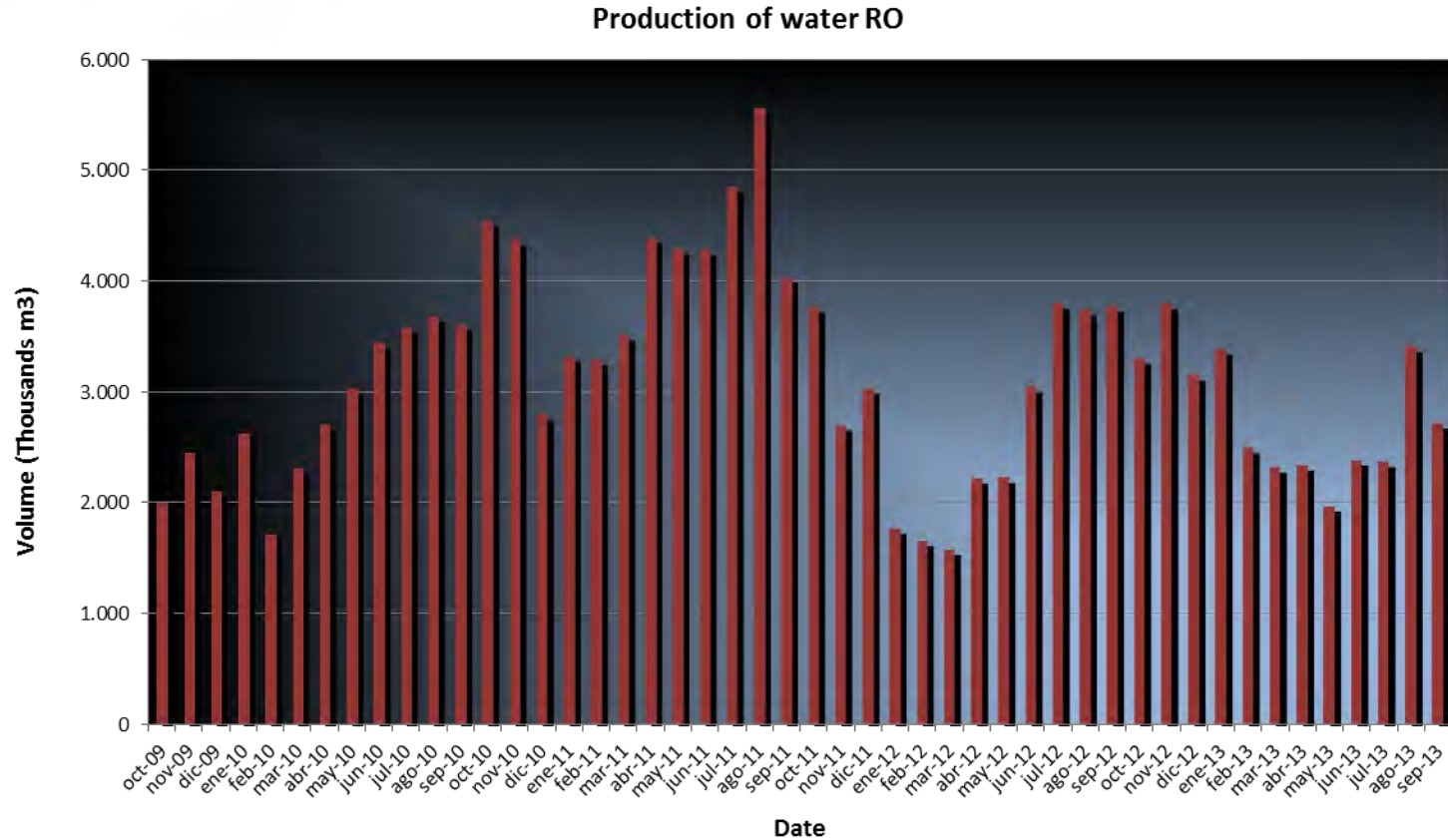


Sant Joan Despí DWTP Improvements: THMs

Total THMs evolution (years 2007-2013) in Sant Joan Despí DWTP



Sant Joan Despí DWTP RO Production



PRODUCTION

2009: 6.58 hm³

2010: 38.48 hm³

2011: 47.13 hm³

2012: 34.14 hm³

2013: 23.45 hm³

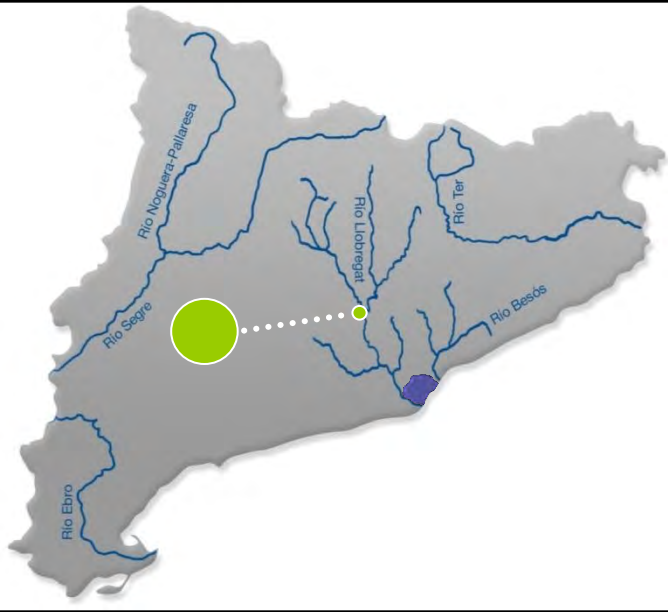
In waters such those from the **Llobregat River**, with a **high content** of **organic precursors and bromides**, it is very difficult to achieve with conventional treatments a concentration of **THM's** below the value fixed by the Legislation in 2009.

The salinity of the water from the River Llobregat was one of the main reason why the organoleptic quality of the water was not satisfactory.

According to the results of the pilot tests carried out, for the quality of the water to be treated in the Sant Joan Despí DWTP, **the most appropriate membrane technology is reverse osmosis**. The objectives to reduce **THM's** and improve the organoleptic quality of the water are obtained by blending, at 50%, water treated by reverse osmosis with water ozonized and filtered by granular activated carbon.

With these types of waters, the pre-treatment of the water to be osmotized is crucial. In this case, and also in accordance with the results of the pilot tests carried out, **ultrafiltration** was chosen.

Abrera DWTP (340,000 m³/d)



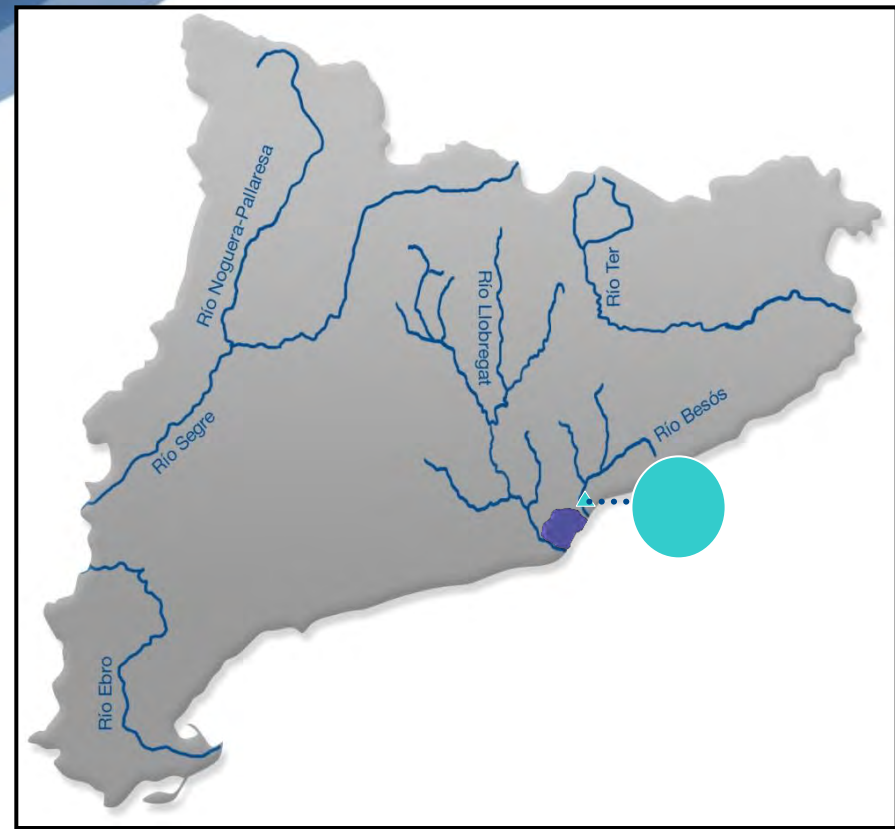
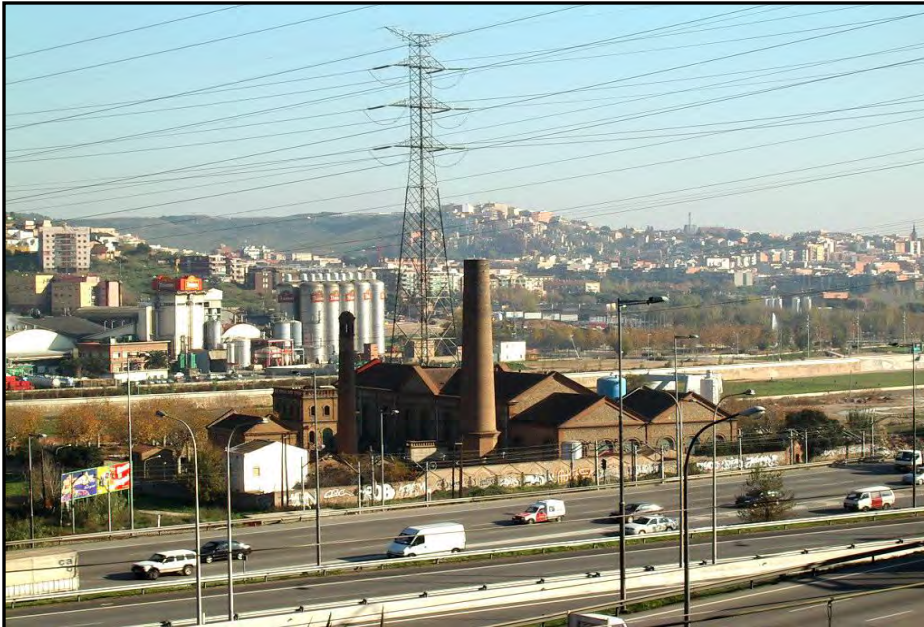
Source: Aigües Ter - Llobregat

Abrera DWTP adopted solution

- Total production capacity:
4 m³/s.
- 2.4 m³/s of the water could be
treated through the reversible
electrodialysis membranes.



Nanofiltration and Reverse Osmosis in Besòs aquifer

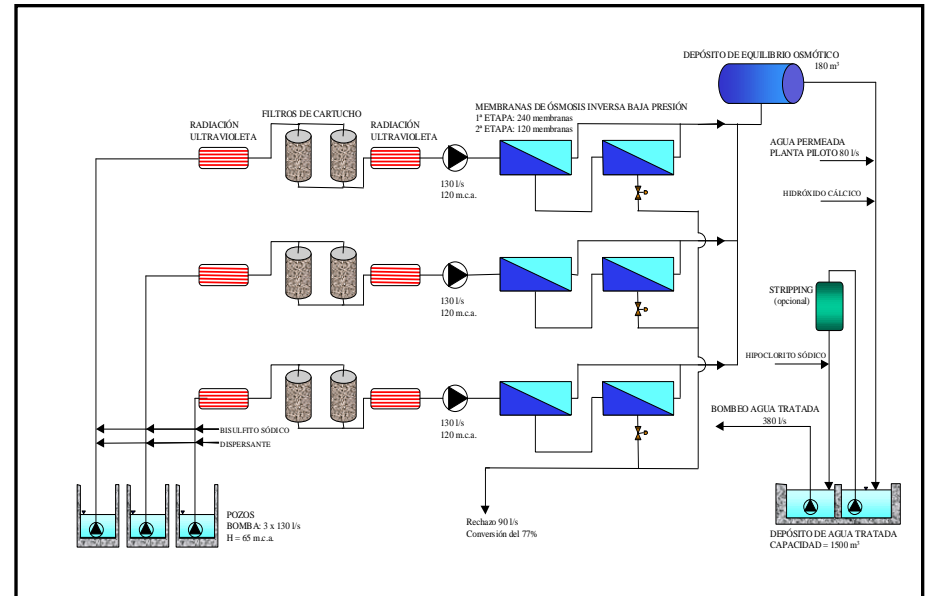
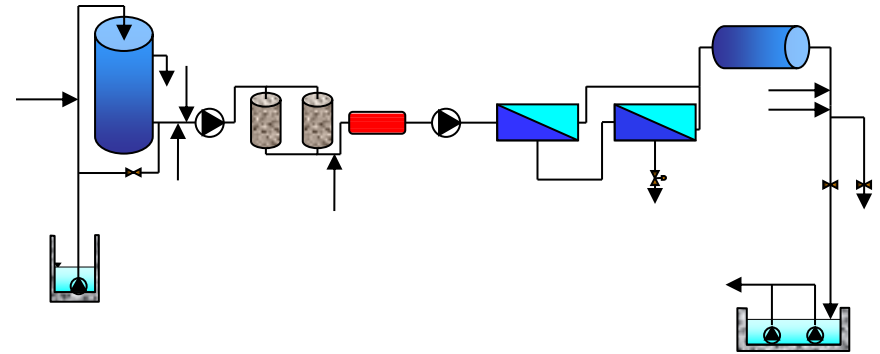


PROBLEMS:

- High level of Sulfates.
- High level of Manganese.
- High level of Ammonium.
- High level of hardness.
- Presence of Nitrates.

Besòs Treatment Plant (370 l/s)

Nanofiltration and Reverse Osmosis



La Llagosta Treatment Plant (150 I/s)



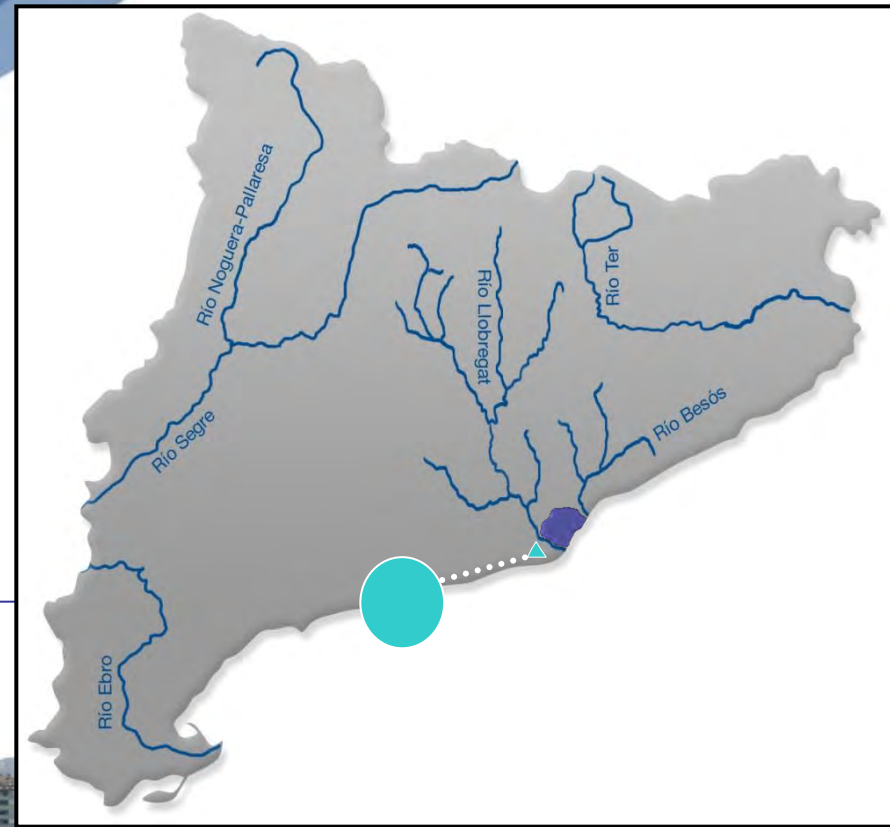
PROBLEMS:

- High levels of Trichloroethylene and Tetrachloroethylene.
- Presence of heavy metals (Chromium and Manganese).
- High level of Ammonium.
- Presence of pesticides (Atrazine, Simazine and Terbutilazine).
- High levels of salinity and hardness.

**Reverse Osmosis
and
Stripping**



Stripping in the Llobregat aquifer



Stripping in the Llobregat aquifer Wells St. Feliu de Llobregat

PROBLEMS: High levels of Trichloroethylene and Tetrachloroethylene.



PRODUCTION: 1,000 l/s





Desalination Plant in Barcelona



Location:

Left margin of the Delta of the Llobregat river, near to the waste water treatment plant of Prat.

Inauguration:

20th July 2009



Desalination Plant water sea catchment



Desalination Plant characteristics

Production

Annual production	60 hm ³
Daily nominal production	180,000 m ³
Daily top production	200,000 m ³

Technology

Reverse Osmosis

Work pressure

70 bar

Conversion

45%

Elimination of salts efficiency

99.7%

Electrical installed power

40,000 kW

Specific consumption

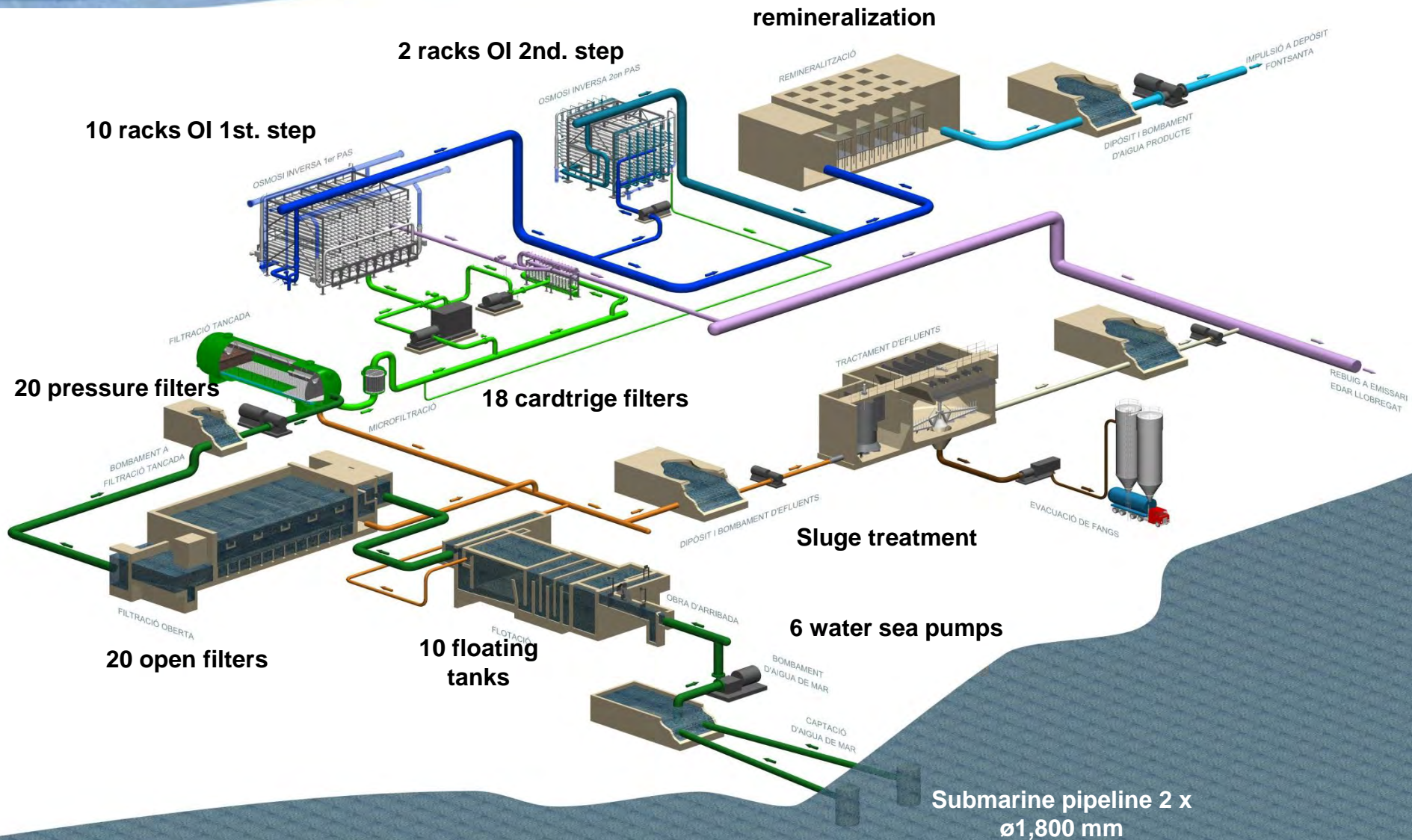
Reverse Osmosis	2.7 kWh/m ³
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Desalination Plant

RO main hall



Desalination Plant treatment process



Why to implement a WSP? Our motivations

- **Water resources are scarce and sometimes polluted.**
- **Preventive management already implemented, but not formalized.**
- **Better control of the supplied drinking water, based in preventive concepts.**
- **To advance in future legislation.**
- **To prioritize investments related to safe drinking water.**
- **To integrate the WSP as an ISO 22000 certification with other systems such as ISO 9001, ISO 14001 and OHSAS 18001.**
- **First water supply in Spain to obtain the ISO 22000 standard.**

Benefits

- **To incorporate a structured risk management frame for drinking water in a complex environment.**
- **To promote preventive versus corrective measures.**
- **To focus on monitoring critical control points of the waterworks and network system.**
- **To support on-line monitoring of water quality in order to react on time.**
- **To guarantee proper risk management based on detailed verification.**
- **To optimize long-term costs concerning water quality analyses, which at the same time improve its quality control and minimize health risks.**

GRAZIE PER LA VOSTRA ATTENZIONE!