04

Francisco Javier Espejo Gutiérrez

PhD. Architect and College degree in Geography and History //
franciscojavier.espejo@universidadeuroepa.es

REIA NO. 21 DIC.2024

ISSN: 2340-9851
www.reia.es

Sistemas y dispositivos para el suministro de agua en la Hispania romana (Parte I)

// Systems and devices for water supply in Roman Hispania (Part I)

Los condicionantes hidrológicos, con fuertes desequilibrios entre cuencas hidrográficas, junto a la desigual pluviometría y una orografía accidentada, supondrán los principales inconvenientes con los que se encontraron los ingenieros romanos en Hispania para proporcionar a las ciudades un adecuado suministro de agua. Estos impedimentos supusieron una oportunidad para el logro de una eficaz gestión en el uso y distribución del agua, a lo largo de un territorio tan complejo. Sobre técnicas y usos de dispositivos, en Hispania se aportaron soluciones propias por dichos motivos. Esta primera parte abordará los sistemas que intervenían en el suministro, dejando para una segunda entrega al acueducto y sus subsistemas, así como en las propias ciudades.

The hydrological conditions, with strong imbalances between river basins, along with uneven rainfall and rugged terrain, posed the main challenges faced by roman engineers in Hispania in providing cities with an adequate water supply. These impediments became an opportunity to achieve effective management in the use and distribution of water across such a complex territory. Regarding techniques and the use of devices, Hispania contributed its own solutions for these reasons. In this first part, the systems involved in the supply will be addressed, leaving the aqueduct and its participating subsystems for a second installment

1*
Introduction

"It is the waters that make the city"
Pliny the Elder (Natural History, XXXI, 4)

This text will introduce a crucial aspect for the proper functioning of cities and other smaller localities: the water supply to their populations, within the context of Roman Hispania. It will be shown that this interest was inherited by the Romans from previous civilizations, as access to water has always been fundamental for human settlement in a territory. The matter became more complex when humans decided to live in communities, as they accepted that their well-being and security would be greater than if they lived apart from others.

There is abundant research on the water supply systems implemented by the Romans in the vast territory they dominated, and more specifically in Hispania. It is also evident that the intervention of the Roman State was decisive. Their engineers developed a science, with complex systems and devices that were part of the design of hydraulic infrastructures, both on a territorial and local scale. Rome undertook this task as a strategic decision in its policy of dominance and exercise of power.

This article does not aim to be an exhaustive study of the elements that were part of Roman hydraulic installations; much has already been written about it. To contextualize the topic, a brief historiographical introduction is necessary. Thus, there is evidence of interest in Roman hydraulic infrastructures in Spain as early as the 17th century, related to the existence of Roman aqueducts south of the Turia River (DIAGO 1653, as cited in HORTELANO 2008:70). This is possible thanks to the chronicles of Francisco Diago, who describes the ruins belonging to València la Vella, which he identifies with the Roman city of Pallantia.

This interest in Roman infrastructures continued in the mid-18th century. For the first time in our history, an initiative related to the cataloging of historical and architectural heritage was developed. The task was directed by the Spanish Crown during the reign of Ferdinand VI, and the responsibility fell on Luis José Velázquez de Velasco y Cruzado, Marquis of Valdeflores, who was assisted by the academic and draftsman Esteban Rodríguez Tizón, brother of the architect Ventura Rodríguez (SALAS 2010:13-14). The city of Mérida was part of the first stage of a journey that took place from 1752 to 1765. (Figure 01).

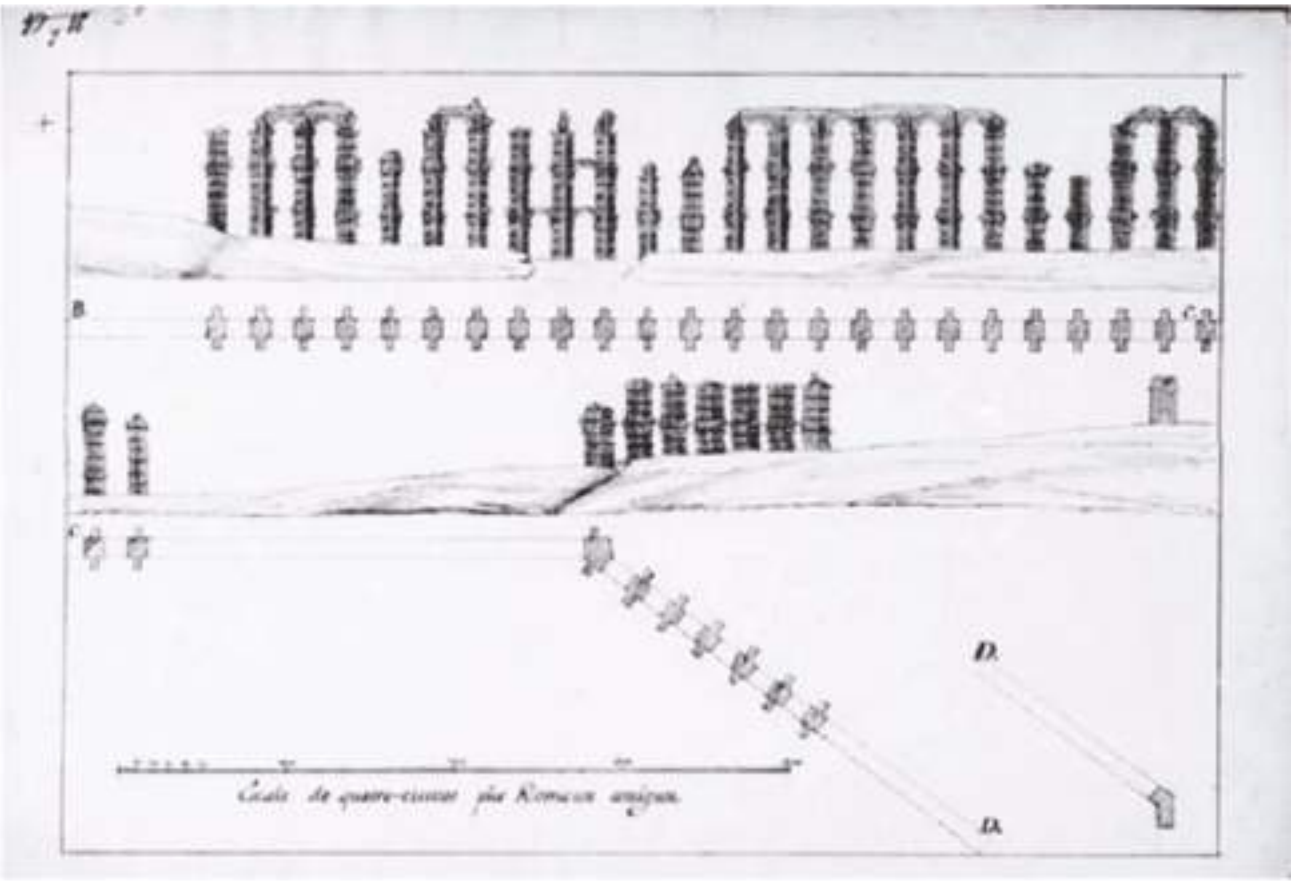

FIGURA 01 » Acueducto de Los Milagros. Drawing by Esteban Rodríguez.

Source: Gabinete Cartográfico de la Real Academia de la Historia. Signatura BA-VI e 87.

At the end of the century, the publication "Viaje de España" (1772-1794) by Antonio Ponz became a reference for understanding the state of Spanish artistic heritage and its works, including the remains of the Roman presence in the Iberian Peninsula.

During the 20th century, various research works were carried out, such as those by the civil engineer Carlos Fernández Casado, which gained special momentum from the late 1970s, when the political regime in Spain changed. With the beginning of the present century, archaeological studies related to the water supply systems to Roman cities increased; at this time, the support of certain institutions, such as that provided by the Tagus Hydrographic Confederation, which wanted to know the state of the Roman water supply to the city of Toledo (ARENILLAS and BARAHONA 2009:95), became important.

Furthermore, it is necessary to differentiate between the implementation of these installations in pre-existing cities and in newly founded cities, as the construction and urban complexities they present are also different.

To analyze these structures and infrastructures, and those that are known, the moment when hydraulic building activity began systematically has been considered, particularly with the construction of aqueducts considered as a system of systems: with the arrival of Augustus to power. In addition, the provincial organization of Hispania, also the work of the same emperor, must be added (Figure 02).

FIGURA 02 » Administrative organization of Hispania during the Early Empire..

Source: Own elaboration based on BELTRÁN F. y MARCO, F. 1996:83.

A large part of the Roman hydraulic infrastructures, especially those that served the interior of cities, have disappeared or are buried. Some are still functioning, others have been repurposed for other uses, and a third group includes those that are assumed to have existed, based on observations in other European cases.

It seems reasonable to consider that Roman engineers would systematize the design and devices, adapted to the particularities of each area, given the vast territory they controlled. This would facilitate construction and the economy of auxiliary means, as well as the necessary personnel for execution. By comparison with other locations, it could be known if this initial approach is feasible. Additionally, it must be taken into account that part of the unused water also served to ensure the good condition of the sanitation and cleaning of the channels intended to evacuate wastewater.

0

2*

State of the issue in Roman Hispania"

It can be stated that Rome made it possible to take the first steps towards the introduction of what is now known as running water. Many of their constructions were lost over time or destroyed, and very few have survived to this day.

As early as 312 BC, the city of Rome had its first aqueduct, the Aqua Appia; previously, the Romans obtained water through direct intakes from the Tiber River, springs, and wells (SALINAS 2007:10). In Hispania, it took longer to see such constructions until the territory came under Roman control, although the peoples who inhabited the Peninsula until then had their own water supply systems.

The definitive boost to hydraulic constructions began with Emperor Augustus, at the start of the Principate, when he gained absolute power in 29 BC. This activity began alongside the administrative restructuring of the territory. In this endeavor, the water supply to cities, whether pre-existing or newly founded, became a priority and essential. Generally, no newly founded Roman city was established where water from a good spring could not reach; however, this principle was not immutable and adapted to the peculiar circumstances of the Hispanic territory.

For the Romans, water was the most important, even strategic, resource, to the point of ensuring that their settlements had the highest possible quality and abundance (MUÑIZ, 2015: [video 1]). To this end, they executed engineering constructions throughout the Roman Empire to bring water to the final urban consumption. The Romans were not satisfied with access to springs or large rivers, both close to urban settlements; either because the flow of the former was not adequate or because the water quality of the latter did not meet desired standards. In this regard, Vitruvius' Book VIII provides valuable information on the required quality of this water. The water had to be of high quality and its supply had to have a large flow. At the same time, a long-term perspective was necessary to ensure the supply to cities for many years (MUÑIZ, 2015: [video 1]).

To understand the knowledge of these infrastructures in Roman Hispania, it is necessary to delve into history and refer to two aspects. On the one hand, the studies of Fernández Casado in 1983 are significant; they mention the difficulty in finding research related to city water supply systems. He links this circumstance to the existence of what he calls the law of archaeological finds by private works, which necessarily predates the Spanish Historical Heritage Law 16/1985 of June 25. This law would have caused the suspension of works, sometimes indefinitely, upon the accidental discovery of archaeological remains during private construction.

What are the consequences of this situation?? In many cases, builders, to prevent the competent authorities from finding out, acted quickly, destroying everything found. Therefore, plans could not be drawn up nor could the findings be documented. Related to this, paradoxical situations have materialized over time. An example was the construction of the Archaeological Museum of Málaga on the same foundations as the Roman theater. There have also been cases where, prompted by the same rulers, significant Roman remains have disappeared. An example is the remains of an imperial Roman villa that fell victim to the pickaxe for the construction of the AVE in the city of Córdoba.

On the other hand, the few Roman water distributions still in use today (such as some sections of aqueducts) are in an advanced state of deterioration. This is due to centuries of abandonment, urban and territorial transformations. Additionally, some materials, such as those used in conduits, were looted or simply deteriorated over time, as in the case of some wooden pipes.

It should also be noted that, in addition to aqueducts for external supply, cities had their own supplies, such as wells in homes and cisterns, some predating the arrival of Rome; the former drew water from the subsoil and the latter collected rainwater. Thus, this dual supply allowed the population of Rome to withstand the siege by the Ostrogoth king Totila during the Third Siege of Rome between 549 and 550 BC. The Ostrogoth sovereign interrupted the water supply to the city through the aqueducts to force the city's capitulation. However, far from achieving this, ancient sources indicate that the population only lamented that these events prevented them from using the baths (SÁNCHEZ 2019:442)

3*
Hydraulic systems used in the Roman context

> Let the majesty of your Empire be adorned with the appropriate prestige of public buildings
> Vitruvius (The Ten Books on Architecture. Dedication, Book I)

Written sources provide a valuable starting point for understanding these systems. Numerous publications are related to aqueducts as part of the infrastructure that supplied water to cities. However, there is not as much information about the existing systems at the territorial level, within the Roman provincial organization that allowed the administration of the Peninsula; nor about how the territorial connection with the distribution within cities was made, understanding everything as a complete system for each city. The origin of this situation can be found in the absence of regulatory norms, contributing to this situation:

a. The limited work dedicated to archaeological research, which increased significantly from the 1970s onwards. Dams, weirs, aqueducts, cisterns, and fountains have mainly been the objects of these investigations.

b. There is a lot of bibliography, even prior to the 20th century, but not many detailed analytical works, such as those on the construction systems used. In the field of representation, there is more indeterminacy, with graphic documentation not entirely accurate. There are accounts and definitions, but detailed and individualized studies are scarce. A good example of this state is related to the analyses carried out around aqueducts (JIMÉNEZ 1976:199).

c. The construction of public works that have destroyed archaeological remains in their path.

d. Additionally, the essence of the following statement can be extrapolated to other territories: "Thus, despite the significant development that urban archaeology has experienced in the city of Seville in recent decades and the constant increase in the number of interventions, the stratigraphic record of Roman contexts remains particularly scarce today" (GARCÍA 2007:126).

Thanks to the exceptional state of conservation of certain archaeological excavations, it has been possible, despite the difficulties in finding reliable information from other sources, to establish certain initial hypotheses. The case of Pompeii (Figure 03) is a paradigmatic example; the circumstances of its disappearance, buried under ashes for centuries, have made it possible to preserve the main devices and layouts of the water channels of a Roman city. This has allowed us to understand in great detail how water supply to an urban environment was possible. Thus, a hypothesis is proposed: that this model was adopted throughout the Roman Empire. Although there isn't evidence to verify this, it seems plausible that it was possible.

It should be noted that this topic gained special relevance thanks to the support and impetus of some state administrations, such as the studies related to the Roman water supply in Toledo. These works were carried out by the Tagus Hydrographic Confederation between 2005 and 2009 and provided abundant information on the water supply to Toletum; above all, they marked a before and after regarding the theories that had traditionally been accepted as true on the subject (BARAHONA 2014:206).

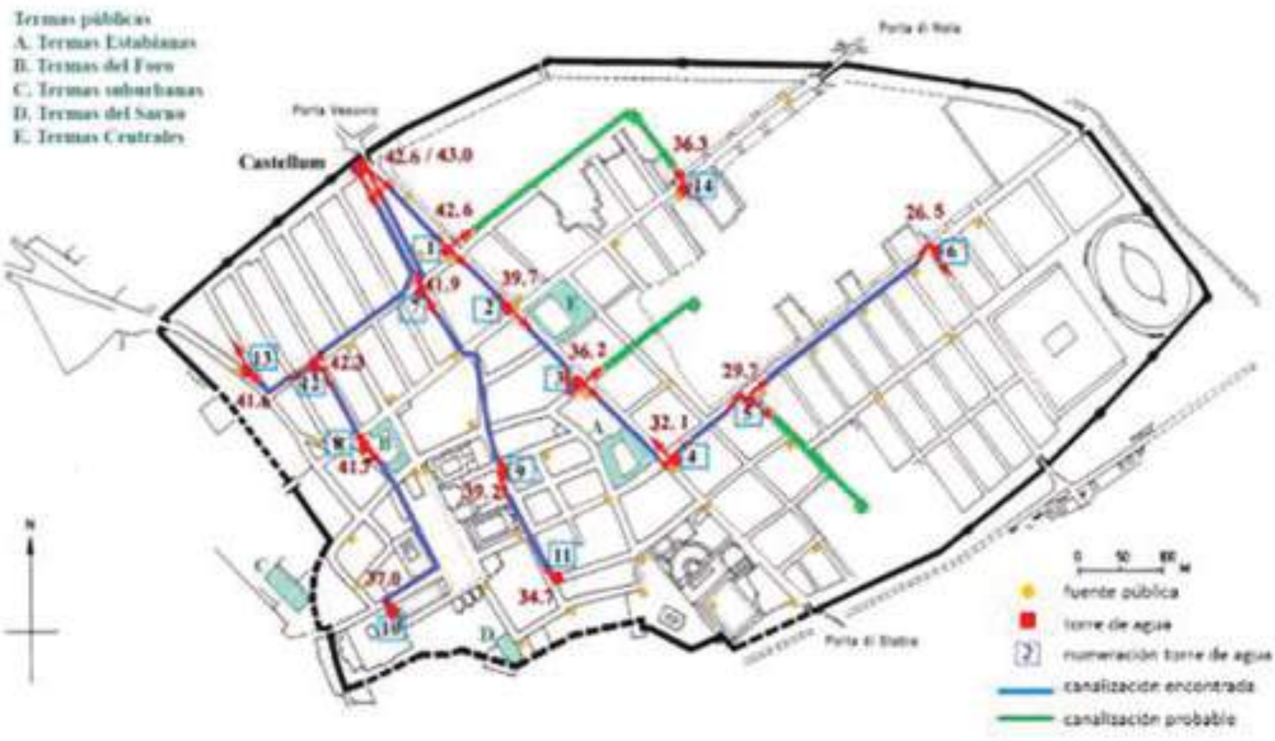

FIGURA 03 » Water distribution in the city of Pompeii, with its main elements and conduits.

Prepared based on the work of OLSSON 2015:18, 91.

Many publications have so far informed us about the current state of research related to the water supply to Roman cities. It also happens that the level of studies does not correspond to the entirety of the cities in Roman Hispania. This seems to be because this field of work is in an incipient stage, for which two possible reasons are estimated: the lack of research work on this line of work or the absence of general archaeological studies. In fact, it is from the 1980s onwards that significant archaeological interventions took place, such as the one carried out in what was the Roman city of Gades; this task made it possible to reveal a large number of archaeological traces in this location (LARA 2018:142).

Vitruvius and Frontinus, through their writings, are the sources that allow us to understand how these systems were executed and under what design and quality parameters. The goal was to achieve a water supply in the best conditions for the cities of the Empire, a strategic objective for the survival of the Roman State. These are two key authors for understanding the importance that Rome placed on water, even from the time it was a republic.

We must be grateful that the texts of these two sources have reached us because, otherwise, certain information would only have been discovered through archaeological work. They are primary sources that give us access to the knowledge and philosophy that made it possible for the Romans to undertake these still ambitious engineering projects.

Vitruvius (80-15 BC), who served Augustus, records in Book VIII of his treatise De Architectura, in a monographic manner, the necessary actions to locate, obtain, transport, and store water for distribution in the cities of the State (RUIZ and DELGADO 1991:79). Rome made it possible to end the dependence on the topographical conditions where cities were or would be established, thus achieving a regular and quality water supply. This policy was extended to all territories under its political and territorial control, with large civil engineering works never seen before.

Frontinus (last third of the 1st century AD), senator and soldier, who in his cursus honorum reached the magistracy of curator aquarum. This position was granted to him by Emperor Nerva in 97 AD and provided him with the capacity to manage the water supply infrastructure to the city of Rome (PANIAGUA 2016:22). As a result of this dignity, he wrote De aquaeductu urbis Romae at the end of the 1st century AD, which is a technical report that recorded all the actions he carried out in the performance of his duties. In this text, not only is the problem of water supply to Rome addressed, along with the solutions adopted; it also provides a relevant compendium of regulations applicable to hydraulic works in all Roman domains (RUIZ and DELGADO 1991:89).

Frontinus not only deals with the supply to cities but also to their ager. In addition to what has already been mentioned, the text identifies two critical stages of water supply to Roman cities (LARA 2018:142):

- Collection and channelling: capture and weirs, dams, aqueducts.
- Distribution in the urban space: cisterns, fountains, nymphaea, and channels buried under the pavement, as well as wells in homes.

In addition to these resources, we have archaeological sources that allow us to better complete the picture of the systems and devices involved in the water supply to Roman cities. In this sense, it should be noted that water always constituted a fundamental element for Roman society; the works and various hydraulic devices, in fact, constitute the most notable sign of Romanization of a city in the Empire.

At this point, we can proceed with the description and study of each of the components that enable the functioning of the water supply infrastructure. The knowledge of these devices allows us to contextualize the complex installations in the urban and historical context of each studied city: storage and regulation systems, transport, storage, channels, distribution, and regulation of flows and pressures.

Dams

Dams, given the volume of water they held and the height they reached, utilized various organizational structures (Figure 04). They were integrated into the territorial system that provided water supply to populations from outside, considering the water scarcity that the Romans had already observed. Sometimes, the exploitation of springs, which is the preferred source of supply, would participate in the territorial system in a mixed manner with the dams. In certain territories with low natural regulation of river flow, the Romans opted for the construction of a significant number of these components. Examples include the cases of Mérida and, occasionally, in the Guadiana basin, on the right bank of the Ebro, and the left bank of the Tagus.

The reason why some areas have low natural regulation of the terrain is due to the presence of depressions where it is more challenging to exploit river flows; therefore, artificial regulation through dams is necessary. Additionally, in those same territories, springs and sources provide low flow rates. Thus, water accumulation was viable during the most favorable times, making it possible to have sufficient distribution capacity throughout the rest of the year (ARANDA 2003:494-495).

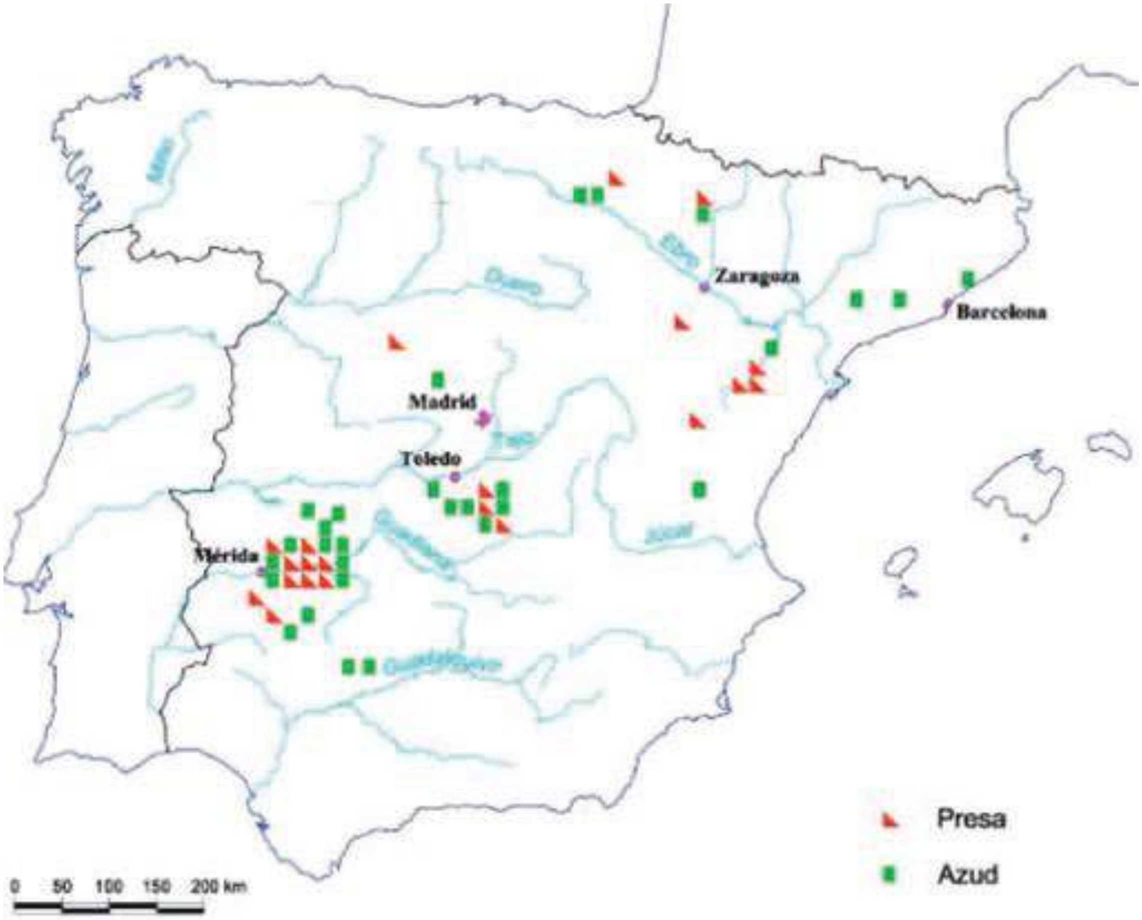

FIGURA 04 » Distribution of Roman dams and weirs in Spain.

Source: CASTILLO 2007:67

These are elevated constructions that function by gravity, meaning that the weight of the materials forming them is capable of withstanding the horizontal thrust exerted by the water on them. They are designed to retain considerable volumes of water. In the case of the Ebro basin, the dams are located halfway along significant rivers, providing real regulation capacity. Regarding the Tagus and Guadiana, the structures are located at the river heads or in small reception valleys, where the river flow is lower. These circumstances conditioned the structural and construction solutions of each area: in the Ebro, the dams are masonry, like the one in Almonacid de la Cuba, conceived as regulation elements. In the central-western part of Roman Hispania, filling systems and impermeable screens were used, such as in Cornalvo and Proserpina, whose role was to serve as storage reservoirs at the beginning of each river structure (ARENILLAS 2003:72).

The construction solution predominantly adopted by Roman engineers was the screen wall, whose function was to provide watertightness to the system. It consists of a main element of opus caementicium, whose primary function was to facilitate the watertightness of the dam; it was backed on both sides by walls of opus incertum, which sometimes served as lost formwork. Occasionally, this screen wall could be solely of opus incertum. Upstream, it could consist of opus quadratum in buttresses (Figure 05), and downstream, it always had a large earth embankment or backfill; this latter element was a compacted material fill that withstood the entire thrust of the impounded water, which made the dam wall unstable when it was empty (Figure 06) (ARENILLAS 2003:73-74).

FIGURA 05 » Walls and buttresses in the Proserpina dam.

Source: FEIJOO 2006:160

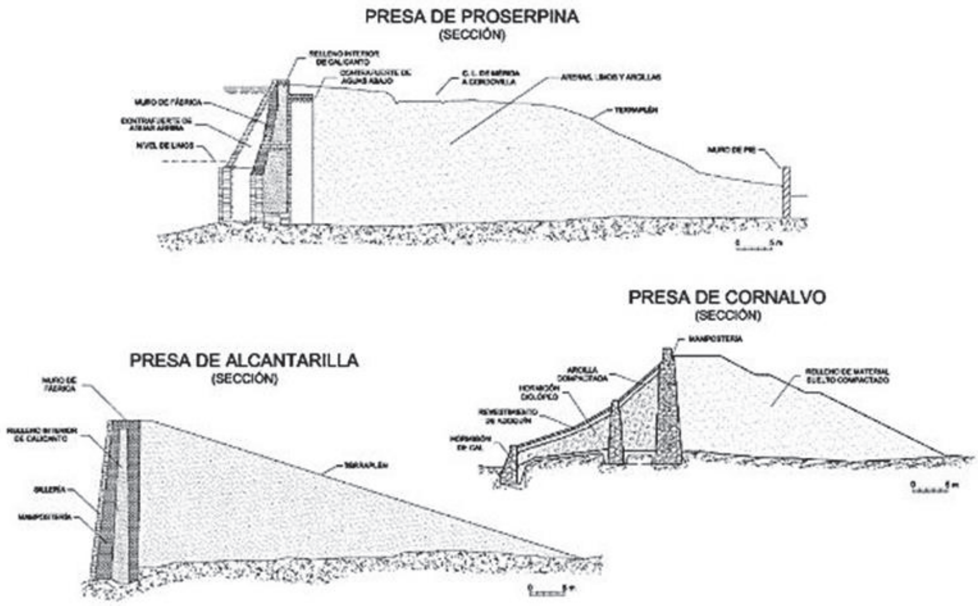

FIGURA 06 » Typical construction sections of three dams in the Guadiana and Tagus basins.

Source: ARENILLAS et al. 2002: Figure 10.

This impermeable screen had its variants, such as in the case of Alcantarilla: an *opus quadratum* wall upstream and *opus caementicium* fill, along with another of *opus incertum* and *opus quadratum* downstream. Or as in Cornalvo, where three parallel opus incertum walls are located upstream, increasing in height as they approach the main wall. The spaces between these walls contain concrete, gravel, clay, and sand fills. This specific feature in Cornalvo could be related to much later reconstructions after the Roman period, as the model it presents is not the one adopted by Roman engineers for dams like Alcantarilla and Proserpina; this does not invalidate the fact that it was originally of Roman construction and later transformed (MARTÍN 2000:668-669)

Weirs

The term "weir," of Muslim origin, is reserved for small dams; their purpose is to raise the river level to divert part of its flow for other uses, such as supplying the specus or channel of an aqueduct, or even for irrigation channeled by ditches. Their capacity to regulate river flow is less than that of a dam, as the river overflows them, although they retain a significant volume of water. Unlike dams, their purpose is not to store water but to raise the river level for diversion. This design factor determined their smaller size. They were located at the heads of hydraulic systems, such as aqueducts. They can have buttresses, like in Consuegra (Toledo) or Villafranca (Teruel); without buttresses, curved with rows of ashlars directly supported on clay layers, like the example of Cubalmena for the supply of Los Bañales, acting as a discharge arch (Figure 07).

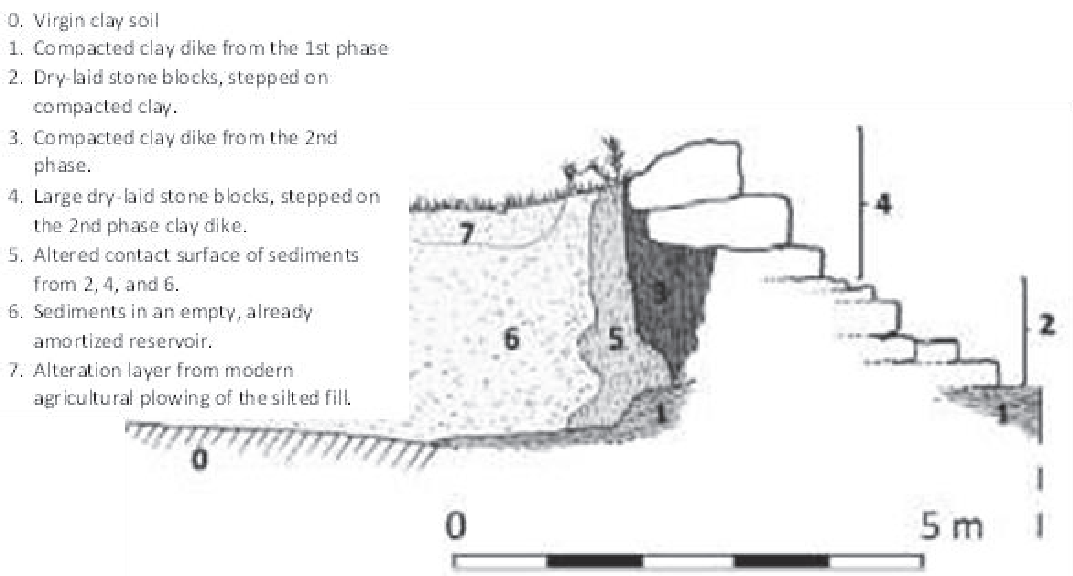

FIGURA 07 » Construction section of the Cubalmena weir.

Source: own elaboration based on ANDREU and ARMENDÁRIZ 2011:208

Weirs would act as decantation devices initially, although they would later drag particles from the banks due to erosion by the advancing water. They are not a direct capture from a spring, which is ideal, but as some authors state, they are "second category" (FEIJOÓ 2006:155). Referring to what happened with the waters transported by the Aqua Anio Vetus and those from its captures, Frontinus comments the following (PANIAGUA 2006:265): “The two Anios spring less clear as they are captured from the river and often, even in good weather, they become turbid because the Anio river, despite originating from a clear lake, drags sediments from the banks, which detach due to the current, thus becoming turbid before reaching the conduits. This inconvenience is suffered not only with winter and spring rains but also with summer ones, a season when that purity in the conduits is most appreciated.”

When opting for this type of capture, the main drawback was that the water became dirty with silt. For this reason, it was necessary to have a piscinae limariae next to the capture point for decanting the fluid before its discharge into the specus (VENTURA 1993:62).

Putei

Wells, or putei, are water collection elements existing in cities, even before the arrival of the Empire in Hispania, but they continued to function even when Roman cities were supplied with running water through aqueducts. They are vertical excavations, predominantly circular in plan; the first section consists of a brick or even ashlar mouth to enhance their durability and preservation (SÁNCHEZ 2019:433).

They allow access to the groundwater levels existing in the subsoil of some cities or by utilizing the permeability of nearby rivers (Figure 08), even taking advantage of karst systems like the one in the city of Tarraco. Sometimes they also acted, optionally, as a reservoir or cistern to accumulate rainwater. Like cisterns, they provided water in case of any supply interruption, whether from aqueducts or other reasons. Many domus were self-sufficient in cities like Augusta Emerita, as they had a well or cistern, in addition to the water supplied by the public network; for illustration, in this city, its inhabitants even preferred the putei. In some neighborhoods of this city, some wells have been documented, excavated in rock, with depths of up to 12 meters (ALBA 2007:165-167). They were also excavated to serve the baths (SCHATTNER and OVEJERO 2007:102).

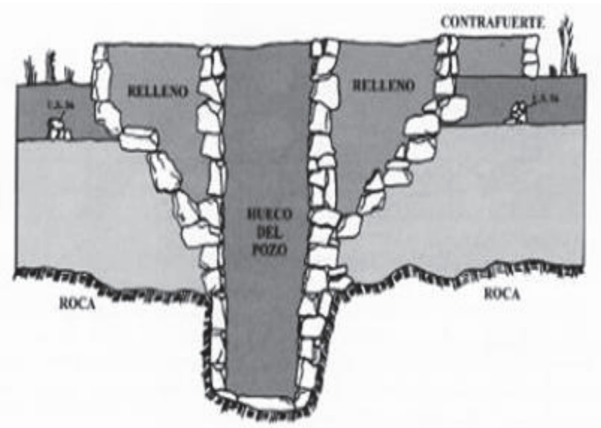

FIGURA 08 » Well in Marroquíes Bajos, Jaén. Source: BARBA 2007:Fig.26 and 28.

Cisterns

Cisterns are elements for collecting rainwater that are complementary and/or alternative to putei, although they can also be public. They served, among other purposes, to collect occasional excess water from aqueducts or for storage during droughts (MARTÍNEZ 2007:268). Cisterns and putei offered the possibility of maintaining a water supply capable of addressing and covering possible supply contingencies, both for regular consumption and other purposes, to the point that they made the development and inclusion of private baths possible (ALBA 2007:166). In pre-Roman Hispania, there was already an established custom of water supply with central cisterns to collect rainwater in *oppida*, excavated in the ground (CASTRO 2016:109).

Many examples have been found and documented (Figure 09). Unlike *castella aquarum*, cisterns store rainwater for consumption; they do not redistribute water as *castella* do (MONTELEONE 2018:22)

Vitruvius only recommends their use in the absence of groundwater that supplies springs or if it is not possible to capture it through putei. Some appear completely buried, but originally they were semi-buried to facilitate inspection and maintenance tasks. They could be excavated in rock (GONZÁLEZ 2007:50) or constructed with *opus caementicium* in their walls and waterproofed with *opus signinum.*

The spaces are covered with barrel vaults of *opus quadratum*, *opus caementicium*, or *opus latericium* to preserve water quality. Generally, they were located in public spaces, associated with fountains, squares, or monumental buildings, due to the role water plays in Roman society and the citizens' right to use it. But they were also found in private spaces, such as the *impluvia* of *domus*; an *impluvium* is a square cistern located in the center of the atrium of a domus, at a lower level than the *atrium* to facilitate the collection of rainwater, where it was stored after being collected from the inverted roofs of the same atrium or patio (GONZÁLEZ 2002:415).

Recent research suggests that they also served as elements within a complex pressure control system (MUÑIZ 2015: [video 2]).

FIGURA 09 » Cistern in the Iberian settlement of Cerro de la Cruz in Almedinilla, Córdoba. Source: CASTRO 2016:109.

Castellum aquae

The term castellum aquae is a generic reference to any Roman construction whose function was the temporary storage and distribution of water from an aqueduct. Examples include diversion boxes, collection boxes, redistribution boxes, and towers. Depending on the type of water use, it is differentiated between castellum publica, as part of aqueducts and city distribution, and *castellum privata*, intended for several concessionaires for private use of aqueduct water (MARTÍNEZ 2007:268). In a *castellum,* regardless of the type, water is constantly entering and exiting; it is a passage point where the outflow is regulated and managed (MONTELEONE 2018:22). They can be found both on a territorial and urban scale, in aqueducts and within cities.

They can adopt various functions, and therefore, other terms are also added according to documentary sources (MARTÍNEZ 2012:142), such as:

- *Castellum divisorium* or *dividiculum:* A device located within the city walls, at the highest point of the terrain. It connected with the specus; from there, after cleaning, flow regulation, and decantation, the water was redistributed or branched through several conduits. The one in Nemausus, now Nimes, has ten conduits, and the one in Pompeii has three, each intended for a different neighborhood or use. For illustration, the one in *Nemausus* (Figure 10) is used due to its excellent state of preservation and the current absence of similar remains in Spain. For its preservation, a protective structure was built, giving it the significance of a castellum or building (MARTÍNEZ 2007:268). This term was created in the 19th century (MARTÍNEZ 2012:142).

FIGURA 10 » Exterior of the *castellum divisorium* in *Nemausus,* now Nimes.

Source: LA ROMANITE AU COEUR DE NÎMES https://nimesromaine.wordpress.com/wp-content/uploads/2014/01/castellum_3.png.

The number of pipes or conduits departing from this device depended on the services to be covered, neighborhoods, and the size of the locality, as well as the existence of other aqueducts that also served the same city, with their respective castellum divisorium. Additionally, the surplus water was used for cleaning the urban sanitation system (MUÑIZ 2015: [video 1]).

Vitruvius provides a series of recommendations related to the construction typology of this structure, which he considers relevant by stating: "When the water reaches the city walls, a reservoir and three cisterns will be built, connected to it to receive the water; three pipes of equal size will be adapted to the reservoir to distribute the same amount of water to the adjacent cisterns, so that when the water overflows the two lateral cisterns, it begins to fill the central cistern. In the central cistern, pipes will be placed to carry the water to all public pools and fountains; from the second cistern, the water will be directed to the baths, which will provide the city with annual income; from the third, the water will be directed to private houses, ensuring that there is no shortage of water for public use. The reason that has driven me to establish this water distribution is that individuals who have water in their own homes must pay taxes for the maintenance of the aqueducts." (VITRUVIUS and OLIVER 2004:319).

- *Castellum aquae* with *piscinae limariae,* for decantation and water cleaning (Figure 11) (MARTÍNEZ 2012:142).

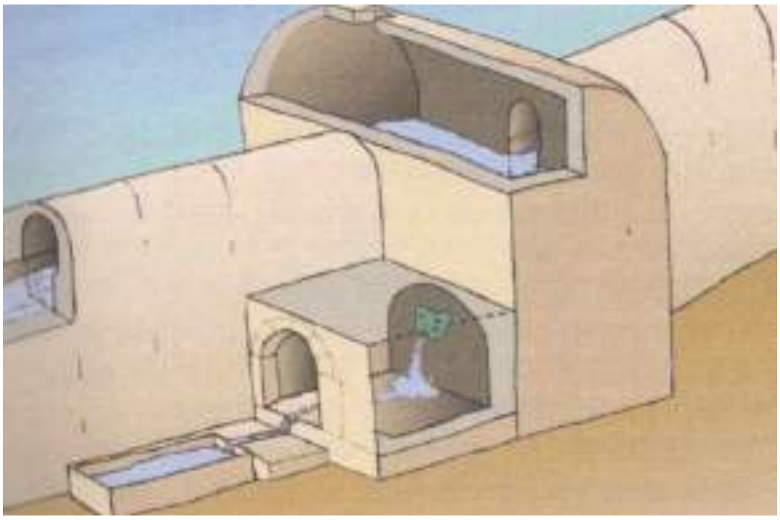

FIGURA 11 » Reconstruction of a *castellum aquae* with *piscinae limariae,* next to a fountain.
Source: FEIJOÓ 2002:387.

- *Castellum aquae* used for inspection, cleaning, or aeration. They are equivalent to the so-called sand traps seen in Segovia (Figure 12) (MARTÍNEZ 2012:142).

FIGURA 12 » First *castellum aquae* for decantation of the aqueduct in Segovia, known as La Casa de la Piedra.
Source: Francisco Javier Espejo.

- Secondary or *second-order castellum aquae, which was the terminal device participating in the distribution system within cities (MARTÍNEZ 2012:142).*

- *Castellum aquae for pressure breakage (like the turris aquae), for pressure control in conduits with steep slopes (MARTÍNEZ 2012:142).*

- Castellum aquae *with overflow regulator function, if the specus exceeded its admissible capacity, sometimes becoming a fountain attached to the aqueduct.*

FIGURA 13 » Terminal secondary castellum aquae with turris aquae function in *Pompeii*.

Included for illustrative purposes of what likely existed in Hispania as well.

Source: https://www.flickr.com/photos/h_savill/2475322869.

Their arrangements and construction forms could be diverse, such as: tower (*turris aquae*) (Figure 13), boxes (*puteus*), pillar (column), or building (*castellum*). Their walls were not intended to contain water but to preserve various components (*inmisairium, emisariu*, *calices, piscinae limariae*, etc.) (MARTÍNEZ 2012:142), so their structure only needed to respond to the stresses derived from the construction itself as a container, not from the device it housed.

4*Conlusions

The complex water situation of the Peninsula, with territories of especially arid climates and low rainfall, along with areas with abundant water resources, does not allow for a single supply solution for each population in the provinces of Roman Hispania. The baths and public baths required a constant and sufficient flow, so the solution of cisterns, which had been used since pre-Roman times, did not guarantee these services continuously.

Some authors estimate that cisterns only collected rainwater, but this hypothesis contradicts the above; to these functions, another of extraordinary importance must be added: the cleaning of the sewer system with the surplus water. Sometimes the water collection, which made these water demands possible, took place several kilometers from the city in question, although constructive evidence of the existence of conduits that made this possible hasn't always been found.

In this sense, it is worth highlighting the difference in nomenclatures adopted to describe the same concept. For example, in Corduba (Roman Córdoba), a turris aquae was also identified, but it was called a second-order castellum; this difference in denominations for the same concept has posed an additional difficulty in analyzing the information and drawing these conclusions. Thus, based on the analyzed data, it can be hypothesized that these towers or second-order castellum must have existed in Roman cities in the same way as in Pompeii, to perform the same function: controlling the pressures of the installation. The cisterns, as in the city of Bilbilis, would have had a similar role in cities with rugged topographies, such as Carthago Nova.

The water collection and distribution systems, following the Roman model almost entirely, were not recovered until the mid-19th century, thanks to the Industrial Revolution. Running water, a true luxury even today in many parts of the world, including in so-called First World countries, was a sign of modernity and progress 2000 years ago thanks to Roman engineering

5* Bibliography"

- ALBA CALZADO, M. "Contribuciones al estudio de las infraestructuras hidráulicas de *Augusta Emerita*". En MANGAS MANJARRÉS, J. Y MARTINEZ CABALLERO, S. El agua y las ciudades romanas. Ediciones 2007. Móstoles, Madrid. pp 147-182. 2007

- ARANDA GUTIÉRREZ, F. et al. "Las presas de abastecimiento en el marco de la ingeniería hidráulica romana. Los casos de Proserpina y Cornalvo". Mérida, excavaciones arqueológicas 9:471-536. 2003

- ARENILLAS PARRA, M. "Presas romanas en España". Ingeniería y Territorio 62:72- 79. 2003

- BARAHONA OVIEDO, M. et al. "En torno a la red romana de abastecimiento de agua a Toledo: excavaciones en los terrenos de la Academia Militar de Infantería". Zephyrus, Revista de Prehistoria y Arqueología vol. 74, pp. 203-223. 2014

- BARBA COLMENAREJO, V. El regadío romano. Instalaciones hidráulicas en la zona arqueológica de Marroquíes Bajos (Jaén). Edita Universidad de Jaén, Servicio de Publicaciones. Jaén. 2007

- BELTRÁN LLORIS, F. y MARCO SIMÓN, F. Atlas de Historia Antigua. Edit. Libros Pórtico. Zaragoza. 1996

- CASTILLO BARRANCO, J.C. "Las presas romanas en España". Revista de Obras Públicas 3475: 65-80. 2007

- CASTRO GARCÍA, Mª M. "Modelos de abastecimiento urbano de aguas en la Bética romana: las cisternas". Espacio, Tiempo y Forma. Serie II, Historia Antigua 30:97-124. 2016.

- FEIJOO MARTÍNEZ, S. "Las presas y el agua potable en época romana: dudas y certezas". En Nuevos Elementos de Ingeniería Romana. III Congreso de las Obras Públicas Romanas. Astorga. 2006

- GARCÍA GARCÍA, M.A. "*Aqua Hispalensis*: Primer avance sobre la excavación de la cisterna romana de Plaza de la Pescadería (Sevilla)". Rómula 6:125-142. 2007

- GONZÁLEZ ROMÁN, C. "Vitrubio y el agua de las ciudades romanas". En MANGAS MANJARRÉS, J. y MARTÍNEZ CABALLERO, S. (eds.). El agua y las ciudades romanas (pp.43-63). Edit. Ediciones 2007. Madrid. 2007

- GONZÁLEZ TASCÓN, I. (coord.) Artifex: ingeniería romana en España. Exposición en Museo Arqueológico Nacional. Edita Ministerio de Educación Cultura y Deporte, Secretaría General Técnica. Madrid. 2002

- HORTELANO UCEDA, I. "La red de acueductos de la Valentia romana. Canales de abastecimiento rural al sur del Turia". Lucentum XXVII: 69-85. 2008.

- JIMÉNEZ MARTÍN, A. "Los acueductos de Emerita". En Simposio Internacional Conmemorativo del Bimilenario de Mérida (pp. 111-126). Mérida.1976

- LARA MEDINA, M. "Sobre el abastecimiento, la distribución y la evacuación hídrica en Gades". Zephyrus, Revista de Prehistoria y Arqueología LXXXI:141-163. 2018

- MARTÍN MORALES, J. *et al.*. "El sistema hidráulico de Cornalvo en Mérida". En Actas del Tercer Congreso Nacional de Historia de la Construcción, Sevilla, pp.665-671. 2000

- MARTÍNEZ CABALLERO, S. "El agua en Tiermes". En MANGAS MANJARRÉS, J. y MARTÍNEZ CABALLERO, S. (eds.). El agua y las ciudades romanas. Edit. Ediciones 2007. Madrid, pp.357-314. 2007

- MARTÍNEZ CABALLERO, S. El acueducto de Segovia. De Trajano al siglo XXI. Edit. Ayuntamiento de Segovia. 2012

- MONTELEONE, M.C. "Defining *castella, piscinae* and Roman water structures: the relevance of geometry, hydraulic operation and water balances". En THE AQUEDUCTU URBIS ROMAE (35 pp.) International Congress on the History of Water Management and Hydraulic Engineering in the Mediterranean Region. Rome. 2018

- MUÑIZ, J.A. Ingeniería romana – Los acueductos I. RADIO TELEVISIÓN ESPAÑOLA [vídeo 1]. 2015. Disponible en: https://www.rtve.es/play/videos/ingenieria-romana/acueductos/5781769/

- MUÑIZ, J.A. Ingeniería romana – Los acueductos II. RADIO TELEVISIÓN ESPAÑOLA [vídeo 2]. 2015. Disponible en: https://www.rtve.es/play/videos/ingenieria-romana/acueductos-ii/5781820/

- OLSSON, R. The water-supply system in Roman *Pompeii.* (Thesis for a licentiate degree). Lund University. 2015. Disponible en: https://lucris.lub.lu.se/ws/files/6332923/8163872.pdf

- PANIAGUA AGUILAR, D. Sexto Julio Frontino. De aquaeductu urbis Romae. Las canalizaciones de agua de la ciudad de Roma. Estudio introductorio, traducción y notas. Edit. Libros Pórtico. Zaragoza. 2016

- RUIZ ACEVEDO, J.M. y DELGADO BÉJAR, F. El agua en las ciudades de la Bética. Editorial Gráficas Sol. Sevilla.1991

- SALAS ÁLVAREZ, J. "El Viaje de España del Marqués de Valdeflores. Un intento fallido de catalogación de los monumentos y antigüedades de España". SPAL Revista de Prehistoria y Arqueología de la Universidad de Sevilla 19:9-24. 2010

- - SALINAS DE FRIAS, M. “Las aguas en el mundo celtibérico: aspectos utilitarios, simbólicos y religiosos”. En MANGAS MANJARRÉS, J. Y MARTINEZ CABALLERO, S. (coords.). El agua y las ciudades romanas (pp. 9-32). Ediciones 2007. Móstoles, Madrid. 2007

- SÁNCHEZ LÓPEZ, E. “Los acueductos urbanos en Hispania”. En CÁMARA MUÑOZ, A. y REVUELTA POL, B. (coords.). Arquitectura hidráulica y forma urbana (pp.11-28). Edit. Ediciones del Umbral. Madrid. 2019.

- SCHATTNER, T.G. y OVEJERO ZAPPINO, G. “Agua en Munigua”. En MANGAS MANJARRÉS, J. y MARTÍNEZ CABALLERO, S. (eds.). El agua y las ciudades romanas (pp.99-132). Edit. Ediciones 2007. Madrid. 2007

- VENTURA VILLANUEVA, A. “El abastecimiento de agua a la Córdoba romana I. El acueducto de Valpuentes”. Monografías nº 197. Servicio de Publicaciones del Seminario de Arqueología, Universidad de Córdoba. 1993

- VITRUVIO POLIÓN, M.L y OLIVER DOMINGO, J.L. (trad.). Los diez libros de Arquitectura. Edit. Alianza. Madrid. 2004 Madrid. 2002