Chapter 6: Aqueducts in the rural landscape

'…one ruler paved the streets and others brought the gifts of the nymphs in conduits, some rulers bringing the waters from the suburbs to the city [*sc.* Antioch], while others conducted them to the newer part of the city from the springs with which the older part abounds…'
[Libanius *Orat*. 11.125 (trans. Petit 1955)]

6.1 Introduction

An aqueduct takes its water from a spring, river or runoff water (see below section 6.2.1) and transports it to a settlement. 'Aqueduct' here refers to the entire length of a water transport channel.[1] Channels that did not clearly feed a settlement have been classified as irrigation channels (see Chapter 5.2). In order to deal effectively with these complex and multifaceted structures, the technological discussion of the aqueduct will see it split up and discussed in its component parts (section 6.2). The sociological and economic aspects of aqueducts will be discussed in sections 6.3.1 (status and power) and 6.3.2 (the rural-urban divide).

The channel *specus* and course (section 6.2.2) includes those parts of an aqueduct where the water is transported in an open or roofed conduit; these can be built or rock-cut. Tunnels (section 6.2.3) pierce ridges, watersheds, saddles between two mountains and projecting spurs. The channel *specus* is often no more than a small conduit cut into the floor of these tunnel sections. Bridges (section 6.2.4), often the most visible sections of aqueducts, take the channel over valleys, which it would not be economical to circumvent. Hydraulically, the water in all these parts of the aqueduct system can be considered as flowing in an open channel. When the water runs in pipelines and inverted siphons, it can be considered to be flowing in a closed pipe (section 6.2.5). An aqueduct may comprise one or more of these components in any combination, i.e. the entire length of an aqueduct may be a pipeline or may have tunnel and bridge sections, but no pipeline.

This chapter is concerned with the role and position of aqueducts in the rural landscape of the Near East. This includes not only aqueducts with a solely rural function

[1] 'Water transport' here refers to the transport *of* water, rather than transport *on* water, as is the case with canals. The terminology of the component parts of an aqueduct follows that used by Hodge 1992.

(supplying water for rural settlements, villas and farms), but also the parts of urban aqueducts that traverse the rural landscape. This is a device by which these complex installations, which function in both the urban and rural landscape, may be considered fully in all their aspects. This will include rural branches (supplying settlements, villas and farms, as well as irrigation projects) from urban aqueducts, which have been the subject of some debate in recent years (section 6.3.2 below). The urban role of an aqueduct will be discussed in chapter 7.

In total, 121 aqueducts have been recorded in the region (Gazetteer 7). An additional 3 aqueducts can be added to this list from the evidence of *nymphaea,* which required running aqueduct water: Kanawat, Scythopolis and Pella.[2] An aqueduct probably also brought water from the dams to the cisterns at Dara.

There is a striking dichotomy in modern research on aqueducts between Israel and the rest of the Middle East [Fig. 6.1]. In Israel and the Palestinian Territories there has been a recent surge in research on aqueducts, embodied primarily in *The Aqueducts of Israel*, which holds almost the entire corpus of work on aqueducts in Israel.[3] Elsewhere in the Middle East there has been little research interest in aqueducts; one exception is research on Nabataean aqueducts mostly centred on Oleson's work at Auara in Jordan.[4] A small amount of work has also been carried out on urban aqueducts in the province of Syria, notably those supplying Antioch, Palmyra, Beirut and Apamea.[5] The majority of other aqueducts in the Middle East are known from 19th-century travel writing. Due to the nature of their discovery and publication, few of these aqueducts have been surveyed and recorded in their entirety.

Unsurprisingly, the majority of aqueducts in the region appear to have been constructed in the Roman period reaching the height of new construction in the 2nd century AD (Table 6.1 and Gazetteer 7.2), which is also reflected by a peak in *nymphaeum* and fountain building (Chapter 7.2.2). There was a clear drop-off in numbers in the late Roman

[2] For details on these sites see Gazetteer 8.
[3] Amit *et al*. 2002.
[4] Eadie 1984; Eadie and Oleson 1986; Oleson 1986; Oleson 1988; Oleson 1990; Oleson 1991.
[5] Antioch: Wilber 1938; Downey 1951; Downey 1961; Lassus 1983; Sinclair 1990.
Palmyra: Wood 1753; Partsch 1922; Musil 1928; Starcky 1941; Starcky 1946-1948; Michalowski 1967; Michalowski and Dziewanowski 1970; Crouch 1975; Teixidor 1984; Meyza 1985; Bounni and As'ad 1989, Davie *et al.* 1997; Piacentini 2001-2.
Apamea: Shahada 1957; Rey-Coquais 1973; Balty 1987.

period; this slump in construction probably reflects the fact that the majority of sites already had aqueducts and possibly that the finance for new aqueducts was no longer available (on the cost of aqueducts see below section 6.3.1.). The early introduction of aqueducts in significant numbers in the Hasmonean and especially Herodian periods seems to be associated with Hasmonean and particularly Herodian palace construction; the influence of Herod will be discussed further below (section 6.3.1).

Table 6.1: Known dates of aqueducts in the Near East.

Period	Dated aqueducts	High confidence	Medium confidence
Hellenistic	3	1	2
2nd century BC	1	1	0
1st century BC	1	0	1
Nabataean	8	4	4
Hasmonean	7	5	2
Herodian	14	10	4
Hasmonean or Herodian	4	4	0
Total Hasmonean and Herodian	**25**	**19**	**6**
1st century AD	7	4	3
2nd century AD	12	11	1
3rd century AD	4	3	1
Roman	11	7	4
Total Roman	**34**	**25**	**9**
4th century AD	1	1	0
5th century AD	2	2	0
6th century AD	2	2	0
Late Roman	13	11	2
Total late Roman	**18**	**16**	**2**

6.2 Technological aspects of aqueducts in the rural landscape

6.2.1 Sources

Water for aqueducts was usually drawn from springs, rivers and runoff. As fig. 6.1 clearly shows, the major source for aqueducts in the Near East was springs (53, i.e. 46%), which follows the pattern seen across the Roman Empire. This was followed by runoff (19, i.e.16%) and rivers (9, i.e. 8%). The sources of the remaining 30% of aqueducts were unspecified.

As is to be expected, few aqueducts were located in the Syrian steppe regions, where qanats were more viable and effective suppliers of water (Chapter 5.3). Aqueducts in Syria seem to cluster in two main groups along the Orontes River valley and in the Hauran. The aqueducts in the Orontes valley appear to have made use of the plentiful springs and, of course, river water available in the area. While the sources of the Hauran aqueducts have not been traced securely, it seems likely that the aqueducts would have been fed by runoff in this basalt landscape. The area west of the Jordan River and Dead Sea saw the highest numbers of aqueducts fed by runoff, in conjunction with aqueducts fed by springs, whereas no aqueducts seem to have been fed by the Jordan River. While there may have been concerns about water purity and pollution from river water, hence the low numbers of river-fed aqueducts generally, it is surprising that no use was made of such a significant water provider and further work in the area may reveal that more use was made than is apparent from the present data.

The source did not seem to govern the length of the aqueducts, though 12 of the 14 aqueducts that were fed by runoff and had a length recorded were less than 3 km in length. Although spring waters were used for a wide variety of different purposes, two-thirds of the aqueducts fed by runoff (14) delivered water to cisterns or reservoirs.

Dates of spring-fed aqueducts seem to be wide-ranging, but river-fed and runoff-fed aqueducts appear to display some interesting chronological data. With the exception of the 2nd-century BC aqueduct at Antioch that is fed by the Onopniktes River [#37], all other dateable, river-fed aqueducts (7) seem to date from the 1st century AD or later. Furthermore, the 2nd-century BC aqueduct at Antioch may have been built with a Roman architect (see below Section 6.3.1). In contrast, of the 16 dateable aqueducts fed by runoff, 11 are dated to the Hasmonean or Herodian periods, 2 to the Nabataean period and 3 to the late Roman period, indicating a lack of runoff aqueducts constructed in the intervening (Roman) period. Eleven of the earlier runoff aqueducts and two of the late Roman runoff aqueducts fed cisterns or reservoirs in rural areas. These data suggest that the Roman technological preference was for river-fed aqueducts over aqueducts fed by runoff, possibly associated with improvements in dam technology in the Roman period (see Chapter 4) as well as being a more reliable, perennial water source.

Various structures were used at the sources to direct the water into the aqueduct: springs were captured either in a springhouse pool (12 recorded) or a tunnel (9 recorded); dams were used at rivers (6), a wadi (1) and to trap runoff (3). Monumental architecture marking the aqueduct source, such as springhouses, is found across the empire.[6] Leveau

[6] Rakob 1974.

has suggested that sources marked by springhouses reflect the existence of a pre-existing cult on the site;[7] this is a possibility on these sites, but cannot be taken as a given without further research into spring cults in these areas. A subterranean installation that comprised a vertical shaft, a vaulted room and a holding pool was used at the beginning of the Emmaus aqueduct [#49], which was fed by groundwater [Fig. 6.2].[8]

6.2.2 Channel specus *and course*

Channels in the Near East appear to show no major anomalies when compared with channels across the rest of the Roman Empire. Rock-cut and built sections are both present on most of the aqueduct lines [Figs 6.3-4]. The building material of the built sections appears to reflect the local geology. A section of the channel on the Antioch mountain aqueduct was faced with *opus reticulatum*;[9] a rare occurrence outside Italy and almost certainly connected with the fact that Antioch was a provincial capital and Caligula was the benefactor. Other examples of *opus reticulatum* from the East come from client kingdoms in the early Roman period: Herodian structures at Jericho and Jerusalem, a wall at Samosata and a tomb at Emesa (Homs).[10] The *specus* is either trapezoidal or (sub-)rectangular in cross-section [Figs 6.3-4].

Although 185 channels or sections of channels have been recorded, only 56 aqueducts have their total length recorded. The aqueduct to Apamea was by far the longest at 150 km.[11] In the 2nd century AD, only the total length of the Carthage aqueduct (132 km) was comparable.[12] The Apamea aqueduct would have been the longest in the Roman world until AD 373 when Valens completed the aqueduct to Constantinople, whose main branch from Vize was in excess of 250 km long.[13] The other aqueducts varied in traceable length from 8.5 m to 39 km. There does not seem to be any clear pattern pertaining to the relationships between length and purpose and, contrary to expectation, length and date

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[7] Leveau 1991, 157.
[8] Hirschfeld 1978; Hirschfeld 2002a, 191-193.
[9] Wilber 1938, 55.
[10] Schick 1879, 102-4, pl. III; Netzer 1975, 93-4; Netzer 1977, 9; Netzer and Ben Arieh 1983; Dodge 1990; Butcher 2003, 175; Wilson 2003b, 369.
[11] Shahada 1957, 159.
[12] The Carthage-Zaghouan section is 90 km, which is more in line with aqueducts to Rome, such as the Anio Novus (87 km) and the Aqua Marcia (91 km), and the Cologne (Eifel) aqueduct (95 km): Hodge 2000b, 65, table 3.
[13] Bayliss *et al.* 2001, 18.

(Table 6.2). There is a possible relationship between longer aqueducts and a Roman date, but the sample is too small to make definite conclusions.

Table 6.2: Lengths of aqueducts according to date

	Under 1 km	**1 - 5 km**	**6 –10 km**	**11 – 20 km**	**21 km +**
Pre-Roman	4	5	1	2	1
Herodian	5	3	1	3	0
Roman	2	5	5	0	5
Late Roman	4	2	1	1	0

The breadth of the *specus* varied from 0.1 m to 2.5 m with 82 of the 95 channels being less then 1 m wide. Aqueducts with channels between 0.5 m wide and 1 m wide mostly fed urban centres. Of the 13 channels over 1 m wide, 6 were on lines used for irrigation and industrial purposes (such as milling) as well as feeding a settlement, which is to be expected as irrigation and agriculture would have required large volumes of water. A further four fed Hasmonean or Herodian palaces, which is harder to explain. Most of the channels (53 out of 70) were less than 1 m deep, but some were up to 3.5 m deep, which must include space for access.

Roofing of the channel is not recorded systematically, but where mentioned was often gabled or covered by flat stones [Figs 6.5-7]. No relationship between roofing technique and the width of the channel is clear, but the widest (1.8 m) and narrowest channels (0.2 m) with evidence for roofing were both gabled. Similarly, the plaster lining is not recorded with enough consistency and nothing further can be added to Porath's discussion (see Introduction).[14]

[14] Porath 2002a.

6.2.3 Tunnels

A total of 47 tunnels have been recorded, of which 10 were tapping tunnels at the beginning of main aqueduct lines or branch lines. The remaining 37 tunnels pierced ridges and saddles along the course of the aqueducts. The tunnels were rock-cut with occasional built sections, which seemed to occur in unstable geology [Figs 6.8-9].

Two tunnels were on rural lines that were also used for irrigation [Cypros #68 and #95]. Two were on the Ramat Hanadiv line, which fed baths. The majority of the tunnels (31) were constructed between the Herodian period and the end of the 2nd century AD, which is to be expected given the high level of aqueduct construction in that period (Table 6.1). In general, there was no pattern concerning the relationship of date with length of tunnel, but the three longest tunnels may be of Herodian date: the Caesarea High Level aqueduct channel A had a 442 m long tunnel; the Jerusalem Biyar aqueduct had a 500 m long tunnel and a 2.8 km long tunnel.[15] The width of the tunnels varied between 0.25 m and 2 m and the height of the tunnels between 0.8 m and 4 m. Only two channels were described specifically: Sepphoris [#62], which measured 0.45 m wide x 0.45 m deep and Beth Govrin [#45], which measured 0.3 m wide and 0.6 m deep.[16]

The shafts down to the tunnels were usually stepped to provide access [Fig. 6.10-11]. The shaft of a tunnel on the Beirut aqueduct had protrusions on its sides that may have been used for climbing up and down the shafts [Fig. 6.12].[17] The shafts on this tunnel were covered with vaults to prevent debris falling into the tunnel;[18] this is the only example of this technique recorded in the region [Fig. 6.13].

The construction technique of these tunnels was in some ways comparable to the construction technique of qanats, particularly the shafts used in both. Indeed, in reports of four of the tunnels [#62 Sepphoris, Caesarea High Level (two) and Jerusalem Biyar aqueduct] it was noted that teams quarried from both directions at once, which is similar to qanat construction and while using more labour reduced the amount of time spent on the project. There are, however, some significant differences between the two. The tunnels were in general shorter than the qanats with most of the tunnels whose length is known (13

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[15] Caesarea: Porath 2002b, 112. Jerusalem: Mazar 2002a, 223, 225.
[16] Sepphoris: Tsuk 2002a, 291. Beth Govrin: Sagiv *et al.* 2002, 183.
[17] Davie *et al.* 1997, 244-247.
[18] *Ibid.*

out of 25) being under 100 m, in contrast to qanats where half were in the 1 km to 5 km bracket (see Chapter 4.3). In addition, the tunnel shafts were spaced significantly wider apart than the qanat shafts. The spacing between tunnel shafts (on the Caesarea, Acco and Armon Hanatziv (Jerusalem Low Level aqueduct) tunnels) was in the range of 30 m to 56 m, whereas qanat shafts were spaced at intervals between 10 m and 22 m.[19] The tunnel wells, which varied in depth from 5.4 m to 40 m (on the Jerusalem Low Level aqueduct),[20] were also deeper than the mother wells of the qanats.

Spring flow tunnels providing urban supply are known from: Muqibleh, Nablus/Balata, Abila, Umm Qes (Gadara) and Palmyra (Efca). They are known from across the Empire, for example on the Aksu line, Pergamon, on the Antoninus Pius line, Athens and on the Zaghouan and Lyon aqueducts.[21] The similarities and differences between this technology and qanats have already been discussed in Chapter 5.6. The tunnels at Muqibleh and Nablus both had corbelled ceilings and may belong to the late Roman period.[22] The tunnel at Nablus was 850 m long, c. 1 m wide and c. 1.5 m high with a channel (0.2 m x 0.16 m) cut into its floor; it had one 3.07 m deep shaft. The length of this spring flow tunnel, as well as the others, makes it more similar to qanats than to regular aqueduct tunnels.

Umm Qes had two spring flow tunnels, both for urban supply and cut through limestone.[23] The upper tunnel, which must be dated earlier than the 4th century AD, was 410 m long, 0.8 m wide and 2.5 m high. It had several narrow shafts with steep stairs as well as lamp niches cut into its walls. Weirs controlled the water in the lower tunnel by diverting water from the main channel into side channels heading north; it is not clear whether this occurred in the tunnel or at its entrance. The tunnel was plastered and was constructed by digging the shafts first and connecting the tunnel between them.

Abila also had two tunnels cut through limestone for urban supply.[24] The upper tunnel, which was 2.5 km long, 0.64 m wide and 1.43 m high, was constructed in a similar

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[19] Caesarea: Porath 2002b, 114. Acco: Frankel 2002, 84. Armon Hanatziv: Mazar 2002a, 220; on this tunnel two shafts were 115 m apart.
[20] Billig 2002, 248.
[21] Fahlbusch 1979, 30; Peletier 1983, 146-151; Stenton and Coulton 1986, 20, n. 15.
[22] Bull 1965, 221-228; Thompson and De Vries 1972, 89-90, 92.
[23] Kerner and Hoffmann 1993, 369-371; Kerner 1997, 285-7.
[24] Schumacher 1889, 23-4; Mare 1984, 48; Mare *et al.* 1985, 228-9; Fuller 1986 228-9; Van Elderen 1989; Mare 1995.

way to the lower Umm Qes tunnel by first digging shafts and then connecting the tunnel between them. This technique is similar to the technique of qanat construction. The 20 m – 30 m interval between the shafts on the upper section of the upper Abila tunnel also brings it in line with qanat technology. On the Khureiba section of the tunnel, however, the shafts were spaced at c. 50 m intervals, which is more similar to the shaft spacings found on the other aqueduct tunnels. This tunnel must have been cut before AD 568 when a painted inscription in Greek on the wall of the tunnel records that the channel was cleared [Fig. 6.14].[25] As well as the Greek inscription, there was also an assortment of 14 incised crosses and 3 Christian monograms, 7 painted Greek letter graffiti and 4 engineering graffiti scratched into the tunnel walls [Fig. 6.15].

Little is known about the lower tunnel at Abila. The tunnel truncated several pre-Roman tombs and so it may date to the early Roman period when Abila saw rapid expansion.[26] The inscription in the upper tunnel, which refers explicitly to an 'upper tunnel', presupposes the existence of a lower tunnel. It would seem reasonable then to suggest that this inscription also provides a *terminus ante quem* of AD 568 for the lower tunnel as well.

6.2.4 Bridges and arcades

A total of 76 bridges was recorded. Sixteen were on rural aqueducts feeding cisterns or reservoirs and seven were on rural lines for irrigation. While the majority of the bridges seems to have been constructed from locally-available stone, four of the bridges on the aqueduct line to Apamea and one of the bridges on the southern Antioch aqueduct were brick-faced [Fig. 6.16].[27]

Once again the majority of the bridges (52) were constructed between the Herodian period and the end of the 2nd century AD, 15 of which were Herodian in date and 28 from the 2nd century AD. The high number in the 2nd century AD probably reflects the peak in aqueduct construction in this period (see Table 6.1). The bridges varied in length from 9 m

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[25] Van Elderen 1989:

[ἐπὶ....τ]ο[ῦ]/ ἁγ[ι]ωτάτου κ(αὶ) μακαρι/ωάτατου ἐπισ[κ]όπου/ ἐξυσθη ὁ αὐ[λῶ]τος ὁ ἀν/ωτερος ἐν [μνη]ὶ σεπτε/μ]βρίωι ὀκτοβρίωι ἰνδ/ι]κτίονος δευτέρας τοῦ/ ἔτους αλχ [...

'[At the time of…] the most holy and most blessed bishop, the upper channel was cleared in the month(s) September (and) October, in the second indiction (and) the year 631.'

[26] Mare 1995, 229.

[27] Apaema: these are Shahada's bridges 2,3,5 and 11: Shahada 1957, 159. Antioch: Wilber 1938, 54.

to 220 m. The shortest bridges (less than 25 m long) were most common (8 out of 16 with recorded lengths) and belonged to a variety of time periods. Three of the four longest bridges were attributed to the Hasmonean and/or Herodian periods: Hyrcania [#70/#71] had a 150 m long bridge and Alexandrion [#64] had a 187 m long bridge.[28] The longest recorded bridge was on the Beirut aqueduct and measured 220 m long with an arch spanning 20 m in the centre.[29] This bridge had three tiers of arches and is comparable in design to the Pont du Gard [Fig. 6.17].[30]

The bridges varied in height from 1 m to 30 m. Only two bridges (out of 15 with recorded heights) were higher than 25 m: Cypros [#94] had a bridge 25 m high dating to the late Roman period and Antioch [#22] had a bridge 30 m high with a Trajanic or Hadrianic date.[31] The height of the Beirut bridge has not been recorded, but probably belongs in this bracket as well. The five bridges [#64 Alexandrion, #68 Cypros, #70 Hyrcania and two bridges at #71 Hyrcania] in the 10 m – 25 m range all dated to the Hasmonean or Herodian periods.[32] This highlights a possible trend towards higher bridges with the advent of the Romans, but the data are too slight to make any firm conclusions.[33]

Five arcades were recorded. Two were dated to the Herodian or procurator period, one to the 1st century AD, one to the 2nd century AD and one was of unspecified date. On the Herodian arcade to Jerusalem (High Level) 15 piers were traced and its length was 2 km.[34] As arcades were clearly a Roman technology, it is particularly interesting that two of the aqueducts with arcaded sections may be Herodian: Jerusalem High Level and Caesarea High Level channel A. This suggests that Herod may have been an agent of transmission of this technology to the east.

[28] Hyrcania: Patrich 2002, 343. Alexandrion: Amit 2002c, 308.
[29] Davie *et al.* 1997, 274.
[30] *Ibid.* The Pont du Gard was 275 m long, 48.77 m high and had a maximum span of 24.52 m: Hodge 2000b, 65.
[31] Cypros: Meshel and Amit 2002, 325. Antakya: Wilber 1938, 56.
[32] Amit 2002c, 308; Meshel and Amit 2002, 321; Patrich 2002, 338-343, 346.
[33] This would be in line with Hodge 1992, 40.
[34] Amit 2002b, 253.

6.2.5 Pipelines and siphons

Twenty-six pipelines and inverted siphons were recorded; of these ten have been identified securely as inverted siphons.[35] An inverted siphon is the common term used to describe the section of an aqueduct that is led through a pipeline in order to cross a depression (as an alternative to circumventing the depression or building a bridge across it) using the hydraulic principle that water will find its own level [Fig. 6.18].

After a masonry *specus*, ceramic pipelines were the most common form of aqueduct in the Roman Empire; they are known, for example from Oinoanda, the Kuttolsheim aqueduct, Rimini and Cosenza.[36] Pipelines were also used as a device by which to transport water through leaking sections of aqueduct channel, for example on a section of the Caesarea High Level channel B aqueduct that suffered repeatedly from subsidence.[37] This aqueduct saw many repairs and alterations, one of which was the insertion of a triple ceramic pipe set in lime concrete on the channel floor to the east of the Jisr az-Zerqa tunnel as a solution to the leaking channel [Figs 6.4 and 6.19]. The pipes themselves were replaced shortly afterwards by an open channel carried on a solid wall (channel C). Similarly, in the Mamluk-Ottoman period, a ceramic pipeline was inserted into the section of the Jerusalem Low Level aqueduct that runs through the Jewish Quarter.[38] This solution was also used at Lyon.[39]

Of the sixteen pipelines recorded, one was in basalt blocks [#51 Susita/Hippos] and eleven were ceramic [Auara, Caesarea-High (3), Tiberias, #74 Jericho palaces, #46 Dor, #49 Emmaus, #52 Susita/Hippos and Umm Ratam]. This higher use of ceramic reflects the pattern across the rest of the empire. The pipelines varied in preserved length from 2 m to 2.5 km. Individual sections of pipeline varied in length from 0.3 m to 0.7 m and in diameter (not including stone sections) from 0.08 m to 0.45 m. Individual sections made of stone had a larger diameter of between 0.6 m and 0.8 m. There was a broad distribution of dates for the pipelines from which no clear pattern could be discerned. This suggests that there was a continuity of this technology over a long period of time. Two pipelines were branches feeding bathhouses and one a reservoir (see below section 6.3.2).

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[35] On the use of the term siphon see Smith 1976, 51; Blackman and Peleg 2001, 411.
[36] Hodge 1992, 113-116; Stenton and Coulton 1986, 18; Bodon *et al.* 1994, 261; Wilson 2000e, 599.
[37] Porath 2002b, 110.
[38] Mazar 2002a, 222, fig. 10.
[39] Hodge 1992, 117.

Of the ten inverted siphons, two of which were on rural lines that also supplied irrigation water, three used stone pipes [Jerusalem – High, Tiberias and #64 Alexandrion] and two ceramic pipes [Caesarea – High and #49 Emmaus]. Again there is no obvious pattern relating to the dates of these structures. Lead was usually used in Roman inverted siphons, but stone pipelines are known from elsewhere in the Roman Empire, particularly in south-western Asia Minor, as well as Italy and North Africa (see Chapter 2.4).[40] Ceramic pipelines in inverted siphons, however, were very rare and were restricted to the Greek world with three other examples from Spain; in general they appear to represent a continuation of previous, Hellenistic practice (see Chapter 2.4).[41] When one takes into account the preference for ceramic pipelines over lead pipelines in urban and domestic contexts (see Chapters 7.4 and 9.2.10), it is not surprising to find that for inverted siphons ceramic was preferred over lead too. It is possible that this difference derived from varying lead resources between east and west. The chief sources of lead were in Spain, Gaul, Sardinia and Britain, though small reserves are known in Asia Minor.[42] The costs involved in transporting such a heavy material, large amounts of which would be needed in an inverted siphon, may have been a strong reason for choosing local materials. In addition, as for arch dams (Chapter 4.3), it is possible that it was not felt necessary to replace an existing, well-functioning technology, i.e. technologically 'superior' options were not necessarily the ones selected from a suite of techniques.

Information concerning the dimensions of these structures is, sadly, quite sparse. Only the head of the inverted siphon on the Alexandrion [#64] and Jerusalem [#29] aqueducts are known: 12.5 m and 34 m respectively.[43] The Jerusalem inverted siphon had a venter bridge, which survives to a height of 0.65 m (though originally it must have been much higher) and a length of 300 m.[44] Both of these examples are not exceptionally high, which in the case of the 2nd-century AD Jerusalem inverted siphon is surprising as most Roman siphons were over 50 m high and bridges were preferred up to that point.[45] It is

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40 Stenton and Coulton 1986, 46, 53 fig. 9; Wilson 2000e, 599.
41 Lewis 1999, 157. See Hodge 1992, 131, 232 on the rarity of ceramic pipes on inverted siphons.
42 Healy 1978, 61-2; Stenton and Coulton 1986, 48.
43 Alexandrion: Amit 2002c, 309. Jerusalem: Peleg 1991a, 130.
44 Mazar 2002a, 227. This is contrary to Stenton and Coulton who state that there was no venter bridge on the Jerusalem siphon: Stenton and Coulton 1986, 51.
45 Hodge 1992, 156.

possible that the Herodian arcade may have been in a poor state of repair and so was replaced by this inverted siphon.

The two inverted siphons on the Apamea line are described as being underground and 'roofed using large rectangular stones in such a way to form a paved road which is level with the surrounding ground, so any rainwater streams can flow over easily. Also the aqueduct water cannot escape under pressure resulting from water flowing into and out of the siphon.'[46] This arrangement in the base of the valley illustrates an astute solution to overcoming damage to inverted siphon lines that ran in the base of seasonal wadis. Damage and subsequent repairs caused by seasonal runoff have been recorded on sections of the Jerusalem Low Level aqueduct that were located on slopes.[47] Furthermore, the inverted siphons at Apamea seem to have been slab-built, rather than being lead, stone or ceramic pipelines; this is of importance as it has been claimed that only three other slab-built inverted siphons are known: one at Alexandrion, one at Lucus Feroniae and the other at Angitia in Italy.[48] We may now add a fourth site to this list.

The phasing of the inverted siphon at Alexandrion is disputed. Garbrecht and Peleg are of the opinion that a slab-built inverted siphon could not have functioned effectively, that it did indeed fail and was replaced by the stone wall (187 m long x 10 m high), which must have been a substructure for a channel, that runs parallel to it.[49] Amit, however, believes that the slab-built inverted siphon was the later construction.[50] He claims that the ramp/bridge/wall was Hasmonean and the inverted siphon Herodian on the strength that the two installations did not function at the same time. Although it may be true that the two installations did not function simultaneously, without further firm dating evidence it cannot be known to which phase each of these structures belongs.

Four lines had special features. Firstly, the inverted siphon on the Beth Yerah branch of the Tiberias aqueduct had circular openings in the basalt pipe blocks measuring between 0.1 m to 0.12 m in diameter [Fig. 6.20]. It is not clear in the report how many blocks had these holes or whether they were, for example, on every block or every second block. Secondly, the ceramic pipeline on the southern Caesarea line had three open tanks

[46] Shahada 1957, 160. Translation kindly provided by Dr Khalid Kamash.
[47] Nadelman 2000, 161.
[48] Jones 1962, 197-200; Amit 2002c, 309.
[49] Garbrecht and Peleg 1994, 168.
[50] Amit 2002c, 309.

connecting pipes going up and back down again [Fig. 6.21-23].[51] The third tank was badly preserved, but the two other tanks were well preserved (0.6 m long x 0.65 m wide x 0.15 m deep (minimum) and 0.65 m long x 0.2 m wide and 0.3 m deep). The bottom of both tanks was situated above the pipeline: 0.8 m above and 1.1 m above respectively. Thirdly, one of the three ceramic pipelines on the Caesarea High Level aqueduct channel B had two pairs of elbow bends that interrupted the flow.[52] Lastly, there were two 'siphons' on the Aleppo aqueduct marked on a plan in the same valley close to Aleppo.[53] These structures are described as columns and were vertical structures containing pipes [Fig. 6.24].[54] It is possible that they belong to a later phase and were *suterazi*. *Suterazi* (= water balance) is a system of repeated raised tanks that limit head; it was used frequently by the Ottoman Turks.

In his description of inverted siphons Vitruvius refers to a series of devices called *colliviaria*, which are commonly explained as being a kind of escape valve used to reduce water pressure or release accumulated air.[55] All of the features described above have been said to be Vitruvius' enigmatic *colliviaria*. As is clear from these examples, there is some discrepancy over the physical attributes of *colliviaria.* This problem has haunted the study of siphons and if we accept that Vitruvius' discussion is obscure, it seems best not to ask whether these are *colliviaria*, but rather to determine what was the function of these features.[56]

It is thought that the Beth Yerah openings may have released air pressure or released air trapped in the system when it was filled. If the pipeline did go sub-atmospheric (i.e. pressure inside the pipeline was below that of atmospheric air outside it), this might be tenable. It is, however, an unnecessary solution in a pipe system that does not go sub-atmospheric because air trapped at a high point is taken into solution and the ensuing confused internal flow will entrain and remove the air.[57] In addition, releasing air pressure

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[51] Peleg 1991a, 137.
[52] *Ibid*. 136 and Porath 2002b, 110.
[53] Mazloum 1936.
[54] Winogradov 2002, 301.
[55] Vitruvius VIII.6; Hodge 1992, 154.
[56] On Vitruvius' discussion see Smith 1976, 55-6; Lewis 1999. A session at the latest *Cura Aquarum* conference in Ephesus (2004) was also dedicated to this topic, again with rival ideas presented, none of which seemed to solve the problem satisfactorily.
[57] Blackman and Peleg 2001, 411.

would not be an issue because there is no air pressure to relieve when the siphon is in flow and air locking cannot be a problem because the siphon does not flow above the hydraulic gradient.[58] If the pipeline did not go sub-atmospheric, the only remaining possibility is that these openings were used to clean the system. Fahlbusch has suggested, somewhat fancifully, with reference to the holes on the pipelines at Patara and Laodikeia in Turkey, that heated vinegar may have been poured into the holes to help with the removal of sinter.[59]

The tank arrangement on the southern Caesarea line was similar in design, if not in scale, to those at Aspendos and on the Madradag siphon at Pergamom. Kessener suggests that these tanks were used to release air pockets during the start up operation, but as shown above this argument is not tenable.[60] Blackman acknowledges that without this theory the reason for such tanks and towers is incomprehensible.[61] It is, of course, possible that the release of air pockets was the reason that the tanks were installed and that it highlights a misunderstanding by the Romans, as well as by several modern writers, on the subject.[62] The elbow bend structures also present problems of interpretation and their purpose is again unclear.

On another technical point, the stone pipelines on the Jerusalem aqueduct [#29] and at Susita/Hippos [#51] were embedded in concrete. This would have prevented leaks and also countered water hammer (a potentially damaging pressure surge or wave created when the water flow is forced to stop or change direction suddenly).[63]

6.2.6 Settling tanks and other installations

A total of 15 settling tanks or basins were recorded. These installations had an even distribution of dates from the Nabataean to late Roman period. Similar small tanks and basins have been found on the Oinoanda, Madradag (Pergamon) and Cologne aqueducts.[64] With the exception of the tank at Khan al-Manqoura, these installations varied in length

[58] Smith 1976, 57-8.
[59] Fahlbusch 1991.
[60] Kessener 2000, 125-6.
[61] Blackman and Peleg 2001, 413.
[62] For example Lewis 1999, 167, who claims that valves are unavoidable in siphon systems to release trapped air at natural humps.
[63] Blackman and Peleg 2001, 413.
[64] Stenton and Coulton 1986, 21; Garbrecht and Holtorf 1973, 68-72; Haberey 1971, 62.

from 0.5 m to 4.5 m, in width from 0.5 m to 1.85 m and in depth from 0.6 m to 5 m. The Khan al-Manqoura settling tank was part of the reservoir and measured 42 m long x 29.2 m wide.[65] Most of the settling tanks were located close to reservoirs, cisterns or pools. The four tanks on the Susita lines were all placed before the beginning of the inverted siphon pipeline and must have been used to prevent the pipeline clogging up with debris.[66] Three of the tanks were recorded as having a plaster lining: #51 and #52 Susita and Banias.[67] It was also noted that the floor of a settling tank on the Banias line was 0.3 m below the level of the pipeline.[68] Two installations described as water-troughs (0.75 m long x 0.75 m wide) were found on the Jerusalem Arrub aqueduct in Wadis Arrub and al-Jisr, but again it is unclear if these are settling basins.[69]

Several other installations and structures were also noted along the course of some of the aqueducts, which seem to be related to their construction and upkeep. Limekilns were observed along the routes of four aqueducts [Jerusalem Arrub; #74 Jericho; #70 Hyrcania and #94 Cypros].[70] On the Cypros line these kilns were located in the vicinity of every bridge or tunnel along the aqueduct's course. In addition, two lime mines were found near the [#71] Hyrcania aqueduct.[71] These installations were almost certainly related to aqueduct construction. A square structure was recorded on the slopes of Wadi Taktak on the Jerusalem Arrub aqueduct.[72] In addition, a rock-cut chamber has been found on the route of the Beirut aqueduct. It seems plausible that these structures were used as shelters by construction or maintenance crews. A manhole was recorded on the Ramat Hanadiv aqueduct [Fig. 6.25].[73] It was constructed of ashlar masonry and measured 1.5 m long x 1.3 m wide x 1.8 m deep externally and 0.6 m x 0.7 m internally.

[65] Musil 1928, 32.
[66] Ben David 2002, 204-5.
[67] Susita: *Ibid.* 204-5. Banias: Hartal 2002, 94.
[68] Hartal 2002. 94.
[69] Mazar 2002a, 217.
[70] Mazar 2002a, 217; Meshel and Amit 2002, 327; Netzer and Garbrecht 2002, 368; Patrich 2002, 344.
[71] Patrich 2002, 341.
[72] *Ibid.*
[73] Hirschfeld 2000, 309; Hirschfeld 2002b, 395.

6.3 Sociological aspects of aqueducts in the rural landscape

6.3.1 Status and power: the building and maintenance of the aqueducts

In the empire as a whole the subject of who paid for and built aqueducts has not been given the attention it deserves in the past, though there are moves towards rectifying this situation. It is the generally accepted opinion that the city collectively would manage to pool resources by either the donations of rich citizens or tax levies since the cost was usually beyond that of a single act of *euergetism*.[74] The cost of building aqueducts was immense; C Iulius Secundus, for example, donated 2 million *sesterces* for the construction of the Bordeaux aqueduct.[75] For this reason private aqueduct construction was rare, except in North Africa where c. 30% of the aqueducts whose funding source we know were privately funded.[76] Alternatively, imperial benefactions were granted to cover the construction costs. It is also proposed that on these occasions imperial architects and foremen were used, as is suggested by the use of building techniques such as *opus reticulatum* outside Rome and Italy (see above Section 6.2.2).[77] In consequence of these imperial associations, it is commonly thought that aqueducts 'constitute physical manifestations of Roman imperialism'.[78] The subject of maintenance and upkeep has received less attention, but is believed in the main to have been undertaken by personnel organised at a municipal level.[79] Sub-contracting or outsourcing is known from an annual contract for running a water supply in Egypt.[80] This model is well reasoned and makes sense, but does it apply to the Near East?

The evidence for who paid for and built the aqueducts in the Near East comes from epigraphic as well as literary sources. On account of the strength of Di Segni's research, the literary and epigraphic material from Israel has received more attention than the rest of the study area (with the exception of Antioch) and will, therefore, have to form the bulk of the evidence for the region as a whole.[81] It should be noted from the start, however, that it is always possible that practices differed across the provinces in question. Sadly, for many

74 Eck 1987, 74-9; Leveau 1991, 153-4; Leveau 1992, 233-5; Wilson 1996, 18.
75 Leveau 1991, 153; *CIL* XIII, 596.
76 Wilson 1997, 146-49.
77 Leveau 1992, 234-5; Wilson 1996, 18-9.
78 Hitchner 1995, 157. Also see Leveau 1987.
79 Leveau 1992, 236.
80 P.Lond.1177.
81 Di Segni 2002.

questions and debates on this topic this level of information and investigation is not open to research due to the present state of work outside Israel.

The Acropolis aqueduct [#40] at Antioch was donated by Julius Caesar. Later, Antioch received aqueducts from three emperors: the north and central aqueduct built by Caligula and the southern aqueduct built by Trajan and Hadrian. These benefactions are all recounted by Malalas in his *Chronicles*.[82] In addition to these benefactions for the building of aqueducts, Justinian also donated money after the earthquake of AD 526 for the restoration of the aqueducts.[83] A fourth aqueduct at Antioch [#37], probably built in the 2nd century BC, may have had Roman involvement too. A graffito of a name inscribed twice in the wall of this aqueduct seems to name Cossutius who may be the same Roman architect who, according to Vitruvius, supervised the work on the Temple of Zeus in the Olympieion at Athens on behalf of Antiochus Epiphanes.[84] While the graffito may have been written by an Italian craftsman, architectural analysis from the Temple of Zeus seems to suggest that Cossutius was working in the Greek architectural tradition, hence his links with the Seleucid monarchy.[85]

Seven inscriptions from the Caesarea High Level aqueduct channel B mention Hadrian and three others were worded to show that the work was carried out on imperial orders and are also evidence for army construction.[86] Pilate also ordered the building of an aqueduct at Jerusalem; this raised a disturbance among the Jewish population because he paid for it using 'Corban', i.e. sacred temple offerings.[87] While the aqueduct was paid for out of expropriated funds, this may have been done under the orders of the Emperor.

The use of legions in the construction of the aqueducts may also point to indirect imperial involvement and contributions, if not in actual monetary terms, at least in provision of manpower. Three aqueducts bore inscriptions that show direct legionary involvement: Jerusalem High Level, Caesarea High Level channel B and Beth Govrin [#45]. Thirty-one inscriptions naming the century of particular centurions have been found

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[82] Malalas 216.21-217.2, 243.10-21, 275.22-276.3, 277.20-278.19. Libanius also makes mention of unspecified rulers conducting water to the city, as quoted at the head of this chapter: Libanius *Orat.* 11.125.
[83] Malalas 422.4-5.
[84] Downey 1938, 160, #90. Vitruvius VII, praef. 15. 17.
[85] Anderson 1997, 20-21.
[86] Di Segni 2002, 47.
[87] Josephus *BJ* 2.9.4.

on the inverted siphon section of the Jerusalem High Level aqueduct [Fig. 6.26-27].[88] The legion was probably the *X Fretensis* that was stationed in Jerusalem from Titus' reign until the late 3rd century AD. Eleven inscriptions (two fragmentary) from the Caesarea High Level aqueduct channel B, indicate that *vexillationes* of no less than four legions (*Legiones X Fretensis, VI Ferrata, II Traiana Fortis* and *XXII Deiotariana*) were involved in its construction [Fig. 6.28].[89] A centurial inscription from Beth Govrin [#45], probably no later than the early 3rd century AD, also points to the work of Roman soldiers (*Legio VI Ferrata*) on this aqueduct.[90]

Military units occupied all these sites and it has been pointed out that almost every place where military units had an attested presence also had an aqueduct.[91] What is the connection between military sites and aqueduct building? Is the provision of aqueducts to military sites one of pure need or is it a demonstration of strength, power and skill? Were the legionaries principally providing for their own needs or helping urban development?

There is some, albeit limited, evidence to answer these questions. The imperial orders instructing the construction of the High Level aqueduct channel B at Caesarea (see above) may point to an imperial concern for general urban development. At Maximianopolis, however, the aqueduct conveyed water to the northern area of the town, which is believed to have been the location of the soldiers' camp, so it would seem that the military were primarily concerned with their own supply.[92] This seemingly self-interested action can possibly be tempered with the idea that the wells and cisterns, which probably provided the main bulk of water for these sites prior to the arrival of the military, would not be able to cope with the sudden influx of people and therefore a greater supply needed to be brought in from elsewhere (see Chapter 7.8.1.). The later introduction of an aqueduct by the

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[88] Vetrali 1967; Di Segni 2002, 41.
[89] Di Segni 2002, 47. Negev believes that these inscriptions commemorate the restoration of the aqueduct rather than its construction, but Di Segni argues that *fecit* points to the construction: Negev 1964, 248; Di Segni 2002, 47.
Imp(erator) Caesar/ Traianus/ Hadrianus/ Aug(ustus) fecit/ per vexillatione(m) leg(ionis) X Fr(e)te(nsis).
'The Emperor Trajan Hadrian Augustus made this through a *vexillatio* of the legio X Fretensis.'
[90] Di Segni 2002, 51.
Vexillatio leg(ionis) VI Ferr(atae) 'A *vexillatio* of the legio VI Ferrata.'
[91] *Ibid.* 52.
[92] *Ibid.*

military to a town has also been noted in France.[93] In addition, the close presence of the military may provide the security and protection that these costly installations would need.

The army, of course, also provided valuable manpower and expertise in aqueduct building. In Numidia, for example, the army was employed in projects for military and veteran towns from the 2nd century AD onwards because they were becoming increasingly idle and there would be an eventual profit from their activities.[94] This seems also to have been the case for aqueducts at Autun and Fréjus.[95] It is also possible that the military were involved only in the hardest tasks involving complex technology. The sections with attested military involvement include the Caesarea High Level channel B arcade and the Jerusalem inverted siphon, both of which represent sophisticated technologies. This is similar to the dam-tunnel complex at Seleucia Pieria, where the engineering challenges appear to have been met by the military as well (see Chapter 4.4). An army engineer, Nonius Datus, was also involved in a tunnelling project in Algeria; the project was almost a failure as the two crews, also military units, tunnelled past each other from either end, but were set right by Nonius Datus.[96] This example shows that it was the use of military engineers, maybe, rather than military manpower that was the important factor in complex construction.

Thirteen aqueducts are attributed to the Herodian period, with four others possibly being Herodian (Table 6.1). Two of these aqueducts fed Roman camps, which highlights the close relationship between Herod and the army. To what extent was the Herodian house influenced by Rome technologically and if it was influenced, what effect, if any, did this have on the transmission of Roman ideas across the region? Herod's Romanophile tendencies are well documented, for example the harbour at Caesarea Maritima and the use of *opus reticulatum* in Herodian architecture are clear examples of Roman technological aid. So, it would be easy to assume that Herod's aqueduct building was 'based on sophisticated hydraulic concepts of Roman engineering.'[97] How much is this true?

In the main, features along the courses of these aqueducts were not out of the ordinary, but did include bridges and arcades. It would seem from this then that the Herodian period was one of transitions, when new technologies were being introduced, but

[93] Février 1983.
[94] Fentress 1979, 164.
[95] Février 1983; Eumenius makes this comment in his panegyric at Autun in spring AD 298.
[96] *CIL* VIII.2728. Hodge 1992, 13, 128.
[97] Mazar 2002a, 238.

were being used alongside older, more established techniques. As noted above (section 6.2.4) the majority of the bridges in the region were constructed between the Herodian period and the end of the 2nd century AD. This suggests that the use of bridges first occurred in Herodian projects. The bridges constructed in the Herodian period were lower than those built later and this may reflect the fact that arches were only just beginning to be used at this point.

Similarly arcades seem to have been introduced to the region during the Herodian period (section 6.2.4). Both of the arcades were built on large urban aqueducts, rather than on private, palace aqueducts, which would suggest that they were built to be seen and admired. A similar point on visibility has been made to explain the use of arches on the aqueducts to Oinoanda and Blaundos, which feature on sections close to, and visible from, the city.[98] It seems possible, then, that another trigger for technological exchange from the higher levels of society may be linked to the functions of benefaction. In this case it seems reasonable to suggest that Herod may have been trying to display not only his own personal close links to Rome, but also to show off the technological benefits of such an association. Indeed, Josephus tells us that as part of his building programme to show his magnanimity (τὸ μεγαλόφυχον ἐπεδείξατο), Herod constructed an aqueduct for Laodicea (ὑδάτων εἰσαγωγήν).[99]

Herod appears to have had a key role in the introduction, transmission and diffusion of Roman technology in the East. He was an effective link between Roman and local. This can be seen as the circulatory effect of the Roman Empire.[100] So, Herod may be described and viewed as an influential agent in 'middle ground' behaviour in the Roman East.

There is limited evidence for municipal involvement in aqueduct construction. The present opinion among Israeli scholars is against the idea.[101] Hirschfeld claims that the Ramat Hanadiv and Shuni aqueducts were not municipal projects, but he presents no clear evidence to back up this assertion.[102] In Syria, however, the aqueducts to Kanata and Suweida were both dedicated to Trajan, under the governor Aulus Cornelius Palma, who

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[98] Stenton and Coulton 1986, 31.
[99] Josephus *BJ* 1.21.11.
[100] Gosden 2004, 105, 110, 113.
[101] Di Segni 2002, 54.
[102] Hirschfeld 2002b, 387-8.

was governor of the province in AD 104/5-107/8.[103] These epigraphic formulae were typical of municipal construction elsewhere in the Empire: dedication to the emperor and mention of a governor who has gained permission to use civic funds.

There is only one attested example from the East for private benefaction: an inscription from a bathhouse in Apamea lists the many and substantial benefactions of C. Iulius Agrippa, including the aqueduct.[104] While the paucity of evidence for private aqueduct benefaction may be explained partly by the low epigraphic habit in the East, it may also indicate that this was not a commonplace activity and that North Africa was exceptional in this regard.

The cost and responsibility of aqueducts did not, of course, stop at construction, but extended into the upkeep and maintenance of these structures. Surprisingly, however, this subject is not studied as much as it deserves; for example, it is all but excluded from Hodge's seminal work on aqueducts.[105] There were three main areas that needed to be dealt with: protection of the aqueducts from vegetation and cultivation; ongoing routine maintenance and major structural repairs.

In the case of protecting the aqueducts from vegetation and cultivation, the Theodosian Code records a ruling from Constantine to Maximilianus, Consular Administrator of the Water Supply that landholders through whose lands aqueducts run must clean the aqueducts when they become choked.[106] Personal responsibility for the protection of the aqueducts is also seen in a post-Justinianic imperial edict found near

[103] Di Segni 2002, n. 95, 101. Kanata:
῾Υπὲρ σωτερίας αὐτοκράτορος Νέρουα Τραιανοῦ Καίσαρος Σεβαστοῦ Γερμανικοῦ Δακικοῦ ἀγωγὸς ὑδάτων εἰσφερομένων εἰς Κάνατα ἐκ προνοίας Κορνηλίου Πάλμα πρεσβευτοῦ Σεβαστοῦ ἀν τιστρατήγου. 'For the safety of the Emperor Trajan Sebastos Germanicus Dacicus an aqueduct was brought to Kanata through the foresight of Cornelius Palma, legatus Augusti pro praetore.'
Le Bas and Waddington 1853, #2305. From the *nymphaeum* at Suweida:
Αὐτοκράτορι Νερούᾳ Τραϊνῷ Καίσαρι, Σεβ(αστοῦ) υἱῷ, Σεβαστῷ Γερμανικῷ Δακικῷ το τ[έμενος] κ αὶ τὸ νύμφαιον ἀφιέρωσεν ἡ πόλις, τὸν ἀγωγὸν τῶν ὑδάτων [κατασκευάσασα], ἐπι Α(ὔλου) [Κορνελίου Πάλμα] πρεσβ(ευτοῦ) Σεβ(αστοῦ) ἀντιστρ(ατήγου). 'For the Emperor Trajan…, the *polis* was blessed with a *temenos* and *nymphaeum*, having been equipped with an aqueduct, in the time of Aulus Cornelius Palma, legatus Augusti pro praetore.'
It is possible that the governor may have been Aulus Cornelius Palma's successor Aulus Julius Quadratus.
[104] ἀλειφαντα καὶ ποιήσαντα ἐν τῷ [...]ῳ ἀγωγῷ ἱκανὰ μείλια 'having anointed and having built in the … channel pleasing gifts as is befitting': *AE* 1976, no. 678; Rey-Coquais 1973, 41-46; Leveau 1991, 154.
[105] Hodge 1992. See Fahlbusch 1991 on the problem of sinter in pipelines.
[106] *Codex Theodosianus* 15.2.1.

Bethlehem.[107] The edict forbids anyone from planting or sowing within 15 feet from each side of the aqueduct on pain of death and confiscation of property [Fig. 6.31]. Similar edicts are known throughout the empire from the Augustan period onwards, though none was as heavy-handed with the punishment as this example. Augustan legislation on the Venafrum aqueduct decreed that 8 *pedes* must be protected on either side of the aqueduct.[108] Frontinus records a decree of the senate that forbade the planting of trees and crops within 15 feet of aqueducts and ordered the uprooting of wild vegetation in this area as well.[109] Two proconsuls from Ephesos issued edicts in the 2nd century AD stressing that a 'safety zone' of 10 *pedes* must be kept on each side of the aqueduct; transgressors had to pay 50,000 *sestertii* to the city and an equal amount to the emperor.[110] One of these inscriptions also attests to illegal tapping in the town, which caused a lot of damage to the aqueduct.[111] A 4th-century imperial decree from Constantinople stated that 10 feet on each side of the aqueduct must be kept free from trees; interestingly in this case the rule also applied to the lead pipes in the Baths of Achilles.[112]

Ongoing routine maintenance seems to have been in the hands of city officials. According to Libanius, plebeian manual labourers overseen by curiales usually undertook the general daily upkeep of the aqueducts at Antioch.[113] Choricius of Gaza tells us that the governor, Stephen, consul of Palestine, improved the Caesarea High Level aqueduct in AD 530–535, removing the old hindrances (τὰ πάλαι κωλύματα).[114] It seems that the municipal authorities and Stephen's predecessors had failed to discharge their duties of maintaining the aqueduct and supervising the maintenance respectively (see chapter 7.8.2). Choricius also suggests that skilled workers carried out the repairs, which may mean that some of the work needed specialist care, for example, replastering the *specus*. In this case,

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[107] Di Segni 2002, 58-9.
[108] *CIL* X 4842 = *ILS* 5743; Johnson *et al.* 1961, 114-5; Bruun 2000, 593.
[109] Frontinus *Aq.* 2.126-27, 129.
[110] *Inschr. Eph.* VII, 3217; Freis 1984; Wiplinger 2004-2006, 21-23.
[111] ἔτι τε τοὺς ἔχοντας ἐν [τῆ] πόλει τάς οἰκίας ἀδικεῖν τὸ ὕδωρ ἀνοίγματα ποιοῦ[ντα]ς καὶ είς ἀπρεπεῖς αὐτῷ ὑπηρεσίας κα[ταχρ]ωμένους ὡς τῆ ἁμαρτίᾳ αὐτῶν πολλὰ άτοπα γενέσθαι...
'The homeowners in the town damaged the water supply, in that they made openings and used the water for inappropriate reasons so that much damage was caused by their wrongdoings...'
[112] *Codex Justinianus* XI 43.6.1-2; Ware 1985; Bruun 2000, 594.
[113] Libanius XLVI.21, XXV. 43.
[114] Choricius of Gaza, *Laudatio Aratii et Stephani* pars. 44-49; Di Segni 2002, 61.

it would seem that as the city authorities had not cared for the aqueducts effectively, the governor had to be called upon; this is more akin to major structural repairs (see below).

Major structural repairs due to damage derived from several, dramatic, sources: earthquakes, seasonal flooding/runoff and subsidence. In some cases this may have resulted in the complete severing of the aqueduct line, such as at Misyaf where a section of the aqueduct was moved several metres to the west by an earthquake [Fig. 6.29]. In other cases severe leaks may have occurred, as evidenced by the limescale incrustation on the outside of one of the aqueduct bridges in Antioch [Fig. 6.30].

Under these circumstances, the aqueducts were repaired by governors and with imperial aid. Evidence from Bosana in Syria suggests that a spring-house was renovated in AD 365 by a syndikos, who seemed to be responsible for defending the interests of their town in front of the emperor or provincial governor.[115] It is possible that this repair may have been necessary due to a big earthquake that year. As noted above, Justinian donated money after the earthquake of AD 526 for the restoration of the Antioch aqueducts.[116] The aqueduct at Bosra, known only from epigraphic evidence, as well as several other public buildings, were renovated under Justinian using money from the provincial funds (παρὰ τῶν δημοτικῶν).[117] This damage may also have been caused by the earthquake of AD 526. In addition, an inscription from the Caesarea High Level aqueduct records that in AD 385 Flavius Florentius, proconsul of Palestine, renovated both High Level aqueducts from the foundations.[118] The inscription was found in the swampy Kabara area where it would seem the aqueduct had been damaged by being on unstable foundations.

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[115] Le Bas and Waddington 1853, #2239:

Ἐκ προνοίας καὶ σπουδῆς Παυλείνου συνδίκου καὶ [Λ]ουκ[ιλιαν[οῦ] πιστῶν, τῶν... εταξυτων?... ἡ π ηγὴ ἐθεμελιώθη καὶ ἀνενεώθη ἐν αὐτῷ τῷ ἐνιαυτῷ, ἔτους σξ τῆς ἐπαρξ[είας.

‘With forethought and speed Paulinus, the *syndikos* and with faith Lucilianus, paid for?/were appointed to? the spring foundations and what lay on it every year, in the … year of the governor.’

On the role of *syndikoi* see Le Bas and Waddington 1853, #1176; Liebeschuetz 1972, 169.

[116] Malalas 422.4-5.

[117] *IGLS* 13.1, 9128-37. Di Segni 2002, 64.

[118] Hamburger 1959, 189-90; Di Segni 2002, 61.

Ἐπὶ Φλ(αουίου) Φλωρεντίου τοῦ μεγαλοπρεπεστάτου ἀνθυπάτου τὰ δύο ὑδραγώγια ἐκ θεμελίων ἀν ενεώθη.

‘In the time of Flavius Florentius, the most magnificent proconsul, the two aqueducts were renovated from the foundations.’

In conclusion, it would appear that several different bodies undertook the costs and responsibility of aqueduct construction: emperor, client king, municipal authorities and the legions. The evidence from Antioch seems to point to a high degree of Roman imperial involvement in aqueduct building there, but it was no ordinary Roman town. As provincial capital, it is more than likely that Antioch had a special status and may have been subject to more imperial favour than other towns and cities. Antioch was maybe exceptional in the number of imperial benefactions that it received and in the extent to which they were documented. Trajan and, to a lesser extent, Hadrian, seem to have been the most prolific aqueduct builders, which is reflected in the peak of aqueduct construction in the Near East in the 2^{nd} century AD (Table 6.1). Herod was also an extraordinary figure in the field of aqueduct construction, being responsible for an early rise in the numbers of aqueducts built in the region (Table 6.1), as well as being a catalyst for the use and dispersal of newer technologies.

As far as maintenance was concerned, it was the responsibility of the landowner through whose lands the aqueduct traversed to protect and maintain that section of aqueduct.[119] Day-to-day upkeep was in the hands of city officials. Larger structural repairs were the responsibility of city officials and provincial governors. Where the structural repairs were caused by a natural disaster, direct imperial help would need to be called upon.

[119] Leveau 1991, 154 notes the responsibility of local users for aqueduct maintenance, but does not consider how expenses were covered in larger renovation schemes.

6.3.2 The rural – urban divide

Of particular interest for this study are the branch lines coming off urban aqueducts. Much previous research into aqueducts across the empire as a whole has been based on the dichotomy of productive rural aqueducts versus consumptive urban aqueducts; a theory embodied by Ellis in his conclusion:

'The aqueduct could thus in itself be a sign of domination, removing the productive capacity from the rural hinterland, and enslaving a rural spirit in an urban fountainhead.'[120]

More recently some strong evidence has been presented suggesting that this theory needs to be adjusted and that there was a more symbiotic relationship between the rural and urban water supply.[121] The significance of this topic goes beyond studies on water supply as the conclusions drawn here can play a key part in economic discussions on the relationships between urban centres and their hinterlands. The bulk of the water supply evidence so far has come from the western provinces and North Africa, but more can now be added from the Near Eastern provinces.[122]

A total (minimum) of 39 branch lines was found in the study on 18 aqueduct lines, 10 of which were urban lines [Caesarea High Level channels A and C and Low Level, Banias, Beth Govrin [#45], Samaria [#60], Sepphoris – e-Reina, Tiberias, Beirut and Sbeiteh] and 8 of which were rural [Cypros [#68], Hyrcania [#71], Jericho palaces – south-west and north, Qumran, Urtas, Machaerus and Umm Ratam].

Twenty-six of the branch lines were probably used for agricultural or industrial purposes, fifteen of which were on urban lines. Around the top of many of the access holes (ranging from 0.42 m to 1.06 m wide) through the top of the vault of the Caesarea Low Level aqueduct a wide ring of mortar was found to support a superstructure that sometimes survives as several courses of cut stone and sometimes a single course of worked stones.[123] It is thought that these may have served to draw off water for nearby agricultural land, most likely using water-lifting devices, possibly a *shaduf*.[124] On the Banias aqueduct a steep

[120] Ellis 1997, 149. Also see: Shaw 1984; Leveau 1987, 96, 98, 104; Corbier 1991; Shaw 1991, Hodge 2000b, 47.
[121] Wilson 1999, 328-9; Gazenbeek 2000. See also Piras 2000, 248 on a branch line from the Aspendos aqueduct. Also Wilson 1997, Intro.
[122] The evidence from the Roman Campagna, the western provinces and North Africa has been thoroughly discussed in Wilson 1999.
[123] Everman 1992, 186.
[124] *Ibid.*; Wilson 1999, 328.

chute [3.8 m long x 0.66 m wide] descended 2.4 m to the west to water nearby fields.[125] A similar chute led to fields from the Sbeiteh aqueduct.[126] A branch line leading to a settling tank (1.48 m wide x 2.38 m long) and rectangular pool (14.5 m wide x 21 m long x 2.2 m (minimum) deep) was found on the Sepphoris aqueduct.[127] The excavators believed that the pool was used seasonally for swimming and bathing, but it seems equally likely, if not more so, that the pool was a storage reservoir for irrigation. A branch line drawn from the tunnel of the Beirut aqueduct probably had agricultural purposes.[128]

Saarisolo found several branches on the late Roman Tiberias aqueduct leading down to the lakeshore.[129] Six storage reservoirs were also found in the agricultural zones near this aqueduct, all lined with the same plaster as the *specus*.[130] The best-preserved reservoir (3.45 m wide x 4.4 m long x 1.5 m deep) seems to have been fed by terracotta pipes and part of a channel leading water from the pool to the fields also survived.[131] In addition, at least six mills seem to have been fed by the aqueduct.[132] The same aqueduct almost certainly supplied a probable dyeing complex of uncertain date consisting of a series of interconnected pools.[133]

Two other features on urban lines may have had rural or agricultural uses. On the Beth Govrin aqueduct [#45] a grooved stone (1.25 m long x 0.45 m – 0.65 m wide) lying in topsoil is believed to have been part of a chute feeding agricultural zones.[134] Secondly, on the Samaria line [#60] a secondary channel was found, but it is unclear if this channel irrigated the slope or was a by-pass channel for the settling pool near by.[135]

Seven of the branches probably fed rural buildings, five of which were taken from urban lines. Three of these branch lines came off the Caesarea High Level aqueduct.[136] One branch piped water west from channel C to a reservoir at either a villa or a monastery at Tell Tadwira. Two branches came off channel A; the first branch (known as Channel E)

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[125] Hartal 2002, 90.
[126] Tsuk 2002c, 77.
[127] Tsuk 2002a, 284-5.
[128] Davie *et al.* 1997, 247.
[129] Saarisolo 1927, 53; Winogradov 2002, 299.
[130] Winogradov 2002, 300.
[131] *Ibid.*
[132] Saarisolo 1927, 15, 51-2; Winogradov 2002, 299.
[133] Saarisolo 1927, 51-2.
[134] Sagiv *et al.* 2002, 181.
[135] Frumkin 2002, 272.
[136] Porath 2002b, 116-7.

seems to have fed a pool at a late Roman site on Tell Tanninim and the second piped water to the 'Christian building' where it fed a bathhouse and fishpond. Finally, the Tiberias aqueduct fed two branch pipelines to bathhouses at Beth Yerah and Hammath.[137]

We know from water laws that the drawing of water direct from aqueduct lines, rather than from reservoirs, was illegal, but numerous archaeological examples suggest that it was common practice.[138] Permission could, however, be sought to draw off water with a regulated *calix*. This rule was often flouted as shown by an inscription from Ephesos that refers to the damage caused to an aqueduct by illegal tapping inside the city (see above section 6.3.1).[139] In addition, the Theodosian Code records specific rules about how much water may be drawn off for private bathhouses.[140] The Theodosian Code also records that pipes off the aqueduct at Daphne were too large.[141]

Some of the branch lines listed above may have been illegal, but some of them may have been granted exemptions. It seems, for example, from Italy and North Africa, that the practice was common. In the cases of the seven branch lines to rural buildings, it would seem reasonable to assume, given the high status of the buildings being fed (villas and bathhouses), that these lines were paid for by the wealthy owners of these rural 'estates'. This also may have been the case in the Roman Campagna; Pliny for example complains that the waters of the *Aqua Marcia* and *Aqua Virgo* were diverted to villas and suburban gardens.[142] In addition, we know from Frontinus that about two-sevenths of the aqueduct water for Rome was delivered outside the city itself.[143] Villas and bathhouses close to the Nîmes and Arles aqueducts also may have benefited from a channelled supply.[144]

It is more difficult to know who owned and paid for the branch lines used for agricultural and/or industrial purposes. There is evidence from the East for the following landholders: the state (fisc or emperor), the Church, large-scale landowners (such as Libanius who owned entire villages peopled by tenants), small to medium landowners and lessees (free-farmer communities, who were not *coloni*) and the military (veterans and

137 Saarisolo 1927, 53; Winogradov 2002, 300-302.
138 *Cod. Theod.* 15.2.4-6; Frontinus 2.97.
139 Wiplinger 2004-6, 21-23.
140 *Cod. Theod.* 15.2.3.
141 *Cod. Theod.* 15.2.2.
142 Wilson 1999, 315. Pliny *NH* 31.42.
143 *Ibid*. Frontinus *Aq.* 78-86.
144 Benoit *et al.* 1994, 160-62; Wilson 1999, 323, 326.

soliders).[145] Unfortunately inscriptions do not survive on the branch lines or installations that might suggest which of these landholders owned them, nor do we have any other evidence concerning landownership in the vicinity of these branch lines, such as the two maps from near Rome, which detailed the names of estate owners and the numbers of pipes they owned.[146]

Several scenarios are possible. The installations may have belonged to wealthy landowners who were entitled to and/or paid for their water supply, such as the state, the Church (in the late Roman period) or large-scale landholders. Alternatively, a group of lower class people may have co-operated to pay for the water supply. While co-operation in agricultural projects specifically is not attested to, there is evidence for groups of farmers pooling money in other contexts. At Qabr Hiram, near Tyre, a group of farmers (*georgoi)* paid for a church mosaic pavement, and at Zahrani, near Sidon a group of farmers donated money for marble revetment of a church ambulatory.[147] In the Hauran, *georgoi* set up a statue to Nike at their own expense.[148] In these two scenarios the cost of the branch line could probably have been easily borne out and recouped by the increase in profit from a higher agricultural yield. The lines may also have tapped the aqueducts illegally. In this case, while it may have been possible that this was the action of a wealthy, but miserly landowner, it seems more likely that it would have been done by poorer, peasant farmers. Where actual channels or pipelines left the aqueduct, as on the Caesarea High Level aqueducts, their visibility would suggest that they were legal (or the channel-builders foolish).

In terms of the rural versus urban debate, it makes good economic sense to use water that is travelling through agricultural land for agricultural purposes as well, especially if it is making previously badly-watered land more productive. This would not only have saved money that would have to be spent on alternative irrigation schemes, but also brought in money. After all, urban centres could not consume what was not being produced. The use of water from urban aqueducts in a rural environment makes them both consumptive and productive.

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[145] Kraemer 1958, 20; Jones 1964, 415-6; Liebeschuetz 1972, *passim*; Mango 1984, 312, 322, 409; Decker 2001, 38-45.
[146] *CIL* VI 1261; *CIL* XIV 3676; Wilson 1999, 315-16.
[147] Chehab 1957, 101; Decker 2001, 42.
[148] Macadam 1983, 113; Le Bas and Waddington 1853, #2479.

It has also been noted that the channel on the Tiberias aqueduct narrowed and carried less water as it reached the city.[149] A similar set-up has been found on the aqueduct to Zabi, Algeria, which has twin, parallel channels measuring 0.6 m and 0.2 m wide, the wider one of which had branch lines feeding land adjacent to it.[150] This led Saarisolo to hypothesise the following:

'The survey is of the opinion that this great aqueduct was built only for the mills and irrigation purposes…But why should the Romans in Philoteria (Kerak), Sennabris (Sinn en Nebrah) and Tiberias not have procured a supply of good drinking water also…?'[151]

Chronological detail would be useful here: were the branch lines and related structures contemporary with the main lines and part of the primary conception or added at a later date? The branches off Caesarea High Level aqueduct channel A fed significantly later buildings, so, while probably legal, were probably a later addition to the network. The similar construction of the reservoirs to the main Tiberias aqueduct line, however, may point to them being contemporaneous and therefore the rural supply was part of its original conception. While it may go too far to suggest that the urban centres were an afterthought in the building process, it is certainly significant that some of the branch lines seem to have been planned from the outset. In such a scenario, rural areas achieve a higher status and importance in aqueduct planning than has sometimes been thought, which should maybe not be a surprise. After all, the urban centres were little without their rural hinterlands, which in turn could not function effectively without a good water supply. The large size of the irrigation reservoirs in comparison to the urban reservoirs, seems relevant here as it again highlights the importance of water supply and storage in rural areas (see Chapter 4.5 and Chapter 7.8).

In the case of branch lines with granted exemptions, it can be argued that Ellis' theory of using water for social control is actually enhanced by this interpretation.[152] If water was brought deliberately to rural areas, not only was a higher yield of crops almost guaranteed, but also the rural populace were placated and would not begrudge their urban counterparts. This would go against popular views of disgruntled Mediterranean peasants

[149] Winogradov 2002, 299.
[150] Payen 1864, 11; Gsell 1902, 76-77; Wilson 1999, 321.
[151] Saarisolo 1927, 15, n. 2.
[152] Ellis 1997.

griping that they 'would have the citizens wash less so as to leave more water for the crops.'[153] In the case of illegal lines, we might see an opportunistic flouting of Roman law for the farmers' ends. Although he is talking about trade, it is interesting that Libanius says that the Antiochene villages had little need for the town; this does not sound like a disgruntled rural population that is being taken advantage of by an urban centre.[154] So, it would seem that, as argued for other parts of the Empire, the relationship between rural and urban environments does not respect the productive:consumptive dichotomy, but was more sophisticated and finely balanced.[155]

Contributing to this idea are four 'urban' aqueducts that fed gardens within or on the outskirts of urban and suburban settlement [Herodion, Daphne, #74 Jericho and Homs]. In the case of the Homs aqueduct, of the 1800 litres per second discharge, only 300 litres per second was directed towards the city; the rest was dedicated to the fertile gardens of Homs.[156] It is tempting to interpret this as a concern for both productive land and consumptive settlement as the whole system seems to have incorporated both urban and rural needs from the outset. A similar situation appears to have held outside Rome, where almost all the water from the Alsietina aqueduct, for example, seems to have been used for irrigation outside the city.[157] The watering of gardens near Antioch and Homs is also interesting, especially when taken with the evidence from Rome, as these important cities would have provided lucrative markets for the extra produce that could be grown with increased irrigation and watering. It has already been noted (chapter 5.8) that this was paralleled in North Africa and Italy where an intensification in rural hydraulic infrastructure seemed to go hand in hand with proximity to urban markets.[158] Furthermore, these data provide a handle for understanding whether aqueducts were a symbol of an imperial authority. In both the legal and illegal scenarios this was arguably not the case: in one, we see a lenient, broad-minded authority and in the other an authority that could be ignored and taken advantage of.

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[153] Leveau 1991, 159. Also see Bruun 2000, 215-6 who has difficulty finding explicit evidence for conflict over water between urban and rural populations.
[154] Libanius *Orat*. 11.230.
[155] Wilson 1999, 328.
[156] Seyrig 1959, 189.
[157] Frontinus *Aq.* 11.1-2, 85; *CIL* VI.31566 = XI 3772a = *ILS* 5796; Taylor 1997, 488-92; Wilson 1999, 317.
[158] Wilson 1999, 323.

Six rural aqueducts [#64 Alexandrion, #68 Cypros, #75 Jericho, Auara, Phasaelis and Khirbet Ayun Ghuzlan] that fed rural settlements were also used for irrigation and agricultural purposes. Four of these six rural aqueducts that have two functions date to the Hasmonean or Nabataean periods. The Alexandrion aqueduct dates to the Hasmonean or Herodian period and the Cypros aqueduct is Herodian. In the case of the Jericho aqueduct [#75], branch lines off the aqueduct seem to have been constructed in a similar manner to the main channel and may therefore have been contemporary. Is it possible, then, that multi-functional aqueducts were a feature of rural communities in the Near East prior to the Roman conquest? If this is the case, what we see in the Near East is a continuation and adaptation of a well-known practice that forms a sensible response to the dispersal of much needed and sought-after water and possibly even a practice that was then adopted by the Romans. The two aqueducts associated with Herod may suggest that he was one of the forces driving this continuation. Again this backs up the idea of the Roman Empire as a circulatory system and of Herod as one of the major agents in that system.

6.4 Conclusions

In general the techniques employed on aqueducts in the Near East did not differ from those across the rest of the empire. The use of ceramic pipelines in inverted siphons is, however, more unusual and seems to follow a pattern of preference for ceramic over lead in many different contexts in the East, as well as Asia Minor and Greece. The major technological progression seems to have been the introduction of the arch. It is interesting that Herod seems to have been a key agent in the introduction of this technology. This seems to derive from his close contacts with Rome, as well as his desire to have a Roman public identity. From the evidence available, it would seem that most aqueducts were constructed with public finance, though there is curiously little evidence for municipal funding. The low degree of private financing follows the pattern seen in the rest of the Empire, with the exception of North Africa.

The evidence from the branch lines has also shown that it is no longer tenable to suggest that aqueducts constitute ‘physical manifestations of Roman imperialism and of the role of the city in the maintenance of imperial authority in the arid, stark world of the steppe.'[159] Instead the economic advantages of aqueducts may have been paramount to the inhabitants of the East. The relationship between urban centres and their rural hinterlands seems to have been more finely balanced than a strict productive:consumptive dichotomy. This close relationship between urban settlement and agriculture has been noted in other areas of the Empire as well, for example the Roman Campagna and North Africa. Evidence for the prominence of the rural landscape, however, seems to be more prevalent in the East. This may be a consequence of what seems to be an earlier practice of mixed use of water, which would be a common-sense approach to limited supplies of water in a semi-arid zone. The development of the rural economy seen here seems to be part of a larger picture of intensification of the rural landscape throughout the period of Roman influence on the East, which culminated in the late Roman period (as seen in Chapter 5.8).

[159] Hitchner 1995, 157.