

# THE BENEFITS OF REUSING WATER IN THE INTERIOR: THE SABADELL CASE

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## SUMMARY

The particular nature of Mediterranean environments increasingly requires an optimisation of the use of water resources. In this piece of work, we look at reusing water as an effective contribution for facing this problem, taking actions started and planned in Sabadell as a case study. The city, which belongs to the basin of the River Besòs, distributes a volume of drinking water of 15.2 Hm<sup>3</sup> a year (mainly from the ATLL [Aigües Ter-Llobregat] network). The Town Council has promoted various actions in the field of water management, such as the construction of an outlet for treated water to guarantee the volume of flow of the River Ripoll as it flows through the municipality and the replacement, in collaboration with Companyia d'Aigües de Sabadell, S.A. (CASSA), of volumes of flow of drinking water of lesser quality for certain uses (watering green areas and cleaning streets), using the existing installations such as the River Ripoll Mine and the Ribatallada Mine. The other action carried out by Sabadell Town Council has been the use of water from the well in the Parc Catalunya to maintain the artificial lake and to water the park. The development of the Master Plan for the use of water from outside the distribution network of drinking water must enable the replacement of 1.1 Hm<sup>3</sup> of drinking water by reclaimed water from the River Sec WWTP and the Ribatallada Mine and the River Ripoll Mine. The price of the reclaimed water necessary to support the introduction and funding of the network, as well as the running and maintenance costs should be 0.713 €/m<sup>3</sup> (North network) and 0.597 €/m<sup>3</sup> (South network). The investment for the introduction of the reclaimed water network in Sabadell referring to the volume available annually is similar to that of the ATLL network and to that of carrying water to Sabadell from Sant Pere Màrtir and Cerdanyola.

**Key words:** Reclaimed water, reusing water, River Ripoll, Sabadell

## **INTRODUCTION**

Mediterranean environments are rather particular with regard to their climate. In these environments one of the most worrying aspects is the long low water level periods and, in general, the shortage of rainfall which often leads to periods of drought. In the inland river basins of Catalonia, this climate leads to a complicated balance between resources and demands, which must make us look more deeply into an efficient management of the resources that covers all the phases of the system, starting with the reservoirs and distribution networks and carrying on until the end user, continuing however until it leaves the WWTP. The importation of resources may be inevitable, however we need to review the current system immediately, before looking at solutions that follow the schemes of the last century. We need to know at which points in the system we can improve the efficiency of the use of the water and it is in this context that reusing water takes on a relevant role.

This article explains the actions that are being started in Sabadell and the future planning as far as reusing water is concerned. Taking this local action as a starting point, we try to extrapolate the benefits obtained and the expected economic costs to the rest of the system, doing the exercise of comparing the cost of availability of reclaimed water with drinking water.

The city of Sabadell has a surface area of 37.89 km<sup>2</sup> and a population of 193,954 inhabitants (2004 census), and it is 20,6 km north west of the city of Barcelona. The natural ecosystems in this area are influenced by the proximity of the Sant Llorenç del Munt massif. with the course of the River Ripoll and its tributaries, the River Tort, Colobriers Stream and Ribatallada Stream. The River Sec, that flows through the southern part of the municipality at its border with Sant Quirze del Vallès, is a mass of water with a lesser volume of flow. The climate in this area is typically Mediterranean, with dry summers and most plentiful rainfall during the spring and particularly in the autumn. The volume supplied by the distribution network of the city of Sabadell is 15.2 Hm<sup>3</sup> a year, mainly from the Aigües Ter-Llobregat (ATLL) network, although there is a symbolic contribution from the Mari-Vinyals mine. The drains network of Sabadell is situated completely on the Basin of the River Besòs.

## **ACTIONS DEVELOPED IN SABADELL**

The city of Sabadell has suffered from water problems throughout its history. Its intense industrial activity has placed heavy pressure on the River Ripoll, both with regard to the exploitation of the resource as well as the incidence of tipping, and its urban growth has meant that resources have had to be imported, either through carrying water from the Llobregat, that was done by Companyia d'Aigües de Sabadell, S.A. (CASSA) in 1952, as well as the recent connection to the ATLL network. The setting up of the WWTP in the River Sec in 1992 and the River Ripoll in 2001 have meant a progressive improvement in the conditions of the rivers in the municipalities, especially in the case of the River Ripoll.

Sabadell Town Council, historically sensitive to the problem of water, has, in recent years, developed a series of actions in this area, such as the environmental improvement of the River Ripoll with the construction of a treated water outlet, and the release of drinking water resources by the use of alternative sources such as the Ribatallada Mine and the River Ripoll Mine.

## **The River Ripoll treated water outlet**

The availability of resources provided by the River Ripoll brought about a concentration of industrial activity along its course. The industry, mainly the textile sector, used water from the alluvial aquifer and tipped it back into the river after it had been used. Although the industries started to have their own treatment systems, to be able to tip back into the river in accordance with the demands of the regulation, the integration of its tipping into the water treatment system of the River Ripoll was planned. This perspective could create a future imbalance between extraction and contributions along the river course, due to the concentration of the return of the treated water at a single point, situated downstream of the main users.

To alleviate this problem, Sabadell Town Council boosted the construction of a pressurised pipeline of treated water to two points in the river, the Torrella Mill, half way along its course and Colobrerers Stream at the beginning of the municipal area, with the aim of guaranteeing the circulating flow of the river and recharging the aquifer. A pipe collects the water that comes from the water treatment plant of the River Ripoll and takes it, by gravity, to the Torrella Mill, where part of it is tipped. From here to the area of Colobrerers Stream, the water is driven by pumping equipment. The length of the outlet is 6,295 metres and it has the ability to return the following volumes to the river:

Sant Oleguer: 12,000 m<sup>3</sup>/day  
Torrella Mill: 10,000 m<sup>3</sup>/day  
Colobrerers Stream: 8,000 m<sup>3</sup>/day

## **Indirect reuse of water from the River Ripoll Mine**

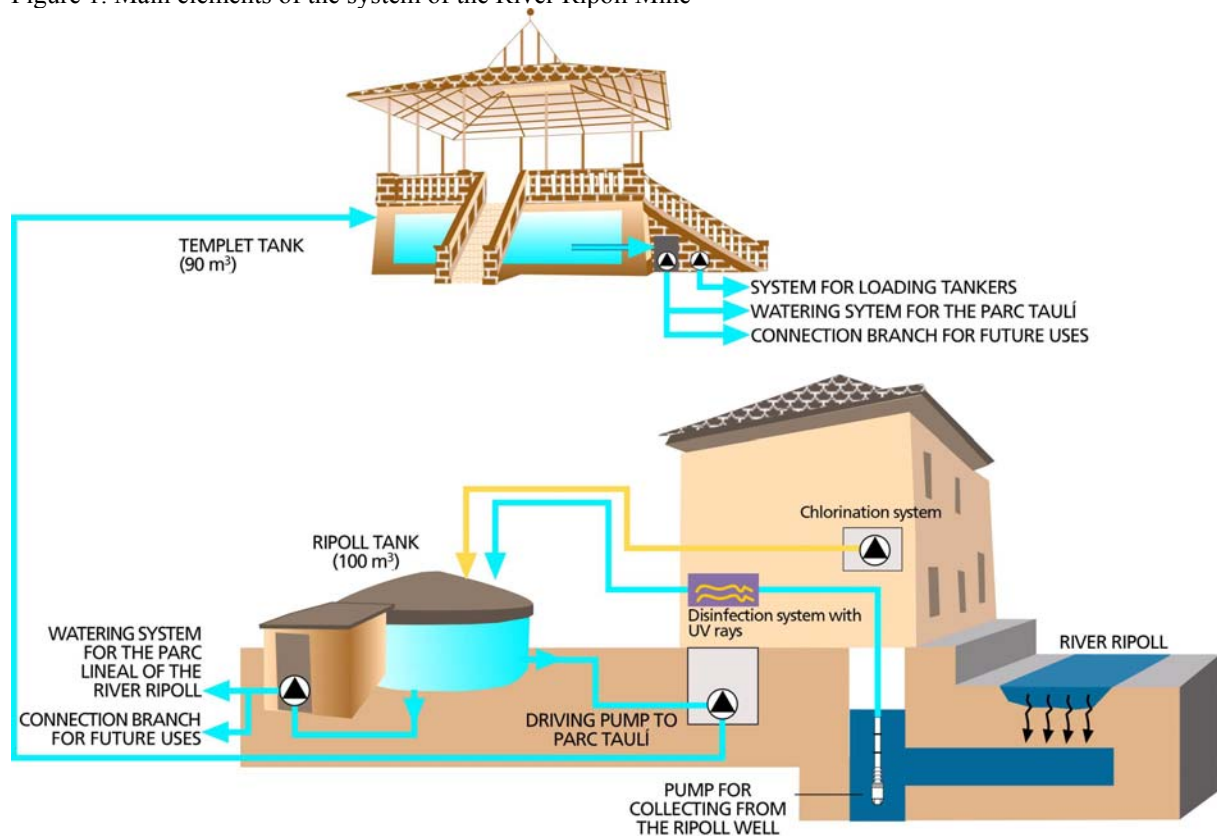
The River Ripoll Mine is an installation that was ceded by Sabadell Town Council to CASSA, that dates from 1914 and was used for supplying drinking water until 1985, when it was abandoned due to the presence of microbiological pollution. In view of the fact that conditioning this water required only disinfection so that it could be used for watering green areas and cleaning the streets, it was decided to renew the existing old equipment and install the necessary elements to guarantee its quality. These installations came into use at the beginning of 2004. They consist of a mine that is 1 metre wide and 1.5 metres high that goes through the riverbed to a depth of 7 metres and takes the water to a collecting well from where it is pumped to the system of disinfection with ultraviolet rays and is stored in a tank with a capacity of 100 m<sup>3</sup>. The water is chlorinated with sodium hypochlorite in this tank, using automatic dosing equipment with a chlorine analyser. In addition to the continuous control of the chlorine, there are transmission and conductivity probes installed to guarantee the quality of the water supplied. Part of the water is driven from this tank to the Taulí tank, from where it supplies the watering system of the park and a service system to load tankers for street cleaning. The rest of the water is taken directly from the tank of the River Ripoll for watering the Parc Lineal of the river. In figure 1 you can see the main elements of this system.

The action of collecting and using water in these installations is directly related to the existence of the outlet of treated water, as it enables the extraction of volumes from the aquifer that have previously been tipped further upstream. In other words, it manages to create a closed circuit in this section of the river that enables the use of a determined volume of water to be guaranteed without decreasing the circulating flow of the river-aquifer system; quite the contrary, the circulating flow along the municipality will always tend to be greater than the preceding section.

## Use of water from the Ribatallada Mine for watering and street cleaning

The Ribatallada Mine, which belongs to CASSA, was one of the most important sources of supply for the city of Sabadell during the 19th and 20th centuries, when it had a small regulation reservoir, no longer operational. It was used for supplying drinking water until 1993, when its use was abandoned on detecting the presence of microbiological pollution.

Figure 1. Main elements of the system of the River Ripoll Mine



Since 2003, it has been operating again for loading tankers for street cleaning and for supplying water to the Via Alexandra sector, which consists of an ornamental fountain and a watering system for the park. The installation consists of a storage tank of 150 m<sup>3</sup> in Carrer de Nàpols, which collects water from the mine, from where the water is distributed by pumping it to the areas where it is used. It has chlorinating equipment and is awaiting the installation of a turbidimeter so that it will have a continuous reading of this parameter.

## Supply to the Parc Catalunya with well water

The Parc Catalunya is possibly the most emblematic one in the City of Sabadell. It has a well, which belongs to the Town Council, with bacteriological pollution which, after being disinfected with hypochlorite, is used for supplying water to the artificial lake in the park and for watering the green areas, as well as a hose for loading tankers that has recently been installed.

## PLANNING FUTURE ACTIONS

The coincidence of CASSA with Sabadell Town Council's water management policy favoured the project to evaluate the chances of reusing water in the city of Sabadell (Collado et al, 2003) within the framework of the 1st edition of the Masters in Integral Water Management. The conclusions of this study served for drafting the Master Plan for the use of water from outside the Sabadell distribution network of drinking water, approved on 27th October 2004 by the Plenary Session of Sabadell Town Council.

The project done studies the alternative sources of supply that exist in Sabadell and determines the quality and treatment necessary, it assesses potential users of reclaimed water and the installations necessary for its distribution, and finally it sets the price the water will have to have to meet the expenses, including the funding derived from the investment to be made.

### Available resources

The available resources have been characterised and quantified based on the information provided by Companyia d'Aigües de Sabadell, S.A. (CASSA) and Sabadell Town Council with regard to the existing collectors they own in the municipality. They have used the information about the flow and the quality of water treated by the WWTPs of the River Sec and the River Ripoll. The ideal nature of each resource and the treatment for reclaiming that is needed for it to be made suitable have been carried out by applying the criteria established by the Agència Catalana de l'Aigua (the Catalan Water Agency) (ACA, 2005). Finally, a series of conditioners have been established for each use and guideline treatments have been suggested, based on the data available of chemical and microbiological analyses provided by the ACA, Sabadell Town Council and by CASSA.

In the case of resources in disuse, we had to base the assessment on quite complete but relatively old analytical data; in the other cases not all the parameters required by the ACA could be compiled from the analyses available. In general terms, the information about the microelements is scarce. Despite everything, according to the analyses carried out on the sludge produced at the WWTP of the River Sec and the River Ripoll, the levels of microelements have not exceeded the limits for metals established in Royal Decree 1310/1990, and based on this, it was considered unlikely that they should exceed the limits recommended for treated water. In Table 1, you can see the summary of the resources available.

Table 1. Resources available, limitations of existing quality and proposed treatments

Resource	Volume of flow (Hm <sup>3</sup> /year)	Limitations of quality	Treatment required
River Sec WWTP	12	<ul style="list-style-type: none"> <li>• Solids in suspension and ammonium</li> <li>• Bacteriological pollution</li> </ul>	<ul style="list-style-type: none"> <li>• Elimination of nutrients</li> <li>• Tertiary treatment</li> <li>• Disinfection</li> </ul>
River Ripoll WWTP	6.5	<ul style="list-style-type: none"> <li>• Solids in suspension</li> <li>• Bacteriological pollution</li> </ul>	<ul style="list-style-type: none"> <li>• Tertiary treatment</li> <li>• Disinfection</li> </ul>
Ribatallada Mine	0.15	<ul style="list-style-type: none"> <li>• Bacteriological pollution</li> </ul>	<ul style="list-style-type: none"> <li>• Disinfection</li> </ul>
River Ripoll Well	0.35	<ul style="list-style-type: none"> <li>• Bacteriological pollution</li> </ul>	<ul style="list-style-type: none"> <li>• Disinfection</li> </ul>
TOTAL	19		

## Potential users

The collective of potential users in the city of Sabadell has been grouped into three main areas: public (watering of urban green areas and cleaning the streets), industrial and agricultural. Although part of the domestic collective is susceptible to being supplied with reclaimed water, for safety reasons it has been rejected in this phase of the project, both for consumption by this part of the population as well as for any kind of industrial activity that could present a hazard for public health (food, industrial laundry, etc.). In the case of public and industrial uses, the quantification of the consumption has been drawn up based on the list of use for 2002 provided by CASSA.

The quantification of the consumption created by the agricultural activity has been obtained indirectly from the data provided by Sabadell Town Council, in this sense, its determination was much more complicated as there was no list of identified users. Most of the agricultural surface area of Sabadell corresponds to dry-ground land cultivation (cereals, sunflowers, etc.). The irrigable land is found between the Horta of the River Ripoll and in part of the Agricultural Park, set along the south-west boundary of the municipality, and involves a consumption of close to 330,000 m<sup>3</sup> a year from the collection of surface water from the River Ripoll or from rural wells. The possibility of covering this use has been ruled out as it was not considered reasonable to try to meet this demand through reclaimed water for the current low cost that resources mean for agricultural uses, as well as its geographical dispersion that makes proposing an economically competitive alternative difficult. Despite this, we have not ruled out trying to cover this consumption in a near future, in a parallel way to Sabadell Town Council boosting the Agricultural Park.

With the data of public and industrial consumption, the potential demand for reclaimed water has been calculated at 1.34 Hm<sup>3</sup> a year registered, with the distribution of uses as shown in Figure 2.

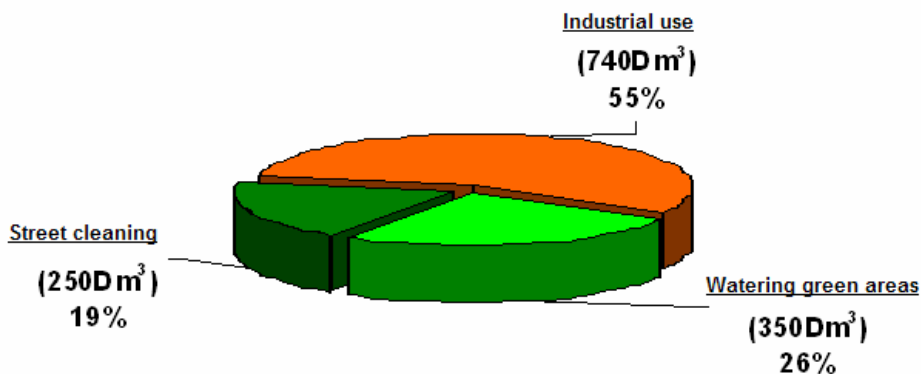


Figure 2. Summary of the potential demand for reclaimed water

The data for public and industrial consumption, detailed by client and use, was located geographically to be able to thus relate the consumption by meter to the location of the point of use. This enabled us to observe that the plan of sectorisation of the Sabadell distribution network offers a sufficient level of resolution to be able to visualise the sum of consumption of clients of each sector as per uses. From here, we grouped all the consumptions of each sector belonging to the same use, thus obtaining a single value per sector. Finally, we proceeded with its graphic viewing on a map by means of a chromatic scale that distinguishes

three sections of consumption. With this exercise, we managed to get a graphic view of the distribution of consumption throughout the city.

Analysing the respective plans, one can see a clear difference in the uses of water according to its location in the urban area. The North Area of the city stands out because of a greater concentration of consumption destined at watering green areas. On the other hand, the Southern Area stands out for its demand that is mainly directed at industrial uses. With regard to street cleaning, it was considered that the consumption is distributed in equal parts between the two areas. Once a selection of users has been set up which, by consumption and proximity, is likely to be supplied by the distribution network, we have obtained the potential demand selected according to uses for the North and South Area, that are shown in figures 3 and 4 respectively.

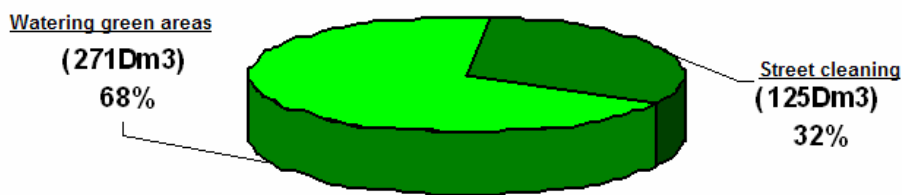


Figure 3. Potential demand selected for the North Area (Annual volume registered: 0.396 Hm<sup>3</sup>)

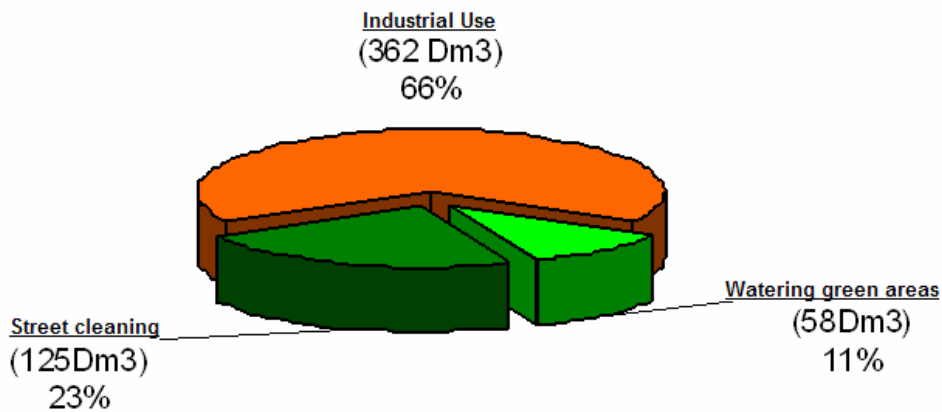


Figure 4. Potential demand selected for the South Area (Annual volume registered: 0.545 Hm<sup>3</sup>)

If we consider a performance of the distribution network of 85%, we will obtain a total volume to distribute of 1.107 Hm<sup>3</sup> a year, of which 0.466 Hm<sup>3</sup> correspond to the North Area and 0.641 Hm<sup>3</sup> to the South.

## **Infrastructures required**

Based on the differentiated concentration of the collectives of users (watering green areas and industrial activity) in the two large areas previously mentioned, it was felt suitable to differentiate between the two basic distribution networks. As Figure 5 shows, in the North Area of Sabadell we are proposing designing a network of distribution exclusively for watering green areas. In the South Area, in the other hand, a network of water distribution is established for industrial uses that also contemplates the watering of green areas close to its path. The proposal of these two distribution networks obeys several factors: 1) Location in the North Area of a greater concentration of uses for water for watering green areas. 2) Quantitative correspondence, also in the North Area, between the demand for watering and the resources available. 3) The resource of the North Area (watering green area) is currently being prepared for use, which is why there are previous actions that facilitate the introduction of the network. The main user of this network is Sabadell Town Council, which means a guaranteed continuity due to their awareness of the need for the sustainable use of water. 4) In the North Area, there only needs to be a disinfection treatment to be able to use the water while in the South Area, it depends on the improvement of the WWTP installations to be able to start any action.

The North Network will have a length of almost 10,800 metres and a standard pipe diameter of 180 mm; it will previously have four regulation tanks, of which three will have a capacity of 500 m<sup>3</sup> and one, which already exists, will have a capacity of 150 m<sup>3</sup>. The South Network will be 7,000 metres long and will alternate different pipe diameters of between 110 and 315 mm; in this case there will be a single regulation tank with a 2,000 m<sup>3</sup> capacity and a tertiary treatment located at the River Sec WWTP. You can find a more detailed description of these distribution networks in Collado et al. (2003).

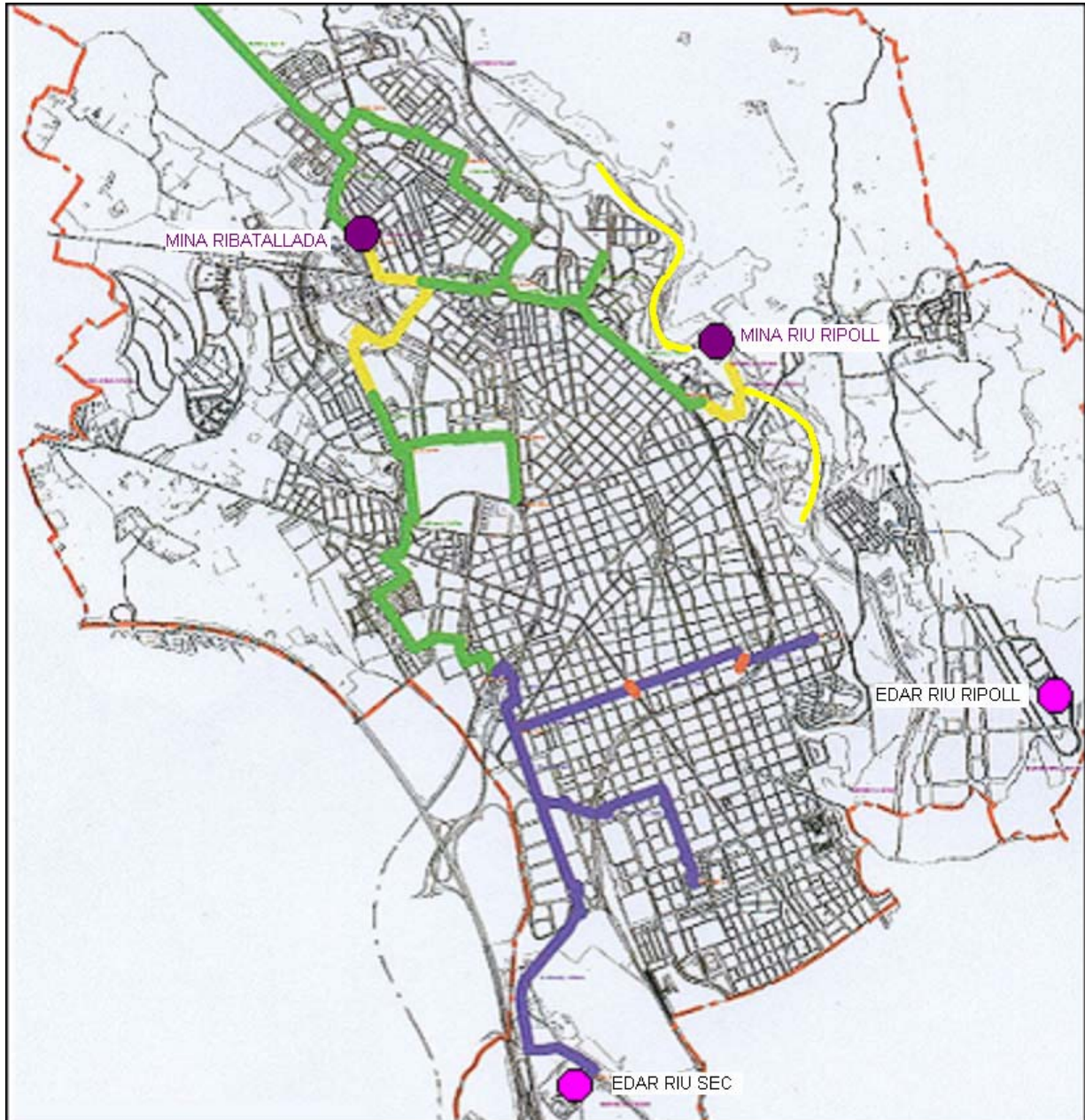


Figure 5 Distribution networks of reclaimed water (Yellow: existing distribution networks. Green: North Network. Blue: South Network)

### Economic study

In the calculation of the price of reclaimed water (established for 2003) three main blocks of expenses were taken into account: the investment costs for the introduction of the network and its necessary associated installations, the running costs and the financial costs.

The investment costs have been defined based on the routes and diameters of the distribution networks planned, also taking into account the associated elements such as pumping equipment, tanks and necessary treatments. The cost of introduction of the distribution networks that was obtained is 2,484,000 € for the North Network and 2,446,000 € for the South, implying an overall cost of close to 5 million euros.

With regard to the running and maintenance costs, the classical aspects of a water distribution network were considered, giving a price of 0.1889 € / m<sup>3</sup> for the North network and 0.2380 €/m<sup>3</sup> for the South. This difference comes from the imputation of the cost of the tertiary treatment to the running costs of the South Area.

Finally, with regard to the financial costs, an 18-year loan has been planned with a 3-year period of only having to pay back interests, to be able to take on the beginning of the running period. The financial study shows that the price of water needed to be able to fully support the introduction and funding of the network and the running and maintenance costs should be 0.713 €/m<sup>3</sup> for the North Area and 0.597 €/m<sup>3</sup> for the South Network. From the financial study, it has been concluded that so that the North Area can maintain the price of water at the current level, it will need a grant to the order of 86% of the full cost of introduction, which would mean a sum of 2,280,000 €, and would enable it to offer the user water at 0.31 €/m<sup>3</sup>. So that the South Network is attractive to users, it will need a subvention to the order of 8%, meaning a sum of 210,000 €, thus securing a water price of 0.57 €/m<sup>3</sup>. One option for achieving this objective would be the subsidised construction of the tertiary treatment of the River Sec, which would be sufficient to be able to offer a competitive price to users in this sector.

The detail of the budgets for investment, running and maintenance and the financial study can be consulted in Collado et al. (2003).

## **BENEFITS OF REUSING WATER AND COMPARING COSTS**

### **The benefits of reusing water**

The multiple advantages of reusing water are known generically. In the Sabadell case, there is a series that has been able to be confirmed palpably, or intuited in a clear way.

**Liberation of resources.** The application of the Master Plan for the use of water from outside the Sabadell distribution network of drinking water should mean the liberation of 1.1 Hm<sup>3</sup> a year of drinking water from the ATLL Network, which will then be available for the other users of the system. This would mean an increase in the guarantee which, although it would be small in relation to the entire volume supplied by the ATLL Network, in the local case of Sabadell would mean 7% of the yearly demand. In other words, 25 days of supply. It should be taken into consideration that in areas with a more important irrigation land agricultural activity than in Sabadell, the volume of drinking water substituted must be easily exceeded, with a lower economic investment as *a priori* we are talking about the most simple distribution networks.

**Persistence of the uses.** Another benefit that the use of alternative sources of supply involves is the maintenance of uses, such as watering green areas and street cleaning, that otherwise would be affected in periods of restrictions. This has been shown in Sabadell during the period of the application of the Drought Decree when we were able to maintain the watering of the green areas supplied by non-drinking water and a fleet of tankers was set up to take this water to areas not connected to the network of reclaimed water.

**Maintenance of environmental uses.** The existence of the pressurised pipeline for returning treated water, has enable the volume of flow of this section of the River Ripoll to be maintained without restrictions.

**Reliability.** The old sources of supply, such as mines and wells, usually have a high rate of reliability, and a considerable delay in the effect of droughts. In the cases of the Ribatallada Mine and the River Ripoll Mine, the extractions have been maintained without problems. When it joins the water network coming from the River Sec WWTP, the reliability of the resource will be increased.

**Solidarity with the rest of users.** The rest of users of the system, including farmers and towns on the Maresme and Costa Brava coast will benefit from the saving that is made in Sabadell, or in other towns on the network.

**Maintenance of collectors.** Another benefit that should not be underestimated is that of maintaining old installations active, which otherwise would become degraded until they disappeared. In most cases, they are installations that have paid for themselves and do not involve any additional cost.

### **Comparison of the cost of availability**

So far, the hydraulic infrastructures have been developed according to the needs of the demand, taking on the cost and passing it on, or not, to the end user. When looking at investments for making reclaimed water available we tend to condition the comparison to the cost of drinking water, a logical thing to do from the economic point of view, but not so logical if we believe in the reuse of water as an alternative to the problem of water.

However, it has been considered interesting to set up a comparison of orders of magnitude of the cost of the availability of reclaimed water as opposed to drinking water. The “cost of availability” has been defined as the investment necessary to make available a determined volume of the resource a year, establishing the unit in €/m<sup>3</sup>/year.

As Sabadell is integrated into the ATLL distribution network, we have estimated that the comparison with the cost of introducing this network could constitute a good reference point.

Taking as a database ATLL's annual report for 2002, we can put a figure on the volume supplied by the network at 259.47 Hm<sup>3</sup> a year and the value of the fixed assets at 1,020.54 million euros. With this data, we get a cost of availability of 3.93 €/m<sup>3</sup>/year.

If we consider the volume potentially distributed by the Sabadell network of reclaimed water (1.1 Hm<sup>3</sup>/year) and the cost of the necessary investments (4.93 million euros), we get a cost of availability of 4.48 €/m<sup>3</sup>/year, 14% greater than that of the ATLL network. However, we should consider certain factors such as the fact that we have not carried out any update on the value of the investments of the ATLL network and it has not had repercussions of the cost of the construction of reservoirs in order to reach the conclusion that we are talking about orders of magnitude that are at least similar.

We can confirm that, in a first very general approximation, but sufficiently reliable with regard to orders of magnitude, the cost of the investments necessary to be able to use reclaimed water is the same rank as that needed to be able to use the ATLL distribution network.

In the specific case of Sabadell, there is another reference value for carrying out a comparison of the cost of drinking water-reclaimed water availability, which is the cost of the pipes that carry the water from Sant Pere Màrtir and Cerdanyola. This work, done in 1952 and 1968

respectively, meant an overall investment, updated in 2003, of the order of 61.7 million euros, to be able to supply a maximum annual volume of 13.14 Hm<sup>3</sup>. The resulting cost of availability is 4.69 €/m<sup>3</sup>/year, slightly superior to that obtained by the network of reclaimed water.

If we accept the similarity of the cost of the investments, it is not difficult to defend the advantage that currently opting for reusing water would mean. In the first place, it will mean a reduction of consumption at the headwaters of the system, favouring the rest of the users of the reservoir and giving them a greater guarantee of supply, in second place it will manage to freeze or even reduce the evolution of the demand for drinking water by replacing the volume of flow, a fact which would end up meaning a saving thanks to the longer periods or effectiveness of the headwater equipments and current reservoirs; as a result of this, there would also be a greater margin for manoeuvring when offering solutions for the increase of future demand.

Despite the simplicity of the exercise proposed, we consider that the result that is intuited invites us to consider future planning taking on new challenges, which will surely be more complex than the solutions adopted to date and will require a greater level of complicity and commitment by the operators and users, but for this same reason, it may help to solve the current problem with a more rational criteria and with the solidness that the involvement of all the sectors affected in finding the solution would mean.

## CONCLUSIONS

The application of the Master Plan for the use of water from outside the Sabadell distribution network of drinking water must permit the liberation of 1.1 Hm<sup>3</sup> annually of the drinking water network.

For this to be economically viable, the distribution networks of reclaimed water must have some kind of subvention, at least during the initial introductory phase. The economic help from public ranks in carrying out this project is justified by the saving in extending infrastructures (reservoirs, main distribution lines, etc.) which mean, medium- and long-term, the use of reclaimed water to meet part of the demand that is currently met with drinking water. Another benefit of this action will be the increase in the guarantee of supply as a result of the decrease in the use of resources from reservoirs, which would help to partly alleviate the recurrent drought periods.

The actions developed and planned in Sabadell will mean a liberation of resources, will permit the persistence of certain uses in periods of drought as well as the maintenance of environmental uses, will enable us to count on a reliable resource and maintain and reactivate old existing installations. Finally, it will also mean a gesture of solidarity with the rest of the users of the system.

The costs of introduction of the network of reclaimed water, defined as euros invested for each m<sup>3</sup> available annually, are 4.48 €/m<sup>3</sup>/year, while the same parameter for the ATLL network is to the order of 3.93 €/m<sup>3</sup>/year. In the case of carrying water from Sant Pere Màrtir and Cerdanyola to Sabadell, the result is a figure of 4.69 €/m<sup>3</sup>/year. The similarity of ranges of these three figures should be an element to be taken into account when planning future actions.

## **ACKNOWLEDGEMENTS**

We would like to thank the Costa Brava Consortium, and in particular Lluís Sala, for the information they provided during the course of the project and the support they offered for the presentation of this speech.

We are particularly grateful for the ideas contributed by Josep M<sup>a</sup> Mañosa and Dolors Vinyoles.

The work of Aleix Collado and Xavier Font.

The help received from the various departments of Companyia d'Aigües de Sabadell, S.A.

The collaboration of the Department of the Environment and Sustainability of Sabadell Town Council.

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