Chapter 3

CONSTRUCTING, REPAIRING, AND MAINTAINING THE AQUEDUCT SYSTEM

The aqueducts, although well-built in appearance, were in fact fragile, and required an excessive amount of labor to continue functioning. If the aqueducts were neglected for a number of consecutive years they would fall into disuse. The water system from beginning to end required armies of men to keep it in a state repair. There was a variety of reasons that caused the aqueducts to fail: the misuse by the owner of fields that the aqueducts crossed, age, the weather, or poor workmanship in the original construction, which according to Frontinus pertained to the more recently built aqueducts.[1]

Most of the historical record of repair work carried out on the aqueducts comes from the inscriptions on arches. Following the construction of the Aqua Anio Vetus, there is an exception. Livy recorded that in 184 B.C. the aqueducts had endured years of neglect, while their waters were robbed ruthlessly by private individuals, until Cato the censor initiated vigorous measures for the abolishment of these abuses.[2] The censors cut off all supplies of water for private houses or land, and they demolished all structures that private owners had built up against public buildings or on public ground.[3]

It is not until the construction of the Aqua Marcia in 144 B.C. that once again we have an account of the water system. According to Frontinus, Aqua Appia and Aqua Anio Vetus had become so leaky, with their water illegally tapped by private citizens, that restoration was again necessary.[4] The Senate commissioned the praetor Quintus Marcius Rex to restore the two aqueducts to their original usefulness, and to protect them. Furthermore, he was also empowered by the Senate to investigate whether he could bring other additional water into the city, which he did.[5]

The Aqua Anio Vetus was paid for from the booty taken in the victory over Pyrrhus.[6] The large sums of money provided to pay for the Aqua Marcia most likely came from the spoils of Corinth and Carthage, both sacked by the Romans in 146 B.C. Frontinus, entering in his book the construction cost of the Aqua Marcia at 180,000,000 sesterces,[7] clearly testifies to an immense public expenditure. Pliny, too, mentions the cost of the Aqua Claudia at 350,000,000 sesterces[8].

The construction of the Aqua Marcia was virtually the same as the previous aqueducts. It did, however, introduce the use of extensive substructures. Other than this difference the Aqua Marcia was practically the same. The line runs for the most part underground, and shows little change from its forerunner, the Aqua Anio Vetus. The channel is almost wholly cut in the virgin rock, or laid in a shallow trench along the hillside by the "cut and cover" system.[9]

Concerning the construction of the Aqua Tepula little is known except from what is written by Frontinus. Based on Van Deman's research, no remains of the early channel have so far been found, or at least identified.[10]

The next substantial record of the aqueducts takes place during the aedileship of Marcus Agrippa in 33 B.C. During his aedileship, the older conduits of the Aqua Appia, Anio Vetus, and Marcia were broken down by old age and neglect. Agrippa extensively restored these ruined aqueducts,[11] and practically rebuilt the entire Aqua Tepula.[12] Along with these restorations, Agrippa constructed the Aqua Julia which was incorporated into the Aqua Tepula. Moreover, in 19 B.C. Agrippa built another aqueduct, the Aqua Virgo, named because of a young girl who showed its springs to some soldiers who were seeking to find water.[13] It supplied the Campus Martius and the public baths erected by Agrippa.

No new principles of construction were introduced during this period, apart from the economical method of superimposing several channels upon a single series of arches. Agrippa replaced the expensive cut stone used in earlier aqueducts, and adopted the new and cheaper material, concrete.[14] This can be seen especially in the method of stacking the aqueducts. The cut stone was used to carry the enormous weight of the structure and the concrete contained the water.

Based on evidence in existing remains, Van Deman discovered a lack of thoroughness during this restoration, and a deficiency of skill in handling the new material, not yet wholly beyond the experimental stage in its development.[15] Therefore, the channels were again sadly in need of repair after only eight years of use. Consequently, Augustus undertook, at his own expense, the rehabilitation of the whole system.[16]

Recognition of the fact that continued damage to the aqueducts took place by private individuals necessitated the need for new protective laws. Unlimited right of way was given to repairmen on private property that the channels crossed,[17] and a space of fifteen feet on both sides of the channel was to remain clear of buildings and trees.[18]

Repairmen that Frontinus mentions are categorized into several classes of workmen: overseers, resevoir-keepers, line walkers, pavers, plasterers, and other workmen.[19] The men came from two gangs of slaves, one belonging to the state and the other to Caesar. The one belonging to the state was older and was left by Agrippa to Augustus, who in turn, gave them over to the state; it numbered 240 men. The number of Caesar's gang was 460; it was instituted by Claudius at the time he brought his aqueduct into Rome.[20]

The wages of the state gang were paid from the state treasury. The gang of Caesar received its wages from the emperor's personal funds, from which were also drawn all expenses for lead, pipes, delivery tanks, and basins.[21]

Frontinus explains carefully the many duties of the water commissioner and emphasizes the fact that the water commissioner must be diligent in his duties. The numerous and extensive works have a natural tendency to fall into decay, and must be attended to before they call for large appropriations.[22]

The aqueducts were so extensive that strict priorities had to be maintained to keep the water flowing. Frontinus correctly recognized the most troublesome aspect of the water system, the substructure.

> As a rule, those parts of the aqueducts which are carried on arches, or are placed on side-hills, and the parts that cross rivers, suffer most from the effects of age or elements.[23]

It is evident that the masonry channels were unreliable, yet they were constructed, and repaired over and over. Frontinus classified repairs into two basic categories: those that could be made without stopping the flow of the water, and those that could not be made without emptying the channel.[24]

Stopping the flow of water was of course the least desirable method. Unfortunately, with the loss of the concrete lining inside the channel and the increase of mineral deposits diminishing the size of the channel, there would be little choice. Furthermore, one aqueduct had to be taken at a time, for if several were cut off at once, the supply would prove inadequate for the city's needs.[25]

Frontinus describes the plight of the administrator of this office when he wrote:

> Greater care is required upon the work which is to withstand the action of water; for this reason, all parts of the work need to be done exactly according to the rules of the art, which the workmen know, but few observe.[26]

Moreover, of the eleven total aqueducts of ancient Rome (only nine in Frontinus' time), five were dependent on just two sets of arches. These two substructures of the Aqua Marcia and Aqua Claudia were designed to carry one aqueduct, but were required to carry respectively, three times and twice their load. The overloading of these stone piers could create anxiety for one who was responsible for their well-being; the additional problem of leaking water continuously washing away the mortar could intensify this concern. One need only look at the aqueducts that exist in Rome today to see how they steadily decay (Plates IX and X). Plants can be seen growing all over the modern aqueducts of Rome, which cause leaks. The leakage of all the ancient aqueducts must have been enormous. So much so as to suspect that less than half the water taken into the aqueducts ever reached the city.[27]

According to Frontinus the total amount of water delivered by the aqueducts was 14,018 quinaria.[28] This is translated by Herschel into 84,108,000 gallons per 24 hour

PLATE IXa

PLATE IXb

Plates IXa and IXb - **Damage Caused by Plants.** Plate IXa - Aqua Felice seen with plants growing into it. Notice the pine tree growing on top. Plate IXb - Looking in the opposite direction of plate IXa; plants can be seen growing into the side of the channel.

PLATE Xa

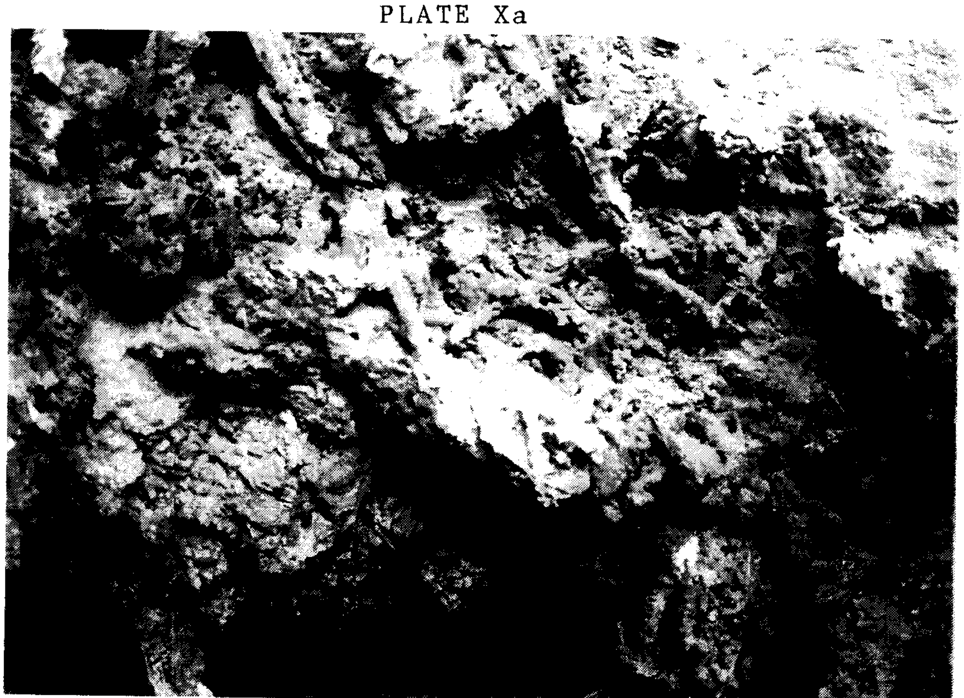

PLATE Xb

Plates Xa and Xb - **Mineral Deposits Indicate Leakage.** Plate Xa - View of the interior of the arches of Aqua Felice show signs of leakage of water from the modern day aqueduct. Plate Xb - This is a close up of mineral deposits from the Neronian arches on the Caelian hill.

period.[29] These figures represent only the nine aqueducts that Frontinus was responsible for. Of these nine aqueducts, we know that the Aqua Alsietina was too poor for human consumption,[30] and the Aqua Anio Vetus was ordered for several reasons to be used for gardens and flushing the sewers.[31] This left seven aqueducts for human consumption; of these seven aqueducts, five were dependent on just two substructures. These two substructures carried 73% of all the drinking water delivered to Rome.[32] Essentially, the Roman water system consisted of not eleven different individual aqueducts, but rather three aqueducts, Aqua Virgo, Claudia, and Marcia. These three aqueducts carried 94% of all the drinking water of Rome. One can now see that if just one set of piers collapsed then up to 33% of the drinking water of Rome could be cut off.

Eventually, every phase of the water system needed to be reinforced, rebuilt or repaired. Channels that were buried underground suffered the least because they were not greatly affected by the elements. Aqueducts carried on arches and substructures needed the most attention because leaks caused damage to their piers and weakened the substructure. Major repairs required the water to be stopped; consequently, reconstruction was limited to the months of April through November, with restrictions on the hottest days of summer because the mortar would not set properly.[33]

Steps were taken temporarily to reroute the water in order to make repairs on the inside of the channels. The concrete lining of the channel was vulnerable to cracking, especially in the summer months when the exterior of the channel is subjected to dry, hot temperatures, while the interior was subjected to wet cool temperatures. Furthermore, the channels needed to have the interior crust of mineral deposits removed as often as possible to maintain the size of the channel. Mineral deposits choked the channel, and eventually the practice of patching the cracks from within the channel was replaced with the practice of patching from outside the channel, against the pressure. In some cases, entire arches were filled in (Plates XI and XII). Patches from within could not be afforded because the crust was already diminishing the capacity of the channel and the additional patch work would only diminish it further.

Inscriptions commemorating the deeds of emperors give examples of how often major repairs were made. We know that in 5 B.C. emperor Augustus Caesar was credited with repairing all of the aqueducts.[34] Aqua Virgo was repaired again in A.D. 31, 41, and 44. We know this from the first inscription on the Porta Maggiore[35] (Plate XIII). The first inscription gives recognition to emperor Claudius for bringing into Rome two new aqueducts, both the Aqua Claudia and the Aqua Anio Novus, completed in A.D 52. After only

PLATE XIa

PLATE XIb

PLATE XIc

Plates XIa, XIb, and XIc - **Patched arches.** Plate XIa - This arch had been completely filled in with concrete faced with brick. It was poorly done as the plate shows. Plate XIb - This is another example of an arch that required extensive repairs. Note: the arch to the left had been only partially filled in. Plate XIc - This arch of Aqua Marcia has been progressively repaired. Note how the quality of masonry declined from the original cut stone to concrete faced with brick. Under this is further repair with concrete mixed with stone. This arch is located immediately south of Porta Tiburtina near the train station in Rome.

Plates XIa and XIb are courtesy of the British consulate in Rome. These arches are located on the private grounds of Villa Wolkonsky, the residence of the British Ambassador.

PLATE XIIa

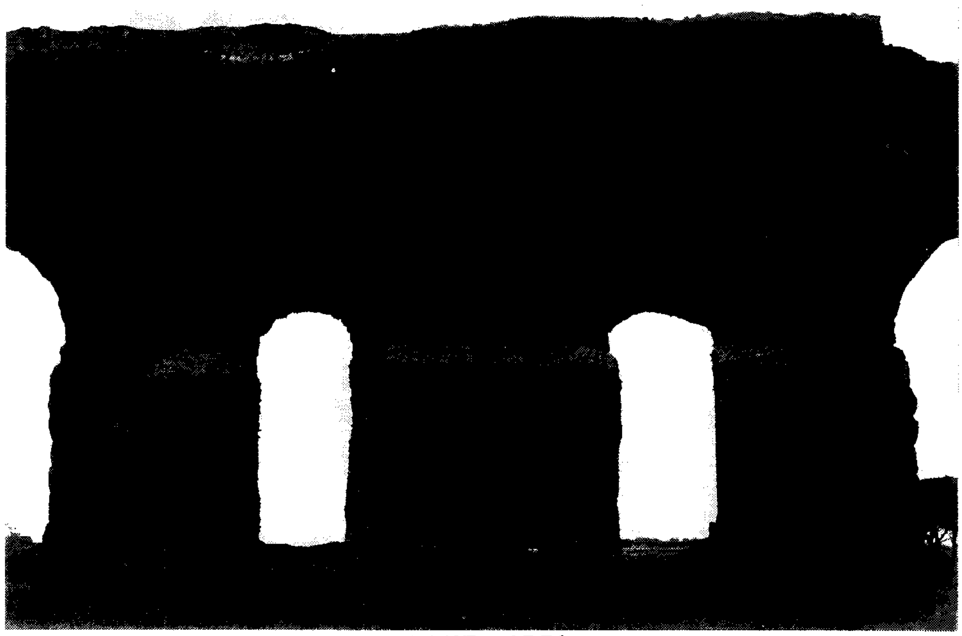

PLATE XIIb

PLATE XIIc

Plates XIIa, XIIb, and XIIc - **Reinforced arches.** Plate XIIa - Note the fifth and sixth arches from the right. They have been reinforced with concrete and brick. The reinforcement had been built-up, much like a buttress, to stabilize lateral movement by the aqueduct. Plate XIIb - Close up of plate XIIa. Plate XIIc - The two arches on the left are both remains of repairs made to Aqua Claudia. The original stone structure is all but gone. These are both excellent examples of the amount of materials used for each arch. These two arches are only partial repairs, compared to others that were made.

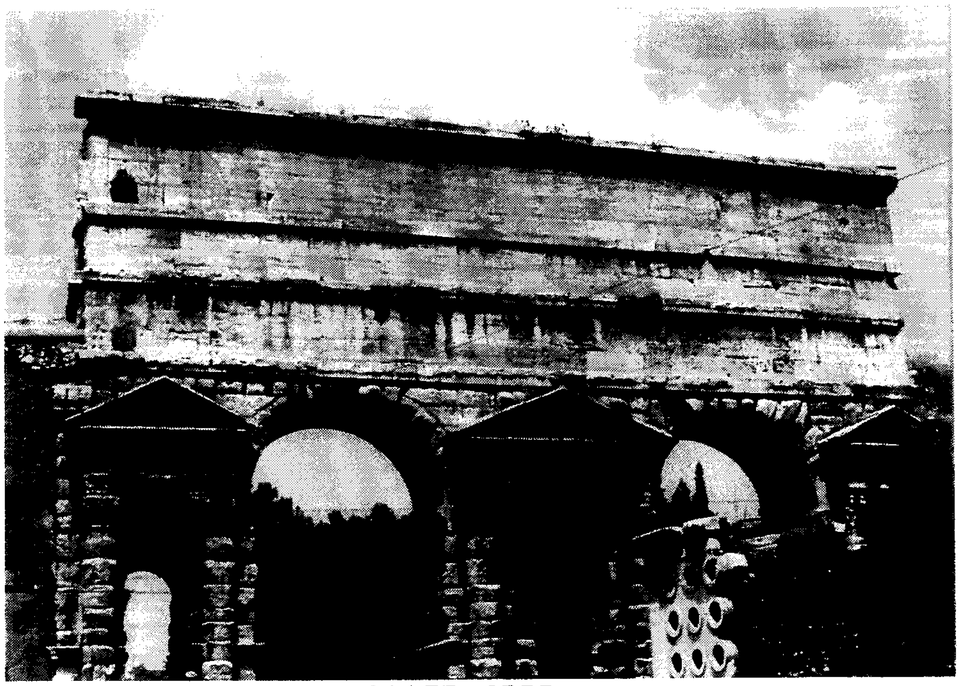

PLATE XIIIa

A--->
B--->

<---C
<---D
<---E

PLATE XIIIb

Plate XIIIa and XIIIb - **Porta Maggiore.** Plate XIIIa - The inscriptions on this double arch are used to date the repairs made to Aqua Claudia and Aqua Novus. Plate XIIIb - This plate is looking just to the right of plate XIIIa. Note: Arrows - A- Aqua Novus, B - Aqua Claudia, C - Aqua Julia, D - Aqua Tepula, E - Aqua Marcia.

ten years of use the Aqua Claudia was in need of repair, but instead fell into disuse. It was finally repaired in A.D. 71 by emperor Vespasian after nine years of disuse.[36] Remarkably the repairs made by emperor Vespasian were not sufficient to keep the aqueducts operating. According to the third inscription on the same Porta Maggiore emperor Vespasian's son Titus also repaired the aqueduct after another ten years of use. With the discovery of more insciptions we would probably find even more repairs

The creation of the office of water commissioner is a formal admission by the Senate of the need for a municipal body to regulate the aqueduct system.

Chapter 4

FINDINGS AND INTERPRETATIONS

Particular facts described thus far must be recalled in order to arrive at some significant conclusions. First, according to traditional Roman history, the site of Rome was chosen for its beneficial, defensive hills and abundant water supplies. We know that Rome grew at a very moderate pace throughout the regal period and first half of the Roman republic.

Rome was sacked and burned by marauding Gauls from the north. They were bought off by the Romans because the Romans could not seem to defeat them. Directly after the sack of Rome in 390 B.C., a wall surrounding the city was built. Today this wall is incorrectly named the Servian wall.[1] This wall that we can still see today in various places throughout Rome cannot be considered as a small public effort, because it is a key turning point in Roman history. It is important because before the attack by the Gauls, Rome had little need for an advanced defense. Rome had some hostile neighbors to be sure, but Rome also belonged to the Latin League that kept its enemies at bay. Besides being attacked on a small scale by its neighbors, Rome had little worry of being conquered by anyone; or did it? Rome was essentially a farming community like all the other Latin communities of the Italian pennisula. Rome did have one significant difference from the other communities, and that was the trading and marketing capabilities growing in Rome's forum. It must be remembered that this forum was possible only because of the Etruscan king of Rome Tarquinius Priscus, who was responsible for the construction of the Cloaca Maxima, that allowed permanent drainage of the swampy lowland of the valley between the Capitoline and Palatine hills. This reclaimed land, insignificant and humble in its beginning, progressively grew into a financial center that eventually rivalled, and then conquered all of the surrounding Mediterranean countries.

The heavily constructed Cloaca Maxima was recognized by the Romans as the proximate cause of the elimination of the swamps and the beginning of prosperity in Rome. Before the clearing of the swamps, Rome could hardly be called prosperous and certainly did not need excessive defenses from marauders.

Because of the growth due to the addition of this subterranean drainage channel the Romans went one step further. They constructed a channel that would convey fresh, clean water into the city. The Aqua Appia must be praised as little more than an extension of the sewer system.[4] The Cloaca Maxima evolved in roughly two stages. First, it was constructed as an open channel in the regal period, and remained as such until about 390 B.C. when it was vaulted over and buried. At the time of the covering, the Cloaca Maxima was not straightened out and shortened, but remained the same. It appears that the Romans historically leave well enough alone. If it works, then why improve it? It has served faithfully for 200 years so far, so why straighten it out and shorten its course? This underlying attitude of the Romans will endure throughout the republic and into the empire. The Cloaca Maxima worked well, so the Romans built the Aqua Appia the same way. The only difference between the Aqua Appia and the Cloaca Maxima was that the aqueduct was supported on substructures above ground for ninety-one meters. Frontinus attributes the design as a defensive measure. This has to carry some merit, but every aqueduct after the Aqua Appia is based on the same engineering as the Cloaca Maxima built back in the last half of the seventh century B.C. Even when Rome's borders grew to be thousands of kilometers away, and the threat of invasion by anyone was absolutely unthinkable, Rome was still building aqueducts that were obsolete. Certainly, the aqueducts were somewhat more reliable when they were subterranean, but in order to convey water from sources that were 100 kilometers away, the Romans were compelled to construct elaborate stone arches that would maintain the proper descent of the slope.

This type of water system outlived its purpose. It no longer worked. The Cloaca Maxima functioned with little or even working. The fact that it was built by Roman predecessors fully justified building another one just like it. At the same time, the Romans would repair and restore all the other aqueducts, too, because they all leaked anyway, and the Romans knew it. The aqueducts were constantly tapped illegally, so the taps would be rechecked also. This way Rome would have an abundance of water for another ten to twenty years or until the aqueducts broke-down. Such break-down was inevitable.

In short, the Roman theory of water supply was the very same theory of water drainage, a gravitational flow, aided by a small fall in the conduit. Some reasons why the drainage systems were cost efficient was because there were no illegal taps destroying the channels, unlike the aqueducts. Furthermore, if the drainage channel developed a leak it would go undetected because there was no administration set up to monitor the productivity of the sewer system. Thus, it was unnecessary to be as diligent as that of the upkeep of the water supply. The drain system had no substructure that constantly required attention. The cost to maintain the drain system therefore was nominal.

As for the cost of the aqueducts, the financial theory upon which the water supply was based differed greatly from what we have developed today. The Romans, we know, paid for most or all of the aqueducts from the spoils of various wars, or heavy tribute charged to a conquered country. What began as an unexpected surplus in funds that were used for public projects, became a fixed policy of expecting spoils or gifts to pay for public works, thereby slowly imposing a binding sense of duty upon successful public men to build such things.

The booty that was in the beginning an accidental windfall to the state created a theory of payment for public expenditure which was based on thoroughly unsound foundations. Rome now acquired the wealth necessary to build great projects by taking all the valuable possessions and resources having monetary value from the newly conquered territories. Gradually, the burden to create and maintain the aqueducts as well as other costly projects was tranferred onto the shoulders of men like Julius Caesar, Augustus Caesar, and Marcus Agrippa, whose fortunes had also been based on the spoils of war.

The consequences of an economy based on the spoils of war can easily be extrapolated when the chronic state of war came to an end, or those who were being conquered were not wealthy opponents. The fact that the emperor took over the responsibility of the public works in Rome only obscurred the problems that were inherent in the system of payments for these large constructions. The emperors were expected to pay for the building and maintenance of large projects, and finally did so by over-burdening the taxpayer, instead of making the projects profitable. But probably the most serious problem was the spread of the custom started by Augustus of presenting charitable gifts to the state by private individuals.[5] This led to a steady absorption of private capital into public projects without any hope of financial returns on the investments. The same individuals might have invested wisely in productive projects that could have provided jobs and profits for the capital invested. Surely, this potentially could have cured a system that was deteriorating from within.

Frontinus wrote that the Aqua Claudia was badly built.[6] The investment in the Aqua Claudia by the state was never paid back. In fact, no investment in any aqueduct was ever paid back; they consumed capital with no return. Some private homes and small businesses had their water supply delivered directly and paid a nominal fee for this special service. This fee, as already mentioned, was the only type of charge made to the consumer, and in no way could the total of all these fees even begin to pay for the upkeep of the aqueducts. The Aqua Claudia had to be rebuilt and restored so many times that in the end it became practically a different aqueduct from that which it was when it was built.

Perhaps, if private investers contracted the work to be done, these projects might not have been so poorly constructed. The Romans did not have cast iron for plumbing, and they did not have enough lead for kilometers of pipe, but they did have sufficient concrete. They became experts in the use of concrete, but apparently never experimented extensively with all its possible uses. The Romans had lead pipes, clay pipes, and even stone pipes; why not concrete pipes? Concrete is a much more inexpensive material than the others and was abundant. Concrete could withstand pressure sufficiently to eliminate the need for costly substructures. The pipe could be buried for defensive purposes, or just to protect the pipe from the elements. Concrete is easy to work with and simple to repair; damaged sections would no longer have to wait until the appropriate times of the year to be repaired, because sections could be made in advance. The advantages of concrete pipes seem endless, which is probably why they are used today.

The Roman government was so successful that evidently the population of Rome relied on it for everything from free water, to free grain, bread, and wine. Maybe because of this, creativity declined, and with it the empire. Perhaps once the citizenry expected such free services as the ones mentioned above, they could not be revoked, without rebellion. Conceivably, since the aqueducts could no longer be supported by the government, they dwindled, failing to supply water to the hills of Rome, which once again became deserted. Possibly, the cost-inefficient water system of ancient Rome may have best served its citizenry by being managed by a non-governmental agency. Private industry could have initiated creativity, change and growth in a system that had remained virtually unchanged since the construction of the Cloaca Maxima in the seventh century B.C.

When Rome could not afford to keep its water supply running, it also could not afford to remain capital of the empire. Perhaps, Rome lost its footholds throughout the empire because they became too expensive to hold onto and maintain. Finally, Rome resembled the city that had been founded ten centuries earlier, depending on a water supply that came from wells, and the Tiber river. It took Rome ten centuries to deplete the wealth of every country it conquered. It appears that the sober sense of reality that we find under the republic was washed away by the extravagant way of life under the empire. When all the debts were called in, Rome could not pay, and so, whatever remained was taken by invaders, just as Rome had taken from others.

The aqueducts cost huge fortunes to build and maintain, and the government unfortunately, in the beginning, had the funds to provide for these expensive monstrosities. These creations inherently required more money, more attention, and more bureaucracy. The population of Rome grew accustomed to this free service and later expected it. The government, eventually, could no longer afford to provide these free services, so it taxed the wealthy, the businessman, and the conquered, till there was no one else to tax. The government's good intentions did not include what the future generations would have to sacrifice; without benefit of an unexpected windfall from a conquered nation. The government saw only the good that would come to the community with their newly created water supply.

Perhaps, no government should provide any service to its populace if it is not willing to pay for it. Maybe those who believe they are doing what is good for their citizens are making an error of unseen proportions. If the people are not willing to pay for a service provided by the government, then the government should probably discontinue the service. The Roman government paid dearly for its good intentions; for once the population expected, and grew used to free services, removing them became impossible.

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NOTES ON CHAPTERS

Introduction

[1]All references to The History of Rome of Titus Livius are based on D. Spillan's edition (New York, 1871), V.54. All references to The Republic of Marcus Tullius Cicero are based on Clinton Walker Keyes' edition (Cambridge, 1928), II.6.

Chapter 1

[1]Livy, op. cit., i.38.6, 56.2.

[2]All references to Natural History of Pliny, books XXXVI and XXXVII are based on D.E. Eichholz's edition (Cambridge, 1963), XXXVI.24.105.

[3]Malaria, mal-bad, aria-air.

[4]Livy, op. cit., ix.29.6.

[5]All references to De Aquis of Sextus Julius Frontinus are based on Charles E. Bennett's edition (Cambridge, 1925), i.18.

[6]The cost is a quote by Frontinus of Fenestella, a Roman historian; he died in 21 A.D., Frontinus, i.7.

[7]Tepula - tepid.

[8]All references to Natural History of Pliny, books XXVIII through XXXII are based on W.H.S Jones' edition (Cambridge, 1963), XXXI.25.42.

[9]All references to The Lives of the Twelve Caesars of Suetonius, are based on Alexander Thomson's edition (London, 1872), Caligula.21.

[10]Ibid., Claudius.20.

Chapter 2

[1]All references to The Ten Books On Architecture of Pollio Vitruvius are based on Morris Hicky Morgan's edition (Cambridge, 1926), VIII.iii.28.

[2]Vitruvius, op. cit., i.7.

[3]Ibid., iv.1.

[4]Ibid., i.1.

[5]Ibid., i.3.

[6]Ibid., i.4-6.

[7]Ibid., ii.1.

[8]Roldolfo Lanciani, _Ancient Rome in the Light of Recent Discoveries_ (Boston: Houghton, Mifflin & Co., 1888), pp. 108-9.

[9]Frontinus, op. cit., i.15.

[10]Ibid., ii.91.

[11]Ibid.

[12]Ibid., ii.92.

[13]Vitruvius, op. cit., iv.7.

[14]The specus is the inside dimension of the channel.

[15]Herschel explained that the Roman method of measuring water was still being practiced as "square feet of water" just as though the law of falling bodies and its application to hydraulics had never been discovered. Clemens Herscel, _The Two Books on the Water Supply of the City of Rome_ (New England Water Works Association), p. 173.

[16]Frontinus, op. cit., ii.92.

Siphons

[17]Thomas Ashby, _The Aqueducts of Ancient Rome_ (Washington, D.C.: McGrath Publishing Co., 1973), pp. 35, 152, 250.

[18]Pliny, op. cit., XXXI.31.57. Pliny mentions that water will rise as high as its source.

[19]Vitruvius, op. cit., vi.5.

[20]Ibid., vi.8.

[21]Vitruvius, op. cit., vi. 10.

[22]Ibid., vi.11.

[23]Ibid.

Distribution

[24]Pliny, op. cit., XXXVI.24.121.

[25]Ibid., vi.2.

[26]Ibid.

[27]Frontinus, op. cit., i.25.

[28]One digit equals 9/16 inch. Herschel, op. cit., p. 40.

[29]Frontinus, op. cit., i.25.

[30]The duties of the aediles were initially to curators of all public buildings. They were the overseers of the city, the market, and customary games. Following the creation of the aqueduct system, this too fell under the duties of the aediles. This responsibility was changed in 11 B.C. when Marcus Agrippa died and passed on his 240 personal aqueduct building slaves to the state. As one of the aediles, Marcus Agrippa constructed the Aqua Virgo and repaired the entire water system. Augustus Caesar created the office of water commissioner using the newly acquired slaves as the official laborers and removed the responsibility from the aediles. All references to The Roman Antiquities by Dionysius are based on Ernest Cary's edition (Cambridge, 1950), VI.xc.2-3. Frontinus, op. cit., i.9-10, ii.98.

[31]Frontinus, op. cit., ii.96-97.

[32]Ibid., ii.87.

Chapter 3

[1]Ibid., ii.120.

[2]Livy, op. cit., xxxix.44.4.

[3]Livy, op. cit., xxxix.44.5.

[4]Frontinus, op. cit., i.7.

[5]Ibid.

[6]Ibid., 6.

[7]Ibid., 7.

[8]Pliny, op. cit., XXXVI. 122.

[9]E.B. Van Deman, _The Building of the Roman Aqueducts_ (Washington, 1934), p. 8.

[10]Ibid., p. 9.

[11]Frontinus, op. cit., i.9.

[12]Ibid., 19.

[13]Ibid., 10.

[14]Van Deman, op. cit., p. 10.

[15]Ibid., p. 11.

[16]Frontinus, op. cit., ii.125.

[17]Ibid.

[18]Ibid., 127.

[19]Ibid., 117.

[20]Ibid., 118.

[21]Ibid.

[22]Ibid., 119.

[23]Ibid., 121.

[24]Ibid.

[25]Ibid., 122.

[26]Ibid., 123.

[27]Herschel, op. cit. p. 167.

[28]Frontinus, op. cit. ii.79.

[29]Herschel, op. cit., p. 211.

[30]Frontinus, op. cit., i.11.

[31]Ibid., ii.11.

[32]According to the figures given by Frontinus and translated by Herschel, 72,096,000 gallons per 24 hours were classified as total drinking water. Of this, the arches of the Aqua Claudia and the Aqua Marcia carried 52,848,000 gallons per 24 hours.

[33]Frontinus, op. cit. i.23. Vitruvius, op. cit. iii.2.

[34]From the Res Gestae of Augustus, located on the Ara Pacis, Rome.

[35]The Porta Maggiore is a marble arch that crosses via Labicana, and via Praeneste. This arch carried both the Aqua Claudia and Aqua Novus.

[36]Second inscription on the Porta Maggiore.

Chapter 4

[1]Servius Tullius, The sixth king of Rome, is credited with building a wall. Excavations carried out at the end of the nineteenth century discovered an ancient agger dated to the period of the kings. An agger is a trench that surrounds the city much like a wall would. The earth removed from the trench is then piled high in front of the trench. The existing wall that is seen today in Rome is probably mistitled because it is so ancient, and we have the historical tradition recording the fact that Servius Tullius built a wall. Furthermore, we now know that this ancient wall that is still visible today to be correctly dated to about 390 B.C., which would place its construction to around the period when Rome was sacked, and well after the regal period.

[2]It must remembered that Tarquinius Priscus and Tarquinius Superbus were undoubtedly Etruscan kings and possibly Servius Tullius too. Their Etruscan influence could be seen in their buildings.

[3]Lanciani, op. cit., p. 33.

[4]Van Deman, op. cit., p. 5.

[5]All references to The Geography of Strabo are based on Horace Leonard Jones' edition (London, 1923), V.3.8.

[6]Frontinus, op. cit., ii.120.

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