

Water Reuse Project of Lloret de Mar Consorci of Costa Brava

Costa Brava

Costa Brava is the geographical designation for the coastal strip extending along the northeastern coast of Spain, in the Catalanian province of Girona. Its rugged coastline and its beautiful secluded beaches have helped to make it one of the most attractive tourist areas in the world. It enjoys a Mediterranean climate, with hot and dry summers, mild winters and usually wet autumns and springs; its average rainfall is 650 mm/year, but with episodic and recurring drought periods that raise considerable concerns among those responsible for providing water supply to resident and seasonal populations as well as to agriculture and aquatic ecosystems.

The Costa Brava coastal strip includes 27 municipalities, distributed along 200 km of coastline. A permanent population of 240,000 people becomes a seasonal population of more than 1 million people during the peak tourist summer season (June to August). Most visitors come from Spain and numerous European countries.

Consorci of Costa Brava

Consorci of Costa Brava (CCB) is the water agency, founded in 1971, to provide integrated management of water resources to the 27 municipalities of Costa Brava. Since 2006, operation and maintenance tasks are implemented through a public-private company named Aigües de la Costa Brava. CCB is responsible for:

- 1) Provision of water supply, as a wholesale drinking water purveyor, to 16 cities (5 of them external to CCB). The water supplied during 2010 was 17.1 hm³.
- 2) Operation of 18 wastewater treatment plants (WWTP) where wastewater flows from 31 cities (4 of them external to CCB) are treated using biological processes. The annual volume of wastewater treated during 2010 was 34.1 hm³.
- 3) Since 1989, operation of an increasing number of water reclamation and reuse projects for non-potable uses; the total flow of reclaimed water produced by the 14 water reclamation plants (WRP) during 2010 was 6.4 hm³, which represents 19% of the secondary effluent produced.
- 4) Design, construction, operation and maintenance of several water treatment facilities, funded by the Catalan Water Agency, the regional water authority responsible for collecting and distributing regional water taxes.

Lloret de Mar Water Resources

Lloret de Mar is a small coastal resort town located in southern Costa Brava; its beautiful landscapes and magnificent beaches soon attracted a mass tourist population, mostly from central and northern European countries. From 1995 till 2011, local resident population has doubled, from 20,000 people to 40,000 people, bringing its summer population close to 150,000 people. Drinking water use ranges from 5 hm³/year to 6 hm³/year, which are all

provided from external sources: on average, 70% is groundwater from the Tordera river aquifer and 30% is desalinated water from Blanes seawater desalination plant, both located some 15 km southwest.

Under conventional water management strategies, this costly imported water was used by the community, turned into wastewater, treated in a biological wastewater treatment plant and, as in other coastal areas, discharged into the sea. In Costa Brava, Lloret de Mar was one of the leading municipalities to understand that a reasonable additional investment could turn wastewater into reclaimed water, a new municipal water resource for supply to non-potable uses, with lower production and conveyance energy requirements than conventional sources. In Lloret de Mar, those favorable conditions are further intensified by the maximum availability of reclaimed water that takes place during the summer season, when demand for non-potable uses is the highest and local resources are more affected by the Mediterranean dry season.

The urban development of Lloret de Mar, in a geographical area exposed to such seasonal water shortages, inevitably implies higher investments to satisfy water consumption, higher energy costs to cover water production and transfer, and higher costs for domestic water supply and for other urban uses, such as irrigation and street cleansing. Non-potable uses are severely restricted during seasonal droughts.

This water resources situation brought the need of developing new, alternative, additional water resources capable of satisfying very specific requirements: 1) to provide a sufficient water volume, 2) to satisfy non-potable uses quality while ensuring public health protection, 3) to require a low energy use for its production, 4) to provide a high supply reliability, particularly during drought periods and 5) to avert any further environmental impact, by preventing additional abstractions from surface or groundwater.

Although reclaimed water does satisfy all those requirements, its beneficial use poses new requirements: the availability of either a groundwater system with enough recharge capacity to absorb reclaimed water and provide the environmental buffer zone required for indirect potable reuse or, alternatively, a distribution system to supply reclaimed water according to demand. The distribution system had to include preferably 3 new water storage tanks: 1) a secondary effluent equalization tank, to ensure reclamation process reliability, 2) a reclaimed water storage tank, provided with chlorination devices and some kind of recirculation and 3) a water tank for gravity feed to the urban distribution network. In summary, development of a new, alternative or additional water resource, of whatever type it may be, involves provision of the additional necessary infrastructures with its corresponding investment.

History of Water Reuse in Lloret de Mar

Lloret de Mar has always been an area with a limited water resources and thus with a current absolute dependence on external sources. The approval of a golf course in the early 1990's further increased the water demand burden while forcing the local development of additional water resources. In 1992, the state-of-the-art WWTP of Lloret de Mar was inaugurated, opening the door for planned water reclamation and reuse in the area. In 1994, after the earlier successful experience of landscape irrigation with reclaimed water in the Mas Nou golf course, in Castell-Platja d'Aro (1989), the Golf L'Àngel also started to use disinfected secondary effluent for landscape irrigation.

For several years, water supply for landscape irrigation at Golf l'Àngel, until its closure in 2009, was the only use of reclaimed water in the municipality of Lloret de Mar, but served as a demonstration project for satisfying new irrigation uses while saving the precious municipal drinking water supplies. In the late 90's, the municipality of Lloret de Mar began planning the construction of a reclaimed water network that became reality in May 2007. The reclaimed water network was designed to provide water suitable for landscape irrigation at the charming Santa Clotilde Gardens, located on a rough cliff contemplating the coastal area and at the end of the municipality opposite to the WWTP. This early development of the distribution network served as the backbone of a new system intended to gradually expand in order to provide irrigation water to other nearby areas that were using either tap water (other municipal gardens) or groundwater from a small aquifer (a Pitch & Putt facility).

Also in 2007 the WWTP of Lloret de Mar began rehabilitation and upgrade works. The new facilities included two biological reactors and an anaerobic digestion reactor, plus a conventional reclamation process to further improve the quality and reliability of reclaimed water.

Lloret de Mar Water Reclamation Process

The WRP of Lloret de Mar has a capacity of 300 m³/h (7,200 m³/day) and includes: coagulation-flocculation, lamella settling, a 10 µm pore size microscreening process and a combined disinfection process using sodium hypochlorite and UV light, at a maximum dose of 37 mJ/cm² (Fig. 1). Reclaimed water is directly pumped to a storage tank of 56 m³, for subsequent distribution. Reclaimed water quality control is performed using: 1) an online turbidity sensor at the WWTP effluent point and 2) an online redox potential sensor at the effluent of the microscreening process.



Figure 1. General view of the water reclamation plant of Lloret de Mar.

Reclaimed water supplied by the WRP of Lloret de Mar during recent years has ranged from 30,000 m³/year to 60,000 m³/year. Reclaimed water has been used for landscape irrigation at the Santa Clotilde Gardens (See Fig. 2) and other public gardens, and at the nearby Pitch and Putt facility. Reclaimed water supplied has decreased over the last few years because of the closure of a local golf course.



Figure 2. Landscape irrigation with reclaimed water at the Santa Clotilde Gardens, Lloret de Mar.

Lloret de Mar Reclaimed Water Distribution System

The reclaimed water distribution system of Lloret de Mar includes a pumping station to bring water to a gravity tank with a capacity of 56 m³ (Fig. 3), through a main of 1.8 km length and 180 mm diameter polyethelene pipe. From the elevated storage tank, water flows to 2 water storage tanks located at the Santa Clotilde Gardens, each of 140 m³ capacity. The distribution system includes another main conduit of 2.2 km length and 200 mm diameter polyethelene pipe, continued by a 700 m length and 160 mm diameter polyethelene pipe. The total length of main lines is 4.7 km (See Fig. 4).



Figure 3. Reclaimed water storage tank at Lloret de Mar.

After the reclaimed water network was completed and set in operation, monitoring took place at the effluent of the WWTP and the inlet and outlet of the 2 storage tanks (a total of 5 sampling points), with the inlet of the first storage tank being the control point for reclaimed water production. Recently, the monitoring strategy has been revised by eliminating those sampling points that were providing redundant information.

The operational strategy for reclaimed water distribution has been: 1) to define an operational protocol among all the interested parties (water producers and water users)

and 2) to install automatic online safety features, to ensure the reliability of reclaimed water quality and the immediate service interruption when a critical water quality parameter goes outside the specified interval.

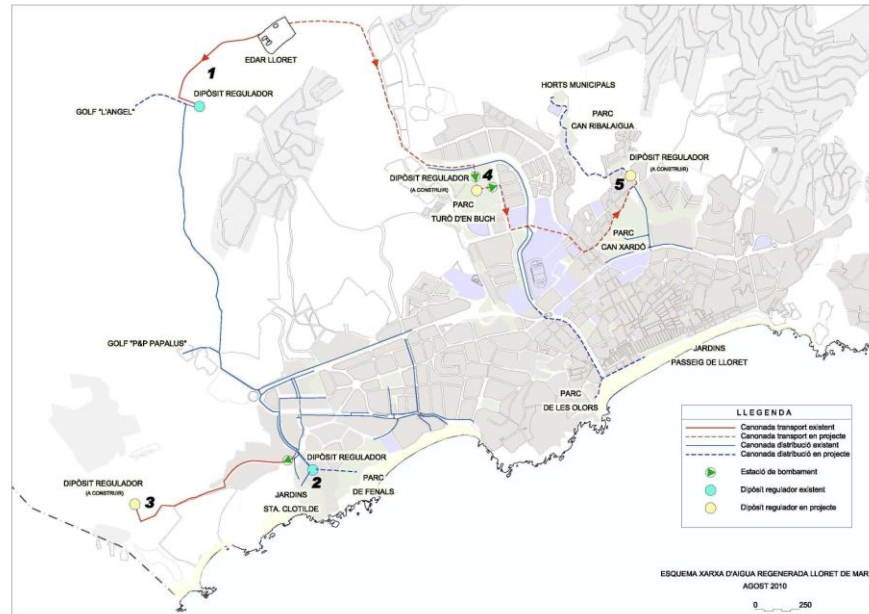


Figure 4. Reclaimed water distribution system of Lloret de Mar, by mid 2010. Solid lines are existing pipeline and dashed lines are pending infrastructures.

Spanish Water Reuse Regulations

Water reclamation and reuse regulations are established by Royal Decree (RD) 1620/2007. In summary, reclaimed water quality is defined by four main parameters: parasitic helminth eggs, *E. coli*, suspended solids and turbidity. Other microbiological parameters, like *Legionella* sp. and physico-chemical parameters are applicable to specific uses of reclaimed water.

Reclaimed water uses are classified according to the expected exposure of workers, the public at large and the irrigated crops to reclaimed water. Quality requirements become increasingly restrictive as the likelihood of human exposure becomes possible, to ensure public health protection and environmental protection. Compliance is established according to the 90 percentile (P90) of the series of water quality parameters recorded during the water reuse period.

Applicable limits for current reclaimed water uses in Lloret de Mar are those corresponding to unrestricted urban use (Quality Use 1.2) with SS, turbidity, parasitic helminths and *E. coli* P90 concentration limits below 20 mg/L, 10 NTU, 1 egg/10L and 200 cfu/100mL. Future mid-term plans include the supply of reclaimed water for irrigation of private gardens, which involves compliance with quality limits for unrestricted residential use (Quality Use 1.1): P90 values below 10 mg/L for SS, 2 NTU for turbidity, 1 egg/10L for parasitic helminths and 1 cfu/100 mL for *E. coli*.

Reclaimed Water Quality

Seasonal samples of reclaimed water collected in Lloret de Mar during 2009 (See Fig. 5) had P90 values for SS concentration of 6.1 mg/L (76 samples), turbidity of 4.8 NTU (75 samples) and absence of *E. coli* in 94% of the 88 samples analyzed. Analogous values for 2010 were 8.9 mg/L for SS (96 samples), 6.7 NTU for turbidity (95 samples) and absence of *E. coli* in 96% of the 94 samples analyzed.



Figure 5. Water sampling at Lloret de Mar reclaimed water distribution network.

Reclaimed water quality satisfied the limits for Quality Use 1.2 during 2009 and 2010. The limits for SS and *E.coli* of Quality Use 1.1 were consistently met during 2009 and 2010; efforts are currently being made to also meet the 2 NTU turbidity limit.

Since 2003, reclaimed water is regularly analyzed for parasitic helminth eggs once a year; no eggs have been detected in either the 25L or 50L water samples analyzed so far.

Residual chorine concentration in the Lloret de Mar distribution network was always detectable, with 10% (P10) concentrations ranging from 0.40 mg/L at the beginning of the distribution pipe, down to 0.03 mg/L at the sampling points further located from the WRP. The P10 value for dissolved oxygen concentration in different sampling points varied from 4.0 to 7.0 mg/L, thus ensuring a lack of undesirable odors during landscape irrigation.

Apart from these specific evaluations on the safety of reclaimed water, the municipality of Lloret de Mar complies with the requirements of Royal Decree 865/2003 relative to the prevention and control of Legionellosis, by cleaning and disinfecting all the sprinklers under its responsibility, whether they use drinking or reclaimed water, thus ensuring the required level of public health protection.

Capital Investment and O&M costs

Table 1 shows the capital investments of the water reclamation and reuse project of Lloret de Mar.

Table 1. Capital investments of the water reclamation and reuse project of Lloret de Mar, up to 2011.

Project component	Dimensions	Cost, in Euros
Water reclamation plant	7,200 m ³ /day	
Civil works		1,200,000
Piping and valves		358,000
Pumping station to gravity storage tank		172,000
Distribution network	4,7 km of main lines of 180 mm, 200 mm and 160 mm 12,2 km total length	
Total investment		1,730,000

Until now, reclaimed water has been supplied to different end users under a case by case technical and economic arrangement. CCB is currently completing the official permitting process established by Spanish regulations (Rd 1620/2007), to obtain the official category of wholesale reclaimed water producer and supplier from the Catalan Water Agency, the water authority in Catalonia. Once that official designation is obtained, CCB will be able to establish the appropriate wholesale reclaimed water supply contracts with municipalities, which will be responsible for managing the technical and economic aspects of reclaimed water distribution to end users.

Further Information

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Technical References

The CCCB's webpage section on water reclamation and reuse provides extensive information on the current activities and future plans concerning the water reclamation and reuse projects conducted at the 27 municipalities of CCB.

(<http://www.ccbgi.org/reutilitzacio.php>)

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