The water-supply network of Samaria–Sebaste

Amos Frumkin

History of research

In the early 1920s Y. Braslavi was the first to identify a network for conveying water from a distance to Sebaste; he visited the impressive water tunnel in Naqura and described it in detail,[1] and he also identified "a narrow stone built channel, with a terracotta pipe inside it, which conveyed water to the magnificent town of Sebaste".[2] During the excavations of 1931 the remains of the aqueducts between Naqura, Ijnisinya and Sebaste were investigated:[3] the remains of the aqueducts in this sector were mapped, cross-sections drawn and elevations taken. Part of an aqueduct at the entrance to the city and the foundations of the aqueduct bridge on the saddle east of the city were excavated. Other stretches (no longer visible today) were checked, but they did not observe the terracotta pipes or remains of the aqueduct from Shechem to Sebaste, and the network of aqueducts between Naqura and Sebaste was misinterpreted. From 1976 a new survey of the ancient water supply was conducted.[4] Various networks were located and studied (fig. 1), and they may be divided into two main types: terracotta pipes and open aqueducts. The former were built underground while the aqueducts were usually open and above ground except for a few tunnels (to hold spring water or to cross a ridge) or roofed sections (beneath a main road).

Four water systems have been discovered, two being terracotta pipes and two being aqueducts. They all made use of the water of springs close to Sebaste (Mafsala, Ijnisinya, Naqura) or further away at Shechem. Their period of use extended over hundreds of years from the Hellenistic to the early Arab period. A wide range of building techniques is represented: built and rock-cut aqueducts, tunnels, a dam, an arched bridge, terracotta pipes, and a siphon. All of the systems encountered a major obstacle at the end of their course — the large saddle east of the city whose bottom is 40-50 m lower than the elevation of the various systems. I will describe each system as it was surveyed up to the saddle, and then treat the question of the saddle separately at the end.

1. The first terracotta pipe

This pipe was found at two places along the ridge between Ijnisinya and Sebaste. The western of the two (fig. 1 no. 1) is on the east slope of the saddle to the east of the city (map ref. 1692 1870). It was exposed by chance when the foundations for a house were being dug. The pipe was installed at a depth of 1-2 m in the bottom of a trapezoidal channel dug into the ground or carved into the bedrock. The channel is visible for a distance of 15 m and the pipe survives for 2 m. This construction method provided excellent protection for the line and makes its archaeological detection difficult. The second location (fig. 1 no. 2) is on a steep slope (ref. 16960 18685) where the earth above had eroded and the pipe had been damaged by ploughing. Parts of the

---

1 Y. Braslavski (Braslavi), "Remains in Samaria and in the Sharon," *The yearbook of Eretz Israel* II-III (1924-25) 72-77 [Hebrew].

2 Ibid., and cf. id., *Studies in our country, its past and remains (L'heqer Artzenu - Avar U'sridim)* (Tel Aviv 1954) 286-92 [Hebrew].

3 J. W. Crowfoot, K. M. Kenyon and E. L. Sukenik, *The buildings at Samaria* (London 1942) 74-81.

4 This survey was conducted by the present author under the auspices of the Ofra field school, Midreshet Shomron, and the Israel Cave Research Center of the Hebrew University of Jerusalem and the Society for the Protection of Nature in Israel. A. Borenstein was in charge of the excavation. Our thanks go to all the participants. For earlier reports see A. Frumkin, "An unknown aqueduct," *Teva Va-Aretz* 20 (1978) 172-77 [Hebrew]; id., "The water supply networks to Samaria-Sebastiya in ancient times," in Z. Erlich (ed.), *Before Efrayim and Binyamin and Menashe* (Jerusalem 1984-85) 179-96 [Hebrew]. This paper summarizes the existing information on the various networks at the conclusion of the survey.

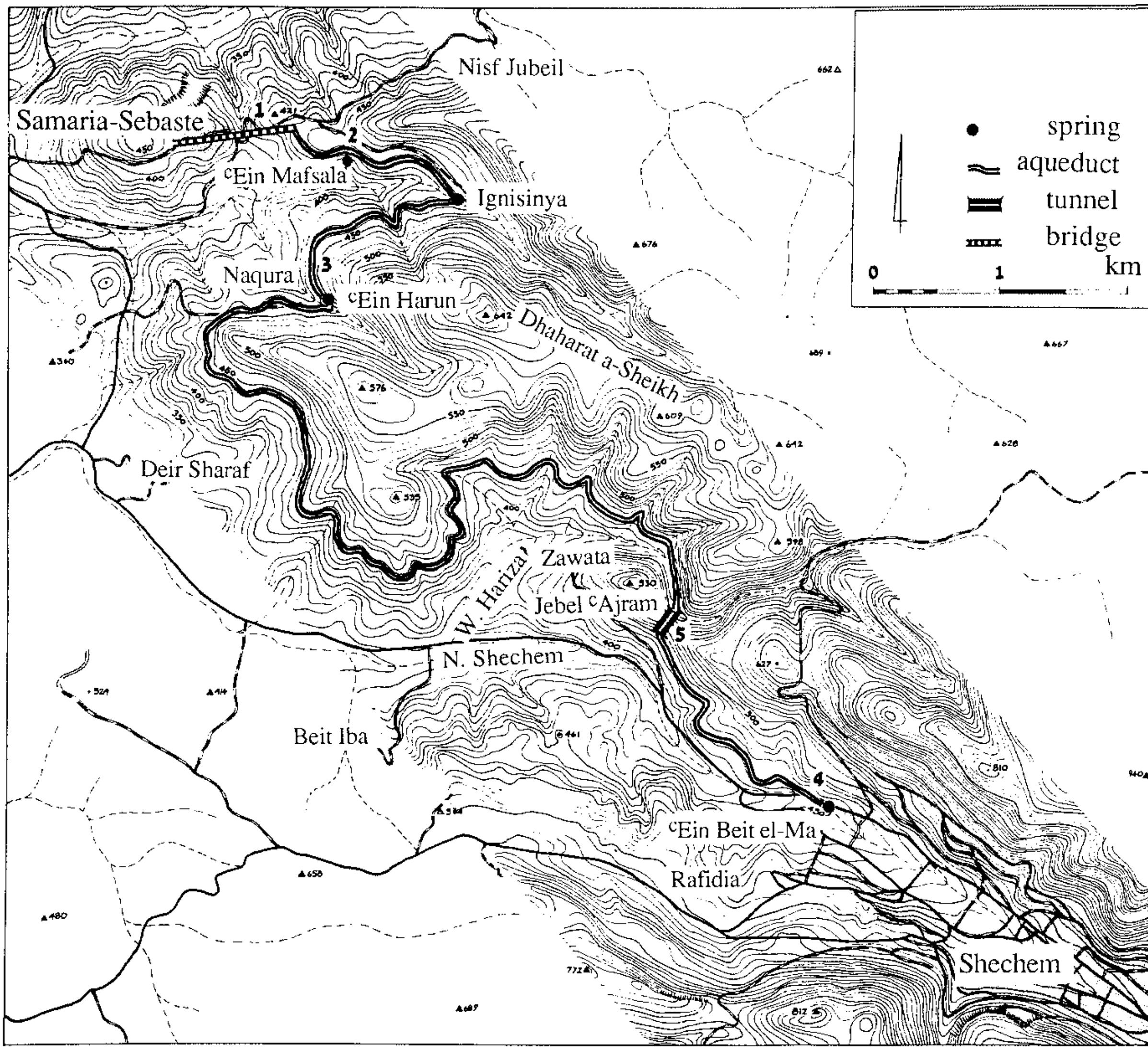
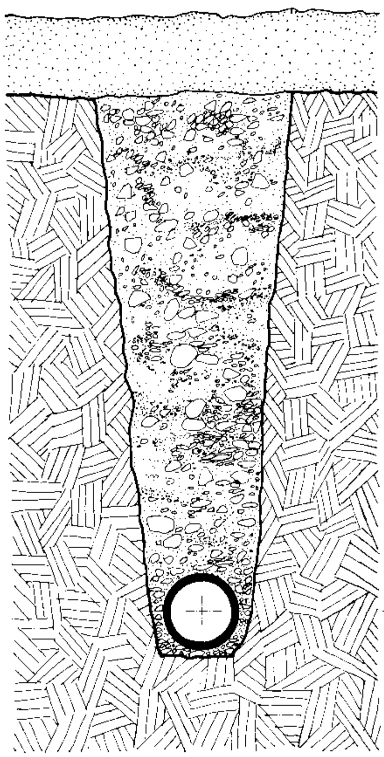


Fig. 1. The aqueduct of Samaria-Sebaste (author).

pipe were discovered nearby *in situ*. The pipe is made of terracotta segments, interior diameter 10-15 cm, length 25-42 cm, thickness of the wall 1.4 cm (the segments are roughly formed and not identical) (fig. 2). At the end of each segment is a projection which fits into the next segment; the join was then sealed with concrete. In the sections which were exposed, the pipe was laid at a constant elevation with a moderate incline, and we may conclude that it was intended to convey water under atmospheric pressure. This method is generally used for aqueducts rather than for pipes, the incline being maintained along the course; in fact this section of its course circumvents the ridge and maintains its elevation. From this assumption that water flowed under atmospheric pressure and from its gradient we can estimate the elevation of its source. The elevation of this system is lower than that of all known major sources that can be associated with the networks of Sebaste. Only one spring, ʿEin Mafsala, emerging about 30 m east of our eastern location (fig. 1 no. 2) is compatible with the elevation of the pipe. However, no remains were found in the spring of a pipe or of an installation for catching the water. This question can only be resolved by excavation. The discharge of ʿEin Mafsala is low and the spring dries up in normal years, but it is the closest spring to Sebaste and the length of the pipe to Sebaste would have been only 1.6 km. This seems to be the reason why the pipeline was built. It is of course possible that the discharge of the spring was greater at that period either through natural causes or because the water flow was maintained artificially. There is no direct evidence for its date but terracotta pipes placed underground, even when there was no need to convey water under pressure, were common in the Hellenistic period, and such a date would be consistent with the overall pattern given by the other networks, namely, that the closest source was exploited first.[5]



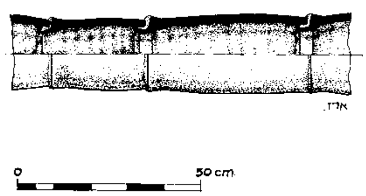


Fig. 2. Longitudinal section of the first terracotta pipe, and a section across the channel with the pipe inside it (author).

2. A second terracotta pipe

A second terracotta pipe was found in the course of agricultural digging near the first, on the eastern edge of the saddle east of the city (ref 16920 18715). The exposed section is 2 m long. It had been laid inside a channel dug to a depth of about 1 m and then covered over. Other sections of this pipe seem also to have been set deep in the ground, which is why they have not been found. The pipe runs from east to west directly towards the city, at an elevation 69 cm higher than that of the first pipe. The terracotta segments differ from the first, with inner diameter of 8-11 cm, length 22 cm, and walls 2.5 cm thick on average, but the segments are joined in the same manner. To judge by its location and direction, this may be part of a siphon to convey water under pressure across the saddle. If so, other parts of this system may have taken a different form, perhaps an open aqueduct (the elevation of all the aqueducts is higher than the elevation of this pipe) or pipes with different dimensions, though the diameter of this pipe is small in comparison with those of the other aqueducts (see below). Certainly the difference in presumed elevation between the two ends of this line on either side of the saddle is enough to create a suitable gradient to supply water under pressure. A second part of the same line may have been located in 1924 by Braslavi at the foot of Sheikh Sha'ala near Naqura. This line may have started from 'Ein Harun, which is higher than 'Ein Mafsala.

3. The Naqura aqueduct

This is the best known of Sebaste's water systems. It begins with the water-holding installation at Naqura (see below) and ends at the saddle east of the city. These remains were found by the expedition of Crowfoot and Kenyon, who also dug a section of aqueduct in the south part of the forum of Sebaste which they attributed to its continuation (no longer visible since in the area of the car park). We have located remains of this aqueduct at several points along two main sections, one being east of the saddle, the other being north of the village of Naqura some several hundred meters from 'Ein Harun (fig. 1 no. 3). Between these two points, near the

5 Josephus reports damage to Hellenistic Samaria by torrents of water in 108 B.C. (*AntJ* 13.10.3), which could possibly relate in part to a water system in use at that time.

village of Ijnisinya, no remains could be found, due evidently to damage from agriculture. But it is clear that the two points were connected, from their respective elevations and the similar plaster treatment of their channels. The elevation of this aqueduct also matches that of 'Ein Harun.

Most of the sections of this aqueduct were built of unhewn stones, with remaining parts being carved out of the Nari rock. The cross-section of the *specus* is trapezoidal, its width at the bottom being 10-15 cm, though elsewhere the 1930's expedition measured a complete cross-section of 30 cm at the bottom, 50 cm at the top and a depth of 76 cm (this section has not survived). The total length of the system is 4.4 km and we calculate its gradient to have been 0.13%. The most impressive section is that exposed beneath the forum for about 100 m, which to judge by its elevation should belong to the same aqueduct. This section is partly rock hewn, partly built, and covered by a gabled roof; one could walk inside it as far as the obstructions caused by fallen débris.

The aqueduct has two layers of plaster. The lower layer is light gray mortar with particles of ash (up to 2 mm) and other binding agents; it is not smoothed and has no sinter on top. Above it is a layer of pink hydraulic plaster using pottery fragments (diameter up to 3 mm) and other binding agents (chiefly white chalk); the surface is smoothed and it bears a thin layer of sinter (0.5 mm) indicating the passage of water. The pink hydraulic plaster according to Y. Porath's typology may date to the 3rd c. Further dating evidence may come from the tunnel of 'Ein Harun where this aqueduct originates, though the first building stage of the tunnel could perhaps predate this aqueduct.

4. The Shechem–Sebaste aqueduct

This aqueduct begins at the springs of Shechem. Being 15 km long it is the longest of the systems; its capacity is also larger than the others. We first discovered part of this system near the village of Zawata and then proceeded to find more remains along the road from Shechem to Sebaste.[6] The aqueduct originates in the valley of Nahal Shechem west of the town itself. It meanders along the sloping N side of the ravine and then moves into the bed of Wadi Hariza north of Zawata. It circumvents the valley of Zawata, crossing the tributaries which drain the southern slopes of Dhaharat a-Sheikh to the east of Sebaste. From here it continues its circuitous route, bending around the slopes above the village of Deir Sharaf until it reaches 'Ein Harun in the village of Naqura. From here it continues through Ijnisinya to Sebaste.

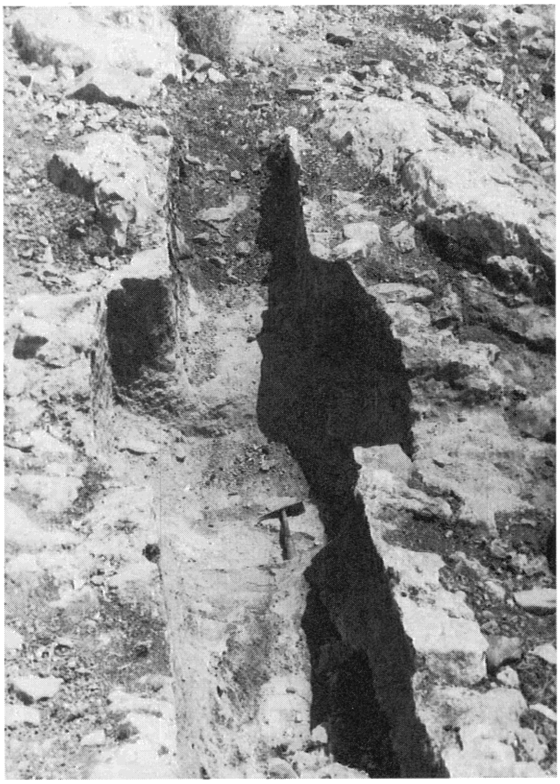
In the first part of its course the aqueduct passes through the Shechem syncline where hard limestone formations are exposed and the chalk is generally covered by a hard Nari crust. In this part many sections of the aqueduct were rock-hewn and they are easy to trace. On the west flank of the Shechem syncline, where the Nari crust is missing in many places and chalk is exposed, the aqueduct was built of unhewn stones. Depending on the nature of the terrain through which it passes, three different building methods were used: a rock-cut channel, a channel built against a rock-hewn wall with the other wall built, and a channel which is entirely built. Sinter up to 15 cm thick on the bottom of the *specus* shows that the aqueduct saw considerable use with varying water levels.

The most easterly segment that definitely belongs to this system is found at map ref. 1734 1819, where the road from Shechem to Tulkarm crosses it. This point is about 100 m west of 'Ein Beit el-Ma, the largest spring of Shechem and the closest to Sebaste.[7] The surveyers of the PEF describe "a building of good squared masonry with a round arched vault over the spring, seem-

---

6 The expedition of the 1930s had located a short section west of the village of Ijnisinya, but they attributed it to an aqueduct which they believed took water from 'Ein Ijnisinya along a large incline to Sebaste.

7 The spring is now closed in a concrete structure and its waters led through a pipe into an adjacent reservoir to be pumped to Shechem.



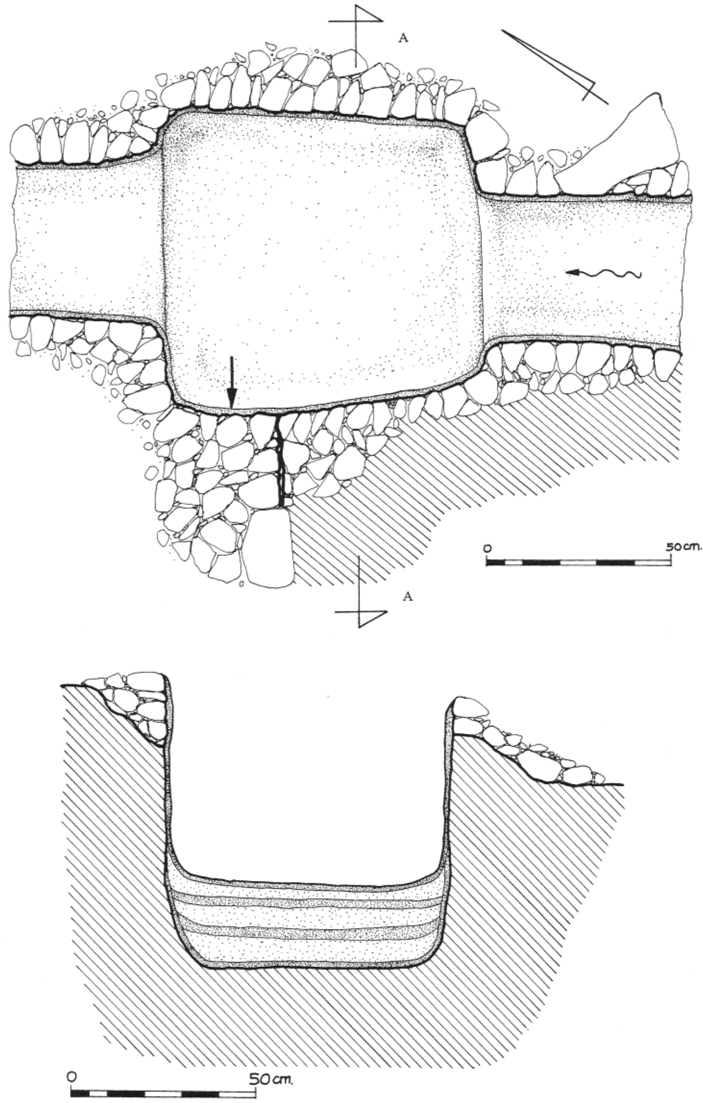


Fig. 3. The Shechem–Samaria aqueduct, a rock-cut settling pool (author).

Fig. 4. The Shechem–Samaria aqueduct, settling pool, plan and section (author).

ingly Roman or Byzantine work".[8] The aqueduct is clearly visible in the earth wall north of the road (fig. 1, no. 4). Here it is roofed with stone slabs to protect it from irrigation agriculture in the valley and from the nearby road. The elevation of the channel here is 2.5 m lower than the level of the modern pipe leading out of the spring, and it is logical to assume that the aqueduct carried water from that spring in antiquity. However, it is possible that it also gathered water from additional springs. The table below presents data on other springs, of which 6 have an elevation higher than that of ʿEin Beit el-Ma and could have supplemented the flow of this aqueduct. Two springs in particular lying about 200 m to the south of ʿEin Beit el-Ma, namely ʿEin Subian and ʿEin Batsa, should be considered. Several local aqueducts, some quite early in date, begin at these springs, intended to irrigate the agricultural plots in the valley and to operate flour mills downstream.

The aqueduct meanders from the spring for about 2 km to the NW to the foot of Jebel ʿAjram (map ref. 172 183) (fig. 1 no. 5), where it passes through a tunnel beneath the saddle that connects Jebel ʿAjram with the Mt Ebal range. About 100 m in front of the mouth of the tunnel we exposed a rock-cut settling pool (figs. 3-4) intended to prevent the tunnel from becoming blocked by sediment. In its excavation 4 layers of plaster, indicative of repairs, and clay which had

8 C. R. Conder and H. H. Kitchener, *The survey of western Palestine* II, *Samaria* (London 1882) 170.

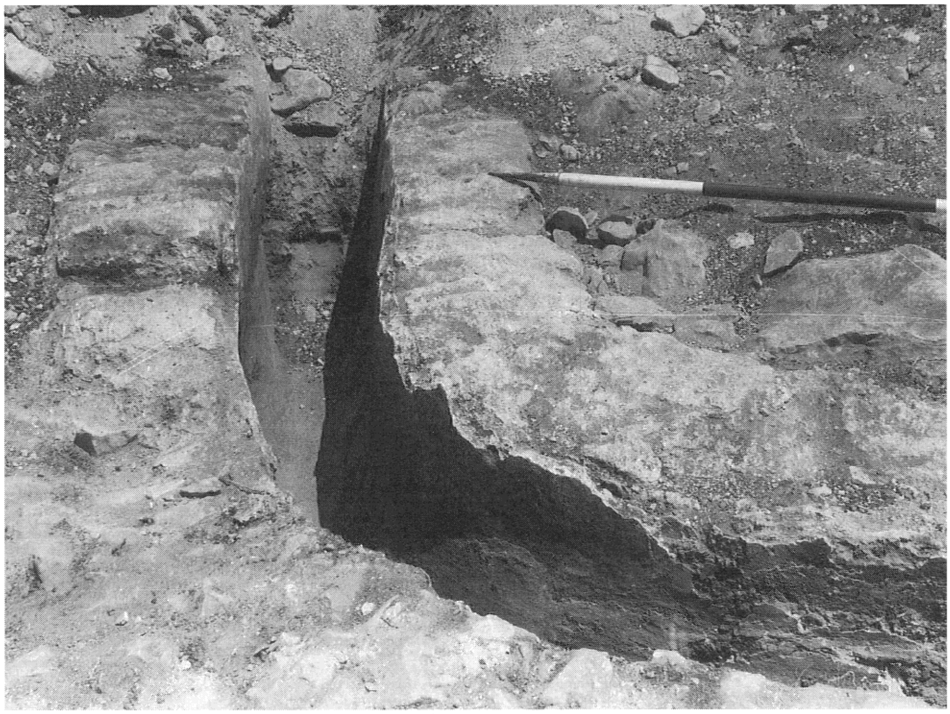


Fig. 5. The Shechem–Samaria aqueduct, a curve in the aqueduct, looking N (author).

settled in the pool were found. A cut channel on the wall of the settling pool, which looks like a branch of the main aqueduct, may have been intended to release surplus water for agriculture nearby on the slope. Possibly this branch was also used for diverting the water while the tunnel was being cleaned out or repaired. About 10 m before the mouth of the tunnel the aqueduct makes a sharp 80° turn to the northeast (fig. 5). On the outer side of the bend a supporting wall 1 m wide of unhewn stones was built (fig. 6) up against the wall of the channel itself (50 cm thick). This wall was intended to counteract the pressure exerted on the wall at the curve. Beyond the bend and adjacent to the mouth of the tunnel the channel is roofed with stone slabs, with a layer of earth above (fig. 7). One of the slabs has a stone groove, perhaps to facilitate moving it (fig. 8). The tunnel itself is now blocked with earth. It is about 200 m long. Its construction obviated the need for a detour of some 2 km. The tunnel also made it possible to maintain the elevation of the channel (otherwise up to 2 m of height would have been lost), it reduced the need to take agricultural land to build the aqueduct, and reduced the need for maintenance work and protection of such a stretch. The tunnel runs beneath the saddle which rises about 30 m above it; the tunnel does not run beneath the lowest point of the saddle but some 30 m to the west of that point. No shafts into the tunnel have been found but they may have become blocked since antiquity.

Immediately upon leaving the tunnel the aqueduct had to cross the bed of Wadi Hariza to its north bank. This was the largest ravine to be crossed, draining water from the N slopes of Mt Ebal. The aqueduct was carried across on a structure, either a dam or a bridge, whose remains are well preserved on the south bank (fig. 9). The massive wall of the structure is 2.3 m thick, of which the trapezoidal cross-section of the *specus* takes no more than 38 cm (fig. 10). Plaster is preserved on the *specus* on the external E side of the structure.

To the west of this wadi the aqueduct is visible meandering around the valley in which Zawata is located. The remains become scarcer on the slopes of Jebel el-Asad because of the local geological conditions.

A section of the aqueduct has survived near the village of Naqura above ʿEin Harun at an elevation which is about 9 m higher than the spring. Two parallel sections of aqueduct, belonging to this aqueduct and the Naqura aqueduct, were found about 200 m to the north. The Shechem aqueduct has the clear benefit of running at the higher elevation, which helps to explain

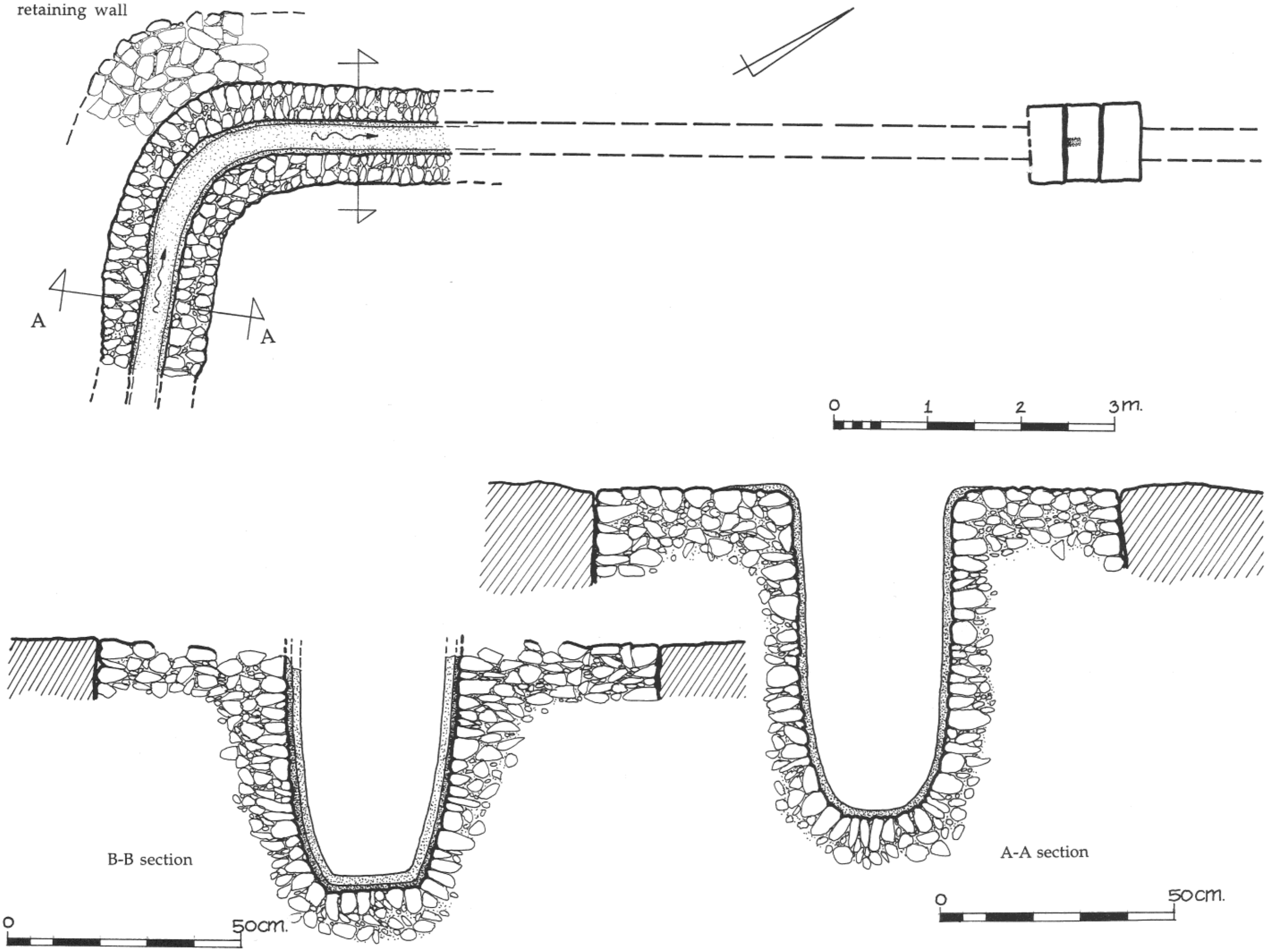


Fig. 6. A curve in the Shechem–Samaria aqueduct, plan and sections (author).

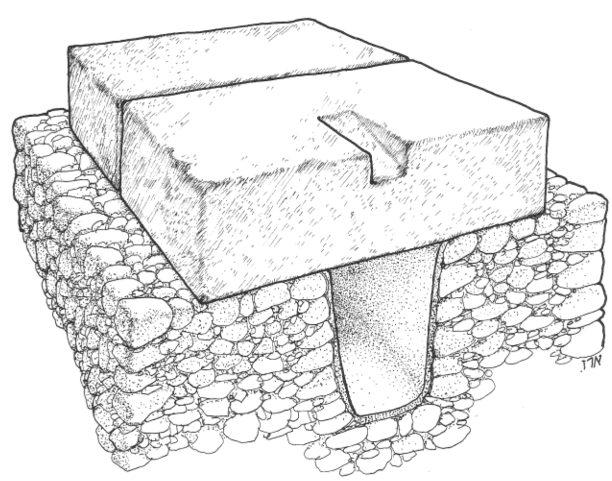


Fig. 7. The Shechem–Samaria aqueduct, stone slabs for roofing. Fig. 8. Same, covered section (both, author).

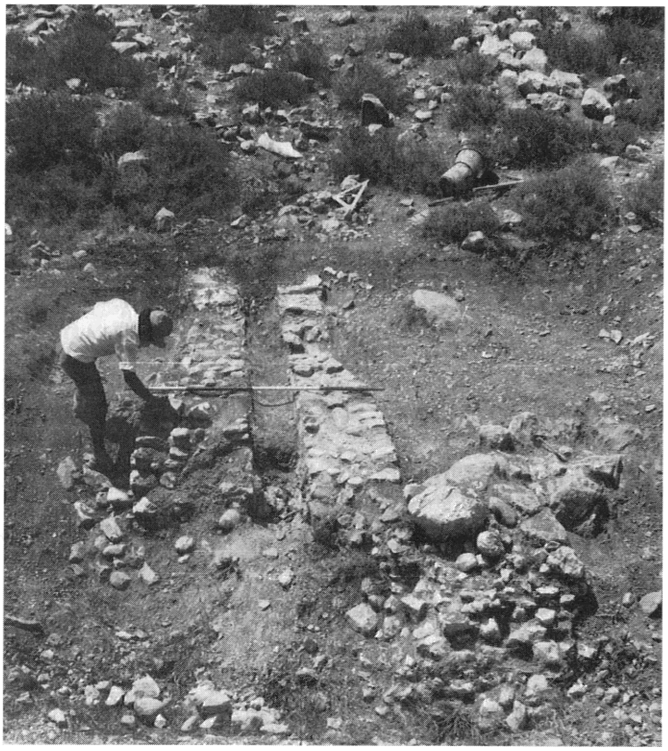


Fig. 9 (above). The Shechem–Samaria aqueduct, the structure crossing Wadi Hariza (author).

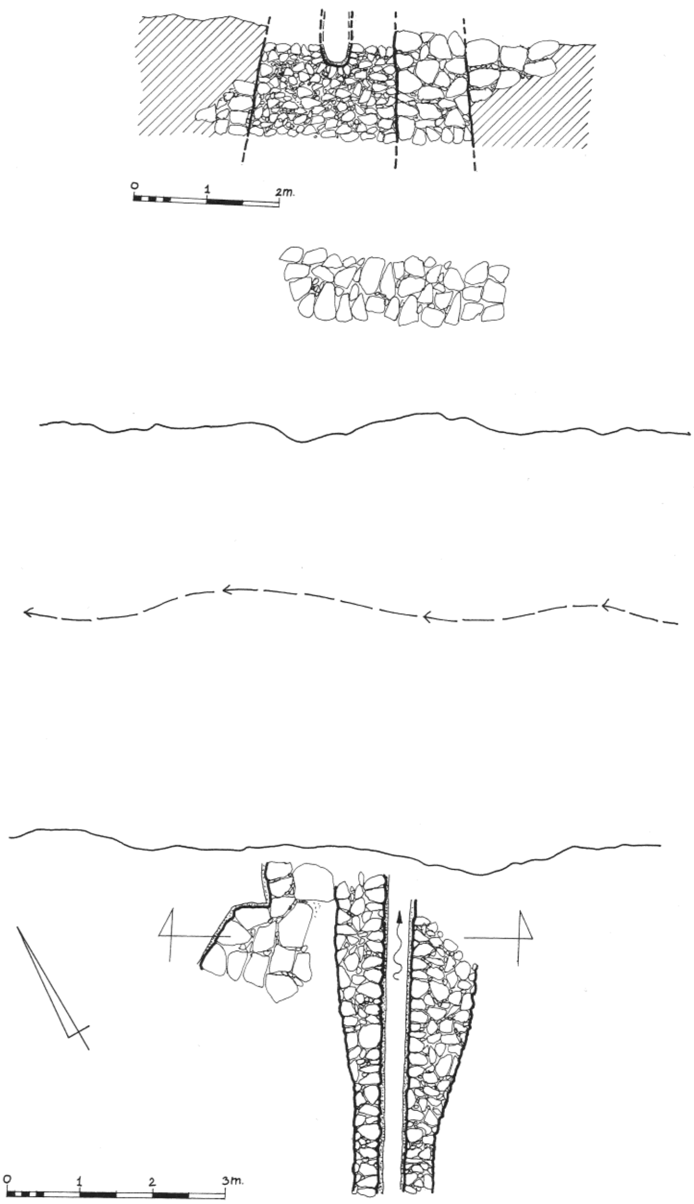


Fig. 10 (right). Same, section and plan (author).

why it was added to the previous systems. A further well-preserved section of the Shechem aqueduct was found west of Ijnisinya in a terrace wall. The expedition of the 1930s assumed that it descended a steep incline towards another ruined structure, but there is no reason to assume that the aqueduct began a steep descent at this point having sustained a moderate incline for the previous 14 km. Its high elevation was doubtless intended to reach the acropolis of Sebaste.

The date of the Shechem–Sebaste aqueduct

Four layers of plaster belonging to two different phases can be recognized in several sectors (fig. 11). Each phase consists of a grey cement-like mortar, a smooth hydraulic plaster above, and a layer of sinter on top. First comes a layer of light grey mortar with ash (diameter up to 2 mm) and other aggregates (mainly chalk and flint, diameter up to 6 mm); above is a pink hydraulic plaster, well smoothed, including ground pottery and chalky aggregates (diameter up to 5 mm), with a thin layer of sinter (0.5 mm). Next comes another grey layer of mortar, darker than the first layer, and including large charcoal granules (up to 15 mm), followed by a

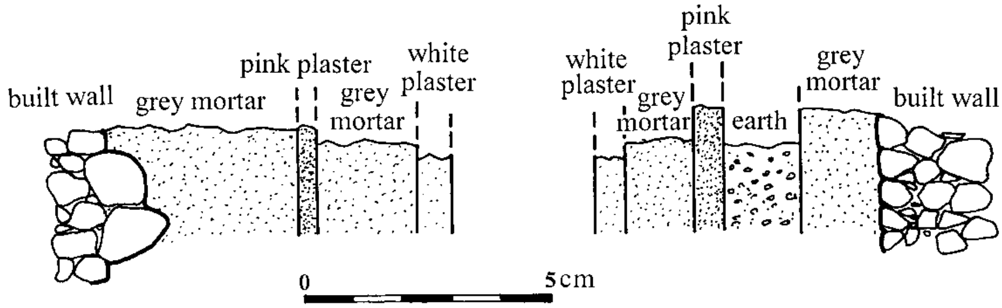


Fig. 11. Shechem–Samaria aqueduct, schematic section of the walls of the aqueduct (not to scale) (author).

layer of smoothed white plaster, including a few ground sherds (3 mm), flint and chalk granules, and finally more sinter deposits from the flow. The pink hydraulic plaster used in the first phase of this aqueduct is thought by Y. Porath to come into use in the 3rd-4th c. This may receive support from a coin of the 4th c. found in an excavation conducted at the S end of the tunnel of Jebel ʻAjram, about 1 m below the ground surface and about 2 cm above one of the roofing stones of the channel, near the mouth of the tunnel. The coin should be connected with the building or repair of the aqueduct since there is no other evidence of ancient habitation here. The grey mortar with large charcoal granules is said by Porath to be typical of the early Arab period; this later layer does not appear along the entire length of the aqueduct but only where repairs were needed. The early layers of plaster are very similar to those in the aqueduct of Naqura, and it may be that both were in use at the same time. Alternatively, Naqura may be earlier because ʻEin Harun was closer to Sebaste, and the Shechem aqueduct may have been built somewhat later to increase the capacity and raise the elevation. Towards the end of the Byzantine period the Naqura aqueduct was evidently abandoned, but the more efficient Shechem aqueduct remained in use into the early Arab period.

The springs of Shechem

The Shechem–Sebaste aqueduct originates in the vicinity of Shechem, but its exact sources are not yet known. Here we speculate on the possible use of Shechem springs for this aqueduct. The *specus* maintains a rather constant shape and size, trapezoidal in shape with rounded lower corners, a depth of 70-80 cm, width at the bottom of *c.*20 cm and *c.*30 cm at the top. It maintains an average gradient of about 0.1%. The Manning friction factor for the plaster seems to be about 0.012, and the maximum discharge of this aqueduct may be estimated at about 114 liters per second (using the Manning equation). It needs to be asked whether this aqueduct was fed only by the Beit el-Ma spring or also from more distant springs. Shechem was always rich in water.[9] The water of Samaria derived from ʻEin Harun could have been enlarged manyfold by utilizing springs in the region of Shechem. Even if the full potential of the Shechem springs were not used, one or two of the largest springs such as ʻEin Ras el-ʻEin, ʻEin Qariun or ʻEin Beit el-Ma would have sufficed. The following table presents data on the capacity of the Shechem springs and on ʻEin Harun.[10]

During the survey we checked the spring-houses to look for a possible connection with the water system of Sebaste. At ʻEin Qariun we found an intricate network of subterranean tunnels that extend under the Kasbah of Shechem but could not locate a link between these tunnels and the installations for Sebaste. This spring seems to have served as a main source for the Roman city of Neapolis, and thus it is unlikely that part of its water was diverted to Sebaste. A tunnel

9 Cf. Conder and Kitchener, ibid. 150, 167: "Nablus boasts of twenty-two springs of fresh water in its neighbourhood ... water seems to run everywhere, the sound of streams below in the valley being audible in the summer. Small mills exist all along the course of Wadi Shair."

10 The average annual capacity given in the table does not reflect sharp seasonal or annual fluctuations; thus the capacity of ʻEin Beit el-Ma measured 45.5 l per second on 2 March, 1969, but only 3.9 l per second on 3, December, 1970: Ministry of Agriculture, The hydrological service, *The springs of Judea and Samaria: description, data on the flow and quality of the water during the period 1967/8–1970/1* [Hebrew].

TABLE

spring	map ref.	altitude (m)	av. annual capacity in $000m^3$	date measured
'Ein Ras el-'Ein	17431 18021	620	462	1967/8-1970/1
'Ein el-'Asal	17445 18040	575	170	same
'Ein el-Jami'a	17460 18040	560	49	1968/9-1970/1
'Ein Qariun	17468 18060	550	572	1967/8-1970/1
'Ein Subian	17445 18165	470	100	1968-9
'Ein Beit el-Ma	17350 18184	458	594	1967/8-1970/1
'Ein Difna	17620 17990	560	103	same
			sum of Shechem springs 2050	
'Ein Harun	16950 18578	445	102	1967/8

The data comes from the Ministry of Agriculture (supra n.10). The table shows the capacity of most of the large springs of Shechem located west of the watershed except for 'Ein el-Fuad and 'Ein Sharish for which we have no data. All the springs are located at a suitable altitude for conveying water by gravity to Sebaste (the aqueduct in the forum lies at *c.*440 m asl).

for water was found by Y. Magen below the Roman *cardo* of Neapolis. It is several hundred meters in length and runs below the main road towards the west-northwest. The question of the relation between the water installations of Shechem and those of Sebaste remains open. However, a magnificent subterranean network reminiscent of the 'Ein Harun tunnel in Naqura was found in 'Ein Ras el-'Ein. Its similar method of building and roofing and its similar entrance room also recall the structure in the Naqura tunnel. The similarity between the two may point to a chronological connection and 'Ein Ras el-'Ein may have served Sebaste.

5. The saddle east of Sebaste

Sebaste sits on a hill which is isolated on all sides. On the E side it is separated from the ridge by a saddle 40-55 m lower than the elevation of the various water networks. We presume that the networks did in fact cross this saddle and that they maintained their elevation so that they could flow into the city. The Naqura aqueduct was indeed found at the correct elevation inside Sebaste, and there can be no doubt that the Shechem aqueduct, which had retained the advantage of its elevation for 14 km, did not lose it at the saddle. Today the village of Sebastiya has extended over the slopes of the saddle and survey is difficult here. Our survey therefore had to stop at the E edge of the saddle. Only the second terracotta pipe can be said definitely to have crossed the saddle with a siphon, by which the water descended to the bottom and climbed back up on the other side. Presumably the first terracotta pipe crossed the saddle in the same fashion, using the advantage of a pipe over an open aqueduct. At the bottom it had to withstand pressure of 5 atmospheres, but that was entirely within the realm of feasibility for Hellenistic engineers. On the E end of the saddle (fig. 1 no. 1) we found (not *in situ*) a square stone with a round hole inset (fig. 12) which may have been a casing for strengthening the pipe of the siphon. A second possible way to overcome the obstacle posed by the saddle was by constructing an arched bridge. The expedition of the 1930s noticed a grey band of soil crossing the saddle from E to W different in colour from the soil on its left and right, and considered it to be the sole remains of a bridge. They then revealed the foundations of two piers, 11 m apart, in an excavation. Each foundation measured 8 x 3 m and they follow the line where one would expect a bridge to be built. The

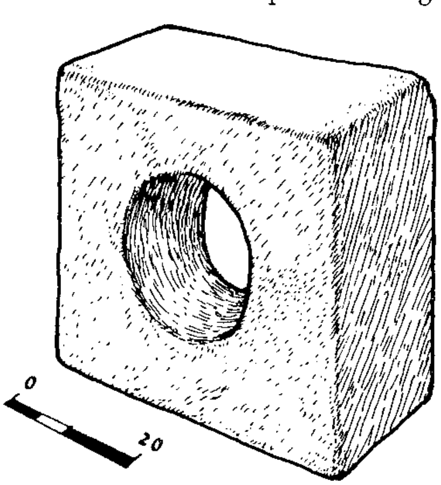


Fig. 12. Stone segment found close to the pipe aqueduct, possibly used to strengthen the pipe of a siphon (author).

foundations are placed in rock-cut trenches, but only a few of the building blocks remained. The excavators interpret them as the foundations of an arched bridge that carried the aqueduct. We assume that such a bridge carried both the Naqura aqueduct and the Shechem–Sebaste aqueduct, each on its own level some 9 m apart. Such a bridge would have been about 50 m high but this was entirely within the realm of what Roman aqueduct engineers could accomplish: a similar structure existed at Antioch.[11]

Summary

The conveyance of water from a distance to Sebaste apparently began in the Hellenistic period. The terracotta pipes which led from the nearby springs of ʿEin Mafsala and ʿEin Harun probably date to that period. Perhaps water from distant sources was used in the Herodian period, when Sebaste flourished, but no system can be definitely dated to that period and the terracotta pipes may have continued in use. The aqueduct from Naqura might have been built by Septimius Severus in *c.*200. The aqueduct which leads from Shechem might have been built by Septimius Severus or, more probably, in the 3rd-4th c., to judge by a coin found in association with the aqueduct.[12] The suggested dating scheme is compatible with the assumption that each system increased the water supply of Sebaste by utilizing a more remote source.

Department of Geography, The Hebrew University of Jerusalem

---

11 D. N. Wilber, "The plateau of Daphne, the springs and the water system leading to Antioch," in R. Stillwell (ed.), *Antioch-on-the-Orontes* vol. 2 (Princeton 1938) 49-56.

12 [Editors' note: Y. Porath's scheme (see above pp. 25-36) cannot be conceived as a conclusive dating device since it lacks any independent data for the long period between Hadrian and the year 385. In our view the Shechem–Sebaste aqueduct may best be ascribed to Septimius Severus, who reshaped the city. The 4th-c. coin and the second layer of plaster can then be attributed to 4th-c. works of repair.]

2002

JRA Supplementary Series no. 46

THE AQUEDUCTS OF ISRAEL

edited by David Amit, Joseph Patrich and Yizhar Hirschfeld