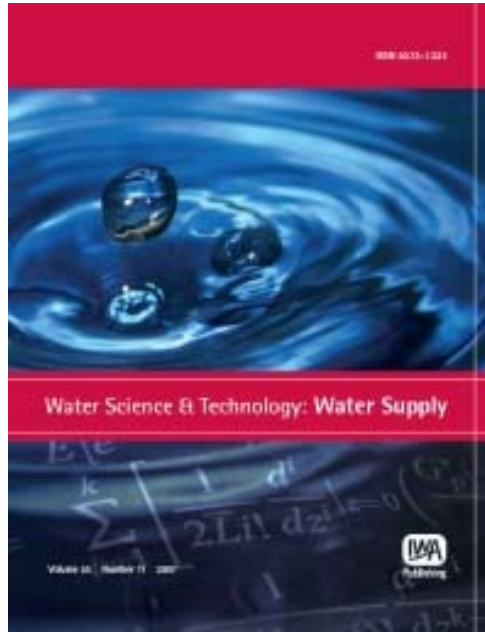


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## Reclaimed water for the Tarragona petrochemical park

J. Sanz, J. Suescun, J. Molist, F. Rubio, R. Mujeriego and B. Salgado

### ABSTRACT

The Camp de Tarragona Water Reuse Project is an emblematic example of how regional water scarcity can be overcome by considering reclaimed secondary effluent, which would otherwise be disposed of in the Mediterranean Sea, as an essential component of integrated water resources management. An advanced water reclamation plant (AWRP) was completed in 2011 to reclaim municipal secondary effluent from Tarragona and Vilaseca-Salou wastewater treatment plants. The reclaimed effluent is used for cooling and process water at the nearby Tarragona petrochemical park. The AWRP's current (2014) capacity is 19,000 m<sup>3</sup>/d (Phase I), and further expansions are planned to produce 29,000 m<sup>3</sup>/d (Phase II) and 55,000 m<sup>3</sup>/d (Phase III) in coming years. This locally available additional water supply will replace surface water supplies currently transferred from the Ebro River for use at the petrochemical park; as a result, an equivalent volume of surface water will be available for urban water supply in the coastal areas of Tarragona province. By developing this new and locally available water supply source, industrial growth in a water scarce region has been supported, while promoting local industry's sustainability. This industrial water reuse project provided 0.20 hm<sup>3</sup> of water from September to December 2012, its first operational year, and 1.37 hm<sup>3</sup> in 2013. The paper presents and discusses the planning, design, construction and operation phases of this water reclamation and reuse project, including start-up and commissioning, facilities preservation protocols from construction completion to servicing start-up, and the operational, management and economic arrangements adopted to provide a reliable source of reclaimed water for cooling water systems and demineralized water for boiler feed at the Tarragona petrochemical park and a nearby cogeneration power plant.

**Key words** | advanced water reclamation, boiler feed water, cooling water supply, industrial water reuse

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### INTRODUCTION

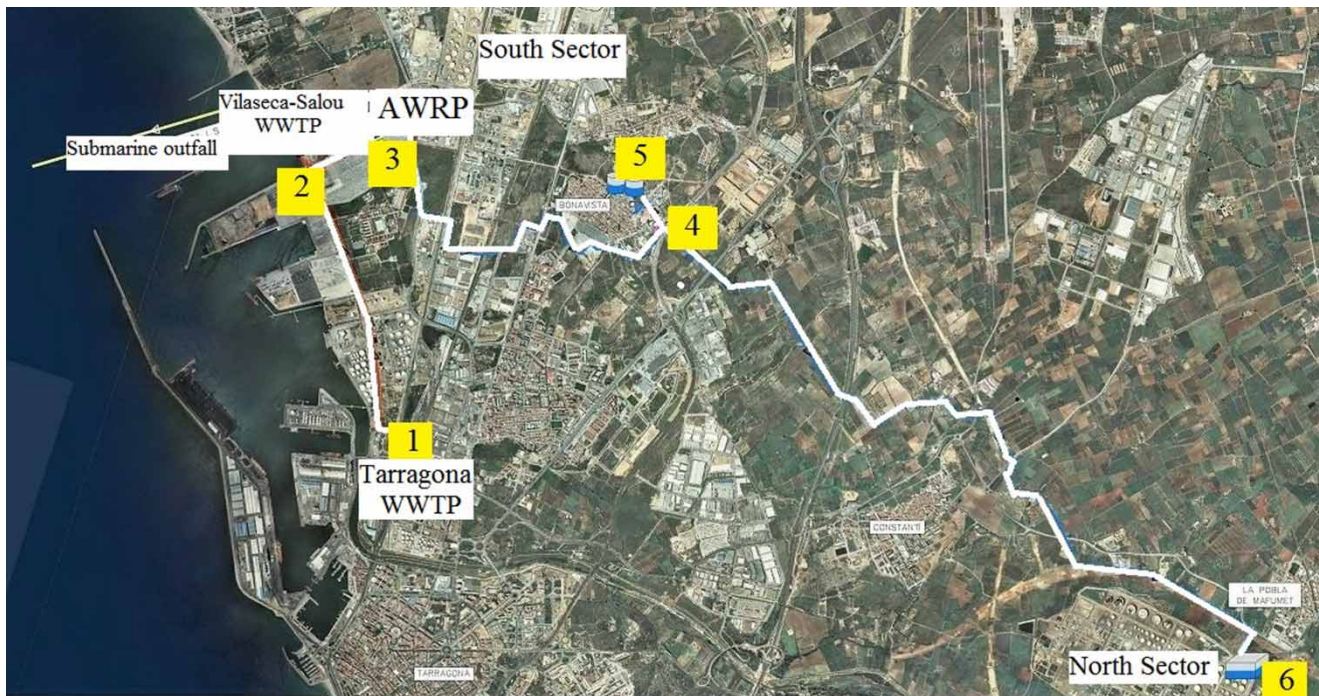
The historical water shortages affecting the Tarragona province during the 1970s were significantly overcome in 1989 by the formation of the Tarragona Water Consortium (TWC; <http://www.ccaait.com/cat/inici.htm>), a public water agency integrated by municipalities and industries, and charged with the construction and operation of a surface water transfer system from the nearby Ebro River. The main initial role of the TWC was to provide the investments necessary for waterproofing the major irrigation channels of the Ebro River irrigation districts (water rights holders); in exchange, the TWC was compensated with a water rights

allocation of a maximum flow of 4.0 m<sup>3</sup>/s and its corresponding maximum annual transfer volume of 120 hm<sup>3</sup>. The water rights transfer was subject to the condition of using water only for urban and industrial water supplies. By 2000, the TWC had invested 140 million euros, representing a water source development cost of 1.17 €/m<sup>3</sup>. The urban growth experienced by Tarragona coastal areas since the 1990s has resulted in summer peak water demands that are close to the upper allocation limit of the water transfer system. Considering that the 1989 TWC statutory agreement does not allow for exceeding the upper limit of 4.0 m<sup>3</sup>/s, the Catalan

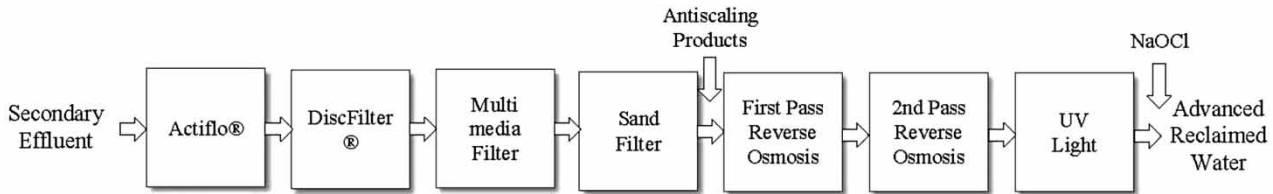
Water Agency (CWA) initiated a search for alternative options that would balance water supply and water demand in the area, mainly using new or non-conventional water supply sources. A water reclamation demonstration project was conducted from May 2008 to February 2009 to test the feasibility of using municipal secondary effluent as a water source for producing reclaimed water that could be used by the nearby petrochemical park. In 2011, the CWA completed the construction of a large advanced water reclamation plant (AWRP) and a reclaimed water supply network (Molist *et al.* 2011) that allows secondary urban effluents to become reclaimed water supplies suitable for the nearby petrochemical park (Figure 1).

The Camp de Tarragona AWRP was included in the CWA's Master Plan for Water Resources Management of 2010–2015 (CWA 2010) to provide additional and more reliable water resources that could be used to balance the prevailing chronic water deficit affecting the region. The Plan's water reclamation sub-program estimates a production capacity of 210 hm<sup>3</sup>/year by 2015, of which 101 hm<sup>3</sup>/year represent a gain of new resources.

The Camp de Tarragona AWRP was planned using as a reference West Basin Municipal Water District (WBMWD; <http://www.westbasin.org/>) of Southern California, where municipal secondary effluent is reclaimed to satisfy up to five different water quality levels, depending on its intended use. WBMWD was founded in 1947, but it was in 1995 when it started to provide reclaimed water for cooling towers and boiler feed supply produced at satellite facilities located in nearby refineries. Although water recycling within industrial facilities is a common practice, reuse of reclaimed municipal effluents is a relatively recent option, mainly promoted by water droughts like those of 1987–1992 in California. The Camp de Tarragona AWRP operates under the principle of producing basic and advanced reclaimed water at a centralized facility. Plans are under way to produce high purity process reclaimed water at satellite facilities within the industrial park. Industrial water recycling has been also practiced in India (Lahnsteiner *et al.* 2011) in response to environmental demands, using water reclamation plants that treat secondary effluents from refinery and various refinery/petrochemical processes,



**Figure 1** | Camp de Tarragona AWRP and reclaimed water supply network for industrial facilities at the Tarragona petrochemical park. (1) Tarragona wastewater treatment plant (WWTP); (2) diversion for submarine outfall; (3) Vilaseca-Salou WWTP and Camp de Tarragona AWRP; (4) diversion to north and south sectors of the petrochemical park; (5) reclaimed water storage tank for south sector; and (6) reclaimed water storage tank for north sector.



**Figure 2** | Process flow diagram of the Camp de Tarragona AWRP.

by means of advanced multi-barrier systems, including ultra-filtration and reverse osmosis (RO).

## OBJECTIVES

The main objective of this paper is to present and discuss the Camp de Tarragona water reclamation and reuse project, including its start-up and commissioning, facilities preservation protocols from construction completion to servicing start-up, and the operational, management and economic arrangements adopted to provide a reliable source of reclaimed water supply for cooling water systems and demineralized water for boilers feed at the Camp de Tarragona petrochemical park.

## CAMP DE TARRAGONA AWRP

The Tarragona and Vilaseca-Salou wastewater treatment plants (WWTPs) were interconnected by a 4-km pipeline to ensure that the AWRP can be supplied with enough secondary effluent from either or both WWTPs. Secondary effluent undergoes a basic reclamation process at the AWRP, consisting of a ballasted clarification step, followed by disc filtration, multimedia filtration and sand filtration (Camp de Tarragona WRP brochure 2011). The effluent undergoes an advanced reclamation process including a two-pass RO treatment processes and disinfection, using ultra-violet light and chlorine, before it enters the reclaimed water distribution system. The process flow diagram of the Camp de Tarragona AWRP (Salgado *et al.* 2012) is shown in Figure 2 and a general view of one of its two-pass RO processes is shown in Figure 3. The capital investment of the first phase of the water reclamation and reuse project was 47 million euros, jointly provided by EU cohesion funds,



**Figure 3** | General view of one of the two-pass RO processes at the Camp de Tarragona AWRP.

the Catalanian Government and the Spanish Ministry of the Environment.

Cooling water supply has been one of the main expected uses of reclaimed water produced at the Camp de Tarragona AWRP. Reclaimed water for cooling towers supply had to meet the quality requirements established by the Spanish reclaimed water regulations (RD 1620/2007) and also the operational specifications applicable to the cooling water systems considered, like concentration limits for ammonia, phosphates, 5-day biochemical oxygen demand (BOD<sub>5</sub>), total organic carbon (TOC), chemical oxygen demand (COD), electrical conductivity, chloride, sulfate, calcium and alkalinity. The critical reclaimed water quality requirements for cooling tower water supply are summarized in Table 1.

**Table 1** | Critical reclaimed water quality requirements for cooling tower water supply at the Camp de Tarragona petrochemical park, according to Spanish reclaimed water regulations

<i>Legionella</i> spp. (cfu/L)	<i>Escherichia coli</i> (cfu/100 mL)	Turbidity (NTU)	Ammonia (mg/L)	BOD <sub>5</sub> (mg O <sub>2</sub> /L)
Absence <sup>a</sup>	Absence <sup>a</sup>	1	<0.8	<4

<sup>a</sup>Detection limit of the analytical method used.

## AWRP START-UP

The AWRP start-up took place during early autumn 2011. Performance tests were conducted using three sources of influent water: (1) secondary effluent from Tarragona WWTP; (2) secondary effluent from Vilaseca-Salou WWTP; and (3) a mixture of secondary effluents from both WWTPs. The AWRP received secondary effluent in a sequential manner from each WWTP and then a mixture of both secondary effluents in a proportion of 70/30 from Tarragona and Vilaseca-Salou WWTPs. After completing start-up tests, the CWA authorized the performance testing protocol.

The full capacity performance testing protocol included a 24-h operation at flow capacity during 3 consecutive weeks: the first week using secondary effluent from Tarragona WWTP, the second week using secondary effluent from Vilaseca-Salou WWTP and the third week using a 70/30 mixture of secondary effluents from Tarragona and Vilaseca-Salou WWTPs. No flushing or chemical cleanings were performed when switching from one to another of the three sources of secondary effluents tested.

Water quality limits for the secondary effluent reaching the AWRP and their expected incidence in the operation of the plant are summarized in Table 2. Those limits were set up as a compromise between the water quality levels likely to be achieved by the WWTP effluents and the reasonably

acceptable water quality limits of the influent to the AWRP, which would ensure production of reclaimed water in accordance with the required reclaimed water limits. Those limits were jointly established by the CWA and the petrochemical industries, while assuring a sustainable operation.

The RO system performance testing protocol resulted in quite different results when processing the three different secondary effluents. Reclaimed water production decreased when processing secondary effluent from the Vilaseca-Salou WWTP, something that was not observed when processing secondary effluent from the Tarragona WWTP (Salgado *et al.* 2012).

Table 3 summarizes the range and the 50th percentile of the main water quality parameters of the secondary effluents reaching the AWRP; Table 4 summarizes the range and 50th percentile of the main water quality parameters of the reclaimed water produced by the Camp de Tarragona AWRP, during the performance testing period. Water samples were analyzed daily by an accredited external laboratory, following the ISO 17025 standard.

## PLANT SHUT-OFF AND PRESERVATION

After performance tests were completed, in October 2011, the AWRP was put to hibernation, as required by the CWA, until the final operational details could be completed for

**Table 2** | Water quality limits for influent and reclaimed water effluent of the Camp de Tarragona AWRP, with their expected incidence and recommended corrective measures

Parameter	Influent limit	Reclaimed water limit	Corrective action planned
NH <sub>4</sub> <sup>+</sup> (mg NH <sub>4</sub> <sup>+</sup> /L)	60	0.8	Decrease of RO recovery to 66–50%. If it is not sufficient, shut down AWRP
Ortho-PO <sub>4</sub> (mg P <sub>2</sub> O <sub>5</sub> /L)	10	3	Increase coagulant dose. Increase OPEX
BOD <sub>5</sub> (mg O <sub>2</sub> /L)	55	4	Decrease RO recovery to 66–50%. If it is not sufficient, shut down AWRP. Increase RO CIP and OPEX
TOC (mg C/L)	50	15	Decrease RO recovery to 66–50%. If it is not sufficient, shut down AWRP. Increase RO CIP and OPEX. Increase coagulant dose
Turbidity (NTU)	28	1	Increase chemical dose of RO pretreatment. If fouling index MFI is higher than manufacturer warranty, decrease RO recovery to 66–50%. If it is not sufficient, shut down AWRP. Increase RO CIP and OPEX
Electrical conductivity (µS/cm)	2,500	2,000	Increase OPEX

CIP: cleaning in place; OPEX: operation and maintenance expenses; MFI: modified fouling index.

**Table 3** | Quality levels of the influent to the Camp de Tarragona AWRP during the 3-week full capacity performance testing period

Parameter	Number of samples analyzed	Range	50th percentile
Ammonium (mg NH <sub>4</sub> <sup>+</sup> /L)	29	7–39	24
TOC (mg C/L)	29	8.5–18	14
COD (mg O <sub>2</sub> /L)	29	30–102	40
BOD <sub>5</sub> (mg O <sub>2</sub> /L)	29	3–16	8

**Table 4** | Quality levels of the reclaimed water produced by the Camp de Tarragona AWRP during the 3-week full capacity performance testing period

Parameter	Number of samples analyzed	Range	50th percentile
Ammonium (mg NH <sub>4</sub> <sup>+</sup> /L)	22	0.05–0.19	0.05
TOC (mg C/L)	22	<1.5	<1.5
COD (mg O <sub>2</sub> /L)	22	<30	<30
BOD <sub>5</sub> (mg O <sub>2</sub> /L)	22	3–11	3
<i>Escherichia coli</i> (MPN/100 mL) <sup>a</sup>	22	Absence	Absence
TSS (mg/L)	22	<5	<5
Turbidity (NTU)	22	0.13–0.87	0.2
Helminth eggs (ova/10 L)	22	<1	<1
<i>Legionella</i> spp. (cfu/L) <sup>a</sup>	22	<30	<30

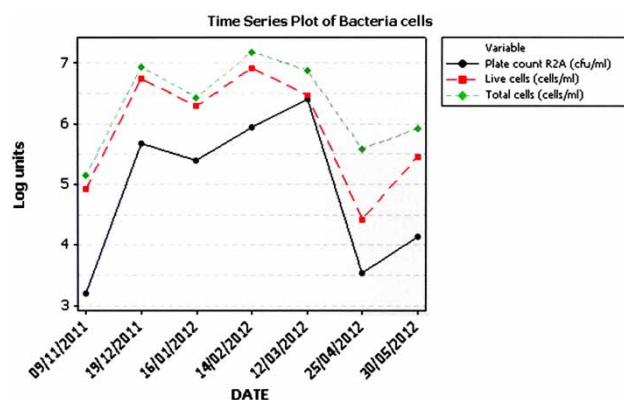
<sup>a</sup>Detection limit of the analytical method used.

the operation of the water distribution system to the Camp de Tarragona industrial park. The objective of the hibernation period was to ensure that membranes would keep their full production capacity during an estimated period of 6–12 months. The first requirement was to identify the most suitable chemical solution for preservation. Sodium bisulfite is the most frequently adopted chemical agent, but it requires a monthly pH control to determine the degree of bisulfite oxidation as well as its potential sulfuric acid production, which has caused corrosion problems in pressure vessels and pipes, and membrane failures in some facilities.

A collaborative effort with Dow Chemical was launched to assess an alternative non-oxidative biocide that would eliminate both the corrosion problems and the critical control of the conservation solution's pH (Majamaa et al. 2011). The biocide finally selected was 5-chloro-2-methyl-2H-isothiazol-3-one/2-methyl-2H-isothiazol-3-one (CMIT/MIT) as it does not modify the pH of the pretreated water solution.

Biocide was added by recirculating permeate containing 15 mg/L of CMIT/MIT through the RO pressure vessels. This solution inhibits biological growth during a shut-down period. Biocide concentration was verified every 30 days, together with pH, electrical conductivity, dissolved oxygen, redox potential and total bacterial count. After 6 months in those conditions, RO pressure vessels were drained and a fresh biocide solution was put in place.

Before biocide application, all the membranes were thoroughly cleaned, using an alkaline solution followed by an acidic solution, according to a standard cleaning protocol. A weekly sampling of each RO pressure vessel from the two-pass RO racks was established as a control. Preservation controls involved determination of biocide concentration and viable count of aerobic bacteria, performed by direct plating onto duplicate R2A agar plates and incubated at 22 °C (Reasoner & Geldreich 1985). Also, total cell count was performed by epifluorescence microscopy in DAPI (3',6-diamidino-2-phenylindole) stained samples filtered on 0.2 µm nucleopore polycarbonate filters (Porter & Feig 1980) and also bacterial viability (quantitative live and dead bacteria cells) using the LIVE/DEAD<sup>®</sup> BacLight<sup>™</sup> assay (a mixture of two nucleic acid stains, green-fluorescent SYTO<sup>®</sup>9 dye and red-fluorescence propidium iodide) with the aid of a flow cytometer. Monthly controls indicated a fast inactivation of the biocide up to its total disappearance, due to degradation processes carried out by nucleophiles (Krzeminski et al. 1975) and a stable microbial cell population of 5–6 log units/mL. Direct counts of living cells determined during the hibernation period appear in Figure 4.

**Figure 4** | Viable counts of bacterial cells in RO membrane systems of Camp de Tarragona AWRP during the preservation period.

The preservation period of the Camp de Tarragona AWRP ended in August 2012 and operation resumed in September 2012 to supply the first industrial users with a flow of 200 m<sup>3</sup>/h. Before resuming production, the RO system was thoroughly cleaned using a short chemical cleaning protocol that provided a full recovery of its normalized permeate production capacity, as has been recently published (Sanz et al. 2014) and is shown in Figure 5.

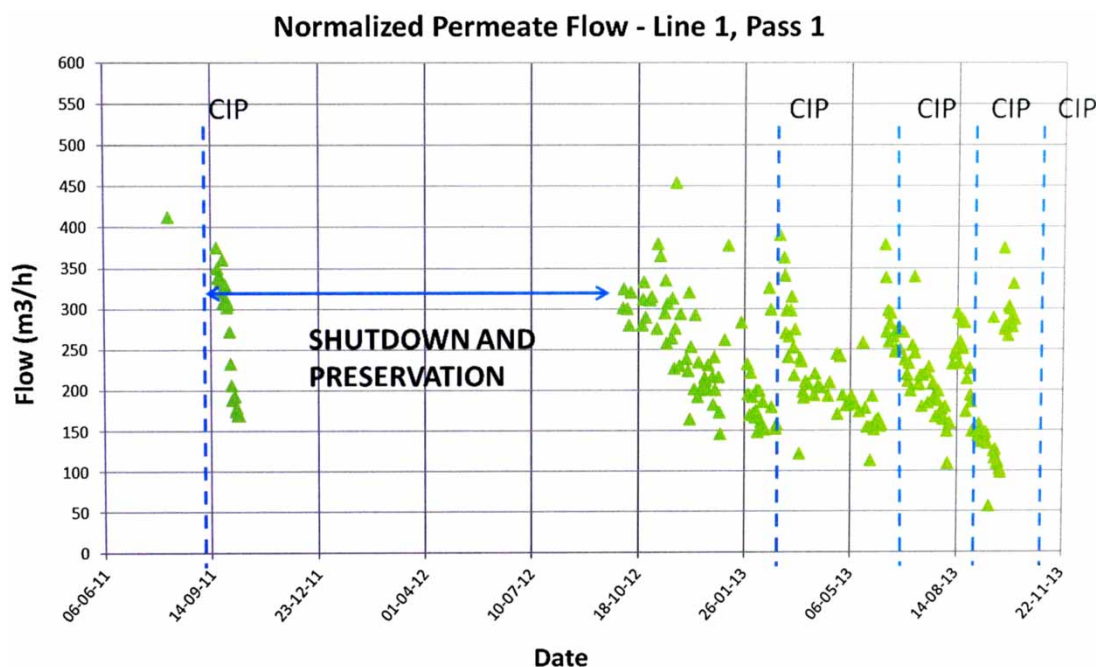
## RECLAIMED WATER PRODUCTION

The Camp de Tarragona AWRP started to provide reclaimed water for cooling water systems in September 2012, using a 14-km pipe distribution system. In June 2014, production of demineralized water for boiler feed was started at a nearby satellite facility within the petrochemical park, using an ion-exchange process. The goal was to raise the overall system capacity to 2.0 hm<sup>3</sup>/year, the maximum flow allowed for its first year of operation, according to the joint agreement of the CWA and the Tarragona Association of Chemical Companies (TACC).

During the testing and performance periods of the AWRP, started in September 2011, the facilities were operated by the

project contractor during a 1-year guarantee period at an operation and maintenance cost of 0.4123 €/m<sup>3</sup>. During the hibernation period, an operating company was formed by Aguas Industriales de Tarragona, S.A. (Industrial Waters of Tarragona, Inc., AITASA) and Veolia Water Technologies, as the technology partner, to conduct a project economic analysis that would determine the actual operation and maintenance costs and the reclaimed water cost applicable to petrochemical park users. The ability to choose among the secondary effluents from the two WWTPs allows for a selection protocol based on their quality and their potential for achieving a higher performance of the RO process. However, the optimal selection is not simple to achieve, because of the flow fluctuations shown by secondary effluents from each WWTP and the variable quality of those effluents, mainly due to the variable quality of the raw wastewater they receive.

Hydraulic and organic content overloads at Vilaseca-Salou WWTP during summer periods and particularly storm periods result in secondary effluents of poor quality. In addition, secondary effluent availability from this facility is also limited by the need to supply an existing water reclamation plant (WRP) for landscape irrigation. To ensure the greatest coordination possible between the secondary



**Figure 5** | Normalized permeate flow of the first-pass of the RO system at the Camp de Tarragona AWRP, during the systematic chemical cleaning processes applied after the preservation period (Sanz et al. 2014).

effluents flows available from the two WWTPs and the flow required by the existing WRP, the CWA calls for regular meetings between the operational teams from the three facilities. The meetings promote a close coordination concerning the availability of effluent flows and their corresponding qualities, the incidents and the actions implemented at each WWTP that can affect the secondary effluents produced and sent to the AWRP and WRP, and any interfering conditions that may occur. The main water quality variations observed in the raw wastewater reaching the WWTPs are caused by sea-water infiltration through the main sewer lines along coastal avenues (increasing electrical conductivity), bulking episodes (increasing TSS), overloading of the biological processes and sudden increases of coagulant demand, whose main causes are still pending determination. In all those cases, the operating conditions of the AWRP basic reclamation step must be adjusted, to keep the RO system influent quality as stable as possible; otherwise, energy consumption increases significantly, mainly due to higher salts concentration and thus the osmotic pressure of the RO feed. Those experimental observations are in excellent agreement with the operational limitations initially established and summarized in Table 2.

RO membrane fouling has been of very limited duration, of reversible character and mainly affecting the three stages of the first-pass RO system. The fouling observed has an organic nature, is produced by proteins and low molecular weight dissolved organic compounds, as established by different analytical determinations, and decreases water production flows, without a corresponding trans-membrane pressure loss. Studies are being conducted (2014) with the objective of identifying the organic compounds involved in this fouling process and facilitating its analytical detection, so preventive measures can be readily applied. Several preventive measures have been already adopted, like using permeate for cleaning the RO system (direct osmosis using permeate back flushing). The cleaning frequency currently applied to the initial stages of the first-pass RO process is once in every 2 months, as it has provided a full recovery of the permeate production capacity.

## RECLAIMED WATER QUALITY

Since the AWRP went into operation in September 2012, 1.57 hm<sup>3</sup> of reclaimed water was supplied to industrial

**Table 5** | Reclaimed water quality at the outlet of Camp de Tarragona AWRP and in the water distribution network to the Camp de Tarragona industrial park

<i>Legionella</i> spp. (cfu/L) <sup>a</sup>	<i>Escherichia coli</i> (cfu/100 mL) <sup>a</sup>	TSS (mg/L)	Turbidity (NTU)	Helminth eggs (ova/10 L)
<80	<1	<2	<0.2 – 0.3 (<0.6 in network)	<1

<sup>a</sup>Detection limit of the analytical method used.

users up to December 2013. The volume supplied during the first quarter of 2014 has been 0.30 hm<sup>3</sup>. The quality control program conducted by an external accredited laboratory confirms that reclaimed water quality conforms to the main quality requirements established for the AWRP effluent (see Table 5). Reclaimed water quality in the distribution network also conforms to those specifications, with only one case of unconformity caused by *Legionella* spp. concentration. To correct possible causes of that unconformity, the water distribution pipe stretch of concern was disinfected with sodium hypochlorite and new analyses for *Legionella* spp. were conducted, both before and after disinfectant application, following the control protocols applicable to cooling towers (Royal Decree 865/2003).

Spanish reclaimed water regulations require a favorable report from public health authorities for any water reuse project proposal. In 2010, the Public Health Protection Agency of Catalonia authorized the production of reclaimed water at the Camp de Tarragona AWRP, during its first year of operation, under the conditions of intensifying its self-monitoring program and specifically assuring an analytical frequency for *Legionella* spp. of three times a week. The favorable results of that monitoring program allowed the CWA to authorize in 2012 the operation of the Camp de Tarragona AWRP. Subsequent assessments of the 2013 and 2014 operating results have served to confirm and continue that initial authorization.

## RECLAIMED WATER FOR DEMINERALIZED WATER PRODUCTION

Reclaimed water from the Camp de Tarragona AWRP has an average electrical conductivity of 20 µS/cm and a TOC lower than 0.2 mg/L, which makes it perfectly suitable for



water supply of cooling towers. Furthermore, that water quality offers the possibility for its use as feed water for demineralization processes by ion-exchange resins. In June 2014, a satellite water demineralization facility went into operation within the petrochemical park to produce 30 m<sup>3</sup>/h of highly demineralized water (0.2 µS/cm) for boiler feed water, using an ion-exchange process and reclaimed water supplied from the AWRP.

An existing cogeneration power plant located next to the AWRP is another potential user for demineralized reclaimed water. This power plant has been using seawater as feed water for demineralization by RO and ionic exchange resins and is the first reclaimed water client willing to switch to the new feed water source, due to the more favorable technical and economic conditions involved. The operating company of the Camp de Tarragona AWRP is currently (2014) planning supply arrangements to provide reclaimed water to this cogeneration power plant (at 1.0 hm<sup>3</sup>/year), as well as to other similar water users within the petrochemical park.

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## INDUSTRIAL END-USERS

In October 2012, the CWA transferred the operation and maintenance tasks of the Camp de Tarragona water reclamation and reuse facilities to AITASA for a concession period of 25 years, in accordance with the provisions of the agreement reached by the CWA and the TACC. AITASA is an operating company of the TACC and has the mission of assuring a diversity of common services for its industrial members, including the operation and maintenance of the advanced water reclamation and reuse project. From early 2013, the AITASA-Veolia operating company assures the operation and maintenance of the AWRP and the ion-exchange processes at the satellite facilities, as well as the operation of the reclaimed water distribution network.

During the first year of the operational contract, the main objective of AITASA has been to demonstrate to all potential users the advantages of using reclaimed water instead of surface river water, from both the technical and the economic points of view. Since September 2012, when reclaimed water production was started, two industries (Repsol and Dow Chemical) have been using reclaimed water for cooling towers supply. They have become the

reference users for demonstrating to all others the benefits derived from the quality and reliability of reclaimed water, in comparison to using surface water from the TWC's water supply system. The main goal of the AITASA-Veolia operating company is to show industrial users the benefits of having a managing organization that ensures production, quality control, distribution of reclaimed water, maintenance of the supply network and economic management of the whole project. The operating company is currently (2014) conducting a series of technical meetings with all other industrial users to present the practical results obtained with the two reference reclaimed water users, including the economic arrangements of the water reclamation and reuse project. The ultimate goal is to increase the number of water users during the second semester of 2014 and reach the 2 hm<sup>3</sup>/year production capacity established in the action program approved by the CWA.

An economic analysis made by the AITASA-Veolia operating company indicated a production cost of 0.5 €/m<sup>3</sup> for advanced reclaimed water, during the 1-year guarantee period. A preliminary economic analysis of the ion-exchange demineralization process for high purity water production, at satellite facilities located within the industrial sites, has provided a production cost of 1.2 €/m<sup>3</sup>. The cost of reclaimed water distribution is currently (2014) under discussion between industrial users and the operating company. The price of reclaimed water will be subsequently established by the operating company, mainly based on reclaimed water quality, water volumes used and water use schedules.

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## CONCLUSIONS

Implementing a water reclamation and reuse project is a very site-specific task, involving definition of the technical facilities necessary to achieve the required water quality limits and also the water distribution infrastructure, the regulatory, administrative, economic and operational requirements necessary for the whole process to work in an orderly fashion. While the selection of the required reclamation technologies is usually a simple process, including testing and demonstration steps, the definition of the regulatory, administrative, economic and operational conditions for water reuse to take

place may require a very specific, elaborated and frequently long process.

The Camp de Tarragona water reclamation and reuse project was launched by the CWA in 2008, because of the need for non-conventional water resources in a geographical area with limited water resources. The project's goal was to implement an advanced reclamation process using secondary effluent from two nearby wastewater treatment plants, whose effluent would be otherwise disposed into the Mediterranean Sea, aside from the treated effluent flows already used to produce reclaimed water for landscape irrigation at nearby parks. The project has produced high quality reclaimed water for cooling towers supply at industrial facilities within the petrochemical park, as well as for further demineralization to produce boiler feed water for industrial use and power generation.

The capacity of the existing AWRP is 19,000 m<sup>3</sup>/d, although it is planned to bring production to 55,000 m<sup>3</sup>/d in the coming years. The production capacity of the AWRP for the first year of operation (2013) was set at 2.0 hm<sup>3</sup>/year (5,500 m<sup>3</sup>/d), but only reached 1.37 hm<sup>3</sup>/year.

An elaborated cooperation process was promoted by the CWA among urban water providers and industrial users to demonstrate to industrial users the quality and reliability levels of the new local water supply source, as well as the economic and strategic advantage of relinquishing their current surface water rights from TWC, in exchange for the local and more reliable advanced reclaimed water. An operating company has been set up with the responsibility to operate and maintain the AWRP for the next 25 years and to ensure distribution of reclaimed water to industrial users, using a dedicated 14-km long water distribution network.

By developing this new and locally available water supply source, an AWRP like that of the Camp de Tarragona prevents water transfers from other basins, supports industrial growth in a water scarce region and further increases industrial sustainability. The water reclamation and reuse facilities had a cost of 47 million euros, jointly provided by EU cohesion funds, the CWA and the Spanish Ministry of the Environment.

The economic analysis made by the operating company indicates a production cost of 0.5 €/m<sup>3</sup> for advanced reclaimed water, during the 1-year guarantee period (from

October 2012); a more recent preliminary economic analysis indicates a production cost of 1.2 €/m<sup>3</sup> for the higher quality ion-exchange demineralized water at the satellite facilities. The cost for reclaimed water distribution is under evaluation.

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