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Ancient Water Supply and Management Systems in the Western Mediterranean

Construction and Operation

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Cover: detail of the Los Milagros aqueduct, Mérida (Photo: J. Acero Pérez).

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Introduction

Water Management in Roman Times: Continuity and Variability in Archaeological Studies[1]

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Humans need water, and therefore effective management and strategic planning for its use and control are required. In ancient times, hydraulic structures were developed to collect water, or to divert its flow, from various sources, including groundwater, rainwater, and surface water. While aqueducts, notably during Roman times, significantly increased the quality and quantity of the water supply, traditional water collection methods - such as wells, cisterns, reservoirs, and drainage channels - continued to be used. These methods served either as complementary systems or for storing surplus water to prevent shortages. Hydraulic structures designed for collecting water were effective because of the construction of devices that distributed water, facilitated its use, and managed drainage These structures formed the 'water cycle', which can be observed in urban, rural, artisan, and cultural contexts. The variety of sources of water and construction techniques reflects a sophisticated understanding of hydrology and technical adaptability, which enabled efficient water management in many communities across the Mediterranean.

Water management has been a topic of scholarly interest for many decades, and examining the material evidence available on this issue is a relevant and contemporary field of research. The regional and local elements s of Roman water management, as expressed through physical artefacts, were influenced not only by the enduring cultural traditions from pre-Roman times in various regions of the Empire but also by the unique climatic and geographical characteristics of different areas. These factors highlight the diversity of the environments and landscapes within the extensive political and administrative structure of the Empire.

Case studies that examine the specific aspects of water management in the territories of the Roman Empire play an important role Publishing collections of data to identify similarities and differences in water management is also important, as it provides a deeper understanding of the continuities, transformations, adaptations, and unique features involved in this field during Roman times (as noted by Klingborg 2022 in the introduction to his work). These efforts to organise information help to clarify the complex nature of a phenomenon that intertwined technical, social, cultural, and environmental factors within the context of Antiquity.

The spread of technical and construction advances in Roman water management across the Empire, along with how experts adapted to various cultural and environmental contexts and the legal and administrative frameworks associated with water management, makes this period a crucial lens for

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understanding the relationship between societies and water resources (Hermon 2008). The author of this volume has holistically examined this comprehensive approach to water management by considering the construction techniques, administrative processes, and social, symbolic, sacred, and ritualistic aspects that established a new way for communities to interact with water.

Incorporating new methodologies, such as spatial, physicochemical, geophysical analyses and digitalization, offers innovative ways to explore how societies interacted with water and the material manifestations employed for its management. The tools offered by these new methodologies enable more precise case studies to be produced and enhance understanding of the complex Roman water collection, distribution, and drainage systems. Additionally, studying these systems provides insights into the symbolic significance of their use.

This monograph offers an updated overview of various case studies on different regions of the western Mediterranean. It examines several themes that illustrate the relationship between the Romans and water, emphasising the tangible aspects of this interaction from an integrated management perspective. The study employs diverse methodological approaches, including archaeology, history, religion, and geography.

The first part of this volume focuses on case studies from Hispania. It reconstructs the water cycle in *Mirobriga* by analysing the material remains available, and it considers public and private perspectives, as well as the topographic layout designed for efficient water distribution. Hydraulic constructions should not be analysed in isolation; they must be understood within their geographical contexts. Technologies such as LIDAR have enabled precise mapping of infrastructures, notably in *Calduba*, which was renowned for its robust hydraulic structures. These new methodologies enhance the understanding of the functionality and symbolism of Roman water collection and distribution systems. This system is an example of practical utility and the aesthetic of this type of structure, reflecting the power and mastery that Rome exercised over nature. A significant, though sometimes challenging to verify, element is the existence of *erogationes*, or the distribution of public water for private use in urban systems, as documented in the works of Frontinus and Vitruvius. This practice has been evidenced in *Augusta Emerita*, thanks to a recent discovery in what is known as the 'House of the Amphitheater'.

Moving into *Gallia Narbonensis*, the southern region of Gaul, remarkable examples of the cultural persistence of hydraulic systems, such as staircase fountains can be found. In Cisalpine Gaul, the study of *Augusta Taurinorum* reveals the complexity of its water supply system through the reconstruction of its water cycle based on the limited remains that have been preserved. While traditional water collection methods continued to be used, the construction of an aqueduct led to the introduction of the advanced technique of an inverted siphon.

On the Italian peninsula, particularly in *Latium*, the use of water and the hydrogeological characteristics of the territory significantly influenced the cultural identity of civic communities, as shown by the study of the city of *Veii*. Urban planning was crucial in water management, incorporating supply, drainage, and sewage systems. For example, the theatre of Ostia featured a complex drainage network integrated into the city's sanitation system to ensure public health.

The imperial villa of Nero at *Subiaco*, located in a mountainous area, is a great example of sustainable water planning with a circular water system designed to adapt to its environment while maximising efficiency. In this context, water was both functional and part of a show of imperial strength, symbolising power and luxury. Likewise, the dynamic nature of water management systems, which adapted to changes in the use of space and the requirements for this usage, is demonstrated in examples such as the luxury villas of *Baiae* and the city of *Abellinum*. Material evidence indicates the evolution of complex water redistribution systems in these locations.

Despite extensive research, Pompeii continues to provide new insights into urban water management. Data management systems and spatial analysis have analysed the various uses of water in artisanal, productive, and commercial contexts. On a domestic level, cisterns located beneath the *impluvia* of the *Domus* offer a glimpse into everyday interactions with water. They demonstrate how access to and maintenance of water were integral to daily life and could be adapted to seasonal needs, highlighting the importance of this resource in Roman households.

As mentioned earlier, the study of water management in Antiquity remains academically relevant and significant. This relevance is evident in the Sustainable Development Goals, particularly Goal 6: 'Clean Water and Sanitation', which emphasizes efficient and universal resource management. Ensuring water quality and adequate sanitation remains a significant challenge for Agenda 2030.

Archaeology and history can play a crucial role in addressing this challenge by raising awareness about the effectiveness of sustainable water systems based on past experiences. This awareness can promote a shift in how water resources are managed at all levels, from individuals to communities. Therefore, these disciplines must actively contribute to fostering a new water culture that is more respectful of the environment, similar to the practices of ancient societies.

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Water Usage in *Mirobriga* (Castelo Velho de Santiago do Cacém, Portugal). An Overview of the Structures of Water Supply and Distribution

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Abstract: the paper discusses the available information on water supply at an Iron Age and Roman Site in southwest Portugal – commonly identified as *Mirobriga Celticorum*. The town rose to awareness in the 1940s largely due to the state of preservation of its two public baths, first identified in 1938. Throughout the 20th century and in the last few decades, the work of several researchers and teams has allowed a concise understanding of this town's urban landscape during the Roman period. In this paper, we hope to add to this knowledge by exploring the documented structures for water supply and its uses in this urban centre.

Keywords: Cistern, *Fistula*, Well, Roman households, Roman baths, Lusitania.

Introduction[1]

The site of *Castelo Velho,* also known as *Chãos Salgados,* near modern Santiago do Cacém (Alentejo), was first documented in the 16th century, in a compilation of Portuguese Antiquities, by André de Resende. Despite some open questions, is widely associated with *Mirobriga* (Encarnação 1996). Resende mentions some of the features he found most striking:

> 'Walls with towers, some intact others ruined, an aqueduct, a bridge in the middle of the valley, and a squared stone 'perennial' fountain, suggested me an ancient city'.[2]

It is widely acknowledged that some of these references are misinterpretations of structures that were only partly visible at the time. Such is the case of the back of the Forum temple, regarded as a tower before its excavation in the 1960s, and the 'square stone fountain' thought to refer to a square *puteal* found near the bridge.

As for the aqueduct, despite Resende's clear mention of it, such a structure hasn't been clearly identified, and the overall subject of water supply to the city poses some critical questions.

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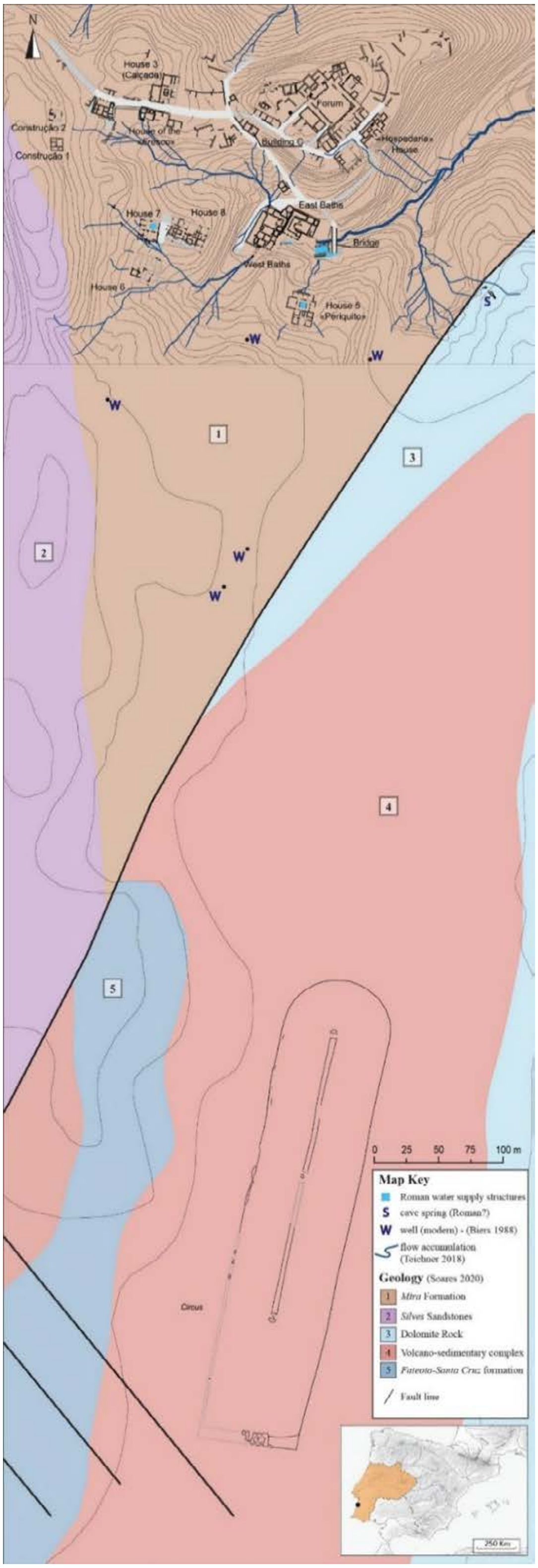
[1] This paper is an expansion on the research for our master's degree on drainage and wastewater management (2017-2019). We thank our supervisors at the time, Profs. José Carlos Quaresma and Rodrigo Banha da Silva; to Filipe Sousa for all the help in on-site recordings and constant fruitful debates; as well as Manuela de Deus of the *Direcção Regional de Cultura do Alentejo*, and the team of the *Centro Interpretativo de Mirobriga*, for the support throughout our research. We also thank *Câmara Municipal Santiago do Cacém* and *Museu Municipal de Santiago do Cacém*, namely Fernanda do Vale, the access to the plumb *fistulae* of the J. G. Cruz e Silva's collection and support given to our research. This research was funded by national funds through the FCT - *Fundação para a Ciência e a Tecnologia* (PhD scholarship 2020.06757.BD) and had the support of CHAM – Centre for the Humanities (Strategic Project UIDB/04666/2020).

[2] Author translation. Original latin text: *Muri cum turribus, alibi integri, alibi vero semidiruti, aquaeductus, pons in intermedia valle, & quadrato lapide perennis fons, antiquae me ciuitatis admonuerunt* (Resende 1593: fol. 188).



The research conducted between 1981-1988 by a team from the University of Missouri-Columbia was the first to mention the subject of water supply. Their surveys found no evidence of a major aqueduct but identified one water spring possibly dating to the Roman period. Later excavations would provide more data on this subject, especially the 2005-2010 research conducted by the team of the University of Marburg on some of the domestic buildings. More recently, M. P. Reis' 2014 research on the bath buildings as well as our analysis on drainage and sanitation, in 2019, have aimed at a wider scope on the subject of the city's water supply.

In this paper, we've aimed to amass the current state of knowledge on the means of water supply, confronting the local geological background and the known structures with the city's documented water needs (**Figure 1**).

Historical synthesis

Human occupation of the site is thought to date to the Bronze Age. However, the most consistent data is from the Iron Age onward, roughly from the 9th/8th *c.* BC (Soares and Silva 1979; Slane *et al.* 1984: 56).

The site was in an area of Celtic/Continental influence. It is plausible that the Iron Age settlement would have occupied only the central hill. Despite the lack of research on this subject, based on the available evidence C. Fabião proposes it may have been a Type V settlement as defined by L. Berrocal-Rangel (1998: 233-234).

The area came under Roman control during the military campaigns of *Decimus Junius Brutus* in Lusitania, *c.* 135-137 BC, at the latest (Quaresma and Silva: 2021). Upon the administrative re-organisation of the *Hispaniae*, the area was ascribed to the *Conuentus* of *Pax Iulia*, nowadays Beja, and likely given the status of *oppidum stipendiarium* (Encarnação 1996). However, little is known about the urban landscape of this period and how much, if any, of the indigenous urbanism survived into Roman times.

Figure 1. Plan of the site Castelo Velho - Mirobriga *and geological map of the area. Own work based on* Mirobriga *site cartography (courtesy of* Centro Interpretativo de Mirobriga*) and information compiled from Biers 1988, fig. 8; Quaresma 2012, figs. 4–5; Soares 2020, fig. V.5; Teichner 2018e, figs. 4–5. Location of the site in the province of Lusitania.*

In effect, most of the known urban layout corresponds to buildings dated from the Flavians onwards. One exception is the *Forum* complex, which dates to Claudius/Nero (Biers *et al.* 1982: 36; Peña Cervantes *et al.* 2018: 209–210; Teichner 2018a). This urban transformation could relate to the settlement's ascension to the municipality in the Flavian Period, as is widely accepted.

Building investment continued throughout the 2nd and, possibly, in the early 3rd century AD. However, the mid-3rd century represents a turning point in the urban landscape, with several buildings being abandoned. Despite subsequent reoccupation and transformation of some buildings, in the late 3rd to early 4th century (Sousa 2019: 101–107; Teichner 2021: 77–78), this period is marked by the absence of new buildings and by the extensive reuse and adaptation of existing buildings, some of which were partly ruined.

There is scarce information about the urban landscape and demography from the 4th century onwards. New analysis and interventions have increasingly provided more information, attesting that the site remained occupied at least until the 6th century. However, the characteristics of this occupation are still an ongoing research topic (Quaresma 2022).

Geological context and hydrogeology

The area's variegated stone and mineral resources are the result of the confluence of various formations and fault lines. The plains surrounding the site are extremely fertile and well irrigated, most included in what is called the Portuguese *Reserva Agrícola Nacional*, a designation that aims at protecting the most fertile lands exclusively for agricultural purposes.

The urban perimeter itself stands in the Palaeozoic *Mira* Formation, dated to the Carboniferous Period, which in this area is mainly made up of shale and some greywacke. Although this type of bedrock is impermeable by nature, water still can infiltrate the superficial and fractured areas (Pinho 2003: 83). In effect, the area is punctuated by small shallow underground perched water tables, which have been efficiently exploited in modern/contemporary times through traditional excavated wells[3] (Inverno *et al.* 1993: 60).

This impervious bedrock is prone to significant accumulation of runoff water and trough flow, as calculated by the Marburg team (Teichner 2018e, fig. 5), and is the reason for the formation of a seasonal stream that crosses the urban centre. This issue, which we've addressed in previous works (Felício, 2019; Felício and Sousa 2023), resulted in the adoption of several waterproofing solutions in various buildings during the Roman Period (Acero Pérez and Felício 2021).

The *circus*, to the south, stands on a different formation, a volcano-sedimentary complex, formed during a rifting event in the Mesozoic, and made up of three deposits of basalt, dolerite and basic tuff, alternating with dolomitic marl and, to a lesser degree, oolite (Lavaredas and Silva 1998). The formations upon which these two areas of the city stand are separated by a fault line and a formation of dolomite rock.

Urban landscape and Demography in Roman Imperial Times (1st – 3rd centuries AD)

There is scarce data regarding the urbanism of both the Iron Age and Early Roman phases of the site. The latter half of the 1st century represents a great transformation brought about by the extensive building investment, overlapping all previous urbanism.

There is also a marked gap in our knowledge of the population that inhabited the site throughout these periods. Did it maintain its numbers or change? Due to the lack of data, there is, unsurprisingly, no

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[3] Loose translation by the author: *Encontram-se nesta situação os depósitos de cobertura de pequena espessura, os 'Grés de Silves' e o Paleozoico, nos quais por razões económicas, profundidade de corrência de água e facilidade da sua captação se construíram poços tradicionais, que dada a grande superfície de entrada de água nestas obras se revelam relativamente eficientes para captarem pequenos reservatórios subterrâneos, quase sempre de tipo suspenso e de natureza local* (Inverno *et al.* 1993: 60).

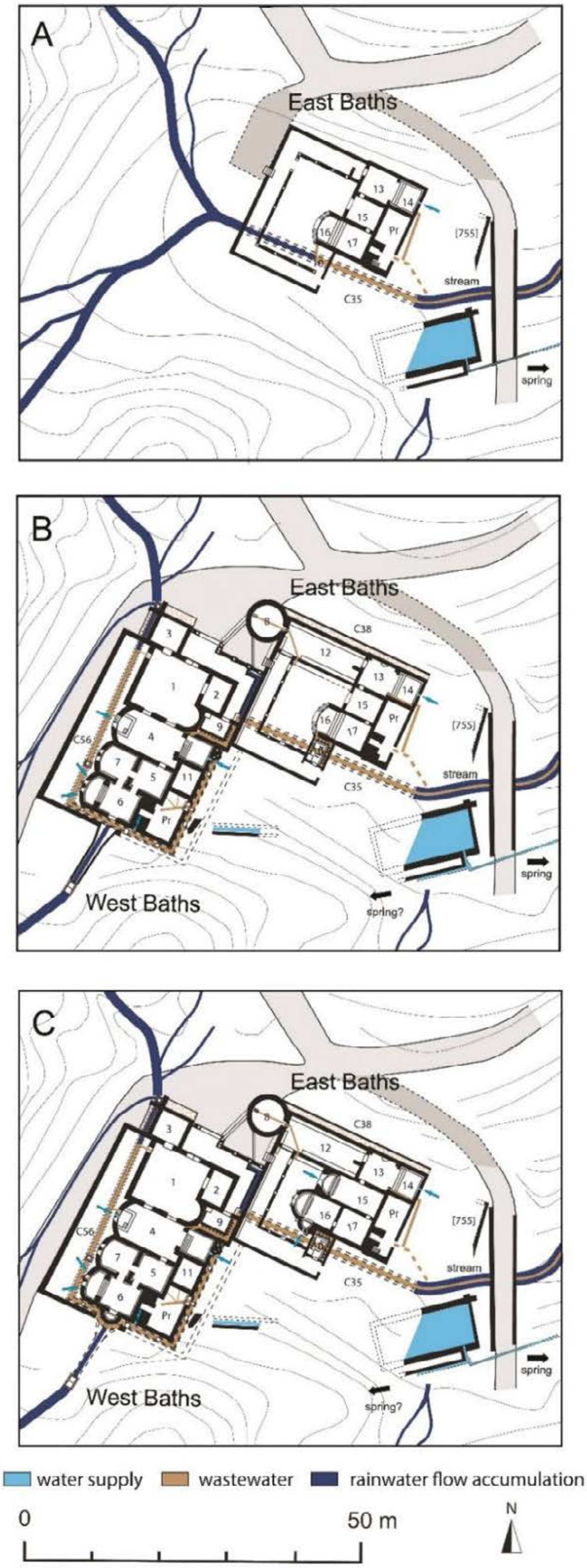

Figure 2. Evolution of the East and West Bath's water systems. Own elaboration (flow accumulation lines adapted from Teichner 2018e, fig. 5).

estimate for the number of inhabitants before the 1st century, and some of the estimates for the Imperial Period (from 1500/2000 to 25000) (Fragoso 2017; Teichner 2021: 72–73), are too variable and based on unreliable or undisclosed criteria to be taken at face value. They also seem, at least to us, exceedingly high.

It seems logical to assume that the likely attribution of the municipal status in the Flavian period brought about a demographic increase. However, the urban perimeter itself is very reduced, as shown by both traditional (Slane 1988c: 23–25) and geophysical surveys (Teichner 2018c). Furthermore, the results seem to point to a scattered pattern of urbanism, made up of isolated or small groups of buildings dispersed throughout the hills and valleys around the forum complex, and connected through a network of roads (Teichner 2021). This suggests the urban perimeter wasn't evenly urbanised, with subsequent implications to the demographic density.

Infrastructure and means of water supply

The bath buildings

The two buildings, sometimes referred to as double baths (e.g. Nielsen 1990), were built in separate moments. The first, called the East Baths, dates possibly to the late 1st to early 2nd century, while the latter, dubbed the West Baths, was probably built a few decades later, in the first half of the 2nd century (Biers and Biers 1988). The second building was placed beside the first, hence creating what some consider a double complex. However, in our view, this designation suggests a cohesion or symmetry between the two, when, in reality, they present different construction techniques, have independent accesses and different interior organizations, and should be analysed individually, as attested in their original publication (Biers and Biers 1988: 106).

Different hypotheses for their placement criteria include: The need to accommodate more users without demolishing the original building; different ownership; or the creation of separate venues for men and women. Regardless of the social motives that dictated the need for the construction of a second building, the reason the two buildings were placed side-by-side seems to be strongly connected to the logistics of water supply and evacuation (**Figure 2**).

The need for an efficient water supply was paramount in both buildings and the topography of the site didn't allow much room to accommodate bath buildings in other areas. This makes it one of the few, if not the only, suitable places to build a bath. Moreover, the known water sources are located at a low level, dictating that efficient water would only be achieved if the baths were also at a low point.

Moreover, the need to evacuate the wastewater produced within the baths also had to be considered when choosing a location. In this regard, it is relevant to point out that the city lacks a proper underground sewage system, and that, for the most part, wastewater was simply disposed of in the streets (Felício 2019; Felício and Sousa 2023). This absence meant that the baths had to be placed in an area where the waste could flow away from the urban perimeter. As such, the seasonal stream, occurring at the bottom of the valley was the selected means of washing away the undesirable used waters.

Evidence strongly suggests that the two buildings had shared ownership and were, as is widely accepted, probably property of the *civitas*. This conclusion arises from the fact that the sewage systems of both were entwined, with the West Baths (most recent) being completely reliant on the system of the East Baths (for the analysis of the bath's sewage system see Felício and Sousa 2020).

As for the supply system, it seems plausible that the two buildings also shared some structures, although, some issues require further excavations.

Water Sources

The surveys conducted in 1981-1984 by the Missouri team, encompassed the known urban perimeter and its surroundings, identifying several wells, modern in construction, and four springs in the vicinity, although none were located within the urbanised area. The lack of built features deemed that only one of these springs could be more soundly considered as being in use since Roman times (**Figure 1**).

This spring is located southeast of the site and consists of a cave-like structure. The cavity was considered manmade and presented reinforced masonry walls on either side. It lies slightly outside the main built perimeter.

The front of the cave presented a structure described[4] as a reservoir or basin, where outflowing water could be contained. The innermost part of the structure was deeper and had steps which allowed the drawing out of water in drier seasons (Slane 1988c: 22) (**Figure 3**).

Outside, in the vicinity of the cave, the author mentions other structures, considered to be modern, attesting to the longevity of this water source (1988c: 23). It was noted that no traces of an aqueduct or

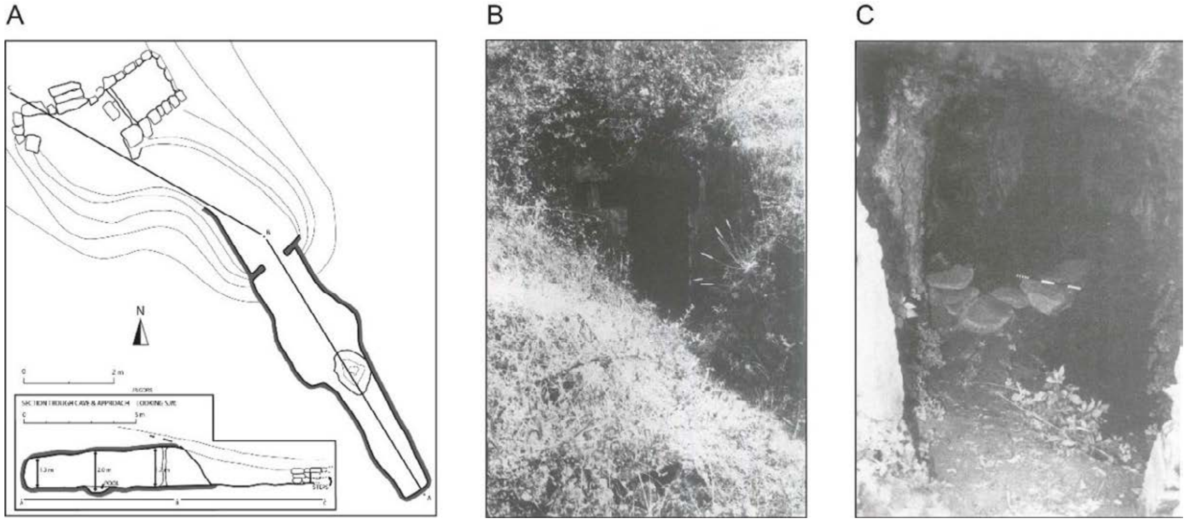

Figure 3. Section and general aspect of the spring cave. Graphical re-work of (Slane 1988a: 268–269).

[4] We refer to K. Slane's published description. The structure isn't currently accessible as it sits in privately owned land.

other water conduction structure were visible at the time (1988c: 12). At the time, K. Slane didn't suggest a specific use for this source's water. In 2014 M. P. Reis proposed a connection between this source and the baths, based on the proximity and compatible elevation of the structures (Reis 2014: 214–215).

The precise location of this spring is interesting as it stands over a fault line at the separation between the *Mira* formation (shale) and the dolomite rock formation (*Silves* Pelite-Carbonate Evaporitic formation[5]) (**Figure 1**). Although both geological formations are very impermeable, fault zones can act as complex hydraulic conduit–barrier systems and create either areas of increased permeability, along their so-called damage zone; or encourage along-fault flow (Bense *et al.* 2013). In either case, this may result in the facilitated occurrence of surface springs and explain the selection of this particular place for the construction of a water collection structure.

Water Storage

In 1992-1994 excavations between the bridge and the East Baths uncovered what was then considered a swimming pool (*natatio*) (Barata 1997, vol. 1: 78; 1999: 69–70). In 2004-2005 a new intervention, albeit focused on the bridge, uncovered new channels connecting to this structure (Quaresma 2004; 2005) (**Figure 4**). The structure's interpretation as a *natatio* was maintained by J. C. Quaresma in this new intervention. It heavily influenced the interpretation of the different contexts and structural stratigraphy published in the author's work (Quaresma 2012; 2014).

Nevertheless, since the structure isn't directly connected to the users' circuit and is, essentially, located outside the precinct of either bath complex, M. P. Reis has reinterpreted it as a water reservoir, associated with the supply of both bath buildings (Reis 2014: 214–215).

The construction of both the bridge and the reservoir was dated to the first half of the 2nd century (Quaresma 2012: 33). This dating was based on the deposits that accumulated in the space between the two structures and, as such, only established *ante quem* for both, and not that they are contemporary. Although the reservoir lacks direct dating, it is unlikely to predate the first bath complex, built somewhere in the late 1st or early 2nd century (Biers and Biers 1988: 109). The relationship between the bridge and channel [742][6], as seen in the report's photographs, suggests that the bridge may have been built after the reservoir, as its structure stops just before reaching the channel as if deliberately avoiding it.

The reservoir is built in stone masonry, with a buttressed corner, facing the stream. The interior waterproofing coating is still preserved. Although still largely unexcavated, a sounding in the NE corner exposed the bottom and revealed that the structure had waterproofing moulding along the bottom and corners[7]. However, this intervention still awaits full publication, and the collapse of the earth banks has since covered the area. The 2004-2005 intervention has removed part of the upper deposits in the reservoir but doesn't seem to have exposed the bottom (Quaresma 2004; 2005). Based on the photo in (Barata 1997, vol. 2) we've estimated the reservoir's depth, from the ledge, at about 2.4m. The maximum water height would have been around 1.5m (**Figure 4: D**). The western limit of the reservoir is still unknown, but the exposed part of the structure is large enough to hold more than 106m^3. M. P. Reis proposed an estimate of 33.15m^3 and 39,97m^3 for each cycle of the East and West Baths, respectively (Reis 2014: 213), which could be satisfied by the volume stored in the reservoir, but the effectiveness of this water storage varies greatly if we consider that it supplied just one or both complexes; how often the water was changed; and how much time it took to fill the reservoir.

Along the southern side of the reservoir runs a second compartment, circa 1m wide, whose western limit is also unknown. Traces of waterproofing are not visible in this structure.

[5] Not to be confused with the *Silves* Sandstone Formation.
[6] Numbers refer to the SUs in reports/pubblications (Quaresma 2004; 2005; 2012; 2014).
[7] Photo 95 in Barata 1997, vol. 2, shows conservation action taking place on the waterproofing lining and it is possible to see the exposed bottom of the reservoir.

J. C. Quaresma suggested this second compartment could be an addition (Quaresma, 2012: 71). However, following the author's description[8], and upon analysing *in situ* the architectonical stratigraphy of the structure, it can be observed that the southern compartment was built along with the reservoir itself. M. P. Reis has proposed this compartment could be a feature for moving water to the *praefurnia* of the West Baths (2014: 215). Unfortunately, the uncompleted excavation prevents us from fully understanding its function.

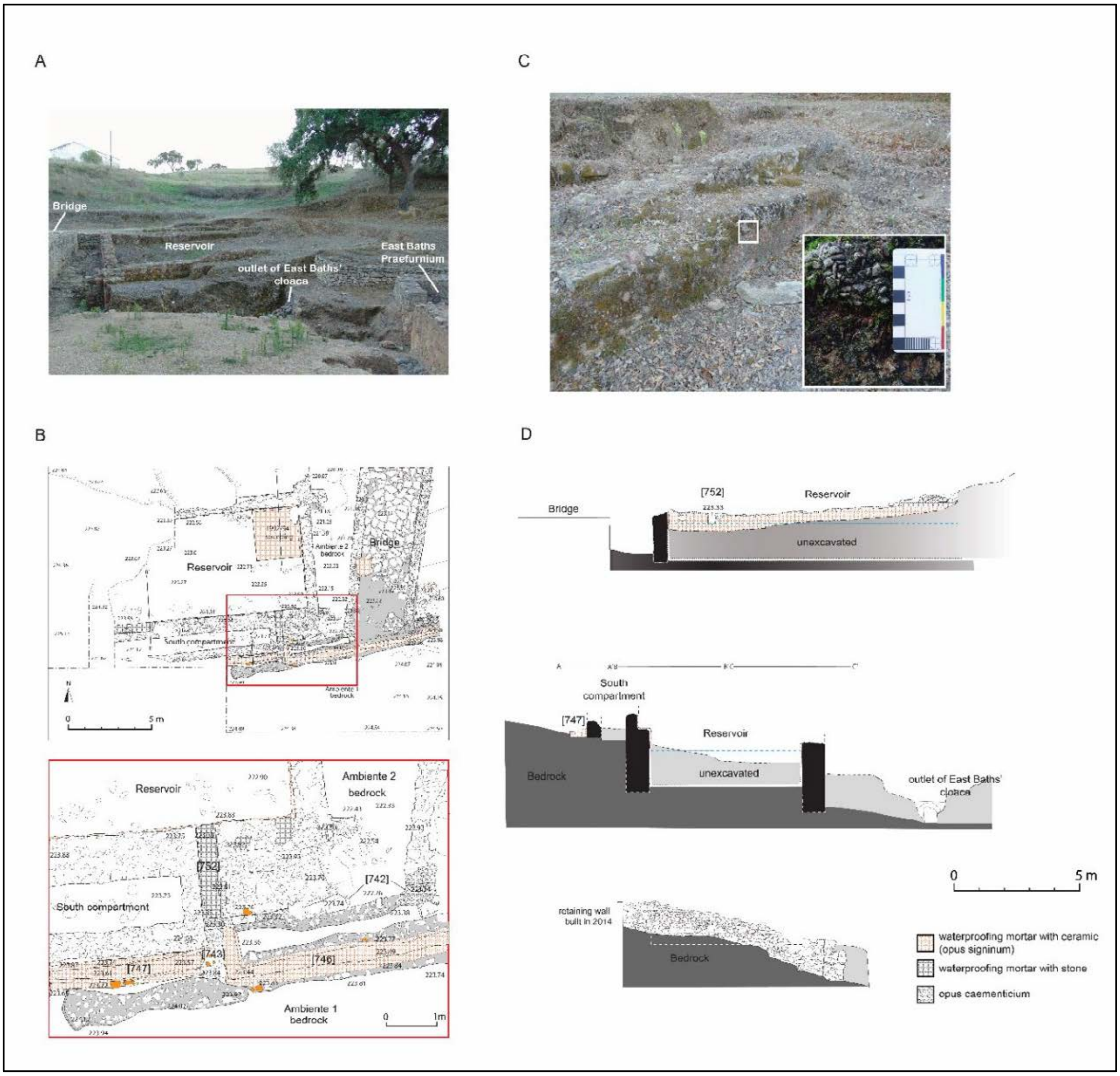

Figure 4. A. Overview of the Reservoir. Photo by the author; B. General plan of the water reservoir and detail of its supply network. Own elaboration from photogrammetric model compiled with plans of pre-restoration/covered structures published (adapted from Barata, 1997, vol. 2, photo 95; 1999, fig. 7; Quaresma 2012, fig. 25); C. Ledge of the Reservoir and detail of the joint between the two waterproofing mortars used (photos by the author); D. Views of the reservoir's elevation and cross sections with hypothetical depth (elab. by the author from a photogrammetric model).

[8] '(...) no *restante muro que divide o compartimento sul do próprio tanque o material parece totalmente imbrincado*' (Quaresma 2012: 71).

The wall that divides the two compartments forms a ledge, coated in a waterproofing mortar, similar to *opus signinum*, but using gravel instead of ceramic fragments. Unlike the inside of the reservoir itself, which uses a typical *opus signinum* mortar and presents a rosed hue, this mortar has a distinct greyish/white colour (**Figure 4: C**). The reasons for using different mortars in the reservoir and ledge are unclear but it seems a contemporary action, and not the result of a reform.

The same mortar was described by J. C. Quaresma in supply channel [752][9], the only documented water inlet, located near the southeastern corner of the reservoir. The inlet was built together with the reservoir's structure and is 0,43m wide and has a preserved height of 0.74m.

The 2003/04 excavations found evidence for several phases in the reservoir's supply channels, indicating that different sources were used over time.

The earliest documented water source is channel [742], a small underground aqueduct built in a coarse *opus caementicium* and covered with limestone slabs (Quaresma 2012: 71).[10] The channel extends outside the excavated area to the east, which, as proposed by M. P. Reis (2014: 214–215), is compatible with the location of the cave spring described by K. Slane (1988c).

Evidence from the excavation strongly suggests that, at a still undetermined moment,[11] this channel collapsed into *Ambiente* 2 (Quaresma 2014: 130) and that the decision fell not on repairing the damages, but on building a new aqueduct parallel to the original: [746].

Based on the published graphic record, there is also a strong probability that channel [747] was added during this intervention. The original excavation report and publication consider that [746] and [747] were built in separate moments, with [746] being later (Quaresma 2004). However, the waterproof moulding of [746] forms an angle that seemingly runs under wall [743], that superimposed the channels in a later moment strongly indicating a continuity of the *opus signinum* mortar and that the two channels may have been built together (**Figure 4: B**).

Both channels share a similar construction and consist of relatively deep trenches dug into the bedrock and lined with waterproofing mortar (*opus signinum*). J. C. Quaresma remarked a difference in the quality of the mortars between the two channels, which resulted in the lining in [746] being less well preserved and presenting a rougher surface. Both present waterproof mouldings and, to achieve the intended profile, small bricks and shale slabs were placed on the sides and used to support the mortar (Quaresma 2012: 71–72). The digging for channel [747] exposed the outer side of the reservoir's south compartment, which hadn't a faced finishing, showing it had been built against the terrain (see Quaresma 2012, fig. 40).

The construction of channel [747] attests that at that moment it was deemed necessary to increase the water supply with the construction of a new aqueduct collecting from a yet unknown source located to the west. It is tempting to associate this increment with the construction of the West Baths. However, besides the absence of dating evidence, it isn't certain that this reservoir supplied both bath complexes.

At some point, channel [747] was deactivated through the construction of wall [743]. Unlike the remainder of the channels, this blockage isn't waterproofed. The reason for cutting off this channel may have been that this second water source was either depleted or channelled elsewhere, forcing the closing of the structure to prevent water still incoming from the east from entering the now decommissioned channel. J. C. Quaresma's description of the technical quality of wall [743], built in poor masonry, using stone and some tile, bound with clayish earth (2012: 72–73), resonates similarly to some vernacular structures found throughout the site, built during the latter half of the 3rd to early 4th century (Oberhofer 2018a; Sousa 2019).

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[9] The author uses the designation *opus caementicium* for this type of mortar in the excavation reports and published works (Quaresma 2005; 2012; 2014). On-site observation has confirmed it to be the same mortar used on the ledge.

[10] The author uses the designation '*pseudo opus caementicium*'.

[11] It has been suggested that these events may have taken place in the late 2nd to 3rd century (Quaresma 2012: 72), however, the only chronological data were found in SU [729], whose stratigraphic connection with the channels isn't direct (see Quaresma 2012, figs. 27, 41 and 42).

The last known stage of the reservoir's functioning saw [746] as the sole remaining water source, presumably still collecting from the cave spring to the east. Since the data from the 1992-1994 sounding isn't currently available and the filling of [746] itself produced no dating finds, the chronology for the reservoir's cease of functioning is still unclear.

The 2004-2005 intervention on the north side of the bridge also uncovered part of another structure, [755], located between the *frigidarium* (rooms 13 and 14) of the East Baths and the bridge. However, it is still insufficiently excavated to have a secure reading (**Figure 5: A**).

Its location shows some similarity with the position of the reservoir to the south and, probably, it may also be connected to the baths. J. C. Quaresma has also noted this and proposed they could be part of the same urban plan (Quaresma 2012: 63; 2014: 127). Although no mortar lining is visible at this stage, the structure may be another reservoir.

If the hypothesis is confirmed, it would imply another water source on that side of the valley. To this regard, we recall the proximity of C38[12], a structure possibly added in Phase 2 of the East Baths, analysed in previous work, and interpreted as a double-walled feature intended to protect the north side of the building from infiltrating water (Felício 2019: 115–118; Acero Pérez and Felício 2021: 152, 156) (**Figure 5: B-C**). If this second reservoir is confirmed, the structure could be related to its supply. In that case, the structure could have acted as a deflective barrier that channelled rainwater to the reservoir. If confirmed, this would mean a mixed supply to the East Baths, provided by both spring and rainwater.

Moving stored water to the service rooms

The incomplete excavation of some of the structures makes it difficult to understand how water was moved to the *praefurnia*. Moreover, as we'll discuss, it is still unclear if the reservoir supplied both complexes or just the East Baths.

The supply to the East Baths was probably made from the reservoir's northwest angle, still unexcavated, which would be the closest to the service room. The means of connecting the reservoir to the *praefurnium* are still unknown. It is plausible to consider the existence of an aerial conduct, crossing the space between the reservoir and the building. In this case, it would be necessary to excavate the area to the east of the latrine, to confirm the existence of support pillars.

It is interesting to point out that the supply to the *frigidarium* (room 14), whose walls are very well preserved, wasn't made through the service room, but rather from the exterior wall, facing the possible second reservoir (**Figure 5: D**).

Regarding the West Baths, in the absence of another visible reservoir, M. P. Reis has considered the working hypothesis that it was also supplied by the one near the bridge. The author noted that the pools in that complex were higher than the reservoir, making it incompatible with gravity-driven supply and proposing the existence of an elevation mechanism (Reis 2014: 214).

However, keeping in mind that there is another undiagnosed water source in the area, where channel [747] was collecting from, the two baths weren't necessarily supplied by the same reservoir. In effect, the West Baths could have been supplied by that yet unidentified source. Although it isn't clear where the water intended for the West Baths would have been stored, there is some evidence for its transport to the *praefurnia.*

M. F. Barata mentioned that in 1996, the removal of stone piles left by previous excavations in the area to the south of the baths uncovered a structure which could be another reservoir, stating the existence of waterproofing mouldings in its base[13] (Barata, 1997, vol. 1: 78). The structure hasn't been excavated and is nowadays partly covered by foliage and accumulated earth. In our observations we could attest

[12] Channel numbers refer to the inventory and study of drainage structure in Felício (2019).

[13] The author refers to photos 91-93 in vol. 2. (Barata 1997). However, the mentioned photos pertain to the latrines and sewer of the West Baths and no photos of this structure were included in the volume.

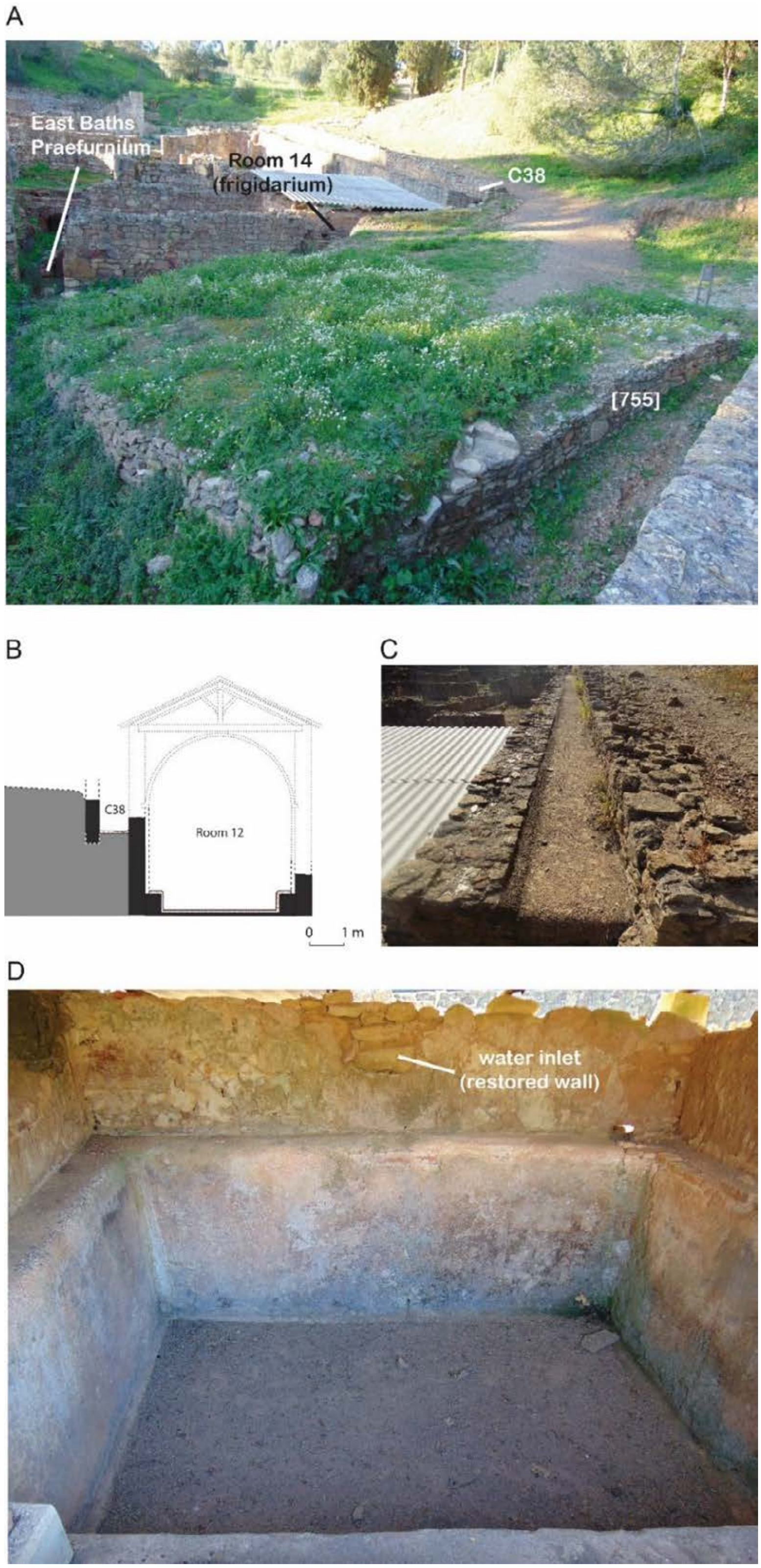

Figure 5. A. View of structure [755]; B. Cross section of structure C38 and Room 12; C. View of structure C38; D. Location of water inlet in the frigidarium *at Room 14 (photos and drawing by the author).*

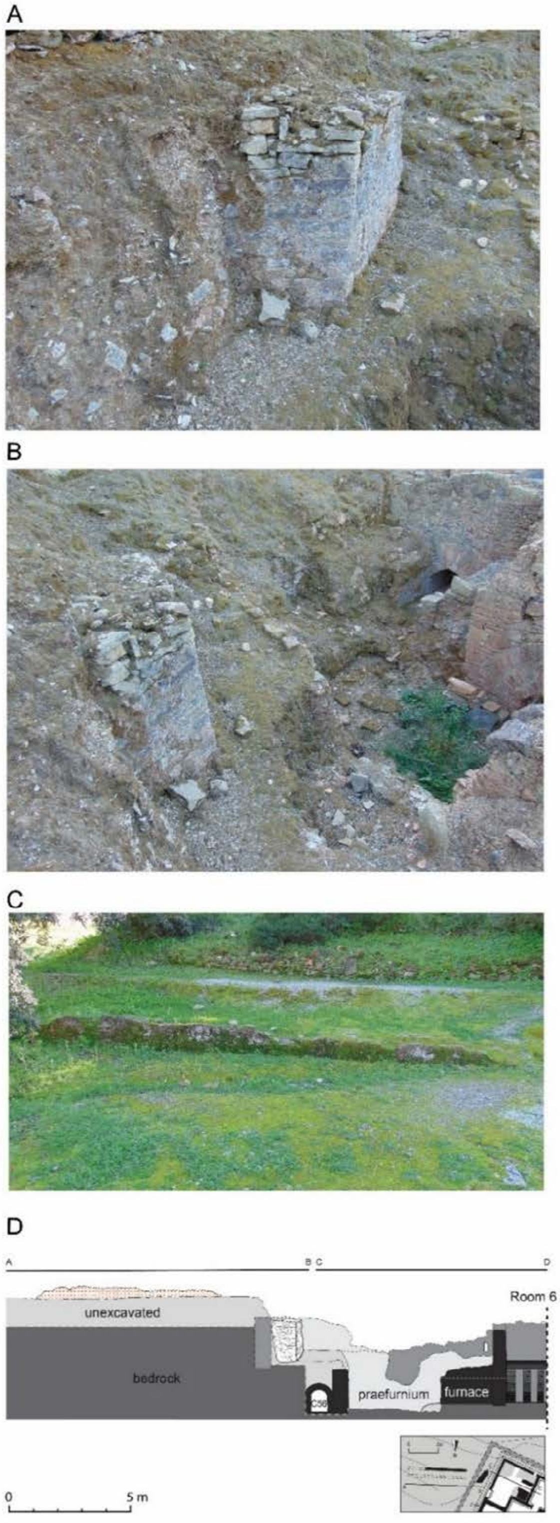

Figure 6. A-B. Views of the tower; C. View of the waterproofed wall (photos by the author); D. Cross section of the structures and the praefurnium *of the West Baths (elab. by the author).*

a single visible wall, with an *opus signinum lining* in its north face. The bottom and waterproof moulding by M. F. Barata were not visible, and we couldn't determine its height. The wall runs roughly West-East, it is 0.38m wide and elevates circa 0.5m from the soil (**Figure 6: C-D**). Its interpretation as a reservoir has raised us some questions because the distance between the structure and the precinct of the East Baths is quite short, and there doesn't seem to be enough space to accommodate a large structure. Moreover, given how slender the wall is, it doesn't seem strong enough to hold the weight of the stored water. This is especially relevant since the structure stands on a slope above the baths. This high location would mean that any storage structure would require extensive reinforcing and buttressing on the lower side, which couldn't be found. As such, we consider it unlikely that this structure could have been a reservoir, and, instead, interpret it as the wall of a channelling structure. The wall disappears just before reaching a structure defined by M. P. Reis as a tower built in stone masonry, located near the service room of the West Baths, which the author proposed could have been a water tower (Reis 2014: 214). It is plausible that these two structures, channel and tower, formed part of a small aqueduct system responsible for supplying water to the *praefurnium* of the West Baths.

Distribution system

Upon arriving near the *praefurnia* water would have been passed from the masonry channels to a pressurised pipeline. Both the Municipal Museum of Santiago do Cacém and the *Mirobriga* Interpretation Centre have a small number of *fistulae* in their collection, found in early campaigns and deprived of context. The collection of the Municipal Museum was gathered during the works of J. G. da Cruz e Silva, a local archaeology enthusiast, who, among other areas, discovered and excavated the West Baths from 1938 onward. The author does mention the existence of plumb pipes in the baths, still visible on-site in 1946, but doesn't describe them nor specify their location. Upon looking at the author's account and at the extent of his excavations (Silva 1946), the *fistulae* of the Municipal Museum likely came from the West Baths, although this is still a working hypothesis. The collection comprises nine fragments of plumb *fistulae*. Eight of these (MMSC 672.1-4) belong to the same pipe, with an inner diameter of 57-65mm, which presents a curve. The other (MMSC 672.5), with an inner diameter

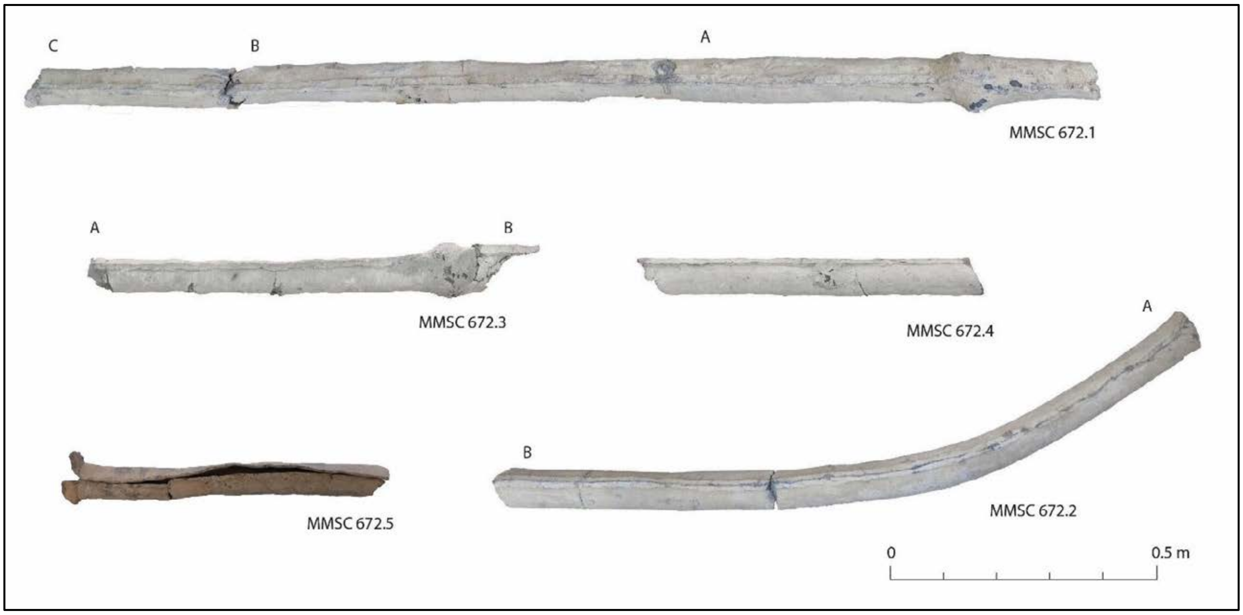

Figure 7. Collection of plumb fistulae *in the Municipal Museum of Santiago do Cacém, found during the campaigns of J. G. da Cruz e Silva (photos by the author).*

of 48mm and a rectangular fitting shows signs of having been placed through a wall and corresponds to a terminal piece which possibly supplied a tank or pool (**Figure 7**).

The supply of the *frigidaria* may have been done directly from the reservoirs to the pools. As seen for the East Baths, the pool was supplied through the east wall, facing the presumable reservoir on the north side of the valley.

As for the larger pool of Room 4, in the West Baths, the opening in the wall for the water inlet is still visible, in the east wall. Directly behind this wall is an interesting set of structures, identified in a sounding by the Missouri team in 1983. They consist of two bonded walls, forming a right angle, that abuts to the back wall of the pool. Between these stands a quadrangular structure, dubbed 'platform', built in brick, stone and white mortar (Biers and Biers 1988: 65). Although some authors have since suggested it could be a pre-existence (Teichner 2020: 830 and fig. 2), the data from the original intervention shows that the structure was built on top of the vault of the sewage channel (C56) and abuts to the wall of the pool in Room 4, making it impossible to predate its construction (Biers and Biers 1988: 65). (**Figure 8: A-B**).

Given its proximity to the inlet, it seems safe to conclude, as proposed by W. R. and J. Biers, that it was part of the bath's water supply, although its precise operation isn't self-explanatory. The authors proposed that the squared feature inside the structure could have been some sort of small reservoir (Biers and Biers 1988: 65). The angle of this triangular structure seems to echo that of the water tower, making it plausible to consider that these structures were connected, forming a small arch or pillar-based piped aqueduct. As the area between the two wasn't excavated, another pillar or base may be still uncovered. Regarding the hot water cycle, despite having more furnaces, each building would have had a single boiler, as attested by the two masonry bases, preserved in the *praefurnia* of each building (**Figure 8: C; Figure 9: A**). While the structure at the West Baths is still partly covered, at the East Baths, it is visible a small staircase that allows access to the top, for operating and maintaining the boiler (Reis 2014: 203). Although the exact configuration of the boiler system is unclear, both bases are large enough for the boiler as well as a raised water tank, akin to the one found at *Villa della Pisanella*, in Boscoreale. In this regard, the Municipal Museum's collection also includes a fragmented piece in plumb. However, it is unknown whether it was found in the baths or not, so it could have belonged either to a boiler or any type of container.

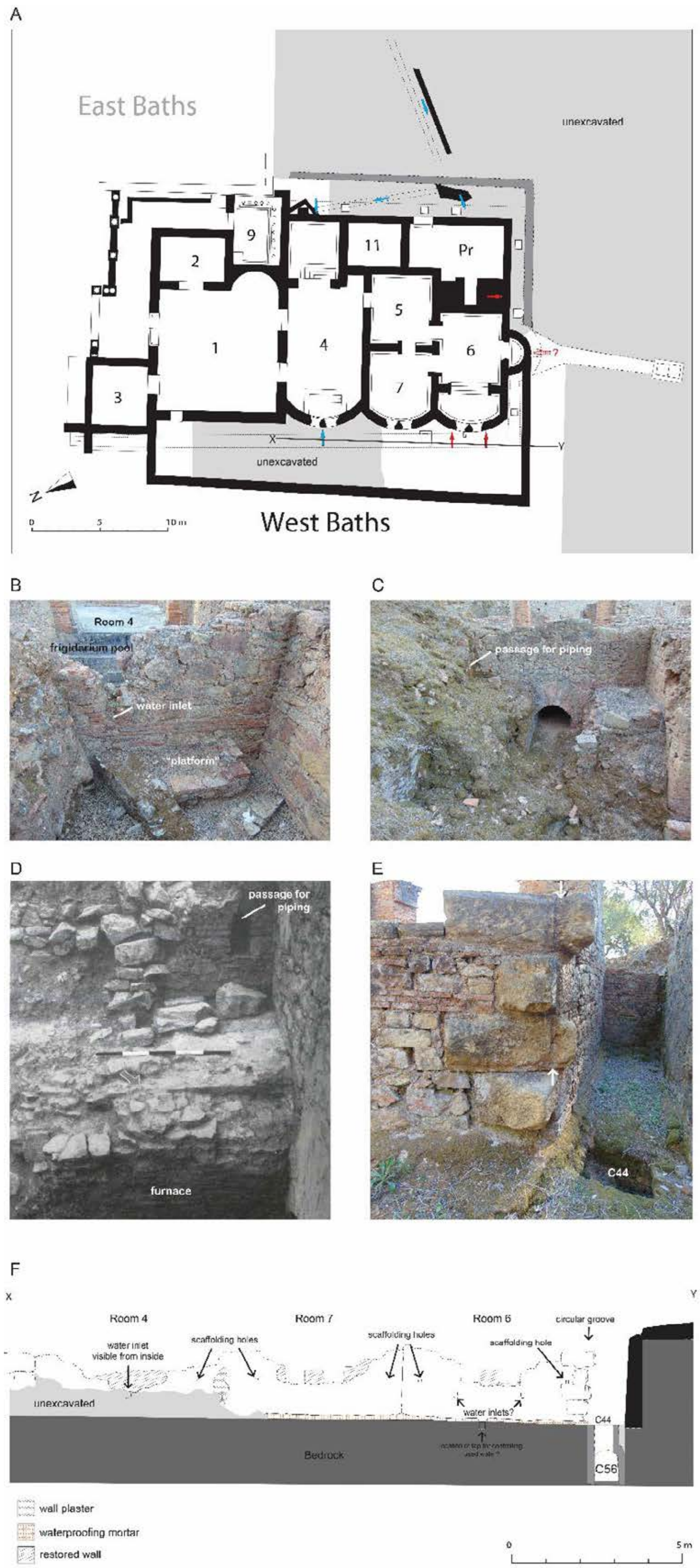

Figure 8. A. Reconstructed floor plan of the West Baths (compilation from Biers 1988 and photogrammetric model), B. View of the structure/base situated near the frigidarium *inlet (photo by the author), C. View of the* praefurnium, *behind Room 6, showing location of the opening (Photo by the author), D. Opening in the southwest wall of the* praefurnium, *above the base for the boiler (Biers 1988, fig. 136), E. View of the west corner of Room 6 showing the groove cut into the ashlar blocks (photo by the author), F. Section of part of the west façade of the West Baths (elab. by the author from photogrammetric model).*

One other aspect shared by both buildings is that the pools are placed on the opposite side of the room from the boiler. This meant that piping would have to go around the building to supply them. As there is no trace of piping inside the walls themselves, they would possibly have been hung on the exterior

Figure 9. A. View of the base for the boiler in praefurnium *of the East Baths, behind Room 17, B. Projecting stones in the apses of Room 16 (photos by the author)*

surface of the walls. This path had obvious implications in terms of energy efficiency, as the uninsulated plumb *fistulae* would probably lose a lot of heat.

The fact that the pipes had to go around the buildings meant that transformations such as the addition of a small apse and pool in the West Baths (Felício 2019; Felício and Sousa, 2020); and the partial demolition of the hot rooms of the East Baths, in phase 3, to build new apses and pools (Biers and Biers 1988), motivated changes not only in the drainage network but also in the distribution pipeline.

The service room of the West Baths presents an opening in its south wall, just over the boiler's base (**Figure 8: D**). This feature has been interpreted as the place where water entered the service room (Biers and Biers 1988: 72–73; Reis 2014: 212). However, given the location of the water tower/pillar, to the east, it is more likely that water entered the service area from that side. Taking into consideration that the pipes connecting the boiler to the pools had to go around the building, this opening could be where the pipes crossed to the outside of the building. In effect, the height of this passage is compatible with the height of two openings in the large apse of the *caldarium* (room 6) and one found above the smaller pool in room 4, that likely to be the pools' supply inlets (**Figure 8: F**).

In the East Baths, the corresponding wall in the service area isn't sufficiently preserved to confirm the existence of a similar opening near the boiler.

As there aren't any obvious traces of metal hooks or supports, it isn't clear how the pipes would be attached to the walls of the buildings. The existence of projecting stones in two of the apses of the East Baths, built in the mentioned phase 3, could have a practical purpose related to the water pipes (**Figure 9**). However, this working hypothesis has some problems, since these stones are not present on the north side of the large apse nor the back wall of Room 15 (*tepidarium*).

The south corner of the large apse in Room 6, in the West Baths, also presents an interesting feature. Here, large, rusticated, ashlar blocks are placed crossways, and their meeting point is excavated to create a round section (**Figure 8: E-F**). This configuration strongly suggests that a large pipe ran at this point and was probably fixed in place by the ashlar blocks. Although this feature is seemingly more consistent with a downpipe for rainwater, it is interesting to point out that the lower block isn't excavated, having its top surface rounded towards the apse, which suggests that the pipe took a curve at this point. This occurs at the same height as the mentioned openings in the apse, which are the possible water inlets.

Domestic buildings

The interventions of the last decades have profoundly changed the knowledge about the site's domestic buildings, making this one of the most numerous ensembles in Portugal.

M. F. Barata initially proposed the existence of a piped network of water supply to domestic buildings (1997, vol. 1: 63; 1998: 49). However, further investigations produced no evidence to sustain that hypothesis, and, upon analysing the *fistula* cited by the author, we've determined that it wasn't a supply feature but rather a means for emptying a masonry vat in a workshop (Felício 2019: 12, 109).

No cisterns were found in any of the eight known domestic buildings. However, wells were discovered at house 5 (*Periquito*) and house 7, which were excavated by the Marburg team in 2005-2010. In both buildings, the wells are in the peristyle's open area, ensuring exclusive use by their inhabitants.

In addition to these two wells, there is a *puteal* that had been standing in the stream's bed near the bridge since at least 1945 (Silva 1946: 342 and fig. 8), and was moved to the site's entrance in the late 1990s, where it currently stands (**Figure 10**).

Since it doesn't go with the known wells, it informs of the existence of another one, yet to be identified. Given its considerable weight, it's likely the structure it belonged to is not very far. In this case, we aren't certain it belonged to a domestic building. The fact it is a monolithic marble element grants it a monumentality which greatly contrasts with the decorative simplicity of the known houses, making it

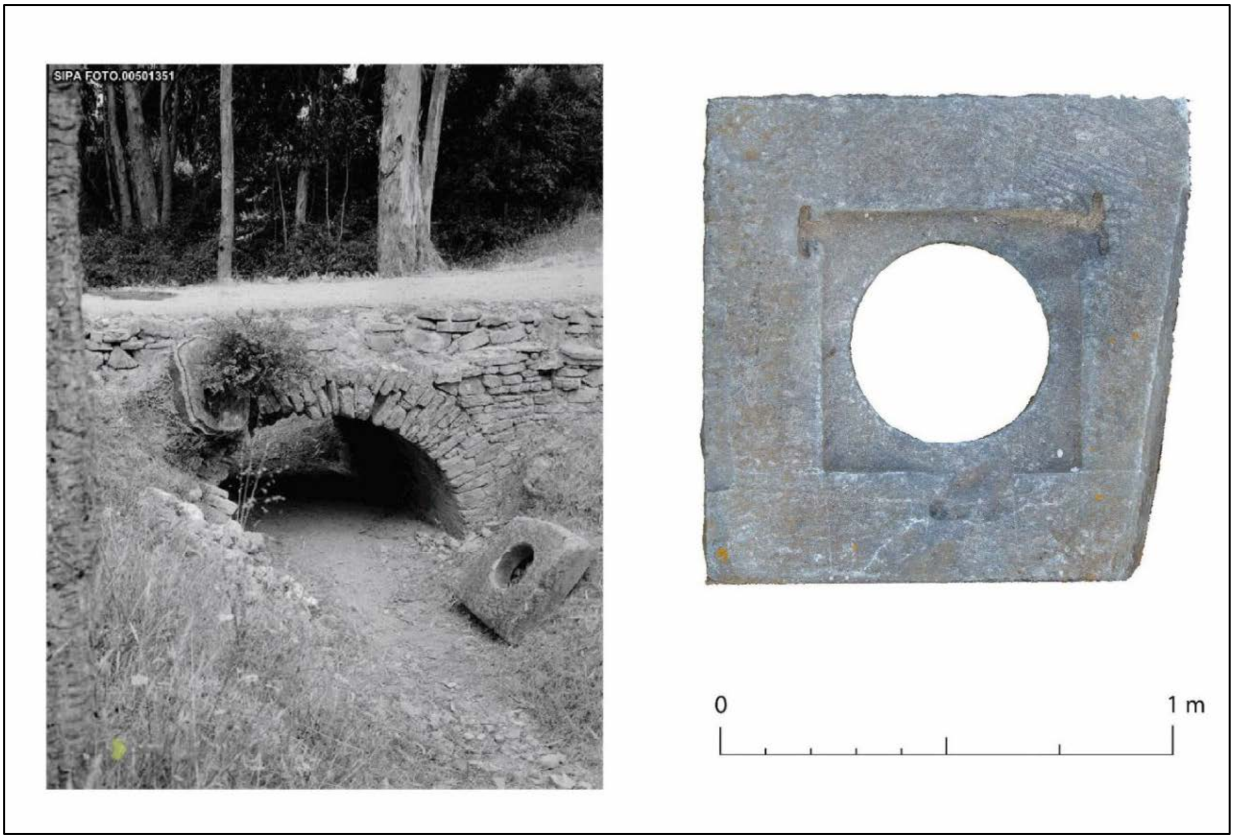

Figure 10. View of the bridge and puteal *from the West in 1959 (PCIP/SIPA Archive FOTO.00501351, Anilde Oscar, 1959. Reproduced under Creative Commons license CC BY-NC-ND-3.0).*

more compatible with a public venue. The *puteal* shows traces of a cover, perhaps a metallic grid or lid. The small entail immediately below the place for the cover indicates that it would have been locked. This is consistent with a well that although accessible in a public area, had a restricted use (**Figure 10: B**).

As mentioned earlier, there is a long-standing interpretation that this wellhead could be the same "square stone fountain" referred to by Resende in 1593 (Barata 1998: 59; Felício 2019: 17; Silva 1946: 342). This association isn't, however, unanimous, as M. P. Reis considers that Resende mentions an actual spring with an inscription or epigraph (Reis 2014: 215).

Out of the two wells that the Marburg team has identified (**Figure 11**), only the one found at House 7 was completely excavated. The excavation was interrupted in house 5 (*Periquito*) after 2m, due to the water level, but test soundings determined that it reached a depth of at least 3.3m (Kopf 2018: 63).

The masonry wellheads are built differently. The one at house 7 has a pseudo vault, made of shale slabs, and a narrow opening (*c.* 0.4m in diameter) (**Figure 11: D**). From the outside, this structure assumes the form of a ring, covered in waterproofing mortar (*opus signinum*). Conversely, the wellhead at house 5 (*Periquito*) is a simple ring in limestone masonry (**Figure 11: B**), providing a wider opening into the well shaft. It is unclear whether the structure had a mortar lining.

At house 7 the well reached a depth of 8.2m and has a quadrangular section throughout (Oberhofer 2018b: 122). K. Oberhofer has noticed the mortar lining was more damaged on the south side and suggested it may be an indication that this side was used most frequently (2018a: 121). This is an interesting observation, especially considering that room 7.1.4, which contains a plausible cooking counter and was likely a kitchen (Oberhofer 2018b: 113), is located at the southern end of the house (**Figure 11: C**).

The excavation of various fillings and contexts found within the well has yielded important data that sheds light on the lifespan of house 7 and the well itself. Additionally, the analysis of the plants and natural landscape found during the well's period of use provided valuable insights into the city's environment at that time (Oberhofer 2018c; Schröer 2018). Carbon dating of three samples from the lower filling of the well, a fine mud layer, point that the well was in use roughly from the late 1st century to the mid-3rd century AD (Schröer 2018: 225-226 and fig. 236).

Regarding the daily operation of the well, the lowest level, Context I, is consistent with objects accidentally dropped into the well (**Figure 11: F**). These findings range from the second half of 2nd to the early 3rd century (complete list in Peña Cervantes *et al.* 2018: 205). K. Oberhofer has linked the formation of this context with a cease in the cleaning of the well (Oberhofer 2018c: 121). However, given how narrow the well is, and the fact it would have been largely submerged, it is doubtful the well could be cleaned at all.

The context included several wooden and organic finds. Two of these, fragments 7 and 8, were believed to be parts of a pulley system used to retrieve water from the well (Oberhofer 2018c: 212, 214). Out of these, the reintegration of frag. 7, made of olive wood, as the fixed support of a pulley (Oberhofer 2018c: 213–214) seems the most plausible.

Context I also produced several vessels that were likely used for retrieving water. The most numerous are ceramic jugs, found in good condition, some almost intact (Peña Cervantes *et al.* 2018: 205–206; Teichner 2018d, tables 15-17). These could have easily been lowered with a rope attached to their handle and pulled either manually or with the help of the pulley. Fragments of a bronze *situla* were also found, and the vessel may also have been associated with the use of the well (Teichner 2018b: 193, fig. 220: 3-5). Additionally, although none of the wooden objects were identified as buckets, several fragments of goat skin were suggested to be part of a wineskin or a leather vessel (Teichner 2018b: 193, fig. 221: 15), which could have, eventually, also been used in the well.

The units that overlay this context of daily use were consistent with an accumulation of debris and an intentional deposition of waste, informing of the deterioration of the house.

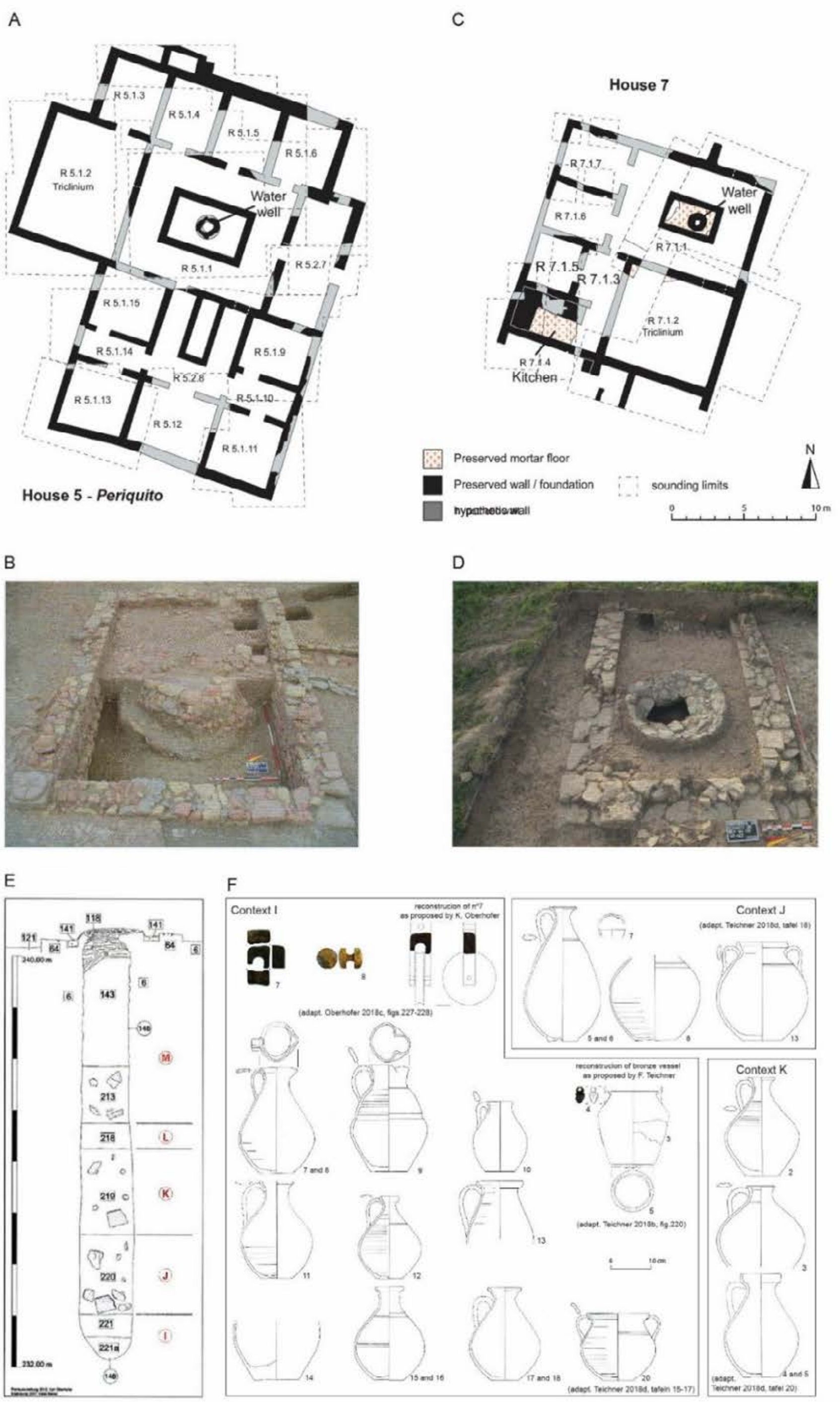

*Figure 11. A. Floor plan of House 5-*Periquito* (compiled data from Kopf 2018); B. Water well in *peristyle* (Room 5.1.1) of House 5 (Kopf 2018, fig. 68); C. Floor plan of House 7 (compiled data from Oberhofer 2018b); D. Water well in peristyle (Room 7.1.1) of House 7 (Oberhofer 2018b, fig. 136); E. Cross section of the well in House 7 and exacavated contexts (Oberhofer 2018b, fig. 139); F. Finds associated with retrieving water from the well in House 7 (compilation of data from Oberhofer 2018c; Peña Cervantes* et al. *2018; Teichner 2018b and d «tafeln». Find numbers correspond to those in the original publications).*

It was observed that Context J, which is the lowest, had several *tegulae* and *imbrices* in a vertical position. This indicates that the roof of the peristyle was collapsing during this period (Oberhofer 2018b: 122). The context has an *ante quem* in the mid-3rd century and yielded numerous ceramic finds (Peña Cervantes *et al.* 2018: 206) as well as the skeleton of a young dog, around 1 to 1.5 years old, which was almost fully complete (Oberhofer 2018b: 123; Prust 2018: 234). It is plausible that the dog may have either fallen or been thrown into the well. Regarding context K, which is located above, it has a *post quem* dating from the mid-3rd century. This further confirms that the well was used as a site for disposing of domestic waste, as evidenced by the significant amount of ceramic and faunal remains found.

It is worth noting that despite the house likely being abandoned or in a state of disrepair during this period, and the well being used for waste disposal, relatively intact jugs were also found in contexts J and K (Peña Cervantes *et al.* 2018: 205–206). These findings make us wonder whether people were still retrieving water from the well during that period. This hypothesis has obvious implications for the quality of the water in the well, likely contaminated by the remains of dead animals, whether the people retrieving it were aware or not. Upper contexts, L and M, also dated with a *post quem* in the mid-3rd c., don't have concrete evidence of the dropping of water retrieval vessels (Peña Cervantes *et al.* 2018: 207), so it is possible that the well stopped being used still in the late 3rd century.

Final remarks

All of what is known about water supply refers to the 1st to 3rd centuries AD. Based on the research conducted by the various teams over the years, it is safe to conclude that the inhabitants of the city thought to be *Mirobriga* did not have access to a public aqueduct for their water supply. Instead, they relied on local sources such as springs and wells located within and around the town. The public baths had the largest demand for water, which is why they were the only buildings that had a piped water supply. To achieve this, water was stored in at least one large reservoir, which was supplied by small-scale underground aqueducts that channelled water from nearby springs.

Supply to the service areas was probably done through masonry conduits and then transferred to pressurised pipelines. One of these masonry structures, either channel C38 or the structures near the West Baths *praefurnium*, may be the aqueduct seen and mentioned by Resende in the 16th century. However, as the boilers were set it the opposite side of *caldaria* pools and other hot water pools, *fistulae* would go around the building, most likely attached to the outside walls.

As for domestic water use, although some houses had private wells in their peristyles, the majority would have relied on public wells or fountains that have yet to be identified. The same applies to workshops and *tabernae* as many crafts and trades required water for production or cleaning.
To this date, the handling of liquid by-products has been identified in at least three workshops, namely *Construção* 1 and 2 and a *taberna* at house 3 (Calçada) (Felício and Sousa 2023: 271–274). These buildings likely required water in their operation, but no dedicated source has yet been found.

The existence of waterproofing pavements with mouldings in some commercial buildings, such as Building C («casa 1» in Arthur 1983: 83), indicated the performing of activities that would have required regular cleaning, and hence water, in their operation. These activities also made part of the city's daily water demand that had to be met by the still elusive public supply.

The second half of the 3rd century brought significant changes to the urban landscape, marking it a critical point in the city's history (Sousa 2019: 101–107; Teichner 2021: 77–78). Although we won't delve into the specifics since they are beyond the scope of this work, we will make some remarks on the evidence regarding the city's water supply.

The excavation of the pool of the *frigidarium* found that around the mid-3rd century, the East Baths had already been abandoned and were collapsing (Slane 1988b). Although fragile, the finding of marble

fragments, described as identical to those from the West Baths, in a context of the first half of the 4th century (Arthur 1983: 96–97) may suggest that the building was already being spoliated.
Until further excavations in the reservoir, it is currently unknown when it stopped being supplied. It is uncertain when the last reform in the supply aqueducts took place, as no concise dating evidence exists. However, the wall that blocked the decommissioned channel seems to have been constructed similarly to other structures of the town dated to the late 3rd to early 4th century. This could suggest, with due caution, that the reservoir could have still been functioning for the use of the general population after the abandonment and collapse of the bath buildings.

The scenario found in the well at house 7, although still an isolated case, marks a change in the waste disposal habits of the town, which was now done inside buildings as well as essential infrastructures. The possibility that the well remained in use for some time during this period, apparently coexisting with this deposition, raises further questions about the overall characteristics of inhabitancy and urban landscape.

This coexistence may have been brief, as the superimposing waste deposit has a similar chronology but no distinct evidence for the retrieval of water. The same applies to all later contexts, with no clear evidence for the retrieval of water from this well in later periods.

It is well established that the town remained inhabited, with dating evidence in the area at least until the 6th century (Quaresma 2012; 2022). However, besides the many open questions regarding the actual demography, urban configuration and status of this period, there are still no new water wells known in this period and the means of water supply in this Late Antique Period remain unknown.

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Water Management in *Calduba* (Sierra Aznar, Arcos de la Frontera, Cádiz): A Terraced System for the Recreation of a *Locus Amoenus*?

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Abstract: the Roman site of Sierra Aznar (Arcos de la Frontera, Cádiz, Spain) stands out for its complex hydraulic system, which characterizes most of the archaeological remains known there. Different hypotheses have been put forward about the functionality of the site, most of which are not mutually exclusive. *Urbs* possibly linked to the *municipium Caldubensis*, its strategic location allowed it to develop infrastructures for collecting, storing and distributing water. Through recent archaeological research and with the help of LiDAR technologies, we have advanced in the site's knowledge and the interpretation of its organization and functionality. In our opinion, the organization of the urbanized space and the hydraulic system implemented have as their main objective the recreation in this space of a *locus amoenus*, an idealized natural environment, related to water as a symbolic element, which must be understood within the framework of the ideological role of this community in this mountainous space, and linked to the construction of the specific identities of the so-called *parva oppida* or small towns in High Imperial times.

Keywords: Small town, *Locus amoenus*, *Calduba*, *Baetica*, Hydraulic system, LiDAR.

Introduction and general characterization of the site[1]

The Roman site of Sierra Aznar (Arcos de la Frontera, Cádiz, Spain) stands out for its complex hydraulic system, which characterizes most of the archaeological remains known there. *Urbs* possibly linked to the *municipium Caldubensis*, its strategic location allowed it to develop infrastructures for collecting, storing and distributing water. Sierra Aznar is located between the Guadalete and Majaceite river basins, in a transitional zone between the highlands and the countryside of the province of Cadiz. This strategic location gives it a notable advantage from a geographical point of view, allowing control over fundamental water resources and offering a view of the surrounding environment, especially the Majaceite basin, located a short distance away. Within the Sierra de Aznar is located the elevation known as Cerro del Moro, occupied by archaeological remains that reach a height of more than 400 meters above sea level; this position provided them with a very broad view of the territory and his terrestrial communications (Rondán-Sevilla *et al.* 2021) (**Figure 1**).

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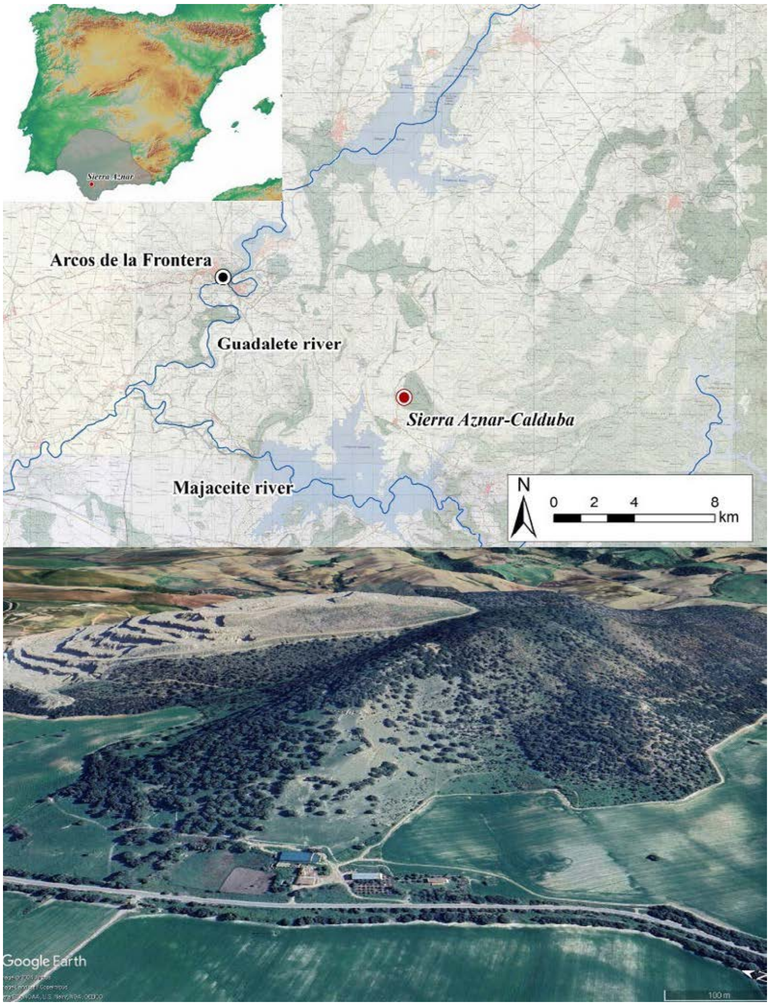

Figure 1. General location of Sierra Aznar and perspective of the Sierra de Cádiz (elab. by the authors).

Cerro del Moro has an irregular orography, with steep slopes that develop from approximately 200 to 400 meters above sea level. The subsoil of Sierra Aznar is composed mainly of clayey loams and calcarenite, materials that favor water infiltration and the formation of aquifers. These subway aquifers were essential for water supply to the site and for the development of water collection, distribution and storage infrastructures. The presence of these geological formations partly explains the abundance of water in the area and helps to understand why this site was chosen for the construction of a major hydraulic system. The geology of the area not only facilitated the construction of cisterns and canals but also allowed for the long-term preservation of these structures, which were integrated into the rocky landscape of Cerro del Moro. This type of geological composition made possible the excavation and construction of subway reservoirs without the risk of landslides, preserving water in optimal conditions (Lagóstena and Zuleta 2009: 37).

The hydrology of Sierra Aznar is determined by the proximity of the Guadalete and Majaceite river basins, which ensures an abundant availability of groundwater and springs. The site's topographic layout allows for the use of rainwater and the upwelling of aquifers, facilitating a constant and predictable supply. This water resource was essential for the development of the storage and conduction infrastructures, which operated through a decanting and distribution system (Rondán-Sevilla *et al.* 2021: 15-22).

The settlement of Sierra Aznar is geographically contextualized within the framework of the pre-Roman and Roman settlement of this southern peninsular territory, whose main feature is its mountainous character. This urbanism shows a settlement pattern with peculiar features and an organization and distribution on the landscape significantly different from other coastal or countryside territories, closely related to the control of the territory both towards the Strait of Gibraltar and towards the estuary of the Guadalquivir-*Baetis* River (Lagóstena 2016: 68-76).

Regarding the chronological sequence of the occupation of the site, it has been proposed the existence of a pre-Roman settlement in the highest areas of the hill, although it is based on the documentation of scarce ceramic materials on the surface (Gener 1993) and it would be a habitat of little entity. Recent surveys developed by our team have documented an orthogonal walled enclosure occupying the highest part of the mountainous formation, associated with ceramic materials from the late pre-Republican period, abundant among them storage and transport containers of Iberian and Italic tradition. We interpret this space as a military fort, probably a *praesidium* established in the first century BC, linked to the strategic control of the territory and of the natural routes of penetration of the highlands, which would constitute the phase of occupation between the pre-Roman settlement and the subsequent High-Imperial architectural monumentalization, implanted at lower levels of the mountain, and associated with water management (AAVV 2020; Ruiz Gil and Rondán-Sevilla 2020; Rondán-Sevilla *et al.* 2021: 47-72; Rondán-Sevilla *et al.* 2022: 439).

Although several Roman construction phases have been identified for the High Imperial period, the main urban planning suggests a unique building program, very well adapted to the orographic and hydrological environment (Guerrero Misa 2001; AAVV 2020; Ruiz Gil and Rondán-Sevilla 2020; Rondán *et al.* 2021: 49-51). There were also documented phases of occupation in Late Roman times in the surroundings of the settlement (AAVV 2020; Ruiz Gil and Rondán-Sevilla 2020; Rondán-Sevilla *et al.* 2021: 70), and occupation of the site and its structures was reused for other non-hydraulic purposes until the Almohad period.

For the denomination of the ancient settlement of Sierra Aznar, its identification with *Calduba*, a city mentioned by the geographer Ptolemy (Ptol. *Geogr.* 2, 4, 13), has been proposed. Three arguments have been put forward so far: the relative geographical location of the site based on the coordinates provided by the Greek geographer, the discovery nearby of an epigraphic bronze that could refer to the legal status of the city (Stylow 2007: 257-266); and the etymology of the word *Calduba* of Indo-European origin and whose lexemes refer to hydronyms (*-Cal*, *Uba-*), whose meaning is compatible with the functionalities of the hydraulic structures characteristic of the site (Mancheño 1901: 341-344; Villar 2000; Lagóstena 2017: 148-151).

The Sierra Aznar site stands out for its sophisticated construction program, which seems to have as its main objective to support the complex designed for water management, implanted from the top to the base of the elevation where the settlement is located (**Figure 2**). The disposition and scale of these hydraulic structures suggest a meticulous planning oriented to a precise water conduction, with purposes that, in our opinion, exceed the functional to reach a symbolic meaning (Rondán-Sevilla *et al.*

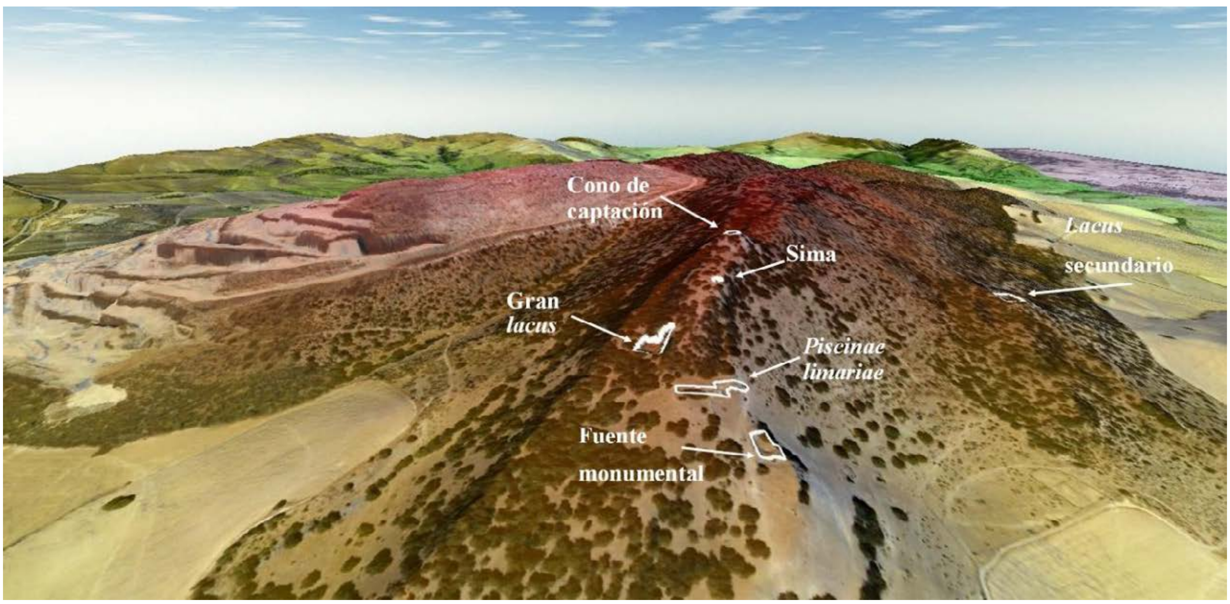

Figure 2. The main constructive elements of the High-Imperial urbs *(Rondán-Sevilla, in press).*

2022: 442). This comprehensive approach to urbanized space for water management reflects an advanced vision of Roman engineering, and an eagerness to dominate the natural frame.

Thus, from an urbanistic point of view, there are several architectural elements present on the site that should be highlighted:

1. a set of walls, which is preserved for much of the perimeter of the urban area, which serves as a walled enclosure, which functionally delimits the urbs, but is also shown as an element that gives strength to the entire building complex and, probably, helped to counteract the pressures exerted by the water storage systems.

2. a system of terraces implanted on the natural slope, articulating the urban area and the layout of the known hydraulic elements, as well as other elements of ancient urban planning that have not yet been identified at the site.

3. and finally, the hydraulic complex is composed of various archaeological structures representing the entire water cycle within the ancient city.

The walled enclosure preserves numerous sections of perimeter walls, distributed around the periphery of the main area of the site. Built at different topographic levels, all these walls seem to correspond, however, to a single element of delimitation. In addition to the fact that we can identify this enclosure with the walls of the city, still preserving a turreted gate that confirms it, it also stands out, in our opinion, as a symbolic constructive element that delimits the civic space and the hydraulic program designed inside.

The artificial terraces, which were built on the slope of Sierra Aznar in ancient times, are essential elements for understanding the general urban planning of the site, along with the rest of the urban features. It is, however, to date, one of the least known remains, especially due to the absence of an exhaustive topographic survey of the archaeological traces, and the presence of a thick mass of trees that hinders the visualization of the whole. These are terraces that articulate the slope and are built with stone walls that delimit and contain the resulting platforms. Thanks to our remote sensing work with LiDAR, as will be discussed below, we can propose a planimetry of the terraces of Sierra Aznar and advance in the urban understanding of the archaeological complex.

The hydraulic complex is the best known and preserved element of Sierra Aznar (Rondán-Sevilla *et al.* 2022; Calvillo *et al.* 2025). It would be composed of different structures linked to the collection, conduction, storage, purification and different uses of water. The system would have several sources of supply: a probable catchment cone in the upper area of Cerro del Moro; an upwelling in the hillside, nowadays exhausted; and at least two aqueducts that provide water from the northern and southern slopes of the mountainous formation. In addition, there are several large storage *lacus*: one attached to the main spring; another outside the urban area, to the east of the Sierra Aznar formation; and another large *lacus* associated with the so-called monumental fountain, as well as several *cisternae* located inside the walled enclosure and on the lower terraces of the complex. The known hydraulic complex is complemented with some *piscinae limariae*, with ten interconnected decanting *lacus*, and other associated annexed hydraulic deposits (**Figure 3**).

Although functionally questioned, the so-called catchment cone would take advantage of its position and the slope of the terrain to direct rainwater to the karstic sinkholes that feed the aquifer and the upwelling captured by the main *lacus*. This great *lacus*, whose construction was attached to the rocky sides of the hill, constitutes the main reservoir of the hydraulic system of the site. The upper part of the walls that make up the *lacus* would function as an ambulatory and would articulate a corridor that allowed circulation through the upper part of the structure to the spring itself. Certainly, this element

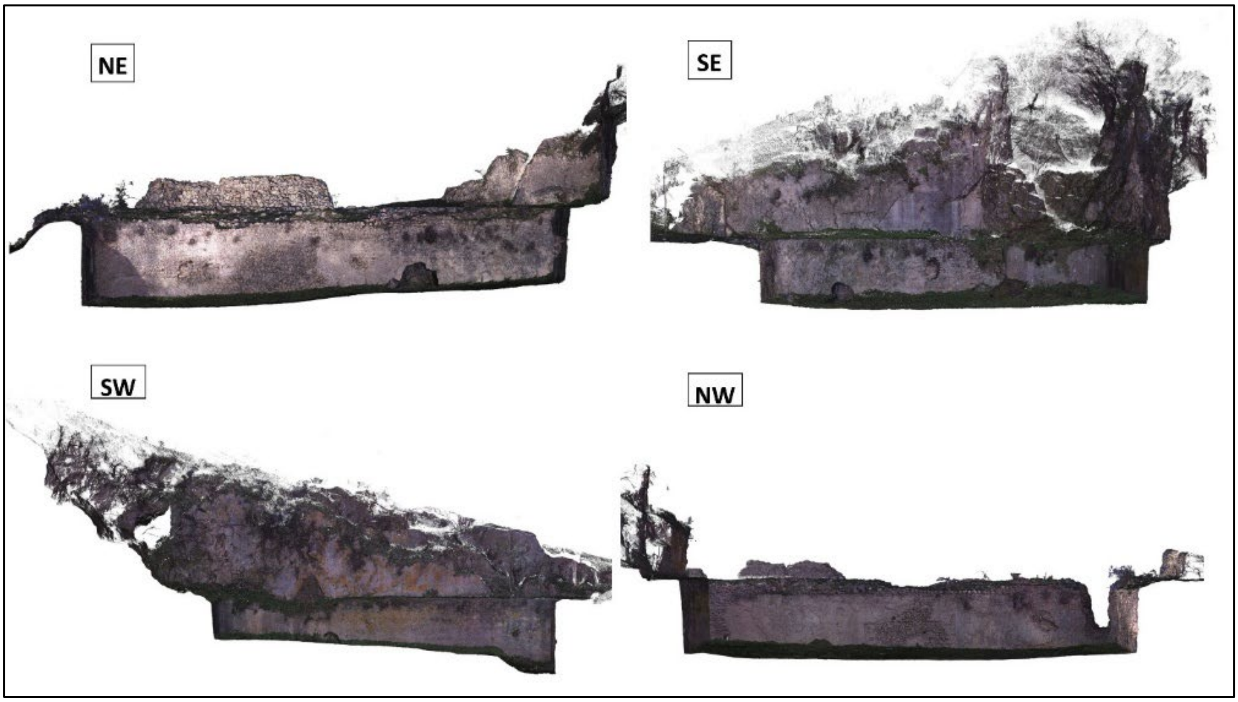

Figure 3. Cross-sectional view of the four sides of the large lacus *(elab. by the authors).*

could serve a practical function for the maintenance and management of the backwaters. The efficiency of this structure suggests a deep knowledge of the hydrological characteristics of the region (Lagóstena and Zuleta 2009: 35).

Hypothesis on the functionality of Sierra Aznar. The symbolic proposal of the *locus amoenus*

The relevance of the hydraulic structures of the Sierra Aznar site has raised many doubts about the historical characterization and functionality of the site in antiquity. Thus, hypotheses have been put forward that give preeminence to its urban function, its link with water collection, or various productive aspects related to agriculture, livestock or mining. For our part, we add to the discussion the symbolic element, as an important part in the historical interpretation of the oversized hydraulic complex of the site. As we have indicated above, the different functional hypotheses are not mutually exclusive, and some of them are clearly complementary.

Sierra Aznar site as *municipium Caldubensis* proposes the identification of the site with the Latin city of *Calduba* attested in Ptolemy. The local chronicler Miguel Mancheño (1843-1922) argued this identification based on the relative geographical position of Sierra Aznar in relation to other well-known cities in the region, and cited in the Ptolemaic geography, located between *Carissa Aurelia* (Espera, Cádiz) and *Saguntia* (San José del Valle, Cádiz), located north and southwest respectively of Sierra Aznar (Mancheño 1893; 1898; 1901) (**Figure 4**). To this argument two more are added: the etymological one based on the interpretation of a toponym of Indo-European base proposed by Villar, as noted earlier, which would allow us to translate *Calduba* as a reference to "turbulent water" that would be related to the hydraulic structure documented here (Villar 2000; Lagóstena 2017: 148-151); and, on the other hand, an epigraphic finding, produced in the nearby borough of Las Abiertas, a fragment of a probable *lex Flavia municipalis*, which would originally come from Sierra Aznar (Stylow 2007: 357-366). This identification with *Calduba* would give preeminence to the urban character of the site over other functional interpretations, and this reinforces the interpretation proposed in this contribution.

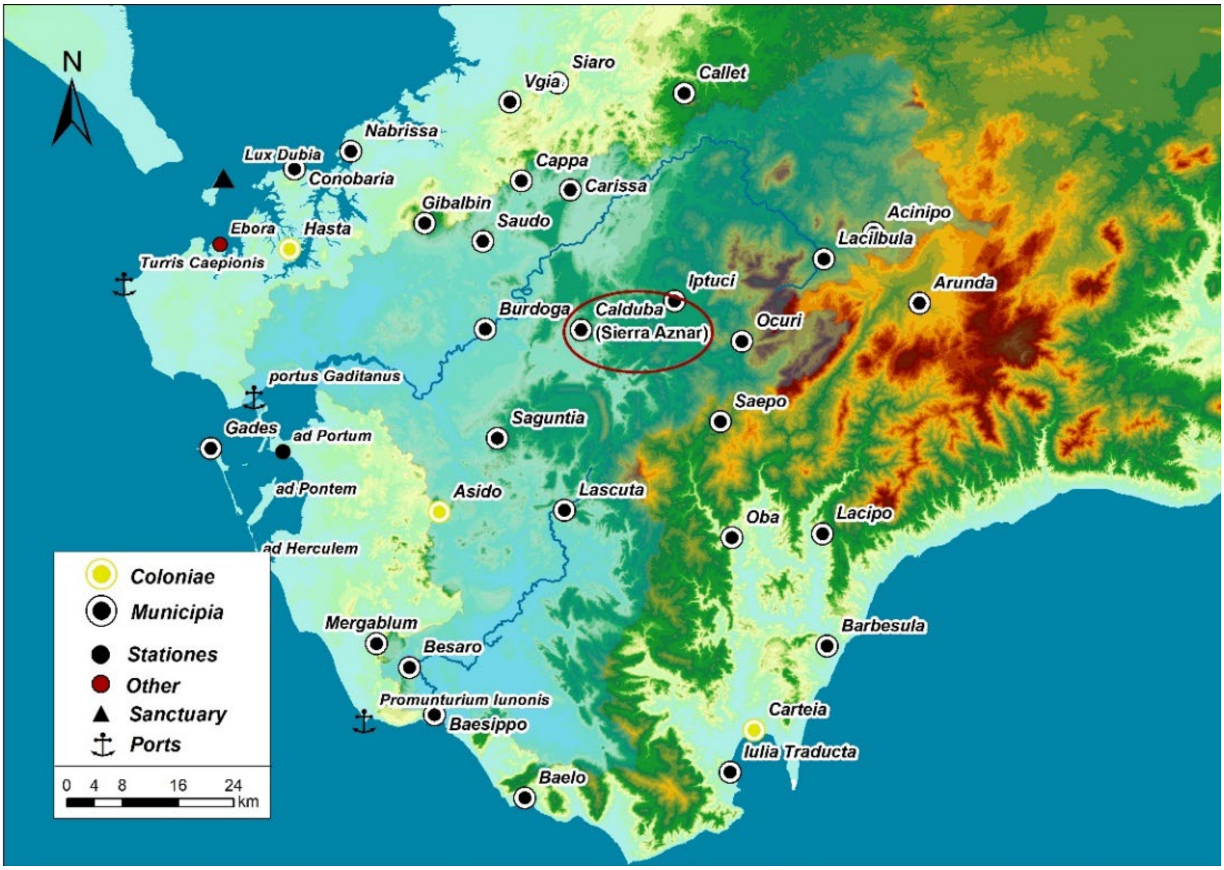

Figure 4. Ancient settlement in the southern end of the Baetica *area (elab. by the authors).*

Another hypothesis focuses on the hydraulic function, and, within it, a double possibility was raised: that the hydraulic complex acted as *caput aquae* of the nearby aqueduct of *Gades*; or as *castellum aquae* of the *Calduba* community itself (Perdigones 1987; Gener Basallote 1993; 2001; Lagóstena and Zuleta 2009; Mata *et al.* 2010; Zuleta *et al.* 2022: 30).

Regarding the productive proposals for the hydraulic structures, it has been suggested that they are related to irrigation canals in the nearby countryside, which would have developed to the southwest of the site, indicating that the water could have been used to support farming activities in the surrounding areas (Richarte 2002: 48). The use of this complex in mining activities has also been proposed, based on a geological environment rich in iron and magnetite, and linking the cisterns and water conduction systems with the washing and processing of minerals (Zuleta *et al.* 2022).

As we have indicated above, we must highlight an initial functionality in the Roman occupation phase, linked to the control from a military enclave of the penetration routes to the current Cádiz's mountain ranges, which is justified by the identification of the *praesidium* located at the top of the Cerro del Moro (AAVV 2020; Rondán-Sevilla *et al.* 2021: 49-51; Rondán-Sevilla, in press).

Finally, after the studies carried out by our team at the site, we propose that the known remains in Sierra Aznar correspond to a phase of monumentalization of the habitat of the *Caldubenses* community. This monumentalization was based on a major restructuring of the settlement, with the creation of at least thirteen terraces, which articulated the urban core, creating a scenario in which water played an important symbolic role, with an ideological and religious message, aimed at the local and surrounding populations. This scenography, with the recreation of a *locus amoenus* around water as a natural element, would emphasize the role of *Calduba* as an administrative center of reference in the High Imperial management of this territory.

New methodological approach to the problematic of Sierra Aznar

To advance in the characterization of the settlement of Sierra Aznar with a non-invasive methodology, we have applied, among other techniques, LiDAR technology, aerial and terrestrial (**Figure 5**). These tools allow us to document and visualize the archaeological elements with a new perspective, to achieve a better understanding of the urban elements present in the site. In our case, we have used LiDAR data from the Spanish National Geographic Institute,[2] as well as data obtained by airborne LiDAR in drones, allowing the combination of the information at different scales and with different resolutions. The equipment used has been the Matrice 300 RTK drone of the company DJI. The LiDAR sensor used is the Zenmuse L1, from the same company. Its specifications include: system performance, with a capacity to acquire up to 480,000 points/second in its triple return mode; the possibility of coloring the cloud obtained thanks to the complementary photo acquisition system; a range accuracy of 3cm at 100m; two scanning modes, repetitive and non-repetitive; and a 200 Hz inertial navigation system (IMU). The area covered was 28.5ha. The flight height was about 40m, relative to the top of the mountain range, giving a GSD of 1.09cm/pixel and a cloud density of 1006 points/m2 of the raw data. The finally treated cloud was classified and filtered, creating models with the ground points, and other models adding the points corresponding to the emerging archaeological remains. The classification and subsequent filtering of the vegetation on the site has made it possible to work with very accurate digital models.

From a terrestrial perspective, the emerging archaeological structures have been digitized and modelled to create high-resolution models, combining terrestrial laser scanning and photogrammetry. These models allow the archaeological structures to be analyzed in detail and precise measurements to be taken. The terrestrial laser scanning equipment used was the Leica BLK 360, a small and light device that allows a complete scan, with a wavelength of 830mm and a minimum range of 0.6m and a maximum range of about 60m, which provides an accuracy of 4mm at 10m/ 7mm at 20m and for 3D of 6mm at 10m/ 8mm at 20m. It includes LiDAR technology that is capable of capturing 360000 points per second. The measurements were made with control points taken by differential GPS with RTK correction, model Leica (GS14/CS15), and total station from Leica, model TS06 Plus.

Towards the topographical understanding of the Sierra Aznar site

With the use of LiDAR techniques for digitization, applied on the geographic base and the archaeological elements of Sierra Aznar, we have obtained precision models that allow us to know the topography of the site, being able to establish a first hypothesis about the location of the terraces that organize the urban planning of the site. It has also allowed us to model the large hydraulic structures, and georeferencing them, to better understand the spatial and topographic relationship between them, and their role in the urban complex. To identify the system of terraces on the digital model obtained, given that in the current state they are not appreciable without a processing of the LiDAR information, it has been analyzed, firstly, the 3D point cloud and different visualizations of it. From this first analysis, and given the characteristics of this data format, sections have been generated in the point cloud that reveal the behavior of the topography, in a way not appreciable with other types of products or from other perspectives (**Figure 6**).

[2] Instituto Geográfico Nacional. Proyecto PNOA-LiDAR Segunda Cobertura: https://pnoa.ign.es/pnoa-lidar/presentacion (consulted on 10.06.2024).

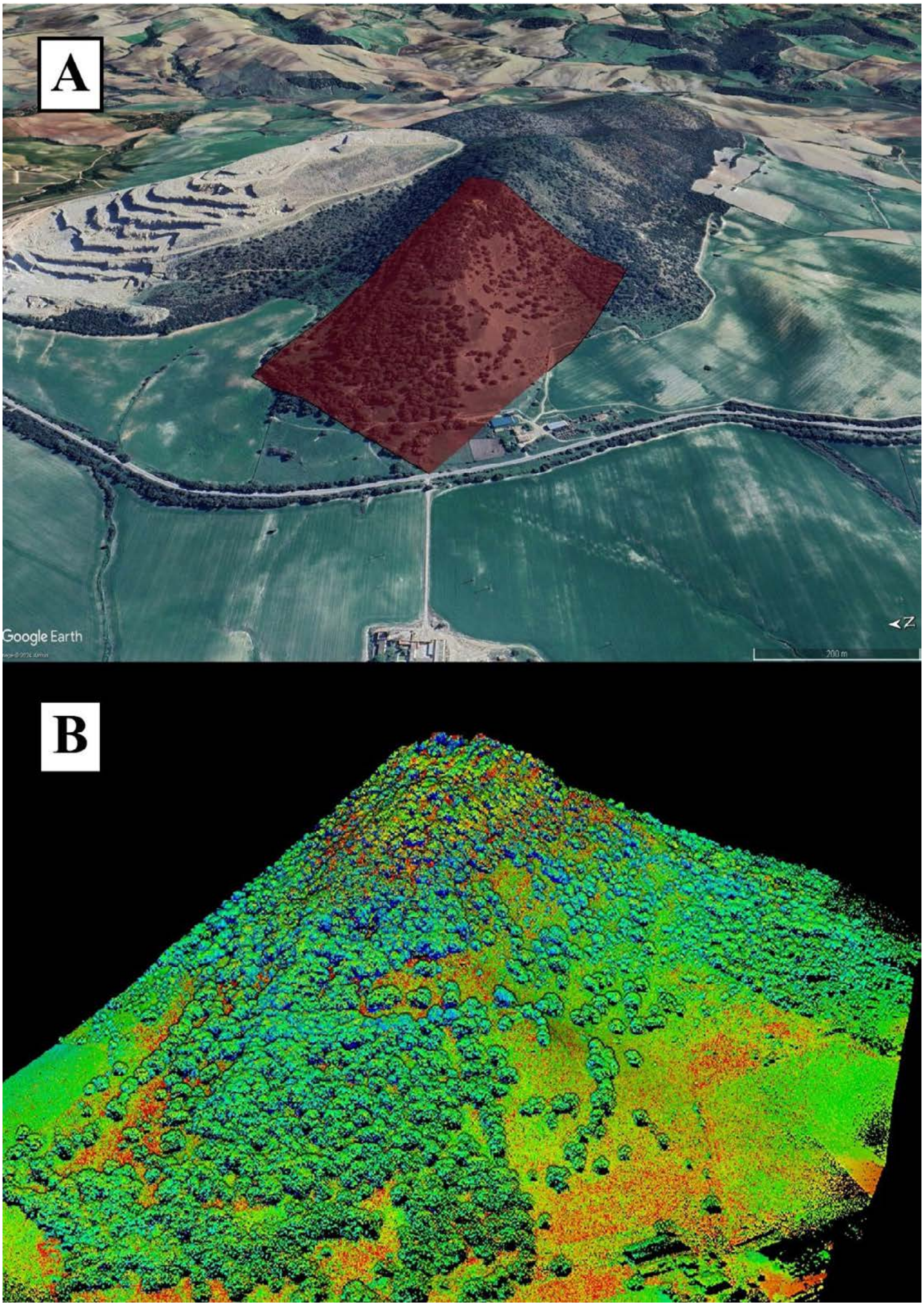

Figure 5. Covered area by the LiDAR flight over the Sierra Aznar site (elab. by the authors).

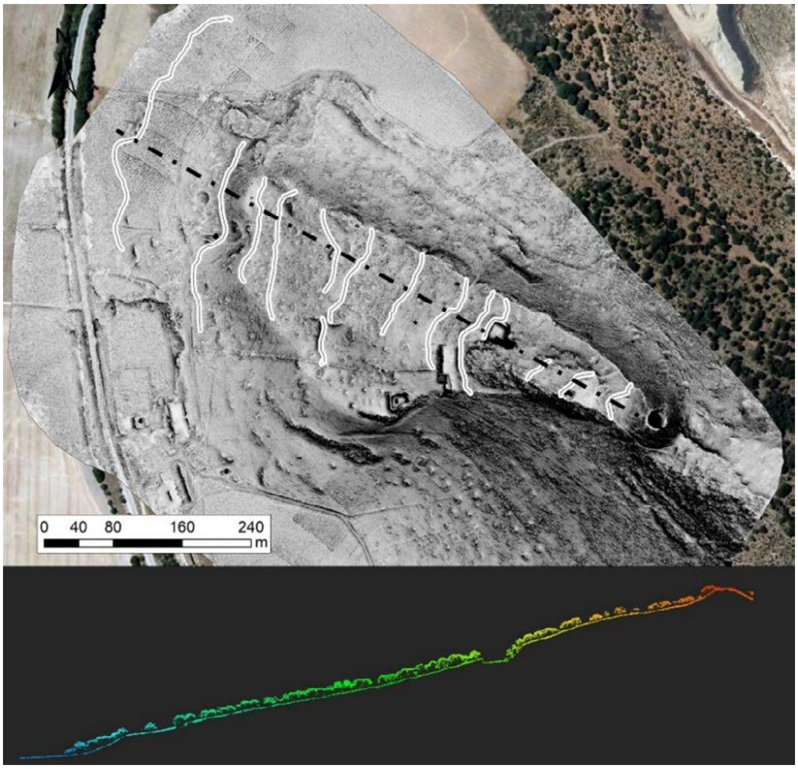

Figure 6. Visualization (VAT) of Sierra Aznar DTM and terrace system detected by LiDAR analysis. Longitudinal section of the site topography (elab. by the authors).

Once the high-resolution model was created, we optimized its visualization, intensifying certain image parameters, such as lighting or shading, through algorithms, and thus highlighting concavities or convexities on the surface, not perceptible to the naked eye (Kokalj and Somrak 2019). One of these combined visualizations has been called Visualization for archaeological topography (VAT), and its comparison with other types of visualizations has allowed us to propose the existence of at least thirteen artificial terraces, arranged in a regular way, and that, in some cases, seem to cross the entire slope in a northeast-southwest direction.

As we have reiterated, water management is the factor that seems to articulate the urban planning of the Sierra Aznar site, from the so-called catchment cone, the karst sinkhole, the spring source and the large *lacus*. These elements establish a central axis in the highest part of the mountain. From the great *lacus* (**Figure 9**), the most important and best known hydraulic constructive elements are located on the meridional side of the site: the set of *piscinae limariae* (**Figure 7**) and what we call the monumental fountain (**Figure 8**). Other *cisternae* have been documented in different parts of the site, at different levels, from the intermediate terraces to the lower ones. However, the northern and western parts of the settlement are the least known, making it difficult for the moment to get an overall view of the whole.

The flow of water through the settlement, in an east-west direction, and its distribution throughout the urban complex, as the water flowed down for the slopes and terraces, probably with different routes, judging by the hydraulic remains, to the north and south, would offer an idyllic image of a profusely irrigated civic community. The terrace system would thus play, in addition to an important role in the organization of other public spaces in the city, a fundamental function in the establishment of water circulation in *Calduba* (Rondán-Sevilla and Calvillo 2023: 608-611).

Conclusion: functionality and interpretative proposal of the constructive program of Sierra Aznar

The explicative hypothesis that we propose, for the understanding of the urban planning developed in the presumed seat of the municipality of *Calduba*, considers the importance of the symbolic role of water for these communities in the mountainous areas of the extreme south of *Baetica*. It also considers the significance of this natural resource as a sign of community identity and relates it to the ideological construction of the *parva oppida*, for their recognition as civic centers linked to the Roman order.

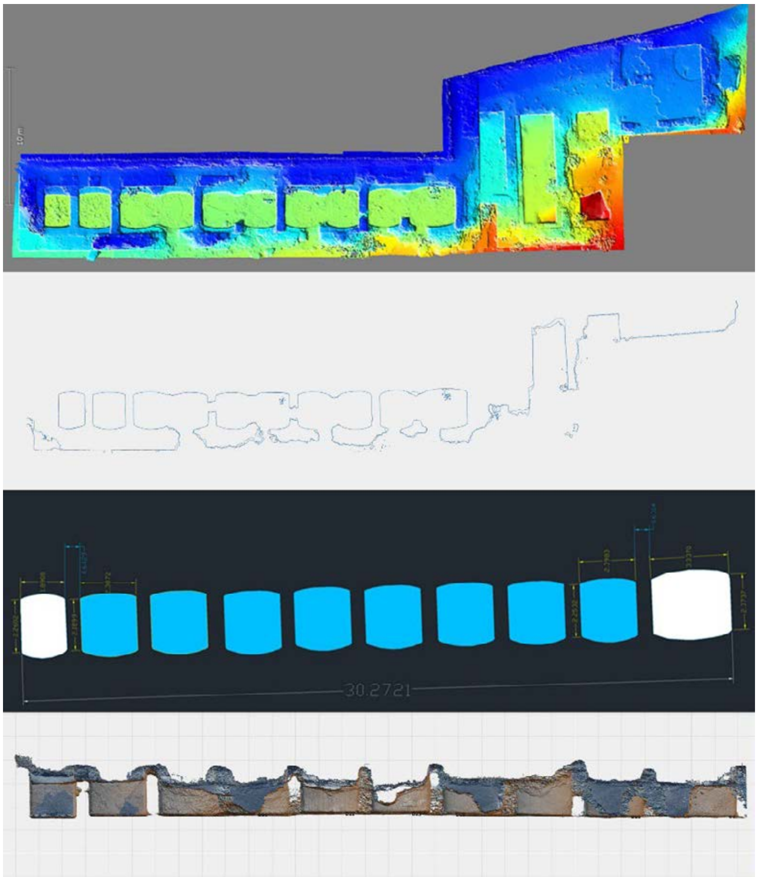

Figure 7. Various perspectives based on the modeling of piscinae limariae *(elab. by the authors).*

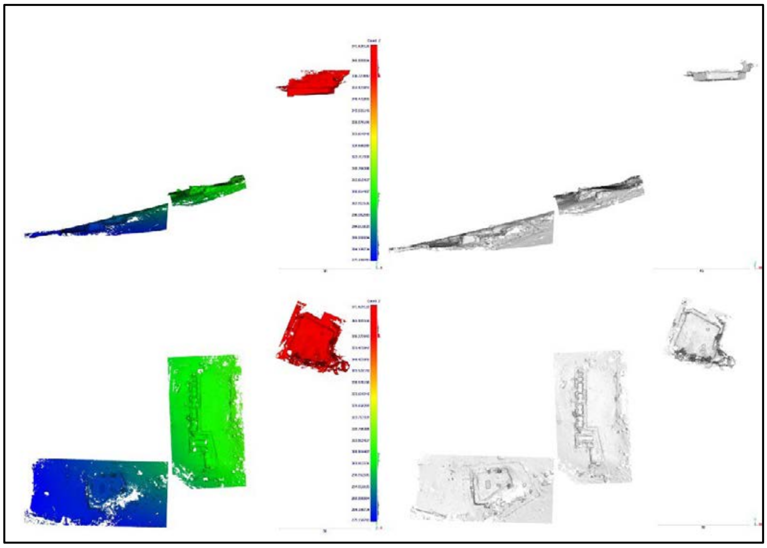

Figure 8. Views in georeferenced elevations, section, and plan of the main elements of the hydraulic complex (large lacus*;* piscinae limariae*; monumental fountain) (elab. by the authors).*

Figure 9. Aerial view of the large lacus *or 'Baño de la Reina' (photo by the authors).*

This "Small Town" model is especially important in the organization of rural and mountainous territories, where large urbanization penetrates with greater difficulty, and in the framework of the civic political model implemented by Rome in the provinces, and which are enhanced at different times of the High Imperial period (Mateos *et al.* 2022). The urban planning that we detected in Sierra Aznar, in the absence of a more complete archaeological documentation, seems to correspond to a single phase of implementation, to a single building program. An integral intervention on the chosen space, establishing the emergence of water as the axis of the design. This territory is walled and terraced, and a well-thought-out water flow seems to be established on it, from the top to the base of the urban complex. The architectural features and the dimensional entity of the constructive elements suggest that we are before a public work, and before a urbs designed ex novo.

How could a modest mountain community become an urban nucleus of reference, adopt its link with water as a sign of identity, and undertake a costly investment to build a new *urbs*, through works for which the knowledge of architecture and hydraulic engineering had to be of great relevance?

We believe that the role of the powerful city of *Gades*, and the relationship established between *Gades* and *Calduba* is fundamental to understand the function acquired by the community of Sierra Aznar-*Calduba* in the network of Roman settlements in the region and the control of the middle basin of the Guadalete River. There is an important factor in this dynamic; which is the appropriation by the *Gaditanii* of the Tempul spring, about 6 kilometers from Sierra Aznar, to turn it into the *caput aquae* of the aqueduct that supplied the influential *Gades*. About this hydraulic structure has recently been investigated in depth (Lagóstena and Zuleta 2009; Lagóstena 2015; 2017). Among the historical conclusions reached we proposed that the water source of El Tempul would be located in the territory and in the same fluvial sub-basin of the pre-Roman community of the later *Caldubenses* (Lagóstena 2017: 28), and that the monumentalization of Sierra Aznar and its important hydraulic complex should be related to the conjuncture of the construction of the *Gades's* aqueduct, and with the presence in the territory of *aquarii* experts for this reason.

Thus, it is likely that the hydraulic construction is due to an intervention of the *Gades* community, a compensatory action for the cession of the Tempul waters. This is an argument for which documentary evidence is lacking. Beyond the urbanization, which would provide the *Caldubenses* with a civic center adequate to the expectations of a new *municipium*, we would be looking at the promotion of a

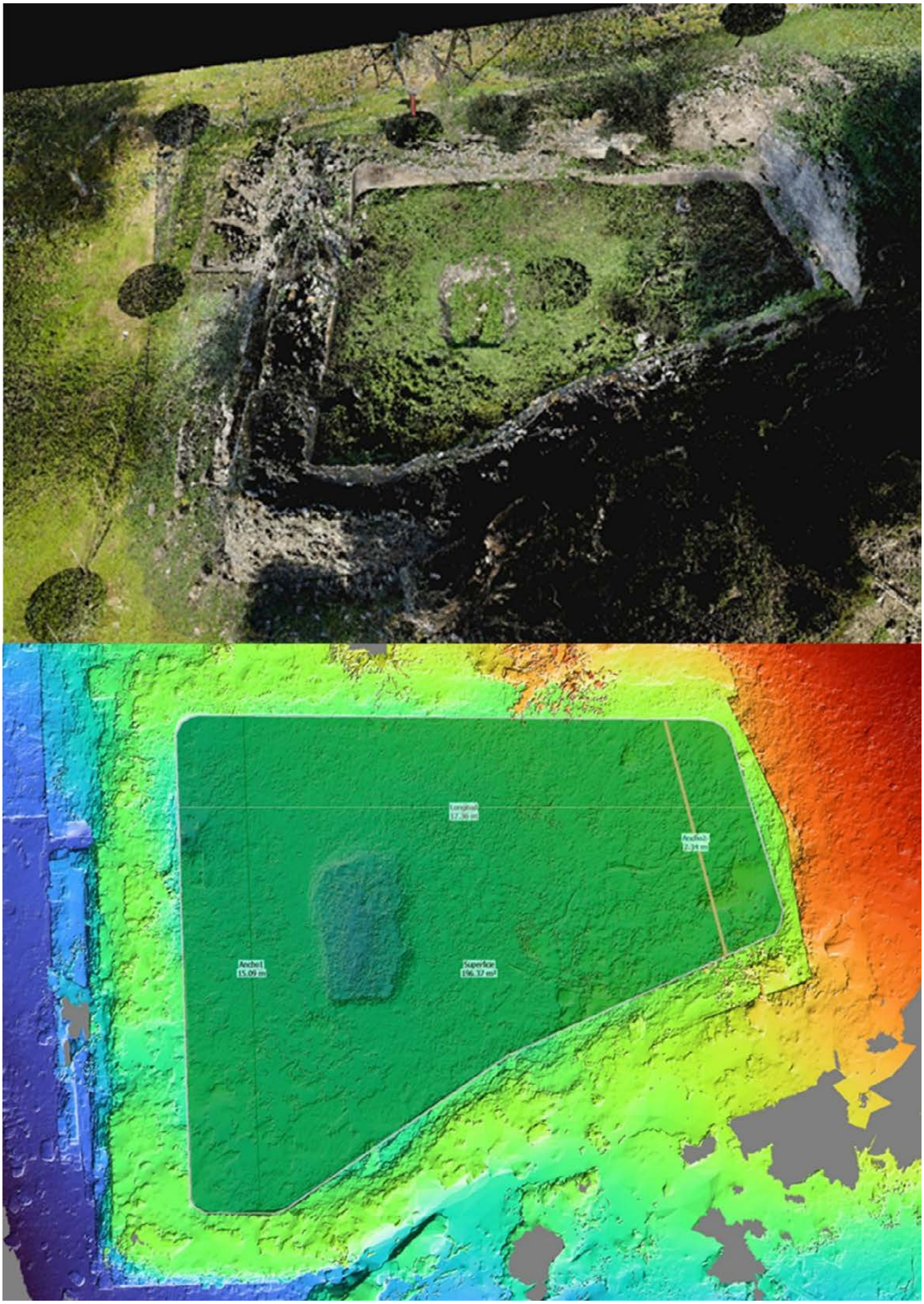

Figure 10. Perspectives based on the modeling of monumental fountain (elab. by the authors).

community destined to play a relevant regional role, within the framework of the provincial policies of the first century AD implanted in the territory of the mountain range from the capital of the *conventus Gaditanus*. The building program of the new *Calduba*, based on the spring water as a sign of identity, an element with symbolic connotations, which runs through the urban core, from the spring to the suburban areas, would have the function of signifying and legitimizing the *Caldubenses* community and its role in the regional context.

Calduba represents the type of community conceptualized as a Small Town, characterized by its modest size, but with significant urban functions for the territory, as these communities played a key role in the territorial organization and control, acting as local centers of administration, trade and cult, especially representing the central power of Rome, where it was more difficult to be exercised (Rondán-Sevilla *et al.* 2022; Rondán-Sevilla, in press).

It is in this explicative framework, in view of the preserved remains, and the organic structure with which the settlement is endowed, which we have outlined through our studies of the site, where we propose that the program of urbanization of Sierra Aznar aimed to present this urban space as *locus amoenus*, reconciling the natural image with the construction of the civic imaginary for *Calduba*, and using water as a sacralized resource. Thus, the concept of *locus amoenus* applies to Sierra Aznar because of the harmonious integration between architecture and natural landscape (Hardie 2002; 2016). The planning of the settlement, with its hydraulic elements and terracing, created an environment that combined functionality and aesthetics, reflecting Roman ideals of beauty and the enjoyment of Nature (**Figure 10**).

It is neither a new nor an exclusive model, but well known in other contexts of the Roman empire, Italic and Hispanic (Coarelli 1987). Monumental hydraulic infrastructures could symbolize power and prosperity, and a control of water that reflected the community's ability to dominate the natural environment. This use of water in ritual and public contexts reinforced collective identity and transmitted political and cultural messages to the surrounding society. *Calduba*-Sierra Aznar may be a well-preserved example of this issue related to the importance and historical role of *parva oppida*.

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Erogationes in the San Lázaro Aqueduct, Mérida? The 'House of the Amphitheatre' Example[1]

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Abstract: we reflect on an *erogatio* detected in the San Lázaro aqueduct, Mérida, as it passes the so-called House of the Amphitheatre, also located in the capital of Lusitania. We analyse the architecture, focusing on the principles of water engineering in order to evaluate the relationship between the house and the aqueduct.

Keywords: Roman domestic structures, Aqueduct, Hydraulic architecture, Water supply systems, Lusitania.

Introduction

In 1947 a house was located in the area of the three public entertainment buildings in the town of Mérida. Its interesting physical characteristics have made it the focus of private architecture analysis, not only in Mérida, but on the whole of the Iberian Peninsula. It is known as the House of the Amphitheatre.

Its structure, ornamentation, location and a recently proposed change in functionality have been the subject of analytical questions that have been suitably resolved. However, despite the interest aroused by this archaeological site, many doubts about it remain and this study aims to shed some light on one of them.
Specifically, we analyse the possible relationship between the building and the San Lázaro aqueduct, which passes just a few metres to its north before entering the town. The needs of a building of these characteristics, as well as the recent discovery of a large baths, raise the question of whether the aqueduct contributed to the correct functioning of the house, as well as the adjacent baths complex.
To meet this challenge, we carried out an architectural analysis based on the principles of water engineering of both the aqueduct and a channel that flanks the house on its western side and is accompanied by at least two small tanks or basins. Unfortunately, although the section of the channel flanking the house is well preserved, the northern part has been lost. That sector would in principle have been its natural development towards the aqueduct and now coincides with a monumental garden. The theoretical prolongation of the channel appears to coincide with two holes in the aqueduct *specus* made after it had been built.
In line with this study, we will evaluate other links that have been archaeologically verified between several aqueducts and other privately owned buildings. This practice was quite common in ancient times, according to the large amount of legal documentation –mainly punitive– we have located.
This study, therefore, serves as a proposal for the water supply of this building from the aqueduct.

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Regarding the House of the Amphitheatre

On 12 November 1947, under the auspices of a report issued by the Mérida Directorate of Archaeological Excavations, the results of a survey sponsored by the Directorate General of Fine Arts and carried out by the General Commissariat of Excavations under the direction of J. C. Serra Ráfols were made public (García de Sandoval 1966: 14). This document brought to light the presence of a Roman house of great importance. Initially called the *Casa de la Madre*, it was subsequently baptised the *Domus del Anfiteatro* (House of the Amphitheatre), due to its proximity to that building (**Figure 1**).

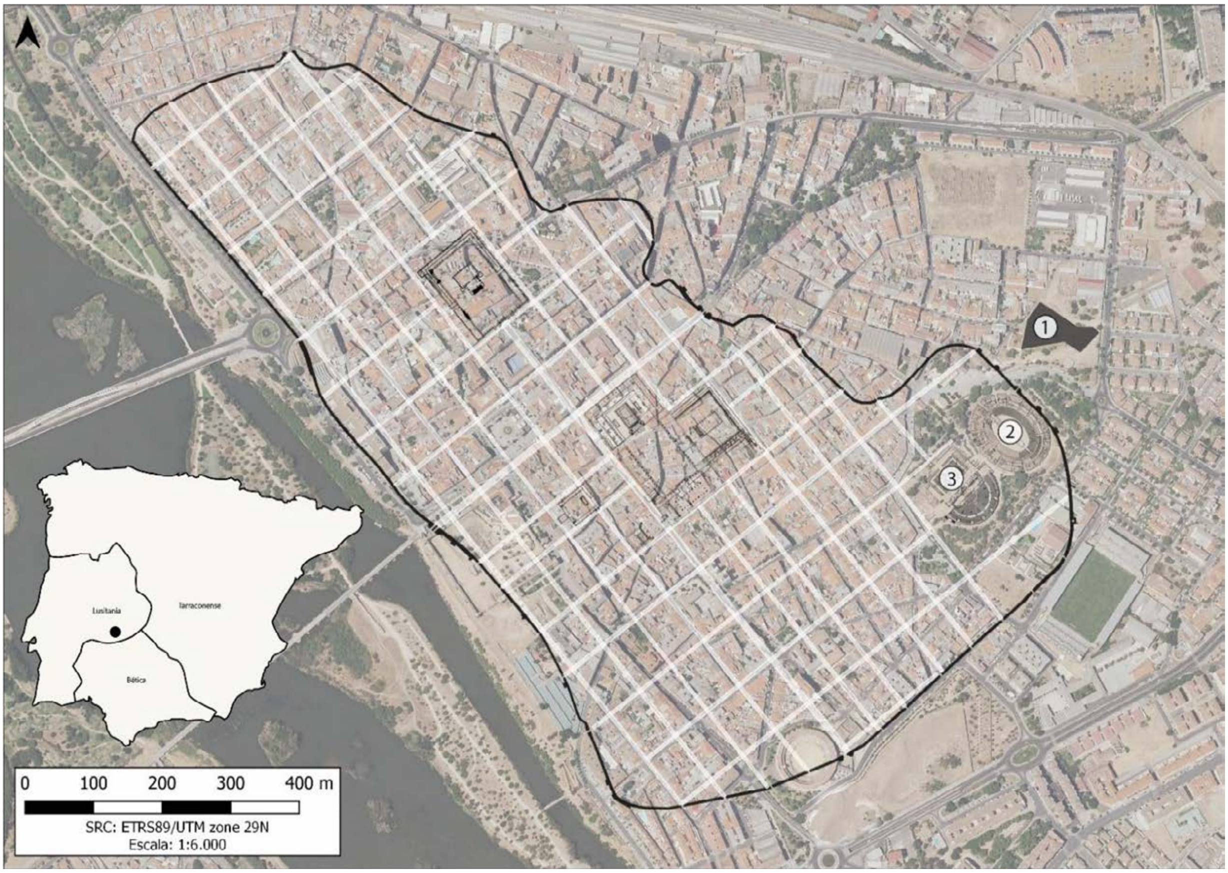

Figure 1. Location of Mérida on the Iberian Peninsula and floor plan of the house (1), amphitheatre (2) and theatre (3) (elab. by the authors).

Although the site has been almost continuously excavated up to the present day, the excavations that revealed most of its floor plan were carried out in the late 1950s by M. Pous, J. Álvarez Sáenz and E. García de Sandoval. After that, the excavations undertaken in the 1980s by the MNAR (National Museum of Roman Art) focused on the late-period baths area on the northern façade.

After a break of several decades, new interventions were activated as part of a project to cover the house. These resulted in the discovery of several rooms, basins (Sánchez 2011) and an open space surrounded by columns (Vargas Calderón and Plasencia Sánchez 2022), all of which can be associated with a baths complex.

The study we present here is part of a research project begun in 2020 that aims, in addition to the archaeo-architectural study of the building, to continue the excavations carried out in 2010-2011. The building in question was located *extramoenia*, to the southwest of the town. It was bordered to the northwest by the *specus* of the San Lázaro aqueduct **(Figure 2)**; to the south by the amphitheatre, theatre and the House of the Water Tower; and to the east, at a somewhat greater distance, by the circus. Added to this is a series of early Roman funerary areas that end up surrounding the building, including the *puticulum* of Hernán Cortés, the so-called necropolis of the Disco and the mausoleum of the lintel of Los Ríos, which is included in the visitors circuit.

In a very synoptic way, we will evaluate certain crucial points for understanding the building, which has traditionally been considered a *domus* with a complex ground plan formed by two modules. The first, more to the north, is where the *fauces* have continuously been located and which would have led to an open space with a central *viridarium*. The second module, to the southwest, is structured around an *oecus* with an ichthyic *xenia* decoration. The analysis of the ground plan, supported by a reading of the walls, raises the possibility that we are looking at two houses (or two modules) which were joined at a later time, the point of union being the corridor Balil (1976: 89) described as 'bayonet-shaped' due to its physiognomy (Pizzo 2004: 344).

In fact, even García de Sandoval (1966: 43) attests that the peristyle sector must have been laid out in the late 1st century AD, while the spaces located to the northwest would date to the 2nd century AD.

Regardless of whether we are looking at one or two *domus*, the excavations carried out over the last decade, and especially in the last five years, suggest that the baths had monumental features; the circuit would have been accessed from the peristyle and it would have had *letrinae*, *apodyteria, caldaria, tepidaria* and several warm-water pools.

The chronology of the building has traditionally been based on both the mosaic and the parietal ornamentation and, to a lesser extent, some material finds that have generated certain doubts from the beginning (Balil 1976: 85). However, García de Sandoval (1966: 43) claims to have discovered finds dating from the late 1st and early 2nd centuries AD and also places the destruction of the *domus* in the

Figure 2. Plan of the House of the Amphitheatre in its early Roman phase indicating the aqueduct and the erogatio *conduit (elab. by the authors).*

second half of the 3rd century AD (García de Sandoval 1966: 43).
The chronology of the mosaic compositions is centred on the 2nd-3rd centuries AD (Balil 1976: 86), to which some scholars add possible refurbishments in the 3rd century (among them García de Sandoval 1966: 43 and Hernández 1993: 999), which may even have continued into the 4th century AD (Álvarez Sáenz de Buruaga 1974: 184 and Álvarez 1982: s/n). The dates given for the pictorial decorations do not differ much from those of the mosaics: Hernández (1993: 1003) suggests a first phase between 220-225 and a second phase in the late 3rd or early 4th centuries.

The new excavations, especially in the baths complex, as well as in some parts of the *domus*, suggest a *terminus postquem* for the construction in the middle of the last third of the 1st century AD, due to the presence of thin local walls and some fragments of Hispanic *terra sigillata*.
Similarly, the interventions carried out in this new stage of the study of this emblematic building point to its possible function as a *hospitium* at the service of the entertainment buildings in its surroundings (Bejarano and Bustamante-Álvarez 2024).

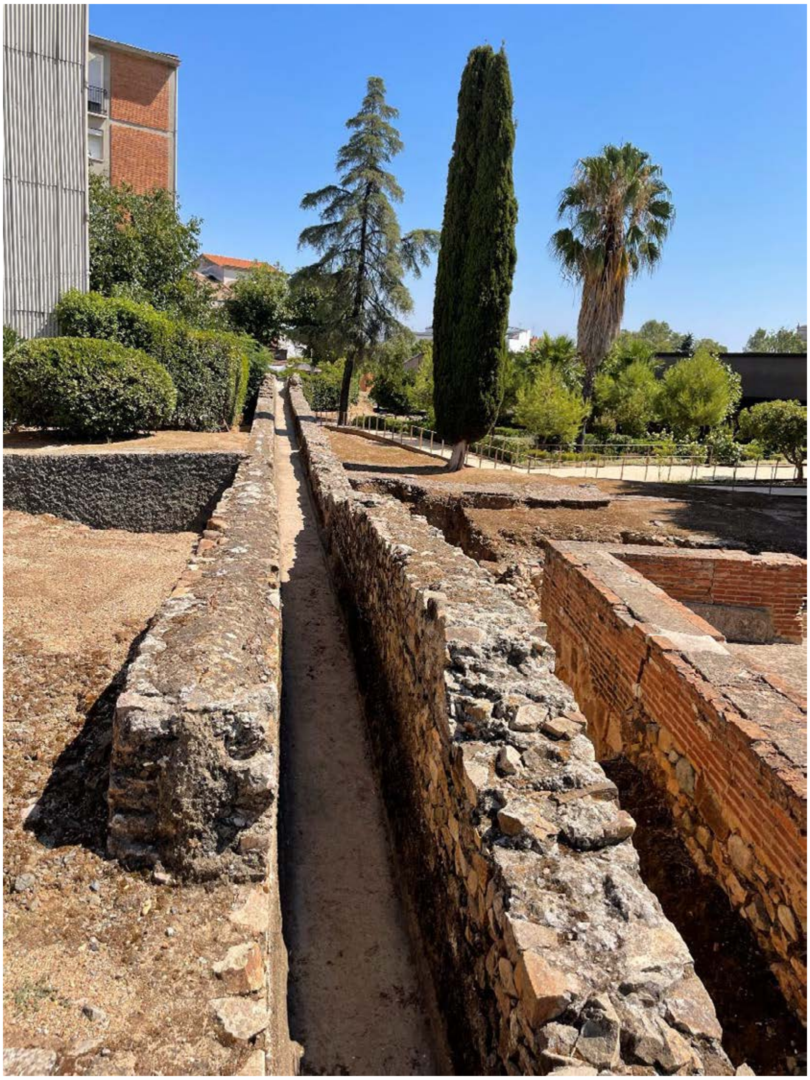

Figure 3. View of the aqueduct and the water outlet with the protome of a lion in the foreground. On the right is the present-day roof of the House of the Amphitheatre (photo by the authors).

The Rabo de Buey-San Lázaro aqueduct

Mérida's water supply system had four aqueducts: Cornalvo, Abadías, Milagros and San Lázaro (summary and bibliography in Sánchez and Martínez 2016). The last of these crosses the defensive walls and enters the town from the southeast, in the vicinity of the House of the Amphitheatre (**Figure 3**).

Probably built in the 1st century AD, the San Lázaro aqueduct had several supply branches: Casa Herrera (channelling groundwater seepage, Gómez *et al.* 2010; Martínez and Sastre 2022), Valhondo (possibly the main *caput*, which drew water from a weir, Álvarez Martínez 2007; Alba Calzado 2007, Gómez *et al.* 2010), and Las Tomas or Las Arquitas (a 4km *cuniculus* accessible through at least 99 *spiramina*, Gómez *et al.* 2010, which may have connected with the remains identified further north, Feijoo and Gaspar 2019; 2023). From the incorporation of this last branch in descending path 1, the flow joins up towards the town and is elevated on *substructiones* and arches (like those preserved after the passage

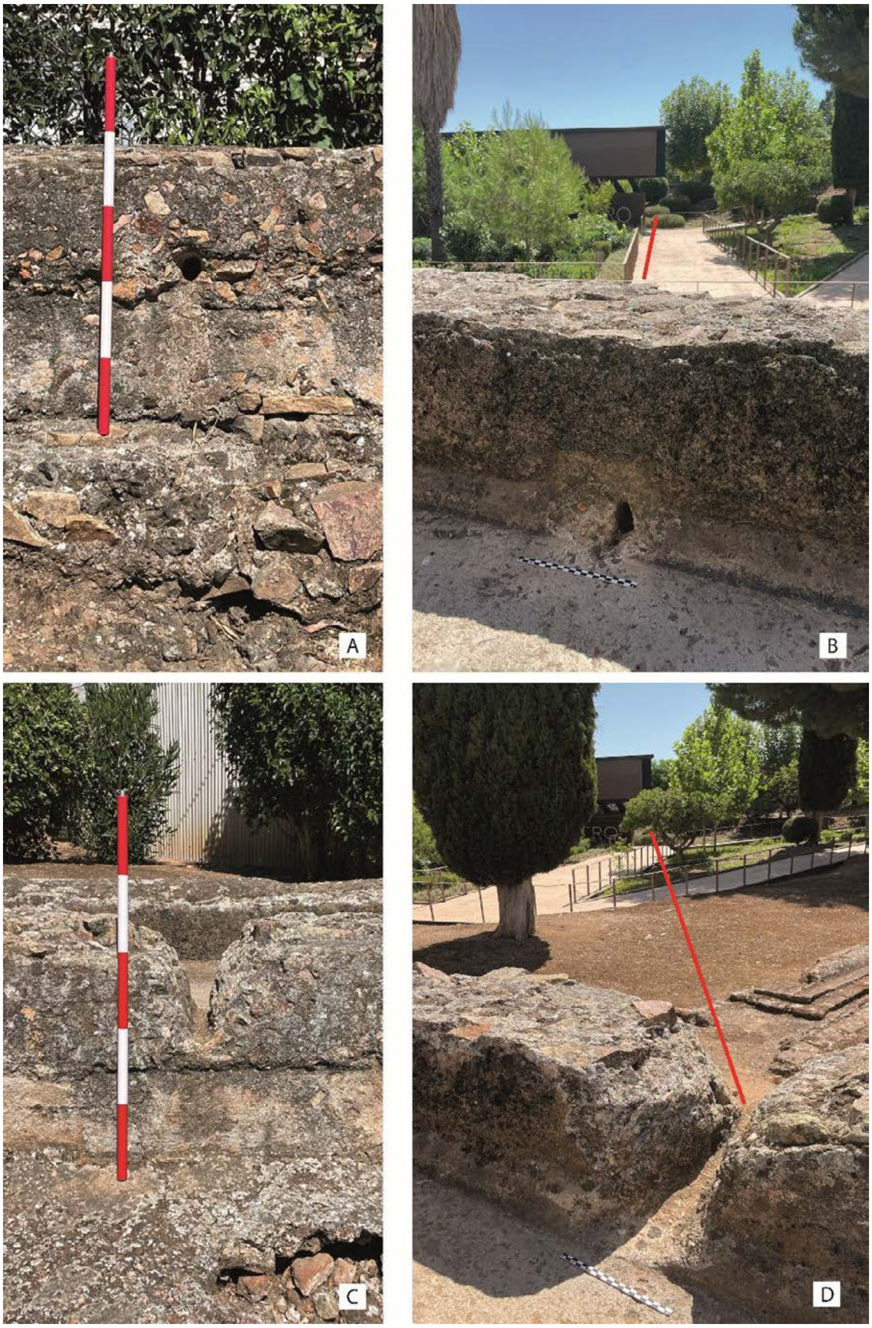

Figure 4. A-B. Exterior and interior view of the first documented outlet; C-D. Exterior and interior view of the second documented outlet. In red, the proposed development to enter in connection with the house (photos by the authors).

of the Albarregas river).

The conduit *castellum*, a decantation tower and an overflow channel in the form of a public fountain decorated with a lion's head were located in the area around the House of the Amphitheatre. At this spot, before crossing the wall, there is also the beginning of a lateral branch, which surrounds the fortification in a westerly direction at least as far as the Rambla de Santa Eulalia (Feijoo 2000: 575-576; Bejarano 2005: 131-157). This probably supplied the peri-urban sector.

In front of this branch, a planned diversion, either built during the aqueduct construction or at a later time, on the opposite side of the channel, i.e. on the eastern wall of the *specus*, there are two small holes (**Figure 4**), in addition to the lion's head overflow channel. In all three cases, we must not forget that we are at a higher level than the footing, which helps to explain the height differences in the channel system to which we will refer.

Although also oriented to divert water, in this case to the easternmost sector of the northern suburb, these holes perforate the channel in an unplanned manner. They are located 22.8m and 16.3m upstream from the exit point of the lateral branch. The first consists of a hole that is 4cm in diameter inside the *specus* and 7cm where it exits on the other side of the wall delimiting the channel (**Figure 4: A-B**). The measurements of the other, located 6.5m downstream, are impossible to define exactly due to the break in the side wall; the hole is currently 15cm wide inside the *specus* and 19cm wide on the outer face of the wall. Despite this, its tendency is more circular than the previous one (**Figure 4: C-D**). In both cases, the perforation of the side wall of the *specus* was made just above the base of the channel, a position that entailed the risk of the opening being obstructed by silt, stones and other heavy objects deposited at the base of the channel.

Similar derivations made by drilling holes in the wall of the aqueduct channel for the supply of *extra urbem* sectors have been documented in other Hispanic aqueducts (Sánchez 2015). In the case of Mérida, they have been observed in the Proserpina-Los Milagros conduit in the Las Abadías area (Méndez 2015: 44-46; Bustamante-Álvarez and Acero 2023). In the two cases identified, the water was channelled to two smaller conduits, one built with laterite material and the other in stone masonry with laterite fragments, in this case at a level similar to that of the *specus* itself and possibly with the clear objective of supplying the adjacent industrial facilities, or in the Cornalvo conduit, also supplying a public fountain with a channel and with two water robberies, one of them plugged, which supplied a *domus* (Alba *et al.* 2022: 90-91). Other examples on the Iberian Peninsula of aqueduct perforations are those of the *Aqua Augusta* in Córdoba (Pizarro 2012: 116) and La Alcantarilla in Toledo (Arenillas *et al.* 2009: 155).

Figure 5. View of the excavations of the channel in the 1950s (García de Sandoval 1966: Plate XXXII, 1).

Connection between the aqueduct and the house?

Unlike the perforations identified in the Proserpina-Los Milagros conduit, in the case of the San Lázaro aqueduct it has not been possible to document their connection with any channel, since neither the early excavations that defined the space where it must have passed as a 'small square' (Balil 1976: 86 or Pizzo 2004: 337) nor the renovations carried out to enhance the value of the house, which created a landscaped area, give any indication of what this connection would have been like. However, there is a conduit a few metres away, bordering the exterior of the southern side of the House of the Amphitheatre. This could have been linked to the furthest orifice of the branch leading to the Rambla de Santa Eulalia, as they coincide in prolongation. A different thing happens with its levels, since the aqueduct *specus* is higher than the channel, which is necessary for the correct flow of water, as we will see below.

The excavation, albeit partial, of this channelling that accompanies the house on its southern flank dates from the late 1960s (**Figure 5**). The first written references to it were published by García de Sandoval (1966: 23) in a reflection on the rooms on the southern side of the peristyle. In this account he refers to 'a rectangular set of four compartments (...) and a triangular-shaped *impluvium* or a room for the collection of rainwater and which has along its southern wall a gutter which then turns and takes a south-north direction at the rear of the east wing of the house'. This paragraph is accompanied by a photograph showing the excavation work (García de Sandoval 1966: Plate XXXII, 1) in which we can see the considerable increase in height as a result of the restoration and enhancement work.

Despite the importance of these channels, no further reference is made to them throughout the study. It is possible to discern a certain relationship with the one defined as 'channel of the fauces' (García de Sandoval 1966: 28-29) which accompanies the peristyle on its northern side and comes from the triangular room (No. 12), to which we will now dedicate a few paragraphs. The canalisation, which adapts to the structures of the house and the orography of the terrain, is lined with *opus signinum*, and can be divided into two sections with different constructive and technical characteristics (**Figure 6**). It is also important to note that many of the visible sections were rebuilt and restored during the 1970s. However, it is easy to distinguish those parts that were replaced.

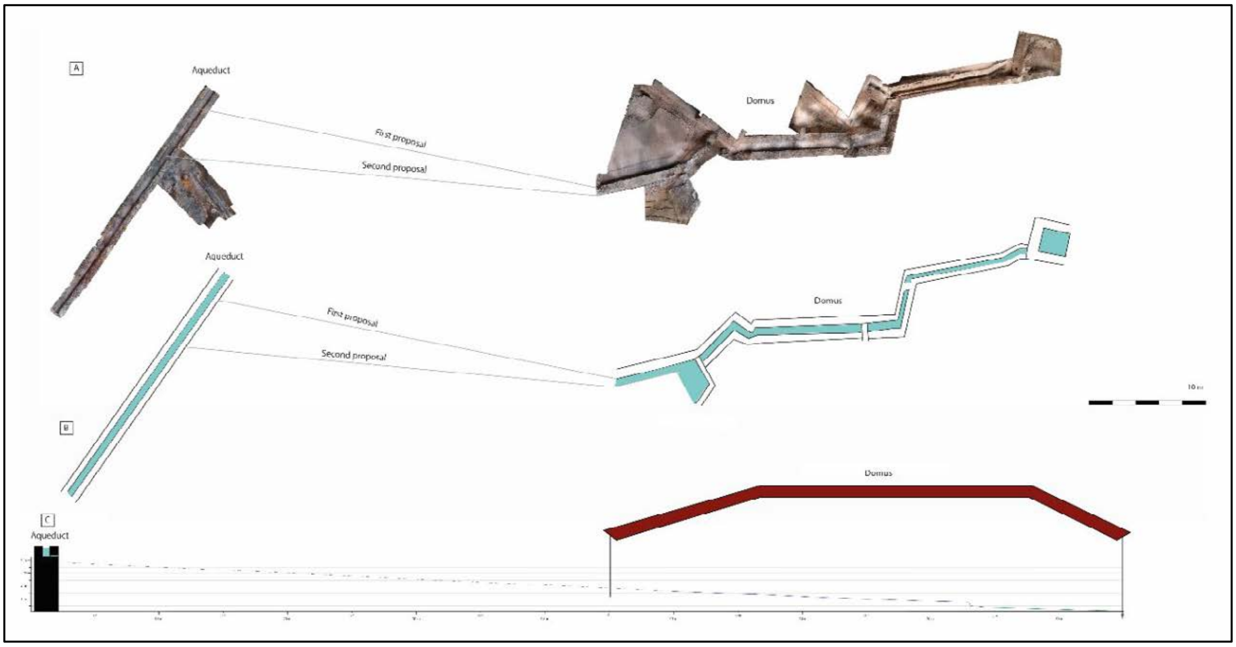

Figure 6. A. Orthophoto of the specus *as well as the channel; B. Drawing of the specus as well as the channel and C) the hypothetical section of the slope between the* specus *and the channel, as well as the trajectory of the latter (elab. by the authors).*

In the case of the first section, approximately 22m long, only the right-hand side attached to the house, is well preserved, as the left/exterior side has been systematically destroyed or is under later structures. Along the entire length of the right-hand side there is a 10/11cm wide and 8/10cm tall hydraulic lip; on the left side it can only be glimpsed, although it has been destroyed in some places. Excluding the half-pipe, the channel has a maximum width of 40/45cm at its base, probably narrowing to a width of around 30cm at some turns.

After crossing a small 29cm high step, the channel makes a right-angle turn, giving rise to a second section just over 10m long. In this case, there are no mouths on the corners and the channel is 24/25cm wide, with side walls that reach a height of 35cm.

Each of the two sections of the channel appears to have a branch. In the case of the first section, it is a hole in the southeastern wall of Room 12 in the House of the Amphitheatre (the triangular *impluvium*); it was originally about 10cm wide, judging by the imprint still visible. At the opposite end of the channel, at the end of the second section, there is a second branch, considerably retouched, that may have channelled water in the direction of Room 28. Around this second branch, a structure of

unknown function drains into the channel; it is lined with hydraulic mortar and was probably some kind of a basin, pond or tank.
Although the channel has an average gradient of 4.4% (44m/km), it can be seen that there are differences between the two sections. The first has an average gradient of around 3.8% (37.86m/km) and the second of approximately 2.7% (2.69m/km). The connection between the two is made via a 29cm high step.

One of the peculiarities of this channel is the accumulation of turns, with angles of almost 90º, especially in the first section and in the connection between the two defined sections. This design was probably intended to adapt to the irregular external structure of the House of the Amphitheatre, which it supplied, but it may also have contributed to slowing down the speed of the water, which must have been high, as can be deduced from the average gradient of 4.4% observed.

Today, the channel begins its course in the easternmost sector of the southern side of Room 12, although some of the published plans of the House of the Amphitheatre lead us to suspect that this conduit could have bordered the entire room, as can still be intuited by the appearance of some isolated remains of *opus signinum* and the existence of a modern conduit. These elements appear to suggest that the conduit continued in the direction of the aqueduct. Although, as mentioned, there is no physical connection with the channel that supplied the colony, the two perforations in the *specus* less than 50m from the remains of the channel suggest it may have carried water to these buildings. The height difference of 2.37m between the perforations in the *specus* of the aqueduct and the base of the conduit surrounding the House of the Amphitheatre would have allowed for this. Taking into account the distance and the height difference, the theoretical slope of this section of the channel would have been around 4.7%, very similar to that calculated for the preserved sections.

The first place water enters the House of the Amphitheatre is, as described above, via a diversion from the perimeter channel through the southeastern wall of Room 12. This space is practically triangular in shape and has a *signinum* floor with an edge 60-80cm wide and 8-10cm high, which runs along the three sides of the room in the manner of a 'wide water mouth'. Room 12 has a steep gradient (approximately 4% with a drop of more than 30cm) in a northerly direction, towards the opening that connects with Room 7. The water inlet is practically at the highest point of Room 21cm above the level of the *signinum* cladding of the base at that point. The water inlet and the *opus signinum* cladding, together with the strange mouths, seem to suggest a water-related function for this space. However, it would not have been used to store water as, despite the slope of the floor, the low elevation of the supply point limits the storage capacity. However, it could have been used as a limited storage space so that, from this point above the peristyle and the baths, the water could have been distributed through pressurised pipes, perhaps to generate water features in these spaces. However, the poor conservation and the reconstruction of the structures prevents us from confirming or disproving this hypothesis, or proposing the exact model of water distribution.

The second diversion from the perimeter channel towards the interior of the House of the Amphitheatre has been completely remade at the level of the base of the canalisation. It flows into a modern conduit that runs below the current ground level in the direction of Room 28. The limited scope of the excavations in this sector prevents us from hypothesising on the functioning and destination of this conduit.

Reflections

In these pages we have discussed the possible relationship between the San Lázaro aqueduct, before it reached the Water Tower of the ancient capital of Lusitania, and the building known as the House of the Amphitheatre.

It is evident that a building of this magnitude and its annexed baths would have required a continuous and efficient water supply system. In this case, unlike other examples studied by the authors, such as the House of the Mithraeum (Sánchez *et al.* 2023), which had at least three cisterns, there was only one well located in the open area traditionally known as the peristyle, where a U-shaped pool would have stored water, as well as two small pools/deposits/tanks linked to the channel referred to throughout the text. In fact, some scholars consider that the deployment of water in the garden known as the peristyle can only be explained by an efficient connection with the San Lázaro aqueduct (Casillas 1998: 307).

Therefore, the links between the two buildings, regardless of their size, must have been remarkable. Nor would this be the first example of a possible *erogatio* concerning this same aqueduct. In fact, in the excavation known as the 'MNAR extension', a ceramic conduit was discovered parallel to the branch of the aqueduct leading to the Santa Eulalia watercourse. It has been interpreted as a possible intake associated with the irrigation of a funerary garden (Bustamante-Álvarez *et al.* 2022).

We suggest that one or both of the orifices found in the *specus* are related to the channel that runs adjacent to the house on its western side. Unfortunately, we do not know what the relationship was between the two elements, as the publications regarding the earlier excavations do not offer any data. Consequently, we are currently faced with several unknowns, the solution to which is hard to find:

1. Regarding the route between the *specus* and the channel itself. It is quite possible, on the basis of the orifice visible today, that the exit was via a *fistula plumbea*, the material of which was much desired for recycling and commonly plundered.

2. Regarding the chronology of this construction. It is clear, given the nature of the two 'perforations', that they were not part of the initial plan. Rather, the needs were defined once the structure was fully active. Similarly, the adaptation of the channel to the physiognomy of the *domus* tells us that it was constructed when the *domus* had already been built. In fact, this connection between the two elements (*specus* and channel) meant that the slope was very steep. This could have been overcome by adapting it to the recesses on the outside of the building, which allowed the speed of the flow to be reduced.

3. Regarding the operation. It is evident that the water circuit worked because of the gradients observed with an outlet from the *specus* to a higher level. However, it is not clear to us whether this flow would have been continuous or whether there would have been a tap to control the flow. Nor do we know how the channel, already attached to the house, would have been linked to the adjacent rooms and to at least one of the possible reservoirs. This room has a steep slope (4%) which would ultimately have channelled the water towards a drain in the northwestern corner of the room, which would have discharged directly into the channel 'of the fauces'. This would mean that the clean water would have been channelled directly into a conduit whose function would have been to supply the *fossa letrinaria*. With regard to the tanks/ponds, we do not know their exact relationship with the channel. In fact, there is no evidence that prevents us believing they were fed by channelling rainwater from the roof.

4. Regarding the functionality of the water. To date, no comprehensive study of the circulation of water inside the so-called House of the Amphitheatre has been carried out. Therefore, it is not possible to define the specific uses of the water derived from the aqueduct. However, the level of the inlet would have made it possible to reach all parts of the *domus* and probably even generate the necessary pressure to create water features in areas such as the peristyle or the baths, as well supplying the latter. Another conceivable destination of the water could have been the possible artisanal textile washing facility recently identified next to the thermal baths. The use of water from the urban network to supply *fullonicae* is well attested. For example, in Pompeii at least eight such establishments were connected to the network (Sánchez 2024: 84).

5. Regarding the ownership of the *erogatio*. Unfortunately, we do not know whether this outlet would have been legal or illegal.

Diversions from aqueducts to different areas were common in Roman times, as evidenced both by archaeology (some Hispanic examples have already been mentioned above) and written sources. In fact, in the introduction to *De Aquaeductu Vrbis Romae*, when Frontinus describes what he is going to expound and which aspects he intends to analyse in each of the conduits, among other technical aspects he includes the flow distributed in the *erogationes*, both those inside the town and those that installed before the channels crossed the walls (*erogationes extra urbem*) (Frontin., *Aq.* 3, 2). And so he proceeds (between *Aq.* 79 and 86) when he describes the distribution of water from each of the aqueducts. According to Frontinus' own descriptions, the flow of these extra-urban derivations could have been destined to supply both public spaces or structures (literally, the Roman writer associates them with Caesar) and others of a private nature.

Derivations could be made from *castella* (reservoirs) or from the channels, either from the main channel or from secondary branches. These were legal, provided they were authorised by the competent authority (*Dig.* 43, 20, 1, 41 and 42), which in the case of Hispania was probably the local senate (Gerez Kraemer 2020: 177-178).

Nevertheless, Frontinus mentions frequent abuses and illicit diversions resulting from the fraudulent activity of some workers in the water supply network management system or by the owners of the land crossed by the publicly owned aqueducts. In this regard, he specifically laments landowners who bored holes in the conduit in order to take water (*possessorum, quorum agris aqua circumducitur, formas rivorum perforant, Aq.* 75, 3). This practice is highly reminiscent of the characteristics of the diversions from the channel of the San Lázaro Aqueduct, which we have suggested may have been related to the conduit than runs around the House of the Amphitheatre. However, in the absence of further data, it is impossible at this stage to determine whether this was an illicit perforation. Nevertheless, we do find of interest the presence in other parts of the *domus*, albeit in a secondary position, of *fistulae plumbae* with inscriptions possibly alluding to the municipality (EX OFFICINALIS). This could be evidence of the ratification of the diversion by the public body and would therefore indicate the legal nature of the water diversion.

Another interesting question is whether the connection of the conduit around the *domus* of the Amphitheatre with the aqueduct would imply that the water derived from it would have had to pass through the grounds of what is known as the House of the Water Tower. This circumstance was resolved by Roman legislation in what was known as *servitus aquae ductus*, understood by Ulpianus as ‘the right to conduct water through another's property’ (*Dig.* 8, 3, 1). With regard to the procedure for this, the written sources mention two possibilities. According to Augustus' edict for the aqueduct of Venafro (*CIL* X, 4842, 46-47), in order to connect directly to a public aqueduct, in addition to the administrative authorisation, one needed the authorisation of the owner of the land to be crossed (Saliou 1994: 136). On the other hand, if the connection was made from a reservoir, a *castellum aquae*, the *ius aquae ex castello* (*Dig.* 43, 20, 1, 38-39) determined that such passage through other people's land could not be obstructed.

In short, the perforation of the walls of the aqueduct, and the characteristics of the conduit around the House of the Amphitheatre, attached to the external wall of the structures adapting to them and their recesses, suggest that it was a channel for private use built after the aqueduct had been put into operation. The connection by perforating the channel shows that the diversion to this sector was not planned at the time of its design and construction, but was carried out at a later stage.

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Monumental Fountains with Staircases at the End of the Iron Age in Southern Gaul

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Abstract: the monumental fountains XXXVI and LX at *Glanum* (Saint-Rémy-de-Provence, Bouches-du-Rhône), commonly referred to as the 'nymphée' ('*nymphaeum*') and the 'puits à dromos' ('*dromos* well'), were for a long time considered to be the exception rather than the rule, due to their imposing size, their walls clad in large stone blocks and the presence of a staircase. The origin of this type of hydraulic structure remained to be determined. Recent discoveries gain a clearer understanding of the origin and development of these original hydraulic structures, which are now considered to be Gallic creations, with only the monumental 'dressing' in the *Glanum* examples resulting from borrowings from Mediterranean architecture.

Keywords: Hydraulic systems, Water, Monumental fountains, Iron Age, Wells.

This paper focuses on the water supply of indigenous settlements in southern France at the end of the Iron Age. On these sites, water appears to have been, in many respects, more repulsive than attractive: the hydraulic structures were designed more to evacuate water - devastating run-off - than to capture, convey or store it (Agusta-Boularot 2004). The inhabitants' need for water, whether for domestic or craft use, was limited. As these settlements were usually located on high ground, water sources (springs, lakes, resurgences, rivers) were located outside the ramparts, and their development was minimal: at best, they were defended by walls or an extension of the rampart, as was the case at Castels (Nages-et-Solorgues, Gard), where the second enclosure, built in the second half of the 3rd century BC, surrounded the perennial spring, while a wall blocked off the valley to protect access (Py 1978: 72-14, 176-177 and fig. 86). Wells are attested at a few sites, often due to the proximity of the water table, as at the *oppidum* of La Courtine (Ollioules, Var), where the water is only 2m deep (Brun 1999: 542-546). Cisterns are very rare: one of the few known examples is a late construction of the 1st century BC on the *oppidum* of La Cloche (Les Pennes-Mirabeau, Bouches-du-Rhône), can certainly be explained by its proximity to Marseilles, as the cistern was plastered with *opus signinum*, a construction technique borrowed from the Greco-Italian world (Chabot 1992).

The monumental fountains XXXVI and LX at *Glanum* (Saint-Rémy-de-Provence, Bouches-du-Rhône), commonly referred to as the '*nymphaeum*' and the '*dromos* well', were for a long time the exception rather than the rule, with their imposing dimensions, large stonework walls and staircase providing access to the water. The origin of this type of hydraulic structure, unique in Gaul, remained to be determined. Given that *Glanum* was a site that was largely open to Mediterranean influences in the 2nd and 1st centuries BC, the hypothesis that it had been borrowed from a Greek city, particularly *Massalia*, or a city in Italy seemed conceivable, even if no similar monument had been found.

Recent discoveries have made it possible to reopen this issue and gain a clearer understanding of the origin and development of these original hydraulic structures, which are now seen as Gallic creations, with only the monumental 'dressing' in the *Glanum* examples resulting from borrowings from Mediterranean architecture.

The '*nymphaeum*' and '*dromos* well' at *Glanum* (Saint-Rémy-de-Provence, Bouches-du-Rhône)

The construction, from the second half of the 2nd century BC, of a rampart and buildings in large, quick-joined units, of a rampart and public buildings, as well as several *domus* with peristyle similar to those found at the same time in Delos or Pompeii, initially led archaeologists at the site to wonder about the status of this town (commercial relay of Marseilles?), the origin of its population (Greek or Gallic?), and the nature of its links (dependence?) with *Massalia* (Picard 1963: 112).

But since the end of the 1980s, thanks in particular to the excavations carried out by A. Roth Congès (1985; 1987; 1990; 1992a-c), the ceramological work of P. Arcelin (1991) and the study of the *graffiti* on the site by M. Lejeune (1985; now *RIIG*), it has been established that *Glanum* was a large Gallic settlement of the Salyens people, inhabited by Gauls rather than Greeks, who settled at the northern end of one of the Alpilles valleys. Although the site was already frequented in the Bronze Age, sedentary occupation is only documented from the Early Iron Age onwards. In the second half of the 2nd century BC, the settlement underwent profound changes. The exceptional monumentalisation that characterises it, the importance of imported ceramics in the finds and the use of Gallo-Greek epigraphy are the most tangible signs of the strong commercial and cultural links that the aristocracy of *Glanum* maintained with the Phocaean city and certainly with other Greek or Hellenized cities in the Mediterranean world. The use of stone extraction, cutting and construction techniques borrowed from the Greco-Italian

Figure 1. Glanum 'nymphaeum'*: 3D model (elab. by IRAA-UAR3155).*

world can only be explained by the presence of architects and teams of craftsmen from Marseilles or, more broadly, from the Greco-Italian world.

The 'nymphaeum' *(monument XXXVI)*

Monument XXXVI (**Figure 1**) was uncovered by H. Rolland in 1952-1953, in the southernmost part of the excavated area, during the last major excavation campaigns he carried out on the site. This area, called the 'spring valley' by the excavator, corresponds to one of the narrowest parts of the Notre-Dame de Laval valley, before it flows out of the Alpilles into the Saint-Rémy-de-Provence plain. The monument, located between the temple of *Valetudo* and the *cosidetto* '*fanum*' of Hercules (XXXVII), includes a water catchment gallery and a large pool, reached by a staircase. At the time of its discovery, the '*nymphaeum*' was in an exceptional state of preservation.

According to the chronology he drew up for the site, H. Rolland dated the '*nymphaeum*' to the '*Glanum* I' period, which he also called 'Hellenistic *Glanum'* and which corresponds to the 2nd century BC, more likely the second half or even the last quarter of that century, according to our current knowledge. A number of buildings (public buildings, private dwellings, ramparts) constructed using the same construction method (large and dry laid blocks with chevron traces) have been attested on the site for this same period.

H. Rolland distinguished three successive states for this building:

- 'a simple basin cut into the rock, leading to a staircase with steps also cut into the stone'. Although H. Rolland did not date this first state, the rest of his reasoning shows that he placed it between the beginning of *Glanum* (6th century BC?) and, at the earliest, the end of the 3rd century BC.

- at the end of the 3rd or beginning of the 2nd century BC, under the influence of Marseilles, the pool was sheltered behind the rampart and monumentalised (large stone walls, paved staircase) in the form of a '*nymphaeum*'.

- at the beginning of the Empire, under Roman influence, the pool was 'restored and dominated by a temple dedicated to *Valetudo*, the Italic goddess who watches over everyone's health, and whose presence here bears witness to the cultic role of the spring in the spiritual life of *Glanum*'.

H. Rolland considered this fountain to be 'one of the most interesting discoveries made since the start of the excavations', but apart from the notes he recorded in his notebooks from day to day, the only documentation available to us was for a long time limited to the ten or so pages he wrote in the *Fouilles de Glanum* (1947-1956) (Rolland 1958: 89-98; with some additions in Rolland 1968; reprinted in Gateau and Gazenbeek 1999: 302-305).

In the 2000s, the building benefited from additional studies[1] - architectural surveys, building studies, hydrogeology - which shed light on its construction and operation (**Figure 2**) (Agusta-Boularot *et al.* 2001; Agusta-Boularot *et al.* 2004: 31-32; Fabre 2009). A 3D digital model has recently been produced.[2]

This monumental fountain consists of two interconnected hydraulic structures: upstream, an underground water catchment chamber, and downstream, a basin that is now open to the air but was covered in ancient times. In its monumental state, the elevations of the two structures rest directly on the limestone Urgonian rock in place.

[1] In 2000-2003, the plan and elevations of the building were produced by S. Agusta-Boularot, V. Mathieu (CNRS) and M. Gazenbeek (Inrap), who benefited from the surveys carried out in 1979 by P. Varène and J. Bigot, which P. Varène had made available to them. The surveys are kept at the *Institut de Recherche sur l'Architecture Antique* (USR3155) in Aix-en-Provence.

[2] This digitisation was carried out by IRAA-USR3155: https://sketchfab.com/3d-models/source-sacree-91ac56e8db2d48bf89e2fb20a494fbc3#upload.

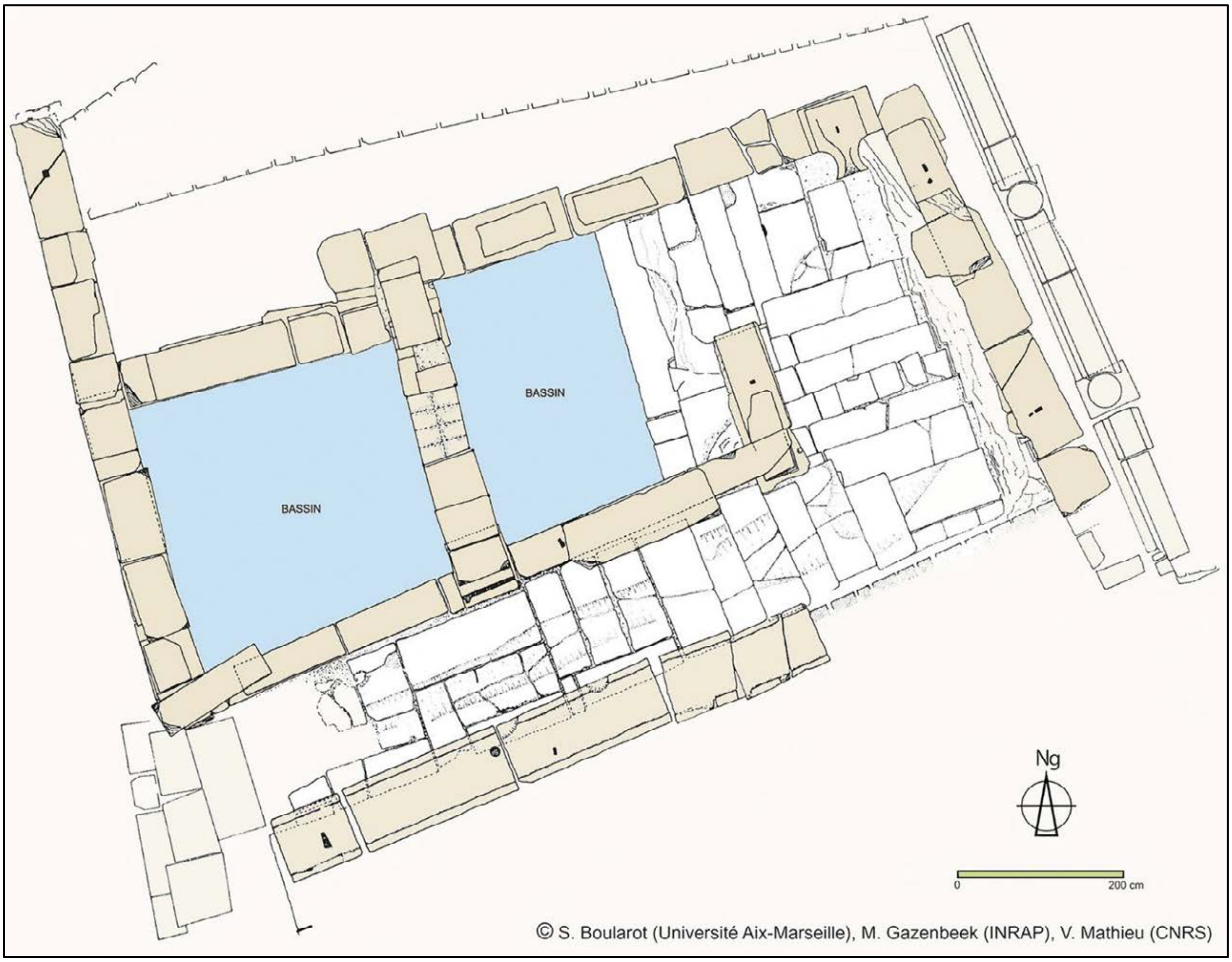

Figure 2. Plan of the 'nymphaeum', Glanum *(elab. by V. Mathieu, ASM-UMR5199).*

The basin has an asymmetrical trapezoidal quadrilateral plan:[3] average internal length: 7.08m; internal width on the west side: 3.30m; width on the east side, at the return of the south wall and the lower steps: 3.00m[4]. The north wall, which is not rectilinear, has a step in the middle: the orientation of these two sections of wall differs by an angle of a few degrees. The surface area of the pool is approximately 21m^2. Depending on the height of the cofferdam that allows water from the collection chamber to flow into the basin (see below), a minimum volume of 10m^3 of water should be permanently available throughout the year.

The walls of the reservoir are built directly onto the specially prepared rock. From the street, access to the water is via a paved walkway over 1.70m wide, followed by a three-flight staircase with 22 steps in all, varying in width from 1.70m to 2.11m. There are two straight landings at the changes of direction. The last steps of the staircase are usually under water, which can rise to cover the lower landing after heavy rainfall. The rounded wear marks on the last steps of the staircase and on the edge of the pool are the result of the repeated rubbing of large jars or other flattened containers that have been plunged into the pool and hauled up.
The water level is an average of 4.5m below the street that runs alongside the monument on its western side, a major thoroughfare that runs north-south through the entire town.

[3] The overall dimensions of the building are: west: 6.57m; north: 10.8m; east: 5.72m; south: 11.65m.
[4] Some of the figures given by Fabre 2009 are incorrect.

This basin functioned as a collector, collecting water from a supply system located upstream. In the SW corner, less than a metre above the bedrock level, a rectangular opening (L = 1.08m x H = 0.56 to 0.6m) provides access to a narrow, deep, low gallery that can only be entered when the basin is completely empty: this is the monument's technical water catchment gallery. G. Fabre (2009: 68-73) provides a detailed description of how this gallery works. It is slightly trapezoidal in plan: the two walls, north and south, are imperfectly straight and roughly parallel. The south wall is 4.89m long, the north wall 5.36m. The eastern wall is limited to an angled arrangement for directing water towards the cofferdam and then the basin. The wall at the end of the gallery, on the west side, is only 1.80 m long. The surface area of this gallery is between 9 and 10m^2. The height of the gallery varies from west to east, from 2.20m to 1.55m, which was high enough to allow men to move around and work easily when the recurrent accumulation of sediment on the bottom required cleaning. Three of the walls (N, S, E) are made of large and dry laid blocks of stone. The faces of the blocks show traces of Hellenistic 'herringbone' or 'fishbone' cutting (Bessac 1995). The blocks of the lower courses, all laid on the cut rock, allow water to circulate through their joints. Only one wall, the west wall, is much cruder in appearance, built of irregular rubble that allows plenty of water to pass through.

At the foot of the south wall, four comb-type drainage barbicans allow water to pass through. This wall was installed directly across the talweg like a dam, in order to collect as much water as possible in the gallery and direct it towards the basin. Stone slabs were erected at the bottom of the north wall to protect it from erosion caused by the impact of the water emerging from the barbicans. The force of the water caused one of the blocks of the south wall to fall to the ground. Through the opening in the barbicans, a rough filling of uncut boulders can be seen behind the large stone wall.

The gallery was covered with stone slabs laid flat on top of the north and south walls, in the same way as the large collectors on the site (Agusta-Boularot 2004: 195-199; Lebret 2023: 199-213).

In the event of a large influx of water, the gallery was protected from the effects of any excess pressure by a chimney (diameter: 0.2-0.3m) at the end of the gallery, which functioned as a vent. Through this device, the water flowed into the imposing collector that runs under the main street from the south to the north of the site. This overflow explains why, even in bad weather, the water level in the basin never exceeds a certain height. The fact that the opening (cofferdam), which connected the water catchment chamber and the basin, was located higher than the level of the bottom of the structures, should have allowed the water to settle: the sediments carried by the water were trapped in the catchment gallery where they were deposited.

The hydrological and hydrogeological study of the site carried out by G. Fabre showed that the '*nymphaeum*' was located at the resurgence point of a vast karstic system, making *Glanum* a site that was very well supplied with water, even during the dry summer months (Fabre 2009). The '*nymphaeum*' received its water from a karstic emergence with impenetrable water intakes carved into the fissured limestone of the Urgonian facies of the Barremian.

When the basin was being filled in, H. Rolland uncovered a number of keystones from the arch that had been reassembled and now surmounts the basin. As the north wall of the basin dips inwards, forming an angle of almost 2° with the vertical, H. Rolland thought that the arch had been put in place to counteract the earth pressure resulting from the erection of the neighbouring temple (*Valetudo*) and therefore attributed the arch to a contemporary restoration phase, i.e. from the beginning of the Empire. The arch is in fact original, as suggested by the fact that the blocks that make it up fit perfectly into the north and south walls of the basin. The presence of this arch meant that a powerful wooden framework had to be restored to support the thick, heavy sawn stone roof slabs, the only type of roofing attested at the time for public buildings in *Glanum* (Olivier 1982).

It is impossible to know when the first water collection basin was built: simply dug into the substrate, it is now masked by the later phase of monumentalisation, which took place at the same time as the protohistoric rampart also received its large stone facing, since the '*nymphaeum*' and the carriage gate of the rampart are structurally linked.

The latest excavations carried out on the enclosure have led J.-L. Paillet and H. Tréziny to suggest that this sixth and final monumental phase was built towards the end of the 2nd or beginning of the 1st century BC, thus clarifying the dating initially proposed by H. Rolland (Agusta-Boularot *et al.* 2004: 29-30). In terms of its Hellenistic cutting and bonding techniques, the *Glanum* rampart should be compared with the enclosures at Marseilles and Saint-Blaise (Bessac 1995). The former was built in the middle of the 2nd century BC (Tréziny 2001: 52) and the latter in the second half of that century, probably before the Roman conquest (Chausserie-Laprée *et al.* 2019: 375-377). The '*nymphaeum*' remained in use until the 3rd century, when the site was abandoned and the basin filled in.

H. Rolland recognised the building's 'utilitarian and cultic character'. He called it a '*nymphaeum*' because of the Greek character, he thought, of the monument, and more broadly of the settlement, and the sacred nature of the spring. He also referred to the southern part of the site as the 'sacred zone', the northern boundary of which would have been the large stone rampart that runs along the valley; the southern boundary could not be specified due to the passing of the departmental road. H. Rolland considered the discovery of this monument to be so important because, in his words, it provided 'an insight into the very origins of the town'. A simple protohistoric settlement would originally have clustered around this spring, and then, as the water source was 'soon endowed with all the supernatural qualities that ancient superstition ascribes to springs', it would have become a 'sacred fountain, reputed to heal', around which 'popular veneration created a sanctuary'. Above the basin, on its north side, *M. Vipsanius Agrippa* had a monument built in 40-37 or 20-19 BC. - the date is controversial (Agusta-Boularot 2015: 321-322) - a temple to *Valetudo*, the divinity of Good Health. To the south, H. Rolland identified a building with a statue of *Hercules Bibax* and several inscriptions to the god as a '*fanum*' of Hercules. The construction of two sanctuaries at the start of the Empire supported H. Rolland's interpretation of the area as a cult site.

Excavations carried out by A. Roth Congès in the southern sector of the *Glanum* site have confirmed H. Rolland's hypothesis: this is indeed the site's longest chronological sequence, from the Late Bronze Age to Late Antiquity and possibly the Early Middle Ages (Agusta-Boularot *et al.* 2004: 41-44). The area around the '*nymphaeum*' was the site of *Glanum*'s earliest urban development, and the perennial spring undoubtedly encouraged the first inhabitants to settle there. Like H. Rolland, A. Roth Congès attributed a religious function to the building, as well as a therapeutic one as part of the cult of *Aesculapius/Asklepios* (Roth Congès 1992a: 51; 1997: 186). A critical re-reading of the archaeological data by R. Golosetti has, in our view, forcefully demonstrated the weakness of the interpretation of the fountain as a place of worship from the Early Iron Age onwards (Golosetti 2015: 625-630). We do not wish to enter into this debate on the religious or non-religious function of the fountain, which goes well beyond the scope of this article.

The 'dromos *well' (monument LX)*

For a long time, the '*nymphaeum*' appeared to be a *unicum* on the scale of the whole of Gaul, until the discovery, also at *Glanum*, of a second, similar hydraulic structure, excavated between 1983 and 1989 by A. Roth Congès (1992a; 1992b; 1992c): here, the pool has been replaced by a well (**Figure 3**). This monumental well, 3m in diameter and originally 10m deep below the ancient floor (preserved to a height of 8m), is built of large-scale, dry laid stonework. Here too, access to the water is possible *via* a staircase with three flights of steps (more than 40 in all), 1.60m wide; at the bottom, a basin cut into the rock collects water from a karstic resurgence. The well must have been surmounted by a circular aedicula (tholos), which has now disappeared, at least according to the reconstruction hypothesis proposed by A. Roth Congès (*ibid.*). This hydraulic structure was originally linked to the neighbouring building (XVII), identified as a Tuscan temple on the basis of surviving architectural elements. Of the two side entrances on either side of the *pronaos*, the one on the right was linked to the staircase leading to the well (LX). According to A. Roth Congès (*ibid.*), this structural link would have led to a functional relationship of a cultic nature between the temple and the hydraulic structure.

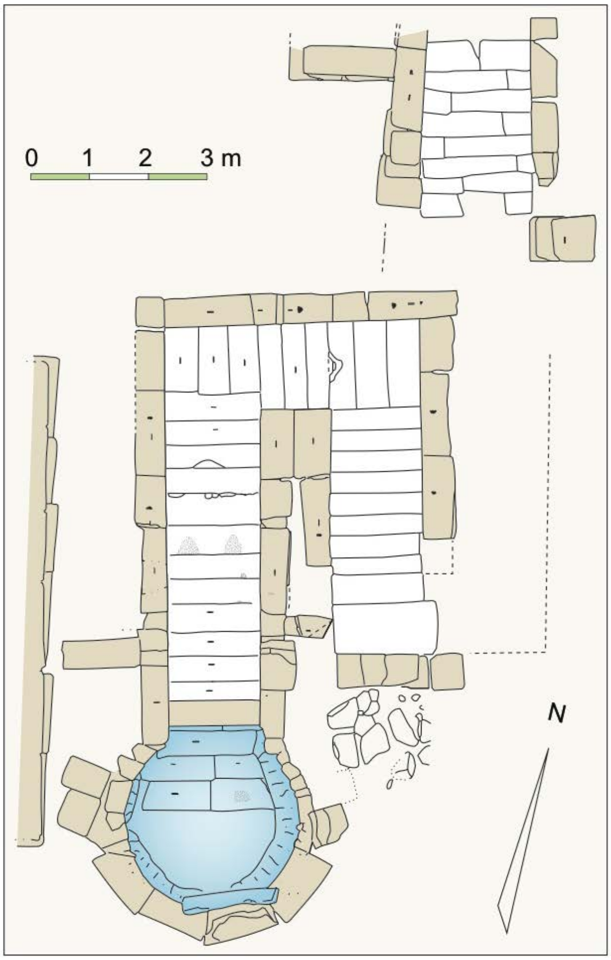

Figure 3. Plan of the 'dromos *well',* Glanum *(elab. by V. Mathieu, ASM-UMR5199).*

Its construction dates back to the end of the 2nd century BC and the early years of the following century. The monument's lifespan was short: it was destroyed between 110-90 BC, possibly as part of the wars between the Romans and the Salyens. The access staircase was filled in, and the shaft lining, originally made of large stones (heavy masonry), was dismantled and then quickly rebuilt using irregular rubble stones bonded with earth. The well, which now had no staircase, served as a water supply for the residential area that was built on the ruins of the destroyed Hellenistic monumental centre. The well was finally filled in when the Augustan forum was built in 40-20 BC.

Following this second discovery, and in the absence of any comparative evidence from southern Gaul and Italy, the origin of this type of monument was sought beyond the Mediterranean. A. Roth Congès found the best comparisons for the *dromos* well, to which she attributed a highly probable sacred character, in the Bronze Age Nuragic sanctuaries of Sardinia, which were still frequented in Roman times (Roth Congès 1992c: 40-42). Given the stone-cutting and construction techniques employed, as well as the obvious similarities between the hydraulic structures at *Glanum* and the Marseilles rampart, S. Agusta-Boularot proposed that they were inspired by Greek models (Agusta-Boularot *et al.* 2017: 62; 2019: 200).

The two hydraulic structures at *Glanum* fall into the category of 'deep basin fountains' as defined by the authors of the *Dictionnaire méthodique de l'architecture grecque et romaine* (Ginouvès 1998: 94). These fountains had a drawing basin located below ground level and were only accessible *via* a staircase. At Delos, in the 'religious' sector of the island, along the alley that ran alongside the sanctuaries of Apollo and Leto, the *Minoé Krènè* (GD30), with its eleven-step staircase leading to the water table, falls into this category (Courby 1912: 103-119). The same applies to the fountain to the south-west of the *adyton* in the *Asklepieion* at Corinth (Glaser 1983: 24-25, fig. 46). In both cases, the staircase is straight. These examples are far too remote to have influenced the work at *Glanum*. The paragon of the '*nymphaeum*' and the '*dromos* well' could have been found in Marseilles, a nearby Greek city, but would have remained unknown since only a small part of the Phocaean city is known. What are we to make of this hypothesis today?

Basins, wells and fountains with staircases in Southern Gaul: new discoveries

The staircase basin at the Alcazar excavation site in Marseilles (Bouches-du-Rhône)

In 1999, the discovery of an imposing Greek hydraulic monument in Marseilles, the only one of its kind in Gaul, provided new evidence for comparison: the staircase basin at the Alcazar site (**Figure 4**) (Bouiron *et al.* 2024: 308-316 and 318-322). The site was located on the outskirts of the Phocaean city,

Figure 4. Detailed plan of the second state of the Greek basin at Alcazar [elab. by E. Plassot (DAO), M. Bouiron, F. Guériel, J. Isnard (Inrap)].

within an enclosed cultivated plot of land whose landscape had been transformed by the digging of a clay quarry in the 6th century BC. During the 5th century, a basin was built from large blocks of carefully crafted white limestone. Its walls define an internal rectangle measuring 2m by 4m, with a depth of 3.60m, giving a maximum capacity of 28.8m^3. The walls are made of limestone blocks from the Saint-Victor quarries in Marseilles. They were squared on all sides and dry laid assembled. The basin sat on top of the existing substrate, with a slab base. It drew water from the water table, but was also fed from the north by a stone pipe. The hybrid nature of its water supply means that this structure can be described as a well-fountain. In its early Classical state, the basin had no steps: water was drawn from it using ropes and containers. A coping, which has now disappeared, would originally have covered its edges.

The basin was then transformed. At the end of the 4th or beginning of the 3rd century BC, the central plot of land was filled in with topsoil for a new type of farming: vine growing. The reservoir was then raised so that it was level with the new soil (**Figure 5**). This required the creation, on the eastern side, of a four-step staircase (H.: 0.14 to 0.28m; W.: 2.06 to 2.10m; D.: 0.29 to 033m) to access the water level; it also led to the modification of the water supply and drainage systems. It was modified several times over the following centuries and remained in use until the early Middle Ages.

Although of major interest, the Marseilles discovery does not provide any answers as to the origin of the two hydraulic monuments at *Glanum*. In fact, the staircase - straight rather than angled - in the Marseilles fountain is not original, but the result of an addition made necessary by the rise in ground level around the structure. What's more, Marseilles's large-scale, dry laid stonework was used as early as the 5th century BC, when the basin was first built.

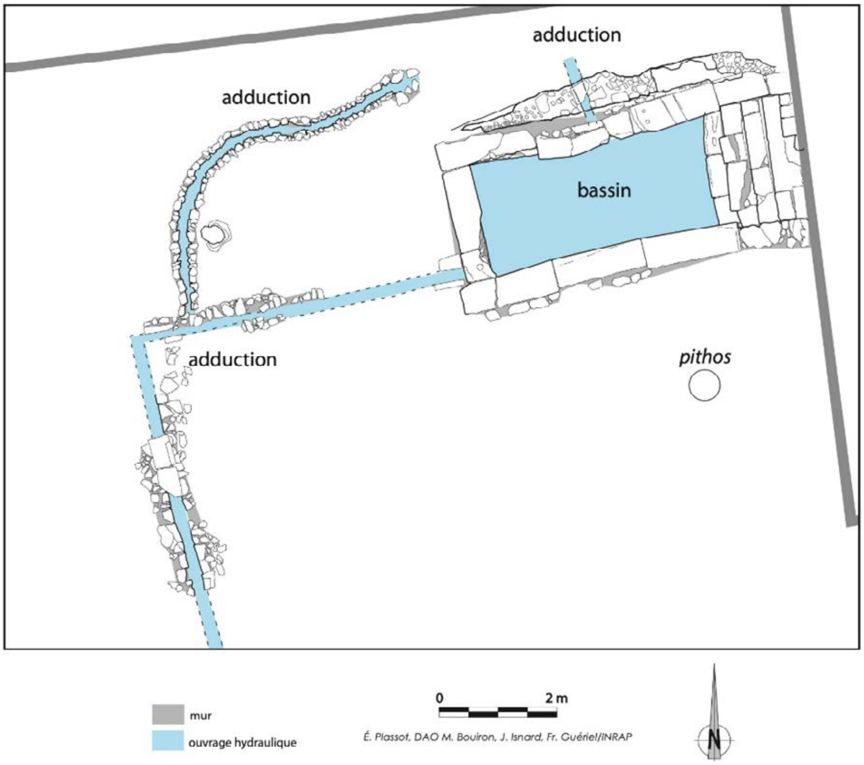

Figure 5. Basin seen from the west (elab. by T. Maziers and F. Parent, Inrap).

There was no evidence in the excavations of an earlier, more basic hydraulic structure. However, at *Glanum*, initial observations from the architectural study of the '*nymphaeum*', some of which have never been published before, have shown that the monument was not built *ex nihilo* in the 2nd century BC, but was simply 're-clad', as was the segment of protohistoric rampart that adjoins the fountain. A number of protohistoric defensive structures in Lower Provence (Saint-Blaise, *Glanum*, Les Tours de Castillon au Paradou, Les Baux-de-Provence), some dating back to the early Iron Age, were 'veneered' with dry laid masonry in the second half of the 2nd century BC or at the beginning of the following century with large units, the monumental appearance of which clearly had a decorative and ostentatious function rather than a structural or defensive one. The same was true of the '*nymphaeum*', beneath which lies an ancient watering place built in a more modest fashion by the Gauls of *Glanum* at a date that is currently difficult to determine. This hypothesis is now supported by a convincing parallel: the '*dromos* well' unearthed in 2015 at Mas de Caylus in Castelnau-le-Lez.

The '**dromos** *well' at Mas de Caylus in Castelnau-le-Lez (Hérault)*

Castelnau-le-Lez is a commune on the outskirts of Montpellier: it covers the protohistoric, then Roman, settlement of *Sextantio*, through which the *via Domitia* runs, on the ancient territory of Nîmes. In Antiquity, the hydraulic structure uncovered (**Figure 6: A-B**) was located in a rural context - the presence of a dwelling is ruled out - 150m from an ancient road, on the side of a damp valley, which was developed in the first half of the 1st century BC (**Figure 7**) (Vacassy and Molliex 2020).

From an architectural point of view, the well and the steps providing access to the water form a whole 6m long and between 0.80 and 1.50m wide. They are built using local materials and vernacular techniques. The staircase consists of nine steps and a corbelled roof can be assumed from some of the slabs found in the abandoned fill.

The structure is located in a shallow paleovalley that drains water from the underlying limestone (**Figure 8**). The excavation reaches the Cretaceous marl and limestone at a depth of 3m, allowing the water that runs off between the marl and the filling of the paleovalley to be recuperated. Although the flow rate may not appear to be very high at first glance, it nevertheless enables the structure to be filled in a matter of hours. Filling takes place at the base, between the gaps in the rough, overhanging blocks of the first bed. Analyses of the water showed that it did not come from surface seepage, but from water

Figure 6. A. Castelnau-le-Lez, Mas de Caylus, zenithal view of the 'dromos *well' (elab. by S. Goumy, Inrap); B. Castelnau-le-Lez, Mas de Caylus, view from the north of the 'dromos well' (elab. by S. Goumy, Inrap).*

seeping in to the surrounding marl-limestone hills. The structure was filled with a large quantity of material, but it did not constitute a primary dump. The ceramics, which are highly fragmented and heavily rolled, have been dated to between 100 and 50 BC.

This 'stepped well' is clearly similar to a well construction technique observed throughout Protohistory in the Nîmes plain (Gard) (Séjalon 2015: 323-324). These wells, dug into the bedrock, had no casing. They took the form of an elongated pit with a characteristic 'teardrop' plan, combining a narrow, sloping section with a wider, deeper section containing water from the water table. At Moulin Villard in Caissargues (Gard), such structures, located some fifty metres from the contemporary settlement, have been dated to the end of the 6th century BC (Freitas *et al.* 1988: 20, 35, 62). Several wells of this type have also been excavated at Mas de Vignoles IX, in Nîmes (Séjalon *et al.* 2012). In the absence of any specific features, P. Séjalon assumed that a step - which has now disappeared - provided access to the shaft located in the widest part of the pit (Séjalon 2015: 324).

Two other examples are also attested at Castelnau-le-Lez, on the Mermoz site (Ott *et al.* 2009: 40, 53-57). One of these two structures - well PT2002 - dates with certainty from the Early Iron Age, since the last level of its fill places its abandonment in the second half of the 5th century BC. The second well (PT2080) (**Figure 9**), whose excavation could not be precisely dated, was abandoned later, in the course of the 4th century BC. Both wells have a step dug into the substratum; the lower levels have been roughly reinforced with fragments of *dolium*, pebbles and large blocks of cold limestone to prevent users from slipping when approaching the water table. The '*dromos* well' at Mas de Caylus therefore appears to be the evolution - with a stone casing - of an ancient type of well structure, which was initially simply dug into the substratum, or built from perishable materials, certainly wood in the deepest cases. It would therefore represent the culmination of techniques mastered over several centuries by local populations. As for its use, although the excavation ruled out the possibility of a permanent dwelling in a nearby enclosure in favour of a cattle stall, it would have been used mainly to supply the herds and, secondarily, for consumption. Its

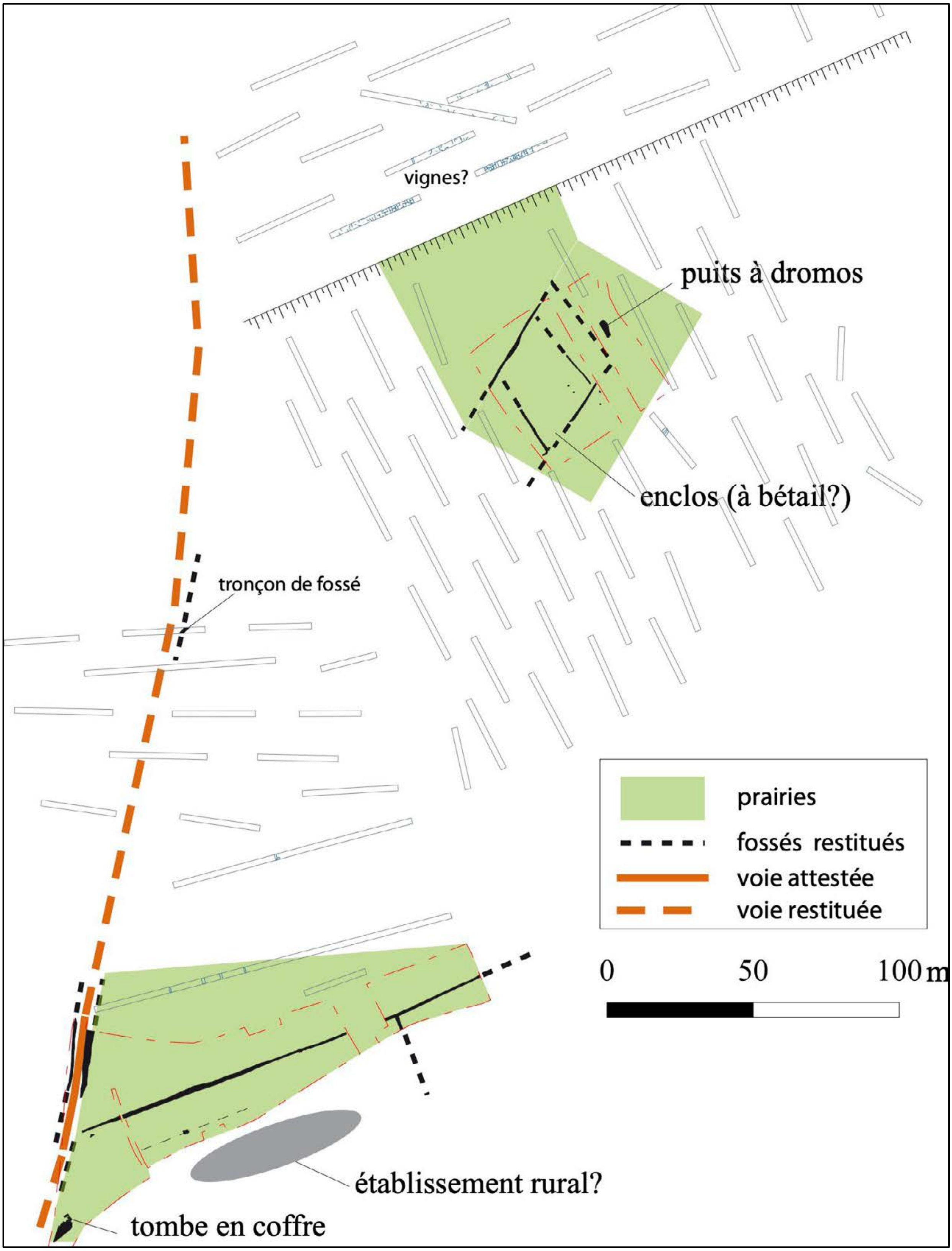

Figure 7. An attempt to reconstruct the landscape of Mas de Caylus in the late-Republican period (c. 100-50 BC), based on excavation data (elab. by Grégory Vacassy, Inrap).

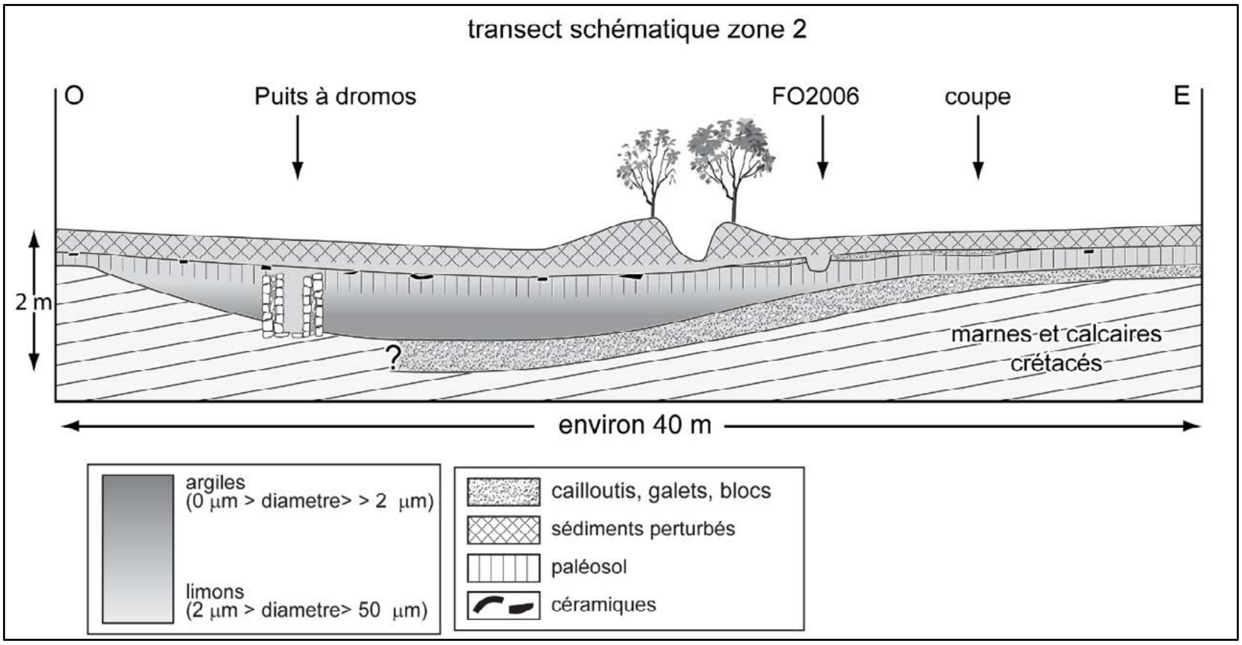

Figure 8. Schematic transect of the area containing the 'Dromos well', Mas de Caylus (elab.by C. Jorda, Inrap).

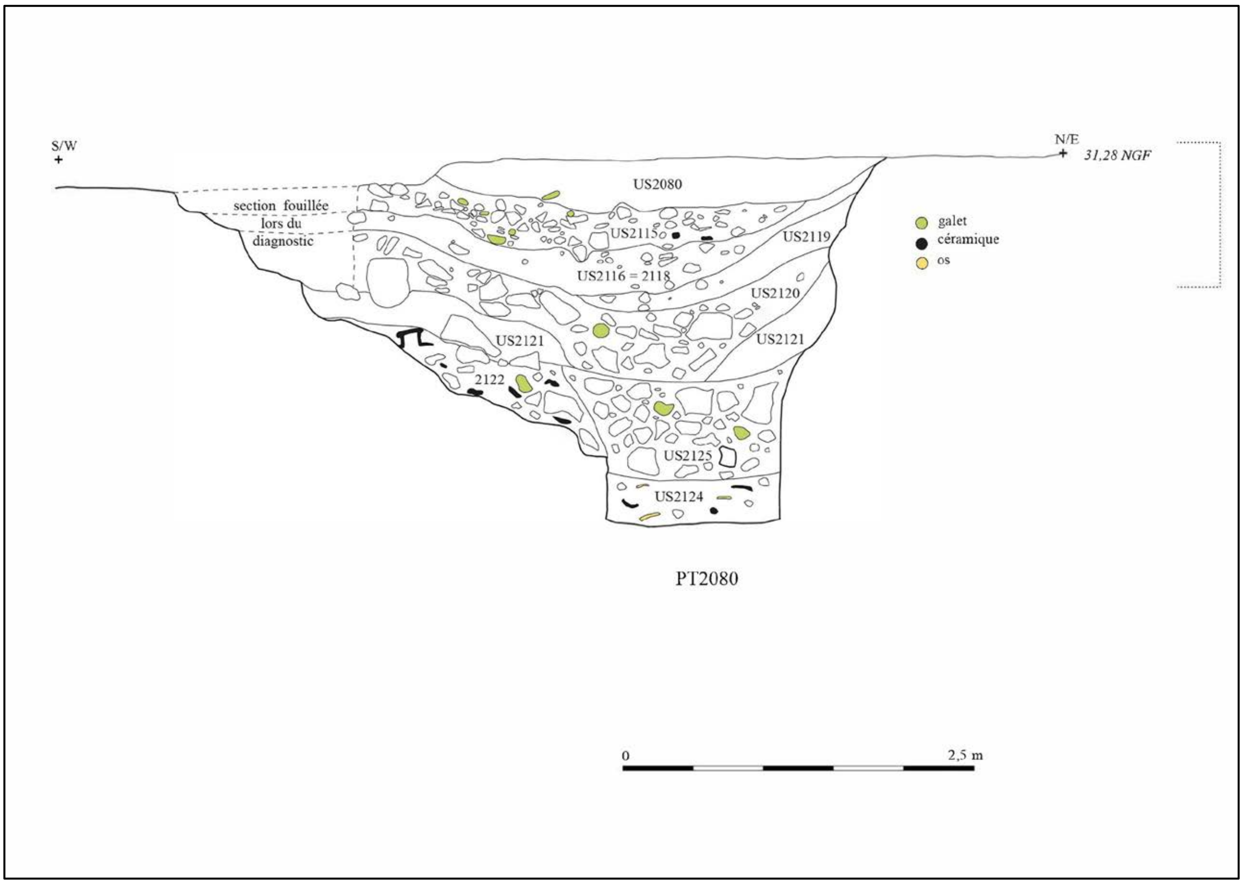

Figure 9. Castelnau-le-Lez, Mermoz II, cross-section of well PT2080 (adapted from Ott et al. 2009: 54, fig. 12).

location, at the interface of the enclosed boundaries and the open spaces some one hundred metres from the track, would confirm that it was used for these purposes (Séjalon 2015: 40).

The '*dromos* well' located near the ancient *oppidum* of *Sextantio* proves that the indigenous communities of southern Gaul were able to use their traditional construction methods to build complex structures to access water, whether from a water table or a resurgence. This type of functional structure has survived the passage of time, with examples similar to the one at Mas de Caylus, but dating from the Early Imperial period, having recently been unearthed in Murviel-lès-Montpellier, Balaruc-le-Vieux and Valergues, three communes in the Hérault department (**Figure 10**).

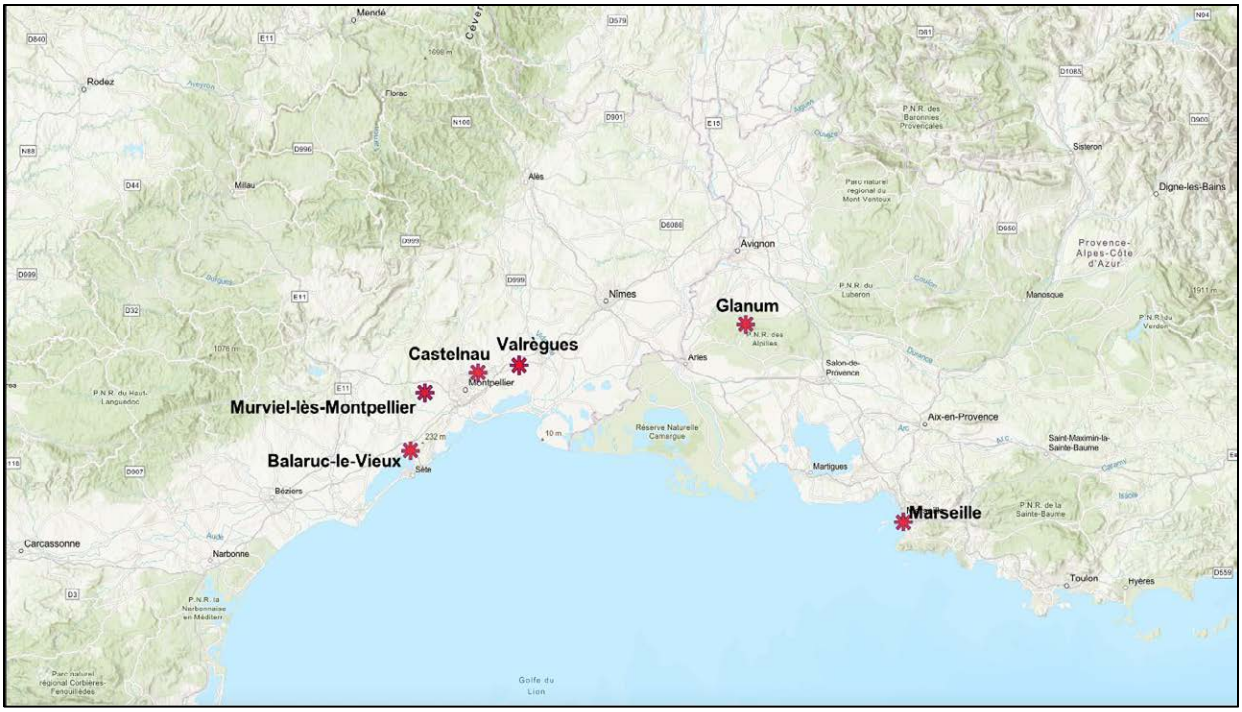

Figure 10. Location of fountains/step wells in southern Gaul (elab. by S. Agusta-Boularot, DAO).

At Murviel-lès-Montpellier, the reservoir, built in the early Augustan period, is a simple excavation dug into the rock and apparently equipped with a basic ramp from the outset (**Figure 11**). It served as a water reservoir for a small bathing area, and its location in the immediate vicinity of a sanctuary on the outskirts of the ancient town suggests that it was used by visitors who came to honour the divinity and make offerings. At Balaruc-le-Vieux, the structure discovered, dating from the Early Roman period (1st or 2nd century), consists of a flight of steps sunk into the ground, partially uncovered, framed by two retaining walls (**Figure 12**). Eight steps were uncovered, but the layout below remains unknown (Lugand and Bermond 2002: 207-208). Finally, in Valergues, at the ZAC de la Roselière, a preventive excavation carried out in 2020 uncovered a well dating from the late 1st century BC or early 1st century AD. It was located on the edge of a road, between an Early Roman burial area to the south-west and cultivated plots to the north-east. Surveys carried out in the area revealed the presence of an ancient *uilla*-type settlement less than 500m away. A vast excavation 6m long and 1.50m wide was first dug into the natural substratum to reach the water table. The walls of the access corridor and the shaft casing, carefully crafted in small-scale stonework, were then installed in this pit. The steps of the staircase, made of monolithic limestone blocks, provided access to the water. The excavation, which was only partial, did not reveal the depth of the well or how it was fed.

Figure 11. 'Dromos *well', Yeuse sanctuary, Murviel-lès-Montpellier (elab. by G. Vacassy, Inrap).*

Figure 12. 'Dromos *well', Balaruc-le-Vieux (elab. by I. Bermond).*

The ceramic material abandonment of the well to between the end of the 1st century and the beginning of the 2nd century (Bigot 2022) (**Figure 13**).

To this regional list should be added a similar structure, dating from the Roman period, unearthed at Levroux (Indre), in the vicinity of an area of road metal, ditches and burial structures that confirm the rural or at least peri-urban character of the site (Bartholome 2021: 67-79), on the ancient territory of the *Bituriges*, in *Gallia Aquitania*. Angular in plan with an apse to the south-west (**Figure 14**), the building's overall dimensions were approximately 3.20m long by 1.60m wide and its internal dimensions were 2.34m long by 0.95m to 0.92m wide from east to west. The thickness of the walls varied (0.28m to 0.70m). The masonry was neat and very homogeneous, consisting of squared limestone blocks and limestone rubble bonded with lime mortar. Of particular note in the interior is the presence of orange mortar (*opus signinum*) in the joints, a waterproofing mortar typical of Roman hydraulic installations, which has not been attested in any of the structures in the south of France. Between the two perfectly parallel north-west and south-east walls, a staircase made of limestone slabs of equal height (0.22-0.23m) led down to the water. The steps of the staircase were chained to the masonry of the walls, showing a unitary construction. The well was installed directly over a shallow water table. Water easily penetrated the structure by seeping between the limestone blocks, as evidenced by the very clear traces of oxidation on them.

Stone-lined wells, with access to water via a staircase of several steps, now appear to be an original creation of Gaulish communities in southern Gaul in response to the problem of supplying water to both humans and animals, as shown by the rural context of several of these finds. These 'well-fountains' or 'deep-basin fountains' are the result of the evolution and monumentalisation of older structures - as demonstrated by the examples dating from the Early Iron Age - but also more basic ones, as the '*dromos* well' is the successor to what was originally just a pit dug into a water table, one side of which had been extended to limit the slope; this allowed an individual to descend to the water and then to climb back up again easily. These monumental examples, where the well casing and staircase walls are often carefully crafted in small-scale stonework, while the steps are made of monolithic limestone blocks, can be dated to the end of the Second Iron Age (late 2nd century BC-early 1st century AD) at the earliest. The functional installations such as the '*nymphaeum*' and the '*dromos* well' at *Glanum* may well have had similar features at first, before they were finished in the large-scale stonework that we know today.

Figure 13. 'Dromos well', Valergues (elab. by F. Bigot, Mosaïques).

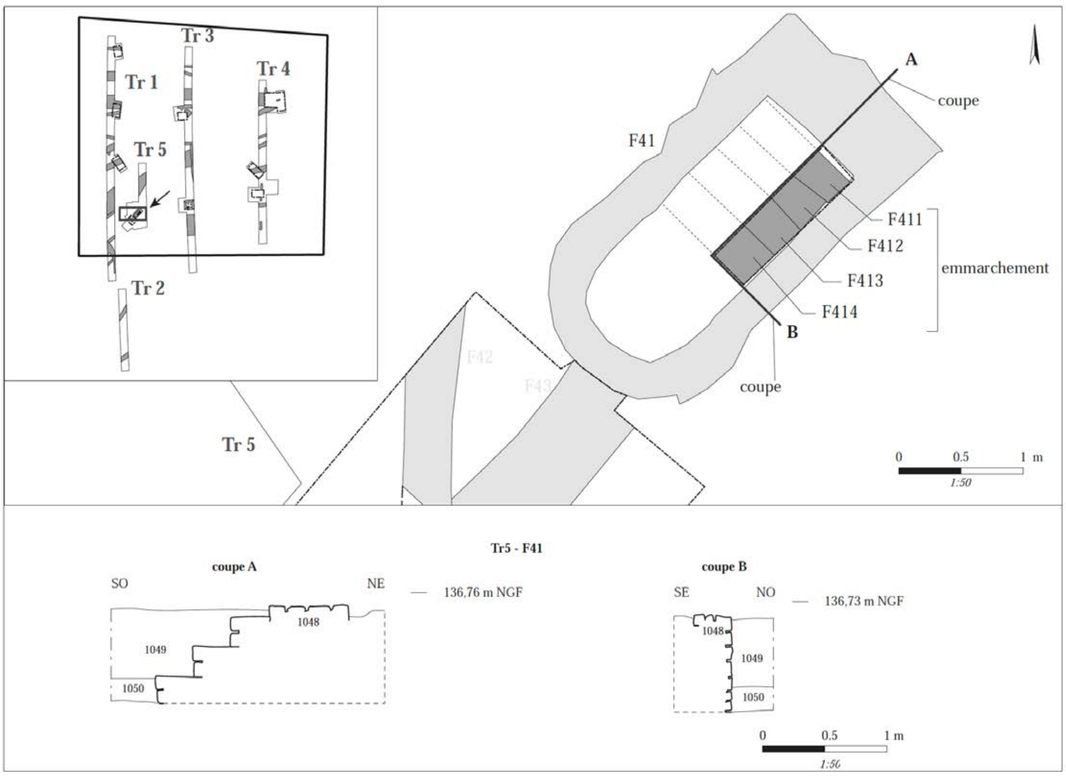

Figure 14. 'Dromos well', Levroux (adapted from S. Bartholome 2021: 67, fig. 28).

Thanks to the discovery of the Mas de Caylus at Castelnau-le-Lez, there is now no need to assume that these hydraulic structures were of Greek or Italic origin: their design, whether in terms of the layout or the water supply system, was unquestionably Gallic, as earlier examples confirm.

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Water Management in a Roman Settlement at the Foot of the Alps: the Waterworks of *Augusta Taurinorum*

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Abstract: this paper brings together the archaeological traces that have been discovered since the end of 19th century, aiming to improve the knowledge of the water management of *Augusta Taurinorum* by analysing different types of data and proposing new interpretations. The paper pays particular attention to the reconstruction of the Roman water management and proposes the idea that an inverted siphon was in operation in Roman times. This hypothesis is integrated with a short appendix by Cees W. Passchier and Gül Sürmelihindi on the carbonate deposits found inside the blocks of the conjectural siphons.

Keywords: Roman archaeology, Ancient topography, Roman aqueducts, Ancient water management, Northern Italy, Ancient cartography.

Introduction[1]

Geographical and historical context

Taurisci/Taurini people, whose Ligurian or Celtic origin is uncertain[2] (Gambari 2010: 48–50), probably occupied the territory of Turin before the foundation of *Augusta Taurinorum*. Some sources describe these people and their largest settlement, called *Taurasia*[3] (Bandelli 1990: 254–255),[4] placing them just after crossing the Alps along the modern border between France and Italy.[5] Hannibal destroyed the site of *Taurasia* in 218 BC[6] because of its loyalty to the Romans and probably due to this for we don't have clear evidence of the continuity of this site with the Roman town. However, some studies suggest that

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[2] Strab. 4, 6, 6: on the opposite side of the mountains, sloping towards Italy, dwell the Taurini, a Ligurian nation, together with certain other Ligurians; Plin. *NH* 3, 21: the colony of Augusta Taurinorum (...) which was founded by ancient race of the Ligurians; Liv. 31, 38, 5: the Taurine Gauls were the first people he encountered on descending into Italy.

[3] App. *Hann.* 2, 5: after a brief pause, he [Hannibal] attacked Taurasia, a gallic town.

[4] The author highlights how the use of specific terms was a way for ancient sources to distinguish different types of sites according to a hierarchy of importance. *Taurasia* is defined as a πόλις by Polybius (3, 60, 9) and by Appian (*Hann.* 2, 5); Livy (21, 39, 4) describes it as *urbs* and *caput gentis eius*.

[5] Pol. 2, 16: Such parts of both slopes of the Alps as are not too rocky or too precipitous are inhabited by different tribes; those on the north towards the Rhone by the Gauls, called Transalpine; those towards the Italian plains by the Taurisci and Agones and several other barbarous tribes; Liv. 5, 34, 9: they themselves crossed the Alps through the Taurinian and pathless forests; Strab. 4, 6, 6: on the opposite side of the mountains, sloping towards Italy, dwell the Taurini. See also Aelius Herodianus (I 153, 25 = II 588, 8 Lentz; I 193, 6 Lentz).

[6] Pol. 3, 60, 9; Liv. 21, 39, 4; App. *Hann.* 2, 5.

a fortified settlement was established close to the Roman site at least from the 4th century BC (Gambari 2010: 48–49), most likely, outside the perimeter later defined by the Roman walls (Gambari 2010: 56–60; Masci 2012: 63–64; Mercando 1990: 441–451). Some scholars suggested that this settlement was located at the confluence of the Dora Riparia and Po rivers (**Figure 1: A**).

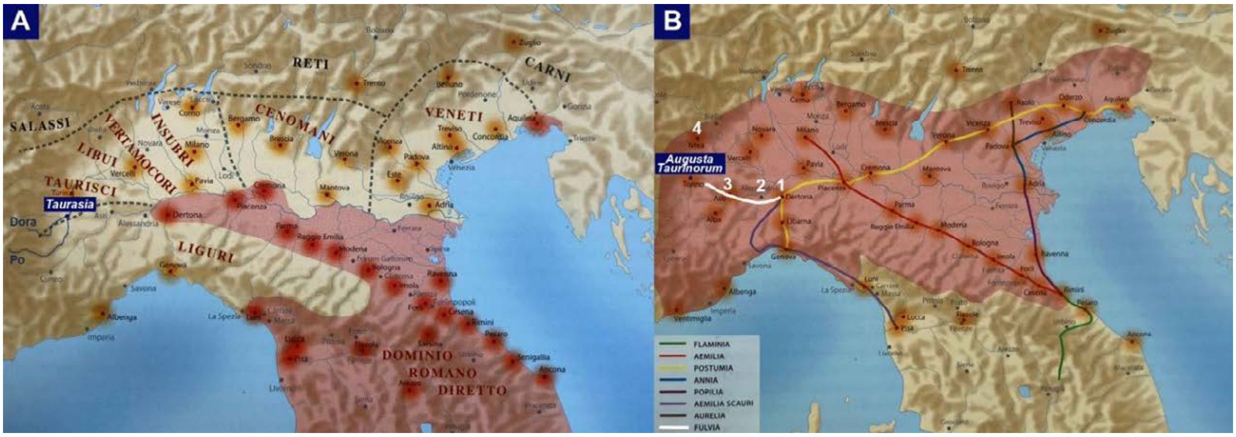

Figure 1. Historical and geographical background of the study area, in red the extension of the territories under Roman control is shown in red: A. Pre-Roman populations in northern Italy (adapted from Malnati and Manzelli 2015: 47); B. The Roman roads in northern Italy: 1. Dertona*, 2.* Forum Fulvii*, 3.* Hasta*, 4.* Eporedia *(adapted from Malnati and Manzelli 2015: 49).*

Pliny the Elder[7] and Cornelius Tacitus[8] confirm the existence of *Augusta Taurinorum* at the end of 1st century BC, but they do not give any information about the *deductio* of the *colonia*. Although the name of the town itself testifies to its association with the figure of Augustus, the existence of two inscriptions[9] referring to the town as *Iulia Augusta Taurinorum* and the mention of certain magistrates typical of *municipia* have led in the past to the assumption that a *municipium* was founded in the time of Caesar, which was later transformed into a *colonia* in the Augustan age (Masci 2012: 64–65). Based on archaeological data there is currently a tendency to place the foundation of the town within a timeframe of 15 years after the battle of *Actium*, between 25 BC and 10 BC (Paci 2003: 111–118; Masci 2012). It is certain that the foundation of the new centre was of strategic importance, both militarily and economically, since it was connected to the Roman road network by the *Via Fulvia* (Alfieri 1964: 63; Zanda 2007) and played a key role in the systems of communication between the Alpine valleys and the Po valley (**Figure 1: B**).

On the basis of these observations, we can stress that the Romans established the first foundations in Piedmont (e.g. *Eporedia*, *Dertona*, *Forum Fulvii* and *Hasta*) long before *Augusta Taurinorum*, which actually represents the last stage of the Roman conquest of this territory, when the conflicts in the area ended (after the battles of *Aquae Sextiae* and *Campi Raudii*), and it became necessary to give land to the veterans (Carducci 1965: 248–249, 255).[10]

The archaeological remains of **Augusta Taurinorum**

As the basic features of the orthogonal layout of the Augustan *colonia* in Turin remained practically unchanged until the end of 16th century, the memory of the *forma urbis* never completely disappeared over the centuries. This is confirmed by a series of maps dating back to 16th century, some of which are

[7] Plin. *NH* 3, 48: *coloniae ab alpium radicibus augusta taurinorum*.

[8] Tac. *Hist.* 2, 66.

[9] *CIL* V, 7047=*EDR*113494; *CIL* V, 6954=*EDR*50127.

[10] Regarding the centuriation of *Augusta Taurinorum* see: Masci 2012: 69–72; Muzzioli 2010: 39.

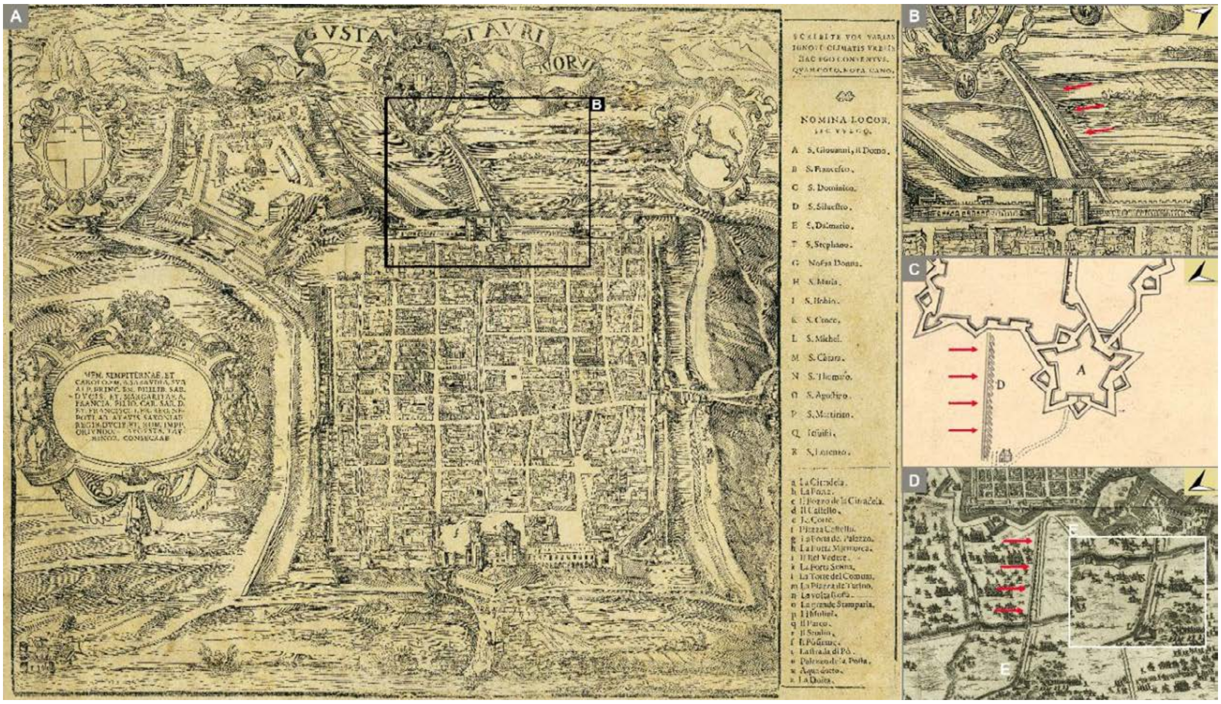

*Figure 2. Identification of the perimeter of the Roman town through historical cartography (red arrows indicate an aqueduct): A-B. G. Caracha's map (*Veduta assonometrica dell'incisore di corte di Emanuele Filiberto di Savoia*; ASCTO, 1572, Collezione Simeom, D.1); B. Detail of Caracha's map (western gate and arches of an aqueduct); C. Detail of* Pianta topografica della città di Torino con la cittadella*, 1640 (BCCTO, Cartografico 8/9.1); D. Section of M.A. Raynero's map (*Piano della circonvallazione fatta alla città di Torino dall'armate di S. Maestà*, 1643; ASCTO, Collezione Simeon, D. 11); E. Detail of Raynero's map.*

very schematic because they were drawn mainly for strategic purposes, showing only the circuit of walls and gates. Caracha's 1572 map[11] is the first to show the layout of the internal blocks, allowing the precise identification of the main *cardo* and *decumanus* (**Figure 2: A, B**) (Viglino Davico 2003: 85–90). However, interest in the topography of the Roman town plan was not revived until the second half of 19th century, during an intense period of urban renewal that led to several new archaeological discoveries.

In 1869, the archaeologist Carlo Promis – since 1837 Inspector of Antiquities Monuments of Regni Sardi – published in his work dedicated to the history of ancient Turin a map of the city with the location of the most important finds (Promis 1869: 183, table 1). The first scientific work, however, dates from 1887, when Alfredo d'Andrade, appointed 'Regio Delegato per la Conservazione dei Monumenti per il Piemonte e la Liguria' (Cerri *et. al.* 1981; Gabucci and Pejrani Baricco 2009: 229–231; Mercando 2003b: 55–79), began to draw up the first 'archaeological map' of *Augusta Taurinorum* (**Figure 3**) on the basis of the municipal cadastral plan, locating each new find. Alfredo d'Andrade updated this map until 1913 and it was for a long time the basis for topographical studies of Roman Turin, at least until 1965, when Silvana Finocchi published an updated version (Finocchi 1965: 600).

The quadrilateral of the Roman town (approx. 710x740m) is still clearly visible, although it has been incorporated into the modern urban layout (Gabucci and Pejrani Baricco 2009) (**Figure 4**). It is located

[11] Giovanni Caracha, *Veduta assonometrica dell'incisore di corte di Emanuele Filiberto di Savoia*, ASCTO (1572), Collezione Simeom, D.1. This map (fig. 2, A-B) and Raynero's map (fig. 2, D) are published with the kind permission of the Archivio Storico della Città di Torino. Any further reproduction or duplication by any means whatsoever is prohibited.

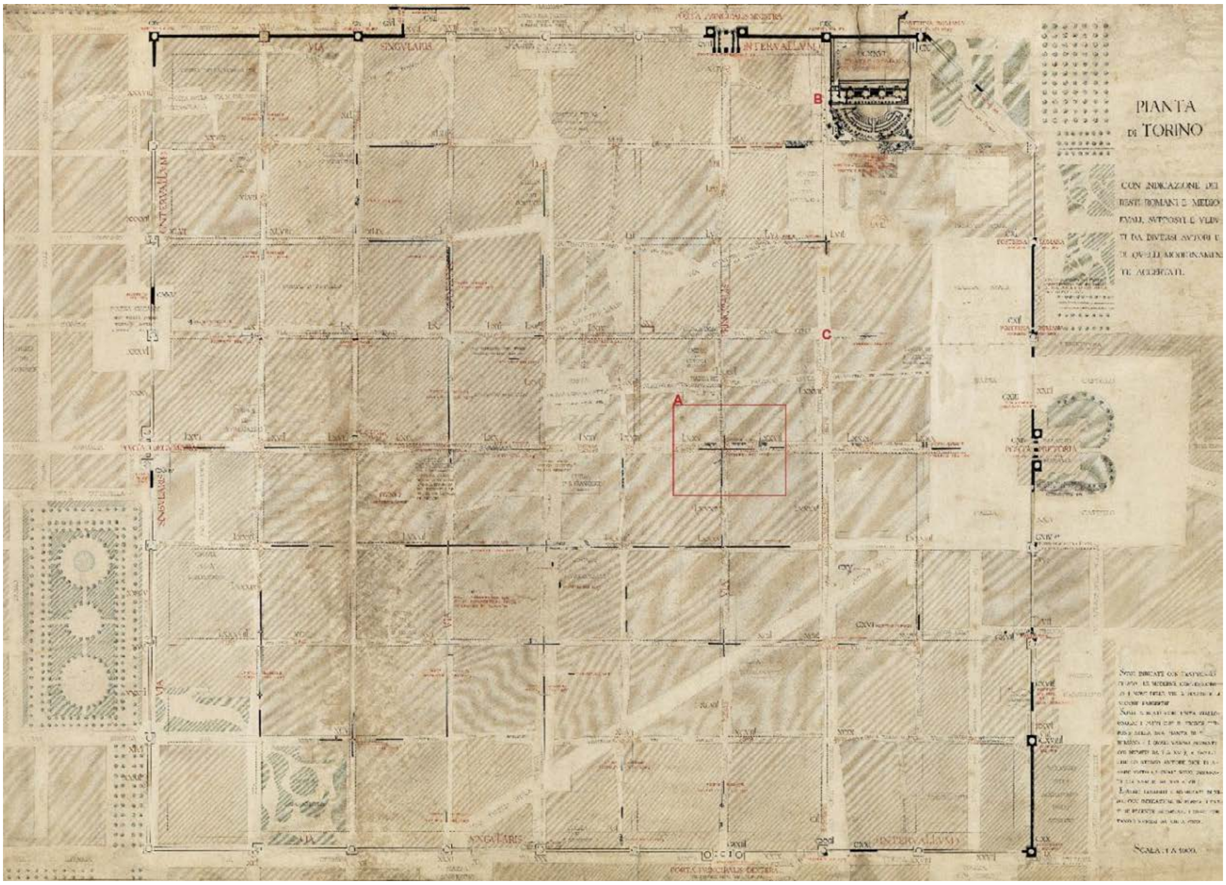

Figure 3. First archaeological map of the city of Turin, drawn by Alfredo d'Andrade and updated until 1903 (SABAP TO): A. Sewers connections from the cardines *to the* decumani*; B. Site where lead pipes were found; C. Site where a fountain was found, probably connected to a* cardo*.*

on the alluvial terrace of the Dora Riparia, far from the confluence of this watercourse with the Po, where marshy areas are thought to have existed. The linear course of the wall is interrupted only on the north-eastern side (**Figure 4: A**) which could be due to geomorphological reasons. Only one of the four gates that gave access to the town is immediately visible: the *principalis dextra* (**Figure 4: B**), known as the Porta Palatina, built in 1st century AD. The towers of so-called Porta Decumana were incorporated into the structure of Palazzo Madama (**Figure 4: C**), whereas the western gate (**Figure 4: D**), also called Porta Segusina, was demolished in 1585 and the so-called Porta Marmorea around 1660 (**Figure 4: E**). The location of the *Forum* and the *Capitolium* has not yet been determined, although according to the standard scheme of Roman town planning, it should have been in the centre of the urban grid, in the area occupied by the Palazzo di Città and the Corpus Domini squares (**Figure 4: F**). The exact location of other public buildings is not known, except for a very brief reference (Promis 1869: 186) to the discovery in 19th century of a supposed suburban baths complex (Ronchetta 1984a: 201, A1/3; Ronchetta 1984b: 797)[12] (**Figure 4: G**) and the Roman theatre (**Figure 4: H**), which is the only public building whose remains are still visible and dated between 1st century BC and 1st century AD.

[12] The researcher links an archaeological note from 19th century to a discovery made in 1955 in Piazza della Repubblica, in via Mameli. Here were found some architectural fragments of recycled marble, probably from the structure of the nearby thermal baths. See also Gabucci and Pejrani Baricco 2009: 235.

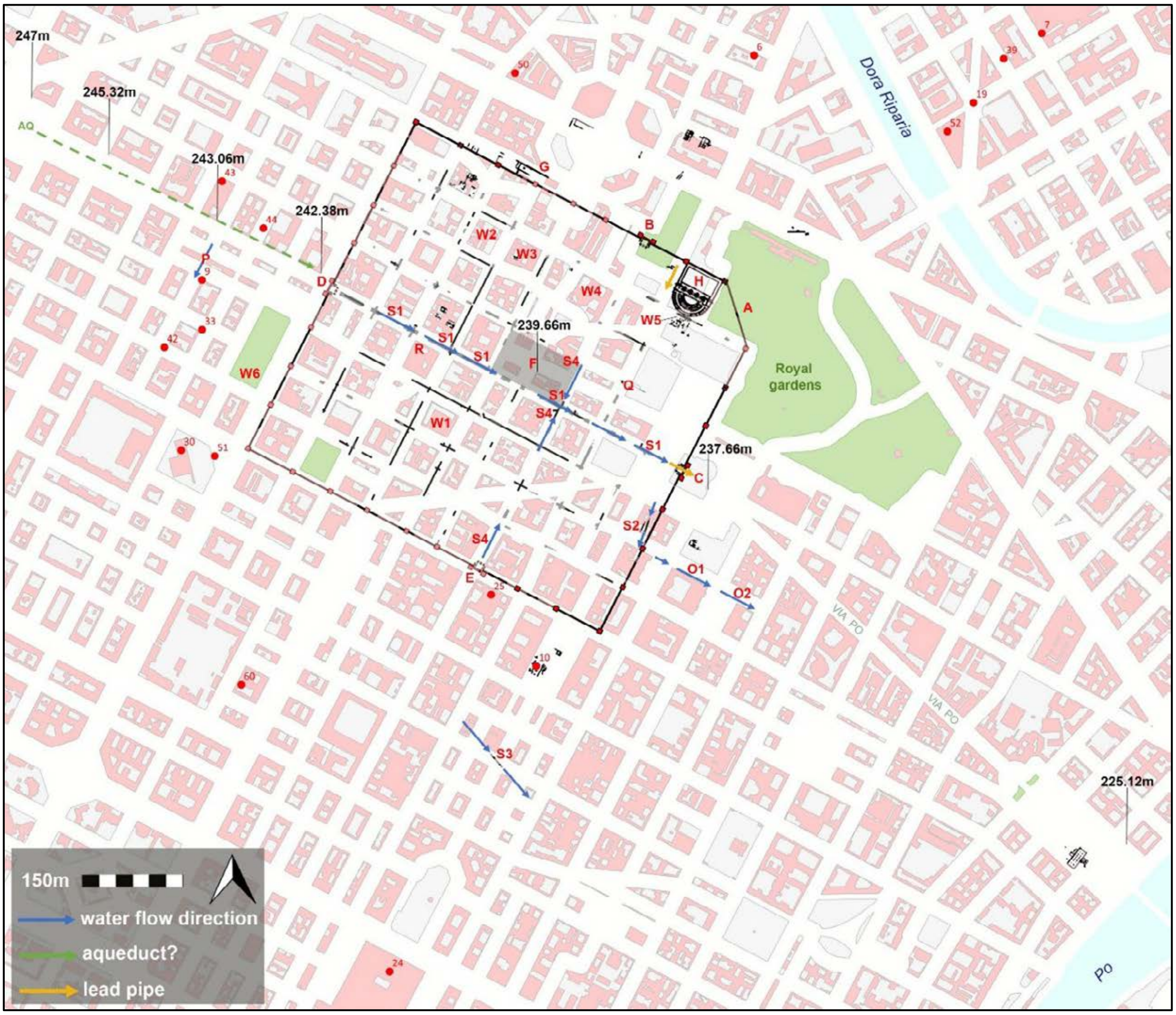

Figure 4. Topography of the archaeological remains of Augusta Taurinorum *(based on SABAP TO data maps): A. Anomaly in the north-western section of the walls; AQ. Hypothethical blueprint of the aqueduct; B. Porta Palatina; C. Porta Decumana; D. Porta Segusina; E. Porta Marmorea; F.* Forum *and* Capitolium *(?); G. Baths complex (?); H. Theatre; N. Sewer; O. Drainage channel (?); P. Cistern connected to a water channel; Q. Fountain (?); R. Location of the blocks of the siphon; S1. Sewers under the main* decumanus*; S2. Sewer in via Cesare Battisti and behind Teatro Carignano; S3. Sewer found at the corner of via Roma-via dell'Arcivescovado; S4. Sewer under the main* cardo*; W1. Well in the area bounded by via Monte Pietà/San Francesco/Botero/Barbaroux; W2. Well in via Orfane n. 18; W3. Well in via Bellezia n. 16; W4. Well in via Porta Palatina n. 19; W5. Well in the block south of the* decumanus *of the theatre; W6. Three wells in piazza Arbarello.*

The water management

Wastewater systems

The Romans built the town on a plain sloping gently towards the north and east, which favoured the natural flow of sewage. They built the sewerage system as part of the monumentalisation of the town – developed in the second half of 1st century AD – following the road network as well as the natural slope of the land. This is a common feature of Roman towns with a regular and well-documented urban layout, especially those founded by Augustus (Bianchi 2018: 154).

The discovery of numerous sewers began in the last decades of 19th century, with a marked increase from 1901, during the construction of the new general sewerage system of Turin. Carlo Promis was the first to report these findings, which were then updated by Alfredo d'Andrade in his archaeological map. The old data, in combination with the discoveries of recent decades,[13] highlight the uniformity of these infrastructures both in terms of design and construction techniques.

The topographically favourable position of the town, at the confluence of the Po and Dora, suggests that the sewage was discharged into these rivers. Archaeological evidence, however, suggests that the water was only discharged into the Po, since direct outlet to the Dora has not been found. In fact, the sewers studied under the *decumani* collected the water from the crossings to discharge in the direction of the Po. However, it is possible that other watercourses surrounding the ancient town were connected to the sewerage system.

The sewers have an average width of 60cm and a height of 120–160cm and were built with a sack-like masonry of pebbles held together by mortar, resting directly on the natural gravel layers, and covered with barrel vaults. We don't have a lot of information about the inside surface, because the bricks used were usually collected and reused in the Middle Ages. That's why the discovery of a complete section of a sewer is rare.

The third-order sewers (Riera 2014: 11–12), which ran in the centre or along the side of the streets, were connected to the second- and first-order sewers (Riera 2014: 11–12) that collected waters from the blocks through brick pipes or brick gutters closed by brick covers or, more rarely, terracotta pipes. In some cases, the second order sewers are connected to the first order sewers by a break in the parapet of the channel, testifying to the diachronic use of these infrastructures and the progressive connection to new structures with subsequent modifications. Inspection shafts ensured the maintenance of the sewers and consisted of square or rectangular openings cut into the barrel vaults, both at the crossing points[14] and along the intermediate sections,[15] with openings covered by stone manholes. Thanks to the material found inside, we can date the final abandonment of the sewerage system between 4th and 5th centuries AD.

The sewer under the main *decumanus* (**Figure 4: S1**), corresponding to the present via Garibaldi, can be traced back to the third order (Riera 2014: 11–12), and it collected the effluent from most of the *cardines* (**Figure 5: E**). Alfredo d'Andrade already noted this feature in the sewers along the main *cardo* (**Figure 4: S4**), both of which flowed into the main *decumanus* sewer, at an angle to each other and at slightly offset points to prevent the water from flowing back in the event of heavy rain (d'Andrade 1902: 280) (**Figure 3: A**). This datum was also confirmed during the excavations carried out in 2003 along the *cardo* to the west of the theatre (**Figure 4: H**), corresponding to the present via XX Settembre,[16] where the sewer showed a marked slope from north to south, despite the steep slope of the street in the opposite direction.

There is only one reference to the extension of the sewerage system outside the walls and it is linked to the discovery of an underground channel in 1938. It was located at the junction of via Roma and via Arcivescovado (**Figure 4: S3; Figure 5: A**) (Carducci 1938: 41–42) and is currently visible within an underground public car park. The sewer runs north-west/south-east and differs from the orthogonal layout of the town. It is considerably higher (185cm at the intrados of the vault) and more solid than other sewers discovered inside the town walls; the bottom is masonry and connected to the parapets,

[13] Via Conte Verde (Filippi *et al.* 1994: 332–333), via Cesare Battisti (Brecciaroli Taborelli and Gabucci 2007: 243–244), via XX Settembre (ASABAP-TO), and *decumanus* south of the theatre (Pejrani Baricco 2003: 303).
[14] Via Conte Verde, via Botero corner of via Barbaroux.
[15] Sewer under the *decumanus* next to the theatre.
[16] ASABAP-TO.

Figure 5. Roman sewage system of Turin: A. Sewer discovered in 1938 at the junction of via Roma and via Arcivescovado (SABAP TO); B. The drainage channel discovered in piazza Carlo Alberto (adapted from Ratto and Ocelli 2021: 264, fig. 39); C. The terracotta pipe that drained the water inside the channel in piazza Carlo Alberto (adapted from Ratto and Ocelli 2021: 264, fig. 40); D. The sewer discovered in via Cesare Battisti next to the walls (SABAP TO); E. Crossing of two sewers from main decumanus and main cardo *in via Cappel Verde (SABAP TO).*

lined with two layers of brick. The combination of these features and the south-facing slope led the scholar who discovered it to interpret it as a large sewer system, probably of the fourth order (Riera 2014: 11–12), which collected water from various branches and channelled it towards the Po. It has also been suggested that this sewer was connected to the amphitheatre, perhaps located in the suburban area to the east of the southern gate, but there are no archaeological data to confirm this.[17]

Archaeological research has not yet fully clarified how the sewerage system was connected to the city walls or directions in which channels were laid or identified the intersection points as the sewerage system in the suburban area. Starting from the first point, a very interesting piece of information comes

[17] Similar features have also been found in *Augusta Emerita* (Acero Pérez 2018: 243–244).

from d'Andrade and his identification of a section of the eastern side of the walls near the second tower south of the Porta Decumana (**Figure 4: C**), at the intersection of via Cesare Battisti and the narrow alley behind the Teatro Carignano (**Figure 4: S2**) (d'Andrade 1902: 278; Pejrani Baricco and Mollo 2001). Here the sewer, which d'Andrade imagined to be always aligned with the grid of the town and on the same axis as the tower, took a curve to avoid the tower's massive base and cut diagonally through the city walls, continuing outside them towards the Po. Some excavations carried out in the 1990s found the same sewer in via Cesare Battisti (**Figure 5: D**) (Brecciaroli Taborelli and Gabucci 2007: 243–244), confirming that already in this section it had an oblique course with respect to the walls, a unique example found in the town, perhaps related to its function as a collector to the outside, crossing the walls at the tower.
Recent excavations, carried out in piazza Carlo Alberto in 2018 and 2019, have revealed new elements to add to this discussion. It occurred during some preventive archaeological studies run for the design of Line 2 of the Turin Metro (**Figure 4: O2**) (Ratto and Ocelli 2021: 263–265). This site is located approximately 160m to the west of the western side of the city walls, in the vicinity of the sewer previously identified in via Cesare Battisti (**Figure 4: S2; Figure 5: D**). The archaeological investigation revealed a channel oriented north-west/south-east (**Figure 5: B**), in line with the Roman urban layout, flowing towards the Po, about 2m deep, with a maximum width of about 7m at the upper edge (233.21m a.s.l.), narrowing gradually to a width of 1.6m (231.28m a.s.l.). A section further to the west of the same channel had already been found in 1999–2000 under the northern wing of Palazzo Carignano (**Figure 4: O1**), but only its northern bank could be identified over a length of about 18m.

The functional importance of the channel as a sewage collector is evidenced by the presence of a terracotta pipe (**Figure 5: C**), coming orthogonally from the north, passing through the north bank. The pipe, exposed over a maximum length of 2m, consists of five elements of varying length (between 40cm and 45cm) with almost perfectly matched male-female joints. The presence of the pipeline, the discovery of another terracotta pipe in the fill layers of the channel, and the identification of some cuts at right angles to it, which can be interpreted as excavation pits for later collection of the pipes, make it likely that there were buildings to the north of the excavation area from which they must have branched off, of which no traces remain visible.

The location of this channel in an area immediately outside the town and its course perpendicular to the town walls had already led to the hypothesis of a connection with the town's sewage system after its first discovery (**Figure 4: O1**), which seems to be confirmed by this more recent discovery. We can therefore assume that it was a drainage channel for the town's sewer system, which did not continue in a structured form outside the walls, except perhaps in the function of public buildings of particular importance, as was the case for the sewer found at the corner of via Roma and via dell'Arcivescovado (**Figure 4: S3**), which was formerly connected to the amphitheatre. The channel probably continued to the Po, taking advantage of the natural slope of the land, with a meandering and only partially regularised course, and also had the function of reclaiming and draining an area at risk of flooding.

Analysis of the ceramic materials, which is still in progress, suggests a chronology dating back to 4th century AD, a period after which the channel, probably no longer in use, was abandoned.

Water supply systems

Past studies have never examined the water supply of the Roman town in detail, apart from brief surveys of the little information available, which has not been updated for several decades (Scalva 1998: 94). Recent excavations have confirmed the widespread presence of wells (**Figure 4: W1-6; Figure 6: A-B**), both within the walls[18] and in the suburban area, such as the three wells discovered in what is

[18] Brecciaroli Taborelli *et al.* 2001: 97–98, table XLIX (Porta Palatina street, n. 19); Mercando 2003d: 135–138 (area bounded by the streets of Monte di Pietà/San Francesco/Botero/Barbaroux); Pejrani Baricco 2003 (block south of

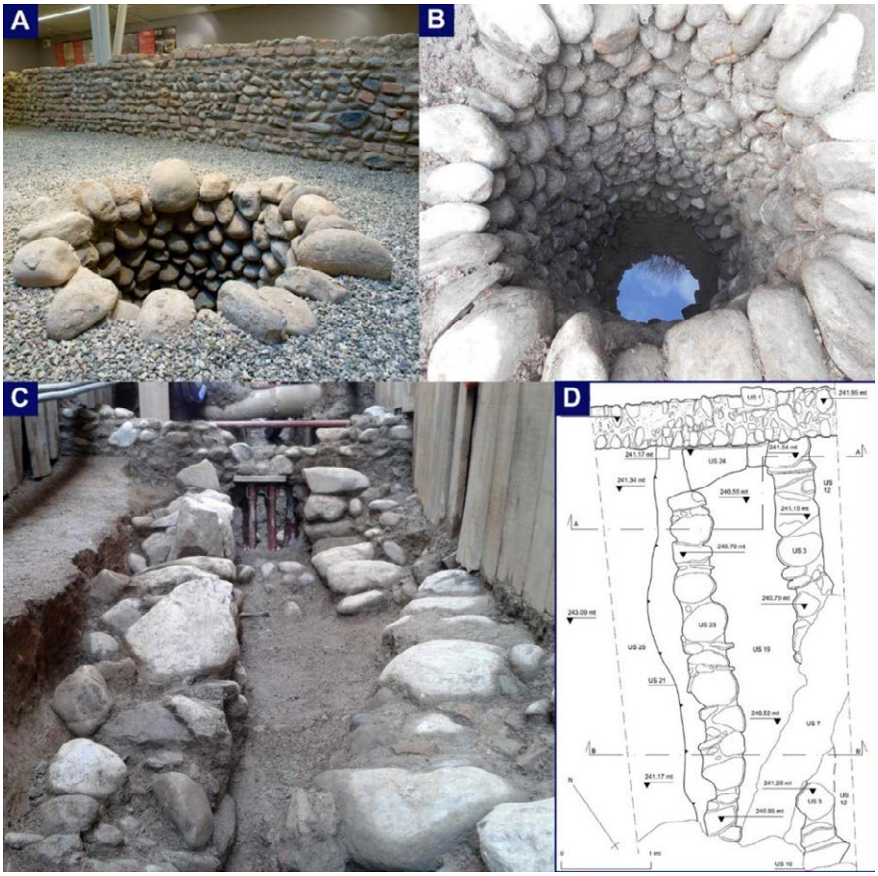

Figure 6. Alternative water collection systems to aqueducts in Roman Turin: A. The wells found in via Bellezia (SABAP TO); B. One of the wells found in piazza Arbarello (SABAP-TO); C. Cistern and water channel found in via Perrone (SABAP TO); D. Diagram of the context found in via Perrone (SABAP TO).

now piazza Arbarello (**Figure 4: W1–6**; **Figure 6: A-B**) (Ratto *et al.* 2020: 66–67). The wells were usually built in courtyards and served several dwellings or workshops. The wells were probably, at least in the early phases, the main system for water supply, and they remained in use for a long time, as attested by the materials found in the fills, which cover long chronologies between 1st century AD (Greppi *et al.* 2011: 49) and Late Antiquity. This is because private water needs were probably met mainly by wells, while the water coming from the aqueduct was mainly used for fountains and public buildings.

Archaeological data provide some information about the construction of the wells. As far as the sewers are concerned, they are built according to a 'stone lining' typology, using only unworked pebbles. This was a rather common technique in the area over a long period of time and therefore does not provide a decisive chronological reference, as it was rather common in the Cisalpine area over a long period of time (Vigoni 2011: 27). In contrast, the specific technique used to excavate the shafts is linked above all to the nature of the embedding soil.

During the excavation of the three wells found in Piazza Arbarello (**Figure 4: W6**), one well was emptied to the bottom, while the others were examined in sections. Thanks to this study it is possible to clearly examine the section of a wider pit surrounding the wells and to verify the absence of any foundation structure, generally necessary to provide a sufficiently solid support for the covering. Both these features are typical of wells dug in stable soils that rest on very compact layers of groundwater flow. The study of these wells has confirmed the use of an unusual construction method: they were dug and completed by lining from bottom to top (Ratto *et al.* 2020: 66).

It is also likely that cisterns for collecting rainwater were quite common, both for domestic and productive activities, although none have yet been identified in urban areas, while small indication was found in a context investigated in 2013 in via Perrone (**Figure 4: P**).[19] During the excavations of a narrow

the *decumanus* of the theatre); Pejrani Baricco *et al.* 2010: 251; Greppi *et al.* 2011: 49 (Bellezia street, n. 16); Ratto *et al.* 2022: 55 (Orfane street, n. 18).

[19] ASABAP-TO.

trench for the laying of underground services, outside the western side of the wall, archaeologists identified a structure that could be interpreted as a cistern. It was delimited by a structure of mortar-bonded pebbles and connected by a stone slab in the form of a chute to an open channel of large pebbles (over 50cm) held together by tough clay, with a north-south slope of 1%, which may have served as an overflow drain by means of a system that cannot be reconstructed (**Figure 5: C, D**). Situated just outside the western walls, it may have been associated with a farm found nearby (**Figure 4: 9**) (Mercando 2003c: 239) and was probably a system for collecting rainwater for agricultural purposes.

Scholars have long hypothesised the existence of an aqueduct supplying water to *Augusta Taurinorum*, based mainly on historical cartography (**Figure 4: AQ**), in particular Caracha's 1572 map (**Figure 2: B**)[20] and two subsequent ones from 1640 (**Figure 2: C**)[21] and from 1643 (**Figure 2: D**),[22] in the absence of any objective archaeological evidence. All three maps, show the arches of an aqueduct approaching the town walls from west. Particularly in the 1643 map (**Figure 2: E**), the aqueduct appears to change from an above-ground to an underground route as it passes through the countryside. In fact, the engraver seems to mark its presence with a different line from the one he uses to indicate road routes. However, some scholars have refuted this hypothesis, believing that the maps show the aqueduct commissioned by Emanuele Filiberto of Savoy in 1572 (Diciotti 2009: 174),[23] rather than the Roman infrastructure. Finally, it cannot be ruled out that the Savoy work, which was completed in a very short time, was at least partly the restoration of an older structure.

The discoveries of d'Andrade

Further evidence of the ancient water supply systems comes from the investigations carried out by Alfredo d'Andrade at the end of 19th century. His investigations revealed the presence of lead pipes (*fistulae*) in two contexts: in Palazzo Madama (**Figure 4: C**) and in the Giardini Reali (**Figure 3: B**). In the first case (d'Andrade 1899: 10), d'Andrade found three lead pipes (**Figure 7: 3, A–C**), two of which belong to the module *quinum denum* (diameter 5.9cm) and the third with a diameter twice as large (perhaps 10cm), which could belong to the category of *vicenariae*.[24] Further clues can be found in an excavation note dated 4 October 1884 (**Figure 7: 3**),[25] which gives a little more insight into the context in which they found the pipes, just below the road, and that they excavated only one of them (**Figure 7: 3, A–D**). Some restoration works, done between 2000 and 2005, rediscovered one of these lead pipes (**Figure 7: 4, C**) (Gabucci and Pejrani Baricco 2009: 235; Pejrani Baricco 2010: 130–133; Pejrani Baricco and Maffeis 2006: 25–27), but we don't have any information about the others.

Scalva briefly reported the second case without any detailed study (Scalva 1998: 94), but thanks to some documents preserved in the *Fondo d'Andrade* of the Archivio di Stato di Torino, we can now clarify the circumstances of this discovery. It consists of a series of four letters,[26] dated between 28 December 1891

[20] Giovanni Caracha, *Veduta assonometrica dell'incisore di corte di Emanuele Filiberto di Savoia*, ASCTO (1572), Collezione Simeom, D.1.

[21] *Pianta topografica della città di Torino con la cittadella* (1640), Biblioteca Civica Centrale di Torino, Cartografico 8/9.1.

[22] M.A. Raynero, *Piano della circonvallazione fatta alla città di Torino dall'armate di S. Maestà* (1643), ASCTO, Collezione Simeon, D. 11.

[23] The author traces the infrastructure back to Emanuele Filiberto di Savoia in C16.

[24] Frontin. *Aq.* 45, 46.

[25] Soprintendenza per i beni ambientali e architettonici del Piemonte, Archivio fuori corso, n. 1070/57/7; Archivio Fotografico Fondazione Torino Musei, fl/10065, LT 1892. See also: Bruno and Nivolo 1981: 216, fig. 7; Filippi 1981: 235, fig. 4.

[26] AST, *Fondo d'Andrade*, busta 72, fascicolo 15, *Torino (resti romani nel palazzo reale)*: 1. lettera datata 28 dicembre 1891 indirizzata al Signor Direttore dell'Amministrazione della Real Casa di Torino; 2. risposta alla precedente lettera, datata 16 gennaio 1892; 3. successiva risposta datata 16 gennaio 1892. AST di Torino, *Fondo d'Andrade*, busta 72, fascicolo 16, *Torino (resti romani diversi)*: 1. dichiarazione su carta intestata, datata 21 gennaio 1892, del Direttore

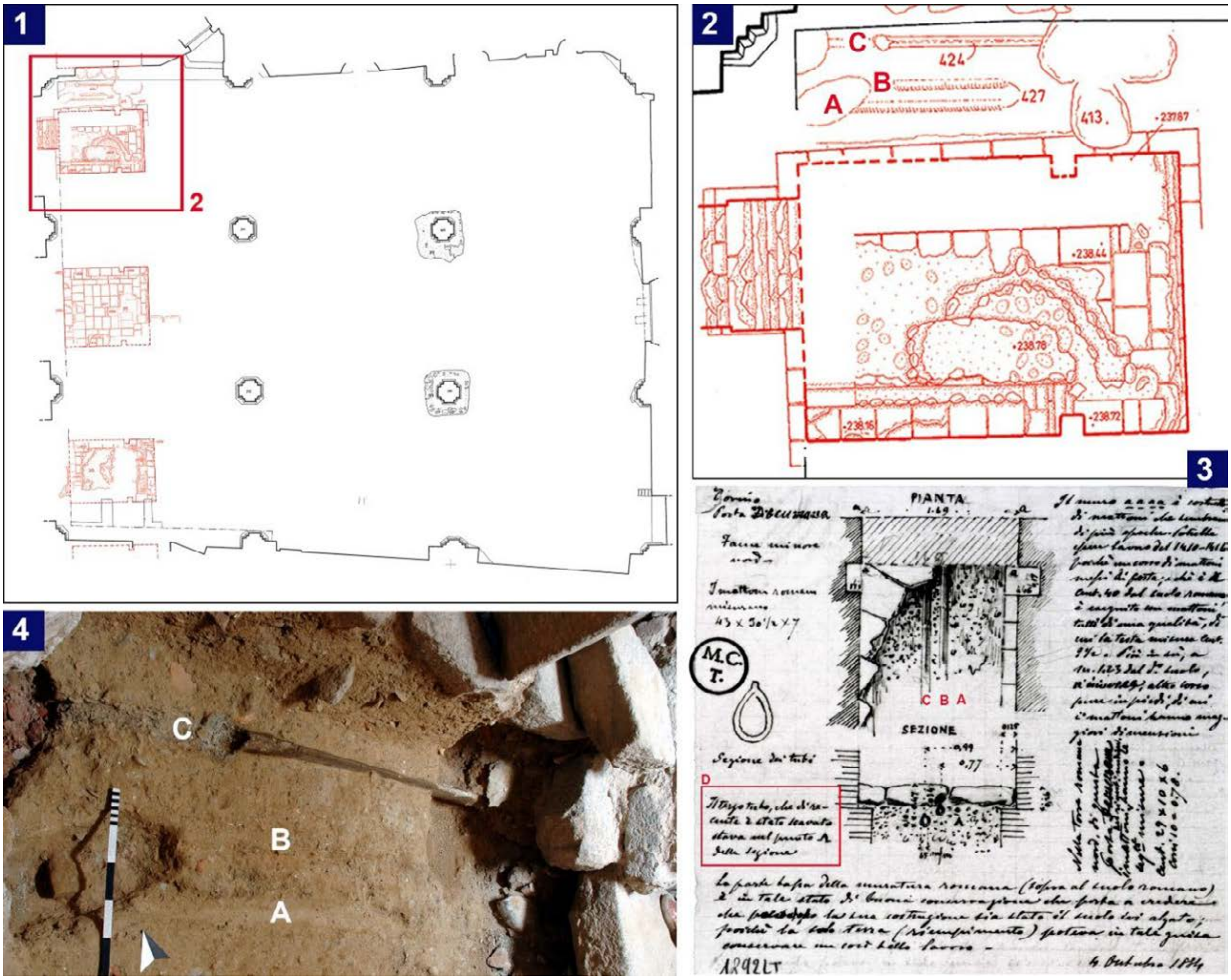

Figure 7. The lead pipes found inside the Porta Decumana (Palazzo Madama): 1. Plan of the modern excavation; 2. Detail of the plan of the modern excavation; 3. Sketch of the 1884 excavation [Alfredo de Andrade, Torino – Porta Decumana, sezione di muro, 1884, (LT 1892), Torino, GAM – Galleria Civica d'Arte Moderna e Contemporanea, Gabinetto Disegni e Stampe, fondo de Andrade (su concessione della Fondazione Torino Musei)]; 4. Photograph of the only lead pipe found in situ during the modern excavation (SABAP TO).

and 21 January 1892, in which it is stated that, during the works for the opening of via XX Settembre, 'three pieces of a Roman lead pipe' were found under the road (**Figure 3: B**). The exchange of letters describes the transfer of custody of the material from the *Casa Reale* to the *Ufficio Tecnico Regionale del Ministero della Pubblica Istruzione per la Conservazione dei Monumenti del Piemonte e della Liguria*, headed by d'Andrade. The three pipe fragments had an oval cross-section of 9 x 5.7cm and a total length of 4.22m.

This topographical clarification is extremely important because, while the same scholar published the first context, the second context remained unpublished and was often generically placed in the royal gardens (**Figure 4**). In addition, this documentation allows us to identify the origin of the find in the 'building site for the construction of the via XX Settembre', an important road because it traces the route of a *cardo* of the Roman town, to the east of the main *cardo* coinciding with what is today via Porta Palatina. This archaeological reconstruction becomes even clearer if we add to it the probable discovery

dell'Ufficio Tecnico della R. Casa in Torino in merito alla ricezione di alcuni oggetti rinvenuti negli scavi fatti per prolungamento della via XX Settembre.

in 2003 of the only known Roman public fountain along via XX Settembre (**Figure 4: Q**).[27] In fact, during some excavations for the reconstruction of the road system, at the crossroads between the *cardo minor* and the *decumanus minor* (via Conte verde/ vicolo San Lorenzo) – in an area already pointed out by d'Andrade (**Figure 3: C**) – the archaeologists found a stone channel with a central depression, delimiting on two sides a quadrangular area about 2m long and 1.5m wide. At the bottom, they also identified the brick preparation for a reservoir and recesses for the insertion of slabs to delimit the basin. It was located at the corner of two streets paved with large stones, so the lead pipes found along the same street were probably also used to supply water to this fountain.

The Musei Reali's collection of hydraulic artefacts

The lead pipes found in Palazzo Madama seem to have been left *in situ* (except for one: **Figure 7: A**), while it is unclear what happened to those found along via XX Settembre, although archival documents indicate that the materials were recovered and preserved. Perhaps these materials were not lost and are still preserved in the deposits of the Museo di Antichità of the Musei Reali of Turin. The data we have allow us to limit the search to a group of three pieces of the same pipe, which together reach a length of 4.22m. We also know that the maximum diameter of the section is 9cm and the minimum is 5.7cm. In the Museum's deposits there is a group of three lead pipes[28] (**Figure 8: A-B**) which could be related to the via XX Settembre find. Unfortunately, the museum's inventory does not help in this regard, as it does not indicate their presence and therefore does not help to clarify their provenance. The dimensions also vary,[29] as the preserved lead pipes together reach a length of more than 5m. The diameter[30] varies between 9.2cm and 11.5cm, which suggests that they belong to the *vicenariae*[31] module, as does one of the pipes found in Palazzo Madama; in this case, too, no inscription has been found. Another noteworthy element is the shape of the joint, which almost seems to have the function of supporting the pipe, forming a kind of foot that keeps it raised above the ground and could be interpreted as a solution for the installation of lead pipes under a paved road (**Figure 8: A**). This feature has also been highlighted in a group of *fistulae* found in Rome and now preserved in the Museo Nazionale Romano.[32] The question therefore remains open, although the data at our disposal suggest that we should not exclude the possibility that these pipes came from the urban context of Turin and were not part of the archaeological collection of the Savoy family. The same collection contains other materials whose identification is complex, as the museum inventory (**Figure 8: C–L**)[33] does not indicate their provenance; however, some of them have previously been traced back to the ancient town of *Libarna* (**Figure 8: E, H, L**) (Scalva 1995: 243, figs. 9-10).[34] The collection includes an inscribed *fistula*, published

[27] ASABAP-TO.

[28] The materials are not included in the inventory of the Savoy Collection, and for the purposes of analysis they have been considered as five separate fragments, in two cases held together by sleeves. They are kept in the deposit, hanging on a metal grid.

[29] The five separate fragments were measured from left to right, top to bottom. A-B and C-D are held together by a connector. The length (l), maximum diameter (m), minimum diameter (n) and thickness of the foil (w) in cm are given: A. l160, m14, n5,5, w0,6; B. l40, m14, n5,5, w0,6; C. l120, m13,5, n10, w0,5; D. l80, m13,5, n10, w0,5; E. l186, m12,5, n6,5, w0,6.

[30] The formula of Jacono (Jacono 1934) was applied; see also Pace 2010: 42–50, 64–78.

[31] Frontin. *Aq.* 46.

[32] *NSc* 1890: 114, 320–321; *CIL* XV, 7399=MNR 50989, 50990, 50992, 50995, 50996, 50997, 50999, 50998, 50994, 51002, 51003, 51004, 51005, 51006.

[33] There are six hydraulic objects in the museum's inventory, all without indication of provenance: n. 1957 – *tubo di bronzo a staffa*; n. 1958 – *tubo a bracci con bocchetta*; n. 1959 – *tubo a gomito con disco*; n. 1960 – *tubo bronzo con disco*; n. 1961 – *tubo bronzo con diramazione*; n. 1962 – *tubo in piombo*. All have been traced except for nn. 1961 and 1962.

[34] Artefacts nn. 1958, 1959, 1962.

in *CIL* XV, 7654 (**Figure 8: L**), which is believed to originate from central Italy.[35] The artefact was purchased at the end of 19th century, and has been restored and exhibits a break right at the inscription: *Cn(aeus) Pedi(us) Phosporus fec(it)*. People mentioned could be interpreted as the owner and craftsman of the pipe, and the measurements indicate that is of the *duodenariae* module.[36] The origin from central Italy of the pipe seems to be confirmed also from another pipe with the same inscription, discovered in Fossombrone (Marche)[37] and from a third lead pipe from the same craftsman held by the National Archaeological Museum of Umbria (Perugia) (**Figure 8: M**) that comes from Pietralunga (Fossalto): *Phosphorus Cn(aei) / Pedi Kari ser(vus) fec(it)*. The pipe has been dated in 1st century AD, which, when considered alongside the inscription and the *status* of the craftsman (from *servus* to *libertus*), suggests that the lead pipe in Turin is more recent.

Another lead pipe of the same family has been discovered in Castel di Guido in Rome's countryside: *[---] et Pediorum / [---]ini cc(larissimorum) pp(uerorum)* (*CIL* XV, 7780).
Finally, a fragment (**Figure 8: D**) could be interpreted as part of a hydraulic pump, which has its own comparison with a piece in the collection of the Musei Capitolini-*Antiquarium* Comunale (Talamo and Usai 1987: 118–119) (**Figure 8: N**).

The blocks discovered in via Botero

Inside the Giardini Reali are 18 blocks of local stone[38] (**Figure 9: C**) (Frisa Morandini and Gomez Serito 1998: 223–233; Gabucci and Pejrani Baricco 2009: 235–236) which are thought to be connected to the Roman town's water supply. The blocks were found in 2010 and 2011 leaning against a modern building in via Botero (**Figure 9: A-B**) (Pejrani Baricco *et al.* 2012), but their antiquity had already been noted by local historians, who had described them in the literature as 'columns of a Roman public building'. The blocks had been reused in a rainwater drainage system, and a stoneware pipe had been inserted inside. This site is close to the main *decumanus* of the town (**Figure 4: R**), and it is likely that the blocks came from nearby, as their heavy weight would have made long-distance transport prohibitive. Archaeological research has allowed some chronological clarifications regarding the reuse of the blocks. The evidence establishes that the laying of the stoneware pipe took place later and that the stone pipe was laid immediately after the construction of the palace cellar. Other blocks were recovered from the rubble and a buried basin with a concrete base measuring 1.95x4m and covered with pottery was found nearby. It was assumed that the basin was connected to a small rectangular pit (1x0.85m) made of bricks and mortar, into which a clay channel flowed. The blocks were removed from their original location and moved first to a deposit and then to the Giardini Reali, where they can still be seen today. In comparison with the published material, 18 blocks could be identified instead of 17 (**Table 1**). The morphology is not uniform, perhaps because it was modified during the process of manipulation aimed at their reuse.[39] The only element that remains almost intact is the size of the internal hole, which varies between 30cm and 35cm in diameter.[40] All the blocks were measured, but some dimensions could not be determined due to accessibility problems.

[35] The artefact has been bought by the director the Museum of Turin from the Ranghiasci collection in Gubbio (Fabretti 1887: 410).
[36] Frontin. *Aq.* 44. The artefacts is 49.5cm long, has a maximum diameter of 7cm and a minimum diameter of 5cm and the thickness of the foil is 0.4cm (see footnote n. 35).
[37] Luni 1993: 44, n. 4: the lead pipe has been found in a locality called S. Cristoforo dei Valli; cfr. *NSc* 1894: 47.
[38] It is probably gneiss from the Susa valley or from Vaie. See the appendix for more information.
[39] Inside the garden, a structure made of concrete and bricks is preserved, inside which the same stoneware pipe as inside the stone blocks is visible. This was perhaps recovered near the foundations of the palace. The diameter is approximately 20–23cm.
[40] This measurement also varies due to the difficulty of making it precisely. Another issue is the widespread carbonate deposit within that changes the original profile.

*Figure 8. Roman hydraulic collection of the Musei Reali of Turin (published by concession of MiC -Musei Reali, Museo di Antichità): A. Two lead pipes (the two red circles show the joints, which probably functioned as supports); B. Lead pipes; C. Bronze shut-off valve; D. Bronze part of a hydraulic pump (?); E. Lead pipes joint; F. Bronze tap with shut-off valve and nozzle; G. Hydraulic key (?); H. Bronze siphon (?); I. Lead pipe with inscription; L. Lead connector with three joints; M. Lead pipe from Fossalto, Pietralunga, held at the Archaeological National Museum of Umbria; N. Reconstruction of the hydraulic pump stored in Musei Capitolini-*Antiquarium *Comunale (Rome), the red arrow indicates the part of the pump that could be compared with the fragment in the Museum of Turin (elab. of D. Gangale Risoleo after Schiøler 1989: 318, fig. 10) (all photographs of D. Gangale Risoleo).*

Some blocks show peculiarities, such as block 1 (**Figure 10: D**), which has a thick deposit of calcium carbonate in its interior. Analysis of the deposit has provided some information on the orientation of the block and the direction of water flow (see appendix). All the blocks have male and female joints on their sides (**Figure 10: A**), which facilitated connection by means of a (sometimes visible) lime seal placed just before the joint. The female joint of block 1 shows part of the male joint of another block.

On one of the faces of block 2, on the male joint, a different technique can be seen; it is not excavated as in the previous block but made in relief. Inside the cavity, the lime used to join the blocks can be seen and part of an earthenware pipe can be seen in the hole.

Block 4 is the largest and has a peculiar morphology, characterised by the presence of two holes (**Figure 9: B, 3**): a larger one in the centre of the block and a smaller one off-centre and diagonal. At the time of its discovery, the block was in its highest position, at a height of 5m. In one corner, traces of reworking are visible, which have been interpreted as a recent intervention related to reuse operations, probably aimed at facilitating the channelling of water. Furthermore, although the smaller hole has been correlated with the reuse phase, the preliminary analysis of the calcium carbonate deposits seems to contradict this interpretation, allowing us to hypothesise that the double hole existed before the recent manipulation. Finally, it should be noted that the male connection is in the opposite direction to the double hole, while the smaller, diagonally oriented hole is adjacent to the female connection. On block 13, the signs of the oldest phases of work still seem to be preserved, as evidenced by the presence of a curved line in the centre of the block itself, which could be interpreted as an indication given by the workers to orient the hole in the central position. Based on the above considerations, we can therefore hypothesise that the different blocks are part of the same hydraulic infrastructure, probably located not far from the town, which was dismantled at some unspecified time to recover some of the building material. The blocks are not uniform, robably because they were modified during the process of reuse,[41] and the male and female joints are not always preserved, although the size of the internal hole seems to be constant (30–35cm in diameter).[42]

Similar finds are known in Piedmont: in Ivrea (**Figure 9: E**), in Pinerolo[43] (**Figure 9: D**), and in Libarna (**Figure 9: F**) (Scalva 1995: 240–241; Quercia *et al.* 2016: 167–171). In particular, the blocks found in Ivrea (**Figure 9: E**) – probably lost[44] – are the closest example to the Turin blocks. The morphology of the blocks found in *Libarna* is different. The use of stone blocks for the construction of aqueducts (Malinowski 1983: 251–252) is also attested in other parts of Italy (Zanovello 1997: 139–144), especially in the north-east, such as Padua and Este (Zanovello 2016: 74–76; Zanovello 1997: 54–74, 122–129), Feltre and Belluno (Tamburrino 2022: 399–404), Trieste (**Figure 9: G**), and Aquileia (Zanovello 1997: 139–140); but also in central Italy, such as in Arezzo (*NSc* 1878: 332), *Alba Fucens* (Rose 2022: 51–62; Rose 2018: 104–113) and Rome (**Figure 9: H**) (Lombardi and Santucci 2020: 279–280). There are no clear chronological references to the use of these materials, except for Padua, which is the only context in which it is possible to place them in a precise chronological framework in relation to the town's water supply. Indeed, the construction of the amphitheatre made it necessary to replace the stone pipes with a branch of lead pipes (Zanovello 1997: 117–119; Ruta *et al.* 2009: 20–25; Zanovello 2016: 76–77; Bonetto *et al.* 2017:

[41] Next to the blocks, a structure made of concrete and bricks is preserved, inside which the same stoneware pipe as inside the stone blocks is visible. This was perhaps recovered near the foundations of the palace. The diameter is approximately 20–23cm.
[42] This measurement also varies due to the difficulty of making it precisely. Another issue is the widespread carbonate deposit within that changes the original profile.
[43] Six blocks can be seen in a garden adjacent to the 'Casa del Senato'. They are characterised by morphological and dimensional differences, while the diameter of the hole inside is nearly constant, varying slightly from 26cm to 28cm. The presence of male-female joints is noted, and it is therefore plausible to assume that they were all part of the same structure. There is no evidence of carbonate deposits.
[44] The blocks were photographed in 2011 in a deposit and went missing.

62–63;).[45] Moreover, different morphologies have been identified in Este, and the square blocks served as connections to the cylindrical pipes (Zanovello 2016: 74). Therefore, comparing the different contexts with others from other areas of the Mediterranean (e.g. Istanbul: Ward *et al.* 2017: 191), it is possible to divide the stone pipes – or to use the term used by Vitruvius, a piece of stone 'with a hole drilled through it'[46] – into three categories: pressure pipes, main pipes integrated with secondary pipes of different materials (perhaps lead or terracotta), and stone pipes intended for the construction of 'inverted' siphons. We could assign the Turin context to the latter category.

Table 1. List of the main characteristics of the blocks (elab. by D. Gangale Risoleo).

Block no.	Dimensions (cm)	Conduit (diameter, cm)	Notes
1	62x63x41	33	Carbonate deposits (6cm)
2	45x60x60	30	Inside is the stoneware pipe inserted in modern times
3	59x47x46	?	/
4	103x62x66	32	Carbonate deposits; double conduits
5	31x50x60	30/21	Different machining of the hole at the two ends
6	60x51x60	30/21	Different machining of the hole at the two ends
7	?	30	/
8	?	30/34	Thick calcium carbonate deposit
9	65x65x37	?	/
10	65x65x59	?	/
11	?x?x30	33	/
12	?x?x30	33	/
13	?x?x30	33	Laterally there is a curved line in the centre of the block
14	60x60x60	30	/
15	60x60x30	30	/
16	60x60x37	30	/
17	60x60x48	33	Thick calcium carbonate deposit
18	60x60x52	35	Thick calcium carbonate deposit

[45] The first aqueduct is dated to the end of 1st century BC, while the new one dates to the second half of 1st century AD.
[46] Vitr. *De Arch.* 8, 6, 8.

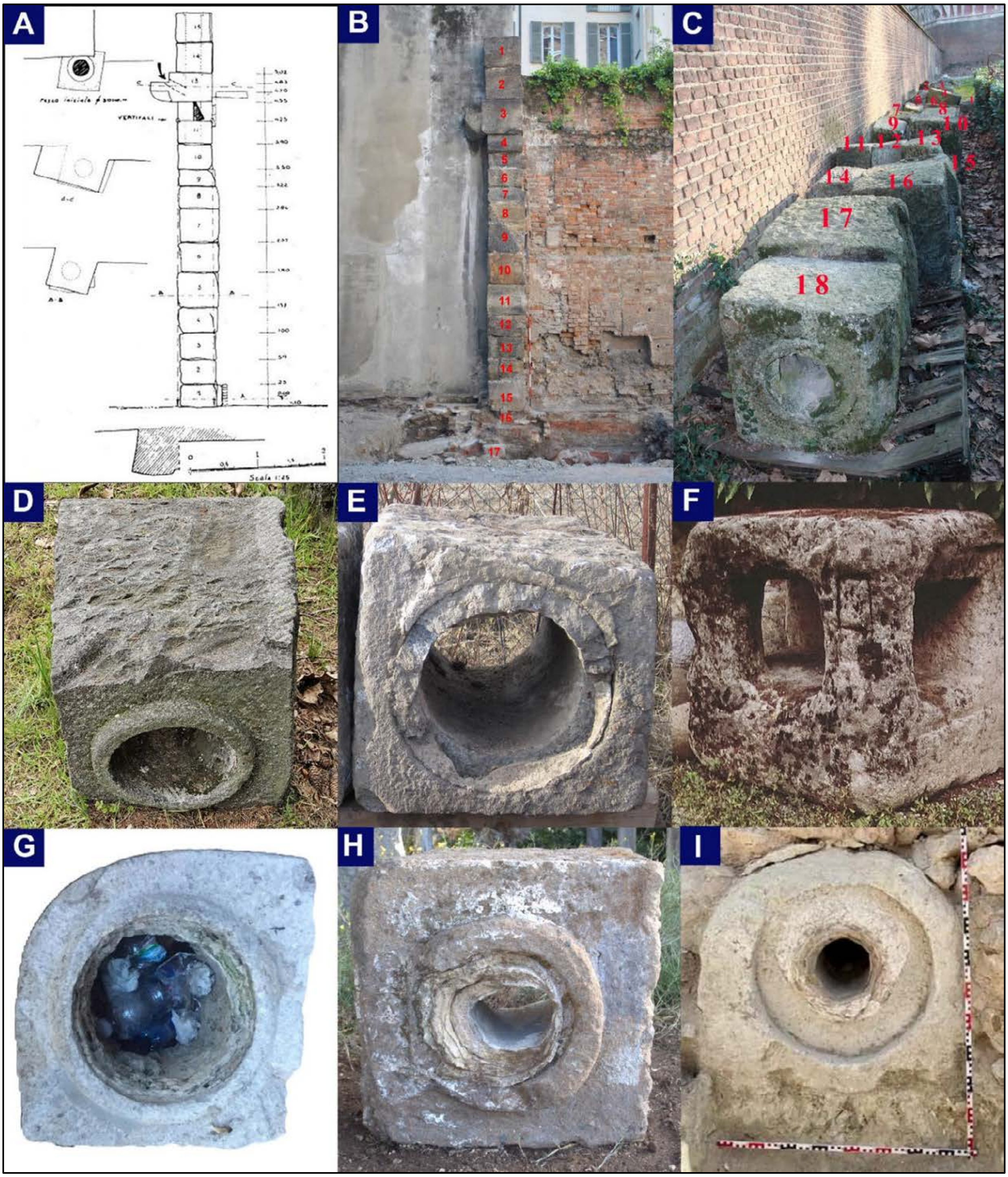

Figure 9. Perforated stone blocks attributable to inverted siphons: A. Sketch of blocks of Turin when they were found (SABAP TO); B. Photograph of the blocks of Turin when they were found (SABAP TO); C. Photograph of the blocks in the royal garden of the Musei Reali of Turin (photo of D. Gangale Risoleo); D. Block from Pinerolo (photo of S. Ratto); E. Block from Ivrea (photo of S. Ratto); F. Stone block in Libarna (adapted from Scalva 1995: 241, fig. 7); G. Stone block in Trieste (photo of C. Passchier); H. Stone block in Rome stored at Antiquarium Comunale (photo of D. Gangale Risoleo – © Roma – Sovraintendenza Capitolina ai Beni Culturali); I. Stone block in Cádiz (adapted from lavozdigital.es).

A siphon for *Augusta Taurinorum*?

Based on the features highlighted so far, we must therefore assume that a siphon (Trevor Hodge 1983: 174-221; Wilson 2008: 299-300; Kessener 2023: 67-103; Kessener 2022: 11-38), or rather an inverted siphon, was in operation in Turin, close to the city walls (**Figure 4: AQ**), perhaps built to overcome an ancient steep gradient. This structure was built by Roman engineers to allow water to overcome depressions without losing/accumulating excessive flow force to ensure a pressurised flow. The water could flow at a higher level than the valley, or it could flow directly into the valley (in this case called an inverted siphon), via a siphon bridge, which Vitruvius called *venter* and which served to dampen the V-shape into a U-shape. In both cases, the water built up considerable pressure which was distributed from a masonry conduit into smaller conduits, sometimes in batteries of several pipes made of lead, terracotta or stone (Kessener 2023: 73, table 2). In the eastern Mediterranean, inverted siphons were often realised using stone blocks, characterised by male-female joints (Kessener 2016: 267–272).

We can locate the hypothetical siphon of *Augusta Taurinorum* in the western area of the town (**Figure 4: AQ**), where historical cartography already indicates the presence of arches that could be recognised as the *venter* on which the blocks were placed (**Figure 2: B-D**), as was the case with the aqueduct of Cádiz (**Figure 9: I**) (Perez Marrero 2012: 93–96, 109–110, 132–133; Sánchez López and Martínez Jiménez 2016: 204–207; Kessener 2022: 14–15).[47]

This area, between the walls and the Dora Riparia, is now characterised by a regular difference in height towards Porta Segusina (**Figure 4: D**), ranging from 247m a.s.l. to 242.38m a.s.l. The difference in height becomes even more pronounced on the way to the Po, where the current height is 225.12m a.s.l. It cannot be excluded, of course, that the difference in height was greater in ancient times. We can therefore imagine that, at some time after the abandonment of the aqueduct, the blocks were recovered and reused in the building in via Botero where they were found, less than 200m from Porta Segusina.

Finally, we have no clear evidence of the original position of the blocks and can only speculate. Perhaps they were placed on a *venter*, or on the same arches that can be seen in historical cartography, or according to the construction plan that has also been recognised in the aqueduct of *Nicopolis in Istrum* (Powlter 2019), Bulgaria, where ceramic pipes were laid together with stone blocks on arches along the course of a siphon. It is also possible that they were laid on a bridge over a watercourse, as has been found in other cases (Zanovello 1997: 142).

Conclusion

The data we have do not allow us to reconstruct the Roman water supply of the town in detail, but they do help us develop new hypotheses. We have highlighted the presence of a common technique in the construction of wells, using large pebbles collected along the river, which were used also for sewers and for the construction of a canalisation outside the urban centre. We do not have enough information to draw up a chronological evolution of the water supply, but it seems more reasonable to hypothesise that this technique was common for the private use of water, especially in the suburban context, probably where the connection to the aqueduct was missing. At the same time, we have highlighted the presence of lead pipes in correspondence of the main streets and gate. The *vicenaria* module seems to be the most used for the main water channel that started from a *castellum* placed next to the west side of the walls. A *castellum* was probably connected to the inverted siphon that we hypothesise was placed in the western part of the town.

[47] The 'sifon de la Playa' is the longest pressure line (19.5km) and part of the blocks have been recovered from the shoreline. A second one is the 'sifon de los Arquillos' (3.5km long and 50m deep), placed in the middle between the spring and the point of arrival of the aqueduct. New discoveries have been made in Jerez de la Frontera in 2023: https://www.lavozdigital.es/provincia/cadiz/descubierto-manera-fortuita-parte-acueducto-romano-jerez-20231017114806-ntv.html [visited on 02/02/2024].

We have no clear chronological references for the construction of the aqueduct, nor do we know its route or its point of entry, although it has been hypothesised that the waters of the nearby Dora Riparia were channelled (Gabucci and Pejrani Baricco 2009: 235), and this seems to be confirmed by carbonate analysis (see appendix), while the Po was the final destination for the waters collected by the sewers. From a chronological point of view, we can link the construction of this infrastructure with the walls building and the main urban features of the town, which, according to detailed chronological studies, date between AD 50 and 75 (Brecciaroli Taborelli and Gabucci 2007: 251, fig. 19). It is similarly possible that this block may be correlated with the aqueduct commissioned by Emanuele Filiberto of Savoy in 1572 (Diciotti 2009: 174).[48]

In conclusion, much work remains to be done to complete the picture of the deep bond between the Roman city and water, of which only faint traces can be seen today. The legacy seems to have been partly taken up by the bull's-head fountains, called *toret*, which began to be installed throughout the city in 1862 to celebrate the birth of the new aqueduct inaugurated in 1859.

Appendix

Carbonate deposits in stone siphon blocks from Turin

by Cees W. Passchier and Gül Sürmelihindi

Siphon block material

The siphon blocks (**Figure 10: A**) were cut from orthogneiss. Orthogneiss is a type of granite deformed at high temperature and pressure at depths of more than 10km in the Earth's crust. At such conditions, the rock flows slowly and crystals and crystal aggregates line up into planes perpendicular to the shortening direction (foliation planes) and into lines parallel to the direction of stretching (stretching lineations) (**Figure 10: B-C**). The orthogneiss from which the siphon blocks were cut is porphyritic, with small plagioclase lenses, and has clear foliation planes and lineations, visible as a 'grain' in the rock (Passchier and Trouw 2005). As in more foliated rocks such as slate, the foliation planes are planes of structural weakness. These features were recognised by the Roman craftsmen who chiselled the siphon blocks. The central cylindrical conduit in the blocks is cut perpendicular to the foliation in all blocks; in this orientation, the chiselling required to make the conduit, as well as the water pressure in the conduit, will not split the rock along the foliation. The lineation is visible on the foliation planes and is parallel to one of the sides of the block (**Figure 10: A-C**). Geochemical analysis of the orthogneiss will allow to determine where the blocks were originally quarried. Since orthogneiss is a common rock type in the western Alps, the blocks probably have a local provenance.

Carbonate in the conduits

Calcium carbonate deposits (Sürmelihindi and Passchier 2024) are present in the conduit of all the investigated blocks and encircle the interior of the entire pipe (**Figure 10: D**). In some blocks the carbonate thickness is equal all around the conduit, indicating that the conduits were completely filled with water, i.e., that the conduit formed a pressure pipe as part of an inverted siphon. In some blocks, however, the carbonate distribution is unequal around the conduit (**Figure 10: D**). Carbonate is commonly thinner on one side, probably due to the occasional presence of air bubbles along the roof of the conduit, common in many siphon pipes, especially if the slope was gentle and the conduit irregular

[48] It was observed that comparable blocks were used in the construction of aqueducts during the medieval period. For example, this can be demonstrated by the case of Potenza in the 15th century (Sanza 2008). For further insights refer to Tamburrino 2022.

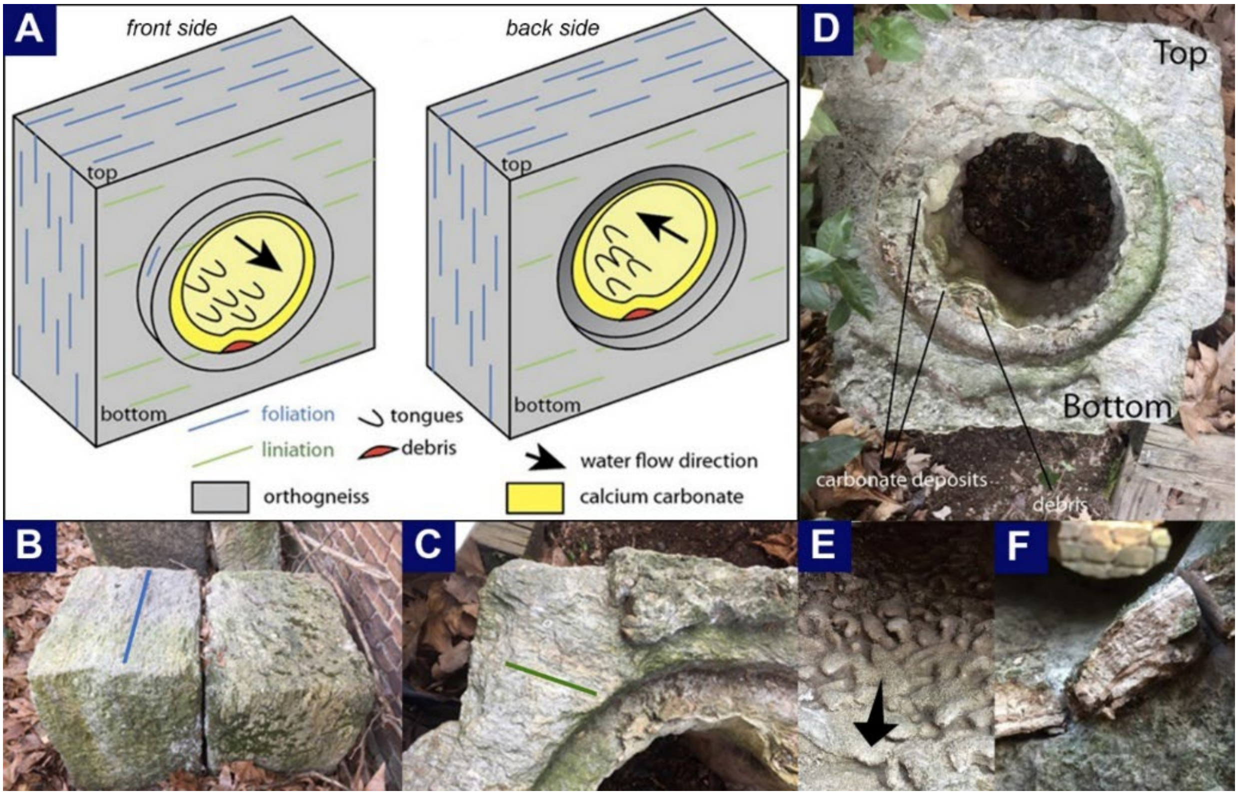

Figure 10. Siphon block material and carbonate in the conduit: A. Schematic illustration of a siphon block with carbonate deposits in two orientations, the front side with a male connection, and the back side with female connection. Siphon blocks are made of orthogneiss with a foliation (blue) and lineation (green). Calcium carbonate deposit in the conduit is thickest at the bottom and may contain tongue-structures and debris inclusions. The water flow direction is indicated by the pointed end of tongue structures (black arrow). The block is shown in the orientation in which it was positioned in the aqueduct line. Water flow is from the female to the male connection, as shown]; B. Foliation in siphon blocks (blue lines); C. Lineation on the back side of a block (green lines); D. Typical siphon block seen from the back side (female connection) with carbonate deposits, which is thickest at the bottom, with a small inclusion of debris at the bottom-right; E. Tongue-structures in carbonate in the conduit (flow is towards the front; arrow indicates flow direction); F. Layered carbonate in the conduit (photos of C. Passchier).

in shape (Kessener 2016). In one block, debris accumulated and was covered with carbonate (**Figure 10: D**; cf. Kessener 2016); this debris probably indicates the bottom of the conduit. The thicker part of the carbonate in the pipes commonly shows tongue-shaped ripploids (Motta *et al.* 2017; Keenan-Jones *et al.* 2022) (**Figure 10: E**). These 'tongue-structures' indicate flow direction in the pipes, in this case from female to male joints in each block. However, such structures have rarely been observed. Carbonate samples of Turin are special in this respect and must be due to the specific flow velocity and surface friction in the conduit or originating from irregularities in the orthogneiss in the walls of the blocks. In most blocks, it is therefore possible to determine the top and bottom of the blocks in their original orientation, and the flow direction: thickest parts, debris inclusions and tongue-structures are present at the bottom, while top deposits are thinner and mostly smooth.

The stratigraphy of the carbonate hand specimens shows a layering defined by colour (**Figure 10: F**). Increasing porosity at the top layers may have been caused by dissolution of carbonate in rainwater when the blocks were used as a rainwater drainage pipe (**Figure 9: B; Figure 11**). Microscopic investigation of the carbonate in the conduits shows that the deposits are composed of masses of very small crystals of calcite ($CaCO_3$) known as 'micrite' (**Figure 11: B**). Layers of micrite alternate with thin clay layers (**Figure 11: A**), while the micrite contains numerous fragments of quartz, chlorite and pelloids (**Figure 11: B–D**). There is no countable seasonal laminae alternation, and hence we could not determine the number of years of the aqueduct's activity. Stable isotope analysis can help to identify the type of seasonal cyclicity.

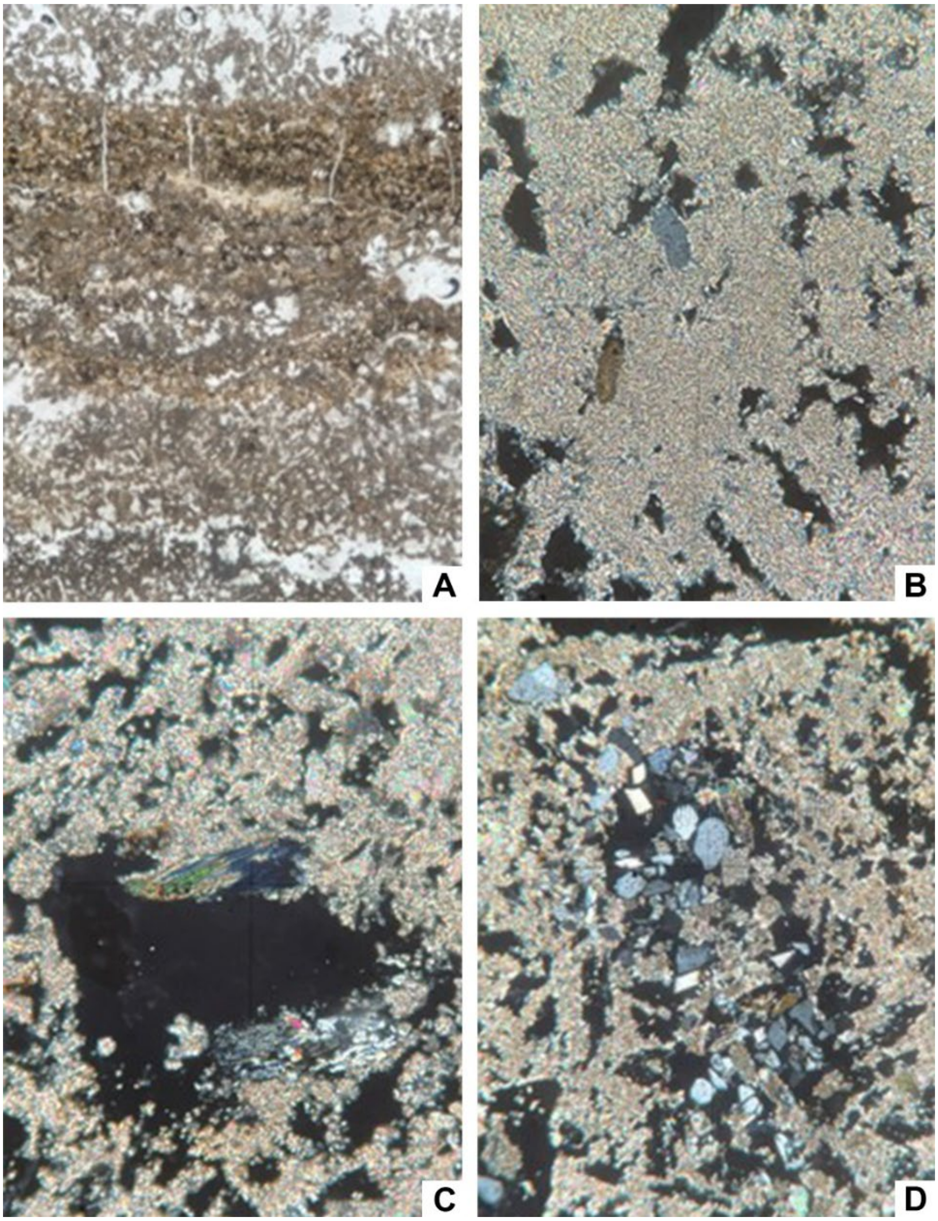

Figure 11. Microfabric of the carbonate deposits. A. Weak layering in the carbonate (The deposits are mostly micrite. At the top a clay layer with vertical tension fractures); B. Isolated angular quartz and pelloid inclusions in micrite; C. Chlorite inclusion (centre) in micrite; D. Aggregate of angular quartz and pelloids grains in micrite. Width of view (A) 10mm, (B) and (D) 1.5mm, (C) 0.8mm.

The inclusion of foreign mineral elements in the carbonate deposits indicates that clastic sediment (sand and clay) entered the aqueduct upstream from the siphon conduit, and that the source of the aqueduct was not a karst spring but probably an open stream, possibly a river. Further geochemical and microfabric analysis of the carbonate deposits will be carried out to obtain more information on water flow in the Turin conduit.

Abbreviations

ASABAP-TO: Archivio Soprintendenza Archeologia Belle Arti e Paesaggio per la città metropolitana di Torino

ASCTO: Archivio Storico della Città di Torino

AST: Archivio di Stato di Torino

BCCTO: Biblioteca Civica Centrale di Torino

CIL: *Corpus Inscriptionum Latinarum*

NSc: Notizie degli Scavi di Antichità

SABAP CZ-KR: Soprintendenza ABAP per le province di Catanzaro e Crotone

SABAP TO: Soprintendenza ABAP per la città metropolitana di Torino

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Water and the City of Veii: A Link between Mythology, Religion, Archaeology, and History[1]

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Abstract: in recent years, substantial progress has been made in understanding the site of Veii, thanks to the publications of the British School at Rome and the multiyear 'Progetto Veio', launched in 1996. This paper seeks to highlight the close link between water and the site, tracing it from its inception through the Roman conquest and beyond. This relationship has its roots not only in the historical and archaeological field, as evidenced by recent reconstructions, but also in the realms of mythology and religion.

Keywords: Veii, Water, Mythology, Religion, History, Archaeology.

Introduction

The objective of this study is to present a non-systematic overview of the relationship between the site of Veii (urban plateau and territory) and water, spanning from the settlement's formation to the Roman conquest (with additional considerations for subsequent phases of the urban plateau). The definition of water as an element should be interpreted in the broadest possible sense: from natural phenomena (such as rainwater, springs, rivers, lakes, and the sea), to the associated deities, and direct and indirect references found in literary and historical sources. Additionally, it encompasses the various types of artificial structures built to store, use, channel, and divert water. Naturally, all of this extensive material is considered according to specific criteria, as outlined in the following paragraph. Due to space constraints, our focus will be primarily on specific aspects, with brief mentions of others. Ultimately, this paper serves as an initial overview of the topic, with the intention of further development through additional research.

Our initial premise is that water played a pivotal role in the history of the settlement. It consistently appears in key historical junctures of political and institutional transformation (such as, for example, the Roman conquest), thereby warranting specific analysis.

Methodology

This study is a continuation and expansion of earlier research efforts on the urban plateau. Initially, emphasis was placed on water infrastructure (Fusco 2011a) and drainage systems (Fusco 2018) at an archaeological site, namely the Campetti southwest area. Following this research, a preliminary survey was conducted of water structures on the plateau spanning from the Etruscan to the Imperial era (Fusco 2022).[2] Therefore, in the paragraph dedicated to the urban plateau, only the conclusions drawn from prior research (updated to Fusco 2022) are summarised. The primary focus remains on highlighting new findings from the Campetti southwest area, which serves as a rich source of data on water-related

[1] This article is part of the scientific dissemination activities of the SACULAND2022 Project (Traditional Approaches and New Digital Technologies in the Analysis and Reconstruction of the Sacred and Cult Landscape in Central Tyrrenian Italy), financed by the NextGenerationEU package - MUR (Ministry of University, Education and Research) – Notice No. 247 dated 19 August 2022, published on 23 August 2022 – PNRR (National Recovery and Resilience Plan).

[2] It is worth noting that a similar project is currently being undertaken by Professor M. L. Michetti of Sapienza University of Rome, with valuable potential for future comparative analysis of the two studies.

topics.[3] As for the section addressing the territory, which spanned an area of approximately 960km^2 during the Etruscan era (Bartoloni *et al.* 2019: 1), the data collection process was not as systematic as for the urban plateau. Several themes are examined using the main bibliography, focusing specifically on the era preceding the Roman conquest. In both topographical contexts, materials were selected carefully (for instance, pottery was not systematically analysed and is only occasionally mentioned).

Bibliographic references are limited to the essential, while valuable insights are obtained from recent research on the topic of water[4] including some accessible publications (Boccaletti 2022).

The Topographic Context of Veii

The Urban Plateau

The archaeological inventory comprises the following artefacts:

Period 1 (7th century to the beginning of the 4th century BC)	15 cisterns, of which 10 are in cultic sites and 5 are in residential/artisan sites; 19 wells, of which 17 are in cultic sites and 2 are in residential/artisan sites; 4 water structures, of which 2 are in residential settings and 2 are in cultic settings.
Period 2 (2nd to the first half of the 1st century BC)	4 cisterns, possibly 2 in cultic sites and 2 in residential sites (an additional 2 cisterns are of uncertain dating and belong to residential sites); 5 wells, possibly 4 in cultic sites and 1 in a residential site (1 well has uncertain dating and belongs to a residential site); 2 water structures possibly in cultic sites (1 water structure has uncertain dating and belongs to a residential site).
Period 3 (end of the 1st century BC to the 3rd century AD)	7 cisterns, including 3 in cultic sites, 2 in residential sites, and 2 in public areas (2 other cisterns have uncertain dating and belong to residential sites); 2 wells, both in cultic sites (1 well has uncertain dating and belongs to a residential site); 12 water structures, with 11 in cultic sites and 1 possibly in a public site (1 water structure has uncertain dating and belongs to a residential site); 4 leaden pipes, with 1 found in a cultic site, 2 in public sites, and 1 in a residential site.

An interesting observation, documented only at specific sites (Macchiagrande-Vignacce and Piano di Comunità), rather than being widespread across the plateau, is the dismantling of water structures through ritual practices. This phenomenon, occurring between the 4th and 3rd centuries BC, appears to be confined to the central part of the settlement and the peri-urban area, at the Sant'Angelo cistern within the sanctuary of Portonaccio (Michetti 2021: 33). Finally, tunnels have been discovered along the periphery of the tufa plateau, serving either to drain water away or transport it to fountains (Fusco 2022: 209, n. 4). We will explore this topic in more detail in section about literary sources, specifically focusing on the famous tunnel built by Camillus to infiltrate the city during the Roman siege. From this summary, two intriguing aspects emerge: the higher frequency of findings in Period 1 and their primary association with the sacred sphere. These aspects are not unexpected, given the political and economic significance of Veii before the Roman conquest (contributions in Tabolli and Cerasuolo 2019) and the pivotal role played by water in the religious sphere (Torelli 1991; De Cazanove 2015).

[3] For other aspects related to the urban plateau, please refer to recent summaries: Colonna 2006; Cascino *et al.* 2012; Cascino *et al.* 2015.

[4] Oestigaard 2011; De Cazanove 2015; Holt 2018; Haug and Müller 2020.

*Recent Archaeological Discoveries at the Campetti Southwest Area and New Interpretation of an Artefact (*Lapis Manalis*?)*

The previous picture can be expanded by incorporating references to specific structures and artefacts discovered at the Campetti southwest area, spanning from the Early Iron Age (**Figure 1: A-B**) to the Late Archaic period (**Figure 2: A-D**). While some of these findings have already been partially published, their relevance to the subject at hand requires further exploration.

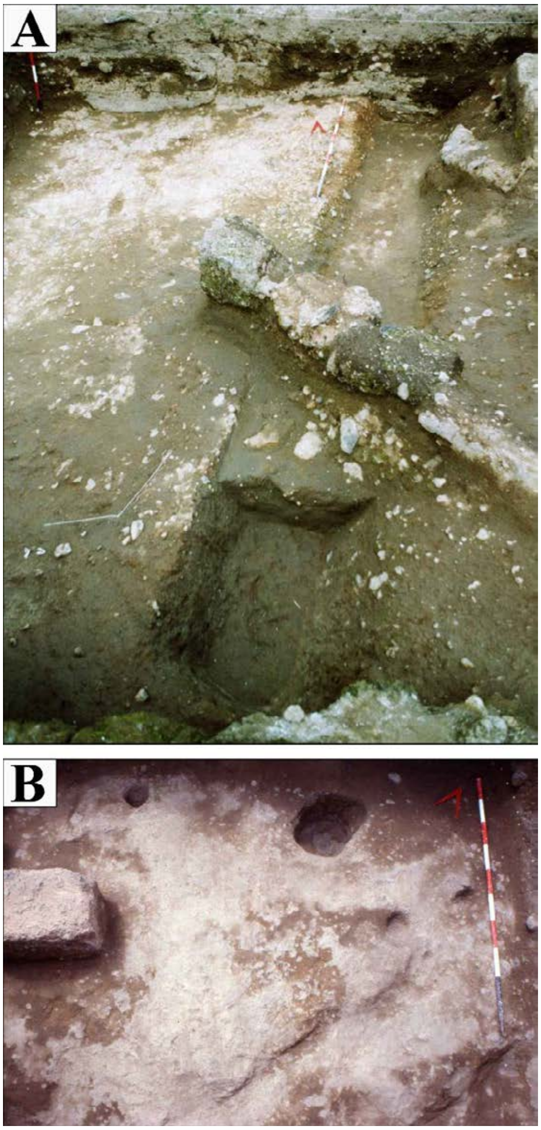

Figure 1. A. Structure embedded in the geological layer; B. Water drainage channels (photos by the author).

Recent Archaeological Discoveries

Evidence of frequentation during the Early Iron Age was found on both terraces of the site (Fusco and Latini 2022; 2023). On the lower terrace, in the area closest to the edge of the plateau, a large rectangular pit (measuring 7.00×1.37×0.58m; capacity 3.83m^3) was dug into the geological tufa layer. Its alignment is linear, oriented southwest/northeast, with only the northern boundary being non-original (**Figure 1: A**). The eastern and western walls are sloped, while the southern wall is vertical. The bottom is flat with a gentle slope from south to north. This finding can be interpreted as a basin for collecting rainwater from the easternmost part of the terrace and possibly linking it to the nearby hut settlement. Slightly further to the west, on the same geological layer, are channels (**Figure 1: B**) carved into the sloped tufa surface near several hut-like structures. These channels are believed to have been used to drain rainwater outside (perhaps to another collection point?) to avoid contact with nearby hut structures. Finally, a biconical vase with an *olletta* inserted in its opening was found inside one of the hut-like structures, predominantly serving as a water jug (Guidi 1992: 461; **Figure 2: A-B**). The artefact is ornate, featuring a tall, outwardly curved rim, a slightly swollen truncated-conical neck, a well-defined shoulder with a broad curve, a truncated body, a flat bottom, and two handles adorned with slanted pseudo-twist handles. The *olletta* has a flared rim, a short horizontal lip, a slightly bulging body, and a lightly curved flat bottom. These two vessels, nearly intact, were discovered lying on their side in a layer adjacent to the hut's embedded foundation trench. However, whether the vessels provide evidence of the hut's usage or served as a votive offering in relation to its construction (see Fusco and Latini 2022) remains open to interpretation.

These findings help paint a vivid picture of how this small area of settlement in Veii was organised during the Early Iron Age. Water and its various related components (including the cistern, channels, and vessels) naturally played a primary role and fulfilled diverse functions in daily life.

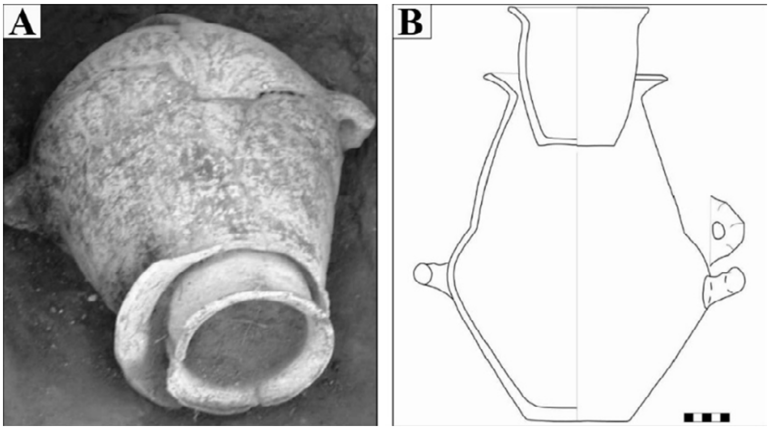

Figure 2. A-B: Biconical vase: photo and sketch (adapted from Fusco and Latini 2022).

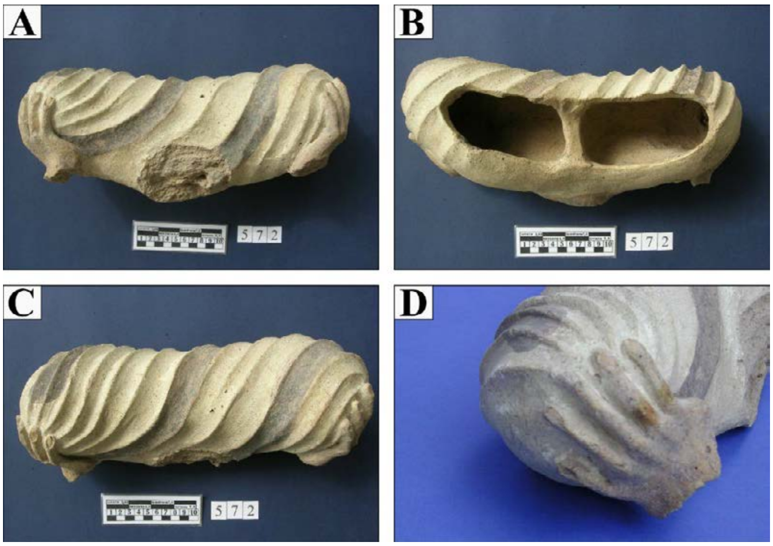

Figure 3. A-D: Terracotta statue fragment details (photos by the author).

New Interpretation of an Artefact (Lapis Manalis?)

A more detailed discussion is reserved for a terracotta statue fragment discovered within the obliteration layers (SU 3248) of an ancient cistern linked to the Etruscan sanctuary, located on the lower terrace (**Figure 4: A-C**). This artefact has been meticulously studied by G. Colonna, who suggests that it belongs to a much more elaborate group of statues depicting Anchises, carried on the shoulders of Aeneas, transporting the Trojan *Sacra* (Colonna 2009; **Figure 5: B-C**). Despite being formulated several years ago, this hypothesis has seemingly been uncritically integrated into the consolidated data on late Archaic statue production in Veii, despite the limited availability of concrete evidence (concerns regarding interpretation in Fusco 2011b: 14, n. 20; detailed analysis of the discovery context in Cerasuolo and Di Sarcina 2011). Upon further consideration, it is time to propose a new interpretation, albeit one that does not solve all of the issues pertaining to this unique object. Due to the complexity of the data to be presented, the following sequence is followed: description; identification and reconstruction by G. Colonna; new identification proposal and comparisons; literary sources; conclusion and new reconstruction.

Description

The artefact (32.5x13cm) consists of three distinct components that can be identified as follows: 1. A roughly cylindrical object; 2. A thin, closely-fitted white-painted fabric comprising 15 folds, some painted black, slanted and parallel, progressively widening from right to left, covering the previous object; 3. The hands of a male figure, inferred from the dark skin tone, placed on top of the fabric and at the ends to support the object, which rests on the head, as indicated by the negative sub-circular imprint (6.5x9cm). Additionally, on the reverse side, two sub-rectangular windows (10.5x6x7.5cm), formed by clay removal post-modelling, serve as hollow channels for firing purposes (**Figure 3: A-D; Figure 5: A**; full description in Colonna 2009: 55).

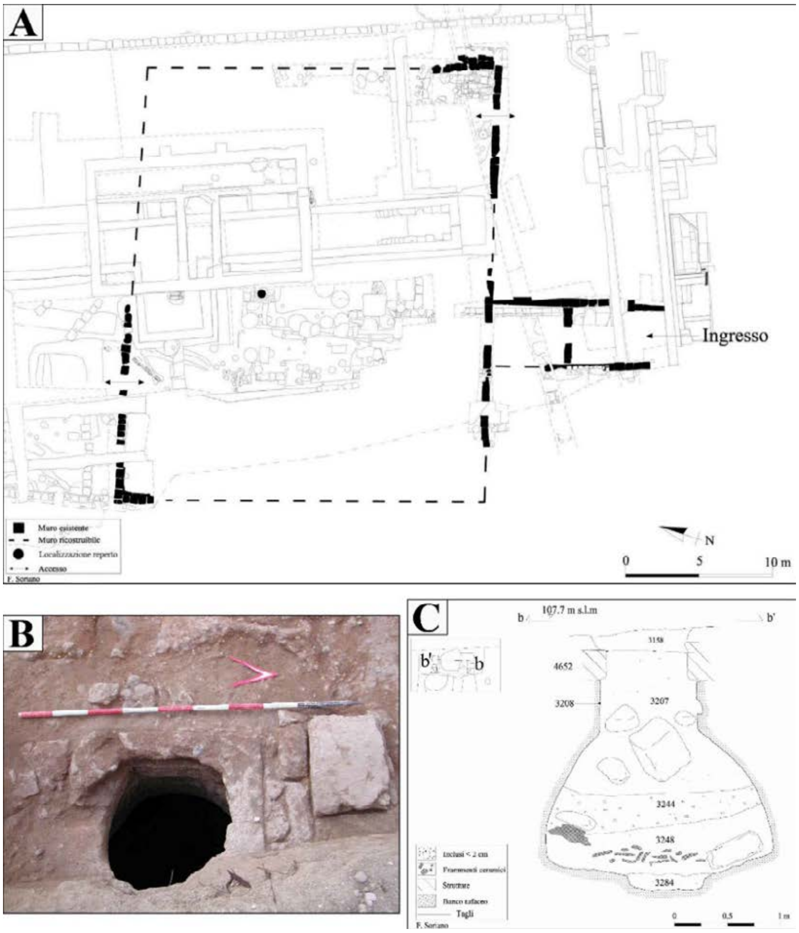

Figure 4. A-C: The context in which the statue fragment was found (adapted from Fusco 2011b).

Identification and Reconstruction by G. Colonna

The study includes some aspects that are widely accepted:

1. The interpretation of the dark colouring of the folds as ribbons with symbolic and/or decorative significance, comparable to those found in aristocratic clothing from the Middle Archaic period onward. These ribbons were used to emphasise the divine, princely, or priestly status of the depicted individual (Colonna 2009: 56).

2. The reconstruction of the estimated dimensions of the original statue, based on the size of the hands and their opening (20cm), as being approximately two-thirds of the height of the real individual (standing figure height: 1.20m; Colonna 2009: 55).

3. The chronological attribution of the artefact to the early 5th century BC, based on its stylistic features and comparisons with statuary finds from the sanctuary of Portonaccio (Colonna 2009: 56-57).

However, other aspects are less convincing, with only the primary ones mentioned below:

1. The identification of the artefact with the Trojan Penates and its final reconstruction depicting a group of statues comprising two figures (Aeneas and Anchises; **Figure 5: C**). The total absence of precise comparisons for this identification raises doubts, especially considering the numerous instances of iconography depicting Aeneas and Anchises fleeing with the *Sacra* (for example, Dardenay 2010). In addition, the final reconstruction, suggesting that the second figure (Aeneas) is carrying the first (Anchises), appears contrived given the available evidence and heavily relies on the subsequent point, which is also highly debated.

2. The attribution to the Etruscan period (second half of the 5th century BC) of the famous terracotta statuettes depicting Aeneas and Anchises feeling (with Anchises embracing his son's neck) – found in two sanctuaries in Veii (the urban one in North Campetti and the peri-urban one in Portonaccio) – plays a fundamental role in G. Colonna's article. These artefacts serve as the model for the iconographic reconstruction of the statue group (with the modified presence of the object held by Anchises and placed on his head) and also provide the ideological backdrop for contextualising the new composition. These terracotta statuettes are interpreted as a further development, dating slightly later than the artefact under examination (and its reconstruction), showcasing Etruscan reverence for Aeneas. This reverence is believed to have reached Veii through interactions with Rome and the Latins. It gained strong ideological momentum, particularly in an anti-Roman context, around the 5th century BC, amid

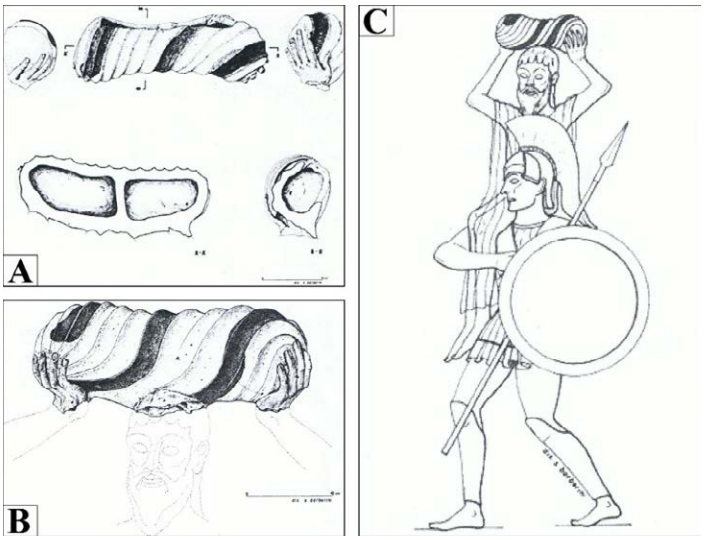

Figure 5. A-C: Sketches of the artefact and reconstruction by G. Colonna (adapted from Colonna 2009).

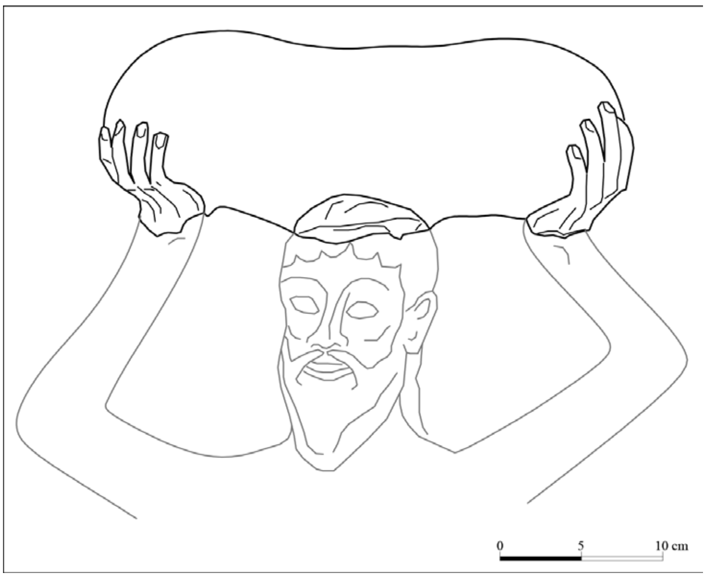

Figure 6. Hypothetical shape of the artefact covered by the fabric (elab. by Fiammetta Soriano).

renewed military tensions with Rome, which itself regarded the Trojan hero as one of its ancestors (Colonna 2009: 69-72). Unfortunately, the chronology of these terracotta statuettes is subject to extensive debate and uncertainty as evidenced by the extensive bibliography on the topic, with the chronological issue widely acknowledged (see, for instance: Zevi 1981: 150; Horsfall 1987: 18 and n. 76; Momigliano 1988: 175-176; Cornell 1995: 66; Michetti 2000: 193). Some scholars attribute the statuettes to the Roman period (first half of the 4th century BC: Torelli 2015: 294-295; 2016: 208-209). G. Colonna strongly opposes this hypothesis, as it would undermine the ideological context for the new evidence, consequently weakening the plausibility of the reconstruction (see insightful comments in Torelli 2016: 208-209). But is it possible to propose an alternative identification and reconstruction of the artefact, one based only on existing evidence? Could the archaeological site where the artefact was found, being the one most closely associated with water in Veii, provide us with a clue?

The New Identification Proposal

Let's consider an alternative interpretation of the object covered by the fabric. There is no compelling reason to interpret it as one of the Trojan *Sacra* (for a comprehensive collection of literary sources on the Trojan Penates and their forms – bronze caduceus, wooden, stone, earth, and marble statuettes, and specific deities – none of which resemble the artefact in question, see: Dubourdieu 1989: 123-153). The fabric adheres closely to the artefact and exhibits creases (artificial or natural?). Therefore, we suggest creating a new render of the object without the fabric: the newly proposed figure (**Figure 6**) should closely resemble the original form, which would have been round, almost cylindrical, smooth, and somewhat weighty, given that it is carried horizontally with both hands and rests on the head. The object that best aligns with these characteristics, in our opinion, is a fairly large stone. For comparison, we reference the inscribed votive stone from Antibes, oval in shape and dated to the second half of the 5th century BC (Lambrinoudakis 2005: 316-321 and no. 77). To further support our theory, we refer to G. Colonna's own theory (55, n. 25, reference to the myth of the stone covered by cloth given by Rhea to Cronus), along with numerous depictions in Greek and Etruscan art featuring similar iconography. These representations include centaurs, giants, tritons, and cyclopes carrying heavy objects, such as boulders, rocks, and logs with raised arms and using their heads (also noted in the same study: 57, n. 35

and fig. 11). In conclusion, we propose a covered oval stone, almost protected by the fabric to accentuate its importance and value, being carried by a male figure.

Literary Sources

Some insights come from a passage by Pausanias (10, 24, 6) referencing an object (a stone) housed at the Temple of Delphi. The comparison with the renowned Temple of Apollo is not incidental. Indeed, the close relationship between Veii, specifically the peri-urban sanctuary of Portonaccio, and the Greek temple has long been acknowledged (Colonna 2019: 122). Pausanias describes a small stone (λίθος ... οὐ μέγας), known as the stone of Cronus, located outside the Temple of Apollo and just past the tomb of Neoptolemus. According to Pausanias, oil was poured over the stone daily, while unprocessed wool was placed on it exclusively during festive occasions (the famous Omphalos of Delphi is disregarded in this study due to its distinct shape, although the rituals are essentially the same: Lambrinoudakis 2005: 319). This stone is believed to be the one Rhea presented to Cronus to save the life of her son Zeus (for depictions of the scene, see: Serbeti 1992: no. 23). Following Cronus's defeat, wherein he later regurgitated the swallowed object, Zeus transported the stone to the Temple of Delphi, as recounted by Hesiod (495-500; the poet describes the stone as large: μέγαν λίθον, 485). The key points inferred from these sources are: the presence of a stone at Delphi with significant prestige, subject to specific rites such as covering it on feast days; according to myth, Zeus personally transported the stone to the Greek temple (Gaifman 2012: 58-60; Bultrighini and Torelli 2017: 402-403). Let us now consider another source, namely Fulgentius, a writer from the 5th-6th century AD, who relays information from Labeo (author of 3rd century AD), taken from his work on Etruscan practices, regarding specific stones: the *manales lapides* (*sermones antiqui* 112. 11 Helm; on the passage where there is information to be used with caution but not to be rejected completely: Mastandrea 1979: 88-95; Wolff 2016). These objects are described as stones (*petras*), which are carried-dragged (*trahere*) in a cylindrical manner (*in modum cilindrorum*), likely indicating they are rolled along boundaries (*per limites*) to encourage rain in times of drought. This Etruscan custom is also noted among the Romans, where the stone serves the same purpose and is employed in the same manner described above. However, it or another stone with the same name, appears to have been replicated also elsewhere for a different purpose in relation to the *Mundus* of the Roman Forum.[5] The *lapis manalis*, used to make rain in Rome, was housed at the Temple of Mars, outside the Porta Capena,[6] and the ceremony in which it was used was known as the *Aquaelicium*.[7] The most noteworthy findings from this source are: the perceived power of stones to induce rainfall, their storage at a temple in Rome, and their use through dragging and rotational actions (indicating a rounded form) along boundaries. Unfortunately, there is no reference to them being covered with a fabric before or after use.

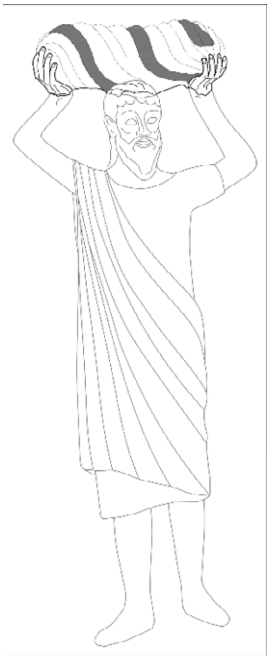

Figure 7. New reconstruction of the artefact (elab. by Fiammetta Soriano).

Conclusion and New Reconstruction

The collected data suggests that the object in question could be identified as a roughly cylindrical stone, possibly imbued with significant prestige or power, hence it being covered as per the custom observed during festive occasions at the Temple of Delphi. This new reconstruction depicts a lone male figure (possibly a priest) carrying the object in question (**Figure 7**). In theory, this depiction could represent the transportation of the *lapis manalis*, housed at the

[5] Varro in Non. 547, 8; Festus, *Gloss. Lat.* 2, 24; 115, 6; *Serv. Dan. Aen.* 3, 175; cf. Wissowa 1984-97: 2308-09; Hild 1904: 1562-3; Kroll 1928: 969-971; Coarelli 1996: 173.

[6] Festus, *Gloss. Lat.* 115, 6; cf. Grüner 2003; Coarelli 2006: 44-45.

[7] Festus, *Gloss. Lat.* 2, 24, see: Wissowa 1895.

sanctuary in Veii, either before or after its ritual use along the boundaries (of the city and/or territory) to induce rainfall (on sacred stones: Eliade 2001: 195-214, and those associated with rain: Frazer 1913: 304-311). This reconstruction is less likely to depict the Greek myth of Zeus transporting Cronus' stone to the Temple of Delphi, based on the available evidence (however, the Etruscan deity Tina, equivalent to the Greek Zeus, is documented at the site in question: Fusco and Maras 2014: 333-336, no. 46).

The Territory

F. Biagi's recent study defines the territorial boundaries of Veii (**Figure 8**) as follows: 'The northeast border coincided with the Vezza River, while to the east and south the Tiber River marked the natural limits of the territory. To the west, the territory of Veii reached the sea, along a brief stretch of the Tyrrhenian coast between the Tiber and the Arrone Rivers. The latter river marked the northwestern border, toward the territory of Caere. The eastern bank of Lake Bracciano, between Anguillara and Trevignano, was also controlled by Veii... In ancient times the Tyrrhenian coast consisted of extensive lagoons and marshes. Large sand dunes separated these internal waters and the open sea. The area of the delta of the Tiber, a landscape characterized by large ponds, was certainly subject to constant change and required continuous maintenance work' (Biagi 2019: 50-51). Even from this brief description, the various water resources available are evident, providing an insight into the territory's main historical and archaeological sources.

Water Resources (Watercourses, Thermal Springs, and the Sea)

Watercourses

As depicted on the map (**Figures 8-9**), the territory boasts several watercourses, with the most significant in terms of settlement and access purposes including: Valchetta (the ancient Cremera) and the Fosso di Galeria. The former meets the Tiber at Fidene, on the opposite side of the river, close to where the famous battle between Veientine and Roman troops took place in 477 BC, resulting in the defeat of the Fabii (Livy 2, 50). Towards the southwest, the Fosso di Galeria ends at Ficana, on the opposite side of the Tiber, before continuing for a long stretch (Bartoloni and De Santis 2019: 92). Additionally, the urban plateau of Veii, which stands on a moderately high tufa plateau, is bordered by two watercourses that are still active today: the previously mentioned Valchetta stream and the Piordo. The Arrone and Tiber rivers have long served as the northern and southern boundaries of the territory, towards Cerveteri and Rome respectively (Colonna 2006: 13-14). Naturally, the Tiber plays a much broader role, encompassing economic and cultural aspects, both extensively explored (Torelli 1991; Colonna 2006; De Cristofaro and Piergrossi 2015-2016).

Thermal Springs

The available data is limited and does not fully capture the complexity of the findings. We will explore two specific strips of land: the peri-urban area and the *Ager Portuensis* area nearer the Tiber. The peri-urban area is home to the Vignacce spring (**Figure 9: B**), located west of the urban plateau near the sanctuary of Portonaccio, along the Piordo valley. Although no longer active, it likely once yielded ferrous mineral water, evidenced by a preserved circular basin with at least two steps; however, there are no documented cult activities associated with it. Another significant site is the Bagni della Regina spring (**Figure 9: C**), located northeast of the urban plateau, along the left bank of the Valchetta stream. This spring is characterised by mineral, carbonated, and ferruginous water. A recent stratigraphic analysis of the sequence of structures present here revealed three distinct periods of occupation: the first consisting of only a few pits, created in the geological layer and filled with archaeological material (such as a serpentinite axe and a leech-shaped fibula, possibly a votive offering); and the second and third periods characterised by the construction of a unified building complex, consisting of structures

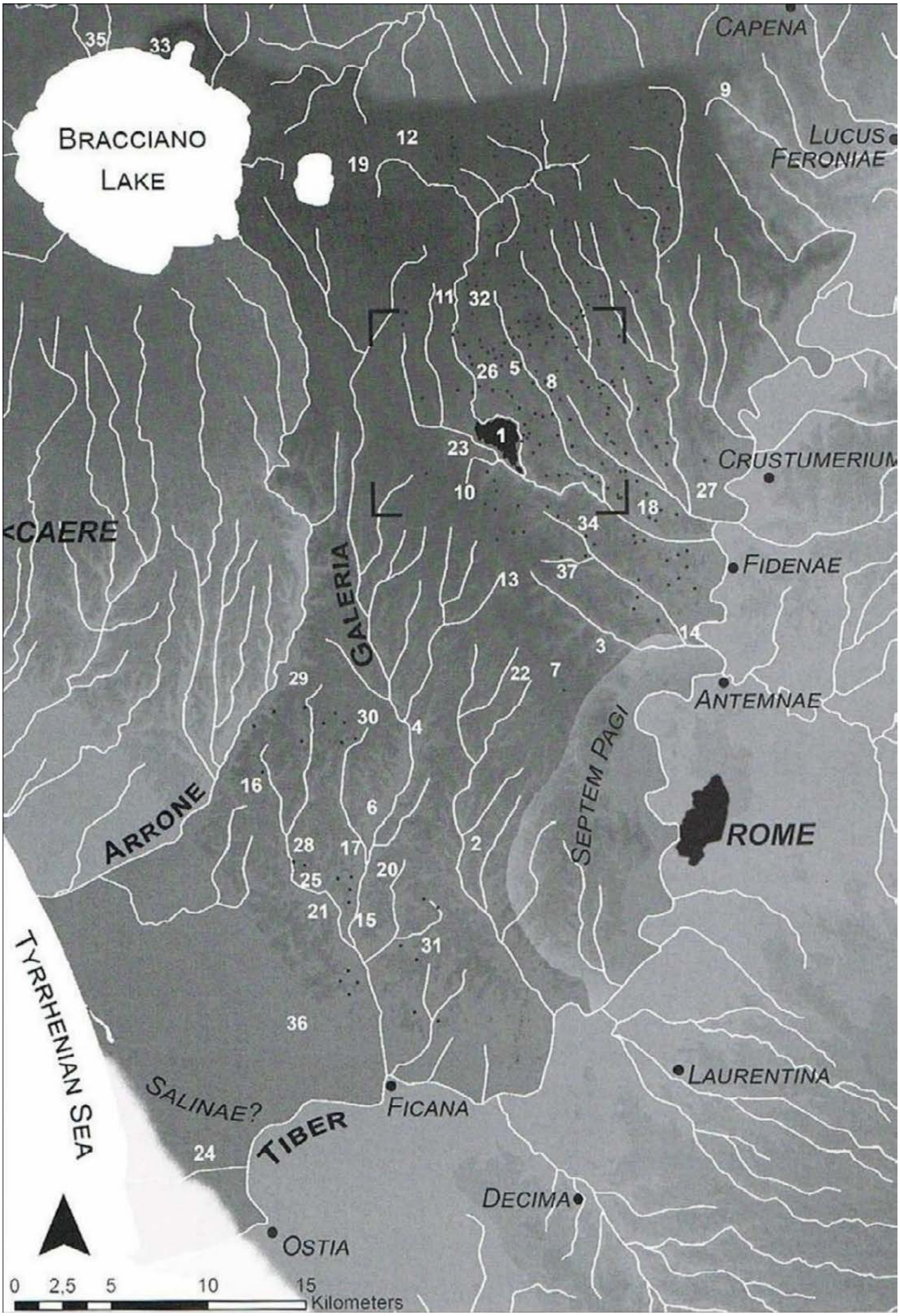

Figure 8. The territory of Veii (adapted from Tabolli and Cerasuolo 2019, map. 1).

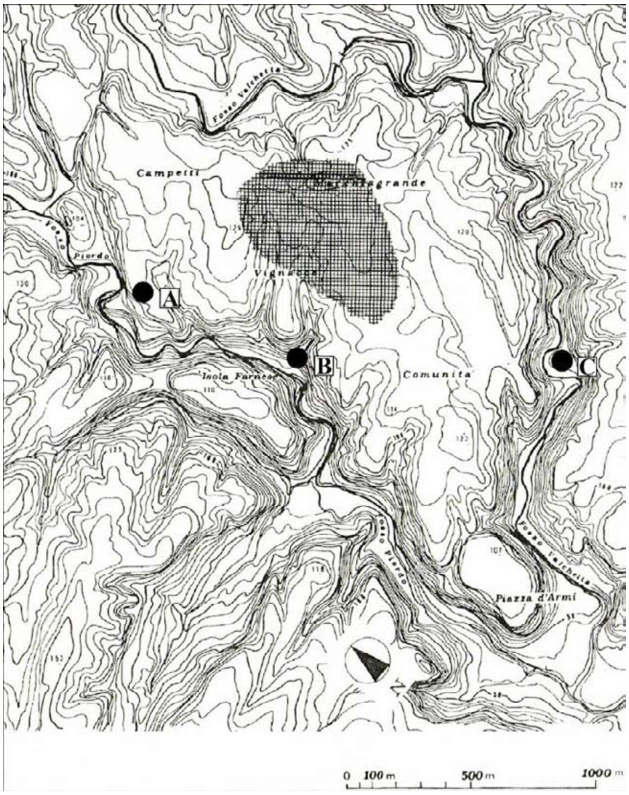

Figure 9. Springs in the peri-urban area of Veii (adapted from Fusco 2019).

and buildings built using different construction techniques and dating between the mid 1st century BC and the 2nd century AD (on these sources: Fusco 2019). In addition, the stretch of the Valchetta stream bordering the urban plateau is characterised by numerous other springs, varying in size, observed during a brief and non-systematic survey. These springs exhibit the same type of water as the Bagni della Regina site, as evidenced by residues on the ground. However, they lack evidence of anthropic presence (further springs visible in Ward-Perkins 1961, fig. 16). In the second strip of land (**Figure 10**), there are several thermal mineral springs and points with strong carbon dioxide emissions that have come to light following excavation activities. Geologists have linked these findings to volcanic phenomena in the final, but still active phase of the volcanic Lake Albano. These features are widespread in the areas surrounding the findings in question (Cébeillac-Gervasoni and Morelli 2014).

Access to the Sea

This topic has recently garnered attention from scholars, with several proposing the notion of a Veii harbour to the north of the Tiber River's estuary, specifically in the Maccarese pond (Zevi 2000, and most recently: Rathje 2019: 101; Cifani 2020: 340-341; Arizza 2020, with earlier references; archaeological findings, such as a Nuragic bronze figurine and a kantharos depicting a sailing scene, supporting this theory: Colonna 1981; Arizza *et al.* 2013; however, the port's existence is not unanimously accepted by scholars). Originally, the area featured a freshwater coastal lake, with evidence of human activity dating back to the Middle and Upper Paleolithic period (Romana De Castro *et al.* 2019; most recently: Nardò 2022). Palaeo-environmental research in the Tiber Delta revealed that the lake's water became brackish between the early Iron Age and the end of the Orientalising period. This shift is attributed to the construction of a canal connecting the lake to the sea, supported by historical maps (e.g. Giovan Battista Cingolani's 1692 map). This location corresponds to the famous saltworks, remaining under Veii's influence until Rome's conquest at the beginning of the 4th century BC (most recently discussed by Arizza *et al.* 2013: 117; De Cristofaro and Piergrossi 2015-16: 63; Romana De Castro *et al.* 2019; Arizza 2020: 138; however, this narrative is also much debated, e.g. F. Coarelli posits that the Veii saltworks were conquered by Rome as early as the end of the 7th century BC, when tradition records the establishment of saltworks by King Anco Marcio: Dion. Hal. *Ant. Rom.* 3, 41, 3 and Livy 1, 33, 9; see: Coarelli 2021: 41-47, supported by Colonna 2006: 6; De Cristofaro 2019: 90; Piergrossi 2019: 56). Notably, archaeological evidence of these claims is yet to surface for the Etruscan period, with only Roman-era findings documented, to which we will return later.

Literary Sources and the Imperial Poseidon Inscription

The available documents stem from Roman tradition, so potential implications for the Etruscan period must be carefully interpreted. All the examined testimonies are well-known and are considered to be central to the topic at hand.

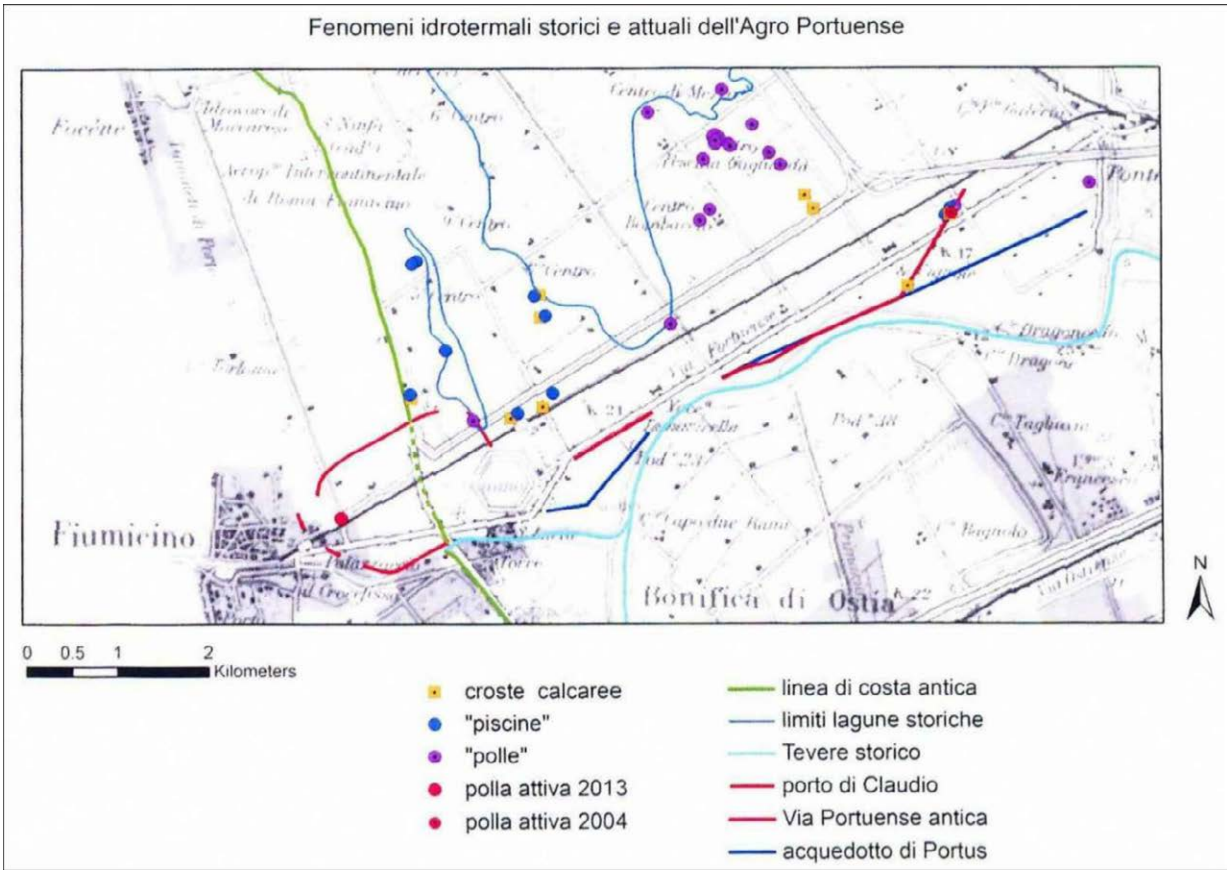

Figure 10. Springs in the ager Portuensis *area (adapted from Morelli and Cébeillac-Gervasoni 2014).*

Literary Sources

The first evidence comes from a passage by Servius, a Latin philologist who lived between the 4th and 5th centuries AD, who recounts the genealogy of the ruling house of Veii. According to this account, King Morrius, of whom no other attestations are known, has *Halesus* as his ancestor, described as the son of *Neptunus* (8, 285; Graf 2006; Piergrossi 2019: 55). This establishes a link between the Veientine kings and the god *Neptunus* (-*Nethuns* in its Etruscan form). The question of the god's origin from the Latin-Italic world (specifically Umbria) and its loan to the Etruscan one is well-known (Arnaldi 1997: 5-17; De Grummond 2006: 144-145; Trafficante 2009: 169-172). Among the Latins, the god Neptune would have originally had a chthonic-subterranean nature and a close connection with inland waters, marshes, ponds, lagoon areas, and thermo-mineral springs (Serv. Dan. *G.* 1, 12, 1-3). The identification with the Greek god Poseidon and the extension of his domain to the sea only occurred later. In Etruria, the cult of *Nethuns*, though documented in various sources (e.g. Liver of Piacenza and in the *Liber Linteus*), is not widespread. This discussion clearly includes Veii and its territory (Trafficante 2009; Giontella 2012: 163). Although the evidence is limited, within the Etruscan-Italic world, there are indications of entities (flere, lasa: Maggiani 1999: 192-193; Chellini 2002: 207-209; Maggiani 2003: 40-41; De Grummond 2006: 168-172), mythological figures (Hercules, Acheloo: Di Giuseppe 2010; Fusco 2011; Giontella 2012: 167-171), and deities (Apollo, *Vei*, namesake deity of Veii, Cupra, Feronia etc.: Giontella 2012) associated with various aspects and forms of water. Thus, it is plausible that the mention of *Neptunus* by Servius served to condense and summarise a previously more intricate mythical narrative, known within the Veientine territory.

Next, let us consider two events connected to a pivotal moment of the Roman conquest of Veii (traditionally dated to 396 BC): 1. the phenomenon at Lake Albano and 2. Camillus' tunnel.

1. During the siege of the Etruscan city, a phenomenon occurs at Lake Albano, where the water level rises for no apparent reason. With no Etruscan augurs available, the Romans decide to dispatch a mission of ambassadors to the oracle of Delphi seeking explanations (Livy 5, 15, 1-4; Plut. *Vit. Cam.* 3, 1-5). Meanwhile, Roman soldiers capture a Veientine oracle/augur, who shares a prophecy known to the Etruscans and contained in the famous *Libri Fatales*: Veii would only be conquered if the Romans drained the waters of Lake Albano following the ritual prescripts (with the famous emissary: Piccirilli 1983: 296, 298) requiring them to keep the lake waters separate from the sea (Livy 5, 15, 4-12 and Plut. *Vit. Cam.* 4, 1-4; for a comprehensive collection and analysis of all sources: D'Arco 1997). This prophecy is also reiterated by the Roman ambassador (Livy 5, 16, 8-11; Plut. *Vit. Cam.* 4, 6-7). The lake phenomenon was caused by a ritual failure on the part of Roman magistrates in connection with the Latin feasts on Mount Albano (Livy 5, 17, 1-4; Plut. *Vit. Cam.* 4, 6).

2. In the war's tenth year, Marcus Furius Camillus, the *fatalis dux*, is appointed dictator to secure victory over the Etruscan city (Livy 5, 19, 2; Plut. *Vit. Cam.* 5, 1). Among the fortification and military constructions, a famous tunnel is excavated towards the arx, where the temple of Juno stands, allowing a covert movement of troops to gain access to the heart of the enemy city (Livy 5, 19, 10-11 and 21, 10; Plut. *Vit. Cam.* 5, 4-5; Dio Cass. 6, 21) and conquer it. These events, especially the lake water phenomenon and the prophecies received by the Romans, have long fascinated scholars, resulting in a significant body of literature on the topic (Gagé 1954; Hubaux 1958; Sordi 1960; Guittard 1989; Cornell 1995: 312-213; Briquel 1993; 1998; Guittard 1998; Fusco, Battistin 2022; on the truthfulness of the lake event: Grandazzi 2008: 83-85).

For this reason, attempting to summarise or present all the issues would be impossible (and may prove futile). Instead, we will present specific considerations. It is important to note that the various events are not only interconnected but also intertwined with mythical figures and themes, including those referred to as 'Homericisms'. These are instances where Homericisms influence the description of the siege of the city of Veii by Rome, continuously interchanging the identities of Romans and Veians, much like the Greeks and Trojans in the context of the Trojan War (Piccirilli 1983: 300 with earlier references). Given this complex scenario, it is important to identify the factor or factors that link Lake Albano, Veii, and Rome, despite the significant topographical distance between the lake (south of the Tiber) and the Etruscan city (north of the Tiber). Essentially, what connects the volcanic Lake Albano to the war between Rome and Veii? Various hypotheses have been suggested, including the following main theories: 1. Chronological and narrative-mythological reasons behind the siege of Veii (D'Arco 1997: 141-142); 2. Economic factors tied to Rome's need for independence from Etruria's cereal imports and Veii's interest in maintaining its maritime trade (Pasqualini 2013: 259-263); 3. A prevalent theory suggests that the unifying factor could be the deity *Neptune-Nethuns*. This theory points to Neptune's role as the founding figure of Veii's royal dynasty, his first mention in Roman records during the first *lectisternium* in 399 BC (Livy 5, 13, 4-8), and his designation, along with Apollo, as the Trojan Penates of Rome, brought by Aeneas to Latium (Arnaldi 1997: 5-17). In addition, Neptune's connection to the rise in the lake's water level, attributed to a Roman sacrilegious act, supports this idea (Ruch 1966; Dumezil 1973: 39-62; Piccirilli 1983: 298-300; Morelli and Cébeillac-Gervasoni 2014; Cébeillac-Gervasoni 2016); 4. Attention has recently been drawn to the hero *Hercules-Hercle* (Maras and Nonnis 2022: 155), who appears to have been worshipped not far from the mouth of the Alban emissary, on a Latin-inscribed base dating between the end of the 5th and beginning of the 4th century BC, almost contemporaneously with the events described (*CIL* I^2, 2659=EDR073057), and at the peri-urban sanctuary of Portonaccio in Veii (Colonna 2019). His expertise in the Etruscan-Italic world with all inland waters and their control is widely known.

As for the matter of Camillus' tunnel, we note that the description of the structure immediately brings to mind the tunnels that supposedly overlooked the tufa cliff of the urban plateau, which archaeological research has identified at several locations (refer to the commentary in Piccirilli 1983: 298 with previous bibliographical citation; excavating tunnels to conquer cities was a well-known technique in antiquity: Piccirilli 1983: 304).

The final source under examination is a passage by Dionysius of Halicarnassus (*Ant. Rom.* 12, 15), which is highly relevant to the topic at hand. Here, the author paints a detailed picture of the environmental characteristics and water resources in the area in question. He describes it as having fertile soil, with a landscape characterised by a mix of hills and plains, blessed with clean and healthy air. Lastly, he mentions the water resources: 'its supplies of water were neither scanty nor brought in from outside, but rose in the neighbourhood and were abundant and most excellent for drinking' (*τὐδάτων τε οὐ σπανίων ὄντων οὐδ᾽ ἐπακτῶν, ἀλλ᾽ αὐθιγενῶν καὶ πλουσίων καὶπίνεσθαι κρατίστων*, translation by Earnest Cary, Loeb).

The Imperial Poseidon Inscription

In the area bordering the newly discovered thermal springs in the *ager Portuensis*, as described above, and not far from where the ancient saltworks of Veii (the Maccarese pond) and the port were thought to be located, a votive inscription dated to AD 135 was recently found on a large block of travertine. The inscription honours Neptune and is dedicated by two *conductores Campi Salinarum Romanorum* (AE 2014, 264: *Neptuno / sacrum /ca<m=P>pi salinar(umj) / Romanar(um) / L(ucius) Virtius / Epaphroditus et / L(ucius) Cornelius / Hesper / conductores / dedicatu<m=S> / Pontiano et / Atiliano co(n)s(ulibus)*). The inscription was discovered inside a building believed to be a warehouse evidently linked to salt production, dating back to the 1st century BC and in use until the 2nd century AD, showing three main phases of construction (Morelli and Forte 2014). This new epigraphic evidence clearly indicates cultic activity towards the god in the 2nd century AD, either within the building or in another sacred structure (temple?) located nearby, which has yet to be found. The location of this finding (close to the saltworks and near an area rich in thermal springs) aligns well with Neptune's domain, as discussed above. However, the suggestion of a pre-Roman cult dedicated to Neptune (or possibly another water-associated Etruscan deity) is more problematic, although clearly intriguing and credible. Nonetheless, this new epigraphic text can be used as decisive evidence when identifying the god Neptune as the link connecting Rome, Veii, and the phenomenon of Lake Albano (Morelli and Cébeillac-Gervasoni 2014; Cébeillac-Gervasoni 2016).

Archaeological Findings

As a final aspect of the study, selected topics related to archaeological findings are explored.

Water Infrastructure. There is ample evidence in the area under review of numerous underground structures, such as tunnels carved into the geological stratum, serving various purposes: to collect spring water; drain damp and marshy soil for cultivation; recover seepage water; and serve as a connection to cisterns or channels for water collection or drainage into ditches. These structures are unfortunately challenging to date due to how they were built, generally spanning from the Orientalising period to the Archaic ages, up to the 4th century BC (Ward-Perkins 1962; Judson and Kahane 1963; Quilici Gigli 1998: 196; Wilson 2000; Damiani 2015; Bizzarri and Soren 2016; Di Giuseppe 2018: 42; most recently on the subject in general: Agusta-Boularot 2022: 10; Arizza and Porfyriou 2023). G. Cifani proposes an intriguing perspective for the central Tyrrhenian area, suggesting powerful leaders as the creators of these projects, who employed unskilled labour using coercive methods (supervised by specialised personnel) for their physical construction, with the middle classes benefitting from the large-scale spatial planning (Cifani 2020: 346-349). Alongside these, cisterns, channels, and wells indicate extensive pre-Roman habitation, production, and defence in the territory (De Cristofaro and Piergrossi 2015-16; Di Giuseppe 2019: 76-81; Bartoloni and De Santis 2019; Arizza and Rossi 2023; on water structures in the Roman period: Wilson 2008), with one such case cited among many, as an example (Rossi 2021). These types of infrastructure are also clearly present in the cultic sphere, where two sanctuaries, Casale Pian Roseto (Torelli 1998) and Portonaccio (Colonna 2019), are well-known archaeologically, with various artefacts indicating their significance, particularly the latter.

Cults. Given the well-known and close link between water and worship among the Etruscans (Aebischer 1932; Gasperini 1988; Torelli 1991; Maggiani 1999; Chellini 2002; Maggiani 2003; Edlund-Berry 2017), this connection extends to the portion of Lake Bracciano within the territory of Veii. We also note that the Tiber River likely held cultic importance for the people of Veii, hinted at indirectly by the Romans' adoption of its Etruscan name, Volturnus, for the *flamen Volturnalis*, a minor priest dedicated to its veneration in the city's early history (see Torelli 1991). In addition, closely linked to the previous point on underground tunnels and human influence on water, is the spread from the 6th century BC of cults involving figures such as Hercules and Achaeus, notably evidenced at the periurban sanctuary of Portonaccio and the settlement (Di Giuseppe 2010; Giontella 2012: 167-171; Colonna 2019; in addition to the deities mentioned above, other deities involved in varying degrees and for different reasons with water should also be considered: Giontella 2012: 163-189). These cults are associated with water regulation and the human desire to assert dominion over the element, under divine protection. Finally, considering the transformations undergone by the natural landscape, it is worth acknowledging the performance of specific ritual acts involving priests, for which no archaeological traces have been preserved (De Cristofaro and Piergrossi 2015-16: 61). An intriguing hypothesis proposed by M. Cébeillac-Gervasoni warrants further consideration: the potential existence of a place of worship (possibly predating the Roman conquest?) in the area where the imperial-era inscription of Neptune was discovered. This notion gains credibility when compared with the famous sanctuaries found at the landing sites near cities like Cerveteri and Tarquinia. Considering that Veii's port is speculated to have been located near the Maccarese ponds, not far from where the dedication to Neptune was discovered, could this busy commercial area have lacked a sanctuary? However, identifying the deity associated with this hypothetical sanctuary presents a considerable challenge. Despite Neptune-*Nethuns* featuring prominently in Roman sources and the interpretations of many academics, it currently appears the least convincing due to its limited archaeological evidence.

Conclusion

The recent studies by M. Cébeillac-Gervasoni have spurred significant interest in exploring this subject further, and to conclude this initial overview, we will summarise the most interesting points. Concerning the urban plateau, the discovery of ritual obliterations of select hydraulic structures (wells, cisterns) raises intriguing questions: why were only certain locations chosen for this practice? The suggestion that the ancient artefact found in the southwest area of Campetti could be a sacred object imbued with special powers, akin to the *lapis manalis*, is compelling. Although unanswered questions remain, an alternative interpretative hypothesis based on concrete evidence has been presented.

Regarding the territory, our analysis has revealed a more complex network of thermal springs than previously thought, clearly delineating the area with chthonic and infernal significance, which aligns with one of the qualities attributed to the deity Vei, the eponymous figure of the site (Colonna 2006: 7-8; Bellelli 2012; Giontella 2012: 178-181). Additionally, initial analysis suggests that not all springs show evidence of cultic activity, confirming theories proposed by J. Scheid from a methodological point of view on the creation of a city's religious landscapes (Scheid 2007-2008; Scheid and De Polignac 2010). Finally, while scholars have highlighted the role of the deity *Neptunus-Nethuns* in the various described events, his cult appears to be not widespread, warranting careful consideration! To fully assess the Veientine context, further comparative study with neighboring centres like Cerveteri, which also boasts a wealth of water-related elements, would be beneficial (e.g. Bellelli *et al.* 2017; 2018; Bellelli 2020).

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The Underground Structures of the Theatre in Ostia: a Preliminary Study on the Sewerage System

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Abstract: the sewerage structure is a vital infrastructure for urban development, whose function can extend from harnessing stagnant water to the water discharge of buildings (wastewater coming from the latrines or urinals, rainwater and excess water). Thus, the theatres were also equipped with a sewerage system, not only for the disposal of rainwater but also for the drainage of latrines or, in some cases, for the water discharged from the *orchestra* or basins for performing aquatic displays. These structures required a prior projection with the building itself, becoming part of the vaster city's underground sewerage system. However, little is known about the sewerage system of Ostia, with no exception of its theatre. The reason has to be traced back, on the one hand, to the difficulty of investigating such buried structures underneath the city and, on the other hand, to the lack of interest in their study until recent times. Nevertheless, the excavation reports constitute an essential storage of information on these structures that, strengthened by fieldwork, are a crucial source of information. In this paper, unpublished data on the theatre's sewerage system are presented and discussed for the first time. The present contribution aims to address the preliminary study on the sewerage structures of the Ostia theatre complex, facing the challenges of their study and analysing every single structure belonging to this network by the use of tables.

Keywords: Sewerage system, Drains, Sewers, Roman theatres, Ostia.

The Roman sewerage system: an overview

> *Sed tum senes aggeris vastum spatium, substructions Capitolii mirabantur, preterea cloacas, opus omnium maximum, subfossis montibus atque, ...*
>
> But at that time elderly men still admired the vast dimensions of the rampart, the substructures of the Capitol and, furthermore, the city sewers, the most noteworthy achievement of all, seeing that hills were tunneled [...]
>
> Pliny, *NH* 36, 24, 104

While listing a series of buildings admired at the time, Pliny refers to the '*cloaca*' as the '*opus omnium maximum*', implying together the engineering aspect in planning the '*cloaca*' network and the importance of their role in guaranteeing the '*salubritas civitatum*' and '*tutela*' of the cities themselves, as it will be remarked by the jurist Ulpian at the beginning of the 3rd century AD.[1] The notion of '*salubritas*' is strictly related to the concept of public health that could have been threatened by the '*caelum pestilens*'

[1] Ulp. *Dig.* 43, 23, 1, 2: *Curavit autem praetor per haec interdicta, ut cloacae et purgentur et reficiantur, quorum utrumque et ad salubritatem civitatium et ad tutelam pertinet: nam et caelum pestilens et ruinas minantur immunditiae cloacarum, si non reficiantur* (By means of these interdicts, the Praetor provides that sewers shall be cleaned and repaired, and both of them have reference to the health and protection of cities; for the filth of the sewers threatens to render the atmosphere pestilential and ruin buildings).

diffused by stagnant and dirty water that would had caused the outbreak of epidemics.[2] The '*tutela*' refers to the '*ruinas*' of buildings in the event of main '*cloacas*' clogged, provoking floods that would had scoured the buildings foundations and the destruction of mud-brick structures (Scobie 1986: 408). The construction of '*cloacae*' was governed by '*iura...cloacarum*' of which the architect gained knowledge (Vitr. *De Arch.* 1, 1, 10). As the extension of the sewerage system advanced with the growth of urbanism, interdicts were then released to safeguard and rule the maintenance of private '*cloacae*' defined as '4. *Cloaca autem est locus cavus, per quem quaedam fluat*', and '6. *Cloacae appellation et tubus et fistula continetur*', (Ulp. *Dig.* 43, 23, 4, 6). Based on this statement, this legislation applied to '*cloaca*' as both an open channel and a sewage disposal structure conveyed in earthen (*tubuli*) or lead pipes (*fistulae*). Therefore, it excluded those structures that had drainage or runoff functions exclusively, such as *fossae*, *cuniculi*, *canales*.[3] However, originally, the word '*cloaca*' referred to both structures that conveyed sewage waste and drained the rainwater as well as the excess water (Fiorentini 2018: 21-23). The archaic verb '*cluĕre*' (**cluo* for '*purgo*') has the meaning 'to wash', 'to clean' and it is related to a root word **kleue-* present among others in the Greek '*κλύζειν*' and its derivates that have the same meaning. From '*cluo*' through the forms '*cluaca*' '*clouaca*', the form '*cloaca*' will be fixed (Riera 2014: 5-6). It is, therefore, a structure for washing and cleaning the environments from anything that could have interfered with their '*salubritas*'. This concept raises another aspect, often neglected, on the function of the '*cloaca*': a medium for water management in environments where the excess and grounding of water made these areas swamp. This is the case of the Cloaca Maxima built initially as a masonry open channel on the place of a natural depression to drain the *Velabrum* valley from rainwater, spring water and the Tiber floods.[4] Although the Cloaca Maxima is one of the most extraordinary urbanistic hydraulic work of the Antiquity, the precedent of these types of structures has to be looked back as early as the 3rd-2nd millennial BC in the sites of Harappa and Mohenjo-Daro in Assyria, or Knossos and Aghìa Triàdha; elsewhere in Greece where since the 5th century BC the sewerage system was well developed in Athens and later in the 3rd century BC in Delos. In the western Mediterranean, there is then the model of the Etruscan hydraulic engineering works that directly set the precedent for what would later be the Roman engineering development in the field of hydraulics (Riera 2014: 13).

In modern time Trevor Hodge distinguished between sewers and drains in the sewerage system; the latter further differentiated in: 'storm drains' where large amount of water flows intermittently, 'drains from swampland' that conveys constant flow as the water that made the area marsh would continue to flow, and 'sewage' characterised by a relative volume but harder to flow (Hodge 2002: 333-334). However, if in origin this distinction is appropriate, and the primary function of these structures was to drain an area from the excess of water, soon they were disposed for a combine task that implied the receiving and transporting of the city's waste (Capogrossi Colognesi 1976: 335). The broader sewerage system set up was the combine system, conveying both rainwater and excess water as well as human excreta, when latrine and urinals were connected with the sewerage system.[5] This categorisation is

[2] The direct relationship between pestiferous odour, air impurity and the threat to urban sanitation was declared in the miasmatic theory expressed in the *corpus Hippocraticum*, then revisited by Galen (Fiorentini 2018: 22, 24-25). The notion of *salubritas* could also be interpreted in connection with the sewerage system's original exclusive function to drain the excess water that would have created marshes areas, hence becoming a medium of land reclamation (Capogrossi Colognesi 1976: 334-335). A deeper insight into this function will be discussed later.

[3] The interpretations of these words, including the word *flumina* (urban open channel for the discharging of rainwater that often conveyed human excreta), have to be analysed by the context in which they were used to avoid abstract and general conclusions, as they can refer to various types of structures (Zaccaria 2018: 47).

[4] The plan of a controlled hydraulic network with a primary collector, the *Cloaca Maxima*, attempts to regulate the water coming from the boundary hills and the intermediate valleys, discharging it to the river. Thus, the '*cloaca*' can be reasonably inserted into practices for land reclamation (Frassine 2013: 84).

[5] A distinguishing case of the combine system was the coexistence of streets functioning as open channels (*flumina*) and the underground sewerage system, as in Pompeii and Cosa. The water flowing on the street surface was

also too rigorous for the study of the '*cloaca*' and implies the preliminary identification of the type of liquid flowing in it that is not always easy to ascertain for such long structures that can run for kilometers; furthermore, it does not consider their capacity that is determined by their urban arrangement. Along with this, it needs to drive attention to the nature of the hydraulic structures that cannot be studied as a typology defined by standard structural features as they adapt to the singularity of each site, where geomorphological characteristics and climatic differences lead to different choices of land organisation and consequently urbanistic development. Indeed, with specific regard to the '*cloacae*', although they were likely not planned with a standard scale, *de facto,* they were built in various dimensions depending on the area served that led to their capacity, determining a hierarchic order. Despite of that, hydraulic structures can be classified on the base of their function in the urban living context where they are located. With respect to these considerations, a lexicon based on the functional aspect of the '*cloacae*' established on the classification developed by Italo Riera will be exposed in this contribution. Riera distinguished the '*cloacae*' in first order that includes '*cloacae*' that convey rainwater, excess water and sewage from several points of use (e.g. the individual '*cloacae*' of a private house or a workshop) to the main single outlet '*cloaca*' that constitutes the second order; the '*cloacae*' of the first order have modest flow rate that is directly proportional to the amount of water consumption that is collected through water inlets. The second order is composed of a main single '*cloaca*' shared by the individual building complex or urban units; this '*cloaca*' could either discharge directly onto the street or may flow into a main '*cloaca*' that composes the third order. The third order is usually organised on the road axes and could receive the water flowing on the streets through the water inlets; it could also be an independent system. The third order was then flowing into the fourth order that served as final outflow, discharging in the countryside, in rivers or seas. These '*cloacae*' of the fourth order look the same as the others, but are larger in dimensions (Riera 2014: 11-12, 14-18). Accordingly, the first and second order are named 'drain', characterised by low or modest flow capacity ('drain of first order' and 'drain of second order'), from which the third and fourth order is distinguished with the term 'sewer' with a higher flow capacity ('sewer of third order' and 'sewer of fourth order').[6]

Little is known about the construction and management of sewerage networks and the disposal of sewerage waste in Roman cities, and what has been acquainted comes from different types of sources spread through the centuries and belonging to various site contexts. The only reference on the engineering project execution plan to make the optimal operation of these hydraulic structures is an epigraph coming from the 'Large theatre' of Pola (Croatia) that indicates the technical prescriptions to

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discharged into the underground sewerage network through water inlets disposed along the street to minimise the risk of flooding. However, this system had to result inefficient, especially in areas exposed to flooding. Stone step bridges were then built to cross over the streets (Riera 2014: 11, 15). It cannot be taken for granted that each *domus* and private or public latrines and urinals were linked to the city sewerage system. Instead, most latrines and urinals were commonly discharging into pits or jars, or in the case of dwellings developed in elevation, the sewage was directly thrown on the streets. Scobie argues that one reason could be the lack of traps to prevent gases such as hydrogen sulphide (H_2S) and methane (CH_4) from dispersing inside the domus; a second reason was of an economic type regarding the work of *stercorarii* who sold human excreta for agricultural purpose or the *fullonica* enterprise. Ancient authors and edicts released by jurists witnessed the state of urban streets being exacerbated by the cities' growth (Scobie 1986: 408-442). For a deeper insight into urban sanitation, see Scobie 1986 and Panciera 2000.

[6] On the contrary, Hodge claimed a distinctive meaning for 'drain' and 'sewer' based, once more, on the different types of liquid they convey and on their location: the rainwater and the excess water flow in drains that can be found in cities as well as in the countryside, whether the sewer carries human waste and can be found only in the cities (Hodge 2002: 332). However, 'drain' is defined in the dictionary as 'a channel by which liquid is drained or gradually carried off; esp. an artificial conduit or channel for carrying off water, sewage, etc…'; and 'sewer' as 'an artificial channel or conduit, now usually covered and underground, for carrying off and discharging wastewater and the refuse from houses and towns' (OED). Therefore, these definitions, straightened by Riera's classification, are both based on the function of the sewerage system and are applied together in the lexicon mentioned above, considering the flow capacity for the study of the sewerage system.

guarantee the correct gradient for the proper functioning of the '*cloaca*'.[7] A further suggestion centred on the construction precept to apply specifically for the proper functioning of sewers and drains for keeping dry the *ambulationes* surrounding the theatre is expressed by Vitruvius.[8] Further indications on the engineering project execution and the construction of the sewerage system can be directly observed on the archaeological evidence. Once more, in the study of Roman architecture, the tight connection between *natura loci* and artefact is explicit. Indeed, the influence of geomorphology on the urban layout is evident in the relationship between roads and sewers or drains, all constructed according to the natural slope of the land when possible, using the physical characteristics of the terrain for hydraulic advantages, but when necessary adapting the environment applying the necessary procedures to make the terrain suitable for sewerage network construction purpose.[9]

Regarding the management of the urban sewerage network, interdicts to control their maintenance have evidenced the existence of public and private drains and sewers. Whether the public drains or sewers were entrusted to the control of the public authority, the administration of the private ones was regulated by interdicts issued with the primary purpose of keeping the urban sewerage system clean and efficient.[10] This legislation on the interdicts *de cloacis* addressed the importance of the *publica utilitas* over the private interest, when some controversy could be raised between the sewer or drain owner's will to unclog an obstruction of the '*cloaca*' in the neighbour's property that the drain/sewer was crossing, who *per contra* wanted to deny it. However, a *cautio damni infecti* was guaranteed to the area's owner in case of damage. The *salubritas civitatis* was considered a priority, and it could have been reached only by keeping the well-functioning of sewers.[11] This legislation also shed light on the existence of subcontracts between the *res publica* and *redemptores* to whom the maintenance of the sewerage system was entrusted since the Republican period. Additionally, sporadic documentation mentions the people who directly took up day by day the sewerage system maintenance: subordinate

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[7] The epigraph *CIL* V, 8146 reports: '*Infra soleam / imam p(edes) III ((digiti II)) ad libr(am) cluac(ae) / imae, soleae summae*' (Zaccaria 2018: 47).

[8] These precepts for *structiles cloacae* are likely based on Vitruvius' own experience when he was working with Agrippa for the reorganisation of the urban hydraulic water supply and discharge, as Frontinus seems to imply (Vitr. *De Arch.* 5, 9, 7; Frontin. *Aq.* 1, 25; Gros 1997: note 301, 754).

[9] A comprehensive example of the geomorphological influence on the construction of a sewerage network is the site of Pavia (northern Italy), where roads and the sewerage network were arranged according to the natural slope of the land, but in sectors with a greater slope where it would have been necessary to slow down the discharge flow, some construction arrangements were applied, such as zig-zag turns or small settling pits (recesses not much deep) on the floor. Additionally, precautions were taken to arrange the highest outflow in the lowest area of the city, in the direction of Ticino flow, to remove the wastewater as fast as possible (Frassine 2013: 85-87).

[10] During the Republican period, *censores* and *aediles* superintended the *tuitio*, with the support of *quattuorviri* and *duoviri viis purgandis* (under Augustus, the title will change to *quattuorviri viarum curandarum*, a name more socially accetable) that managed the *purgatio* of the sewerage system in Rome, as mentioned in the *Tabula Heracleensis*, 50-52 (*CIL* I^2, 593). In the colonies and *municipia*, this administration was entrusted to the local magistrates, *duoviri*, *quattorviri*, and *aediles*. Under Trajan, in Rome, the *cura cloacarum* was committed to the magistrature of the *Curatores alvei Tiberis et riparum*. This title will be subjected to variants during the centuries until the 4th century CE. However, in the case of colonies and *municipia* there is evidence of private intervention to supplement the public financing of these facilities (Panciera 2000: 102-105; Zaccaria 2018: 42-44).

[11] The interdicts *de cloacis* are expressed in Ulpian's *edicta* in the Digest: 43, 23, 1; 43, 23, 1, 2; 43, 23, 1. 4; 43, 23, 1, 7; 43, 8, 2, 28; 43, 8, 2, 26; 43, 23, 1, 8; 43, 23, 1, 11; 43, 23, 1, 15 (Fiorentini 2018: 24-25, 30-32, 35-36). Cleaning was vital to maintain the well-functioning sewerage system: *aqua caduca* (the water in excess) was directed to flow in the sewerage network to wash drains and sewers continuously. Because the use of *aqua caduca quae ex lacu abundavit* was aimed by privates, an imperial *caput mandatorum* was issued for guaranteeing the priority use for washing drains and sewers: Frontin. *Aq.* 2, 111: *Caduca neminem volo ducere nisi qui meo beneficio aut priorum principum habent. Nam necesse est ex castellis aliquam partem aquae effluere, cum hoc pertineat non solum ad Urbis nostrae salubritatem, sed etiam ad utilitatem cloacarum abluendarum* (Fiorentini 2018: 24).

Figure 1. Location of the city in exam (modified by the author from Google Earth).

officials (*adiutores*), public sewers and drains contractors (*cloacarii*) and when the drains were not linked to the latrines and urinals the *stercorarii* emptied the latrines and transported sewage out of the city.[12]

After this brief disclosure of what is known about the Roman sewerage system and having addressed the study of this urban network, the preliminary study on the sewerage system of the theatre of Ostia can be laid out as point of departure for further research.

Geological setting

Ostia is now located about 25km from Rome and 4km from the coastline, close to the Tiber River (**Figure 1**). The Tiber flows for 405km in the Roman Comagmatic Province, stretching along the coast for 30km, draining a watershed of 17.375km^2, where it separates into two water courses flowing in the Tyrrhenian Sea: Fiumara Grande on the north, the natural watercourse of Tiber, and Fiumicino canal on the south (Bellotti *et al.* 1994: 423; 2007: 507). However, at the time of Ostia's foundation, the *castrum* was raised close to the southern Tiber bank, near the river mouth, but set back from the promontory, at a distance of about 2km from the shoreline (Arnoldus-Huyzendveld 2017: 178). The city sets on sand belt (β belt set), formed by the Tiber sediment supply, which therefore indicate the progradation of Tiber seaward during the centuries, starting to create the lower delta plain (**Figure 2**). Tiber progressive deposition

[12] Trajan decreed that old prisoners should be employed to clean and unclog drains and sewers, among other slight tasks, instead of slaves. Diocletian's *Edictum de pretiis* established a maximum service fee for the *cloacarius* (Fiorentini 2018: 34; Zaccaria 2018: 46).

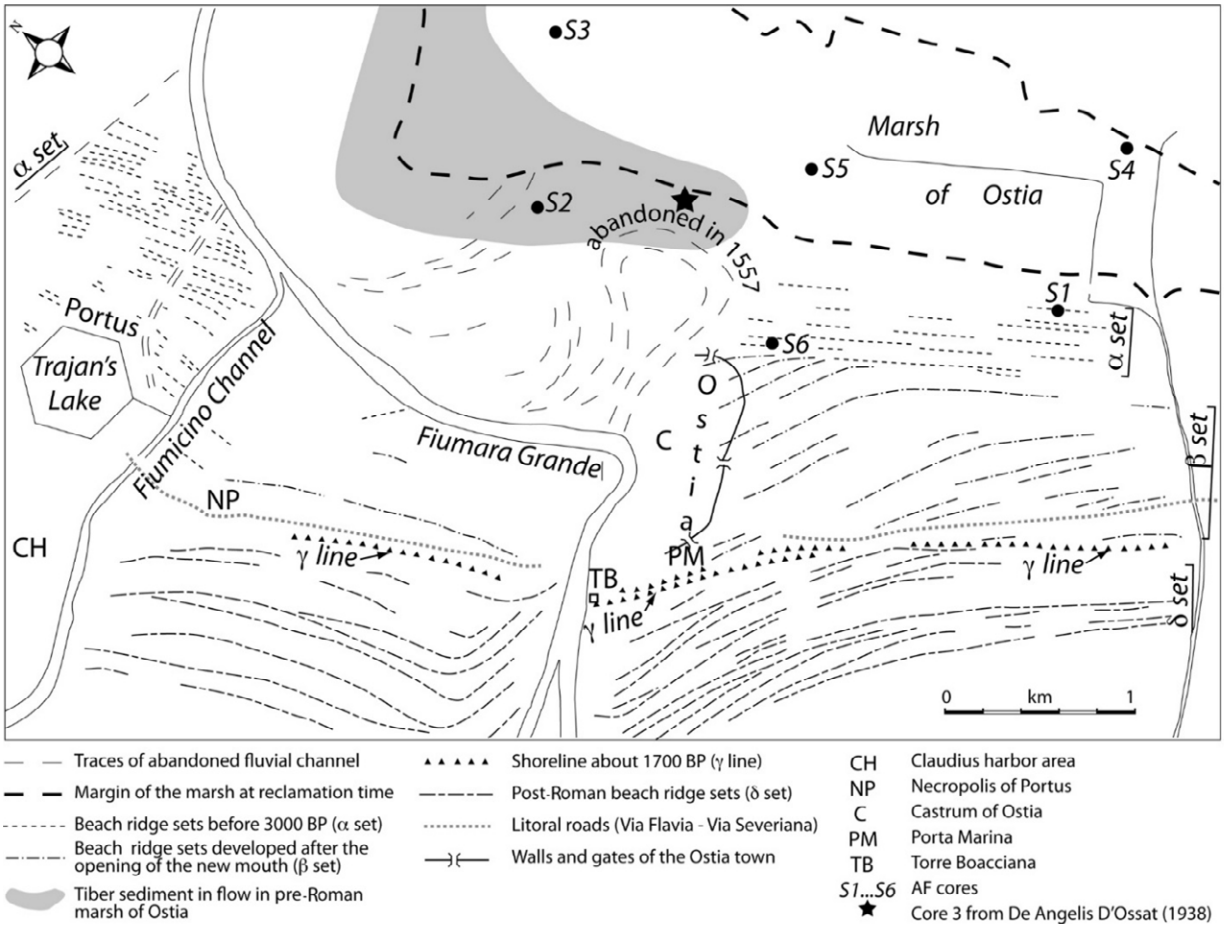

Figure 2. Morphological features of the delta plan with the sand belts (adapted from Bellotti et al. *2011, fig. 3).*

assembled amalgamated sand belts forming a sandstone body, about 20m thick, with a coarsening-upward trend. These belts are regular with a quasi-symmetrical disposition on both sides of the river mouth, implying a main wave direction from the west. Facies analysis of cores in correspondence of sand belts and river mouth reveals a cyclic grain-size variation and beach and lagoon environments succeeding (Bellotti *et al.* 1995: 625-626; 1994: 430; 2007: 507; Milli *et al.* 2013: 176-177; 2016: 1912).

The phreatic aquifer is very close to the ground level, at a depth of 2-3m below ground level with seasonal water table variation of about 1m. Since the city's foundation, the water table has risen by approximately 0.30m due to rising sea levels. Two water circulations flow in the Ostia area: a shallow upper one under the city and a deeper one in the abandoned Tiber meander. A partially impermeable sandy clay deposit divides the two water circulations at -1 to -1.40m a.s.l. (Ricciardi 1996: 247; Mastrorillo 2015: 40; Bellotti *et al.* 2018: 13; Bonamico 2021: 14).[13] The Ostia's aquifer system is part of the Hydrological unit of the Tiber River delta characterised by a joint permeability degree, flowing on a low-permeability clayey substrate (aquiclude), coinciding with the Monte Mario sequence (MMS).[14]

[13] In the area of Castelfusano, along the coast has been identified a shallow fresh aquifer overflowing with two deeper confined salinised aquifers. They form a dune aquifer (Mastrorillo *et al.* 2018: 16-17).

[14] The other hydrological units are the Monti Sabatini, and Colli Albani, the unit of pre-volcanic continental deposits, the unit of recent and current alluvial deposits, defined by the different geological domains and, therefore, grade of permeability (Mazza *et al.* 2015: 19; Mastrorillo *et al.* 2015: 37; 2016: 426).

The main direction of the aquifer flowing underneath the ancient city is from the east to the west. The aquifer's highest surface is at about 20m a.s.l., with a hydraulic gradient lowering seaward, from 1% to approximately 0.3%, due to the baseflow level approach and a hydrodynamic condition change. Indeed, from being a semi-confined aquifer flowing in the gravel deposits and silty layers of the inner delta, it becomes an unconfined and multi-layered aquifer, running through the dune belt of the lower delta plain (Mastrorillo *et al.* 2015: 37-38; 2016: 426; Mazza *et al.* 2015: 23, 28; Bonamico *et al.* 2021: 4). The water table level is relatively uniform, indicating communication within the multi-layered aquifer. Since the aquifer flow pattern does not mark external water supply zones, the supply for the aquifer comes from zenith infiltration (rain), where the outcrop is predominantly sandy. The vicinity of the aquifer to the walking soil surface, combined with intense and prolonged rainfall events, causes flooding with the outflow of underground water. The return to a stable condition is subjected to the decreasing velocity of the underground water level.[15]

By then, the landscape was characterized by topographic differences that changed over time concerning the river course line, coastal change and the sea level due to sediment supply, tectonic uplifts, volcanic activity acting with climate change, and anthropogenic factors. The landscape transformation and the shift in the city's position to the inland have been the object of numerous studies conducted by geologists and archaeologists in the last century. The geomorphology here delineated has influenced the settling and future development of the ancient city, determining the evolution of the urban planning including the sewerage network.

The theatre

The theatre together with its *quadriporticus* (125x80m, the so-called Piazzale delle Corporazioni) constitutes a grandiose complex on the north of the 'life-line that runs through Ostia', the *Decumanus Maximus*, built at the behest of Agrippa in 18-17 BC. (**Figure 3)**.[16]

The theatre was oriented N/N-E, had a *cavea* with a diameter of 79.80m and an *orchestra* with a diameter of 18m. The *cavea* was built on substructures where the lower part was constituted of radial rooms filled in with a mix embankment of marine and river sand and clay with fragments of amphorae and other vases, tiles, tuffs and painted plaster, whether the external part had hollow radial rooms. A perimetral porticus enclosed the hallow radial rooms, becoming the theatre's façade along the *Decumanus*. The inner wall foundation of the porticus is 2.10m wide, whether the width of the perimetral wall is 3.60m. The foundations, 3.20m high, were built in irregular stone blocks and black pozzolana, on which rise the elevation in *opus reticulatum*; the perimetral porticus was in tuff blocks.[17] Beyond the

[15] The extensive sewerage system network below the buildings and streets and the absence of a cesspit evidence the ancient inhabitants' awareness of underground water outflowing (Mastrorillo *et al.* 2015: 36; 2016: 434).

[16] Stöger 2011: 42-43. The accurate date of 18-17 BC has been proposed on the base of the junction between one fragment found under the stage and the other two in the stage area. Back then, only these two fragments were considered part of the same inscription, referred to Agrippa's consulship by scholars, specifically in 27 BC. However, the text inscribed in the three fragments assembled mentions Agrippa's *tribunicia potestas* received in 18 BC. As long as he set off for the East in 17 BC and died in 12 BC, the theatre was potentially constructed when he was still in Rome, in 18-17 BC (Cooley 1999: 175-177). Contemporary scholars have established a modern division of Ostia into *Regiones* to indicate the individual excavated buildings. This denotation includes the *Regio* in Roman numerals, the *insula* within the *regio* in Roman numerals, and the building in Arabic numerals (i.e. the theatre is in Regio II, insula VII, building 2: VI.VII.2).

[17] André 1891: 492-505; Vaglieri 1910: 171-183, 376-377, 434-435; 1911: 47, 324, 344, 407-408; 1912: 392; 1913: 50-82; Tosi 2003: 85-87; Sear 2011: 129. Evidence of the theatre façade, later destroyed by its enlargement, was found during the excavation in October 1913. During Vaglieri's excavation, succeeding floor levels were found regarding the roar of the *cavea* and the *cavea* itself dated to this phase: a floor in parallelepiped (0.15 m high) tuffs was discovered in front of the perimetral wall of the *cavea* at 2 m below the modern ground floor, related to the external area of the theatre. Additionally, at 0.45 m below the threshold of the radial rooms of the second phase of the theatre, the floor of the *cavea* in *bipedales* was unburied. On three *bipedales,* the stamp '*OPVS FIGLINIS*

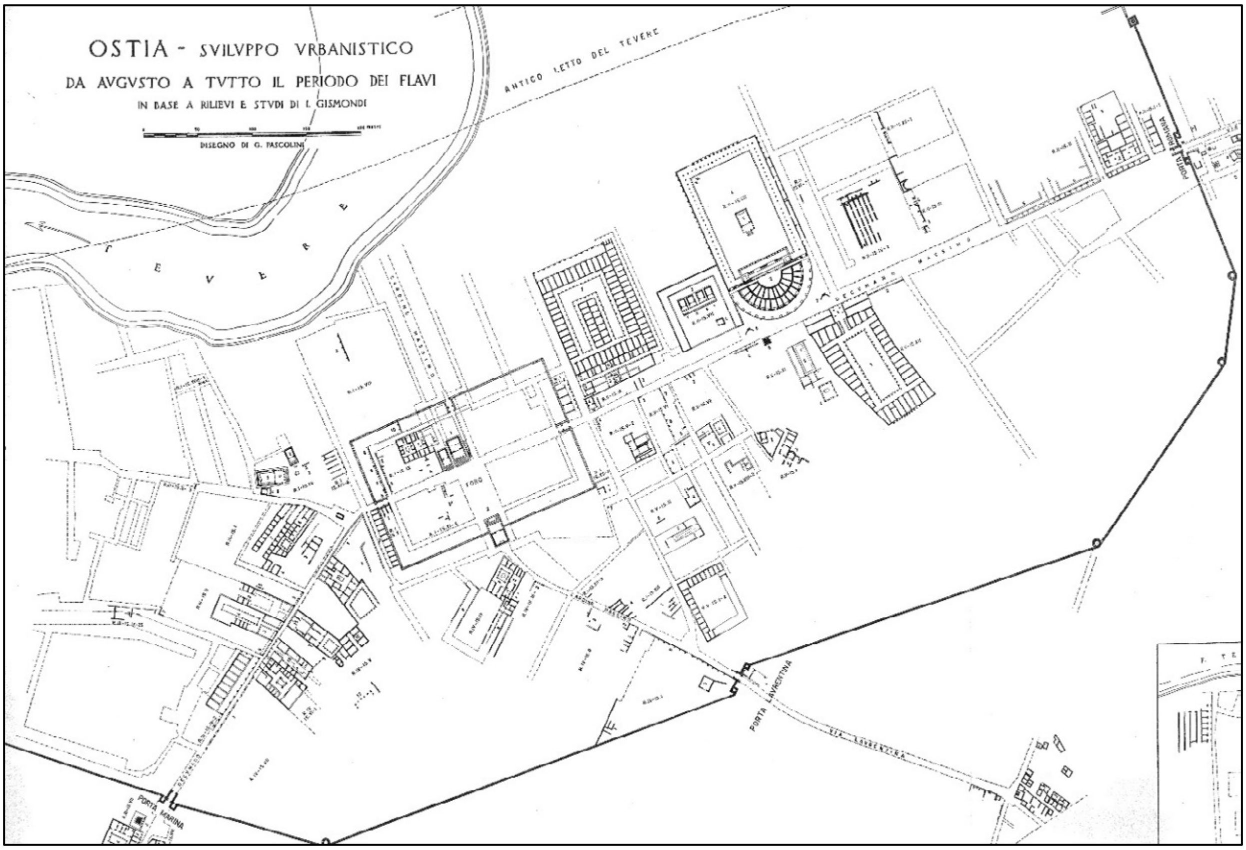

Figure 3. Plan of Ostia with the construction of the theatre in the 18-17 BC (adapted from Calza et al. *1953).*

scene building a grandiose *quadriporticus* opened, connected with the Tiber bank across eleven entrances along its northern porticus. The four porticus of the *quadriporticus* were constituted by two walls in *opus reticulatum* (the external one abutted by pillars) at a distance of 9m one from the other forming the porticus itself, and enclosing an open area embellished as a courtyard.[18] The entire complex

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MACEDONIA'; on one of them, the stamp *CIL* XV, 167. At 0.25m below it, another floor in mortar with terracotta inclusions. At 0.72m below this floor the foundation of the perimetral wall of the *cavea* was exposed (Journal of excavation 1910, 1913; Vaglieri 1910: 289; 1912: 211-212; 1913: 469; 1914: 72; Calza 1927: 10-15).

[18] Assumptions on the appearance of the *quadriporticus* in this phase are still undefined, although few interpretations have been formulated. Ingrid Pohl suggested the construction of a *cryptoporticus* with a first floor, but contrary to this reconstruction was Gabriella Greco, opposing the limiting thickness of the external wall (0.55m with a foundation of 0.32m high) not able to sustain a vault with an upper floor and the small elevation difference (1.60m) between the southern and northern sides of the *quadriporticus*. Instead, Greco sustained the existence of a *quadriporticus* with relative light structures and interpreted the elevation point of -10m a.s.l. as a construction site level of the porticus. Further data obtained by other trenches opened on the eastern and northern porticus did not help to make clear the interpretation of this first construction phase of the *quadriporticus* (Calza 1914: 284-290; Journal of excavation 1963, 1966 and 1980; Pohl 1978a: 173; Battistelli and Greco 2002: 395-404). If the reconstruction of the elevation of the *quadriporticus* remains vague, what can undoubtedly be stated, based on the data obtained from the excavation, is the terrain slope profile towards the Tiber bank that can be calculated in a difference of 1.10m instead of 1.60m, considering the upper part of the foundation (wall B) as a ground level and the elevation point +1m a.s.l. of the southern porticus. Conforming to these elevation points is the courtyard's elevation point that resembles the one recorded for Dr.17 (+0.62/0.65m a.s.l.), the open drain running along the southern porticus of the *quadriporticus* of this phase. Later, this *post scaenam porticus* in Ostia

raises on a mixed river and sea sandy layer scattered with alluvial clay, fragments of ceramic, wing tiles and tuffs deposit, thicker towards the Tiber (**Figure 4**).[19] However, it seems that the perimetral sector of the *cavea* and the roar area was built on an areal backfill constituted of a levelled earth ground surface and sand, approximately 1.10m high, below which the sand belt and the water table was found.[20]

After various restoration works on the entire theatrical complex that also implied the rise of the ground level in the area under Claudius, then Domitian and later under Hadrian, the enlargement of the theatre began with Commodus and was accomplished by Septimius Severus, reaching a capacity of 4000 spectators.[21] The new additional sector along the perimeter of the *cavea* was built on a platform laid partially on the earlier hollow substructures of the *cavea* and on its perimetral porticus, whose elevations were therefore curtailed. The two extremities of the earlier porticus, abutting the back wall of the scene building were destroyed. The additional perimetral hollow radial rooms were built on the earlier perimetral porticus of the *cavea*, and a new perimetral porticus, 2.90m wide with 23 arches façade now tangent to the *Decumanus*, was added. The façade of the theatre along the *Decumanus* appeared with two levels of arcades and a second floor likely adorned with windows. Together with this architectonic enlargement, a raised level composed of marble fragments, mosaic tiles, painted pieces of plaster and other material of almost 1m, was laid on the earlier ground level, reaching the elevation point of +2.595m a.s.l. And so forth it met the contemporaneous surface level of the *Decumanus Maximus* that was raised again at +2.86m a.s.l.[22] Consequently, the thresholds of the earlier radial rooms of the external hemicycle were lifted at the same level as the new rising layer. The earlier inner wall of the previous porticus was enlarged to the outside, and the side walls of the earlier radial rooms of the external hemicycle were reinforced to sustain the new order of seats and the new loggia on the top. Four staircases allocated within four radial rooms accessed these new added upper floors. Furthermore, in correspondence with the central axis of the theatre, the radial rooms were partially demolished, and a new central vaulted entrance was opened. The two *aditus* developed unalike in length because of the different spaces at disposal, creating an asymmetrical disposition of the two accesses to the *quadriporticus*. The new rise of the ground level created a difference in elevation of about 1m between the floor of the new perimetral porticus together with the new radial rooms of the *cavea* and the floor surface of the scene building with the *porticus post scaenam*, which remained unchanged at +2m a.s.l.[23] A floor surface coating in 'battuto alla veneziana' characterised the perimetral corridor of the *cavea*, the scene building and the spaces aside it; instead, the external floor of the theatre has travertine slabs as a surface coating. This open area on the south-east corner of the roar of the *cavea* was delimited

will address its function in commercial and maritime traffic offices. However, the inner arrangement for the commercial rooms was organised when the entrances of the *quadriporticus* towards the Tiber were already closed (Pavolini 1986b: 83-84).

[19] These layers of alluvial clay with construction material fragments indicate a flooding event. Few trenches were opened along the radial rooms of the *cavea* and in the *quadriporticus* (position not better specified) in 1911 and 1912, aiming to investigate the soil stratigraphy. These trenches reached the sand belt and the aquifer below it (Journal of excavation SAOA 1911, 1912). In trench c dug in the western porticus of the *quadriporticus*, the sea sand soil (layer VIII) has been excavated for a depth of 0.30, reaching the water table at 2.32m from the mosaic floor. On it, there is a layer of 0.22m thick clay mixed with pebbles and rubble (layer VII) (Pohl 1978a: 170).

[20] Journal of excavation 1910.

[21] Although a dedicatory inscription (*CIL* XIV, 114) mentioning Septimius Severus, dated to the CE 196, has been found in the scene building area, numerous brick stamps related to the age of Commodus have been found in the *cavea* (Lanciani 1881: 110-111; Battistelli and Greco 2002: 416).

[22] Vaglieri 1912: 212; Journal of excavation SAOA 1913. The elevation points of the *cavea* was recorded by the total station during the fieldwork in 2021/2022, whether the data on the elevation point of the *Decumanus* in front of the theatre was kindly given by Ogawa Takuro (University of Kyushu). This ground level is visible nowadays. However, the elevation point of the *Decumanus* outside Porta Romana has been recorded at +2.15m a.s.l. (Heinzelmann 1999: 87).

[23] It is unknown if the *Decumanus* was raised at this time with the enlargement of the theatre or earlier period (Vaglieri 1910: 102, 175; Battistelli and Greco 2002: 417-418).

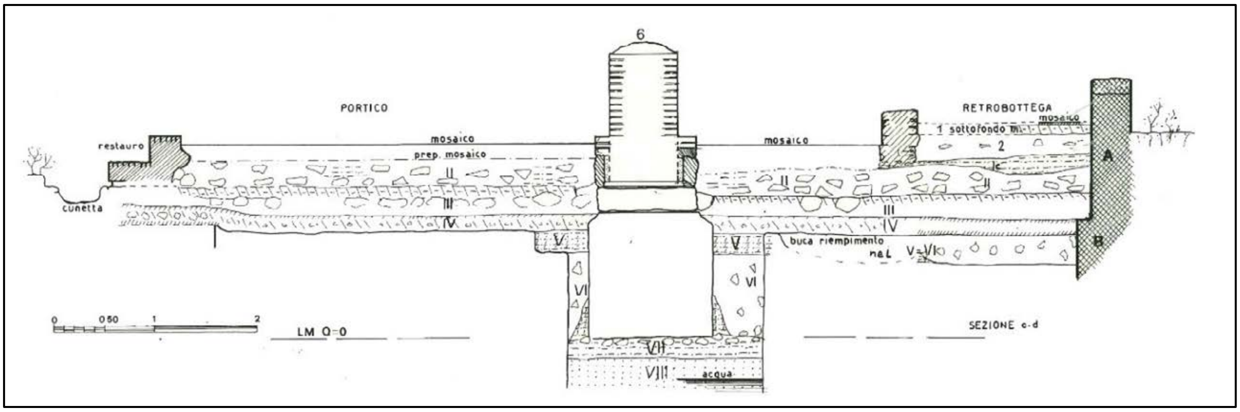


Figure 4. Section of trench C dug in the quadriporticus *(adapted from Pohl 1978a, fig. 7).*

by boarding travertine stones (*cippi*) holding up a gate at a distance of 2.30m from one to the next one.[24] The new enlarged theatre built in bricks, had an *orchestra* diameter of 23m about and a *cavea* diameter of 89.90m that included within its porticus the earlier well in front of it.

Other restorations works affected the axial corridor of the theatre before its last adaptation and transformation.

In the 4th century AD the theatre was the object of a last massive transformation for hosting aquatic displays: the radial rooms and the axial corridor were converted into tanks and the *orchestra* into a *κολυμβήθρα*.[25]

The sewerage system

The sewerage system analysed here is part of a dynamic system that continuously collects and discharges wastewater through an urban sewer and drain network.

Since its foundation, Ostia has been provided with an urban sewerage network, whose evidence has been found underneath the *castrum* road system that extended into the suburban area to channel the stagnant water that affected the suburban territory likely caused by the water table outflow.[26] The reason for this early sewerage network for managing the city's wastewater has to be looked at the geomorphological context on which Ostia sets, already called in ancient times *agrum macerrimum littorosissimumque* ('soil very dry and very sandy') that required the construction of the *fossae quiritium*.[27] As G. C. M. Jansen remarks, the presence of groundwater at 2-3m below ground level and Tiber flooding

[24] 'Battuto alla veneziana' is a term given by Lanciani to define a surface floor made of a mixture of white and coloured marble flakes with light-coloured mortar (Journal of excavation 1910; Vaglieri 1910: 171; 1913: 79; 1914: 73-75; Calza 1927: 15-18).
[25] The previous scholarship dates the transformation of the theatre to host the aquatic displays in the second half of the 4th century CE, based on masonry analysis (Gismondi 1955: 308; Traversari 1960: 43).
[26] Sommella 1988, 221. Within the *castrum*, the drains of the second order flowed from the buildings into the main sewer located under the *Cardo Maximus*, which has a slope towards the south and, therefore, is not discharging into the Tiber. The sewer of third order under the *Cardo Maximus* (0.45 m width and height) has greenish tuff slabs as floor (0.17 m thick) and as side walls (from 0.25 to 0.35 m thick); various numbers of slabs cover the sewer, one of those present a hole of 0.25 m of diameter functioning as water-inlet. Regarding the secondary drains, different building techniques can be listed: drains with the floor in tuff and tapered tuff side walls; drains with interlocking flat tiles as floor and tapered tuff side walls, with tuff slabs as a roof (0.35 m width); and lastly, drains with a two-roof slope as covering. (Calza et al. 1953: 73-74, 95).
[27] These *fossae* have to be interpreted as masonry sewers (Paschetto 1912: 59).

would have made the construction of the cesspits impossible because of the water contamination, whether the use of the streets as 'open sewers' was likely avoided because of the relatively flat area with some depression in the middle in which Ostia was founded; only the rainwater dropping directly on the streets was flowing on their surface.[28] The proposal of another area of discharge for the sewerage system, on the southern area of the city where likely a sewer discharged into the sea, rather than the Tiber, taking into account its spring flooding that would have blocked the sewers' outlets and use on the contrary, the entire system to flood the city, has been proposed again by G. C. M. Jansen.[29]

Within the urban sewerage system, the one belonging to the theatre would have been included at the moment of its construction during the Age of Augustus. As the theatre's sewerage network was projected with the building itself, it came long before the structures of the theatre were adapted for the water supply system to host the aquatic displays. Being the theatre a public building, its sewerage system was of public ownership and therefore, public authority supervised its maintenance. Because the theatre's sewerage structures belong to one building, they can be classified as drains of the first and second order; twelve sewers have been recorded, of which five are underneath the *Decumanus Maximus*, and the others as part of a deviation towards the theatre complex area, whose extension in this sector has not been recorded. The theatre's sewerage system was sought until the area of the *quadriporticus*, where a sewer crossed the courtyard along its length. For comprehensive matters, it has been decided to include all the drains present in the *quadriporticus* of the theatre.

Except for the published excavation reports in 'Notizie degli scavi di antichità', where some information on the sewerage system of the theatre have been found, no other edited works on the building describe or even mention these hydraulic structures.[30] This is the first issue when approaching the study of sewerage system, due to the lack of past interest on the subject as well as of the difficulties in their investigation. Therefore, the study of the theatre's sewerage system is based on the excavation reports written by Dante Vaglieri and Raffaele Finelli between 1910 and 1913, Pohl's excavation in 1970 and the Università la Sapienza in the 1990s, and it was enriched by the fieldwork in 2021–2022. [31]

The data collected have been sorted into summary tables (**Table 1-14**), which are used as studying mediums for the sewerage structures. These tables display a complete overview of all evidence. The

[28] An investigation on the direction of the rainwater flow above the streets' surfaces was conducted by Jansen considering the elevation points of the last imperial street floor. With the awareness that not all these data refer to the original ancient street pavements due to the lifting of the road floors during the excavation of the last century, Jansen arrived at the conclusion that the rain flowing on the streets northern the *Decumanus* was directed to the Tiber (i.e. via delle Corporazioni has a slope of 0.02% towards north), the rainwater dropping on the streets close to Porta Romana run out of the city gate, whether in the city centre this water was discharged into the underneath sewers through the water inlets disposed on the streets (Jansen 2000: 45-49; 2002: 164-165). However, the assumption that Ostia was built on three hills, of which the one where the Terme di Nettuno sets have the higher elevation points, remarked by Jansen, cannot be taken for granted as this elevation point is the result of the massive rise of the ground level operated during the Imperial period from Claudius to Hadrian. A study on the original confirmation of the soil level before the Ostia foundation and its development during urbanism is still missing.

[29] Jansen 2002: 163-164. However, the hypothesis of using a 'culvert' that had the outlet in the Tiber, with a valve opening from the inside with the pressure of the wastewater discharge and then closing when it finished, has been advanced again by Jansen (2002).

[30] 'Notizie degli scavi di antichità' is an Italian archaeology periodical journal founded in 1876 by the archaeologist and politician Felice Bernabei, where the archaeological excavation reports from the Ministero dei Beni Culturali are published. This journal is under the authority of the scientific committee of Accademia dei Lincei.

[31] Acknowledgments are due to the *Parco Archeologico di Ostia Antica* for the permits granted to this research, in particular to the architect Valeria Casella for the support and disponibility in organising this fieldwork. Further acknowledgments go to Elettra Santucci for the precious suggestions on the theatres' sewerage system study and to the BSR archaeology manager, Stephen Kay, without whom the recording of the elevation points of the sewers and drains would not have been done.

first stage in the analysis process for the study of the sewerage system is to identify the type of sewerage structures: 'down pipe' for the discharge of rainwater, 'drain' and 'sewer' follow the criteria before explained, 'water inlet' through which the rainwater, excess water, wastewater was discharged in the sewerage network, 'maintenance hole' used to have access to the sewerage network for maintenance operations, and 'drainage hole', used to drain the excess water from the hill slopes (in cases where the perimetral wall of the *cavea* was abutting the hill). The second stage in the studying process is to analyse the hydraulic structure's masonry, examining the material, building technique, dimension, elevation points and chronology when possible. This information can be used to calculate the flow velocity, flow rate, specific energy of the flow, and sewer conveyance.

However, it needs to be reminded that further invasive research (for instance, excavation and urban speleology investigation) will implement these data and the knowledge on the urban sewerage system. Difficulties in interpreting every single drain and integrating it within the theatre's sewerage network were caused by modern building works. Examples are the substantial restoration works on these structures and the construction of modern maintenance holes and of a modern drain, direction E-W, to connect Sw.12 and the sewerage network via della Fontana and via dei Vigili to drain the terrain, as well as the placement of pumps in the points of intersections between ancient and new drains. Nonetheless, the data at our disposal, gathered together in tables, are an essential source of information that, in the majority of the cases, let us follow the drains phases of construction, restoration, dismission and reconstruction through the detailed account of their location and, sometimes, stratigraphic relationships with the surrounded structures and sequence layers.

The assumption that the urban sewerage network was not substituted or heavily reconstructed, also in relation to the rise of the ground level, during its lifetime proposed by Jansen can be disputed by the study on the theatre's disposal system (Jansen 2002: 159-160). A commentary on the material and building techniques of the data at disposal is here discussed.

Analysis of the construction characteristics of the sewerage system (Appendix)

The sewerage network passing across or as part of the theatre complex itself present five section types of sewers and drains: vaulted drains/sewers (**Figure 5: A**), gabled roof drains/sewers, gabled roof covered by a vault sewers (**Figure 5: B**), rectangular cross-section drains (**Figure 5: C**) and 'U' section open drains (**Figure 5: D-E**; **Figure 6**).

The vaulted roof is in *opus caementicium* mixed with tuff fragments poured on centring, whose traces have sometimes remained impressed on the roof (**Table 9: Dr. 12**), whether drain/sewer with the gabled roof is usually in tiles or *bipedales.* The sewers with gabled roofs covered by a vault have the first roof in tiles or *bipedales* and had the reinforced vaulted roof covering it in *opus caementicium,* which could be embellished with voussoir bricks as Sw.5. The side walls can be in *opus reticulatum*, or bricks disposed in regular, horizontal courses, the floor in *opus caementicium* mixed with tuff fragments, or composed of irregular brick fragments, or also in tiles.[32] The sewers' dimension varies between 0.70m and 1.16m in height; the width between 0.50m and 0.60m.

The rectangular cross-section drains are associated with the temple in the centre of the courtyard, located on both sides of the sacred building (**Table 12: Dr. 19, Dr. 20**), whose material and building technique have not been described; the marble slabs of the sidewalk cover (**Table 12: Dr. 19**) and likely Dr. 20. The dimension is recorded only for Dr. 19 with a height of 0.84m and a width of 0.55m. This

[32] Some of the sewers and a drain have been documented and partially observed during the fieldwork season 2021–2022 (Table 1), when Sw. 4 and Sw. 5 were seen through Mh.1 from the *Decumanus* ground floor; Sw. 6 and Dr. 5 from the metal grating in the axial corridor floor, with Dr. 5 also visible in the breakthrough the floor in latrine 2 (Lat. 2); Sw. 7 from the water inlet in the *orchestra*. However, the state of partially filled-in in which they were and the impossibility of accessing them for security reasons have not permitted to document them entirely.

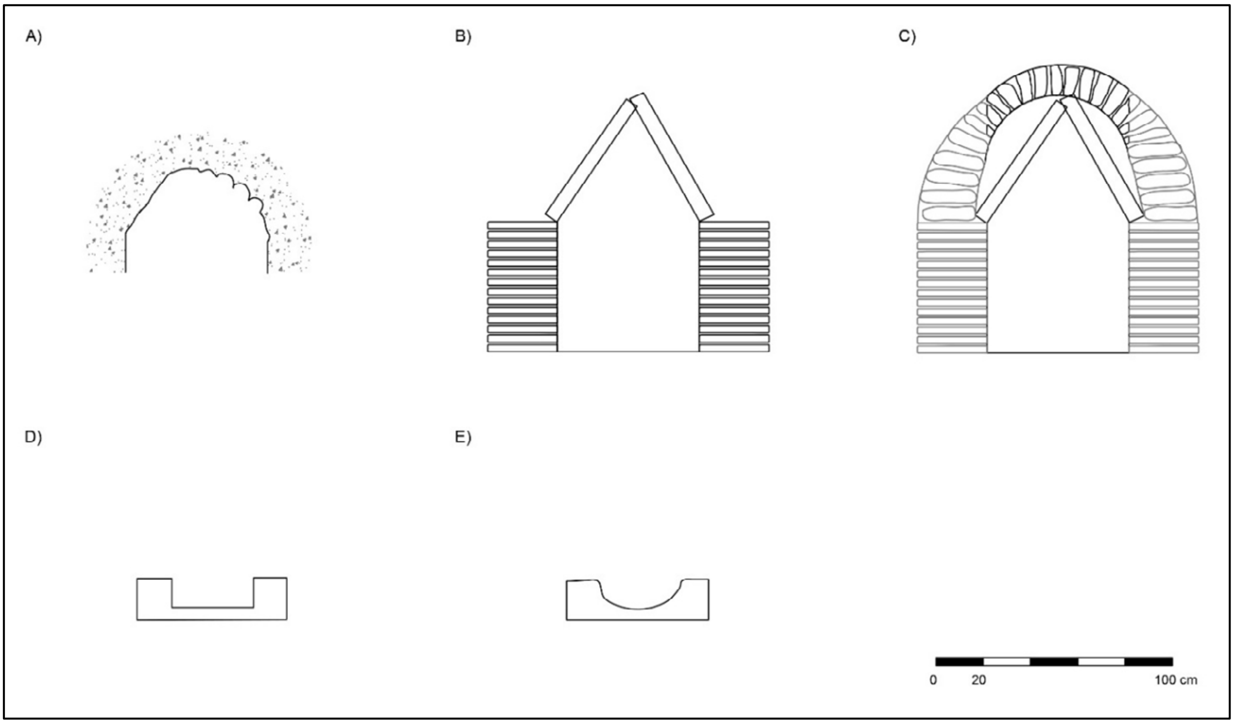


Figure 5. Reconstruction of the five section types of sewers and drains identified (illustrations were created by the author): A: vaulted roof sewer, B: gabled roof drains/sewer, C: rectangular cross-section open drain, D: rectangular section open drain, E: 'U' section open drain.

section type of drain is also to be attributed to the later Dr. 2, along the roar of the *cavea*, covered by a travertine drain grating. The 'U' concave section open drains have been identified running along the inner perimeter of the *quadriporticus* towards the courtyard. Two distinctive phases have been recognised of these drains: in the first phase, the drain running along the southern porticus of the *quadriporticus* (**Table 10: Dr. 14**) was constructed in *opus caementicium*, presumably coated with travertine slabs of which some spots have remained; in a successive phase, with the rise of the ground level of the courtyard and of the *quadriporticus*, the new drain running along the inner perimeter of the porticus, was made of travertine blocks and without a roof, with a width of 0.52-0.80m. These two section types of drains directly collect the rainwater from the roof of the central temple and the roof of the *quadriporticus,* respectively, likely through the medium of downpipes.

Along with sewers and drains, other functional structures for the working and maintenance of the sewerage network have been documented, such as water inlets and maintenance holes. One water inlet (Wi. 1) has been recorded in the theatrical complex along the southern porticus of the *quadriporticus* on the floor of Dr. 12. However, others had to be present along this drain running along the inner perimeter of the porticus. It is fitted with a travertine drain grating decorated with three ellipsoidal holes. The other water inlet is the one opened on Sw. 7, heavily restored during the excavation of the 19th century. Five maintenance holes have been then documented: one along the intersection of sewers of the third order under the *Decumanus* (**Table 3: Mh. 1**), one on the lengthened stretch of Sw. 11 (**Table 9: Mh. 2**) and three along Sw. 12 (**Table 11: Mh. 3, Mh. 4**). They all have a quadrangular shape and have side walls in bricks disposed in horizontal courses. Only Mh. 3 and Mh. 4 present steps along the side walls to get underground to access the drains. Whether a marble drain grating covers Mh. 4, there is no information on the drain gratings of the other two, and a modern grating now covers Mh. 1. The dimensions known are related to Mh. 1: 0.68 x 0.68m and 2.06m deep.

As part of the sewerage system is also the downpipes identified in a total number of 11 (**Tables 3-6: Pi. A-M**) along the inner walls of the perimetral radial rooms (also known as *tabernae*) during the fieldwork season 2021–2022. None of these downpipes has been preserved, except for a quadrangular shape terracotta downpipe that is glimpsed at its uppermost tract, embedded within the masonry in the northern wall of the western room from the axial corridor (**Table 4: Pi. E**). Only the recesses, where these downpipes were located, remains as evidence of their existence sometimes together with their squared passage through the vaulted roof (**Tables 4-5: Pi. D, Pi. F, Pi. I**). They were quadrangular downpipes attached to the wall, likely by the presence of metal joints, whose traces are the irregular holes left on the back wall of the recess, but they are not present in all the prepared recesses. The width of these prepared recesses varies between 0.22 and 0.30m, but the height can be measured only in correspondence to the ground floor, the unique level of the theatre preserved: 4.31m. Indeed, it needs to be assumed that each downpipe came from the second floor of the building, or more precisely from the roof, proceeding down and crossed the second, first and ground floor to discharge in Dr. 5.[33]

These downpipes, which can be also called 'down drains', were not meant to be visible from the outside, being placed in their recess set in the thickness of the wall created during its elevation and embedded within it by the later addition of bricks. These bricks were accurately arranged in order to match each brick to the respective horizontal brick course of the wall on which the recess was located.[34] This is a common practice in Ostia, where down drains were placed inside the building and because of their low risk of leakage could be hidden from the outside for aesthetic reasons.[35]

Unfortunately, not many detailed masonry descriptions have been outlined in the excavation reports and building features have not been observed during the fieldwork for each drain, as most of these structures have not been accessible. Therefore, the information is little. Nevertheless, it has been noticed that the material and building technique used for these sewers is strictly related to their period of construction: indeed, the sewers and drain of the period between 27 BC and AD 54 are generally built in *opus caementicium* mixed with tuff fragments and present a vaulted roof poured on centring. Among these sewers, the one that shows the most accurate masonry is Sw. 12, whose side walls are made in an accurate *opus reticulatum*, likely due also to the importance of its role within the sewerage network as a main collector. The later construction or restoration of these sewers and drains show the use of tiles or *bipedales* for the roof and the use of bricks for the side walls, among which the sewers of the Severan period represent the greatest work of this type of masonry. Because of the workload they had to bear, like traffic congestion or the load of the buildings above them, they were sometimes reinforced by the shelter of a vault built above their gabled roof. The later restorations of sewers and drains show the use of the most diverse reused material, such as amphora fragments or marble slabs.

Ultimately, the account of their location, more specifically the description of their points of departures and arrival, and connections permit to understand their function within the sewerage network system. Thereupon, the following step of this research will be to formulate a proposal on the chronological phases (relative chronology) of the succeeding changes of the theatre's sewerage network as a result of new architectural interventions conducted on the theatre complex before and after its enlargement and as adaptation to the continue rise of the ground level in Region II as medium against the geomorphological conformation of this area that needs to be examined.

[33] The hypothesised reconstruction of the theatre entails the existence of the ground floor, a first floor characterised by arches, and a second floor with windows instead, framed by half pilasters (Calza 1927: 20-21).
[34] Although only two downpipes have the bricks filled in and still preserved (Table 1: Pi. E and Pi. F), it is plausible to expect the same techniques for the other downpipes.
[35] Delaine 1997: 155-156; Jansen 2002: 161-162. Similar down drains placed in the recesses within the thickness of the wall were found, for instance, in the 'Case Giardino' built under Hadrian (Stevens 2005: 119).

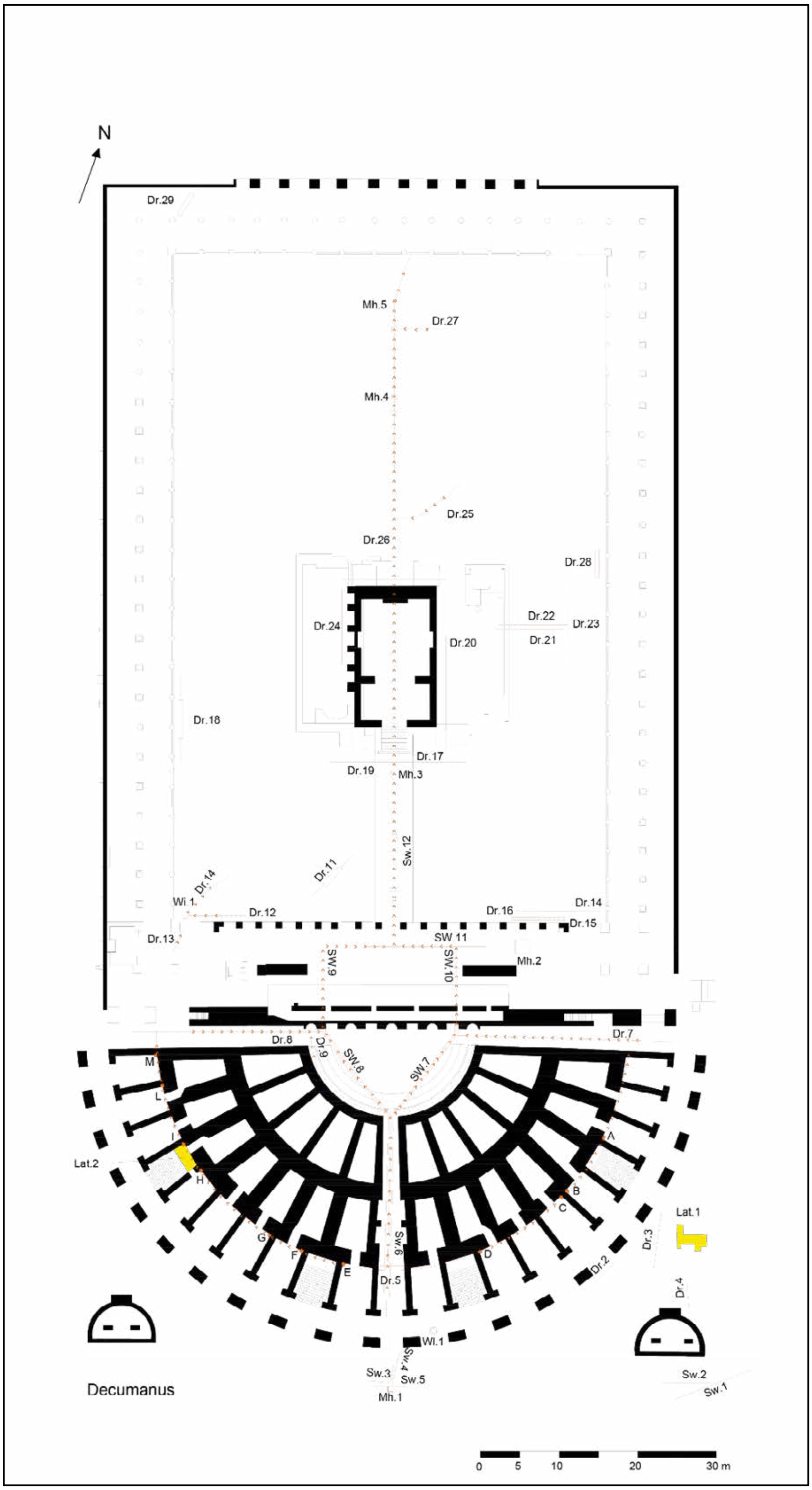


Figure 6. Schematic plan of the theatre's sewerage system (elab. by the author).

Appendix - ***Tables of the sewerage system:*** *the tables of the single sewerage structures distinguished by type on the base of their function (Dr. = drain; Sw. = sewer; Mh= maintenance hole; Pi. = pipe) follow. The pictures included have been take by the author.*

Table 1.

Regio I Ostia (Os.)	**Dr. 1**	**Dr. 2**	**Dr. 3**	**Dr. 4**
Material and building techniques	It has a gabled roof. The drain was later dismissed as masonry blocks the passage. The drain bottom is at the same level as the S. Ciriego church floor and 0.15m above the floor of the 2nd phase of the theatre.	Travertine drain gratings.	-	It has a gabled roof.
Dimension	Height: 0.63m; Width: 0.59m.			
Elevation points	-	-	-	-
Position and orientation	It is located in the S-E outside of the theatre, passing through the N wall of the church of S. Ciriego, nearby the E nymphaeum. Direction S-W/N-E.	It is in front of the fifth room from the E side of the *cavea*, and runs underneath the last rise floor made of reused marble slabs outside the *cavea*.	It is located in Lat.1. Direction N-S. It drains the discharge of Pi. 1.	It is located between the E nymphaeum and Lat.1. Direction N-S.
Chronology	*Terminus post quem* 4th century CE.	*Terminus ante quem* end of 4th century CE.	*Terminus ante quem* end of the 4th century CE.	*Terminus ante quem* end of the 4th century CE.
Picture	-	-	-	
References	Journal of excavation SAOA 1910	Journal of excavation SAOA 1910; Vaglieri 1910: 172.	Journal of excavation SAOA 1910; Vaglieri 1910: 375.	Fieldwork season 2021/2022.

Table 2.

Regio I Ostia (Os.)	**Sw. 1**	**Sw. 2**	**Sw. 3**	**Sw. 4**
Material and building techniques	-	-	-	
Dimensions	-	Height: 0.70m.	-	Height: 1m; Width: not measurable.
Elevation points	-	-	-	+0.764m a.s.l.
Position and orientation	It is located underneath and placed transversely with respect to the *Decumanus*, crossing it. It links to Sw. 2. It was observed in front of the church of S. Ciriego, at 2.25m below the ground level. Direction S-E.	Located underneath and along the *Decumanus.* It links to Sw. 1. It was observed in front of the church of S. Ciriego, at 2.25m below the ground level. Direction W-E.	It is located below Sw. 4. It does a right angle with Sw. 4 going towards the theatre.	It is located underneath the *Decumanus.* It is slightly turning E towards the theatre. It links with Mh. 1 and Sw. 5.
Chronology	AD 180-211 (likely) (2nd phase of the theatre)	AD 180-211 (likely) (2nd phase of the theatre)	*Terminus ante quem* AD 180-211 (2nd phase of the theatre)	AD 180-211
Picture	-	-	-	
References	Journal of excavation SAOA 1910.	Journal of excavation SAOA 1910.	Journal of excavation SAOA 1907; Vaglieri 1907: footnote 1, 656.	Journal of excavation SAOA 1907; Vaglieri 1907: 656; Paschetto 1912: 258; Fieldwork season 2021/2022.

Table 3.

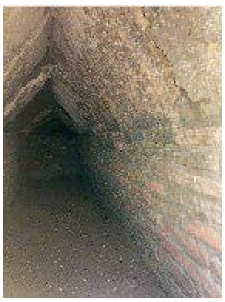
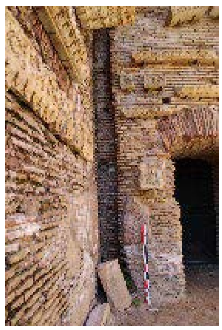
Regio I Ostia (Os.)	**Sw. 5**	**Mh. 1**	**Pi. A**	**Pi. B**
Material and building techniques	The floor is in tiles. The side walls are in bricks disposed in regular horizontal courses. It has a gabled roof in tiles.	It has side walls in bricks disposed in regular horizontal courses.	There is the prepared recess where the pipe was inserted into. Two holes, at a distance of 1.35m, are on the recess created by the joints attaching the pipe to the wall.	There is the prepared recess where the pipe was inserted into. There are no holes for the joints attaching the pipe to the wall.
Dimension	Height: 1.05m; Width: 0.60m; Roof wing tiles: 0.60x0.60m.	0.68 x 0.68m; Depth: 2.06m.	Width: 0.28m; Height: not measurable.	Width: 0.25m; Height: not measurable.
Elevation points	E part: +0.880m a.s.l.; W part: +0.847m a.s.l.	+0.795m a.s.l.	-	-
Position and orientation	It is located underneath the *Decumanus*. Direction W-E links with Mh. 1 and Sw. 4.	It is located along the *Decumanus* in front of the axial corridor of the theatre and links with Sw. 4 and Sw. 5.	It is located in the N-W corner of the third perimetral radial room of the theatre, departing from the E side. It linked with Dr. 5.	It is located in the N-W corner of the fourth perimetral radial room of the theatre, departing from the E side (not including the staircase). It linked with Dr. 5.
Chronology	AD 180-211	AD 180-211	AD 180-211	AD 180-211
Picture				
References	Journal of excavation SAOA 1907; Vaglieri 1907: 656; Paschetto 1912: 253; Fieldwork season 2021/2022.	Fieldwork season 2021/2022.	Fieldwork season 2021/2022.	Fieldwork season 2021/2022.

Table 4.

Regio I Ostia (Os.)	Pi. C	Pi. D	Pi. E	Pi. F
Material and building techniques	There is the prepared recess where the pipe was inserted into. In this case, there are no holes for the joints attaching the pipe to the wall.	There is the prepared recess where the pipe was inserted into. One squared hole is on the recess created by the joints attaching the pipe to the wall.	There is the prepared recess where it was inserted into. In this case, there are no holes for the joints attaching the pipe to the wall. For half of its height from the bottom, the recess has brick facing covering it.	There is the prepared recess where the pipe was inserted into. In this case, there are no holes for the joints attaching the pipe to the wall. For half of its height from the bottom, the recess has brick facing covering it.
Dimension	Width: 0.28m; Height: not measurable.	Width: 0.30m; Height: 4.31m.	Width: 0.22m; Height: not measurable.	Width: not measurable; Height: not measurable.
Elevation points	-	-	-	-
Position and orientation	It is located in the N-E corner of the fifth perimetral radial room of the theatre, departing from the E side. It linked with Dr. 5.	It is located in the N-E corner of the seventh perimetral radial room of the theatre, departing from the E side. It linked with Dr. 5.	It is located in the N-W corner of the tenth perimetral radial room of the theatre, departing from the E side. It linked with Dr. 5.	It is located in the N-E corner of the eleventh perimetral radial room of the theatre, departing from the E side. It linked with Dr. 5.
Chronology	CE 180-211	CE 180-211	CE 180-211	CE 180-211
Picture				
References	Fieldwork season 2021/2022.	Fieldwork season 2021/2022.	Fieldwork season 2021/2022.	Fieldwork season 2021/2022.

Table 5.

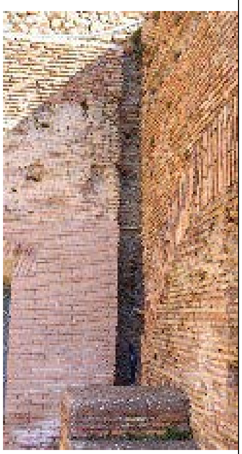
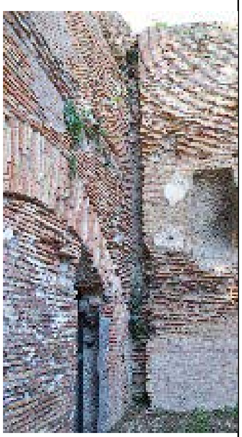
Regio I Ostia (Os.)	**Pi. G**	**Pi. H**	**Pi. I**	**Pi. L**
Material and building techniques	There is the prepared recess where the pipe was inserted into. One squared hole is on the recess created by the joints attaching the pipe to the wall.	There is the prepared recess where the pipe was inserted into. There are no holes for the joints attaching the pipe to the wall.	There is the prepared recess where the pipe was inserted into. In this case, there are no holes for the joints attaching the pipe to the wall.	There is the prepared recess where the pipe was inserted into. There are no holes for the joints attaching the pipe to the wall.
Dimension	Width: 0.27m; Height: not measurable.	Width: 0. 25m; Height: not measurable.	Width: 0.26m; Height: not measurable.	Width: 0.28m; Height: not measurable.
Elevation points	-	-	-	-
Position and orientation	It is located in the N-E corner of the twelfth perimetral radial room of the theatre, departing from the E side. It linked with Dr. 5.	It is located in the N-W corner of the fourteenth perimetral radial room of the theatre, departing from the E side. It linked with Dr. 5.	It is located in the N-W corner of Lat. 2. It linked with Dr. 5.	It is located in the N-W corner of the sixteenth perimetral radial room of the theatre, departing from the E side. It linked with Dr. 5.
Chronology	AD 180-211	AD 180-211	AD 180-211	AD 180-211
Picture				
References	Fieldwork season 2021/2022.	Fieldwork season 2021/2022.	Fieldwork season 2021/2022.	Fieldwork season 2021/2022.

Table 6.

Regio I Ostia (Os.)	**Pi. M**	**Dr. 5**	**Dr. 6**	**Sw. 6**
Material and building techniques	There is the prepared recess where the pipe was inserted into.	Brick-facing walls disposed in horizontal and regular courses. It has a gabled roof composed of *bipedales*. Above it there is also a barrel vault covering it. The bottom is not visible because of the filling, but a tile is visible from a corner.	Brick facings walls. It has a gabled roof.	The floor is in mortar with small irregular tuff and has a vaulted roof.
Dimension	Width: - Height: -	Width: 0.50m; Height: 1.23m.	Width: 0.70m.	Width: 0.73m; Height:1.13m.
Elevation points		+1.165m a.s.l.		-0.165m a.s.l.
Position and orientation	It is located in the N- W corner of the seventeenth perimetral radial room of the theatre, departing from the E side (not including the staircases). It linked with Dr. 5.	It has been found in the third room from the W, underground of the axial entrance and runs along the N wall of all rooms of the external ring of substructures of the *cavea*. It is also visible along the S wall of the W aditus, where a relieving arch overcomes a point of access to the drain. It is visible through two modern holes on Lat. 2 at 0.60m from the ground level. It discharges the rainwater of pipes inserted in Pi. A, B, C, D, E, F, G, H, I, L, M, and the waste of Lat.2. Slope from N-W to N-E.	It crosses the fourth perimetral radial room from the E side of the *cavea*. Direction: E-W.	It is located underground along the axial corridor. Direction S-N. It has a gradient from S to N. It has been found in front of the perimetral wall of the 1st phase of the theatre. The vault was destroyed due to the extension of the theatre when Dr. 5 was constructed. It is probably cut or blocked in the N direction and it splits in Sw. 7 and Sw. 8 in the *orchestra*.
Chronology	AD 180-211	AD 180-211	-	18/17 BC
Picture			-	
References	Fieldwork season 2021/2022.	Journal of excavation SAOA 1913; Fieldwork season 2021/2022.	Journal of excavation SAOA 1910; Vaglieri 1910: 172.	Journal of excavation SAOA 1913; Fieldwork season 2021/2022.

Table 7.

Regio I Ostia (Os.)	**Dr. 7**	**Dr. 8**	**Dr. 9**	**Sw. 7**
Material and building techniques	It has a gabled roof in the last tract linking with Sw. 10 and Sw. 7 (visible from the modern water inlet in the *orchestra*).	-	-	It has a vaulted roof in *opus caementicium* composed of mortar, and small irregular tuff was poured on the centring. The negative tracks of the wooden centring are visible on the inner surface of the vault. At 20m from the scene building corner, the vault was restored with travertine blocks and a marble cippus with an inscription named Trajan. At 24m from the scene building, the construction of a wall blocked the sewer. The vault starts at 0.04m from the *orchestra* ground level.
Dimension	-	-	-	Height: 1.16m; Width: 0.60m.
Elevation points	-	-	-	(From S/W to N/E): -0.381m a.s.l.; -0.410m a.s.l. (modern water inlet); -0.432m a.s.l.
Position and orientation	It is located on the E side of the *cavea*, on the S side of the *opus reticulatum.* wall's pilaster. It runs along the E *aditus*, proceeding towards W and in the *orchestra* area with a curve passing through the scene building wall. From this point, it proceeds in direction N-W. It links with Sw. 10, Sw. 7 and Dr. 9.	It was observed underneath along the W *aditus*. In the *orchestra* area, it links with Dr. 9, Sw. 8 and Sw. 9.	It is located underneath the *praecinctio* following the *orchestra.* It links with Dr. 8 and Dr. 7. Unclear is the relation with Sw. 6.	Linked with Sw. 6. It departs from it, direction N-E, crossing the *orchestra.* It has a slope from S-W to N-E. In front of the rectangular niche of the stage wall it proceeds towards N-W under the scene building. It links with Dr. 7 and Sw. 10.
Chronology	18/17 BC	18/17 BC	*Terminus post quem* 18/17 BC	18/17 BC
Picture	-	-	-	
References	Journal of excavation SAOA 1913; Vaglieri 1913: 50; Fieldwork 2021/2022.	Journal of excavation SAOA 1907; 1908.	Journal of excavation SAOA 1907.	Journal of excavation SAOA 1907; Vaglieri 1907: 655; Paschetto 1912: 258; Fieldwork season 2021/2022.

Table 8.

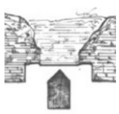
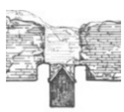
Regio I Ostia (Os.)	**Sw. 8**	**Sw. 9**	**Sw. 10**	**Sw. 11**
Material and building techniques	-	It has a gabled roof.	It has a gabled roof. The dimension reported in the Journal of excavation 1910 does not seem probable (0.46x0.34m).	(1st phase) an extrados roof with a slight gradient from S to N covers the drain. (2nd phase) a regular cut broke through the E side of the drain. A new gabled roof composed of *bipedales* bricks was coated by an *opus caementicium* structure. This structure is a vault (excavation report of 1908). On the W side, the gabled roof was composed of marble slabs. The side walls are in *opus caementicium* of different compositions.
Dimension	-	Height: 0.90m; Width: 0.53m.	Height: 0.94m; Width: 0.55m.	-
Elevation points	-	-	-	-
Position and orientation	Linked with Sw. 6. It departs from it, direction W, crossing the *orchestra*. In front of the rectangular niche of the stage wall, it proceeds towards N-W under the scene building. It links with Dr. 8 and Sw. 9.	It is located on the W side of the a *cavea* and scene building. It departs from Sw. 8, proceeds N crossing the scene building and it turns towards E under the *porticus post scaenam*. It links with Dr. 8.	It is located on the E side of the area of the scene building and goes through the foundation of it; it cuts Sw. 11. (Excavation report, 1910) it passes through the S wall of the E side of the scene building. It links with Sw. 11, Sw. 7 and Dr. 7.	It is located on the E side of the area of the scene building, abuts the N side of the foundation of the wall of the scene building and links to Sw. 10, Sw. 9 and Sw. 12. Direction E-W.
Chronology	18/17 BC	18/17 BC	1st phase: 18/17 BC 2nd phase: *Terminus ante quem* AD 81-96	1st phase: 18/17 BC; 2nd phase: *Terminus ante quem* AD 81-96.
Picture	-			-
References	Gismondi 1955: Fig. 1.	Journal of excavation SAOA 1907, 1908; Plan SAOA Inv. 588.	Journal of excavation SAOA 1910, 1993; Plan SAOA Inv. 588; Fieldwork season 2021/2022.	Journal of excavation SAOA 1908; Journal of excavation SAOA 1993.

Table 9.

Regio I Ostia (Os.)	**Mh. 2**	**Dr. 10**	**Dr. 11**	**Dr. 12**
Material and building techniques	It has a rectangular shape.	It has a gabled roof covered by an *opus caementicium* vaulted roof.	It has a gabled roof. The side walls are in bricks disposed in regular horizontal courses.	It has a concave section; built in travertine blocks (two have been noticed). On its E side were two bricks and a piece of marble to cover Wi. 1. On the floor of it is Wi. 1.
Dimension	-	-	Height: not measurable; Width: 0.58m.	Length: 4.90m (JE 1912); Width: 0.52m (JE 1912); Width: 0.80m about. Thickness on the W side: 0.28m about. Preservation length: 2.40m about.
Elevation points	-	-	-	Gradient between +1.45 and +1.147m a.s.l.
Position and orientation	It is located on the E stretch of Sw. 11, lengthened during Hadrian's building works.	It is located on the W side of the *quadriporticus*. It has been observed under Wi. 1. It links to Wi. 1 collecting the rainwater. It probably links to Dr. 13. Direction N-S. If it is the same structure observed in the excavation of 1912, it proceeds along the W side of the *quadriporticus*. In 1912 it was noticed on the W side of the central temple, direction S-N.	It is located in front of the fifth intercolumn of the S porticoes of the *quadriporticus*. Direction S-N.	It is located on the S-W corner of the *quadriporticus*. It is below the travertine step level, along the structure in *opus caementicium* of the stairs of the porticoes and links to Wi. 1. Direction E-W.
Chronology	AD 117-138	AD 117-138	*Terminus ante quem* AD 180-211	AD 117-138
Picture		-	-	-
References	Plan inv. 10994; Battistelli and Greco 2002: 414.	Journal of excavation SAOA 1912; 1994.	Fieldwork 2021/2022.	Journal of excavation SAOA 1912; 1994.

Table 10.

Regio I Ostia (Os.)	**Dr. 13**	**Dr. 14**	**Dr. 15**	**Dr. 16**
Material and building techniques	It has a gabled roof: two pairs of *bipedales* are visible. An *opus caementicium* vaulted roof covers the previous roof. The N side of the drain looks older than the S side.	*Opus caementicium.* It has a "U" section. On the floor, some spots of travertine have been identified.	It has two low walls sides that have been cut probably by the construction of Dr. 16.	The side walls are in *opus caementicium* mixed with small irregular tuff fragments. The floor is in irregular brick fragments.
Dimension	-	-	-	-
Elevation points	-	W part: +0.62m a.s.l. E part: +0.65m a.s.l.	-	-
Position and orientation	It is located on the S-W corner of the *quadriporticus.* Direction S-W/N-E. It is probably linked to the N-E side of Dr. 10. It has a gradient from S to N.	It is located on the S-E side of the *quadriporticus.* Direction E-W. It was observed at about 1.60m deep from the soil level and 1.60m far from the foundation of the colonnade. It is built above the same foundation in *opus caementicium* where Dr. 15 is built.	It is located on the S-E side of the *quadriporticus* under Dr. 16. Direction E-W. It was observed between the second and third columns from the N-E side. On the S it abuts a foundation and it is built above the foundation in *opus caementicium*.	It is located on the S-E side of the *quadriporticus*. It is below of 0.80m from the upper level of the pillar foundation. It abuts the N side of the foundation of the colonnade and is above Dr. 15, on the S side. Direction E-W. It was observed between the second and third columns from the N-E side.
Chronology	1st phase: *terminus ante quem* AD 81-96; 2nd phase: *terminus ante quem* AD 117-138. The roof was partially exported and then restored in the S stretch.	18-17 BC	18-17 BC	41-54 BC
Picture	-	-	-	-
References	Journal of excavation SAOA 1994.	Journal of excavation SAOA 1993.	Journal of excavation SAOA 1993.	Journal of excavation SAOA 1993.

Table 11.

Regio I Ostia (Os.)	Dr. 17	Sw. 12	Mh. 3	Mh. 4
Material and building techniques	-	The side walls are in *opus reticulatum*, while the floor is in bricks. A gabled roof and, in some parts, a vaulted roof covers it. During the excavation of 1908, it was observed that after the central temple, 8 amphoras (fragments) disposed in horizontal courses covers a tract of the drain. The latter roof is a later restoration.	Brick walls with steps to go underground and get to Sw. 12.	Brick walls with steps to go underground and get to Sw. 12. A marble drain grating covers it.
Dimension	-	-	-	-
Elevation points	-	-	-	-
Position and orientation	It is in front and below the first step line of the central temple staircase. Direction E-W. It links to Sw. 12.	It is located on the N side of the scene building and in the area of the *quadriporticus*. It is along the axis of the theatre. It is transverse to the foundation of the wall of the scene building. It crosses the foundation of the space behind the scene building. It proceeds towards N-W. It crosses the courtyard of *quadriporticus* in the direction of Tiber. It links to Sw. 9, Sw. 11, Dr. 17 and Dr. 25, Dr. 26 and Dr. 27. During the excavation of 1908, some water inlet (not better specified) and Mh. 3 were observed on the S-E side of the central temple. In addition, it was noticed that along the N-W side of the central temple, the sewer had two maintenance holes (Mh. 4 and Mh. 5). At 2.90m from Mh. 5, it was lightly curving towards N. It was then proceeding for 10m far from Mh. 5 towards Tiber. Slope N-S.	It is located along Sw. 12, in front of the central temple (S side). Now, it is no longer visible.	It is located along Sw.12; 21m to the N far from the central temple. Now, it is no longer visible.
Chronology	1st phase: 18/17 BC, probably it was restored under Claudius (AD 41-54)	1st phase: 18/17 BC; 2nd phase: AD 41-54 roof restoration with gabled roof; 3rd phase: Late Antiquity with the use of amphorae as a roof.	1st phase: 18/17 BC; 2nd phase: AD 41-54.	1st phase: 18/17 BC; 2nd phase: AD 41-54.
Picture	-	-	-	-
References	Journal of excavation 1908.	Journal of excavation SAOA 1908; 1910; 1994; Vaglieri 1908: 470-471.	Journal of excavation SAOA 1908; Vaglieri 1908: 471.	Journal of excavation SAOA 1908; Vaglieri 1908: 471.

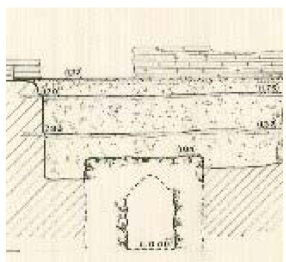
Table 12.

Regio I Ostia (Os.)	**Mh. 5**	**Dr. 18**	**Dr. 19**	**Dr. 20**
Material and building techniques	Brick walls.	It is built in travertine blocks and has a concave section.	Marble slabs of the sidewalk above the drain, cover it.	-
Dimension	-	Width: 0.52m; Length preserved: 4.90m.	-	Height: 0.84m; Width: 0.55m.
Elevation points	-	-	-	-
Position and orientation	It is located along Sw. 12; 8m to the N far from Mh. 4. Now, it is no longer visible.	It is located along the W porticoes of the *quadriporticus*, below the steps level. Direction N/E-S/W. (There is no more precise indication about its location).	It is located in the W side of the central temple, running along it. Direction S-N. It links with Dr. 20. It is not said if it links with Sw. 12.	It is on the E side of the central temple, running along its entire perimeter. Direction N-S. It links with Dr. 19; it is not said if it links with Sw. 12.
Chronology	1st phase: 18/17 BC; 2nd phase: AD 41-54.	AD 117-138	AD 81-96	AD 81-96
Picture	-	-	-	-
References	Journal of excavation SAOA 1908; Vaglieri 1908: 471.	Journal of excavation SAOA 1881; 1912; Lanciani 1881: Tav. I;	Journal of excavation SAOA 1881; Lanciani 1881: 119.	Journal of excavation SAOA 1881; Lanciani 1881: 119, n.3.

Table 13.

Regio I Ostia (Os.)	Dr. 21	Dr. 22	Dr. 23	Dr. 24
Material and building techniques	-	It has a gabled roof.	-	It is built in travertine blocks and has a concave section.
Dimension	-	-	-	Width: 0.53m; Length preserved: 3.60m.
Elevation points	-	-	-	-
Position and orientation	It is located on the E side of the central temple, abutted by Dr. 22.	It is located on the E side of the central temple. It is built above Dr. 21 and links to Dr. 23.	It is parallel to the E side of the central temple and links to Dr. 22.	It is located roughly in correspondence with the centre of the E porticoes of the *quadriporticus*, below the steps level.
Chronology	18/17 BC	AD 41-54	AD 41-54	AD 117-138
Picture	-	-	-	-
References	Journal of excavation SAOA 1912.	Journal of excavation SAOA 1912.	Journal of excavation SAOA 1912.	Journal of excavation SAOA 1912.

Table 14.

Regio I Ostia (Os.)	Dr. 25	Dr. 26	Dr. 27	Dr. 28
Material and building techniques	-	-	-	Side walls in *opus caementicium*, likely with tuff fragments.
Dimension	-	-	-	Height: 0.84m; Width: 0.53m. (These measurements have been calculated from the section C-C').
Elevation points	-	-	-	-0.01 (?) m a.s.l.
Position and orientation	It is located on the N side of the central temple, 6 m far from it. It departs from Sw. 12 and proceeds toward N-E for about 3 m. At this point, it does an obtuse angle going towards N, probably to avoid the foundation of an earlier structure found here.	It is located in the courtyard of the *quadriporticus*, behind the central temple. Direction E-W.	It is located on the N side of the central temple, at 8m N from Mh. 3. It links to Sw. 12 in correspondence with Mh. 4. It proceeds in the E direction towards Caserma dei Vigili.	It is located in correspondence of the second room of the northern porticoes from the N-W corner. Direction N/E-S/W.
Chronology	1st phase: 18/17 BC, probably it was restored under Claudius (AD 41-54).	*Terminus ante quem* AD 180-211	1st phase: 18/17 BC, probably it was restored under Claudius (AD 41-54).	AD 41-54
Picture	-	-	-	
References	Journal of excavation SAOA 1912.	Journal of excavation SAOA 1912.	Journal of excavation SAOA 1912.	Plan SAOA, inv. 5613B.

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The Villa Under the Lakes. Water Management of Nero's Villa in Subiaco, Rome

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Abstract: Subiaco, near Rome, is the heir of the villa built there by Nero before AD 60: this Roman villa was called *Sublaqueum*, that means 'under the lakes' as actually the villa was, with pavilions overlooking them and surrounded by the mountains in a highly rainy territory. This artificial landscape and its maintenance required a remarkable engineering effort to manage both the fluvial and the rainwater. Therefore, the *Sublaqueum* is an interesting case study for the Roman hydraulic technology for a sustainable water management, to make a potential problem a resource.

Keywords: Water management, Water supply, Roman baths, Artificial lakes, Dams, Roman villa.

A valley surrounded by mountains, rich in plants and animals, woods and water and dug by a river, this is the place where the emperor Nero built his first *villa*. It is the territory of the current city of Subiaco, about seventy kilometres far from Rome and the heir in culture and name of the Neronian palace, called *Sublaqueum*. Nero created a *villa* divided in different pavilions overlooking three artificial lakes (**Figure 1**) and so it was a properly *Sublaqueum*, a villa under the lakes. For this reason, it required a demanding engineering effort for its construction, especially for the hydraulic structures and infrastructures to allow its use and maintenance. This article focuses precisely on these aspects and on one of the five building found and excavated, the thermal pavilion (**Figure 2**), the so-called Building A, to cast light on an illustrative example of sustainable Roman water management.

The historical and geographical context

Exactly the richness of water was the reason why Nero chose that territory for his *villa*. Probably, he had accompanied his adoptive father, the emperor Claudius, to this area for the inauguration of two of the four aqueducts (Carosi 1970: 10; Di Matteo 2005: 171), the *Aqua Claudia* and the *Anio Novus*, that carried the water of the Anio river to Rome (Frontin. *Aq*. 13). There, the mountains called Simbruini, the Anio river and its canyon probably perfect to Nero for a new model of *villa*. It was not a single palace, but a seventy-five-hectares wide (Tomei 1984: 251) estate with three artificial lakes surrounded by at least five pavilions (**Figure 1**).

This impressive imperial *villa* was built before AD 60. Indeed, this was the year, as Tacitus (*Ann.* 14, 22) tells, when a lightning struck the table where Nero was banqueting; thus, he left the *Sublaqueum* and, four years later, he would start the construction of his most famous palace, the *Domus Aurea* in Rome. For their similarities, the *Sublaqueum* is considered to be the prototype of the following *villa* and to have been projected by the same architects, Celer and Severus (Carosi 1970: 10; Tomei 1984: 251). Both in Subiaco and in Rome, Nero wanted artificial basins, respectively three *Simbruina Stagna* and the *Stagnum Neronis*, a squared basin surrounded by a quadrangular portico in the place of the future Flavian Amphitheatre, the Coliseum. Furthermore, the *Domus Aurea* reflected the model already experimented in Subiaco, with different pavilions pertinent to an eighty-hectares-wide estate. The differences between these two Neronian palaces are due to the diversity of the two territories, on one side a mountainous area and on the other a city centre.

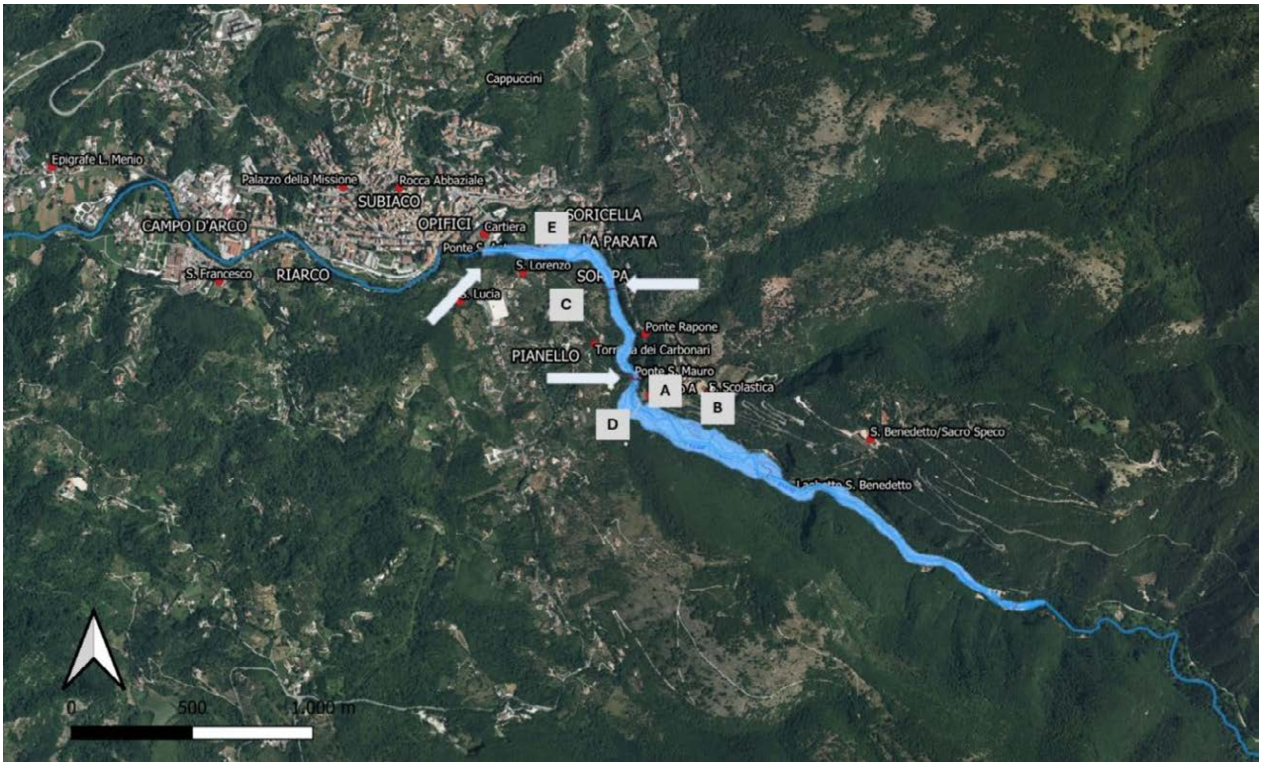

Figure 1. Subiaco from Google Earth, with the five (A-E) discovered pavilions (the squares) and the three dams (the arrows). In blue, the Anio river and the three Neronian artificial lakes (elab. by the author).

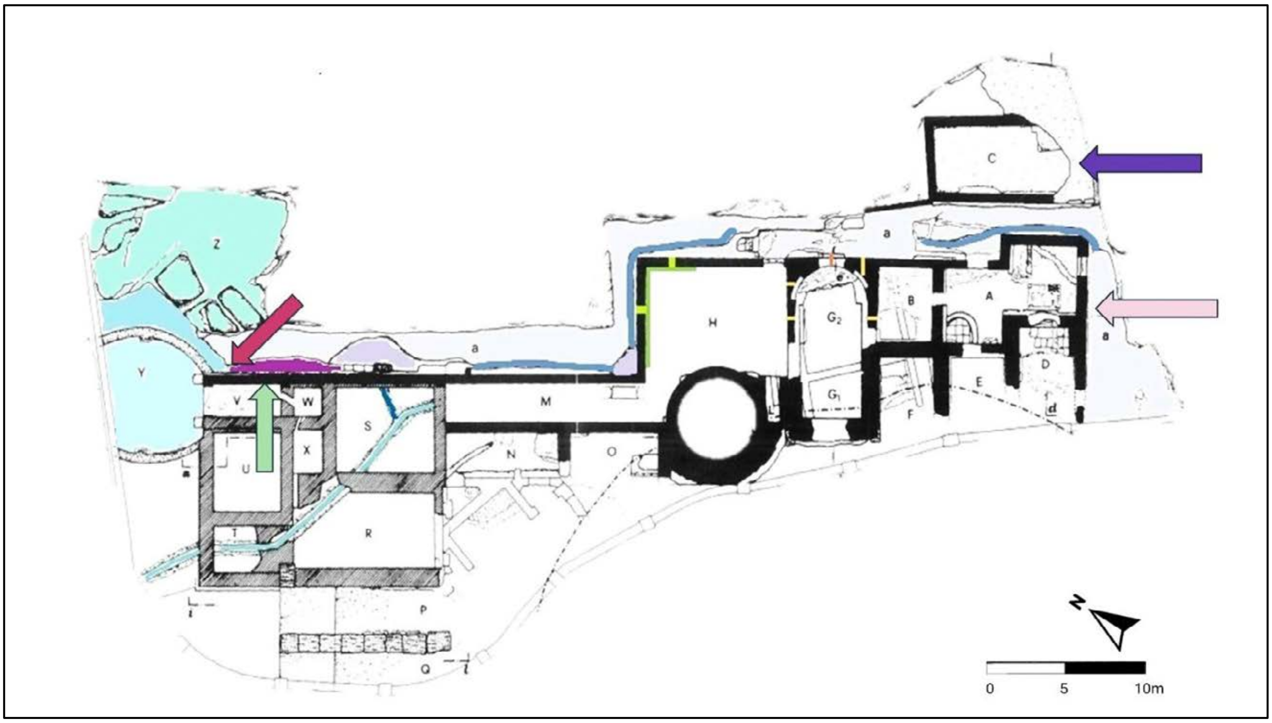

Figure 2. Planimetry by Mari (2003) with the different elements mentioned in this speech (elab. by the author).

However, after the abandon of the *Sublaqueum*, its structures continued to be maintained and restored (Fiore Cavaliere *et al.* 1999: 139), especially to preserve the artificial lakes. Indee, in the 2nd century, Trajan, who also built a *villa* (Fiore Cavaliere and Mari 2003; Mari and Fiore Cavaliere 1998; Mari and Fiore Cavaliere 2000) in Arcinazzo Romano, near Subiaco, moved the source of the *Anio Novus* (Betocchi 1879: 12; Bonamore 1884: 18; Cabral 1779: 204-209; Canina 1856: 157; Frabretti 1680: 72; Holstenio 1666: 167; Mari 2008: 50; Panimolle 2007: 83-86) into one of the Neronian lakes: according to the different scholars it was the upper (Carosi 1987: 18), the middle (Egidi *et al.* 1904; Lanciani 1880: 140), or the lower (Giuliani 2002). Frontinus (*Aq.* 15, 93) just tells that the source was moved into the lake *super villam Neronianam Sublacensem*. Anyway, the intervention under Trajan's reign was due to the quality of the water arriving in Rome: it used to be very dirty and muddy (Cabral 1779: 204-209; Mari 2003: 197). The decision to purify the water moving the source of the *Anio Novus* into one of the Neronian lakes could be connected to the original function of these three artificial lakes, later explained.

However, after Trajan's restoration, at least in Building A, in the Late Antiquity, there were some modifications and additions, such as some bricked up openings and a possible heated bathtub, demonstrating that the pavilion was still frequented. Instead, after the Collapse of the Western Roman Empire, baths were reused by Saint Benedict as the mother house among his twelve (Camiz 2013: 207; Di Matteo 2005: 34; Federici 1940: 54; Fiore Cavaliere 1994: 13; Fiore Cavaliere *et al.* 1999: 142; Iannuccelli 1956: 109; Pujati 1816: 11) or thirteen (Caronti 1964: 103; Carosi 1956: 51; Tozzi 2022: 40) monasteries there. The pavilion was not damaged or destroyed, but modified: as a result, the rooms of the Neronian baths changed mode of use (Fiore Cavaliere 1994: 17-19; Fiore Cavaliere 1996). For instance, in the thermal *praefurnium* (**Figure 2**, room A) a kitchen was placed with an oven and, probably, the nymphaeum (**Figure 2**, room G) became a church. In this way, the villa-under-the-lakes became the Monastery of Saint Clemens: it was so until a strong earthquake that in the 12th century completely and permanently destroyed it (Di Giovambattista and Tertulliani 1996: 16; Mari and Fiore Cavaliere 1996).

Nowadays, just three of the five pavilions (**Figure 2**, Buildings A, B and D) are visible and just one of them, the above-mentioned baths (i.e. Building A), is accessible. Instead, the decoration got lost. Indeed, the marble slabs were reused in the nearby Monasteries of Saint Benedict and Saint Scholastica as part of their decoration. Possible frescoes and statues were dispersed, just some fragments are documented in the excavation reports: just three statues are traceable. The so-called Ephebe of Subiaco (Lanciani, in Fiorelli 1883) probably part a sculpted group of the dying Niobites (Mari 1994: 5; Mari 2008: 44) and a female head, related or not (De Lachenal 1979; Mari 1994: 5) to the same myth were moved to the Museo Nazionale Romano in Rome at the beginning of the 20th century. The third documented statue from Subiaco, instead, is a male bronze torso now in the Metropolitan Museum of New York (accession number 20.194): on the museum website it is reported to have been found in Subiaco and acquired in 1920 from Mr Boni, through Carlo Morelli. I have recognized in this bronze statue the one in a document of the State Archive in Rome:[1] it is dated 16 June 1905 and it reports the finding of a bust completely similar to the American one in dimension and shape, by the Piatti Company working in locality *Sorricella*. There, a *triclinium* (**Figure 1**, Building E) is thought to have been (Tomei 1984: 254). Interestingly, in the local dialect, *Sorricella* means 'small coast', identifying the area where a pavilion of the *Sublaqueum* was overlooking the lakes.

A different situation, instead, can be traced about the hydraulic structures, such as the lakes. Two of them disappeared from the local historical sources without an explanation or a date (Di Giovambattista and Tertulliani 1996: 9; Tozzi 2022: 47-50). The last and the upper one, instead, was affected by a flood

[1] Sovrintendenza Capitolina ai Beni Culturali, Archivio Storico e Disegni, Ripartizione AA.BB.AA, III versamento, II parte, busta 61, fascicolo 126: Subiaco, ruderi della villa neroniana.

Figure 3. Detail of the so-called fresco of The Miracle of the Goth by Sodoma in the Monastery of Monte Oliveto Maggiore in Tuscany (photo by the author).

on 20 February 1305 (Fabretti 1680: 73), when the chronicles of the Monastery of Saint Scholastica tell that some monks removed stones from the dam in order to make holes to empty the lake: they just weakened the dam, that collapsed. However, the last Neronian structure to fall was a bridge we are going to talk about. Probably, it crossed the just-mentioned and already-disappeared upper lake, connecting the thermal pavilion to a nymphaeum on the other border of the canyon (respectively Building A and D). This bridge was preserved, even if damaged, until the second half of the 14th century. This is proved by mentions in the local chronicles (Capisacchi 1573) and by some early-sixteenth-century frescoes by the Italian painter Sodoma, i.e. Giovanni Antonio Bazzi, in the Monastery of Monte Oliveto Maggiore in Tuscany about the life of Saint Benedict (Tozzi 2022: 58-62). There, precisely in the painting about the so-called Miracle of the Goth, a wooden boardwalk is shown to be attached to the arches of another one in blocks of stone on the right side of a river (**Figure 3**). I think that this fresco could be something very close to a photograph of the bridge between the two pavilions we are going to talk about.

The dams: a panoramic expedient or and hydraulic need?

After this historical and geographical introduction, it is fundamental dealing with the most demanding structures of this *villa*, the dams for the artificial lakes. A lot has been said about them: their position and reason behind them, even their quantity, have been much debated (for a specific dissertation Tozzi 2022: 132-139). About the latter aspect, Pliny (*NH* 109) said: *Ex alia parte Anio, in monte Trebanorum ortus, lacus tris amoenitate nobiles, qui nomen dedere Sublaqueo, defert in Tiberim*, talking about three lakes: this number is the most supported one, by me and by some scholars[2], whilst other scholars have sustained different hypothesises concerning the quantity of the lakes and their dams. Some of them, indeed, talk about a natural narrowing rather than an artificial obstacle, dividing a lake in two portions and creating three basins with two dams (Doronzo 2018: 21; Egidi *et al.* 1904). Others think about two Neronian lakes

[2] Abbate 1894: 764; Canina 1856: 158; Caronti 1964: 121; Carosi 1987: 16; De Rossi 1973: 286; Fabretti 1680: 72; Iannuccelli 1851: 16; Iannuccelli 1856: 16; Mari 1994: 4; Nibby 1819: 217; Parker 1876: 95; Smith 1970: 60; Tomei 1984: 250.

Figure 4. Locality La Parata*, with possible evidence of the middle dam (photo by the author).*

and a fifteenth-century third one (D'Orefice *et al.* 2014: 109-110), whilst Gori (1866: 26) talks about three lakes and four dams, with an upstream upper block.

In the same way, different hypothesises have been formulated about their position, also in relation to the just-mentioned debate about their quantity. In this speech, I propose in short my idea about their location on the base of previous studies, local toponymies and archaeological remains. One of them, that is thought to be the lower (**Figure 1**), was found by Mario Torelli in the 1970s near the sixteenth-century paper mill: unfortunately, nowadays the remains of this dam are out of reach because of the development of the factory and of the nature all around. About the middle one, I noticed possible evidence (**Figure 4**) in a very narrow stretch of the Anio gorge, in a locality with the telling name of *La Parata*, that literally and evocatively means 'the barrier' (**Figure 1**). Approximately in the same places, in the 16th century, the noble family Barberini built another dam and a channel to convey the surplus of water to the downstream paper mill: this event identifies this area as a strategic point for a hydraulic infrastructures. The third and upper dam, instead, was built very close to the thermal pavilion, in the place where, in the 19th century, the bridge of Saint Mauro was constructed (**Figure 1**). Thus, both the upper and middle dams were built in two narrow points along the Anio gorge.

However, especially the upper dam has been very controversial, because of the nearby remains of a structure (**Figure 5**), which connected the thermal pavilion (**Figure 1**, Building A) on the right side of the gorge and a nymphaeum on the left (**Figure 1**, Building D). Some scholars (Ashby 1935; Canina 1856: 158; De Rossi 1973: 286; Egidi *et al.* 1904; Fiorelli 1883: 425) have identified it as one of the dams. Nevertheless, a weak point of this identification is the territory morphology: indeed, the dimensions of the gorge, its transverse section in this point and the resulting volume of the upstream lake are clarifying and indispensable to think about the nature of the structure located there.

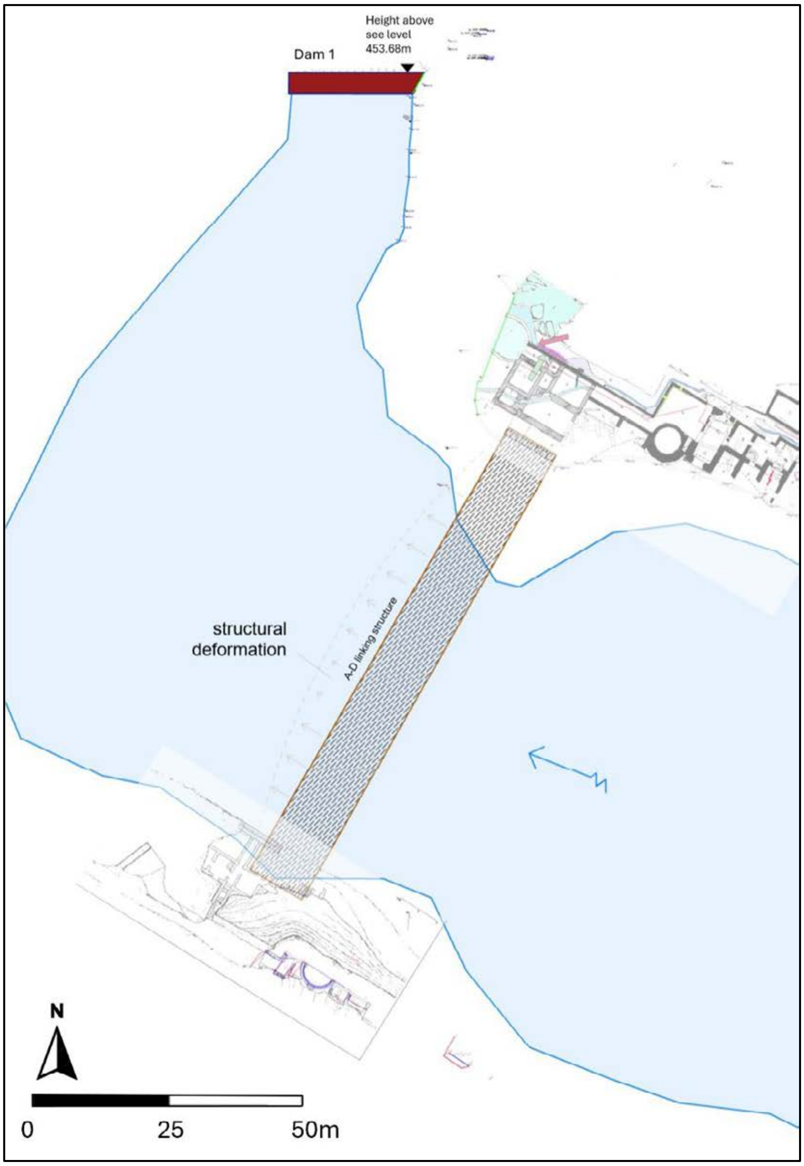

Figure 5. The upper dam (in red) and part of the related lake (border in light blue and a possible flooding area stressed with the hatching). Between Building A (Mari 2003) and D (Di Matteo 2005) the bridge and, downstream, the deformation pertinent to a possible dam there (elab. by the author).

The depth of the gorge, currently, is about 70m and, at the pavilions level, its sides are 60m distant. Certainly, nowadays its depth is higher than in Roman times, but probably not so much. To simplify, in this speech I chose to report estimates based on the current measures. The resulting thrust surface of the water on a potential dam there would be about 2000m^2. Comparing this data to the ones from other Roman dams in Europe and their reported dimensions (Di Matteo 2005: 102-103), there are dams with measures exceeding the ones in question, but not both depth and top length at once. In fact, generally the ratio of the dimensions seems to be high, but always with a remarkable difference between depth and top lenght; instead, the ratio of depth to top length in the supposed dam in Subiaco would be very close to 1, due to the similar value of the two measures. There is just a ratio similar to the one in question, i.e. the dam of *Glanum*, an arch dam in France. However, it was in a 22m large and 13m deep gorge, measures much lower than in Subiaco.

Furthermore, supposing a dam between the two pavilions. I made some evaluations. It should have had an average height of 30m, considering a maximum of 60m at the dam and a minimum of 0m, at the beginning of the lake, i.e. when the lake surface level and the natural level of the upstream river corresponded. The basin would have been averagely 64m wide (considering the highest and the lowest value) and 1817m (based on the contour lines). As a result, the hypothetical upstream lake would have contained 3,5 million m^3 of water. Such an enormous amount would have entailed a high structural deformation because of the water thrust (**Figure 5**), not tolerated by the structure abutments, still preserved attached to the thermal pavilion (**Figure 2**, room P and Q, the spans of two barrel-vaults).

Moreover, about 80m distant, where I have located the upper dam, the gorge narrows up to 20m, with a resulting thrust area on the dam of 120m^2, very much lower than the above-mentioned supposed barrier (**Figure 5**). With such an appropriate place, it seems very unlikely a dam in a very disadvantageous position close to it. Furthermore, as it has been already reported here, the local chronicles distinguish the upper dam, collapsed at the beginning of the 14th century, and the bridge, preserved until the mid-century and probably represented in the above-mentioned fresco by Sodoma (**Figure 3**).

Since the structure between the two opposite buildings was not a dam, it was more likely a bridge across the upper lake. In the local chronicles, close to the Monastery, two nearby bridges are reported, one called *pons mire magnitudinis*, impressive in dimension, and the other *pons minimus*, a smaller one. Considering highly probable that on the three dams there were overpasses to cross the lakes, they were respectively the structure between the two pavilions and the close upper dam. Consequently, it is spontaneous wondering the reason why a long and challenging bridge was necessary very close to the upper dam.

Probably, a so demanding structure in dimension and position should have been crucial not just for the use of the pavilions, which were served by the bridge on the aforementioned dam, but for the construction phase. First of all, a foreword is required. In Subiaco there are two calcareous stones, a white compact calcarenite (**Figure 6**, in dotted orange) and a brownish alveolar calcareous tufa (**Figure 6**, in striped blue), locally called *cardellino*.

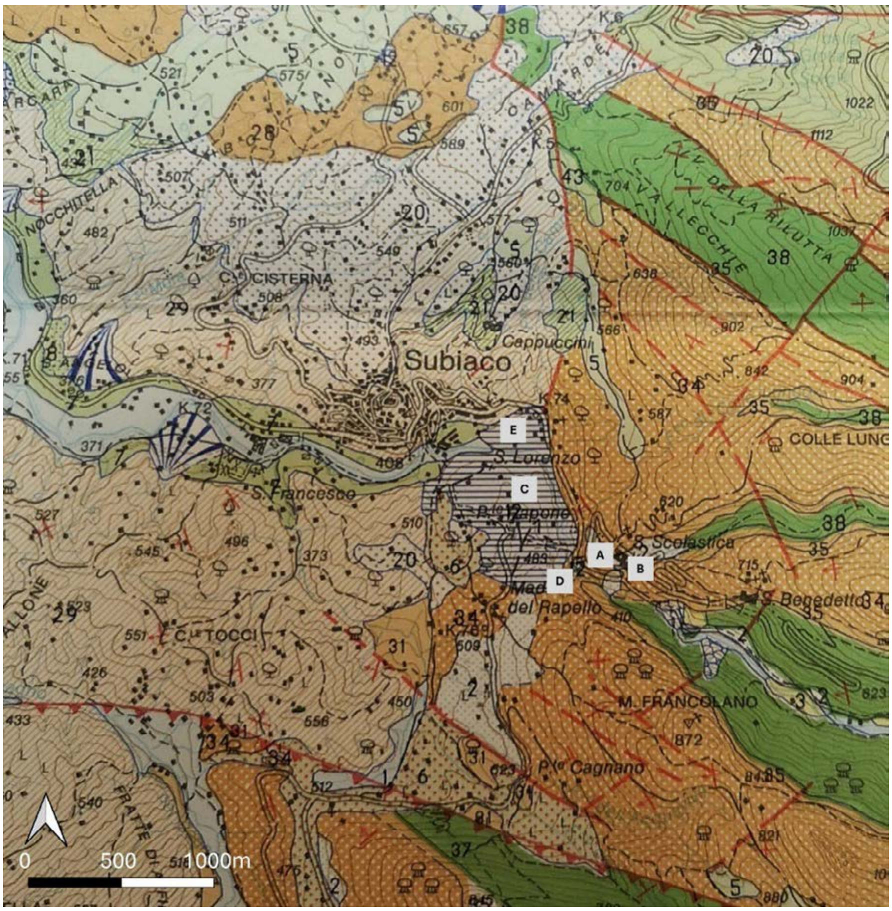

Figure 6. The detail with Subiaco of the Carta Geologica d'Italia*, sheet 376, with the letters of the five Neronian pavilions (elab. by the author).*

Both were used for the Neronian buildings, but their quarries were on the opposite sides of the Anio gorge, where the two pavilions in question are: the first stone, constitutes the Mons Taleo, where the thermal pavilion, and the second Mons Francolano, where the nymphaeum is located.

After this necessary break about local building materials, we return to the bridge between Building A and D and the upper dam. Necessarily, the first was built before the latter and so before the lakes, to avoid an unnecessary underwater construction in a deep gorge. Moreover, the bridge was strictly structurally connected to the two pavilions. Especially the thermal building, as it will be analysed, is nestled in the compact calcarenite quarry, previously excavated both to have room for the construction and to reuse the stone for it.

In this view, the first works were related to the quarries, followed by the construction of the bridge, whose pillars are made of the compact calcarenite. It is at least evocative noticing that in the above-mentioned Miracle of the Goth fresco (**Figure 3**) by Sodoma the bridge arches on the right (before the wooden addition already said) seem to be made up by some whitish blocks of stone, very similar to the ones in compact calcarenite archaeologically evident. However, once the foundation of the bridge was ready, the pavilions were built, moving both the types of stone across the bridge. In this way, it was first a solution for the construction to cross the empty gorge, then a bridge on the lake to enjoy.

Summing up, there were three dams and at least a monumental bridge and it is spontaneous wondering why this demanding hydraulic structure. Some scholars, such as Abbate (1894: 764-765), have interpreted the lakes as a way to create a wonderful landscape. An Italian scholar, Federico Di Matteo (2005: 172-173), has thought, instead, Nero wanted to create a Nilotic landscape in Subiaco, but no Egyptianizing items or Egyptian marbles have been found there. In my opinion, none of aesthetic structures, especially the most challenging, was done without a practical aim attached. In this view, the main will of the Neronian architects could be to allow the water supply from the Anio River filling its deep gorge and purifying the water through two upper lakes for the so-called Building E (**Figure 1**). It was the lowest and it has interpreted as the residential pavilion. Not one, even three artificial lakes, could have worked as settling basins, decanting the water twice and removing any impurity. Not by chance, in the 2nd century, when the water used to arrive dirty to Rome, Trajan moved the *Anio Novus* source into one the lakes. So, a wonderful landscape was just a collateral result and a value added, not the inspiring idea.

The Neronian baths: a case study in water management

As it has been said, nowadays the only accessible pavilion is the thermal one, called in the studies Building A (**Figures 1-2**). The monastic reuse as the benedictine mother house in Subiaco is the reason both of its preservation and its modification throughout centuries. During the last excavations in the 1990s (Mari 2003), the two lives of this building have been investigated, as it has been already explained. The third part of this dissertation starts from those data and compares them to a new observation of the site, to focus on the water management of the Neronian baths.

The anti-rainwater system: the gap-corridor a

Of the proper baths, archaeologists have found a raised tank (**Figure 2**, room C), the *calidarium* (**Figure 2**, room D), the *praefurnium* (**Figure 2**, room A) and, in it, a possible Late-Antiquity heated bathtub, all of them in the eastern wing of the pavilion. Anyway, this building is nestled in the quarry on Mons Taleo used to bring the above-mentioned compact calcarenite (**Figure 6**, in dotted orange). In addition, Subiaco is a highly rainy territory as shown by the name of the local mountains to the right of Anio river: this chain is called Simbruini, that in Latin literally means 'under the rain'. As a result, rainwater would have been a problem for a building strictly connected to a quarry. For this reason, a ramified hydraulic system was projected both to avoid the functioning of the thermal rooms and to manage the rainwater.

For these intents, it was obtained a corridor, called *a* (**Figure 2**, in light blue; **Figure 7**), running between the backside of the building and the cut face of the Mons Taleo, to insulate the structure from the back mountain. Along this gap, two channels (**Figure 2**, in indigo) were dug in its rock floor, the eastern one behind rooms B and A and the western one, the longest, behind rooms H and M, both parallel to the back walls. Their function was to allow the water from the mountain and from the roofs to flow away.

The functioning of such a rainwater disposal system is particularly evident on the west side of the archaeological site. Unfortunately, the use of the western rooms is not archaeologically evident: this

Figure 7. The gap-corridor a*: on the left, the artificially cut rocky wall and, on the right, the backside of pavilion A (photo by the author).*

lack of data is due to the unpreserved noble level there, except for room H (**Figure 2**), with holes for the metal brackets of the disappeared marble slabs, and room M (**Figure 2**), that was a corridor as it is deducible from its shape. Instead, rooms R-X (**Figure 2**), which constitute a quadrangular block, were certainly under the unpreserved noble floor at the same level of the above-mentioned bridge and so they were functional spaces. However, behind this western wing, along the channel in the gap-corridor, there are two basins (**Figure 2**, in lilac), one in the external corner between rooms H and M (Basin aHM)[3] and one behind room S (Basin aS). Evidently, rainwater flowed into them. In the basins, there are some deep brick wells, as the ones found in the 1990s (Mari 2003) behind room S. Through these two wells, the water could cross the walls under their foundation. On the other side, under the backwall of the service room S (**Figure 2**), it is visible a nozzle that allowed the water to enter a narrow collector gutter (**Figure 2**, in azure) on the floor and then a deep and large sewer (**Figure 2**, in light blue), running through the whole building.

Rooms H and G: two different variations of the rainwater system

A similar ramified system is evident behind and in room H (**Figure 2**). There, the north-west portion of the foundation for the unpreserved floor was the rock surface of the flattened mountain: it was cut in correspondence of the northern and western walls foundation to create a channel parallel to them (**Figure 2**, in green). There, the water arrived from the gap-corridor *a* (**Figure 2**, in light blue) through two nozzles (**Figure 2**, in light green), under forementioned walls. Behind the northern one, a brick well (**Figure 8**) in corridor *a* (**Figure 2**, in light blue) came across when I literally fell into it. In the gap-

[3] For this speech, the author has chosen to refer to elements in the Corridor *a* calling them *a*- followed by the letter associated to the room they are behind.

Figure 8. The brick well near the northern wall of room H (photo by the author).

corridor, the level of the irregularly flattened rocky floor, where the above-mentioned western channel is. It is upper than the room H floor. Between the raised southern border of the channel and the parallel back wall of room H there is an elongated hollow running, where the well at issue is located. Thus, it and the nozzles were probably part of an overflow system, to empty the corridor when it was too full.

However, I report a difference between the 1990s planimetry of room H (**Figure 2**) and the nineteenth-century ones after the first excavation campaigns in the thermal pavilion. The site was dug for the first time by a monk of Saint Scholastica, Mellito Dolci, between September 1818 and March 1819, finding twelve rooms. The results of this research were reported in an annotation on the edge of a copy of the seventeenth-century Chronical of Subiaco by Cherubinus Mirtius from Treviri kept in the Saint Scholastica Monastery archive (Dolci 1819). The rooms discovered may be seen in a survey by Nibby, who visited Subiaco and the *villa* in 1827: representing the building (Nibby 1827: 64-66), he drew room H (**Figure 2**; called by him room a) differently to the modern plan and similarly to the one (Mari 1994: 6) by Lanciani at the end of the 19th century. He led the first proper archaeological campaign, before the construction of the road in front of the thermal pavilion.[4] Both in Nibby's and Lanciani's (Mari 1994) planimetry, in room H (**Figure 2**) there was a nowadays missing southern wall discovered. Currently, instead, nothing has remained of this structure, at least on the 1990s excavations by Mari. On the floor, there is just a depression along the southern horizontal portion of the room, probably due to the large sewer evident in the western wing of the site (rooms R-T) and in room G (**Figure 2**), east to H.

Room G was one of the most impressive settings of this pavilion and of the *villa*. In addition, it has shown one of the most interesting pieces of evidence about the construction of the *Sublaqueum*. The room was,

[4] For further information see Tozzi 2022: 120-122.

indeed, a scenic nymphaeum overlooking the upper artificial lake and nearly opposite to the other one on the left side of the gorge (Building D). However, what the archaeologists discovered at the end of the 1990s is that room G is just the second nymphaeum built there: it was predated, indeed, by another one underneath, slightly differently orientated (not north to south, as the second one, but north-west to south-east). There, it was found the floor in Italian Bardiglio marble slabs *in situ* and the collapsed 'camorcanna' vault, i.e. the reed matting of the false vault ceiling with evidence of the original decoration in plaster, glass mosaic *tesserae* and shells (Mari and Fiore Cavaliere 2001: 270-274; Mari 2003: 237-242; Mari 2008: 47). However, this nymphaeum, called room G1 (**Figure 2**), was probably destroyed by the collapse of the artificially cut rock face. To replace it, on the first nymphaeum a second one, Room G2 (**Figure 2**), was built and its apse is still preserved. The two of them are considered to have been built under Nero's reign.

Anyway, the nymphaeum was strongly characterized by the presence of water. There, the water supply was permitted by a no more existing central pipe (**Figure 2**, in orange) at the unpreserved floor level. It brought the water from the back corridor to the nymphaeum, crossing the wall in the middle of the apse. Aside there were, four fountains, as it may be deduced from four holes (**Figure 2**, in yellow) on the semicircular wall. The western one corresponds to a groove in the east wall of room H, where there was a later removed lead pipe. The pipes of these fountains were fed by the rainwater of the corridor, but especially by the raised a tank (**Figure 2**, room C) used for the thermal rooms. The exceeding water of the nymphaeum went certainly under the unpreserved floor, where part of the mouth of the sewer is still evident.

The water dumping

The just-mentioned sewer was the main channel to collect the whole water of the site, crossing it to east to west (**Figure 2,** in light blue): it has been documented in rooms G, S. R and T and so it continued also under H, where an elongated depression on the ground is evident, and under M. Thus, it was the artery of the thermal pavilion, allowing the water management: the whole surplus from the rooms, indeed, was dumped into this sewer and then into the front artificial lake. In fact, the last preserved part of this channel is still evident west to room T (**Figure 2**), close to the modern enclosure and the current gate. There, I reconstructed its border on the basis of the contour lines of the area upstream to the upper dam. Towards Building A, I added a blue hatching (**Figure 5**) to represents the area at the same level of the lake surface and corresponding to a meander of the gorge. Likely, this part was occupied most likely by the very lake, at least when it was in flood, as it is evident from some brownish calcareous concretions under the impost and the haunch of the first damaged vault (**Figure 2**, room P) of the A-D bridge.

The N-sector

To the south, in the corner between the eastern and the western wings, there are some low walls delimiting five spaces. Two of them were called in the excavations room O and N, while I refer to the others as room N1, N2, N3 and N4 (**Figure 2**). There four of them have a completely different orientation not perpendicular to the cut back mountain, as well as all the other rooms, but rotated 45 degrees to east. As a result, the four rooms N1-N4 are perpendicular to a curve of the gorge in front of them. Thus, the common point among all the rooms is to be perpendicular to the lake. In general, the building is orientated to south, to provide light all day long. In the case of the differently orientated rooms, the aim could have been creating a scenic terrace over the lake. Indeed, the 1990's excavator (Mari 2003: 221-223) hypothesised these rooms to be substructures both to sustain upper spaces and to support the soil.

However, there are two cuts in the rocky soil: they are parallel to the northern wall of N1 and to the eastern curved wall of N4. Thus, the rocky bank was specifically cut for the construction of this part of

Figure 9. The sluice gate in mortar and calcareous tufa blocks which closes basin aVW to the west (photo by the author).

the pavilion. Moreover, in rooms O, there is the upper step of a staircase used to enter the noble floor of the pavilion through the corridor, i.e. Room M. In the nineteenth-century planimetry by Lanciani (Mari 1994: 6) in Room N, west to Room O, another staircase is documented to go to the same corridor M. So, rooms N and O were nobly frequented, and not just service spaces. In particular, in the case of rooms N1-N4, south to room N, there are two resulting possibilities: that they were used to have access to the room N staircase, or also they were occupied by it. Anyway, the current situation does not allow to clearly notice the presence or the absence of a front wall to close rooms N1-N4. In the latter case, they would have been opened and exposed to the front lake water. They, indeed, fill diagonally the corner between the first arch of the bridge, where evidence of water presence is documented, and room N, where some channel and nozzles have been found. However, only suggestions about this part are possible so far.

The western sector: a different water management

After this dissertation about the eastern and the central part of the pavilion, now we consider the western sector, where a different water management system is evident. As it has already said, behind room S, there is basin aS (**Figure 2**, in lilac), excavated in the rocky bank. There, in the 1990s two wells where found. Next to this basin, behind rooms W and V, there is a narrower one, cut in the rock and called in this speech aVW (**Figure 2**, in purple). Differently to the previous one, basin aVW is closed on the western side by a sluice gate (**Figure 2**, the magenta arrow) 0.5m thick made in blocks of the local *cardellino* and mortar. This lock occupies the 0.26m large gap between the foundation of room V backside and the artificial little spar of basin aVW (**Figure 9**). It is not a following addition, but it was created at the same time of the construction of the building: this may be deduced from the absence of any interruption between the foundation of the forementioned wall and the sluice gate, representing the same archaeological activity. To clarify the function of this lock, it is useful to underline that it is at is its level, the same level of a groove (**Figure 3**, the light green arrow) of an unpreserved pipe in the back wall of room V. This split in the wall is 0.7m high and 0.17m large with regular borders. This profile was damaged when the pipe, that crossed the wall in this point, was removed. The original pipe carried the water to room V, but it is not possible deducing what the water was used for, because the scarce preservation of the room. However, the sluice gate seems to have made the water arrive to the pipe level.

However, west to this lock, the gap (**Figure 2**, in darker blue) between the mountain and the pavilion continues. North to it, there is a raised area called Z (**Figure 2**, in aquamarine). This is an area of the mountain that was roughly levelled. In fact, it remains very irregular due to the presence of at least

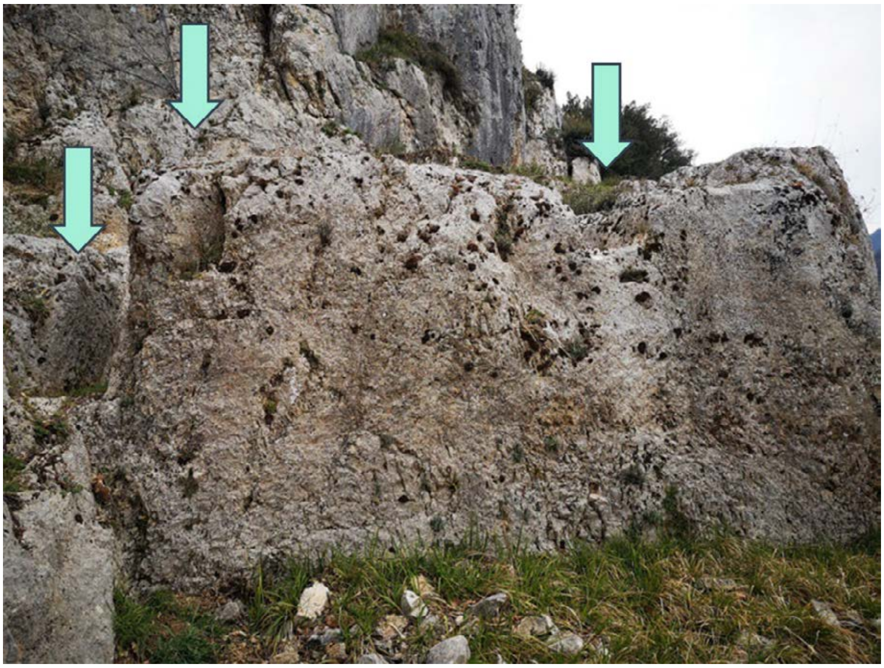
Figure 10. Area Z with its possible channel dug in the rocky bank (photo by the author).

three horizontal spurs sticking out from the rocky soil. Area Z was interpreted as part of the quarry of compact calcarenite by Mari (2003: 201), when he excavated the pavilion in the 1990s. In particular, the above-mentioned spurs seem sketched blocks of stone ready to be extracted and then left *in situ* (**Figure 2**, in aquamarine). Anyway, between them, there are some deep grooves on the floor (**Figure 10**). Certainly, the rainwater funnelled through them and then it fell. As a result, brownish calcareous deposits are still evident at the base of the rocky wall under the grooves on top. So, the entire area of the pavilion was certainly used as a quarry at the beginning because, otherwise, there wouldn't have been room for the building, but in the grooves, originally left between the unused sketched blocks in Area Z, rainwater flowed because of their depth and slope.

Through them the water fell into the western part of the gap-corridor (**Figure 2**, in darker blue), where the forementioned deposits are. Here, there is room Y (**Figure 2**, in lighter blue). In that portion of the corridor *a* (**Figure 2**, in light blue) and at the basis of one the already-mentioned grooves on top, it seems to have been dug a channel on the rocky floor, currently covered but evident in the pictures of the 1990s excavation (Mari 2003: 233). This potential canal, connected to one in Area Z, seems to cross transversely the gap-corridor towards the border of room Y. On it, there are some holes, possible nozzles, the water passed the room. It has been interpreted (Mari 2003: 226) as a fishpond, due to the discovery of a hook, during the last excavations in the 1990s. Obviously, the fish supply could have been guaranteed by the artificial lakes: indeed, the Anio river in Subiaco has been always rich in freshwater species such as trout (i.e. *Salmo trutta fario*). For this reason and for its scarce dimension, the tank was probably just to take delight in. Unfortunately, any hypothesis about the whole fishpond cannot be developed because of the damage of its west side and of the absence of its evidence between rooms Y and V, east to it (**Figure 2**).

Some provisional conclusions

In conclusion of this dissertation about the Neronian *villa* in Subiaco, it is evident that it was an impressive palace both for its construction and its organization. It fascinated a lot of European artists who travelled to Italy for the so-called *Grand Tour* in the 19th century (Tozzi 2022: 88-110). These drawings and painting represent the first signs of the thermal pavilion and the nymphaeum. However, this was not the beginning of this phenomenon: indeed, ideal representations of the *villa* and its structure may be recognized both in the above-mentioned pictorial cycle by Sodoma near Siena and in a 15th-century fresco (Tozzi 2022: 60-61) by Perin del Vaga, Raphael's pupil, in the Colonna Family banquet hall of the Subiaco Abbatial Fortress. These documents, together with historical maps (Tozzi

2022: 61-96), such as an unpublished one of the 18th century by Placidi (Tozzi 2022: 155-158), show precious details and pieces of information about this place. However, these aspects deserve a specific dissertation. In this speech, I just underline that a study of the *Sublaqueum* should not forget the whole territory and different kinds of documents.

As it has been already said, such a challenging structure, with its pavilions, the quarries excavations, dams and lakes (**Figure 1**) required a not-indifferent effort. Unfortunately, the current conservation and exposure limit more detailed reports and new hypothesis about the whole *Sublaqueum*.

However, the investigated portion of the hydraulic system has revealed the great potential of the *villa* in Subiaco. The three dams, whose position (**Figure 3**, arrows) I have expressed my opinion about, could have worked not just as scenic structures, but also as functional infrastructures for the water supply and purification.

Moreover, in the thermal pavilion it is still evident a ramified system (**Figure 2**) of channels, both excavated in the mountain and built in bricks, for the water management in this building. There, indeed, the water was essential both for the rooms and for scenography reasons. The high rainfall in Subiaco was useful to collect water in at least one tank still preserved (**Figure 2**, room C with the violet arrow). The water flew through some channels to be carried elsewhere: three basins (**Figure 2**, aHM, aS, in lilac and aVW in purple) conveyed it into vary drains and pipes for its use in the thermal pavilion in different ways. Thus, this engineering effort was primarily necessary to avoid the water being in contact with the structure, not to damage it. Indeed, the proximity of the mountain, the pavilion had been nestled into, could be a problem for its preservation. A secondary aim achieved though this ramified system, however, was not to waste a precious resource, but to recycle it, conveying it to the rooms where it was necessary.

Likely, also the front lake was a source of water, but the collapse of the sector near it (i.e. the southern portion, because of the twelfth-century earthquake) (**Figure 2**) does not allow to understand how water supply worked there. The surplus, however, was dumped into the upper lake. So, there was a round circuit, to make a potential problem a resource: an example of sustainability, very popular in these days, and an interesting case study for the Roman water management and supply. A new model of water-integrated *villa* divided in pavilions, which spread all over the Roman world.

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Late Antique Transformations in Water Provision, Management and Distribution in the Thermal Bath Archaeological Park of *Baiae* (Bacoli, Naples)

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Abstract: the Archaeological Park of *Baiae* is a large site in a very dramatic location. Lying on the slop of the 'Sella di Baia' hill, huge buildings (with pillars, porches, gardens and many water fountains) facing the *Lacus Baianus* and overlooking the Bay of *Puteoli* and Mount Vesuvius far away. Here, for almost five centuries (end of the 2nd/1st BC – 4th AD), the Roman aristocrats spent their relaxing holidays in the renowned *otium* of the *pusilla Roma*, as *Baiae* was called. Several large domes were raised including bathing systems and many underground structures and their transformations over time are an interesting guideline to better understand the use and the destiny of the main water supply of Campania: the Serino aqueduct (the famous *Aqua Augusta* built by the Emperor Augustus for the Royal Navy at *Misenum*). The modifications suffered by the different sectors of the archaeological area are important not only to surface the building phases, but also to have a clearer idea of what happened to the aqueduct in the years: integrating bibliographic data with theoretical insights, closer research methods and procedures of data analysis, this research obtained new results on the history of the Roman aqueduct in *Baiae*, above all on its Late Antique period. In fact, they will be able to explain well all the different transformations recorded on drainpipes, water tanks with large layers of limestone, wells and rooms turned into cisterns.

Keywords: Aqueduct, *Baiae*, *Aqua Augusta*, 'Villa dell'Ambulatio', Water supply.

The *Aqua Augusta* at *Baiae*

The Thermal Baths Archaeological Park of *Baiae* (Bacoli - Naples) is a large site that sits in a very dramatic location (**Figure 1**). Lying on the slope of the 'Sella di Baia' hill, huge buildings (with pillars, porches, gardens and many water fountains) facing the *Lacus Baianus* and overlooking the Bay of *Puteoli* and Mount Vesuvius far away. Here, for almost five centuries (end 2nd/1st BC – 4th AD), the Roman aristocrats spent their relaxing holidays in the renowned *otium* of the *pusilla Roma*, as *Baiae* was called (D'Arms 2003). Several large domes were raised including bathing systems and many underground structures and their transformations over time are an interesting guideline to better understand the use and the destiny of the main water supply of Campania: the Serino aqueduct (the famous *Aqua Augusta* built by the Emperor Augustus for the Royal Navy at *Misenum*, when Marcus Vipsanius Agrippa was *curator aquarum* in Rome, between 33 and 12 BC). As known the *Aqua Augusta Campaniae* was aimed at providing fresh water to civil and military settlements in the Phlegraean Fields (Keenan-Jones 2010; Genovese 2018: 217). Although we can no longer establish with certainty how it had to obtain water for the long journey it travelled, it is likely that it drew from various sources, winding mostly through underground tunnels and providing numerous branches that served the various centres located along its route.

The *Aqua Augusta* is exceptional in size (103km the main trunk and 60km the branches) and technical complexity. It tapped large springs and run mostly underground. The main springs were in the area of Serino, south of *Abellinum*. The choice of the springs of Serino area as *caput aquae* of the aqueduct appears bold and extreme for the technical possibilities of the time, but the springs on the right side

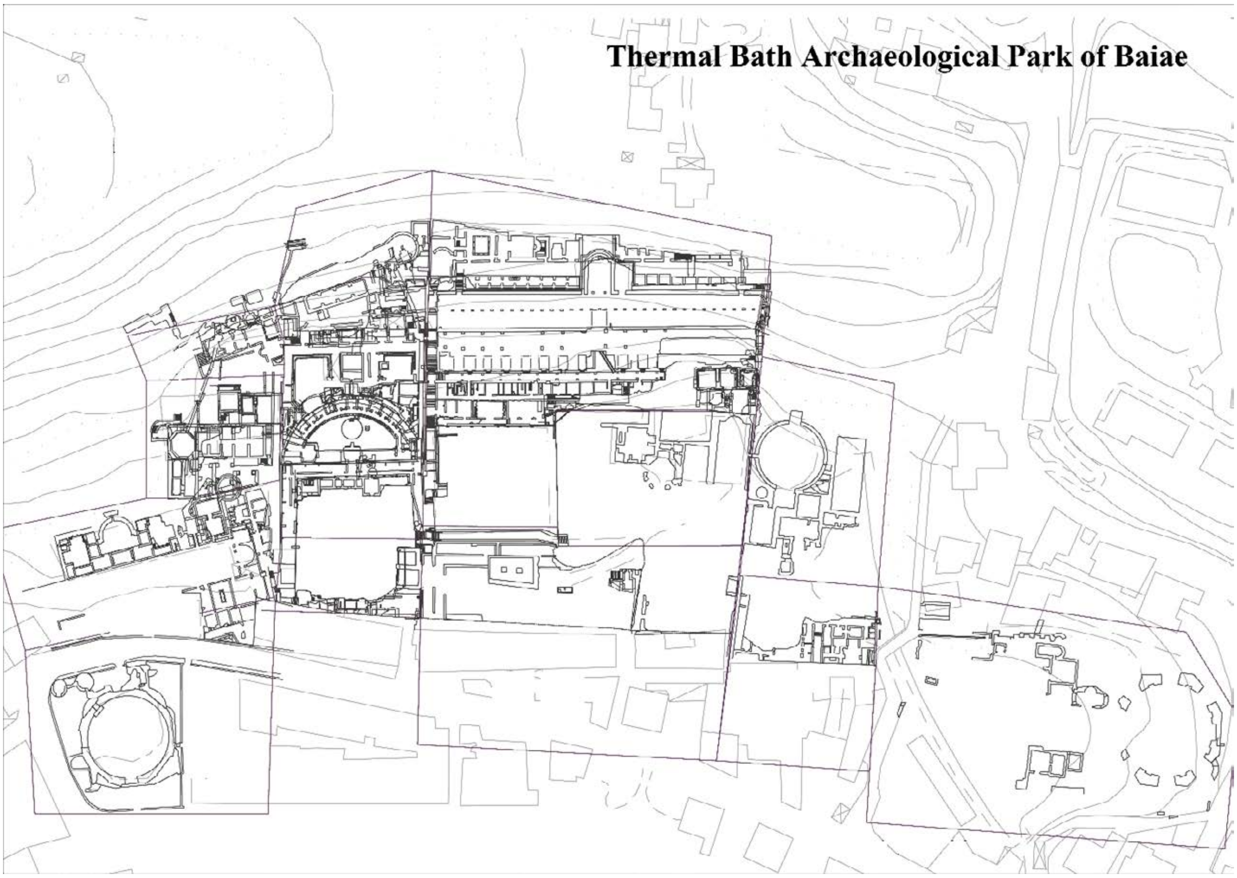

Figure 1. Baiae: *Thermal Bath Archaeological Park. Plan (elab. by M. Nieberle).*

of Clanis river had to be excluded because of the overcoming of the Clanis valley would have entailed very long and high arches. It was also necessary to rule out the use of the springs of the *Sarnus* river as a possibility, because they were at a low altitude (30m a.s.l.). Thus, only the rich springs of Serino area remained, offering abundant high-quality water. It also left branches to important ancient cities, such as *Nola*, *Neapolis* and *Cumae*. The main branche skirted *Neapolis* (some of its arches are still visible in the so called 'Ponti Rossi') and reached the port of *Puteoli*, the Augustan *Portus Iulius* Navy harbour, the wealthy villas facing the Lucrino Lake and the *Lacus Baianus* and *Misenum*, after leaving a side branches to Cuma, explaining the considerable investment, estimated between 140 and 450 million sesterces (Keenan-Jones 2010). In the last 20 years several hydraulic infrastructures have been identified and explored and according to their position, elevation and morphology, most of them can be attributed to the *Aqua Augusta* (Ferrari *et al*. 2018). The segments going from *Puteoli* to *Misenum* are the most interesting to our research. Got past *Puteoli*, the *Aqua Augusta* ran towards *Cumae*, turning around the northern side of Lake *Avernus*. A branch reached *Cumae* by gallery and another branch, after turning around the southern side of the Lake and running for a while on arches, headed towards *Baiae* and *Bauli* and reached *Misenum*.

The data are helpful in checking and better understanding how and where it passed through and what it was also for. Most of the underground sections have been dug out into the volcanic rock and they don't have masonry but only a thick layer of *opus signinum*; the sections with a masonry have been realized with two different techniques, the *opus reticulatum* first and yellow ashlars of different size and very thick layers of concrete, later (**Figure 2**) (Ferrari and Lamagna 2015). We know from the inscriptions at Rome the imperial administration exercised some control over the augustan aqueducts

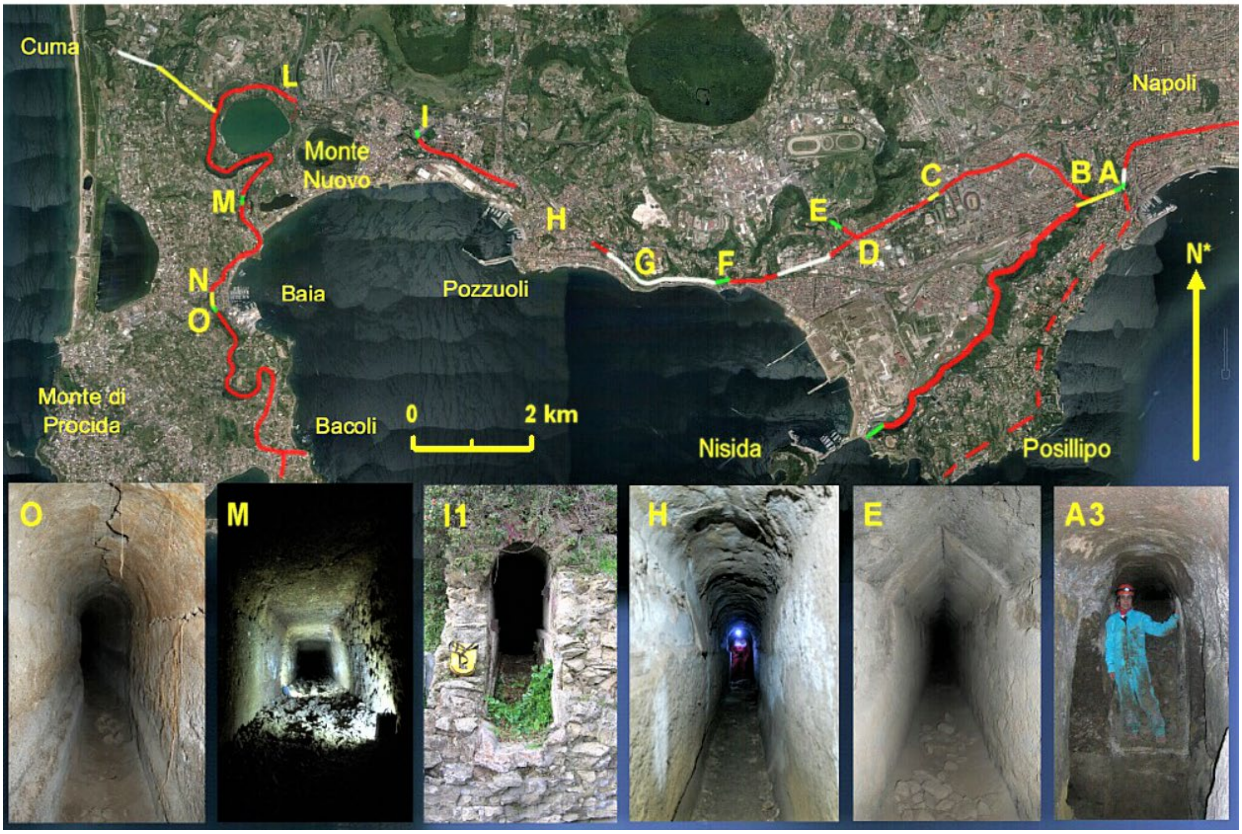

Figure 2. Baiae: Aqua Augusta, *underground sections (adapted from Ferrari and Lamagna 2015: 2, fig. 1).*

in this period. Where the status of the private users on the stamps can be determined, they are members of the Rome-based senatorial class. At Rome, a letter from the emperor was required to gain a private connection and the imperial favour was a factor in accessing the *Aqua Augusta* (Keenan-Jones 2010; Camodeca 2018).

The well-known Scalandrone inscription (**Figure 3**) informs us the *Aqua Augusta* was already working in AD 10 and it seems likely it served the several villas overlooking the *Baianus sinus*, where Gianfrotta points us the finding of a cippus with a number close to a pillar and he quotes it was related to a side branch of the aqueduct running on arches and reaching the sea front where most of the luxury villas were, including the imperial estates. This area is now called 'Punta Epitaffio' and it is under the sea level (**Figure 4**): it is the place where the imperial villa of Claudius was and where most of the Roman aristocrats had their own houses (the Piso family, *Cassius Frugi* and many others) (Gianfrotta 2012: 292-293). The same area is the only part of *Baiae* where segments of a road have been identified and it's likely the aqueduct or an independent branch was nearby to serve the villas (Libertini *et al*. 2017).

Already in the 1st century AD there was a competition between the main cities for the *Aqua Augusta* control and Cuma was the first to have its control for the strong bonds with Augustus, then *Puteoli* became the leader in water control, and it had it until the end of the 3rd century. Campania became a province with imperially appointed governors in the late 3rd century AD and since the moment, only the emperor could control the water management. After this time, there is no further evidence for municipal administration but clear evidence for imperial involvement: the Constantine inscription (**Figure 5**) and the *Codex Theodosianus* are clear examples. The inscription dates to the years AD 324/326 and regards repairs which took place at that time to carry the water to several cities attested by the same text: *Puteolis*, *Neapolis*, *Nola*, *Atella*, *Cumae*, *Acerrae*, *Baiae* and *Misenum* (Camodeca 2018).

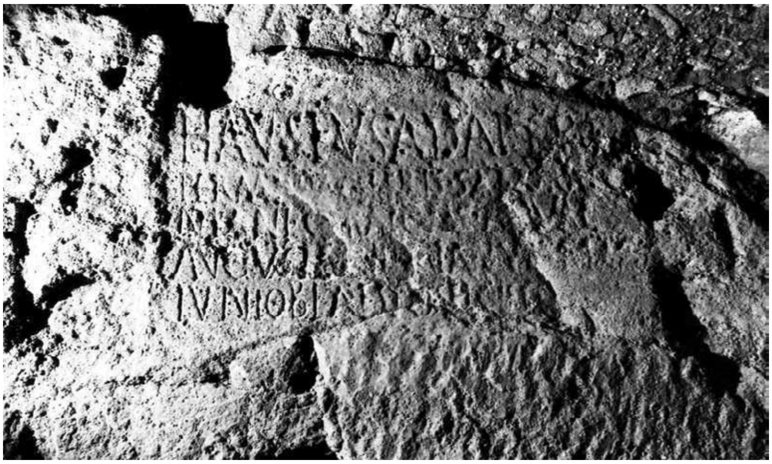

Figure 3. Baiae*: Scalandrone's inscription (photo by the author).*

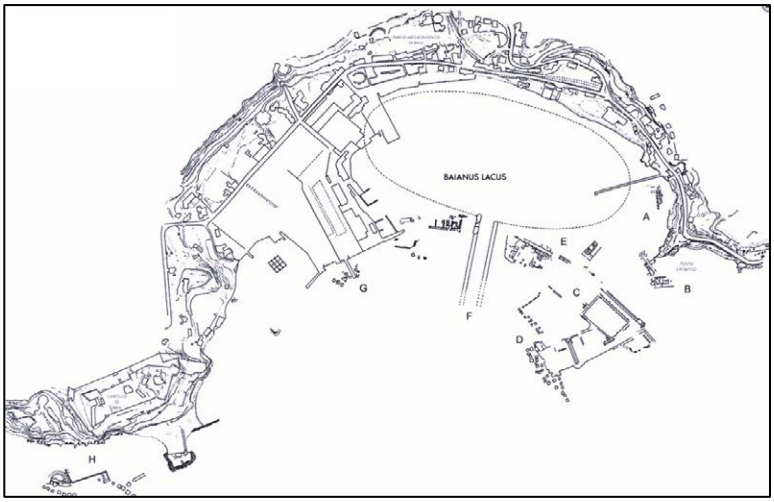

Figure 4. Baiae*: Archaeological plan (adapted from Gianfrotta 2011: 22, fig. 5).*

The last dates back to AD 399 and it reminds us of repairs and decisions regarding the use of Augusta's water. Currently the imperial administration seems also to now have, in theory at least, complete control of the use of its water, being able to ban all private connections (Biavaschi 2018: 105-108). However, it is known that Alaric, in AD 410, devastated the Campania region as well, and seriously damaged the aqueduct in some key points. From AD 465 Campania suffered numerous incursions by the Vandals coming from the sea and the Vesuvian eruption of AD 472 would have blocked its functioning at all, if it had been still running. In AD 536, when Belisarius penetrated *Neapolis*, the cut of the aqueduct to enter the city seems to indicate it was inactive for many decades and the city was already served by a more ancient aqueduct (Savino 2005).

The *Aqua Augusta* on the 'Sella di Baia' hill

The modifications suffered by the different sectors of the archaeological area of *Baiae* are important not only to surface the building phases, but also to have a clearer idea of what happened to the aqueduct in the years. In fact, a truly particular development in the history of the aqueduct has been highlighted by the most recent analyses of archaeological data.

We start from the so called 'Villa dell'Ambulatio' (**Figures 6-8**): it is a big villa built on terraces dating back to the 1st century BC. The villa has been used until the middle age. Even if it is not possible to be sure about its original layout and structure (because it has been not only transformed many times in the past, but also because it has been restored in the modern age after the excavations) it has a large number of cisterns and drainpipes on each single level. Originally the water provision was based on the rainwater and there were cisterns everywhere. If we consider the villa built in the late 1st century BC and the *Aqua Augusta* already working in AD 10, we can say in the first phase the villa was not connected with the aqueduct: at this moment its water supply was through rainwater and possibly local sources. The life of the villa was interrupted by a natural disaster after which a large part of its northern side was strongly damaged and abandoned. For this reason, the villa itself was abandoned. It is most likely that the structural failure was due to the downward sliding of the ridge due to bradyseism or a change in the regime of the spring waters, which could have caused infiltrations and damage to the buildings. Subsequently, it was determined that the structures had collapsed, however, they were no longer restored. Instead, in place of the hole left by the landslide, the rock face was made safe and the space below was cleared of rubble. In the meantime, previously unknown thermal waters had come to the surface or, probably, had emerged following these seismic events.

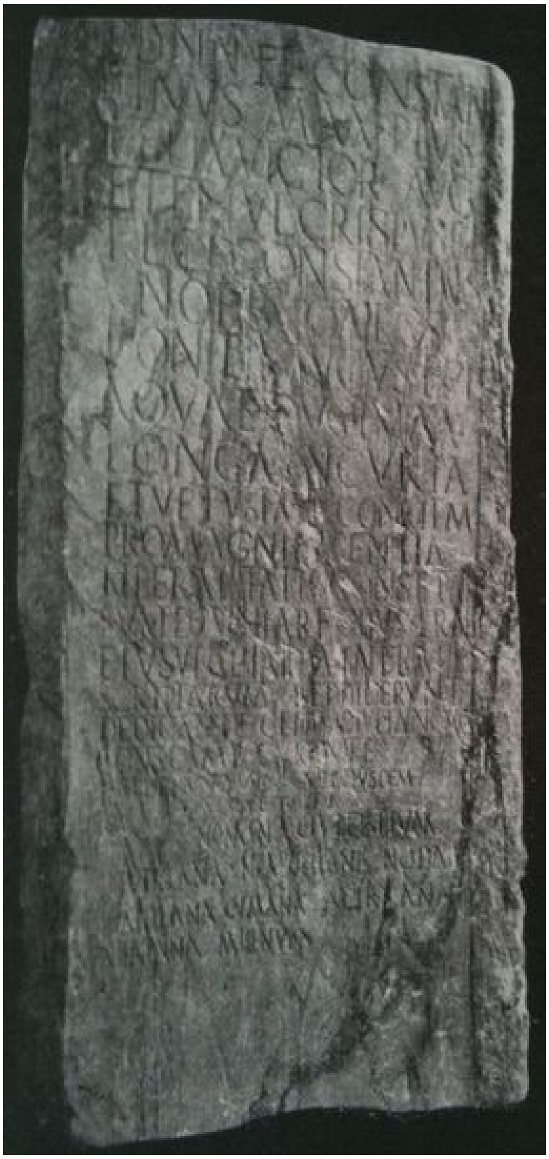

Figure 5. Baiae: *Constantine's inscription (adapted from Camodeca 2018: 21, fig. 1).*

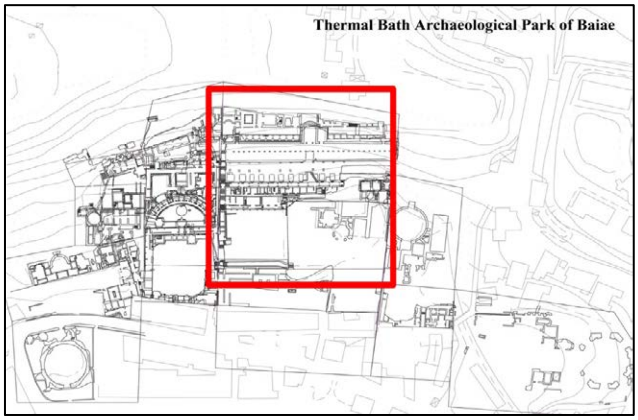

Figure 6. Baiae: *Thermal Bath Archaeological Park and the 'Villa dell'Ambulatio' plan (adapted by the author on the elab. by M. Nieberle).*

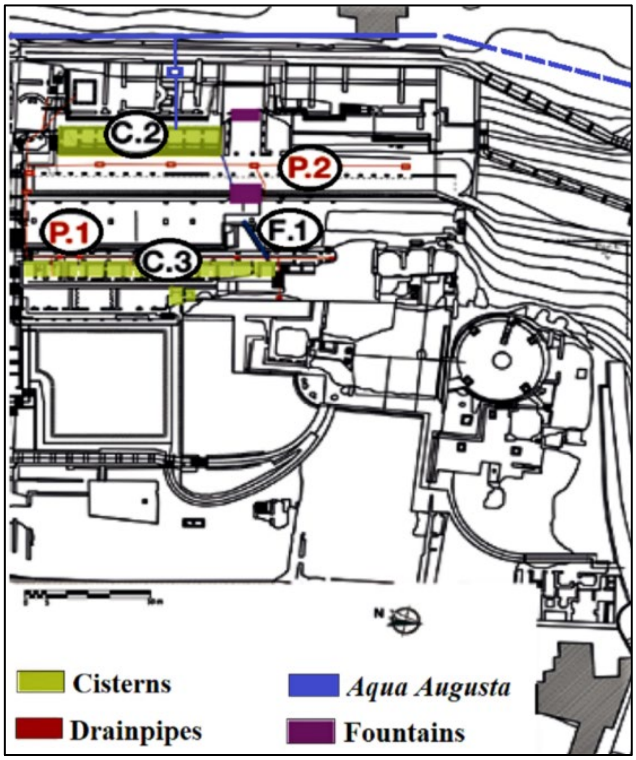

Figure 7. Baiae*: Thermal Bath Archaeological Park. 'Villa dell'Ambulatio' plan: hydraulics structures (adapted from Miniero* et al*. 2022: 328, fig. 40.3).*

In between 3rd and 4th century AD it was rebuilt: one of the the upper terraces was embellished with two large marble fountains and on the lowest terrace an elegant nymphaeum was built up overlooking the terrace garden below (Di Luca and Cristilli 2024). At this time, it seems the villa had its private connection with the *Aqua Augusta*: the openings to catch the rain water are now closed or covered with something else (for example, above the cisterns of the terrace C a large water fountain was built up and the chambers are reduced in size and capacity to better contain and support di arrival of a larger quantity of water). In between terrace C and B some years ago was explored and cleaned up a large portion of an 18m long passage leading up to an underground vaulted room lined with masonry in *opus reticulatum*, 7m wide, 4m long and 3m high, where, right in the middle, a section of the aqueduct runs. From this branch another tunnel leads to the terrace B, the opening is hidden by a staircase. The masonry is in tuff stone ashlars (Miniero *et al.* 2022). The intervention observed at the 'Villa dell'Ambulatio' appears to be a personal action undertaken by the villa's owner, potentially executed under circumstances that may not adhere strictly to legal standards. The incision made in the wall adjacent to the aqueduct is notably rudimentary, lacking the integration of specialized structures or designated spaces tailored for this modification. Nevertheless, the most significant aspect lies in the manner in which the newly established water connection significantly alters the spatial organization of the villa. In fact, this modification prompts an exploration of innovative architectural and aesthetic approaches, with the nymphaeum on terrace F serving as the most prominent illustration of this transformative process (Di Luca and Cristilli 2024).

The near so called 'Villa della Sosandra' (**Figure 9**), thanks also to well preserved wall paintings, gives us the opportunity to better understand its lifetime: from the Nero's age, when it was built up, to the late 4th century AD, when its use was changed. The subject building is characterized by its strategic placement adjacent to a *clivus* on its southern side, contributing to its unique architectural significance. This structure is systematically organized into four successive terraces that extend in a north-south direction, gradually descending towards the sea. The terraces are delineated into eight distinct architectural levels, showcasing a thoughtful integration of design and landscape. Notably, this building is situated immediately south of the 'Villa dell'Ambulatio', further contextualizing its role within the broader architectural framework of the area. Its design not only serves functional purposes but also reflects the aesthetic and engineering practices of the period. Although when the villa was built up, the *Aqua Augusta* was already working, the hydraulic system of the building is organized in a complicated system of catch holes, drainpipes and water tanks based on rainwater only to create a waterfall in the middle. At this stage, there was an absence of connection to the aqueduct in question, which indicates that the water supply was assured through alternative means. Moreover, this also underscores the adaptability and ingenuity employed in ensuring the availability of water resources, suggesting that other methods were utilized to fulfil the necessary supply demands.

After the mid-3rd century AD (probably in the mid-4th century AD) the villa was divided in two parts. The upper part was totally destroyed to leave the space to a large cistern and many others hydraulic structures (**Figure 10**). The cistern is built up with tuff stone bricks and thick layers of concrete and shows large traces of hydraulic plaster. This structure is oriented in a north-south direction and boasts a high construction standard. It is composed of four large contiguous chambers, which collectively cover a total surface area of 20.67m by 4.60m and reach a height of 6.5m. The overall volume capacity of the chambers is estimated to be approximately 214m^3. This structure, in turn, exemplifies both functional utility and structural integrity, making it a noteworthy subject of study within the field of architecture. The maintenance of the cistern (nearby there is also an impressive manoeuvring room and a *piscina limaria*) was facilitated through an opening located in the western wall of the first chamber on the southern side, situated at a height of 3.75m above the ground. This opening served as the origin for an L-shaped staircase composed of 16 steps, which descended to the bottom of the cistern. Analysis of the circular aperture positioned in the southwest corner of the first chamber, alongside the limited traces of calcareous concretions, suggests that these deposits were formed by splashes resulting from an incoming jet of water. Consequently, it can be inferred that the cistern was supplied by the *Aquaeductus Fontis Augustei*. A passage of the aqueduct in question runs beside. From that point two large passages start: one goes down to the so called 'Terme del Livello intermedio', a new bathhouse built over previous buildings, nearby the main source of heat; and the other fills two large, vaulted rooms decorated with elegant plasterworks, once part of a bathhouse of a private villa (?), the so called 'Stanze di Venere', now turned into large cisterns with a thick layer of hydraulic plaster.

The lower part of the same 'Villa della Sosandra', a portico surrounded by columns and finely decorated, was divided in many small rooms and turned in hospitality area for the near bathhouses.

The northern side of the villa was divided in two parts as well: the upper terraces turned into a residential villa; the lower part turned into facilities for customers of the entire thermal area. It is very likely that the owner had his house and his business one next to each other. It looks like the description of Baiae we read in the letters of Simmacus.

Moreover, the analysis of the available data indicates that in the 4th century AD, the southern section of the 'Sella di Baia' hill was intricately linked to the *Aqua Augusta* aqueduct. This significant undertaking appears to have been meticulously planned to support the burgeoning thermal business of *Baiae*, which was concurrently under construction. The new thermal district was designed to utilize an existing thermal system that had been in operation for centuries, known as the 'Piccole Terme', which featured the renowned thermo-mineral jet (the 'Great Antrum'). Additionally, it incorporated a more contemporary facility, the 'Terme del Livello Intermedio', which had been previously mentioned. This spa was constructed using a traditional terrace system, albeit in this instance, it involved the creation of a masonry substructure due to the steep and vertical nature of the hill's southern slope.

The thermal baths, situated on the two upper terraces, were supported by brick structures that extended down to the valley floor, necessitating the construction of a large terrace. This engineering feat resulted in the destruction of the upper southern section of the adjacent 'Villa della Sosandra'. The establishment of the 'Baths of the Intermediate Level' inherently required a connection to the aqueduct, as the volume of water needed to fill the expansive pools of the new facilities could not have been sustained without a corresponding influx of water. This interdependence highlights the critical role of the *Aqua Augusta* in facilitating the development of *Baiae*'s thermal infrastructure, underscoring the intricate relationship between architectural innovation and the natural resources available at the time.

For this reasons it seems likely that the connection with *Aqua Augusta* in the Archaeological Park of *Baiae* dates back to the late 4th century AD as we can argue from the structures and from the transformation of the residential villas.

At the same time all around the *Baianus* Lake most of the luxury villas baths started to be opened to the public: the thermal areas of these buildings, and sometimes even the villas themselves, are adapted to accommodate a larger number of customers, assuring them of total comfort. If we consider also the climate changing recorded by the ancient writers from the end of the 2nd century to the 4th when the rainfall decrease and the lowering of temperatures were the cause of a greater need of water storages and hydraulic infrastructure, we can better understand the new construction of more bathhouses. The *Aqua Augusta* was never enough for the needs of a so densely populated area and most of the scholars agree about the existence of many fresh springs along its course. In particular, the Phlegraean Fields are very rich in springs and the several tunnels running through the volcanic hillsides have different size, levels and positions and they are not all related to the *Aqua Augusta*.

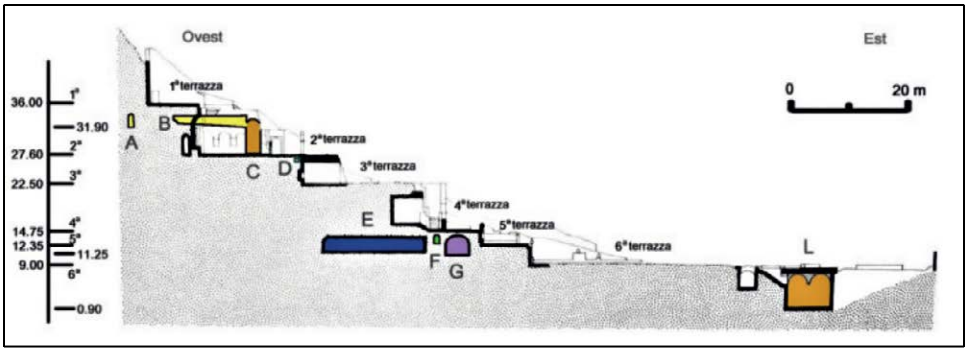

Figure 8. Baiae: Thermal Bath Archaeological Park. 'Villa dell'Ambulatio' plan: hydraulic structures levels (adapted from Miniero et al. *2022).*

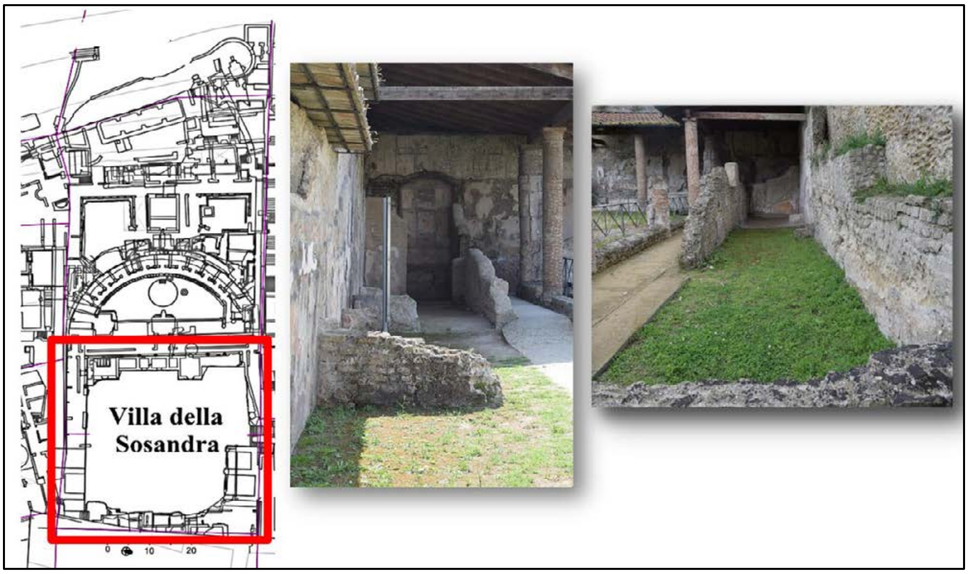

Figure 9. Baiae: Thermal Bath Archaeological Park. 'Villa della Sosandra' plan and porches views (photos and plan adapted by the author).

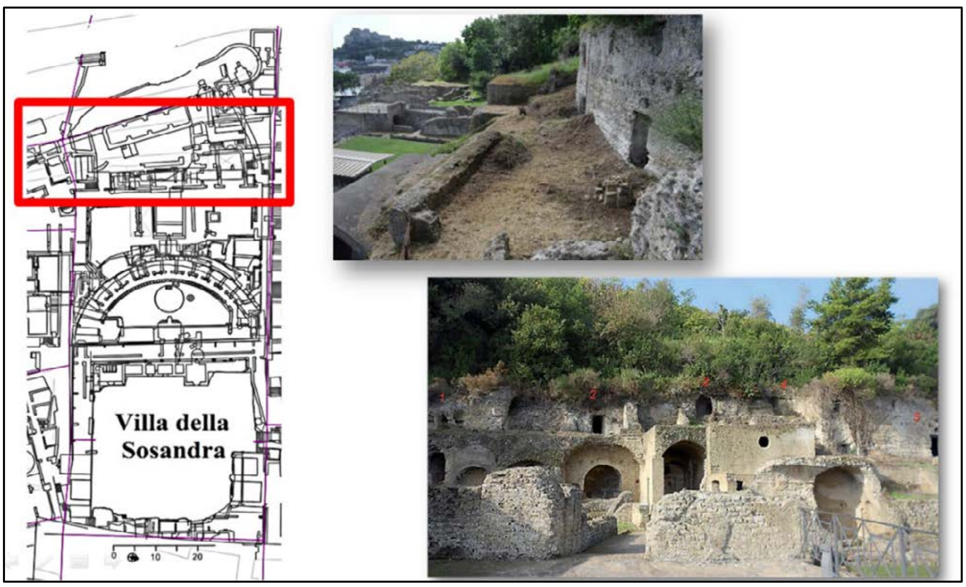

Figure 10. Baiae: Thermal Bath Archaeological Park. 'Villa della Sosandra' plan and hydraulic structures views (photos and plan adapted by the author).

Conclusions

The hydraulic constructions located on the hillside of *Baiae* are integral components of the *Aqua Augusta*, originating from the late 4th century AD, subsequent to the extensive restoration efforts initiated by Constantine. These structures were predominantly managed by the senatorial elite, who possessed substantial estates within the Phlegraean Fields. During this period, the senatorial class in *Baiae* held a strategic position, overseeing the transportation of grain from Africa to *Misenum*, as noted by Simmacus, and they were uniquely positioned to utilize the *Aqua Augusta* to meet their demands and support the burgeoning operations of public bathhouses.

However, the economic landscape of Campania deteriorated significantly in the 5th century AD, influenced by various factors such as the catastrophic eruption of Vesuvius in AD 472 and subsequent barbarian invasions, as documented by Savino (2005: 511). Despite this decline, Cassiodorus, writing in the early 6th century, depicts a vivid image of the Campania plain during this tumultuous period, suggesting that the *Campi Flegrei*, particularly *Baiae*, retained some of their former allure as a tourist and thermal destination. Following these upheavals, the Serino aqueduct faced a terminal decline, further aggravated by volcanic and bradyseismic pressures, which rendered it increasingly impractical. Although some segments of the aqueduct were reportedly revitalized in the early Middle Ages through the use of local springs, it ultimately remained a mere vestige of its once magnificent state. In summary, the discussion focuses on the *Aqua Augusta* within the broader context of the settlements and the regions it served. The Phlaegraen Fields exhibit a scarcity of ancient roads and varying settlement densities, complicating our understanding of the development and trajectory of its infrastructure. Nevertheless, the *Aqua Augusta* serves as a crucial component for gaining insights into the historical dynamics of each locality it traversed throughout different eras, especially at *Baiae*.

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Analysing the Water Supply to Roman Artisanal and Commercial Facilities: Pompeii as a Case Study

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Abstract: traditionally, the analysis of water supply in Roman towns has focused on the study of aqueducts, while much less attention has been paid to other sources such as wells and cisterns. Furthermore, their joint use to guarantee water in urban contexts has been ignored. In the same way, studies of the water supply to specific places in the towns have been limited to public fountains, thermal baths and houses. This paper seeks to present a summary of the studies undertaken in recent years regarding the supply of water to artisanal and commercial premises and to show the study methodology used and the results obtained from the analysis of a particular case, that of the town of Pompeii.

Keywords: *Fistulae plumbeae*, Cistern, Water network, Workshop, Roman archaeology.

Introduction

Pompeii's water supply and distribution network is today one of the most studied Roman-era water supply systems. Despite this, there are still many unknown factors and aspects that have been little analysed by researchers. Numerous interpretative problems derive from the fact that the network of pipes that distributed water from the Porta Vesubio *castellum* was undergoing restructuring work at the time of the volcanic eruption. Nevertheless, of note are the studies of the routes taken by the different branches of the network (Wiggers 1996; Jansen 2002; Schmölder-Veit 2009; Keenan Jones 2015; Olsson 2015), their circulation below pavements and streets (Nappo 1996; 2002; Keenan Jones 2015), the functioning of the secondary *castell*a (Dybkjaer Larsen 1982; Wiggers 1996; Peleg 1996; Monteleone *et al.* 2007), and the connections and functioning of public fountains (Schmölder-Veit 2009; Monteleone *et al.* 2023).

However, other water supply systems have attracted much less interest. Thus, there are few studies of the wells and cisterns distributed around the town. Possibly due to the hardness of the terrain and the depth of the water table, wells intended to take advantage of underground water were not numerous and they were mainly dug in early phases of the town's occupation (Jansen 2002: 71). Much more frequent appears to have been the use of cisterns, as can be seen from the identification of their access heads in numerous premises, although there are few cases in which these infrastructures have been excavated. As a consequence, although the documentation of these elements related to water extraction or access to deposits is common, there are few examples for which we have data on the shape or size of the underground structure. Nor have the public deposits, such as the one in the vicinity of the forum, received the attention of researchers.

Unequal interest has also been paid to the spaces in which water was used and the functions it performed. Although in recent decades the connections to private houses from this urban distribution network have been analysed specifically, a subject for which the work of H. Dessales (2007; 2013) and G. Jansen (2001; 2002) is essential, there are few studies that have taken into account other spaces that consume water. And there are even fewer that have considered their presence and other supply infrastructures in buildings other than thermal baths or domestic environments.

The objective of this publication is to draw attention to the frequent existence of structures related to water supply in a specific set of premises in the town of Pompeii: those dedicated to artisanal and commercial activities. It also presents the methodology that has been used for this first study proposal developed within the framework of the AQUAROLE and AQUA et TABERNA projects.[1]

Water use in craft and commercial premises in Roman times

In 2015, within the framework of the AQUAECO Project (2015-2019 financed by the University of Granada's Own Research Plan), a line of research began focusing on the role of water in different productive activities. It drew attention to the fact that water was essential for a large part of the craft activities undertaken in Roman-period urban and peri-urban contexts. Some of these uses were quite evident: for example in the workshops devoted to textile work, which required water for washing and dyeing fibres and cloth (Sánchez 2020), or in bakeries that needed it to prepare the dough for bread making. At other times the role of water in the production process can be more difficult to understand, as is the case with its function in the production of salted fish and fish sauces (Sánchez 2018). Over the years, experimental archaeology approaches have also been used to try and quantify these water needs. Since 2020 these studies have been integrated into the AQUAROLE Project (2020-2023) funded by the Spanish Ministry of Science and Innovation. This research line incorporates the analyses of pottery manufacture in which water was essential for the preparation of the clay or the moulding of the pieces (Padilla and Sánchez 2022), as well as the production of mortars used in the construction of buildings and infrastructure in towns (Martínez Jiménez 2022; Martínez *et al.* 2024).

However, beyond understanding the role of water in different craft processes, an interesting question when analysing its management in productive spaces is to study its origin.

On occasions, water could have been available within the workshop itself, either from wells that allowed access to the water table, or through rainwater storage cisterns. In other cases it was brought from outside the premises, either transported in small containers from nearby fountains, wells or deposits; or via conduits normally connected to the urban network supplied by an aqueduct (Sánchez 2023; 2024).

In most cases, however, the partial conservation of archaeological remains complicates the determination of the origin of water used in workshops. Its presence is evidenced by the existence of basins and/or drains (Sánchez 2020), but it is difficult to ascertain its origin (well, cistern, nearby fountain, pipes?). Even more difficult is to be able to count on a sufficient variety of establishments by which to determine whether there were patterns in a town or in relation to a certain activity. Generally, the state of conservation of archaeological sites only allows partial approaches to this subject.[2]

Nor do the written sources shed much light on the matter, although there are some mentions of the role water played in certain productive activities. One example is from Vitruvius (*De Arch.* 2, 5) and his reference to quicklime slaking for use in mortar manufacture. Pliny (*NH* 18, 27) identifies a specific type of bread, *panis aquaticus* or *parthicus*, which uses more water in the dough to make it lighter. He also explains the flax retting process used to extract the fibres (*NH* 19, 3). Mentions of the origin of the water used are even less frequent. While some Egyptian papyri dated to the mid-3rd century AD identify water for cisterns among the elements that workshop proprietors were obliged to supply to

[1] The AQUAROLE Project (*Water for production. Water management in urban and peri-urban productive contexts in Roman times* PID2019.106686GA.I00) was funded by the Ministry of Science and Innovation (MCIN/AEI/10.13039/501100011033). The AQUA et TABERNA project (Water supply to artisanal and commercial establishments in Pompeii) was financed by the Logos Programme of the BBVA Foundation for Research Aid in the Area of Classical Studies.

[2] Examples of these studies could be the recent analyses in *Baelo Claudia* (Borau and Sánchez 2023) or Mérida (Bustamante-Álvarez and Acero 2023).

the potters who rented them (Mayerson 2000), Frontinus specifically mentions the use of *aqua publica* from the urban network supplied by aqueducts for the functioning of *fullonicae* (*Aq.* 94, 4).

It was in this context that the idea arose to use Pompeii as a case study for the analysis of the water supply systems to these facilities; on the one hand, because of the well preserved condition of the archaeological site and, on the other, because the conserved graffiti allows a more or less clear identification of the spaces. Although there is sometimes a diversity of opinions on the specific attribution of a premise to a particular artisanal or commercial activity, there is generally quite a consensus in the bibliography regarding the identification of certain activities, such as textile workplaces (*officinae infectoriae, offectoriae, lanifricariae, fullonicae*) and bakeries, among others. This also applies to many commercial premises, especially those related to the sale of prepared food. The other reason for choosing Pompeii was based on the state of conservation and level of knowledge of the town's water supply network.

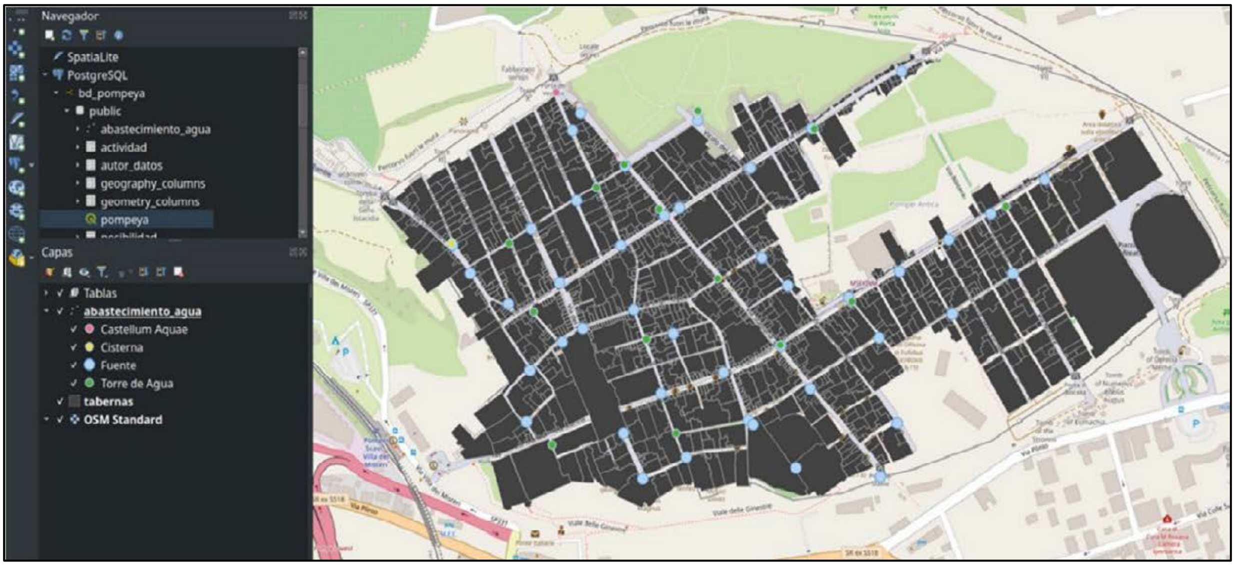

Figure 1. GIS used to organise the information on water management in the artisanal and commercial premises (elab. by AQUA et TABERNA Project).

Dealing with the huge amount of information on Pompeii

The first approaches to the water supplied to Pompeian artisanal premises evidenced the large amount of information disseminated by the huge catalogue of publications that, throughout the 20th and 21st centuries, have discussed the finds buried in the town by the eruption of Vesuvius. This information was initially complied in a standard database designed in Microsoft Access. However, this soon proved insufficient, not so much for the management of the information collected in the bibliography, but for its correct analysis, especially from the point of the spatial distribution of the different workshops and the attempt to determine whether patterns existed or not.

It was necessary to georeference the information and complete the bibliographic data with fieldwork to familiarise ourselves with the town planning, as well as to attempt to document the water supply structures in establishments for which we had no publications. This finally resulted in the AQUA et TABERNA Project (2020-2023, financed by the BBVA Foundation Logos Programme). This project sought to analyse the water supply to Pompeii's artisanal and commercial spaces in an attempt to determine possible patterns in the choice of the supply source: well, cistern or connection to the network. These patterns were, a priori, defined as possibly related to the type of economic activity or to the location of these premises in the urban layout.

As part of the project a geospatial database was then designed using the available online open access cartography generated by the *Pompeii Bibliography and Mapping Project* (https://digitalhumanities.umass.edu/pbmp/) and the *Pompeii Artistic Landscape Project* (PALP) (**Figure 1**), both from the University of Massachusetts (United States). All the information was analysed to verify that the structure and nature of the information were correct and adapted to the needs of the new tool, which was designed in collaboration with the company *3DScanner. Patrimonio e Industria*.

First, the information already collected on the Pompeian artisanal and commercial premises and their water supply and management systems was geolocated using QGIS software. The data collected included:

- The location of the establishment in the town layout using the traditionally established nomenclature (*regio, insula, civico*), although referenced by the main entrance where there were several accesses.
- The alternative nomenclature, in those cases where the establishment was known by a specific name, for example the *Fullonica di Stephanus* (I 6, 7).
- The definition of the economic activity carried out on the premises. This was based on the identifications available in the Pompeii bibliography (particularly noteworthy are the works of Eschebach (1993; 1996), Flohr (2005) and Monteix (2010), among others, as well as more specific research on specific spaces, e.g. Monteix *et al.* 2010; 2011; 2012; 2014; 2015).
- Identification of the type of water supply: autonomous (well/deposit) or connection to the urban network.
- Data on the water supply structures described in the bibliography, including those related not only to supply, but also to water management in the workshop, its use and drainage.
- Data on the water supply structures recognised during the field work.
- Bibliographic list.

It was also decided to design a tool that, on the one hand, would allow simple management of the database contents and, on the other, their accessibility and dissemination. To do this, the information was made accessible through a server and with PostgreSQL, a powerful object-oriented, open-source relational database manager, as its postGIS extension allows spatial queries, adding types, functions and analysis to improve spatial data handled within a relational database structure with relative ease. PostgreSQL data management allows data to be processed from many environments, such as desktop software (QGIS) or even the internet.

For the AQVA et TABERNA Project, the company *3DScanner* developed a web application (https://3dscanner.es/dev/web_pompeya/login.php) based on HTML5, PHP, Leaflet and Postgres, in which visualisation tools, online editing and search filters were implemented (Sánchez and González 2023). This application allows rapid data visualisation and editing via the web by users who must identify themselves in advance, otherwise they can only view the data. Furthermore, there is no risk of duplication or erroneous writing of the data since the fields have writing rules thanks to defined attributes.

Once in the web application (**Figure 2**), a satellite image of Pompeii appears, although it is also possible to use an open maps service database. Two layers of information can be activated on it. One with a map of the town that marks the perimeter of the defined spaces and constructions (streets, squares, buildings), whose geolocation, as we mentioned previously, was obtained from the *Pompeii Artistic Landscape Project*. Another shows the main elements of the water distribution network: the *castellum aquae*, the 13 secondary *castella* and the 44 public fountains. Simplicity was sought in the operation of this database to avoid major complications in its use. Two procedures can be used to select the point for which you wish to see the information. One is a manual search by selecting it on the viewer map, which shows the nomenclature of the space and its function. The other is by entering the name of the *civico* in the automatic search engine in the drop-down menu on the left. Once

Figure 2. Web application for the visualisation of water management data in Pompeii's artisanal and commercial premises (elab. by AQUA et TABERNA Project).

selected, the information appears in two different ways. Initially, you are shown a reduced view of it. This is limited to the function of the premises, whether it has some type of autonomous water supply (i.e. a well or cistern) and if a connection to the public water supply network has been documented. To access the rest of the fields (comments, field data and bibliography), once the *civico* has been chosen, click on 'show table' and a tab will open with all the compiled information (location, name, activity, type of water supply, published data, new data from fieldwork and the bibliography).

The possibility of data filtering has also been enabled. It is based on the type of activity carried out on the premises, the existence of a structure for an autonomous water supply and/or a connection to the urban network. Once made, in the drop-down tab on the left of the viewer, the selection of those *civici* that meet the selected parameter(s) are shown marked on the map in red. The total search result, i.e. the number of places that meet the defined parameters, is also indicated in the drop-down tab.

Within the framework of the AQVA et TABERNA Project, the objective was to analyse the supply and management of water in the artisanal and commercial spaces of the Roman town of Pompeii. Therefore, to date these are the premises for which information on the elements linked to these questions have been incorporated. However, the platform could be used to incorporate information about many other places in the town (houses, public buildings, cemeteries, etc.), making it a useful tool for the study of overall water management in Pompeii.

Fieldwork methodologies

In addition to a deep-seated bibliographic review of Pompeii's water supply structures and distribution network and the town's known artisanal and commercial premises, it soon became clear that it was necessary to complete the information with first-hand data obtained in the field. For this purpose, permission was sought from the *Parco Archeologico di Pompei* to access the approximately 900 spaces linked in the bibliography in one way or another to economic activities, including some *domus* in which possible activity of an artisanal nature or catering establishments (sale and consumption of prepared food) was proposed. The fieldwork allowed us mainly to document wellheads or cisterns, ponds (in a wide range of sizes) and pipes. These elements were documented and, in addition to being photographed, their presence, measurements and characteristics were added to the online accessible database.

However, in most cases, the lead pipes used to connect to the water supply network were invisible because they were below ground level. Although in some cases the *fistulae* were above the surface in some rooms, it was impossible to determine how the water supply installation was laid out and therefore its relationship with the structures.

At the beginning of the 21st century, G. Jansen had published two works in which she proposed the reconstruction of the pipe network in a group of Pompeian *domus* using a metal detector. However, in those texts she recorded how the intense mineralisation of the sediment, the presence of abundant ferrous particles due to the volcanic nature of the soil, the large amount of metallic rubbish left behind by tourists and the restoration work to reactivate some of the fountains had complicated the study (Jansen 2001; 2002). Nevertheless, taking into account the evolution of the technology and the greater capacity of the surveying devices over the past two decades, it was decided to carry out a new archaeomagnetic metal detector survey (**Figures 3-4**) to attempt to reconstruct the water supply networks that used lead pipes. This new survey, undertaken in collaboration with Nicolas Monteix (from Rouen-Normandie University), focused on premises related to craft activities (Monteix and Sánchez 2023), as Jansen's previous publications only included one of these, the *fullonica* of M. Vesonius Primus (VI 14, 21-22). The work focused on the study of textile workshops and bakeries. These are facilities in which the function of water is well known and the archaeological identification of the structures where it was used is most clearly seen: basins for rinsing fabrics or soaking grain, receptacles lined with lead sheet for dyeing fibres, water heaters built into bread ovens.

The first step was to check the viability of the proposal. For this purpose, an initial campaign was carried out in July 2021, when three workshops were selected for prospecting (Monteix and Sánchez 2023). The first premise to be studied was the *fullonica* of M. Vesonius Primus (VI 14, 21-22), as the water pipes were visible at some points; the objective was to try and detect them in the buried sections to see if it was possible to rebuild the network. Next were the workshops where the layout of the pipes was known although not visible. Among them the *fullonica* of Stephanus was selected (I 6, 7), where photographs taken during a 2014 restoration (Giudice *et al.* 2018: 337, fig. 11) confirmed the layout identified with the metal detector. Another was the bakery at IX 3, 19-20, where the network documented during the 2008 excavations was detected (Monteix 2009: 328). Once the validity of the method had been confirmed, in April 2022 a second campaign was carried out in which all the textile workshops and bakeries for which an access permit had been granted by the *Parco Archeologico di Pompei* were systematically surveyed (Monteix and Sánchez 2023).

Among the premises prospected with the metal detector was the *fullonica* situated in the peristyle at the rear of House VI 8, 20-21.2. At the time of the volcanic eruption, the workshop occupied an L-shaped sector at the western end of the portico. Attached to the north wall were six fulling hammer posts and to the west four basins. M. Flohr (2008) determined that Basin 1 (the southernmost) had been supplied by a lead pipe, of which only evidence of its imprint remained in the structure near the southeastern corner. However, apart from this, the data provided by the study in relation to water management were only linked to the connection between the basins and the waste water drainage system towards a channel that drained into the street to the south of Basin 1, coinciding with the entrance gate. No data were provided on the origin of the water. However, the metal detector survey carried out as part of the AQUAROLE Project identified a lead pipe that ran along the southern corridor of the peristyle portico. This layout is consistent with the location of the water inlet to Basin 1. In the case of the bakery at VII 1, 36-37, the most recent archaeological excavations (Monteix *et al.* 2015) had identified a lead pipe bordering the *impluvium* (converted in the last phase of the house into a basin in which to soak grain). This pipe divided into two branches, on one side to supply the *impluvium* and, on the other, the back room where the oven was located.

Figure 3. Field work. A. Use of the metal detector; B. Data collection for flow calculation (photos by AQUAROLE Project).

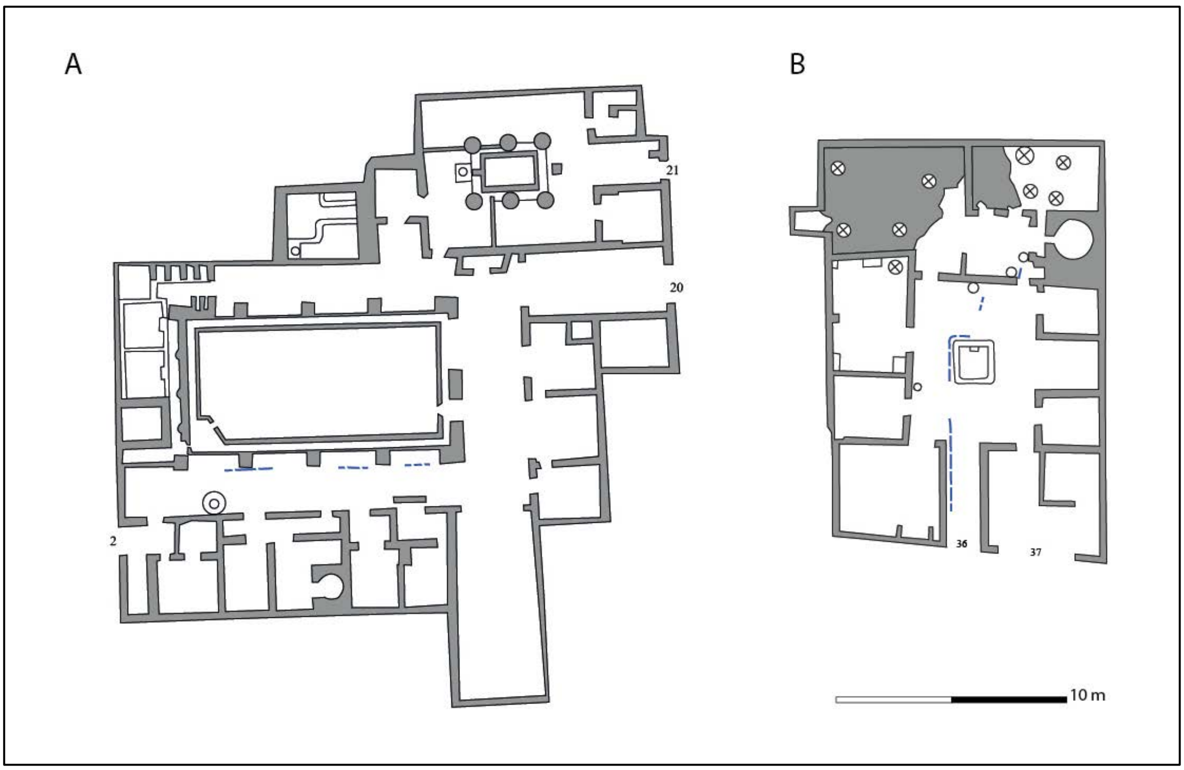

Figure 4. Location of pipes with metal detector. A. VI 8, 20-21.2; B. VII 1, 36-37 (elab. by AQUAROLE Project).

With the detector it was possible to follow the conduit's route, as well as to confirm that it entered on the eastern side of the house access corridor.

The results of the use of a metal detector to study the Pompeian water supply network present limitations. In most cases, they have not allowed the reconstruction of complete networks, only segments of them. However, it has been possible to trace the pipes in places where their entrance from the street has been identified and where there was an idea of where they may have led, documenting their presence in places where 19th century excavations do not mention their existence (Monteix and Sánchez 2023).

Furthermore, it has been possible to document how, in cases of workshops installed in *domus*, the network supplied both the domestic areas and those devoted to working practices. On this basis a new collaboration was proposed within the framework of the AQUAROLE Project, in this case with Maria Carmela Monteleone (Northumbria University). The objective was to use flow calculations to try and determine whether both areas could have used water at the same time or whether stopcocks would have been necessary to regulate the supply to the different spaces, as well as how water was administered in the workshops. The first analysis was carried out in the *fullonica* of M. Vesonius Primus (VI 14, 21-22) where, thanks to the metal detector, it was established that the pipe supplying the basins in the peristyle at the rear of the house had a branch in the atrium, where it fed two fountains. The flow studies, based on the diameter and length of the pipes, the differences in elevation, the relationship with the nearest secondary *castellum*, and the number of spaces in the house consuming water allowed us to propose that the three *fullonica* rinsing basins were able to function with a continuous flow of water, and that it was possible for the peristyle textile workshop and the ornamental fountains in the atrium to operate simultaneously (Monteleone and Sánchez 2023).

Proposal results and conclusions

Beyond the results of using the metal detector and flow calculations to understand the water management in a specific establishment, the centralisation of data on water supply structures in commercial and artisanal establishments through a georeferenced database has made it possible to propose some reflections on Pompeii's water supply systems.

Almost 900 establishments are linked in the bibliography to some type of economic activity, either artisans' workshops, commercial premises or business establishments operating inside dwellings. Based on the bibliographic review and fieldwork, in 184 of them it was possible to identify elements linked to water supply. In 145 establishments, it has been proposed that the water could have been provided from cisterns, since a deposit head has been identified on the property, either in the workshop itself or in the domestic environs.

In 65 cases (to which must be added another 19 in which the hypothesis is probable), the water was brought from outside the facilities through pipes connected to the urban distribution network. There are also 47 establishments where it has been possible to define a combination of supply systems by identifying both tanks and pipes (Sánchez 2024).

However, archaeologically it is more difficult to define the facilities that could have been supplied from outside by transporting water from neighbouring cisterns or nearby public fountains. An example of the first option has been suggested for the *officina tinctoria* of Terentius (I 8, 2-19), which could have been supplied from the cistern in the neighbouring house; while the *officina infectoria* at V 1, 5 could have been supplied from a fountain located a few metres away (Borgard and Puybaret 2003). The latter must have been the most common solution in facilities where there were no cisterns, wells or pipes. However, we cannot automatically assume as valid the option of water transportation in all establishments where no evidence of elements related to the supply has been found, as our knowledge of these places is still fragmentary.

Figure 5. Map showing the location of commercial and artisanal establishments, distinguishing the identified water supply systems (none, connection to the urban network, cistern or both) (elab. by the author according to the data collected until the end of 2023).

The general analysis of the location of artisanal and commercial premises in Pompeii (**Figure 5**) in relation to its water supply system shows that the distribution was homogeneous throughout the entire town. However, a smaller number of facilities connected to the network are observed in *Regiones* I, II and VIII, precisely those located in the lowest part of the urban fabric. This circumstance also coincides with a lower number of places connected to the network in general.

This situation may be the result of mismatches in research, which over the years has shown more interest in some *regiones* than others. However, it could also be related to the structure of the Pompeian water supply network itself, as these are precisely the areas of the town furthest from the *castellum aquae* and therefore the worst served.

In any case, according to the data currently available, in Pompeii 44 public fountains, baths and more than 140 other places were connected to the urban water distribution network, including at least 65 related to the undertaking of artisanal and/or commercial activities (Sánchez 2024). These figures should lead us to consider the importance the water requirements of these premises may have had in the design of the supply network that was being reformed in AD 79. We should also take these needs into account in our attempts to understand the operation of the network in its different phases of use.

Nevertheless, even today information related to water management in Pompeii remains elusive; either because the early excavation reports did not concern themselves with documenting and describing the elements found during the excavations (pipes, channels, wells, cisterns, basins, various containers, etc.), or because there are many more recent excavations whose results are not yet accessible.

The general understanding of the water supply to Pompeii and its different spaces and the relationship between the urban network and the autonomous supply structures (wells and cisterns) necessarily involves a global project. This will have to incorporate data from the different teams that are working or have worked on the archaeological site, including those belonging to the *Parco Archeologico* itself.

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Rainwater Collection and Storage in the Pompeian House: Slaves at Work

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Abstract: of old, people in the Roman town of Pompeii (Italy) relied on rainwater for everyday use. The different parts of the rainwater collecting system were aligned with each other to create a good working system. Although it is obvious that without human intervention the different parts of the system were not working and that no clean water ended up in the cistern, this human side of the system has not yet been explored much. In this contribution we will take a look at what actors and actions were involved in the daily use of rainwater in a Pompeian household.[1]

Keywords: Rainwater catchment systems, Roman households, Roman slaves, Pompeii, Roman cisterns.

Introduction

At Pompeii, people collected rainwater in underground cisterns in their homes for domestic use. Even after the installation of an aqueduct around the time of Augustus, many of these rainwater catchment systems remained in operation.[2] In the more than 1200 houses that have been excavated at Pompeii to this date, the different components of these rain water collection systems were found: sloping roofs, waterspouts, *impluvia*, gutters in the garden, cisterns and cistern mouths. These different parts and the technical aspects of these systems have recently received increased intention, see for example Jansen (2023).

However, this system was not a machine that worked automatically: human attention and human effort was needed to get clean rainwater into the cistern and to where in the house water was used. This human aspect of the system has remained somewhat under the radar to this day. In this respect, books by Alexandra Croom (2011) with a holistic view on running Roman households and by Sandra Joshel and Lauren Hackworth Petersen (2014) on Roman slaves in the Pompeian home, are both eye-openers to see the work needed and to see these workers inside the Pompeian houses**.** In this contribution we assume – in line with Joshel and Hackworth Petersen's thinking - that in a Pompeian house a freeborn (extended) family was present together with a group of slaves. The label 'servants' is not used as an euphemism for slaves.

Presumably, the house owner took most of the major decisions. He, or the foreman of the slaves, chose what kind of water systems to install (wells, rain water collection systems, a connection to the city mains, or a combination of these), the appearance of the system (material, decoration etc.) and he decided whether a system was relinquished, for example when a cistern could be turned into a cellar or a cesspit. The role of the house owner or the foreman is indeed an important topic in need of exploration, but it is not the subject of this contribution.

[1] This contribution could not have been written without the valuable feedback of the participants of the session 'Water management and storage systems in Antiquity' at the EEA conference August 31, 2023. For additional help, I owe credit to Peter van der Pasch and Stephanie Hoss. Patrik Klingborg was so kind as to read the first draft of this contribution and his remarks and suggestions improved it considerably. All images of Pompeii have been published by permission of the *Ministero della Cultura – Parco Archeologico di Pompei* and any further reproduction or duplication by any means is prohibited.
[2] See Keenan-Jones 2015.

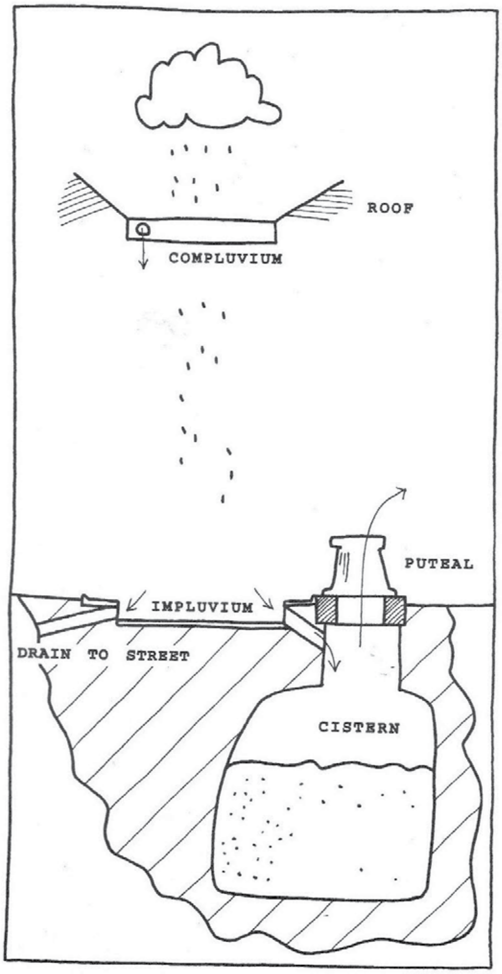

Figure 1. Pompeii, schematic presentation of the rainwater collection system in the atrium (drawing by the author).

Here we are interested in the tasks of the slaves and other members of the household, who took care of the daily hauling up of the water from the underground cistern, dragging full buckets through the house, as well as the regular maintenance and cleaning of the different elements. We will focus on the actions related to rainwater systems, on the utensils the slaves used to fulfill these tasks, on their skills, and we will end with a timeline to understand at what moments during the day these actions took place. To get there, we have to make a lot of assumptions and hypotheses, though all are based firmly on the research on Pompeian rainwater systems by the author (Jansen 2002: 22-26; 2023).

Appearance of rainwater systems

To start with the rainwater harvesting systems, in Pompeian houses rainwater was gathered mostly at the *atrium* and the peristyle, and the lightwell. These courtyards are different in character and therefore the appearance of the systems present differ.[3]

Best-known is the system in the *atrium*: this courtyard positioned at the front of the house had an inward-sloping roof with a square opening, called *compluvium* (**Figure 1**). It was decorated with waterspouts to direct rainwater into a basin, called *impluvium*, situated below. From this *impluvium* water was led into an underground storage tank: the cistern. These water tanks were dug in the ground, walled up and lined with waterproof *opus signinum*. They were mostly rectangular with a barrel vault. Water could be obtained from the cistern mouth, usually placed on or near the rim of the *impluvium*. This mouth was covered by a heavy stone slab with a hole in the middle, through which a container could be lowered. With a stone lid the hole could be closed off. In other cases, an elevated cistern mouth (a so-called *puteal*) was placed on top of the stone slab. The *impluvium* had a second drain leading to the street through which, when the cistern was full (enough), the surplus could be channeled to the street.

The second courtyard, the peristyle garden (**Figure 2**), was situated further into the house, and here rainwater fell from the portico roofs in an underlying gutter at ground level, running around the portico. These gutters, though very different in design, operated like an *impluvium* with two drains. Due to the presence of the garden, we can assume that a great deal of dirt was expected to enter the system, as trees and plants were cultivated here. Therefore, small rectangular settling basins were positioned in the gutter (**Figure 3**). Due to their width and depth, these devices caused the water to slow down, allowing unwanted substances such as sand or small stones to sink, thereby preventing it from entering

[3] For a more elaborate description, see Jansen 2023. There are also other open areas in the Pompeian house where rainwater was collected and a cistern was located: the rather large lightwells and kitchens. These are discussed at Jansen 2023: 105-106.

Figure 2. Pompeii, house I 14, 2, peristyle around garden with rain gutter at ground level and cistern mouth in portico (photo by the author, published with permission of the Ministero della Cultura - Parco Archeologico di Pompei*).*

the cistern. Floating debris, on the other hand, such as twigs and leaves, was occasionally barred by perforated lead sheets fixed with iron nails in front of the cistern opening.

As these two areas differed in character, their rainwater collection systems, composed of different parts, were adapted to the specific needs.

Operation

As mentioned earlier, this body of different parts did not work automatically. Rainwater ran by itself, but - of course - not necessarily in the right direction. A helping hand was required. Moreover, the system needed maintenance in order to receive clean water in the cisterns. Slaves in the Pompeian household almost certainly played a large role in this: they ensured that clean water entered the cistern, they brought up the water and took it to the places in the house where it was needed. They were also the ones that carried out regular maintenance, including cleaning the cistern.

Besides the archaeological remains, ancient texts referring to these actions can give some information, the same applies for ancient images. For the Greek world these texts are studied by Patrik Klingborg (2016; 2017; 2023). Much information can be gained from the so-called Astynomen inscription found at Pergamon and some *ostraca* from Sbeitah (Israel).[4] For the Roman world, texts have not yet been studied systematically. Images of the actions relating to rainwater collection and taking water from a cistern

[4] For the Astynomen inscription, see Klaffenbach 1953 and Saba 2012; for the *ostraca* from Sbeitlah, see Youtie 1936.

Figure 3. Pompeii, house I 9, 11.12, gutter in garden with access to cistern: a settling basin and in front of the opening to cistern a lead perforated sheet attached with iron nails (photo by the author, published with permission of the Ministero della Cultura - Parco Archeologico di Pompei*).*

are rare. Though the depiction of the Samaritan woman hauling up water from the well (note: not cistern) in many catacomb paintings from Rome dating to the 4th century might give some information (**Figure 4**). Due to this lack of studies into the texts and the scarcity of images, I shall describe several scenarios in order to bring these activities to life.[5]

Collecting clean rainwater

The first task refers to collecting clean rainwater. When it started to rain after a dry period, the first rainwater coming down was polluted with dust that had accumulated on the roofs.[6] To avoid this polluted water from entering the cisterns, the *impluvia* and the gutters in the peristyle, all had two drains. It is assumed that when it started to rain the drain to the cistern was closed by a plug. Although wooden plugs have not been preserved at Pompeii, these do occur at other Roman sites such as Eschenz in Switzerland (**Figure 5**). A stone covered with a cloth could also be used, as well as a lead stopper, which has been found in the Casa del Menandro (I 10, 4.14.15) (**Figure 6**). It is not known whether this lead stopper belonged to the *impluvium* of the house, but of course it could be used as a plug. In this way the polluted water was led directly to the streets. As soon as the water became clear, a slave had to remove the plug from the cistern inlet and close the drain to the street. And this was all it took to get clean water into the cistern.

Figure 4. Samaritan woman at the well (from Daremberg and Saglio 1877-1919, 4.2, 780).

Hauling up water

The second task involved pulling up water for daily use. Water was taken through the cistern mouth, sometimes closed by a stone lid with a metal ring (**Figure 7**). The lid

[5] For a general overview of these tasks in Greek households, though mainly focusing on drawing water, cleaning the cistern and repairing cracks, see Klingborg 2017: 86-92. For Roman households, see Brinker 1990: 57-75.

[6] See Klingborg and Finné 2018 for an overview of this process in classical Greece and the importance of getting clean water into the cistern.

Figure 5. Eschenz, wooden stoppers (Amt für Archäologie Thurgau, www.archaeologie.tg.ch, photo by D. Steiner).

Figure 6. Pompeii, Casa del Menandro (I 10, 4.14.15), lead plug (from Allison 2006, pl. 47, no 4, photo by J. Agee).

prevented not just dirt, but also small animals and children from falling into the cistern, plus it stopped adults from stumbling or breaking their legs. The raised cistern mouth, the so-called *puteal*, had almost the same effect, however it was a more user-friendly alternative. The slave did not need to lift the heavy stone lid, since as the *puteal* was open on top, he or she could access the water easily.

For a long time it was assumed that water was taken from the Pompeian cistern with a wooden bucket on a rope. A wooden bucket has a substantial weight and together with the water in it, that would make the task of hauling very heavy.[7] It seems that at Pompeii a lighter object was used: due to analysis by Penelope Allison (2006), who investigated finds inside Pompeian houses, and of Susanna Tassinari (1993, i 231), who studied bronze vessels of Pompeii, we know that a specific kind of bronze vessel (round based, ovoid body, iron handles and a height of about 30cm) with rope attached around the rim was in many cases used to collect water.[8] These vessels have been found near cistern mouths, as can be seen at a picture of the latest excavation by the *Parco archeologico di Pompei* in 2018 (**Figure 7**). Ropes have not been excavated at Pompeii, although sometimes 'concretion' has taken place, a corrosion process by which the outlines of the rope have been preserved, while the rope itself has rotten away (**Figure 8**).

Hauling up water from the cistern required some practice as simply throwing down a vessel attached to a rope does not suffice. The vessel has the tendency to float and one has to manipulate the vessel a

[7] A terra cotta vessel to draw up water would be very heavy to haul up.

[8] Not many cisterns in Pompeii have been excavated and of those who have, there is no report on the finds inside. The objects found on the cistern floor could reveal a lot about their use and operation. For a list of excavated cisterns, see Jansen 2002: 76, note 82.

Figure 7. Pompeii, Casa di Leda e il cigno (V 6, 12), cistern mouth with stone cover in atrium together with a bronze water drawing vessel (published with permission of the Ministero della Cultura - Parco Archeologico di Pompei*).*

Figure 8. Pompeii, storeroom, bronze lifting vessel with corroded rope (photo by the author, published with permission of the Ministero della Cultura - Parco Archeologico di Pompei*).*

little so that it tips over and starts to be filled with water.[9] The deep signs of wear caused by the scraping ropes implies that vessels were not taken up from the middle of the cistern shaft, but along the wall.[10] It would be interesting to examine metal vessels for dents caused by this hauling up method. Besides, the work had to be done carefully so that the rope with the container attached to it did not slip into the cistern.

Hoisting up was also a demanding job which can be deduced from the deep signs of wear caused by the scraping ropes. And in those cases where there are no signs of wear present at the rim of the cistern mouth, this is not necessarily an indication that the cistern was out of use, but rather hints at the use of a mechanical drawing device. For example, a small wooden winch reinforced by iron rods has been found in the Casa dei quatro stili (I 8, 17).[11]

From finds near the cistern mouths we know that water was used at this very spot. A good example can be found in the Casa degli amanti (I 10, 10.11): here a terracotta wash basin on a stand has been found next to the terracotta *puteal*, together with an *amphora* and three bronze vessels, one of which is the standard vessel for taking water from cisterns (**Figure 9**).[12] That is the one that is found inside the wash basin.

Monitoring

So far, we have discussed what needed to be done when it started to rain, and what was done every day to bring up water from the cistern. However, other tasks had to be done less often, albeit at regular intervals. One of these tasks was keeping an eye on the amount of water in the cistern. Not only the amount of water still in the cistern was of concern, one also had to check whether the water was clear and free of smell and bad taste.

Someone in the household had to monitor how much extra water could enter the cistern in case of a rain shower, and, perhaps more importantly, had

[9] See Brinker 1990: 67 and Klingborg 2017: 90 for this problem.
[10] Klingborg 2017: 87 notes this for Greek cisterns.
[11] Ciarallo and De Carolis 1999: 395.
[12] Elia 1934: 335; Allison 2006: 261-262, 393.

to determine how much water could be taken out every day. My guess is that checking the water level has been done by lowering a wooden stick in the cistern, or a rope with a weight. Apart from how this was done, this monitoring task seems pretty difficult: one had to consider how much water was in the cistern, how much water needed to be kept in store in the near future together with a weather prognosis. This seems a task for an experienced individual. When we assume that such a supervisor was needed, this implies that the other slaves in the house could not take water at random from the cistern but had to do this in close contact with such a person, so that at least one individual had an overview. It will be interesting to know what happened in case of miscalculation and a sudden scarcity of water in the cistern. Klingborg and Finné (2018) show with their simulation for the Greek world that this is not very likely to happen in wet years, though this could easily occur in dry years. In case of such an incorrect assessment at Pompeii water could be fetched at the public fountains in the streets (if the aqueduct was running). Whether one could ask the neighbors for water is not known at Pompeii, nor whether water sellers were active here.

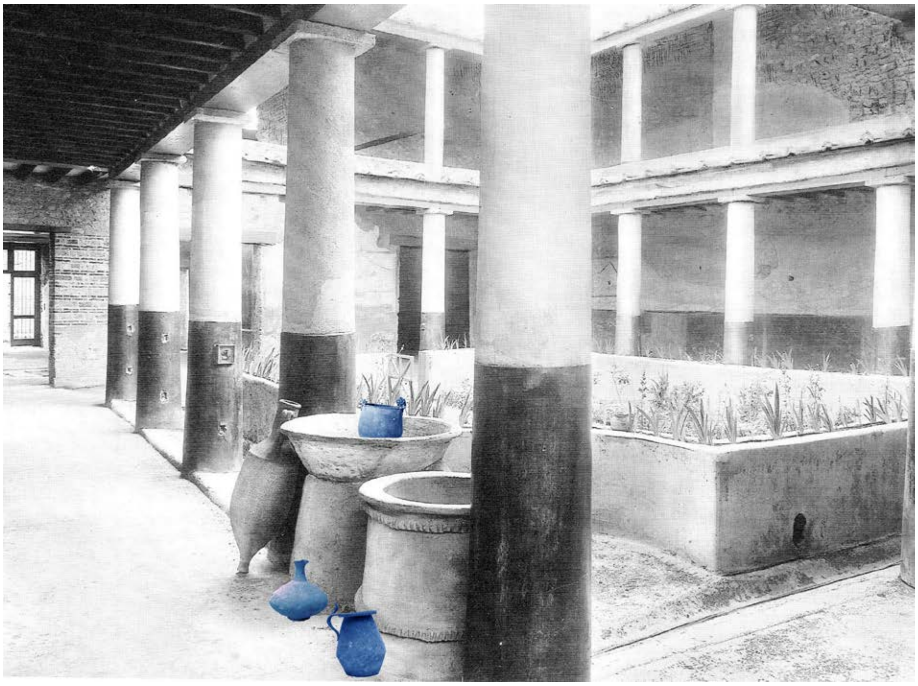

Figure 9. Pompeii, Casa degli amanti (I 10, 10.11), puteal*, wash basin and amphora in porticus together with the three bronze vessels found here. The standard vessel for taking water from cisterns was found inside the basin (elab. by E. Jansen, pictures taken from Jashemski 1993: 50 and Allison 2006: pl. 113, nos 2-4, photos by J. Agee).*

Cleaning

Another recurring task was keeping the different parts of the system clean and free from blockages. First, there was the roof, where all kinds of larger bits of dirt, such as leaves, tree branches or dead birds, could block the passage through the waterspouts. We must imagine a person in the *atrium*, holding a ladder and another person on top of it, with a bucket for this debris. Also *impluvia* had to be kept clean and swept, and especially the gutters in the peristyle, since these were in gardens. Leaves of trees and even plants would have ended up in this gutter, together with garden soil. At regular time intervals, the settling basins in the peristyle gutters had to be cleared from sand, mud and debris (**Figure 3**).

Not only the supply pipes to the cisterns had to be kept clean, but also underground drains carrying away surplus water. From the *impluvium* or peristyle gutters these drains usually took the shortest way out (via the entrance, the *fauces*) to empty their contents onto the street pavement in front of the house. At joints of two underground drains there were many small inspection holes with a stone cover that could be lifted easily (**Figures 10-11**). These inspection holes, and the need to keep a regular eye on the underground drains and to take away blockages (without breaking up floors) shows that one was anxious to prevent that blockage in these drains caused the *atrium* floor to be flooded. In these drains,

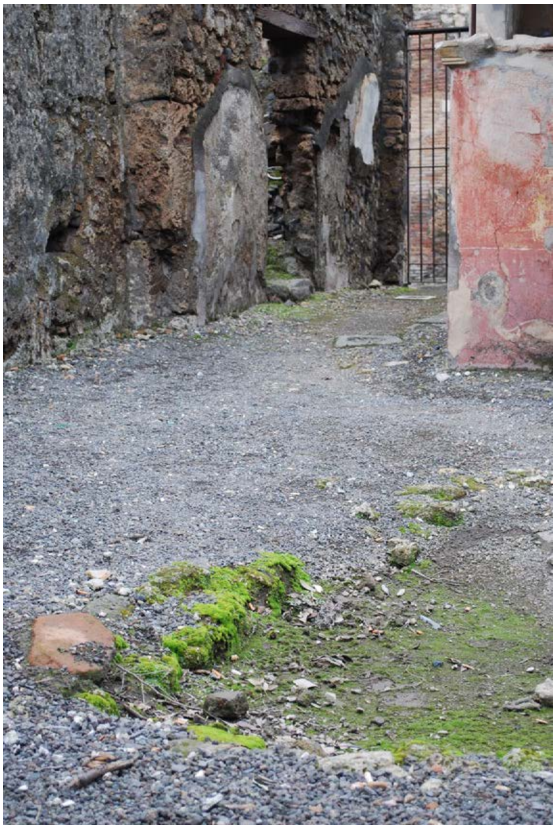

Figure 10. Pompeii, house IX 2, 26, badly preserved impluvium with drain to street visible by two little inspection holes (photo by the author, published with permission of the Ministero della Cultura - Parco Archeologico di Pompei*).*

silt could accumulate, little branches or other things fallen in through the *impluvium* outlet. These drains, however, were also home to rodents: in one drain more than 141 mouse bones have been found.[13] Clearing these underground drains could be done by hand (as far as the hand reached) or by poking with some flexible rod.

Cleaning and inspecting the underground cistern itself was a more arduous operation, which could last for a day or two, and had to be timed more precisely. Dust collected at the cistern bottom as well as things that got into it through the cistern opening by accident had to be taken away. It is generally assumed that this was done once a year, when there was not so much water in the cistern, which would have been at the end of the summer and before the start of the welcome autumn rains.[14] The cistern would be out of use during that time, and the remaining water might be stored elsewhere in the house in the containers, or in a second cistern, which were available in most Pompeian houses.[15]

This was a task for at least two people. To enter the cistern, objects on top of the shaft had to be removed: the *puteal* or the cistern mouth together with the closing stone, all heavy objects. The closing stone has in general a passage of 45- 50 cm, too small for a normal person to go through. Only then was it possible to go down the shaft with the help of climbing holes (**Figure 12**). As the climbing holes are only in the shaft, one needed a ladder or rope anyway to reach the cistern floor, which is in many cases more than 2m below the last climbing hole of the shaft. The part of the cistern just underneath the shaft was probable lighted well enough to work. But as most cisterns are long rectangular rooms with the drawing shaft at one end, at the other end additional light in form of an oil lamp or a torch was likely needed. Buckets filled with the silt that has accumulated for a whole year could be lifted, with the help of a second person standing outside the cistern.

Repairing

The annual cleaning was also the moment to inspect the cistern to see whether waterproof lining or plaster had fallen off, or whether cracks had formed. This was the time for repairs. It is highly likely that no one in the household was capable of plastering the cistern walls and that a craftsman from outside had to be called in. In addition, the materials to make waterproof plaster itself are not standard material in the Pompeian home. Of course, water was available but quicklime, sand and tiles ground to

[13] Holt and Palazzo 2013: 136, 139.

[14] Klingborg 2017: 91 suggests September or October.

[15] The very last water that was polluted with mud and probably of very poor quality, was not stored elsewhere of course (personal communication with Patrik Klingborg).

Figure 11. Pompeii, Domus Sirico (VII 1, 47), detail of inspection hole with marble cover (photo by the author, published with permission of the Ministero della Cultura - Parco Archeologico di Pompei*).*

Figure 12. Pompeii, Casa del porcellino (IX 9, c), descending foot holes in cistern shaft (photo by the author, published with permission of the Ministero della Cultura - Parco Archeologico di Pompei*).*

split had to be bought.[16] The heaps of chalk and tile split excavated in house I 10, 8 (room 10), are presumably the preparations for cistern restauration works.[17] The plasterer, after mixing the ingredients, had to go down in the cistern with a small container (small enough to fit through the narrow cistern mouth). Down there he needed a light to see where to work and a ladder to get to the parts that needed repair. He also needed a panel trowel to get the plaster on the wall. This work (applying plaster to a wall) is visualized at a Pompeian fresco (**Figure 13**), though this person is not working in a cistern. The work took some time, as several layers of plaster had to be applied to the cistern wall; the previous layer had to be rather dry, but at the same time still a bit wet to attach the next layer.

Tools needed

Most tools mentioned above for getting clean rainwater into the cistern, for cleaning all parts of the system, for keeping the drains clear of blockages, for monitoring and repairs, were everyday equipment of Pompeian households: brushes, brooms, containers, lamps, ropes and even ladders. As most of these tools were of organic materials, they have not survived at Pompeii and therefore it remains unknown where they were stored in the house.

What kind of slaves?

We also need to consider who is hauling up water, and in a broader sense which slaves were at work at the rainwater system. We can look at gender and age. Most of the work mentioned above is light (not much body strength is needed) and this can be done by all slaves in the house, young or old, and both sexes. Hauling up water and repairing the cistern walls with new plaster is definitely heavy work, done by adult males (or strong females). When there is a winch or pulley to draw the water, the task is much lighter and this can easily be done by everyone in the household. Whether or not mechanical help was present, a bit of experience and skill are required to get water into the container. For preparing plaster and applying it in several layers to the cistern wall, some knowledge is essential and it was probably done by a craftsman. Maybe such a person was not present

[16] For preparing Roman mortar and instruments with which it is applied to the wall, see Jansen 2019: 380-381, 389-390.

[17] Elia 1934: 316.

Figure 13. Pompeii, house IX 5, 9, fresco of plasterer at work (now lost) (Ling 1991: 200, fig. 219).

in the household and had to be called in. The person who was in charge of the cistern, of the available amount of water in it and who has to decide what to moment is to start the annual cleaning, must have been a senior slave with a lot of experience regarding the subject. From this and the tasks related to the rainwater system listed above, it can be concluded that quite a few persons in the household had a role in providing fresh and clear rainwater for domestic use.

Timeline

It would be interesting to explore at what times a day all these activities took place, as they might interfere with other activities in the house especially two specific activities of a more formal nature. The first official activity that is relevant is the *salutatio* held by the house owner around the *atrium* in the morning during the first two hours after dawn. The second one is diner for friends and relatives in the late afternoon, in a room along the garden peristyle. The cleaning of the roofs, drains, the cistern, and repairs were time-consuming activities and might be planned when the house owner was away for a day. But other activities such as cleaning, hauling up water, and carrying it around were daily routine. It seems unlikely that they were carried out during the salutation and the evening diner. Though it is possible that water was drawn from a cistern at a courtyard (another *atrium*, light well etc.) that was out of sight of the guests. After the *salutatio* the house owner went out to conduct business often followed by a visit to the public baths in the early afternoon. These were the moments that there were no guests in the house and water could be taken and small cleaning tasks could be carried out. Maybe water needed for the evening diner and tasks that had to be executed in the later afternoon was then already collect.

Though I wonder what happened when – unfortunately – it started to rain during the *salutatio* or afternoon dinner. I could imagine the slaves running quickly and silently to change the stoppers in the *impluvium*, gutters and basins in order not to interfere too much with these official occasions. A sudden rain shower (together with some wind), however, would have created some chaos anyway in the *salutatio* ceremony as the waiting clients had to take care to not get wet in the *atrium*, which was only partly roofed over.

Conclusion

The above was a first attempt to focus on the operators of the Pompeian rainwater systems. While these were just lines of thought and perhaps somewhat speculative, they nonetheless make us aware of the fact that these systems only worked if they were actively operated by slaves in the Pompeian household. It stands out that the tasks were many and diverse. Most chores were light labor and could be executed with everyday tools, present in all Pompeian households. Other tasks were heavier or needed skilled labor, requiring also specialized equipment. Most slaves in the house could perform these tasks, whether old or young, whether male or female. However, an older slave stands in the spotlight, the person with the most experience regarding the system who supervised the amount of water in the cistern and decided when it was time to clean.

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Abellinum and its Water Distribution System: New Evidence for a Wider Comprehension of the Hydraulic Infrastructures

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Abstract: situated on the left bank of the Sabato river, the city of *Abellinum* (Campania region, southern Italy) represents a tangible testimony to the influence of the Roman civilization in *Irpinia*. Archaeological evidences are located on and around the Civita plateau, where it is also possible to identify some structures (the baths and the *natatio* of a *domus*) connected to the water distribution system of the city, served by the Augustan Serino-*Beneventum* aqueduct.
Recent investigations have increased our knowledge of methods and water distribution solutions in the Roman period.

Keywords: *Abellinum*, Landscapes, Water distribution system, Fountain, Piezometric tower, Urban planning.

Historical and archaeological introduction

The ancient city of *Abellinum* (Atripalda, Province of Avellino, Campania Region, southern Italy) is located on the left bank of the Sabato river, in a strategic geographical position for controlling the river valley and the connection routes. The settlement occupies the Civita, a plateau of about 25 hectares, located at the confluence of the Rigatore torrent in the Sabato River. The particular position favoured the creation of an *oppidum* in the Samnite period (4th-3rd century BC) which is attested through the remains of a fortification wall in *opus quadratum* and votive materials relating to a sacred area (Colucci Pescatori 1991: 106-107; 1996a).

In the Roman period, the plateau was occupied by a vast settlement whose layout assumed an urban development starting from the late Republican period. Although some structures of the end of the 2nd century BC support the hypothesis of a foundation of a colony in the Gracchan period, also indicated by the gromatic sources (*Lib. colon.* L. I, 229, 16-18), other archaeological data tell us about a Roman colony in the Sullan time. It was certainly in the first decades of the 1st century BC that the city was provided with walls in *opus reticulatum* and between the 1st century BC and the 1st century AD the urban layout was structured consisting of: the orthogonal road system of *cardines* and *decumani*; the residential areas, such as the one in the north-east corner of the plateau, where the *domus* of *Vipsanius Primigenius* stands, overlooking the Sabato valley (**Figure 1: A**); the public area at the centre of the plateau (**Figure 1: B**), to the west of the public baths (**Figure 1: C**); and, outside the city, the necropolis to the south and east and the amphitheatre (**Figure 1: D** and **E**) (Buonocore 2019-2020; Colucci Pescatori 1987; 1991; 1996a; 2013; 2021: 178-182; De Girolamo 2019-2020; Fariello Sarno 1979; 1988; 1996).

Abellinum remained an active and vital centre for the territory at least until Late Antiquity. Although the earthquake of AD 346 and the eruption of Pollena, from AD 472, caused damage to the city and probably led to a contraction of the settlement, the area was still occupied until the 6th century AD. Both on the Civita and to the east of it, traces of a community, now Christian, have been found, with the

Figure 1. Plan of Atriplada (AV) showing the main structures of ancient Abellinum *(elab. by D. Musmeci).*

Basilica of Capo la Torre, on the right bank of the river, as a reference point (**Figure 1: F**) (Colucci Pescatori 1996b: 193-196; 2021: 178-182; Fariello Sarno and Lambert 2009).

The city represents a tangible testimony to the Roman influence in *Irpinia* and it is one of the major Irpinian and Samnite settlement, together with other centres such as *Compsa, Aeclanum* and *Beneventum* (Colucci Pescatori 2021; Johannowsky 1987). In fact, the hydrographical and orographic systems have favoured a network of passages and connections, especially along the river valleys (Sabato and Calore Rivers and their affluents), which have made it necessary to have stable, strategic settlements with continuity of life. In the Roman times, they became *municipia* or *coloniae* and organised the settlement network in the territory, consisting of *villae*, agricultural and productive facilities, necropolis and sacred areas. The Sabato valley, in particular, represents a very favourable context for the settlement of the colony of *Abellinum*, which took advantage of the plain and sub-plain areas in the hills and along the slopes, as well as the availability of land for agricultural practices (Santoriello 2022). The valley also constitutes a fundamental north-south communication axis connecting the Tyrrhenian coastal area, with *Paestum* and *Salernum*, and Sannio with *Beneventum*. This city plays a controlling role and is a point

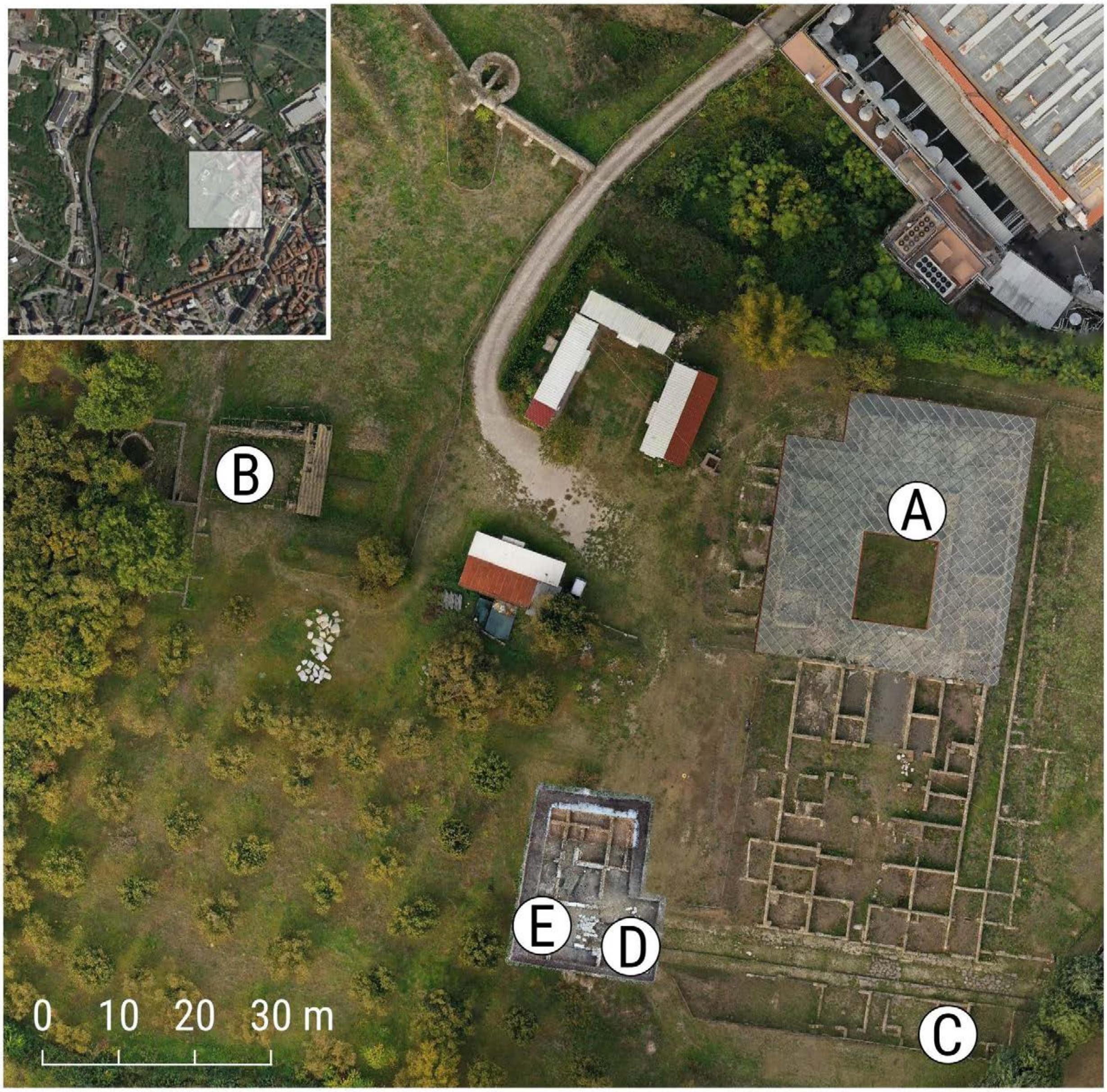

Figure 2. Plan of the North-eastern part of the city of Abellinum (elab. by the authors).

of cultural and commercial passage between the Tyrrhenian and Adriatic sides, thanks to the efficient Roman roads of southern Italy (e.g. Via Appia, Via Latina, Via Traiana). The relationship between *Abellinum* and *Beneventum* is strong and their historical events intersect, both in Roman times and in the previous territorial systems of the Samnite era and then in the subsquent ones, considering the role that the cities still have during the Gothic War (Rotili 1986; Giampaola 1998; 2000; Torelli 2002; Tomay 2009; Tomay *et al.* 2012; Tomay 2015; Santoriello 2015; Santoriello and De Vita 2018; Santoriello and Musmeci 2019). Road systems such as the *Via Antiqua Maior,* and infrastructural systems, such as the Augustan Serino-*Beneventum* aqueduct, constitute strong links between the territories of the two cities, both of which were of political interest to Rome, especially from the Augustan period onwards, with investments and works of urbanization and monumentalisation (Colucci Pescatori 1987; 2021).

In *Abellinum*, although we see this phase of growth within the city, there were not many indications so far of the presence of a water distribution system. A private *natatio* (a pool, **Figure 2: A**) is located in the already known *domus* of *M. Vipsanius Primigenius* which took on its final appearance visible today between the last twenty years of the first century BC and the Flavian period (Colucci Pescatori 1991: 113-116). The pool is located in the most representative part of the house, the peristyle, immediately in front of the *triclinia*. The rectangular basin was bordered by dressed limestone blocks: it could be accessed by four limestone steps on the west. The water flowed in through a tufa block *specus* covered by an arch with ashlars of the same material: both the *specus* and the arch are visible inside a quadrangular well to the north-west of the *natatio*.

In the same house, the presence of a kitchen has been hypothesized, due to the discovery of a fireplace and a *lararium*: it is to be identified in the rooms located in the north-eastern part of the *atrium* (Colucci Pescatori 1991: 114). In the adjacent rooms, there could be remains of private baths: in fact, an ancient raised floor is still visible above square-sectioned terracotta *pilae* and circular-sectioned terracotta pipes in the walls. In a later period, another private bath was perhaps built, located in some rooms attached to the western side of the *domus*, on the western side of the peristyle. Here, remains of pipes have been observed on the walls of a room with an exedra (Nava 2011: 745) and behind it, a space that could have functioned as a *praefurnium*.

The evidence in the domus is one of the first clues within the city that gives us information about the use of water supplied by the aqueduct. Surely, since there were private buildings that used large amounts of water, as in the case of the *domus* pool, there must have been a good urban water supply network, which primarily should had served public buildings. One of these are the public baths (**Figure 2: B**), located between the *domus* and the central area of the plateau in the Late Republican-Augustan period and used at least until the Imperial age. They were excavated in the last decades of the 20th century (Colucci Pescatori 1986: 126; 1996a: 108-109). The hypocaust heating system has been brought to light: it uses a floor resting on *suspensurae* (brick pillars); in the *caldarium*, the tubular tiles that allowed the passage of hot air along the walls are still preserved.

Other traces of an aqueduct are reported along the southern defensive walls (Colucci Pescatori 1986, fig. 11; 1991: 112; 1996b: 194), but no trace of them could be found during recent surveys, perhaps because of the dense vegetation covering the plateau. The last evidence of structures related to water distribution within the city occurs in a document dated back to 1778. Barberio mentioned the presence of aqueducts with bronze ducts - 'acquedotti con canali di bronzo' - on the Civita plateau (Barberio 1778: 26). According to this data, it is not possible to specify where the aqueduct entered the city walls or where the *castellum aquae* was located.

New evidence of the presence of a distribution system comes from research carried out since 2019 by the project '*Abellinum*. Piano per la conoscenza, la tutela e la valorizzazione dell'antico centro irpino' (A. Santoriello Scientific Director, DISPAC, University of Salerno; Santoriello and Musmeci 2022; Musmeci 2022; Santoriello 2022).[1] The results obtained so far allow to add new data for a reconstruction of the urban system and to advance reflections on the water supply system. [D.M.]

[1] The project was born from a collaboration between the Soprintendenza Archeologia, Belle Arti e Paesaggio per le province di Salerno e Avellino, the Municipality of Atripalda (AV), the Direzione regionale Musei Campania and the Dipartimento di Scienze del Patrimonio Culturale (DiSPaC), Università degli Studi di Salerno (https://www.dispac.unisa.it/ricerca/focus?id=454 (viewed 25 February 2024). Research and excavation activities are carried out under a three-year concession (MIC_DG-ABAP_SERV II 01/06/2022. 0020738-P [34.61.07/1.27.1/2019] – DG ABAP|31/05/2022| DECRETO 696). The project, directed by Prof. Alfonso Santoriello, assisted by Giacomo Pardini and Daniela Musmeci of DiSPaC, includes the participation of the Dipartimento di Ingegneria Civile (DICIV, Università di Salerno) for the surveys and representation of the area; the support of the Dipartimento di Farmacia (DIFARMA, Università di Salerno) for the analysis of the vegetal and environmental heritage, and the collaboration of Centro ICT per i Beni Culturali (Università di Salerno) for the communication and transmission of knowledge through new technologies. The geological and geomorphological study is entrusted to Prof. Vincenzo Amato of the University of Molise; geophysical surveys are carried out by Dr. Amedeo

New investigations and data acquisition

The *Abellinum* project responds to the need to acquire new data on the ancient city and to systematise all the information in order to create a dynamic archaeological map of the city and its territory, which in Roman times included a large part of the Sabato valley (Santoriello 2022). With the integration of archaeological data with other data sets (geomorphological, botanical, etc.) and the application of diverse survey methodologies, both invasive and non-invasive, the project aims to build a cultural ecosystem available to the community (Antinozzi *et al.* 2022; De Falco *et al.* 2021; Pagano *et al.* 2022).

New important data about the urban layout, the organization of spaces in the north-eastern area of the plateau and the phases of occupation of the city are emerging from the 2021-2023 investigations. In particular, a stratigraphic excavation was carried out to the west of the *domus*, on the continuation of the *decumanus*, and is currently investigating the phases of occupation immediately preceding and following the eruption of Pollena (AD 472) (**Figure 3**).[2] With the discovery of a new *cardo*, in the south-eastern corner of the excavation, the structures brought to light are located to the west of a crossroad with the *decumanus* and thus occupy another city block, next to the *domus*.

To the north of the *decumanus*, the structures belong to a building that has been partially investigated. At least ten rooms are known, which, with plan modifications and building interventions, were reorganised into a housing unit that continued to be used after the eruption. In particular, in one of the rooms, a duct made of clay pipes was installed and discharged outside directly onto the road using an

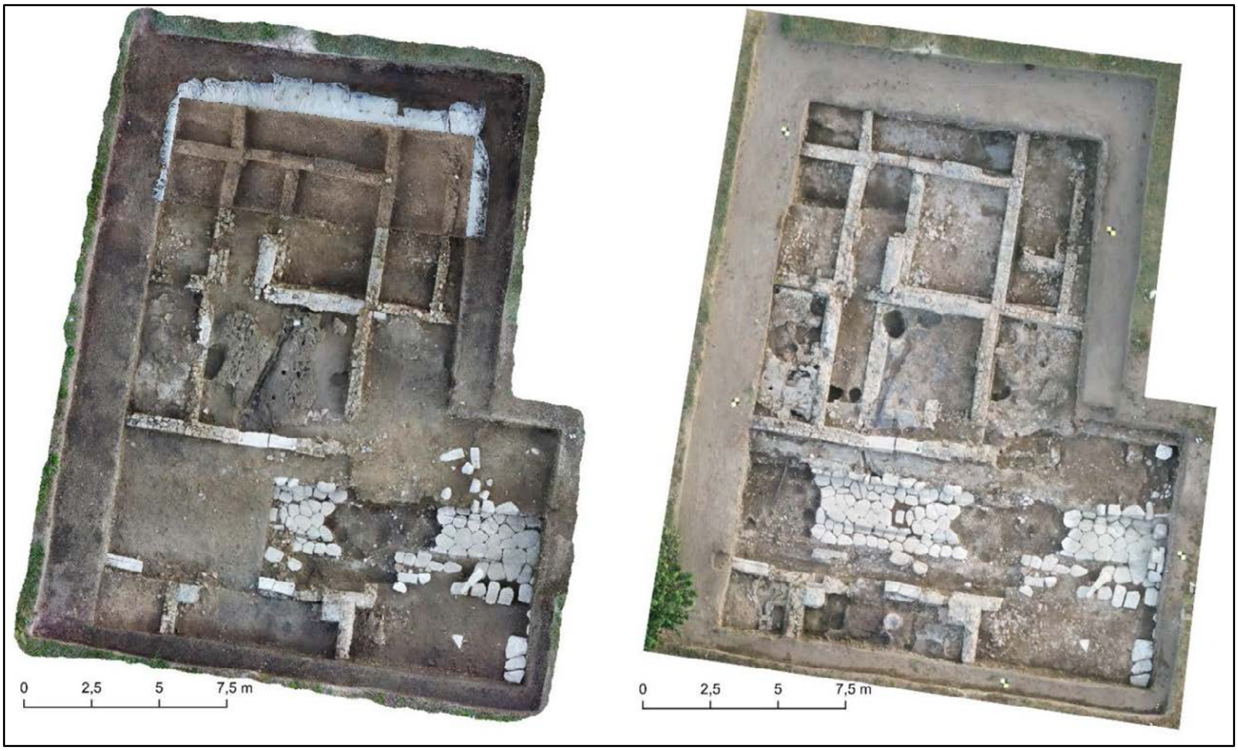

Figure 3. Orthophotos of the buildings north and south of the decumanus*, at two different excavation times: post-Pollena (AD 472) occupation phase (left, excavation 2022); pre-Pollena occupation phase (right, excavation 2023) (elab.* Abellinum *project, DISPAC).*

Rossi, while the geomaterial study and the analysis and mapping of degradation are carried out by Prof. Celestino Grifa of the Dipartimento di Scienze e Tecnologie (Università del Sannio).

[2] For more detailed data see the Dataset published in 'Geoportale Nazionale per l'Archeologia': https://data.d4science.net/GKAi (viewed 27 February 2024).

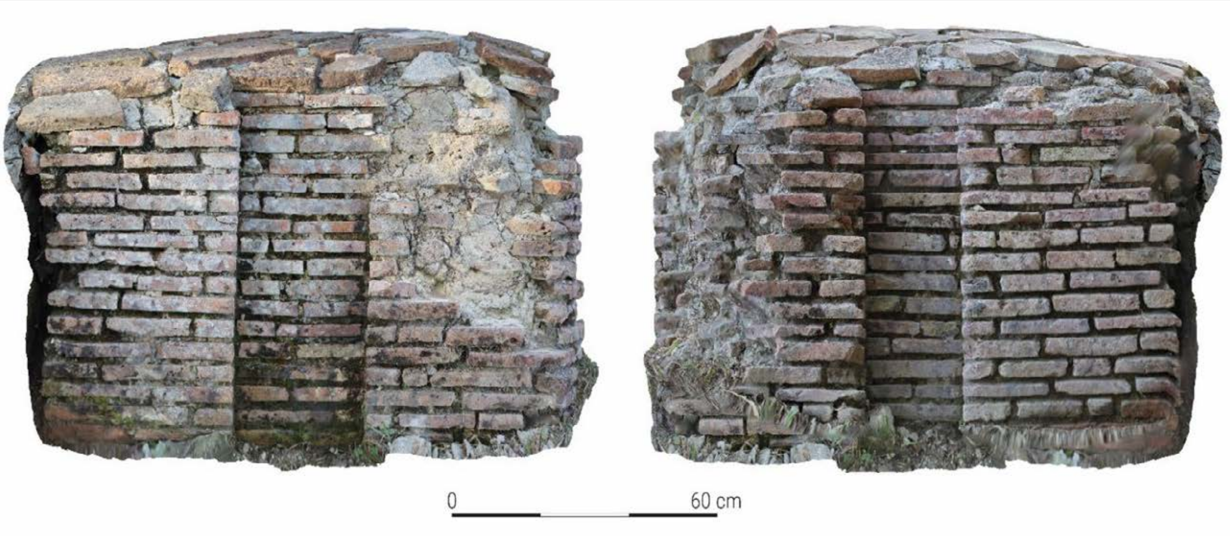

Figure 4. Northen and southern facing of the piezometric tower (elab. by M. Covolan).

arrangement made of tiles and tuff blocks. South of the *decumanus*, remains of masonry indicate the presence of another building, of which two rooms open onto the road are known at present. They are probably *tabernae* or spaces used for production activities and in both there are traces of water management systems (gutters with tile floor and covering).

In addition to these clues about the water management and disposal, there are also three new pieces of evidence that can be directly linked to the water distribution system within the city, all of which are somehow related to each other and thus identify a widespread distribution system characteristic of every Roman settlement. A piezometric tower or secondary *castellum* (**Figure 2: C** and **Figures 4-5**) has been identified along the *cardo* to the east of the *domus* and the *tabernae*, in the section south of the *decumanus*, which was revealed by investigations in 2008 (Nava 2011). The second new piece of evidence is a limestone fountain pillar (**Figure 2: D**). It was found overturned on the paving stone, in a disused context, in the area of intersection between the known *decumanus* and the recently discovered *cardo*. The conditions and the context of its discovery suggest that the pillar was part of a fountain located in the open space between the two perpendicular roads. This discovery provides important new insights into the public amenities and water supply system of the ancient city, to which a lead *fistula* can also be attributed (**Figure 2: E**). The *fistula*, found during the last excavation campaign in the preparation layer of the *decumanus*, has yet to be excavated and studied. This new archaeological find confirms for the first time Barberio's words about the presence of bronze ducts.

[D.M.]

The water supply and distribution system

Abellinum *hydraulic system*

The first hydraulic structure we will analyse will be the piezometric tower or secondary castle (**Figure 2: C**). This type of pressure regulation system is very common inside the city in order to allow a correct water distribution without the risk of breaking pipes or taps. Direct and well-known comparisons are present in the Vesuvian towns of Pompeii and Herculaneum. Generally speaking, this type of structure is not isolated, and there are many within a town. This is not yet the case in *Abellinum*, where only one has been identified, which makes it more complicated to analyse it in broader terms than the general town planning of the city. For both Pompeii and Herculaneum, the secondary castella are arranged along steeply sloping streets which is not the case in *Abellinum*. This detail will be taken into account in the general reading of *Abellinum*'s water distribution system.

Figure 5. The piezometric tower in the cardo (photo by the authors).

This structure has a quadrangular plan (137cm x 123cm) and it is preserved for a height of 90cm (**Figures 4-6**). The piezometric tower is realized with bricks disposed in horizontal courses with the use of mortar. At the front and rear is a groove 15cm deep and respectively 30 and 23cm wide, where the lead pipes going up and down from the cistern should have been situated. This cistern, made of the same material of the pipes, normally is located at the top of the tower itself (**Figure 6**). The different width of the groove is probably due to a different thickness or number of tubes present.

Another difference with the Vesuvian piezometric towers is the lack of limestone concretions along the walls and along the grooves where the pipes were located. The presence of concretions was highly probable, considering that limestone concretions were found along the entire route of the aqueduct that supplied *Abellinum* (AAVV 1883). The reuse of the structure as the eastern jamb of the access to a room created by the closure of the *cardo* in late antiquity, possibly involved the removal of these concretions, thus explaining why they are not found today. The creation of a closed space that reuses the structure for another purpose also denotes the necessary end of the use of the structure for its primary task.

The fountain pillar (**Figure 2: D**) is 108cm in height and 32,5cm in width in the upper part (**Figures 7-8**). It had to be embedded inside the rear slab of the fountain, having the back side flush with the outside of the slab itself. At the rear it has the groove for the lead pipes (made of lead considering the size of the recesses), which had to reach all the way to the fountain, which also had to have a tap at the front (diameter of hole 8,5cm). Of the fountain, which was most probably composed of four monolithic stone slabs (**Figure 8**), on the model of the better-known fountains of Pompeii and Herculaneum, only the small pillar remains. The pillar has a bas-relief decorating the mouth of the fountain. According to iconographic comparisons with the fountain found just inside Porta Stabia in Pompeii, the

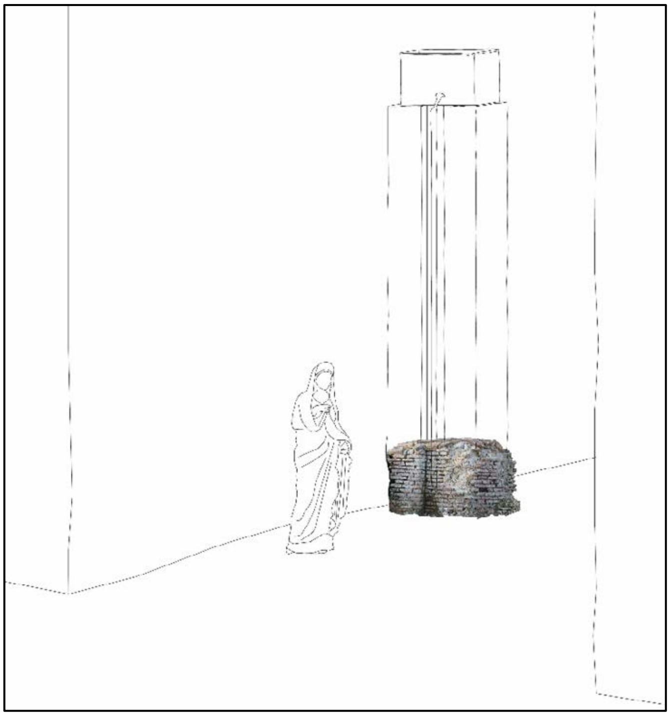

Figure 6. Reconstruction of the piezometric tower (elab. by M. Covolan).

Figure 7. The face and the rear of the fountain pillar (elab. by M. Covolan).

representation could be that of a water deity. However, it is possible to be interpreted as a lion, or a gorgoneion for a least plausible hypothesis.

Due to the condition of its discovery, its correct location is unknown, but if there was a fountain, there had to be lead piping. No information was available on this type of evidence until the last excavation was carried out, as already mentioned in the previous section, with the exception of Barberio's reference (Barberio 1778: 26).

The lead *fistula* (length 190cm, diam. 6cm; **Figure 9**) was found inside the preparation levels of the *decumanus* and it had to be placed immediately below the flagstones. The lead *fistula*, which is arranged perpendicular to the direction of the *decumanus*, consists of at least two segments welded together. Of the *fistula*, we see only the top part where the lead sheet is welded, and for the moment, there are no visible stamps indicating the manufacturer of the pipe. The *fistula* is identified from the northern sidewalk (where it continues within the layers of preparation and has not yet been possible to investigate), slopes down towards the central part of the road, and then re-emerges to the south, at the edge of the southern sidewalk, where she is questioned because of a clean excision. The large amount of metal slag found in the vicinity of the fistula is likely to be related to work on the pipeline.

The 'acquedotto sannitico'

For the Campanian area, the great hydraulic works subsidized by Augustus influenced in many ways the evolution of the landscape and the settlements. The imposing *Fontis Augustei Aquaeductus* is one of the best-known and investigated works for its length, flow rate and the high number of cities and urban aggregates that it reaches, thanks to its secondary ramifications (AAVV 1883; Catalano 2003). Less known is the stretch called 'Acquedotto sannitico', which from Serino goes northwards **(Figure 10)**, with the aim of supplying water first to the city of *Abellinum*, and then that of Benevento.

The study of this aqueduct is the object of the European postdoctoral fellowship project "SeBNA - Water distribution system in the Ancient World: forms of

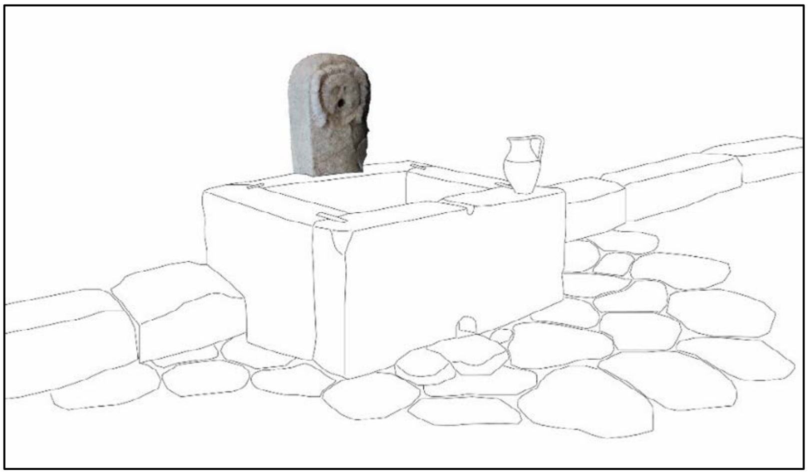

Figure 8. Reconstruction of the fountain (elab. by M. Covolan).

Figure 9. The lead pipe as discovered during the last excavations (elab. Abellinum *project, DISPAC).*

continuity, permanence and subsistence in contemporary society" (CIVIS3i, H2020-MSCA-COFUND-2020).[3]
The aqueduct has never been well investigated and the only complete study of its entire course dates back to the end of the 19th century, thanks to the *Società Veneta per imprese e costruzioni pubbliche* (AAVV 1883). It is a valuable engineering document, which not only meticulously describes the largest aqueduct that carried water to the Neapolitan and Phlegraean areas, but also makes the only accurate description of the so-called 'Acquedotto sannitico'. The dating of the aqueduct fluctuates, according to different researchers, between the Augustan age and the beginning of the 2nd century AD (Potenza 1996; Colucci Pescatori 1996c; Catalano 2003; Vigorito 2017). An important reconstruction seems to be the one carried out by the Benevento consul *Egnatius Certus*, as recorded in an inscription dated between AD 200 and 230.[4] The aqueduct seems to have been in use until the 8th-9th century, according to the materials found at the *castellum aquae* of Benevento (*Rocca dei Rettori*), in obliteration of the canal's *specus* (Vigorito 2017).

The aqueduct channel, probably 34 to 36km long, originated from the main spring group of Urcioli, in the municipality of Serino. The *caput aquae* was located at approximately 324m asl, while the arrival located in a cistern after the arch of Trajan at Benevento was at an altitude of no more than 150m a.s.l. From these data, the average slope of the structure is about 5m per km. In fact, the stretches of the aqueduct which ran along the Sabato river, also crossing it with several canal bridges, presented

[3] The project is led by M. Covolan. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 101034324. Ce travail a bénéficié d'une aide du gouvernement français au titre de France 2030, dans le cadre de l'Initiative d'Excellence d'Aix-Marseille Université – A*MIDEX.

[4] *Eph. Ep.* VIII, 862=*EDR*101257 *[C(aio) Egnatio C(ai) f(ilio) / Certo, c(larissimo) v(iro) / co(n)s(uli) p(atrono) c(oloniae) / d(ecreto) d(ecurionum)].*

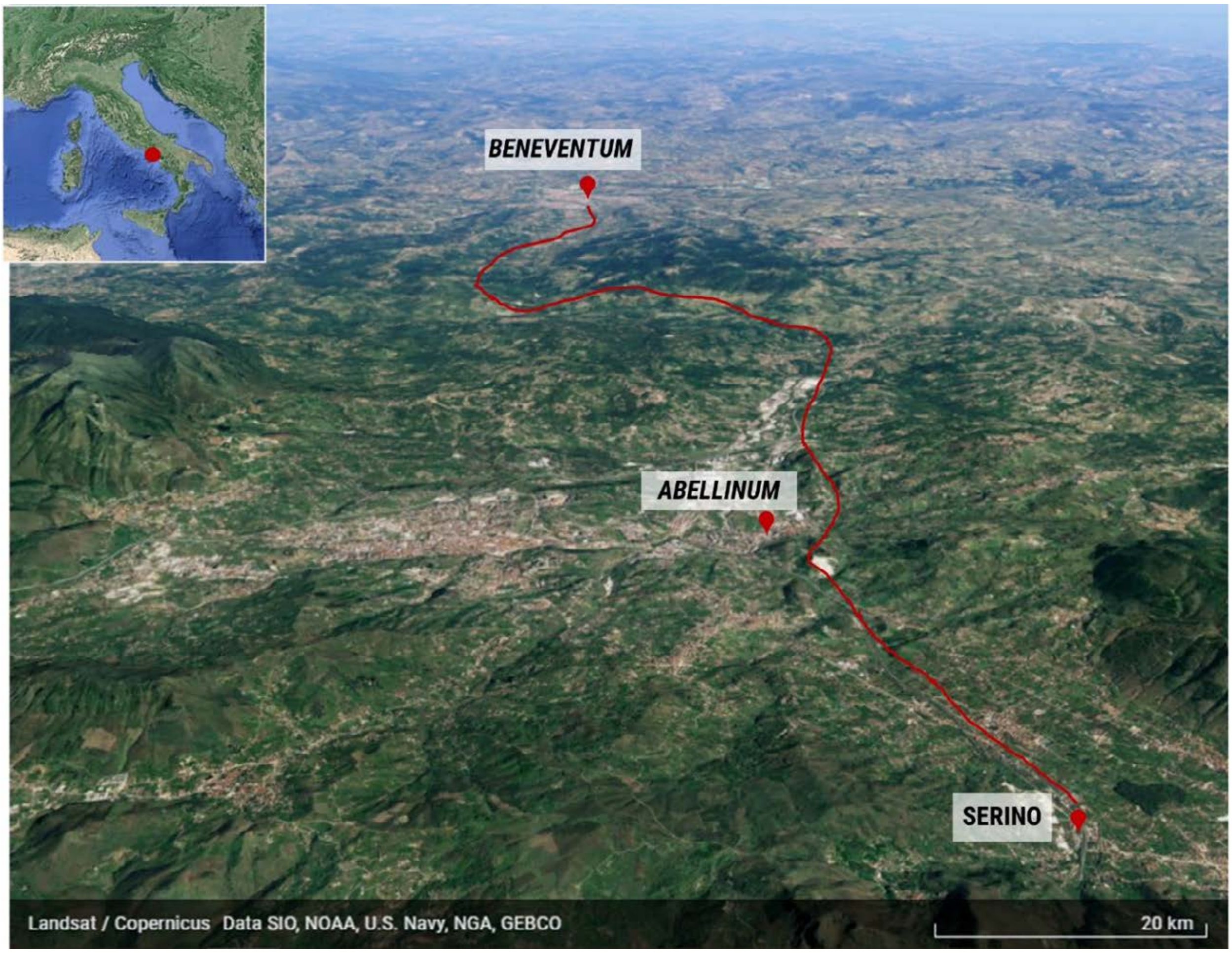

Figure 10. Path of the Serino-Benevento aqueduct (elab. by M. Covolan).

different slope values, some of them considerable. The initial section had a gradient of 1m per km. Near the village of Prata di Principato Ultra this value rose to over 7m per km, from Altavilla Irpina to Ceppaloni it was over 13km, and finally the above-mentioned value, in the Benevento area, was 2m per km (Potenza 1996).

The city of *Abellinum*, as far as is known from published studies (Colucci Pescatori 1991; 2013), was served by the aqueduct arriving from Serino and had to enter the city from the south. New research is proving, however, that the aqueduct could have entered the city from the south-east, as it seems possible to accept that the city's *castellum aquae* should be located in the area of the actual Palazzo Caracciolo (**Figure 1: G**), as was also hypothesised by the engineers of the *Società Veneta* (AAVV 1883). Nevertheless, the aqueduct enters the Civita at an altitude of about 310m a.s.l. or more, since the plateau has no significant variations in altitude.

[M. C.]

Conclusions

Thanks to the new archaeological evidence, it is now possible to delineate the water distribution system within the city of *Abellinum*. Although, to date, the *castellum aquae* has not been identified, a canonical system is outlined with the presence of secondary *castella* (or piezometric towers) to regulate water pressure. As already noted, this type of technical solution is generally used in cities with a steeper slope. In the case of *Abellinum*, as we do not know whether there is a *castellum aquae* on the Civita or where the aqueduct enters the wall circuit, the presence of a piezometric tower is peculiar. If we accept the hypothesis that the *castellum aquae* is located in the area of Palazzo Caracciolo (323m asl), on the opposite hill to the east of the Civita, we can assume that there is a need to re-calibrate the water pressure once it reaches the city. This need may be really pressing when one considers that in the approximately 570m separating the two hills, there is a difference in elevation of 13m.

As for the entrance of the aqueduct on the Civita, with the data currently available it is not possible to add much. The reference made by Colucci Pescatori (1986, fig. 11; 1991: 112; 1996b: 194) to the identification of a part of the aqueduct along the southern part of the city walls is curious. If we consider the existence of the *castellum aquae* at Palazzo Caracciolo valid, the aqueduct canalization should make a very wide tour to pass south of the plateau. A long distance, like the one assumed with an entrance of the aqueduct to the east of the plateau, or very long, if we consider an access to the south, it would require however a redistribution of water pressure and therefore require the presence of piezometric towers in the city.

However, considering the section of *specus* reported by Colucci, one can assume the presence of a second water conduit that supplied the city from the south. We mean either another aqueduct or another sub-branch of the main branch of the Samnite aqueduct. There is no evidence that it has been possible to verify, but from the archives of the Soprintendenza there is news of a section of conduit found in 1977 in the southern area of today's Atripalda[5].

For the direct water distribution there is evidence of use in both public and private contexts and this supply was done through lead pipes. The presence of the pilaster, indicating a public fountain and the baths are two of the public structures linked to the water system. The private pool and baths in the *domus* of *M. Vipsanius Primigenius* are the private counterpart of water use. This use is possible only thanks to the presence of lead pipes, which reach not only public but also private structures.

Thanks to the new evidence it is also possible to refine the chronological information about the so-called 'Acquedotto Sannitico' and also about the urban water distribution system. The dating of the public baths complex and the installation of the *fistula* in the Late Republican/Augustan era suggests the existence of a hydraulic system dating back to this same period. Given the size of the baths and the necessary large amount of water, this structure could not exist except in connection with the aqueduct. This argument is further enhanced when considering the absence of testimonies of other systems of water supply (for example wells) on the hill of the Civita for the preceding period.

If we compare this information with what is known about the 'Acquedotto sannitico', we can assume that this is, slightly prior to the *Fontis Augustei Aqueductus*, which, as the name indicates is built in the Augustan period.

Thanks to the context in which the secondary *castellum* is inserted, we can also think about the period of use of the *Abellinum* water system. The creation of a closed space condemned the use of the *cardo* as a circulation space, but above all, the possibility that the piezometric tower still worked, from a temporal limit to the arrival of water on the Civita. In Late Antiquity, when many of the Roman structures were reoccupied (Colucci Pescatori 1986), the hydraulic system had to be in ruins. The use of the piezometric tower as the jamb of a door and the consequent loss *in primis* of the pipes and the boiler in lead, but also of the limestone incrustations, is plausible evidence to support that the water of the 'Acquedotto sannitico' in the Late Antiquity did not arrive on the Civita hill or at least no longer used this access.

[M. C.]

[5] Information taken from the archive documents of the then Soprintendenza alla antichità delle province di Salerno Avellino e Benevento, currently part of the archives of the Soprintendenza Soprintendenza Archeologia, belle arti e paesaggio per le Belle Arti e Paesaggio di Salerno e Avellino. Document dated 27/04/1977, no. prot. 1851/502.

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'Domesticating Water': Some Conclusions on Water Infrastructure in the Ancient World

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Readers will have noticed that previous chapters provide extensive information with multiple implications at various levels. Here, we will merely present some brief general observations that we deem of interest. First, it is important to highlight that water plays a key role in human settlements – a statement whose relevance is not diminished by its apparent obviousness. Water is generally a resource that can be used for multiple purposes; yet, it is sometimes to be avoided, especially when it appears in excess (intense rainfall, river flooding, flood-prone areas, etc.). Rivers are key drivers for human settlement: if navigable, they serve as communication routes, they also provide fishery resources and supply water for several purposes (hydropower, irrigation, water supply, etc.). Rivers also play an important role as a means of waste disposal. This factor, which has been underexplored by research, is likely to have carried significant weight in the search for specific settlement locations in Antiquity. Rivers – and seas, in the case of coastal settlements – facilitate the removal of solid waste and the disposal of wastewater, which is channelled through sanitation networks. Prime examples can be found in *Augusta Taurinorum* and Ostia, as discussed in this monograph. In the latter, where the geomorphic peculiarities of its location in the Tiber delta resulted in a high water table, sewers also played a crucial role in terms of draining natural groundwater from the terrain.

Therefore, the utilisation of water resources and their adaptation to human necessities required the construction of hydraulic works that alter the original natural conditions. These infrastructures eventually impacted the landscape and settlement, as observed by U. Fusco in the territory of the ancient *Veii*, or by G. Di Luca in Campania. However, it is worth noting that, despite the importance of hydraulic works for human settlements, these have often received scarce research attention and have been frequently subordinated to architectural or urban considerations deemed of greater importance. This is noted by K. Gottardo in the study of the sanitation system of the theatre in Ostia. Whenever attention has turned to hydraulic installations, the focus has been on supply infrastructure rather than sanitation. Within the former, the emphasis has been on monumental and prominent constructions (aqueducts, *castella*, supply pipes, etc.) at the expense of other collection systems that were either simpler or more difficult to document due to their underground location (wells, cisterns, *cuniculi*, etc.). Likewise, priority has also been given to the water supply in certain buildings that represent the splendour and grandeur of the Roman world, notably baths and public and domestic fountains. Nevertheless, E. H. Sánchez López's work in Pompeii also shows the connection between artisanal and commercial facilities with supply systems, whether through cisterns, connections to the general water distribution network, or combining both sources.

Wells and cisterns have traditionally been the most widely used supply systems in cities. They were still used even after the construction of aqueducts, as exemplified by the cases analysed here, Pompeii and *Augusta Taurinorum*. In *Baiae*, the luxurious villas were also supplied with rainwater collected through cisterns, prior to the construction of the Serino aqueduct.

Other cities opted to exploit nearby springs, although remains of channelling or storage structures are scarce, and their interpretation remains uncertain. This appears to be the case in *Mirobriga*, a small town on the westernmost side of the Iberian Peninsula, where the location of the two thermal complexes in the lower part of the town showcases a smart utilisation of available water resources. Water from a nearby spring was seemingly used and presumably stored, according to the interpretation presented here by C. Felício, in a large reservoir adjacent to both buildings. Furthermore, both complexes were built over the valley that was formed by a seasonal water stream, which was used and partially channelled to discharge waste and excess water.

No other water collection systems are known in *Mirobriga*, except for some wells located in the peristyle of residences – thus, in private spaces – so the existence of any public collection system remains uncertain. One clear aspect is that the town never had an underground sewage network other than the system serving the drainage of the two aforementioned thermal complexes. Thus, this urban centre prioritised the drainage of rainwater and wastewater along the street surface, facilitated by its natural inclination, as seen also in Pompeii and other cities. This compelled the adoption of various waterproofing solutions to protect the façades of buildings from humidity and water infiltration.[1]

Springwater, together with a karst doline, also appears to have been the main source of water supply in the Roman settlement of Sierra Aznar, linked to the ancient *Calduba*, in the South of the Iberian Peninsula. In fact, water seems to have been a central element in the urban planning of this settlement, which was also characterised by a system of artificial terraces adapted to the natural slope. However, to date, little is known about the functioning of the hydraulic complex, which includes channels, large ponds, and settling tanks, among other elements, and about its actual purpose. Previous proposals have suggested practical applications linked to water collection or productive activities. Building on these proposals, I. M. Roldán-Sevilla, J. A. Calvillo Ardila and L. G. Lagóstena Barrios offer a hypothesis linking these infrastructures, in light of their location and scale, to the symbolic and scenographic value of water and the objective of turning a small mountain town into a *locus amoenus* – an idyllic setting characterised by the seamless integration of architecture and the natural landscape.

In any case, it is worth recalling that water in the ancient world often carried a symbolic or even sacred connotation, regardless of the multiple purposes it may have served. Hence, from a present-day perspective, it is difficult to assess the value and actual use of an element that embodied the ambivalence between symbolism and utilitarianism, with the prominence of one or the other depending on the context. In this regard, there are two notable collection structures known in the *oppidum* of *Glanum*: the so-called *nymphaeum*, which appears to sacralise and monumentalise a notable spring, and the *dromos* well, whose primary function, whether sacred or profane, has been the subject of extensive discussion. The chronology of the two structures and the origin of their design has also been debated and they have thus far been attributed to Hellenistic tradition. The location of similar new collection structures in Southern France, as presented here by S. Agusta-Boularot, M. Bouiron, G. Vacassy and G. Vincent, leads these authors to suggest a Gallic origin for these structures. If that is the case, it would further support evidence that, in the hydraulic field as in many other areas, indigenous traditions were adapted to Hellenistic and Roman models.

A large share of pre-Roman collection structures in *Glanum* remained in use as the settlement underwent significant urban development starting from the Augustan period. An aqueduct and a water distribution network were built, the latter supplying the so-called 'triumphal fountain', a new monumental fountain located in the town's redesigned administrative and religious centre. Although not addressed in this monograph, previous literature has suggested that the aqueduct may have originated from a dam located around 400 metres in a straight line from the urban centre, built at a

[1] For more details on this topic, which is not specifically addressed in this monograph, see Acero Pérez and Felício (2021).

narrow point in the small Baume valley.[2] The dam has so far been identified as the only Roman urban supply dam in Gallia. However, there are no visible remains of the original structure, except for the markings in the lateral sockets of the rock, as it was concealed by the current dam erected in 1891. It is thus difficult to determine the exact chronology of the old dam and its precise connection to the Roman aqueduct.

While dams were used in the Roman world as a means of water collection, particularly in arid and semi-arid environments, they were predominantly employed to supply villas and other rural facilities, or for irrigation and mining purposes. The use of dams to supply cities has been more widely debated. For instance, in Spain – the Western European country with the largest share of theoretically Roman dams, some of which are located around notable cities – these constructions have been the focus of intense discussion regarding their chronology and function. This is, however, not the place to delve into this issue, which is still open and requires in-depth analysis.[3] Suffice it to state here that the use of dams for urban supply purposes in Roman times appears to have been highly limited. In fact, apart from the examples in Hispania, which remain subject to debate, only two other cases are frequently cited for the rest of Europe. On the one hand, the aforementioned *Glanum* dam and the challenges related to its conservation. On the other hand, the Subiaco dams in Italy, analysed in this monograph by E. Tocci, clearly represent an exceptional case, as they were constructed under imperial initiative in a mountainous area to supply Nero's sumptuous villa, where water played a central role. It was not until sometime later, during the Trajanic period, that the head of the *Anio Novus* was relocated to one of the lakes, where water was of higher quality than that previously collected from a lower section of the river.

There is no doubt that the construction of aqueducts, regardless of their *caput aquae*, enabled a larger and more consistent water flow compared to other supply systems. Additionally, the connection to pressurised distribution circuits significantly enhanced the potential for water use. However, the construction of these elements required meticulous calculations of altitudes and gradients. The varied methods used in aqueducts to overcome differences in elevation, such as *subctructiones, arcuationes* or siphons, are well known. Among these, the use of the latter appears to have been more limited due to the technical complexities of building and maintaining large pipes, sometimes kilometres long and subject to high pressure. The already-known list of stone siphons is now complemented by the one proposed by D. Gangale Risoleo and S. Ratto in Turin, who hypothetically place it on the Western flank of the city. It was not uncommon for siphons to be located along the final sections of aqueducts, before reaching cities, as these were often surrounded by rivers or valleys, sometimes too wide or deep to be crossed by arcades, which were the preferred option whenever possible.

Risks of breakage or malfunctions also affected the pressurised channels that were part of internal distribution circuits in cities. To prevent these issues, Roman engineers employed various mechanisms that enabled the operation of the system and were adapted to the technical and topographic conditions of each context. In Pompeii and Herculaneum there are well-known cases of towers or secondary *castella* that regulated pressure and ensured the capillary distribution of water to various recipients. Additionally, M. Covolan and D. Musmeci present a similar tower located in the nearby city of *Abellinum*. The concentration of similar cases in Campania may suggest a regional model of water distribution

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[2] See Agusta-Boularot and Paillet (1997a; 1997b).

[3] A large share of the debate has focused on dams located around Mérida, traditionally regarded as the paradigm of Roman dams in Hispania (Aranda Gutiérrez *et al.* 2006) and whose origin has been questioned in recent decades (Feijoo Martínez 2004; 2006; Feijoo Martínez and Gaspar Rodríguez 2019). The debate has revolved mostly around three issues: the potability of stagnant water, the constructive characteristics of dams and their relation to the aqueducts they supposedly served. For more about the constructive characteristics and the function of these constructions, see the recent monograph of Barahona Oviedo (2023) and, specifically for Italy, see Barahona Oviedo and Pizzo (forthcoming).

systems, but it does not seem to be applicable to other cities or regions. In fact, in many other well-known cities, there are no piezometric towers, and the structures identified as *castella aquarum* do not align with the 'Pompeian model' seemingly corresponding to Vitruvius' description (*De Arch*. 8, 6, 1-2). On the contrary, archaeological evidence shows a wide variety of water collection and distribution mechanisms in Roman cities, featuring diverse and complex technical solutions adapted to the singularities of each setting.

Furthermore, attention shall be given to the supply from aqueducts to *extra moenia* areas in cities, an aspect that has thus far received little attention in research on urban water supply. It is widely acknowledged that *suburbia* in Roman cities were versatile spaces where multiple land uses could coexist – residential, recreational, funerary, industrial, agricultural, ritual, etc. – within well-planned urban organisations. Many of these activities required an adequate supply of water, mainly provided by urban aqueducts. As examined in this monograph, an example thereof can be found in *Augusta Emerita*, one of the main cities in Hispania, which had as many as four aqueducts. Previous studies have already revealed direct connections – whether legal or illegal – from public channels to supply *extra urbem* spaces with industrial uses.[4] The work of M. Bustamante-Álvarez, E. H. Sánchez López and A. M. Bejarano Osorio highlights another connection between the Rabo de Buey aqueduct and the so-called 'House of the Amphitheatre', traditionally interpreted as a large suburban *domus* and now regarded as a possible *hospitium* with extensive baths. It is worth noting the existence of a division in this aqueduct, shortly before reaching the city walls. The main channel entered into the Roman theatre, while the other branch ran parallel to the outer walls, its final destination unknown. In all likelihood, this branch supplied the baths, *domus* and industries of the northern suburb, which was the most densely occupied area along the perimeter of the city. This required the installation of distribution structures to deliver water among various recipients in the area, thereby demonstrating an effort to directly channel public water to peripheral neighbourhoods without requiring the flow to first pass through distribution *castella* in the inner urban centre.

Lastly, apart from technical questions, the human aspect of water distribution is also a key element. G. Jansen addresses this question in relation to the storage systems in Pompeian houses. This perspective is particularly valuable not only in terms of understanding the operation of hydraulic systems, but also as it offers a vivid portrayal of daily realities in the ancient world. Jansen raises questions about the individuals (slaves) responsible for various tasks related to rainwater collection: cleaning roofs, periodically cleaning cisterns, performing maintenance work, monitoring and forecasting stored water, and collecting water for daily use, among others. It is worth recalling in this context the role of the *servi opifices*, cited by Frontinus, who maintained the Roman aqueducts (Frontin. *Aq*. 96), and the convicted who were forced to serve in public baths, clean sewers, or repair streets and roads, whom Pliny consulted Trajan about in the cities of Bithynia (Plin. *Ep*. 10, 32, 2). We are left to wonder about the working conditions of the individuals who built the narrow and kilometres-long underground 'tunnels' for various hydraulic works (*cuniculi*, aqueducts, conduits, sewers, etc.). In short, we must not overlook the human element in the design, construction and maintenance of hydraulic works in the ancient world. After all, we are studying History, and it is individuals, albeit largely anonymous, who are its true protagonists.

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[4] See a summary in Bustamante-Álvarez and Acero Pérez (2023).

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