

APHRODISIAS V

THE APHRODISIAS
REGIONAL SURVEY

Edited by

Christopher Ratté and Peter D. De Staebler

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VERLAG PHILIPP VON ZABERN

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In memory of
Crawford H. Greenewalt, Jr.,
teacher and friend.

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The Aqueducts of Aphrodisias

ANGELA R. COMMITO and FELIPE ROJAS¹

INTRODUCTION

An abundant and reliable water supply was crucial for the growth of civic life at Aphrodisias and the development of the countryside surrounding it. Public waterworks such as cisterns, fountains, baths, and aqueducts were indispensable to urban development and conspicuous both inside and outside the city. Aqueducts built during the Roman period carried water over long distances to supply prominent urban monuments such as the Hadrianic Baths and South Agora pool and perhaps to facilitate the agricultural development of the valley.

Although ancient aqueduct bridges and tunnels have been visible in the Morsynus river valley and neighboring Tavas plain since antiquity, the material remains of waterworks in and around Aphrodisias have never been systematically documented or comprehensively studied. Previous scholarship on the city's water supply and management has been limited to the cursory treatment of remains such as cisterns and water pipes, or to the more detailed discussion of scattered epigraphic and numismatic evidence; little if any attention has been paid to extrurban remains.²

1. Commito is the author of the text and catalogue, except the sections "Previous Research on Water Management and Supply at Aphrodisias" and "Historical Analysis," both of which were written by Rojas. "Dating, Purpose, and Funding of the Aqueducts" was written by Rojas and Commito. Rojas was also responsible for the production of nearly all the drawings, except those produced by him in collaboration with E. Putalik, E. Corbett, or Commito.

2. Scholars have repeatedly expressed the need for a study such as the present one. Consider, e.g., F. Imhoof-Blumer's remarks concerning the identification of the Timeles river: "Zur Aufklärung dieser Flussverhältnisse bedarf es weiterer topographischer Forschungen, denen es vielleicht gelingt, Spuren des Aquäduktes aufzufinden"; F. Imhoof-Blumer, *Fluss-und Meergötter auf griechischen und römischen Münzen* (Geneva 1923) 129; and J. Reynolds's more recent comments: "We are, however, in need of a modern study of the availability of water and the arrangements for bringing it to and distributing it within the city"; J. Reynolds, "New Letters from Hadrian to Aphrodisias," *JRA* 13 (2000) 18. See also M. Guy, "Apport de l'interprétation des images de SPOT à l'exploration du site," *Aphrodisias Papers* 3, 77, who notes the need for scientific maps of the sort included in this volume. A preliminary analysis of water management within the city is currently being undertaken by A. Wilson.

The Aphrodisias Regional Survey has produced an up-to-date and detailed account of the city's extrurban aqueducts, engineering works that enabled the enhancement of the city's public infrastructure as well as the development of the countryside. We have identified and documented six separate aqueducts, named after local toponyms: Seki, Işıklar, Derince Dere, Kavaklıdere, Ören Deresi, and Timeles (Fig. 1). Three of these, the Seki, Işıklar, and Timeles aqueducts, supplied Aphrodisias in the Roman period. The Derince Dere aqueduct may have supplied two small baths in Aphrodisias during the Ottoman period. The Kavaklıdere and Ören Deresi aqueducts, remains of which are located at elevations lower than the city, may have supplied a village, farmstead, or villa, or provided water for irrigation during the Roman or Byzantine period.

The most impressive aqueduct was the Timeles, which carried water to Aphrodisias from the neighboring valley of the Yenidere Çayı. It was a major piece of Roman engineering, more than 25 km long, running in tunnels up to 50 m deep, and crossing at least a dozen bridges, which ranged in height from 5 m to nearly 30 m. This is surely the aqueduct commemorated by coins and inscriptions of the mid-second century A.D. that document the "introduction" of the river Timeles into Aphrodisias. The identification of the Timeles with the Yenidere Çayı presumably indicates that at least a portion of this river lay within or on the edge of the territory of Aphrodisias.

This chapter provides the first detailed account of the extrurban aqueducts that supplied Aphrodisias in antiquity. It also represents the first attempt to document all the major waterworks in the region, including aqueducts with destinations other than Aphrodisias and the Ottoman cisterns located throughout the valley.

PREVIOUS RESEARCH ON WATER MANAGEMENT AND SUPPLY AT APHRODISIAS

By the late nineteenth century, the main numismatic and epigraphic evidence concerning the Timeles river and its connection to Aphrodisias was already known: early

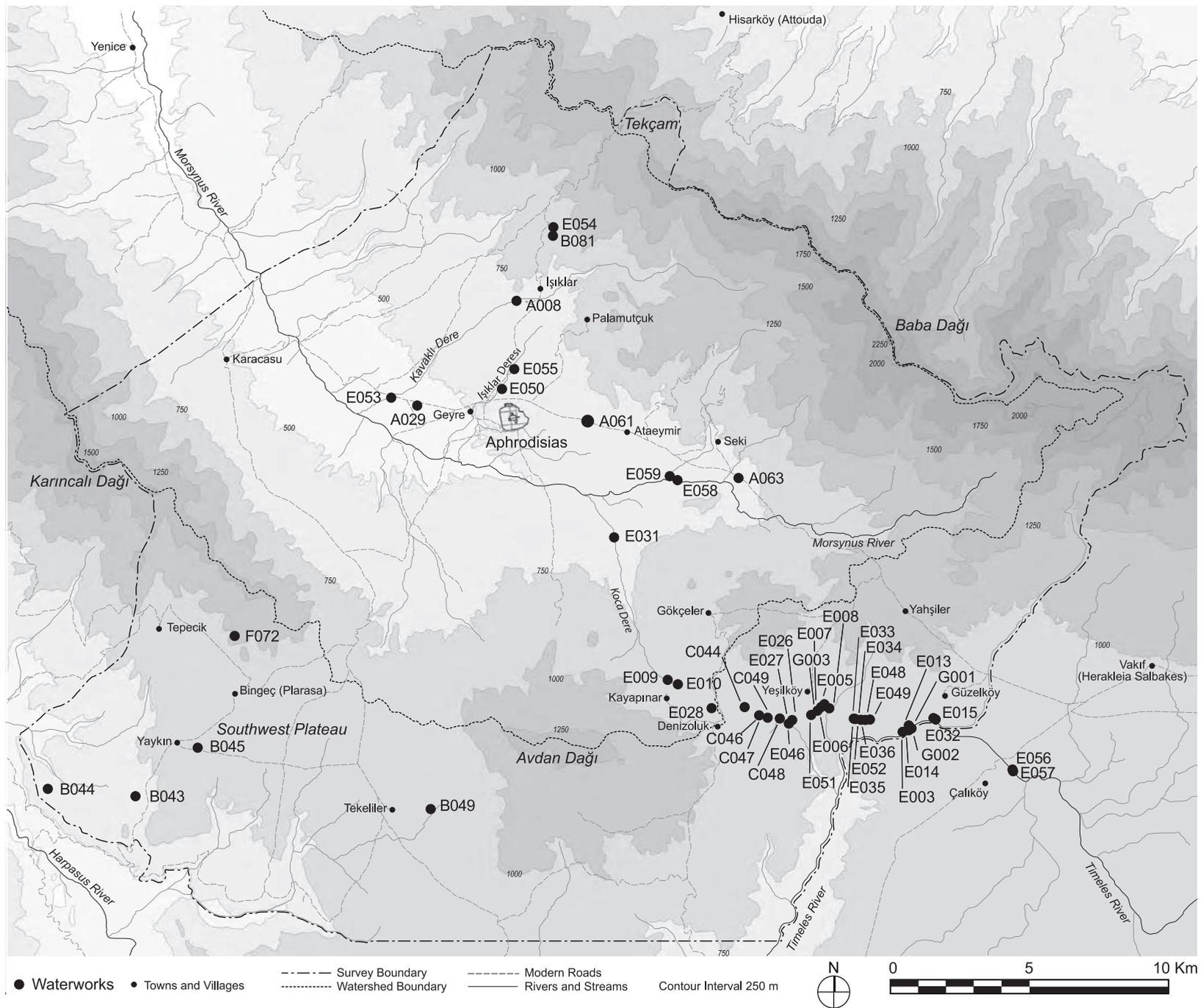


Figure 1. Map of Aphrodisias survey region showing the locations of six documented aqueducts and other ancient and medieval waterworks (1:200,000).



Figure 2. Early second-century A.D. coins of Aphrodisias (left) and Herakleia Salbakes showing a river god labeled Tímeles. After Imhoof-Blumer, *Fluss-und Meergötter*, nos. 291, 292, pl. IX no. 28 (Aphrodisias); no. 295, pl. X no. 3 (Herakleia Salbakes).

second-century A.D. coins of both Aphrodisias and Herakleia Salbakes show a river god labeled Tímeles (Fig. 2),³ and a contemporary inscription from Aphrodisias first recorded in 1705 and published in 1843 mentions the “introduction” of that river into the city.⁴ In 1895 W. M. Ramsay argued using this evidence that the Tímeles river lay within the territory of Herakleia in the ridge separating the valleys of the two towns and that an aqueduct connected it to Aphrodisias, but he did not suggest more precise topographical locations for either the river or the aqueduct.⁵

In 1904 G. Weber dedicated a few paragraphs of his “Wasserleitungen in kleinasiatischen Städten” to the issue of water management at Aphrodisias. In addition to mentioning the Tímeles aqueduct, Weber noted the remains of several water features in and around the city including baths, cisterns, basins, and pipes, which he variously and summarily assigned to the Roman, Byzantine, or Turkish periods.⁶ In 1909 H. Kiepert labeled one of many streams flowing down the slopes of Mount Kadmos (modern Baba Dağı) that feed the Yenidere Çayı as the Tímeles river, but it is unlikely that any stream ever flowed exactly as Kiepert envisaged, and it is impossible to say precisely which, if any of them, was ever called Tímeles.⁷

In 1927 R. Vagts pointed out the appearance in inscriptions of diverse water facilities;⁸ these included the “summer Olympian bath of Rhodopaios” (τοῦ Θερινοῦ

3. Imhoof-Blumer, *Fluss-und Meergötter* (supra n. 2) nos. 291, 292, pl. IX no. 28 (Aphrodisias); no. 295, pl. X no. 3 (Herakleia Salbakes).

4. *I Aph2007* 12.1111. Although here we include articles dealing with the Tímeles river, the reader is referred to the section “Historical Analysis” below for a full discussion of this material.

5. W. M. Ramsay, *The Cities and Bishoprics of Phrygia* (Oxford 1895) 189–90.

6. G. Weber, “Wasserleitungen in kleinasiatischen Städten,” *JdI* 19 (1904) 91–92.

7. H. Kiepert, *Formae Orbis Antiqui* (Berlin 1909) map IX, *Asia provincia*; for problems in Kiepert’s identification, see infra n. 93.

8. R. Vagts, *Aphrodisias in Karien* (Borna-Leipzig 1920) 49.



Figure 3. Relief from Herakleia Salbakes showing the personification of the Tímeles river. After Sheppard, “R.E.C.A.M. Notes and Studies No. 8,” 29.

Ὀλυμπίου λουτροῦ),⁹ the still unidentified baths of Hierokles,¹⁰ and some water reservoirs or holding ponds (τὰ ὑδροεγδοχεία καὶ τὰς ἐν αὐτοῖς δεξαμενὰς καὶ τὰ ὕδατα).¹¹

In 1954 L. and J. Robert discussed the topography and hydrology of the region in what was to date the most useful and comprehensive study of water management in Aphrodisias and the surrounding territory.¹² The Roberts also took into account the available numismatic and epigraphic evidence, and proposed the identification of the Tímeles river with the modern Yenidere Çayı in the neighboring Tavas plain. Our findings validate their identification, and we examine their discussion in greater detail under “Historical Analysis.” Also in 1954, J. M. R. Cormack collected what until then was the main epigraphic evidence for water supply at Aphrodisias and distinguished two major water management projects: the Tímeles aqueduct constructed under the Antonines, and a different project undertaken in the reign of Domitian.¹³ In 1981 A. R. R. Sheppard published a relief from Herakleia Salbakes that almost certainly depicts a personification of the Tímeles river (Fig. 3), thereby adding a sculptural representation of the river to the epigraphic and numismatic documentation.¹⁴

9. See Roueché, *ALA/eALA* 87; L. Robert, *Hellenica* 4 (1948) 127–28.

10. P. Le Bas and W. H. Waddington, *Inscriptions grecques et latines recueillies en Grèce et en Asie Mineure* (Paris 1870) no. 1592.

11. *I Aph2007* 12.314; on these reservoirs, see A. Chaniotis, “Twelve Buildings in Search of Locations: Known and Unknown Buildings in the Inscriptions,” in *Aphrodisias Papers* 4, 61–78.

12. L. Robert and J. Robert, *La Carie II* (Paris 1954) 46–49.

13. J. M. R. Cormack, “Epigraphic Evidence for the Water-Supply of Aphrodisias,” *BSA* 49 (1954) 9–10.

14. A. R. R. Sheppard, “R.E.C.A.M. Notes and Studies No. 8: The River God of Heraclea-on-Salbace,” *AnatSt* 31 (1981) 29.

In their report on the 1993 field season at Aphrodisias, R. R. Smith and C. Ratté mentioned the standing remains of a pier of a Roman aqueduct bridge in the vicinity of the village of Işıklar (see below, Figs. 8, 9).¹⁵ In 1996 M. Guy published an analysis of satellite imagery that was intended to illuminate the hydrology of the region further, but no attempt was made in the field to check the assumptions gleaned from photographs. Thus, although Guy's brief description of the overall hydrology remains useful, the various features identified as aqueducts in the satellite imagery have little or no correlation with the remains of ancient structures on the ground; many correspond only to modern ditches.¹⁶ Also in 1996, Ü. Öziş briefly noted the existence of two ancient water conveyance systems northeast of Aphrodisias, one at Işıklar and another between Işıklar and Palamutçuk.¹⁷ In 1997 J. Reynolds analyzed a problematic inscription that sheds light on the history of bathing facilities in the city. She distinguished at least two previous bath complexes at the site where the Hadrianic Baths were eventually erected: the Eusebian Baths, which were likely built under Tiberius and ruined ca. A.D. 41, and a second complex incorporating parts of the destroyed Eusebian Baths and itself used in the creation of the so-called Hadrianic Baths.¹⁸ Reynolds also concluded that public baths at Aphrodisias very likely first existed in the Julio-Claudian period. In preparation of a forthcoming analysis of water management within the city, A. Wilson argues against the existence of an intermediate bath building and points out that the inscription does not, in fact, indicate that the Eusebian Baths had necessarily been located at the same site as the Hadrianic Baths.¹⁹

15. "Aphrodisias, 1993," 33–58, at 38.

16. Guy, "Apport de l'interprétation des images de SPOT" (supra n. 2).

17. Ü. Öziş, "Historical Water Schemes in Turkey," *International Journal of Water Resources Development* 12 (1996) 347–84.

18. J. Reynolds, "The Dedication of a Bath Building at Carian Aphrodisias," *Studia in honorem Georgii Mihailov* (1997) 397–402; the inscription in question is *I Aph2007* 5.6. For the reuse of building material in Aphrodisias, see Chaniotis, "Twelve Buildings" (supra n. 11) 68–69.

19. Pers. comm., 5 August 2011. Although there is no certainty as to the exact location of the Eusebian Baths, we agree with Reynolds, "The Dedication of a Bath Building at Carian Aphrodisias" (supra n. 18) 398, that "the economy of using pre-existing arrangements for water supply and drainage would strongly encourage rebuilding and replacement-building of baths one after the other on the same site." However, we agree with Wilson in thinking that there is no need to hypothesize an intermediate bath complex. The baths mentioned in *I Aph2007* 5.6 were dedicated to the Olympian Gods. *I Aph2007* 11.515 mentions the contributions of Rhodopaios to the Olympian Baths; although this inscription was not found in situ, two other inscriptions mentioning Rhodopaios (*I Aph2007* 5.16 and 5.17) were found near the Hadrianic Baths, and it is likely that *I Aph2007* 11.515 stood close to

In 2000 Reynolds returned to the question of water management at Aphrodisias and published an important collection of four letters from the emperor Hadrian to the magistrates, council, and people of Aphrodisias; two of these letters concern an aqueduct that is probably the Timeles aqueduct.²⁰ Most recently, in 2008, A. Chaniotis clarified the discussion of an inscription relevant to water management, concluding that the text did not imply an aqueduct as previously suggested but rather dealt with the construction and repair of intra-urban water facilities (including gutters, canals, and reservoirs or holding ponds) undertaken during the reign of Domitian.²¹ The interpretation of these various inscriptions remains open to debate and is discussed further in "Historical Analysis."²²

SURVEY OBJECTIVES

The overarching objective of the Aphrodisias Regional Survey was to place the Graeco-Roman town in a regional context by exploring the interaction between the region's human population and the surrounding environment, from prehistory to the present day, and by investigating the Hellenistic and Roman city's exploitation of natural resources, including water. The survey goals also included those directed specifically at understanding the waterworks in the region. The survey aimed to study the hydrology of the region to identify the water sources most likely to have been exploited for urban supply and rural irrigation. In addition, it set out to investigate and document surviving aqueduct structures and to reconstruct the paths of these aqueducts using both documented structures and predictive modeling. The final goal was to place the region's aqueducts in context with a technical analysis to understand how they were built and a historical analysis to understand the circumstances of and motivations for their construction and use.

them. Finally, one of the building inscriptions of the Hadrianic Baths (*I Aph2007* 5.5) uses the honorary title "Olympios" to refer to Hadrian. All this could explain why the Hadrianic Baths were known as the Olympian Baths in Late Antiquity.

20. Reynolds, "New Letters" (supra n. 2) 16–20.

21. Chaniotis, "Twelve Buildings" (supra n. 11); the relevant inscription is *I Aph2007* 12.314.

22. Wilson would rather see the inscription (*I Aph2007* 12.314) as referring to water-related structures built specifically in association with a new aqueduct constructed at the same time; pers. comm., 5 August 2011. We did not obtain three Turkish publications that deal with water management and supply in Aphrodisias: M. Cakir, Ö. Verim, and R. Afsar, *Antik Afrodiasias Kenti Su Yapıları* (Izmir 1978); Ü. Öziş, *Su Mühendisliği Tarihi Açısından Türkiye'deki Eski Su Yapıları* (Ankara 1994), in which Aphrodisias is reported to be treated on pages 72–73 and 176–84; and Ü. Öziş, *Çağlar Boyunca Anadolu'da Su Mühendisliği* (Istanbul 1995), in which Aphrodisias is reported to be treated on page 29.

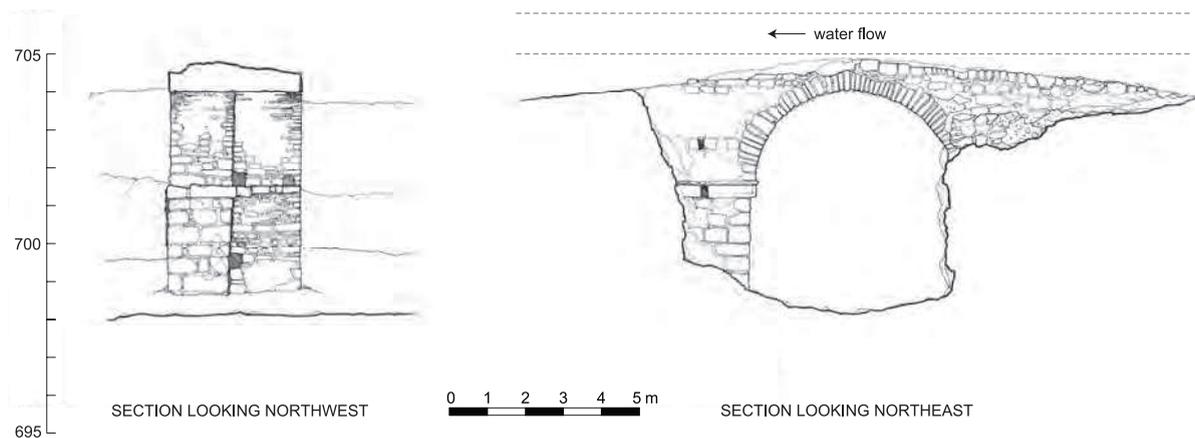


Figure 4. Yüksekkekem Deresi bridge of the Seki aqueduct (A063) (1:200).



Figure 5. Southwest side of the Yüksekkekem Deresi bridge of the Seki aqueduct, looking north (A063).

SURVEY METHODS

When the survey began in 2005, the pier of an aqueduct bridge crossing a *dere*²³ near the modern town of Işıklar had already been identified and briefly recorded (A008) (see below, Figs. 8, 9).²⁴ The survey team intended to document fully the bridge pier at Işıklar and to identify other aqueduct structures. The bridge of a second aqueduct was then identified near the village of Seki where it spanned the Yüksekkekem Deresi near the modern

23. In Turkish, a *dere* is a channel or gully of an ephemeral or intermittent stream that is usually dry but may have significant flow after a precipitation event.

24. "Aphrodisias, 1993," 38.

highway that runs through the valley (A063) (Figs. 4, 5). The Yüksekkekem Deresi aqueduct bridge was discovered during the survey team's inspection of the Ottoman bridge into which it had been incorporated.

Local informants familiar with the region pointed out most of the other aqueduct structures documented by the survey team; we then visited and investigated them for additional remains. All major structures, including bridges, conduits, tunnels, and shafts, were documented with digital photographs and measured architectural section and elevation drawings. These data were compiled into both the main survey database and a separate catalogue of aqueduct remains, which follows.

By the end of the 2008 season, six aqueducts had been identified in the region: Seki, Işıklar, Derince Dere,

Kavaklıdere, Ören Deresi, and Tımeles. Analysis of the aqueducts began by exploring the area around each of the identified structures to understand their relationship to the local topography and to search for associated remains. In addition, some of the most prominent remains such as bridges and spoil heaps from the excavation of vertical shafts could be identified on satellite imagery, which was examined in an effort to pinpoint additional traces of the aqueducts.

The locations of the identified structures of the Işıklar and Tımeles aqueducts were mapped into a Geographic Information System (GIS), and these known points were used to create predictive models to investigate possible paths for the two aqueducts. The predictive model created by A. Kuznetsov for the Tımeles aqueduct was followed on foot to check the viability of the model and look for further remains, and each new find increased the accuracy of the model. The location of documented structures was also analyzed in relation to the hydrology of the region using topographic maps marked with the location of natural springs and a soil moisture index map created with GIS data. Finally, features of the Tımeles aqueduct, by far the longest and most substantial in the region, were analyzed in comparison to other Roman aqueducts supplying ancient cities across the empire.

HYDROLOGY OF THE SURVEY REGION

A hydrology map of the survey region was created using Turkish General Directorate of Maps topographic maps at a scale of 1:25,000 marked with the location of natural springs, digital elevation and soil moisture index maps created with GIS data, and on-site observation of the valley's streams.²⁵ Aphrodisias is located in the valley of the Morsynus river (modern Dandalas Çayı), a tributary of the Maeander river fed by perennial springs east of the ancient city near the modern village of Seki. While the springs that supply the Morsynus are perennial and among the most abundant in the valley, the moderate discharge of the river itself decreases dramatically in the summer. Its resources alone could not provide the volume of water required by the ancient city, especially after the construction of immense public works such as the Hadrianic Baths and South Agora pool.

The potential water supply of Aphrodisias was further checked by the existence of an east–west-oriented ridge north of the city near the modern village of Palamutçuk. By directing the flow of water to the west of the city, this ridge effectively blocks the runoff from the springs and surface drainage of the Baba Dağı range, the

large mountain range to the north, from reaching Aphrodisias and the eastern part of the valley. Therefore, the residents of Aphrodisias had to tap sources to the east and north of the city to supplement the insufficient local supply.

Municipal information on local water management indicates that the largest springs in the region supply the villages of Dikmen, Seki, and Yeniköy in the east of the valley, while other important springs are located in the northwest near Dedeler, in the western area of the Baba Dağı range, and in the center of the valley near Ataeymir. Local inhabitants of the region emphasize the importance of the springs near Seki for agriculture and household consumption. The construction of a trout farm, water mill, and hydroelectric plant in the mid-twentieth century in the western part of the valley highlights the abundance of water resources west of Aphrodisias at elevations lower than the ancient city. In the neighboring Tavas plain to the southeast, a modern dam marks the previous location of a series of Ottoman mills powered by water from the Kepiz Çayı and its tributaries, all of which feed into the Yenidere Çayı.

Though the surface hydrology regime described here is based on modern environmental conditions, its implications for likely ancient aqueduct water sources correspond well with the actual remains. The Seki aqueduct must have tapped the abundant springs in the eastern portion of the valley. The remains of the Işıklar and Derince Dere aqueducts suggest that both were supplied by water that gathered in the western slopes of the Baba Dağı range. The Kavaklıdere and Ören Deresi aqueducts, located west of Aphrodisias, possibly collected water from the streams of the western part of the valley that are deeper and narrower than those in the east due to the influx of water shunted westward by the Palamutçuk east–west ridge.

In addition, the residents of Aphrodisias drew on water sources located outside their own valley. The longest, most substantial aqueduct was the Tımeles, which tapped tributaries of the Yenidere Çayı (Tımeles) in the Tavas plain, located beyond the hills that mark the eastern edge of the Morsynus valley. The headwaters that supplied the Yenidere Çayı provided an ample discharge of water that not only fed the Roman aqueduct of Aphrodisias but in more recent centuries supplied villages and mills and is currently stored by a modern dam.

THE AQUEDUCTS: DESCRIPTION AND RECONSTRUCTION

Assigning dates to most of the aqueducts we recorded is difficult. Construction methods and technical characteristics help determine broad chronological distinctions only. Epigraphic evidence suggests waterworks were

25. See Stearns, "Geoarchaeological Investigations," in this volume, Fig. 6, which also offers more detailed information on the hydrology of the survey region.

constructed at Aphrodisias in the Julio-Claudian period and during the reigns of Domitian and Hadrian. As discussed at length below, the Hadrianic-period aqueduct known from inscriptions of the second quarter of the second century A.D. almost certainly corresponds to the massive and technically sophisticated Timeles aqueduct (see “Historical Analysis,” below). The other water management projects known from inscriptions include at least one bath complex built before the Hadrianic Baths and perhaps on the same site. This complex, called the Eusebian Baths, was likely built in the reign of Tiberius and destroyed around A.D. 41; its materials or endowment were used for the construction of the Hadrianic Baths or, following Reynolds, for a second bath complex that preceded the Hadrianic Baths.²⁶ During the reign of Domitian, a prominent citizen named Adrastus built a system of cisterns, canals, and gutters to control the flow of water within the city.²⁷ Presumably the construction of bath complexes of the first century A.D. required an abundant, aqueduct-fed water supply. Whether the water-control facilities provided by Adrastus were constructed in association with a new aqueduct is unclear, but this seems possible. If so, it is reasonable to assume that the aqueduct in question would have been the Seki or Işıklar line. We know from the inscriptions only that the existing water management systems were repaired at this time.

This epigraphic evidence does not preclude the existence of other water-related projects including aqueducts for which no textual evidence has survived. The temptation to correlate the documented physical remains with the known epigraphic evidence must be treated with caution. However, the Seki and Işıklar aqueducts are the most likely candidates for one or more aqueducts built in association with first-century A.D. water facilities known from the inscriptions discussed above. They are smaller in length and capacity than the Timeles aqueduct and, unlike the two aqueducts in the lower valley, are located at elevations adequately high to supply the city. And whereas the Derince Dere aqueduct runs in a terracotta pipeline, which may indicate an Ottoman date, the Seki and Işıklar aqueducts appear to have run in non-pressurized conduits, as was also true of the Timeles aqueduct.

Water from the Upper Valley

1. Seki Aqueduct

Only one structure has been identified of an aqueduct at least 9 km in length, but probably longer, that must have

26. Reynolds, “The Dedication of a Bath Building at Carian Aphrodisias” (supra n. 18); the inscription is *I Aph2007* 5.6. The possibility of a transferred endowment was suggested by A. Wilson, pers. comm., 5 August 2011.

27. Chaniotis, “Twelve Buildings” (supra n. 11) 14–15; the inscription is *I Aph2007* 12.314, *SEG* 1964.731. See supra n. 22.

tapped the abundant springs in the east of the valley around the modern village of Seki. Residents of the valley today depend on these springs for their domestic and agricultural water supply. The remaining bridge of the so-called Seki aqueduct is located 8.5 km east-southeast of Aphrodisias, just northeast of the main road running through the valley (A063) (see Figs. 4, 5). The bridge is oriented southeast–northwest across the small Yükksekemer (“High Arch”) Deresi, a tributary of the Morsynus river, and sits at an elevation of 705 masl, more than 280 m above Aphrodisias.

The aqueduct bridge over the Yükksekemer Deresi is well preserved because it was incorporated into a later road bridge, becoming the southern portion of the wider structure. Constructed of mortared rubble faced with petit appareil masonry, the bridge stands at a height of 6 m and stretches 15 m across the streambed, which lies 5.9 m below the bottom of the arch. The structure is 1.7 m wide and has an arch span of 5 m. The bridge was widened in the Ottoman period by the construction of an additional arched bridge flush with its north side. The composite structure was also leveled and resurfaced with a slightly pitched profile for use as a road bridge. Calcium carbonate deposits line the underside of the aqueduct bridge’s arch and the interior of its southeast pier, confirming its use as a water-bearing structure. A modern water pipe runs parallel to the ancient structure.

The facing blocks and voussoirs of the aqueduct bridge include local materials such as fieldstones of quartz and sandstone. Marble blocks originally dressed for other purposes are incorporated into the footing and projecting courses, and a white marble block makes a prominent keystone for the arch. A pale beige lime mortar with stone inclusions, most not larger than 0.05 m, bonds the facing stones, while a hard, blue mortarlike material covers the joints between the large blocks at the base of the northwest pier and appears to be a later application for strengthening the structure. Large blocks up to 1 m in length provide stable footing for the bridge piers. The projecting course, which is visible only on the northwest pier, begins 2.5 m above the base of the pier. Above the projecting course, smaller blocks form the superstructure of the bridge. The arch springs from a point two courses higher than the projecting course. No trace of the conduit remains.

A clear seam delineates the Roman aqueduct bridge from the Ottoman bridge built against its northeast side. The Ottoman bridge is also constructed of mortared rubble faced with petit appareil masonry, but the facing blocks are smaller and more varied in size than those of the aqueduct bridge, and chinking stones are used more liberally. The later section is 1.8 m wide and has a projecting course that does not span the entire width of its northwest pier, as it is built to accommodate the

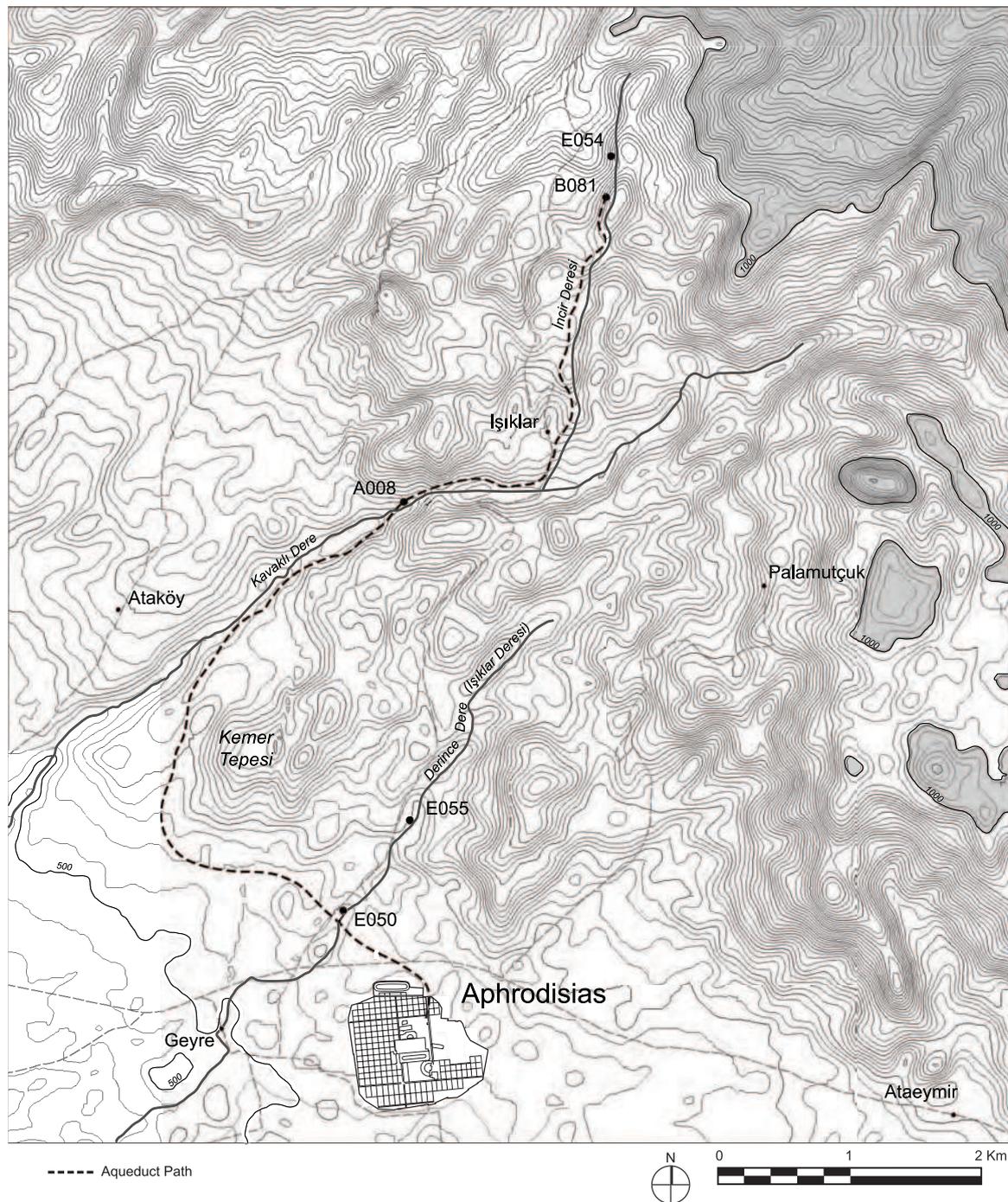


Figure 6. Documented remains of the Işıklar and Derince Dere aqueducts and reconstructed path of the Işıklar aqueduct based on standing remains and least-cost analysis predictive modeling (1:50,000).

projecting course of the aqueduct bridge, with which it is in line. The arch has a slightly greater span than the arch of the aqueduct bridge, and putlog holes remain under the arch directly above the projecting course and in the southwest corner of the pier's base.

The next stream to the west is the Alçakkemer ("Low Arch") Deresi, on the east (left) bank of which we noted a scatter of highly eroded mortared rubble, apparently in situ. This masonry may be the remains of another bridge carrying the Seki aqueduct across the next dere

on its path toward Aphrodisias, or it could be the remains of another road bridge built during the Ottoman period. Regardless, the Seki aqueduct likely passed over this stream to carry water to Aphrodisias.

The Seki aqueduct was probably built in the first century A.D. to support the consumption needs of the growing population of the city and perhaps specifically to supply a new bath complex. The aqueduct may have also supplied water to agricultural fields in the eastern portion of the valley.



Figure 7. Rock-cut tunnel of the Işıklar aqueduct in the İncir Deresi, looking south (B081).

Water from the Baba Dağı Range

Two aqueducts were identified near the modern town of Işıklar, located north of Aphrodisias in the foothills of the Baba Dağı range (Fig. 6). Both waterlines probably tapped the springs feeding the tributaries of the İncir Deresi around Çayırkazan located northeast of Işıklar in the middle elevations of the mountain range between the northernmost remains of the aqueducts at about 800 masl and the high ridge of the Baba Dağı range hundreds of meters above. Alternatively, if the aqueducts were much longer, they could have collected water from the numerous springs around Yayla Arası northwest of Işıklar, or from the springs just west of Tekçam that feed into the Dem Deresi north of Işıklar.

After tapping these springs, both aqueducts traveled from the İncir Deresi at about 800 masl, southward down the foothills of the Baba Dağı range toward Aphrodisias, across the Derince Dere (a local name for the Işıklar Deresi used throughout this chapter) at about 540 masl, and ended 20 m lower in elevation at the city. Remains of a bridge of the so-called Işıklar aqueduct on the upper portion of the Kavaklıdere indicate that this aqueduct traveled through or around the west side of the Kemer Tepesi and surrounding hills before entering the small valley of the Derince Dere. The so-called Derince Dere pipeline, however, may have taken a more direct route from the İncir Deresi to the valley of the Derince Dere by traveling east of the Kemer Tepesi.

While the Işıklar aqueduct appears to date from the Roman period, the Derince Dere pipeline may have been built in the Ottoman period to supply a smaller community living on the same site. It is possible that at higher elevations not investigated by the survey, the Derince Dere aqueduct used the same structures as the Işıklar aqueduct.

2. Işıklar Aqueduct

The three extant structures of the Işıklar aqueduct indicate that it collected water from the middle elevations

of the Baba Dağı range and carried it south toward Aphrodisias along a route at least 10 km in length (see Fig. 6). The northernmost documented structure is a tunnel cut into the west (right) bank of the İncir Deresi, almost 7 km north of Aphrodisias and more than 280 m higher in elevation than the city (B081) (Fig. 7). The tunnel is carved into an outcrop of schist and quartz, at a height of about 2 m above the streambed and 2.75 m below the ground level of the stream bank above, and can be followed from the north for 8 m, beyond which point rising sediment infill makes it impassable. Though sediment infill obscures the original dimensions, the tunnel is 0.93 m wide at the floor, tapering to a width of 0.42 m at the ceiling, and it has an internal height of 0.7 m at the entrance. Niches, smaller than 0.10 m square, can be found along the eastern interior wall of the tunnel and were perhaps used to hold lamps during construction. Calcareous deposits cover all the interior surfaces, including the top, indicating natural water percolation from above rather than from water flowing through the tunnel.

Pockets of standing water dotting the streambed suggest that the water table is located at an elevation too low to supply the tunnel situated 2 m above the streambed. The Işıklar aqueduct must have carried water gathered at a higher elevation, and not from the stream, though it is unclear how the aqueduct was carried elsewhere along the streambed. The fact that the later Derince Dere pipeline follows the streambed suggests the Işıklar aqueduct may have as well. As described below, the Timeles aqueduct also follows a streambed for a significant portion of its course.

After losing 200 m in elevation over a distance of about 2 km, the Işıklar aqueduct was carried over the Kavaklıdere on a bridge built of mortared rubble set in layers and faced with petit appareil masonry (A008) (Figs. 8, 9). One complete pier of the aqueduct bridge with partial remains of two springing arches stands on the north (right) bank of the stream. Other remains of the bridge include two masses of mortared rubble, one approximately 4 m north of the standing pier on the same bank and another on the opposite side of the stream about 18 m from the pier. These structures must be the remains of additional pier footings. The standing pier is not preserved to the height of the conduit, and no trace of the conduit can be found in either stream bank.

Collapse or settling of the pier has resulted in a large hole through the structure, revealing its mortared rubble core, and the pier wall under the north arch has collapsed. The upstream (east) face of the structure is more heavily damaged, with a greater loss of facing blocks than the downstream side. The standing pier is 1.65 m wide and has a maximum preserved height of 7.8 m and length of 6.6 m. The arch has a projected span of 9.5 m

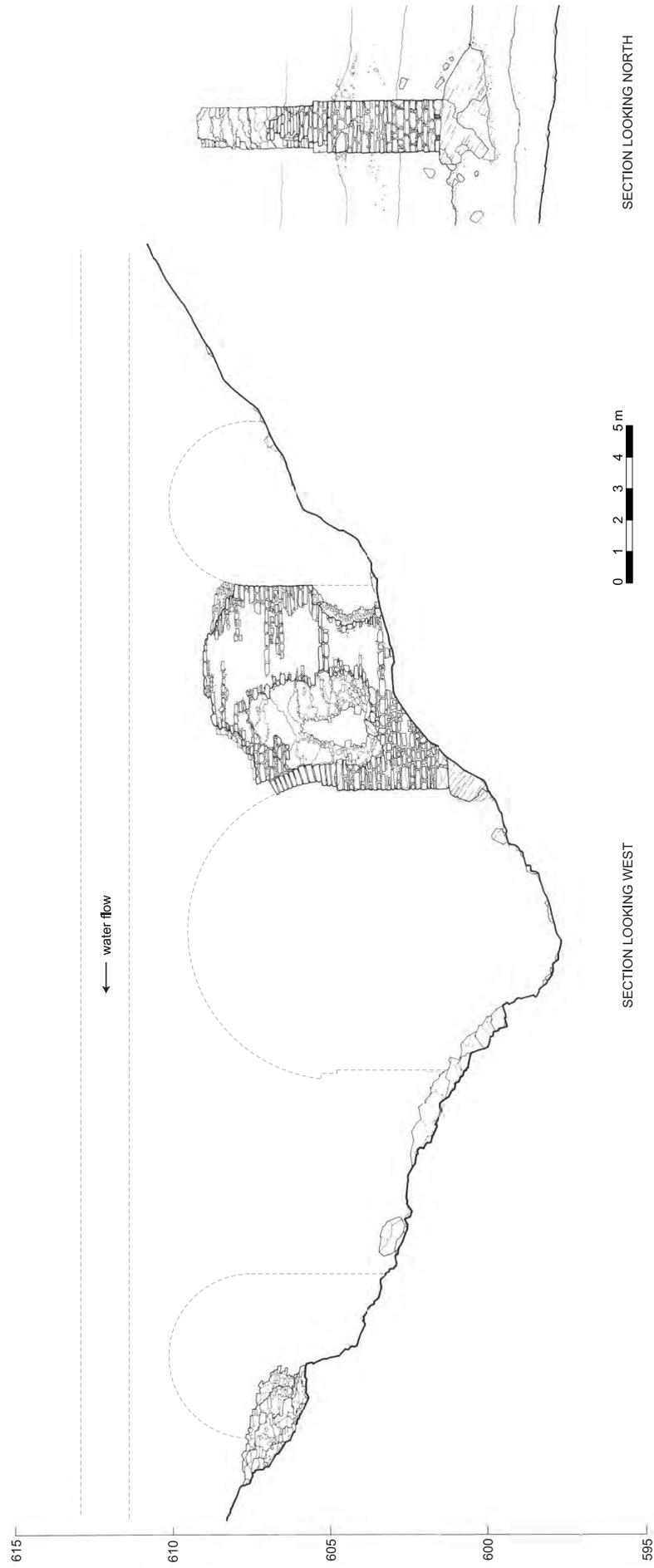


Figure 8. Kavaklıdere bridge of the Işıklar aqueduct (A008) (1:200).



Figure 9. East side of the standing pier of the Kavaklıdere bridge of the Işıklar aqueduct, looking southwest (A008).

and a projected height above the streambed of 11.5 m. The original bridge may have been more than 42 m long and 15 m high.

The facing blocks and the stones of the rubble core vary greatly in size, and most are fashioned from the same locally available, garnet-embedded schist into which the upstream tunnel was dug. In contrast, almost all the external voussoirs are marble. Courses of blocks of standard size are interchanged with courses of smaller, more irregular stones, with an extensive use of chinking stones. The lime mortar used throughout the structure is pale gray-tan, with densely packed stone inclusions no larger than 0.01 m.

Where the pier is closest to the stream, large blocks form a foundation resting on a rock outcrop. The arch springs from a point 3.6 m above the base, and the three lowest courses of voussoirs are recessed 0.15 m from the short (south) side of the pier facing the stream. The other voussoirs are recessed an additional 0.15 m, so that the resulting double-stepped profile of the arch provides two ledges that could have supported a wooden framework for construction of the arch. Above this upper recess, the pier narrows in width by 0.10 m on either side above a course of large facing stones. These lateral ledges extend even to the voussoirs of the arch spanning the stream, with the result that the lowest three courses of the arch are wider than the rest. In contrast, the arch on the north side of the pier has no ledges to support a framework, but a putlog hole just above the springing of the arch fulfills the same purpose. It is noteworthy that

both arches were equipped with support for a framework at a point that is three voussoirs above the spring point, and that two different methods were used.

Between the bridge over the Kavaklıdere and Aphrodisias, the aqueduct crossed the Derince Dere on a small bridge of which only a masonry wall remains (E050) (Fig. 10). The wall is constructed of mortared rubble faced with petit appareil masonry and is built into the east (left) bank of the stream. The top of the wall is flush with the ground level of the stream bank, suggesting that the structure has been leveled off during centuries of agricultural activity in the surrounding fields. The wall is 0.80 m wide and extends 2 m below the current ground level of the stream bank.

The masonry includes fieldstones of quartz, schist, and sandstone varying greatly in size and bonded with a gray-tan lime mortar with stone inclusions no larger than 0.01 m. A possible construction trench, 0.70 m wide, is discernible next to the south (downstream) side of the wall. The earth within the trench is a yellow-tan sandy infill with small fieldstones and differs from the bedded stream deposits, mostly rounded pebbles and sand, through which it cuts. The stone placed at the bottom of the wall is considerably larger than the others and probably acted as a foundation stone for the wall as it was built into the trench.

The location of the wall falls very close to the route of A. Kuznetsov's predictive model of the route of the Işıklar aqueduct based on least-cost analysis (see above, Fig. 6). The preserved wall is probably the foundation of



Figure 10. Masonry wall of the Işıklar aqueduct on the Derince Dere, looking southeast (E050).

the pier of an aqueduct bridge. Without rock outcrops on which to construct the bridge, the builders founded the bridge pier deep within the streambed deposits of the east bank, using the trench on the south side as a workspace, which they filled in after construction. The narrowness of the wall, which is less than half as wide as the bridge pier on the Kavaklıdere, suggests that the conduit was perhaps only 0.4 m or so wide internally and that here it ran close to the ground, perhaps even in a pipeline, rather than atop a tall substructure.

Like the Seki aqueduct, the Işıklar aqueduct was probably built in the first century A.D. to supply new buildings in Aphrodisias, such as a bath complex, and to support the needs of a growing population in the valley. The aqueduct may also have supplied water to agricultural fields in the northern portion of the valley.

3. Derince Dere Aqueduct

The two documented structures of the Derince Dere pipeline suggest that its route overlapped with that of the Işıklar aqueduct and tapped the same abundant springs somewhere along the western portion of the Baba Dağı range (see Fig. 6). The northern structure is an

open channel along the west (right) bank of the İncir Deresi in the vicinity of the rock-cut tunnel of the Işıklar aqueduct discussed above (E054). It can be traced for approximately 280 m. The channel rests on a substructure of parallel walls, each ranging from 0.30 m to 0.60 m thick, built of roughly worked schist slabs bonded with a tan-white lime mortar with densely packed stone inclusions smaller than 0.005 m. In several areas, the wall closer to the streambed has fallen away, indicating that the two walls are not bonded together. The channel runs along the west bank of the stream but maintains a roughly level elevation, while the streambed rapidly loses elevation as it travels south. Therefore, the channel begins at almost the same level as the streambed, but as it travels south, it gets higher and higher above the stream below.

Where the channel level is close to the level of the streambed, the channel floor is visible. The channel is 0.33 m wide and has a bedding of pink mortar, 0.02 m thick, covering the channel floor and preserved to a height of 0.03 m along the interior walls. The pink mortar is laid directly on top of the masonry substructure. Layered calcium carbonate deposits, 0.01 m thick in total, cover all preserved portions of the pink mortar, suggesting that water flowed in the open channel rather than in a sealed pipeline laid on its floor.

The channel is located at a considerably higher elevation than the rock-cut tunnel of the Işıklar aqueduct, a second indication, in addition to the style of masonry, that it is not part of the same system. The original pink mortar channel was refashioned in more recent times by the application of hard, white cement to form an altered, V-shaped conduit. A local informant said the conduit was reworked with cement recently and was used to carry water all the way south to the town of Işıklar more than 2 km away.

The pink mortar channel could be the remains of a later system that used the same water source as the Roman Işıklar aqueduct. The relatively small size of the channel, the lack of a mortared rubble core within its substructure, and the survival and recent reuse of the channel make it significantly different from the remains of the more substantial Işıklar aqueduct. Even though the pattern of calcium carbonate deposits suggests that at some point water ran in the open channel rather than in pipes, we have decided to group this structure with the remains of an aqueduct located approximately 5 km downstream on the Derince Dere, which obviously ran in a pipeline. The two structures appear to be part of a series of waterworks built after the Roman period to carry water from the important springs on the Baba Dağı ridge southward to Işıklar and Aphrodisias.

The remains on the Derince Dere consist of the substructure of a bridge that must have crossed the dere and been associated with a terracotta pipeline still preserved



Figure 11. Bridge substructure and pipeline on the Derince Dere, looking southeast (E055), with arrow indicating the remains of a trench in the east (left) bank into which the pipeline was placed.

on the opposite stream bank (E055) (Fig. 11). The substructure is built of mortared rubble faced with petit appareil masonry of roughly worked fieldstones of widely varying sizes and materials. It is 1.33 m wide and preserved to a height of 1.8 m and length of 40 m. The substructure approaches the west (right) stream bank from the northwest, but it turns slightly to the east about 4 m from its eastern endpoint, perhaps to cross the stream at a slightly less acute angle. Almost directly across the stream from this substructure, at least six segments of a terracotta pipeline are visible, placed in a trench dug into the eroding shale of the east (left) bank. Erosion of the rock has caused the collapse of the side of the trench facing the streambed, revealing the terracotta pipeline within. The terracotta pipe segments, joined with white mortar, are each about 0.5 m in length and 0.15 m in diameter. The pipes have a smooth exterior surface but are gently ribbed inside, and two parallel grooves circumscribe the upstream end of each pipe segment.

The Derince Dere pipeline is the only aqueduct in the region along which terracotta pipes have been found, and these pipes match those found in the Ottoman baths at Aphrodisias. The pipeline may have entered the city from the east where the remains of what appear to be two pressure-regulating water towers have been identified, as discussed below in “Technical Analysis, *Suterazi*” (Fig. 12). As a likely supplier of water for the Ottoman settlement, this aqueduct underscores the longevity of human occupation at the site of Aphrodisias and the continued importance of the springs on the western slopes of the Baba Dağı range in supporting these communities.

Water from the Lower Valley

The remains of two aqueducts located west of Aphrodisias help to form a more complete picture of water management in the Morsynus river valley. Because both

are open-conduit aqueducts run by gravity and are situated at levels more than 50 m lower in elevation than the city, they could not have supplied Aphrodisias. Instead, they may have carried water to a settlement, farmstead, or villa, or provided water for the irrigation of surrounding agricultural fields. Combined with evidence for farmsteads, settlements, and agricultural blocks in this area of the valley just west of Aphrodisias, the identification of the Kavaklıdere and Ören Deresi aqueducts provides evidence for a valley dense with human occupation that depended on locally available natural resources such as water.

The remains of these two aqueducts have been identified at only a single location each, so their respective routes and destinations must be reconstructed based on other factors. Because the western part of the Morsynus river valley receives the runoff of the springs and surface drainage of the Baba Dağı range, it has deep, narrow streams that provide a more abundant water supply than in the central part of the valley. These aqueducts may have tapped springs along the Baba Dağı range or the upper reaches of these relatively high-volume streams. While it is possible that they supplied agricultural irrigation systems, their location in a relatively well-watered part of the valley suggests that they were constructed to bring water from a higher elevation to a destination at a lower elevation that would not otherwise have received water of adequate volume or quality. Likely candidates for this type of water requirement are the settlements, farmsteads, or villas located in the area at elevations lower than the documented remains. Therefore, the two aqueducts in the lower valley were probably built in association with one or more of these sites dated to the Roman or Byzantine periods.

4. Kavaklıdere Aqueduct

The conduit of the Kavaklıdere aqueduct is visible in cross section in the west (right) bank of the Kavaklıdere almost 5 km west of Aphrodisias (E053) (Fig. 13). The water of the meandering Kavaklıdere must have facilitated the collapse of the subterranean conduit at this point where it ran close to the stream. The vaulted conduit is built of mortared rubble masonry in a single layer of fieldstones including schist and quartz and smoother stream stones, which are between 0.20 m and 0.30 m long, with smaller stones of 0.05 to 0.10 m interspersed throughout. The masonry is bonded with a blue-gray lime mortar with densely packed and very small stone inclusions about 0.001 to 0.002 m in size. Interesting to note, the floor of the conduit is not constructed of the same rubble masonry. Only a sand-rich sediment layer remains of the conduit floor, which must have originally been equipped with a more substantial bedding, perhaps a hydraulic mortar, that has disintegrated. The interior dimensions of the conduit are 0.47 to 0.50 m wide and



Figure 12. One of two possible pressure-regulating water towers (*suterazi*) at Aphrodisias, outside the city to the northeast.

0.77 m high. The thickness of the walls and vault ranges between 0.20 m and 0.30 m.

It is difficult to reconstruct the relationship between the streambed and the conduit when it was originally built. The conduit is situated about 3 m above the current streambed and 1.8 m below the ground level of the bank. A construction trench above the conduit extends all the way to the current ground level and cuts through multiple layers of stream deposits. After the bedding and vaulted masonry conduit were constructed within the trench, mortared rubble was piled on top of the vault, so that the exterior of the conduit appears rectangular in section. The trench was then backfilled.

The conduit is almost completely filled with the same red, iron-rich sediment as that of the stream bank surrounding it. The sediment in the conduit is about 0.64 m high, the same height as the calcareous deposits lining the north interior wall, and includes no stones larger than 0.05 m. Presumably the fill is sediment deposited in the conduit when water was still flowing through it. If so, the aqueduct may have tapped water from a sediment-laden stream almost identical to that of the

Kavaklıdere, rather than from one of the springs on the Baba Dağı range. In any case, slow water flow allowed both the accumulation of calcium carbonate and the deposition of suspended sediment.

5. Ören Deresi Aqueduct

As with the Kavaklıdere aqueduct, the vaulted and mortared masonry conduit of the Ören Deresi aqueduct is visible only where it has been exposed in the west (right) bank of the Ören Deresi, where the stream runs just over 3 km west of Aphrodisias (A029) (Fig. 14). In the segment currently visible, the conduit wall closer to the stream has collapsed, revealing both the longitudinal section and cross section of the structure. Also preserved is a rectangular shaft, possibly for maintenance and inspection.

In cross section, the interior of the conduit is 0.50 m wide with a 0.30 m wide channel centered in the floor. The channel is 0.90 m in height, and the rest of the conduit rises another 0.90 m above the channel. The conduit side walls are 0.40–0.50 m thick. The vault is made of a single layer of fieldstones with rubble packing on the exterior, all bonded with a beige lime mortar with small stone inclusions. However, the exposed interior surface of the conduit wall reveals a different treatment. A very hard mortar with a reddish orange color covers not the stones of the wall but their interstices. This mortar could simply be the same mortar as that used in the vault, stained by iron-rich sediment infill, or it could be the remains of a waterproofing mortar now so damaged that it is not easily distinguishable as an even coating.

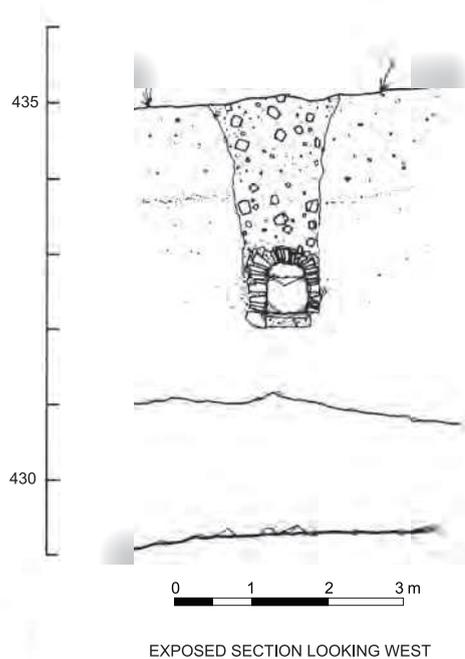


Figure 13. Conduit of the Kavaklıdere aqueduct, visible in cross section in the west (right) bank of the Kavaklıdere (E053) (1:100).

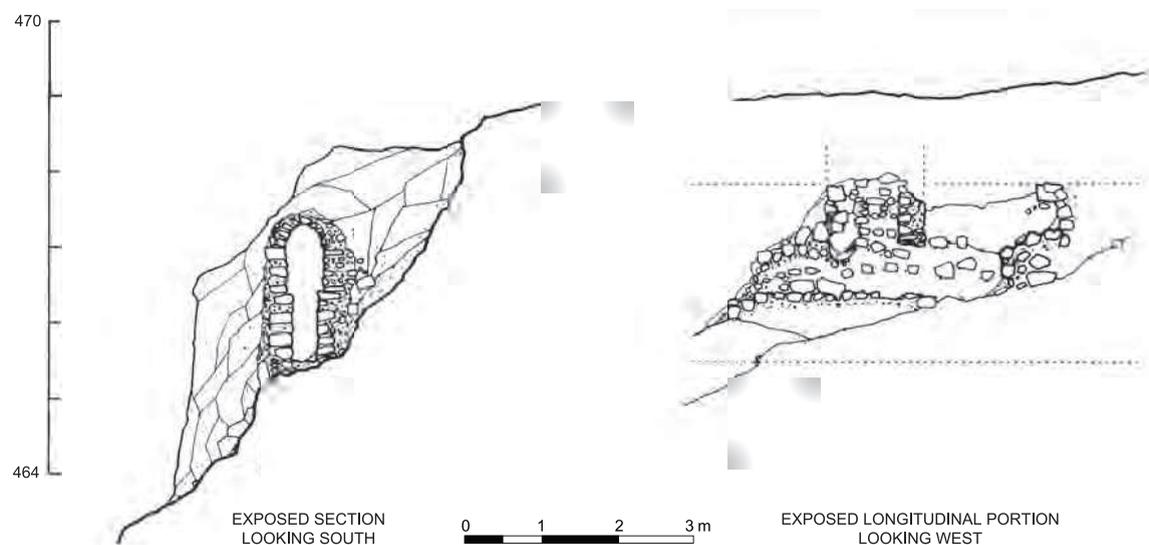


Figure 14. Conduit of the Ören Deresi aqueduct, visible in the west (right) bank of the Ören Deresi (A029) (1:100).

An opening in the vault's roof leads to an inspection shaft that rises vertically from the conduit and is preserved to a height of 0.3 m above the vault. Both the opening in the vault and the shaft itself have interior width dimensions of about 0.9 m parallel to the conduit and 0.5 m perpendicular to the conduit. The well-preserved west wall of the shaft, which is built into the stream bank, is 0.65 m thick. The east walls of the shaft and conduit have collapsed. The shaft walls perpendicular to the conduit have damaged interior surfaces and a preserved thickness of 0.4 m. A single putlog hole is visible in the interior west wall of the shaft and was likely used to facilitate both construction of the shaft and access into the conduit after construction.

The conduit is filled with sediment to a height of 1.2 m. The Kavaklıdere and Ören Deresi aqueducts were subterranean conduits that ran adjacent to deep streams for at least part of their route. Both seem to have eventually collapsed as a result of their proximity to these meandering streams.

Water from Beyond the Valley

6. Timeles Aqueduct

The Timeles aqueduct is the largest and most substantial of the six identified aqueducts (Figs. 15, 16). It tapped tributaries of the Yenidere Çayı in the Tavas plain and carried water westward through the hills that mark the boundary between it and the adjacent valley of the Morsynus river. This structure, over 25 km in length, almost certainly corresponds to the Hadrianic-period aqueduct known from inscriptions of the second quarter of the second century A.D. found at Aphrodisias, which are discussed at length in "Historical Analysis" below.

History of investigation. Remains of the Timeles aqueduct were first visited by the survey team in 2006,

when a local informant showed us the standing piers of a large collapsed aqueduct bridge on the Şaban Deresi near the village of Denizoluk and told us that a number of other such remains could be found in the area (C048) (see below, Figs. 31, 32). Investigation of those remains was a major focus of the 2007 season. Our objectives were to determine whether all the remains belonged to the same aqueduct and then to trace that aqueduct as completely as possible from its source to its ultimate destination, while at the same time documenting all major bridges, conduits, tunnels, and shafts with digital photographs and architectural section and elevation drawings.

We began our investigation in 2007 by visiting structures known to our local informants, who first showed us a series of tunnels made visible by a recent road cut along the northern banks of the Kepiz Çayı, near the village of Güzelköy on the Tavas plain (G002). We met with residents of the villages of Kayapınar and Yeşilköy to examine the shafts, tunnels, and bridges known to them. Exploration over two days of the areas between these known points led to the discovery of further remains.

During the final season of investigation of the aqueducts in 2008, we focused on completing the architectural records of the surviving bridges, conduits, and shafts. We were also shown two additional bridges in the floor of the Morsynus river valley, which provide crucial information about the path of the aqueduct between the ridge separating the Morsynus and Timeles valleys and Aphrodisias (see Fig. 15, E058 and E059).

The source and Kepiz Çayı. Using the methods outlined above, we were able to trace the path of the aqueduct and reconstruct its route from the presumed source to Aphrodisias. We identified an exposed segment of the mortared masonry walls of the conduit as the easternmost trace of the aqueduct, following the contours of

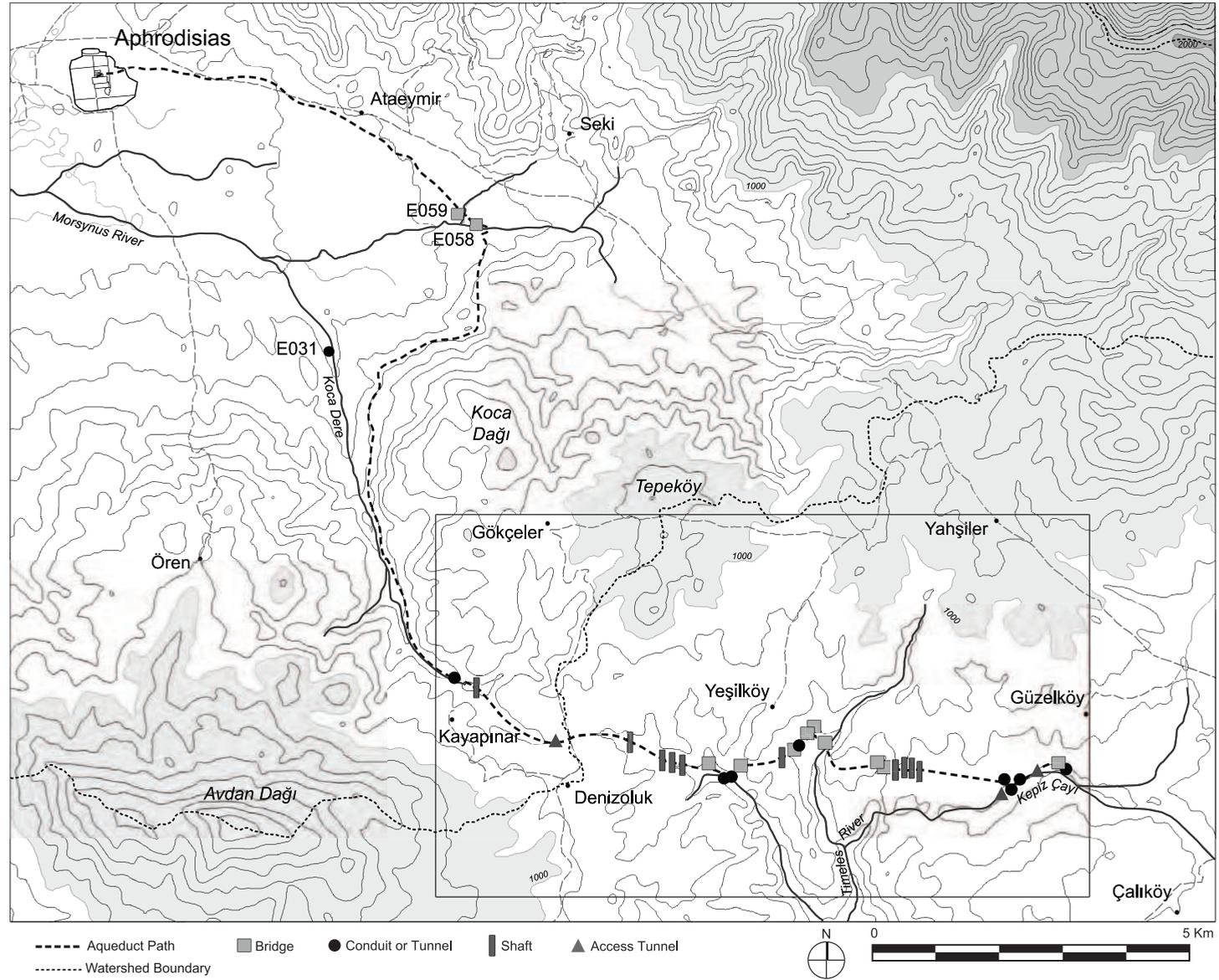


Figure 15. Reconstructed path of the Timeles aqueduct based on standing remains and least-cost analysis predictive modeling (1:100,000). A map of the outlined field is provided in Figure 16.

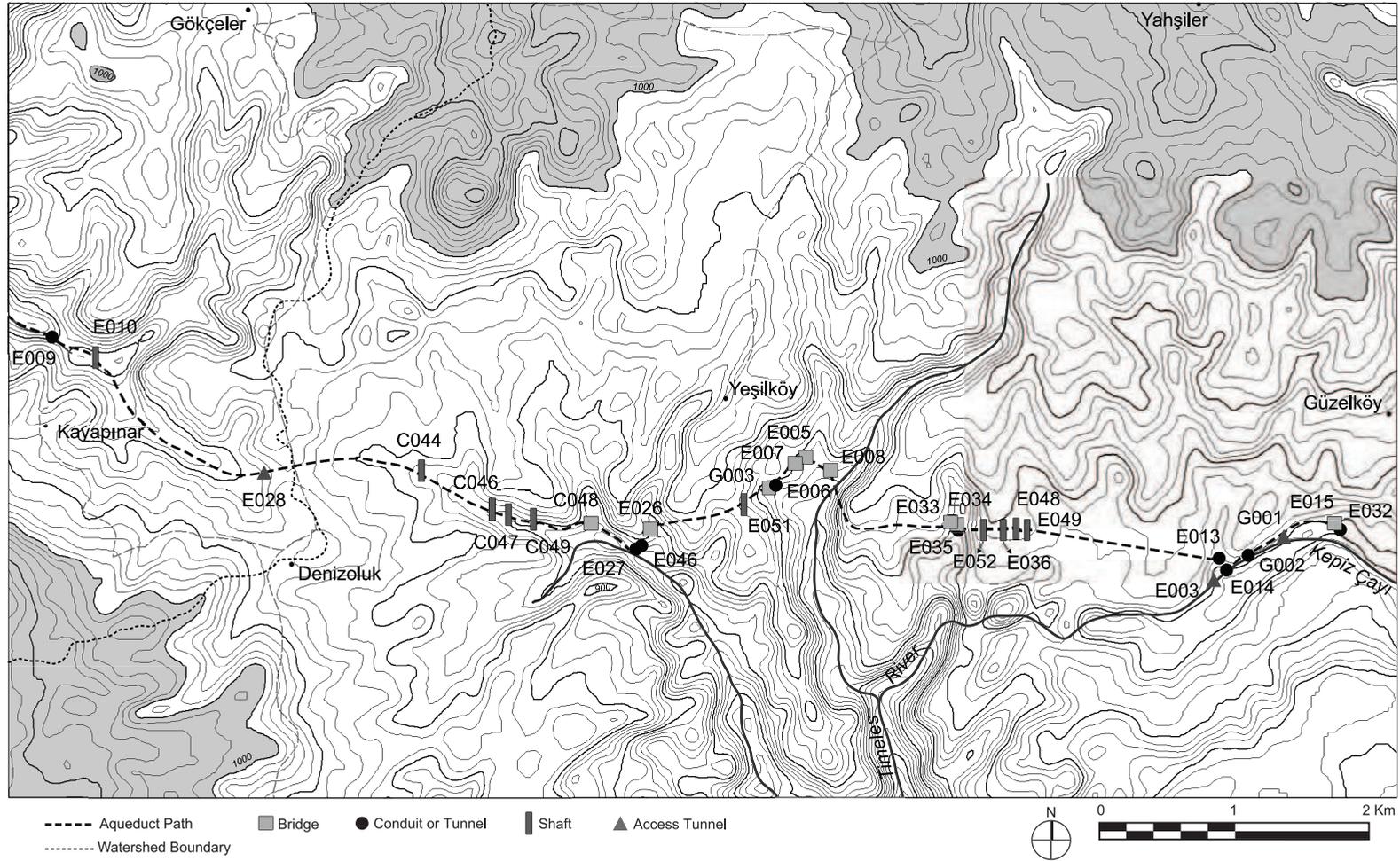


Figure 16. Eastern (upstream) portion of the reconstructed path of the Tímeles aqueduct, from Kepiz Çayı to Kayapınar, based on standing remains and least-cost analysis predictive modeling (1:50,000).



Figure 17. Bridge on a feeder dere of the Kepiz Çayı with Ottoman and modern reconstructions, looking northeast; only the lower courses are part of the original Roman aqueduct bridge (E015).

the north (right) bank of the Kepiz Çayı near the modern village of Güzelköy (E032) (see Fig. 16). Originally running underground, the conduit has been exposed by erosion of the bank. A modern dam has been built near the exposed conduit at the point where several small tributaries join together to form the Kepiz Çayı, which itself feeds into the Tımeles river (Yenidere Çayı) as it skirts the western edge of the Tavas plain.

The construction of the modern dam has possibly destroyed or obscured the beginning of the aqueduct. The area around the dam is certainly a viable site for the aqueduct's source. According to local informants, the Kepiz Çayı and its headwaters used to be more copious and clean than they are today, and until quite recently the Kepiz Çayı fed canals that powered a series of Ottoman mills located downstream of the dam and just east of Çalıköy, one of which remains standing.²⁸ However, the source of the aqueduct could have been as far away as Kırkpınar ("Forty Springs"), an area located about 5 km east of Çalıköy noted by Robert and Robert in their description of the Tavas plain as particularly well watered.²⁹ Today Kırkpınar is an important source of water for the residents of the Tavas plain. The exact source of the Tımeles aqueduct therefore remains unknown.

Starting from the easternmost remains noted above, the conduit continued to hug the north bank of the Kepiz Çayı and then passed over a small tributary dere atop a bridge that has been refashioned as part of a later

water-carrying system, apparently connected to the Ottoman mills mentioned above (E015) (Fig. 17). Both piers remain standing, but only the lower nine courses can be securely identified as part of the Roman aqueduct bridge. The bridge is constructed of mortared rubble faced with petit appareil masonry of roughly worked blocks of schist and quartz, leveled with chinking stones and bonded with a beige lime mortar with stone inclusions smaller than 0.02 m. The bridge survives to a height of 3 m and is 3.20 m wide. The total length of the bridge is about 9 m, and the distance between the piers is 2.7 m. The presumably Ottoman conduit, open on top and coated in white waterproofing mortar, is 1.5–1.7 m wide and 0.8 m deep. Additional masonry, possibly for buttressing the bridge, is joined to the downstream (south) side of the piers.

After passing over this bridge, the aqueduct conduit resumed its route along the north bank of the Kepiz Çayı. Construction of a modern road along the bank, following the same path as the aqueduct, has scraped away the contours of the hillside, revealing sections of the conduit and two tunnels perpendicular to the conduit that provided access from the stream bank to the conduit itself where it ran deep within the hillside. These tunnels, dug through sandy conglomerate rock, have a roughly vaulted profile. The eastern of the two tunnels is 0.7 m wide at the floor and 0.4 m wide at the top and can be entered and followed for almost 11 m into the hillside, at which point it connects to the aqueduct's masonry conduit (G001). As the tunnel approaches this intersection point, it gradually increases in height from 0.8 m at the entry point to about 1 m, as sediment from wind, erosion, and road construction has been deposited on the floor of the exposed tunnel. The tunnel connects directly to the conduit, which is a vaulted structure built of worked blocks bonded with a white lime mortar with densely packed stone inclusions. The blocks, roughly fashioned from the local conglomerate outcrops, are 0.30–0.40 m long and 0.20 m high. Calcium carbonate deposits (sinter) created by slowly flowing water cover the interior walls to a height of about 1 m from the current level of the conduit floor, which is covered by infill. Putlog holes are located along the walls at a height of five courses, or just less than 1 m, above the current floor level. Located at the spring point of the vaulted ceiling, these putlog holes held a wooden centering framework on which the stones of the vault were laid, mortared, and allowed to set.

The interior of the conduit is about 1.7 m wide and 1.7 m high and can be followed in both directions. To the east, it curves slightly north to follow the contours of the dere for 27 m, after which it is impassable. To the west, it ends after 8.4 m where the modern road cut has scraped away the stream bank, removing the conduit along with it. From this point, a longitudinal section of

28. In this area, along the Kepiz Çayı east of Çalıköy, we documented a masonry-lined shaft (E057) connected to a rock-cut tunnel (E056) that pierces a large bedrock outcrop (see Fig. 1). While this tunnel could be connected to the Roman aqueduct, it appears instead to have directed water toward a later, perhaps Ottoman mill located next to the stream, now defunct and used to shelter sheep.

29. Robert and Robert, *La Carie II* (supra n. 12) 46–47.



Figure 18. Longitudinal section of the subterranean conduit visible along the road cut by the Kepiz Çayı, looking northeast (G002).

the conduit becomes visible along the road cut for about 270 m (G002, E013, E014) (Fig. 18). The regular blocks that formed the interior of the conduit have been lost, revealing the mortared rubble packing that supported both the conduit floor and the northern side wall. The mortared rubble packing along the side wall is 0.7 m thick and is constructed of roughly regular blocks of the local conglomerate rock laid in courses of varying heights. The mortared rubble bedding below the conduit floor is 0.2 m thick and covered with 0.03 m of calcareous deposits. A second level of calcareous deposits, 0.035 m thick, is located 0.3 m above the lower layer, with a layer of sediment and pebbly fill in between. This double layer of sinter, separated by deposits of sediment and pebbles, could be the result of two distinct periods of use.

The intersection point between the eastern access tunnel and the masonry conduit was left open for at least some of the time during which the aqueduct was in use. Calcareous deposits line the conduit blocks and rubble packing where they adjoin the tunnel, indicating that the water flowed freely in this open space. The distance between the current floor levels of the tunnel and the conduit is 0.4 m, but the calcareous deposits extend to a height of 1 m above the current floor of the conduit. To prevent the leakage of water from the conduit through the access tunnel, there must have been a device to seal off the conduit. The junction could have been blocked up by temporary rubble masonry, torn down and rebuilt

as needed during maintenance, or possibly used as an off-take point.

Aqueduct conduits running through soil close to the ground surface could be built in relatively shallow trenches, covered with backfill after construction and accessed by short, vertical inspection shafts if necessary.³⁰ The conduit along the Kepiz Çayı, however, ran through both earth and rock and at some places ran deep within the hillside of the stream bank, making construction in a trench impractical. Instead, the builders pierced the stream bank with horizontal access tunnels through the rock and then dug at a perpendicular to create a tunnel into which they then laid the masonry conduit of the aqueduct. These horizontal access tunnels, used for construction and possibly maintenance as well, performed the same function as the more typical vertical shafts, either cut through rock or lined with masonry, found farther down the Tımeles aqueduct.³¹

After following the north bank of the Kepiz Çayı,

30. As, e.g., on the Eifel aqueduct at Cologne, Germany; see A. T. Hodge, *Roman Aqueducts and Water Supply*, 2nd ed. (London 2002) 93–94.

31. Vertical shafts have been documented along well-known aqueducts such as those supplying Carthage and Thugga and the Gier aqueduct of Lyon. Carthage and Thugga: A. I. Wilson, “Water Management and Usage in Roman North Africa: A Social and Technological Study,” Ph.D. dissertation (University of Oxford 1997) 67. Lyon: J. Burdy, *Les aqueducs romains de Lyon* (Lyon 2002) 123–27. See “Technical Analysis, Tunnels and Shafts” below for more information.

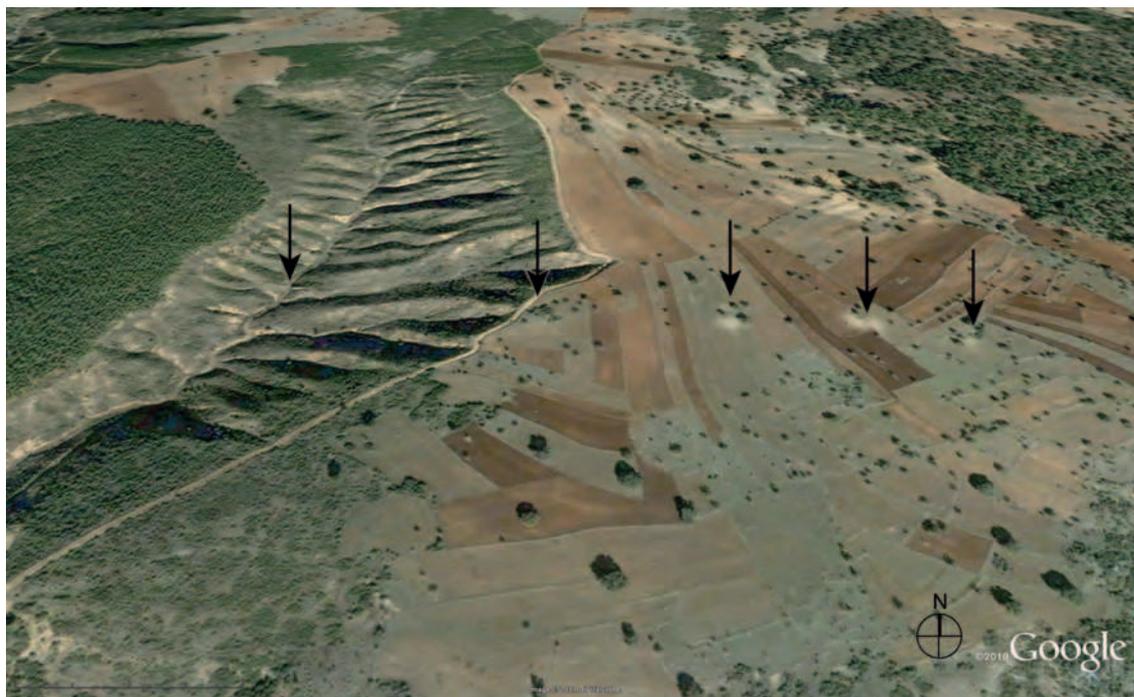


Figure 19. Satellite image showing three mounds of rock chips and one masonry-lined shaft on the Yahşiler plateau (right to left), corresponding to the course of the aqueduct conduit underground, and remains of the bridge at far left where the aqueduct crossed the Ciglek Deresi (east to west: E049, E048, E036, E052, E033). Google Earth satellite image (© 2010 Google, © 2011 DigitalGlobe).

the aqueduct turned to the northwest and crossed another small feeder dere. The second preserved access tunnel is located about 350 m west of the first, on the other side of the feeder dere, but cannot be entered because of sediment infill (E003). The local informant who showed us the access tunnels said that there had once been a bridge crossing the feeder dere, but no trace of the bridge remains visible today. Other evidence for the aqueduct in this area includes a curved fragment of precipitated calcium carbonate. Presumably formed on the inside of a terracotta pipe, the fragment may indicate that the Roman aqueduct conduit was tapped for use in a nearby farmstead, village, or for irrigation. Alternatively, the pipe could have been associated with the Ottoman mills in the area. The possibility that the Timeles aqueduct provided water for local consumption is in evidence at several points along its path to Aphrodisias and is discussed in “Technical Analysis, Rural Water Supply,” below.

Yahşiler plateau. After crossing this bridge, the aqueduct conduit entered a tunnel that ran up to 50 m underground for almost 2 km through a wide, flat plateau south of the modern village of Yahşiler. Over this distance, on top of the plateau, mounds of rock chips at ground level mark the course of the aqueduct conduit deep below the surface (east to west: E049, E048, E036). While one mound to the east of this series has been scattered by agricultural activity, these three mounds are large features highly visible in the landscape and even in satellite imagery (Fig. 19). The striking re-

semblance of the mounds, about 10 m in diameter, to tumulus tombs encouraged an attempted looting of one of them. The deep looter’s trench revealed a thick layer of rock chips, 2.3 m deep, created during construction of the aqueduct.

These mounds are heaps of backdirt (spoil) created as construction crews dug deep shafts from the surface down to the level of the tunnel. Creating vertical shafts rather than boring straight through the plateau provided several points for surveying the orientation and gradient of the tunnel, helped expedite the tunneling process by opening up multiple work surfaces from which workers could dig simultaneously, and provided air to the workers and exits for the removal of backdirt.

To the west of the mounds, a deep depression in the earth marks the location of a fifth shaft, with traces of masonry lining the entry point (E052). In contrast to the masonry-lined shafts and large rock-cut shaft farther along the aqueduct, discussed below, there is no clear evidence that these mounds corresponded to shafts that were left open after construction. Two additional shafts can be tentatively identified using satellite imagery, in which the scattered rock chips of the mounds appear as white blotches distinct from the agricultural fields surrounding them. The seven possible shafts are placed at various intervals ranging from 87 m to 550 m. The three intact mounds are separated by intervals of 87 m and 98 m, representing the shortest intervals identified. Shafts could have originally been placed every 90–100 m, or the spacing could have been inconsistent.



Figure 20. Where the conduit emerges from a hillside in the Ciğlek Deresi (left), a cross section is visible (marked with arrow), looking southeast (E035). Piers of the large bridge are visible at right (E033).

Our local informant said that earth piles from the digging of shafts or inspection points used to be discernible every 100 m or so. A more detailed consideration of these shafts and the tunnel to which they connect is provided in “Technical Analysis, Tunnels and Shafts,” below.

Ciğlek Deresi. The aqueduct emerged from its subterranean tunnel under the Yahşiler plateau to cross two closely spaced bridges, first turning north to pass over a small gully, then turning west along a ridge to cross the larger Ciğlek Deresi (Figs. 20–22). The first bridge, which must have spanned about 8 m to cross the gully, no longer stands, but traces of the masonry conduit on either side of the gully indicate its original length (E034). On the south side of the gully, the conduit is well preserved and can be entered where it runs underground (E035). On the north side of the gully, traces of the conduit side walls connect to the large bridge that crosses the Ciğlek Deresi itself (E033).

Where the conduit on the south side of the gully connected to the aqueduct bridge that no longer stands, a clear cross section of its foundation, floor, and the lower portion of its side walls is visible, embedded in the eroded hillside (E035) (Fig. 23). Here the conduit is 1.50 m wide, with side walls 1.15 m (east) and 1.18 m (west) thick. The conduit side walls are built of regular blocks of the local sandy conglomerate bonded with mortar and topped with a barrel vault. These blocks are 0.10–0.40 m long, 0.16–0.20 m high, and 0.15–0.20 m deep. Around these blocks, mortared rubble packing consist-

ing of stones varying greatly in size and shape supported the vaulted conduit. The side walls are bonded with pink-beige lime mortar with densely packed stone inclusions smaller than 0.01 m.

The side walls and conduit floor rest upon a foundation layer of smaller stones 0.30–0.35 m thick. Above this rubble foundation, the conduit floor is equipped with a bedding of white-gray lime mortar with densely packed stone inclusions smaller than 0.01 m. The mortar bedding is 0.25 m thick under the center of the conduit floor but tapers to a thickness of 0.10 m about 0.20–0.35 m from both edges of the floor. On top of this white-gray mortar bedding is a very thin layer, 0.001 m thick, of pink waterproofing mortar, created by the use of crushed brick or the local, iron-rich, sandy conglomerates, as used in the mortar of the conduit side walls. On top of the pink waterproofing mortar is a layer of sinter, 0.05 m thick, created by the gradual accumulation of precipitated calcium carbonate in layers, each less than 0.001 m thick.

The conduit arrived from underneath the Yahşiler plateau to the east, continued running west within a ridge between two dry gullies perpendicular to the broad Ciğlek Deresi, and turned north at a 125° angle to cross a dry gully over the bridge that no longer remains (E034). Following the conduit from the cross section visible in the south side of the dry gully and moving up the course of the aqueduct, the conduit has collapsed and is filled with earth and vegetation for 6.7 m. In this segment, only the lower few courses of the conduit side

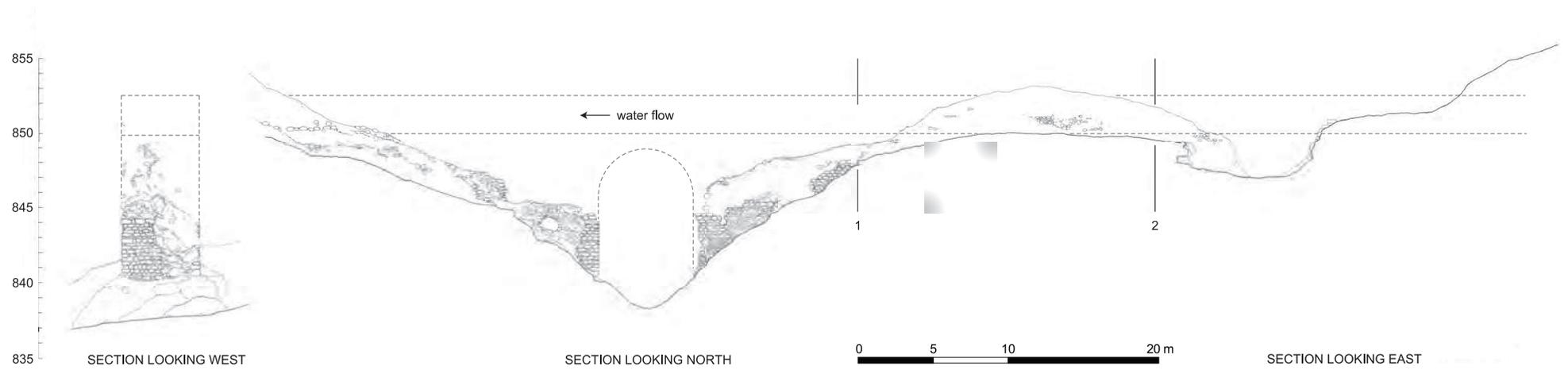


Figure 21. Bridges and tunnel in Çiğlek Deresi (E033, E034, E035) (1:400).

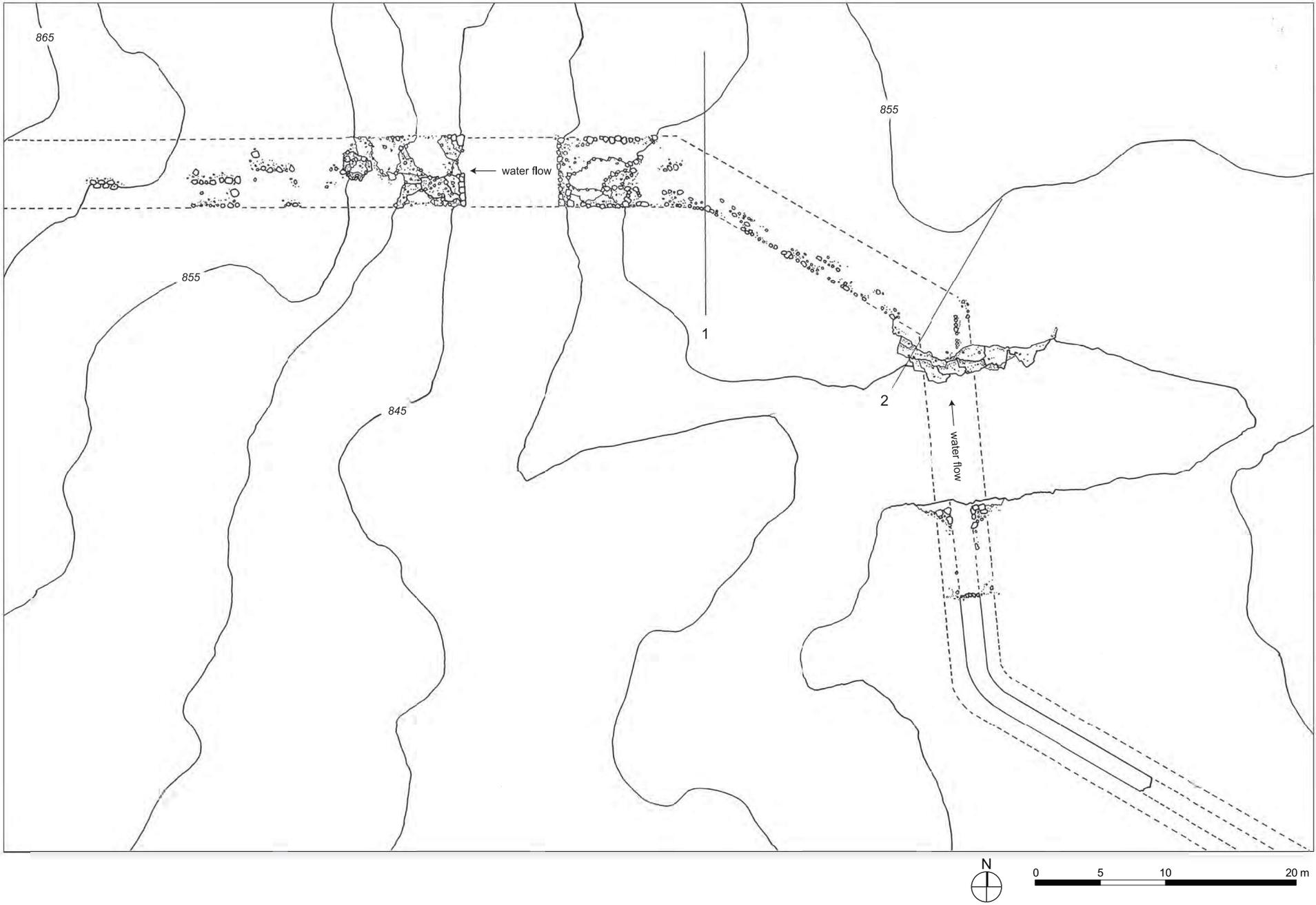


Figure 22. Plan of bridges and tunnel in the Ciglek Deresi (E033, E034, E035) (1:400).

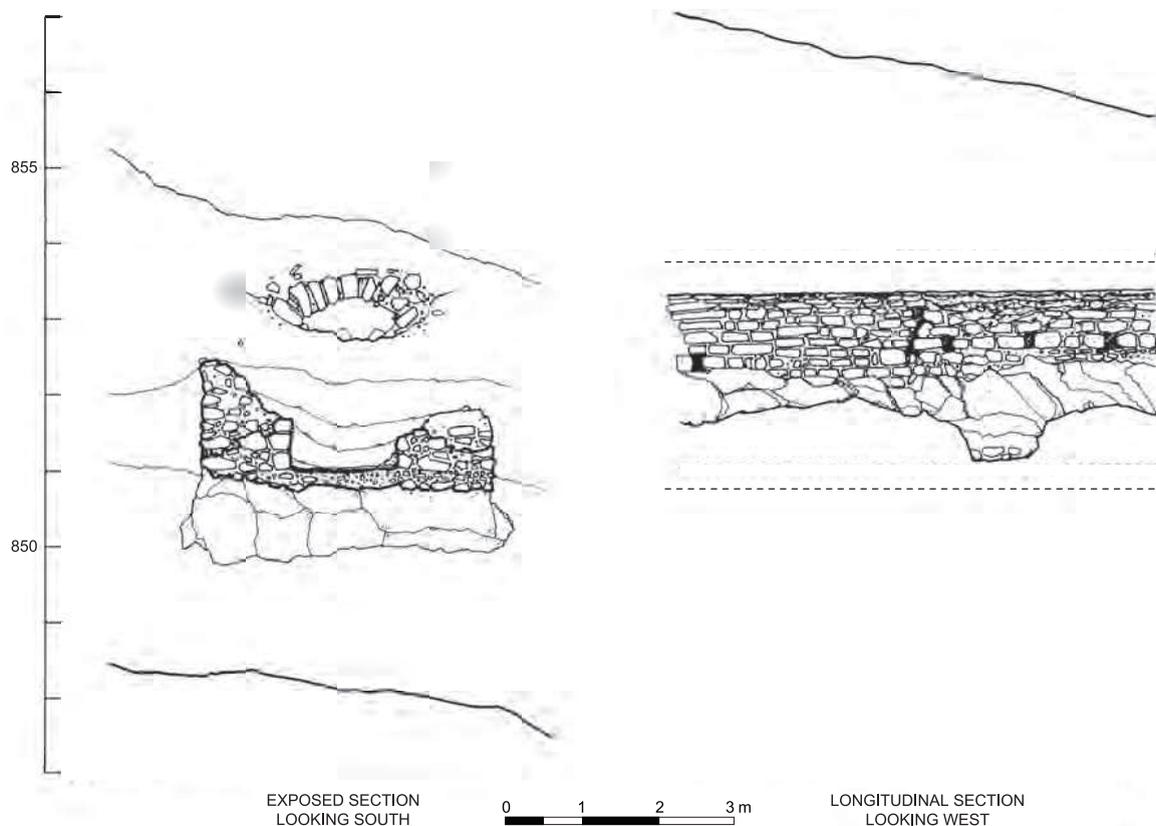


Figure 23. Conduit exposed in hillside and inside the tunnel in the Ciğlek Deresi (E035) (1:100).

walls are standing. After this segment, the conduit is fully preserved within the ridge and can be entered for about 22 m, at which point the vault has collapsed. A short segment of conduit can be entered again after this collapse, but a second collapse seals it off completely. The conduit is 1.50 m wide, and heavy sinter deposits begin about 0.95 m down from the top of the rubble vault. Much sediment and debris cover the conduit floor. Measuring from the floor as exposed in the cross section of the conduit visible by the missing bridge, the original height of the conduit can be calculated at 2.25 m. Assuming that the sinter deposits on the conduit floor and side walls were laid at the same time, the water could have run 1.30 m deep, allowing for the rough estimate of discharge discussed in “Technical Analysis, Discharge,” below. At the current floor level of the conduit, the sinter is 0.2 m thick in some places.

The masonry of the conduit is not uniform but can be divided into three distinct segments. As one enters the conduit, the first segment extends 8 m on the outer side wall (west) of the turn and 7 m on the inner (east), which is executed more sharply than the gently curving outer side wall. The rubble used in the vault consists of roughly worked stones varying greatly in size and arranged like voussoirs in an arch. About 3.5 m into the conduit, on the west side wall only, there is 3 m stretch extending to the end of the rubble-vault segment, in which three courses of small stones are used in place of

one course of regular blocks. This stretch occurs along the outer (west) side wall exactly where the conduit curves. The lime mortar of the rubble vault is beige-pink with small, loosely packed stone inclusions.

Where the conduit turns, a clear seam is visible separating the rubble-vault segment from the adjacent segment in which the vault is constructed of the same regular blocks as the side walls (Fig. 24). These two segments are different in several ways. First, in the two other places where the intact aqueduct conduit is visible, at Kepiz Çayı (G001) and at Yeşilköy (E006), both the side walls and the vault are constructed of regular, rectangular blocks, just like this second segment at Ciğlek Deresi. The rubble vault is thus an anomaly. Second, at the seam where the rubble vault meets the regular vault at the conduit bend, the two are offset on the outer (west) side wall by 0.10–0.13 m. In addition, a deep pit dug into the sediment infill of the conduit has revealed the profile of the west side wall of the rubble-vault segment near the point where it meets the regular-vault segment. The upper courses of the side wall are set back 0.05–0.10 m from the lower courses revealed within the pit. Third, the putlog holes in the rubble-vault segment are located one course above the putlog holes of the regular-vault segment. Fourth, the mortar of the rubble vault seems to have less densely packed stone inclusions than the mortar used in the side walls of the conduit where it emerged to cross the bridge that no longer



Figure 24. Interior of the conduit before it emerges at the Ciglek Deresi, looking southwest (E035). Where the conduit turns, a seam separates the upstream segment vaulted with rectangular blocks (left) from the downstream segment with a rubble vault.

stands (E034). Finally, at the entrance to the conduit, where the vault has collapsed, the east side of the vault is constructed with the same regular, rectangular blocks used in the side walls and in the regular-vault segment. These blocks are displaced about 0.08 m lower than the level of the rubble vault and could be the remainder of the original conduit, which would explain the displacement as well. Alternatively, they could have been reused during the construction of the rubble vault and displaced as a result of the collapse at this point.

Deep inside the hill the conduit was built within a rock-cut tunnel. Where it emerged to cross the small gully, however, it was built in earth, probably in a trench refilled with backdirt. These two construction methods may explain the differences in vault construction seen within the conduit. The builders may have chosen to construct a rubble vault where the conduit was laid in earth, relatively close to the ground surface above. Alternatively, the rubble-vault segment may be a later rebuilding of the original conduit where it turned, and therefore

was more susceptible to damage by moving water, and exited the hillside. In this case, the original conduit would be represented by the second segment with its vault of regular blocks identical to those of the side walls.

About 8.8 m upstream from the seam and the conduit bend, a third segment begins, in which the top portion of the vault of regular, rectangular worked blocks appears to have been rebuilt in rubble masonry with thickly applied white-blue lime mortar with large, densely packed stone inclusions, most between 0.005 m and 0.012 m. The added rubble masonry is 0.60 m wide across the top of the vault and has a level profile, making it not a true vault but a much weaker structure, no doubt responsible for its collapse about 5 m farther along the conduit. The roughly worked stones of the “false” vault are placed lengthwise across the width of the conduit, in contrast to the stones of the rubble-vault segment discussed above, which are placed like voussoirs in an arch. The stones used in the false vault include both fieldstones and roughly worked blocks of the local conglomeritic sandstone, just like the blocks used in the side walls and in the vault and side walls of the adjacent regular-vault segment, suggesting that perhaps some of the blocks of the original conduit were reused to create this false vault. The thickly applied mortar protrudes below the level of the vault of regular, rectangular blocks built with a centering framework, further suggesting that this false vault is a later rebuilding, intended to mend a collapse or patch up the conduit after maintenance of some sort. In this segment, the putlog holes are located one course above the putlog holes of the regular-vault segment. Patches of a smooth, white lime mortar without inclusions surround the blocks of the upper side walls and lower vault in this segment as well. The mortar was applied horizontally in layers, leaving a distinct ribbed pattern.

The false vault was certainly a repair job. Sinter accumulation up to 0.20 thick on top of the smooth, white mortar indicates that the aqueduct was still in use after its application. In one place, a 1 m stretch of sinter has been intentionally chipped off with a pick, perhaps for reuse as building material elsewhere.

As noted above, the putlog holes are located at different heights within the three segments, the most obvious difference being their location one course lower in the regular-vault segment than in the other two segments. The putlog holes of the rubble-vault segment are set at intervals ranging from 0.35 to 1.40 m in no clear pattern and are matched only roughly in pairs across the conduit. The putlog holes are set at shorter intervals at the inner part of the conduit curve. In the regular-vault segment, the putlog holes are set at intervals ranging between 0.40 m and 2.90 m, and are not matched across the conduit due to the bend. In the false-vault segment, the putlog holes are matched in pairs across the conduit,

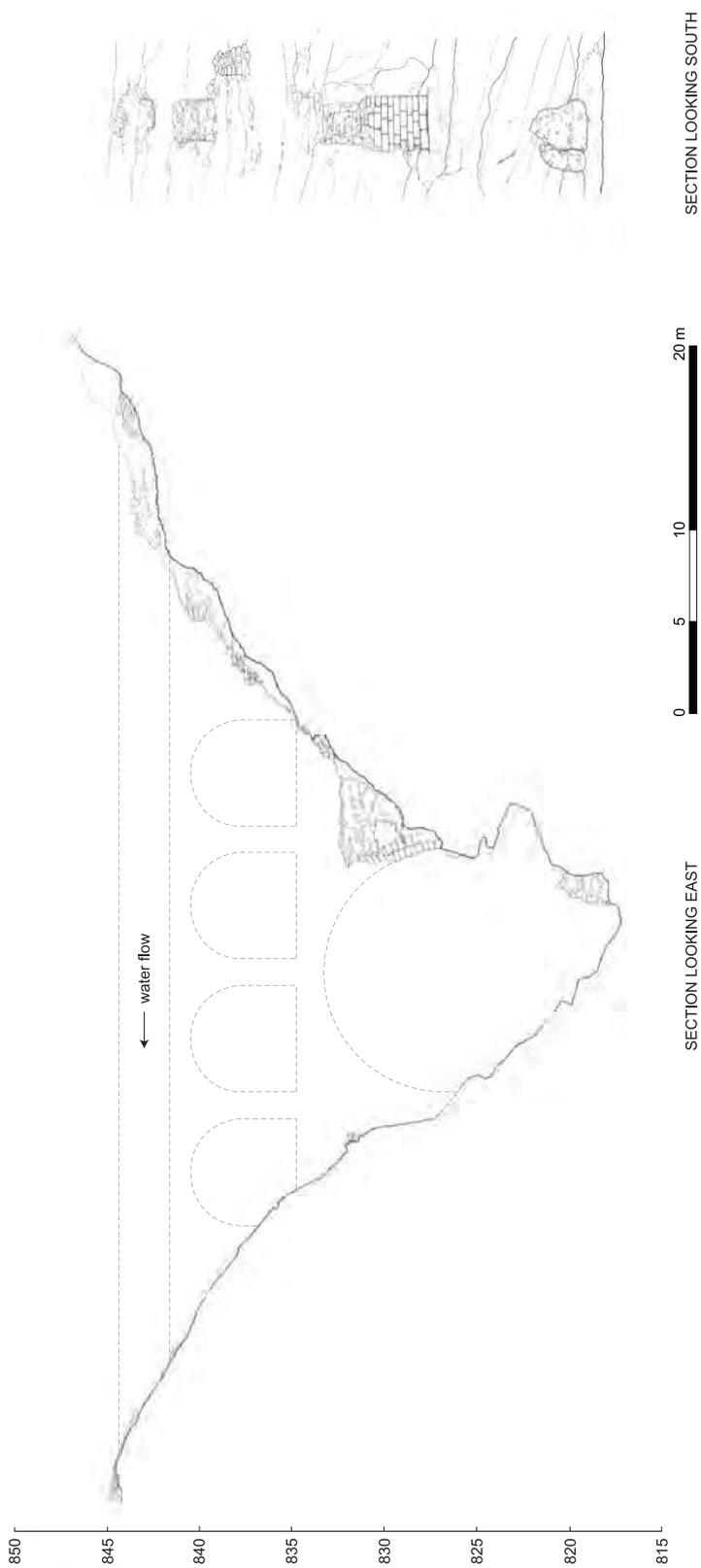


Figure 25. Two-tiered Harami Deresi bridge near Yeşilköy (E008) (1:400).

but those on the northeast side wall are located about 0.14 m below those on the opposite side wall. The irregular intervals of the putlog holes suggest rebuilding or building with purposefully distinct segments, perhaps to accommodate the bend. Additional discussion of the technical aspects of conduit construction follows in “Technical Analysis, Conduit,” below.

Two piers of an aqueduct bridge are preserved on either side of the dry Cıglek Deresi (E033) (see Fig. 21). The total length of the bridge is approximately 42 m, and the estimated height of the aqueduct conduit above the streambed as it ran across the bridge is 11.5 m. The arch and upper portions of both piers have collapsed, leaving a scatter of mortared rubble across both sides of the dere. The piers are constructed of mortared rubble faced with petit appareil masonry. The facing blocks are worked from the well-cemented, sandy conglomerates located throughout the area. Other blocks are fashioned from locally available low-grade, gray-blue marble and quartz. The facing blocks and rubble core are bonded with pink-beige lime mortar with stone inclusions smaller than 0.01 m. The mortared rubble core is structured in layers, and the facing blocks are leveled with small chinking stones.

The base of the west pier is 5.2 m wide and is founded on a rock outcrop. At 18 courses (3.6 m) above the base of the west pier is a leveling course of blocks larger than the other facing stones, all fashioned with a chisel from locally available low-grade, gray-blue marble. The leveling course does not project from the sides of the pier and appears to be too low to have served as a spring point for the arch, which would have spanned just over 6 m.

The west pier is better preserved than the east and has many in-situ facing blocks on the south face, and only a few on its west and north faces. On both piers, the downstream (south) side is much better preserved than the upstream (north) side, which has suffered greater damage from the forces of wind and weather, as seen on all the other aqueduct bridges documented. See “Technical Analysis, Bridges,” below, on the causes of upstream damage.

Yeşilköy. From the Cıglek Deresi, the conduit disappeared underground to run northwest for about 1 km until it once again emerged on a series of bridges crossing deep gorges near the village of Yeşilköy. The bridges are constructed of mortared rubble set in layers and faced with petit appareil masonry. Incorporated into the facing of the piers are periodic leveling courses, which project slightly from the masonry above and below them. These projecting courses are invariably built of marble, also used for some of the voussoirs, and they include occasional reused blocks.

The aqueduct conduit first ran across a tall bridge above the Harami Deresi (E008) (Fig. 25). Although the

bridge is poorly preserved, analysis of the standing remains on both banks of the gorge suggests that the bridge was originally two-tiered, with a lower arch supporting possibly four arches above, topped by the conduit. Traces of the conduit survive on the south (left) bank of the gorge, indicating that the bridge as a whole was about 65 m long and 27 m high.

While nothing remains on the north (right) bank of the gorge except weathered mortared rubble and scattered facing blocks, the bridge is better preserved on the opposite bank. The few facing blocks of the bridge that remain in situ are located on the west (downstream) side of the south pier and are fashioned from the sandy conglomeratic outcrops forming the banks of the gorge. Three kinds of mortar are visible in the remaining sections of the structure. Ubiquitous is a white lime mortar with stone inclusions no larger than 0.005 m. Also visible around the crumbling mass of the upper north pier is a light gray lime mortar with larger stone inclusions up to 0.01 m in size. A third type of lime mortar can be found on the buttressed middle mass on the south bank; it has a very loose, pinkish tan matrix with stone inclusions as large as 0.02 m.

The single arch of the lower tier springs from the bedrock of the steep south (left) bank of the gorge at a height of 10 m above the bottom of the gorge. The tier is preserved to a height of 5.5 m, and the arch originally spanned a distance of approximately 13 m. The arch, only 12 courses of which remain standing, is constructed of two layers of voussoirs, the upper blocks carved from the local well-cemented, sandy conglomerates and the lower of marble. The maximum preserved width of the lower arch is about 3 m, though the facing blocks of the upstream (east) side are missing. Marble voussoirs and a large mass of mortared rubble litter the streambed below the arch and farther downstream along the gorge for at least 20 m. The marble blocks are variously dressed with anathyrosis, clamp cuttings, lifting bosses, and moldings, indicating that they were recycled as voussoirs.

The second tier of the bridge survives mostly in traces on the south (left) bank of the gorge and begins approximately 4.5 m above the remains of the lower tier. It has been reconstructed as a series of four arches, centered on the lower arch and each spanning 5.75 m. A notable feature of the remains is a buttressing structure, perhaps added after the time of initial construction, which joins the downstream (west) side of the second tier in a clear seam. As the upstream (east) side of the second tier on both banks is heavily damaged and has no preserved facing blocks, the buttress on the downstream side must have been built to offset the destabilizing effects of wind and weather on the tall structure. Notably, only the second tier, which had to span a much wider part of the gorge than the tier below, was

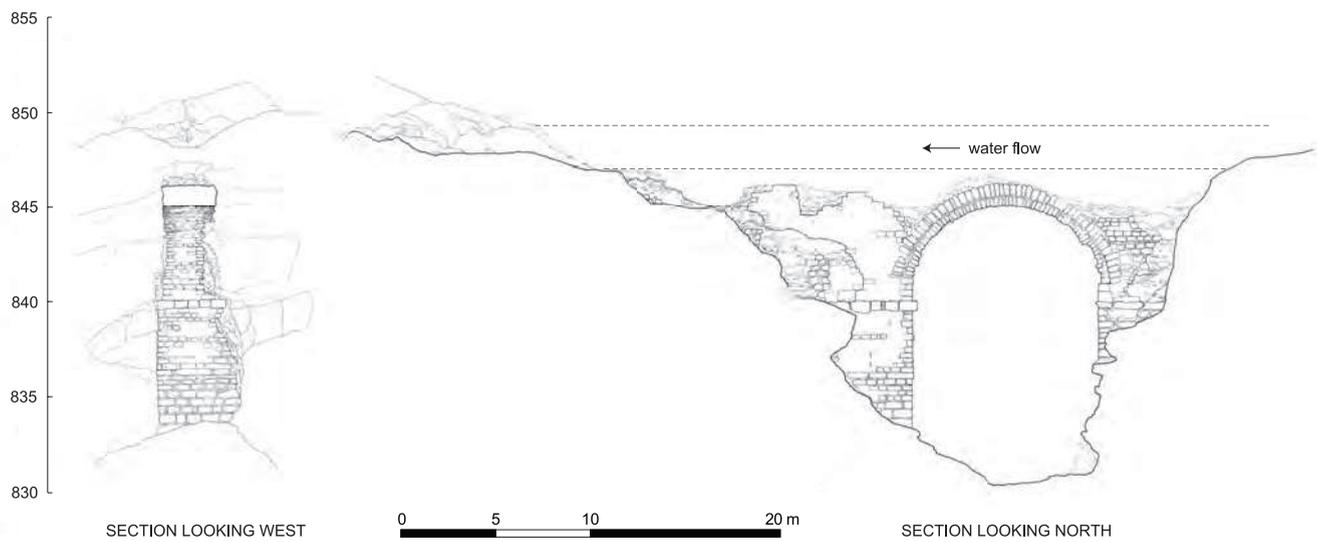


Figure 26. Kırkım Deresi bridge near Yeşilköy (E005) (1:400).



Figure 27. North side of the Kırkım Deresi bridge near Yeşilköy, looking southwest (E005).

equipped with a buttress. Approximately 1 m above the upper tier, the side walls of the conduit are visible emerging from the hillside.

After running underground for 190 m, the aqueduct then passed over another bridge spanning the Kırkım Deresi on an arch that remains intact and can still be crossed on foot (E005) (Figs. 26, 27). On the west (right) bank, a section of the vaulted conduit and tunnel is exposed. Pickmarks line the exposed surfaces of the tunnel, excavated from the conglomerate bedrock of the gorge, into which the vaulted conduit was laid using small blocks of the same rock. The conduit ran approximately

36 m across the bridge and 16.7 m above the gorge below. Based on the remains of the conduit and tunnel, the height of the entire structure is reconstructed as 19 m.

Both piers are founded on rock outcrops. The base of the east pier sits 3.7 m above the base of the west pier. The base of the west pier is constructed of marble blocks several times larger than the other facing blocks. As on the Harami Deresi bridge, the upstream side of this bridge has suffered considerably more damage than the downstream side, on which facing blocks are preserved. Nevertheless, the width of the better-preserved west pier can be reconstructed at 4.3 m. The facing

blocks are fashioned from the same sandy conglomerate outcrops ubiquitous in the region and used for the conduit and other bridges. The lime mortar is white with small stone inclusions, most no larger than 0.05 m.

Both piers terminate in projecting courses of marble blocks, from which the arch of the bridge springs. Interesting to note, the top of the projecting course on the east pier is approximately 0.15 m lower in elevation than the corresponding course on the west pier, which has an additional projecting course located approximately halfway between the upper projecting course and the base of the pier. The lower projecting course of the west pier, 2.6 m above the base of the structure, is made of marble blocks more uniform in size and shape than those of the upper projecting course, located 3.2 m above the bottom of the lower course. The arch spans 9.8 m across the gorge and has two layers of voussoirs, the upper layer being larger than the lower.

After crossing this bridge, the aqueduct turned southwest, running underground for a short distance and then emerging in a poorly preserved bridge, of which only the large footing blocks of sandy conglomerate and the weathered mortared rubble core remain (E007). The east pier of the bridge is 4.4 m wide, with a maximum preserved height of 6 m. The masonry is bonded with white lime mortar with stone inclusions, most smaller than 0.05 m.

Between this bridge and the next one, the conduit ran underground in a tunnel that can be entered from the downstream side and followed for more than 150 m

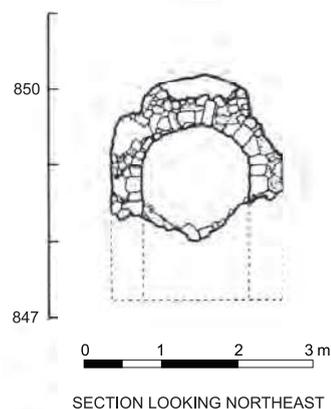


Figure 28. Masonry conduit inside the tunnel near Yeşilköy (E006) (1:100).

(E006) (Figs. 28, 29). Comparable to the conduit segments at Kepiz Çayı (G001) and Ciğlek Deresi (E035), the vaulted conduit is 1.44 m wide and at least 1.9 m high and is built of regular, rectangular blocks cut from the local sandy conglomerate bedrock. The conduit blocks are 0.30–0.40 m long and 0.20 m high. The smaller blocks of the leveling course at the spring point of the vault are 0.30 m long and 0.13 m high. The lime mortar is beige-pink with densely packed stone inclusions smaller than 0.01 m. No trace of waterproofing cement or other treatment of the interior surfaces is visible. No clear sinter level is discernible, and calcareous deposits lining the vault and walls appear to be the result of water percolating through the tunnel and conduit walls.



Figure 29. Masonry conduit inside the tunnel near Yeşilköy, looking northeast (E006).

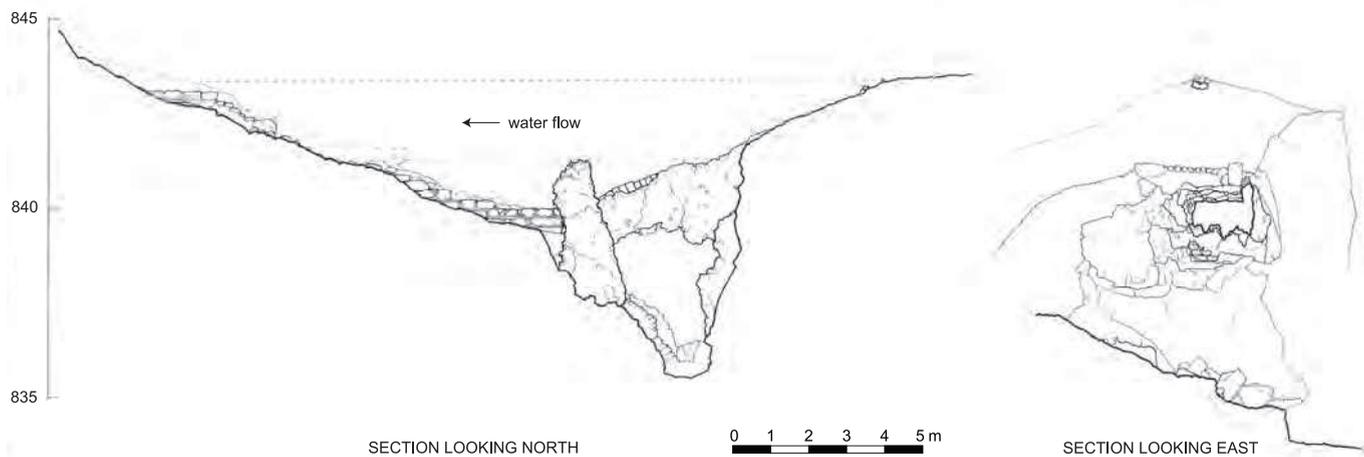


Figure 30. Soğanlık Deresi bridge between Yeşilköy and Denizoluk (E026) (1:200).

The space between the vaulted conduit and the tunnel, excavated from the rock with a “head-and-shoulders” profile, is filled with mud and rubble packing. At 86 m from the entry point, the direction of the tunnel bends slightly to the north, and approximately 5 m later returns to its original orientation, perhaps indicating the meeting point of two construction crews working from opposite directions. Regular putlog holes in the segment downstream from the bend placed at alternating intervals of 0.35 m and 1.40 m indicate that the centering framework was about 1.75 m long. In contrast, the putlog holes in the segment upstream from the bend appear to be differently spaced, with intervals of 0.75 m and 1.30 m, suggesting the use of centering 2.05 m long.

The conduit emerged from this tunnel to cross a low, dry dere. A severely eroded mass of mortared rubble on the south side of the dere is all that remains of the bridge that would have carried the conduit about 9 m above the streambed below (G003).

After the series of bridges around Yeşilköy, the aqueduct returned underground for 1.5 km before crossing a narrow gorge on a small bridge (E026). Between these bridges, the top of a masonry-lined shaft is visible nestled in the contours of a dere hillside (E051). Now filled in with earth and fallen blocks, the shaft is 1.25 m by 1.30 m in internal dimension and is constructed of fieldstones of widely varying shape and size, about 0.20 to 0.50 m long and 0.05 to 0.30 m high. The stones are bonded with white lime mortar with small stone inclusions. This shaft was presumably built to facilitate construction of the subterranean tunnel and conduit, which lay at least 25 m below ground level. It may have been backfilled after construction, in which case settling of the earth has revealed the masonry lining needed to form the shaft until the diggers struck rock below, as seen around one of the shafts on the Yahşiler plateau mentioned above (E052) and those near Denizoluk, discussed below. Alternatively, this

shaft may have remained open as an inspection shaft to allow access for maintenance. If so, it could have been filled in after the abandonment of the aqueduct either as an intentional safety precaution or as the gradual result of neglect.

The next small bridge, which crosses the Soğanlık Deresi, is heavily encrusted with calcareous deposits (E026) (Fig. 30). These deposits were formed by the slow flow of water leaking from the aqueduct conduit while water still passed through it. Such extensive calcareous incrustations could indicate that here the aqueduct was tapped for local irrigation or some industrial use, perhaps once the aqueduct no longer supplied the city.³²

Traces of the conduit vault are visible on both sides of the bridge, indicating that the structure was 5.5 m high and approximately 20 m long. The dimensions of the conduit side walls, each 1.2 m thick, and floor, 1.50 m wide, suggest that the whole structure was 3.9 m wide and therefore retained the same dimensions as the observed segments of conduit located upstream. The upstream (north) side of the bridge has deteriorated to the extent that it is only half as wide as it was originally. Like the other bridges, this small bridge is built of mortared rubble faced with petit appareil masonry bonded with a pinkish tan lime mortar with stone inclusions, most less than 0.01 m. The facing blocks are carved from the local low-grade, blue-gray marble and fieldstones such as schist. The arch, which springs from the banks of the gorge, has two layers of voussoirs carved from the blue-gray marble and spans 4 m across the gorge.

Denizoluk. Returning underground, the aqueduct conduit changed direction, running west-northwest

32. As seen, e.g., along sections of the Nîmes aqueduct and the first Arles aqueduct that, no longer suitable to supply the city of Arles, was restructured to power the mills of Barbegal. P. Leveau, “Research on Roman Aqueducts in the Past Ten Years,” in A. T. Hodge (ed.), *Future Currents in Aqueduct Studies* (Leeds 1991) 149–62, at 152–53.

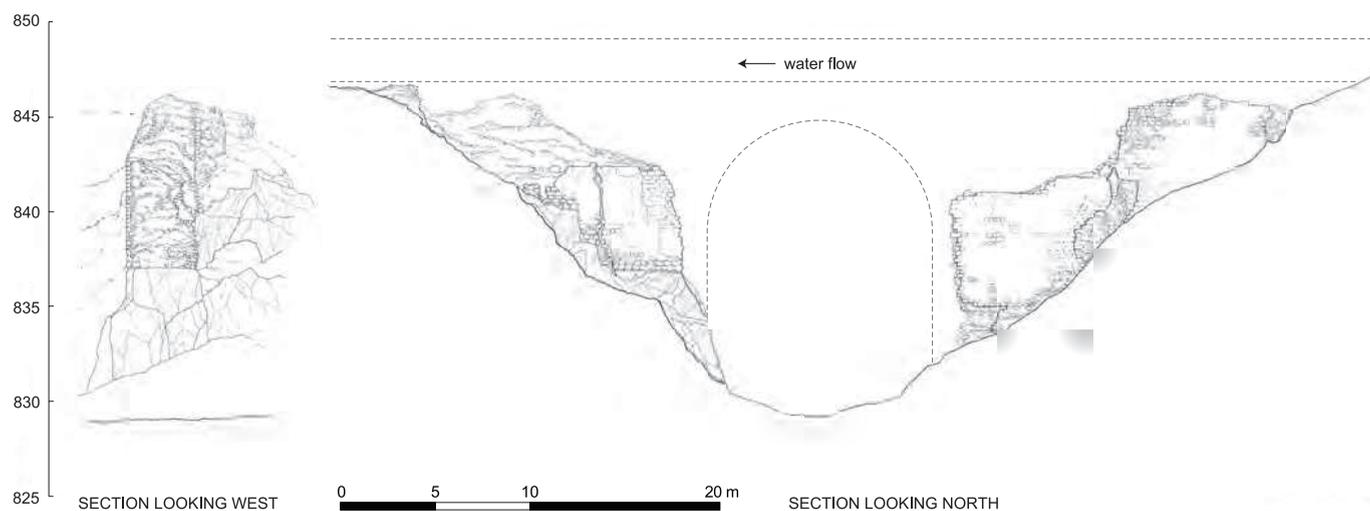


Figure 31. Şaban Deresi bridge near Denizoluk (C048) (1:400).



Figure 32. South side of the Şaban Deresi bridge near Denizoluk, looking northeast (C048).

along the northern bank of a streambed. Traces of the conduit side walls are visible along the sloping north bank of the İnce Dere (E046, E027). Where the stream is joined by the Şaban Deresi, the aqueduct conduit traveled across this tributary gorge on the widest of all the documented bridges, located near the village of Denizoluk (C048) (Figs. 31, 32). The bridge was originally more than 50 m long, is preserved to a maximum width of 6.7 m, and carried the conduit an estimated 18 m above the streambed below. The height of the entire structure may have been 20 m. Nothing remains of the arch, though large masses of mortared rubble sitting in

the streambed below the bridge hint at how immense the structure originally was.

The bridge is constructed of mortared rubble set in layers and faced with petit appareil masonry leveled with chinking stones. The blocks of the face and the rubble core include various kinds of locally available fieldstone such as schist, and in many areas the face is obscured by a thick and crusty layer of calcareous deposits. The white lime-based mortar has densely packed stone inclusions that vary greatly in size, with most less than 0.02 m. The well-preserved masonry of the downstream (south) side is noticeably different from that of the other bridges

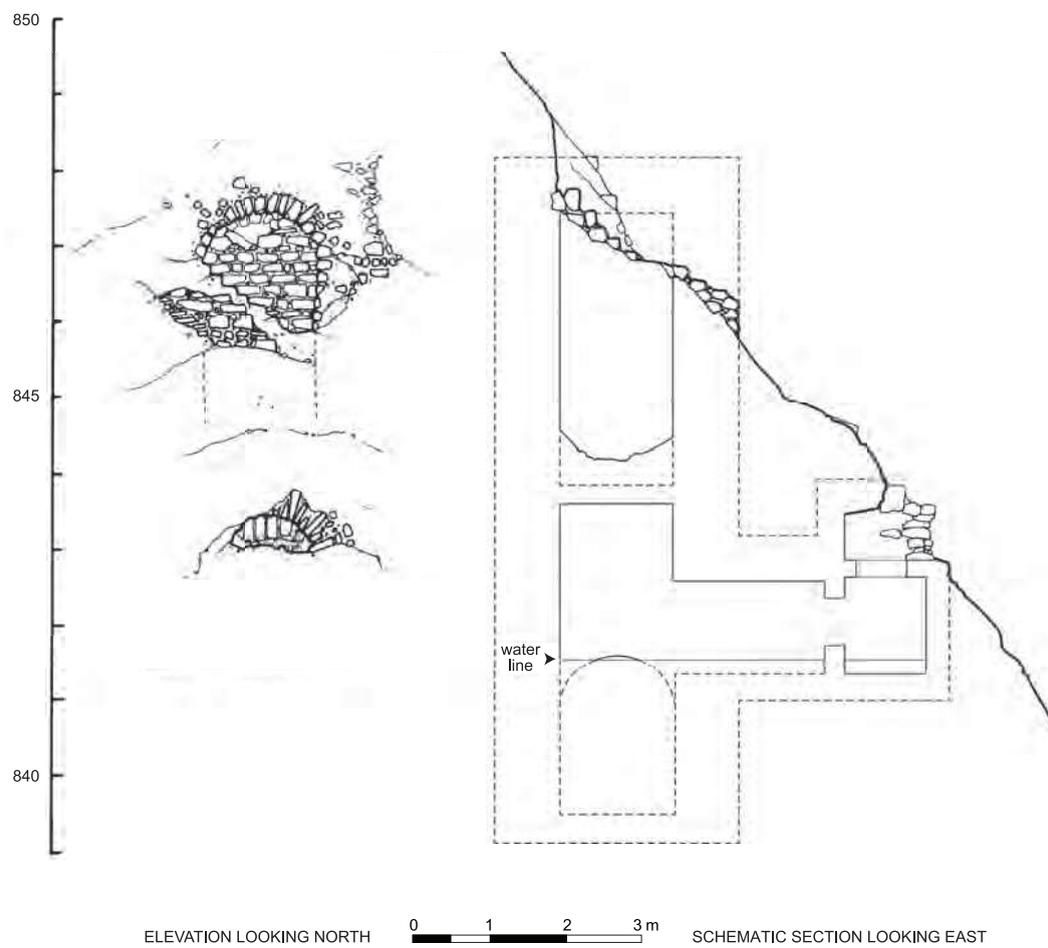


Figure 33. Masonry inspection shaft on the İnce Dere near Denizoluk (C049) (1:100).

both in the regularity and level placement of the facing blocks and in the pointing of the joints, which gives the bridge a more finished appearance.

The west pier is founded on an outcrop of peridotite, a red-purple rock highly susceptible to erosion. One of the large chunks of mortared rubble in the streambed has a fragment of peridotite still attached to it, suggesting that the innate weakness of the rock on which the bridge was founded quickened the collapse of its arch. A spring or leveling course projects slightly from the south face at a height of 2.5 m above the ground on the west pier and 6 m above the ground on the east pier. The blocks of this course are not significantly different in size or material from the other facing blocks.

As on the other two large bridges, the facing blocks are preserved only on the downstream (south) side of the bridge, while much of the upstream side is missing. The unstable peridotite on which the west pier is founded and the effects of wind and weather in the wide gorge probably caused the collapse of the bridge, large sections of which now lie in the streambed. Nothing remains in situ of the arch that must have carried the aqueduct across the gorge. While the distance between the eroded piers is currently 14.5 m, the arch has been reconstructed with a span of approximately 12 m, because masonry missing from

the interior sides of the piers indicates that the original distance between them was smaller.

The bridge appears to be a combination of two separately built structures. The original structure carried the conduit across the gorge. The conduit floor as preserved on the west pier of the bridge is 1.50 m wide, and the single fully preserved (south) side wall is 1.10 m wide. Assuming that the other side wall was also 1.10 m wide, the total width of the original bridge was 3.70 m. A separate mortared rubble structure 3.20 m wide abuts on the south face of the original bridge. Only the south face of this structure is faced with petit appareil masonry, as described above. Its mortared rubble core is laid directly up against the south side of the original bridge. This arrangement suggests that the southern structure is a buttress built sometime after the construction of the bridge. A later date for the construction of the buttress would explain the unusual treatment of the masonry in contrast to that of the other bridges. As on the upper tier of the two-tiered bridge over the Harami Deresi near Yeşilköy (E008), the buttress was built on the downstream side of the bridge to help stabilize the structure against the forces of wind and weather approaching from upstream. Such support was especially necessary in the wide Şaban Deresi as well.



Figure 34. Masonry inspection shaft on the İnce Dere near Denizoluk, looking north (C049).

Pottery sherds pepper the west bank around the base of the pier, and walls of roughly worked stones are visible along the streambed south (downstream) of the west pier. The pottery and walls may remain from the period of the bridge's construction, during which time groups of workers may have camped on-site and used ramps to facilitate building the bridge on steep rock outcrops. Alternatively, the walls could be the remains of a road following the course of the streambed or some structure built to manipulate stream flow.

After traversing this wide bridge, the aqueduct continued to hug the north bank of the İnce Dere on its westward path. The conduit itself is not visible, but its path is indicated by traces of the conduit walls and a series of shafts. While two of the shafts are discernible only as depressions in the ground, two others are still well preserved. The first, located about 450 m west of the Şaban Deresi bridge along the north bank of the İnce Dere, is lined with roughly worked, mortared fieldstones (C049) (Figs. 33, 34). It is topped by a barrel vault oriented perpendicular to the streambed and to the aqueduct conduit underground and built of stones of the same size. The bottom of the shaft at its point of in-

tersection with the conduit is accessible via a horizontal access conduit, which emerges from the north (left) bank of the stream. The streambed and the conduit run parallel to each other, with the access conduit perpendicular to both. The floor of the access conduit lies approximately 0.1 m lower than the top of the vault of the aqueduct conduit. The aqueduct conduit itself is currently filled almost to the top of its vault with mud, debris, and water flowing slowly from east to west.

The structures are currently being used as part of a modern pumping system, access to which is provided by a rectangular concrete manhole connected to the ancient access conduit. About 2 m above the aqueduct conduit, the shaft has been sealed with concrete to prevent debris from falling into the water collected in the modern system.

The internal dimensions of the shaft are 1.45 m by 1.45 m, and the vertical walls are 0.90–1 m thick. The stones of the shaft are 0.20–0.30 m long, 0.10–0.15 m high, and 0.20–0.30 m deep. Most of the vault has collapsed, but presumably it was pierced by a manhole that would have been covered when not in use. The depth of the shaft, from the vault to the top of the conduit below, is approximately 6.3 m. The horizontal access conduit is barrel-vaulted and built of mortared masonry, with regularly shaped, rectangular blocks 0.20–0.30 m on a side. The access conduit intersects with the vertical shaft about 5 m down from the top of the shaft. The conduit, which at the time of investigation during the summer was filled with water to a depth of 0.1 m, is 2.3 m long, 1.45 m wide, and about 1.25 m high. A pair of putlog holes under the springing of the vault is located 0.2 m from where the conduit meets the shaft.

At the southern end of the horizontal access conduit, where it approaches the stream, a barrel-vaulted structure has been attached, which appears to be a later addition. A vertical wall approximately 1 m high and built of stones with their long sides placed vertically, rather than horizontally as seen on the inspection shaft, connects the two barrel vaults. This barrel-vaulted structure is more than 1 m long and approximately 1.2 m wide. The walls below the vault no longer stand, making the full height of the structure unknown. The stones used in this vault are larger than those used in the vault of the inspection shaft and are at a slight upward angle, and the mortar of this structure is thickly and unevenly applied, unlike that of the inspection shaft and access conduit.

While the vertical shaft was likely built to provide a permanent point of access for inspection and maintenance, the function of the horizontal conduit is less clear. It is built so that its floor is at the level of the top of the vaulted aqueduct conduit, probably to prevent it from being flooded by water carried in the aqueduct. There is no trace of waterproofing mortar or sinter on

its interior surfaces, indicating that it did not carry water to the conduit. The combination of a horizontal conduit and vertical shaft that meet at a right angle is also seen in the large shaft cut into the rock, almost 1 km to the west, discussed below (C044). The general similarity in form suggests that the horizontal conduit seen here, like the horizontal tunnel at the rock-cut shaft, was likely built before the aqueduct conduit to facilitate its construction by providing access for workers and supplies more conveniently than that provided by a vertical shaft. The standing vertical shaft, probably built at the same time, could have been used in conjunction with the horizontal conduit to provide light and air to the construction crew. One or both of the structures, most likely the vertical shaft, could have remained open as a point of access for inspection and maintenance.

As noted earlier, the eroded vaulted structure connected to the southern end of the horizontal access conduit appears to be a later addition. It may have been added during the life of the aqueduct, perhaps to elongate the access conduit, making it easier to enter and less likely to become covered up by earth eroding from the stream bank. If it was intended to make access to the aqueduct conduit more convenient, it may indicate that this location was used not only as a point for inspection but also as a place from which water could be drawn directly from the aqueduct conduit, perhaps by residents of the surrounding countryside.

Between this inspection shaft and the next one with visible remains, the locations of two additional shafts are indicated by depressions in the ground following the path of the aqueduct (C046, C047). To the west of these lies a large shaft that originally extended down about 50 m to the aqueduct conduit running below (C044) (Fig. 35). The shaft is cut through rock, above which one side is lined with mortared petit appareil masonry forming a barrier against the loose earth around it. A system of horizontal tunnels running perpendicular to the shaft appears to have been created at the same time as the shaft. One tunnel connects the shaft to the sloping ground surface of the surrounding stream bank. A second tunnel runs deep into the hillside and splits into numerous dendritic and serpentine branches.

The shaft has been filled in with eroded earth and rock so that it is currently only 13.3 m deep. For most of its preserved depth, the shaft is 2.2 m by 2.6 m wide. However, about 1 m above the current bottom of the shaft, its walls are undercut irregularly on three sides. Pickmarks matching those higher up on the walls indicate that these undercuts are not natural but man-made. The shaft may have been widened to form a staging area, the first of several in a stepped profile created to facilitate the lowering and lifting of workers, supplies, and backdirt up or down the 50 m required to meet the level of the aqueduct conduit below.

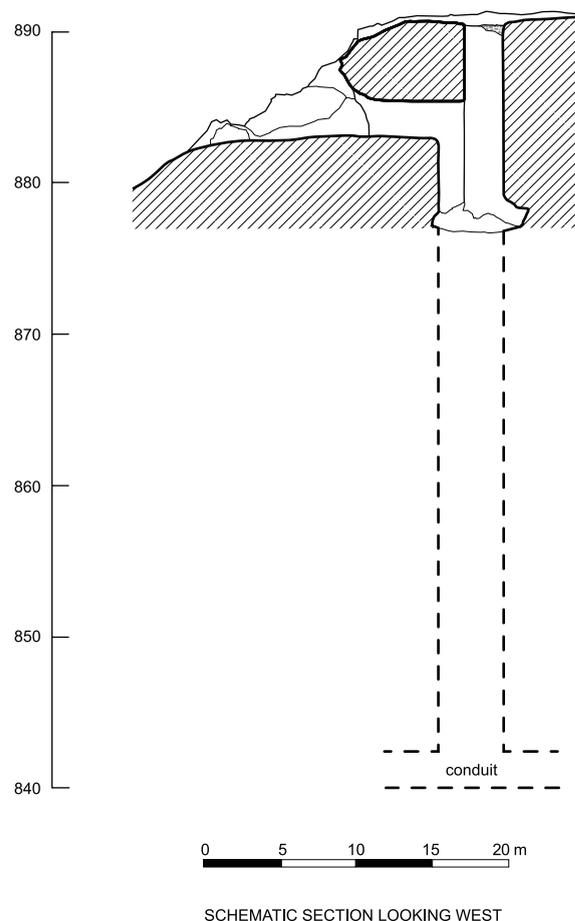


Figure 35. Schematic section of the large rock-cut shaft on the İnce Dere near Denizoluk (C044) (1:500).

In lowering and lifting workers and materials, the construction crew apparently used a rope and pulley system, controlled by a winch and secured by a series of cuttings in the walls of the horizontal rock-cut tunnel that connects to the shaft. This tunnel is 2.5 m high, 1.3 m wide, and preserved to 5 m long. Close to where it meets the shaft, the tunnel is equipped with three pairs of roughly square cuttings, each across from its mate, arranged vertically. The lowest pair seems to have originally included two cuttings on each side. Directly under the tunnel, the southern wall of the shaft is recessed 0.4 m, most likely to provide space for the rope and materials maneuvered by the pulley system. Another cutting is visible near the top of the tunnel on its east wall. Because the matching west wall is damaged due to rock collapse, the probable mate to this cutting is not preserved.

The function of the elaborate tunnel system extending into the hillside is unclear. Its various branches are approximately 0.75 m wide, varying in height from about 0.8 m to 1.5 m. The system looks like a series of exploratory tunnels dug in search of a spring along the upper reaches of the İnce Dere. In this case, the tunnels were probably not constructed in association with the

aqueduct. Alternatively, the tunnel system could have been used to collect water percolating through the hillside and to conduct it into the shaft, where it would have added to the volume of water already flowing through the aqueduct below. It may instead have been used as an air barrier to prevent the seepage of water into the shaft during its construction, helping to keep the work surface visible and dry.

The hillside above the shaft is covered with a considerable amount of pottery. It is tempting to interpret this pottery scatter as either the traces of the construction crew, temporarily camping on-site to speed up construction time, or the remains of a small settlement or farmstead. Inhabitants of the settlement or farmstead could have obtained water for drinking and irrigation from the tunnel system, acting as a drainage gallery, or, after the construction of the aqueduct, by drawing water from the conduit itself. In the latter case the same type of rope and pulley system used during construction could have been used to draw water from the conduit, essentially using the aqueduct as a well.

When viewed together, the impressive depth and size of the shaft, the elaborate system of associated tunnels, the multiple cuttings for a rope and pulley, and the pottery scatter indicate that this site was a major focus of construction for the aqueduct. The fact that over 13 m of the shaft is still exposed suggests that it was never completely filled in and could have possibly remained open to provide access to the conduit both for maintenance and for water supply to the local population.

The Morsynus river valley. The next point we were able to identify lies about 5 km to the west, near the village of Kayapınar in the hills marking the southeast limit of Morsynus river valley. Over this distance the aqueduct must have traveled underground from the watershed of the Timeles river into the Morsynus river valley by piercing a relatively low saddle in the chain of hills that forms the boundary between these two valleys. The hills to the southwest (Avdan Dağı) and northeast (Tepeköy) of this saddle rise to elevations above 1,000 masl. The aqueduct builders chose to tunnel through this saddle because of its low and level elevation relative to the ridges on either side. At this point, the backdirt pile or spoil heap of a shaft and a section of tunnel are visible at the beginning of a large streambed known as the Kocadere (E010).

However, one structure likely related to the aqueduct was identified in this area before the aqueduct reached the Kocadere. Turning along the contour of a small hill, a tunnel with a head-and-shoulders profile similar to the tunnel at Yeşilköy (E006) but considerably smaller, may have served as an access tunnel for the subterranean aqueduct conduit (E028). The maximum preserved dimensions of the tunnel, cut through rock, are 0.65 m



Figure 36. Vertical cutting with visible pickmarks along the Kocadere near Kayapınar, looking northwest (E009).

high and 0.85 m wide at the base. The profile narrows to 0.4 m wide and then 0.2 m at top. The tunnel is preserved to a length of 5.5 m.

After tunneling through the low saddle between Avdan Dağı and Tepeköy, the aqueduct entered the Morsynus river valley along the west bank of the Kocadere, one of the gorges that drain surface runoff and spring water on a northbound course from the southeastern hills of the valley to the Morsynus river itself. Near the head of the Kocadere, the backdirt pile or spoil heap of a shaft is visible just below the village of Kayapınar (E010). The Kocadere soon becomes a narrow gorge cutting deep into the southeastern hills of the valley. About 380 m downstream from the shaft, the rock of the west (left) bank of the gorge is cut vertically to create a level bedding for the aqueduct conduit. Pickmarks are preserved on the vertical rock face (E009) (Fig. 36). It is unclear whether the rocky stream bank was originally cut to form a tunnel or an open channel into which the conduit was laid. While the conduit itself is not preserved, the local informant who showed us the remains remembered being able to enter a conduit farther upstream that, according to his description, was similar to the vaulted masonry conduit documented elsewhere along the aqueduct.

The narrow Kocadere broadens as it travels northwest, merging with other streams until it joins the Morsynus in the level plain southeast of Aphrodisias. About 5.7 km downstream from the rock-cut tunnel (or channel) at Kayapınar, a segment of rubble masonry conduit is visible in the eroded west (left) bank of the Kocadere, several meters above the modern streambed (E031) (Fig. 37). The conduit is built of unworked fieldstones of varying sizes, has a flat rather than a vaulted roof, and is approximately 1 m high and 0.5 m wide internally, with side walls 0.2 m thick. It is located downstream from the point where the Timeles aqueduct presumably turned northeast to head through the foothills of Koca Dağ just northwest of the town of



Figure 37. Cross section of the masonry conduit in the Kocadere, looking northwest (E031).

Gökçeler. In addition, the conduit in the Kocadere is located at least 20 m lower in elevation than the aqueduct bridges in the Morsynus river valley. These circumstances, as well as differences in construction, indicate that this conduit it is not the main conduit of the original aqueduct. However, its location near the probable route of the aqueduct suggests that it was connected with it in some way, perhaps as a subsidiary conduit that tapped water from the main aqueduct to supply a nearby village or farmstead or to irrigate fields. Alternatively, it could be a self-contained, small-scale aqueduct similar to the Kavaklıdere and Ören Deresi aqueducts discussed above.

At the very end of the final season of investigation in 2008, a local informant showed us the remains of two bridges in the Morsynus river valley that spanned streams feeding into the Morsynus river from the north, and remembered being able to enter a tunnel that pierced the foothills of Koca Dağ situated between the Kocadere and these streams. It is possible that the aqueduct ran through this same hill—rather than hugging its contours—south of the two bridges in the river valley before crossing them and heading west toward Aphrodisias.

The first of the two bridges crossed by the aqueduct spanned the Gümüş (Korkor) Deresi (E058) (Fig. 38). Only one pier remains of this bridge, which is built of mortared rubble faced with petit appareil masonry and stands on the north (right) bank of the stream. The length of the pier has been cut in two to accommodate a dirt road parallel with the stream. In contrast to all the other bridges of the aqueduct, the better preserved side is the upstream (east) side, though in this area of the valley, carpeted by orchards and agricultural fields, the most deleterious force on the bridge was likely not weather but the reuse of the bridge's blocks to build the stone walls that delineate the fields and even abut the bridge itself.



Figure 38. Bridge on the Gümüş (Korkor) Deresi, looking northeast (E058).

The pier is preserved to a maximum width of 3.5 m, length of 12 m, and height of 4.8 m. The rounded fieldstones that make up the structure are not as internally consistent in shape and size as those of the other bridges along the aqueduct, and many of the facing blocks are larger than those of the other bridges. The lime mortar is gray with densely packed stone inclusions smaller than 0.02 m. The pier rests on a rock outcrop forming the bank of the dere. No leveling courses are incorporated into the pier, and because nothing remains of the arch or the conduit that must have originally spanned the Gümüş Deresi, the height and length of the entire bridge are unknown. The pier extends to the north into agricultural fields, where it is no longer traceable.

The second bridge in the Morsynus river valley is the closest structure to Aphrodisias we were able to identify (E059) (Fig. 39). The lower courses of both sides of the arch are well preserved, while the upper portions of the arch and both piers have been cut down to serve as a substructure to support a modern concrete channel for the irrigation of the extensive agricultural fields in the area. The upstream (north) side has suffered more damage than the downstream side. The bridge, spanning 5.8 m to cross the Seki Deresi, is 5.2 m wide and survives to a height of 8 m above the streambed below. The visible

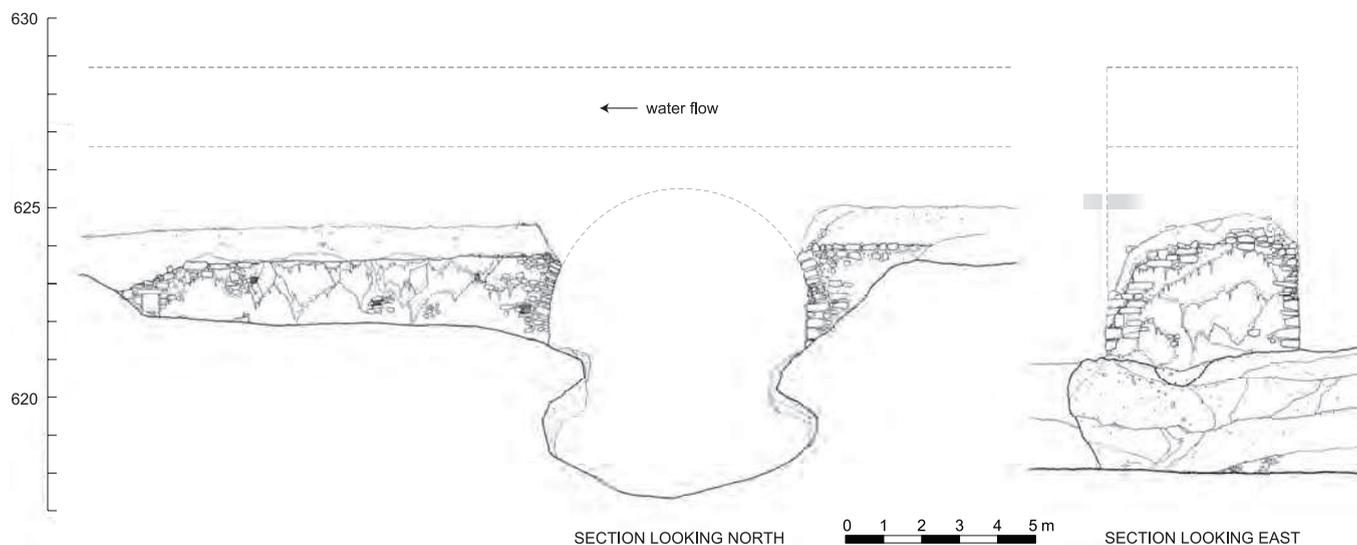


Figure 39. Seki Deresi bridge (E059) (1:200).

structure is more than 50 m in length and may have originally been 11 m high.

The bridge is built of mortared rubble faced with petit appareil masonry. Both piers of the bridge are founded on the bedrock forming the banks of the Seki Deresi. At its east and west extremities, the structure is buried under agricultural fields. The west pier alone extends 34 m from the streambed before disappearing into the ground. At about 10 m from the streambed, the west pier is pierced by a drainage conduit included as part of the original structure. This conduit must have served, as it does today, to prevent surface water from gathering along the foundations of the pier and undermining its structural integrity. Unlike the arches of the other bridges on the aqueduct, here there is only a single layer of voussoirs, which incorporate both fieldstones and marble blocks.

This structure is especially interesting because it is the best-preserved aboveground section of the aqueduct, apart from the bridges. Because the agricultural fields in which the aqueduct is located have been worked intensively for centuries since the aqueduct was abandoned, it is unclear at what point the conduit once again entered the ground. The apparent absence of other aqueduct remains west of this point makes it unlikely that the aqueduct resurfaced before reaching Aphrodisias itself. Presumably the builders chose to carry the conduit on a solid substructure across the level valley because the difference between the elevation to be maintained by the conduit and the elevation of the ground surface was not large enough to necessitate the construction of an arched arcade.³³ No remains of the Time-

les aqueduct have been identified between this substructure and the city.

TECHNICAL ANALYSIS

Discharge

While the Seki and Işıklar aqueducts collected water from springs in the hills and mountains surrounding the Morsynus river valley, engineers had to search farther afield for a source adequately abundant to supply the large-scale projects envisioned for the growing city. The perennial springs along Baba Dağı have only a small recharge area from which they gather snowmelt, and most of the streams in the valley were likely ephemeral or intermittent in antiquity as now. Furthermore, the most abundant perennial springs at Seki and on the western slopes of the Baba Dağı range were already being exploited to supply the city. The closest area where plentiful, perennial streams could be found was in the neighboring Tavas plain, where multiple tributaries run together to form the Timeles river (Yenidere Çayı). The Timeles aqueduct stretched southeast from Aphrodisias to tap these tributaries.

Unfortunately, modern discharge data for these springs and streams have not been collected, and corresponding ancient data will in any case remain unavailable. It should be noted that even perennial streams such as the Kepiz Çayı and other tributaries of the Yenidere Çayı can have significant variability in discharge from season to season and even from day to day. Analysis of modern flow rates for the springs that fed Roman aqueducts at Metz, Fréjus, and Nîmes shows that variations

33. Substructures were not uncommon on Roman aqueducts. E.g., where the conduit of the Gier aqueduct at Lyon ran less than 3 m above ground level, the builders opted to support it with a solid concrete substructure faced in *opus reticulatum* rather than with arches, which were constructed elsewhere along the aqueduct where the conduit ran at a greater height above the ground.

J. Burdy, "Some Directions of Future Research for the Aqueducts of Lugdunum (Lyon)," in Hodge, *Future Currents in Aqueduct Studies* (supra n. 32) 29–44, at 41; Burdy, *Les aqueducs romains de Lyon* (supra n. 31) 51–52, fig. 20.

between minimum and maximum daily flow rate, and between daily discharge of the days within a given month, were within one to three orders of magnitude.³⁴ Though it is not clear whether the Timeles aqueduct tapped the Kepiz Çayı, another stream, or the springs feeding these streams, it is important to note that variability in source output certainly had implications for source selection, the schedule of aqueduct maintenance, and the distribution of water within the city itself. Most important, the flow rate of its source waters determined the discharge of the aqueduct itself.

Although discharge at the aqueduct source cannot be measured, an estimate for the potential volume of water transported by the aqueduct can be tentatively gleaned by analyzing the accessible segments of conduit. Where the conduit is exposed in the Cıglek Deresi (E035), it is 1.50 m wide, and heavy sinter deposits begin about 0.95 m down from the top of the rubble vault. Using the cross section of the conduit made visible by the collapse of the adjacent bridge, the original height of the conduit is calculated at 2.25 m. Assuming that sinter deposits on the conduit floor and side walls were laid at the same time, the water could have run 1.30 m deep. With these measurements plus values for the average slope of this section of the aqueduct, the discharge of the aqueduct at this point can be estimated.

Using both the Bazin and Manning formulas for mean velocity and two possible values for the Chézy coefficient (concerning the roughness of the conduit surface), the result is a minimum potential discharge per day of 214,963 m³ and a maximum of 286,589 m³ (see Appendix, Calculation 1). Even the lowest estimate for potential daily discharge of the aqueduct—214,963 m³/24 hours—is extremely high in comparison with estimates for the aqueducts of Rome. For example, the Aqua Claudia and the Aqua Anio Novus, both built in the first century A.D., had an estimated discharge of 184,220 and 189,520 m³/24 hours, respectively.³⁵ The Anio Novus, in fact, was the most abundant of Rome's eleven aqueducts. While the mean velocity calculated for the Timeles falls comfortably within the "normal" range for Roman aqueducts, about 1.0–1.5 m per second, its discharge does not.³⁶ The suspect variables, then, are water level height and gradient. The gradient used for this section of the aqueduct, from the modern dam to the rock-cut tunnel at Kayapınar, is 0.95 m per km, certainly not excessively steep in relation to Roman aqueducts in general or even to other sections of this aqueduct.

34. H. Chanson, "The Hydraulics of Roman Aqueducts: What Do We Know? Why Should We Learn?" in R. W. Babcock, Jr., and R. Walton (eds.), *World Environmental and Water Resources Congress 2008 Ahupua'a*, American Society of Civil Engineers (Reston, VA 2008) 1–16, at 6–7.

35. Hodge, *Roman Aqueducts and Water Supply* (supra n. 30) 347.

36. *Ibid.*, 220.

More likely, the value of 1.30 m for depth of water at this point is an overestimation. The accumulations of sinter on the conduit floor may have been deposited earlier than those on the conduit side walls, which instead represent a later period of water flow after sinter and sediment accumulation raised the level of the conduit floor and thus raised the water level as well. The fact that in this area the conduit was constructed using three different techniques may indicate that the conduit segment from which the height of sinter on the side walls was taken belongs to a later construction phase not associated with the original conduit floor, also resulting in an overestimation of water depth. Unfortunately, the measurements cannot be corrected by comparison to the segment of conduit visible at Yeşilköy (E006), because here no clear maximum sinter level is preserved on the side walls. Instead, calcareous deposits lining the vault and walls appear to be the result of water percolating naturally through the tunnel and conduit masonry. In addition, the floor level of the conduit visible along the Kepiz Çayı (G001) has been significantly raised due to erosion and infill via repeated entry and damage caused by the construction of the modern road nearby.

As a control, however, the average distance between the top of the vault and the level of the putlog holes, which do not contain sinter, in these two sections of conduit can provide a rough estimate of maximum water level. The maximum preserved interior height of the conduit at Yeşilköy, less subject to sediment infill than the conduit at Kepiz Çayı, is 1.90 m. The average distance between the top of the vault and the level of the putlog holes in both segments of conduit is about 0.80 m. Allowing 0.10 m for sediment accumulation, erosion, and infill on the conduit floors, we can use 1.00 m as a tentative estimate of the height of water flowing through the conduit.

Changing just this one variable has considerable ramifications for our minimum calculation of the aqueduct's potential daily discharge: the new figure is 156,989 instead of 214,963 m³/24 hours (see Appendix, Calculation 2). In this case, the Bazin formula is used to compute velocity, and a value of 60 is used for the Chézy coefficient to obtain the minimum possible velocity. A second potential problem is the gradient, 0.95 m per km, which is calculated over a distance of 11 km, and therefore may not correspond to the actual gradient of the conduit at this particular point. To flesh out the parameters of potential discharge for the aqueduct, halving the gradient gives an estimate of almost 111,000 m³/24 hours, while doubling the gradient results in a discharge of about 222,000 m³/24 hours (see Appendix, Calculation 3). The aqueduct, then, likely carried somewhere around 150,000 m³ of water into the city each day and, given its remarkably wide conduit, could have transferred considerably more. The important point to glean from these calcula-

tions, some of which amount to mere educated guesswork, is that the Tímeles aqueduct seems to have provided a volume of water comparable to the most abundant aqueducts serving the city of Rome.

The construction of such an enormous aqueduct for Aphrodisias underscores a particular approach of Roman engineers, namely, to use a standardized model for aqueduct construction rather than to tailor each project to local specifications. In addition, the structure had to be large enough to enable access by human operators, both during construction and after for maintenance. Alternatively, the engineers and patrons responsible for this building project may have decided to build as large an aqueduct as possible both to accommodate the possibility of increased demand in the future and to make a strong claim of political and economic importance for the present and future. The intentional construction of an aqueduct with a capacity exceeding anticipated needs may also be the result of practical considerations. Aqueducts were susceptible to leaks, especially where they ran underground in long tunnels that were difficult to access and maintain. The anticipation of water loss in subterranean segments such as the 2 km long tunnel running 50 m below the Yahşiler plateau may account in part for the decision to transport a greater volume of water than required. In any case, certainly the Tímeles was the largest of the three Roman aqueducts to supply Aphrodisias, which must have depended on it for full operation of the Hadrianic Baths and, possibly, the pool stretching across the South Agora.

Gradient

Between its source near the modern dam and the tunnel near Kayapınar, a distance of about 11 km, the aqueduct lost about 0.95 m in elevation per km (0.095 per cent).³⁷ Below Kayapınar, however, it seems to have run along

37. Gradient estimates differ depending on whether (1) the tunnel at Çaliköy (E056) or the modern dam is considered to mark the location of the source and (2) the masonry conduit in the Kocadere (E031) is included in the aqueduct path reconstruction. The estimates given in this chapter work on the assumption that (1) the modern dam more likely marks the source of the aqueduct and (2) the masonry conduit in the Kocadere tunnel should not be included in the aqueduct path reconstruction. The possible gradients of different sections are:

- Çaliköy tunnel (E056) to Kayapınar tunnel (E009)
= 34 m / 14.25 km = 2.39 m/km
- Modern dam to Kayapınar tunnel (E009)
= 10.5 m / 11.04 km = 0.95 m/km
- Kayapınar tunnel (E009) to Kocadere conduit (E031)
= 233 m / 5.69 km = 40.95 m/km
- Kayapınar tunnel (E009) to Gümüş Deresi bridge (E058)
= 209 m / 9.49 km = 22.02 m/km
- Kocadere conduit (E031) to Aphrodisias
= 82 m / 11.05 km = 7.42 m/km
- Gümüş Deresi bridge (E058) to Aphrodisias
= 106 m / 7.25 km = 14.62 m/km

the Kocadere and turned east to hug and then possibly tunnel through the hillside south of the two bridges in the Morsynus river valley. From Kayapınar to the two bridges in the valley, the aqueduct ran at a significantly steeper gradient of about 22 m per km (2.2 per cent) for a distance of approximately 9 km. Assuming this gradient is correct, it is possible that steep chutes or drop-shaft cascades were incorporated into the aqueduct to help manage the flow of water. This possibility is discussed in detail below.

After crossing the bridges in the Morsynus river valley, the aqueduct could have flowed at a gentler gradient of about 15 m per km (1.5 per cent) over the distance of approximately 7 km to Aphrodisias by following the hills that circle the valley, before reaching the east side of the city itself. This is the route suggested by A. Kuznetsov using least-cost path analysis. Two *suterazi*, or Ottoman “water balance” towers used to control water pressure, were built along the eastern edge of the city, suggesting that, at least in later centuries, water entered the city from this direction.

Special Problem: The Kocadere

From Kayapınar to the two bridges in the Morsynus river valley, the Tímeles aqueduct ran along the Kocadere at the steepest gradient of its entire route. The average gradient for this section, which covered about 9 km, is 22 m per km (2.2 per cent). While this gradient is not impossible (a 6 km section of the aqueduct at Carthage ran at 28 m per km), it is certainly far above the average slope of most Roman aqueducts, which tended to remain within a range of 0.5–5 m per km.³⁸ It therefore seems likely that the aqueduct did not run at this steep slope over the entire length of this section. Instead, builders could have mitigated the potentially deleterious effects of rapidly flowing water by incorporating steep chutes or drop-shaft cascades along the aqueduct’s path. These structures would have allowed the conduit to rapidly decrease in elevation by conducting the water down vertical or near vertical declines.

Well-documented evidence of both techniques can be found along aqueducts at Cherrhell, Djemila, Cologne, Lyon, Montjeu, and Rome.³⁹ In these cases, chutes and drop shafts provided rapid changes in elevation and in some instances were linked together in series several kilometers in length. At Lyon, the Yzeron aqueduct included a series of shafts at Recret that achieved an overall drop of 38 m along 490 m (about 78 m per km). These shafts, each dropping in elevation by a few meters, could have been part of a “hydraulic stairway”

38. Hodge, *Roman Aqueducts and Water Supply* (supra n. 30) 347–48.

39. H. Chanson, “Hydraulics of Roman Aqueducts: Steep Chutes, Cascades, and Dropshafts,” *AJA* 104 (2000) 47–72, at 60, 67.

2 km long, along which some 50 shafts achieved a reduction in the elevation of the conduit by dozens of meters, one step at a time.⁴⁰

Along the aqueduct of Chercell (Caesarea Mauretaniae) in Algeria, a 3 km long loop along the Oued Illelouine valley was cut off by a bridge. To compensate for the severe drop in elevation, a series of four steep chutes, each followed by a drop shaft, was constructed on the upstream side of the bridge to bring the water level down by 12.28 m.⁴¹ Steep declines could also be used to lower the water level rapidly. A Hadrianic restructuring of the Anio Vetus in Rome shortened its route with the addition of a new bridge, the Ponte S. Gregorio, which compensated for the change in elevation with a steep reduction in the height of its last few arches. Here the aqueduct lost 4.09 m in 25 m (about 164 m per km).⁴²

Unfortunately, the only aqueduct structure identified along the Kocadere is the rock-cut tunnel or open channel near the village of Kayapınar (E009) (see Fig. 36). Comparable examples of vertical cuttings made in the rocky cliffsides of stream banks that act as bedding for the conduit include part of the aqueduct of Cahors where it passes through the Vers valley in France and the aqueduct at Side on the southern coast of Turkey.⁴³ In these cases an open trench was excavated from the cliff so that on the exterior side, a wall of rock remains, part of the original cliff face. The barrel-vaulted masonry conduit of the aqueduct supplying Ephesus built by Claudius Aristion in the second century A.D. was laid in a rock-cut channel carved from the hills of the Kaystros valley. According to the reconstruction, the rock-cut channel was 1.90 m wide with a maximum height along the rock face of 2.50 m. The internal dimensions of the conduit were 1.05 m wide by 1.40 m high, making it comparable to the conduit of the Time-

les.⁴⁴ Along the Hadrianic aqueduct at Corinth, vertical rock cuttings formed a secure base on top of which the side walls and vault of the masonry conduit were constructed.⁴⁵ The width of the rock-cut channel was 1.20 m, the same as the internal width of the conduit where it was built entirely of masonry, and the interior surfaces of the rock were coated with plaster to reduce friction and block seepage. Thus, where possible, the builders exploited limestone outcrops for use as a solid and perhaps more expedient conduit foundation. Likewise, the aqueducts of Fréjus and Amasya included a combination of rock-cut channel and built masonry.⁴⁶

In conclusion, when it reached the Kocadere, the water of the Timeles aqueduct ran either in a masonry conduit built into a rock-cut passageway along the gorge or in the rock-cut passageway itself. The rock-cut passageway could have been an open channel like the structure we documented or an enclosed tunnel, or it could have included both. It seems more likely that the passageway was an open channel within which the enclosed masonry conduit was built. In either case, the conduit itself was certainly enclosed. This reconstruction corroborates our local informant's description of a now lost masonry conduit in the area, and matches the reconstruction of the Aristion aqueduct at Ephesus. Where a level rock-cut bedding could not be created for the masonry conduit, builders could have instead constructed masonry supporting walls to serve as substructures for the conduit as it ran along the gorge. Such supporting walls have been identified on the Hadrianic aqueduct at Corinth, the Çaykavuştuğu aqueduct of Tralleis, and the mid-second-century A.D. Değirmendere aqueduct at Ephesus, where supporting walls with buttresses carried the conduit alongside steep terrain.⁴⁷ Finally, although no physical evidence of such structures has been identified, the steep gradient of this section of the aqueduct suggests that chutes or drop-

40. Burdy, "Some Directions of Future Research" (supra n. 33) 34–35, fig. 5; idem, *Les aqueducs romains de Lyon* (supra n. 31) 129–30, fig. 57.

41. P. Leveau and J.-L. Paillet, *L'alimentation en eau de Caesarea de Maurétanie et l'aqueduc de Cherchel* (Paris 1976) 150; Hodge, *Roman Aqueducts and Water Supply* (supra n. 30) 146.

42. P. Aicher, *Guide to the Aqueducts of Ancient Rome* (Wauconda, Ill. 1995) 125; Hodge, *Roman Aqueducts and Water Supply* (supra n. 30) 146, citing T. Ashby, *The Aqueducts of Ancient Rome* (Oxford 1935) 69, fig. 2, and 70 n. 1.

43. Cahors: D. Rigal, "L'aqueduc antique de Cahors," in R. Bedon (ed.), *Les aqueducs de la Gaule romaine et des régions voisines* (Université de Limoges 1997) 311–30, at 316–17, 328, fig. 4. Side: H. Fahlbusch, "Side," in *Die Wasserversorgung antiker Städte: Pergamon, Rechte/Verwaltung, Brunnen/Nymphäen, Brauelemente, Geschichte der Wasserversorgung 2* (Mainz am Rhein 1987) 218–21, fig. 2; K. Grewe, "Antike Welt der Technik VI: Die römische Wasserleitung nach Side (Türkei)," *Antike Welt* 25.2 (1994) 192–203; Ü. Özış, "Historical Water Schemes in Turkey" (supra n. 17) 347–83.

44. G. Wiplinger, "Wasser für Ephesos: Stand der Erforschung der Wasserversorgung," in idem (ed.), *Cura Aquarum in Ephesos: Volumes I and II*, Proceedings of the 12th International Congress on the History of Water Management and Hydraulic Engineering in the Mediterranean Region (Leuven 2006) 23–40, at 28.

45. Y. A. Lolos, "The Hadrianic Aqueduct of Corinth," *Hesperia* 66 (1997) 271–314, at 282.

46. Fréjus: J.-M. Michel, "Chapitre 4: Le canal: caractéristiques et particularités," in C. Gébara, J.-M. Michel, and J.-L. Guendon, *L'aqueduc romain de Fréjus. Sa description, son histoire et son environnement, Revue archéologique de Narbonnaise*, Suppl. 33 (Montpellier 2002) 121–36, at 121–26. Amasya: O. Nicholson and C. Nicholson, "The Aqueduct at Amasya in Pontus," *Anatolian Studies* 43 (1993) 143–46.

47. Corinth: Lolos, "The Hadrianic Aqueduct of Corinth" (supra n. 45) 283–85. Tralleis: N. O. Baykan and Y. E. Tanriöver, "Water Supply System of the Ancient City Tralleis," in Wiplinger, *Cura Aquarum in Ephesos* (supra n. 44) 133–36, at 135. Ephesus: Wiplinger, "Wasser für Ephesos" (supra n. 44) 32–33.

shaft cascades were used to bring down the level of the water rapidly.

Conduit

As it made its way from the Tavas plain to Aphrodisias, the conduit ran through rock-cut tunnels, in trenches excavated from the earth, over bridges, and atop substructures. Different construction techniques may have been used to meet the various conditions created by each situation. Unfortunately, we have physical remains of the conduit only where it ran underground in rock-cut tunnels or trenches. However, an indication of what the conduit looked like when it sat atop bridges and substructures can be gleaned from comparable aqueducts elsewhere. Because measurements and other specifications have been provided above and in the catalogue, this section focuses instead on important technical aspects of the conduit. Interesting to note, however, is the remarkable size of the conduit, with an average internal width of 1.50 m.

Features of the conduit are most visible at the Çiğlek Deresi, where the cross section of the conduit is visible in the hillside (E035) (see Fig. 23). Here, builders dug a trench in the ground, laid a rubble foundation, protected the floor with two layers of mortar, built the side walls and vault of the conduit, surrounded the side walls and vault with rubble packing, and then refilled the trench with dirt. The rubble foundation layer was topped by a bedding of white mortar, laid thickest at the center of the conduit. Coating this white mortar bedding was a very thin layer, only 0.001 m thick, of pink waterproofing mortar, itself covered by layers of precipitated calcium carbonate. Neither of these layers extended under the side walls of the conduit.

Both the thin layer of waterproofing mortar and the mortar used to bond the blocks of the side walls and rubble vault have a red tint, created by the use of pulverized terracotta or of the local iron-rich sandstone, crushed up and added as aggregate to the lime. Silica (SiO_2) is a common cementing material in sandstone, and silica along with alumina (Al_2O_3) are components of pozzolans, materials with water-resistant properties. Pozzolans were combined with lime, burned, and then mixed with water to produce hydraulic cement, which in turn could be combined with sand and water to make a hydraulic lime mortar.

At no point along the aqueduct is there clear indication that crushed pottery or brick was used as a component of its mortar. Instead, the red tint of one type of mortar found throughout the aqueduct is likely due to the use of the local iron-rich sandy conglomerates prevalent throughout the region, crushed up and added to the lime. Thus, the builders quarried locally available sandstone for blocks to use in the conduit and bridges, and crushed it to make hydraulic mortar. Similar use of

local resources for building materials has been noted along the aqueducts of central and south Tunisia and Tripolitania, which use predominately a type of mortar that does not include pottery or tile (that is, not *opus signinum*).⁴⁸ Oligocene sandstone in the Meliane valley was used extensively in the construction of the aqueduct supplying Carthage. It was quarried into blocks used in both the interior and exterior of arcade construction, and small fragments of this sandstone, probably detritus from block carving, were used as aggregate for the concrete.⁴⁹

This red-tinted mortar is one of two types found over the course of the Timeles aqueduct. Both are lime-based with stone inclusions, but the other type is white or white-gray. The lack of a red tint suggests the white mortar includes neither crushed terracotta nor pulverized sandstone, making it nonhydraulic. Interesting to note, the white mortar is found predominantly in bridges, while the pink mortar is found in both bridges and the conduit. Obviously, the pink, hydraulic mortar would have been preferred for the conduit to make it waterproof, and because it was able to set even in moist conditions, such as in a subterranean tunnel. Should leaks occur, however, the white, nonhydraulic mortar used in bridges and as a bedding under the conduit floor would have allowed seeping water to drain from the structure and evaporate, rather than freeze and crack the masonry, thereby maintaining the stability of the structures. The results of this permeability are the amorphous deposits of calcium carbonate covering many of the bridge piers along the aqueduct.

It is unclear whether the water ran in a masonry conduit where the aqueduct traveled deep underground in long tunnels such as the one under the Yahşiler plateau. The places where the conduit is exposed—along the Kepiz Çayı (G001) and at Çiğlek Deresi (E035) and Yeşilköy (E006)—are all close to the surface, indicating that masonry conduits were built at least at the ends of a tunnel where it was more susceptible to erosion but providing no clue as to whether the subterranean tunnels themselves were equipped with masonry conduits. Both scenarios exist along the aqueducts around Aphrodisias. The rock-cut tunnel of the Işıklar aqueduct on the İncir Deresi has no masonry conduit inside (B081), but all 150 m of the subterranean tunnel at Yeşilköy does (E006). In both cases, however, the tunnels are much shorter and closer to the surface than the one under the Yahşiler plateau. Comparative examples from

48. Wilson, "Water Management and Usage in Roman North Africa" (supra n. 31) 52–53.

49. A. Alvarez et al., "Characterisation of Materials Used in the Aqueduct of Zaghuan-Carthage (Tunisia) along Construction and Restoration Periods," in E. Galán and F. Zezza (eds.), *Protection and Conservation of the Cultural Heritage of the Mediterranean Cities* (Lisse 2002) 101–6, at 102.

elsewhere only complicate the issue. The 18 km tunnel of the early imperial aqueduct of Bologna under the Reno valley, for example, includes both stretches of masonry conduit and stretches where the tunnel is simply rock-cut; this tunnel is at least 66 m deep in some areas.⁵⁰ However, the tunnels of the Gier aqueduct at Lyon and the aqueduct of Nîmes, which ran from approximately 2 m to 22 m below the ground, were for the most part equipped with masonry conduits, although in the La Perrotte tunnel the masonry conduit was not roofed.⁵¹ To save time and materials, the engineers probably constructed a masonry conduit only where it was deemed necessary and practical, while also taking into consideration the qualities of the rock through which they had to dig.

The section of conduit visible at the Ciglek Deresi contains an interesting combination of construction techniques highlighting the flexibility in construction demanded by local topographic features. The current collapse of the conduit's "false" vault discussed above reveals the profile of the conduit within the rock-cut tunnel that houses it. The space between the masonry conduit and the tunnel is filled with rubble packing, similar to the treatment of the conduit and tunnel at Yeşilköy. Where the conduit emerges from the hillside, however, it appears to have been built not in a tunnel but in the earth, probably in a trench refilled with spoil after completion of the masonry conduit.

The difference in stratum poses a second possibility for two of the types of vault construction seen within the conduit: rubble masonry versus regular, rectangular blocks (see Fig. 24). The builders may have chosen to build a rubble vault where the conduit was laid in earth, relatively close to the ground surface above, but to build a different kind of vault in a rock-cut tunnel. This scenario makes sense because, when working in cut rock, workers had to build the vault "horizontally" — that is, by pushing or sliding the squared stones into place. When the conduit was built in a trench, however, workers could build the vault partly from above by laying mortared rubble over the centering.

In the two other places where the aqueduct conduit is visible, at Kepiz Çayı and at Yeşilköy, both the side walls and the vault are constructed of regular, rectangular blocks, just like the other segment of conduit at the Ciglek Deresi. The segment of rubble vault is thus an

anomaly. The seam separating the rubble segment, which has a preserved length of 7 m, from the block segment, which is 8.8 m long, also marks a turn in the direction of the conduit. Alternatively, the rubble vault may be the result of rebuilding, perhaps due to damage at this weak point, where water turning the bend undercut the external masonry side wall.

While it is clear that the conduit was vaulted where it ran underground, no remains of the conduit are preserved to indicate how it was roofed where it emerged to cross bridges and run atop the substructure west of the bridge over the Seki Deresi in the Morsynus valley (E059) (see Fig. 39). Some comparative Roman aqueducts maintain the vault of the conduit even where it sits atop bridges and substructures and therefore does not have to support a vertical load of earth. Remains of the Gier aqueduct at Lyon and the first-century A.D. aqueducts at Almuñécar (ancient Sexi) and Fréjus indicate that the conduits were topped by a barrel vault across bridges and arcades.⁵² Vaulted conduits have been documented for the arcades and most of the bridges of the aqueduct of Nîmes and reconstructed for the Hadrianic aqueduct at Corinth where it emerged to cross bridges.⁵³ Rome's Aqua Claudia appears to have been roofed with a gable or vault except where the Aqua Anio Novus ran on top of it, where travertine slabs separated the two channels.⁵⁴ The Aqua Anio Novus itself was roofed with a gable or vault, even where it ran inside the attic of the Porta Maggiore.⁵⁵ Where the Aqua Marcia carried the Aquae Tepula and Julia, it was flat-topped, but the Tepula was vaulted in some stretches even with the Julia, itself vaulted for at least some parts of its journey, stacked on top.

52. Lyon: Burdy, *Les aqueducs romains de Lyon* (supra n. 31) 80–81, fig. 38, and 116, 122–23, fig. 56. Almuñécar: C. Fernández Casado, *Acueductos romanos en España* (Madrid 1972) *Acueductos de Almuñécar* (no page numbers or figure numbers printed); idem, *Ingeniería hidráulica romana* (Madrid 1985) 320–23, 438–41; K. Grewe, "Antike Welt der Technik I: Die römische Wasserleitung von Almuñécar (Sexi)," *Antike Welt* 22.1 (1991) 49–53, at 52, figs. 4–6. Fréjus: Michel, "Chapitre 4: Le canal" (supra n. 46) 121–26.

53. Nîmes: G. Fabre, J.-L. Fiches, P. Leveau, and J.-L. Paillet, *The Pont du Gard. Water and the Roman Town*, trans. J. Abbott (Paris 1992) 76, 94; Fabre et al., "Chapitre 3: Le tracé de l'aqueduc" (supra n. 51) 80 (e.g., the arcaded bridge at La Lône); for a reconstruction of the bridge at La Lône, see J.-L. Fiches and J.-L. Paillet, "Chapitre 19: De la mise en eau au démantèlement: essai de périodisation," in Fabre et al., *L'aqueduc de Nîmes et le Pont du Gard* (supra n. 51) 410, figs. 238, 239; Hodge, *Roman Aqueducts and Water Supply* (supra n. 30) 95, fig. 47. Corinth: Lolos, "The Hadrianic Aqueduct of Corinth" (supra n. 45) 288, fig. 4.

54. Ashby, *The Aqueducts of Ancient Rome* (supra n. 42) 316–20 (appendix).

55. R. Coates-Stephens, *Porta Maggiore. Monument and Landscape*, *Bullettino della Commissione Archeologica Comunale di Roma*, Suppl. 12 (Rome 2004) 50–51, 54.

50. D. Giorgetti, "L'aquedotto romano di Bologna: l'antico cunicolo ed i sistemi di avanzamento in cavo cieco," in *Acquedotto 2000. Bologna, l'acqua del duemila ha duemila anni* (Bologna 1985) 37–107, *passim*, and at 92–93.

51. Nîmes: G. Fabre, J.-L. Fiches, J.-L. Paillet, and J. Pey, "Chapitre 3: Le tracé de l'aqueduc dans son environnement," in G. Fabre, J.-L. Fiches, and J.-L. Paillet (eds.), *L'aqueduc de Nîmes et le Pont du Gard. Archéologie Géosystème Histoire*, 2nd ed. (Paris 2000) 57–119, at 97–99. Lyon: Burdy, *Les aqueducs romains de Lyon* (supra n. 31) 88–94.

Aboveground conduits could be topped by flat stone slabs instead. This technique was used to roof the conduit of the aqueduct of Nîmes where it crossed the Pont du Gard and the Coste-Belle culvert at Vers.⁵⁶ The interior width of the flat-topped conduit of the Pont du Gard is 1.20 m, double the width of the vaulted conduits of the Gier aqueduct at Lyon and the aqueducts at Almuñécar and Fréjus.⁵⁷ Engineers may have opted to top the wide conduit of the Pont du Gard with stone slabs to avoid the lateral thrust of a vault, which could have weakened the side walls of the wide conduit. However, even when it ran atop the Aqua Claudia on an arcade more than 27 m high, the conduit of the Aqua Anio Novus was vaulted, not flat-topped, and its conduit was more than 1.1 m wide.⁵⁸

Because the conduit of the Tímeles was 1.50 m wide, even where it crossed the 27 m tall, two-tiered bridge over the Harami Deresi near Yeşilköy (E008) and the 18 m tall bridge over the Şaban Deresi near Denizoluk (C048), it is possible that here the conduits were equipped with a roof of flat stone slabs (see Figs. 25, 31, 32). However, no slabs have been found, and the side walls of the conduit were more than 1 m thick, which may have provided adequate support in opposition to lateral thrust to allow for the construction of a vaulted conduit.

Tunnels and Shafts

Where the aqueduct ran underground in a long tunnel, the engineers built vertical shafts to open up multiple work surfaces, to facilitate surveying the orientation and gradient of the tunnel, to expedite the tunneling process, and to provide air to the workers and exits for the removal of backdirt. Two types of shafts have been identified on the Tímeles aqueduct. One was created and used during construction only, after which it was filled in with backdirt. Remains of this type are the mounds on the Yahşiler plateau, which correspond to shafts that were about 50 m deep (see Fig. 19). The other type was used during construction but also kept open for inspection and maintenance during the life of the

aqueduct. Examples include the masonry-lined shafts by Denizoluk and Yeşilköy, which range from 6 m to more than 25 m deep (E051, C049) (see Figs. 33, 34).

The deepest shaft for which we have clear evidence on the Tímeles aqueduct is the large rock-cut shaft near Denizoluk, which extended 50 m down to the aqueduct below and appears to have been left open (C044) (see Fig. 35). The depth of this shaft and the provision of at least one staging platform with cuttings for a pulley system indicate that it may have been carved with a stepped profile to create multiple staging platforms.⁵⁹ According to this reconstruction, each staging platform would have been equipped with a pulley system so that workers, equipment, and backdirt could be lifted and lowered in multiple stages to increase control and decrease the likelihood of accidents. However, because the shaft is now filled in and cannot be explored, this reconstruction remains hypothetical.

The tunnel under the Yahşiler plateau is almost 2 km long and runs up to 50 m underground. It is the longest and deepest tunnel on the Tímeles for which we have clear evidence. Recent research on the aqueduct of Nîmes has proposed an excavation rate of 1.5 m³ per day per work post (each “poste de travail” representing one work team made up of two excavators plus one operator to remove backdirt) in an analysis of the tunnels of La Perotte and Cantarelles in the Escaunes valley.⁶⁰ Using this excavation rate, it is possible to provide some indication of the time it took to construct the 2 km long tunnel and the shafts connected to it under the Yahşiler plateau based on measurements of documented structures along the aqueduct. The rock-cut shaft near Denizoluk (C044) is 2.16 m by 2.25 m wide, while the masonry inspection shaft not far from it (C049) has internal dimensions of 1.45 m by 1.45 m. The 50 m deep shafts on the Yahşiler plateau were likely more similar to the former than the latter. Rounding down to just 2 m by 2 m for a hypothetical shaft and dividing the resulting area (4 m²) into the rate of 1.5 m³ per day per work post, the linear digging rate would be 0.38 m per day per work post for the shafts. The tunnel at Yeşilköy (E006) is approximately 2.3 m wide by 3.0 m tall. Using this area (6.9 m²), the linear digging rate would be 0.22 m per day per work post for the tunnel.

56. Nîmes: Fabre et al., “Chapitre 3: Le tracé de l’aqueduc” (supra n. 51) 78.

57. Nîmes: Fabre et al., *L’aqueduc de Nîmes et le Pont du Gard* (supra n. 51) 26; see also Fiches and Paillet, “Chapitre 19: De la mise en eau au démantèlement” (supra n. 53) 409, fig. 237; Lyon: Burdy, *Les aqueducs romains de Lyon* (supra n. 31) 80–81, fig. 38, and 116, 122–23, fig. 56. Almuñécar: Fernández Casado, *Acueductos romanos en España* (supra n. 52); idem, *Ingeniería hidráulica romana* (supra n. 52) 320–23, 438–41; Grewe, “Antike Welt der Technik I” (supra n. 52) 52, figs. 4–6. Fréjus: Michel, “Chapitre 4: Le canal” (supra n. 46) 121–26.

58. This arcade, the highest of the two aqueducts, is located between Tor Fiscale and Romavecchia. Aicher, *Guide to the Aqueducts of Ancient Rome* (supra n. 42) 96. Width of conduit: Ashby, *The Aqueducts of Ancient Rome* (supra n. 42) 240, fig. 25, 319 (appendix).

59. Pliny the Elder’s description (*HN* 36.124) of the construction of the tunnel draining Lake Fucino is apt: “The expense was indescribable and the workers numberless over so many years because, where the mountain was earthy in character, the spoil from the channel had to be cleared out through vertical shafts by means of winches, and elsewhere the bedrock had to be cut away.” Translation provided by K. Grewe, “Tunnels and Canals,” in J. P. Oleson (ed.), *The Oxford Handbook of Engineering and Technology in the Classical World* (Oxford 2008) 319–36, at 327.

60. J.-C. Bessac, “Le chantier du creusement des galeries dans le vallon des Escaunes à Sernhac,” in Fabre et al., *L’aqueduc de Nîmes et le Pont du Gard* (supra n. 51) 377–405, at 390–91.

The five securely identified shafts on the Yahşiler plateau (west to east: E052, E036, E048, E049, and one scattered mound without a database number) must have been approximately 50 m deep. Assuming only one work team excavated each shaft, and all five work teams dug the shafts simultaneously, it would have taken them 132 days, or almost four and a half months, to complete the work. With the five shafts finished, a total of 12 work posts were now open (one at each end of the tunnel and two at the bottom of each shaft). With 12 work teams digging simultaneously at a rate of 0.22 m per day per work post, it would have taken 758 days, or just over two years, to finish this tunnel. The total time to complete the digging alone would therefore be two years and four and a half months.

However, over the 2 km length of the tunnel there must have been more than just five shafts. As discussed above in the description of the Tímeles aqueduct (“Tímeles Aqueduct, Yahşiler plateau”), two potential additional shafts were identified using satellite imagery, but the distances between the three preserved backdirt mounds or spoil heaps, 87 m and 98 m, are more helpful. Using 100 m as a hypothetical interval between the shafts, there may have been a total of 19 shafts and therefore 40 open work posts for digging the tunnel. Even with these additional shafts, if we assume there were 19 work teams digging simultaneously, it would have taken the same amount of time to complete them: 132 days, or four and a half months. However, having over three times as many work posts for the tunnel would reduce its construction time by more than one-third, to 227 days, or just over seven and a half months. The new estimate for the total time would therefore be 359 days, or just under one year.

These calculations provide minimum estimates, because they do not take into account, for example, interruptions due to construction problems, mismanagement, funding gaps, engineering errors, festivals, or worker shortages. Also ignored is the time it would have taken to survey the tunnel, find adequate work teams, build and replace tools and wooden machinery, and construct a masonry conduit inside the tunnel, if it existed. The project likely took much longer than a single year to complete.

The walls of the Reno valley tunnel of the Bologna aqueduct contain a series of markings, including figures cut every 25 Roman feet (7.40 m) that indicate the number of days spent digging each preceding section. These figures, which vary from 17 to 38 days, have been used to provide an average rate of construction of one Roman foot (0.2956 m) per day.⁶¹ This estimation is similar to the one obtained for the Yahşiler plateau tun-

nel (0.22 m per day per work post) using the rate of 1.5 m³ per day per work post, as suggested by the investigator of the La Perotte and Cantarelles tunnels on the aqueduct of Nîmes.

While the tunnels of the Tímeles aqueduct are not unique, the considerable length and depth of the Yahşiler plateau tunnel make it technically noteworthy and impressive in relation to most documented Roman aqueduct tunnels. Comparable examples do exist, of course. In length and depth below the surface, it is similar to the Siouri tunnel of the Hadrianic aqueduct at Corinth, which is 1.07 km long with a maximum depth of 80 m, or the 1.66 km long Drover Berg tunnel near Düren.⁶² Other Roman aqueduct tunnels exceed these specifications: the Reno valley tunnel at Bologna is at least 18 km long, while the tunnel under the plateau of Venelles heading to Aquae Sextiae (Aix-en-Provence) is 8 km long with shafts up to 80 m deep.⁶³ Even these, however, cannot compare to the famous tunnel built by the emperor Claudius to drain Lake Fucino; over a decade of work resulted in a tunnel 5.595 km long with shafts up to 122 m deep.⁶⁴

Shaft systems comparable to that of the Tímeles can be found on many Roman aqueducts. The Hadrianic aqueduct at Corinth was equipped with circular rock-cut shafts, constructed at regular intervals of 30–40 m along the Siouri tunnel, and rectangular masonry inspection shafts.⁶⁵ While many documented aqueduct tunnels have shafts spaced at regular intervals within the range of 20 m to 45 m, in other cases great variability among tunnels on the same aqueduct and even along the same tunnel resulted from the variability of local topographies.⁶⁶ The Gier aqueduct at Lyon has man-

62. Corinth: Lolos, “The Hadrianic Aqueduct of Corinth” (supra n. 45) 289–90. Düren: Grewe, “Tunnels and Canals” (supra n. 59) 321, table 12.1, and 328.

63. The tunnel at Bologna was probably originally 20 km long. Giorgetti, “L’acquedotto romano di Bologna” (supra n. 50) 47; Grewe, “Tunnels and Canals” (supra n. 59) 321, table 12.1; Hodge, *Roman Aqueducts and Water Supply* (supra n. 30) 209–10. Aquae Sextiae: P. Leveau, “Les aqueducs d’*Aquae Sextiae* et la gestion de l’eau sur le territoire de la cité,” in *Carte archéologique de la Gaule* 13 (2006) 93–109, at 94–95, 99–101, fig. 13.

64. Grewe, “Tunnels and Canals” (supra n. 59) 327.

65. Lolos, “The Hadrianic Aqueduct of Corinth” (supra n. 45) 282, 289–90. While only one masonry shaft has been identified along the aqueduct, Lolos assumes there were originally others, now obscured or destroyed.

66. Inspection shafts set at regular intervals are common in North Africa, e.g., at Carthage and Thugga; see Wilson, “Water Management and Usage in Roman North Africa” (supra n. 31) 67. The aqueduct at Pisidian Antioch has three manholes spaced 45 m apart and, about 1.15 km farther downstream, another group of three spaced at intervals of 200 m and 42 m; see S. Mitchell and M. Waelkens, with J. Burdy, *Pisidian Antioch: The Site and Its Monuments* (London 1998) 180. The vertical shafts of the Kokkinopilos tunnel of the Nikopolis aqueduct are spaced

61. Giorgetti, “L’acquedotto romano di Bologna” (supra n. 50) 98.

holes at 77 m intervals, apparently in accordance with a rule of one shaft for every two *actus* (1 *actus* = 120 Roman feet, or 35.47 m) of aqueduct, while the shafts of the aqueduct tunnels at Düren and Saldae, Algeria, are placed farther apart as the tunnels get deeper underground.⁶⁷ The three intact backdirt mounds or spoil heaps of the Tímeles tunnel under the Yahşiler plateau are separated by intervals of 87 m and 98 m, which are the shortest intervals identified. Centuries of agricultural activity on the plateau have undoubtedly obscured many of the backdirt mounds, making it difficult to reconstruct the original shaft intervals. However, shafts placed every 90–100 m would be within the realm of possibility suggested by comparative examples.⁶⁸

Bridges

The tallest bridge of the Tímeles aqueduct is the two-tiered bridge that rises to a reconstructed height of 27 m above the Harami Deresi near Yeşilköy (E008) (see Fig. 25). It is comparable to the well-known two-tiered aque-

duct bridge of Segovia, which is 28.5 m high, and to less familiar structures such as the three-tiered, 29 m high Taşkemer bridge at the intersection of the Çaykavuştuğu and Taşkemer aqueducts supplying Tralleis in Turkey.⁶⁹ At 65 m, the Harami Deresi bridge is also the longest on the Tímeles aqueduct, which also includes bridges shorter than 10 m in length.

The Tímeles aqueduct carried water over at least 12 bridges, nine of which are well enough preserved to allow an assessment of their overall design and construction. These bridges come in a variety of shapes and sizes in response to local topographic features. Only two bridges have a fully preserved arch, but all of the bridges appear to have spanned a streambed or other depression with a single arch. The Harami Deresi bridge is the only one with two tiers, the lower of which was constructed with a single arch spanning 13 m.

While the bridges vary in height and length according to the topography, construction techniques are standardized. All the bridges are built in mortared rubble faced with *petit appareil* masonry. The mortared rubble core is laid in layers, and the facing blocks are leveled with small chinking stones. Several of the bridges incorporate leveling courses, some of which also acted as projecting courses and spring points for an arch, thereby providing support for scaffolding or a centering frame. The Kırkım Deresi bridge has a projecting leveling course that acts as a spring point for the fully preserved arch, and the west pier has a lower leveling course that also projects from the structure and was probably used to support scaffolding (E005) (see Figs. 26, 27). The bridges over the Cıglek Deresi (E033) and the Şaban Deresi (C048) each have a leveling course that may have served as a projecting course or spring point; the current state of preservation makes their original functions unclear (see Figs. 21, 31, 32). The standing remains of the lower arch of the two-tiered bridge over the Harami Deresi (E008) spring directly from a rock outcrop that forms the stream banks (see Fig. 25). All the arches with standing remains have two layers of voussoirs, except for the single-layer arch of the Seki Deresi bridge (see Fig. 39).

When constructing these bridges (and the conduit), the builders quarried blocks from locally available sources, especially the well-cemented, sandy conglomerates and low-grade, gray-blue marble found along the course of the aqueduct. Fieldstones of quartz and schist are also commonly used. High-grade, white marble

40 m apart; see P. N. Doukellis, J.-J. Dufaure, and É. Fouache, "Le contexte géomorphologique et historique de l'aqueduc de Nicopolis," *Bulletin de correspondance hellénique* 119 (1995) 209–33, at 215–16. The manholes of the Hadrianic aqueduct at Athens are placed at 35–37 m intervals; see Lolos, "The Hadrianic Aqueduct of Corinth" (supra n. 45) 305. An 800 m long tunnel along the aqueduct of Carhaix in Brittany ran 25 m deep and had a series of 10 shafts spaced 21 m to 44 m apart, and after construction the bottoms of the shafts were blocked up with masonry, which is still visible from inside the aqueduct tunnel; see A. Provost and B. Lepretre, "L'aqueduc gallo-romain de Carhaix (Finistère): rapide synthèse des recherches en cours," in Bedon, *Les aqueducs de la Gaule romaine et des régions voisines* (supra n. 43), 525–46, at 533.

67. Lyon: Burdy, *Les aqueducs romains de Lyon* (supra n. 31) 123–27. Twenty-nine shafts have been identified on the nine known tunnels of the Gier aqueduct, and they range from 6 m to 20 m deep. Düren: Grewe, "Tunnels and Canals" (supra n. 59) 329. Saldae: J.-P. Laporte, "Notes sur l'aqueduc de Saldae (= Bougie, Algérie)," in Bedon, *Les aqueducs de la Gaule romaine et des régions voisines* (supra n. 43) 747–79, at 757–60. In a famous funerary inscription set up in Lambaesis (Algeria) by Nonius Datus in the second century A.D. (*CIL* VIII 2728 = *ILS* 5795), the retired surveyor of Legion III Augustus describes how he rectified a botched tunneling job at Saldae. The tunnel was 428 m long and ran about 86 m or more beneath the ground surface. Roman flood control tunnels at Pergamon, Nysa, and Çevlik (near Antakya) offer another interesting comparison; see Ü. Öziş et al., "Flood Flows and Capacities of the Historical Pergamon and Nysa Tunnels in Anatolia," *International Association for Hydraulic Research, 18th Congress Proceedings* 6 (Cagliari 1979) 695–98; A. Alkan and Ü. Öziş, "Çevlik Canal and Tunnels from the Point of View of Hydraulics Engineering History," *Teknik Dergi Digest* (1991) 92–95; G. Garbrecht, "Talsperre und Tunnel am Hafen Seleukia," in *Historische Talsperren* 2 (Stuttgart 1991) 277–94; K. Grewe, *Licht am Ende des Tunnels: Planung und Trassierung im antiken Tunnelbau* (Mainz 1998).

68. Shaft intervals range from as short as 10 m to as long as 200 m; see M. J. T. Lewis, *Surveying Instruments of Greece and Rome* (Cambridge 2001) 203.

69. Segovia: J. Mancera-Taboada, P. Rodríguez-González, and D. González-Aquilera, "Turning Point Clouds into 3D Models: The Aqueduct of Segovia," in O. Gervasi et al. (eds.), *Computational Science and its Applications—ICCSA 2009* (Berlin 2009) 520–32, at 521; see also Fernández Casado, *Acueductos romanos en España* (supra n. 52). Tralleis: Baykan and Tanriöver, "Water Supply System of the Ancient City Tralleis" (supra n. 47) 134.

blocks dressed for other purposes are sometimes incorporated into the leveling/projecting courses of the bridge piers and are used as voussoirs. The marble blocks dressed with anathyrosis, clamp cuttings, lifting bosses, and moldings built into these bridges may have originally been intended for buildings at Aphrodisias itself. The reuse of these previously worked blocks in a structure that also makes predominant use of stone available on-site underscores a certain frugality on the part of the builders in their choice not to quarry high-grade marble unnecessarily. However, transporting these previously dressed blocks from a quarry, from Aphrodisias, or from a nearby structure was certainly more expensive than using locally available low-grade marble, suggesting that the builders' desire to use high-grade marble for important blocks outweighed the inclination to cut costs indiscriminately.

The facing blocks and rubble core are bonded with two types of lime mortar, one of which is white or white-gray, while the other is pinkish and probably waterproof through the addition of pulverized sandy conglomerate rock as aggregate, as discussed above. The mortar between the facing blocks is pointed only on the Şaban Deresi bridge. Lime would have been produced from the limestone and marble found throughout the region. An important limiting factor was the availability of timber to make scaffolding for bridge piers, centering frames for arched bridges and the conduit vault, supports for vertical shafts, and machinery to lift blocks, backdirt, and workers.

Where possible, the bridge piers are founded on rock outcrops lining the stream banks. Doing so was problematic only for the Şaban Deresi bridge, whose west pier was built on top of an outcrop of peridotite, a weak rock that may have been partially responsible for the bridge's collapse. The only surviving fragment of the lower arch of the two-tiered bridge over the Harami Deresi springs directly from a sandy conglomerate outcrop, emphasizing the soundness of this technique when the foundation material is appropriate.

While there is no striking correlation between bridge width and arch span, there is a pattern in the use of buttresses. All the bridges have suffered dramatically greater damage on their upstream sides, except the bridge on the Gümüş (Korkor) Deresi (E058). In most cases, the upstream side has almost completely fallen and eroded away, with no preserved facing blocks and with considerable loss of material. This side was apparently more vulnerable to forces such as wind and rain, especially deleterious to the bridges made more susceptible to weather conditions because of their height. A buttress or supporting structure was built against the downstream side of the two tallest bridges, the two-tiered Harami Deresi bridge (E008) and the Şaban Deresi bridge (C048), apparently to offset the forces damaging

the upstream side (see Figs. 25, 31). In both cases, a clear seam delineates the two masonry structures, suggesting that the buttresses were built later than the bridges, perhaps in response to problems observed or anticipated in the stability of the bridges. The two-tiered Harami Deresi bridge may have been deemed vulnerable due to its multiple levels, and presumably only the top tier was buttressed. The Şaban Deresi bridge was founded on peridotite, the weakness of which is indicated by the fact that one of the large pieces of fallen masonry in the streambed has a piece of peridotite attached to it, suggesting that the mortared rubble masonry is stronger than the rock on which it was founded. In contrast to the two-tiered Harami Deresi bridge, this bridge may have been augmented with a buttress to offset the instability of its weak geological foundations.

Arcaded portions of the Hadrianic aqueduct at Corinth were repaired with the addition of reinforcing walls and buttresses similar to those supporting the arcades of the aqueduct at Fréjus.⁷⁰ Along the aqueduct of Nîmes, the arcaded bridge at La Lône and the bridge over La Sartanette valley were reinforced with masonry facings that acted as lateral buttresses similar to the structure on the Şaban Deresi bridge.⁷¹ Multiple buttressing structures were added to many of the bridges of Rome's aqueducts for centuries after their construction, including the Ponte Lupe and Ponte S. Pietro of the Aqua Marcia and the Ponte S. Antonio of the Aqua Anio Novus.⁷² General comparanda for the bridges of the Temeles aqueduct in terms of height, length, and construction techniques include the large bridge of the Roman aqueduct of Ilion across the Kemerdere valley, the bridges of the Aristion and Değirmendere aqueducts at Ephesus, the petit appareil bridges of the aqueduct of Nîmes, the bridges of the aqueduct of Fréjus, and the one- and two-tier bridges of the aqueduct at Almuñécar.⁷³

70. Corinth: Lolos, "The Hadrianic Aqueduct of Corinth" (supra n. 45) 291. Fréjus: I. Béraud, "Chapitre 5: Les ouvrages d'art: caractéristiques et descriptions," in Gébara et al., *L'aqueduc romain de Fréjus* (supra n. 46) 137–61, at 146–61.

71. The arcaded bridge at La Lône is reinforced with buttresses built both at the time of construction and later; the original buttresses are built up against the downstream side of the bridge. The facing of the bridge over La Sartanette valley is 0.92 m thick. G. Fabre, J.-L. Fiches, and J.-L. Paillet, "Interdisciplinary Research on the Aqueduct of Nîmes and the Pont du Gard," *JRA* 4 (1991) 63–88, at 82–85, figs. 9–10.

72. Ponte Lupo: Aicher, *Guide to the Aqueducts of Ancient Rome* (supra n. 42) 116–22, figs. 28–30, citing Ashby, *The Aqueducts of Ancient Rome* (supra n. 42) figs. 11–12. Ponte S. Pietro: Aicher, *Guide to the Aqueducts of Ancient Rome* (supra n. 42) 126–28, figs. 33–34, citing Ashby, *The Aqueducts of Ancient Rome* (supra n. 42) fig. 10. Ponte S. Antonio: Aicher, *Guide to the Aqueducts of Ancient Rome* (supra n. 42) 129–32, fig. 35, citing Ashby, *The Aqueducts of Ancient Rome* (supra n. 42) fig. 32.

73. Ilion: W. Aylward, G. Bieg, and R. Aslan, "The Aqueduct of Roman Ilion and the Bridge Across the Kemerdere Valley in the Troad," *Studia Troica* 12 (Mainz am Rhein 2002) 397–427, at

Rural Water Supply

In addition to large-scale urban aqueducts such as the Tímeles, smaller water lines could be built to supply rural communities, private estates, and irrigation networks. Residents in the countryside through which an urban aqueduct ran might pay for the right to draw water from the main conduit or might take matters into their own hands and tap it illegally.⁷⁴ These private watercourses could be high-profile structures such as the arcaded lines diverting water from Rome's main aqueducts to Sette Bassi and to Villa dei Quintilii at Romavecchia, or the lead pipes leading from the Aqua Marcia to the villa of Manilius Vopiscus at Tivoli across the Aniene river.⁷⁵

Of course, rural inhabitants could construct their own aqueducts. A small-scale aqueduct in the Alban Hills called the Aqua Augusta, known only from surviving *cippi*, was equipped with points for public access.⁷⁶ The treatise of Frontinus, Rome's water commissioner (*curator aquarum*) under Trajan, and two inscriptions from Italy and North Africa relate how water from an aqueduct or other source could be divided among several estates based on a system of time-share.⁷⁷ Small aqueducts constructed to supply rural farms and villas have been documented by the *Forma Italiae* surveys in the region surrounding Rome. These range from rock-cut channels to conduits of stone blocks, hydraulic concrete, cemented

stone and brick, or terracotta slabs.⁷⁸ In the region around Thugga (Dougga), North Africa, several small-scale aqueducts have been identified that supplied farms, villas, and small settlements during the Roman period.⁷⁹

In fact, it has recently been argued on the basis of evidence from Roman aqueducts around the Mediterranean that urban and rural water needs were considered complementary, and could even be met by the same system.⁸⁰ Numerous aqueducts supplying towns in North Africa also fed reservoirs, branch lines, and access points as they snaked through the countryside.⁸¹ The aqueduct serving Carthage was elaborated over time by a series of branches linked by reservoirs, which may have supplied water to farms and villages along its route.

While no directly comparable structures have been found in the region around Aphrodisias, some of the identified remains may have served similar functions. It is tempting to interpret the relatively small-scale, poorly built conduit along the Kocadere as a water line built to supply a farm or rural village, or for the irrigation of agricultural fields (E031) (see Fig. 37). It may be a secondary branch of the Tímeles aqueduct or an independent structure, built in association with a series of rubble walls situated on the stream bank opposite the visible remains of the conduit. Likewise, the Kavaklıdere (E053) and Ören Deresi (A029) aqueducts may have provided water for agricultural, industrial, or residential use, or for a combination of these (see Figs. 13, 14). The residents of the Roman and post-Roman farmsteads, settlements, and agricultural sites identified throughout the Morsynus river valley are all potential consumers of these aqueduct-fed waters.

Hints that the Tímeles aqueduct itself may have supplied rural consumers include a fragment of sinter curved in the shape of a now missing terracotta pipe found near the conduit along the Kepiz Çayı (which may instead be associated with the Ottoman mills formerly active in the area), the potential for water access offered by the open rock-cut and masonry inspection shafts on the İnce Dere near Denizoluk (C044, C049) (see above, Figs. 33–35), and the massive calcium carbonate incrustations covering the small bridge over the

408–12. Ephesus: Wiplinger, "Wasser für Ephesos" (supra n. 44) 23–40. Nîmes: Fabre et al., "Chapitre 3: Le tracé de l'aqueduc" (supra n. 51) 57–119. Fréjus: Béraud, "Chapitre 5: Les ouvrages d'art" (supra n. 70) 137–61. Almuñécar: Fernández Casado, *Acueductos romanos en España* (supra n. 52); idem, *Ingeniería hidráulica romana* (supra n. 52) 320–23, 438–41; Grewe, "Antike Welt der Technik I" (supra n. 52) 49–53.

74. In *De aquis urbis Romae*, Frontinus gives the volume of water delivered *extra urbem* to private and imperial properties (78–86) and discusses illegal tapping (75–76, 97, 112–15). See also J. P. Oleson, "Irrigation," in Ö. Wikander (ed.), *Handbook of Ancient Water Technology* (Leiden 2000) 183–215, at 210–14.

75. Romavecchia: R. G. Thomas and A. I. Wilson, "Water Supply for Roman Farms in Latium and South Etruria," *PBSR* 62 (1994) 139–96, at 146–47, nn. 33–34. Thomas and Wilson provide several examples of both rural aqueducts and rural branch lines from urban aqueducts (147–50). Tivoli: H. B. Evans, "In Tiburtium Usum: Special Arrangements in the Roman Water System (Frontin. *Aq.* 65)," *AJA* 97 (1993) 447–55, at 452. See also A. I. Wilson, "Deliveries *Extra Urbem*: Aqueducts and the Countryside," *JRA* 12 (1999) 314–32.

76. Thomas and Wilson, "Water Supply for Roman Farms" (supra n. 75) 147 n. 35. Thomas and Wilson supply the following information: the *cippi* are inscribed with *aqua Aug(usta) ½ put(eus) p(ublicus) ½ cip(us)* followed by a sequence number (*CIL* XIV 2567^{a-c}).

77. *Ibid.*, nn. 37–38. Thomas and Wilson supply the following source information: Frontin. *Aq.* 9; *CIL* XIV 3676, VI 1261. B. D. Shaw, "Lamasba: An Ancient Irrigation Community," *Antiquité africaines* 18 (1982) 61–103.

78. Thomas and Wilson, "Water Supply for Roman Farms" (supra n. 75) 148.

79. Wilson, "Water Management and Usage in Roman North Africa" (supra n. 31) 105.

80. A. Wilson argues in favor of "a certain symbiosis" between inhabitants of the city and countryside in their joint use of urban aqueduct waters. His view represents an abandonment of the long-standing and strict "consumptive/productive dichotomy" between city and countryside, according to which ideological and utilitarian functions for an aqueduct are mutually exclusive. Wilson, "Deliveries *Extra Urbem*" (supra n. 75) 314–32, quoted at 329 and 328.

81. The following two examples are from Wilson, "Water Management and Usage in Roman North Africa" (supra n. 31) 101–5, but see also Wilson, "Deliveries *Extra Urbem*" (supra n. 75) 314–32, for examples from North Africa, the Roman *campagna*, southern Gaul, and elsewhere.

Soğanlık Deresi between Yeşilköy and Denizoluk (E026) (see Fig. 30).

Rural inhabitants and estate owners required water not only for personal consumption but also to irrigate vegetable gardens and orchards. Roman authors describe the irrigation of vegetable and luxury gardens as well as grain fields, but it seems, at least in Italy, that the latter more usually received water from precipitation alone.⁸² These needs may have been adequately met by the collection of rainwater in cisterns, by wells, and by diverting water from nearby streams and springs. However, research on the water requirements for various growth stages of several crops in the region around Rome has found that most ancient Roman cisterns were not large enough to supply two months' worth of irrigation for vegetables covering over half a hectare.⁸³ Instead, areas larger than half a hectare on which water-dependent crops such as vegetables were grown must have been irrigated directly using stream diversions or aqueducts, or using cisterns fed by stream diversions or aqueducts. Grain sown later than February and maturing in the summer needed irrigation on a massive scale, perhaps prohibitively so, while fruit trees were likely irrigated to a smaller degree. These conclusions are based on modern rainfall and water requirement data from the eighteenth through twentieth centuries around Rome, but they may nevertheless give some indication of agricultural uses for water supplied by rural aqueducts.

Suterazi

Two brick-faced towers preserved in Aphrodisias near the City Wall in the east may be part of a water supply system that fed two Ottoman baths in this area of the city. These structures appear to be *suterazi* used in Ottoman water-supply systems to relieve variations in pressure and velocity in the pipelines to which they were attached (see Fig. 12). They function in the same way as earlier Roman examples such as the spectacular set of towers along the siphon of the aqueduct at Aspendos and, on a smaller scale, the towers integrated into the urban water supply system at Pompeii.⁸⁴ Water was conducted in lead or terracotta pipelines acting as siphons attached to a series of brick piers, each topped by an open tank. Running under pressure, the water would flow up one side of the tower and empty into the open tank, thereby relieving pressure and releasing air, before

heading back down the other side of the tower. With each successive trip up and down a pier, the pipeline lost "head" (or distance below the water's natural surface level), resulting in an overall sloping gradient. The towers were also convenient points for changes in the direction of the pipelines, branching lines, distribution reservoirs, and shut-off during maintenance.⁸⁵

At Istanbul, the Üsküdar (sixteenth–nineteenth century) and Büyükdere (1731) aqueducts incorporated *suterazi* situated at intervals of around 200 m to relieve water pressure in the inverted siphons connecting them.⁸⁶ During the Seljuk period, the Roman (or possibly Hellenistic) Şirince aqueduct was reused to supply the neighborhood of the Isa Bey Mosque in Ayasoluk (Selçuk, Turkey). Instead of resting on the preexisting aqueduct bridges as a substructure, the two terracotta pipelines of the aqueduct ran along the ground south of the bridges and over a series of *suterazi*.⁸⁷ *Suterazi* have also been attested along pipelines at Aleppo in Syria, Acre in Israel, and at Cadiz and Toledo in Spain.⁸⁸

It is tempting to link what appear to be *suterazi* to the two Ottoman bath complexes in the eastern area of the city and the remains of the Derince Dere pipeline found just north of the city. Unlike the other aqueducts found in the region, the Derince Dere pipeline is the only one along which terracotta pipes were found, and these pipes match those found in the Ottoman baths at Aphrodisias. Without the large pools of a Roman bath, the Ottoman baths could have been adequately supplied by a pipeline. The Morsynus river valley and surrounding area also contain a network of cisterns built in conjunction with the Ottoman road system (Fig. 40). These cisterns are described in the catalogue that follows.

HISTORICAL ANALYSIS

The Identification of the Timeles River with the Yenidere Çayı

The main waterway in the Morsynus valley is the eponymous river, attested in numerous ancient sources including coins from Aphrodisias and Antioch on the Maeander.⁸⁹ The Timeles river is a separate waterway,

85. Öziş, "Historical Water Schemes in Turkey" (supra n. 17) 377; Hodge, *Roman Aqueducts and Water Supply* (supra n. 30) 165–66.

86. Öziş, "Historical Water Schemes in Turkey" (supra n. 17) 375–76; Hodge, *Roman Aqueducts and Water Supply* (supra n. 30) 165.

87. Wiplinger, "Wasser für Ephesos" (supra n. 44) 26.

88. Hodge, *Roman Aqueducts and Water Supply* (supra n. 30) 433 n. 77.

89. Imhoof-Blumer, *Fluss-und Meer-götter* (supra n. 2) no. 290, pl. IX no. 27 (Aphrodisias); nos. 287–89, pl. IX no. 26 (Antioch on the Maeander).

82. Oleson, "Irrigation" (supra n. 74) 211–14. Oleson provides and discusses excerpts concerning irrigation from ancient sources.

83. Thomas and Wilson, "Water Supply for Roman Farms" (supra n. 75) 158–62.

84. Aspendos: P. Kessener, "The Aqueduct at Aspendos and Its Inverted Siphon," *JRA* 13 (2000) 104–32. Pompeii: G. Jansen, "Urban Water Transport and Distribution," in Ö. Wikander (ed.), *Handbook of Ancient Water Technology* (Leiden 2000) 103–26, at 113–14, fig. 7.

the Tímeles river, he was indeed on the right track about its general location.⁹³

It was only in 1954 that Robert and Robert conjectured that the Tímeles should be identified with the modern Yenidere Çayı.⁹⁴ The Yenidere runs through the Tavas plain collecting waters from the Baba Dağı range around Herakleia Salbakes (modern Vakıf). Aphrodisias and Herakleia are located in different valleys separated by a significant rise in topography with no connecting ravines. Both cities minted coins depicting the personified Tímeles because, although Aphrodisias was on a different plain, the city also benefited from the Tímeles's waters, as a local inscription makes clear. The Roberts' solution to the vexing issue of topography was to hypothesize an aqueduct that channeled part of the water of the Yenidere Çayı through the ridge that separates the Tavas plain from the Morsynus valley. Scholars before them did not readily imagine that the Aphrodisians would undertake the enormous effort of bringing water from one fertile valley to another by tunneling through the intervening ridge. Most probably thought with Ramsay that the Tímeles's head was in the saddle proper. But this is not the case. To this day a traveler will notice that while the Morsynus plain is relatively well watered, the Tavas plain, especially near the villages of Güzelköy and Çalıköy, where the Tímeles now rises, is lush and viridescent even at the height of the summer.

The Tímeles does not appear on the coins or inscriptions of other cities on the Tavas plain. It is unlikely that this is a result of chance; for if the Tímeles should be identified with one of the streams in the immediate vicinity of Herakleia, other cities on the plain (and specifically Apollonia Salbakes) could not have benefited from its waters. In fact, the city of Herakleia itself could not have used any of these small streams as they passed by the city in any practical way, for at that elevation their flow would have probably been too scant for urban needs. Rather, once they merged to form the Yenidere in the plain, their combined waters benefited

93. So was Kiepert, *Formae Orbis Antiqui* (supra n. 7) map IX, *Asia provincia*; but two things are amiss about Kiepert's map. First, he locates the Tímeles stream not properly on the saddle separating the Morsynus valley from the Tavas plain but rather on the slopes of Mount Kadmos within the territory of Aphrodisias, so he then has to show the stream flowing seemingly across the rise that separates the valley of Tavas from that of the Morsynus; the course of the stream he depicts is very improbable given the local topography. Second, he identifies the Tímeles with one of many rivulets that run down the slopes of Mount Kadmos (labeled "Salbacus M." in Kiepert's map) in the general vicinity of Herakleia. Although it is conceivable that one of the streams that even today feed the Yenidere Çayı was itself called Tímeles, and although it could have been thought to be the main origin of the Yenidere, we cannot know which one it is with the evidence now available to us.

94. Robert and Robert, *La Carie* II (supra n. 12).

the *chora* of Herakleia, not the city proper, which stands significantly above the river.

The Tímeles is the most important perennial stream on the Tavas plain, and carries much more water than the Morsynus does, at elevations well above that of Aphrodisias. The Tímeles flows southwest from below Herakleia, eventually joining the Harpessus river (modern Akçay) in a gorge south of the village of Görle. The fact that the Tímeles was not useful to Herakleia for urban water supply may help to explain why the Herakleians allowed the Aphrodisians to take advantage of it.⁹⁵ Also noteworthy, while Aphrodisias was a free city, Herakleia was not; authority over the waters of the rivers in Herakleia's territory would not have been necessarily in the hands of the local government. That a relatively distant river would serve a city with a much nearer source of water is not at all unusual.⁹⁶

Until now, the Roberts' argument that the Tímeles was the Yenidere remained a conjecture, because the aqueduct that they tentatively hypothesized had not yet been identified. The combined epigraphic and numismatic evidence from Aphrodisias and Herakleia strongly suggested that the Tímeles and the Yenidere were in fact one and the same river; but now, with the discovery of the aqueduct and especially the aqueduct tunnel through the ridge, this identification is virtually certain. The inscriptions, considered below, further suggest that the aqueduct was built in the reign of Hadrian.

Epigraphic Evidence Pertaining to the Tímeles Aqueduct

Epigraphic evidence can be used to date the aqueduct as well as to shed light on its financing. A well-known in-

95. The political borders of the region are not well understood; the fact that the Aphrodisians effectively tapped the Tímeles's waters may be an indication that the river, rather than the ridge, marked the limits of their territory.

96. As Hodge, *Roman Aqueducts and Water Supply* (supra n. 30) 70, notes: "Cities even when built upon major rivers for communication and commerce, seldom used the river water flowing by their doors. For one thing, it was too polluted, and for another, given gravity flow, a river can hardly serve a town built on its banks." The second reason alluded here by Hodge, combined with the fact that the waters of the tributaries of the Morsynus had become insufficient and the floor of the valley is nearly flat (see Stearns, "Geoarchaeological Investigations," in this volume), made it necessary for the Aphrodisians to tap the Tímeles river in the second century A.D. The intended scale of the new Hadrianic Baths perhaps meant that more water would be required than for either of the two previous bath complexes on the same site; alternatively, much of the new water may have been intended for extrurban projects. This was certainly the case with several of the smaller aqueduct lines found near Işıklar, which flow at elevations below that of Aphrodisias. In Rome, approximately one-third of the water transported by aqueducts was destined for the irrigation of extrurban villas, horti, and farmsteads; see H. B. Evans, *Water Distribution in Ancient Rome* (Ann Arbor 1994) 141, commenting partly on figures in Frontin. *Aq.* 78.2-3; see also R. H. Rodgers, *Frontinus: De Aquaeductu Urbis Romae* (Cambridge 2004) ad loc. and table 6 for the breakdown of the figures.

scription from Aphrodisias honors an adopted citizen, M. Ulpius Carminius Claudianus, scion of a distinguished family of Attouda (modern Hisar) on the northern slopes of Mount Kadmos (Baba Daği).⁹⁷ The text celebrates, among Carminius Claudianus's various exploits, "oil distributions that occurred at the time of the introduction of the Tímeles river" (ἔλαια δρακτοῖς πολλάκις τεθεικότα ἐν τῷ καιρῷ τῆς τοῦ Τιμέλου ποταμοῦ εἰσαγωγῆς; lines 39, 40). While the inscription helps narrow the dating of the Tímeles aqueduct, it does not imply that Carminius Claudianus paid anything for its construction, a point first made by Cormack.⁹⁸ Aqueducts were usually sponsored by the emperor, the community, private citizens, or a combination of these, but the funding of an aqueduct by a single private individual was exceedingly rare.⁹⁹

The exact dates of our Carminius Claudianus have been the source of much debate, primarily because it is not easy to distinguish him from other male members of his family, including his father and one of his sons.¹⁰⁰ A.-V. Pont has recently argued persuasively for a floruit ranging from the A.D. 130s to the beginning of the 160s.¹⁰¹ She believes the relevant inscription should date to the A.D. 160s or slightly later, and this gives a firm terminus ante quem for the completion of the aqueduct; whatever the exact dates of Carminius Claudianus, this inscription must refer to the aqueduct that carried the water from the Tavas plain to Aphrodisias.

Further epigraphic evidence helps to secure this identification and suggests a more precise dating of the building of the aqueduct to the time of Hadrian. In 1994 several fragments of an inscription were found reused as paving stones in the street just west of the Civil Basilica

97. *I Aph2007* 12.1111. On M. Ulpius Carminius Claudianus, see most recently A.-V. Pont, "L'inscription en l'honneur de M. Ulpius Carminius Claudianus à Aphrodisias (*CIG*, 2782)," *Cahiers du Centre Glotz* 19 (2010) 219–45, and also, P. J. Thoneman and F. Ertuğrul, "The Carminii of Attouda," *EpigAnat* 38 (2005) 75–86.

98. Cormack, "Epigraphic Evidence for the Water-Supply of Aphrodisias" (supra n. 13) 9–10.

99. See Hodge, *Roman Aqueducts and Water Supply* (supra n. 30) 6, with n. 5, who puts it succinctly: "unlike such things as theaters, even millionaires could not afford to finance [an aqueduct] single-handedly." K. M. Coleman, "Exchanging Gladiators for an Aqueduct at Aphrodisias (*SEG* 50.1096)," *Acta Classica* 51 (2008) 41, lists some extraordinary exceptions, including those attested in *CIL* 2.3361 and *IGRP* 3.804. On the funding of Roman aqueducts, see W. Eck, "Die Wasserversorgung in römischen Reich: sozio-politische Bedingungen, Recht und Administration," in R. Frei-Stolba and M. A. Speidel (eds.), *Die Wasserversorgung antiker Städte. Geschichte der Wasserversorgung* 2 (Mainz 1987) 74–79, and also P. Leveau, "Aqueduct Building: Financing and Costs," in D. E. Blackman and A. T. Hodge (eds.), *Frontinus' Legacy: Essays on Frontinus' de aquis urbis Romae* (Ann Arbor 2001) 85–101.

100. Thoneman and Ertuğrul, "The Carminii of Attouda" (supra n. 97), propose a floruit for him of A.D. 150–180.

101. Pont, "L'inscription *CIG*, 2782" (supra n. 97) 19.

and south of the Hadrianic Baths in Aphrodisias. In 2000 Reynolds published these documents, which record four letters from the emperor Hadrian to the magistrates, council, and people of Aphrodisias.¹⁰² The last two letters include discussion of an aqueduct, and both can be very precisely dated by the emperor's titles: one to A.D. 124 and the second to A.D. 125. We believe that the aqueduct discussed in these inscriptions is the same aqueduct we have documented. The text of the earlier letter is very badly damaged,¹⁰³ little can actually be read apart from titulature and greetings. Reynolds's text and translation read as follows:

41 ἐπὶ στεφανηφόρου Τιβερίου Κλαυδίου Ὀπλωνος υἱοῦ Ὑψικλέους Αὐτοκράτορος Καίσαρος, θεοῦ Τραϊανοῦ Παρθικοῦ υἱός, θεοῦ Νέ-
ρουα υἱωνός, Τραϊανός Ἀδριανός Σεβαστός, ἀρχιερεὺς
μέ[γιστος],
δημαρχικῆς ἔξουσίας τὸ η', ὑπατος τὸ γ', Ἀφροδεισιέ[ων τοῖς
ἄρ]-

45 χουσι καὶ τῇ βουλῇ καὶ τῷ δήμῳ χαίρειν ὡς ὑπέ[· c. 13 ··]
ΚΑ ἀθροοὶ προσαγορεύσαντες ΜΕ[· ? ··]
ὔδατος καταγωγὴν τυχεῖν[· ? ··]
Διογένους ὃν προεβ[ευτήν· ? ··]
ὑμετέρ[· ? ··]
[· ? ··

When Tiberius Claudius Hypsikles, son of Hoplon, was stephanephoros, the emperor Caesar, son of divine Trajan Parthicus, grandson of divine Nerva, Trajan Hadrian Augustus, pontifex maximus, holding tribunician power for the eighth time, consul for the third time (A.D. 124) greets the magistrates, the council and the people of Aphrodisias. As [.. ? ..] they, being gathered in a body, addressed ?me [.. ? ..] aqueduct (accusative case) to get [? help .. ? .. name (accusative case) son of Diogenes whom [?you had appointed as] ambassador [...

Reynolds argued that the use of the phrase ἀθροοὶ προσαγορεύσαντες (l. 46) suggested a body of people addressing the emperor viva voce. She believed that this probably occurred about A.D. 123 or 124 during Hadrian's stay in western Asia Minor; as Reynolds herself noted, this does not imply an actual visit to Aphrodisias, or even Caria, for that matter. The words ὔδατος καταγωγὴν (l. 47) make clear that this letter concerns an aqueduct. The appearance of καταγωγὴν instead of the more usual εἰσαγωγή or simply ἀγωγή is suggestive. Reynolds proposed that the emperor was echoing the exact wording the Aphrodisians themselves used in appealing to him. She argued that the prefix κατα- was to be taken strictly: "for it is almost inevitable that water would be brought down from the hills to the north/east of Aphrodisias."¹⁰⁴ But if the word had any special force at all, something beyond mere downward directionality would be implied. There were likely already two or more aqueducts bringing water to the city from the hills

102. Reynolds, "New Letters" (supra n. 2); *SEG* L 1096; *I Aph2007* 11.412.

103. *I Aph2007* 11.412, lines 41–end.

104. Reynolds, "New Letters" (supra n. 2) 18.

to the north and east; the Aphrodisians were probably trying to emphasize that a much larger undertaking was required to harness the waters of the Tavas plain, which was literally across the mountain.

The letter of a year later is much better preserved. The document reads as follows, again in Reynolds's text and translation (modified at lines 36–38, following Chaniotis's interpretation):¹⁰⁵

27 ἐπὶ Κλαυδίου Ὑψικλέους ἡρώως. Ἀυτοκράτωρ Καῖσαρ,
[θ]εοῦ Τραϊανοῦ Παρθικοῦ υἱός, θεοῦ Νέρουα υἱώνος,
Τραϊανὸς Ἀδριανὸς
Σεβαστός, ἀρχιερεὺς μέγιστος, δημαρχικῆς ἐξουσίας τὸ
ἕνατον,
30 ὑπάτος τὸ τρίτον. Ἀφροδισιέων τοῖς ἀρχουσι καὶ τῇ βουλῇ
καὶ
τῷ δήμῳ χαίρειν. τοὺς πόρους οὓς ἀπετάξατε εἰς τὴν τοῦ
ὑδάτος
καταγωγὴν βεβαιῶ. ἐπεὶ δὲ ἦσαν τινες πολεῖται ὑμέτεροι
λέγον-
τες εἰς ἀρχιερωσύνην ἀδύνατοι ὄντες προβεβλήσθαι
ἀνέπεμψα αὐ-
τοὺς ἐφ' ὑμᾶς ἐξετάσσοντας πότερον δυνατοὶ ὄντες
λειτουργεῖν δια -
35 δύονται, ἢ ἀληθῆ λέγουσιν. εἰ μὲντοι φαίνονται τινες αὐτῶν
εὐπορώτε-
ροι, προτέρους ἐκείνους ἀρχιερεῖσθαι δίκαιον. συνχωρῶ
ὑμῖν παρὰ τῶν
ἀρχιερέων ἀντὶ μονομαχιῶν ἀργύριον λαμβάνειν καὶ οὐ
συνχωρῶ μόνον
ἀλλὰ καὶ ἐπαινῶ τὴν γνώμην. οἱ αἰρεθισόμενοι ὑφ' ὑμῶν
ἐπιμελη-
ταὶ τοῦ ὑδραγωγίου περὶ ὧν ἂν γνώμης δέονται καὶ
συλλήψεως δθνή-
40 σονται τῷ ἐπιτρόπῳ μου Πομπηίῳ Σεβήρῳ ἐντυγχάνειν, ᾧ
κάγῳ γέγραπ-
φα. εὐτυχεῖτε

In (the stephanephorate of) Claudius Hypsikles, heros. The emperor Caesar, son of divine Trajan Parthicus, grandson of divine Nerva, Trajan Hadrian Augustus, pontifex maximus, holding tribunician power for the ninth time, consul for the third time (A.D. 125) greets the magistrates, the Council and the People of Aphrodisias. The funds which you have reserved for the aqueduct I confirm. And since there are certain of your citizens who say that they have been nominated for the high priesthood when they are incapable of undertaking it, I have referred them to you to examine whether they are able to undertake the liturgy and are evading it, or are telling the truth; if, however, some of them were to appear to be better off, it is fair that they should hold the high priesthood first. I allow you to receive money instead of gladiatorial shows from the high priests, and not only do I allow you this but I also praise this proposal. The supervisors who will be chosen by you for the water-channel will be able to get advice and help on those matters on which they need them from my procurator Pompeius Severus, to whom I have written. Farewell.

This letter sheds light not only on the dating of the aqueduct but also on its financing and, more generally, on the administrative and fiscal complexities of the relationship between a free city and Rome. The text of this letter has been the subject of recent analyses with di-

vergent interpretations. According to Reynolds, the document implies that the high priests were unwilling to divert monies otherwise destined for gladiatorial shows to pay for the aqueduct.¹⁰⁶ More recently, K. Coleman has argued that the exact opposite was the case, and that a subvention for the aqueduct was the solution to the problem of the high priests' unwillingness to fund gladiatorial shows. Coleman concluded that the imperial priesthood in Aphrodisias preferred to be associated with a lasting monument that was essential to the city's daily life instead of basking in the ephemeral praise of their fellow citizens during the day of the shows.¹⁰⁷ A. Chaniotis suggested a different interpretation, considering contemporary parallels. According to Chaniotis, Hadrian's intervention resulted from disagreement in Aphrodisias concerning two separate issues: the funding for the aqueduct and the type of *summa honoraria* to be contributed by high priests (money or shows).¹⁰⁸

Quite apart from local disagreements about the preferred ends of euergetism in second-century A.D. Aphrodisias (whether games or water supply), the letters provide evidence of a free city's need or desire to secure sanction from Rome for major expenditure projects—even when *only* municipal resources would be tapped to pay for such projects. The aqueduct in question was to be sponsored not by the emperor, nor even as a joint imperial-municipal venture, but rather exclusively by the city; even so, the Aphrodisians sought Hadrian's authorization. In a brief discussion of these inscriptions, D. Campanile has rightly called attention to the fact that the Aphrodisians solicited imperial approval to fund their aqueduct because, among other things, its funding involved the reallocation of monies that were otherwise destined to pay for public spectacles in the emperor's honor.¹⁰⁹

Further epigraphic and literary evidence supports the notion that by the second century A.D., cities in the provinces—free or not—sought imperial approval to undertake urban projects at this scale. Such behavior helps explain dedicatory inscriptions that explicitly mention a proconsul—even when subvention for the projects in question was furnished entirely from a city's own resources; inclusion of the name of a proconsul presumably reflects the imperial magistrate's personal

106. Reynolds, "New Letters" (supra n. 2) 19.

107. Coleman, "Exchanging Gladiators for an Aqueduct" (supra n. 99). For an inscription from Late Antique Aphrodisias mentioning "lasting memory" (αἰωνία ὑπόμνησις) that results from building monuments, see C. Roueché, "Acclamations in the Later Roman Empire: New Evidence from Aphrodisias," *JRS* 74 (1984) 181–99, no. 8.

108. A. Chaniotis, "Macht und Volk in den kaiserzeitlichen Inschriften von Aphrodisias," in G. Urso (ed.), *Popolo e potere nel mondo antico* (Pisa 2005) 47–61, at 57–59.

109. D. Campanile, "Noterelle ai nuovi documenti da Afrodisia," *ZPE* 135 (2001) 138.

105. *I Aph2007* 11.412, lines 27–41. See Chaniotis *infra* n. 108.

intervention with the emperor on behalf of the city.¹¹⁰ Literary sources may also be provided; for example, when the younger Pliny seeks Trajan's advice about public works in the cities of Bithynia, the monies in question sometimes seem to come from municipal not imperial or private funds.¹¹¹

The inscriptions from Aphrodisias document the process of a free city's requesting the sanction of Rome. The original letter from the Aphrodisians to Hadrian specified from where funds for the aqueduct would be taken and sought his approval. Ultimately, Hadrian confirmed that the Aphrodisians should use the compulsory fee of the high priesthood to build their aqueduct. In addition to imperial approval, the emperor also promised technical assistance that was surely required to undertake the construction of an aqueduct more than 25 km long, with tunnels up to 50 m deep and at least a dozen bridges, which ranged in height from 5 m to almost 30 m. The surveying alone would have exceeded by far the limits of local specialists.

Conclusions

All this evidence indicates that the aqueduct we have found is the same one mentioned in coins and inscriptions, and that it should be dated to the second quarter of the second century A.D. Construction of the Tímeles aqueduct probably began in the reign of Hadrian, during or shortly after the time the letters were written.¹¹² Arguably, the citizenry of Aphrodisias, or rather certain prominent Aphrodisians, decided to undertake this massive project when they heard that the emperor was coming in the hope of obtaining imperial benefaction. As mentioned above, the fact that Aphrodisias and Herakleia both minted coins mentioning the Tímeles, although they were located in different valleys, was a source of confusion for scholars attempting to elucidate local history and topography. Robert and Robert offered a solution to this apparent numismatic paradox by hypothesizing an aqueduct carrying the waters of the Tímeles (= Yenidere Çayı) to Aphrodisias. We have found and documented

the remains of this aqueduct, thus validating the Roberts' hypothesis. But if the Tímeles river—rather than the watershed of the ridge separating the Morsynus river valley from the Tavas plain—delimited the territory between Aphrodisias and Herakleia, there would be no paradox at all, for this would mean that the Tímeles ran along the territory of Aphrodisias. In any case, the exact political boundaries remain unclear, and either the Tímeles river or the mountain range separating the two valleys could have acted as a clear physical limit between Aphrodisias and Herakleia.

The Tímeles aqueduct was the grandest aqueduct of the city but not the first; the one or two bath complexes in operation before the Hadrianic Baths would themselves have needed major water conveyance facilities. But by the time of Hadrian's reign, water in the Morsynus river valley was perceived to be insufficient for the needs of the city and perhaps also its *chora*. In the city, the Tímeles aqueduct most likely fed the luxurious complex known as the Hadrianic Baths, and it was surely related to other civic monuments, such as public fountains. It is possible that a monumental waterspout in the shape of a ship that was found in the vicinity of the Civic Basilica (Fig. 41) could be related to the grand terminus of this aqueduct.

DATING, PURPOSE, AND FUNDING OF THE AQUEDUCTS

For two and a half centuries after the foundation of Aphrodisias in the early second century B.C., the residents of the city obtained water from wells, cisterns, and the nearby Morsynus river.¹¹³ The city dwellers even benefited from seasonal springs within the city proper, which they later collected, controlled, and celebrated in the grand ornamental pool in the South Agora built in the early Julio-Claudian period.¹¹⁴ By the late first century A.D., however, water management problems within the city had become acute, perhaps as a result of the growing population. The existing urban infrastructure was insufficient to handle excess seasonal waters. The city probably suffered periodic flooding as a result of pervasive encroachment on public areas initially des-

110. For a useful discussion of how an emperor's generosity, as well as that of his ministers, is variously commemorated in provincial inscriptions, see S. Mitchell, "Imperial Building in the Eastern Roman Provinces," *HSCP* 91 (1987) 333–65, at 343–49.

111. In Plin. *Ep.* 10.39.1–3, a distinction is drawn between a private subvention (*ex privatorum pollicitationibus*) and an earlier influx of unspecified, but presumably municipal, funds; similarly, in *Ep.* 10.37.1, the monies used by the Nicomedians to fund an aqueduct are not associated with the emperor nor with private individuals, and may very well have been municipal, as A. Zuiderhoek explains in *The Politics of Munificence in the Roman Empire* (Cambridge 2009) 42.

112. Reynolds, "New Letters" (supra n. 2) 18, believes that the Domitianic inscription *I Aph 2007* 12.314 (mentioned supra nn. 11, 20, 27) implies an aqueduct, but we would rather agree with Chaniotis, "Twelve Buildings" (supra n. 11), in thinking that it refers merely to drains, gutter, canals, and reservoirs or holding ponds.

113. The city was founded in the early second century B.C. when the preexisting population around the sanctuary of Aphrodite and that of Plarasa (modern Bingeç), located 15 km to the southwest, combined at Aphrodisias. The location of the sanctuary and the city was determined partly by the fact that the site had a plentiful water supply. Pausanias (1.26.6) mentions a brackish spring in connection with the sanctuary, but its exact location is unknown; the well in the nave of the Christian church into which the Temple of Aphrodite was converted in the fifth century A.D. was presumably made to tap a fresh water source.

114. Chaniotis, "Twelve Buildings" (supra n. 11) 14–15, with n. 82.



Figure 41. Waterspout found near the Civic Basilica at Aphrodisias, with Lionel Bier in background.

tined for water circulation. Eventually Adrastus, a prominent and wealthy citizen of Aphrodisias, privately funded citywide measures to relieve the problem, including the purchase of land and the building of water holding ponds. Some of these features, rather than an aqueduct, are most likely the ones mentioned in an aforementioned Domitianic inscription; however, it is also possible that Adrastus built these structures in association with a new aqueduct constructed at the same time.¹¹⁵ The growing city certainly required a more abundant and reliable water supply. This supply could be met only with the construction of aqueducts tapping more distant sources, because although fed by perennial springs, the Morsynus river decreases significantly in volume in the summer, and the Palamutçuk ridge directs water from the springs and surface drainage of the Baba Dağı range away from the city and toward the west. Therefore, the Aphrodisians had to tap sources located north and east of the city to make up for the insufficient local supply, and they eventually built the Timeles aqueduct to bring water from the Tavas plain.

We have identified and documented six separate aqueducts, four of which supplied Aphrodisias (three certainly in the Roman period) and two of which fed a settlement, farmstead, or villa, or provided water for irrigation. The Işıklar and Derince Dere aqueducts collected water north of Aphrodisias on Baba Dağı, while the Seki aqueduct tapped springs to the east of the city. The Kavaklıdere and Ören Deresi aqueducts, running

at elevations too low to have supplied the city, collected water in the western portion of the valley. The Timeles aqueduct brought water into the Morsynus river valley from the Tavas plain to the southeast. The striking fact that the most abundant water sources used today are the same as those tapped by these aqueducts underscores an understanding of hydrology and exploitation of natural resources on behalf of the engineers and the local residents who no doubt informed them.

The different aqueducts served various purposes in and around Aphrodisias. Several of them supplied water to public bath complexes within the city. Presumably, the Işıklar and Seki aqueducts—or at any rate, an aqueduct or aqueducts tapping the springs on the western slopes of Baba Dağı—supplied water to the one or two bath complexes that predated the Hadrianic Baths and are attested only in inscriptions.¹¹⁶ We do not know anything about the funding of these aqueducts.¹¹⁷ Since

116. *Supra* nn. 18, 19, 26.

117. In only a few instances do we know who designed and surveyed a Roman aqueduct. One exception is provided by a remarkable inscription from Lambaesis, Algeria (*CIL* VIII 2728 = *ILS* 5795) documenting the case of the second-century A.D. hydraulic engineer and legionary officer Nonius Datus in Numidia. Nonius was picked to survey an aqueduct in *Saldæ* in the neighboring province of Mauretania. He was called back twice, once to correct a failed engineering job involving a tunnel; see Laporte, “Notes sur l’aqueduc de *Saldæ*” (*supra* n. 67) 747–79; Grewe, “Tunnels and Canals” (*supra* n. 59) 329–33. In his correspondence with Trajan while governor in Bithynia-Pontus, Pliny the Younger describes how, after two failed attempts at building an aqueduct, he fears he has the manpower but not the expertise to

115. *Supra* nn. 11, 20, 22, 27.

the first of these complexes, the Eusebian Baths, dates to the early Julio-Claudian period, one of the aqueducts must have been built at least this early. Unfortunately, we were not able to date precisely the Işıklar and Seki aqueducts, partly because the remains are scarce and not very distinctive, and partly because local communities have continuously reused these structures so that many of the surviving remains are in fact a patchwork from different periods. In addition, one or both of these aqueducts may have been constructed in association with Adrastus's refurbishment of the water management system within the city during the reign of Domitian.

The Timeles aqueduct was planned in the second quarter of the second century A.D. to tap water sources outside the Morsynus river valley from the southeastern slopes of Mount Kadmos (Baba Dağı), near the town of Herakleia (modern Vakıf). It likely supplied the large Hadrianic Baths and may also have fed other complexes such as the so-called Theater Baths at Aphrodisias. We know from inscriptional evidence that this aqueduct was financed with funds reserved by the city and also with monies taken from private citizens serving as priests. We also know that other possible means of funding, including diverting money from gladiatorial shows, were considered but were dismissed by the emperor Hadrian.¹¹⁸ The letters from Hadrian discussed above in the section "Historical Analysis" suggest that ambassadors from Aphrodisias asked Hadrian for financial approval and technical assistance for the construction of the Timeles aqueduct.

In the later letter regarding the aqueduct, Hadrian approves the Aphrodisians' funding scheme, indicates that the Aphrodisians should select curators for the project, and offers the assistance of his procurator Pompeius Severus. The engineer and architect who surveyed

and designed the Timeles aqueduct may have been selected by the procurator, by local curators with a better knowledge of local topography and resources, or by a contractor.¹¹⁹ When, during the reign of Hadrian, the people of Saldæ in Mauretania wanted to build an aqueduct, they requested help from the procurator of the province, who asked the legate of Numidia to select an engineer from the Third Legion Augusta.¹²⁰ The legionary officer and *librator* Nonius Datus was sent to Saldæ to survey the aqueduct, and soldiers provided labor for the project. The Aphrodisians likely took Hadrian's offer and turned to the procurator Pompeius Severus for recommendations. Presumably the city contracted local skilled and unskilled labor for the actual construction of the aqueduct, but the expertise required to survey and design the technically challenging and sophisticated structure must have been found outside the valley.

The Timeles aqueduct incites questions regarding the administration and use of local resources. It seems unlikely, for example, that subsistence reasons alone motivated the construction of this aqueduct, for both the Morsynus river valley and the Tavas plain are quite fertile. While the population of the valley in antiquity was likely roughly comparable to what it is today,¹²¹ present-day farmers use only locally available water from the springs and streams described above to manage crops such as olives, wheat and barley, tobacco, and grapes; no additional supply from outside the valley is required. This situation suggests that in antiquity, too, the water from the western slopes of Mount Kadmos was probably sufficient for the agricultural needs of Aphrodisias and the smaller settlements in the valley. Although we have found clues that the Timeles aqueduct may have supplied the residents of farmsteads, settlements, villas, and agricultural sites in the valley, this aqueduct was never equipped with the kind of elaborate and substantial mechanisms for rural supply documented, for example, along aqueducts in North Africa and at Rome discussed above in "Technical Analysis, Rural Water Supply."¹²² Clearly the Timeles aqueduct was intended to channel the vast majority of its waters into the city itself.

Presumably the Timeles, Seki, and Işıklar aqueducts supplied more than just drinking water for the estimated

construct an aqueduct and a canal (*Ep.* 10.37, 41–42, 61–62). Trajan then suggests he requisition an expert from the governor of the Moesia Inferior, the closest province to Bithynia with army presence. Other inscriptions attest to the existence of *libratores* and even student engineers in the army, which required such expertise; see, e.g., *ILS* 5759a, *discens libratorum*, from an inscription in North Africa of the third century A.D., commemorating the opening of a new aqueduct. See also, P.-A. Février, *L'armée romaine et la construction des aqueducs* in *Aqueducs romains, Dossiers de l'archéologie* 38 (Oct.–Nov. 1979) 88–93; and idem, "Armée et aqueducs," *Journées d'études sur les aqueducs romains, Lyon, 26–28 Mai, 1977* (Paris 1983) 133–40.

118. The emperor is commenting on and partly approving a funding plan proposed by the Aphrodisians. It would seem that even a free city such as Aphrodisias actually required the emperor's approval on major capital expenditure projects; see Campanile, "Noterelle ai nuovi documenti" (supra n. 109); alternatively, but less likely, the correspondence might have been initiated by the Aphrodisians in an attempt to obtain imperial benefaction. See "Historical Analysis" above and the references there, especially Reynolds, "New Letters" (supra n. 2) 14; and Coleman, "Exchanging Gladiators for an Aqueduct" (supra n. 99).

119. Fabre et al., "Interdisciplinary Research on the Aqueduct of Nîmes and the Pont du Gard" (supra n. 71) 74–75.

120. Supra n. 117.

121. It has been estimated that in the Imperial period, the valley sustained between 20,000 and 30,000 people. According to the official Web page of the Karacasu municipality, www.karacasu.gov.tr/Karacasu.aspx?Sayfa=Nufus (accessed 1 January 2010), the valley sustains 21,980 people.

122. Wilson, "Water Management and Usage in Roman North Africa" (supra n. 31) 101–5; Thomas and Wilson, "Water Supply for Roman Farms" (supra n. 75) 139–96.

10,000–15,000 residents of the Imperial-period city. The Tímeles aqueduct alone may have provided 157,000 m³ of water each day. Perhaps the desire for a grand public bath at a scale unprecedented for the city, and also the desire to maintain a concentrated population in a relatively dense urban environment, motivated members of the Aphrodisias élite to undertake this bold project. Ultimately the bath and the aqueduct itself became monuments of civic cohesiveness; thus, the rather distant Tímeles river was celebrated on coins, and the occasion of its introduction into the city was used as a chronological reference in inscriptions.¹²³ Although the inscriptional evidence suggests that the entire project, and especially its enormous cost, was initially divisive, the Aphrodisians must have remembered proudly how they managed to survey the hilly terrain, erect numerous bridges over steep gorges, and tunnel more than 2.5 km through the mountain range to bring water from the Tavas plain to their city.

The hypothesis that the main purpose of the Tímeles, Seki, and Işıklar aqueducts was to supply Aphrodisias does not preclude the limited use of their waters outside the city. The Tímeles aqueduct may have been tapped at multiple points along its route, and the route of the Roman Işıklar aqueduct was reused multiple times after the depopulation of the city (including iterations as the Derince Dere pipeline and the more modern cement channel), highlighting the fact that aqueducts were built to supply nonurban consumers as well. More important, these three aqueducts were not the only water lines built in the valley. The Kavaklıdere and Ören Deresi aqueducts ran at elevations lower than that of Aphrodisias and therefore must have provided water to one or more of the Roman or post-Roman farmsteads, villas, settlements, and agricultural sites identified throughout the Morsynus river valley. The aqueducts documented by the survey help break down the view of Roman aqueducts as structures built solely for the provision of large-scale public buildings, especially those devoted to display and recreation.

We do not yet know exactly how the water these aqueducts carried was distributed within the city. Surely the aqueducts that supplied water to the baths also fed public fountains, pools, and nymphaea in Aphrodisias. One possible terminus is a niched structure in the northeast part of the city identified as a nymphaeum at the time of excavation. Though the structure contains no pipelines or channels, its location—at an elevation higher than the rest of the city and to the northeast, where it seems the three Roman aqueducts entered Aphrodisias—is optimal for water collection and distribution. Judging from the extensive remains of pipes and water facilities in Late Antique élite houses such as the

Triconch House and Atrium House, the aqueducts eventually supplied water also to private residences. In addition to the baths and fountains, we know from archaeological and epigraphic evidence about other intraurban water facilities for both storage and disposal of water. The different pools in the city are not all related to aqueducts; some are rather reservoirs to contain and control rainwater as well as the flow of seasonal springs within the city.

The Hadrianic Baths associated with the Tímeles aqueduct continued to be used for at least four centuries, as is attested epigraphically.¹²⁴ Presumably, even before the city was abandoned, the aqueducts fell into disrepair, as sinter accumulated on channel walls, and tunnels and bridges began to collapse. Maintaining the Tímeles aqueduct was beyond the material possibilities of the communities that inhabited the Morsynus river valley after Late Antiquity. However, it is clear that some of the smaller aqueducts tapping the streams on the western slopes of the Baba Dağı range within the Morsynus valley were in fact repaired.

During the Ottoman period, these local water sources and at least some tracts of the infrastructure were again used to supply bathhouses in the old village of Geyre. The major change in the use and management of water that Ottoman rule brought about was the placement of cisterns along roads to facilitate traffic through the region (see Fig. 40). We have documented them summarily in the catalogue below, but they require fuller treatment by competent authorities.

The aqueducts and cisterns investigated and documented by the Aphrodisias Regional Survey emphasize the ongoing exploitation of water as a vital natural resource over millennia of interaction between the region's human population and the surrounding environment. That the residents of Roman Aphrodisias supplied their marble-clad city with abundant water from multiple aqueducts is perhaps not surprising. More interesting are the different types of waterworks in the region and the diversity of needs they were built to accommodate. These factors draw attention to the longevity of human-environment interaction in the region and its changing appearance over time. Most intriguing, however, is the way in which the shifting forms of this interaction reflect much broader historical changes, as the water lines supporting the high-density city and settled countryside of the Hellenistic and Roman periods fell out of use, and effort was redirected to the creation of cisterns along a network of travel and communication that united a new Ottoman empire.

124. There is epigraphic evidence confirming the maintenance and repair of the Hadrianic Baths into the sixth century A.D. See, e.g., Roueché, *eALA* 74, 86, 87, and n. 106 on a sixth-century A.D. restoration by Rhodopaïos of a portion of the Hadrianic Baths known as the summer Olympian Baths.

123. See “Historical Analysis” above.

APPENDIX

A. Calculation 1

Variables

$$A = \text{cross-sectional wetted area} = 1.50 \times 1.30 = 1.95 \text{ m}^2$$

$$P = \text{wetted perimeter} = 1.50 + 2(1.30) = 4.10 \text{ m}$$

$$R = \text{hydraulic radius} = A/P = 1.95/4.10 = 0.476 \text{ m}$$

$$S = \text{slope} = 10.5 \text{ m}/11.04 \text{ km} = 0.95 \text{ m}/\text{km}$$

$$= 0.95 \text{ m}/1,000 \text{ m} = 0.00095$$

(Modern dam to Kayapınar tunnel [E009])

$$C = \text{Chézy coefficient} = 60\text{--}80 = \text{smoothly plastered concrete}$$

(80 = smoother, newer concrete)

$$K = \text{Kutter coefficient} = 55\text{--}100$$

(55 = very rough concrete; 100 = very smooth concrete)

$$\text{Bazin formula for mean velocity} = V = C \sqrt{(R \times S)}$$

$$V = 60 \sqrt{(0.476 \times 0.00095)} = 1.276 \text{ m/second}$$

(using 60 to obtain a minimum mean velocity)

$$V = 80 \sqrt{(0.476 \times 0.00095)} = 1.701 \text{ m/second}$$

(using 80 to obtain a maximum mean velocity)

$$Q = \text{discharge} = AV = 1.95 \times 1.276 = \mathbf{2.488 \text{ m}^3/\text{second}}$$

(minimum discharge)

$$= 1.95 \times 1.701 = \mathbf{3.317 \text{ m}^3/\text{second}}$$

(maximum discharge)

$$\text{Manning formula for mean velocity} = V = KR^{2/3}S^{1/2}$$

$$V = 75(0.476)^{2/3}(0.00095)^{1/2} = 1.409 \text{ m/second}$$

$$Q = \text{discharge} = AV = 1.95 \times 1.409 = \mathbf{2.748 \text{ m}^3/\text{second}}$$

Discharge per day

(Bazin)

$$2.488 \text{ m}^3/\text{second} \times 86,400 \text{ second/day}$$

$$= \mathbf{214,963 \text{ m}^3/24 \text{ hours}}$$

(minimum discharge per day)

$$3.317 \text{ m}^3/\text{second} \times 86,400 \text{ second/day}$$

$$= \mathbf{286,589 \text{ m}^3/24 \text{ hours}}$$

(maximum discharge per day)

(Manning)

$$2.748 \text{ m}^3/\text{second} \times 86,400 \text{ second/day}$$

$$= \mathbf{237,427 \text{ m}^3/24 \text{ hours}}$$

B. Calculation 2

New variables

$$A = \text{cross-sectional wetted area} = 1.50 \times 1.00 = 1.50 \text{ m}^2$$

$$P = \text{wetted perimeter} = 1.50 + 2(1.00) = 3.50 \text{ m}$$

$$R = \text{hydraulic radius} = A/P = 1.50/3.50 = 0.429 \text{ m}$$

$$\text{Bazin formula for mean velocity} = V = C \sqrt{(R \times S)}$$

$$V = \text{mean velocity} = C \sqrt{(R \times S)}$$

$$= 60 \sqrt{(0.429 \times 0.00095)} = 1.211 \text{ m/second}$$

(minimum mean velocity)

$$= 80 \sqrt{(0.429 \times 0.00095)} = 1.615 \text{ m/second}$$

(maximum mean velocity)

$$Q = \text{discharge} = AV = 1.50 \times 1.211 = \mathbf{1.817 \text{ m}^3/\text{second}}$$

(minimum discharge)

$$= 1.50 \times 1.615 = \mathbf{2.423 \text{ m}^3/\text{second}}$$

(maximum discharge)

$$\text{Manning formula for mean velocity} = V = KR^{2/3}S^{1/2}$$

$$V = 75(0.429)^{2/3}(0.00095)^{1/2} = 1.315 \text{ m/second}$$

$$Q = \text{discharge} = AV = 1.5 \times 1.315 = \mathbf{1.973 \text{ m}^3/\text{second}}$$

Discharge per day

(Bazin)

$$1.817 \text{ m}^3/\text{second} \times 86,400 \text{ second/day}$$

$$= \mathbf{156,989 \text{ m}^3/24 \text{ hours}}$$

(minimum discharge per day)

$$2.423 \text{ m}^3/\text{second} \times 86,400 \text{ second/day}$$

$$= \mathbf{209,347 \text{ m}^3/24 \text{ hours}}$$

(maximum discharge per day)

(Manning)

$$1.973 \text{ m}^3/\text{second} \times 86,400 \text{ second/day}$$

$$= \mathbf{170,467 \text{ m}^3/24 \text{ hours}}$$

C. Calculation 3

New variables

$$S_1 = 0.00095 / 2 = 0.000475 \quad (\text{half the slope})$$

$$S_2 = 0.00095 \times 2 = 0.0019 \quad (\text{twice the slope})$$

$$\text{Bazin formula for mean velocity} = V = C \sqrt{(R \times S)}$$

$$V = \text{mean velocity} = C \sqrt{(R \times S_1)}$$

$$= 60 \sqrt{(0.429 \times 0.000475)} = 0.856 \text{ m/second}$$

(minimum mean velocity, half the slope)

$$= C \sqrt{(R \times S_2)}$$

$$= 60 \sqrt{(0.429 \times 0.0019)} = 1.713 \text{ m/second}$$

(minimum mean velocity, twice the slope)

$$Q = \text{discharge} = AV = 1.50 \times 0.856 = 1.284 \text{ m}^3/\text{second}$$

(minimum discharge, half the slope)

$$= 1.50 \times 1.713 = 2.570 \text{ m}^3/\text{second}$$

(minimum discharge, twice the slope)

Discharge per day

$$1.284 \text{ m}^3/\text{second} \times 86,400 \text{ second/day}$$

$$= \mathbf{110,938 \text{ m}^3/24 \text{ hours}}$$

(minimum discharge per day, half the slope)

$$2.570 \text{ m}^3/\text{second} \times 86,400 \text{ second/day}$$

$$= \mathbf{222,048 \text{ m}^3/24 \text{ hours}}$$

(minimum discharge per day, twice the slope)

CATALOGUE

1. Seki Aqueduct

Bridge, Yüksekkeşer Deresi, Seki Aqueduct (A063)

(Figs. 4, 5)

Location: The bridge crosses the Yüksekkeşer Deresi, a tributary of the Morsynus river. It is located 8.5 km southeast of Aphrodisias and 1.5 km southeast of the modern village of Seki, just northeast of the main road running through the valley.

Elevation: 705 masl

Coordinates: Latitude: 37°41'15.96"N; longitude: 28°48'56.10"E

Preservation: The piers and arch of the bridge are well preserved because they were incorporated into a later (probably Ottoman) road bridge. However, the composite structure was leveled and resurfaced at that time, so the masonry above the arch and the conduit are not preserved at all. The southeast pier is covered with calcium carbonate incrustations.

Construction: The bridge is constructed of mortared rubble faced with petit appareil masonry. The facing blocks and voussoirs include fieldstones of quartz and sandstone, as well as larger blocks of marble, some originally dressed for other purposes. The facing blocks are 0.30–0.40 m long and 0.15–0.20 m high; the blocks above the projecting course of the northwest pier are smaller than those below. The blocks

of the projecting course are up to 1.20 m long and 0.30 m high. The voussoirs range in size from 0.30 to 0.50 m long and 0.15 to 0.20 m wide at the extrados. The lime mortar is pale beige with stone inclusions, most no larger than 0.05 m, while a hard blue mortarlike material covers the joints between the large blocks of the base of the northwest pier.

Description: The Roman bridge is preserved to a height of 6 m, a width of 1.7 m, and a length of 15 m. Large blocks form the base of the northwest pier, founded within the soil of the stream bank. A projecting course is visible only on the northwest pier, 2.5 m above the ground. The arch springs from a point two courses higher than the projecting course and spans 5 m.

The Ottoman bridge is built against the northeast side of the aqueduct bridge. It is constructed of mortared rubble faced with petit appareil masonry, but the facing blocks are smaller and more varied in size (with a maximum length of 0.60 m) than those of the aqueduct bridge, and chinking stones are used more liberally. The bridge is 1.8 m wide and has a projecting course that does not span the entire width of its northwest pier because it is built in line with the projecting course of the Roman aqueduct bridge. The arch has a slightly greater span than the arch of the aqueduct bridge, and putlog holes are visible under the arch directly above the projecting course and in the southwest corner of the base of the pier.

Major Dimensions (Roman aqueduct bridge):

p. H: 6 m
 W (northwest pier): 1.7 m
 p. L: 15 m
 Arch span: 5 m
 H (ground to bottom of projecting course): 2.5 m
 H (streambed to bottom of arch): 5.9 m

Photograph Numbers: D2005.0469–0475, D2008.1312–1316

Drawing Numbers: RS 28: Section looking northwest and section looking northeast at 1:50 scale

2. Işıklar Aqueduct

Tunnel, İncir Deresi, Işıklar Aqueduct (B081) (Fig. 7)

Location: The tunnel is cut into the west (right) bank of the İncir Deresi, a deep gorge that flows into the Morsynus river from the north. It is located almost 7 km north of Aphrodisias and 1.5 km north of the modern town of Işıklar.

Elevation: 804 masl

Coordinates: Latitude: 37°46'00.63"N; longitude: 28°44'30.20"E

Preservation: The tunnel can be followed from the north for 8 m, after which sediment infill makes it impassable. Calcareous deposits from natural water percolation line all interior surfaces of the tunnel.

Construction: The tunnel is carved into an outcrop of schist and quartz.

Description: The tunnel lies at a height of about 2 m above the streambed and 2.75 m below the ground level of the stream bank above. The tunnel has a roughly vaulted profile. Its preserved height is 0.7 m, and it is 0.93 m wide at the floor and 0.42 m wide at the ceiling. It is preserved to a length of 8 m. Niches slightly smaller than 0.10 m square line the eastern interior wall.

Major Dimensions:

p. H (tunnel): 0.7 m
 p. W (tunnel): 0.93 m (floor); 0.42 m (ceiling)
 p. L (tunnel): 8 m

Photograph Numbers: D2006.0776–0786

Drawing Numbers: Drawing not inked (north elevation at 1:50 scale)

Bridge, Kavaklıdere, Işıklar Aqueduct (A008) (Figs. 8, 9)

Location: The remains of the bridge are located on both banks of the Kavaklıdere, a tributary of the Morsynus river, approximately 4 km north of Aphrodisias and 1 km southwest of the modern town of Işıklar.

Elevation: 609 masl

Coordinates: Latitude: 37°44'46.02"N; longitude: 28°43'25.08"E

Preservation: One complete pier of the aqueduct bridge with partial remains of two springing arches stands on the north (right) bank of the stream. Other remains of the bridge include two masses of mortared rubble, one approximately 18 m from the standing pier on the opposite bank of the stream and another about 4 m to the north of the standing pier. The standing pier is not preserved to the height of the conduit, and no trace of the conduit can be found in either stream bank. The pier is pierced by a large hole as a result of collapse or settling, and the pier wall under the north arch has collapsed. The upstream (east) face of the structure is more heavily damaged than the downstream side.

Construction: The bridge is constructed of mortared rubble faced with petit appareil masonry. The facing blocks, most of which are schist fieldstones, are 0.10–0.60 m long, 0.05–0.20 m high, and 0.20–0.40 m deep, with extensive use of chinking stones as small as 0.05 m long and 0.01 m high. Courses of blocks of standard size are interchanged with courses of smaller, more irregular stones. A few of the external voussoirs are schist, but most are marble blocks. They range from 0.30 to 0.40 m long, 0.10–0.15 m wide at the extrados, and 0.20–0.40 m deep. Courses of four to five blocks span the width of the arch. The lime mortar is pale gray-tan with densely packed stone inclusions no larger than 0.01 m.

Description: The north pier of the bridge is preserved to a height of 7.8 m, a width of 1.65 m, and a length of 6.6 m. The original bridge was likely more than 42 m long and 15 m high. The large blocks of the base rest on a rock outcrop. The central arch, which may have originally spanned 9.5 m, springs from a point 3.6 m above the base, and the three lowest courses of voussoirs are recessed 0.15 m from the short (south) side of the pier facing the stream. The other voussoirs are recessed an additional 0.15 m. Above this upper recess, the pier narrows in width by 0.10 m on either side above a course of large facing stones. This lateral ledge extends even to the voussoirs of the arch spanning the stream, with the result that the lowest three courses of the arch are wider than the rest. In contrast, the arch on the north side of the pier has no ledges to support a framework, but a putlog hole just above the springing of the arch fulfills the same purpose.

Major Dimensions:

p. H: 7.8 m
 W (north pier): 1.65 m
 p. L: 6.6 m
 Projected original H: 15 m
 Projected original L: more than 42 m
 Projected original H (conduit above streambed): 13.5 m
 Projected original span (central arch): 9.5 m
 Projected H (arch bottom from streambed): 11.5 m

Photograph Numbers: D2005.0053–0061, D2008.1385–1400

Drawing Numbers: RS 29: Section looking west and section looking north at 1:50 scale

Bridge, Derince Dere, Işıklar Aqueduct (E050) (Fig. 10)

Location: The wall is built into the east (left) bank of the Derince Dere, a tributary of the Morsynus river, 0.7 km north of Aphrodisias, and appears to be the foundation of a pier of an aqueduct bridge.

Elevation: 544 masl

Coordinates: Latitude: 37°43'05.019"N; longitude: 28°43'04.661"E

Preservation: The wall is preserved to a height of 2 m, above which it has been leveled to match the elevation of the stream bank into which it is built.

Construction: The wall is constructed of mortared rubble faced with petit appareil masonry, including fieldstones of quartz, schist, and sandstone varying greatly in size. The lime mortar is tan-gray and has stone inclusions no larger than 0.01 m.

Description: The wall is preserved to a height of 2 m and a width of 0.80 m. The bottom of the wall is anchored by a stone larger than the others used in the wall. A construction trench 0.70 m wide is visible on the south (downstream) side of the wall and contains yellow-tan sandy infill that cuts into the bedded stream deposits of the bank.

Major Dimensions:

p. H: 2 m

Th: 0.80 m

Photograph Numbers: Unknown

Drawing Numbers: None (notebook sketch only)

3. Derince Dere Aqueduct

Channel, İncir Deresi, Derince Dere Aqueduct (E054)

Location: The channel is located along the west (right) bank of the İncir Deresi, a tributary of the Morsynus river, just under 7 km north of Aphrodisias and 2 km north of the modern town of Işıklar.

Elevation: 817 masl

Coordinates:

Pink mortar channel: Latitude: 37°46'10.09"N; longitude: 28°44'32.25"E

North extent of masonry walls in dere: Latitude: 37°46'11.37"N; longitude: 28°44'32.67"E

Preservation: The preserved length of the channel is approximately 280 m. At its northern extremity, the structure seems to disappear into the jumbled stones of the streambed. Its southern traces have been rebuilt to create a modern system described below. In several areas, the wall closer to the streambed has fallen away.

Construction: The channel rests on a substructure of parallel walls, each raving from 0.30 to 0.60 m thick, built of schist slabs bonded with a tan-white lime mortar with densely packed stone inclusions smaller than 0.005 m. The two walls are not bonded together. The channel is 0.33 m wide and is equipped with a bedding of pink mortar 0.02 m thick that covers the floor and the interior walls, which are preserved to a maximum height of 0.03 m.

Description: The masonry walls are built into the stream bank, and the pink mortar is laid directly on top of the walls, which are preserved to a width of 0.60–1.20 m. The interior width of the channel is 0.33 m, and its walls are preserved to a height of 0.03 m. Layered calcium carbonate deposits, 0.01 m thick, cover all preserved surfaces of the pink mortar bedding. In more recent times, a hard, white cement has been applied to the pink mortar channel to form a V-shaped conduit.

Major Dimensions:

Th (masonry substructure): 0.60–1.20 m

p. L (masonry substructure): 280 m

Interior W (channel): 0.33 m

p. H (channel side walls): 0.03 m

Photograph Numbers: Unknown

Drawing Numbers: None (notebook sketch only)

Bridge and Pipeline, Derince Dere, Derince Dere Aqueduct (E055) (Fig. 11)

Location: The remains of the substructure of the bridge are located on the west (right) bank of the Derince Dere, a tributary of the Morsynus river, while the terracotta pipeline is visible across the stream from it. Combined, they form the remains of a bridge situated 1.4 m north of Aphrodisias.

Elevation: 543 masl

Coordinates:

Bridge substructure: Latitude: 37°43'27.20"N; longitude: 28°43'26.00"E

Preservation: The bridge substructure is severely damaged due to its location in active agricultural fields. The upper courses of the structure lie in a jumbled mass directly to the north-east. At least six segments of the terracotta pipeline are visible where erosion of the stream bank has caused the collapse of the trench in which they were laid, and several of these segments are pierced with jagged holes.

Construction: The substructure is constructed of mortared rubble faced with petit appareil masonry of roughly worked fieldstones of widely varying sizes and materials. The terracotta pipeline was laid in a trench along the east (left) stream bank.

Description: The substructure is 1.33 m wide and preserved to a height of 1.8 m and length of 40 m. It approaches the west (right) stream bank from the northwest but turns slightly to the east about 4 m from its eastern endpoint. The terracotta pipe segments are joined with white mortar and are each about 0.5 m in length and 0.15 m in diameter. The pipes have a smooth exterior surface but are gently ribbed inside, and two parallel grooves circumscribe the upstream end of each pipe segment.

Major Dimensions:

p. H (substructure): 1.8 m

p. W (substructure): 1.33 m

p. L (substructure): 40 m

Internal Diam. (pipe) (approximate): 0.15 m

Th (pipe wall) (approximate): 0.03 m

L (pipe segment) (approximate): 0.5 m

Photograph Numbers: D2008.0622–0634

Drawing Numbers: None (notebook sketch only)

4. Kavaklıdere Aqueduct

Conduit, Kavaklıdere, Kavaklıdere Aqueduct (E053) (Fig. 13)

Location: A cross section of the conduit is visible in the west (right) bank of the Kavaklıdere, a tributary of the Morsynus river, almost 5 km west of Aphrodisias.

Elevation: 432 masl

Coordinates: Latitude: 37°42'54.83"N; longitude: 28°40'15.35"E

Preservation: The subterranean conduit is located in a highly erosive sandy escarpment under cultivated fields. The conduit itself is well preserved, but it has been made visible at this point where the waters of the meandering Kavaklıdere likely facilitated its collapse. The original conduit floor appears to have disintegrated, leaving only a sand-rich sediment layer.

Construction: The vaulted conduit is built of mortared rubble masonry in a single layer of fieldstones including schist and quartz and stream stones. The thickness of the walls and vault ranges between 0.20 m and 0.30 m. The stones are between 0.20 m and 0.30 m long, with smaller stones of 0.05–0.10 m interspersed. The masonry is bonded with a blue-gray lime mortar with densely packed and very small stone inclusions about 0.001–0.002 m in size. The floor of the conduit is not constructed of the same rubble masonry;

only a sand-rich sediment layer is preserved with stone inclusions varying in size from 0.01 m to 0.12 m. A packing of mortared rubble was piled on top of the vault, so that the exterior of the conduit appears rectangular in section.

Description: The external dimensions of the conduit are 0.9 m high and 1 m wide. The interior dimensions of the conduit are 0.47–0.50 m wide and 0.77 m high. The conduit is situated about 3 m above the current streambed and 1.8 m below the ground level of the bank. A construction trench above the conduit extends all the way to the current ground level and cuts through multiple layers of stream deposits. The conduit is filled with sediment to a height of about 0.64 m, the same height as the calcareous deposits lining the north interior wall, which are 0.005–0.007 m thick, and includes no stones larger than 0.05 m.

Major Dimensions:

H (total): 0.9 m
W (total): 1 m
Th (side walls and vault): 0.20–0.30 m
Interior H (conduit): 0.77 m
Interior W (conduit): 0.47–0.50 m

Photograph Numbers: D2008.0039–0040

Drawing Numbers: RS 36: Exposed section looking west at 1:50 scale

5. Ören Deresi Aqueduct

Conduit and Shaft, Ören Deresi, Ören Deresi Aqueduct (A029) (Fig. 14)

Location: The conduit and shaft are visible in the west (right) bank of the Ören Deresi, a tributary of the Morsynus river, just over 3 km west of Aphrodisias.

Elevation: 468 masl

Coordinates: Latitude: 37°42'47.16"N; longitude: 28°41'06.18"E

Preservation: The conduit running along the west (right) bank of the Ören Deresi has been exposed where the stream has eroded the earth of the stream bank into which it was originally constructed. The conduit wall along the stream has collapsed, revealing the longitudinal section and cross section of the structure as well as the longitudinal section of a rectangular shaft rising from the vault of the conduit.

Construction: The vault is made of a single layer of fieldstones with rubble packing on the exterior, all bonded with a beige lime mortar with small stone inclusions. On the interior surface of the conduit wall, a very hard mortar with a reddish orange color covers not the stones of the wall but their interstices.

Description: The external dimensions of the conduit are 2.5 m high by 1.2 m wide. In cross section, the interior of the conduit is 0.50 m wide with a 0.30 m wide channel centered in the floor. The channel is 0.90 m in height, and the rest of the conduit rises another 0.90 m above the channel. The conduit side walls are 0.40–0.50 m thick.

An opening in the roof of the vault leads to an inspection shaft that rises vertically from the conduit and is preserved to a height of 0.3 m above the vault. Both the opening in the vault and the shaft itself have interior width dimensions of about 0.9 m parallel to the conduit and 0.5 m perpendicular to the conduit. The well-preserved west wall of the shaft, which is built into the stream bank, is 0.65 m thick. The east walls of the shaft and conduit have collapsed. The shaft walls perpendicular to the conduit have damaged interior surfaces and a preserved thickness of 0.4 m. A single putlog hole, 0.15 m by 0.17 m, is located 1.05 m above the ledge in the interior west wall of the shaft. The conduit is filled with sediment to a height of 1.2 m.

Major Dimensions:

H (total): 2.5 m
W (total): 1.2 m
p. L: 7 m
Th (conduit side walls): 0.40–0.50 m
Interior H (conduit): 1.80 m
Interior W (conduit): 0.50 m (above channel); 0.30 m (within channel)
p. H (shaft): 0.3 m
p. W (shaft): 0.9 m by 0.5 m
Th (west wall of shaft): 0.65 m

Photograph Numbers: D2005.0189–0194

Drawing Numbers: RS 62: Exposed section looking south and exposed longitudinal portion looking west at 1:50 scale

6. Timeles Aqueduct

Bridge, Kepiz Çayı, Timeles Aqueduct (E015) (Fig. 17)

Location: The bridge crosses a small dere that feeds into the Kepiz Çayı, a tributary of the Yenidere Çayı, from the north. It is located 1 km southwest of the modern village of Güzelköy in the Tavas plain, a total distance of 18 km southeast of Aphrodisias.

Elevation: 848 masl (floor of open channel)

Coordinates: Latitude: 37°36'31.40"N; longitude: 28°53'35.20"E

Preservation: Both piers of the bridge remain standing, but only the lower nine courses can be securely identified as part of the original Roman aqueduct bridge. The top courses have been refashioned into an open conduit coated in white waterproofing mortar, perhaps in association with a series of Ottoman mills that used to be in service in the area.

Construction: The bridge is constructed of mortared rubble faced with petit appareil masonry of roughly worked blocks of schist and quartz about 0.20–0.30 m long and 0.15–0.20 m high, leveled with chinking stones and bonded with a beige lime mortar with stone inclusions smaller than 0.02 m.

Description: The bridge survives to a height of 3 m and is 3.20 m wide. The total length of the bridge is about 9 m, and the distance between the piers is 2.7 m. The open conduit is 1.5–1.7 m wide and 0.8 m deep. Additional masonry, possibly for buttressing the bridge, is joined to the downstream (south) side of the piers.

Major Dimensions:

p. H: 3 m
p. W: 3.20 m
p. L: 9 m
Projected original arch span: 2.7 m

Photograph Numbers: D2007.0400–0407

Drawing Numbers: None (notebook sketch only)

Access Tunnels and Conduit, Kepiz Çayı, Timeles Aqueduct (G001, G002, E014, E013, E003) (Fig. 18)

Location: A stretch of conduit and two access tunnels connected to it have been exposed in the north (right) bank of the Kepiz Çayı, a tributary of the Yenidere Çayı, 1.6 km southwest of the modern village of Güzelköy and 18 km southeast of Aphrodisias.

Elevation: 848 masl (conduit floor) (E013)

Coordinates:

East access tunnel (G001): Latitude: 37°36'24.11"N; longitude: 28°53'12.10"E

Conduit (G002): Latitude: 37°36'22.29"N; longitude: 28°53'07.37"E

Conduit (E014): Latitude: 37°36'20.50"N; longitude: 28°53'02.60"E

Conduit floor (E013): Latitude: 37°36'23.40"N; longitude: 28°52'57.60"E

West access tunnel (E003): Latitude: 37°36'18.20"N; longitude: 28°52'58.40"E

Preservation: The recent construction of a road along the north bank of the Kepiz Çayı has revealed and caused damage to sections of the conduit and two access tunnels perpendicular to it. The machinery used to cut vertically into the hillside exposed several longitudinal cross sections of the aqueduct conduit, effectively scraping away its entire southern side wall and the rubble masonry supporting it, as well as, in some areas, the blocks that formed the interior northern side wall of the conduit, revealing the mortared rubble packing that was built around both the conduit floor and the northern side wall (G002, E014, E013). In addition, the two horizontal access tunnels visible along the road cut were likely shortened in length as a result of the construction, and the western tunnel (E003) has suffered soil infill due to erosion so that it cannot be entered. The two tunnels are located about 350 m apart, but only the eastern tunnel (G001) can be entered.

Construction: The tunnels are carved out of sandy conglomerate rock. The subterranean conduit is a vaulted masonry structure built of regular blocks of the same sandy conglomerate rock, bonded with white lime mortar with densely packed stone inclusions. The blocks are 0.30–0.40 m long and 0.20 m high. The side walls and floor of the conduit are surrounded by mortared rubble packing, 0.7 m thick along the northern side wall and 0.2 m thick below the floor.

Description: The eastern tunnel (G001) is 0.8–1 m high and 0.7 m wide at the floor and 0.4 m wide at the ceiling. It can be followed for almost 11 m, at which point it connects directly to the subterranean masonry conduit. The interior of the conduit is about 1.7 m wide and 1.7 m high. Putlog holes line the interior of the conduit at a height of five courses, or just under 1 m, above the current floor level. It can be followed 27 m to the east and 8.4 m to the west, after which the modern road cut has damaged the remains. From this point headed west, a longitudinal section of the conduit is visible for about 270 m (G002, E013, E014).

Major Dimensions:

- p. H (east access tunnel) (G001): 0.8–1 m
- W (east access tunnel) (G001): 0.7 m (floor); 0.4 m (ceiling)
- p. L (east access tunnel) (G001): 11 m
- p. internal H (conduit) (G001): 1.7 m
- Internal W (conduit) (G001): 1.7 m
- p. L (conduit) (G001): 35.4 m
- p. L (exposed conduit) (G002) (approximate): 270 m

Photograph Numbers: D2007.0377 (E003); D2007.1012 (E012, E013); D2007.0378–0382 (E013); D2007.0383–0399, 0408–0409 (E014)

Drawing Numbers: None (notebook sketch only)

Bridge, Conduit, and Tunnel, Cığlek Deresi, Timeles Aqueduct (E034, E035) (Figs. 20–24)

Location: The bridge, conduit, and tunnel are located on a small gully branching off the east side of the Cığlek Deresi, a dry dere that runs north–south and connects to the Kepiz Çayı to the south. The Cığlek Deresi forms the western limit of the Yahşiler plateau. The remains are located 4 km southwest of the modern village of Yahşiler, 2 km southeast of the modern village of Yeşilköy, and 16 km southeast of Aphrodisias.

Elevation: 849.8 masl (conduit floor, E035); 851.3 masl (tunnel, E035)

Coordinates:

Conduit floor (E035): Latitude: 37°36'32.207"N; longitude: 28°51'40.653"E

Tunnel (E035): Latitude: 37°36'32.207"N; longitude: 28°51'40.653"E

Preservation: The bridge that crossed the small gully north of the conduit no longer stands (E034), but a cross section of the foundation, floor, and lower portion of the side walls of the conduit itself is preserved in the south hillside of the gully (E035). The entire conduit is preserved inside the subterranean tunnel for 22 m, at which point the vault has collapsed. A short segment of conduit is preserved after this collapse, but a second collapse seals it off completely.

Construction: Nothing can be said about the construction of the bridge that no longer stands (though see the projected original dimensions below). The conduit is a vaulted masonry structure built of regular blocks of the local sandy conglomerate rock, bonded with pink-beige lime mortar with densely packed stone inclusions smaller than 0.01 m. The blocks are 0.10–0.40 m long, 0.16–0.20 m high, and 0.15–0.20 deep. Mortared rubble packing supports the exterior of the side walls and vault.

The conduit floor also rests on a foundation of mortared rubble of smaller stones that is 0.30–0.35 m thick. The foundation is topped by a bedding of white-gray lime mortar with densely packed stone inclusions smaller than 0.01 m. The mortar bedding is 0.25 m thick under the center of the conduit floor but tapers to a thickness of 0.10 m about 0.20–0.35 m from both edges of the floor. On top of this bedding is a very thin layer, 0.001 m thick, of pink waterproofing mortar. On top of the pink waterproofing mortar is a layer of sinter, 0.05 m thick.

Description: The bridge must have originally been 5.5 m high, 3.8 m wide, and 8.0 m long. The interior of the conduit is 1.50 m wide and has a reconstructed height of 2.25 m. Where the side walls are visible, they are 1.15 m wide (east) and 1.18 m wide (west). The portion of the conduit that has collapsed is 6.7 m long.

The preserved conduit within the hillside, which includes a 125° bend, can be divided into three segments according to differences in masonry. The first segment (as one enters the conduit from the north) is 8 m long on the outer side wall (west) of the bend and 7 m long on the inner (east) side wall, which is executed more sharply than the gently curving outer side wall. In this segment the vault is built of rubble masonry bonded with beige-pink lime mortar with small, loosely packed stone inclusions. A seam separates the rubble-vault segment from the next segment, which is 8.8 m long and has a vault built of the same regular blocks as the side walls. The third segment has a vault of regular blocks, a portion of which has been rebuilt in rubble masonry with white-blue lime mortar with large, densely packed stone inclusions, most between 0.005 m and 0.012 m. The stones of the rebuilt portion are placed lengthwise across the width of the conduit and have a level profile, making it not a true vault at all.

The putlog holes of the conduit are located at different heights within the three segments. They are located one course lower in the regular-vault segment than in the other two segments. The putlog holes of the rubble-vault segment are set at intervals ranging from 0.35 m to 1.40 m in no clear pattern and are matched only roughly in pairs across the conduit. The putlog holes are set at shorter intervals at the inner part of the conduit curve. In the regular-vault segment, the putlog holes are set at intervals ranging between 0.40 m and 2.90 m, and are not matched across the conduit due to the bend. In the “false”-vault segment, the putlog holes are matched in pairs across the conduit, but those on the north-east side wall are located about 0.14 m below those on the opposite side wall.

Major Dimensions:

Projected original H (bridge) (E034): 5.5 m
 Projected original W (bridge) (E034): 3.8 m
 Projected original L (bridge) (E034): 8 m
 Projected original internal H (conduit): 2.25 m
 Internal W (conduit): 1.50 m
 p. L (conduit): 6.7 m (exposed) and 22 m (subterranean)
 Th (side walls): 1.15 m (east) and 1.18 m (west)

Photograph Numbers:

D2008.0350–0354, 0363–0364, 1317–1337 (E034)
 D2008.0363–0364, 0728–0731, 1317–1337 (E035)

Drawing Numbers:

RS 32: Section looking west (E033) and combined section looking north to east (E033, E034, E035) at 1:50 scale
 RS 33: Plan of structures in Cığlek Deresi with contours (E033, E034, E035) at 1:250 scale
 RS 34: Exposed section looking south and longitudinal section looking west (E035) at 1:50 scale

Bridge, Cığlek Deresi, Timeles Aqueduct (E033) (Figs. 20–22)

Location: The remains of the bridge are located on both sides of the Cığlek Deresi, a dry dere that runs north–south and connects to the Kepiz Çayı to the south. The Cığlek Deresi forms the western limit of the Yahşiler plateau. The remains are located 4 km southwest of the modern village of Yahşiler, 2 km southeast of the modern village of Yeşilköy, and 16 km southeast of Aphrodisias.

Elevation: 848.1 masl (west pier preserved height)

Coordinates: Latitude: 37°36'33.276"N; longitude: 28°51'38.755"E

Preservation: The arch of the bridge has collapsed, leaving two piers standing on either side of the Cığlek Deresi. The upper portions of the bridge have fallen as well, and the upstream (north) side of the piers is more heavily damaged than the downstream side, leaving a scatter of mortared rubble on the ground below. The west pier is better preserved than the east, which has preserved facing blocks mostly on the south side and only a few facing blocks in situ on its west and north faces. No clear trace of conduit remains, but its elevation can be reconstructed using the conduit section exposed nearby (E034, E035).

Construction: The bridge is constructed of mortared rubble faced with petit appareil masonry. The facing blocks are carved from sandy conglomerate rock, fieldstones of quartz, and low-grade, gray-blue marble, all leveled with small chinking stones. The facing blocks are 0.15–0.60 m long and 0.15–0.30 m high. The blocks and rubble core are bonded with pink-beige lime mortar with stone inclusions smaller than 0.01 m. The blocks of the leveling course are 0.60–0.80 m long and 0.25–0.30 m high and are carved exclusively of low-grade, gray-blue marble.

Description: The Roman bridge is preserved to a height of 9 m, a width of 5.2 m, and a length of 42 m. The base of the west pier is 5.2 m wide and is founded on an outcrop of sandy conglomerate rock. Approximately 18 courses up (3.6 m) from the base of the west pier is a leveling course. The arch originally spanned approximately 6.2 m to cross the dere.

Major Dimensions:

p. H: 9 m
 W (west pier): 5.2 m
 p. L: 42 m
 Projected original H: 13.7 m
 Projected original H (conduit above streambed): 11.5 m
 Projected arch span: 6.2 m
 H (west pier base to bottom of leveling course): 3.6 m

Photograph Numbers:

D2008.0355–0358, 0363–0364, 1317–1337

Drawing Numbers:

RS 32: Section looking west (E033) and combined section looking north to east (E033, E034, E035) at 1:50 scale
 RS 33: Plan of structures in Cığlek Deresi with contours (E033, E034, E035) at 1:250 scale

Bridge, Harami Deresi, Timeles Aqueduct (E008) (Fig. 25)

Location: The remains of the bridge are located on both banks of the steep Harami Deresi, one of the many small tributaries of the Yenidere Çayı. The remains are located just under 1 km southeast of the modern village of Yeşilköy and 15.5 km southeast of Aphrodisias.

Elevation: 844.8 masl (p. H of north pier)

Coordinates: Latitude: 37°36'47.548"N; longitude: 28°51'02.316"E

Preservation: While nothing remains of the bridge on the north (right) bank of the gorge except weathered mortared rubble and scattered facing blocks, the remains on the south (left) bank are better preserved. These include a portion of the arch of the lower tier of the bridge, remains of the upper tier and buttress, and traces of the conduit. The downstream (west) side of the bridge is better preserved than the upstream side. Fallen voussoirs and large masses of masonry litter the streambed below.

Construction: The bridge is constructed of mortared rubble faced with petit appareil masonry. The facing blocks and the upper voussoirs of the arch are fashioned from sandy conglomerate rock, while the lower voussoirs are carved from marble. The facing blocks are approximately 0.5 m long and 0.3 m high, while the voussoirs are 0.50 m long, 0.30 m wide, and 0.40–1 m deep.

Three types of mortar are visible. Ubiquitous is a white lime mortar with stone inclusions no larger than 0.005 m. Also visible around the crumbling mass of the upper north pier is a light gray lime mortar with larger stone inclusions up to 0.01 m in size. A third type of lime mortar can be found on the buttressed middle mass on the south bank; it has a very loose, pinkish tan matrix with stone inclusions as large as 0.02 m.

Description: The remains of the bridge suggest that it was originally two-tiered, with a lower arch spanning 13 m and supporting possibly four arches above, each spanning 5.7 m, topped by the conduit. The bridge is preserved to a height of 17 m, a width of 3 m, and a length of 65 m. Traces of the conduit indicate that it was originally 65 m long and 27 m high.

The single arch of the lower tier springs from the bedrock of the steep south (left) bank of the gorge at a height of 10 m above the bottom of the gorge. The tier is preserved to a height of 5.5 m. The arch is constructed of two layers of voussoirs. The fallen marble blocks used as voussoirs are variously dressed with anathyrosis, clamp cuttings, lifting bosses, and moldings. The second tier of the bridge begins approximately 4.5 m above the remains of the lower tier. A buttressing structure joins the downstream (west) side of the second tier in a clear seam. Approximately 1 m above the upper tier, the side walls of the conduit are visible.

Major Dimensions:

p. H: 17 m
 p. W (south lower pier): 3 m
 p. L: 65 m
 Projected original H: 27 m
 Projected original L: 65 m

Projected original H (conduit above streambed): 24.5 m
 Projected original arch span: 13 m (lower tier); 5.7 m (upper tier)

W (conduit): 1.50 m

p. H (south lower pier): 5.5 m

p. H (south upper pier): 4 m

p. L (south upper pier): 5 m

Distance (H) between south tower pier and upper pier: 4.5 m

Distance (H) between south upper pier remains and conduit bottom: 1 m

p. W (south pier buttress): 1.5 m

Photograph Numbers: D2007.0460–0469

Drawing Numbers: RS 24: Section looking east and section looking south at 1:50 scale

Bridge, Kırkım Deresi, Timeles Aqueduct (E005) (Figs. 26, 27)

Location: The bridge is located on the Kırkım Deresi, one of the many small tributaries of the Yenidere Çayı. The remains are located 0.7 km southeast of the modern village of Yeşilköy and 15.2 km southeast of Aphrodisias.

Elevation: 845.8 masl (p. H of bridge), 846.6 masl (conduit)

Coordinates: Latitude: 37°36'49.862"N; longitude: 28°50'55.298"E

Preservation: The arch of the bridge is preserved intact and can still be crossed on foot. Facing blocks and voussoirs remain in place on the downstream (south) side of the bridge, which is much better preserved than the upstream side. A section of the vaulted conduit and tunnel, in which pickmarks are visible, is preserved in the west (right) bank.

Construction: The bridge is constructed of mortared rubble faced with petit appareil masonry. The facing blocks, carved from sandy conglomerate rock, are 0.30–0.50 m long, 0.20 m high, 0.30–0.40 m deep, and are laid out in courses interchanged with courses of small stones that help to level each course. The lime mortar is a white with small stone inclusions, most no larger than 0.05 m.

The lower projecting course of the west pier is constructed of worked marble blocks 1 m long, 0.20 m high, and at least 0.4 deep. The worked marble blocks of the upper projecting course of the west pier are taller (about 0.5 m) but not as long (about 0.5 m), and are not of uniform size or shape as are those of the lower course. The lower voussoirs include blocks 0.30–0.50 m long and approximately 0.20 m wide at the extrados. The upper voussoirs are larger, 0.40–0.70 m long and about 0.30 m wide at the extrados.

Description: The bridge is preserved to a height of 13.3 m, a width of 4.3 m, and a length of 36 m. Both piers are founded on rock outcrops, and the base of the east pier sits 3.7 m above the base of the west pier, which is constructed of marble blocks several times larger than the other facing blocks.

Two projecting courses run through the west pier, while the one projecting course of the east pier sits about 0.15 m lower in elevation than the upper projecting course on the west pier. These courses project approximately 0.10–0.15 m from all faces of the pier. The lower projecting course of the west pier sits 2.6 m above the base of the structure, and the upper sits 3.2 m above the bottom of the lower course. The arch is constructed of two layers of voussoirs and spans 9.8 m.

Major Dimensions:

p. H: 13.3 m

W (west pier): 4.3 m

p. L: 36 m

Projected original H: 19 m

Projected original L: 42 m

Projected original H (conduit above streambed): 16.7 m

p. arch span: 9.8 m

p. W (conduit): 1.2 m

H (arch bottom from streambed): 14.8 m

Photograph Numbers: D2007.0410–0429, D2008.1338–1352

Drawing Numbers: RS 25: Section looking west and section looking north at 1:50 scale

Bridge, Dere Feeding into the Kırkım Deresi from the West, Timeles Aqueduct (E007)

Location: The bridge is located on a shallow dere feeding into the Kırkım Deresi from the west, one of the many small tributaries of the Yenidere Çayı. The remains are located 0.7 km southeast of the modern village of Yeşilköy and 15.2 km southeast of Aphrodisias.

Elevation: 846 masl (conduit)

Coordinates: Latitude: 37°36'48.402"N; longitude: 28°50'51.975"E

Preservation: Only the large footing blocks and weathered mortared rubble core remain of the bridge. Traces of the conduit are visible as depressions in the earth on both sides of the bridge.

Construction: The bridge is constructed of mortared rubble faced with petit appareil masonry. The facing blocks are carved from sandy conglomerate rock, as are the footing blocks, which range in size from 0.60 to 2.03 m long and 0.60–0.70 m high. The masonry is bonded with white lime mortar with stone inclusions, most smaller than 0.05 m.

Description: The east pier of the bridge is 4.4 m wide with a maximum preserved height of 6 m. The approximate width of the conduit is 1.5 m, though no clear side walls are visible to provide an accurate measurement.

Major Dimensions:

p. H (approximate): 6 m

W (east pier): 4.4 m

p. L (approximate): 15 m

Projected original H (approximate): 8 m

Projected original L (approximate): 15 m

Projected original H (conduit above streambed) (approximate): 6 m

Photograph Numbers: D2007.0448–0457

Drawing Numbers: Drawing not inked (section looking south and section looking east at 1:50 scale)

Tunnel and Conduit, Dere Feeding into the Harami Deresi from the West, Timeles Aqueduct (E006) (Figs. 28, 29)

Location: The entrance to the tunnel and conduit is located on the northeast bank of a dry dere feeding into the Harami Deresi from the west, one of the many small tributaries of the Yenidere Çayı. The remains are located 0.8 km southeast of the modern village of Yeşilköy and 15.2 km southeast of Aphrodisias.

Elevation: 846.8 masl (southwest entry point), 850 masl (northeast limit at conduit vault near E007 bridge)

Coordinates:

Southwest entry point: Latitude: 37°36'43.391"N; longitude: 28°50'45.947"E

Northeast limit at conduit vault near E007 bridge: Latitude: 37°36'47.966"N; longitude: 28°50'51.704"E

Preservation: The tunnel and conduit are preserved to a length of more than 150 m within a hillside between two bridges. They can be entered from the downstream side of the aqueduct, within the northeast bank of a shallow, dry dere. Along the first few meters of the tunnel within the entry point, the conduit has collapsed.

Construction: The conduit is a vaulted masonry structure built of regular blocks of the local sandy conglomerate rock. The

conduit blocks are 0.30–0.40 m long and 0.20 m high. The smaller blocks of the leveling course at the spring point of the vault are 0.30 m long and 0.13 m high. The lime mortar is beige-pink with densely packed stone inclusions smaller than 0.01 m.

Description: The interior of the conduit is 1.44 m wide and at least 1.9 m high. At 86 m from the entry point, the direction of the tunnel bends slightly to the north, and approximately 5 m later returns to its original orientation. Regular putlog holes in the segment downstream from the bend are placed at alternating intervals of 0.35 m and 1.40 m, while those in the segment upstream from the bend have intervals of 0.75 m and 1.30 m.

The tunnel is preserved to a height of 2.55 m and a width of 2.3 m. The space between the vaulted conduit and the tunnel, excavated from the rock with a head-and-shoulders profile, is filled with mud and rubble packing.

Major Dimensions:

- p. internal H (conduit): 1.9 m
- p. internal W (conduit): 1.44 m
- p. L (conduit): 150 m
- p. H (tunnel): 2.55 m
- p. W (tunnel): 2.3 m

Photograph Numbers: D2007.0435–0445, D2008.1353–1368

Drawing Numbers: RS 35: Section looking northeast at 1:50 scale

Shaft, Dere Feeding into the Harami Deresi from the West, Timeles Aqueduct (E051)

Location: The shaft is located on the northeast bank of a dry dere feeding into the Harami Deresi from the west, one of the many small tributaries of the Yenidere Çayı. The remains are located 0.9 km south of the modern village of Yeşilköy and 15.1 km southeast of Aphrodisias.

Elevation: 875.1 masl

Coordinates: Latitude: 37°36'38.704"N; longitude: 28°50'36.296"E

Preservation: The interior faces of two walls of the masonry shaft are visible in the northeast bank of a dry dere.

Construction: The shaft is built of mortared, roughly worked fieldstones.

Description: The shaft is 1.25 m by 1.30 m in internal dimension and is constructed of fieldstones of widely varying shape and size, about 0.20–0.50 m long and 0.05–0.30 m high. It is preserved to a depth of 2 m. The stones are bonded with white lime mortar with small stone inclusions. The shaft may have originally been at least 25 m deep.

Major Dimensions:

- p. H (D): 2 m
- Internal W: 1.25 m by 1.30 m
- Projected original D: 25 m

Photograph Numbers: Unknown

Drawing Numbers: None

Bridge, Soğanlık Deresi, Timeles Aqueduct (E026) (Fig. 30)

Location: The bridge is located on the Soğanlık Deresi, one of the many small tributaries of the Yenidere Çayı. The remains are located 1.2 km southwest of the modern village of Yeşilköy and 14.7 km southeast of Aphrodisias.

Elevation: 843.1 masl (conduit vault)

Coordinates: Latitude: 37°36'33.628"N; longitude: 28°50'08.142" E

Preservation: The arch of the bridge remains intact, but the upstream (northeast) side of the bridge is so heavily damaged that most of it is preserved to half its original width. The bridge is encrusted with massive calcium carbonate deposits

that almost completely obscure its southwest side. Traces of the conduit are visible on both sides of the bridge.

Construction: The bridge is constructed of mortared rubble faced with petit appareil masonry. The facing blocks are carved from the local low-grade, blue-gray marble and fieldstones such as schist. They are 0.30–0.40 m long, 0.20 high, and 0.20–0.30 deep and are interspersed with smaller chinking stones, all bonded with a pinkish tan lime mortar with stone inclusions, most less than 0.01 m. The voussoirs of the arch are carved from the blue-gray marble and are 0.30 m long, 0.12–0.14 m wide at the extrados, and 0.20–0.35 m deep.

Description: The bridge is preserved to a height of 5.5 m, a width of 3 m, and a length of 20 m. The interior of the conduit is 1.50 m wide and has side walls 1.2 m thick, indicating that the bridge was originally 3.9 m wide. The arch, which springs from the bedrock forming the banks of the dere, is constructed of two layers of voussoirs and spans 4 m.

Major Dimensions:

- p. H: 5.5 m
- p. W: 3 m
- p. L: 20 m
- p. original H: 7 m
- p. original W: 3.9 m
- p. original L: 20 m
- p. original H (conduit above streambed): 5.8 m
- Arch span: 4 m
- Internal W (conduit): 1.50 m
- Th (side walls): 1.2 m
- H (bottom of arch to streambed): 4.5 m

Photograph Numbers: D2007.0692–0703 = D2007.0968–0979

Drawing Numbers: RS 26: Section looking north and section looking east at 1:50 scale

Bridge, Şaban Deresi, Timeles Aqueduct (C048) (Figs. 31, 32)

Location: The bridge is located on the Şaban Deresi, a wide dere feeding into the İnce Dere, a tributary of the Yenidere Çayı. The remains are situated 2.3 km east of the modern village of Denizoluk and 14.4 km southeast of Aphrodisias.

Elevation: 846.2 masl (conduit)

Coordinates: Latitude: 37°36'35.057"N; longitude: 28°49'48.864"E

Preservation: The two piers of the bridge remain standing on either side of the dere. The arch has collapsed, and large masses of mortared rubble sit in the streambed. Facing blocks remain in place only on the downstream (south) side of the bridge, which is much better preserved than the upstream side.

Construction: The bridge is constructed of mortared rubble faced with petit appareil masonry. The facing blocks include various fieldstones such as schist, 0.20–0.50 m long, 0.15–0.20 m high, and 0.20–0.50 m deep, and leveled with chinking stones. The white lime-based mortar has densely packed stone inclusions that vary greatly in size, with most less than 0.02 m. The masonry is noticeably different from that of the other bridges, both in the regularity and level placement of the facing blocks and in the pointing of the joints.

Description: The bridge is preserved to a height of 13 m, a width of 6.7 m, and a length of 50 m. Based on the visible remains of the conduit, the bridge was originally 20 m high. The west pier is founded on an outcrop of peridotite. A spring or leveling course, with blocks similar to the facing blocks, projects slightly from the south face at a height of 2.5 m above the ground on the west pier and 6 m above the ground on the east pier.

The bridge is a composite structure. The original structure carried the conduit across the gorge. The conduit is 1.50

m wide internally and has one preserved (south) side wall 1.10 m wide. Assuming that the other side wall was also 1.10 m wide, the total width of the original bridge was 3.70 m. A separate mortared rubble structure 3.20 m wide abuts on the south face of the original bridge. Only the south face of this structure is faced with petit appareil masonry, and its mortared rubble core is laid directly up against the south side of the original bridge. It is likely a buttress. The distance between the damaged piers is 14.5 m, and the arch has been reconstructed with a span of approximately 12 m.

Major Dimensions:

p. H: 13 m
 p. W: 6.7 m (west pier and buttress); 3.7 m (east pier)
 p. L: 50 m
 Projected original H: 20 m
 Projected original L: more than 50 m
 Projected original H (conduit above streambed): 18 m
 Projected original arch span: 12 m
 p. W (conduit): 1.50 m
 p. Th (side walls): 1.10 m (south); 0.9 m (north)
 Projected original W (west pier): 3.70 m
 W (west pier buttress): 3.20 m
 Preserved distance between piers: 14.5 m

Photograph Numbers: D2007.0147–0149, D2007.0472, D2008.1369–1371

Drawing Numbers: RS 27: Section looking west and section looking north at 1:50 scale

Shaft, İnce Dere, Timeles Aqueduct (C049) (Figs. 33, 34)

Location: The shaft is located on the north (right) bank of the İnce Dere, a tributary of the Yenidere Çayı. It is situated 1.8 km east of the modern village of Denizoluk and 14.1 km southeast of Aphrodisias.

Elevation: 847.5 masl (shaft vault)

Coordinates: Latitude: 37°36'36.115"N; longitude: 28°49'32.335"E

Preservation: The barrel vault of the vertical shaft has collapsed, along with the upper courses of the west, east, and south walls of the structure. Only the north wall, along with a portion of the vault, are built into the hillside and are therefore well preserved. The aqueduct conduit and horizontal access conduit have been incorporated into a modern pumping system, so they too are well preserved. Most of the barrel-vaulted structure attached to the southern end of the access conduit has been destroyed, so that only a little more than 1 m of it stands. Only the highest voussoirs of the vault of the aqueduct conduit are visible, because the conduit is full of water, mud, and debris.

Construction: The vertical shaft is built of roughly worked, mortared fieldstones and is topped by a barrel vault. The stones of the shaft are 0.20–0.30 m long, 0.10–0.15 m high, 0.20–0.30 m deep. The horizontal access conduit is barrel-vaulted and built of mortared masonry, with regularly shaped, rectangular blocks 0.20–0.30 m on a side.

Description: The vertical shaft is 1.45 m by 1.45 m internally, and the vertical walls are 0.90–1 m thick. The depth of the shaft, from the vault to the top of the conduit below, is approximately 6.3 m. It is topped by a barrel vault oriented perpendicular to the streambed and to the aqueduct conduit underground. The bottom of the shaft at its point of intersection with the conduit is accessible via a horizontal access conduit, which emerges from the north (left) bank of the stream. The access conduit runs perpendicular to the aqueduct conduit. The floor of the access conduit lies approximately 0.1 m lower than the top of the vault of the aqueduct conduit.

The access conduit intersects with the vertical shaft about 5 m down from the top of the shaft. The conduit is 2.3 m long, 1.45 m wide, and about 1.25 m high. A pair of putlog holes under the springing of the vault is located 0.2 m from where the conduit meets the shaft. A barrel-vaulted masonry structure has been attached to the southern end of the access conduit. A vertical wall approximately 1 m high and built of stones with their long sides placed vertically, rather than horizontally as seen on the inspection shaft, connects the two barrel vaults. This barrel-vaulted structure is more than 1 m long and approximately 1.2 m wide.

Major Dimensions:

p. H (D) (exterior shaft): 6.3 m
 p. W (exterior shaft): 3.5 m
 W (interior shaft): 1.45 m by 1.45 m
 Projected original D (floor of conduit): 9 m
 p. H (access conduit) (approximate): 1.25 m
 W (access conduit) (approximate): 1.45 m
 p. L (access conduit) (approximate): 2 m

Photograph Numbers: D2008.1372–1384

Drawing Numbers: RS 37: Elevation looking north and schematic section looking east at 1:50 scale

Shaft, İnce Dere, Timeles Aqueduct (C044) (Fig. 35)

Location: The shaft is located above the north (right) bank of the İnce Dere, a tributary of the Yenidere Çayı. It is situated 1.2 km northeast of the modern village of Denizoluk and 13.3 km southeast of Aphrodisias.

Elevation: 887 masl

Coordinates: Latitude: 37°36'48.376"N; longitude: 28°48'58.528"E

Preservation: The shaft is currently only 13.3 m deep, but it originally extended down 50 m to the aqueduct conduit underground. Only a few courses of masonry are preserved lining one side of the top of the shaft. The rock above the tunnel system connected to the shaft has collapsed.

Construction: The shaft is cut through rock. The top of one side is lined with mortared petit appareil masonry built where loose earth sits on top of the bedrock. The system of horizontal tunnels, all dug from the rock, connects to the shaft.

Description: The shaft, filled in with eroded earth and rock, is currently only 13.3 m deep. For most of its preserved depth, the shaft is 2.2 m by 2.6 m wide. About 1 m above the current bottom of the shaft, the walls are undercut irregularly on three sides and have pickmarks that match those higher up on the walls.

A tunnel connecting the shaft to the sloping ground surface of the surrounding stream bank is 2.5 m high, 1.3 m wide, and preserved to 5 m long. Close to where it meets the shaft, the tunnel is equipped with three pairs of roughly square cuttings, each across from its mate, arranged vertically. The lowest pair seems to have originally included two cuttings on each side. Directly under the tunnel, the southern wall of the shaft is recessed 0.4 m. Another cutting is visible near the top of the tunnel on its east wall.

An additional tunnel runs deep into the hillside and splits into numerous dendritic and serpentine branches, which are approximately 0.75 m wide, varying in height from about 0.8 to 1.5 m.

Major Dimensions:

p. H (D): 13.3 m
 p. internal W: 2.2 m by 2.6 m
 Projected original H (D): 50 m
 p. H (tunnel): 2.5 m
 p. W (tunnel): 1.3 m
 p. L (tunnel): 5 m

Photograph Numbers: Unknown

Drawing Numbers: Schematic section looking west at 1:100 scale

Tunnel, Denizoluk/Kayapınar, Tímeles Aqueduct (?) (E028)

Location: The tunnel is located within the side of one of the low hills that form the ridge separating Denizoluk and Kayapınar. It is situated 0.6 km north of the modern village of Denizoluk, 1.7 km southeast of the modern village of Kayapınar, and 12.6 km southeast of Aphrodisias.

Elevation: 923.65 masl (?)

Coordinates: Latitude: 37°36'48.449"N; longitude: 28°48'10.813"E

Preservation: The tunnel is preserved to a length of 5.5 m within the hillside. It can be entered through a hole created by the collapse of its ceiling.

Construction: The tunnel is cut through the rock of the hillside with a head-and-shoulders profile.

Description: The tunnel follows the contours of the hillside into which it was dug. It is preserved to a length of 5.5 m, a height of 0.65 m, and a width of 0.85 m at its floor. The profile narrows to 0.4 m and then 0.2 m wide at the ceiling.

Major Dimensions:

p. H: 0.65 m

p. W: 0.85 m (base); 0.4 m (middle); 0.2 m (top)

p. L: 5.5 m

Photograph Numbers: Unknown

Drawing Numbers: None (notebook sketch only)

Tunnel, Kocadere, Tímeles Aqueduct (E009) (Fig. 36)

Location: The tunnel is located on the west (left) bank of the Kocadere, a tributary of the Morsynus river. It is situated 0.7 km north of the modern village of Kayapınar, and 11 km southeast of Aphrodisias.

Elevation: 835.39 masl

Coordinates: Latitude: 37°37'22.288"N; longitude: 28°47'06.962"E

Preservation: Only the floor and west surface of the tunnel are preserved in the bedrock forming the west (right) bank of the Kocadere.

Construction: The tunnel is carved from the bedrock of the stream bank.

Description: The tunnel is preserved to a height of approximately 1.5 m, a width of approximately 0.5 m, and a length of approximately 2 m. Pickmarks are visible on the vertical, west surface of the tunnel.

Major Dimensions:

p. H (approximate): 1.5 m

p. W (approximate): 0.5 m

p. L (approximate): 2 m

Photograph Numbers: Unknown

Drawing Numbers: None

Conduit, Kocadere (Gökgölet Deresi), Tímeles Aqueduct (?) (E031) (Fig. 37)

Location: The conduit is located on the west (left) bank of the Kocadere (also called the Gökgölet Deresi in this location), a tributary of the Morsynus river. It is situated 4.2 km south of the modern town of Ataeymir and 5.6 km southeast of Aphrodisias.

Elevation: 601.713 masl

Coordinates: Latitude: 37°40'09.231"N; longitude: 28°45'49.578"E

Preservation: The conduit is visible where the west (left) bank of the dere has eroded, leaving the conduit exposed. A portion of the conduit has collapsed so that a cross section is visible.

Construction: The conduit is constructed of mortared rubble

masonry. It is built of unworked fieldstones of varying sizes and has a flat roof.

Description: The conduit is approximately 1 m high and 0.7 m wide internally, with side walls approximately 0.2 m thick. It is situated several meters above the modern streambed and below the ground level above and is preserved to an approximate length of 10 m.

Major Dimensions:

Interior H (approximate): 1 m

Interior W (approximate): 0.5 m

Th (side walls) (approximate): 0.2 m

p. L (approximate): 10 m

Photograph Numbers: Unknown

Drawing Numbers: None

Bridge, Gümüş (Korkor) Deresi, Tímeles Aqueduct (E058)

(Fig. 38)

Location: The remains of the bridge are located on the north bank of Gümüş (Korkor) Deresi, a tributary of the Morsynus river. The bridge is located 2 km southwest of the modern village of Seki, 2.8 km southeast of the modern town of Ataeymir, and 6.3 km southeast of Aphrodisias.

Elevation: 626 masl

Coordinates: Latitude: 37°41'13.30"N; longitude: 28°47'27.10"E

Preservation: Only one pier of the bridge remains standing, located on the north bank of the dere. In contrast to the other bridges, this one is better preserved on its upstream (east) side. The length of the pier has been cut in two to accommodate a dirt road parallel with the stream. Nothing remains of the conduit.

Construction: The bridge is constructed of mortared rubble faced with petit appareil masonry. The rounded fieldstones that comprise the structure are not as internally consistent in shape and size as those of the other bridges along the aqueduct, and many of the facing blocks are larger than those of the other bridges. One large facing block preserved on the south side of the pier facing the dere is 0.60 m long, 0.25 m high, and 0.50 m deep. The lime mortar is gray with densely packed stone inclusions smaller than 0.02 m.

Description: The pier is preserved to a height of 4.8 m, a width of 3.5 m, and a length of 12 m. The pier rests on a rock outcrop forming the bank of the dere. The pier extends to the north into agricultural fields, where it is no longer traceable.

Major Dimensions:

p. H (north pier): 4.8 m

p. W (north pier): 3.5 m

p. L (north pier): 12 m

Photograph Numbers: D2008.1769–1774

Drawing Numbers: None (notebook sketch only)

Bridge, Seki Deresi, Tímeles Aqueduct (E059) (Fig. 39)

Location: The remains of the bridge are located on the north bank of Seki Deresi, a tributary of the Morsynus river. The bridge is located 2.1 km southwest of the modern village of Seki, 2.5 km southeast of the modern town of Ataeymir, and 6 km southeast of Aphrodisias.

Elevation: 617 masl (streambed)

Coordinates: Latitude: 37°41'19.40"N; longitude: 28°47'14.10"E

Preservation: The lower courses of both sides of the arch are well preserved, but the upper portions of the arch and both piers have been cut down to serve as a substructure to support a modern concrete irrigation channel. The upstream (north) side has suffered more damage than the downstream side. Nothing remains of the conduit.

Construction: The bridge is constructed of mortared rubble faced with petit appareil masonry. The facing blocks are 0.15–0.60

m long and 0.15–0.30 m high, and most are worked from locally available materials such as sandstone, quartz, and, occasionally, marble. The voussoirs include both fieldstones and marble blocks, which range in size from 0.30 to 0.60 m long, 0.10 to 0.25 m wide, and 0.20 to 0.60 m deep.

Description: The bridge is preserved to a height of 3.5 m, a width of 5.2 m, and a length of 50 m. Both piers are founded on the bedrock forming the banks of the dere. At its east and west extremities, the structure is buried under agricultural fields. The west pier alone extends 34 m from the streambed before disappearing into the ground. At about 10 m from the streambed, the west pier is pierced by a drainage conduit included as part of the original structure. The arch, which has only a single layer of voussoirs, spans 5.8 m.

Three levels of voussoirs up from the bottom of the arch, putlog holes punctuate the south face of each pier, about 0.20 m back from the curved sides of the arch facing each other across the stream. Two stacked levels of putlog holes spaced erratically are visible along the entire south face of the west pier.

Major Dimensions:

p. H (east pier): 3.5 m

W: 5.2 m

p. L: 50 m

Projected original H: 11 m

Projected original L: more than 50 m

Projected original H (conduit above streambed): 9 m

p. arch span: 5.8 m

Photograph Numbers: D2008.1775–1784

Drawing Numbers: RS 39: Section looking north and section looking east at 1:50 scale

7. Ottoman Cisterns

Cistern, Between Aphrodisias and Ataeymir (A061)

Location: The cistern is located just north of the main road running through the Morsynus river valley between Aphrodisias and the modern town of Ataeymir. It is situated 1.5 km west of Ataeymir and 2.5 km east of Aphrodisias.

Elevation: 554 masl

Coordinates: Latitude: 37°42'25.08"N; longitude: 28°45'15.72"E

Preservation: The cistern has been reused and is relatively well preserved.

Construction: The cistern is a composite structure formed by a polygonal drum on top of which rests a dome. It is built of petit appareil masonry using fieldstones with brick infill.

Description: The cistern has a polygonal footprint, unlike the round cisterns documented at Tepecik and Tekeliler, and is roofed with a dome covered with a layer of modern white cement. The polygonal drum on which the dome rests is about 1.5 m high and has 19 sides ranging from 1.6 m to 1.7 m long. The doorway built into this substructure is 0.7 m wide and faces west. The doorway is constructed of reused marble blocks for jambs topped with an arch of fieldstones. There is a recessed niche on the left interior wall of the doorway (as viewed from the outside).

Major Dimensions:

H (drum): 1.5 m

Photograph Numbers: D2005.0460–0465

Drawing Numbers: None (notebook sketch only)

Cistern, Between Tepecik and Bingeç, Bingeç Plateau (F072)

(Fig. 40)

Location: The cistern is located near a modern dirt road that climbs the hills east of Tepecik on the Bingeç plateau, 2.8 km southeast of the modern village of Tepecik, 2.2 km north of

the modern village of Bingeç, and 12.6 km southwest of Aphrodisias.

Elevation: 881.73 masl

Coordinates: Latitude: 37°38'22.61"N; longitude: 28°36'31.31"E

Preservation: The outer layer of cement covering the dome is missing and has not been reapplied as it has on other cisterns in the region. The cistern is filled with water of an unknown depth. White seepage deposits line the inside of the dome. Irrigation canals have been dug in the fields surrounding the cistern, perhaps encouraging its abandonment and the infill of sediment-laden water.

Construction: The cistern is a composite structure formed by two stacked cylindrical drums on top of which rests a dome. The cistern is built of petit appareil masonry presumably around a mortared rubble core. The fieldstones, many of which are schist and quartz, are stacked and bonded with a white, lime-based mortar with stone inclusions smaller than 0.01 m. The stones vary greatly in size. Those forming the instep or ledge at the top of the lower substructure are 0.60 m by 0.30 m, but most are between 0.20 m wide by 0.50–0.10 m high, with greatly varying depth.

Description: The cistern incorporates two stacked cylindrical drums, the lower of which is 1–1.50 m high, and the upper of which is 0.80 m high. The lower cylindrical drum of the cistern has an exterior circumference of about 27 m at ground level and an overall diameter of 8.6 m. The dome “springs” from the upper drum. The lower drum is 0.90 m thick, and the higher is 0.55 m thick. There is an instep 0.20–0.50 m wide between the two drums, but no instep between the upper drum and the dome. While the upper drum on which the dome rests is constructed of horizontally laid stones, the dome is built of stacked and angled stones, making it a true rather than corbelled dome. The dome is approximately 3.5 m high and has an internal diameter of approximately 7 m. The outer layer of cement covering the dome is missing and has not been reapplied as it has on other cisterns in the region. The dome is topped by a block that sticks up about 0.30 m from the top of the structure. The doorway into the cistern pierces the lower drum and faces east. Due to its incorporation into a curved wall, it is 1 m wide on the exterior and 0.80 m wide on the interior. The walls along vertical sides of the doorway are recessed, perhaps to hold a wooden door that is now missing. Into the left (south) wall of the doorway has been created a recessed niche 0.20 m by 0.20 m and 0.34 m deep, 0.56 m below the instep or ledge. The doorway is topped by a corbelled vault 0.30 m high, above which is a patch of gray cement 0.50 m high that must have originally held an Arabic inscription, as seen in the cistern at Tekeliler (B049).

A series of windows pierces the bottom courses of the upper drum directly above the instep or ledge that separates it from the lower substructure. One of these windows is 0.30 m square and is located on the west side of the cistern, directly across from the doorway. The other windows are all 0.20 m square. Five pierce the southern side of the cistern, and two pierce the northeast side.

Major Dimensions:

H (total) (approximate): 5.5 m

Diam (total): 8.6 m

H (lower drum): 1–1.50 m

Th (lower drum wall): 0.90 m

H (upper drum): 0.80 m

Th (upper drum wall): 0.55 m

H (dome) (approximate): 3.5 m

Internal Diam (dome) (approximate): 7 m

Photograph Numbers: D2008.1067–1076

Drawing Numbers: RS 63: Elevation looking north and plan of cistern at Tepecik (F072); elevation looking west, section looking north, and plan of cistern at Tekeliler (B049) at 1:100 scale

Cistern, Tekeliler, Bingeç Plateau (B049) (Fig. 40)

Location: The cistern is located on the Bingeç plateau, 1.4 km east of the modern village of Tekeliler and 14.2 km south of Aphrodisias.

Elevation: 853 masl

Coordinates: Latitude: 37°34'57.30"N; longitude: 28°41'14.82"E

Preservation: The exterior coat of cement on the dome and the interior mortar waterproofing appear to date to 1964. The cistern currently contains no water but shows evidence of use as a campsite.

Construction: The cistern is a composite structure formed by a cylindrical drum on top of which rests a dome. The cistern is built of fieldstones and bricks presumably around a mortared rubble core. The fieldstones, many of which are low-grade marble and quartz, are not laid in courses and are bonded with a white, lime-based mortar with dense red inclusions smaller than 0.015 m. The stones vary greatly in size.

Inside the cistern, the even courses of regular, rectangular blocks forming the dome are visible. The blocks are about 0.20 m long and 0.10–0.15 m high. These courses start directly above a line of putlog holes set into the interior of the dome. This line of putlog holes is situated about 1 m above the top of an interior coating of mortar within the cistern, which extends up about 2 m from the bottom of the cistern. The putlog holes are placed about every 0.30 m.

Description: The cistern is situated near a Byzantine settlement where a large, vaulted subterranean cistern and agricultural blocks have been documented (F009). The cylindrical drum of the cistern has an exterior circumference of about 32 m at ground level and an overall diameter of 10 m. The cistern incorporates a drum approximately 2.5 m high, on top of which sits a dome covered in white-gray cement. An instep or ledge between the drum and the dome is obscured by this layer of cement. The thickness of the drum varies from 1.10 m at the ground level to 0.75 m where the dome begins. The dome is approximately 3 m high, has an internal diameter of approximately 9 m, and is topped by a vertically placed stone.

The doorway faces east and pierces the drum. The jambs and lintel are all reused marble blocks. The bottom of the lintel has been carved with a semicircular opening. A stone slab with an Arabic inscription is cemented into the wall above the lintel. The dome and the upper courses of the drum are coated in a damaged layer of gray cement, into which is carved the year 1964 above and to the right of the doorway. This exterior coat of cement and the interior mortar waterproofing seem to date to the same time, perhaps 1964.

Within the left (south) interior wall of the doorway is placed a recessed, triangle-shaped niche. The niche is 0.24 m wide, 0.20 m high, and 0.30 m deep. The flat surface of this niche is smooth, and the worn edge of the marble block that forms the bottom of the niche indicates a long period of use, perhaps to hold a water container.

The current floor inside the cistern is 2 m below the ground level outside. A staircase leads down from the doorway of the cistern to the floor. From inside the cistern, three entryways are visible at the level of the top of the 2 m high mortar lining. They are about 0.25 m by 0.30 m and are topped by large stone slabs. Two of these entryways have been filled with stones.

Major Dimensions:

H (total) (approximate): 5.5 m

Diam (total): 10 m

D (below ground level): 2 m

H (drum) (approximate): 2.5 m

Th (drum wall): 0.75–1.10 m

H (dome) (approximate): 3 m

Internal Diam (dome) (approximate): 9 m

Photograph Numbers: D2006.0308–0316

Drawing Numbers: RS 63: Elevation looking north and plan of cistern at Tepecik (F072); elevation looking west, section looking north, and plan of cistern at Tekeliler (B049) at 1:100 scale

Cistern, Yaykın, Bingeç Plateau (B043)

Location: The cistern is located on the Bingeç plateau, 2.3 km southwest of the modern village of Yaykın and 19 km southwest of Aphrodisias.

Elevation: 776.26 masl

Coordinates: Latitude: 37°35'17.867"N; longitude: 28°34'02.465"E

Preservation: The inscription above the doorway has been lost.

Construction: The cistern is a composite structure formed by a cylindrical drum on top of which rests a dome. The cistern is built of mortared petit appareil masonry bonded with a considerable amount of brick infill. The dome is constructed almost entirely of small blocks of schist with a few bricks.

Description: The drum is 2.65 m in height and approximately 10.6 m in diameter. The dome contains an oculus with a diameter of 1.55 m. Inside, the current floor of the cistern is 1.4 m below the ground level outside. A doorway and two windows pierce the drum. The window opposite the doorway is 0.40 m wide and 0.48 m high. At the same height of the windows are situated two putlog holes centered on the east and west sides. Two circles with diameter of 0.25 m are inscribed on either side of the lintel of the doorway. On the east side of the cistern there is a small channel for water, 0.27 m wide and 0.40 m high, located at ground level.

Major Dimensions:

H (drum): 2.65 m

Diam (drum) (approximate): 10.6 m

D (interior below threshold): 1.4 m

Diam (oculus): 1.55 m

Photograph Numbers: D2006.0258–0271

Drawing Numbers: None

Cistern, Yaykın, Bingeç Plateau (B044)

Location: The cistern is located on the Bingeç plateau, 4.8 km southwest of the modern village of Yaykın and 21.3 km southwest of Aphrodisias.

Elevation: 711.59 masl

Coordinates: Latitude: 37°35'27.051"N; longitude: 28°31'53.708"E

Preservation: Unrecorded.

Construction: The cistern is a composite structure formed by a drum on top of which rests a dome. The cistern is constructed of petit appareil masonry of small limestone blocks with a large amount of brick infill.

Description: The drum is 2.25 m in height and approximately 10.5 m in diameter. At the top of the dome is a round block (0.27 m in diameter) with hole in the center (0.07 m in diameter). The block protrudes 0.05 m above the surface of the dome. Inside, the current floor of the cistern is 2.1 m below the ground level outside. Twenty-eight putlog holes line the interior of the cistern at the same height as the top of door-

way, which is 1.72 m high and 0.82 m wide. The lintel block is decorated with an inscribed pattern.

Major Dimensions:

H (drum): 2.25 m

Diam (drum) (approximate): 10.5 m

D (interior below threshold): 2.1 m

Photograph Numbers: D2006.0272–0280

Drawing Numbers: None

Cistern, Yaykın, Bingeç Plateau (B045)

Location: The cistern is located on the Bingeç plateau, 0.8 km east of the modern village of Yaykın and 16.3 km southwest of Aphrodisias.

Elevation: 822.41 masl

Coordinates: Latitude: 37°36'13.385"N; longitude: 28°35'34.836"E

Preservation: The interior surfaces of the cistern have been coated in modern mortar to a height of 1.5 m above the current bottom of the cistern.

Construction: The square cistern is constructed of coarsely worked fieldstones including limestone and quartz, at the

top of which is a subashlar course incorporating some brick for chinking. The white mortar bonding the masonry has small stone inclusions. A staircase of marble blocks leads down to the bottom of the cistern.

Description: The square cistern measures 8.3 on a side. According to a local informant, about 100 years ago a resident of Tavas built walls around the earlier structure to prevent animals from falling into it. Modern mortar, which is 1.5 m high along the interior walls of the cistern, covers a layer of older red-orange mortar with sparse, small stone inclusions, which seems to be a hydraulic lining for the original walls of the cistern. The local informant suggested the marble blocks of the staircase were brought here from the nearby ancient site of Bingeç (Plarasa).

Major Dimensions:

p. D (total): 3 m

Internal dimensions: 8.3 m by 8.3 m

Th (walls): 0.49 m

p. D (mortar): 1.8 m

Photograph Numbers: Unknown

Drawing Numbers: None