volcanic eruptions damned the river with deposits of ash, called tuffs[6], and changed its course. Both of the volcanic fields, the Sabatini to the northwest and the Alban hills to the southeast, played important roles in creating the terrain; plateaus pinching the Tiber floodplain and creating high ground for Rome (Heiken, Funiciello & De Rita, 2005:11). Despite the advantageous location, Rome is still susceptible to flooding due to the large drainage area of the Tiber. The climate from the end of the republic, throughout the years of the Empire, up to perhaps between 800 and 1200 A.D., was warmer and drier than later years. During the wet period between 1310 and 1320 A.D., and the so-called "little ice age" of 1500 to 1800 A.D., Rome was more susceptible to flooding (Lamb, 1995). This is perhaps a good thing, as repeated natural destruction of the city may have had a large influence on the superstitious Roman mind, providing "evidence" for the displeasure of the gods, and perhaps the resulting abandonment of the site.

The Alban hills are approximately 50 kilometres in diameter with an elevation of nearly 1000 metres above sea level, and span the coastal plain between the Apennines and the sea. The summit is broad and dominated by a caldera, which has mostly been covered with material from later volcanoes. The slopes were once covered with oak, hazel and maple trees. Archaeological evidence from around the edges of the Nemi and Albano lakes indicate that the area has been occupied since the Bronze Age. Most of the Alban hill's volcanic deposits were produced by pyroclastic flows, which flowed in all directions, including into the area that became Rome (in deposits 5- to 10-metres thick). Much of the stone used to surface the highways near Rome came from these lava flows (Heiken, Funiciello & De Rita, 2005:33). The most common building stone used in Rome from the 6th to 5th centuries BC, *Tufo pisolitico* was quarried from deposits left by eruptions in the Alban hills 600,000 to 300,000 years ago.

[6]See chapter 4.9.1 for further discussion of this useful material

After the conquest of Veii in 396 BC the Romans acquired new territories to the north. There, in the Sabatini volcanic fields, they began to quarry *tufo Giallo*, which replaced the weaker *Tufo pisolitico* as the favoured building stone. The volcanic events that created these tuffs were at least seven in number and occurred about 500,000 years ago. The flows covered an area of about 400 square kilometres (Heiken, Funiciello & De Rita, 2005:44). The history of Rome can be read in the stone used to build her.

The highlands of the Alban hills and the Sabatini volcanoes have a rain catchment area of 5,100 square kilometres, which recharges a number of lakes and the aquifers[7] below the hills and fields. Today, the area provides a cumulative flow of surface and groundwater amounting to 45,000 litres per second. (Heiken, Funiciello & De Rita, 2005:137). The water derived from all these various sources makes Rome the only city of its size in the world that is chiefly supported by groundwater in a sustainable manner.

Figure D.11 shows a collage of satellite images of western Italy from a height of eighty kilometres. Rome can be seen slightly left and down of centre. To the top left (northeast) is Lake Sabatinus, known today as Lake Bracciano. The bottom right (southeast) shows the Alban hills with Lake Albanus, known today as Lake Albano. The Tiber can be followed for most of its course.

As a result of the structure of the land and its location, much of Rome was once under water. The *Forum Romanum*, the *velabrum*, the *Campus Martius* and other valleys were once almost impassable marshes and pools of water. As Ovid put it (Fast. 6.401): "*Hic, ubi nunc Fora sunt, udae tenuere paludes*". Dionysius (2.50) speaks of the site of the forum having formerly been a marshy thicket owing to the depressed nature of the ground: "διὰ τὸ κοῖλον εἶναι τὸ χωρίον". The draining of these valleys was effected by means of the *Cloacae*, which were amongst the first important architectural

[7] Water-bearing, permeable deposits.

works of Rome.[8] As Varro says (*Lin. Lat.* 5.149): "*lacum Curtium in locum palustrem, qui tum fuit in Foro, antequam cloacae factae sunt*". Moreover, the hills and ridges of Rome were once more numerous and abrupt than they are. At an early period, when each hill was crowned by a separate village and surrounded by hostile tribes, the inhabitants naturally wanted to increase the steepness of the cliffs to make their villages more difficult for enemies to access. In later years, when these various villages were united into a single city and surrounded by a wall, this became inconvenient. The tendency became, especially in Imperial times, to get rid of all the features that tended to break the city into separate parts. Tops of hills were levelled, whole ridges cut away and gentle slopes formed where there once were abrupt cliffs. The levelling of the *Velia* and the excavation of the site for Trajan's Forum are instances of this (Middleton, 1892a:4).

As the Tiber leaves Rome the slope of the riverbed decreases and the flow is placid as the river approaches the sea. This is an important factor in the economic and military success of Rome, making it possible to establish ports near the city and thus ship men, materials and goods upriver to the city (Heiken, Funiciello & De Rita, 2005:11).

It is perhaps of importance to consider the *Porta Praenestina*, or Porta Maggiore as it is called today, because of its importance to the aqueduct system in ancient Rome and as one of the best surviving parts of that system. See Figure D.12 for a satellite image of the modern Porta Maggiore; remains of the aqueduct system can be clearly seen. Frontinus called this entire area the *ad spem veterem* because of its proximity to an old temple of Hope. The *Porta Praenestina* was the highest point on the eastern side of Rome, and was thus selected by the engineers of the aqueducts from the upper valley of the Anio and from the Alban Hills as the point at which the water

[8] While originally designed to drain the marshes, it is estimated that by the the imperial period 5000 kg of city waste was being drained through it every day into the Tiber (Gowers, 1995:25)

channels should enter the city, so that as little pressure as possible was lost. It was therefore the meeting point of eight or nine aqueducts and as many roads, and therefore one of the most important topographical centres of the ancient city (Ashby, 1970:128). Three of the aqueducts were at ground level or below, so nothing can be seen of them. These were the Anio Vetus, Alexandrina and the Appia. The channels of the Claudia and Anio Novus arrived on tall arches, the latter running atop the former.The location of *Porta Praenestina* can be seen on Map D.4. This Porta consists of a double arch of the Aqua Claudia and Anio Novus that Claudius built to take the new aqueduct over the Via Praenestina and Via Labicana just beyond their point of divergence. The arches are at an angle to each other and built of blocks of travertine with heavy rustication. The whole is 32m high by 24m wide by 6.2m deep (see Figure D.21). In the central pier there is a small arch, now almost entirely buried. Above this and to either side of the main arches are narrow arches framed with an engaged Corinthian order and pedimented entablatures. The attic is divided into three fasciae, each of which bears an inscription relative to the building or repair of the aqueducts (*CIL* 1256-1258) (Richardson, 1992:307). The inscriptions can be seen quite clearly in the engraving by Piranesi (see Figure D.22) The *Porta Praenestina* was incorporated into the Aurelian Wall, and Honorius changed it considerably (Platner & Ashby, 1965:412). The Aurelian Wall still linked to the travertine aqueduct arches is also responsible for preserving short sections of the other three elevated aqueducts that entered Rome here, the Marcia, Tepula and Julia. The branch aqueduct *Arcus Neroniani*, built by Nero, begins at the *Porta Praenestina* (Aicher, 1995:53). See 3.5 for information on the inscriptions found here.

On the right bank of the Tiber, especially in the area of the Janiculum and Vatican Hills, are extensive remains of an ancient beach, conspicuous in parts by its fine golden sand and deposits of pure greyish-white clay. At a few places, especially on the Aventine and Pincian Hills, under-strata of

Travertine crop out. The conditions under which the tufa hills were formed have been various, as can be seen by the examination of rock at various places. The volcanic ashes and sand, of which tufa is composed, appear in parts to lie just as they were showered down from the crater. In this case, the tufa shows little or no sign of stratification and consists wholly of igneous products. In parts time and pressure have bound together these *scoriae* into soft and friable rock. In other places they still lie in loose and sandy beds, which can be dug out with a spade. Other masses of tufa show signs of having been deposited in water or else washed away from their first resting place and redeposited elsewhere with visible marks of stratification. This is shown by water-worn pebbles and chips of limestone rock which form a conglomerate, bound together by volcanic ash into a sort of natural cement. On the Palatine Hill there is evidence of extremely hot ash falling on a thick forest. The burning wood of this forest, partly smothered in ashes, has been converted into charcoal, large lumps of which are embedded in the tufa rock. In some places charred branches of trees can be easily distinguished. The so-called *Walls of Romulus* and some of the other prehistoric buildings on the Palatine were built of this conglomerate of tufa and charcoal. A perfect section of a branch of a tree is visible in the face of one of the massive tufa blocks on the north side of the *Scalae Caci* (Middleton, 1892a:8).

6.3 Early history of the aqueducts

The Romans were not the first people channel water long distances. The Assyrians developed the technique of tunnelling that is still used today in the Iranian plateau to supply modern Tehran with water. These tunnels, named qanats, tap underground aquifers and drain the water out to the side of a hill. They are usually about 1.5 metres wide and 3 metres tall. The Assyrian ruler Sargon II spread the technique of building qanats in the 8th century BC. His engineers may have learned the techniques when they visited northern Iran and western Turkey during military campaigns. The qanat supplied the cities of the Medes and Persians with water, and then spread throughout space and time to be used in north Africa, Spain and even the Americas to this day. Two of the Roman aqueducts, the Appia and Virgo, bear a resemblance to to qanat construction: they tap underground water sources and lead the water to to a hillside exit by means of a tunnel. These Roman aqueducts had their model in the Etruscan techniques of drainage, such as can be found in the valleys near Veii.

A different system supplied Assyrian Nineveh. Three construction projects re-routed water from a tributary of the Tigris, using dams and broad open-air canals. The last and most elaborate of these projects channelled water into a reservoir made by damming a gorge of the Atrush river, approximately 55 kilometres from Nineveh. From this dam an older canal carried the water to the Khosr river, where the water was again dammed and routed by another canal to the city. A notable achievement of this early 7th century project is the Jerwan aqueduct bridge, which crossed a valley between the Atrush river dam and the Khosr. Made from stone, it still exists and measures 300 metres long and 12 metres wide.

The Greeks supplied many of their towns with aqueducts before Roman occupation. The typical Greek technique was to channel water through pipes laid in a secondary channel. Herodotus describes an engineering feat on the island of Samos (3.60):

> *... a tunnel nearly a mile long, eight feet wide and eight feet high, driven clean through the base of a hill nine hundred feet in height. The whole length of it carries a second cutting thirty feet deep and three feet broad, along which water from an abundant source is led through pipes into the town.*

Classical Athens had several aqueducts. One drew water from Mt. Pentelicus and had to pass through a hill outside of Athens by means of a tunnel. In the early 2nd century BC, Pergamum acquired an aqueduct 42 kilometres long. This consisted of two, and in places three, parallel subterranean terracotta pipes. This was one of the high points of Hellenistic engineering, and included a section under pressure that enabled the pipes to cross two valleys at elevations below that of the water's terminus in the town (Aicher, 1995:2).

The modern consensus is that the Etruscans had developed techniques of land-drainage and water-supply which involved tunnelling through the soft volcanic rock of the region.[9] The Etruscan kings are also credited with Rome's first notable hydraulic work. During the reign of Tarquinius Priscus in the 6th century BC, the low-lying areas of Rome were drained by means of a system of canals. The main canal, running from the Subura through the area that was to become the forum, was named the *Cloaca Maxima* (Torelli, in Rosenstein & Morstein-Marx, 2006:81). It collected water from a large number of feeder drains, and was vaulted over in the 2nd century BC. It still carries run-off water into the Tiber today. The mouth of the tunnel is visible in the left bank of the river downstream of the Tiber Island and Ponte Palatino. Rome's sewer system was the hidden half of Rome's water system. Strabo (*Geography*, 5.3) and Cassiodorus (7.6) state they were equally as impressive as the roads and aqueducts.

It was only through Tarquinius Priscus' construction efforts that the valley between the Capitoline and Palatine Hills was rendered dry enough to construct the forum. This area, though insignificant at first, grew into the financial and political centre of Rome, and subsequently of the Roman Empire.

The earliest aqueducts of Rome were constructed in a manner similar to the drainage channels built by the Etruscans. The aqueducts evolved over time, becoming more complex and specialised, with the Romans benefiting from the experience of those that came before them. Roman economy and

[9] Patterson, in Rosenstein & Morstein-Marx (2006:347), provide a short discussion of the archaeological evidence for an early development of Rome.

society, the system of patronage and love of baths, encouraged the undertaking of large civic projects. Distant and secure borders made this possible.

It is unlikely that the censor Appius Claudius Caecus would have been able to build either the Appian Way or the Aqua Appia had it not been for Rome's military successes in the preceding two centuries. Building roads and aqueducts requires some measure of stability, or at least the ability to enforce and maintain law and order over some area. The outcome of the Latin, Samnite and Etruscan wars in a sense paved the way for Rome's civil expansion into Italy, the local control and stability allowing the Romans to improve their city, and this in turn feeding back and allowing them to extend their reach, which in turn lead to the development of stabilising infrastructure.

During the period preceding and during the construction of the first aqueduct, the Appia, Rome fought a remarkable series of battles. The fact that the Romans were capable of this series of battles while transforming their civil practices speaks of their vigour at this time. A list of the most important battles follows (Flower, 2004:24).

- **327-326**: Neapolis
- **326-304**: The Samnites
- **312-298**: The Marsi and other tribes of cental Abruzzo
- **311-308**: The Etruscans
- **310-308**: The Umbrians

6.4 Administration of the aqueducts

Until the last century of the Republic the *censors* had charge of all the aqueducts (Livy, 39.44), and built three of the four republican aqueducts. The *censors* had to contract out and inspect the work. The task of inspection might be delegated to an *aedile*, who oversaw the distribution of water in the town. Then the aqueducts were for a short time under the administration of the *aediles* and *quaestors*. The *quaestors* acted in their capacity as treasurers. The *aediles* would deputise two locals on each street to police their neighbourhood fountain. During the periodic vacancy of the censorship, questions of jurisdiction sometimes fell to a *praetor* to decide (Aicher, 1995:23). This lasted until the reign of Augustus, who instituted a new a complete system of management directed by a *Curator Aquarum* who was appointed for life.[10] It was an office of great dignity, resembling in function that of a *Curator Viarum* or *Frumenti*. The first *Curator Aquarum* was, in effect, Marcus Agrippa, who held the office from 36 BC until his death in 12 BC (Middleton, 1892:317). He had at first acquired the office of the aedileship in part to give his intervention in the water-supply some constitutional precedence. Once out of office, he retained his position as chief supervisor of the aqueducts. The senate acknowledged the office of *Curator Aquarum* the year after Agrippa's death, in 11 BC (Aicher, 1995:23).

The *Curator Aquarum* managed the public water supply, and also adjudicated over right-of-way disputes and cases of water-law violations. He managed a number of minor officials and personal attendants (*apparitores*) to assist with these tasks, such as secretaries (*scribae libarii*), ushers (*accensi*), criers (*praecones*), three public slaves (*servi publici*), engineers (*architecti*) and two lictors when outside the gates of Rome. The public office of the *Curator* was called the *Statio Aquarum*. A number of clerks were attached to it, known as the *Tabularii Stationis*. Other subordinate officials of relevance were the two assistants, *Adiutores*, men of senatorial rank, one *Procurator Aquarum*, usually an Imperial Freedman, and a *Tribunus Aquarum*. The artisans who worked under the *Curator* were classed as belonging to the *Fa-*

[10]However, it was not necessarily a full-time appointment. Appointees could carry on their private work simultaneously. This did not extend to important offices like the consulship (Ashby, 1935:20). When Frontinus was appointed *consul* in 98, he must have resigned from the office of *Curator Aquarum*.

milia aquaria publica and *Familia aquaria Caesaris.* These included *Aquarii* or *Villici*, presided over by a *Praepositus*, who made and laid the lead supply pipes; *Libratores*, who measured levels of the water; *Castellarii*, who kept the *Castella* or reservoirs in order; *Circitores*, inspectors of the works; *Silicarii*, who took up and relaid the *silex* (lava) street pavement, when mains were laid or repaired; *Tectores*, tilers, and other workmen, such as bricklayers, masons, *Pestatores*, pottery crushers (*testae tunsae*), to make the *opus signinum* of lining the channels and reservoirs.[11]

Agrippa bequeathed to his emperor a vast fortune, including a private crew of 240 slaves that had been employed in the maintenance of the city's aqueducts. Augustus gave these to the state, and the Senate's legislation organised them into a *familia publica*, in essence a slave gang supported by public funds and under the direction of the curator (Aicher, 1995:23). These were known as the *aquarii.*

Claudius (d. AD 54) introduced reforms in line with his policy of concentrating authority in the civil service directly under his authority. He created the *Procurator Aquarum* post and appointed men to it. Trajan and his successors were to appoint the occasional equestrian to the post. Claudius added another 460 slaves to the *aquarii.* They were now called the *familia Caesaris* and were controlled by the procurator.

The curatorship of the aqueducts might have been the most prestigious non-political office in ancient Rome. Its holders were generally senators who held distinguished positions both before and after their terms as curator. A curator received many honours extended to other high offices of the Roman state. These included certain immunities of office, and the right to wear the *toga praetexta.* The curator was appointed by the emperor and served for an

[11] Immense quantities must have been used. The great heap of broken pottery (mostly from amphorae from the ships) called Monte Testaccio, south of the Aventine Hill, was very likely used for this purpose.

indeterminate amount of time, ranging from a few months to many years. The post may have been left unfilled for some period of time, and there is some evidence that two men may have held it from time to time. It was not meant to be a full-time occupation. A resolution of the senate, as quoted by Frontinus (101), prescribes that the *curators* devote one quarter of the year to the public office (Aicher, 1995:24).

The physical location of the *statio aquarum* is not known, if there was one. At the end of the second century AD the title *curator aquarum et Minuciae* appears, indicating that the same official oversaw the water-supply and distribution of free grain. The latter occurred from the Porticus Minucia, which was probably located in the Campus Martius east of the four Republican temples in Largo Argentina (Aicher, 1995:25). Inscriptions from Constantine's reign found on a statue in some rooms near the spring and temple of Juturna in the Forum have led to speculation that the office was relocated to the forum in the 4th century. Bruun argues against the existence of and special physical office at all (Bruun, 1991). Richardson states that the speculation is probably accurate (Richardson, 1992).

Considering how copious the water supply was in Rome, the *silicarii* must have been constantly at work, pulling up and relaying the pavements of the streets when the mains or their branches needed repair. In some cases, especially for more important streets, the Romans formed tunnels in which the pipes were laid, and could thus be repaired without breaking up the street. This wise policy has not been widely adopted in modern cities (Middleton, 1892:318). It is possible that the Roman pipes, made from thick lead, was more robust than modern pipes and thus required less frequent repairs.

There is evidence that the construction of new aqueducts was carried out in part by public contractors (*Redemptores operum publicorum*).

The reforms of 11 BC simplified the administration of the aqueducts. A law was passed requiring a clear space of 15 Roman feet (4.5 m) to be maintained on each side of arcades and substructions, and 5 feet (1.5 m) on each side of a subterranean channel. This was to ensure ready access to the channel, and to avoid damage caused by tree roots. Tombs and other edifices were also prohibited from encroaching on the space above channels. A second law required that owners of adjacent land supply construction material at a fair price, and allow construction and repair crews right-of-way to the channel (Aicher, 1995:25).

A Republican law stipulated a fine of 10,000 sesterces for anyone who polluted a a public fountain. The *aediles* appointed two men on each street as caretakers and watchmen of the fountains. Augustus imposed a 10,000 sesterces fine on anyone who planted trees or shrubs in the clear zone around aqueducts. This fine would be divided, half going to the state, and half going to the person whose information led to the conviction. A fine of 100,000 sesterces was imposed on anyone who wilfully destroyed any aqueduct structure (Aicher, 1995:26).

6.5 Aqua Appia

Frontinus tells us that *"For four hundred and forty-one years from the foundation of the City, the Romans were satisfied with the use of such waters as they drew from the Tiber, from wells, from springs"*. By the late fourth century, about thirty years after the beginning of the Samnite War (343 BC), this supply was to prove inadequate to meet the city's growing commercial and private sectors.[12] Another reason may have been reduction in the qual-

[12]Compare this to the Croton Aqueduct, which was a large and complex water distribution system constructed for New York City between 1837 and 1842. It was named after its source, the Croton River. The island of Manhattan, surrounded by brackish rivers, had a limited supply of fresh water which dwindled as the city grew rapidly after the American Revolutionary War. Before the aqueduct was constructed, residents of New York obtained water from cisterns, wells, natural springs, and other bodies of water n a manner

ity of well water. As Hodge points out (2002:71), most of the Roman well water would have been water from the Tiber that had percolated through. With the increased use of the Tiber, and probably consequent increase in pollution, the quality of well water may have decreased. However, this is not likely, as the ground would have provided an adequate filter.

In response to the probable growing need for water, the censor Appius Claudius Caecus built the Aqua Appia in 312 BC. It was the procedure in Rome to entrust to the two *censors* during their eighteen months of office the building of public works. The *censor* Gaius Plautius was entrusted with the task of finding a new water supply, which he did. To Appius Claudius was given the responsibility of building the aqueduct, as he was already busy with the Appian Way. The aqueduct had not been completed by the time the *censors* were to leave office. Plautius stepped down, but Appius Claudius argued that the *Lex Aemilia* did not apply to him, and remained in office until the aqueduct was built and, as per custom, named after him.

The Appia's source was approximately 24 meters above sea level (20 metres below ground level), at a series of springs discovered by Gaius Plautius Venox. The cognomen *Venox* was acquired due to this feat. There is no consensus as to the exact location of the source, as the springs were located 16 m. below ground level and have probably been covered over again (Aicher,

similar to that of the Romans. But rapid population growth in the Nineteenth Century and encroachment on these areas as Manhattan moved further North of Wall Street led to the pollution of many local fresh water sources. The Old Croton is considered one of the engineering achievements of the 19th century. The tunnel is an elliptical tube 8.5 feet high by 7.5 feet wide. It is brick-lined and uses hydraulic cement for most of its length. The outer walls are of hammered stone. The tunnel is gravity fed for its entire length, dropping gently 13 inches per mile. To maintain this steady gradient through a varied terrain, its builders had to cut the conduit into hillsides, set it level on the ground, tunnel through rock, and carry it over valleys and streams on massive stone and earth embankments and across arched bridges. Typically, it is partly buried, with a tell-tale mound encasing it. The Old Croton was used until 1955, even though it had been replaced by the New Croton, build between 1885 and 1890. See Koeppel (2001).

1995:34). The intake is described by Frontinus as being 780 paces to the left of the Via Praenestina between the seventh and eighth miles, at a place called Ager Lucullanus. Middleton (1892:336) believes this to be a mistake, and that the probable intake is the reservoirs formed in the ancient quarries, now called *latomie della Rustica*. The location of the sources is unknown today. See Map D.3 for a guide to the paths that the aqueducts probably took to reach Rome, and Map D.4 for a guide to the paths that they took within Rome.

It entered Rome underground[13] in the area of Spes Vetus, crossed both the Caelian and Aventine Hills and terminated at the Clivus Publicius in the southern *Forum Boarium*[14], in the Porta Trigemina[15], near the Salinae. [16]. In level it was the lowest of all the aqueducts (Ashby, 1965:21). Compared to later lines the design of the Appia was very basic; for it had no piscina and travelled almost completely underground for its sixteen kilometre length, excepting for its terminus and at an arcade [17] bridging the valley between the Caelian and Aventine Hills near the eastern end of the Circus Maximus.

[13]See Figure D.13 for a photograph of a model showing the Appia, Anio Vetus, Julia, Tepula and Marcia entering Rome.

[14]While the northern *Forum Boarium* was well supplied with water, the southern *Forum Boarium* had only one spring that we know of, the *Fons Scaurianus*.

[15]The Porta Trigemina was an important gate, mentioned often in the ancient sources, but its location is a matter of dispute. It was on the Servian wall between the Aventine and the Tiber, in Region XI (Platner & Ashby, 1965:418

[16]Aicher (1995:35) speculates that this was probably the site of an ancient salt flat. Evans (1997:68) believes it was the site where salt was either stored or refined. Platner & Ashby (1965:462) are in agreement with Evans, stating that the Salinae contained warehouses to store salt brought up the Tiber. Richardson (1992:341) states that the location would not have been convenient for warehouses, and that the name suggests a place where salt is refined. Evans goes further to speculate that if salt refining took place as late as 312, then a large supply of water would be needed. He states this is unlikely and is in agreement with Aicher, Platner & Ashby and Richardson that by 312 nothing but the name remained.

[17]If this arcade dated from the original construction of the Appia, then it one of the very earliest, if not the earliest, use of an arcade in Roman architecture (Evans, 1997:67).

This arcade stood just inside the Servian Wall and no longer exists. From this point the channel continued underground again, probably following the ridge taken by later lines and paralleled by the *Arcus Caelimontani* of the Aqua Claudia, traversing the Aventine to end near the Tiber. Frontinus notes that the Appia did emerge from its subterranean course at the Porta Capena, however, he continues to point out that there was no *castellum* installed at this point. Because of its low level, the aqueduct can be traced mainly from the evidence of Frontinus (Evans, 1997:65). The water system pursues this subterranean course probably for reasons of security. Rome was burdened by frequent battles with the Samnites who could have, in an attempt to siege the city, cut the water supply in an attempt to paralyse Rome. Indeed, this is just what happened during the Goth invasions of the early 6th century.

According to Aicher (1995:35) the Appia had more in common with early drainage systems than with later aqueducts. Drainage tunnels had long been dug by the Etruscans in the fields north of Rome. Etruscan kings had begun the drainage system of Rome with the Cloaca Maxima. The Appia lacked any *piscina*, in contrast to the later aqueducts.[18] Nonetheless, the Appia was probably considered a marvel at the time of its construction (Evans, 1997:65).

Despite their reputation as marvels of engineering, the aqueducts leaked quite badly and required frequent maintenance. Besides information attesting to this in Frontinus, Juvenal and Martial mention the leaks in the Aqua Marcia as it passed over the Porta Capena. The Appia was repaired by Q. Marcius Rex between 144 and 140 BC (Pliny, 36.121) and again by Agrippa (Frontinus, 1.9) and lastly by Augustus in 22-4 BC. Augustus also added a new feeder branch, the *Appia Augusta*, of 6,380 *passus*. This drew water from springs located between the Via Prenestina and the Via Collatina.

[18](Torelli, in Rosenstein & Morstein-Marx (2006:93), states that it did have a *piscina publica*.

This would be closer to Rome than the original branch and joined the Appian channel near a location Frontinus calls *ad Gemellos*, which is probably at the *Porta Praenestina.* This introduces an inconsistency; an entire new aqueduct is considered only a feeder, while aqueducts like the mixed Tepula and Julia maintain their identities.

Platner & Ashby (1965) curiously do not mention Agrippa's repairs. Frontinus states that in "year 719" Agrippa

> *... repaired the conduits of Appia, Old Anio and Marcia, which had almost worn out, and with unique forethought provided the City with a large number of fountains.*

The traditional founding of Rome is 753, so presumably Frontinus refers to about 34 BC, which accords well with Richardson and other scholars' dates. There can be little doubt that repairs were carried out by Agrippa, and Platner & Ashby's omission must be in error.

It is problematic to argue that the Appia's main purpose was to supply surrounding inhabitants with water as, over a course of 11,190 passus (16.2 km), the Appia's elevation fell to about 15 meters. This decline, 8 meters or 5%, reflects the minimum "drop off" prescribed by Vitruvius. Therefore the line posed several problems for its contemporary engineers, and their task to provide water to higher elevations, especially residential areas. In fact, as Evans (1997:66) states, that from a technical standpoint the Appia's low level prevented distribution to higher areas. It seems probable, however, that the key reason for the Appia's introduction was the increasing commercial importance of the *Forum Boarium.* While the northern *Forum Boarium* had the spring of Lupercal, the southern end had no such supply. The positioning of the aqueduct's terminus and the growing number of cults lend support to this theory. Cults such as, Portunus, Fortuna, Hercules, Diana, Mater Matuta Ceres and Liber played a quintessential role in the marketplace of the Boarium, and therefore, it seems likely that the aqueduct was instituted to meet the increasing need for water that could not be supplied by existing cisterns. Frontinus agrees with this theory. By his time the Appia had been reworked three times. He states that the Appia served seven of the fourteen Augustan regions: the Caelian, Roman Forum, Circus Flaminius, Circus Maximus, Piscina Publica, Aventine, and Transtiber. Frontinus believes that roughly one fourth of the Appia's water was distributed to private inhabitants. This seems very plausible given the date of the aqueduct's introduction, its low level and small rate of declination. Frontinus' figures illustrate that the Appia delivered 70% of its volume to imperial and public buildings. This adds more evidence to the contention that the Appia was instituted for civic as opposed to private needs and perhaps aided the commercial growth of the Boarium and its cults. Over time, as Rome's requirements grew, more uses were found for the Appia's waters.

6.6 Aqua Anio Vetus

The construction of the Anio Vetus, occurring merely forty years after that of the Appia, was an ambitious undertaking. Its course was approximately four times the length of the Appia and the source was much higher than the Appia. In time it became known as the "Old Anio". Funded by the spoils of the Pyrrhic war, it was constructed between 272 and 269 BC. The source is the river Anio, a tributary of the Tiber, in the upper Anio valley, and was the first of four to take water from that place. Frontinus states that "the intake of the Old Anio is above Tibur at the twentieth milestone...", which is too low a figure, whereas it is too high a figure if Tivoli is meant. Most archaeologists believe its source to be between Vicovaro and Mandela, 850 metres upstream of the gorge at S. Cosimato. The intake, off a basin filled by river water, was 260 metres above sea-level (Aicher, 1995:35). Ashby (1935:57) concludes that Frontinus was mistaken in the length of the Anio Vetus.

Like the Aqua Appia, the Vetus' course was primarily underground. Later, however, as technology advanced, the addition of bridges and substructures shortened its course to between 64 and 81 kilometres. Frontinus records the lower number, Blackman (1979) states this is too low and gives the higher figure. The Vetus' general path to Rome became the template for future aqueducts, except for its supplementary channel that took short cuts to avoid the paths along the sides of valleys. From its source it descended along the river to Tivoli where it left the Anio valley and sloped south towards the Alban Hills to near Gallicano, below Palestrina. From here turned west again towards Rome. It crossed under the Via Latina near the 7th mile marker, southeast of the city.[19] At the 4th milestone the aqueduct turned northwest to enter Rome.

After entering the city underground via the Porta Praenestina it terminated inside the Porta Esquilina. Frontinus states that the aqueduct served the following areas: the Porta Capena; Isis and Serapis; Templum Pacis; Esquiliae; Alta Semita; Via Lata; Forum Romanum; Circus Flaminius; Piscina Publica; and Transtiber. Both the Vetus and the Appia served the Forum Romanum and Circus Flaminius, thus alluding to the increased needs of the city's centre, particularly the subura, an area which could not be supplied by the Appia alone; on account of its low level and terminal position near the Tiber. Frontinus documents that only 5.8% of the Vetus' total distribution supplied imperial buildings. This illustrates an important difference with the Appia, which gave almost 22% to such buildings. Approximately 44% of the Vetus' volume was delivered to the privati located on the eastern hills. A remaining 49.8% supplied the usibus publicis. Included in this category are fountains and industrial and irrigation areas. Water was reserved for the latter two areas so that the Marcia was free to supply public taps and water troughs for animals. It is important to note that the water, due to its poor quality, was used primarily for public baths, gardens and industry. The

[19] Near the terminal subway station at Anagnina

water was muddy after storms, and cloudy even in good weather. Frontinus estimated that the Anio Vetus delivered 180,000 m^3 per day (Aicher, 1995 and Frontinus, 1925).

The Vetus approached the city in the same fashion as the Appia; underground near the Spes Vetus and distributed its water inside a gate of the Servian Wall. The Vetus and the Appia complement each other in a fashion that suggests the careful planning of the Vetus. The aqueducts serviced two of the same regions due to the increased demands, however, they also fuel separate areas with regards to the low and high lands of the city. However, the two aqueducts differed considerably in construction. The Vetus was much more complex in design, for it incorporated a piscina, drew some of its water from the Marcia, and supplied a branch line of its own called the specus Octavianus. Frontinus indicates that the Vetus had 35 *castella*, indicating its widespread distribution. The Vetus, however, probably did not supply the drinking water to the Roman aristocracy. Confirmation of this hypothesis is found in Frontinus' discussions regarding the quality of the water in the Vetus line. Frontinus indicates that the Vetus had "muddy water" and goes on to state that the aqueduct did not pollute the lines of later aqueducts that ran similar courses.[20] This alludes to the fact that the Vetus ran beneath these future lines and thus did not have the ability to service the higher locations within the city (Aicher, 1995 and Frontinus, 1925).

There are two known branches of the Vetus. The branch known as the *specus Octavianus* diverted from the Vetus less than four km from Rome. Augustus erected the only *cippi* recorded for the Anio Vetus, and it was no doubt he that constructed this branch (Ashby, 1935:55). There are now no remains left of the *specus Octavianus*. The other branch is only mentioned

[20]Perhaps the muddy water was the reason for the *piscina* less than 8 km from Rome, as mentioned by Frontinus (1.15). It is also probably the *Castellum Viae Latinae contra dracones* mentioned in the inscription *CIL* 6.2345.

by Livy once, on the work knows as the Oxyrhynchus Epitome, in book 54.

6.7 Aqua Marcia

Waters flowing into the city via the Aqua Appia and the Anio Vetus satisfied the needs of Rome's population for about ninety years. Or perhaps it should be said that the Romans had to be satisfied with the supply[21]. The near cataclysm and associated expenses of the Second Punic War caused an understandable hiatus in building projects in Rome. When supplies became inadequate to support Rome's public fountains private users were removed from the system by cutting off their pipes. Marcus Aemilius Lepidus and Marcus Fulvius Nobilior, censors from 179 BC to 174 BC, let contracts to construct a new water supply, but Livy tells us that the project was blocked by Marcus Licinius Crassus, who would not allow the aqueduct to cross his property (See 6.19. Consequently, no new water was brought into Rome for another thirty years, until the praetor Quintus Marcius Rex was charged with restoring the existing aqueducts and building a new one (Heiken, Funiciello & De Rira 2005: 145).

The only aqueduct built by a praetor, the Aqua Marcia[22] was constructed between 144 and 140 BC, one hundred and thirty years after the construction of the Vetus and became perhaps the most famous of the Roman aqueducts. It was financed with booty taken from Carthage and Corinth after 146 BC (Evans, 2000:84). Frontinus states that Q. Marcus Rex was also charged with the responsibility of repairing the Appia and Anio Vetus, which by this time where leaking badly, and many citizens where stealing water for their own use without paying taxes. The Marcia provided clean water to the city that had more than doubled in size since the previous aqueduct was built,

[21] Accounts of the censorship of Cato the Elder (184 A.D.) include notices that the censors reclaimed public water flowing onto private property. Evans (2000:83) sees this as an indication of an attempt to make the best use of a limited resource.

[22] According to Pliny (*Nat. Hist.* 31.41), the Marcia was originally named the Aufeia. There is no other evidence for this.

and was continuing to expand as a result of military success against Carthage and Macedonia. In the years following the Second Punic War water was in such demand that private lines were reclaimed for public usage. Both Livy (39.44.4-5)[23] and Plutarch (*Cat. Mai.* 19)[24] indirectly support the notion of this water shortage, and indicate that it was a limited resource. Frontinus hints that the old aqueducts were in such bad repair that their supply was wholly inadequate.

The Marcia's source[25] was a series of springs located on the right bank of the Upper Anio, just below Agosta on the road to Subiaco. This is in the same area where numerous spring houses gather water today for the Marcia's modern counterpart, the Acqua Marcia Pia (Aicher, 1995:36). The ancient channels are now approximately eight metres below ground, the floor of the Anio Valley having been raised by calcareous deposits and the springs themselves (Ashby, 1935:95). *Apparently, the pools of water that seeped from the ground until the 1920s was from leaks in the ancient channel.* Several underground catchment channels and the run-off from the slopes of the Simbruini ridge may also have contributed. Frontinus describes the reservoir at the source, *Its waters stand like a tranquil pool with a deep green colour.* Tacitus (*Ann.* 14.22) states that Nero swam in the sacred pool, and shortly afterwards fell sick. From its source, the Marcia descended mostly underground along the river's right bank, until it crossed to the left bank near Vicovaro and took almost the same route to Rome that the Anio Vetus took. The Marcia emerged from the ground to finish the last ten kilometres to Rome aboveground, near the farmhouse named Romavecchia. Incorporating both sub-channels and arches, the aqueduct entered the city through the Porta Maggiore and terminated in a large tank on the Viminal

[23]To quote Livy: *The censors cut off all public water that had been piped into a private building or into private land, after giving thirty days notice.*

[24]To quote Plutarch: *He cut off the pipes by which people were in the habit of diverting some of the public water supply into their houses and gardens...*

[25]Pliny calls the spring *Pitonia* (*Nat. Hist.*, 31.41).

hill, located north of Diocletian's Baths. This would be under the present Ministry of Finance. Near the Porta Tiburtina, however, a branch of the Marcia, called the Rivus Herculaneus, diverged from its original path only to transverse the Caelian Hill and terminate at the Aventine Hill. The Aqua Marcia was the longest aqueduct spanning 91 km and yielded and estimated 190,000 m$\hat{3}$ per day. Eighty kilometres of the channel lay underground, 1.5 kilometres on substructures and 9.5 kilometres on arches.

Martial (*Epi.* 9.18) gives us some evidence that the Marcia was also delivered to the Quirinal Hill.

> *I possess, and pray that I may long continue to possess, under your guardianship, Caesar, a small country seat; I have also a modest dwelling in the city. But a winding machine has to draw, with laborious effort, water for my thirsting garden from a small valley; while my dry house complains that it is not refreshed even by the slightest shower, although the Marcian fount1 babbles close by. The water, which you will grant, Augustus, to my premises, will be for me as the water of Castalis or as showers from Jupiter.*

The Marcia supplied supplemented the Tepula and Anio[26](2.67). On the surface this fact complicates the task of assessing the number of aqueducts in Rome. However, the supplementary volumes are so low that in this case the aqueducts can maintain their separate identities.

The Rivus Herculaneus crossed the valley between the Caelian and Aventine Hills on an arcade, like the Appia. Lanciani's (1990) hypothetical reconstruction of the channel has the arches of the Marcia parallel and abutting the Servian Wall, on the basis of references to an old arcade and a wet gateway at Porta Capena by Juvenal (3.2) and Martial (3.47.1). Juvenal refers to the arch *veteres arcus madidamque Capenam.* Martial refers to it

[26]Presumably Anio Vetus

as *arcus stillans.* Aicher (1995:37) thinks these descriptions may refer to an even older arcade of the Appia, on the basis of evidence in Frontinus (1.5) which supports his version. By Frontinus's time a higher branch on arches delivered water to the heights of the Caelian and Aventine Hills.

The Marcia was appreciated by the Romans for the quality of its clear, cold water, which derived from rainwater on the slopes of the Simbruini ridge west of the valley. Here, Mt. Autore reaches a height of 1,850 metres. The rain takes several months to percolate through the porous limestone before it wells up in the valley springs. This makes the water hard, and the Marcia's channels were quickly coated with a calcareous deposit that had to be removed periodically (Aicher, 1995:37).

The Marcia underwent several restorations and additions during its lifetime. Augustus significantly increased its capacity by adding a supplemental source called the Aqua Augusta. This source, after the introduction of the Claudia, was reserved as a supplemental supply for the Marcia and occasionally for the Claudia. Evidence regarding Augustus' overhauling of the line appears as an inscription on the Porta Tiburtina, or in literary sources such as the Res Gestae. Finally in AD 212, Caracalla added another secondary channel, the Aqua Antoniniana, near Torfiscale, in order to supply water to his baths. Diocletian also made renovations for the same reasons as Caracalla. The result of these extensive restorations and additions was a complex distribution system that delivered water to a diverse area. The Marcia was the first aqueduct that supplied the high elevation districts of Rome. Archaeological evidence suggests that widespread distribution occurred in the area of the Porta Viminalis. The only evidence visible until quite recently, of this distribution was marked by a small circular structure outside the line of the Servian Wall (Evans, 1997:85). Its other location outside the Porta Viminalis, coupled with its small size, indicate that this was part of a secondary branch. The Marcia supplied the Palatine and by means of a siphon, the Caelian, the Aventine, the Forum Romanum, the southern Campus Martius, and the locations too high for the Vetus on the eastern hills of the city.

The Aqua Antoniniana ended in the large cisterns of Caracalla's Baths.[27] These remain on the south side of the baths (below Via Baccelli), buttressed against the hill on which the aqueduct arrived. The water was stored here for distribution from 32 chambers of approximately two stories each. Such a high capacity would have served the baths well should the water supply have been interrupted.

A branch of the Marcia was also taken to the Capitoline Hill. This against the opposition of a number of politicians, who were rivals of the builders. They cited an oracle of the Sybilline books that prohibited water of Anio Valley from touching the Capitoline (Frontinus, 7). According to Livy, the Anio Vetus was also brought here.

Frontinus observes that only a small portion of the Marcia's flow was allotted to public buildings, public works and ornamental fountains. The greatest volume of water was delivered to privati (49.3%) and to public lacus (23.2%). Approximately three-fourths of the Aqua Marcia was reserved for drinking, either for private citizens or for public basins. This explains Frontinus' efforts to keep the integrity of the line, saving it for human consumption whenever possible. The only regions not supplied were the Circus Maximus and Piscina Publica.

The Marcia has a number of well-preserved *cippi*. Ashby (1935:93) lists ten. Their inscriptions are mostly preserved in *CIL* 6.3156 and 6.3157. He mentions another fourteen that are joint *cippi* for the Marcia, Tepula and Julia. These mostly in *CIL* 6.31561 and 6.1249.

[27] The Baths of Caracalla would have required a copious supply of water. Grant (1968:101) estimates that it could accommodate 1600 bathers at one time. The baths which Diocletian and maximian built after the fire of 283 are estimated to have been twice that size; perhaps they could accommodate 3000 bathers.

The Aqua Marcia was an ingenious, well-built and handsome engineering system. Its length set a record that would stand for centuries, and would never be broken in Rome. It supplied two and a half times as much clean water than the Appia, and more water even than the Anio (Hauck, 1988:35). It was in use until the 10th century.

6.8 Aqua Tepula

We know little of the original Tepula, as it was completely reworked and the original path abandoned by Agrippa. According to Frontinus, it was built in 126 BC by the censors G. Servilius Caepio and L. Cassius Longinus and took its water from the estate of Lucullus (2.8). Though modern scholars believe that the Tepula drew its waters from the foot of the northern slope of the Alban Hills, its source was a number of streams in the Marciana valley, about two kilometres west of Grottaferrata. Ashby (1935:159) believes it to be the Sorgente Preziosa. The water temperature here is indeed still quite warm. Frontinus has this to say (2.68):

> *Tepula is credited in the records with 400 quinariae. This aqueduct has no springs; it consists only of some veins of water taken from Julia.*

This is rather an odd statement by Frontinus, as the Tepula is older than the Julia. It is true that they used the same channel, and as Frontinus says (1.9):

> *The Name Julia was given to the new aqueduct by its builder, but since the waters were again divided for distribution, the name Tepula remained.*

It can be argued that mixed water cannot be divided into its original components, so perhaps the birth of the Julia meant the transformation of the Tepula into a branch of the Julia.

Nothing remains of the Tepula's collection system, but the same warm water (16 C) that gave the Tepula its name feeds the fountain named Sorgente Preziosa today. It was introduced in order to service the Capitoline Hill, and would have been a high-level line, similar to that of the Marcia. In fact it entered Rome atop the Marcia and was the highest of the "contemporary" aqueducts, thus allowing it to have the potential to service regions of higher elevation. As indicated by its name the aqueduct delivered "tepid" water and therefore was not as valued as other aqueducts, especially the Aqua Marcia. Its temperature made the Tepula unpalatable and therefore its flow was used for industrial purposes. This is no bad thing, because s a result of the addition of the Tepula the waters of the Marcia were freed for drinking purposes. The Tepula, passing through 14 *castella*, delivered water to four regions, Templum Pacis, Esquiliae, Alta Semita, and Via Lata. Three-fourths of its waters furnished private citizens and 15% was assigned to usibus publicis. These statistics coupled with the regions that the Tepula served adds weight to the statement that the role of the aqueduct was to complement the other lines, such as the Marcia, that provided water to the eastern districts of the city. According to Evans (2000:96), the Tepula's limited length and capacity were perhaps dictated by economic considerations during the politically unstable decade of the 120s BC

It is interesting to note that the Tepula served the same region as the Marcia, and this less than twenty years after the former's construction. This may point to rapid growth in the city, especially after the wars of the 130s,[28] or the land problems that spurred the Gracchi to action. There was probably a serious requirement for the extra water, considering that lower quality water was accepted and that no opposition to the Tepula's construction on the Capitoline is recorded, in contrast to the Marcia. The Tepula's small size may have been an economic necessity; the 140s saw full coffers and

[28]This included wars against the Numantines in Spain, against the Scordisci in Macedonia and against a slave revolt in Sicily. None of these conflicts could have produced much booty and probably represented a net loss.

extravagant spending, but the minor wars, land problems and grain problems (caused by the Sicilian Slave wars, the revolt led by the slave Eunus) meant that spending in the 130s and early 120s was restricted (Boren, 1958:900).

The Tepula originally ran its own course from source to terminus. In 33 BC, in an attempt to improve both the water quality and its volume, Agrippa combined water from his new aqueduct, the Aqua Julia, to the existing Tepula. The two waters of the Tepula and Julia ran together to their piscina and then divided back into two channels at a clearing basin somewhere near today's Capannelle, subsequently travelling to their respective terminus. Due to the cost of its forerunner, the Marcia, and the poor nature of the water, however, the Tepula did not fulfil this expectation. In fact it was Rome's smallest line, spanning a mere eighteen kilometres, and delivered only 17, 800 m^3 per day[29].

The Aqua Tepula proved to be the most problematic of all the Republican aqueducts. The constructs of the original Tepula are unknown; because all of Frontinus' discussions refer to the line after Marcus Agrippa made extensive restorations[30]. Because there is no trace of the original channel, it is inferred (reasonably) that the initial channel was abandoned and a new one instituted. Frontinus indicates that the aqueduct possessed no source of its own, but drew its waters from springs that later supplied the Aqua Julia. This confirms the belief that the line had a restricted capacity.

[29] Alone of all the aqueducts listed by Frontinus, the Tepula lost none of its waters between its source and terminus.

[30] According to Evans (2000:97), the Tepula ceased to have it's own identity after Agrippa. This argument has much to recommend it.

6.9 Aqua Julia

The political and social chaos during the last century of the Republic prevented the establishment of any new major water system until the Julia. As early as 33 BC it had become apparent to Octavian that he would have to reorganise the public works administration (Anderson, 1997:89). The existing four aqueducts were in dire need of restoration, as they had become an administrative and maintenance disaster. Agrippa (c. 63 - 12 BC), holding the office of aedile, played a crucial role in the restoration and repair of the system, perhaps the most important role. He established an administration policy for the aqueducts. Acting as the *curator aquarum*, he instituted a permanent staff for the operation and maintenance of the water systems of Rome. His energy, creativity and competence formed a model for successive generations.

It is generally accepted that Agrippa built the Aqua Julia in 33 BC[31]. Its source was a few kilometres upstream to that of the Tepula, southeast of Grottaferrata [32] and below the roads to Marino and Rocca di Papa. This source is a number of springs that gather in a catch basin approximately three kilometres before its subterranean course in the Marciana Valley[33]; Frontinus states that it was not possible to judge the volume of water at the intake because of the number of tributaries involved. According to Frontinus (1.9), the Julia was also supplemented by water from a brook called Crabra, the main supply of Tusculum[34]. As the Julia ran its course, it was mixed with waters from the Tepula some three of four kilometres

[31]The date is disputed. Dio Cassius (49.32.3) states that the line was introduced in 40 BC This suggests that the Julia was Julius Caesar's project, and finished by Agrippa after his death. This would also explain the name, which according to Evans (2000:99) would be a typical act of Agrippan self-effacement. Wright (1937) has another theory for the origin of the same; he postulates a family relationship between Caesar and Agrippa

[32]Middleton (1892:341) states a mile north of Grottaferata, and Ashby (1935:162) places it in the region of Ponte degli Squarciarelli.

[33]This water now feeds the Marrana Mariana.

[34]This practice was stopped and the supply returned to Tusculum.

from the beginning of its subterranean course in the Marciana valley, passed through a piscina near Capannelle after another six kilometres, and finally rode atop the Marcia on its way into the city (See Figure D.13). Frontinus indicates that a subsidiary branch of the Julia, diverging from the main conduit near Spes Vetus, supplied *castella* on the Caelian. This was made possible due to the Julia's elevation that was slightly higher than that of the Marcia. The Julia also furnished the Palatine via a siphon. Frontinus lists its widespread distribution, indicating that the Julia supplied the Caelian, Isis and Serapis, Esquiliae, Alta Semita, Forum Romanum, Palatine, and Piscina Publica. The Julia's main terminus was a reservoir near the Porta Viminalis and a secondary branch delivered water to the Caelian and Aventine Hills. The aqueduct was between 22 and 23 kilometres long, and yielded 48,000 m^3 per day.

According to Frontinus, the Julia may have been introduced to meet the water needs of the Augustan building program. Sixty five percent of its capacity was allocated for usibus publici, of which 30% was allotted for public works. Only 3% of its total distribution supplied imperial buildings and property.

6.10 Aqua Virgo

There is a great deal of literature about the Aqua Virgo, because it is the one ancient aqueduct that remains functional within modern Rome. Fourteen years after he built the Aqua Julia, Agrippa constructed the Aqua Virgo (19 BC) in order to supply water to the Campus Martius, which Augustus was in the process of developing. There are two theories with regards to the aqueduct's name. Frontinus suggests that it was named after the young girl who discovered its source. Others, however, believe that it was named after a statue of a water goddess housed in a temple near the source.

The Virgo's source was positioned near Rome in a marshy area north of the Via Collatina, just before the 8th milestone. Several feeder channels throughout its course augmented the Virgo's water volume. One consequence of these channels was an influx of precipitate impurities that could impede or even obstructed its flow, and therefore the Virgo required periodic maintenance. The plan of the Virgo complemented that of the Julia and met the specific requirements of the districts that were poorly served by earlier aqueducts. The Virgo distributed water to the Via Lata, Circus Flaminius, Campus Martius and Transtiber. The service to the Transtiber illustrates one of the main reasons for the construction of the Pons Agrippae. The Virgo required a bridge to carry the water to the Transtiber. Frontinus notes that the Transtiber already received water from the Appia, Anio Vetus and Marcia, but this supply was limited by the constraints of the delivery pipes running across the Pons Aemilius. The aqueduct was also to service Agrippa's baths near the Pantheon and the artificial stream near the baths, called the Euripus. The Virgo entered Rome via a circular route to the north, subsequently eliminating the difficulties of tunnelling through densely inhabited areas. It terminated at the Villa Julia and transported 100,000 m^3 of water per day into Rome. All but about one kilometre of the Virgo ran underground.

Frontinus suggests that little of the Virgo's volume was allocated for private use, only about 15%. This seems plausible because of its distribution to the Campus Martius that is primarily a non-residential area. Certainly some of the water was intended for Agrippa's public bath near the Pantheon. It also supplied an artificial stream near the baths namd the Euripus (Aicher, 1995:39). About 22% of the Virgo's capacity was used for buildings in the Martius and Transtiber, including warehouses and industrial zones along the Tiber. Its limited service to the Transtiber probably indicates that the water was used for public means and not as a luxury for private dwellings. The remaining 63% of the water was distributed for *usibus publici.*

The Virgo's water was apparently quite cold and pure, according to Seneca and Martial. Seneca refers to it as pleasant water to bathe in, while Martial twice mentions its coldness. Cassiodorus (*Var.* 7.6) says

> *The Aqua Virgo runs with delightful purity, for while other waters during excessive rains are invaded by earthy matter, the Vitgo's current runs pure as a never-clouded sky.*

The Virgo is one of the aqueducts that was in use the longest. It is still used today, though the water is unsuitable for drinking. The Trevi Fountain, on the Collis Quirinalis, and other display fountains on the Campus Martius are supplied with water by the Virgo.

6.11 Aqua Alsietina

Augustus constructed the Aqua Alsietina in 2 BC. The Alsietina and Traiani are the only two aqueducts to draw their water from an area other that the Anio watershed to the east and southeast of Rome. The Alsietina took its water directly from the southern side of Lake Alsietinus, at a height above sea level of 207 m, a small crate lake east of Lake Sabatinus. The opening of the tunnel, which was the lake's only emissary, has been found in the hillside 12 metres above the current water level (Aicher, 1995:41).

Of the Alseitina's 33 kilometre length, only about 500 metres was above ground. Much of the course is unknown. From the lake it headed due south towards Osteria Nuova. South of here it passed near to the abandoned S. Maria di Galeria, where a branch from Lake Sabatinus joined it. It entered the city to the north side of the (later) Porta Aurelia and after a short stretch of arches dropped underground again to the Trastevere. A short section of its tunnel has been discovered near S. Cosimato (Aicher, 1995:41). Frontinus mistakenly states that the Alsietina is the lowest of the aqueducts.

Frontinus states that he is unclear as to why the Alsietina was built because its waters were unfavourable for drinking. He assumes that its purpose was to furnish Augustus' Naumachia at Trastevere with water, and while that was not in use, all the water was delivered *extra urbem.* There was no evidence regarding the existence of any piscina, which adds weight to the theory that the Alsietina did not service public needs, but was used for private purposes. There is some evidence from Frontinus, however, that indicates that its waters were also used to irrigate gardens and country villas located along the Alsietina's course, thanks to the generosity of Augustus. Despite its poor quality, the water was used for drinking when the conduits of the Marcia and Virgo, crossing the river to Trastevere, were closed for repairs. This aqueduct supplied only 6,000 m^3 of water per day.[35] All of this water was consumed outside of the city.

One problem with using the Alsietina's water for the Naumachia was its height. The Alsietina entered the city at a much higher level than the Naumachia; dropping the height of the water over such a short course is problematic.

6.12 Aqua Claudia

Started by Caligula (AD 12 - 41) and officially finished by Claudius (10 BC - AD 54), the Aqua Claudia was constructed between 38 and 52 AD. The date of completion is given in an inscription at Porta Maggiore, but Tacitus (2.13) suggest that the aqueduct was in use by 47 AD. It was fairly common practice to begin using an Aqueduct before construction was completed. Caligula ordered its construction because the seven existing aqueducts were by now inadequate due to the demand for water from consumption and utilities such as the baths. It is on account of its massive arches that the Claudia is one of Rome's most visually impressive aqueducts.

[35] Aicher (1995) differs in his estimate, giving a figure of 16,000 m^3 per day.

Its source is a number of springs in the Anio Valley, near Agosta and close to the sources of the Marcia. Originally there were two springs, the Caeruleus and Curtius. Later these were to be supplemented by the Albudinus spring. From its source the Claudia descended along the right bank of the Anio, mostly underground and slightly uphill from the Marcia. Originally the Claudia crossed to the left bank of the Anio over a bridge below Vicovaro. Remains of this bridge have been incorporated in a modern road bridge. Hadrian built an alternate loop that crossed the Anio upstream at the gorge of S. Cosimato near the base of the hydroelectric dam. On the left bank of the Anio the Claudia followed approximately the same route as that of the Marcia and Anio Vetus, even crossing their paths occasionally on its way around Tivoli towards the Alban Hills. Like the Marcia, he Claudia emerged above ground near Capannelle and crossed the land near Romavecchia on a long series of high arches. After about ten kilometres on arches, the Claudia entered Rome at Spes Vetus and crossed the Via Prenestina and Labicana on Porta Maggiore. Its *castellum* was on the Esquiline Hill, near the temple to Minerva Medici.[36] Nothing remains of this once imposing *castellum*, which was destroyed by fire in 1880 when it was being used as a hay barn (Aicher, 1995:55). Piranesi's etching (see D.27) is useful when imagining what the 21.5 by 14.2 metres and several stories high *castellum* looked like. Porta Maggiore can be seen in the background of this etching.

Inscriptions on the Porta Praenestina indicate that Vespasian (AD 9 - 79) and Titus (AD 39 - 81)[37] repaired the aqueduct shortly after its completion, in 71 AD, after a nine year period of inoperation. Furthermore, Hadrian (AD 76 - 138) and the Severans carried out later restorations. Brick stamps from 123 AD provide the evidence for Hadrian's restoration, which had an elegance about them which was unusual in this type of undertaking. Restorations during the latter, less prosperous period were more utilitarian in nature. After Nero (AD 37 - 68) built the Arcus Neroniani, one of the

[36]See Figure D.2 for a photograph of a model of a section of the Aqua Claudia.
[37]See Chap. 3.5

Claudia's branch lines, and because of its height, the aqueduct could supply water to all fourteen districts. Domitian (AD 51 - 96) also added a branch to supply water to the imperial palaces on the Palatine Hill. It was one of the more difficult aqueducts to maintain, possibly because of its innovations. The Claudia was 69 km long and delivered 185,000 m^3 per day.

While the measurements for the water volume at their intakes are close for the Claudia and Marcia, Frontinus describes the Claudia as *abundantior aliis*. He also states that the channel could not receive all the water available at the intake.

The nine year hiatus in operation is a puzzling aspect, especially when it is realised that the Claudia accounted for nearly 20% of Rome's water supply at that time. It is exceedingly strange that the aqueduct should break only 15 years after entering operation, and only 8 years after its official opening, unless it was poorly constructed or suffered a series of unfortunate disasters, or both. The relatively low cost of the Claudia points to lower quality building materials or hurried construction.

However, while low quality material and construction might explain why the Claudia collapsed, it does not explain why it took so long to repair it. Some major events of the 60s serve to provide clues for this. Firstly, a there was major earthquake in southern Italy 5 February 62 AD, which caused extensive damage to a number of towns, including Pompeii. Though there is little to no evidence suggesting that the earthquake effected Rome, the date coincides with the breakdown of the Claudia. In the same year a storm wrecks 200 ships in the newly constructed but still incomplete Claudian harbour at Ostia, and a 100 more by accidental fire further upstream (Tac., *Ann.* 15.18).). The storm may have been a Tsunami caused by the same earthquake that damaged Pompeii. If this is the case, it points to a powerful earthquake that might have caused some damage to Rome. One result of the storm was the loss of huge quantities of corn at the harbour, in warehouses and on the ships. The destruction of so much corn, when Nero has just thrown away vast quantities of old spoilt corn, must have led to shortages. These particular events may not have damaged the aqueduct itself, but may have further drained the imperial coffers (Nero was well-known for his financial irresponsibility (Cary & Scullard, 1975:361).

The fire that swept through Rome for more than a week in 64 devastated Rome. Tacitus (15.37) gives a dramatic account, stating that the fire left only four districts intact, destroying three totally and reducing the other seven to smoking ruins. In his own words (15.38):

> *It began in the circus, where it adjoins the Palatine and Caelian Hills... the conflagration instantly grew and swept the whole length of the circus... the fire swept over the level spaces and then climbed the hills, but returned to ravage the lower ground again.... When [the residents of Rome] escaped to neighbouring quarters, the fire followed even into districts believed too remote to be involved... the flames overwhelmed the whole of the Palatine... [the fire] was finally stamped out at the foot of the Esquiline Hill.*

However, flames broke out again and many temples and "pleasure arcades" were destroyed. [38]. It is possible that the Claudia was damaged by the fire, as it would have passed through some of the worse effected regions. However, as the Claudia and Anio Novus met in Rome and there is no mention of the Anio Novus being damaged, the damage that caused the shutdown of the Claudia is unlikely to be the fire. Instead, the fire may have reduced the combined Claudia/Anio Novus line to the extent that it would be unwarranted to repair the Claudia until the damage within Rome had

[38] While Nero deserves credit for his not-inconsiderable relief measures and reconstruction efforts, he did spend a small fortune on building his new 120 acre palace, the *Domus Aurea*. It was perhaps for this reason that his relief efforts were not met with approval

been repaired. This is indeed quite plausible. Also, this expenditure and diversion of resources may have further delayed the repairs of the Claudia.

The fire may have had another effect. Subsequent to the fire massive rebuilding took place in the area where the Colosseum would later be built. Nero began to build his Domus Aurea, or Golden Palace, which consisted of a 120 foot statue of Nero, parks, colonnades and, most significantly, a large lake. The most convenient aqueduct to use to fill and maintain the lakes would have been the Claudia. It is possible that Nero drained the Claudia for this purpose. Sometime between 70 and 72 AD Vespasian began construction of the Flavian Amphitheatre, later known as the Colloseum. It would have been necessary to drain Nero's lakes to build the amphitheatre, at which time the water from the Claudia would no longer be needed. The timing of these two events is suggestive of a link.

A somewhat prosaic explanation may be that, during the construction of the Arcus Neroniani, the Claudia was shut off. This is unlikely, as it would have not been necessary to cut of the supply for more than a week, if it was cut off at not just diverted, which was the common practice.

Finally, there was the political unrest which culminated in 69. Nero toured Greece from 67-68. His imperious showmanship not only caused him to neglect urgent public business, but involved him in riotous expenditure which threw the state finances into grave embarrassment (Cary & Scullard, 1975:359).

Taken in isolation these events suggest little, but in concert may have resulted in delayed repairs for the Claudia.

The remains of the Claudia show repeated efforts at repair from its construction and throughout the second and third centuries (Richardson, 1992:16). It is entirely possible that the Claudia was badly built and suffered from poor workmanship. Despite Vitruvius, many Roman buildings did not exhibit *firmitatis*. Disasters due to poor workmanship were not unknown. Suetonius tells us of the panic in the Theatre of Marcellus shortly after its completion under Augustus, brought on by the crowd's fear of the structural integrity of the building. At the collapse of the amphitheatre at Fidenae, which killed perhaps as many as twenty thousand people, which was considered a grievous calamity, Tiberius returned from his island retreat of Capri (Taylor, 2007:5), an unusual act.

The interruption has also been doubted by a number of authors (Richardson, 1992:16 and Evans, 1983:393). One of the reasons given is that Vespasian claimed to have repaired the Claudia for propaganda reasons.

Later, Pliny the Younger (13.17.3) writes of the Anio flooding, causing extensive damage. Though it is a stretch, earlier floods may have had a detrimental effect on the Claudia (and other aqueducts). In Pliny's words:

> *The Anio... has broken off and carried away most of the glades with which it is shaded. It has undermined the hillside, and in several places it is blocked by massive landslides. In it's search for its lost course, it has battered buildings and forced its way, extricating itself over the fallen masonry... [e]ven areas not reached by the rising river have not escaped the calamity. Instead of riverfloods they have had incessant rain, tornadoes hurtling down from the clouds...*

In all probability, low quality construction, fire and alternate uses for the water explain why the Claudia was out of operation for such a long period of time.

The Arcus Neroiani[39] is one of the most prominent ruins of the aqueducts within Rome and seems to have been in use until the 11th century. It ran for

[39] Referred to as the *Arcus Caelimontani* in later inscriptions

two kilometres, starting from where the Claudian arcade makes its first turn at Porta Maggiore and ending on the Palatine Hill, at a major distribution reservoir above the Colosseum. From here its waters were distributed to the Aventine and Trastevere (across the Tiber) as well as to the Palatine itself, after an extension by Domitian. In addition, it supplied the Domus Aurea, Nero's estate built on urban land cleared by the fire. The Arcus Neroiani was probably built after the fire of 64 AD, which had given Nero the opportunity to rebuild much of Rome. A branch of the Marcia supplied the same areas with good water, but was in such bad repair that Nero seems to have taken the decision simply to replace it. The Arcus Neroiani was built mainly with concrete, as opposed to the heavy stone-block construction of earlier arcades for arches. They can be seen in the etching by Piranesi (see D.29). This proved a poor choice, and both Domitian and Septimius Severus had to renovate it extensively, using brick-faced concrete. Nero and his architects may have been trying to minimise the size of the arcades. This may have been a common practice; when Hadrian restored the Claudia, smaller brick and concrete arches were placed within the older ones. The Severan repairs dimin

The *Arcus Caelimontani* furnishes new insights into Nero's sometimes overlooked accomplishments as an urban planner, while they also prompt us to reassess the true achievement of the Claudian aqueducts. Nero's branch played a significant role in supplying water to residential neighbourhoods. Because of their position and capacity, the *Arcus Caelimontani* may have eliminated the need for introduction of additional aqueducts into the centre of Rome. Despite the steady growth of the city in the late first century and the demands of the Flavian building program, no new aqueducts were added for over sixty years, until the Aqua Traiana was introduced to the Transtiber (Evans, 1983:399). Whether or not this was intentional, or merely good fortune, cannot be established for certain.

Frontinus shows his concern to make most efficient use of water. He states that water should be reserved for human consumption and that water of poorer quality for irrigation or industrial purposes (1.91). Specialized distribution through branches like the Arcus Caelimontani indicates a high degree of sophistication in the Roman water-system (Evans, 1983:399), which was not to be matched until the 19th century.

About twenty years after the original Neronian construction, Dominitian had an extension built from the original terminus at the Temple of Claudius to his new palace on the Palatine. Before this time, the Palatine relied on the Julia for its water. Septimius Severus extended the dimensions of the palace and restored the Palatine aqueduct, perhaps in conjunction with the restoration of the Arcus Neroiani (Aicher, 1995:68).

6.13 Aqua Anio Novus

The Aqua Anio Novus proved to be the zenith of all ancient Roman aqueducts. Both the physical remains and purpose of these two lines can be argued to be the most ambitious and innovative of the Roman aqueducts. Certainly they are the most visually impressive. Like the Aqua Claudia, the Anio Novus was started by Caligula and completed by Claudius. The steady growth of imperial Rome in the early first century increased the demand for water that was not only used for drinking and washing, but also for luxurious and decorative purposes. Frontinus (2.14) indicates that its muddy source was situated near that of the Marcia and Claudia

> *The Anio Novus has its intake at the forty-second milestone on the Via Sublacensis in Simbruibe territory, from the Anio River, which flows muddy and turbid even without the bad effect of rain, since it has cultivated and such lands around it, and as a result, quite loose banks. For this reason a settling tank was installed away from the intake of the conduit, where the water might settle*

and be filtered between the river and aqueduct channel. But even so, it comes to the city turbid whenever there are heavy rains.

Trajan responded to the shortcomings of the source mentioned by Frontinus by moving it upstream to the lake formed when Nero dammed the Anio for his villa.[40] According to Frontinus (1.15), it is supplemented by *the Herculanean Brook, which has its source... opposite the springs of Claudia.* From its source, the channel descended along the river, always on the left bank and generally underground. The aqueduct divided into two channels above Tivoli, one of which followed the traditional hillside course, while the other took a shortcut by turning south and tunnelling deep into the mountain before rejoining the original channel near Gericomo on the slopes above the Campagna. When the Anio Novus surfaced, just after its clearing tank near Capannelle, it travelled on the Claudia's channel into Rome.[41] Its terminus was a large *castellum* on the Esquiline Hill near the temple to Minerva Medici that the Novus shared with the Claudia (see D.27). Frontinus indicates that the *castella* in which the two systems flowed made service possible to the Caelian, Palatine, Aventine and Transtiber. Supplies were first brought to the Palatine through siphons, however, restorations soon allowed for the waters to be carried over an aqueduct bridge. Frontinus alludes to an impressive bridge that permitted distribution to the Aventine. There is, however, no remaining archaeological evidence to confirm the descriptions this. The same is true with the delivery to the Transtiber. Frontinus does not note any arcade in connection with this district, and therefore one must conclude that water travelled here through pipes along the Pons Aemilius. The Anio Novus delivered 190,000 m3 per day. According to an inscription on the Porta Maggiore, the Novus spanned 87 km before Trajan lengthened it to 92 km. It was the highest of the Roman aqueducts.

[40] Very little is known of what must have been a remarkable dam. It is estimated that it was 40 metres high. Little of the remains have been found, perhaps due to the ruggedness of the location. The dam was destroyed in 1305 A.D. by floods (Hodge, 1991:124).

[41] This can be clearly seen in Figure D.28. The construction of the Novus channel has a different look to the older Claudian structure.

The relationship between these the Anio Novus and Claudia parallels that of the Tepula and Julia. The waters of the two aqueducts were mixed and then separated as each channel entered the city. Archaeological evidence supports this connection with the findings of various *castella* and the actual positioning of their respective specus. The two systems did enter Rome separately, and it is worth noting that the Arcus Caelimontani was a crucial branch of the Claudia. This branch line might have been built to supply the Domus Aurea, particularly its extensive waterworks including the *stagnum* located in the valley of the Colosseum, and the nymphaeum on the Caelian. It might have been used to augment the water supply on the Palatine and in the centre of Rome after the fire of AD 64. Because of this maintenance required by these two aqueducts, water administrators and maintenance crew doubled in numbers. Men were employed to patrol the courses of the lines to dismantle the numerous illegal taps.

One interesting, but puzzling, feature of the Anio Novus is the *castellum*, now known as the Grotte Sconce. It is located along the Viottola Pomata on the same side of the road as the Arcinelli bridge, closer to Tivoli by several hundred metres (Aicher, 1995:136). Through the *castellum* would have served as a settling tank, it had another purpose. This was to divert water to the three aqueducts on the slope below it. A diversion channel descends rapidly from the Novus, and about 75 metres from the *castellum* a vertical shaft drops water directly into the Claudian channel. A similar technique was used on the Marcia 15 metres further on, and again for the Vetus at the end of the side channel. For what purpose water was diverted from the Novus can only be guessed. One possible reason is that the diversion would allow the channel after the *castellum* to be worked on without depriving Rome of its water. It would also allow work on the Marcia and Vetus upstream of this point without completely depriving their distribution points of water (The Novus and Claudia used the same *castellum* in Rome, so this would not apply to the Claudia). Another possibility is that after a storm, when the Vetus ran muddy, the Vetus supply was suspended and water from the Novus was diverted instead.

The Novus has another side channel at Fossa della Noce, which may have also served to divert water to the Marcia below. This may have been a simpler but functionally equivalent system to that at Grotte Sconce, suggesting that this system of water diversion was perhaps fairly common. The reason was probably to divert water while repairs and maintenance was undertaken.

Frontinus' data on the Anio Novus and Claudia point to the differences between them and previous aqueducts. Instead of having a specialised purpose, these systems provided water for a wide variety of uses. Approximately one-fourth of its capacity furnished imperial buildings and property (the palace complex on the Palatine took most of this), roughly 45% of its total volume supplied privati. Less than one-third served usibus publici. The Claudia and the Anio Novus almost doubled the existing total water supply in Rome. The introduction of the two systems took a great deal of time, money and administrative re-engineering, but the result was the increase in water supply for every aspect of its usage.

6.14 Aqua Traiana

As suggested by its name, Trajan built the Traiana. Before its construction, the Trastevere region depended on aqueducts across the river (Aicher, 1995:44). The literature and study of the Aqua Traiana is somewhat limited because it was established after Frontinus. Inscription *CIL* 6.1260 (See Chapter 3.5), however, does indicate that it was established in AD 109. Further evidence commemorating its establishment is found on a sestertius coin dating from the Trajan's fifth consulship and by a lead *fistulae* found on the Esquiline near the baths of Trajan bearing the markings *"THERM(ae) TRAIAN(i)"* and *"AQ(ua) TR(aiani)"* (Evans, 1997:131). It is also mentioned in the *Liber Pontificalis* in the life of Felix II (AD 355-8) and in an inscription which records repairs to it by Belisarius (Ashby, 1935:299). This inscription seems to have been lost since the seventeenth century.

Its source was taken from the high-quality springs located near Trevignano, northeast of Lake Bracciano. Its course generally ran south following the high lands of its region. One section of its conduit was discovered in 1912 underneath the American Academy and is still accessible today. Another discovery was made in 1990 and 1991 in the Via Giacomo Medici. Remains of a mill powered by the aqueduct were found at this location. Other evidence suggests that a terminal *castellum* of the Traiana resided under the present day casino of the Villa Spada. The Traiana's estimated length was 35 to 60 km. A more accurate figure is difficult due to the lack of written sources and material remains.

The height of the aqueduct and its point of entry made it possible for the Traiana to distribute water to all fourteen districts in Rome. The point of entry, above the Transtiber, indicates that its primary role was to service the needs of that district. This area had grown rapidly during the first century and required more water to satisfy the district's needs. The Appia and the Alsietina would have been too low to have fulfilled this requirement.

The necessity of supplying his Baths with water seems to have been met by Trajan with the introduction of the Aqua Traiana. Epigraphical evidence suggests that a certain amount was distributed throughout the city and either supplied the new Baths directly or freed water from other aqueduct lines for that purpose (Anderson, 1985:508).

Recent excavations on the Janiculum have lead to speculations about the use of water mills on the Aqua Traiani. An excavated complex in the region shows that location of water mills, using undershot wheels at the point where the Traiana's gradient starts to increase but before it becomes steep enough to use overshot wheels, looks like an attempt to squeeze in the maximum number of mills possible in this area. The course of the Traiani and Alsietina follow the peculiar configuration of the Janiculum salient traced by the Aurelian Walls at this location (Wilson, 2002:13). Interestingly, Procopius tells us that the line of the Aurelian Walls on the Janiculum was intended to protect the water-mills there.

The Traiani was the last great aqueduct built in Rome. Frontinus' (87.2, 88.1 and 89) praise of Trajan seems well justified when considering Trajan's foresight in building the first aqueduct on the western side of the Tiber, and using it to supply the Eastern side. This was opposite of the usual practice (Evans, 1997:132).

6.15 Aqua Alexandrina

Like the Traiani, the Alexandrina was built after Frontinus, so there is little but the material remains as evidence. The Alexandrina was built, circa 226 AD, primarily to serve the baths built by Alexander Severus (AD 208 - 235) in that same year. Severus' baths, located between the Pantheon and the Piazza Navona, replaced the earlier baths of Nero, located between the Pantheon and today's Piazza Navona. Alexandrina ran a course approximately 22 kilometres long and entered Rome at ground level near the Spes Vetus.

The Alexandrina's source was the marshy basin of the Pantano springs, one mile south of Via Prenestina's 14th mile, at the foot of the hill of Sassobello. Instead of making for the ridge to the south that the other aqueducts followed to Rome, the Alexandrina headed due west, almost paralleling the Via Prenestina. Brick arcades carried the aqueduct across a series of valleys, cut by the tributaries of the Anio. At some undiscovered point it turned north towards Porta Maggiore, where it entered Rome at ground level. No remains have been found between Porta Maggiore and its terminus in the Campus Martius at the Severan baths. Despite the impressive arches, the Alexandrina was one of the lower aqueducts, approximately level with the

Anio Vetus at Porta Maggiore. No remains have been found in Rome between Porta Maggiore and the terminus in the Campus Martius.

This constitutes the extent of knowledge regarding its course and distribution. This aqueduct was established for the sole purpose of Severus' remodelling of the Thermae Neronianae in the Campus Martius. If it did have further applications its elevation would have been greater so that it could service a wider range of areas

6.16 Water distribution

We can easily see that the combined Claudia/Anio Novus aqueduct distributed water through all fourteen regions. However, by referring to Table C.5 we can see that the earlier lines were also important. The Appia's low volume and elevation prevented its widespread distribution. The Marcia was distributed more widely than the Anio Vetus. The Virgo brought enormous volumes, but only to three regions. The Tepula and Julia, reworked by Agrippa, was quite widely distributed, having 31 *castella* between them (Evans, 1997:139).

Looking at Table C.7, we can see that the aqueducts catered for all fourteen regions in Rome. It does not appear as if any master plan was followed to achieve this, but rather a policy of building a new aqueduct when necessary, and distributing water where needed. While this is a flexible approach, it requires strong central authority and considerable financial outlay to achieve.

6.17 The later history of the aqueducts

At the time of the sack of Rome in 410 AD the eleven aqueducts were feeding 1212 public fountains, 11 imperial *thermae* and 926 public baths (Morton, 1966:31). All trace of this achievement vanished during the bar-

barian invasions. Under Vitiges, the Goths cut the aqueducts in 537 AD. They probably were well acquainted with the utilities of the Romans by this time, as they had ruled much of Italy for the previous half century. By then, the Romans were a shadow of their former selves, and Vitiges actions diminished them further, forcing them to again take their water from wells and the Tiber. When Constantine moved the capital to Constantinople he took with him a host of patricians, artisans and professional men, to the detriment of Rome. The next two centuries became a cycle of neglect and decline, and depredations by Goths, Vandals and waves of Roman refugees. Morton (1966:56) estimates that perhaps 100 fountains were still working when Vitiges cut the water supply. Belisarius had taken Naples by sending men through an empty aqueduct. To prevent this happening again, he blocked many of Rome's channels with masonry. Nonetheless, an attempt was made. Procopius tells that a sentry saw the gleam of eyes and flicker of a torch in an aqueduct channel near the Pincian Gate. The Goths were prevented from further progress by one of the masonry walls. Belisarius sent a patrol into the aqueduct and discovered evidence that the Goths were scouting for an entrance into Rome. He kept the channel under close guard after this incident (Procopius, 6.9.1). The fact that the aqueduct could so easily be navigated suggests that little to no water flowed through it, perhaps as a result of Vitiges actions or neglect. Belisarius had taken Naples by sending men through an empty aqueduct.

One of the most notable of the Goths camps during their siege of Rome was located in the area south of Tor Fiscale in the area still known as Campo Barbarico. In his history of the Gothic wars, Procopius (7.3.3-7) describes the camp and the reason for its location among the aqueducts:

> *Now there are two aqueducts between the Latin and Appian Ways, exceedingly high and carried on arches for a great distance. These two aqueducts meet at a place 50 stades distant from Rome and cross each other, so that for a little space they reverse their rela-*

tive position. For the one which previously lay to the right from then on continues on the left side. And again coming together they resume their former places, and thereafter remain apart. Consequently the space between them, enclosed, as it is, by the aqueducts, comes to be a fortress. And the Barbarians walled up the lower arches here, with stones and mud and in this way gave it the form of a fort, and encamping there to the number of no fewer than seven thousand men, they kept guard that no provisions should thereafter be brought into the city by the enemy.

The two aqueducts Procopius refers to are the Claudia and Marcia arcades that are found in that area. He is mistaken in his measurement of 50 stades, the truth is closer to 30, which is about 6 kilometres from Rome. The Goths remained in the camp for a little over a year, between February 537 and March 538, until pestilence forced them to abandon the siege.

One consequence of Vitages cutting the aqueducts was to put the corn mills out of action. In response Belisarius mounted mills on rafts and moored them in the Tiber, and used the current to turn them. Vitages left without doing much more damage, but nine years later the Goth Totila captured Rome and evacuated the city. Rome may have been totally abandoned for forty days (Morton, 1966:57). After imperial victory, Belisarius repaired the aqueducts. Many of them continued to function until at least the 10th century. Only the Virgo continued to supply water into the middle ages. By the 14th century Rome and been reduced to 25000 inhabitants. It would not be until the 16th century when a prosperous Rome would build a new aqueduct (Aicher, 1995:6).

At the end of the 6th century Pope Gregory the Great refers to a *comes formarum*, indicating that the office of the *curator*, though now called a *comes*, still existed, as did the aqueducts, as often called in the middle ages *formae*. By this time the city was poor, and little arrived in the way of patronage from Constantinople. The church took up the case of the aqueducts, unlike most of the other building and monuments, and the Popes continued to renovate them until the middle ages (Aicher, 1995:29).

Pope Hadrian I carried out several restorations in the late 8th century. His restoration of the Traiana supplied the Trastevere region again, with its watermills on the Janiculum Hill.[42] St. Peter's Basilica also received this water, which played an important role in the religious life of the region. Hadrian also restored the Claudia. Nero's branch of the Claudia ran adjacent to the other major centre of the Church in Rome, St. John of the Lateran. Besides ensuring supply to these religious centres, Hadrian also renovated the Virgo and Marcia (Aicher, 1995:29).

References to working aqueducts dwindle in the following centuries. While we have no dates to indicate when any of them ceased to function, we can be reasonably sure that by the end of the 10th century the people of Rome were again getting their water from wells and streams. The Traiana was repaired as late as the 9th century, but nothing more is heard of it until Pope Paul V incorporated parts of it into a new aqueduct in the 17th century. Both the Claudia and Anio Novus were out of commission by the 12th century, when an open-air ditch named the *Marrana Mariana* was built to supply the Lateran region (Aicher, 1995:29).

Like most of Rome's physical ruin, the process of losing water and sanitation was gradual. The agencies of destruction were invasion, erosion, earthquake and sedimentation, and the people lacked the will and resources for maintenance. Only the Virgo continued to function into the Middle Ages, however at a much reduced capacity (Aicher 1995:29).

[42] The Janiculum is not one of the so-called seven hills. It lay to the west of the Tiber, outside the traditional city walls.

It is a tragedy to see how so great a system, created and extended in days of law, order and prosperity collapsed under the pressures of anarchy and invasion. In such a spectacle, there are many lessons to be learned.

6.18 Rome's minor and missing aqueducts

The Curiosum, Notitia and Silvius all list a number of aqueducts that are either unknown or not known for certain. See Table C.3 for a complete list of aqueducts listed in these sources.

The aqueducts in doubt are: Annia, Atica, Attica, Anena, Herculea, Heracliana, Caerulea, Augustea, Ciminia, Aurelia, Damnata, Severiana, Antoniniani and Dorraciana. These may be aqueducts that are unknown to us today, but it is far more likely that they are misnamed or renamed known aqueducts or branches of known aqueducts. The following section will discuss each of the above, as well as some other possibilities from other sources.

To this list can be added the Annesis

6.18.1 Annia

As both the Anio Vetus and Novus are not mentioned in the list, it is likely that this is corruption for one or both of them. The fact that there is no other listing of an Annia adds weight to this hypothesis (Platner & Ashby, 1965:21). Richardson (1992:15) agrees with this interpretation. The Annia may very well be Polemius Silvius' (545) *Anena*. The similarity of *Annia* to *Anio* adds weight to this belief.

6.18.2 Atica and Attica

According to Platner & Ashby (1965:21), this is also likely to be a corruption of Anio Vetus or Novus. This requires a greater stretch of the imagination. Richardson (1992:16) states that Atica or Attica is probably a corruption of the word "Antiqua". This might then refer to an older aqueduct.

6.18.3 Antoniniani

This may refer to the fons Antoninianus, which was added to the Marcia's supply by Caracalla, according to Platner & Ashby (1965:25). According to Richardson (1992:18), this probably occurred outside the city , perhaps at the third milestone of the Via Latina. This new branch, the Antoniniani, would have supplied the Baths of Caracalla[43].

6.18.4 Augustea or Augusta

Platner & Ashby (1965:22) state that this may refer to the Aqua Alsietina, or possibly (at a stretch) the fons Augustae of the Aqua Marcia. Richardson (1992:16) states that it is an alternative name for the Alsietina, and also the name of a supplement of the Appia that joined it at Gemellos. This is in agreement with Frontinus (1.1), who states clearly: *Alsietina, which is also called Augusta.* However, Frontinus also states of the Appia (1.5): *Near Spes Vetus... there joins it a branch of Augusta, added by Augustus, as a supplementary supply.* Ashby (1935:50) concurs with this.

Frontinus mentions two other possibilities for Augustea or Augusta. The first (1.11), is the Alsietina, which is no doubt where Richardson drew his conclusion from. In I.12 Frontinus states that Augustus added a feeder to the Marcia, which was called Augusta after its donor. Occasionally, when the Marcia could not carry the volume of water from the Augusta, it would be diverted to the Claudia.

It is not clear which of these is the one referred to by the Curiosum, Notitia and Silvius. The Augusta mentioned in 1.12 seems to be a minor branch; but one is tempted to to come to the conclusion that it is the aqueduct in question, especially considering it fed two aqueducts. However, a larger aqueduct is more probable.

[43] So great was the water supply to the Baths of Caracalla that a water-mill was installed in the basement (Hodge, 2002:270).

6.18.5 Aurelia

Platner & Ashby (1965:22) offer no explanation for this aqueduct, but, like the Ciminia, believe that it might actually refer to a road. Richardson (1992:16) is of the opinion that it might refer to a spring near the summit of the Janiculum north of the Via Aurelia. However, he goes on to make an excellent point. He states that as all the identifiable items in the Curiosum, Notitia and Silvius Polemius, it is more likely that the Aurelia is an alternate name for one of the more familiar aqueducts. This logic applies equally to the other unidentified items in the lists.

6.18.6 Caerulea

Platner & Ashby (1965:22) identify this with the Aqua Claudia. This possibly after the fact that one of the springs that fed the Claudia was the Caeruleus. It is also possible that Caerulea is an alternate name for the Claudia, or perhaps a part of it, after the Neronian Arcus Caelimontani, but this is admittedly a stretch.

6.18.7 Cernens

The *Cernens* is only mentioned in the Notitia. Platner & Ashby (1965:22) offer no explanation. Richardson (1992:16) speculates that it might refer to a fountain on Vicus Tuscus or the lower slopes of the Palatine, and not an actual aqueduct. Translating the name *Cernens* provides a tempting clue, a suggestion that it might be a branch and not a separate aqueduct.

6.18.8 Ciminia

Platner & Ashby (1965:22) offer no explanation for this aqueduct, but believe that it might actually refer to a road. Richardson (1992:16) believes identification to be unlikely.

6.18.9 Conclusa

The Conlcusa is mentioned only in one inscription, recorded in *CIL* as 6.33087 (see Chapter 3.5). It places the aqueduct on the Esquiline, but is probably the name of one of another aqueduct's tanks (Platner & Ashby, 1965:23). Richardson (1992:17) speculates that it might refer to a covered *piscina* or the *castellum* of the Claudia and Anio Novus. The word *Conclusa* certainly seems to indicate this.

6.18.10 Damnata

Platner & Ashby (1965:23) offer only speculation about this aqueduct. They speculate it may be the same as Polemius Silvius' (545) Aqua Dotraciana or Dorraciana. Jordan (1907) suggests it might be a corruption of Diocletiana. While this may be true, it does little to clear the matter up. Richardson (1992:17) believes it may be a nickname for the Alsietina. Fabretti (Evans, 2002:186) states that the Damnata is the name that was given to the Crabra after its waters become too foul for drinking purposes. Originally, Agrippa had not used this water to supply the Julia, but later corrupt water-men had. Frontinus restored the Crabra "at the emperor's command" and restored its waters to the Tusculan proprietors. Frontinus (1.9) is quite clear that the Crabra is a brook; Frabretti's reasoning is unclear on this matter and we defer to Frontinus.

6.18.11 Dorraciana

It has been speculated that this is the Damnata by Platner & Ashby (1965:23). However, there is little solid evidence for this speculation. There is even less evidence to lead to any substantial speculation as to the actual nature of the Dorraciana.

6.18.12 Drusia

The Drusia is mentioned only by Polemius Silvius(546). Richardson (1992:17) speculates that it may be the Anio Vetus, which may have passed over the Arcus Drusi.

6.18.13 Herculea or Heracliana

According to Platner & Ashby (1965:23), this is not an aqueduct, but rather the *rivus Herculaneus* of the Aqua Marcia. The Anio Novus also has a branch with the same name (Frontinus, 1.15),[44] and Pliny (31.31) connects the rivus with the Aqua Virgo. For both these latter cases Platner & Ashby are difficult to reconcile with the evidence.

6.18.14 Mercurii

Ovid (*Fasti*, 5.673) is the only one to mention this aqueduct and he only mentions it once. He places it near the Porta Capena. The only mention is:

> *est aqua Mercurii portae vicina Capenae;*
> *si iuvat expertis credere, numen habet.*
> *huc venit incinctus tunica mercator et urna*
> *purus suffita, quam ferat, haurit aquam.*

Richardson (1992:18) states that it is unlikely that there was ever a separate spring dedicated to Mercury, so it is unlikely to have been an aqueduct. The Mercurii is probably an invention of Ovid for fictional purposes.

6.18.15 Pinciana

The Pinciana is known only from a single inscription on a waterpipe (*CIL* 15.7259) near the porta Salaria (See chapter 3.5). Platner & Ashby (1965:27) speculate that it might have carried water to the Domus Pinciana. Thus it was perhaps not an aqueduct but merely a pipe. Richardson (1992:18) is

[44] Frontinus calls it a brook.

puzzled, because it is logical to expect that the Domus Pinciani would be supplied by the Virgo, but the location of this pipe would make it unlikely. Perhaps then the Pinciani was a supplement, built for reasons now unknown.

6.18.16 Severiana

The Severiana is mentioned only in the *Not. app.* and Polemius Silvius. Platner & Ashby (1965:27) offer no further ideas as to the nature of this aqueduct. Nor does Richardson (1992:18).

6.19 The *aqua* that never was

According to Livy (40.51.1), in 179 BC censors M. Fulvius Nobilior and M. Aemilius Lepidus enjoyed the allocation of an entire years *vectigal*[45]. This money was to be used for public building contracts. This included aqueduct repair and the creation of a new aqueduct. The construction of the new aqueduct was blocked by M. Licinius Crassus, who would not give right of way for the construction over his land (Anderson, 1997:83). See chapter 3.4 for a discussion of the numismatic evidence, which sheds some light on the matter.

However, some believe that the aqueduct may actually have been built, at least partially, and that the Marcia was built from this pre-existing but incomplete aqueduct. As the Marcia was the longest of the aqueducts by a fair margin, there may be some truth to this belief. However, the evidence is lacking, and most scholars, notably M.G. Morgan reject the notion that construction began on this earlier aqueduct.

6.20 Conclusion

We cannot conclude that 11 is a reliable number for the number of Roman aqueducts. The Tepula and Julia were really a single aqueduct, having

[45]Tax revenue.

joined outside the city before using the same structure as the Anio Novus, Claudia, Marcia and Anio Vetus to enter the city, while the Marcia supplemented them but maintained its identity as a separate aqueduct. The Anio Novus and Claudia also joined, but only within the city, thus we can reasonably conclude that they are in fact separate aqueducts. There is little evidence that the Crabra, or Damnata, was anything more than a brook that was used by the water-men to cover their theft of water from the Julia by supplementing it. The Augusta seems to merit the distinction of being labelled a separate aqueduct, excepting for the fact that it itself does not terminate in Rome, but in the Marcia or occasionally the Claudia.

Thus, if the Augusta is included as an aqueduct, there are 11 major aqueducts, if not, then 10 is the likely number. However, in a sense there is only an aqueduct system, with the parts having names, and these names are the names of the aqueducts.

Chapter 7

RESEARCH PROBLEMS

7.1 Introduction

The problems of researching the Roman aqueducts in general, and particularly from South Africa, can be summarised as follows:

- Access to literature
- Access to the material remains
- The complexity of the undertaking

Naturally, these problems are not unique to the study of the aqueducts, but can be found in any similar undertaking when the researcher is working in isolation and far away from the subject of the research. Rather than not undertaking such a study, strategies must be developed to cope with the difficulties.

7.2 Access to literature

While much has been written on the subject of the aqueducts, much of it is not readily accessible due to being out of print, high cost or general unavailability of the material. Specialist literature is by its nature expensive, has limited print-runs and usually only available in European and American libraries. In South Africa, the problem of high cost is compounded by the relative weakness of the currency as compared to American or European currencies.

As in any niche area with a small publication run, books on the subject of the aqueducts are expensive. This places them out of the reach of the majority of students. The high cost also prevents libraries from buying copies, as the topic is not considered essential by most universities and industries, especially in South Africa. The result is that most local libraries have very small ancient history collections, and that mainly of populist books.

Some of the books and maps have been out of print for many years, and are thus also difficult to get hold of. Some may be available through a library, but are more likely to be found in American or European libraries than South African libraries. Often these books and maps are not available for inter library loan, due to their rarity. Often, they are available for viewing only; while it is not impossible to view these books, it is an added expense and there is little time to spend with the book or map.

Much of the literature on aqueducts is written in English, but a significant percentage is written in Italian, French and especially German. These texts are typically not available in South Africa. When they can be obtained, skill in one or more of these languages are required, or translation. In the case of the aqueducts, the country with the most vigorous research is currently Germany.

Lastly, much that was written in ancient Rome is no longer extant, having been lost due to the ravages of time. Much of what was written mentions the subject of study only in passing. Of course, this is not only a problem for lone researchers, but is a general problem in historical research.

Some material is available on the World Wide Web (WWW). However, much of this is derived from the books, and much that is original is of dubious quality, repetitive or basic and incomplete. Often, historical criticism and analysis requires many thousands of words to build a coherent argument; such lengthy material is ill-suited to the WWW. The higher quality books are generally not available online. A problem that arises especially for novice researchers is that on the Internet it is not always a simple matter to judge the value and accuracy of material. Entirely plausible but incorrect arguments are placed on an equal footing with valid arguments; only a knowledge of the subject domain can help differentiate the two.

7.3 Access to the material remains

It a study of the aqueducts, or indeed any of the buildings of any ancient city, nothing can replace actually viewing and examining the remains first-hand. However, there are three factors that make this difficult to impossible.

Firstly, the expense is prohibitive. It would involve travel to Rome, local transportation in Rome, provisions and accommodation for what may be many months to perhaps years of work. Additionally, specialised equipment is needed, such as cameras and surveying equipment.

Secondly, it would take many months to study the remains, perhaps years. Unless the researcher is in possession of a large grant and not of a family, this is a rare luxury few can afford.

A third factor is that not all of the remains are accessible. This may be for several reasons, including the destruction of major sections, the mystery of the location of much of the remains and access problems due to the remains being buried underground or built on top of. Another major problem is that much of the remains will be on private property. Not all property owners are willing to allow access to their property for the purposes of historical research.

These factors restrict research to literature reviews and the examination of epigraphic and numismatic in the literature. For viewing the aqueducts, photographs and models are used.

7.4 Complexity of the undertaking

Studying the aqueducts requires an interdisciplinary approach. The skills of historian, archaeologist, statistician/mathematician, geologist, hydraulic engineer, civil engineer, town planner, architect and surveyor are all required to some degree. This range of skills is not usually found in a single individual; nor is it a trivial matter to build a team with these skills.

When undertaking research of this nature, a broad range of literature is consulted. The danger here is that the knowledge gained, while broad, lacks depth. Thus, when commenting on some technical detail or historical fact, only a very superficial commentary can be made. Many of the subtleties that come with a deeper knowledge of a subject are missed, and this can lead to error, misunderstandings or too narrow a focus. This is especially true when the student of history, and not yet an expert in that area, attempts to write about engineering. The deficiencies in historical scholarship are compounded by the deficiencies in engineering understanding, and the final work is poorer for it.

7.5 Isolation

Studying in isolation, without the sustaining conversation of like-minded people, is a problem that leads to doubt, demoralization and questions on the worth of the undertaking.

When researching a question that is, by the standards of the general public, quite obscure, the researcher misses the benefit of discussion and debate.

The benefits of immediate criticism and the sharing of ideas and new discoveries is often overlooked, but cannot be underestimated. A few minutes discussion with a like-minded colleague can not only solve a problem, but open entirely new areas for thought and research. While isolation is mitigated by the Internet to some degree, email and discussion[1] boards are not substitutes for discussion. Regular discussion on a particular subject reveals more to and inspires the researcher, especially about the current status of the discipline, than a roomful of books and journals.

The result of this is that the isolated researcher has no checks and balances in place to ensure that their work is on the right path and valid academic work. This can be demoralising; the demoralised researcher tends to procrastinate and produce lower quality work; a vicious spiral. Low quality and productivity result.

Technology solves the problems of isolation to some degree. For example, email discussion lists can be used as a substitute for group discussion. However, the signal to noise ratio on these lists tends to be low. Furthermore, it takes more effort to read messages than to listen, with the result that some messages are inevitable skipped; perhaps the wheat is lost in the considerable chaff. Online discussion forums, email and multimedia resources are all necessary and extremely useful, but are restricted by Internet connection capacities, search tool accuracy and understanding of the technology. Of course this is not written in stone, but the argument can be made that the majority of academics produce their best work when not working in isolation. Discussion, positive criticism and daily guidance are essential for sustained academic success.

[1] Email and discussion boards are important *additions* to academic discussion.

7.6 Conclusion

Historical research in isolation and at a distance is subject to many obstacles. These obstacles can be overcome, but at a cost. The most obvious cost is the increased time needed to complete the research. The lack of access to archaeological and primary sources is a barrier to fresh interpretation of evidence. The researcher must base his or her conclusions on the evidence and conclusions of previous researchers in the field. The lack of access to secondary sources in the study of aqueducts potentially leads to re-inventing the wheel, and reaching incorrect conclusions based on partial evidence.

However, these obstacles should not prevent the researcher from undertaking the research. Indeed, if they did, the majority of research would not be undertaken, for these problems are common ones. The intelligent use of modern communication technology plays a mitigating role and helps connect the lone scholar with his or her peers. More importantly, diligence, discipline and perseverance are traits to be cultivated, which will lead to success.

Chapter 8

CONCLUSION

8.1 Introduction

In chapter one the objectives of this study was outlined as follows:

- To discuss the technical aspects of Roman aqueduct construction. This has been covered in chapters 4, 5 and 6.
- To research the so-called minor Roman aqueducts (see Chapter 6)
- To research the problem of the partial, but premature, collapse of the Aqua Claudia (see Chapter 6.12)
- To discover the prevailing political climate during the time each aqueduct was constructed. This is an aspect that requires more research.
- To reflect on the aqueducts as indicators of the health of the Roman republic and empire, the argument being that the health of the aqueduct system was a reflection of the health of the Roman state
- To reflect on the role of the aqueduct system in the decline of the Empire. This is answered in Section 8.2.
- To reflect on the research process itself (see Chapter 7)

- To produce a list of important Roman aqueduct related inscriptions, with *CIL* numbers when available (see Chapter 3)

These objectives have been, on the whole, accomplished. The research has shown that it is difficult to count many of the aqueducts as separate entities, but rather they must be seen as part of a system. The traditional names then become the names, not of whole aqueducts, but of parts of the system.[1] Roman construction technique and project management (as it is called today) was of extremely high standard, and recognised the need for high-quality construction using minimally skilled workmen; thus skills that were easy to teach and tasks that were easy to accomplish were the order of the day. The timing of the construction was as much driven by the construction of the baths, and politics, as by any demand for potable water. While the Romans did not seem to see political stability as a prerequisite for undertaking such large building projects, many of the aqueducts were built after successful wars, when the coffers were full of war-booty. Insofar as can be judged, the aqueducts make a coarse instrument for judging the health of the Empire, having declined in step with it, and thus can be seen rather as a symptom of the overall problems than a cause. However, this gives rise to the question of how the aqueducts might have contributed to the decline of the Empire.

8.2 Role in the decline of the empire

As marvellous as the aqueducts were, there were serious problems in their construction, and serious deficiencies in the design of the overall system. This should not come as a surprise; the aqueducts were built and modified as necessity called for and resources allowed, and not according to some overall plan. Also, the Romans lacked the tools for improving their water-system; these would only arise in the 19th century, when the western world rediscovered much that was lost. These problems with the aqueducts may

[1] This is certainly true by the time the Julia was constructed.

have almost paradoxically turned one of the great engineering marvels into one of Rome's major problems.

There is a theory that maintains that the Roman Empire fell due to lead poisoning from the pipes. Hodge quickly dismisses this, stating that the insides of the lead pipes rapidly acquired an encrusted calcium carbonate coating that separated the lead from the water.[2] The water was in any case in constant flow, and was never in contact for long enough periods to take any harm from it (Hodge, 2002:3). Besides, the city of Rome still used wells and springs for some percentage of its water, and many important Romans and military men spent long periods of time outside of the city. If lead poisoning was a factor in the downfall of Rome, it did not come from the lead aqueduct pipes, and some other source must be found.

Of the nine aqueducts in Frontinus's time, the Alsietina was not fit for human consumption and the Anio Vetus was used mainly for other purposes. That left seven aqueducts to cater for Roman thirst for drinking water and bathing.[3] Of the eleven total aqueducts in Rome, five were dependent on just two sets of arches, those of the Aqua Marcia and Aqua Claudia. Both of these had been designed to carry only one channel, but now the Marcia carried three and the Claudia two. This additional stress resulted in more frequent repairs, and hence cost, than would have been needed if they had not been so burdened.

These two substructures carried approximately 64% of the water supply into Rome [4]. Thus, in a sense, Rome had only three major aqueducts; the Virgo, Claudia and Marcia, with the Virgo contributing almost 10% of the

[2] The water delivered to Rome was quite hard, that is to say, had high levels of dissolved minerals. Hodge is no doubt correct in his analysis.

[3] Or perhaps only 6, as the Tepula cannot be counted as a separate aqueduct by this time. Of course, it is the volume of water that matters, and not the number of water channels.

[4] Using Hodge's figures as a guide.

supply. Almost 75% of Rome's water depended on only three aqueducts. Trajan's decision to build the Traiana, which contributed 10% of the total water supply and reduced the total of the Virgo, Claudia and Marcia to only 64% of the total supply, was a good one. The improvement was quite significant. The addition of the Alexandrina, which contributed less than 2%, would not have contributed significantly.

As Rome increased it water's supply, the people would have become acclimatised to the abundance of water, especially during the summer drought, when cooling drinks and refreshing baths would have been in high demand. Indeed, the proliferation of baths would have demanded an abundance. It would have been necessary for the Roman government to maintain the aqueducts, which would have been a huge expense. With the change of method of financing the construction and maintenance of the aqueducts, the money would come mostly from taxing the relatively inefficient output of the citizens and industry. Thus, in the later Empire, the aqueducts may have contributed an unsustainable drain on the imperial coffers.

Irrigation must have consumed vast quantities of water, but we have no records with which to make any reasonable estimate as to how much water was used for that purpose. Indeed, the dearth of references to irrigation is a problem. It is possible that the Romans did not actually irrigate their lands effectively, but relied on nature to water their crops. Pliny (*Nat. Hist.* 19.60):

> *There is no doubt that the gardens should adjoin the farmhouse, and above all they should be kept irrigated by a passing stream, if there happens to be one. But if not, they should be irrigated from a well by means of a pulley or force pumps or the bailing action of a shaduf.*

In the following extract, Pliny seems surprised by the actions of the people of Sulmo (*Nat. Hist.* 17.250):

In the Italian territory of Sulmo, in the Fabian district, they irrigate even the ploughed land.

However, Frontinus does say that aqueduct water is used to irrigate gardens (2.92):

It was decided then to keep all the aqueducts separate, and besides that each of them be regulated in such a way that first of all the Marcia might serve only for drinking, and that the rest, each according to its own particular quality, should be allotted suitable applications, so that the Anio Vetus, for many reasons, might be applied to the irrigation of gardens and for the more base tasks of the city proper.

A field of one hectare[5] would require approximately $20,000m^3$ of water (Hodge, 2002:247)[6]. Thus 10 hectares of land could consume the entire supply of even the Anio Vetus. Allowing for wells, rain, water from rivers, the supply was probably barely adequate for Roman agricultural needs and may have throttled agricultural expansion. The Roman method of tillage was not efficient, and did not produce the best crops, but did leave the surface soil in a rough condition which retarded evaporation in the summer sun (Cary & Haarhoff, 1968:108). A better water supply might have improved crop yield.

It would indeed be puzzling if the Romans used water to irrigate gardens but not farmland. More research in this area is needed.

Tardieu (1986) argues that, as the Roman aqueducts aged, they would have cost more money to maintain. While some emperors may have been tempted to neglect them, especially in the later empire, to do so would

[5]That is, $10,000m^2$, 0r 2.47 acres.

[6]Hodge does not specify over what period of time this quantity of water would be required.

have been a bad idea. The aqueducts had become so much a part of the fabric of Roman life, that to diminish the supply of water (and thus the availability of potable water, water for ablutions, but most importantly, water for the baths) might have caused civil unrest and cost even more money (and possibly political careers). Thus, once created, the Roman water system had to be maintained, no matter what the cost, as the alternative was even worse.

Wilson (2002:30) argues that the Roman Empire saw considerable growth due to technological innovation. He states that agriculture remained fundamental to the Roman economy, but the Roman Empire saw both aggregate and per capita economic growth, due to significant technological progress, both in agricultural technology to sustain a greater number of non-agricultural workers and in non-agricultural technologies, such as mining. He argues that the economic boom of the first and second centuries AD is partly attributable to the boost to state finances given by the use of advanced mining technologies, on top of a very healthy agrarian base which grew in the provinces under the stimulus of the opening up of new markets as vast swathes of territory came under Roman control. If Wilson is correct, then a partial re-examination of the aqueducts place in Roman political and fiscal life must be made. This will require further research.

8.3 Marcus Agrippa: unsung water-man

The Roman water system in the early empire can be said to be the product of one man: Marcus Agrippa. Though he constructed only three of the six aqueducts existing at that time, he so improved and extended the others that his contributions may have outweighed the original construction. A careful reading of Frontinus suggests that he believed that Rome had Agrippa to thank for the good state of the aqueducts. We find ample mention of Agrippa's building activities in the ancient sources, for example in Strabo (5.3.8 and 13.1.19), Pliny (*Nat. His.*, 36.102, 104-108 and 121)and Dio (49.43, 53.27, 54.29, 55.8 and 56.24).

Agrippa's life until his friendship with Octavius is obscure (Reinhold, 1965:1). We know nothing of his parents and his early days. Agrippa was likely slightly older than Octavius. It is surprising that Agrippa, belonging to one of the most humble gens, the Vipsania, was educated with Octavius and became his closest friend by the age of 17. Wright (1937:9) hazards a controversial guess, that Agrippa's father was in reality Julius Caesar. As evidence, he points out that Caesar led a loose life, and that if Caesar was indeed the father, this would explain why Agrippa received an education usually reserved for rich men's sons. It would also explain why Caesar had Agrippa as well as Octavius accompany him on his Spanish expedition, and why both men were send to study at Apollonia together. It is also interesting to note that Agrippa usually dropped his middle name, and Herod named his grandson after him, calling his grandson Marcus Julius Agrippa. Certainly Marcus Agrippa had Caesars drive and energy.

Agrippa's extraordinary range of accomplishments and his evident competence indicates that perhaps Octavius would not himself been so accomplished were it not for Agrippa[7]. It was perhaps Agrippa, and not Augustus, who "found Rome brick and left it marble" - Agrippa seemed to have been a self-effacing man, and besides, it was normal practice for an emperor to take credit.. Among his many accomplishments are the reconditioning of the sewers, building public bathes in the *Campus Martius*, building the Pantheon and setting up the naval base *Portus Julius* at Cumae. It is perhaps suggestive of the respect in which he was held, that Hadrian had the Pantheon inscription bearing Agrippa's name installed when he rebuilt it. He also established a permanent Roman navy and put an end to the Mediterranean pirate bands, commanded the fleet at Actium and fought in nearly every major battle of his time. Agrippa was also responsible for the construction of two aqueducts, an accomplishment matched by no other individual, and apparently at his own expense.[8] Though his involvement with the aqueducts

[7] Reinhold (1965) agrees on this point.

[8] See Dio Cassius (49.43.1).

is well documented, further research is still needed to assess quantitatively as well as qualitatively exactly what his contribution was, not only in Rome, but wherever he contributed to the water supply. Certainly there is evidence that he was an innovator as well as an administrator. Frontinus (1.25) notes that it was a common belief that it was Agrippa who introduced the *quinaria*.

In a sense, the Empire's aqueduct system was an extension of Agrippa's ideas. The later aqueducts offered some innovation in construction, but the system within the city remained very much the same as it was in Agrippa's day. This is not to say that branches were not added, or water was not delivered to dry areas and baths; on the contrary, the system expanded beyond control. However, the methods of storage, delivery and measurement were those known before Agrippa or introduced by him. We find much evidence of Agrippa's building activities.[9] However, his water planning deserves more recognition. He built the foundation for imperial administration of Rome's aqueduct system, which was never entirely superseded. The city's needs for water increased with steady growth and new tastes in monumental architecture that used water more, and more for decorative purposes such as fountains. Later lines introduced by Claudius and Trajan were of much higher elevation and greater capacity but while they distributed water all over Rome, our evidence concerning their delivery indicates that they functioned as general and not specialized lines serving a wide variety of uses. While the Claudian aqueducts dwarfed all earlier lines in their height and volume (Pliny HN 36.122), quickly becoming the master part of the entire system, they and the Aqua Traiana appear to have been built to provide an overall supplement to existing aqueducts rather than to replace the distribution plan Agrippa had devised (Evans, 1982:411).

A final accomplishment of Agrippa's worth mentioning: Frontinus credits him with the invention of a new system of measuring water, the *quinaria*,

[9]Strabo 5.3.8 and 13.1.19; Pliny *Nat. His.* 36.102, 104-108 and 121; Dio 49.43, 53.27, 54.29, 55.8 and 56.24

which has been extensively discusses in a previous chapter. This is the system that continued to be used for at least several hundred years. Though it is inadequate by today's standards, it is probable that it was better than the previous system.

Not only did Agrippa lay the foundation for the imperial administration of Rome's aqueduct system, but it can be argued that his plan for water distribution was never entirely superseded. The city's needs for water increased with growth and new tastes in monumental architecture that used water for decorative purposes. Later aqueducts introduced by Claudius and Trajan were of higher elevation and greater capacity. While they distributed water all over Rome, our evidence concerning their delivery indicates that they functioned as general and not as specialised lines. While the Claudian aqueducts dwarfed all earlier lines in their height and volume, quickly becoming the master part of the entire system, the evidence shows that they and the Aqua Traiana were built to provide an overall supplement to existing aqueducts rather than to replace the distribution plan Agrippa had devised (Evans, 1982:411).

Appendix A

The seven hills of Rome

Traditionally, it is held that Rome was built upon seven hills (though in fact it is difficult to ascertain precisely). Figure D.10 is a satellite photograph of modern Rome, showing the location of the seven hills. A brief account of each of them is illuminating.

1. *Palatium:* The chief of the seven hills, and apparently the first of the hills to be inhabited (OCD, 770-771). The etymology is obscure, but might have something to do with a pasture or place of shepherds. "Palatium" later comes to mean palace, from which the English word derives. The palaces of the emperors finally came to occupy the entire hill. At 44-acres, the Palatine was high enough for defence and cooling summer breezes. Excavations on the western corner of the Palatine have unearthed the foundations of a village at the lowest archaeological strata. Remains of pottery found there have been dated to the 8th century B.C., which corresponds closely with the traditional date of the founding of Rome, 753 B.C. (Stambaugh, 1992:11).

2. *Capitolium:* Originally a description limited to the temple of Jupiter in Rome on the summit of Mt Saturnius or Tarpeius and only later came to describe the entire hill. The Romans seemed to believe the name originated from the discovery of a man's head when the foundations of the temple were laid. The word has lived on; today we have *capital*

cities, and the *Capital Hill* in the USA.

3. *Collis Quirinalis:* The Quirinal is the most northerly of the hills and was ocuupied early on, possibly by Sabines. The name means "of or belonging to Quirius". This refers to Romulus, the founder of the city.

4. *Viminalis Collis:* The name Viminal is derived from a willow-copse found there. *Vimin* means a plinat twig, or woven work such as a basket.

5. *Esquilinae:* A plateau formed from the *montes Oppius* and *Cispius*. It is the largest of the hills, 70 acres, with several summits, hence its plural form. Traditionally added to the city by the king Servius Tullius, it was in early times used as a burial place and also a place of execution.

6. *Caelius Mons:* Named after the Etruscan Caeles Vibenna, but originally called Querquetulanus (OCD, 188). Vibenna, perhaps from Veii, is said to have settled here after helping one of the kings, Tarquinius Priscus (OCD, 1119). It is the most south-easterly of the hills, and one of the most densely populated in earlier times. It measures 69 acres.

7. *Aventinus Mons:* The name possibly dervived from Aventinus, a king of Alba Longa. Traditionally outside the city until the reign of Ancus Marcius and, until AD 49, also outside the *pomerium*, or religous boundary (OCD, 155). The hill was well populated , and a thriving commercial sector of the city from early times, with several temple sites associated with the Latin League. The Aventine is the southernmost of the hills and closest to the tiber. Though 96 acres, it is similar to the Palatine in form, from which it is seperated only by the small calley that is the Circus Maximus.

Appendix B

The fourteen regions

In 7 BC, for political, social and religious reasons Augustus planned and carried out a complicated division of the whole intra-mural and extra-mural city into *Regiones* and *Vici*, each with its set of officials, both municipal and religious. The main divisions were into fourteen *Regiones*. Each *Regio* was subdivided into *Vici*, varying in number from seven in the smallest (the *Regio Caelimontana*) to seventy-eight in the largest (*Regio Transtiberina*). The fourteen *Regiones* contained 265 *Vici*. Each *Vicus* formed a religious body with its *aedicula Larium* or *Compitalis*. They were presided over by the *Magistri vicorum*, the lowest ranking of the Roman magistrates (Middleton, 1892a:379). This organisation lasted more-or-less intact until the seventh century (Richardson, 1992:331).

The following list of the *Regiones* was taken from the regionary catalogues, which were mainly compiled during the reign of Constantine. However, some of the boundaries, espcially around the outer edge of the city, are uncertain.

1. *Porta Capena:* It was named for the gate in the Servian Wall from which the *Via Appia* issued. Extended beyond the fork of the *Via Appia* and *Latina*, probably as far as the later circuit wall of the Aurelianus. It was divided into ten *Vici*.

2. *Caelimontana:* Included the Caelian Hill. It was divided into seven

Vici.

3. *Isis et Serapis:* It included the valley of the Colosseum and the adjacent part of the Esquiline Hill. It was divided into eight *Vici.*

4. *Templum Pacis:* It was divided into eight *Vici.*

5. *Esquilina:* It included the Viminal Hill and the northern part of the Esquiline. It was divided into fifteen *Vici.*

6. *Alta Semita:* It included the Quirinal Hill as far as the Praetorian Camp. It was divided into seventeen *Vici.*

7. *Via Lata:* It was bounded on the west by *Via Lata* and extended to the east as far as the Quirinal Hill. It was divided into fifteen *Vici.*

8. *Forum Romanum:* It included not only the forum from which it took its name, but also the Fora of Julius Caesar, Augustus and Trajan, and the whole of the Capitoline Hill. It was divided into thirty-four *Vici.*

9. *Circus Flaminius:* It was bounded by the Capitoline Hill, the *Via Lata* and *Flaminia* and the Tiber. It was divided into thirty-five *Vici.*

10. *Palatina:* It included the whole of the Palatine Hill. It was divided into twenty *Vici.*

11. *Circus Maximus:* Named for the square near its southern extremity. It included the whole valley between the Aventine and Palatine Hills. It was divided into eighteen *Vici.*

12. *Piscina Publica:* Named for an old tank that was probably originally a public resevoir, and later a public swimming pool. It included the space between the Caelian and the Aventine. It was divided into fourteen *Vici.*

13. *Aventina:* It included the whole of the Aventine Hill, and its slopes down to the river. It contained seventeen *Vici.*

14. *Transtiberina:* It included the entire transpontine city, with the Janiculan and Vatican Hills, and also the island in the Tiber. It was divided into seventy-eight *Vici.*

Appendix C

Tables

ROMAN NAME	MODERN NAME
Allia	Fosso della Bettina
Aqua Traiana	Acqua Paola
Aqua Virgo	Acqua Vergine
Arretium	Arezzo
Campus Martius	Corso
Lake Alsietinus	Lake Martignano
Lake Sabatinus	Lake Bracciano
Porta Praenestina	Porta Maggiore
Tibur	Tivoli
Varia	Vicovaro
Via Lata	Via del Corso

Table C.1: Selected modern place names

DATE	EVENT
753 BC	Foundation of the city
396 BC	Fall of Veii
377 - 353 BC	Servian Walls constructed

Continued...

356 BC	Etruscan war begins
351 BC	Etruscan war ends
343 BC	First Samnite war begins
341 BC	First Samnite war ends
327 BC	Second Samnite war begins
312 BC	Aqua Appia completed
304 BC	Second Samnite war ends
278 BC	Alliance with Carthage
273 BC	Treaty with Egypt
273 BC	Anio Vetus completed
264 - 241 BC	First Punic War
218 - 202 BC	Second Punic War
212 BC	Servian Walls repaired
140 BC	Aqua Appia and Aqua Vetus repaired
144 BC	Aqua Marcia completed
125 BC	Aqua Tepula completed
87 BC	Servian Walls repaired and strengthened
44 BC	Assassination of Caesar
33 BC	Aqua Appia, Aqua Marcia repaired. Aqua Julia completed and mixed with Aqua Tepula. Aqua Virgo begun
19 BC	Aqua Virgo completed
2 BC	Aqua Alsietina completed
14 AD	Aqua Julia repaired
38 AD	Aqua Novus and Aqua Claudia begun
52 AD	Aqua Claudia completed
52 AD	Anio Novus completed

Continued...

71 AD	All existing aqueducts repaired
79 AD	Aqua Marcia repaired
81 AD	Aqua Claudia repaired
103 AD	Aqua Traiani completed
196 AD	Aqua Marcia repaired
226 AD	Aqua Alexandrina completed
537 AD	Aqua Traiani cut by goths. Rome sacked

Table C.8: Timeline of selected events

Location	**Length (KM)**	**Construction date**	**Constructed by**	**Discharge** (m^3)	**Source**
Appia	16	312 BC	Appius Claudius Caecus	73,000	Springs
Anio Vetus	64	273 BC	Manius Curius Dentatus and Lucius Papirius	175,920	River Tivoli , Anio Valley
Marcia	91	144 BC	Quintus Marcus Rex	187,600	Anio Valley Springs
Tepula	18	125 BC	G. Servilius Caepio and L. Cassius Longinus	17,800	Alban Hills
Julia	22	33 BC	Agrippa	48,240	Alban Hills
Virgo	21	19 BC	Agrippa	100,160	Marshy area North of Via Collatina
Alsietina	33	2 BC	Augustus	15,680	Lake Alsietinus
Claudia	69	38 - 52 AD	Caligula and Claudius	184,220	Anio Valley Springs
Anio Novus	92	38 - 52 AD	Caligula and Claudius	189,520	Unknown, perhaps near the Anio Valley
Traiana	35 - 60	103 AD	Trajan	113,920	Lake Bracciano
Alexandrina	22	c. 200 AD	Alexander Severus	21,160	Pantano Springs

Table C.2: Summary of major roman aqueducts

	Curiosum and Notitia		Polemius Silvius
1	Traiani	1	Traiani et
2	Annia ?	3	Atica ?
3	Attica ?	2	Anena
4	Claudia *	4	Claudia *
5	Marcia *	5	Marcia *
6	Herculea (*)	6	Heracliana (*)
7	Caerulea (*)	15	Virgo *
8	Iulia *	8	Julia *
9	Augustea (*)	12	Ciminia
10	Appia *	13	Aurelia
11	Alseatina *	9	Augustea (*)
12	Ciminia	11	Alsitina *
13	Aurelia	10	Appia *
14	Damnata ?	17	Severiana
15	Virgo *	18	Antoniniani
16	Tepula *	19	Alexandreana
17	Severiana	7	Caerulea (*) et
18	Antoniana	14	Dorraciana ?
19	Alexandrina		Drusia
20	Cernens		

Table C.3: Aqueducts listed in the Curiosum, Notitia and Silvius (Jordan, 1871:223)

Roman Size	Lead/10 feet (kg)	Diameter allowing for overlap (cm)
100-digit	392.25	57.4
80-digit	313.7	45.5
50-digit	196.1	27.8
40-digit	157	22
30-digit	117.6	16
20-digit	78.5	10.2
15-digit	59	7.2
10-digit	39	4.3
8-digit	32.7	3
5-digit	19.5	1.32

Table C.4: Table of lead pipe sizes (Hodge, 2000:44)

Appia	20
Anio Vetus	35
Marcia	51
Tepula	14
Julia	17
Virgo	18
Claudia/Anio Novus	92
TOTAL	247

Table C.5: Number of *castella* (Evans, 1997:139)

Number	Latin Name	Diameter (digits)	Diameter (cm)	Circumference (cm)	Area (cm^2)	Capacity (quinariae)
5	quinaria	$1\frac{1}{4}$	2.31	7.26	4.191	1
8	octonaria	2	3.696	11.611	10.728	$2+\frac{161}{288}$
12A	duodenaria	3	5.544	17.417	24.14	$5+\frac{219}{288}$
12B	duodenaria	$3+\frac{18}{288}$	5.659	17.779	25.151	6
20A	vicenaria	$5+\frac{13}{288}$	9.323	29.29	68.265	$16+\frac{7}{24}$
20B	vicenaria	$4\frac{1}{2}$	8.316	26.125	54.315	13
40	quadragenaria	$7+\frac{39}{288}$	13.186	41.425	136.56	$32+\frac{7}{12}$
60	sexagenaria	$8+\frac{212}{288}$	16.144	50.71	204.69	$48+\frac{251}{288}$
80	octogenaria	$10+\frac{26}{288}$	18.646	58.58	273.06	$65+\frac{1}{6}$
100A	centenaria	$11+\frac{81}{288}$	20.847	65.495	341.33	$81+\frac{130}{288}$
100B	centenaria	12	2.176	69.668	386.24	92
120A	centenum-vicenum	$12+\frac{102}{288}$	22.83	71.724	409.35	$97\frac{3}{4}$
120B	centenum-vicenum	16	29.568	92.89	686.64	$163+\frac{11}{12}$

Table C.6: Most common sizes of calix listed by Frontinus (Hodge, 2000:55)

Region	Appia	Anio Vetus	Marcia	Tepula	Julia	Virgo	Alsietina	Claudia	Claudia/Anio Novus
I Porta Capena		X	X						X
II Caelimontana	X				X			X	X
III Isis et Serapis		X	X		X				X
IV Templum Pacis		X	X	X					X
V Esquilinae		X	X	X	X				X
VI Alta Semita		X	X	X	X				X
VII Via Lata		X	X	X		X			X
VIII Forum Romanum	X	X	X		X				X
IX Circus Flaminius	X	X	X			X			X
X Palatium			X		X			X	X
XI Circus Maximus	X								X
XII Piscini Publica	X	X			X				X
XIII Aventinus	X							X	X
XIV Transtiberim	X	X	X			X	X	X	X

Table C.7: Regional distribution by aqueduct (Evans, 1997:177)