The Roman Aqueducts

A system of pipes, canals, and supporting structures used to convey water from its source to its main distribution point.

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Figure 1 *Aqua Claudia*, Parco degli Acquedotti, Rome.

Context.

Location: Rome, Italy
Period: 312 B.C. to A.D. 226
Function: Bring water from outside sources into cities
Type: Artifical system
Area: 201562 ha
Water Quality: Fresh and drinkable water

"If we consider the distances traversed by the water before it arrives, the raising of the arches, the tunneling of mountains and the building of level routes across deep valleys, we shall readily admit that there has never been anything more remarkable in the whole world."

Pliny the Elder, Roman author, I century AD

The Roman aqueduct was a channel used to transport fresh water to highly populated areas. Aqueducts were amazing feats of engineering given the time period. Though earlier civilizations in Egypt and India also built aqueducts, the Romans improved on the structure and built an extensive and complex network across their territories.

Figure 2 Continental scale Europe and Italy.

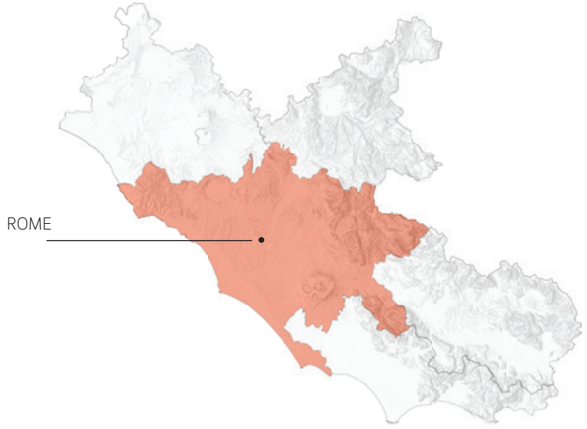


Figure 3 Regional scale and Rome's municipality in red.

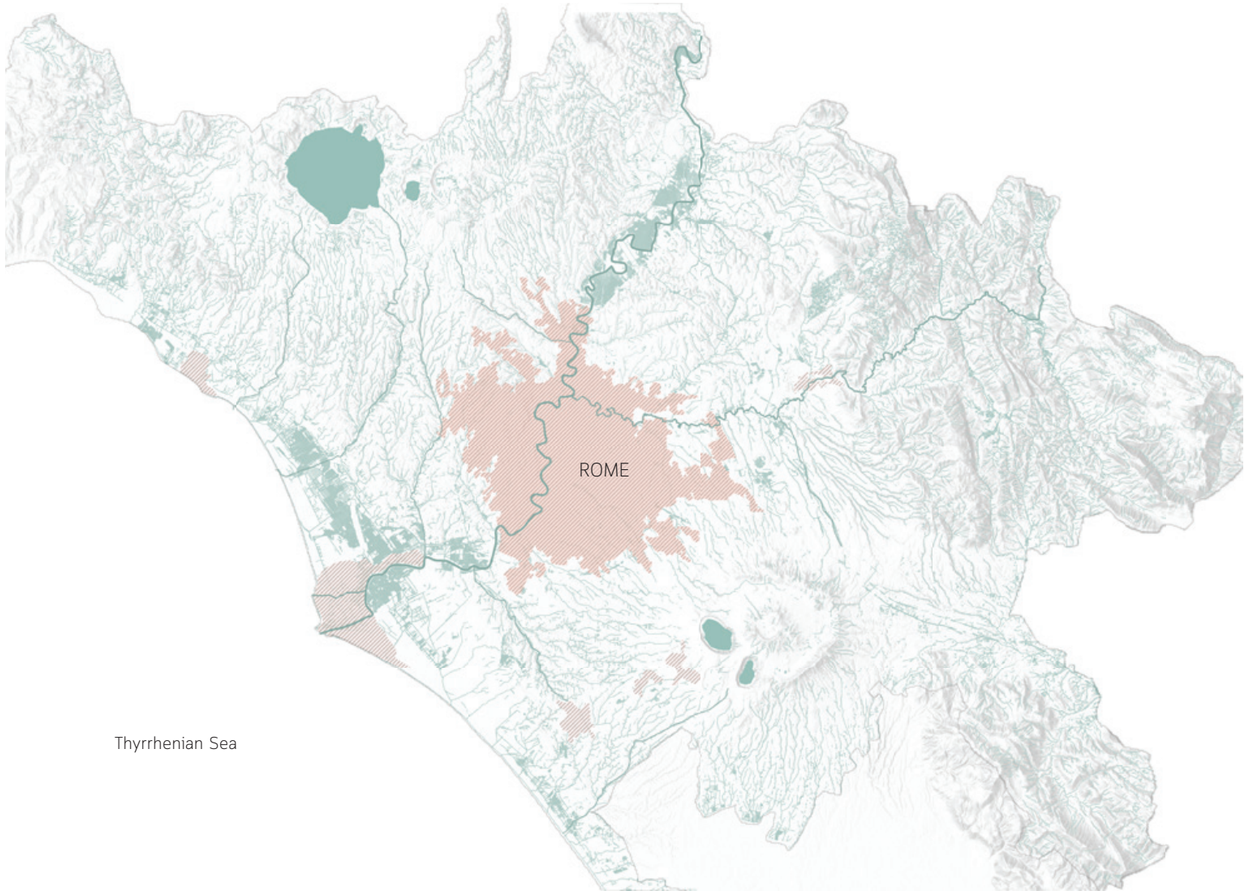


Figure 4 Hydrographic Map.

Archaeological ruins of the Aqueducts.

The aqueduct system consisted of several elements, of which the remains can still be seen. The *piscina limaria* that were sedimentation tanks that were used to purify the water, the *cisterna*, cistern, that collected rainwater or excess water from the aqueducts for periods of drought. At the end of the aqueducts there was the *castellum aquae* which distributed the water inside the city. The aqueducts were fundamental to provide drinking water to the city but also for other functions such as *thermae*, baths, that helped the well-being and health of citizens.

Figure 5 *Piscina Limaria*, water settling and sedimentation tanks (top left).
Figure 6 Aqueducts and *cisterna*, cistern in order to collect rain water (top right).
Figure 7 *Castellum aquae*, water distributor (bottom left).
Figure 8 Aqueducts and *cisterna*, cistern in order to collect rain water (top right)..

Climate.

Climate zone:	**Temperate**
Sub-climate:	Mediterranean

Climate & Weather Averages

High t°:	31.2°C
Low t°:	1.9°C
Mean t°:	18°C
Precipitation:	50 mm
Humidity:	45%
Wind:	13 km/h
Hottest Months:	July (28°C avg)
Coldest Month:	January (3°C avg)
Wettest Months:	November
Windiest Months:	April
Annual Rainfall:	837.3 mm per year

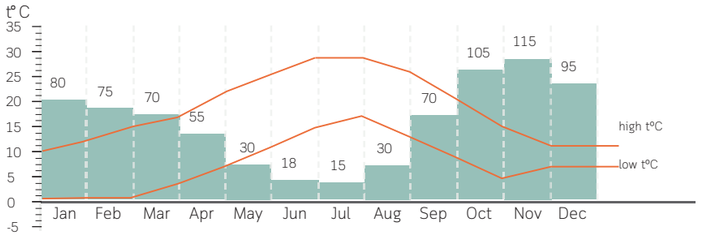


Figure 9 Venetian lagoon annual precipitation and temperature

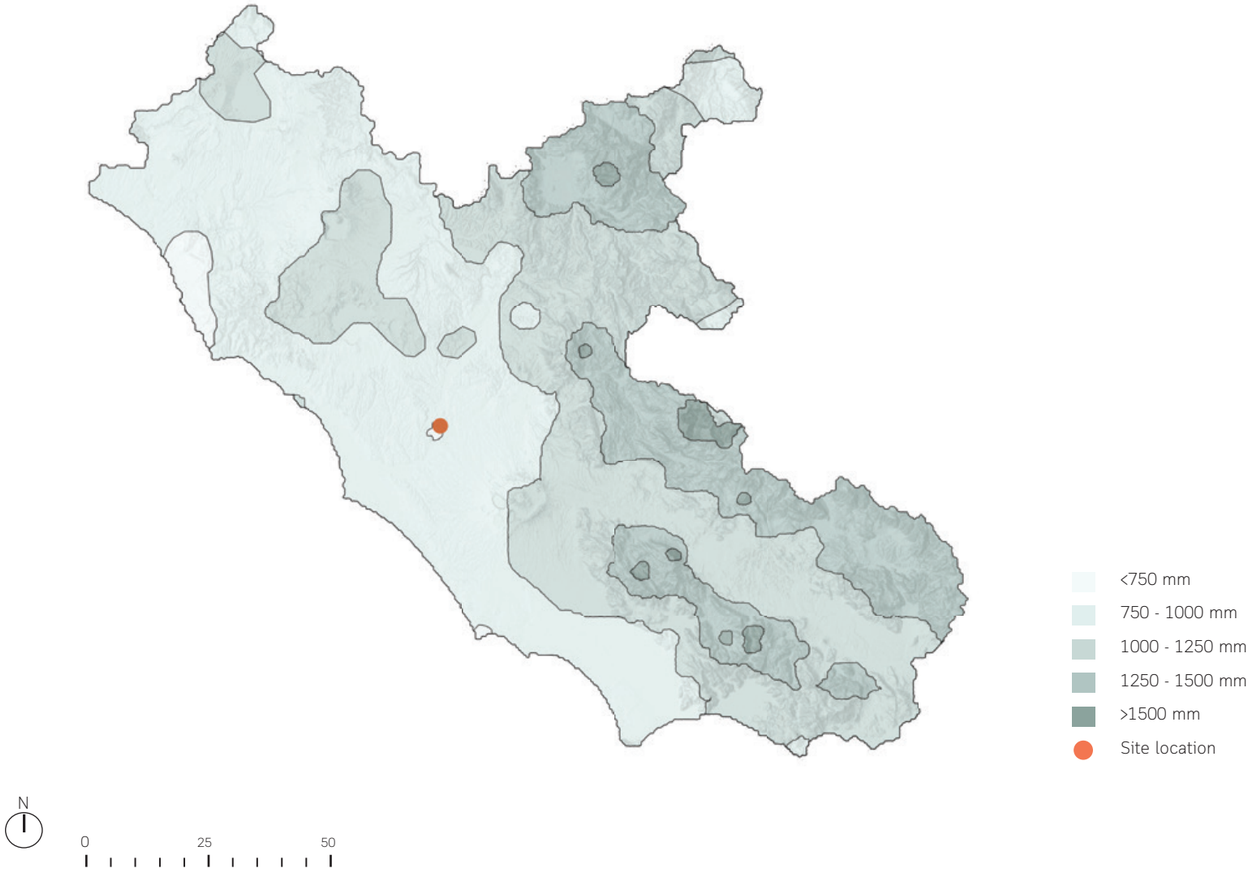


Figure 10 Average rainfall (mm).

The Aqueducts system.

Roman aqueduct systems were built over a period of about 500 years, from 312 B.C. to A.D. 226. Both public and private funds paid for construction. The city of Rome had around 11 aqueduct systems supplying freshwater from sources as far as 92 km away.

The aqueducts were made from a series of pipes, tunnels, canals, and bridges. Gravity and the natural slope of the land allowed aqueducts to channel water from a freshwater source, such as a lake or underground springs , to a city. As water flowed into the cities, it was used for drinking, irrigation, and to supply hundreds of public fountains and baths.
The principle was relatively simple: pure and abundant sources in the hills around Rome could be tapped, and their waters diverted into artificial channels running gently towards the city on a gradient designed to deliver them at a useful height, to flow around the city and feed street fountains, baths, and (for a fee) private houses.
The cheapest route had to be surveyed very precisely: the gradient had to be steep enough to ensure a good flow (to stop the water dropping sediment which would clog the system), but shallow enough to avoid damaging surges. An array of settling tanks, distribution towers or *castella*, pipes, cisterns and fountains had to be built and, for maximum publicity value, richly decorated.

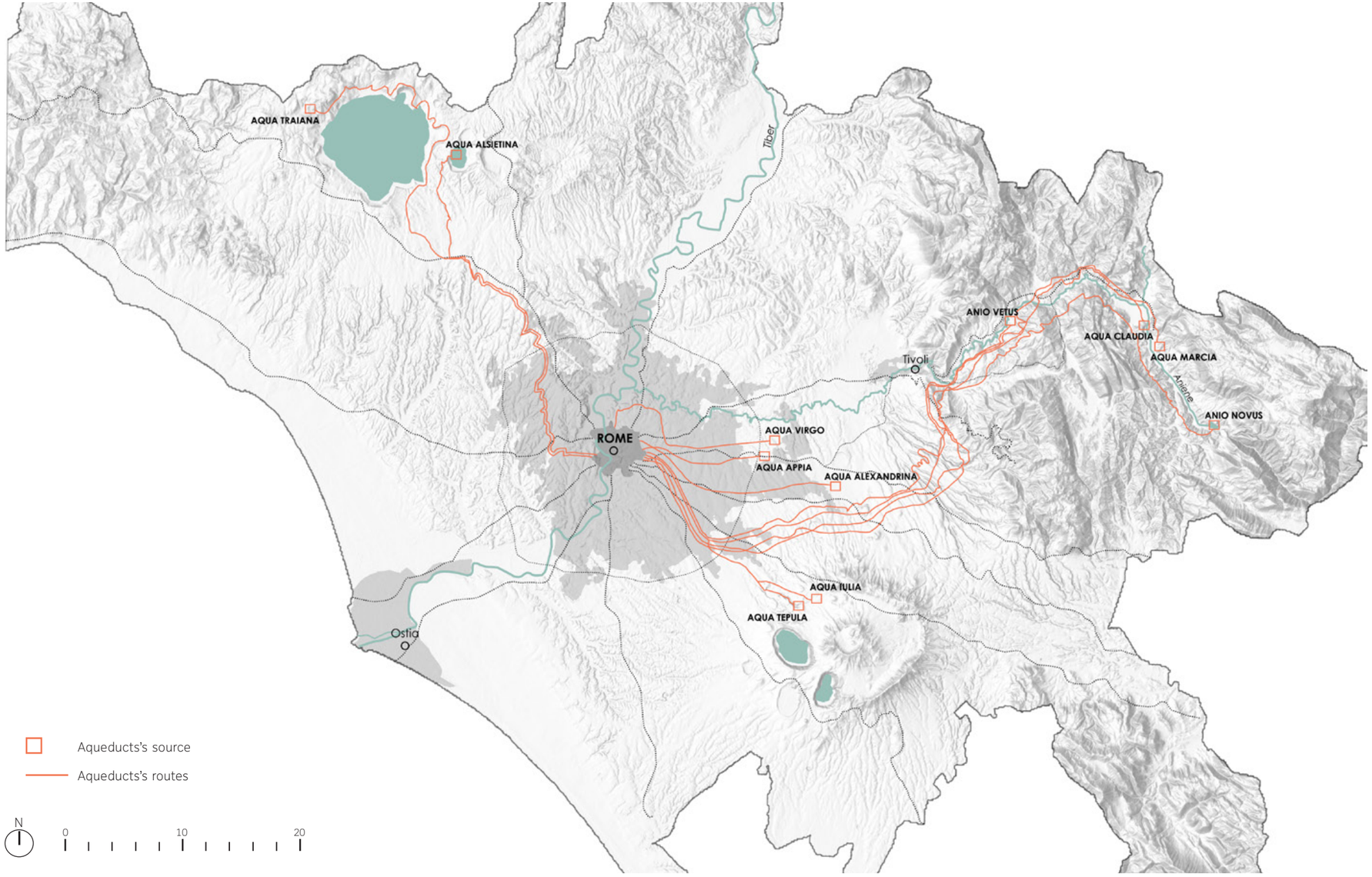


Figure 11 Map of the aqueducts, from the countryside to the city center.

The Aqueducts over time.

Figure 12 Rome's city center during Roman Empire. All the water elements are highlighted. In dashed line there is the zoom which is on the following page.
Figure 13 Rome's city center during Medieval Era.
Figure 14 Rome's city center during Renaissance.

Naumachia
Fountains
Baths
Artificial Lake
Aqueduct
Castellum

312 B.C TO A.D. 226

Rome's first aqueduct, the Aqua Appia, was built in 312 BC. This brought water in from about 16km away, ran almost all its length underground, and could only supply a small and low-lying part of the city. Within 170 years the Marcia aqueduct was built that tapped springs over 90km away, and ran for over 10km on arches; by the I century AD the entire city was served by aqueduct water, and by the early third century there were 11 major aqueducts, mostly running in from the Sabine Hills to the southeast, converging at the "Porta Maggiore" gate. They brought to the city an availability of water of about 1,127,000 cubic meters each day, distributed among the private houses, about 1300 public fountains, 15 monumental fountains, and around 11 public baths, as well as basins used for shows such as *naumachie*, water battle, and artificial lakes.

V to XV CENTURY

With the fall of the Western Roman Empire, some aqueducts were deliberately cut by enemies, but many more fell into disuse due to the lack of organized maintenance. The scarce presence of aqueducts and therefore of public fountains led to a serious hygienic-sanitary situation within the city, diseases were widespread and the population dropped from its peak of over 1 million inhabitants in the imperial era to 30,000 in the Middle Ages.
The inhabitants returned to refer to the river Tiber as the main source of water.

XVI to XVII CENTURY

Thanks to the Baroque (XVI-XVII) and the period known as *renovatio romae* that the ancient splendor of the city returns to shine.
The popes understood the importance of running water in a city and above all they understood the power it can bring. In fact, the popes wanted to oppose the austerity of the protestantism, which was spreading at the time in the northern Europe, with the elegance, the magnificent, the creativity of the Catholic Church, who amused and improved the life of their faithfuls. Therefore, some of the ancient Roman aqueducts were rebuilt and a lot of money was invested in famous public works such as the fountains, through which the city returned full.

Water distribution system.

A *castellum* is a Roman structure that was situated at the end of an aqueduct, where the water was delivered to a basin and then dispersed.
It is estimated that there were about 247 *castella* in Rome, usually located in the highest point of the city, and they received water from the aqueducts, taking advantage of the fall pressure, and then the water was conveyed into three conduits, so as to reach the whole city; however, a shutter system regulated the flow of water according to availability.
Castellum Aquae has a circular plan, with a dome vault with a diameter of six meters and externally it has a trapezoidal shape. Inside, the large tank was divided into three compartments, each of which fed a pipeline: one was used for fountains, one for public buildings, such as baths and the other for private houses; in case of lack of water, the only supply was that for public fountains.

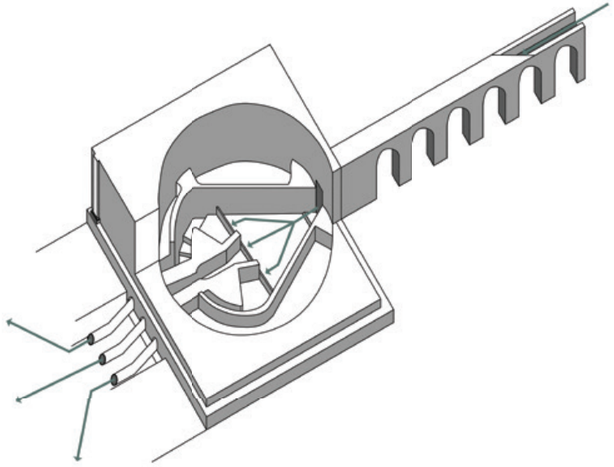
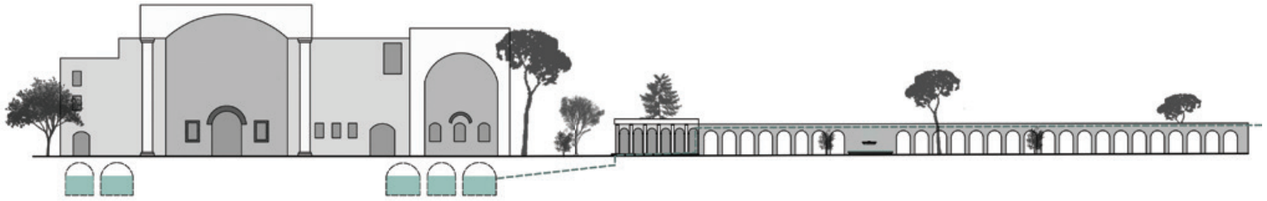
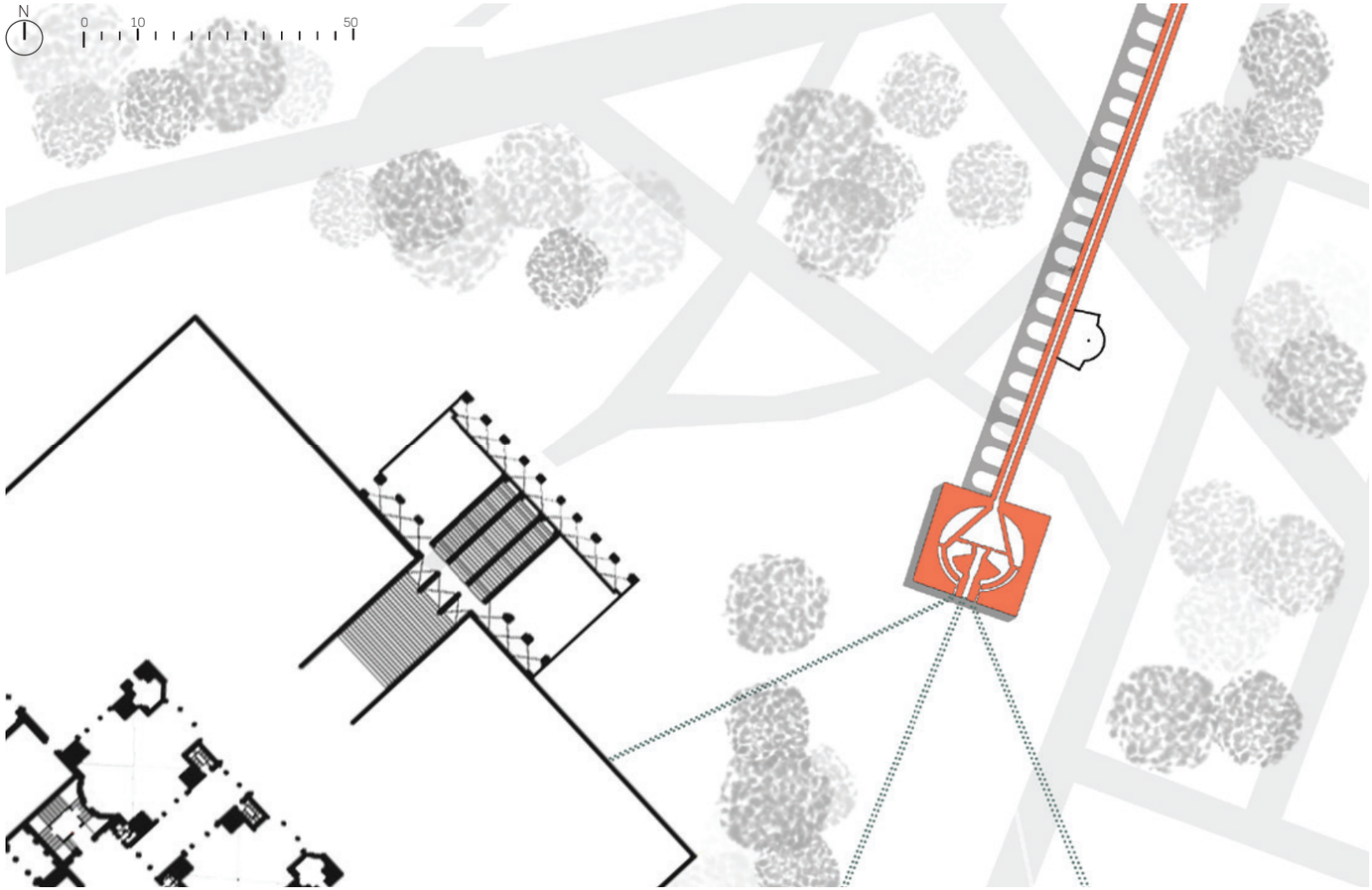


Figure 15 Plan of Trajan's Bath and the detail of the aqueduct system with the *castellum* and the pipes (bottom right).
Figure 16 Section of Trajan Bath (top right).
Figure 17 Axonometry of the *castellum* (left).





Circularity.

The first thing to do to start the construction of an aqueduct was to find a source of water that was drinkable and at a certain height that could allow its exploitation through pressure. After the inspection of the water quality they built long underground tunnels in which the water flowed. Through the inspection shafts they could verify that the pipes were working. Moreover, the purification of the water was also guaranteed by the porosity of the soil (mainly tuff) that filtered the rainwater, which was then collected in the tunnel.

Finally, the settling tank (*piscina limaria*) improved the water purification by collecting the debris at the bottom of the tank. The canal, or *specus,* were constructed to maintain a constant slope so as to overcome the differences in height the arches. Excess water from the aqueducts and rainwater was collected in the cisterns. Often in the countryside, they were then used to water the fields.

Once arrived in the city, the water was distributed through the *castellum* in three different directions: for public fountains for baths and for some privileged private houses. The water was also used to clean the streets, improving the sanitary quality of the city. Only then, this water was channeled into the sewer system and then ended up in the river which was organized with a system of grain mills.

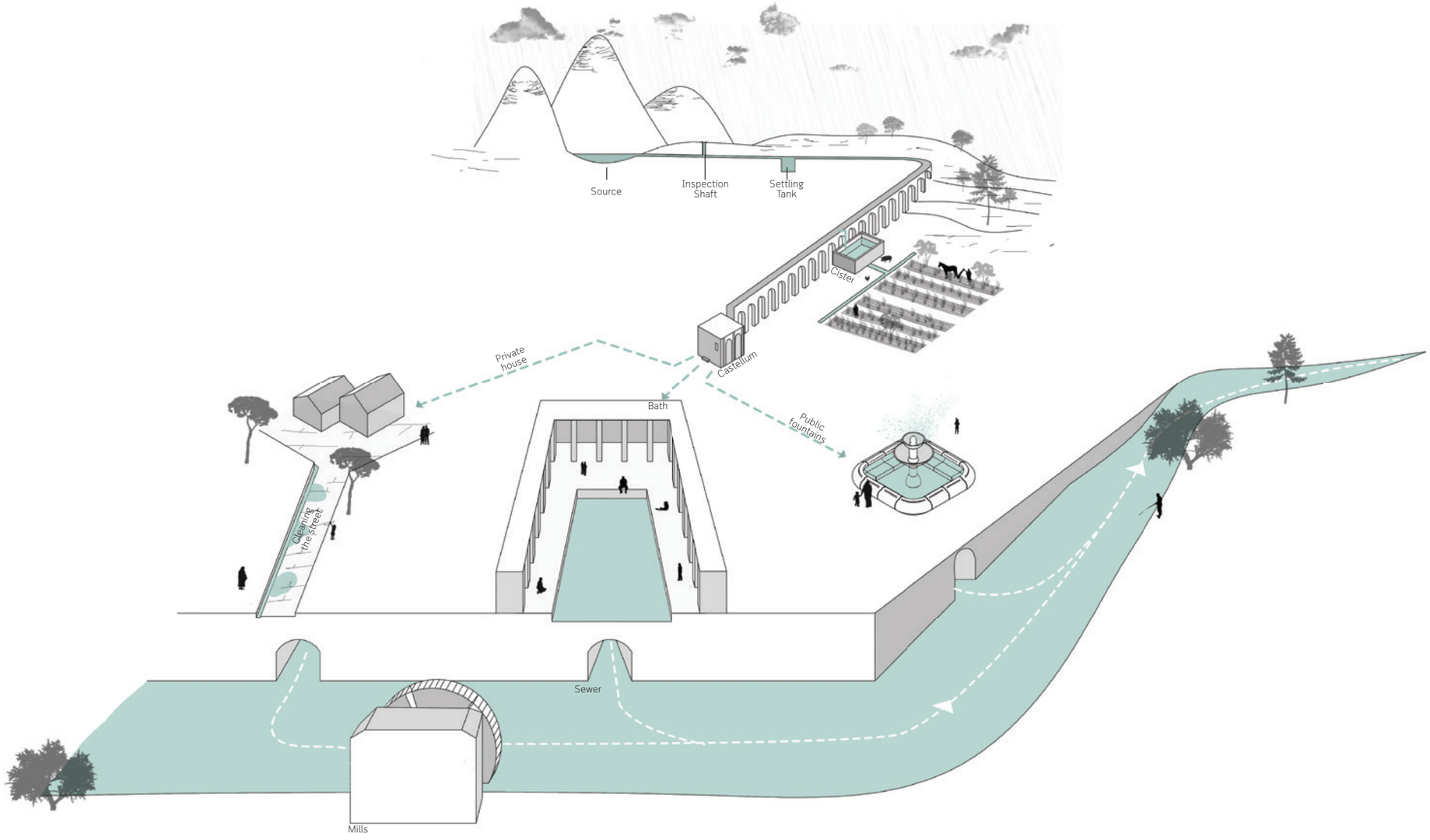


Figure 18 The spatial representation of an aqueduct and the different functions that the water has before its final destination, the river.

Cultural Significance.

The aqueducts went wherever Rome went, an outward symbol of all that Rome stood for and all that Rome had to offer. The aqueducts gave the city of Rome the opportunity to grow economically and culturally.

Some elements that highlight the importance of the aqueduct system are still visible within the city of Rome, highlighting the incredible engineering effort of the Romans.

Porta Maggiore
Located in the point where eight of the original eleven roman aqueducts converged, it could be found in *Porta Maggiore* Square, a fundamental area in the road network of the city, point of convergence of *via Prenestina*, *via Casilina*, the Esquilin area and *San Lorenzo* district. The square derives its name from one of the ancient gates of Rome, *Porta Maggiore* (Larger Gate), so called because of its imposing dimension.
This monumental gate was built in 52 A.D. by the emperor Aurelian to celebrate the end of the construction of two large aqueducts, the *Aqua Claudia* and the *Anio Novus*.

Bocca della Verità - Mouth of Truth
According to the legend all the people telling a lie keeping the hand into the mouth of the mask would have lost it, eaten by the terrible mouth.
In reality, during Roman age, this mysterious mask was a sewer cover connected to the *cloaca maxima*, the main sewage system of the roman forum.
In order to celebrate the sewage system that managed to clean the city, it was decorated with these manholes represented water and river divinities, drinking the rain, letting the water flow to the sea.

Mostra d'acqua - Water Show
Mostra comes from the Latin word *mostrare* that it means to show, to reveal, to exhibit.
These beautiful fountains were the terminal of the aqueducts.
The fountains become a visible element to show the great engineer's effort of the complex system of the aqueducts.

Figure 19 *Porta Maggiore.*
Figure 20 *Bocca della Verità.*
Figure 21 *Mostra dell'Acqua Felice.*

Conclusion.

As symbol of civilization and progress, the aqueducts were built throughout the empire. The aqueduct system was an incredible monumental work, a symbol of the cultural and engineering progress of the ancient Romans. Thanks to the aqueducts, the Roman empire had the opportunity to exist and expand throughout Europe.

Architectural values - The aqueducts of the Romans may be divided into three general groups, according to the materials with which they are constructed. This classification is more convenient in that it conforms very nearly to their chronological arrangement. The earliest of these monuments that show any architectural character was built around 144 B.C. entirely of cut stone, laid dry in regular courses. During the early Empire, the Romans continued to employ *tufa* and *peperino* cut and laid similarly, though with rather less care and precision. Under the Emperor Augustus, it had become the custom to build the smaller aqueducts, and those in the provinces, of concrete faced with a revetment of a stone laid in courses or the form of *opus reticulatum.*

Functional values - The general and fundamental principle on which the construction of the aqueducts are based is the gravity flow. It meant that the engineer had to lay out a line avoiding both too steep a gradient, a fast flow, in fact, would erode or damage the conduit, and one too shallow, to avoid the current stagnating. For this reason, sometimes bridges and viaducts were needed to cross intervening valleys.

Landscape values - Although the aqueducts are artificial artifacts, they are extremely connected with the ground. The slope, the heights and the distances were carefully studied to obtain the most effective result.

Strategic values - As mentioned above, gravity was the fundamental principle of the aqueduct; this meant that the study of topography was essential. The aqueducts ran mostly underground, and the study of the terrain was essential for building shorter routes and with the right endurance. By studying the maps, it is possible to understand how the course of the aqueducts often followed the terrain itself, avoiding sudden changes in altitude unless necessary.

Values of Sustainability - Most of the outlets, private and public, were kept running 24 hours a day, the aqueducts were like a river and they carried water from the source to the city continuously. Any attempt to stop the flow would have resulted in structural damage as well as have made the water overflow from the conduits and flood the town. Although this may seem wasteful today, in reality, the Romans didn't waste even a drop of water. If the water from the aqueducts was in excess it was kept in the cisterns and used for irrigation, or, in the city, it was used for washing the streets. The continuous flow, also, had the advantage that the sewers were kept constantly flushed, allowing a high level of hygiene in the city.

Ethnographic and Identity values - *"I ask you; just compare the vast monuments of this vital aqueduct network with those useless Pyramids, or the good-for-nothing tourist attraction of the Greeks! "* (Frontinus, De Aquaeductu, I 16). This was the spirit of the Romans when they referred to the aqueducts, in fact, this system is not a simple and useless piece of art but something solid, grand, practical, complex and a symbol of civilization. The aqueducts went wherever Rome went, an outward symbol of all that Rome stood for: civilization, engineering genius, pragmatism. To possess an aqueduct was a clear mark of prestige and prosperity that none could mistake.

Lessons to learn - The Roman aqueducts were one of the first great human works which, by combining ingenuity and aesthetics, contributed to the founding of one of the most important ancient cities in the world.
Without the help of any kind of mechanical or electrical instrument the Romans were able to bring fresh and drinkable water miles and miles away to their cities.
Although, of course, we refer to a very different era, in which thousands of slaves were exploited for this type of work and the command and decisions were made by one man, the emperor, it is clear that this work was exceptional.
Their genius was the care and study carried out on their territory: to study its properties, a porous soil that filtered a lot of water into the subsoil must also have contained many aquifers, and its characteristics, so as to be able to adequately exploit the slope in order to transport the water with the right moderation. And then the invention of the materials for the pipes and the accurate and solid construction of the aqueducts, which still today, 2000 years later, mark and characterize the landscape of the Roman countryside, making it unique in the world.
Despite the fact that today the construction of modern aqueducts is easy and quick thanks to the mechanical pumps that conveniently distribute the water in every house, it is important to remember that great results can be obtained even with the scarcity of tools. The care, patience and careful study of the surrounding area has given the Romans the possibility to have running water and to be able to use it for alimentary, sanitary but also recreational purposes.

Figure 22 Montage of the aqueduct arriving into the city.

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Project 4 - The Roman Aqueducts

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