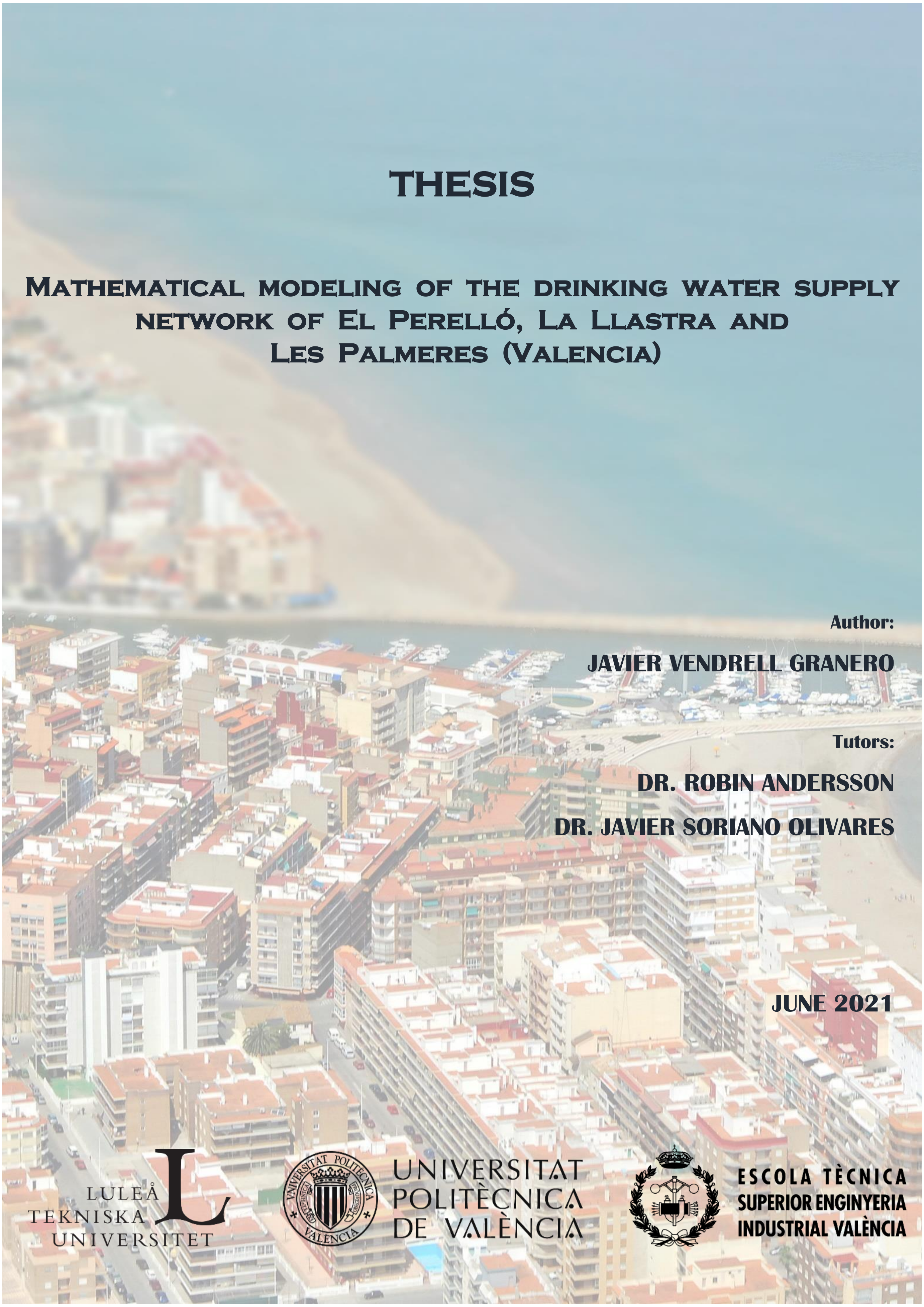

THESIS

Mathematical modeling of the drinking water supply network of El Perelló, La Llastra and Les Palmeres (Valencia)

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ABSTRACT

In this Final Degree Project the mathematical model of the drinking water supply system of the population centres of El Perelló, La Llastra and Les Palmeres, belonging to the municipality of Sueca (Valencia) is elaborated. In order to make a modeling that fits the reality, in the most reliable way, the Epanet program is needed as well as data and characteristics of the installation. These have been provided by the municipal company Aigües de Sueca, which is responsible for the management of the network, both in the city and in the coastal population centres of the municipality. Initially, we start from the AutoCAD street map of pipes, provided by Aigües de Sueca, which is transformed to Epanet with the EpaCAD program. This helps us to have an estimated drawing of how the different pipes of the network are distributed through the population centres. Then we define all the hydraulic parameters and characteristics in Epanet and we present analyses by means of simulations, for different situations, of the main hydraulic variables. All this will allow us to observe the possible points of action, as well as the hydraulic losses of the current network, in order to be able to make proposals to improve the current operation of the system.

Keywords: mathematical model; Epanet; water supply; pipe network, simulation.

RESUMEN

En el presente Trabajo de Fin de Grado se elabora el modelo matemático del sistema de abastecimiento de agua potable de las poblaciones de El Perelló, La Llastra y Les Palmeres, pertenecientes al término municipal de Sueca(Valencia). Para hacer un modelado que se ajuste a la realidad, de la forma más fidedigna, se necesitan el programa Epanet así como datos y características de la instalación. Éstos han sido facilitados por la empresa municipal Aigües de Sueca, que se encarga de la gestión de la red, tanto de la ciudad como de las poblaciones costeras de su término municipal. Inicialmente, partimos del mapa callejero de tuberías de AutoCAD, facilitado por Aigües de Sueca, que se transforma a Epanet con el programa EpaCAD. Éste nos sirve para tener un dibujo estimativo de cómo se distribuyen por las poblaciones las diferentes tuberías de la red. Seguidamente definimos todos los parámetros y características hidráulicas en Epanet y plateamos análisis mediante simulaciones, para diferentes situaciones, de las principales variables hidráulicas. Todo ello nos permitirá observar los posibles puntos de actuación, así como las pérdidas hidráulicas de la red actual, con el fin de poder plantear propuestas que mejoren el funcionamiento actual del sistema.

Palabras clave: modelo matemático; Epanet; abastecimiento de agua; red de tuberías; simulación.

RESUM

En el present Treball de Fi de Grau s'elabora el model matemàtic del sistema de proveïment d'aigua potable de les poblacions de El Perelló, La Llastra i Les Palmeres, pertanyents al terme municipal de Sueca(València). Per a fer un modelatge que s'ajuste a la realitat, de la forma més fidedigna, es necessiten el programa Epanet així com dades i característiques de la instal·lació. Aquests han sigut facilitats per l'empresa municipal Aigües de Sueca, que s'encarrega de la gestió de la xarxa, tant de la ciutat com de les poblacions costaneres del seu terme municipal. Inicialment, partim del mapa de carrer de canonades de AutoCAD, facilitat per Aigües de Sueca, que es transforma a Epanet amb el

programa EpaCAD. Aquest ens serveix per a tindre un dibuix estimatiu de com es distribueixen per les poblacions les diferents canonades de la xarxa. Seguidament definim tots els paràmetres i característiques hidràuliques en Epanet i plategem anàlisis mitjançant simulacions, per a diferents situacions, de les principals variables hidràuliques. Tot això ens permetrà observar els possibles punts d'actuació, així com les pèrdues hidràuliques de la xarxa actual, amb la finalitat de poder plantejar propostes que milloren el funcionament actual del sistema.

Paraules clau: model matemàtic, Epanet, proveïment d'aigua, xarxa de canonades, simulació.

ACKNOWLEDGEMENTS

I would like to dedicate this thesis to my "auelita" Tonica, who taught me to value the coast and the person who made me know and love El Perelló.

I would like to thank my family, friends and colleagues of my degree for their support in the development of this work. I would especially like to thank my tutors Robin and Javier, without them this work would not have been possible. Finally, I would like to acknowledge the continuous work, communication, debate and the great help I have received from three people who have been key for me: Jose Augusto (head plumber at Aigües de Sueca), Antonio (engineer at Aguas de Valencia) and Enrique (multipurpose electrician-plumber at Ajuntament de Sueca); their closeness and willingness to teach me have made this work an enjoyable and didactic task.

To all of them, THANK YOU.

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INTRODUCTION

Water is a vital natural resource for mankind and essential for many of our daily activities. The use of this resource has increased in recent decades, so on the one hand, society is trying to raise awareness of the need to make reasonable use of this resource, and on the other hand, water service managers are promoting sustainable management with the aim of having more efficient systems, reducing water losses and providing a better quality of service.

As drinking water supply networks are underground, it is difficult to control them. Therefore, the implementation of mathematical models is a necessary task to better understand their behaviour and facilitate their management. To carry out these mathematical models for supply networks, the Epanet programme is the tool par excellence that allows a precise diagnosis of the behaviour of the network in order to evaluate it and be able to propose improvements in its operation.

OBJECTIVES

The main objective of this thesis is to propose a mathematical model that defines as faithfully as possible the future reality of the drinking water supply network of El Perelló, El Socarrat, La Llastra and Les Plameres. The aim is to provide a support tool for the technicians of the municipal company Aigües de Sueca to help them understand how the network behaves, to help them optimise the management of the available resources and to be able to find points of action for future improvement measures.

More specifically, the aim is to:

- Describe the different components that make up the network.
- Collect information on the water consumption of the populations in order to analyse them and characterise the demand profiles defining the future reality.
- Explanation of the network modelling process from the characterisation of the elements to the introduction to the simulation of the mathematical model.
- Simulation of different scenarios to understand the behaviour of the network under different circumstances.
- Analysis of the results obtained in the different simulated scenarios.
- Proposal of measures to improve the operation of the supply network.

HISTORICAL CONTEXT

The drinking water supply system for the maritime area of the municipality of Sueca began to be built during the 1960s. It was then when the users' cooperative decided to build, by private initiative, the pipe system that now supplies the different holiday resorts. From north to south they would be El Perelló, La Llastra, Les Palmeres, Mareny de Barraquetes, Playa del Rei, Bega de Mar and Mareny de Vilches. It was in 1968 when an elevated reservoir was built at the top of the Muntanyeta dels Sants, as can be seen at Figure 1.

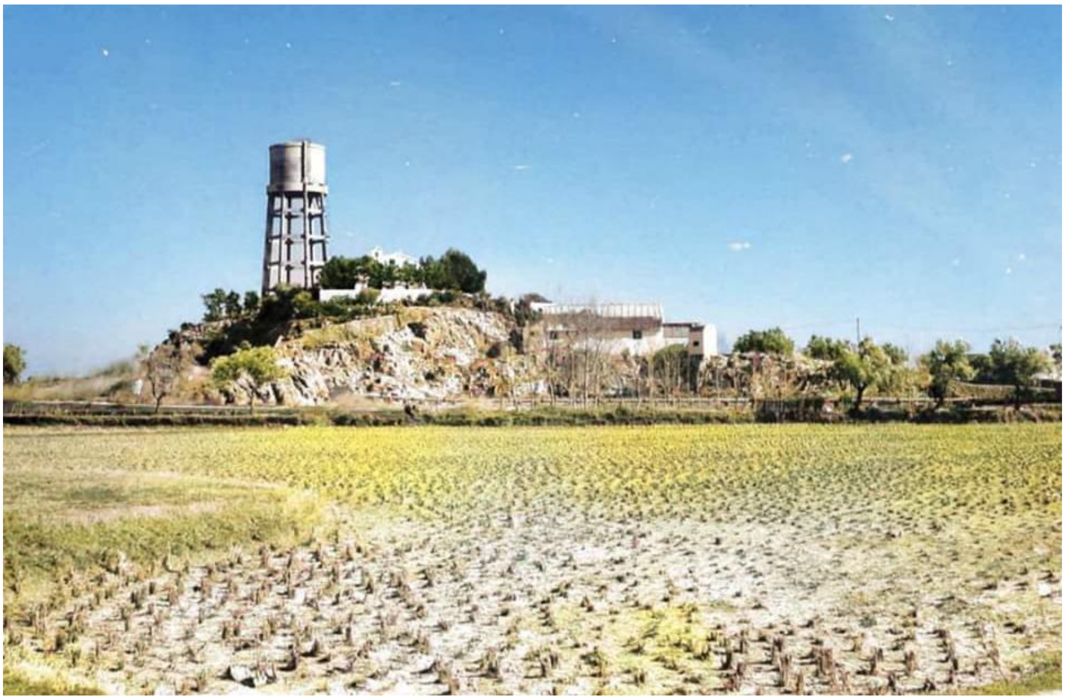


Figure 1: Muntanyeta dels Sants elevated reservoir

To supply water to this tank, a submerged pump was installed in the well at the foot of the mountain. This pump provided between 4 and 5 kg/cm^2 of pressure to overcome the 50-metre difference in height between the two. Therefore, the coastal villages had a network of pipes supplied by gravity. In addition, at that time, the water had to be coloured in the reservoir so that the water on the beach had the chlorine required for human consumption. It was in 1983 when this installation became public property of the Sueca Town Council. At present, the management of the integral water cycle is in the hands of Aigües de Sueca, a municipal company with which we have been in constant contact for the completion of this final degree project. Subsequently, in 1993, the Provincial Council of Valencia subsidised the construction of the Depósit Regulador d'Aigua Potable-Zona Costera that appears in the Figure 2, also known as the Depósito de La Malva.

Figure 2: La Malva reservoir

This construction provided the coastal towns with a 2200m^3 tank comprising two vessels, a 380 volt medium voltage transformer station, which would feed the pumping group, also subsidised. When it was put into operation, it was observed that the electrical installation and consequently the pumping system was incapable of supplying the necessary flow and generated many problems. As a result, this infrastructure was never used and the gravity system was maintained.

Around 1995, the Albufera Natural Park was named as such and the municipality of Sueca was warned of the need to demolish the elevated reservoir at Muntanyeta dels Sants as it was an artificial element within a natural park. It was then that Sueca invested in putting the Malva facility into operation. The construction structure was maintained and a new electrical panel was installed, a speed variator and a pumping group which, today and after 25 years, continues to supply the coast of the municipality of Sueca. As for the work at Muntanyeta dels Sants, the pipe between the well and the elevated tank was removed, as was the tank. A pump was installed to provide the necessary flow, but this time it only provided 1.2 kg/cm^2 of pressure in order to overcome the losses in transport to the La Malva tank without providing excess pressure and thus generating unnecessary energy consumption. In addition, a pipe was installed around the Muntanyeta dels Sants, which connected this last pump with the transport pipe to the beach, as these are on opposite sides of the Muntanyeta. And it is also at this time that the chlorination changes to the La Malva tank itself, where the water is treated. Two years after the start-up of the La Malva installation, the elevated tank was finally demolished, leaving the Muntanyeta dels Sant with the sole and important water function of being the source from which the water is currently extracted. It is now an enclave that respects the environmental policy of the Albufera Natural Park. The pumping installation of La Malva has not needed major changes since then, the impulsion and suction collectors have been reformed. And as notable improvements, in 2008 the reservoir was fitted with a generator that in the event of a power cut does not compromise the continuity of the drinking water supply. Months later, the deficient electrical insulation of the transformation centre was replaced due to its deterioration caused by the saline environment that characterises the areas near the beach.

As for the water supply, in 1987 work was done on what is now known as the Pou del Institut a nd which appears in the following image.

Figure 3: Well of el institut

The borehole was drilled, a submerged pump was installed to extract the water, the hut was built and the medium voltage 380 volts transformation centre was constructed, which supplied the institute and the public facilities at the time. Together with this work, the reservoir located in Mareny de Barraquetes was also built, with its pumping equipment, which was supplied and continues to be supplied today from the sports centre of this minor entity in which it is located.

Figure 4: Mareny de Barrquetes reservoir

Over the years, the pumps at the Pou del Institut have been replaced and only in 2010 was the main pump and the speed variator of the aforementioned tank replaced by one exactly the same so as not to change the boilerwork. However, due to old age, the boilerwork was replaced in 2012 for the delivery and suction collectors. From that year onwards, the entire installation has not undergone major modifications, with the exception of the re-installation in the Pou del Institut, where the submerged pump was also replaced in 2019. This pump, like the previous ones, must provide different pressures depending on the situation. This installation supplies the municipality of Sueca on exceptional occasions, such as emergencies, and therefore has to provide a pressure of 3.5kg/cm^2. While the beach uses it during the summer, and as a support for the Muntanyeta dels Sants well. In this case, the pressure must be 1.2 as mentioned for the other well, as it is sufficient to fill the Mareny de Barraquetes tank.

It should be noted that a new tank has been built 200 metres from the latter, which will replace it in about a year, from the presentation of this final degree project.

Figure 5: New reservoir in Mareny de Barrquetes

Its construction was completed in 2016 and it has a capacity of 5600 m^3, larger than the largest reservoir in this coastal area and has 5 pumps and 2 variable speed drives. It can operate in winter and summer mode. In winter, 2 small pumps are connected in parallel, with a variable speed drive on one of them. On the other hand, for higher demands, the summer mode uses the three remaining pumps in parallel, also of higher power, with a variable speed drive on one of them.

Figure 6: Pumping system for the new Mareny de Barraquetes reservoir

This tank can be supplied by the Pou of the institute but also by the Mareny de Barraquetes drinking water treatment plant. This installation has not yet been put into operation, as the electricity supply contract has to be registered and the work approved before it can be put into operation by the competent institution. However, as mentioned above, it will replace the Mareny de Barraquetes reservoir and will support the Malva reservoir in the future. According to the Aigües de Sueca team, they are considering the option of both reservoirs supplying different areas of the beach independently and that occasionally and when required, they will serve as support, reconnecting both parts of the coastal area of the municipal district of Sueca.

DESCRIPTION OF THE ACTUAL POTABLE WATER SUPPLY NETWORK INSTALATION

The different components that make up the supply network are now explained in a more precise and detailed way. It starts with the wells from which the water is extracted, followed by the tanks that store it, to continue with the elements that help to provide energy to the water, measure, control and provide quality to the water so that it is suitable for human consumption and finally the pipes will be explained as the union of all these elements that make up this water distribution system.

WELLS

Currently, the maritime area of Sueca is supplied by two wells from which water is pumped to their respective reservoirs. The main well is located in La Muntanyeta dels Sants and is the only one of the two that supplies drinking water all year round. The secondary well is known as El Pou del institut, because it is near the IES Joan Fuster (Sueca), in street dels Ensenyants. It is only necessary from the end of June to September, months characterised by a high demand due to the summer migration to these beach areas. The first of these has a maximum extractable flow of 390m^3/h. It is absorbed by a well pump model CITISA IK-450-1 that supplies the pipe that goes to the drinking water regulating tank - Coastal or Malva area without pressure. The one at the institute has a pump model Grundfos SP-160-4 that works in the same way and this well has a maximum extractable flow rate of 145m^3/h. Both wells are capable of providing a more than sufficient flow so that there are no water cuts due to inability to supply water.

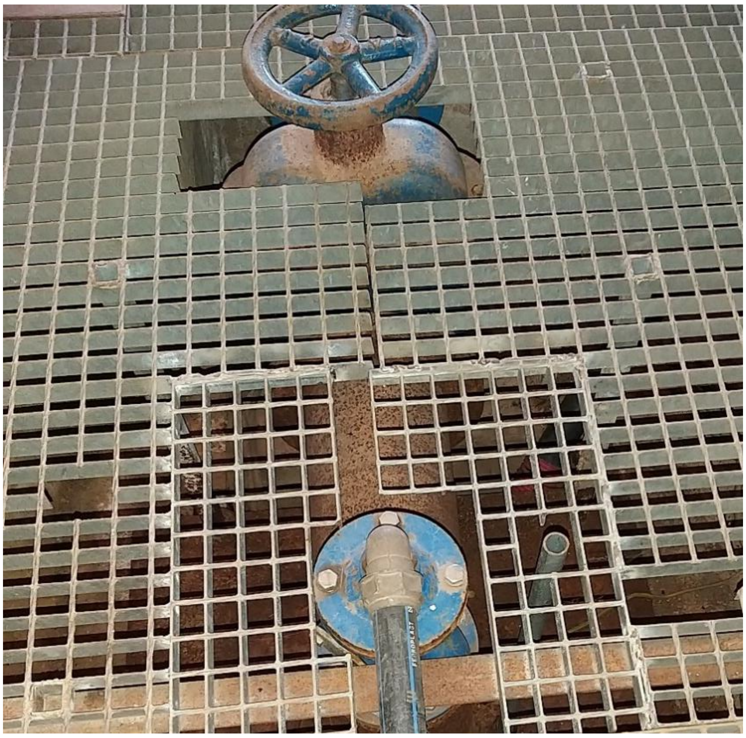


Figure 7: Extraction well Muntanyeta del Sants

Figure 8: Extraction Pou del institut

RESERVOIRS

As mentioned above, each well is supplied by a suction pump to its respective tank. The main well supplies the Drinking Water Regulating Tank - Coastal Zone or La Malva, which has a capacity of 2200 m^3. This is made up of two identical vessels of 31 metres long and 10 metres wide, with a maximum water level of 3.75 metres and a minimum of 0.4 metres, so if we subtract the structural elements (dividing wall, interior columns, pillars and sandpit) we obtain the aforementioned amount.

Different pipes leave and enter the tank, as can be seen in the Figure 9. The pipe coming from the Muntanyeta dels Sants well is separated into two inlet pipes, with red arrows, to both vessels. The water from these pipes is poured into some sandboxes, as can be seen in the Figure 10, which evacuate the sand through the outlet pipes, with brown arrows. The water level is regulated by the system of buoys shown in the Figure 11.If the level exceeds 3.75 metres, the vertical pipe with green arrow serves to evacuate the excess water from both tanks from the evacuation basin, which can be seen in the Figure 10. In the lower part we see two pipes marked with black arrows in the Figure 9, which are the drains of both tanks that are used to empty them for maintenance work. Finally, the water outlet pipes to the pumping system are those marked with blue arrows.

Figure 9: Inlet and outlet pipes in La Malva reservoir

Figure 10: Evacuating vessel and sand traps

Figure 11: System of buoys in La Malva reservoir

Additionally, the secondary tank supplied by El Pou del institut is located in the Mareny de Barraquetes Sports Centre, which is only active during the summer months as mentioned above. It has a capacity of 150m^3, quite reduced compared to the previous one, so in a few years it will be replaced by the new tank of El Mareny de Barraquetes. The latter has a larger capacity and was already built years ago for this purpose however is awaiting a licence. The reservoir of Mareny de Barraquetes works in a similar way to the one described for the La Malva reservoir, but it only contains one vessel for water storage and can be seen as it is in the Figure 12***.***

Figure 12: Mareny de Barraquetes reservoir

PUMPING

In the well of La Muntanyeta del Sants there is a submerged pump, CITISA IK-450-1model that drives the water to the tank of La Malva. There is a pumping system composed of 3 pumps in parallel with ITUR IN-80/200B models that pressurize the water entering the pipe network. These two installations are active throughout the year. A variable speed drive Power Elctronics Elite SD 700 model regulates the main pump, adjusting its operating point to the demand at all times. When it is not able to meet the required demand, the system activates the second pump in parallel. This is a fixed speed pump, therefore, it has only one operating point, so it will be the main pump that will reduce its speed to adjust in conjunction with the second pump to the required demand. This case will occur in the summer months when the population grows exponentially and on rare dates such as Easter and some weekends. It is in the summer months when the third pump comes into operation, if the demand cannot be covered by the first two pumps. It will be activated in the same way as the second one, at a fixed operating point. Then, together with these last two pumps running at fixed speed, the main pump will regulate the demanded flow variations. If the water consumption decreases, the system will reduce the speed of the main pump; if it decreases sufficiently, the third pump will be deactivated and then the main pump will increase the speed to cover the demand at that moment together with the second one. In the same way, if the demand decreases enough so that only the main pump supplies the pressurization needs, it will reduce its speed until the second one is also deactivated and then the system will increase the speed of the first one to supply the demanded consumption. With this it is possible to cover the different requirements of the water consumption network during most of the year.

It is in summer, from the end of June until the beginning of September, when El Pou del institut and the sports center of El Mareny de Barraquetes come into play. The Pou del institut also has a submerged pump Grundfos SP-160-4 model to supply water to its respective tank in these months and on rare occasions to the town of Sueca. In the Polideportivo de El Mareny de Barraquetes we find an installation similar to that of La Malva with 3 pumps in parallel, of Ideal-RFI 65-20/20 model, and a variator in the main one, of model PDL Electronics LTD-ME-46. This installation has the same operation as the one already mentioned with the exception that it is only activated when the demand requires it, that is, when the population is higher and with it the consumption of drinking water. In order to start up this installation, in June some shut-off valves near the tank are opened so that the growing demand can be supplied from two points simultaneously.

The fact that the pumps are in parallel not only makes it possible to meet different demands with a variable speed drive on the first pump (the most frequently used), but it is also advantageous in the event that one of the pumps should break down. Because the other pumps can assume most or all of the demand, thus avoiding the complete depressurization of the network.

Figure 13: La Malva pumping system

FLOW METERS

The flow meters currently installed are insertion, mechanical and electromagnetic. Some of them are active and collect data on the flows that circulate through them, which are recorded on the analysis platform provided by Aigües de Sueca. It has not been possible to access it, but at least the volumes of the beach that it has recorded have been made available, as can be seen at Table 1. Other flow meters are planned or installed, but not active. The insertion flow meters (such as the one at Figure 14) installed and in operation are at the entrance to El Perelló, in the pipe that, after the bifurcation of the La Malva supply pipe, heads south. They are also in El Socarrat, La Llastra, Motilla, Playa del Rei and Bega de Mar.

Figure 14: Insertion flow meter

Figure 15: Electromagnetic flow meter

The flow meter that provides data at the La Malva reservoir is electromagnetic. Lastly, as there is no flow meter at the Mareny de Barraquetes reservoir, the data provided come from the mechanical flow meter at the Pou del Institut in Figure 16.

Figure 16: Mechanical flow meter

The chief plumber commented that some of the insertion flow meters, such as the one at the south fork, did not count all the water flowing through them. Therefore, the Transport Nord sector of the next table no has a reliable value, as it is taken as a differential. Likewise, the municipal company does not know how the Motilla flow meter measures when the water flow circulates in the opposite direction in the summer months. This data is therefore of no use to us. Therefore, only the values that appear as S. Perelló, S. Socarrat, S. Pouet Calderer (which corresponds to the Llastra), S. Platja del Rei and S. Bega de Mar will be taken as valid for the subsequent demand analysis. The one for S. Mareny's is not known either, that is to say, to which non-sectorised areas it assigns this differential value.

Playa	**81.713**	**980.556**	**164.965**	**787.264**	**74.868**	**63.386**	**77.454**	**81.278**
S.Perelló	22.011	264.128	63.599	317.997	11.288	9.455	15.664	17.462
S. Socarrat	3.174	38.084	9.829	49.145	2.927	2.439	2.892	2.803
S. Transport Nord	5.739	68.865	15.020	75.100	13.169	11.819	13.128	12.663
S.Pouet Calderer	13.645	163.744	38.954	194.772	7.358	7.174	7.897	8.599
S.Montilla	13.138	157.651	16.845	67.381	20.965	14.631	15.587	16.198
S.Mareny´s	20.689	248.264	18.803	75.211	17.845	16.583	20.163	20.620
S.Platja del Rei	1.959	23.504	891	3.564	803	795	867	1.099
S.Bega Mar	1.360	16.315	1.023	4.093	513	490	1.256	1.834
TOTAL	**235.304**	**2.823.645**	**320.248**	**1.408.396**	**236.957**	**208.898**	**235.888**	**236.375**

Table 1: Distribution of volumes in the beach area

VALVES

With regard to the valves, this installation consists of shut-off valves only, which can be used to isolate different areas, neighborhoods or streets if maintenance work is required or to shut off water circulation due to faults or other reasons. The criterion followed for its operation was to install gate valves for diameters less than or equal to 250 mm and butterfly valves for all diameters greater than 250 mm.

PIPING NETWORK

The piping system dates back to the 1960s and is currently composed of pipes of different diameters and materials. Most of them are made of fiber cement as the original installation was designed to be implemented with this material. However, as the years have progressed, different materials have been chosen when replacing them due to breakdowns or works in the vicinity. These can be ductile cast iron, iron or, the most commonly used, polyethylene. In its design, many years ago, it was oversized in order to be able to cover the growing demand for water in the years to come. For this maritime area has undergone a progressive urbanization since then, and now it can be seen that it is very adequately adjusted to the current demand for drinking water. Broadly speaking, the pipes that connect the wells with their corresponding tanks are 500mm long. From these, different branches with diameters of 400 and 350mm are opened which, when they reach the population centers, feed different pipes that run through the avenues or larger streets of these centers with diameters that vary from 250, 300 to 100mm. From these, the different streets are supplied with 80 to 25mm pipes that directly supply water to the homes.

DESCRIPTION OF THE DIFFERENT POPULATION CENTERS PIPING NETWORKS

The towns that make up the beach of the municipality of Sueca are now explained in more detail in terms of the distribution of the pipes along their streets. A map of the area and a map of the AutoCAD street map will be included to better understand their layout and format.

El Perelló

El Perelló is a minor entity that covers the largest area on the beach of Sueca. The pipeline coming from La Malva reaches the center of the town and has different exits. It supplies the northern district by means of a meshed ring that covers the different blocks and branches off in the district near the Club Náutico de El Perelló. From this 250Fb ring, pipes branch out to supply the northwestern and western neighborhoods. Once again, this ring feeds a 200Fb pipeline that with a circuit of branched and meshed pipes will cover the different streets and blocks of the southern area of El Perelló.

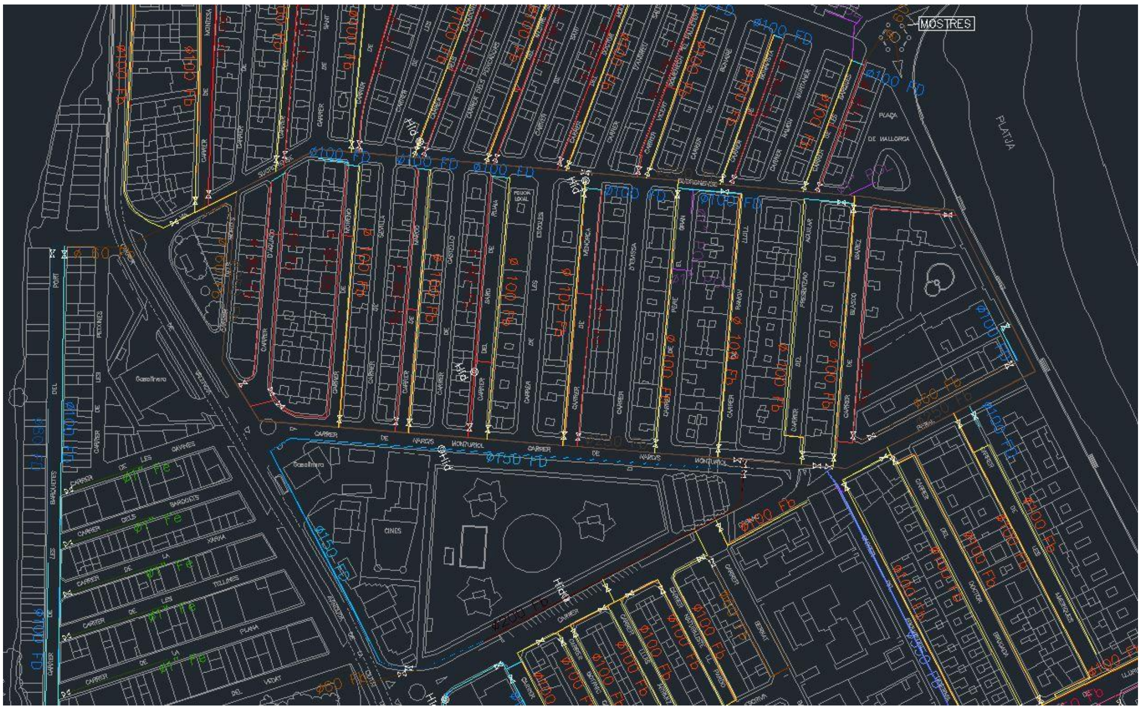


Figure 17: AutoCAD street map of El Perelló

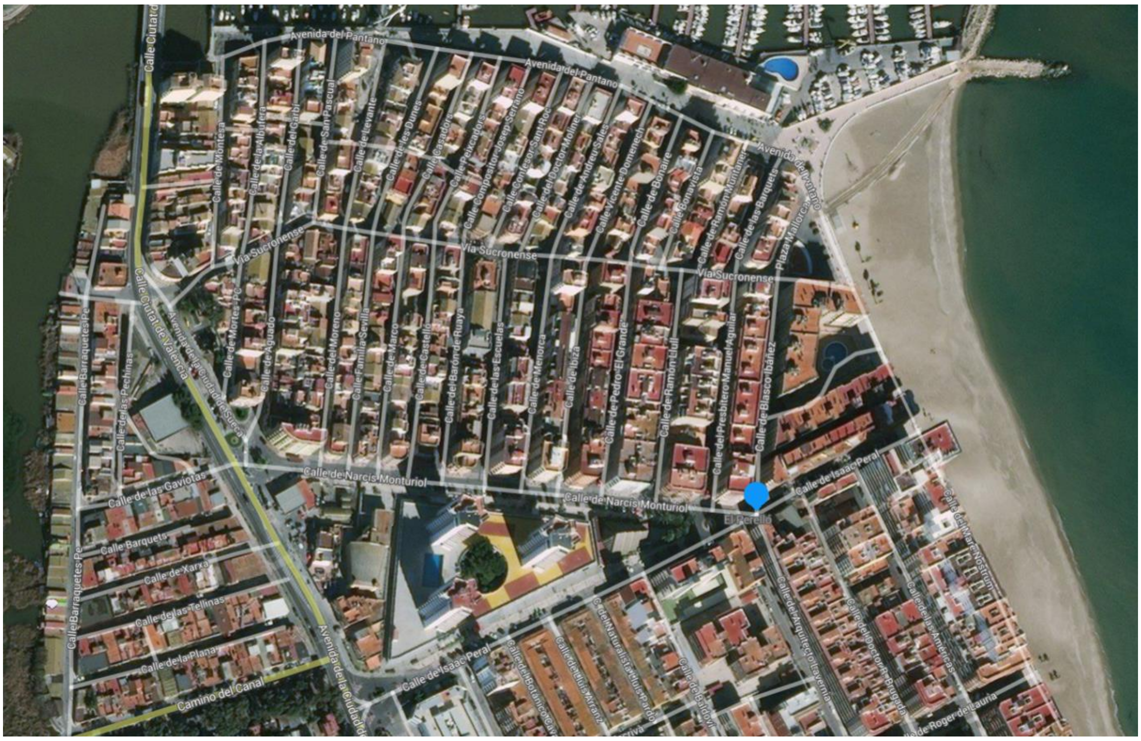


Figure 18: Bird's eye view map of El Perelló

El Socarrat

This minor entity of El Perelló also includes the maritime area of El Socarrat. In this area, the 350Fb pipeline supplies from the northwest to a 100Fb pipeline that will have outlets in several branches that will be meshing the different blocks of this area of the beach.

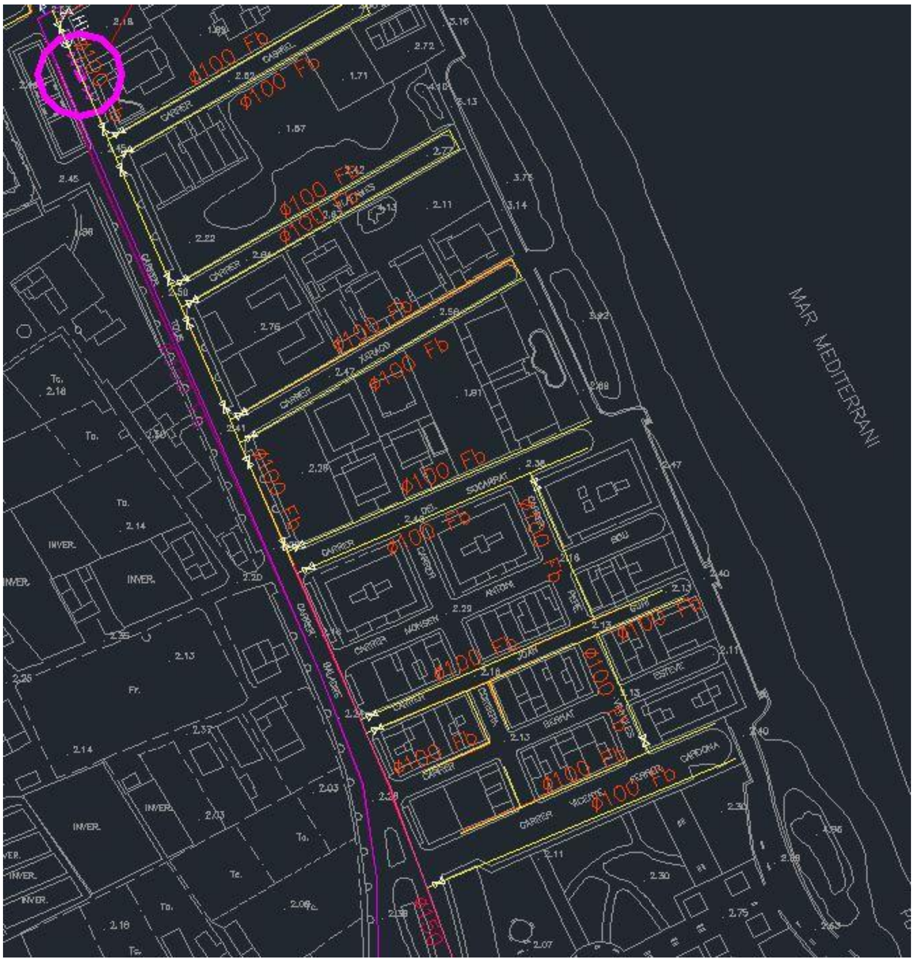


Figure 19: AutoCAD street map of El Socarrat

Figure 20: Bird's eye view map of El Socarrat

La Llastra

This area of the coast includes, described from north to south, El Pouet, Torres al Mar, SOS and Calderer. It is supplied by the 400Fb pipe that comes from La Malva on the west side, which is where the tank is located. In the southern area the streets are supplied by pipes of varying diameters, arranged in a less meshed form and to a greater extent in a branched form. While in the central and northern part the pipes are distributed in meshes along the streets with diameters of 80 and 100 in fiber cement.

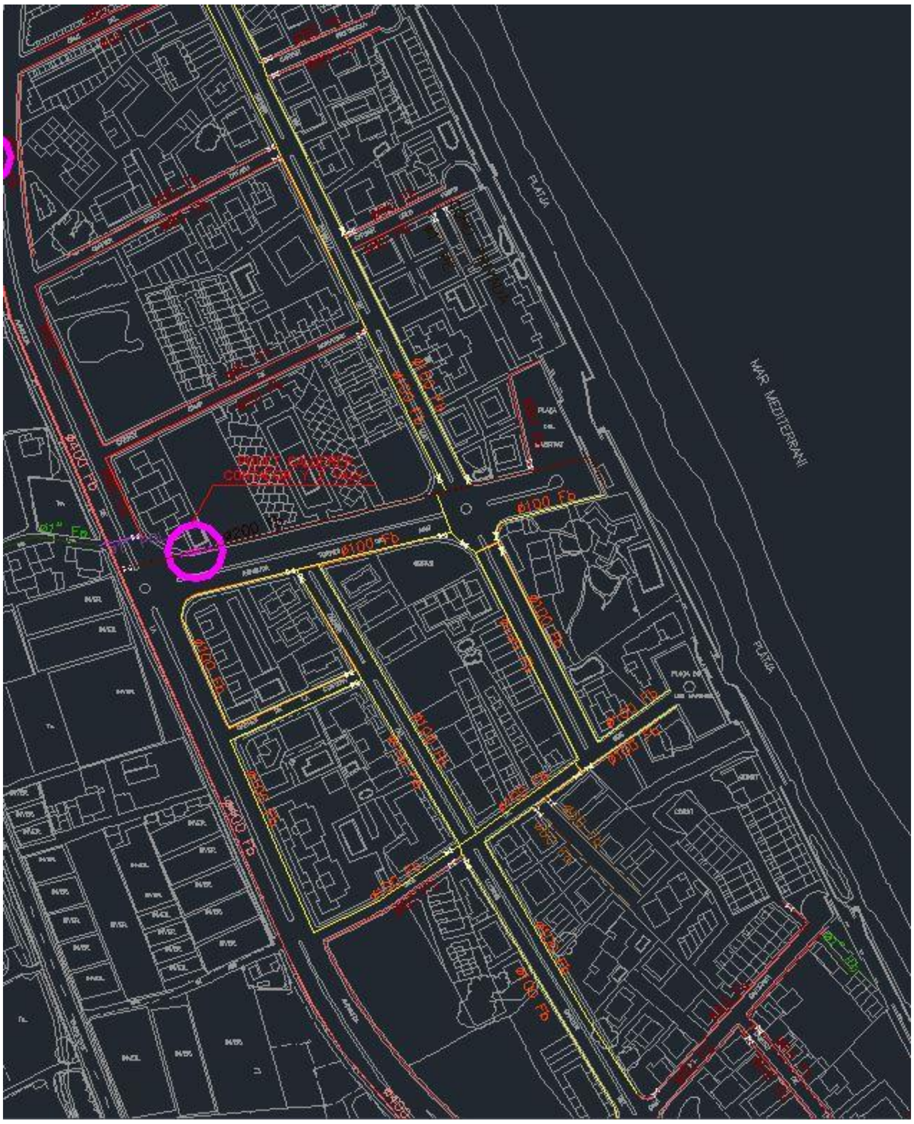


Figure 21: AutoCAD street map of La Llastra

Figure 22: Bird's eye view map of La Llastra

Les Palmeres

This population center is supplied by the La Malva pipeline, which is now a 350FD pipeline. Branches and some rings are coming out of it that will be meshing the different streets with diameters that vary in material and diameters from 150 to the inch. The same happens in the area of Motilla beach, located south of Les Palmeres and which we will include in the area of Les Palmeres. As well as Fernandet and La Lotería, to the north, which also have a similar supply.

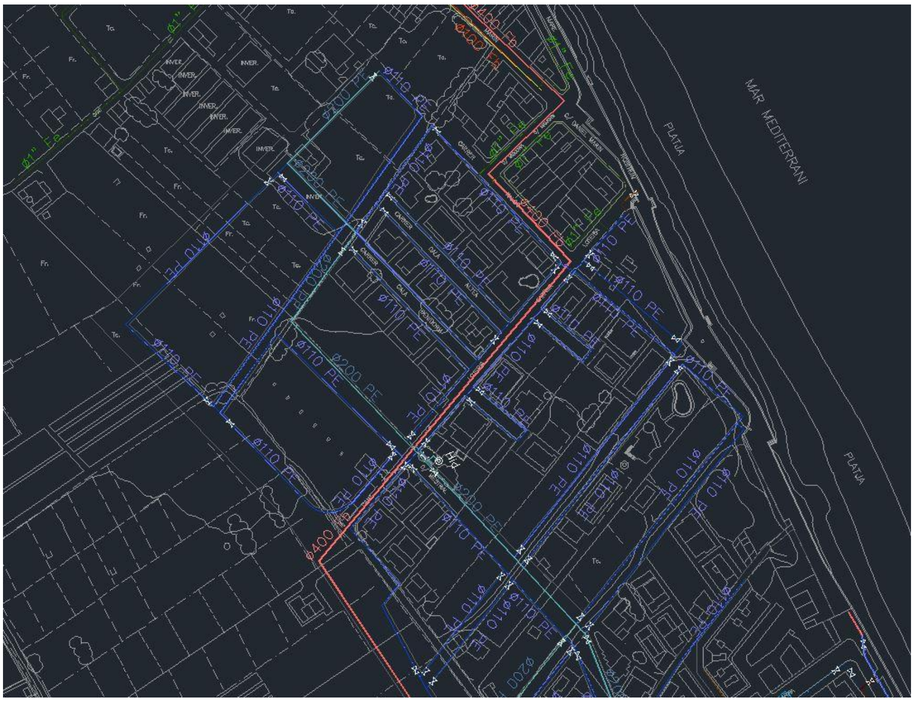


Figure 23: AutoCAD street map of Fernandet-La Lotería

Figure 24: Bird's eye view map of Fernandet-La Lotería

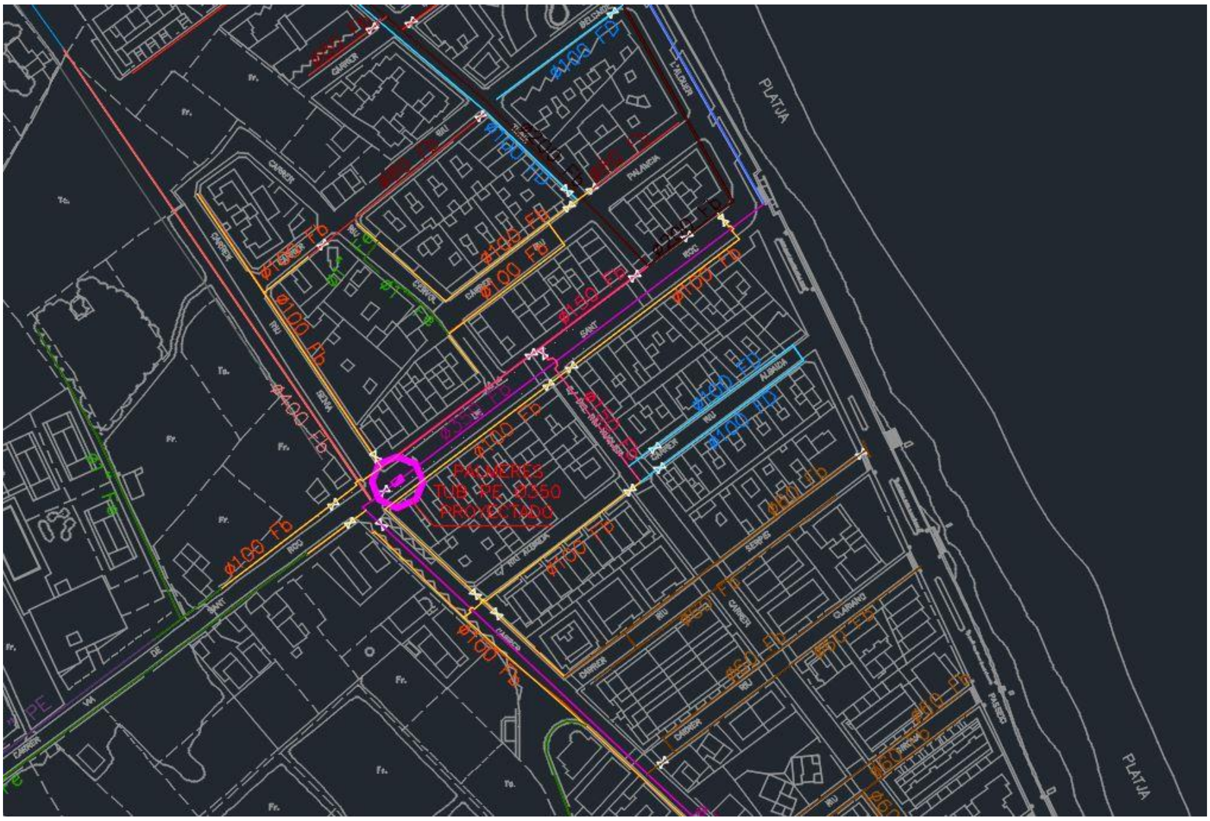


Figure 25: AutoCAD street map of Les Palmeres

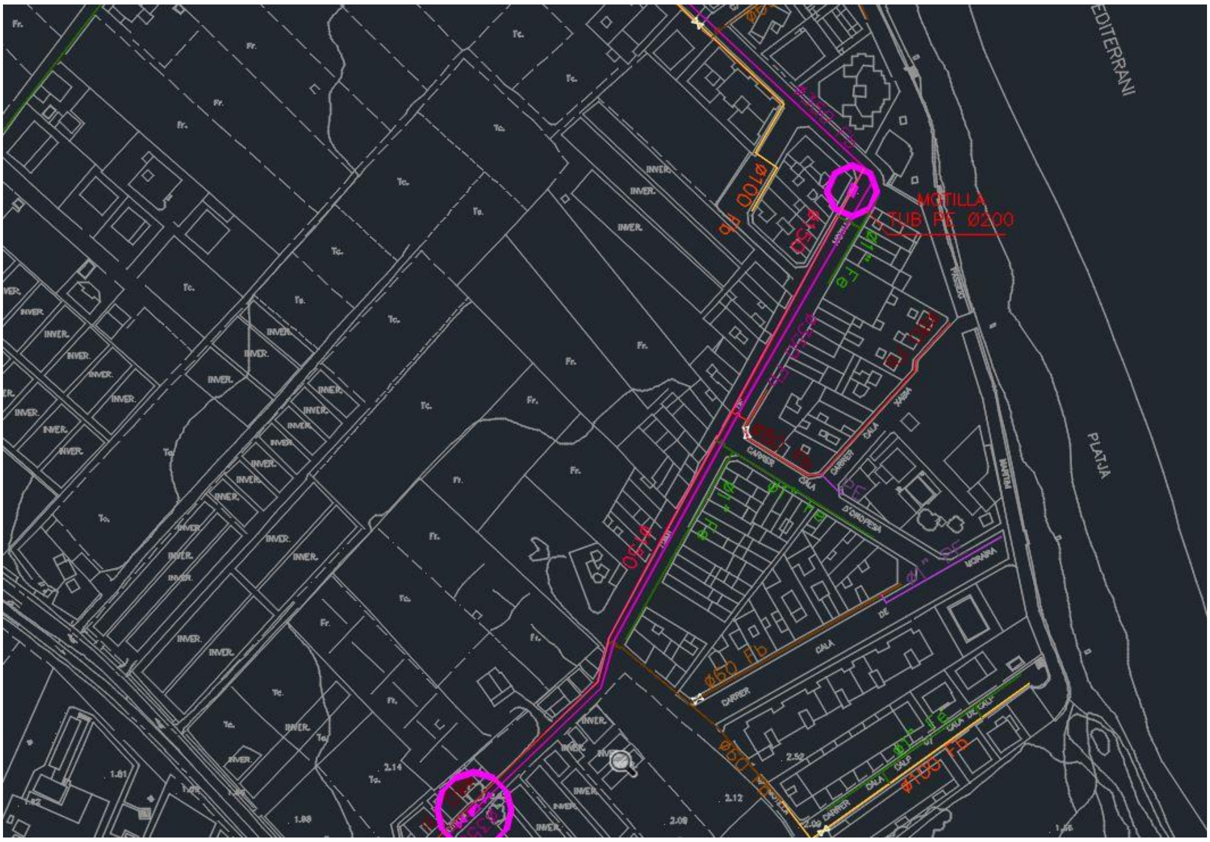


Figure 26: AutoCAD street map of Motilla

Figure 27: Bird's eye view map of Les Palmeres-Motilla

Mareny de Barraquetes

Throughout the year, this minor entity is supplied by the pipeline coming from La Malva to the north. This supplies some branches of 100Fb and a ring of 150Fb also, which will be meshed inside with smaller pipes. In summer, the sports center tank comes into play. This is connected to the La Malva pipeline by another 350Fb pipeline which is not operational during the year. Therefore, when the demand increases, there is an incoming water flow through this pipe that helps to cover the high consumption in this summer season. As far as Camping Les Palmeres is concerned, it is included in the Mareny de Barraquetes area and is supplied from the south by a 100Fb pipeline located in the azequia.

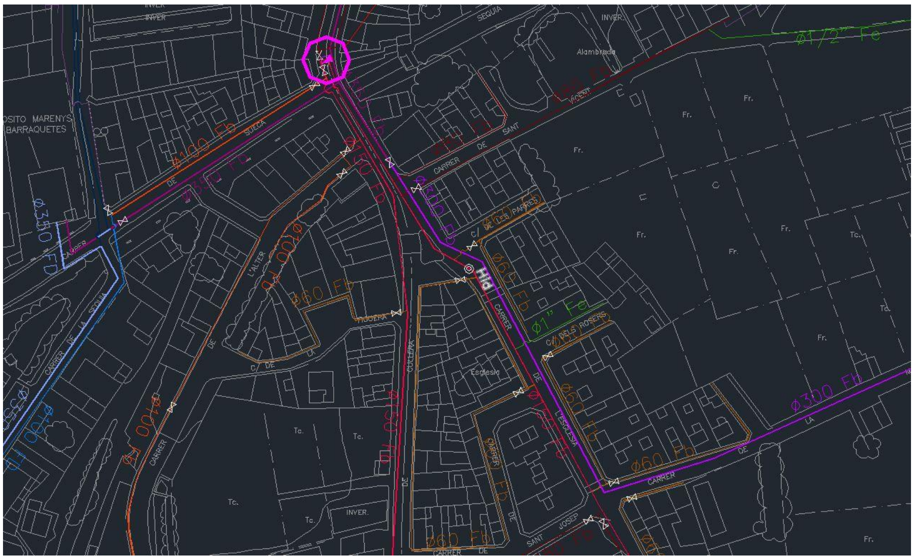


Figure 28: AutoCAD street map of Mareny de Barraquetes

Figure 29: Bird's eye view map of Mareny de Barraquetes

Playa del Rei

It is supplied from the northwest by a pipe coming from the Mareny de Barraquetes of 300Fb that later will continue along the beach to supply the Bega de Mar and Mareny de Vilches. In its passage through the northern part of this nucleus it branches to supply water to the first streets. The same will happen from the beach where different pipes will enter the streets in a meshed form, with diameters ranging from 100 to one inch, to cover the supply of all homes.

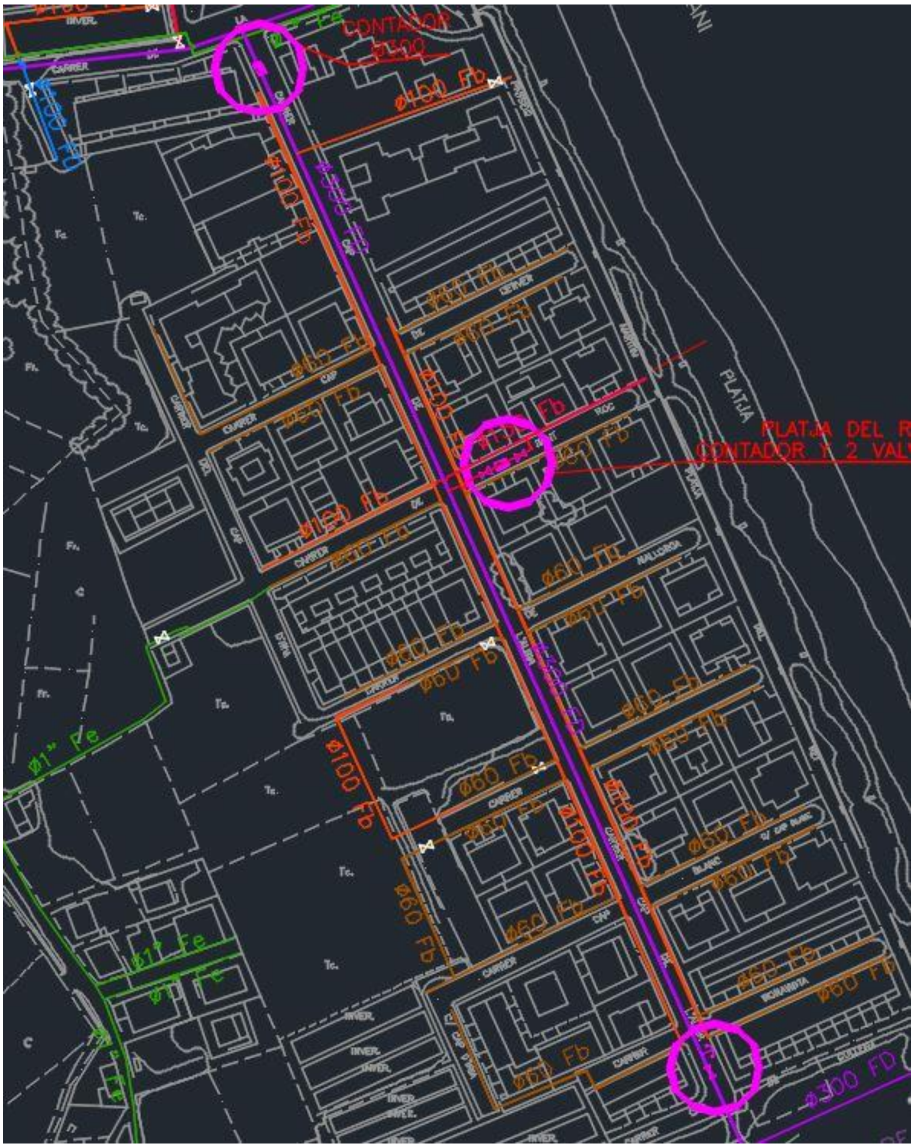


Figure 30: AutoCAD street map of Playa del Rei

Figure 31: Bird's eye view map of Playa del Rei

Bega de Mar

The 300Fb pipeline that supplies this core through the beach has several outlets to the houses with different diameters ranging from 100 to one inch in Fb, FD, Fe and PE and manages to encompass all the houses and farms in this area of the coast.

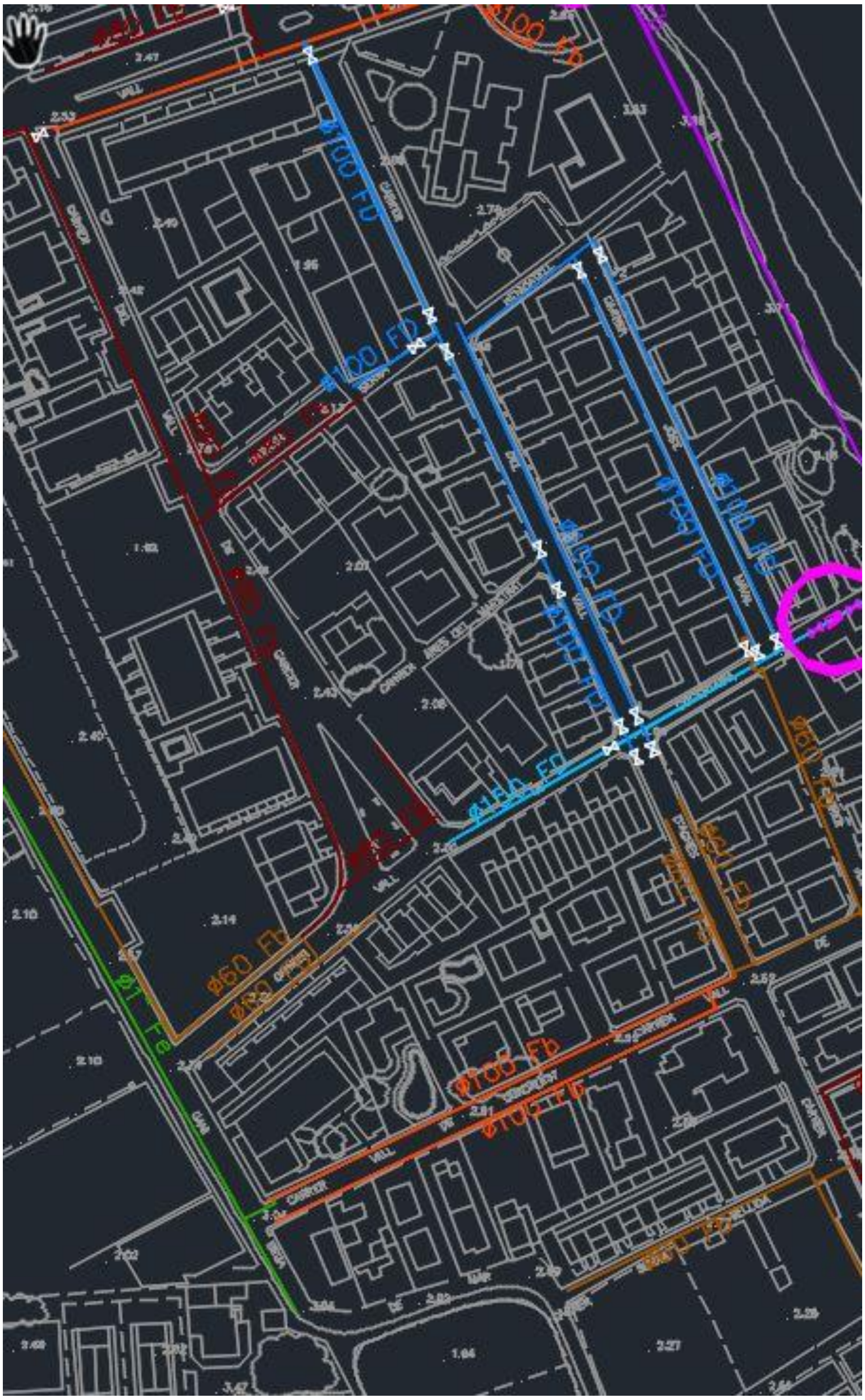


Figure 32: AutoCAD street map of Bega de Mar

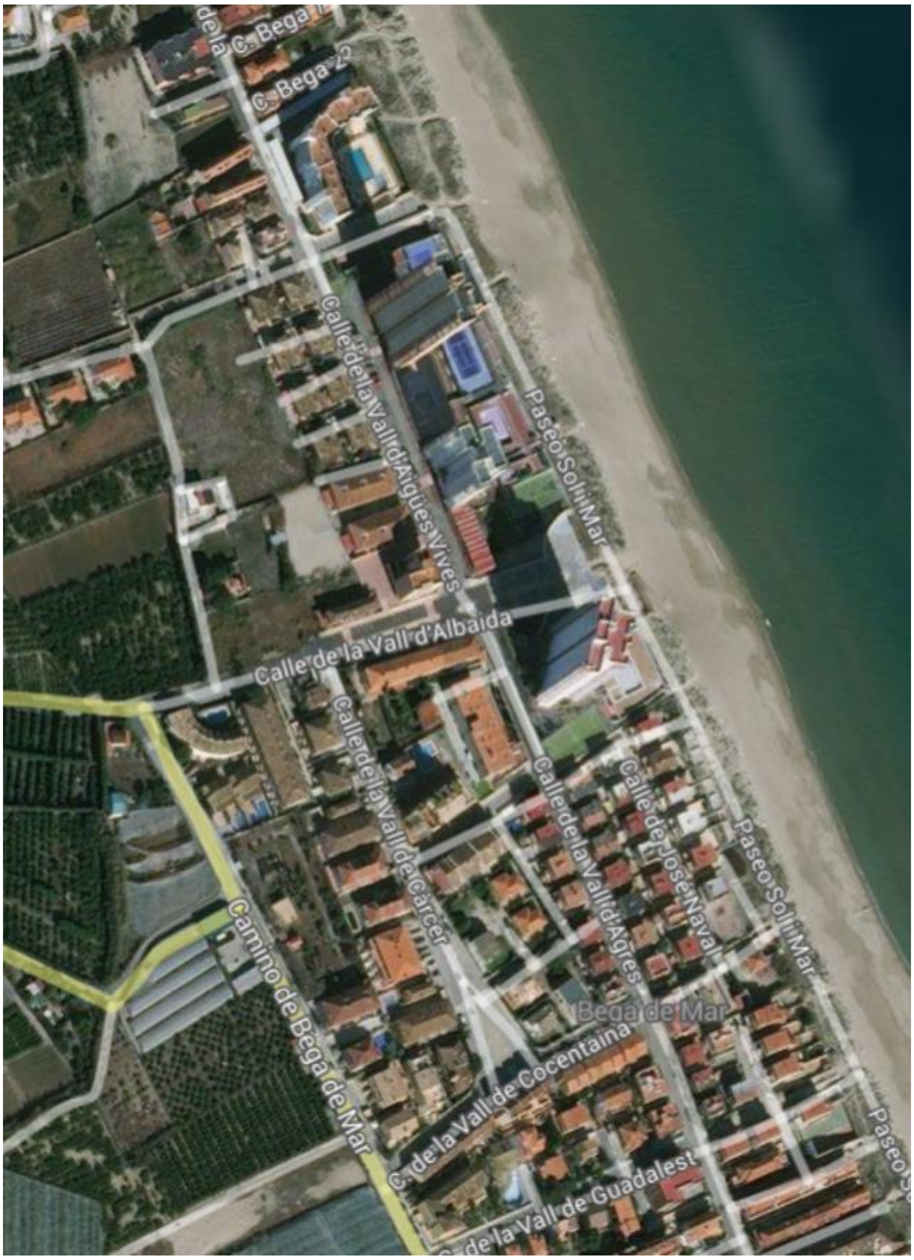


Figure 33: Bird's eye view map of Bega de Mar

Mareny de Vilches

It is connected to the north with a 250 FD pipe that opens to the east with a 150FD pipe and to the west with a 150Fb pipe. These will close the northern part (urbanization Mareny Blau) and center with a ring that will be diversified in a meshed form by the different streets in smaller pipes of fiber cement 80-60Fb and in the same way the southern and western part with pipes of 60Fb.

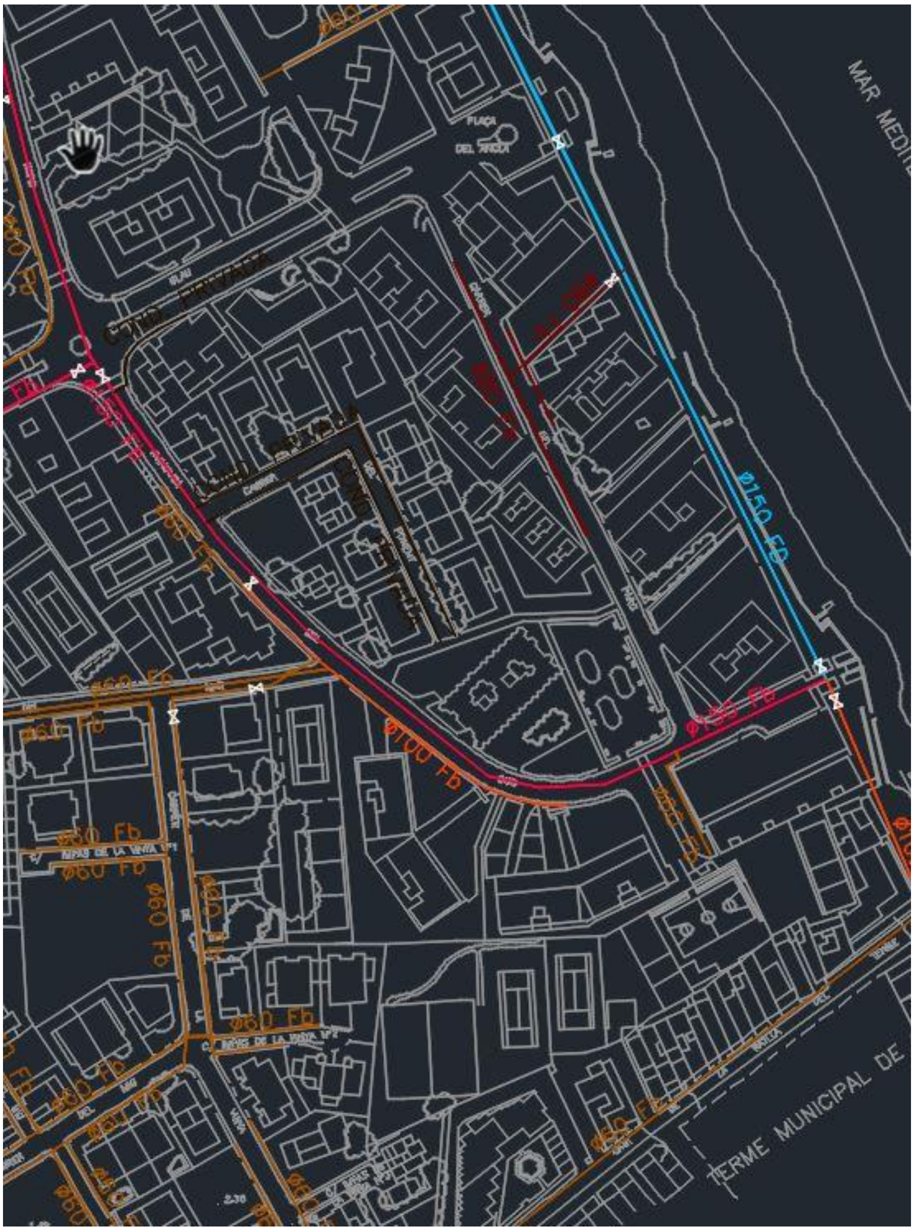


Figure 34: AutoCAD street map of Mareny Blau (Mareny de Vilches)

Figure 35: Bird's eye view map of Mareny Blau (Mareny de Vilches)

DEMOGRAPHY

The population centres under study are holiday areas. Throughout the year they tend to be sparsely populated as there is no established economic activity in this area of the coast. Instead, it is the nearby municipalities such as Sueca, Polinyá del Xúquer, Riola, Sollana, Cullera, Almussafes and Albalat de la Ribera that have the main economic activity in the Ribera Baixa region. This is why these coastal towns are mainly inhabited by day labourers who are looking for cheap housing and by elderly people who live on the coast as a minority. It is in summer, when tourists and mostly coastal homeowners move to the beach or live there more frequently due to the arrival of good weather. As a result, the economic activity increases and with it the consumption of drinking water. Not only at the residential level, but also in commercial premises there is a considerable consumption of this resource. Most of the dwellings are inhabited by families and elderly couples who settle down for a few months and then return to their official dwellings. There are no hotels, so foreign tourists are not the main inhabitants, but are mostly indirect consumers, except for those who rent the houses to spend a few months near the beaches.

SELECTION OF TARGET POPULATIONS

The population centres in the coastal area of the municipality of Sueca that will be studied are El Perelló, El Socarrat, La Llastra and Les Palmeres. This decision was based on the hypothesis that in less than a year, according to Aigües de Sueca, the new reservoir at Mereny de Barraquetes will come into operation. Therefore, the analysis of the operation of the entire network of the beach, taking into account the current Mareny de Barraquetes and Malva reservoirs, operating as at present and in the past years, would soon be out of date and would not be very useful for gaining a better understanding of the operation of the area. For this reason, and in order to generate a mathematical model that will help in the future in the management and knowledge of the drinking water supply infrastructure, it has been decided to take the towns to the north of this new reservoir and consider the case as an independent operation of the south coastal area. El Perelló, El Socarrat, La Llastra and Les Palmeres will be included in the study as a system that in the future will only be supplied by the current Malva reservoir. Assuming this, the population centres of Mareny de Barraquetes, Playa del Rei, Bega de Mar and Mareny Blau will be supplied by the new reservoir, thus forming two independent systems. In exceptional cases, due to breakdowns, maintenance or special needs, they may be joined together to continue to provide a quality supply to all users of the coastal network. It is thus confirmed that the model is built for a possible future supply of the network, which is limited to the south in the Camí de Motilla street that serves as a boundary between Mareny de Barraquetes and Motilla, as can be seen in the Figure 36 below.

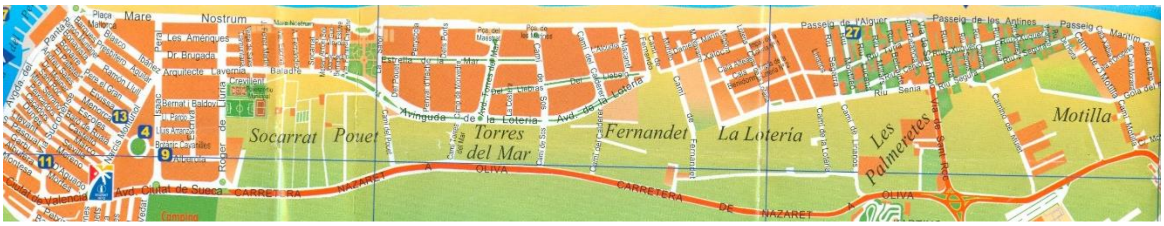


Figure 36: Map of the study area

PROCEDURE FOR THE DEVELOPMENT OF THE MATHEMATICAL MODEL

Mathematical hydraulic models are able to theoretically reproduce the behaviour of pressurised drinking water supply networks. Given the complexity of the environment of pipes, pumps, tanks and other elements that make up the installations, these models become a very useful tool for predicting the behaviour of the network in the face of different consumption or operating hypotheses. The success of a model lies in its ability to define the real installation as accurately and faithfully as possible. And they are designed with the intention of guaranteeing a constant and adequate supply in terms of water pressure and quality to the user. For the mathematical modelling, in this project, we will use the Epanet program in version 2.0. This public domain software was developed by the United States Environmental Protection Agency (EPA) and plays a major role in this project as it allows us to design our mathematical model. It allows us to hydraulically analyse the behaviour of the network, based on the physical characterisation of its nodes and pipes, being able to simulate flows in the pipes and pressures in the nodes, as well as to analyse the quality of the water, among other functionalities. Once the results of the different simulations have been obtained, it will be possible to analyse the current deficiencies of the network and thus put forward various proposals for improving its operation.

STARTING POINT

The modelling process starts from the AutoCAD file, provided by Aigües de Sueca, of the street map of the coastal population centres where all the pipes that make up the installation are drawn. In it we can find different layers for each of the materials and diameters, for pipes from one inch to 500mm in fibre cement, ductile iron, polyethylene and iron. It also contains the shut-off valves and drains, which are not important for the modelling, unlike the hydrants, which will be emphasised later on, and some of the flow meters, which were also indicated.

MODIFICATIONS

This .dwg format file had to be modified to adapt it to be valid for the type of file that Epanet recognises. Together with the plumbing manager of Aigües de Sueca, the entire map was thoroughly reviewed to modify and add all the components that currently exist in the installation. Some flow meters and pipes were not defined, other pipes had been assigned an incorrect material or diameter and, due to the Gloria storm that hit the Valencian coast in January 2020 and destroyed some pipes on the seafront, some of them have been eliminated so as not to compromise the modelling. Once these have been made, the file represents the structure of the network and serves as an estimated drawing of the distribution of the pipes in the population centres. Once the network has been correctly defined, the whole pipe layout has to be redone, superimposing each and every one of the pipes of the installation with the polyline command, this being a laborious task given the large number of pipes and connections. This has to be done since the original file causes connection problems between the pipes, as it is not designed for this type of function but as a rough map for the company. So all the layers must be redefined and superimposed, under the criterion of assigning for each pipe connection the start or end of the polyline so that Epanet subsequently detects it as a connection between pipes and, as explained below, excessive nodes are not assigned to the network when converting the file with EpaCAD.

EXPORTING THE AUTOCAD MODEL TO EPANET

The next step consists of converting this .dwg file to .dxf, which is the one recognised by EpaCAD. This free programme developed by the Instituto Tecnológico del Agua (ITA) interprets the .dxf files and gives the option of selecting the layers that we want to dump in Epanet ex post as shown in Figure 37. It is capable of recognising the coordinates (x,y,z) of our file, so it will generate a network conserving the lengths of the pipes and their geographical location. In this model we will use the option "Vertex Mode" to assign a node only at the end and at the beginning of each polyline, which does not generate too many nodes as "Node Mode" does, which also assigns nodes for each change of direction of the polyline. Although the polylines have been entered meticulously, we use the tolerance tool, as shown in Figure 37, offered by the program, assigning it a value of 0.1m so that it automatically assigns an element that, due to inaccuracy, is not really joined but is within this tolerance radius.

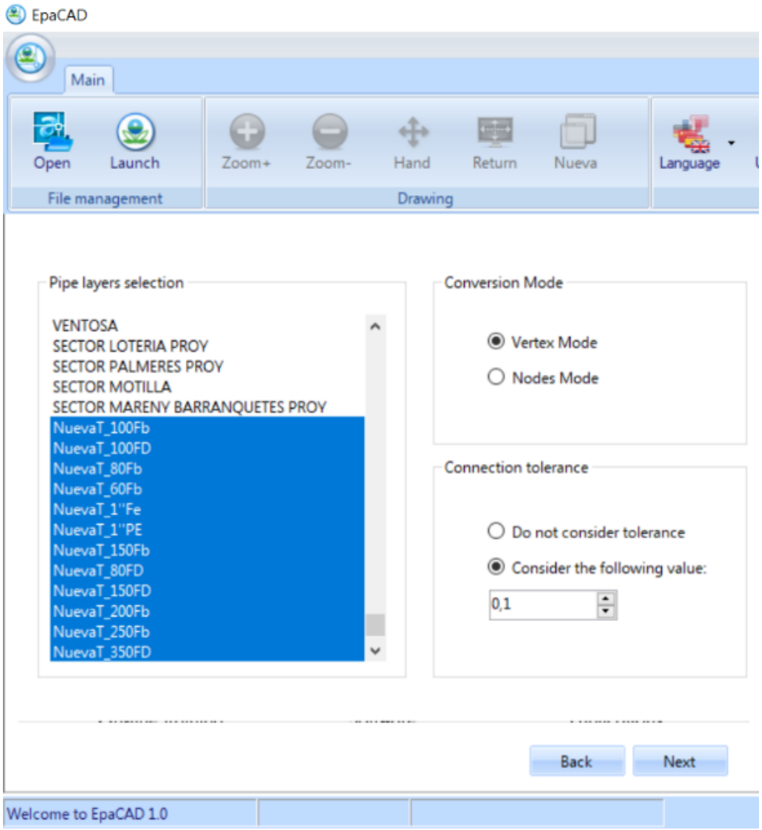


Figure 37: EpaCAD functionalities

Likewise, when launching the converter and before saving it, it will offer a preview as shown in Figure 38 to validate if the process has been carried out correctly. The output file will have the extension .inp, which is the one recognised by Epanet.

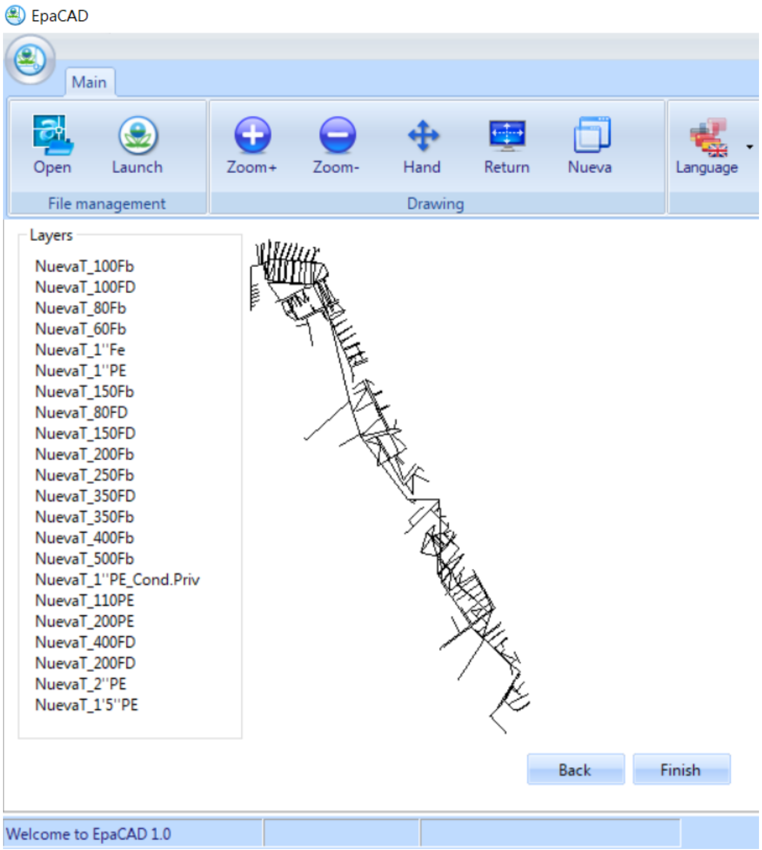


Figure 38: EpaCAD preview map

CONSTRUCTION OF THE MODEL

Once the above has been done, we have the input file to Epanet and we can start working with it. The first simplification that is decided to apply to the file is the elimination of the pipes with a radius of less than 2 inches and the nodes assigned to them. This is done, because sometimes the programme shows negative pressures, so their elimination prevents this type of errors generated by small diameter pipes compared to the average. Next, we proceed to check connection by connection to see if any of the pipes are not interconnected with the others or if there are nodes that visually appear to be connected but are really independent. As mentioned before, if we dump the AutoCAD source file into Epanet with EpaCAD without redoing the network by superimposing the new layers with the polyline criterion, no pipes and nodes would be connected in Epanet. That is why, once the previous step is done in AutoCAD, in Epanet all the connections are well done and the revision only confirms that it has been done correctly.

CHARACTERISATION OF THE PIPES

Then, the diameter of each and every one of the pipes of the installation is introduced one by one; as EpaCAD does not recognise the legend of each pipe in AutoCAD and it is a job that must be carried out by the student. It should be noted that the diameters that appear on the AutoCAD map correspond to the nominal diameters and for the asbestos cement and ductile iron pipes we can introduce these as internal diameters. However, for polyethylene pipes, the nominal diameter does not correspond to the inside diameter. In order to find out the inside diameter of the polyethylene pipes that make up part of the installation, (DITECO S.A.) and (Tubos y Accesorios REKALDE S.L., n.d.) are used as sources of pipe manufacturers, which are based on the standard (UNE, 2012) and what is extracted is shown in Table 2. The design pressure has been selected for 1 MPa because the installation operates for values between 0.3-0.4 MPa or 3-4 kg/cm^2.

PE pipe (polyethylene)			
DN	Dex	esp	Din
200	200	11,9	**176,2**
110	110	6,6	**96,8**
2"	63	3,8	**55,4**

Table 2: Inner diameters of polyethylene 1 MPa pipes

Once this step has been carried out, the roughnesses are treated in the same way. In this case, the simplification of assigning a roughness of 0.15 to the asbestos cement and ductile iron pipes and 0.1 to the polyethylene pipes has been considered. However, in order to speed up the process, the "Select Region" and "Edit group" tools have been used to assign the most common pipe material to the different zones and only have to modify one by one, after this, those that differ from the common one in each zone.

With regard to the elevations of the network pipes, it is assumed that the difference in elevation is zero. This is because the different population centres under analysis are at 2 metres above sea level and are located between the first line of the coast and a maximum of 610 metres inland. In addition, it is known that the mountainous areas are far away from these populations, so it is corroborated that they are practically flat populations due to their proximity to the sea.

CHARACTERITATION OF THE CONSUMPTION NODES

This part of the work is the most complex as a large number of assumptions have to be made. All of them are supported by studies, as well as by the experience of the professors who have tutored this project. Thanks to their background in countless projects, they have been able to help in making decisions and criteria for the demand analysis. All of this has helped me to achieve the most realistic modelling of the network, within the limited information available, which I will describe below.

The different population centres, which are the object of analysis, are mostly sectorised. As described above, there is a flow meter at the entrance to El Perelló, another at the entrance to Socarrat and another that also supplies the area of La Llastra. The problem arises in the area of Les Palmeres, which is not currently sectorised. The volumes of water that the company Aigües de Sueca has registered do not provide information on this area. Some of them, as mentioned, are calculated as differentials. This last population centre of Les Palmeres is included together with others, whose consumption is also unknown, in a considerably large group of areas with a volume consumed that is not known and not separately differentiated. This means that the total volume consumed in the region under analysis is not known. Therefore, in order to find the values that describe not only this last population centre on an annual and monthly basis, but also the whole area supplied by the Malva reservoir, a framework of assumptions is opened at one's own discretion.

STARTING SITUATION

The values of volumes consumed in 2020 per year for El Perelló, El Socarrat and La Llastra were used as a basis, together with their monthly values for the months of January, February, March and April of this year 2021. For the month of May, on the other hand, only the information for El Perelló and La Llastra could be provided, as there was a counting problem at the El Socarrat meter for this month and this data was not available. The number of users of the network is also available, which helps to get an estimate of how consumption is distributed per m^2 of population surface area. Census population values for each of the areas were requested from the Sueca Town Council and the same was done with the head of plumbing and the municipal electrician in order to contrast it with popular knowledge, which is usually more accurate as they travel the coast daily and have an estimated idea of the population that resides throughout the year.

Subsequently, we have received information on the quarterly volumes invoiced for each sector, which helps us to know the performance of the network for each sector. In this case, the value of the Les Palmeres sector is included, as these are values from the internal meters of each user added together and Aigües de Sueca, as the company that charges for the supply service, does have these values for each area. Data was also provided on average daily flow rates and minimum night-time flow rates, which will help to provide an indication of the performance of the network by making a comparison with the flow rate consumed by the sector at night, most of which is linked to leaks. The plumbing manager provided data on where the leaks have occurred throughout 2021 and the material and diameter of the pipe in which they occurred.

INTRODUCTION TO THE ESTIMATION OF THE 2021 DEMAND PROFILE

With the scarcity of data, an estimated monthly demand profile has to be established with the aim of being able to define in an orientative manner the behaviour that the network will have throughout the months of 2021. Based on what is obtained in the areas where the volumes are known for the first months, the demand profile corresponding to the area of Les Palmeres can be found. Therefore, criteria must be sought to help us define the consumption of the remaining months, based on the calendar of public holidays in the Valencian Community and establishing similarities between months with similar demand. In addition, it must be taken into account that these population centres are located on the coast, so the number of inhabitants will increase when the good weather arrives and even more so if it is also a public holiday. All this analysis is collected in an Excel spreadsheet which, once the 2021 demand profile has been constructed, can be seen below at Table 3.

	Volume Consumed (m^3)													
	January 2021	February 2021	March 2021	April 2021	May 2021	June 2021	July 2021	August 2021	September 2021	October 2021	November 2021	December 2021	AVERAGE	SUM
El Perelló	11288	9455	15664	17462	17747	38000	62000	80000	28000	11500	10000	11300	26035	312416
Socarrat	2927	2439	2892	2803	3300	6300	12000	17000	5500	3000	2700	2950	5318	63811
La Llastra	7358	7174	7897	8599	9630	25000	32000	42000	20000	7500	7200	7400	15147	181758
Les Palmeres	5400	4900	6600	7000	7600	20000	33500	48000	19000	5500	4900	5500	13992	167900

Table 3: Estimated monthly and annual consumptions for 2021

In it, iterations have been carried out to adjust the assumptions to the real behaviour of demand over the months. As the aim of this final degree project is to build the model that is as close to reality as possible, a multiplicity of assumptions are made to achieve this, as justified below.

ESTIMATES

Starting with the month of December, in the first iteration, it is assigned a similar consumption to January. Given that both months have 31 days, that the Christmas holidays are between 23 December and 7 January, i.e. 8 and 7 days of holidays respectively, a slightly higher consumption is assigned to December. Consumption in November should be similar to that of January and December, but lower, since, as we have said, the better the weather, the higher the population, and in the Valencia region November is cold and with relatively low temperatures which do not encourage people to visit these towns. Moreover, this lower consumption is supported by the fact that it is not a month with public holidays in the Valencian Community. On the other hand, in October, the weather is not much better, but there are public holidays in Spain and in the Valencian Community, which means that the population is slightly higher and with it the demand for drinking water. To validate the values imposed on each month, two tables are used. The first of these is Table 4 and includes the monthly, average and total values for daily consumption in m^3, for consumption in litres per inhabitant per day and the month factor that defines how many times the month is above or below the average consumption of the different months of the year for the four areas of analysis, all including leakages. In the same way, the monthly, average and total values, this time of the m^3 actually consumed by the users in each sector and in litres per person per day, without leakages. Which are equivalent to the water that the flow meters in the connections measure for each inhabitant, are also shown in the Table 5.

	January	February	March	April	May	June	July	August	September	October	November	December	AVERAGE	SUM
EL PERELLÓ														
m^3 / day	364	338	505	582	572	1267	2000	2581	933	371	333	365	851	10211
l / pers day	202	188	213	228	209	267	276	267	213	206	185	203	221	2656
Month factor	0,43	0,40	0,59	0,68	0,67	1,49	2,35	3,03	1,10	0,44	0,39	0,43		
EL SOCARRAT														
m^3 / day	94	87	93	93	106	210	387	548	183	97	90	95	174	2085
l / pers day	1180	1089	1111	1062	1109	995	1200	1275	940	1210	1125	1190	1124	13484
Month factor	0,54	0,50	0,54	0,54	0,61	1,21	2,23	3,16	1,05	0,56	0,52	0,55		
LA LLASTRA														
m^3 / day	237	256	255	287	311	833	1032	1355	667	242	240	239	496	5953
l / pers day	949	1025	970	1042	1035	1263	1024	1008	1094	968	960	955	1025	12294
Month factor	0,48	0,52	0,51	0,58	0,63	1,68	2,08	2,73	1,34	0,49	0,48	0,48		
LES PALMERES														
m^3 / day	174	175	213	233	245	667	1081	1548	633	177	163	177	457	5488
l / pers day	697	700	774	778	785	1011	1072	1152	1039	710	653	710	840	10080
Month factor	0,38	0,38	0,47	0,51	0,54	1,46	2,36	3,39	1,38	0,39	0,36	0,39		

Table 4: Monthly and annual parameters for the verification of the consumption profile 2021

	January	February	March	April	May	June	July	August	September	October	November	December	AVERAGE	SUM
EL PERELLÓ														
m^3	6726	5634	9334	10405	10575	22644	36945	47671	16685	6853	5959	6734	15514	186166
l /pers day	121	112	127	136	125	159	164	159	127	123	110	121	132	1583
EL SOCARRAT														
m^3	1346	1122	1330	1289	1518	2898	5520	7820	2530	1380	1242	1357	2446	29353
l /pers day	543	501	511	488	510	458	552	587	432	556	518	547	517	6203
LA LLASTRA														
m^3	3458	3372	3712	4042	4526	11750	15040	19740	9400	3525	3384	3478	7119	85426
l /pers day	446	482	456	490	487	594	481	474	514	455	451	449	482	5778
LES PALMERES														
m^3	2573	2334	3144	3335	3621	9528	15959	22867	9051	2620	2334	2620	6666	79986
l /pers day	332	333	369	371	374	481	511	549	495	338	311	338	400	4802

Table 5: Monthly and annual drinking water consumes without counting the leakages

The efficiency is the quotient between the volume of water entering the flow meters of the consumers and what is injected into the network. The difference between the two is due to real and apparent losses. The former refers to leaks in the elements of the installation such as pipes, joints or connections. While the latter refer to flow meter counting errors or unauthorised or unrecorded consumption. It will be assumed that all losses are real, i.e. leaks, as it is impossible to know, with the level of detail that this final degree project covers, whether they are apparent or real. Therefore, the yield of each sector will be defined as the amount of water that reaches the consumers in that sector without leakage compared to, as mentioned, the amount that enters through the sector's flow meter. These yields are obtained by knowing the efficiency of the network for each zone. These have been calculated taking into account two different criteria and deciding which of the two best responds in each case to what is happening in each area of the network. For the first, with the help of the information provided by Aigües de Sueca on minimum night-time flows and average daily flows, the quotient of the two has been calculated. Thus it is known, as mentioned above, that if there is an average daily flow, which is what the population demands, and that the minimum nocturnal flow corresponds to the leaks that the network has, since during the night there is no notable human consumption and it is similar to the flow that leaks into the network at night. Therefore, it is possible to obtain yields with these parameters that the consumption control platform of the municipal company is able to provide. Additionally, this criterion is counterbalanced with the yield obtained by dividing the quarterly flow rate billed by the company to each group of users by the flow rate recorded by the flow meters. Therefore, once the yield values have been obtained, the values that each one has are observed and, knowing the type of dwellings, their concentration by surface area and the number of dwellings per km of pipe, it is possible to establish which yields are better adjusted. And the results show that for El Perelló the performance is 60%, El Socarrat would have a yield of 46% and for La Llastra 47%.

In Les Palmeres, the volume invoiced in the area is not known. In order to estimate it, a study is made of the typology of housing that exists in this area of the coast, which not only serves to endorse the performance criterion but also, and in the following paragraphs will be introduced, to support the monthly consumption values of the Table 3.

Starting from north to south, the first town is El Perelló. El Perelló is, of the four, the most densely populated of the four, with estates of two to six flats, as we can see in the next photo.

Figure 39: Illustrative photo of the typology of housing in El Perelló

Therefore, it could be categorised as a flats area exclusively. Consumption is not very high as the number of users is very low compared to the other pools, as can be seen in Table 6.

Population nucleus	Pools	% of total	Users	Range *(pool / 100inhab)*
El Perelló	7	8%	3009	0,23
Socarrat	13	14%	600	2,17
La Llastra	42	47%	1289	3,26
Les Palmeres	28	31%	2371	1,18

Table 6: Number, proportion and range of swimming pools per 100 inhabitants according to population centre

Therefore, as there is a greater number of consumptions per km of pipe, the losses are consequently lower and the efficiency of the sector will be higher than in the following ones.

El Socarrat is made up of two types of housing, to the north are usually two-storey villas with gardens and swimming pools and to the south are three-storey flat estates. So it is quite easy to understand that the consumptions that appear in the Table 5 are much higher than those of El Perelló. As there are gardens, the use of water by the owners of these properties is higher for irrigation than in the previous town. In addition, as there is a high number of swimming pools per 100 inhabitants, the water supply must also be increased. On the other hand, each kilometre of piping in comparison to El Perelló has a lower consumption of drinking water, so that the yield of 46% is an acceptable value. Despite the fact that, according to the experts who have helped in this work, the average efficiency of the installations is very low in comparison, it is understandable because the installation dates from the 1960s and has not undergone any major reforms up to now.

Figure 40: Illustrative photo of the typology of housing in El Socarrat

Speaking of La Llastra, it can be seen at Table 5 that the consumes, that not include the leakages; are somewhat lower than in the previous case. This is easy to interpret due to the type of housing that characterises this area, as although there are also two-storey villas with gardens, the majority are high-rise properties and two-storey townhouses, as can be seen at Figure 41.

Figure 41: Illustrative photo of the typology of housing in La Llastra

As a result, water is not used as much throughout the year, something that changes in the summer months, as we shall see. However, we can see that the performance is similar, as although La Llastra is larger, it has an average population per km^2 and therefore a very similar amount of consumption per km of pipe. In addition, fibre cement is the material that makes up almost all the pipes in both areas, so the leaks are similar and with them the performance.

To finalise the yields, Les Palmeres is studied, which includes the northern part of La Lotería. In La Lotería the properties are three-storey and there are also two-storey terraced houses, some with swimming pools and gardens. In the central part of Les Palmeres, the houses are tall fincas and two-storey terraced houses and can be seen in the Figure 42.

Figure 42: Illustrative photo of the typology of housing in Les Palmeres

Lastly, in the southern area is Motilla, which is characterised by estates of three or four storeys. It can be said that this area is a mixture of the type of houses that exist in El Socarrat and La Llastra, but without many gardens. Moreover, its extension is similar to that of La Llastra, as well as the population that exists during the year, which is the same, as can be seen in the following table.

Population nucleus	Inhabitants winter/autum
El Perelló	1800
Socarrat	80
La Llastra	250
Les Palmeres	250

Table 7: Population in the different population nucleus

These values are indicative and try to reflect the population living in each area in the autumn and winter months and have been established according to different sources. The first corresponded to the census of inhabitants provided by the Town Council of Sueca, which has data from all the population centres in the municipality. These values do not really correspond to reality because there are many people who are registered in towns outside the large urban centres in order to pay less taxes; but they do not really live there, as is the case here. On the other hand, there are people who usually live in these towns on the Valencian coast and yet they are not registered. But at least these census values are useful to know the estimated distribution between these four areas. The second source is the head plumber of Aigües de Sueca and the third source is the electrician of the town hall, with whom we have direct contact. These people know the coastal area and its inhabitants well as they frequent it on a daily basis and are in direct contact with the users who live there throughout the year. The values they provided are very similar, so their information will be taken as valid by applying a multiplicative coefficient, as it is understood that there will be people who are not known to inhabit the dwellings.

As mentioned above, the population is the same in La Llastra and Les Palmeres, so a similar yield of 48% is assumed for La Llastra. On the other hand, as there are fewer swimming pools for every 100 inhabitants and fewer gardens, the estimated consumptions per inhabitant not including the leakages are lower, as can be seen in Table 5. If we now average the yields of this northern part of the coast with the value of Les Palmeres we get 50%. This is the same value that the engineer of Aigües de Sueca tells us that the complete installation of the beach has, data that provides veracity to the estimated demand profile.

In order to check whether the consumes, that not include leakages, obtained from the estimated demand profile are in line with real cases, the results have been validated by comparing them with real studies. The non-governmental organisation FACUA has been contacted and has provided information on consumption per inhabitant per day. The value comes from EMIVASA, which is the water supply company for the city of Valencia, and which for March 2021 assigns a value of 106 litres per inhabitant per day for the city of Valencia. This data helps us to verify that as El Perelló is a town with a similar type of housing as Valencia, but with properties with fewer flats, it will have a similar consumption but higher in El Perelló as there is a higher concentration of swimming pools. As no clarifying studies have been found to define the average consumption values of the different coastal towns of El Socarrat, La Llastra and Les Palmeres, they have been validated using the criteria of the type of housing that characterises them. These typologies mean that the volume consumed is clearly higher and for the professionals who have supported the carrying out of this work they are valid.

Having considered the autumn months, we now turn to the summer months. It is known that due to the start of the school holidays on 23rd June, demand will start to increase and in July it will increase even more. The municipality of Sueca and the surrounding villages, together with Valencia and the surrounding area, is where most of the owners of the properties in El Perelló, El Socarrat, La Llastra and Les Palmeres are concentrated; a large number of them will move or move more frequently to these properties. And so they will progressively increase, until August, when the peak of the volume consumed will be reached. It will be for this month that the case of peak demand is assumed for the day of highest consumption of drinking water. To strengthen the assumption that demand increases in the summer months, it should be noted that this type of population does not only use drinking water for common household use. During these months, many private swimming pools, both communal and family pools, are put into operation. In addition to this, it must be added that the showers of the users of the network are more frequent on their return from the beach.

Studying area by area, it is at Table 4 where we can see how the month factor increases as the summer progresses until August, when it is at its highest. In El Perelló it is the highest, this is due to the fact that in summer the San Pascual Campsite has a high consumption due to the external tourism and that the Nautical Club of El Perelló also increases considerably the water consumption. The latter increases because the boats are more active in summer and therefore the owners of the boats desalinate them after each day. On the other hand, it should be noted that most of the shops in this minor entity open their doors in summer and do not do so all year round, which also means an increase in consumption. These have a greater weight than the low concentration of swimming pools seen before. On the other hand, there is the growth experienced in these months by El Socarrat and La

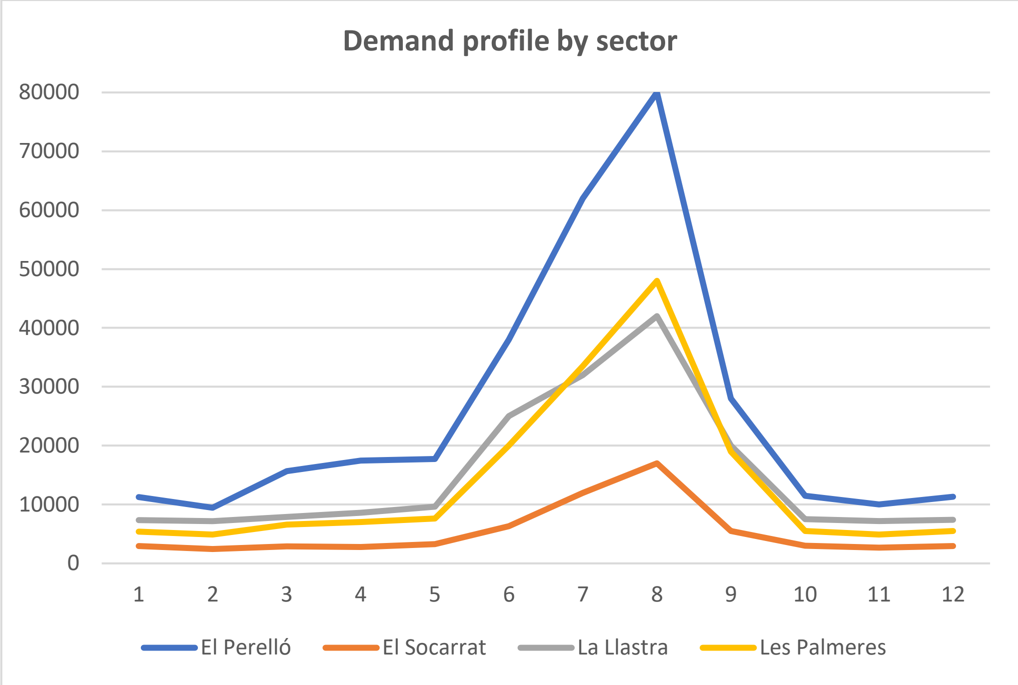
Llastra, where the hypothesis that the number of swimming pools per 100 inhabitants is very high and generates a very high consumption of drinking water.

To obtain the consumption values in litres per inhabitant per day for both the Table 4, which does not take into account the yields of the different areas, and for Table 5, which does take into account the yields, we have assumed values of population growth with respect to that which exists throughout the year. In order to do this, and knowing the seasonal nature of the coastal area of Sueca, equal growth has been proposed for the four sectors and has been calculated on the basis of the case of El Perelló, as this is the only one for which data is known. These data have been provided by the staff of the Sueca Town Council, who have provided the date from the following table in which the summer population values for weekdays and weekends appear as a guide, as these values are difficult to be exact, but they are useful for the growth analysis.

Month	Week	Weekend	Wkend days	Days	Week	Mult Fctr.	Avrg.Popu
June	5000	10000	8	30	22	2,6	4750
July	7500	15000	9	31	22	4,0	7258
August	10000	20000	9	31	22	5,4	9677
Septem.	4500	9000	9	30	21	2,4	4388

Table 8: Population and calculation of multiplicative coefficients

For the different months, the number of days corresponding to weekends and weekdays have been taken from the calendar and an average population has been obtained and then multiplied by 0.75 as the values were given as indicative maximums that are not reached. With it and assuming that in El Perelló there are an estimated 1800 inhabitants throughout the year, the multiplicative coefficients of population have been obtained. They are quite significant in terms of the increase in the holiday population and are therefore applied to all the areas, thus obtaining an estimate of the number of consumers by multiplying these monthly coefficients by the population for each sector throughout the year. As mentioned above, the values of Table 4 and Table 5 in terms of litres per inhabitant per day have been obtained. Analysing these values for the months of July and August it is quite easy to see that for both tables the values are very high and increase compared to other months due to the pools in El Socarrat and La Llastra. In El Perelló the growth is due not to the swimming pools but to the number of shops that open and to the consumption of the Nautical Club, as mentioned before, and the San Pascual Campsite. As far as Les Palmeres is concerned, the Graphic 1 shows a more marked growth than the others.



Graphic 1: Demand profile of all sectors

This increase is not arbitrary, but has been estimated in a premeditated manner. The quarterly consumption figures (counting December as the first month of the first quarter of the year) by sector for the four areas analysed were provided by the Aigües de Sueca IT team and are shown in the following table.

	2020				2021	
	D-E-F	M-A-M	J-J-A	S-O-N	D-E-F	M-A-M
El Perelló	22597	18387	53143	21800	19094	23329
Socarrat	4505	3666	10595	4346	3807	4651
La Llastra	**9790**	**7810**	**36619**	**21830**	**13219**	**9171**
Les Palmeres	**7012**	**6376**	**40666**	**20001**	**7527**	**7565**

Table 9: Quarterly consumption billed for the different sectors

And from this we can extract that in the quarter of June, July and August the flow billed in Les Palmeres, despite the fact that throughout the year its consumption is lower, exceeds that of La Llastra in this quarter. This town had a similar housing typology, an equal population and therefore an equal seasonal growth, which served as an example of values for Les Palmeres. However, this different behaviour has a simple explanation and that is that, despite having fewer swimming pools per 100 inhabitants, Les Palmeres and El Perelló are population centres with commerce, unlike La Llastra and El Socarrat. And this has a great weight in the consumption of drinking water in the months of high season, so the values shown in the table Table 3 are supported by this behaviour.

The month of September is somewhat different from the big holiday months of June, July and August. Although there are families who use their working holidays in September, it does not account for a large number of them compared to the migratory flow to the coast in previous months. But there is no doubt that consumption must be higher than in the autumn and winter months. In addition to the above, there are some families who take advantage of the still good weather on the coast to delay their move to their main home, even though their working holidays are over. And there is still a notable occupation of elderly people who continue to live the whole month of September on the coast. All this, together with the closure of shops and the emptying of private and communal swimming pools, means that the volume and the population coefficient is reduced and with it, the Table 5 consumptions, the monthly consumption and consequently the month factor of the Table 4.

We will now comment on the spring months, when the weather is better than in winter and therefore the population and consumption should grow moderately. For the month of March, it should be taken into account that in the Valencian Community there is the Fallas festival from the 1st to the 19th. This means a holiday period and the good weather encourages homeowners not to settle down, but to frequent more the coastal area of Valencia. Consumption will increase and therefore, in order to reflect the real behaviour of water demand in the parameters, a multiplicative coefficient of 1.3 has been assumed. This assumption clearly reflects reality, and although in El Perelló the Table 4 and the Table 5 of consumptions reflect slightly higher values for March as expected, for El Socarrat, La Llastra and Les Palmeres their values, although consumption increases, the consumptions mentioned above decrease with respect to the winter months. This occurs because the festivity is celebrated in large towns such as Sueca and in this case in El Perelló, but in small towns the spectacle is transferred to El Perelló, which concentrates the attention of the festive tourism during these days. For this reason, instead of defining the same multiplying coefficients for all the towns as in summer, in this case the population growth for El Socarrat and La Llastra is taken as 1.05 because they do not have the same population growth as El Perelló and for Les Palmeres it is taken as 1.1 because the festivity also attracts tourism to this town. Continuing with the month of April, we take into account another very important holiday, Easter, which includes 15 public holidays from 29th March to 12th April. The situation is repeated for this month as consumption increases and the same happens with El Perelló, which concentrates the opening of part of the commercial activity on the coast during these days, as well as the increase in population, leaving the other towns with a less notable growth. And for the month of May, although there are no big festivities, the weather is very similar to the summer months and during the weekends the population grows and with it its consumption that begin to be greater also per inhabitant since some swimming pools are starting up and above all the commerce that supposes an increase of the consumption per inhabitant and day of the Table 4. Therefore, the coefficients chosen for April and May are 1.4 and 1.5 for El Perelló; somewhat lower for Les Palmeres which does not have so much activity until the summer when the shops open and are 1.2 and 1.25. And for El Socarrat and La Llastra which do not have shops that contribute a great weight to consumption, but they do have swimming pools that gradually increase consumption as they fill up and their multiplicative coefficients are assigned 1.1 and 1.2.

As a summary of this gradual spring growth, a very explanatory parameter is the month factor, which we can see is growing gradually, always below the summer growth, assuming a growing demand in all the coastal population centres. And it should be noted that for all the months other than June, July, August and September this factor for the whole beach is around 0.5. This is due to the fact that summer consumption is exaggeratedly high and the monthly average value rises a lot, which means that the parameter of the month factor will decrease for all the months that do not suffer great variations between them during the year.

Once the consumption assumed for each month has been analysed and validated with arguments and criteria, the aim is to verify that the consumption recorded for the first months of 2021 is coherent. In this way, we can check whether the data are valid to carry out this estimate of the demand profile for this year. It is quite normal for February to be lower than January as there are no major public holidays in this month. In addition, it is a cold month so there will be fewer people on the coast. Later on, we will establish it as a month with lower demand and we will assume a valley demand at night, which will be a point of study to be considered. As far as March is concerned, we see that it is higher than January. The simple explanation for this is that from 1 to 19 March, the aforementioned Fallas festival is celebrated and temperatures also rise. This is when many families decide to go to the coast and the population increases for this part of the month. The month of April sees higher temperatures that invite the population to go progressively to the beach at weekends. May, as we can see, follows the same progression for the same reasons. It can therefore be verified that the data provided by Aigües de Sueca on the monthly consumption of El Perelló, El Socarrat and La Llastra are valid as a basis for obtaining the consumption established for Les Palmeres and for estimated volumes for all the months of 2021 for which no data is available.

Finally, once the monthly demands for each of the population centres have been defined, it can be seen that the values that appear on the Table 3 as total annual volumes for 2021 are greater than those provided by Aigües de Sueca for the year 2020 of the Table 10. This only supports the consumption curve defined, as 2020 was a year affected by the global pandemic of COVID-19. In Spain, and specifically for the Valencian Community, traffic between municipalities was restricted to a large extent, and in the same way, traffic between autonomous communities was more strictly regulated. This considerably reduced not only provincial, inter-community and inter-municipal tourism, but also international tourism. In the same way, public holidays this past year were not celebrated in the same way, so that homeowners were not able to travel to this coastal area. This, of course, affected the consumption of drinking water, as neither the houses were frequented as much throughout the year for the holidays, nor were all the swimming pools filled. Neither did the summer trade, and even the local shops, which are normally open all year round, open their doors as much as in the average year. Therefore, the fact that the values for 2021 are measurably higher than those for 2020 is a clear symptom that the estimate is in line with the actual behaviour of the pipe network.

Monthly 2020	Annual 2020
22011	**264128**
3174	**38084**
13645	**163744**

Table 10: 2020 annual and monthly average consumption for El Perelló, El Socarrat and La Llastra

CHARACTERITATION OF THE RESERVOIR

The model has been simplified by replacing the pumps with a reservoir at a constant level and with a height of 35 metres of water column to provide 3.5kg/cm^2 of pressure. This simplification is supported by the information provided by the plumbing manager of Aigües de Sueca, who indicates that the pumps have not caused any significant problems since their installation 25 years ago, providing an uninterrupted supply and maintaining the set pressure. These values change depending on the time of day. The daily setpoint is 3.5 kg/cm^2 from 6:00 AM to 2:00 AM and the nighttime setpoint is consistently from 2:00 AM to 6:00 AM with a value of 2.8. This is done so that when there is no consumption at night, the pressure is maintained, but at a lower value to reduce losses. As for its elevation, it is set at 0, as the tank together with the pipe network are at sea level and the slight variation in elevation that may exist is simplified, as it does not provide a key component for the model. The information of the setpoints will be taken into account in the subsequent study of base demands and when simulating the network model.

The result of the characterisation of the elements considered in the installation can be seen in the following image.

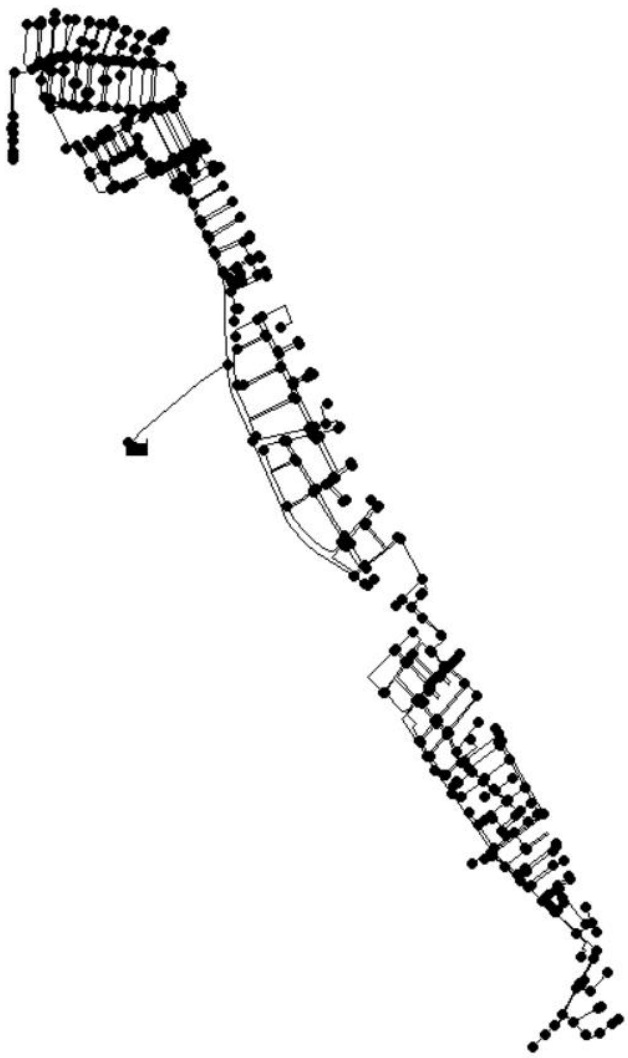


Figure 43: Final model in Epanet

HYDRAULIC LOAD OF THE MODEL

Once all the elements that make up the drinking water supply network have been characterised, we move on to the hydraulic loading of the model. In this, the first step consists of calculating the base demand of the nodes that make up the network. This is the average flow of the users connected to the node in question and for which the units in Epanet are in litres per second (l/s). A base demand will be established for each of the sectors described in order to obtain a mathematical model that more reliably defines the reality and the demands for two opposite scenarios will be proposed. The summer scenario, which for this installation is the case of highest demand, will be made for the month of August and for the winter scenario the month of February will be taken, which is when there is the least demand for flow in the network. With these scenarios, a study of pressures, flow rates, velocities and unit losses is carried out.

CALCULATION OF THE BASE DEMAND

In order to calculate the base demand of the nodes, it is first necessary to consider the volumes of water to be defined as such. It is therefore necessary to return to the aforementioned yields and establish the limitations of development of this final degree work. Thus to take the appropriate criterion for the mathematical modeling. The first thing to analyze is the water balance of the network.

The water balance of our installation is the balance between the inflow and outflow of water. The input is simple to establish as it is the La Malva reservoir which, for our future mode of operation, is the only flow input that supplies the system. One of the outlets would be the connections of the users, both private at the residential level and public in terms of gardens, fountains and public buildings or facilities. These are defined in the nodes, each one of which houses different sets of users. But, on the other hand, outflows are also the apparent and real leaks explained above, which are an important part of the volume injected into the network by the La Malva reservoir. These leaks depend on the state of conservation of the pipe installation and the control of the apparent leaks.

The operation of the network under study is future and consequently the volumes recorded for all the months of the year after May are not known. That is to say, those entering at the service connection level and which represent the volume actually consumed by users. Therefore, due to the lack of information registered on the Aigües de Sueca platform, it is not possible to assign the base demand of the volumes billed to the nodes. Therefore, the base demand will be assumed to be the flow injected into each of the sectors. This is the one estimated above and reflected in the Table 3, which includes the registered or invoiced volumes, as well as the apparent and real leakage. This approach is not unwise, in fact, it has two strong points in its favour. One is that the time constraint of this thesis does not cover the parallel analysis of the invoiced volumes, if available. On the other hand, and as a fundamental point, if only the flow consumed by private and public users is assigned to the consumption nodes, the error is made of introducing less flow than is actually flowing through the network, with all the inaccuracies that this entails.

Then, once the limitations and criteria to be taken into account for the analysis of the base demand are clear, a first hydraulic load in Epanet is proposed to see how the network behaves in a possible scenario. This is done with the sole objective of checking that no errors have been made in the characterisation of the elements that could pose a problem for the subsequent simulation of the case studies. To do this we assume an average monthly consumption of 2021 of flow for each sector as can be seen in the following table.

NODE NUMBER	SECTOR	NODE BASE DEMAND		SECTOR BASE DEMAND
		m^3/año	l/s	l/s
205	**El Perelló**	1517	**0,04809**	9,91
40	**El Socarrat**	1595	**0,05059**	2,02
66	**La Llastra**	2754	**0,08733**	5,76
164	**Les Palmeres**	1024	**0,03246**	5,32
475 + 11	**TOTAL - AVERAGE**	**1497**	**0,04746**	23,02

Table 11: Average annual base demand by sector

The calculation has been made by dividing the annual volumes of each of the sectors that come from the Table 3 by the number of nodes that exist per sector, as counted in Epanet. Eleven nodes have been left uncounted, corresponding to points in the network where there is no consumption, so that the demand in them is 0, and this is how they have been assigned. These are located near the reservoir (3), at the intersection where the pipe that supplies El Perelló-El Socarrat and the one that supplies La Llastra-Les Palmeres (1) separate, at the entrance to La Llastra before reaching the flow meter (1), at an elbow to the southeast of La Llastra (1), another elbow to the southeast of the same (1), to the south of the previous one (3) and the node that limits our network to the south (1). This makes a total of 486 nodes which, depending on their sector, are assigned either 0, as above, or the average monthly consumption value for 2021, which corresponds to the base demand. This criterion of equitable distribution of the demand for drinking water between nodes for each sector has been established because the flow rate demanded by each user of the network is not known. In addition to the fact that establishing the value for each one would be an extremely costly task, it would also not be very operational, as estimates and averages of consumption must be established to group sets of consumption within the same consumption pattern, as has been done in this case and in the above.

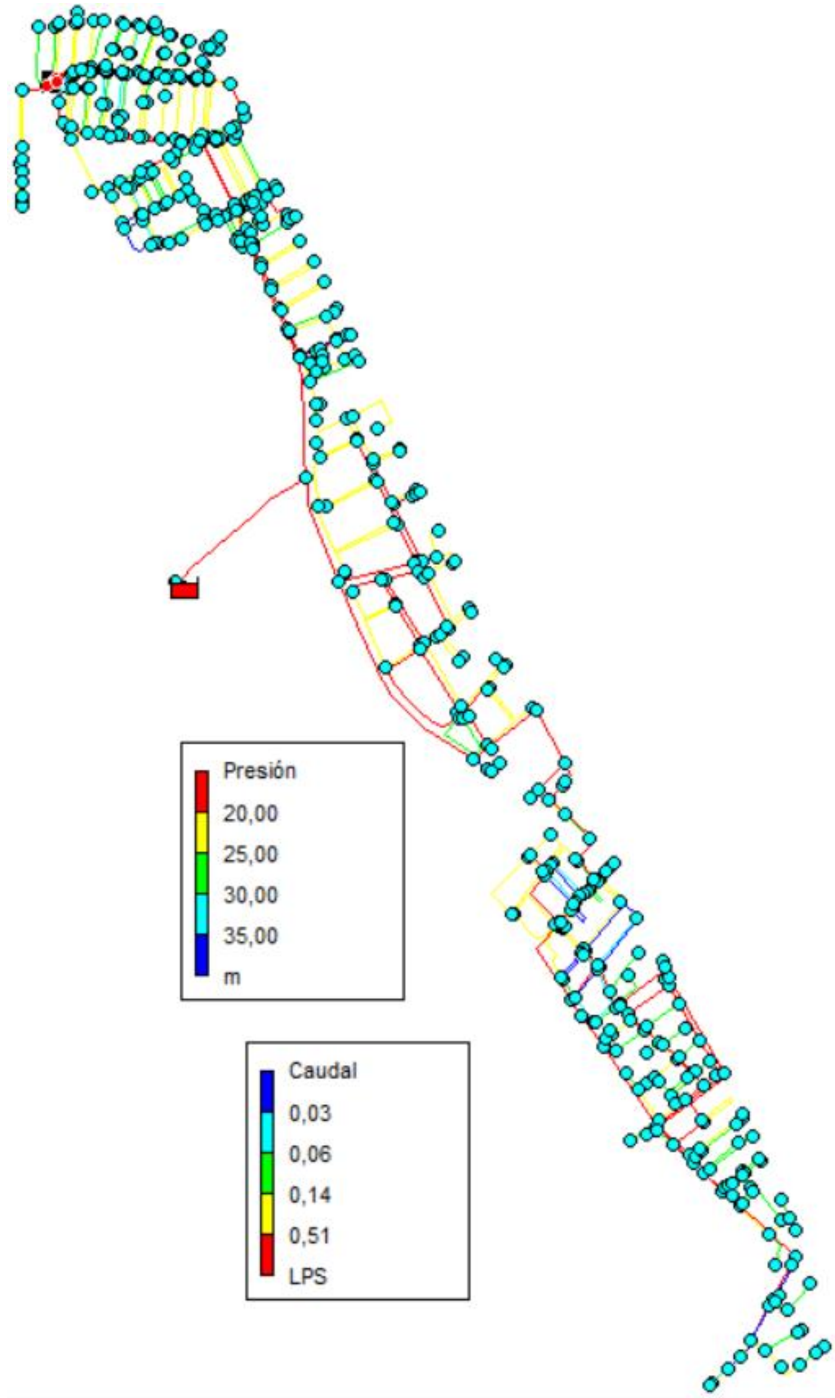


Figure 44: First simulation

Once this has been done, the first simulation is run, the result of which is shown in the previous figure, in order to make the relevant checks. No outliers are observed in this first approach case for monthly average values. Among other checks, it has been verified that the flow entering each of the sectors and the flow injected from the tank, through its inlet pipes, corresponds to the last of the columns of the Table 11, and so it is, as the values are exactly the same or very similar, due to rounding, as can be seen in the following images.

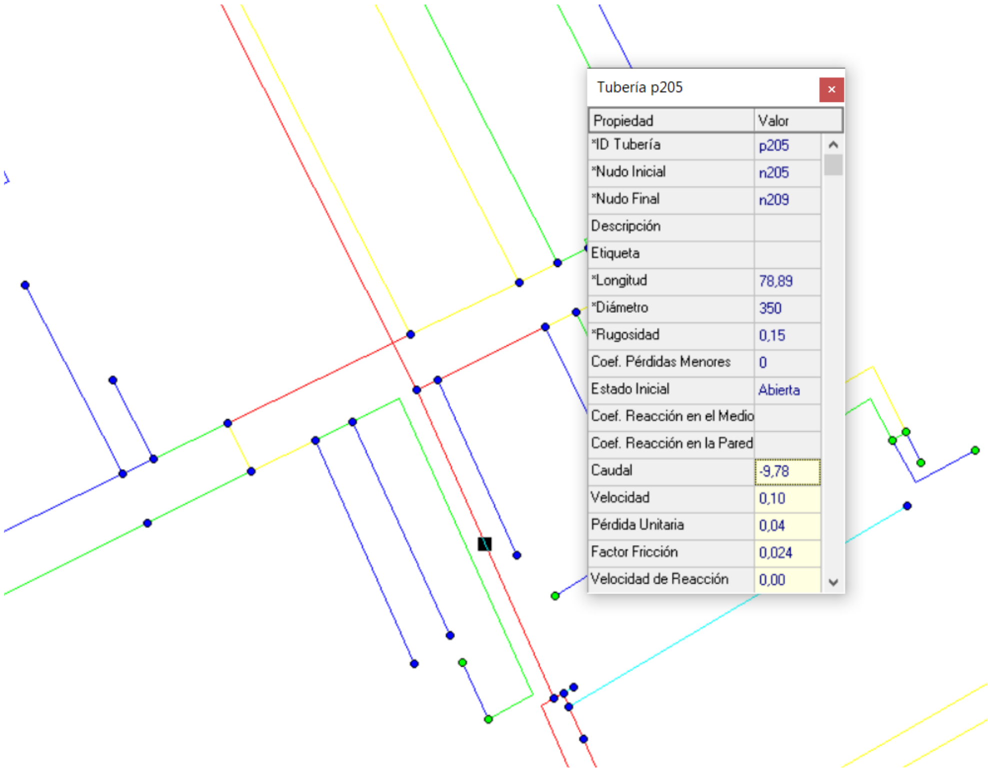


Figure 45: Checking the base demand in the inlet pipeline to the El Perelló sector

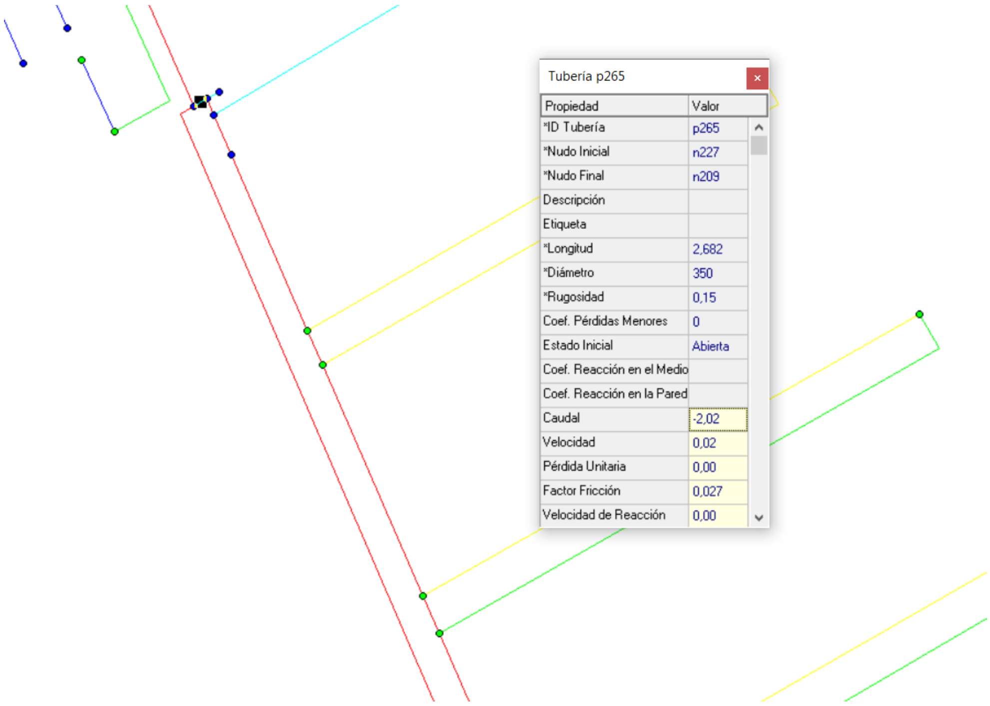


Figure 46: Checking the base demand in the inlet pipeline to El Socarrat sector

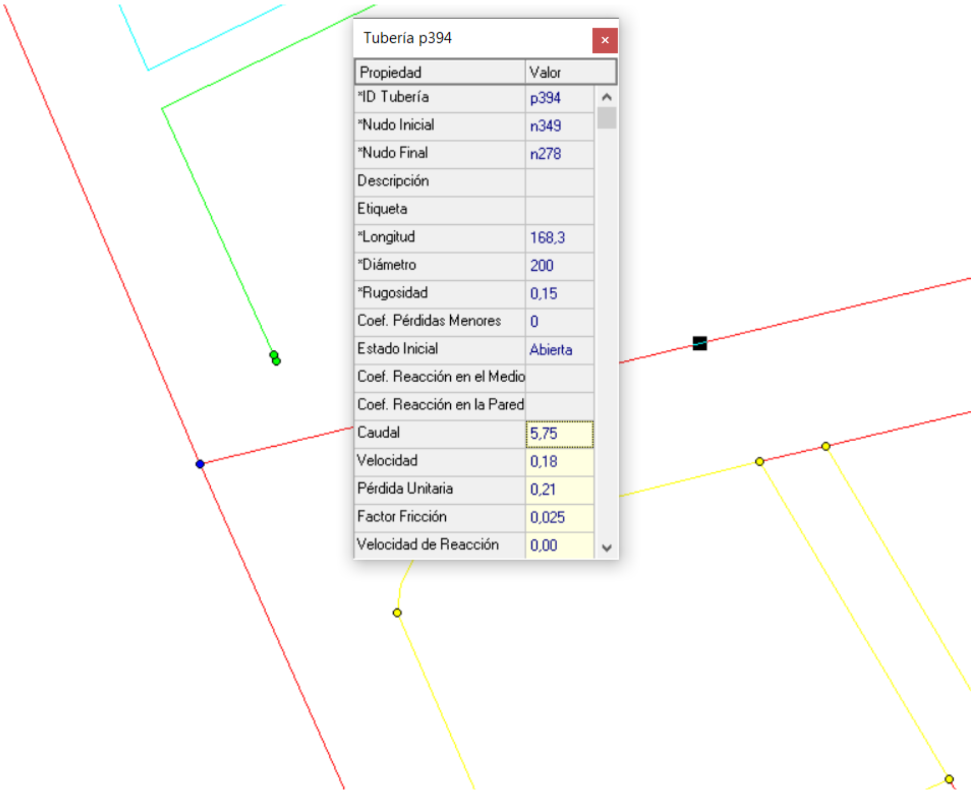


Figure 47: Checking the base demand in the inlet pipeline to La Llastra sector

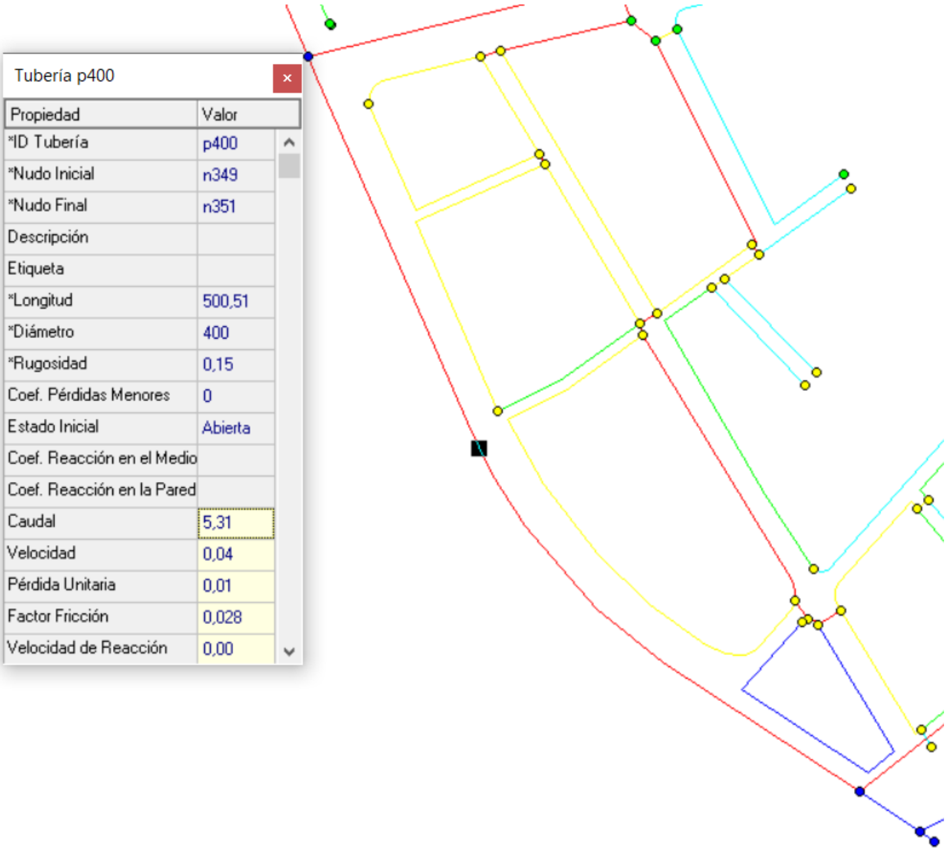


Figure 48: Checking the base demand in the inlet pipeline to Les Palmeres

CASE STUDIES

For the installation, the two most unfavourable possible cases are proposed for which we want to observe how the network behaves. If the system can be improved for the extreme cases, all the intermediate values will see their operation, if possible, even more improved, and this is the aim of this study. The first case corresponds to the August scenario for which the peak hour of the peak day will be selected as the time of greatest demand for network flow. To this end, with respect to the average monthly base demand for 2021, mentioned above, demand factors will be used for each sector together with multiplicative coefficients that will allow this case to be simulated by taking the demand to what the network would consume at this time. Likewise, for this same peak day in August, the case of the off-peak hour will be used to compare values and provide more information for the study. In the same way, an off-peak hour of the off-peak day corresponding to February is chosen to plan the opposite case. As in the previous case, the peak hour of the same day will be studied. The analysis carried out is based on pressures, velocities and unit losses, where the different problems are detected for the scenarios proposed. There is no great debate on flow rates, as once it has been checked that the quantities entering each sector correspond to the base demand for each flow meter in the sector, it is known that the water will be distributed through the different meshes and branches to reach the nodes. Therefore, the application of the multiplicative demand coefficients will not be a problem. It is simply an increase or reduction of the flow demanded by the nodes, since Epanet distributes the flows through the pipes according to the demands assigned to the nodes.

CASE 1: PEAK HOUR OF THE PEAK DAY

In this case, the 15th of August has been chosen, which is understood to have the highest demand for drinking water throughout the year. August is the month in which people in Spain usually have their holidays, as a general rule, and in addition, for those who are still working, Sunday is also a public holiday, which means that these areas of the Valencian coastline will be busiest and therefore have the highest consumption. As far as the time is concerned, it is known and contrasted by the Aigües de Sueca team that it would correspond to 1 PM. At this time, families come back from the beach to cook their meals, which means that not only is consumption for the preparation of the meal, but also that the showers in the swimming pools are activated much more. This is also the case for the communal showers of some fincas and single-family houses where the same situation occurs. In addition, for people who have gone to spend the day at sea, this is the time when the skippers return to port and use a lot of water to desalinate the boats.

To simulate this high demand, the first thing to do is to take as the multiplicative coefficient for each sector the value for the month of August of the Table 4 that corresponds to its month factor. In other words, multiply the base demand by 3.03 for El Perelló, 3.16 for El Socarrat, 2.73 for La Llastra and 3.39 for Les Palmeres to simulate the average base demand for August. To do this, the group of nodes in each sector is selected and their demand is multiplied by the month factor for each sector. As the base demand value when doing this type of operations in Epanet is rounded to the hundredth, it has been calculated with Excel, in the Table 12 the assigned values are shown, and for each node the value has been introduced with four decimals to avoid rounding errors in the model.

	Values entered for summer/winter scenario	
	August	February
El Perelló	0,1458	0,0191
Socarrat	0,1596	0,0254
La Llastra	0,2385	0,0451
Les Palmeres	0,1099	0,0124

Table 12: Base demand values entered after the peak and off-peak multiplicative coefficient has been applied

Subsequently, as the intention is to simulate the peak hour of the peak day, a demand factor of 1.8 was introduced. This value has been extrapolated from two end-of-degree theses from the Polytechnic University of Valencia, since no study has been found to provide clarification for the type of population analysed in this work. In the first one (Martínez, 2018), being a housing development of villas with swimming pool and large gardens, consumption is understood to be higher and therefore the peak coefficients of 2.45-2.5 will also be higher than for the study population. On the other hand, in (Belda, 2018), we find a municipality with buildings of 2 to 5 storeys where the holiday growth is not as high as in the previous one. But it serves as an opposite case due to the housing typology that is more similar to that of El Perelló and Les Palmeres. Here the peak coefficients are consequently lower and are around 1'3-1'2. And in the first of the final degree projects, the housing typology could be more similar to El Socarrat and La Llastra. Therefore, taking the average of values as the study population is a mixture of housing typology and holiday growth profile, we obtain 1.8, which is assigned, as we have already mentioned, to the demand factor of the whole network.

It is known that the set pressure assigned to the pumping group is 3.5 kg/cm^2, but as the pumping group has not been introduced, a value of 33 metres of water column is assigned to the reservoir to simulate that the pumping group is not perfect and that in the face of so much water demand it is not capable of providing the set pressure but some 3 metres of water column less. Once everything is defined, we can simulate our model for the case of the peak hour of the day with the highest consumption of the year.

Pressures

The first thing to be measured are the pressures at the different nodes of the network. The aim is to ensure a pressure greater than or equal to 30 metres of water column for all the nodes of the network.

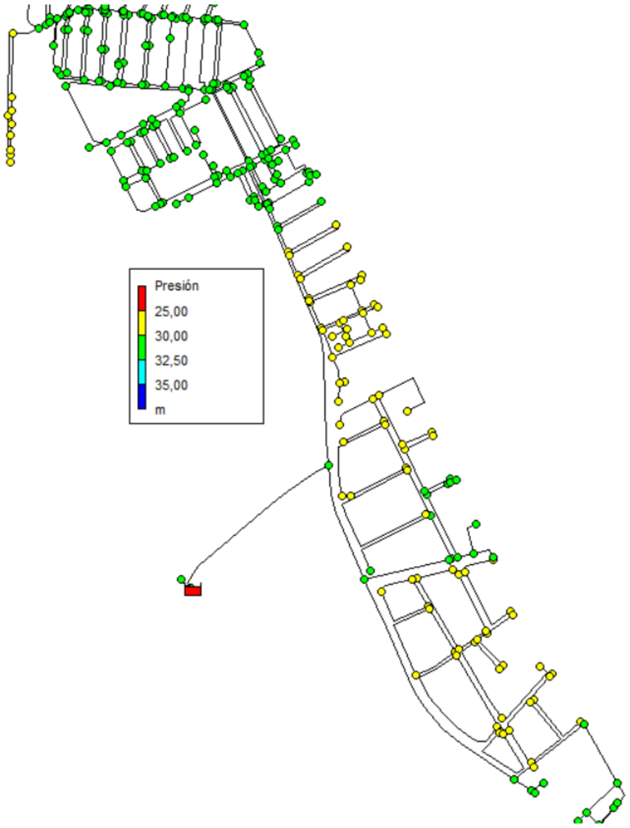


Figure 49: Map indicating where low pressures exist

Due to the fact that the pipe network is almost flat, there will not be large differences in pressure. However, it is clear from Figure 49 that in several areas the yellow knots do not reach a pressure of 30 metres water column (mwc). Starting with the area of El Perelló, it can be seen that in the western quarter they are slightly below the desired pressure. However, this area would not require a change in the configuration as the dwellings are single-storey and there are some two-storey dwellings.

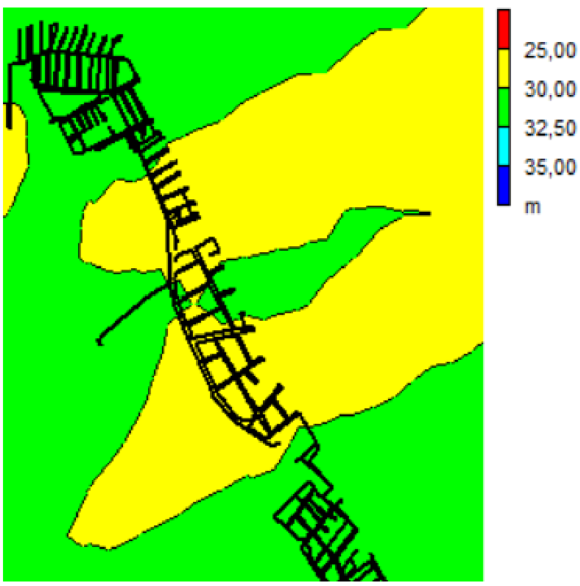
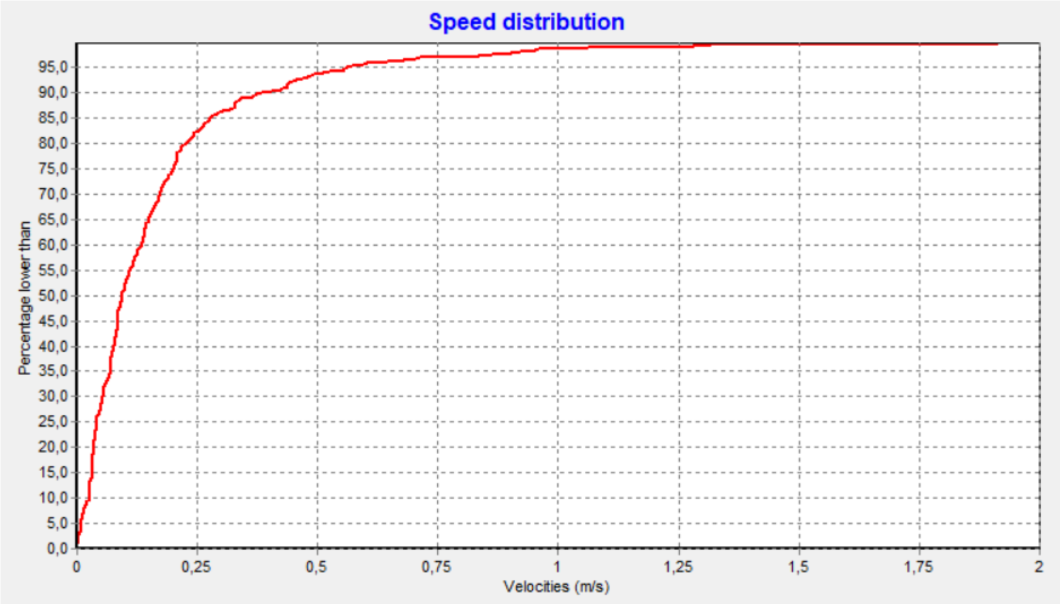


Figure 50: Isobaric map of pressure hotspots

In the area now known as El Socarrat, the pressures are low, in fact, most of them are below 28 mwc. This will cause problems for users, who will not have sufficient pressure in their homes. In La Llastra, low pressures are also observed in a large number of its nodes, as can be seen in the isobaric map of Figure 50, more precisely in the most conflictive areas. Since in La Llastra the properties are higher and would not have adequate pressure values for the upper floors.

Velocities

As far as velocities are concerned, the network velocity should be between 2.5 and 0.5 m/s that are ideal values for piping networks.



Graphic 2: Speed distribution of the pipin network

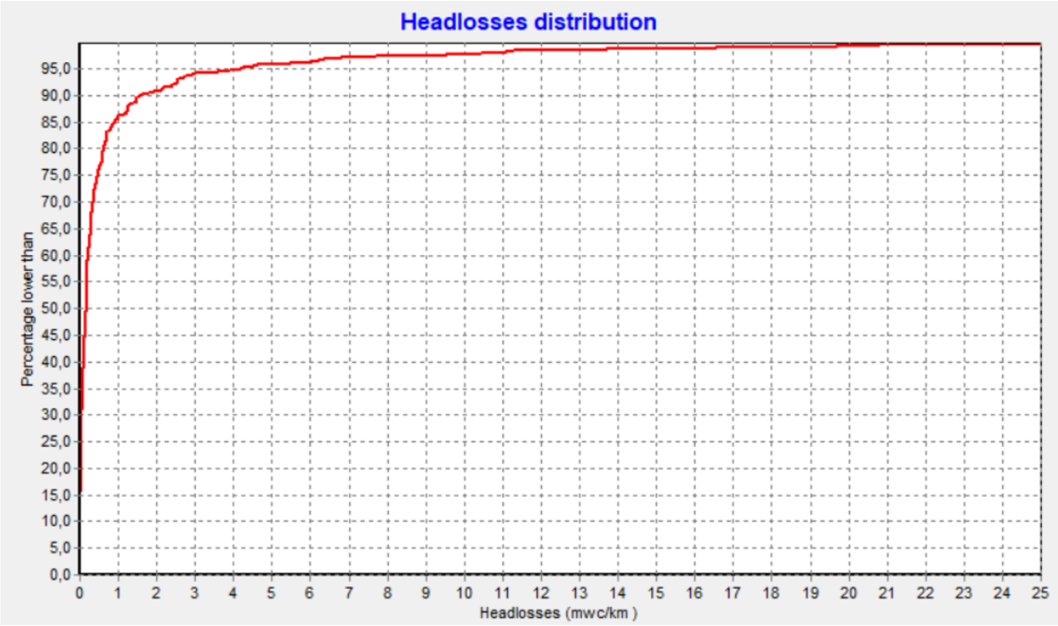
However, if we can see at Graphic 2: Speed distribution of the pipin network Graphic 2 that around 94% of the 566 pipes ones have velocities lower than 0.5, which can cause sedimentation problems in the network and thus a reduction in the diameter of the pipes, as can be seen in the next image (extreme case not belonging to this network).

Figure 51: Pipeline with extreme case of sedimentation

In addition, low velocities can lead to a decrease in chlorine concentration due to increased residence time, resulting in an eventual loss not only of efficiency due to these velocities but also of water quality. However, these values, although worrying, as only the main pipes entering the sectors and leaving the tank exceed 0.5 m/s, are also quite common in the networks. This network was oversized at the time so that, although it had this problem of velocities, it would be capable of covering the drinking water demands of some coastal populations. These, since the initial construction of the network, have been growing with new dwellings, which today are no longer increasing at the same rate as in previous decades, according to the urban development plans for the coast.

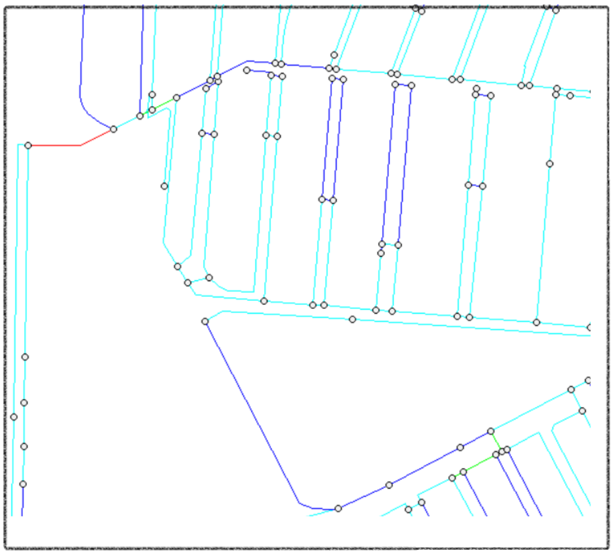
Headlosses

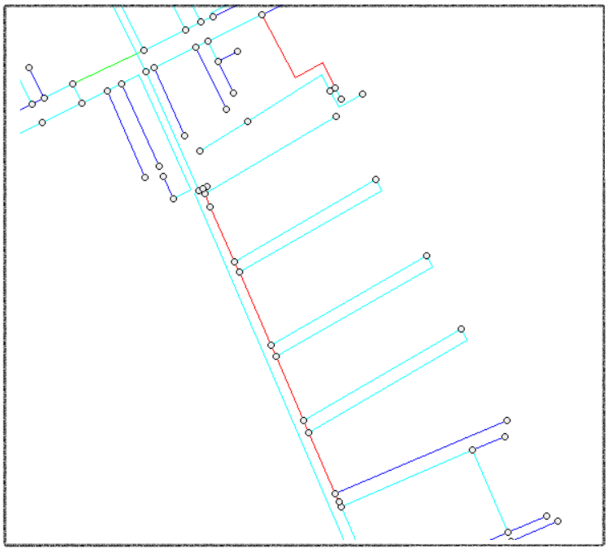
The unit losses are defined as the pressure that is lost along the passage of the pipe for each unit of length of the same and that in Epanet is established, by default, as the unit of metres of water column divided by kilometre of pipe (mwc/km). These are caused by the friction of the fluid with the pipe walls and follow the Darcy-Weisbach equation. So the diameter, roughness, pipe length and material, as well as the velocities analysed above establish the dependency of this loss calculation that Epanet performs automatically. Ideally, 5 mwc/km should not be exceeded, and if we consider the analysis in the Graphic 3, we realise that 95% of the pipes have values lower than 5 mwc/km.



Graphic 3: Headlosses distribution of the pipin network

As regards the other 5%, it can be seen in the following images where the pipes are located, which in red exceed 7 mwc/km and in yellow those with unit losses of between 7 and 5 mwc/km. It has been checked that all of them have internal diameters of 60 and 100, which warns us that they are possibly undersized for the flow that, according to the simulation, they are transporting.





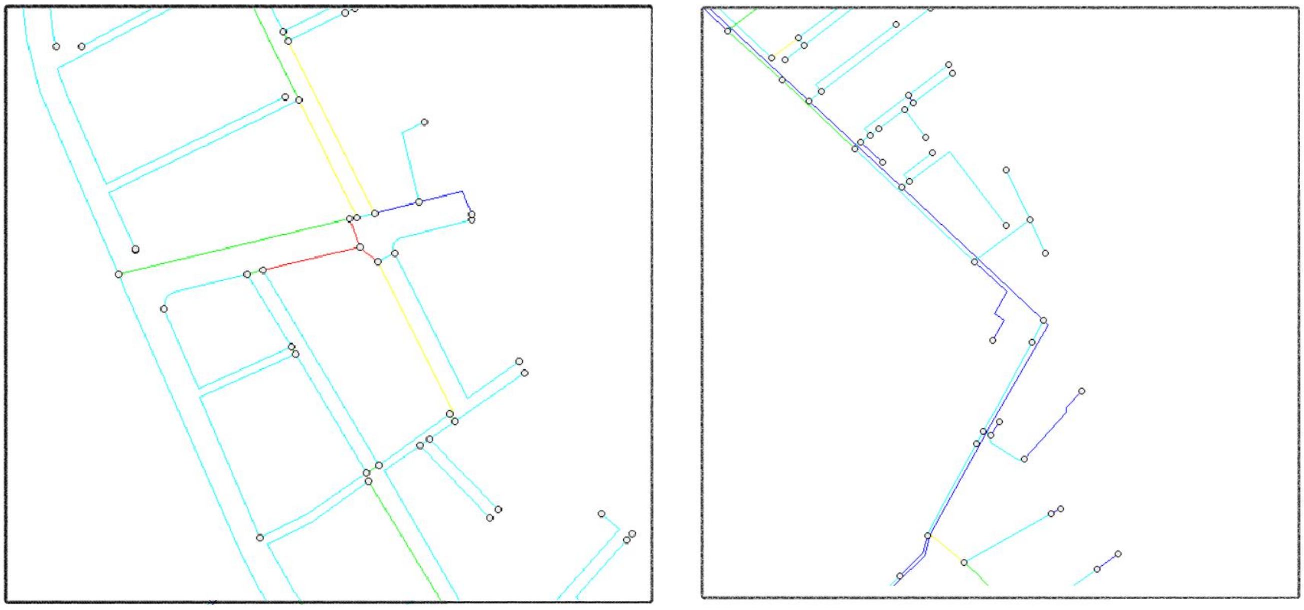


Figure 52: Pipelines with headlosses above 5 mwc/km

CASE 2: OFF-PEAK HOUR OF THE OFF-PEAK DAY

For off-peak demand, the month of February is taken as it corresponds to the month with the lowest monthly demand, as can be seen at Table 3. As for the day, it is considered that this can correspond to any day during the week. With regard to the time, a time of night has to be chosen, which will be when the network users are sleeping and there is practically no consumption other than that linked to leaks or isolated consumption. Therefore, a standard time is chosen, such as 3:00 AM, which meets this description.

As the aim is to simulate the lowest possible consumption in order to see how the network behaves in this scenario, valley coefficients and a demand factor have to be established, as before, to define it. As was done for case 1, the same monthly factors are used for all the population centres under study, but in this case for February. These are 0.4 for El Perelló, 0.5 for El Socarrat, 0.52 and 0.38 for La Llastra and Les Palmeres respectively. Following the same procedure as above, these are assigned for each sector and then a demand factor is assumed for this off-peak hour which has also been obtained from (Martínez, 2018) and (Belda, 2018). This, extrapolating it to our area of holiday villages, is 0.6.

Pressures

As far as pressures are concerned, there will be no major problems as it is a flat area due to its proximity to the sea, so as there are no major differences in elevation there will be no major problems as far as high pressures are concerned. The value established, as mentioned above, is 2.8 kg/cm^2 for the hours between 2:00 AM and 6:00 AM, so the constant level of the reservoir has been changed to

28 mwc. If we consider the simulation, the pressure does not drop below 27.5 mwc at all points in the network.

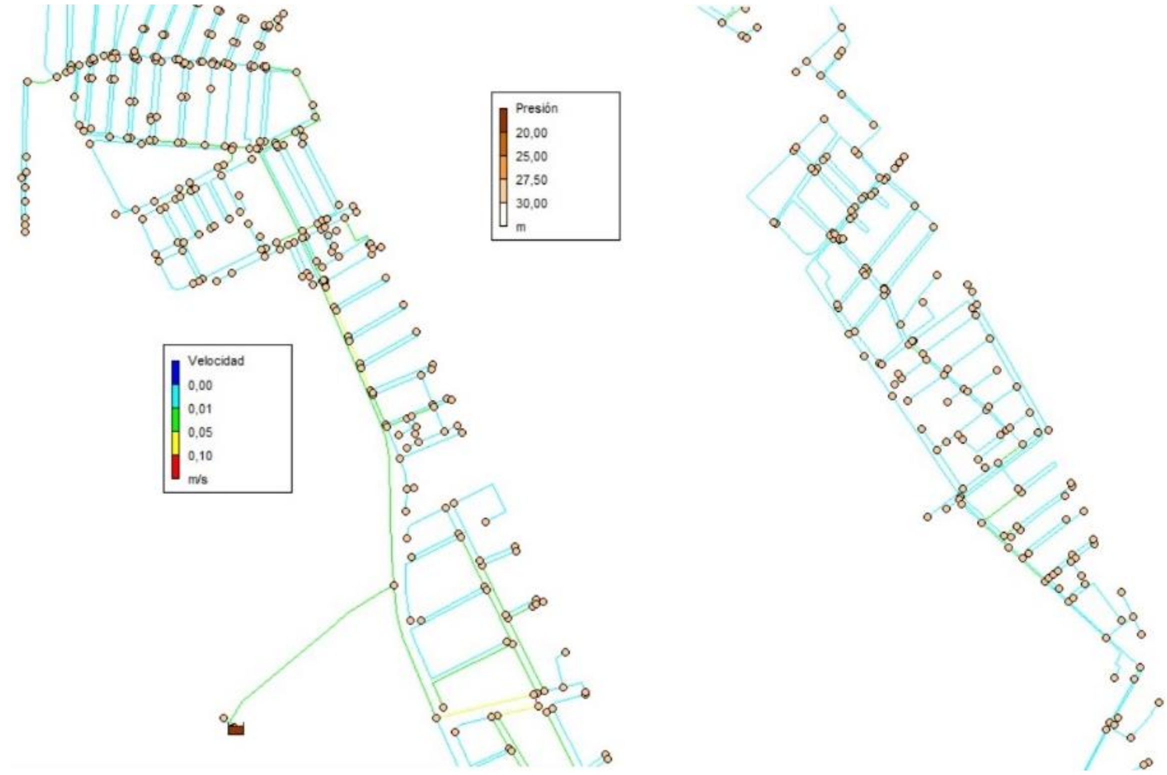


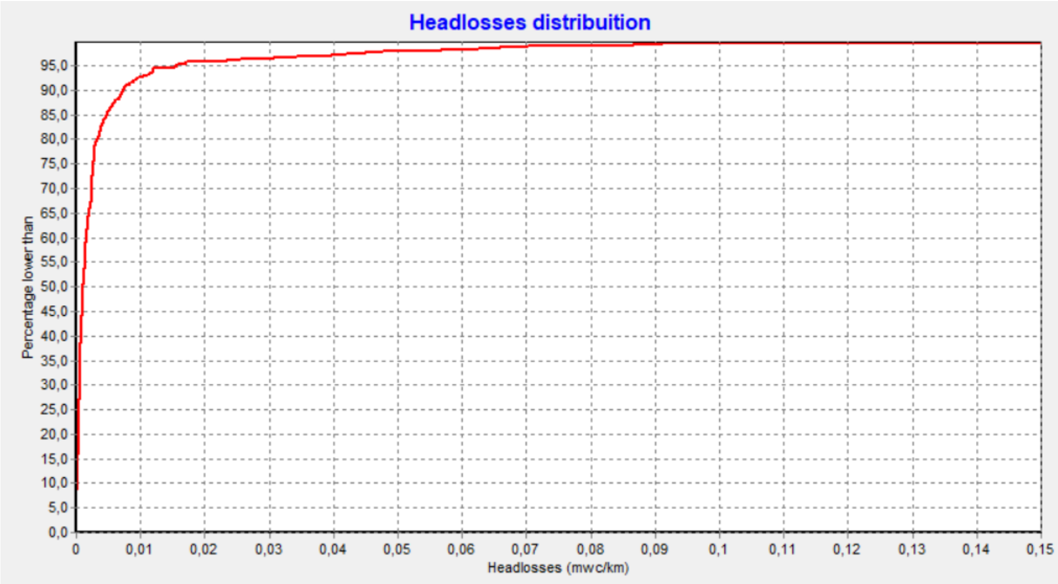
Figure 53: Map of speeds in the winter scenario

Velocities

As expected from this section, the velocities will be extremely low, none of them exceeding 0.1 m/s as can be seen in the previous figure. Therefore, the problems described in case 1 would be more likely to occur for these operating conditions. The explanation is quite simple and it is that, following the equation of Q=v*A; if the flow (Q) demanded, and therefore circulating through the pipes of section A, the velocity (v) in the same will also be reduced. In some cases Epanet shows null values, but this is due to the rounding to the hundredth, so there are pipes in which their nodes have very little demand and the pipes will appear as if there were no circulation, even though there is circulation, but very little.

Headlosses

As far as losses are concerned, it is expected and verified that they are lower than in the peak case. As they are speed-dependent, if the speed is reduced, the losses will also be reduced up to a percentage of 98% with values below 0.05 mwc/km as can be seen in Graphic 4.



Graphic 4: Distribution of headlosses in the winter scenario

This brings us back to the Figure 53 where it has become clear that the set pressure of the pumping unit is very similar to that of all points in the network, since there is not much water in motion and therefore the losses in the pipes are minimal, thus obtaining an almost identical pressure in the system.

STUDY ON RECORDED LEAKAGES

A study has been made of the leaks in the population areas under study to find out if the leakage problems follow any pattern and thus be able to find a solution. The starting point was the data from the leakage register kept by the plumbing manager of Aigües de Sueca for the months of January, February, March, April and May 2021, with the streets, population areas, days and diameters of the pipe that had the leak. Based on this data, the information has been extended by asking the same plumbing manager about how long each of the pipes has been leaking, taking into account the time prior to its detection until the water supply to that pipe is cut off. With this, calculations were made to find out how much water had leaked for each pipe. In these calculations, based on the previous velocity analysis, an average velocity in the pipes of the installation of 0.8 m/s was assumed, and that the leakage accounted for 20% of the water carried by the pipe. With these criteria, the aim is not to obtain an exact figure for the volume leaked, but rather an indicative figure that focuses the problem on the areas where the most leaks occur. Then, having areas, average speed and leakage times of each pipe, the volume leaked can be calculated. And if these values of the volumes are added up for each of the zones studied, the following table is obtained.

Poblation zones	Leakage volumes (m3)
Loteria	**806**
Fernandet	106
Perelló	102
Llastra	63
Palmeres	56
Motilla	18
Socarrat	11
TOTAL	**1162**

Figure 54: Indicative leakage volume per study area

It can be seen that La Lotería has 8 times more leaks than any other area. Analysing the pipe map, it can be seen that almost all the pipes in La Lotería are made of PE, as in 2004 the work was carried out to replace the previous pipes with those of this material. This is the differentiating parameter, as this area stands out from the others due to the material of its pipes. The problem, according to what has been discussed with the plumbing team, is that the PE has to be welded and the expansion and contraction of the pipe due to temperature variations ends up breaking the welds, causing leaks. That is why the replacements that are made prioritise the installation of ductile cast iron instead of polyethylene, although the price is higher.

As far as Fernandet and Perelló are concerned, we can see that the volumes are similar and this raises the first question. Fernandet is a much smaller area than El Perelló, but nevertheless, so far this year, the volume of leaks is practically the same. For the area of El Perelló we rule out that it is something unusual, because knowing the number of users and that it is a minor entity in this area of the coast, it is assumed that it is a normal volume of leakage. But Fernandet is a group of 5 streets, so it is strange that there are so many leaks. We can associate this problem with the material of which most of the pipes in the area are also made, which is iron. Both the service connections and the distribution pipes are very old and this is where the problem of leaks lies. Part of the Fernandet pipes do not appear in the model because, as was mentioned at the beginning of this work, they have been eliminated to avoid negative pressure errors in the programme. However, it is commented on in this section, as it is an area that has to be supplied and it is studied in order to comment on it in the improvements to be made to the network.

PERFORMANCE OF THE NETWORK UNDER FIRE EMERGENCY CONDITIONS

Drinking water supply networks must function well in emergency situations such as fires. For this reason, the operation of hydrants is now analysed to see if they would be able to respond to the guidelines set by the NBE-CPI/96 in (AEBOE, 1996), which is the reference standard for urban networks. The standard indicates that they must be located in accessible places that are not trafficked or occupied by vehicles and properly signposted. According to the technical parameters, they must provide a minimum flow of 16.6 l/s and have a pressure of more than 10 mwc.

If we go to the AutoCAD file we can see where the hydrants are located along the whole installation. In the area of El Perelló that appears in the Figure 55 and in the Figure 56 there are 3 in the north neighbourhood and another 3 in the south neighbourhood and in La Lotería there is one as can be seen in the Figure 57.

Figure 55: Fire hydrants in El Perelló in the northern district of El Perelló

Figure 56: Fire hydrants in El Perelló in the southern district of El Perelló

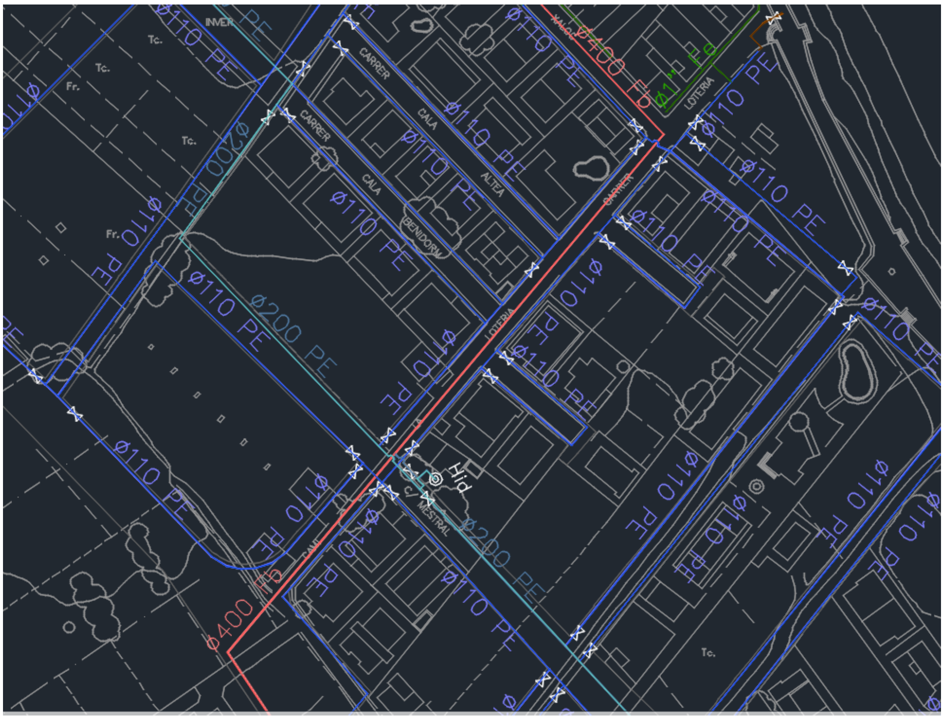


Figure 57: Fire hydrants in La Lotería

For El Perelló, the analysis is proposed for 1 hydrant for each neighbourhood, in which the most unfavourable one is chosen, which corresponds to the hydrant that is furthest north in the Figure 55 and in the Figure 56 to the one that is also in the upper part. They are then assigned a flow rate of 16.6 l/s and simulated in Epanet.

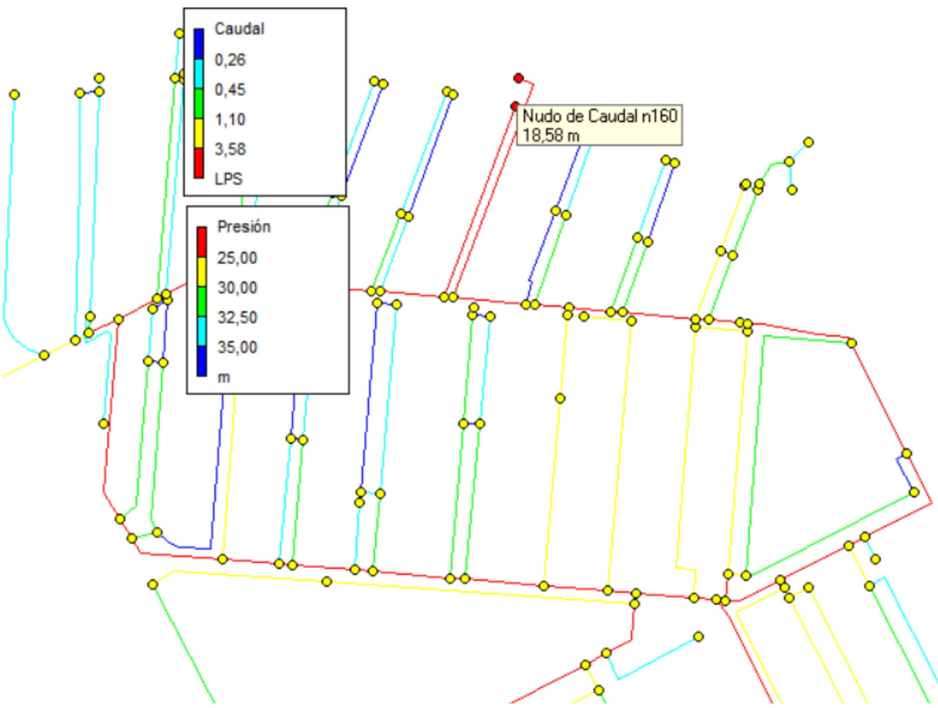


Figure 58: Simulation of the fire situation in the northern district of El Perelló for case 1

It is obtained that for case 1, which is the most demanding in terms of the network and therefore the most unfavourable, the pressure that the hydrant can provide is 18 mwc and that all the nodes in the El Perelló area have a pressure of less than 30 mwc. These values are around 28-29 mwc, which means that users will not have at this time of emergency the pressure that is intended to ensure in the case of peak demand for drinking water in August. The drop is not very sharp, so it should be assessed whether for this type of extreme case, as in case 1, modifications should be considered in the network or whether, given the low probability of coincidence of both events, it would be better to reject the modification as it would compromise users to a slightly lower pressure in this exceptional situation.

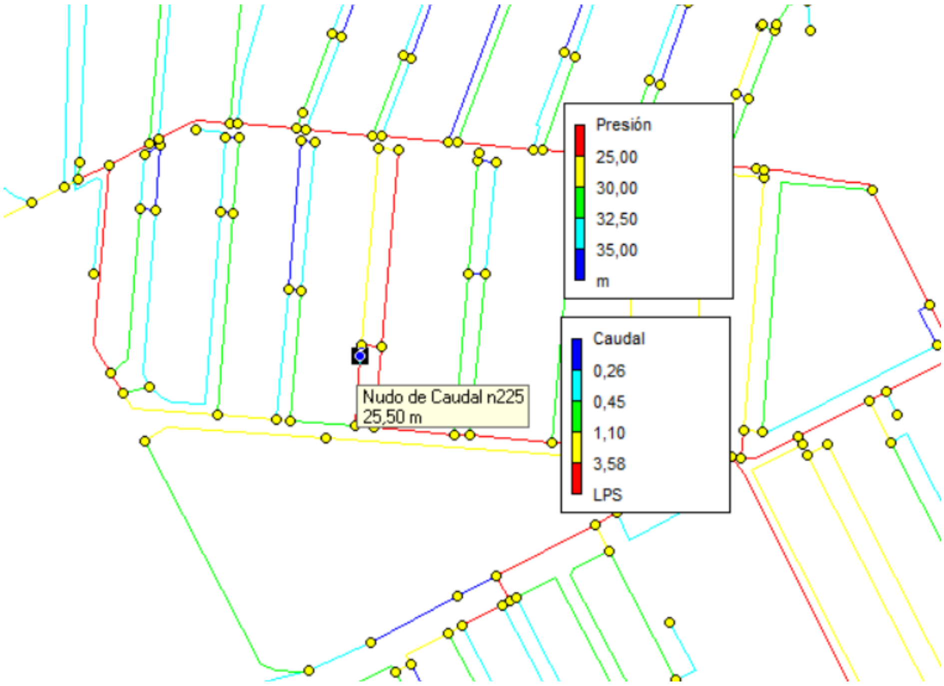


Figure 59: Simulation of the fire situation in the southern district of El Perelló for case 1

A very similar case occurs in the southern neighbourhood, even less unfavourable, as the pressure of the hydrant is 25.5 mwc and that of the nodes in the El Perelló sector is still around 28-29 mwc. Therefore, there is nothing different with respect to the previous reflection.

With regard to the La Lotería hydrant, practically the same thing is happening. All the nearby nodes see their pressure reduced to slightly lower values than the pressure that is to be assured to the user, but in this case they do not drop below 29 mwc, so the drop is less marked than in the previous cases in El Perelló. And in the hydrant for this demand of 16.6 l/s, the pressure is 29.86 mwc, even higher than in the previous cases, as can be seen in the following image.

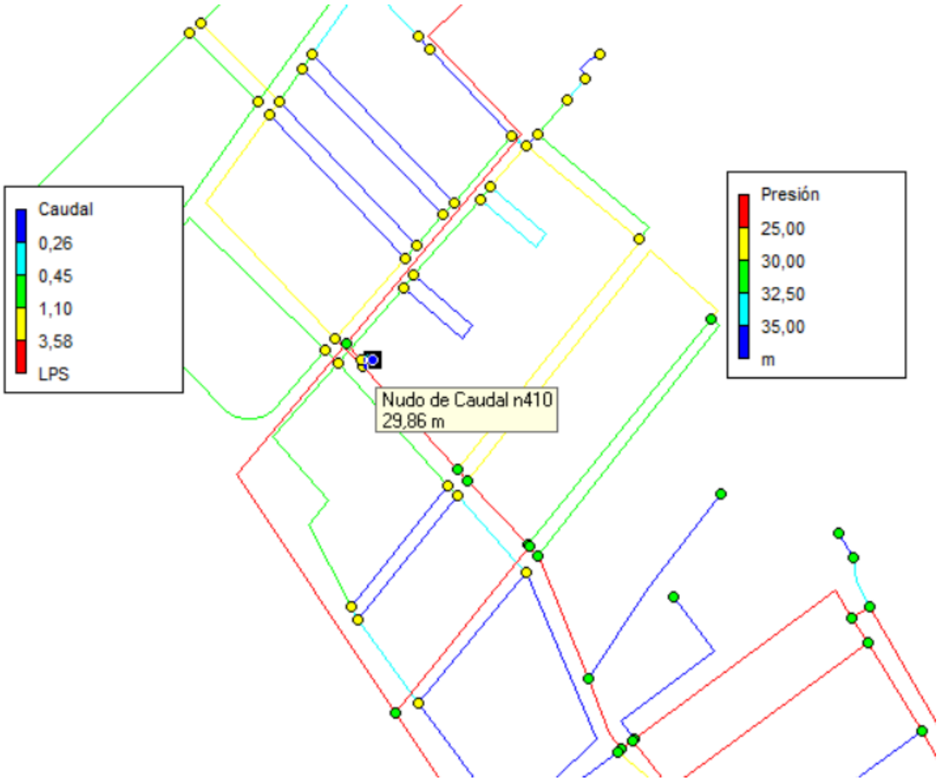


Figure 60: Simulation of the fire situation in La Lotería for case 1

Given these three cases and seeing that the first of them is the most unfavourable, the same simulation is carried out but assigning, in addition to the upper hydrant at Figure 55, a flow rate of 16.6 l/s to the one on the left to see how the network behaves in the vicinity of the fire.

It can be seen that the pressure in the El Perelló nodes drops and in the western district it drops to 26.5 mwc. However, despite the doubling of the base demand of the hydrants, the pressures that these two have are still higher than 10 mwc. In this case, 16.58 and 26.32 mwc respectively, so as far as the regulations are concerned, the guidelines continue to be complied with as seen in Figure 61.

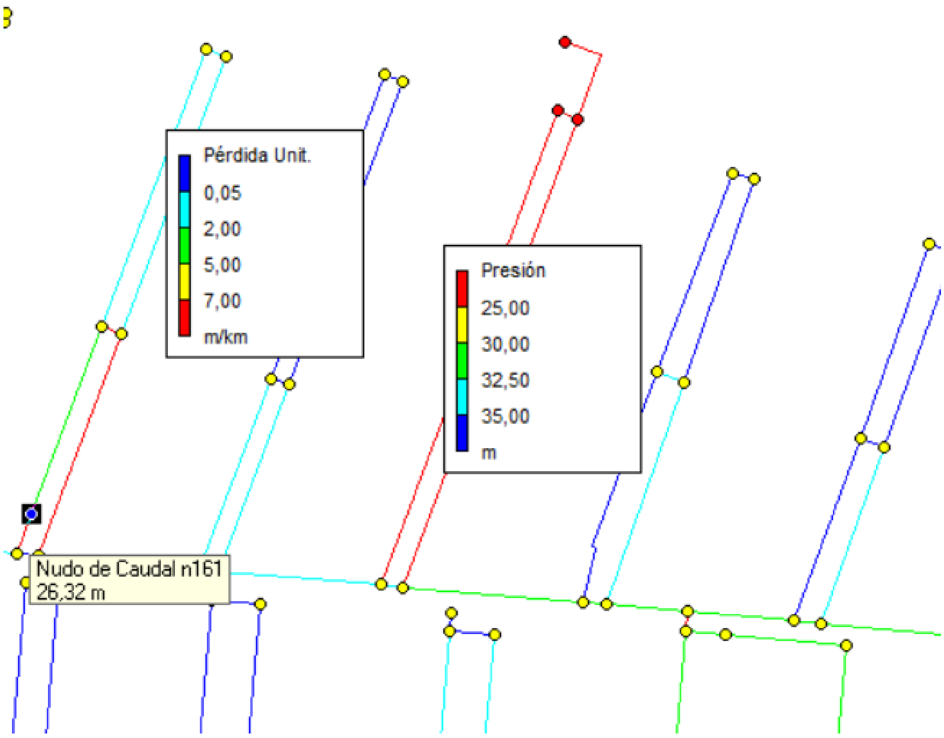


Figure 61: Simulation of the fire situation with 2 fire hydrants in El Perelló northern neighbourhood for case 1

As far as the fluid velocity in the pipes in question is concerned, it has grown considerably in all cases, up to values close to 2m/s. This, as explained above, is due to the fact that if the flow rate increases, so does the velocity in the pipe in a proportional manner. However, as regards the losses in these pipes near the junction, the growth is potential, since in the Darcy-Weisbach equation, the value of the velocity is squared, which means that the losses grow considerably, up to maximum values of 70 mwc/km.

For the valley demand scenario, there should not be any type of problem in terms of hydrant pressure and even less so at the nodes near the hydrant. To check this, the most unfavourable possible case is considered, which consists of activating the two hydrants mentioned in the last of the cases analysed, also with the flow values required by the regulations of 16.6 l/s. It can therefore be seen that, as predicted, the pressures practically do not vary and the nodes continue to be able to provide pressures of 26.53 and 27.66 mwc, as shown in the following image. The losses, as mentioned, potentially grow together with the velocity, which grows proportionally with respect to the flow rate. However, in this case the increase is lower since the demands of the entire network are also lower.

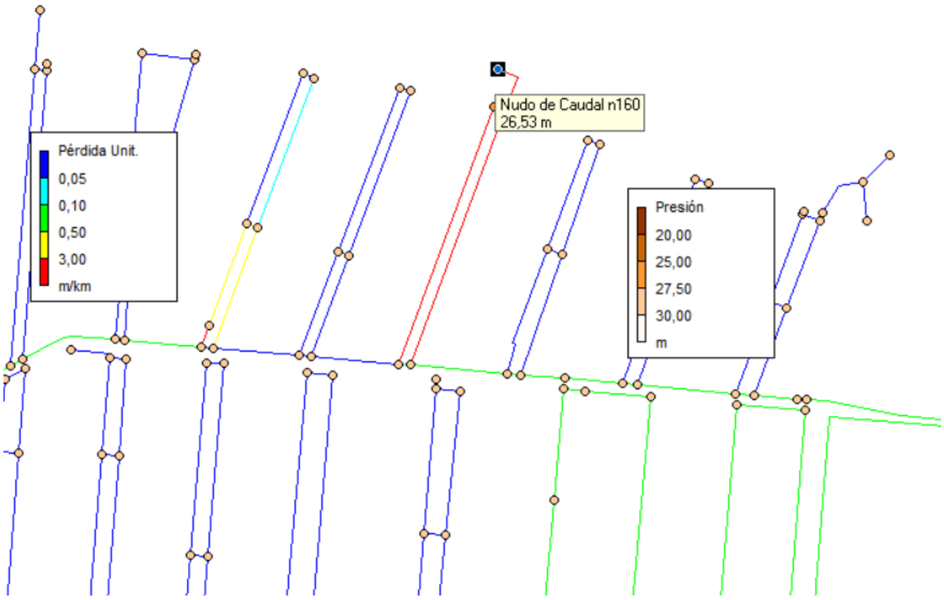


Figure 62: Simulation of the fire situation with 2 fire hydrants in El Perelló northern neighbourhood for case 2

PROPOSALS FOR IMPROVING THE NETWORK

Drinking water supply networks can be analysed in order to propose improvements in their operation, management and quality of service. Thanks to the analysis carried out, we can extract interesting points for action. In this section, different measures are proposed to the municipal company Aigües de Sueca so that it can consider their application in the future.

PIPE REPLACEMENT

This measure is fundamental for the improvement of the network, as it solves problems not only of unit losses but also of pressures. As was seen in the case of peak demand for the summer scenario, there were conflictive pipes in which there were unit losses above the desirable 5 mwc/km. Furthermore, some of them coincide in that the nodes downstream of them acquire pressures of less than 30 mwc. The pipes causing this type of problem are the 100 and 60 mm diameter asbestos cement pipes.

These types of pipes have not been manufactured in Spain since 2001, because although in the urban expansion of the 60s, 70s and 80s, fibre cement was a material widely used due to its lightness and low price, it is known to contain asbestos particles. The pipes do not release them directly into the water that circulates through them, but their handling must be carried out by a company authorised to do so, which in Spain must be registered in the RERA (in English, Register of Companies at Risk of Asbestos), as in their removal and handling they can release asbestos fibres that are carcinogenic to the human body. However, the age of the piping network must be taken into account, as after 40 years of age, as is the case of the study network, these particles can end up being released into the water. Although there are currently no studies that show clear evidence of the carcinogenic effects of drinking water with traces of asbestos, the directives require that the pipes be replaced with other types of pipes.

Once introduced, the controversy and problematic of this material, the substitution that will be considered will be to ductile cast iron or polyethylene pipes. The preference of the plumbing equipment, although it is more expensive, is for ductile iron because of the durability of the pipe and because it does not generate welding problems like PE, since the pipe comes with the coupling fittings and does not have to be welded. The PE, on the other hand, needs welding for its union and the change of temperatures expands and contracts the material, breaking them. As a result, leaks are more frequent and maintenance needs increase.

Once the material has been chosen, it is necessary to consider how large the diameter should be. The larger the diameter, the higher the price. Therefore, it is necessary to reach a compromise solution in which the pipes installed reduce or eliminate the problems that the replaced ones generate, but without losing sight of the cost of the replacement. The ductile iron pipe catalogue of (Rekalde, Rekalde-Canalización y obras públicas, s.f.) has been taken as a reference for the simulation, with different diameters.

Location	Street	Diameter (mm)	Material	Headlosses (mwc/km)	New DN (mm)	New Inlet D (mm)	New material	Length (m)
Llastra C	*Torres del Mar roundabout + street*	100	Fb	43,0	150	159	DI	108,7
Socarrat W	*Tous (from Verge de Sales to Socarrat)*	100	Fb	19,7	125	132	DI	205,7
Perrelló W	*Barraquetes*	60	Fb	16,6	80	86	DI	52,3
Perelló E	*Amériques + Tramuntana*	60	Fb	7,7	80	86	DI	79,6
Llastra S	*Sos / Lleveig crossing*	100	Fb	6,4	125	132	DI	6,3
Llastra N	*Estrella de Mar (from Torres del Mar to Ports) x2*	100	Fb	6,4	125	132	DI	228,6
Llastra S	*Estrella de Mar (from Torres del Mar to Sos)*	100	Fb	6,2	125	132	DI	121,4
Palmeres W	*Riu Serpis (from Riu Segura to Riu Xúqer)*	60	Fb	6,0	x	x	x	x
Motilla S	*Gola del Rei*	60	Fb	6,0	x	x	x	x
Llastra S	*Lleveig / Calderer crossing*	100	Fb	4,6	125	132	DI	33,0
Palmeres W	*Riu Albaida (from Riu Segura to Riu Xúqer)*	100	Fb	3,0	x	x	x	x
Llastra S	*Lleveig (from Sos to Claderer)*	100	Fb	2,9	125	132	DI	162,2
Palmeres W	*Riu Segura (from Riu Albaida to Riu Girona)*	100	Fb	2,4	x	x	x	x

Figure 63: Table of conflicting pipelines with current and proposed characterisation

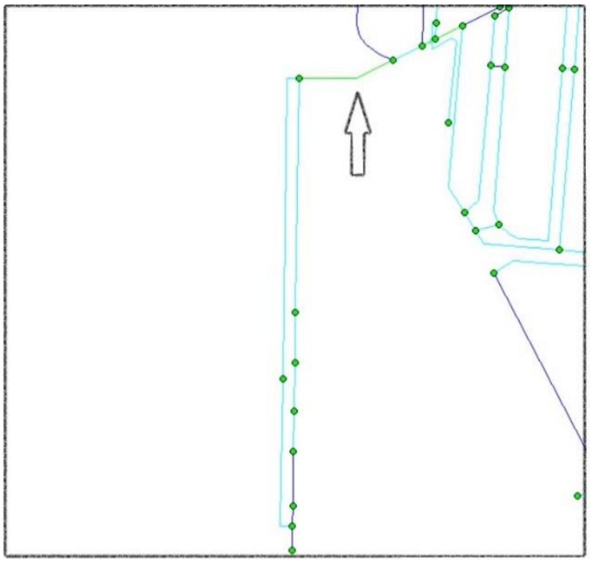
The vast majority of pipes have been replaced with the immediately larger diameter appearing in the catalogue, as shown in the table above. This ensures that the budget is not excessive for what is sought with the measure. In addition to the fact that this diameter has to comply with the unit losses being less than 5 mwc/km and the pressures downstream of the pipe in question exceeding 30 mwc. Except in the case of El Socarrat, where the substitution has been considered for a DN 125 pipe and the losses are very slightly higher than 5, however, as the substitution has been considered in accordance with the summer peak scenario, this case can be saved, as 5 is the recommended value.

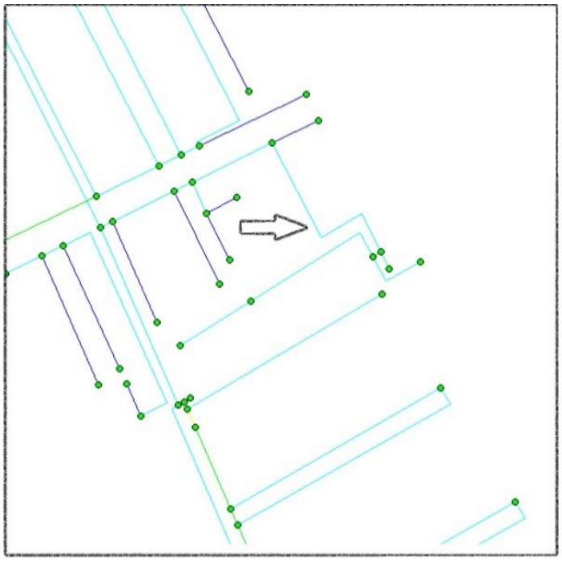
For a small minority, and this is the only case of the street and roundabout of Torres del Mar, it has been necessary to go from 100 to 150 as the headlosses were the highest of the whole coast and also supply a lot of flow to the southern area of La Llastra.

In addition to this criterion of headlosses per pipe, it has been necessary to replace some pipes which, despite having headlosses of less than 5, due to the number of knots downstream that they supplied, the pressure that reached them was lower than the 30 that is to be ensured. This is the case for supplying the southern nodes of La Llastra, where changing the Sos/Lleveig and Lleveig/Cladererer street crossings is not enough, so the section between the two crossings of Lleveig street is also changed from 100 to 125.

And in the case of Palmeres and Motilla, the replacement has been rejected so as not to increase the budget. Although the pipes studied generate losses, they do not cause pressure problems in the downstream nodes. And in view of the fact that the replacement is proposed to solve the problem of case 1, in average operation there will continue to be no pressure problems.

The following images show the pipes that have been replaced in operation for the most unfavourable case, which is the peak summer scenario.





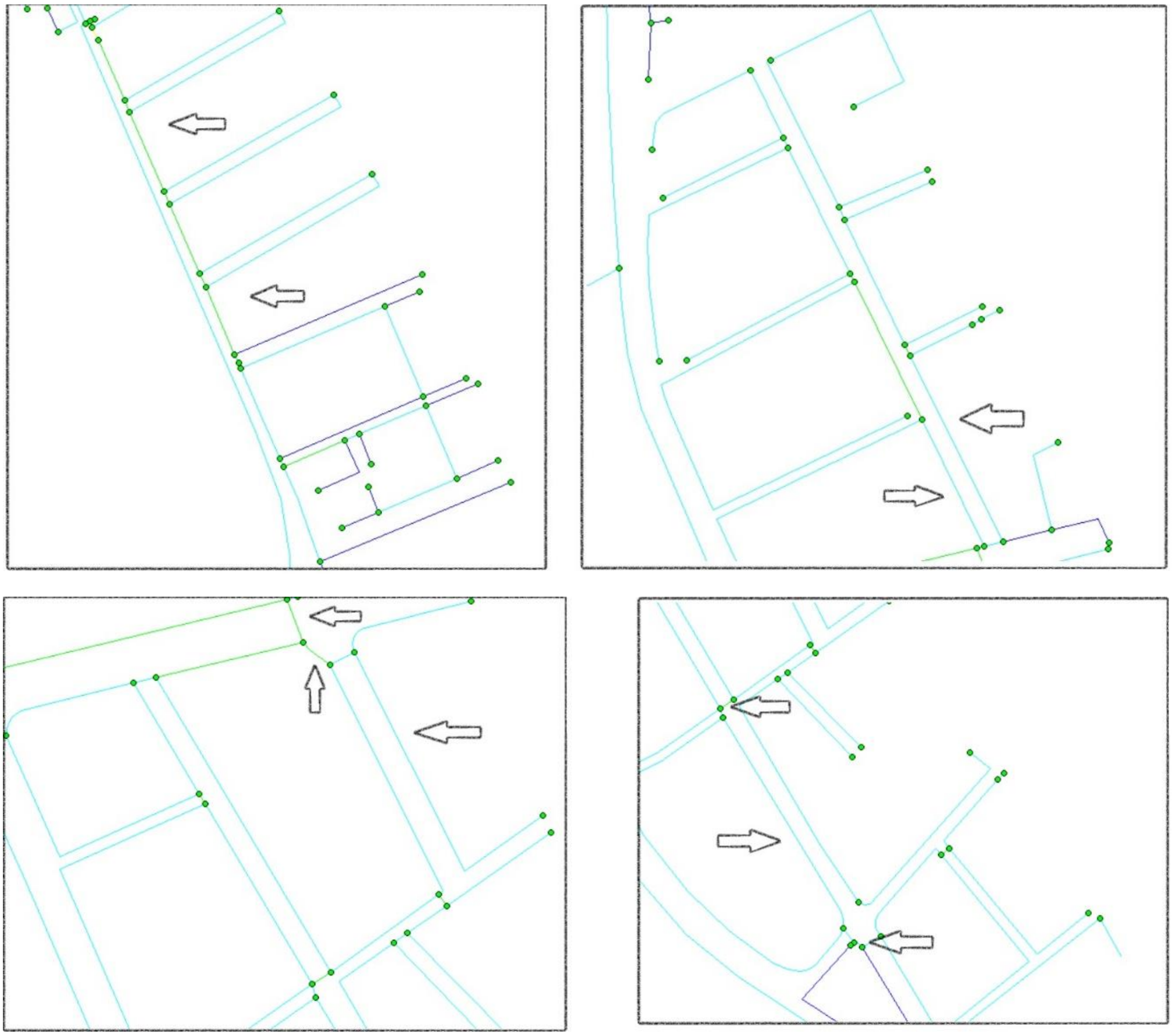


Figure 64: Marking of the replaced pipes and their functioning for case 1

As far as the roughness of the pipes is concerned, it was not necessary to modify it, as the same was taken for both asbestos cement and ductile iron, with a value of 0.15.

On the other hand, as mentioned in the section on leaks, both La Lotería and Fernandet have major leakage problems, which not only entails an expense in terms of drinking water but also higher than normal maintenance needs. Therefore, a plan to replace the polyethylene pipes in La Lotería and the iron pipes in Fernandet is proposed.

SET PRESSURE REDUCTION

In view of the fact that the network is close to the sea and therefore the difference in elevations is practically nil, the pressure values along the network do not vary much, as can be seen in the Figure 65 where the network has been simulated for the average demand conditions during the year 2021 of the Table 3. This has been considered in two different ways, one of them with the installation in its current state and in a second case the substitutions of the problematic asbestos cement pipes considered previously. Furthermore, in both cases it has been assumed that this is the peak hour for this demand and the demand factor has been changed to 1.8 and the reservoir has been characterised with a constant level of 35mwc.

CURRENT SITUATION

The current situation is more unfavourable than once the pipeline replacement work mentioned above has been carried out. However, we can see in the following image that, for the demand conditions described and the reservoir at 35 mwc, there is room to reduce the daytime pressure.

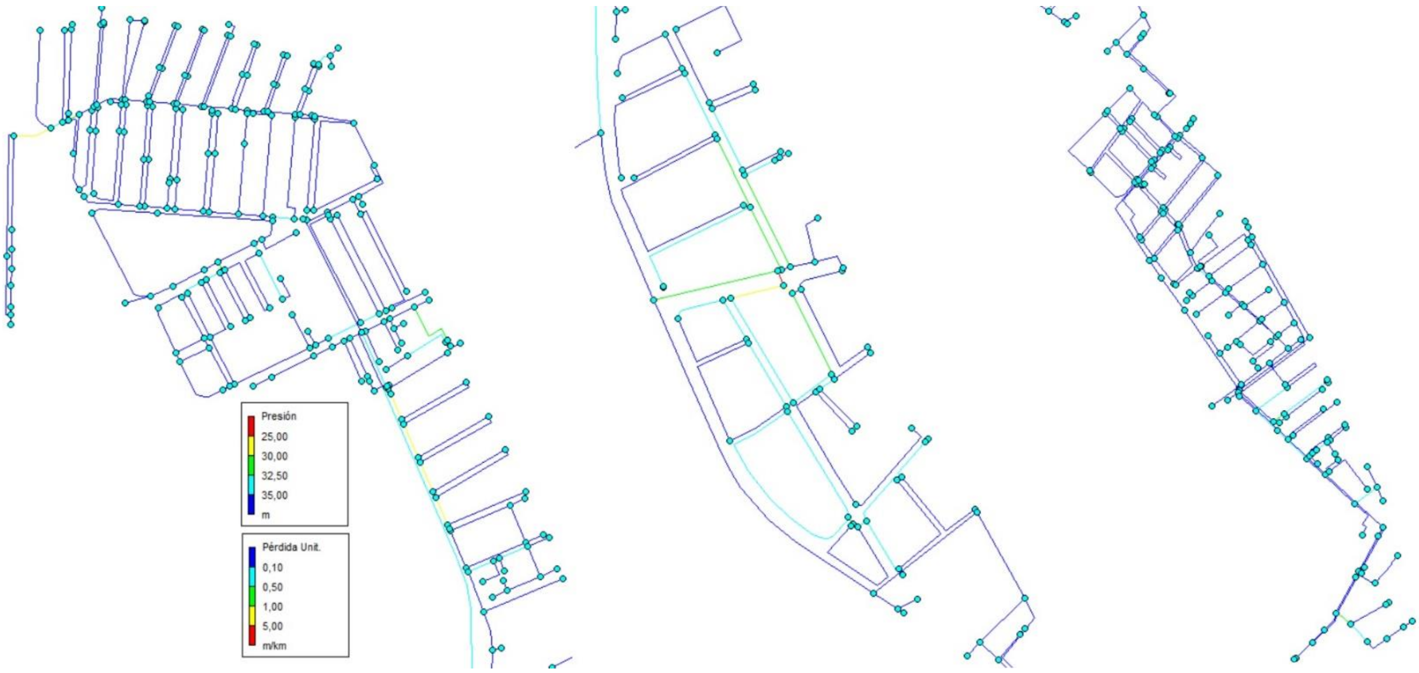


Figure 65: Current situation of the network operating under average demand conditions with a demand factor of 1.8 and total reservoir head of 35 mwc

It can be seen that although there are headlosses in some cases higher than 1 and even 5 mwc/km, the pressure values are higher than 30mwc. Epanet shows that the lowest value is 34.4 mwc. Therefore, it is considered to lower the setpoint pressure during the months of January, February, March, April, May, October, November and December. As the average demand is increasing with the demand factor, the months with a slight increase in consumption (March, April and May) will also be covered. To this end, iterations are started, lowering the total height of the reservoir, checking that the pressure in all the nodes of the network continues to be higher than 30 mwc until the value of 32 mwc is reached. For this value, although the headlosses continue to imply a drop in pressure, the pressure values that the user wants to be assured will remain intact.

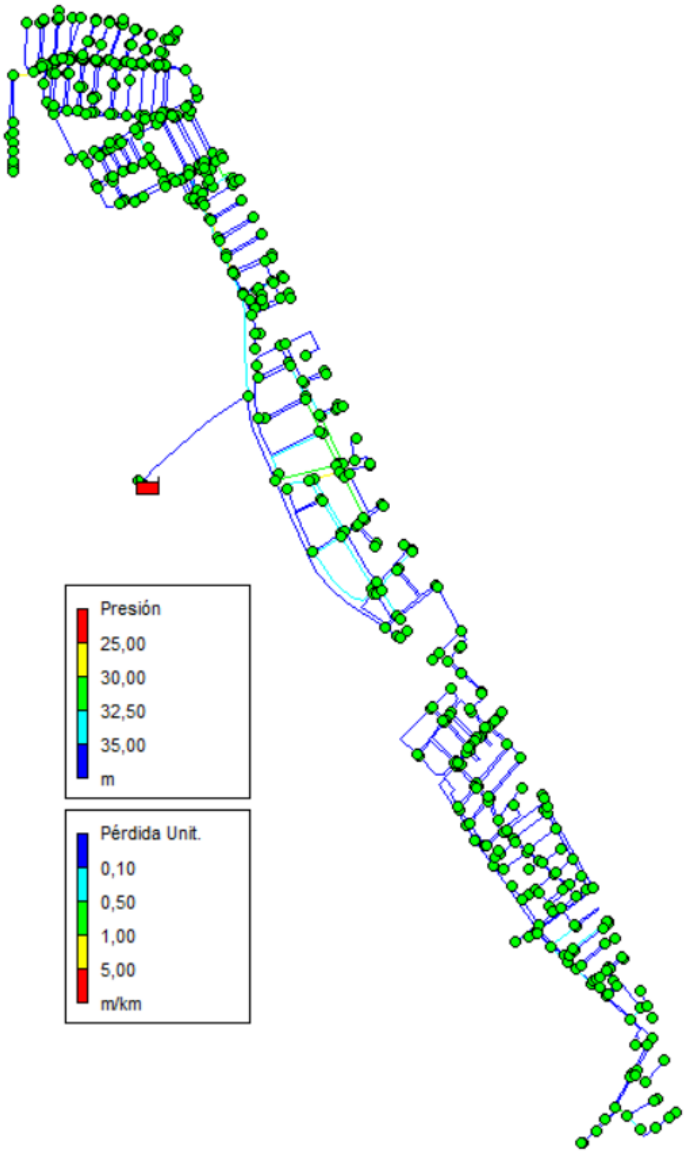


Figure 66: Expected operation of the network in current situation and lowering the set pressure to 32 mwc.

AFTER PIPE REPLACEMENT

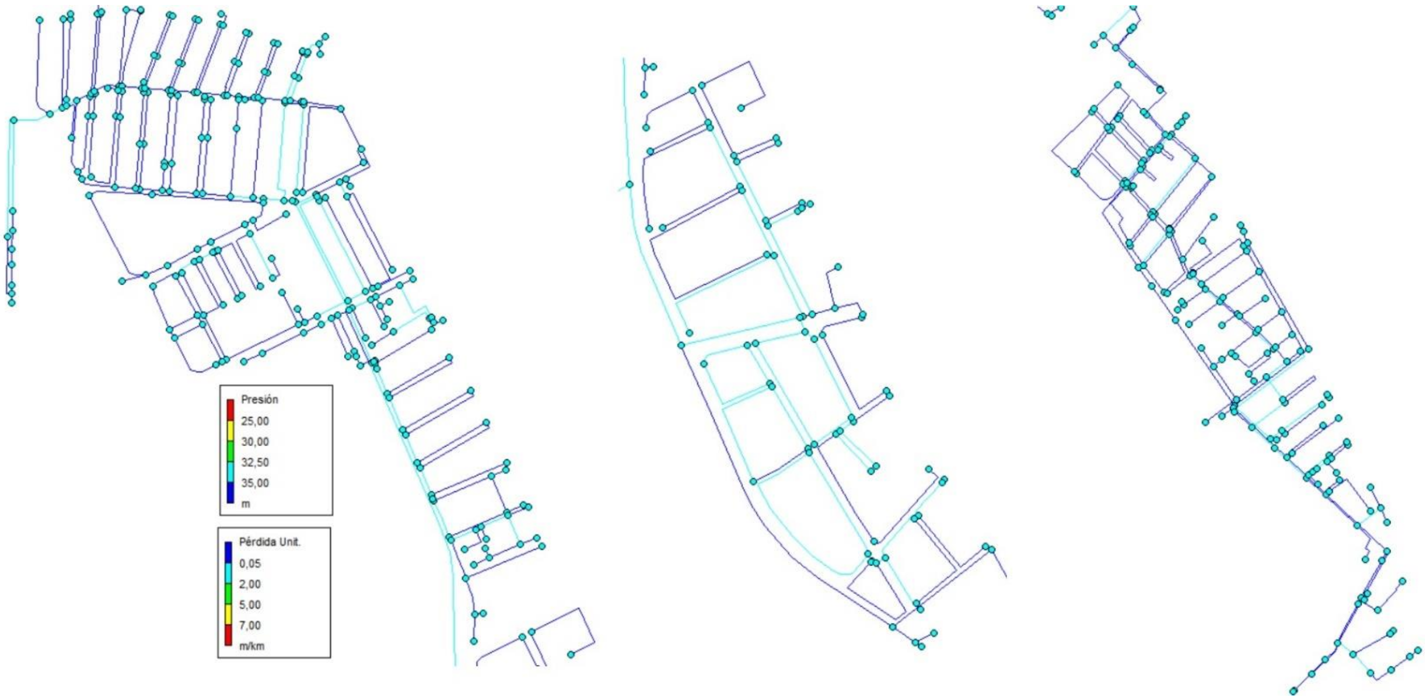
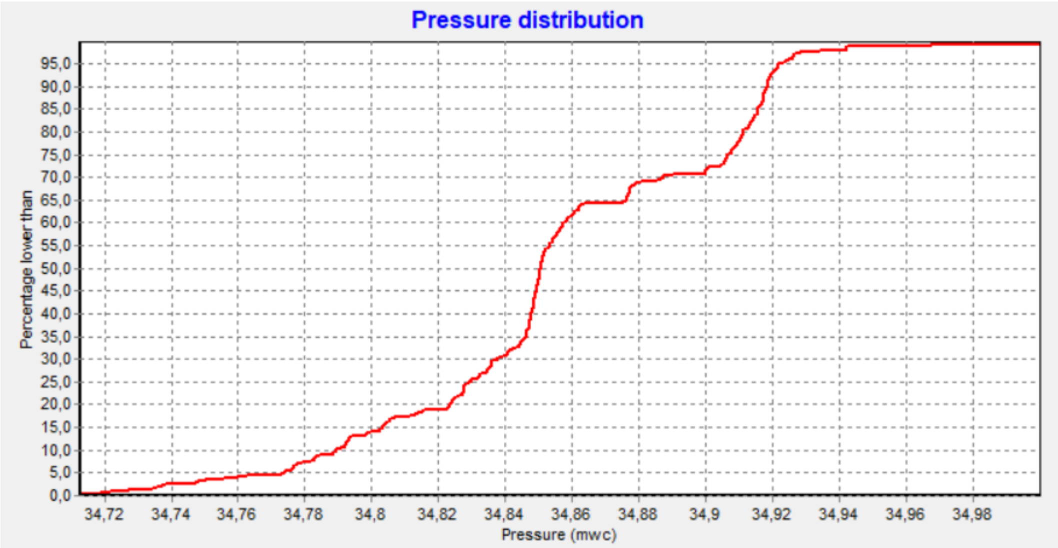


Figure 67: Network operating after pipe replacement and under average demand conditions with a demand factor of 1.8 and total reservoir head of 35 mwc

For this mode of operation it is clear that all headlosses are less than 2 mwc/km and the following graph shows that the pressure at all nodes is higher than 34.7 mwc, so the pressure will always be higher than 30 mwc.



Graphic 5: Pressure ditribution after pipe replacement and with reservoir at 35 mwc

The total head value, in the reservoir, that continues to maintain the required pressure conditions is in this case 31. The network with this reduction will continue to operate within the ranges necessary to ensure a quality supply in the months of January, February, March, April, May, October, November and December, as shown in the following image.

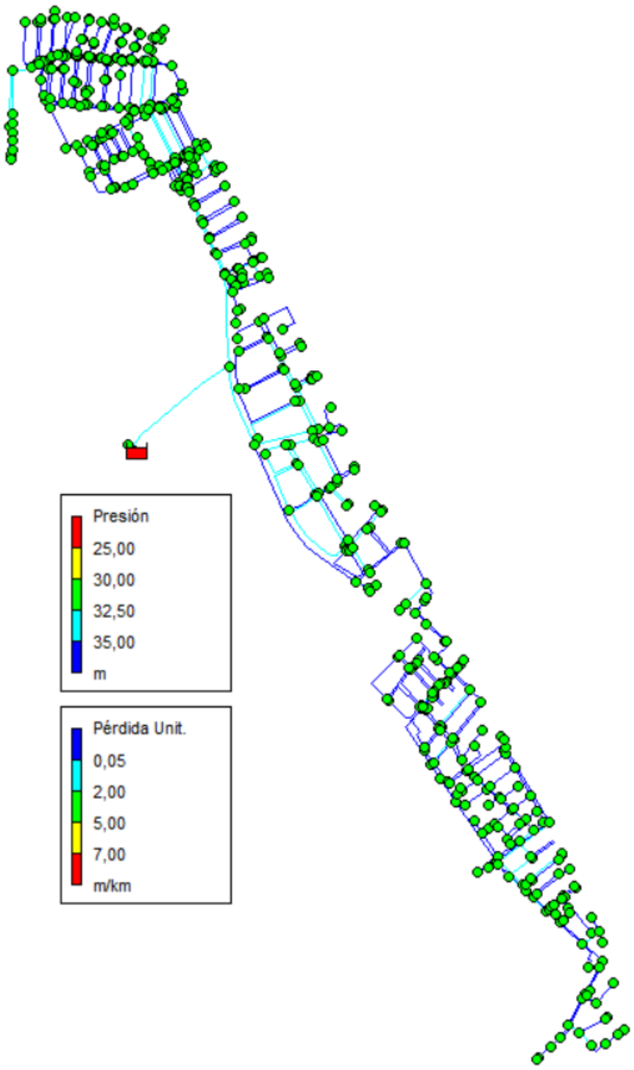
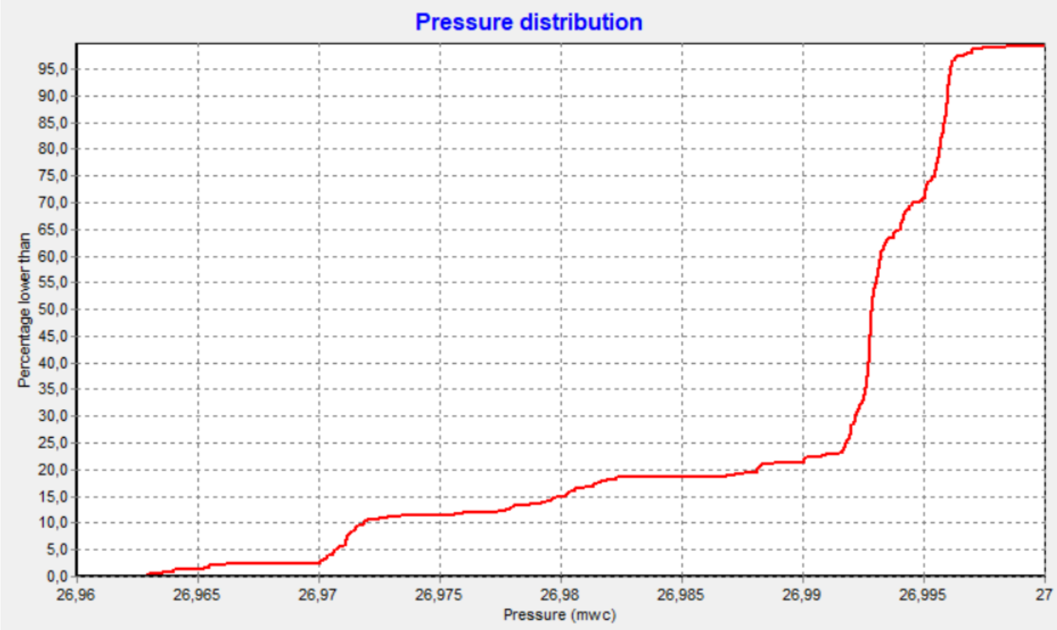


Figure 68: Expected performance of the network after pipe replacement and lowering the set pressure to 31 mwc

In addition, the reduction of the night setpoint value, which we recall was set at 2.8 kg/cm^2, has been considered. In this part, the variation with respect to whether or not the problematic pipes have been replaced is very slight and the level of precision is outside the capabilities of this work and is not relevant. Instead of 0.6, a demand factor of 0.8 has been considered so as not to be so tight, and a minimum pressure of 25 mwc has been set to be supplied to the user at night. For this case the setpoint pressure can be lowered to 27 for, in this case, the months of January, February, October, November and December without causing any pressure problems for the user. This is demonstrated by the pressure distribution below where it can be seen that the pressures practically do not vary from 27 mwc.



Graphic 6: Pressure distribution for a demand factor of 0.8 in winter scenario

This will not only reduce the power consumption required by the pumps, but will also reduce leakage throughout the installation and thus reduce water wastage while ensuring the quality of service for all beach users.

SECTORISATION

The sectorisation of an area or population is always a measure that helps to have greater control and thus to be able to better manage that area and the network. If the volume entering the sector is known, it is possible, together with the volume billed to users, to determine the volume of apparent and real losses and, consequently, the performance of the area. This can provide us with very useful information to understand if it is one of the areas that needs an action plan or if its behaviour is normal and should not be the focus of attention in the network. Therefore, it should focus on other areas in order to propose improvement measures. In addition, knowing these volumes, other consumption parameters can be obtained that illustrate how drinking water is consumed in that area, such as those obtained previously in the estimation of monthly demand for 2021.

It is for all these reasons that the improvement proposed is the sectorisation of Les Palmeres, which, although it has been treated as a sector in this work, is not really sectorised. Rather, as has been developed previously, the values of consumption injected into this area have been obtained by means of estimates and taken as if it were reality.

Therefore, for this area, comprised from north to south by Fernandet, La Lotería, Les Palmeres and Motilla, it should be equipped with flow meters that have a record of the water that enters them. Either a single flow meter for the whole of this area or two that would collect water from Fernandet-La Lotería and Les Palmeres-Motilla.

DATA CHECK POINTS

This model could be calibrated if there were data verification points along the network. That is to say, pressure and flow controllers at strategic points that would provide information to check the operation of the network. In this way the model would be much more accurate and reliable as it could be calibrated to better match actual behaviour.

OTHER TECHNOLOGICAL PROPOSALS

In addition, the following technological measures are proposed to carry out a more precise control of the hydraulic variables of the network in order to detect possible problems:

REMOTE READING (TELELECTURA)

Currently, the flow meters in the coastal area of Sueca are individual flow meters at the household level and to a lesser extent communal flow meters. This creates a need for operators to go and read flow meters in the homes themselves, where sometimes the owner is not present and the reading cannot be recorded. The user is even given the opportunity to write down the value of the reading in an envelope and deliver it to a mailbox where these letters are collected. This means that a large amount of consumption is not registered, either because the owner is not at home to read it or because of simple negligence. As can be seen, the means used are very rudimentary and not at all efficient, so that there is no real control of the volumes consumed at the household level.

It is therefore proposed to gradually install smart flow meters in homes in order to automate this task without having to rely on operators to go to the homes or on the willingness of the owners to provide the value through the mailbox. These flow meters are connected to a data logging platform that would collect the value of water entering the home, commonly known as remote reading. It is advised, and it is a point of view shared by the plumbing manager, that the first remote reading system should be installed in La Lotería because of the problem generated by the leaks in the polyethylene installation. In this way, it would be possible to limit the problem and have a real record of what the user consumes and what is lost due to leaks in this area. Over the years, all the sectors could be equipped with this type of flow meters until the entire beach area of the municipality of Sueca is covered.

ALERTS SOFTWARE

Consideration should be given to the implementation of an alert system that directly alerts the technician on duty so that he can stop problems that could be more serious if action is not taken quickly. Currently, the software used provides the values and the technician has to check whether everything is within the acceptable values for the consumption of the installation. At the same time, the company Aguas de Valencia, which provides this software, pays attention to the municipality of Sueca, among other municipalities in the region, through a technician in charge of the same, so that in the event of detecting a problem that Aigües de Sueca's technician did not see, he would be notified so that he could take action. However, due to the fact that there is no control at all times of the abstraction network by both entities, a problem could be generated that would not be detected until hours or even days later.

Therefore, it is suggested to implement the software or to purchase a new one in which reference values are assigned for different zones and monthly cases with a margin of difference compared to these values. This is done by means of a time series control that evaluates the maximum and minimum flows, pressure drops, night flows, among other functionalities. Therefore, the system would warn the operator or technician on duty by means of an alert on an intelligent device that there is a variable that is out of line with the established standards. Even more interesting would be if the software itself could identify the type of problem and act automatically, but this would only be applicable if the network was automated. It is understandable that the more automatic you want a software response and action to a problem to be, the more the software has to be customised to the installation and the more expensive it becomes. Therefore, providing ranges of values outside the acceptable ranges for the correct functioning of the network could be the most appropriate and viable solution for this installation. The technician should simply evaluate the situation and decide, according to the alert and the parameters considered, what type of action to carry out. It is therefore considered an interesting measure that can be implemented as the recording of the network's hydraulic variables improves.

REMOTE CONTROL (TELEMANDO)

As mentioned in the previous measure, network automation is a process that must be approached progressively in order to have a more efficient control of the network. For this reason, the last of the proposed improvement measures, commonly known as remote control, is proposed. This consists of the implementation of a SCADA system with which the technician in charge would be able to close valves, deactivate pumps, reset flow meters with multilog, open spillways, among other functions remotely. With this, it would not be necessary to travel to the element in question to activate it, which would mean quick and efficient action. These types of measures should be implemented progressively in supply networks in order to convert current installations into more sustainable systems that reduce water losses and provide a better quality of service.

BUDGETS

The first budget defines the cost that would be generated by the replacement of the conflictive pipes that exist in El Perelló, El Socarrat and La Llastra. This has been proposed following a previous work budget in which one of the pipes destroyed by the Gloria storm that hit the Valencian coast in January 2020 was removed. Therefore, the pipe was replaced on the seafront promenade and moved to inland streets so as not to generate this risk of breakage due to a storm again. By eliminating certain items and creating new ones, which take into consideration the casuistry of replacement, an estimated budget has been drawn up which does not intend to reflect the budgetary reality but to give an overall idea of the budget items included and the approximate cost they would generate. The price of the ductile iron pipes has been proposed on the basis of the prices available at (Rekalde, s.f.). With all this, the replacement budget would have a cost of 311013.19 €.

Budget

Code	NatuCo	Ut	Summary	Comment	N	Length	Width	Height	Quantity	BudgQuant	Budg	AmouBud
SUECA BEACH	**Chapter**		**REPLACEMENT OF PIPES PERELLÓ-SOCARRAT-LLASTRA**							**1**	**309.013,19**	**309.013,19**
PIPE1	**Chapter**		**PREVIOUS WORKS**							**1,00**	**3.336,01**	**3.336,01**
DDTECSERV	Work item	UD	DETECTION OF EXISTING SERVICES Day of detection of services by electromagnetic means.							2,00	543,38	1.086,76
				2 WORKDAY	2,0	0,00	0,00	0,00	2,00			
									Total DDTECSERV	**2,00**	543,38	**1.086,76**
CATA1	Work item	UD	EXECUTION OF MANUAL MEANS + REINSTATEMENT Execution of 1.50x1.50 cata, carried out by manual means, including demolition. Without replacement.							15,00	149,95	2.249,25
				1/50 ml	15,0	0,00	0,00	0,00	15,00			
									Total CATA1	**15,00**	149,95	**2.249,25**
									Total PIPE1	1,00	**3.336,01**	**3.336,01**
PIPE2	**Chapter**		**DEMOLITIONS**							**1,00**	**37.838,48**	**37.838,48**
DA02150	Work item	M2	DEMOLITION AGLOM. ASF. 10 CM. Demolition of 10 cm thick asphalt agglomerate paving, with clean and straight cut of the trench edges, including loading of rubble onto lorry.							1.197,36	8,23	9.854,27
				STREET BARRAQUETES	1,0	52,30	1,20	0,00	62,76			
				STREET+ROUNDABOUT TORRES DEL MAR	1,0	108,70	1,20	0,00	130,44			
				ST ESTRELLA DE MAR(Ports to Sos) x2	1,0	350,00	1,20	0,00	420,00			
				LLEVEIG STREET(from Sos to Claderer)	1,0	201,50	1,20	0,00	241,80			
				STREET AMÉRIQUES+TRAMUNTANA	1,0	79,60	1,20	0,00	95,52			
				TOUS ST(Verge de Sales to Socarrat)	1,0	205,70	1,20	0,00	246,84			
									Total DA02150	**1.197,36**	8,23	**9.854,27**
DA02150B	Work item	M2	DEMOLITION OF CONCRETE BASE Demolition of concrete paving base, with clean and straight cutting of trench edges, including loading of rubble onto lorry.							1.197,36	12,01	14.380,29
				STREET BARRAQUETES	1,0	52,30	1,20	0,00	62,76			
				STREET+ROUNDABOUT TORRES DEL MAR	1,0	108,70	1,20	0,00	130,44			
				ST ESTRELLA DE MAR(Ports to Sos) x2	1,0	350,00	1,20	0,00	420,00			
				LLEVEIG STREET(from Sos to Claderer)	1,0	201,50	1,20	0,00	241,80			
				STREET AMÉRIQUES+TRAMUNTANA	1,0	79,60	1,20	0,00	95,52			
				TOUS ST(Verge de Sales to Socarrat)	1,0	205,70	1,20	0,00	246,84			
									Total DA02150B	**1.197,36**	12,01	**14.380,29**
DA02075	Work item	ML	KERB PULLING Kerb removal, including concrete base and loading of rubble onto lorry.							20,00	6,58	131,60
				Estimation	1,0	20,00	0,00	0,00	20,00			
									Total DA02075	**20,00**	6,58	**131,60**
DA02090	Work item	ML	RIGOLAS UPROOTING Removal of rigola, including concrete base and removal of debris to landfill.							20,00	6,58	131,60
				Estimation	1,0	20,00	0,00	0,00	20,00			
									Total DA02090	**20,00**	6,58	**131,60**
DA21621	Work item	M3	LOADING AND TRANSPORT PRODUCT. EXCAV. DUMP. Transport of demolition products to landfill at any distance including landfill fee.							582,31	22,91	13.340,72
				Pavements	0,0	0,00	0,00	0,00	0,00			
				ST ESTRELLA DE MAR(Ports to Sos) x2	1,0	350,00	1,20	0,00	420,00			
				STREET+ROUNDABOUT TORRES DEL MAR	1,0	108,70	1,20	0,20	26,09			
				STREET BARRAQUETES	1,0	52,30	1,20	0,10	6,28			
				LLEVEIG STREET(from Sos to Claderer)	1,0	201,50	1,20	0,10	24,18			
				STREET AMÉRIQUES+TRAMUNTANA	1,0	79,60	1,20	0,10	9,55			
				TOUS ST(Verge de Sales to Socarrat)	1,0	205,70	1,20	0,10	24,68			
				Wrapping	0,0	0,00	0,00	0,00	0,00			
				Estimation	1,0	20,00	0,20	0,20	0,80			
				Estimation	1,0	20,00	0,20	0,20	0,80			
				Sponging	0,3	233,09	0,00	0,00	69,93			
									Total DA21621	**582,31**	22,91	**13.340,72**
									Total PIPE2	1,00	**37.838,48**	**37.838,48**
PIPE3	**Chapter**		**WORK WITH FIBRE CEMENT**							**1,00**	**1.812,78**	**1.812,78**
DECMTRA1	Work item	UD	MANAGEMENT OF ASBESTOS CEMENT REMOVAL, LICENCE, WORK PLAN, ETC. Management of the removal of fibre cement, control documentation, monitoring of hazardous waste and disposal certificate, including obtaining a licence, preparation of the work plan and personal and environmental measurements in accordance with rd 396/2006 and the displacement of decontamination equipment.							1,00	836,25	836,25
					1,0	0,00	0,00	0,00	1,00			
									Total DECMTRA1	**1,00**	836,25	**836,25**
CO_AMIA	Work item	TN	LOADING AND TRANSPORT TUB. FIBROCEMENTO A GESTOR AUTO. C/CORTE Loading and punctual transport to an authorised waste manager, including landfill fees.							0,60	457,02	274,21
				Estimation	2,0	2,00	0,15	0,00	0,60			
									Total CO_AMIA	**0,60**	457,02	**274,21**
DESMONFIBRO	Work item	ML	PUNCTUAL DISMANTLING OF FIBRO TUBE Ø 60/100 Punctual dismantling of existing fibre cement piping d60-100 mm following the requirements of the pptp, by authorised personnel, including wetting with encapsulating liquid, personnel and environmental measures required according to rd396/2006, signalling and delimitation of the work area, decontamination esculsa, ffp3 epi's, and all the measures linked to this type of material, not including excavation, finished.							4,00	175,58	702,32
				Estimation	2,0	2,00	0,00	0,00	4,00			
									Total DESMONFIBRO	**4,00**	175,58	**702,32**
									Total PIPE3	1,00	**1.812,78**	**1.812,78**

PIPE4	**Chapter**		**EARTHWORKS**							**1,00**	**100.288,97**	**100.288,97**
DA21030	Work item	M3	EXCAV. PEQ. MAQ. DITCHING Z. URBAN GROUND							1.347,05	22,16	29.850,63
			Mechanical excavation of trench in earth, in urban area, with a tolerance of +/- 5 cm, including loading on lorry.									
				UNDER NORMAL CONDITIONS	0,0	0,00	0,00	0,00	0,00			
				ST ESTRELLA DE MAR(Ports to Sos) x2	0,9	350,00	1,00	1,50	472,50			
				STREET+ROUNDABOUT TORRES DEL MAR	0,9	108,70	1,00	1,50	146,75			
				STREET BARRAQUETES	0,9	52,30	1,00	1,50	70,61			
				LLEVEIG STREET(from Sos to Claderer)	0,9	201,50	1,00	1,50	272,03			
				STREET AMÉRIQUES+TRAMUNTANA	0,9	79,60	1,00	1,50	107,46			
				TOUS ST(Verge de Sales to Socarrat)	0,9	205,70	1,00	1,50	277,70			
								Total DA21030		**1.347,05**	22,16	**29.850,63**
DA21080	Work item	M3	EXCAV. MANUAL EARTH TRENCH							149,69	43,69	6.539,96
			Excavación manual de zanja en tierra, con una tolerancia de rasanteo de +/- 5 cm., Incluso carga sobre camión.									
				EN PASOS BAJO INSTALACIONES	0,0	0,00	0,00	0,00	0,00			
				ST ESTRELLA DE MAR(Ports to Sos) x2	0,1	350,00	1,00	1,50	52,50			
				STREET+ROUNDABOUT TORRES DEL MAR	0,1	108,70	1,00	1,50	16,31			
				STREET BARRAQUETES	0,1	52,30	1,00	1,50	7,85			
				LLEVEIG STREET(from Sos to Claderer)	0,1	201,50	1,00	1,50	30,23			
				STREET AMÉRIQUES+TRAMUNTANA	0,1	79,60	1,00	1,50	11,94			
				TOUS ST(Verge de Sales to Socarrat)	0,1	205,70	1,00	1,50	30,86			
								Total DA21080		**149,69**	43,69	**6.539,96**
DA21621t	Work item	M3	LOADING AND TRANSPORT PRODUCT. EXCAV. DUMP.							1.664,22	22,91	38.127,28
			Transport of products from excavation to landfill at any distance including landfill fee.									
				STREET+ROUNDABOUT TORRES DEL MAR	1,0	108,70	1,00	1,50	163,05			
				ST ESTRELLA DE MAR(Ports to Sos) x2	1,0	350,00	1,00	1,50	525,00			
				STREET BARRAQUETES	1,0	52,30	1,00	1,50	78,45			
				LLEVEIG STREET(from Sos to Claderer)	1,0	201,50	1,00	1,50	302,25			
				STREET AMÉRIQUES+TRAMUNTANA	1,0	79,60	1,00	1,50	119,40			
				TOUS ST(Verge de Sales to Socarrat)	1,0	205,70	1,00	1,50	308,55			
				ESPONJAMIENTO	0,2	837,60	0,00	0,00	167,52			
								Total DA21621t		**1.664,22**	22,91	**38.127,28**
DA21420_MORTA	Work item	M3	SANDING OF THE TRENCH							348,82	28,17	9.826,26
			Covering and watering of the trench with sand for pipes, in the bed, sides and back of the pipe, covering it at least 15 cm. above the generatrix.									
				STREET+ROUNDABOUT TORRES DEL MAR	1,0	108,70	1,00	0,75	81,53			
				ST ESTRELLA DE MAR(Ports to Sos) x2	1,0	350,00	1,00	0,75				
				STREET BARRAQUETES	1,0	52,30	1,00	0,75	39,23			
				LLEVEIG STREET(from Sos to Claderer)	1,0	201,50	1,00	0,75	151,13			
				STREET AMÉRIQUES+TRAMUNTANA	1,0	79,60	1,00	0,75	59,70			
				TOUS ST(Verge de Sales to Socarrat)	1,0	205,70	1,00	0,75	154,28			
				A DESCONTAR TUBO	-3,1416	698,00	0,25	0,25	-137,05			
								Total DA21420_MORTA		**348,82**	28,17	**9.826,26**
DA21450	Work item	M3	TRENCH COVERING WITH GRAVEL							498,90	31,96	15.944,84
			Covering and compacting of the trench with the addition of clean crushed gravel, spread in layers of 25 cm maximum thickness. Maximum thickness, and compacted to 95 % of the modified proctor.									
				STREET+ROUNDABOUT TORRES DEL MAR	1,0	108,70	1,00	0,50	54,35			
				ST ESTRELLA DE MAR(Ports to Sos) x2	1,0	350,00	1,00	0,50	175,00			
				STREET BARRAQUETES	1,0	52,30	1,00	0,50	26,15			
				LLEVEIG STREET(from Sos to Claderer)	1,0	201,50	1,00	0,50	100,75			
				STREET AMÉRIQUES+TRAMUNTANA	1,0	79,60	1,00	0,50	39,80			
				TOUS ST(Verge de Sales to Socarrat)	1,0	205,70	1,00	0,50	102,85			
								Total DA21450		**498,90**	31,96	**15.944,84**
								Total PIPE4		1,00	**100.288,97**	**100.288,97**
PIPE5	**Chapter**		**DRINKING WATER NETWORK**							**1,00**	**70.425,11**	**70.425,11**
SUPPLY DI 125	Work item	ML	SUPPLY AND ASSEMBLY OF CAST IRON PIPE Ø 125							744,00	34,79	25.883,76
			Supply and assembly of cast iron pipe ø 125, unloading, stockpiling, hauling, haulage, trajin, positioning and plugging. Levelling and alignment. Includes proportional part of cleaning, dragging, disinfection and pressure tests.									
				STREET+ROUNDABOUT TORRES DEL MAR	1,0	108,70	0,00	0,00	108,70			
				ST ESTRELLA DE MAR(Ports to Sos) x2	1,0	350,00	0,00	0,00	350,00			
				STREET AMÉRIQUES+TRAMUNTANA	1,0	79,60	0,00	0,00	79,60			
				TOUS ST(Verge de Sales to Socarrat)	1,0	205,70	0,00	0,00	205,70			
								Total SUPPLY DI 125		**744,00**	34,79	**25.883,76**
TE 125	Work item	UD	SUPPLY AND ASSEMBLY OF CAST IRON Ø 125							1,00	890,55	890,55
			Supply and assembly TE cast iron BBB 125-125-125, including proportional part of supply of bolts and gaskets. Standardised tightening with hydraulic machine.									
				TES	1,0	0,00	0,00	0,00	1,00			
								Total TE 125		**1,00**	890,55	**890,55**
BUTTERFLY 125	Work item	UD	SUPPLY & ASSEMBLY BUTTERFLY VALVE Ø 125 mm							3,00	2.059,21	6.177,63
			Supply and assembly of butterfly valve ø 125 mm, including proportional part of supply of screws and gaskets. Standardised tightening with hydraulic machine.									
					3,0	0,00	0,00	0,00	3,00			
								Total BUTTERFLY 125		**3,00**	2.059,21	**6.177,63**

GATE 125	Work item	UD	SUPPLY AND ASSEMBLY GATE VALVE Ø 125 mm Supply and assembly of gate valve ø 125 mm, including proportional part of supply of screws and gaskets. Standardised tightening with hydraulic machine.							1,00	1.913,76	1.913,76
					1,0	0,00	0,00	0,00	1,00			
									Total GATE 125	**1,00**	1.913,76	**1.913,76**
CE 125	Work item	UD	SUPPLY AND ASSEMBLY EC Ø 125 Supply and assembly CEU 125. Includes proportional part of supply of screws and gaskets. Standardised tightening with hydraulic machine.							17,00	776,72	13.204,24
				CEU	17,0	0,00	0,00	0,00	17,00			
									Total CE 125	**17,00**	776,72	**13.204,24**
ELBOW 125	Work item	UD	SUPPLY AND ASSEMBLY ELBOW Ø 125 Supply and assembly ELBOW 90° BB 125. Includes proportional part of supply of screws and gaskets. Standardised tightening with hydraulic machine.							4,00	880,97	3.523,88
				ELBOW	4,0	0,00	0,00	0,00	4,00			
									Total ELBOW 125	**4,00**	880,97	**3.523,88**
CARRETE 125	Work item	UD	SUPPLY AND ASSEMBLY SPOOL Ø 125 Supply and assembly of BB 125 reel. Includes proportional part of supply of screws and gaskets. Standardised tightening with hydraulic machine.							1,00	619,78	619,78
				CARRETE	1,0	0,00	0,00	0,00	1,00			
									Total CARRETE 125	**1,00**	619,78	**619,78**
BLIND FLANGE 125	Work item	UD	SUPPLY AND ASSEMBLY ARMOURED FLANGE Ø 125 Supply and assembly BLIND FLANGE 125. Includes proportional part of supply of screws and gaskets. Standardised tightening with hydraulic machine.							1,00	484,23	484,23
				BLIND FLANGE	1,0	0,00	0,00	0,00	1,00			
									Total BLIND FLANGE 125	**1,00**	484,23	**484,23**
REDUCTION 125-80	Work item	UD	SUPPLY AND ASSEMBLY Ø 125-80 REDUCER Supply and assembly of reduction 125-80 bb. Includes proportional part of the supply of bolts and gaskets. Standardised tightening with hydraulic machine.							1,00	668,12	668,12
				REDUCTION 100-60	1,0	0,00	0,00	0,00	1,00			
									Total REDUCTION 125-80	**1,00**	668,12	**668,12**
DAH2016	Work item	ML	HORM. VIBR. HM-20 PROT. CROSSROADS Protective casing Ø 150 reinforced with vibrated concrete hm-20, plastic consistency, maximum aggregate size 20 mm, placed for protection at crossings, covering at least 20 cm. On the back of the protection pipe, which serves as lost formwork.							30,00	54,25	1.627,50
				Prevision	6,0	5,00	0,00	0,00	30,00			
									Total DAH2016	**30,00**	54,25	**1.627,50**
DAH2018	Work item	M3	HORM. IN MASS HM-20 FOR BUFFERS Mass concrete hm-20, plastic consistency, max. aggregate size 20 mm, For special parts stops and anchorages; Poured against the ground.							30,25	79,07	2.391,87
				TES 125	1,0	2,00	2,00	0,00	4,00			
				TES 80	1,0	1,50	1,50	0,00	2,25			
				ELBOWS 125	4,0	2,00	2,00	0,00	16,00			
				PLUG 125	1,0	2,00	2,00	0,00	4,00			
				CARRETE 125	1,0	2,00	2,00	0,00	4,00			
									Total DAH2018	**30,25**	79,07	**2.391,87**
DDAPG08M 125	Work item	UD	CONNECTION TO EXISTING NETWORK 100 Connection to existing network 100.							2,00	622,41	1.244,82
					2,0	0,00	0,00	0,00	2,00			
									Total DDAPG08M 125	**2,00**	622,41	**1.244,82**
DDAPG08M	Work item	UD	CONNECTION TO EXISTING NETWORK 80-100 Connection to existing network 80-100.							4,00	358,94	1.435,76
				CONTRIBUTIONS	4,0	0,00	0,00	0,00	4,00			
									Total DDAPG08M	**4,00**	358,94	**1.435,76**
DD92920B	Work item	ML	PIPE MARKING TAPE Laying of plastic tape for underground pipe marking, including installation.							997,80	0,36	359,21
				STREET+ROUNDABOUT TORRES DEL MAR	1,0	108,70	0,00	0,00	108,70			
				ST ESTRELLA DE MAR(Ports to Sos) x2	1,0	350,00	0,00	0,00	350,00			
				STREET BARRAQUETES	1,0	52,30	0,00	0,00	52,30			
				LLEVEIG STREET(from Sos to Claderer)	1,0	201,50	0,00	0,00	201,50			
				STREET AMÉRIQUES+TRAMUNTANA	1,0	79,60	0,00	0,00	79,60			
				TOUS ST(Verge de Sales to Socarrat)	1,0	205,70	0,00	0,00	205,70			
									Total DD92920B	**997,80**	0,36	**359,21**
MISCELLANEOUS BRANC	Work item	PA	MISCELLANEOUS BRANCHES Provision for possible connections to existing networks or new branches. TO JUSTIFY							1,00	10.000,00	10.000,00
				TO JUSTIFY	1,0	0,00	0,00	0,00	1,00			
									Total RAMALES VARIOS	**1,00**	10.000,00	**10.000,00**
									Total PIPE5	1,00	**70.425,11**	**70.425,11**

PIPE6	**Chapter**		**REPOSITIONS**							**1,00**	**86.311,84**	**86.311,84**
DA11110	Work item	M2	RECOMP. PAVTº AGLOM. ASF. 10 CM Trench recomposition of pavement with 10 cm thick asphalt agglomerate, spread in two layers. Thickness, spread in two layers.							1.197,36	39,28	47.032,30
				STREET+ROUNDABOUT TORRES DEL MAR	1,0	108,70	1,20	0,00	130,44			
				ST ESTRELLA DE MAR(Ports to Sos) x2	1,0	350,00	1,20	0,00	420,00			
				STREET BARRAQUETES	1,0	52,30	1,20	0,00	62,76			
				LLEVEIG STREET(from Sos to Claderer)	1,0	201,50	1,20	0,00	241,80			
				STREET AMÉRIQUES+TRAMUNTANA	1,0	79,60	1,20	0,00	95,52			
				TOUS ST(Verge de Sales to Socarrat)	1,0	205,70	1,20	0,00	246,84			
								Total DA11110		**1.197,36**	39,28	**47.032,30**
DA11110X	Work item	M2	RECOMP. HOR. 20 CM Sub-base recomposition in pavement trench with 20 cm thick concrete.							1.197,36	19,72	23.611,94
				STREET BARRAQUETES	1,0	52,30	1,20	0,00	62,76			
				STREET+ROUNDABOUT TORRES DEL MAR	1,0	108,70	1,20	0,00	130,44			
				ST ESTRELLA DE MAR(Ports to Sos) x2	1,0	350,00	1,20	0,00	420,00			
				LLEVEIG STREET(from Sos to Claderer)	1,0	201,50	1,20	0,00	241,80			
				STREET AMÉRIQUES+TRAMUNTANA	1,0	79,60	1,20	0,00	95,52			
				TOUS ST(Verge de Sales to Socarrat)	1,0	205,70	1,20	0,00	246,84			
								Total DA11110X		**1.197,36**	19,72	**23.611,94**
DA11075	Work item	ML	PREFABRICATED KERBSTONE 20X25X50 CM Prefabricated concrete kerb 20x25 cm, including concrete base type hm-20/p/40/i, grouted with cement mortar, fully installed.							20,00	19,07	381,40
				Estimation	1,0	20,00	0,00	0,00	20,00			
								Total DA11075		**20,00**	19,07	**381,40**
DA11090	Work item	ML	PREFABRICATED RIGOLA 20X50X7 CM Laying of rigola, including concrete bedding and grouting with cement mortar.							20,00	14,31	286,20
				Estimation	1,0	20,00	0,00	0,00	20,00			
								Total DA11090		**20,00**	14,31	**286,20**
REPOS SERV 125	Work item	PA	WORK ITEM APPEAL FOR REINSTATEMENT Work item raised to justify in reinstatement of services.							1,00	15.000,00	15.000,00
					1,0	0,00	0,00	0,00	1,00			
								Total REPOS SERV 125		**1,00**	15.000,00	**15.000,00**
								Total PIPE6		1,00	**86.311,84**	**86.311,84**
PIPE7	**Chapter**		**HEALTH AND SAFETY**							**1,00**	**9.000,00**	**9.000,00**
S Y S T2	Work item	PA	HEALTH AND SAFETY Health and safety.							1,00	9.000,00	9.000,00
								Total PIPE7		1,00	**9.000,00**	**9.000,00**
								Total PERELLÓ-SOCARRAT-LLASTRA		1	**309.013,19**	**309.013,19**
FEES	**Chapter**		**SYS COORDINATION FEES**							**1**	**2.000,00**	**2.000,00**
HO NOR	Work item	MES	S AND S FEES Monthly fees for Health and Safety coordination							2,00	1.000,00	2.000,00
								Total FEES		1	**2.000,00**	**2.000,00**
								Total		1,00	**311.013,19**	**311.013,19**

Figure 69: Budget for the replacement of pipes in El Perelló, El Socarrat and La Llastra

The second of the budgets corresponds to the installation of a new flow meter with a record of Fernandet, La Lotería, Les Palmeres and Motilla. In this way, this area of the coastline will be dry and, as we have seen in this thesis, there is no record of the volume of water consumed. This budget has been obtained based on the installation of a smaller flow meter from another budget provided. The flow meter installed is a Siemens SITRANS F M of the diameter series shown in the following image.

Figure 70: Siemens Flow meter series SITRANS F M

This would be installed in the 400 mm pipe that starts in the eastern part of Calle de l'Alacantí in order to have a record of the flow consumed up to the last user in Motilla. As there is no price data available for the 400 mm diameter, the price of the components and of the flow meter itself for the values of diameter 250 has been multiplied by a coefficient of 1.5 to represent the approximate cost of the installation, which for this budget does not take into account either civil works or manholes. But it does give an idea of what it would cost to carry out this measure, which is the objective of this estimate, which amounts to 9652.67€.

WATER METER LES PALMERES					**6.703,7**
GATE VALVE 0400	Ut	2,0	673,77	754,62	1.509,24
WATER METER 0400 MM	Ut	1,0	1646,40	1843,97	1.843,97
CAPE EXTREME PE. 0250 EXT.0250 AUTOBLOC	Ut	1,0	351,03	393,16	393,16
TE H. DI. FLANGE 0400 X 0250	Ut	1,0	631,07	706,80	706,80
PLATE ON REDUCTION H. DI 0250X0080	Ut	1,0	283,73	317,78	317,78
FLANGE-HOLDER WALLOON 0400 -EXT. 0400-	Ut	4,0	62,30	69,78	279,13
CRAZY FLANGE-HOLDER 0400 POLIET.	Ut	4,0	92,88	104,02	416,09
GATE VALVE 0080	Ut	1,0	99,53	111,47	111,47
CABO EXTREMO PE.DE 050 EXT.063 AUTOBLOC	Ut	1,0	64,12	71,81	71,81
GASKETS AND FASTENERS	Ut	1,0	87,00	97,44	97,44
ASSEMBLY PARTS Hº Fº ø 80	Ut	1,00	23,78	26,63	26,63
ASSEMBLY PARTS Hº Fº ø 400	Ut	3,00	115,41	129,26	387,78
MONTAJE VALV. COMPUERTA ø 400	Ut	1,00	199,71	223,68	223,68
GATE VALVE ASSEMBLY ø 80	Ut	1,00	37,35	41,83	41,83
WATER METER ASSEMBLY ø 400	Ut	1,00	247,25	276,91	276,91

This quotation does not include civil works and manholes.		
his estimate is valid for two months. Once the estimate has been accepted and payment has been made, work may begin after three working days, provided that the civil works are completed and in the conditions indicated by the company's personnel.	**TOTAL SUM OF CHAPTERS**	6.703,71
	13% G.G. e UNEXPECTED EVENTS	871,48
	6% INDUSTRIAL BENEFIT	402,22
	SUBTOTAL	7.977,41
	IVA	1.675,26
	TOTAL	**9.652,67**

Figure 71: Budget for the installation of a flow meter to dry the area of Les Palmeres

CONCLUSIONS

In this thesis, a mathematical model of the drinking water supply network of the northern coastal area of the municipality of Sueca has been carried out. This coastal area is made up of El Perelló, El Socarrat, La Llastra and Les Palmeres, all of them population centres with different types of housing and a marked seasonal profile of demand for drinking water. This means that although the population throughout the year does not exceed 2,500 inhabitants, in summer, being an area of mainly holiday homes, it grows exponentially and with it the volumes consumed.

The information is based on the annual consumption data for 2021 for the sectors of El Perelló, El Socarrat and La Llastra together with the monthly values for January, February, March, April and May. And with an AutoCAD street map showing the pipes distributed along the different streets and their diameters. All this information has been provided by the municipal company Aigües de Sueca, which has been providing information throughout the development of this work, has helped, explained and discussed different evaluation criteria for this work. The first step was to re-design the pipe layout in AutoCAD so that it could be entered in Epanet, where elements such as pipes, reservoir and nodes were characterised for subsequent simulation.

In view of the limited data available in terms of consumption, a large number of assumptions were made, backed and justified by different criteria to establish a demand profile for each of the months of 2021 that were not available. This process took the longest time to produce a profile that was as reliable and as close to reality as possible, describing each and every one of the study areas, including Les Palmeres, for which no consumption data was available.

Once this consumption profile by sector and month had been completed and it had been verified, using different parameters, that it was in line with the estimated future reality of the year 2021, two extreme scenarios were used for the study. The first of these is August, for which the month factor has been multiplied by the average base demand for the whole year for each of the sectors. This was divided equally between the nodes in each sector and then multiplied by a demand factor of 1.8. The same was done for the month of February with its month factor and a demand factor of 0.6. In this way, a summer peak scenario and a winter off-peak scenario are proposed to simulate the most unfavourable cases to which the network is subjected. For which, if we manage to get the network to work while ensuring the appropriate service parameters for the user, it will function correctly throughout the year. The results obtained in both cases have been analysed by means of a study of pressures, speeds and headlosses. For case 1 of peak demand in August, it has been observed that in the western area of El Perelló and in a large part of the El Socarrat and La Llastra nodes, the minimum supply pressure set at 30 mwc is not guaranteed. In the study of headlosses it has been found that the pipes close upstream of these nodes have large headlosses due to insufficient diameters for the flow they supply. As far as velocities are concerned, they are very low in both scenarios, with special focus on the winter scenario. This problem, although quite common in this type of network, can cause a decrease in the concentration of chlorine, which leads to a final loss of water quality. The valley scenario also shows that at all points the pressure supplied is sufficient and that the unit losses are potentially reduced due to the decrease in velocities, as can be seen from the Darcy-Weisbach equation.

In addition, and in order to have a more complete study of the network, the leaks that the plumbing manager had recorded for the past months of 2021 were analysed and the estimated volume of leaks was calculated for each zone of the coastline. It was concluded that La Lotería is an area with a serious leakage problem caused by the rupture of the welds of the polyethylene pipes due to changes in temperature. And to finish the study of the network, the hydrants were analysed to see if, by subjecting them to a fire emergency situation, they were capable of ensuring the parameters stipulated by the NBE-CPI/96 regulations. All of them verified that for the summer peak case they were capable of supplying, even activating two of them simultaneously, 16.6 l/s at pressures well above the minimum of 10 mwc.

Considering the study carried out for this network, proposals have been made to improve its operation, management and quality of service, which will be proposed to Aigües de Sueca. The main one was the replacement of the fibre cement pipes that were causing pressure problems with larger diameter ductile iron pipes. On the other hand, the need to change the installation of polyethylene pipes in La Lotería to ductile iron was also considered. On the other hand, the reduction of the daytime setpoint pressures in the months of January, February, March, April, May, October, November and December has been studied. By considering the casuistry of the current installation and also when the pipes are replaced, it was concluded that the set point of the pumping group could be lowered to 32 and 31 mwc respectively. As a final improvement, the need for secotrización of the area catalogued as Les Palmeres is introduced. Either totally or separating it into Fernandet-La Lotería and Les Palmeres-Motilla. And finally, the option of installing pressure and flow data verification points to be able to calibrate the model and adjust the demand values more reliably to the real situation.

With all this, a useful and reliable tool has been developed for the management of this drinking water supply network, which Aigües de Sueca's technicians will be able to use and improve when the information for the whole of this year is available. The objectives that were set out at the beginning of this thesis have thus been met. This has been achieved not only by developing a mathematical model of the network that is as close as possible to the future reality, but also by identifying the points of action and putting forward the relevant proposals for improving its operation, management and quality of service.

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