PLANNING WATER MANAGEMENT FOR AN ANCIENT GREEK CITY

Dora P. Crouch
School of Architecture, Rensselaer Polytechnic Institute,
Troy, New York, USA 12180-3590

ABSTRACT

Traditional knowledge of finding and collecting water and increased sophistication in fresh and used water transport characterized water management of Corinth and Syracuse in the 7th to 1st centuries BC. Both survival and amenity were assured. Potential water decisions were evaluated as to cost and ecological impact. The systems changed over time.

INTRODUCTION

Careful attention to water supply and distribution was essential for a Greek city. Some ideas—cisterns—were basic, easy to manage even in primitive conditions. Other ideas required sophisticated technology likely to be found at important cities such as Corinth and its colony Syracuse, founded in 734 BC. There were close cultural and economic relations between mother-cities and their colonies although Greeks did not form an empire. Colonies which survived were those endowed with the water and other resources they needed, indicating the relationship between water management and urbanization. Colonists from Corinth were aware of how important water was in the flourishing condition of their home city, and deliberately sought not only a new site with a positive resource base, but specifically one where their customary technical knowledge was appropriate to handle the new situation: same geology, same climate, similar flora and fauna, especially MAN and all his works. Those who settled Syracuse carried with them a mind-set that accepted new mechanisms for water management, so that as water technology changed at home in Corinth, the same new ideas found acceptance in Syracuse. Whatever elements of watersystem Corinth and Syracuse have in common owe much to the fact that water is consistent in its behaviour, thus calling for consistent solutions to the problems of managing it. The similarity also owes something to the common technological knowledge in the old home and new city.

Traditional knowledge of finding and collecting water was supplemented by increasing technical skill in the transport of both fresh and used water during the period studied. The control of building projects indexes the growing sophistication of the technology: In the seventh century, the tyrant Theagenes at Megara kept firmly in his own hands the power to build his famous fountainhouse. In 6th century Athens, Peisistratos gave this power to a board of commissioners for the aqueduct that carries his name, while in the 5th century the engineer Eupalinos of Megara was solely responsible for the tunnel at Samos. In the fourth century building commissioners approved the alignments for water lines. Later still, the architect-engineer delegated responsibility for actual construction of the line to a businessman/contractor.
During the same centuries, diversification increased within the water system. At Corinth and Syracuse, we find springs, fountains, cisterns, wells, pipes and channels. This paper deals first with the fountains of Corinth and Syracuse, then the long-distance lines of each site, the baths, and a little about domestic arrangements.

Abundance of water was a prime reason for selection of each site for settlement, as for continued growth. "The ancient city (Corinth) grew up on the slopes of Acrocorinth...on the north slope of the hill...there were good supplies of water combined with gently sloping terraces of fertile fields...". The archeological evidence from the earliest period is scanty but "...wells of the late 8th and 7th centuries which have been found in and around the area of the later marketplace indicate the presence of houses or civic buildings..." Early remains are scarce at Syracuse, where archeological curiosity has to contend with modern occupation of the site. Corinth is some 3-5 km inland, while Syracuse was founded on the island of Ortygia and grew gradually inland. Corinth lay at the foot of Acrocorinth, while Syracuse's uphill termination was the fortress of Euryalus, perhaps as tall as Acrocorinth, but reached by gradually sloping terrain. Geologically, the sites are similar in that layers of permeable rock and impervious clay collected water in quite similar fashion and made it available to human use. Natural channels through the rock seem at both sites to have been amplified and directed to behave as underground aqueducts. At Corinth, the impervious clay lay under porous conglomerate. Water trickled through the rock and spread out along the surface of the clay, to be easily collected. By the sixth century, the Corinthians had learned to make a spring house by cutting back the clay under an overhang of rock, and then to cut tunnels just under the stone, to tap the water-bearing seam. Three fountains are known in the Corinthian agora area that date from the sixth century or earlier—the Cyclopean Fountain, Peirene, and the Sacred Spring. The Glauke fountain, set apart from the others beyond the archaic temple, may belong to this early period also.

Let us consider them in that order.

Cyclopean Fountain

The Cyclopean Fountain was located near the road that led up from the coast to the agora. Its rough-hewn stones formed a "natural" grotto suggesting great antiquity. Both this and the Peirene Fountain at right angles to it were tucked in under the conglomerate and were originally supplied by the same small spring, probably by the end of the fifth century BC supplemented by a supply tunnel. Because of this spring and its two outlets, the agora developed here. When the city was destroyed in 146 BC and rebuilt as a Roman town, the remodeled Peirene squeezed against and concealed the old Cyclopean Fountain, but in the Byzantine era the latter was reopened.
Pierene Fountain

Peirene Fountain, most important source at Corinth, was formalized no later than the sixth century BC and is still flowing. Several building periods are in evidence, from the earliest channels barely 0.25 m. below the rock, through many deepenings, extensions, and remodellings. Changes in the levels of the early spouts and in the parapets for the later draw-basins culminated in the Roman period in the elaborate rebuilding of the courtyard. Behind the Roman columns, the inner facade is the old Hellenistic one with small Ionic columns and well-worn parapets. Farther in were the four long basins of the archaic reservoir. The supply system was essentially unchanged throughout the Greek era although to keep the spring flowing copiously it was necessary to compensate for the natural tendency of the water to cut deeper beds for itself. Some tunnels eventually ran over 3500 meters back toward Acrocorinth.

Sacred Spring

The Sacred Spring, third of these very early fountains, stood across the main street. This fountain is known from remnants below the present ground level, a fine ashlar wall screening the channels which brought water to this place. Sixth century BC bronze lion heads were found in situ on the wall, and the gutter into which their water poured lay at the base of the wall. A small gutter indicating that the flow of the spring by then was meager. The water of the original spring at this spot was amplified by channel for several centuries because of the sacred nature of this spring.

Glauke Fountain

The last fountain is Glauke, off by itself southwest of the other three, of the same rough native rock as the archaic temple. When the hill was quarried for blocks to build the temple, this 15 m cube was left in place. Someone had the inspiration to use the quarry trenches as reservoirs, and to fit the big block a fountainhouse, with draw-basins, access stairs, and supply pipes. Its date is still being argued.

Although this account by no means exhausts the list of fountains at Corinth, it is sufficient to give a sense of the provision of water at the center of the city. Would that it were as easy to describe the fountain at the center of Syracuse! The process is clear, but the details are lost. City founders and builders selected the site of Syracuse for its inherently positive base including water supply and then located public buildings, private shops, houses according to the customs of daily life. Many of the same processes were at work here as in Corinth, with water cutting its own channels through rock and etching out access shafts, so that the engineers had rather to manage the water than to find or import it during the eighth to fifth centuries BC.
Ortygia

Most notable source of water on Ortygia, the first site of settlement, is the seaside spring named Arethusa, one of a line of springs that used to be visible in both harbours, in ancient times spilling fresh water, but salty since an earthquake in the 12th century. These intrusions into the salt water, variously explained as natural springs or as breaks in an undersea aqueduct, were not visible to me in 1985, but "found" later amid other information on karst phenomena. The water in the rocks of a karst formation keeps cutting down farther and farther, making solution channels even at great depth. The limestone layer at Syracuse slopes in a great disk shape from the fortress of Euryalus, down and under the city, coming to the surface again on the island. Groundwater runs along bedding planes in limestone, but tries to come up to the surface through shafts; from time to time, the top of one of these shafts collapses, allowing the fresh water to flow out under pressure, forming an artesian spring on land or in the sea. To tap the water in bedding planes near the surface of Ortygia, there were three or four water lines on the island. Ortygia was the focus of urban life with the earliest temples, the agora and other municipal functions, which would have needed the usual complements of public fountains, drains, etc., but these have not been systematically located, and may prove irrecoverable because of the density of later use of the site.

Syracuse

Other visible features of the water system at Syracuse are located on the mainland, many of them near the series of grottoes above the theatre, where water still collects. (Since water naturally forms caverns in limestone, it is common for the pressure of water farther uphill to drive springs out into the open wherever such caverns intersect the surface). Over time (two or three centuries), two contradictory things happened at Syracuse: the water found new paths, farther down the hill, and the increase of population caused the city to grow up the hill, which increased demand for water at higher levels. Suburban settlement had originally taken place around the springs, so it was convenient to continue to use these grotto outlets, but to supply them from long-distance lines located towards the top of the hill, for gravity distribution.

The dates of construction of elements of the water system at Syracuse are hard to ascertain, but I will hazard the following chronology: Water with CO$_2$ in solution carved out channels in the limestone, a process beginning eons ago and still continuing. Natural springs in caves drew settlers. Greeks of the archaic/classical periods used these little caves and channels to serve as fountains and aqueducts, enlarging them as necessary, during at least a thousand years. The ruler Gelon in the first quarter of the fifth century brought settlers in from nearby towns settling them in Tyche, Achradina, and Ortygia areas for which he is known to have built aqueducts. Water had to be brought in from farther away and from higher sources (late classical and Hellenistic eras), necessitating the construction of long distance water supply lines, possibly including pressure pipe lines (5th to 3rd century). Water continued to cut new beds at lower levels; the Greeks responded (as would modern engineers) by waterproofing tunnels, diverting streams, and using parts of old tunnels as reservoirs. Flow of water at the grottoes dwindled, while increasing
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Population required more long-distance water supply, so the Aqueduct of the Nymphs and Galermi Aqueduct were built in the third century BC. After the Roman conquest, new water system elements were added replacing old ones, and providing normal Roman bathgymnasiums. By the second or third century AD, maintenance had long been minimal. Reduction of population paralleled gradual down-cutting of underground water; the population moved downhill to utilize lower outlets. Abandoned grottoes and underground tunnels were pressed into service as tomb sites (catacombs) perhaps as early as the last century BC. In modern times, the expanding populations located new water sources (deep pumping in the plains west of the city), and began to renovate the old Galermi aqueduct.

Water lines

Turning to the water lines that supplied the fountains, we have no evidence for long-distance supply lines in the Greek world as early as the eight and seventh centuries when Syracuse was colonized from Corinth. Therefore, if we find similarities in the two cities it must be as a result of two factors: First, both adopted the same technology from Asia Minor, one easily adapted to their own purpose by those with centuries of observation behind them. Second, the geology of the two sites was such that the same technology worked at both. Colonists from Corinth had been looking for a site where they could apply what the knew of water management, and found it at Syracuse. Let us then consider the evidence for long-distance water supply at Corinth and then at Syracuse.

In Corinth, Peirene was supplied by water from the east tunnel that filled a series of reservoirs and draw basins, and from the west tunnel which "strengthen(ed) and direct(ed) the flow...from several small streams as its line crossed theirs". This tunnel is typical at Corinth, in that it has many short branches for collecting water, tapping not only springs, but also seeps and oozes. Well-shafts in the tunnels facilitated both cutting and maintaining them. The shafts date from the sixth century BC to the sixth century AD by their fill. Cross tunnels ran between the major lines. A second set of important water tunnels and cisterns was found about 1000 m southwest of the agora. The length of 3500 m of channels attested for Corinth was far outstripped by the longest of the waterlines at Syracuse: the Galermi Aqueduct, some 25 km long, and still flowing. Some 14 other waterlines are known at Syracuse. In the case of the grottoes above the theatre and the lines that supplied them, the continuum spring-fountain-waterline exhibits all the complexity that is possible, given centuries of changes in both the locations of the veins of water and the preferences of the human users.

Public baths

Public baths are also known at both cities. At Corinth, four baths are known from the Greek period, the earliest fifth century BC. Tradition adds another at the "baths of Aphrodite" on the scarp just above the coast, directly north of the city. At Syracuse, only four baths are known so far for the population of nearly a quarter of a million. The locations and the variations in the types of baths at Syracuse indicate that up-to-date baths were added as the city grew, supplied by the water lines to the fountains, probably with
spur lines to the bathing establishments, located as close as possible to the aqueducts.

**Wells and cisterns**

The importance of wells and cisterns for assuring the water supply for residences and industry is demonstrated at both cities. In Corinth, for example, wells and cisterns reveal houses: near the Asklepsion and gymnasium during sixth and fifth centuries; east of the theatre since Early Neolithic times; in the agora during the 10-8th centuries; west of the agora in fifth and fourth centuries; under and around the South Stoa; and south of the Sacred Spring during the sixth and fifth centuries. Additional cisterns were located on Acrocorinth, to accommodate worshippers and to safeguard the garrison in time of seige. East of the Corinth Museum are wells and cisterns whose contents give a capsule history of the area (construction, use, filling, clearing out, re-use, and re-filling) as the fortunes of the city changed.

Only a few cisterns are known at Syracuse, entirely from the late Hellenistic/early imperial Rome period. Although a few house walls from the eight and seventh centuries have been found at both sites, there are not enough water system elements to allow us to describe in detail the common provision for domestic water during the earliest period. Even later pipes, channels, and drains at Corinth and Syracuse have not been explicitly published. The evidence does assert that both mothercity and colony had mixed systems of water supply, where the oldest methods (wells, cisterns, springs) were gradually supplemented—not replaced—by methods relying on water transport. Engineering gradually learned to amplify the waters of a spring directing to it flows and seepages from farther uphill, and to supply artificial fountains such as Glauke. Water was available for domestic use, for industry, and for public baths. Every feature of the developed water system contributed to both survival and amenity, from the "insurance" of private wells and cisterns "duplicated" by the public water lines, to the sophistication of re-using waste waters for irrigation to insure a continuous crop of trees (for fuel and building materials) near the city.

Since the water tradition responded to the real risks of urbanization in this climatogeological niche, the tradition emphasized having a multiplicity of supply sources, each a safeguard against failure of the others. Every potential water decision was evaluated as to its cost in human effort and wealth. Weighed in the cost-benefit analysis were reuse and extended use.

Dr.-Ing. H. Fahlbusch has discussed their cost-benefit analysis, reading ancient decisions from the waterlines as built, by a modern hydraulic engineer trained to make exactly the same kinds of analysis. It is not coincidental that Gelon who moved the populations of several towns to Syracuse also built aqueducts for them. The pressure pipe line (siphon) functioning in Syracuse by 450 BC may be associated with the increased wealth and population of Gelon’s reign. Syracuse was a large, wealthy city where money was deliberately invested in the water system. Similarly, governmental money must have gone into the water system when it was decided to rebuild the city of Corinth and turn it over to Roman army veterans. These two cities provide powerful examples of water in the urban landscape and water as the sine qua non of urban ecosystems.

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