

# A ROMAN ROAD SOUTHEAST OF THE FORUM AT CORINTH

## TECHNOLOGY AND URBAN DEVELOPMENT

### ABSTRACT

A wide, unpaved, north–south Roman road was established in the Panayia Field at Ancient Corinth in the last years of the 1st century B.C. Over the next six centuries, numerous civic and private construction activities altered its spatial organization, function as a transportation artery, and use for water and waste management. Changes included the installation and maintenance of sidewalks, curbs, drains, terracotta pipelines, and porches at doorways. The terracotta pipelines are presented here typologically in chronological sequence. The road elucidates early–colony land division at Corinth, urbanization into the 4th century A.D., and subsequent deurbanization in the 6th century, when maintenance of the road ended.

Between 1995 and 2004, excavations conducted by the American School of Classical Studies in the Panayia Field at Ancient Corinth revealed a wide, unpaved Roman road at the eastern side of the property, adjacent to areas dating to several phases of habitation (Fig. 1: Panayia road).<sup>1</sup> The exposed portion of the road is about 180 m southeast of the Roman forum. It is oriented 3° west of north, with a gradient of 3.5° down from south to

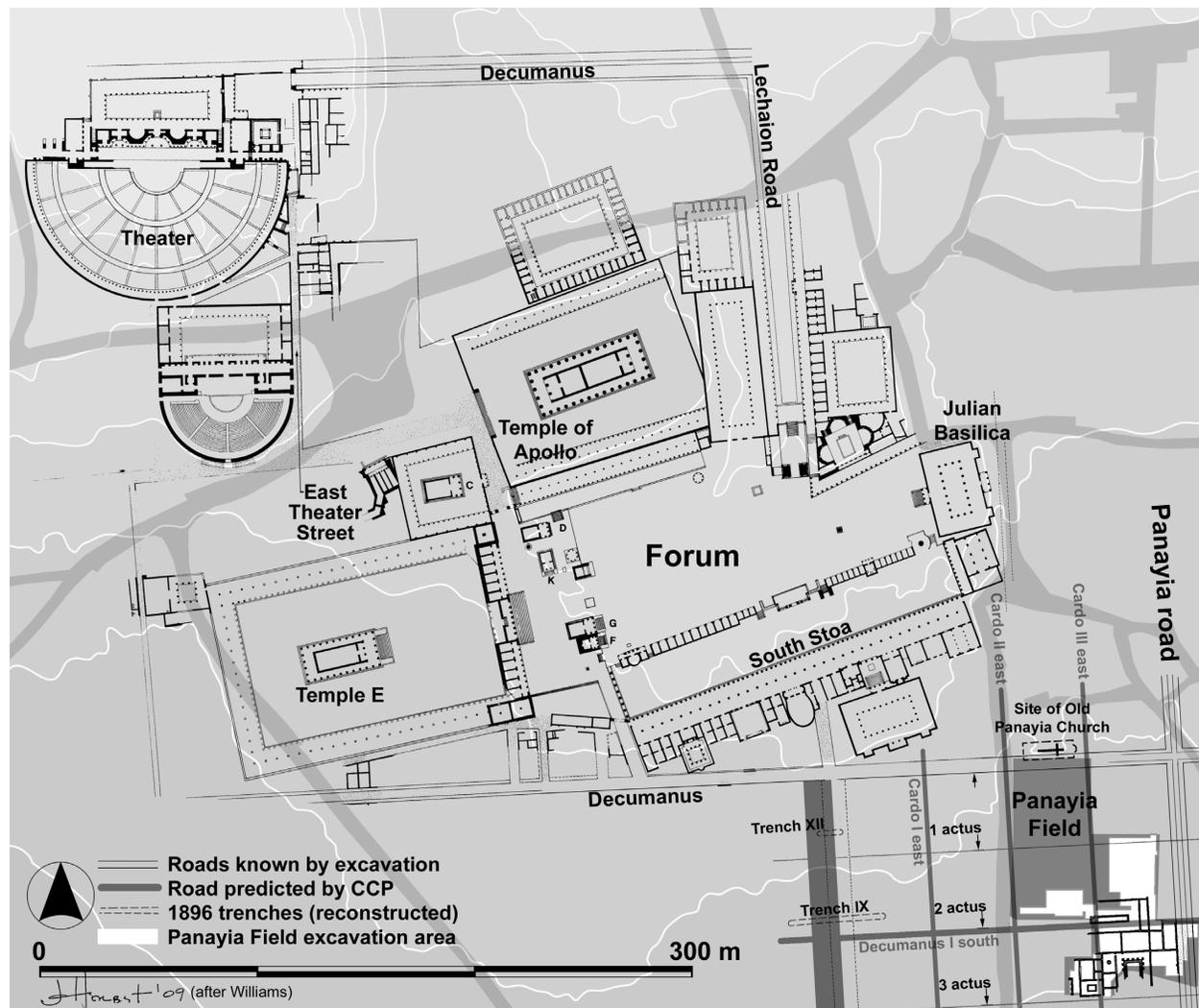
1. Preliminary presentation of the road in the Panayia Field was as a poster at the 106th Annual Meeting of the Archaeological Institute of America in Boston in January 2005. For a general introduction to the excavations at the Panayia Field, see Sanders 1999; 2004, pp. 176–179.

We are especially grateful to Guy Sanders, Director of the Corinth Excavations, for entrusting publication of the road to us, as well as for his counsel and support. Excavations at the Panayia Field began under the direction of Charles K. Williams II, Director Emeritus of the Corinth Excavations. We are also grateful to the successive

Assistant Directors, Nancy Bookidis and Ioulia Tzonou-Herbst, for facilitating our study of finds from the road; to Dimitris Notis and Anastasios Kakouros, for mending the ceramic pipes; to the previous foreman, the late Aristomenes Arberores, and the current foreman and assistant foreman, Athanasios Notis and Panayiotis Kakouros; and to the conservators Nikol Anastasatou and Stella Bouzaki. Orestes Zervos identified the coins from the road and Michael Ierardi provided further numismatic information. Ino Ioannidou and Lenio Bartzioti took many of the site and object photographs. Sarah Lepinski served as a helpful sounding board for architecture

and phasing and shared ideas gleaned from her work on Roman wall painting.

Special thanks are due to Kathleen Slane for dating the pottery. Nancy Bookidis, Charles K. Williams II, Kathleen Slane, and David Romano generously read drafts of this article and offered important insights. Student supervisors were Leda Costaki, Floris van den Eijnde, Matt Gonzales, Laura Gawlinski, Athina Hadji, Christine Smith, Drew Wilburn, Mark Alonge, Johanna Beck, Denver Graninger, Kirsten Day, Michael Laughy, Douglas Post Park, and Dimitri Nakassis. Field supervisors were Ioulia Tzonou-Herbst, Sarah Lepinski, and Jennifer Palinkas.



north. This *cardo*, or north–south road, is parallel to and 167 m east of the *cardo maximus*, the city’s main north–south thoroughfare, better known as the Lechaion Road. It is 78 m south of the well-established east–west line of a limestone-paved *decumanus* south of the temenos of Temple E and the forum.<sup>2</sup> Excavation uncovered 23 m of the earthen roadbed;

2. The general location of the road was first anticipated by David Romano’s analysis of topographical survey data collected by the Corinth Computer Project (see Romano 1993). The distance from the Lechaion Road (at the Propylaia) to the road in the Panayia Field was measured from center to center of the two roads. The Lechaion Road was uncovered south of the forum as it emerged from the South Stoa, and farther south the paving of the Lechaion Road was uncovered in 1896 in trenches IX and XII, but the exact location of the trenches and the edges of

the road is now uncertain; see Richardson 1897, pp. 473–474. The limestone-paved *decumanus* has been revealed in several places across the city, such as in the area south of the temenos of Temple E, where excavations directed by Charles Williams uncovered this road; see Williams and Zervos 1987, pp. 1–3; 1988, pp. 95–108. Farther east, Henry Robinson excavated more of this road south of the South Stoa (Robinson 1966, p. 133), and farther yet, some 200 m east of the Panayia Field, rescue excavations by the 37th Ephoreia of Prehistoric and

Figure 1. The Roman forum and the Panayia Field. Scale 1:3333. J. A. Herbst

Classical Antiquities revealed another portion of it. Another 500 m east, geophysical subsurface survey using electrical resistivity imaging performed by Michael Boyd detected another small portion of the same road. The area south of the South Stoa is currently being reinvestigated by the Corinth Excavations. New excavation is generating important information on the intersection of the Lechaion Road and the *decumanus*, which will refine Robinson’s earlier interpretations of the area (1961–1962, p. 61; 1965, p. 290; 1966, p. 133).



Figure 2. The Panayia road from the south. Photo courtesy Corinth Excavations

additional geophysical survey detected a further 90-m stretch of the road some 91 m south of the Panayia Field.<sup>3</sup> When initially laid out, the road was 7.4 m wide, or 25 Roman feet, but in the latter half of the 2nd century curbs were added, creating broad sidewalks on each side.<sup>4</sup> In this period, the sidewalks each measured 2.77 m and 2.47 m wide, or about 9 Roman feet, and the road itself measured approximately 2.15 m, or 7 Roman feet (Fig. 2).

Roads systems have been a rich subject of debate in Corinthian scholarship.<sup>5</sup> Most work has been done at a regional level, however, and fully and systematically excavated roads are relatively few in the landscape. Many roads were cleared before stratigraphic excavation methods were employed, and other road excavations, just short of digging a complete history, stopped at the pavement, leaving buried important evidence of a road's foundation and early history. The new road in the Panayia Field joins a number of known Roman roads in an orthogonal grid plan that was established after the foundation of the Roman colony in Corinth in 44 B.C.<sup>6</sup> Along with only one other road, East Theater Street, it holds the

3. The subsurface electrical resistivity imaging in this area was also conducted by Boyd.

4. Unless otherwise specified, all dates in this article are A.D.

5. See Poehler 2006, p. 53, for the relevance of streets to ancient urbanism, especially at Pompeii. For the Roman road system at Corinth, see Walbank 1986, 1997, 2002; Doukellis 1994;

Romano 1993, 2000, 2003, 2005, 2006.

6. Romano (2003, p. 283) counts 22 excavated roads, 13 north-south and 9 east-west.

distinction of having been investigated through its complete stratigraphic sequence, covering some six centuries.<sup>7</sup> Because the entire stratigraphy was recovered, from the establishment of the road to its abandonment, it presents a clear chronology of urban and technological transformation in a district located outside the city.

As specific objects of inquiry, roads are significant to urban archaeology for the issues they raise and the multiple roles they play in the built environment at a wide range of scales. At the urban scale, roads are a principal component in the structure and organization of a city, and at a human scale, they are a significant urban spatial component, whose edges often link interior and exterior, private and public, personal and civic. Roads link points, or nodes, in a network of streets: conceptually and physically they allow people to navigate space to get from place to place. As such, the road in the Panayia Field provides insight into Roman road planning and indicates many engineering concerns in this particular area of Corinth. When considered with the other Roman structures uncovered in the vicinity and the network of streets in Corinth, this *cardo* provides information on the centuriation, or the division of land, of the Roman colony in Corinth. In this article we consider the road as a spatial entity in its own right and with its own character as it developed over time.

Technologically, roads were not only conduits for people, goods, and wheeled traffic but they were also arteries for facilitating the transport of water and waste via underground utility networks. The road in the Panayia Field contains 31 successive lines of pipes and drains that represent solutions to water supply and sewage management within the city.<sup>8</sup> With the archaeological evidence, we describe the major phases of the road, accounting for implications for the urban environment; we discuss the function and typological sequence of the ceramic pipelines that ran through the road; and, finally, considering the greater context of the city and its urban plan, we discuss the roads located in the vicinity of the Panayia Field. An appendix presents detailed characteristics of the pipelines and their fabrics, along with a catalogue of pipe segments.

## PHASES OF DEVELOPMENT

The complex depositional formation of the road required the meticulous excavation of many thin street surfaces and strata that were cut by later construction activities of pipelines and other structures. Although the lifespan of the road extended over six centuries and consisted of hundreds of excavation contexts, it was compressed into little more than a meter in depth (Figs. 3, 4). None of the surfaces remained completely intact due to continuous construction of drains, water pipes, and curbs. We have divided the development of the road into five major stages from its foundation to its latest service. The earliest street surfaces constitute the first phase, which dates from the late 1st century B.C. to the mid-1st century A.D. Phase 2 began in the late 1st century—when large-scale construction appeared flanking the road—and continued into the mid-2nd century. The establishment in the mid-2nd century of curbed sidewalks initiates

7. Williams and Zervos 1983, 1984, 1985, 1986, 1987, 1988, 1989. Williams is currently preparing these excavations for their final publication in the *Corinth* monograph series. During the East Theater Street excavations, Williams documented phases similar to those we outline below for the road in the Panayia Field, but as the area was closer to the civic center of Corinth, the phases there are not exactly equivalent to those of the Panayia road. See Williams and Zervos 1984, pp. 85–89.

8. There are 27 ceramic pipelines, 1 robbed line, and 3 built drains. These lines are numbered on the phase plans, Figs. 11, 17, 18, and 20.

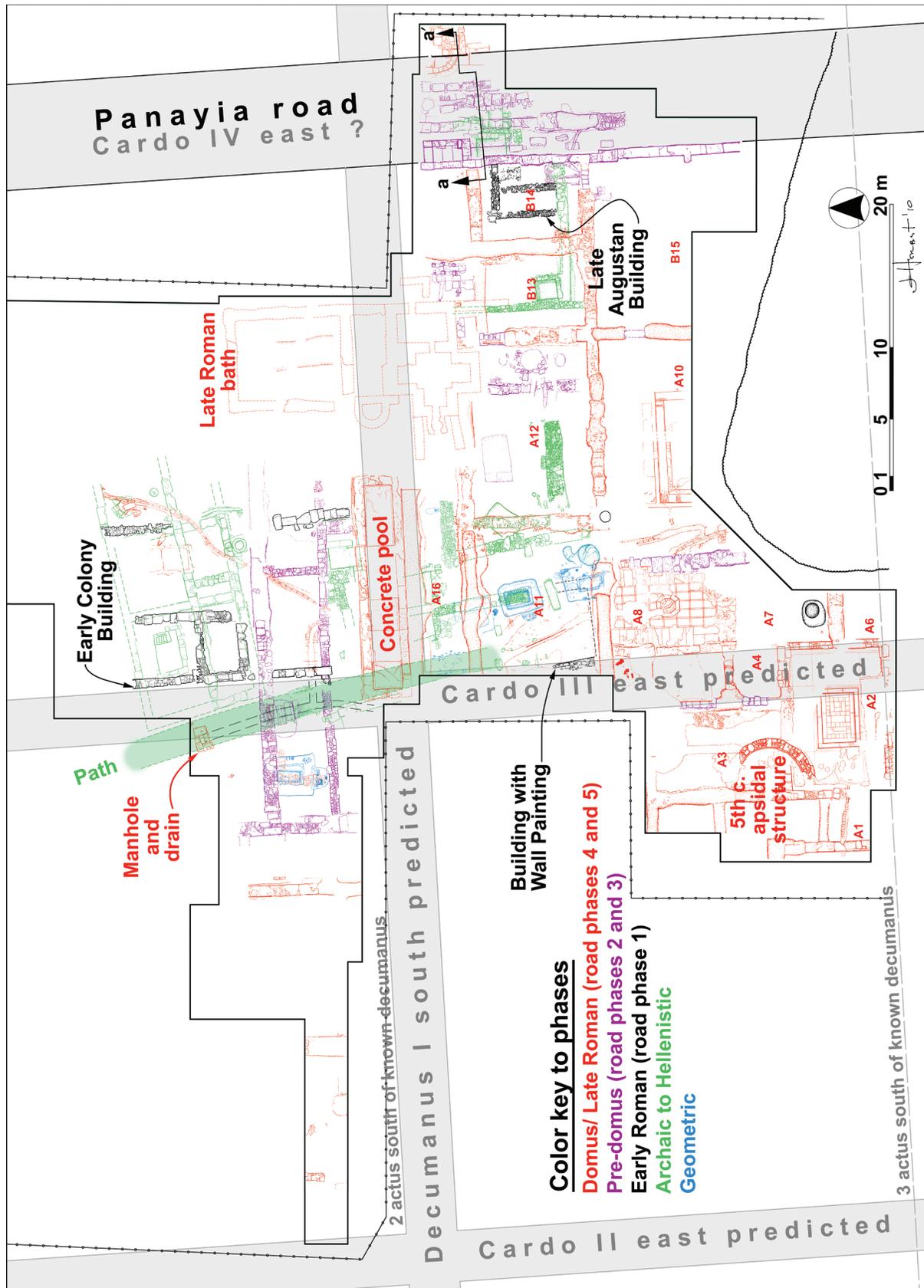
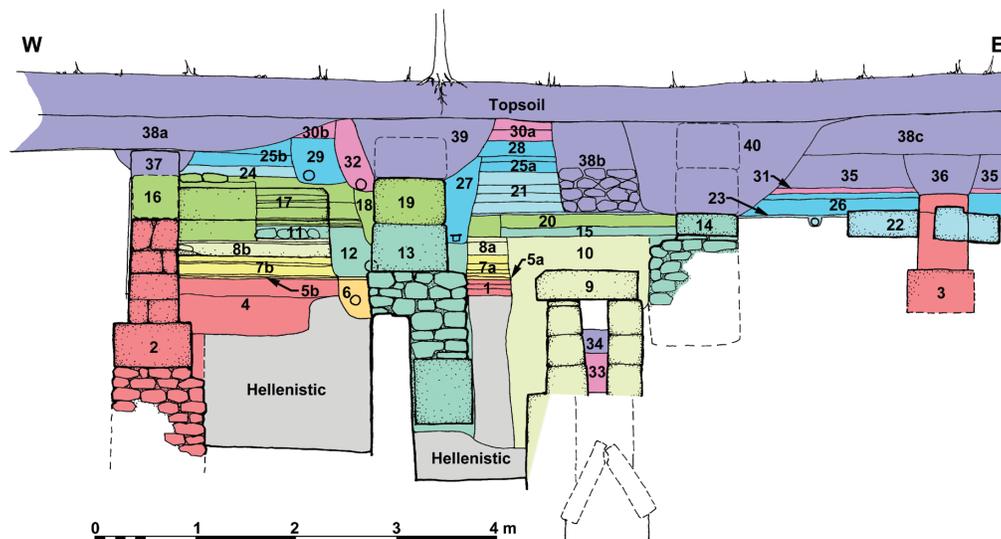


Figure 3. State plan of the Panayia Field showing Geometric through Roman phases. Scale 1:400. J. A. Herbst



phase 3.<sup>9</sup> The fourth phase begins in the mid-3rd century when a Roman domus was constructed west of the road and lasts until the domus was destroyed in the mid-4th century. Phase 5, the final phase, encompasses the last maintenance of the road. It runs from the late 4th into the 6th century, after which the road decays in the Byzantine period.

#### PHASE 1: FOUNDATION OF THE ROAD, LATE 1ST CENTURY B.C. TO MID-1ST CENTURY A.D.

The earliest archaeological evidence for the road in the Panayia Field includes several thin, hard-packed surfaces (lot 2004-48) that sit solidly upon the remains of a partially preserved Hellenistic building containing a cistern and a cellar (Fig. 3; Fig 4: stratum 1).<sup>10</sup> Very little of these strata remained undisturbed by later construction, with the total preserved area covering about 4 m<sup>2</sup> (Fig. 5). The lowest elevation for the road was established at 92.23 masl; the fragmentary pottery from these surfaces dates to the late 1st century B.C.<sup>11</sup>

During this period and contemporary with the founding of the road, three partially preserved but notable freestanding structures existed in the Panayia Field. Two of the buildings are located roughly 30 m west of the road. The northern building, with two rooms remaining, has been designated the Early Colony Building (Fig. 3). More perplexing is the southern one, consisting of a single wall and two robbing trenches aligned with the other Hellenistic structures in the area but with unquestionably

9. Phases 2 and 3 of the road are equivalent to a general period in the rest of the Panayia Field that has been called the pre-domus horizon, which is characterized by multiple, poorly preserved phases of structures.

10. Several of these layers, made up of a fine sandy matrix 0.05–0.10 m

thick, were located at the northern end of the roadway. To the southwest, the layers were composed of a brownish-black matrix of clay with denser pebble inclusions. Deposits in the cistern and cellar as well as similar Hellenistic deposits from the Panayia Field have been studied by Sarah James and are

Figure 4. East-west section through the northern end of the Panayia road. See section a–a' in Figure 3. Scale 1:75. J. A. Herbst

presented in her doctoral dissertation (James 2010).

11. This date is based on the absence of Italian sigillata, although the context does include 20 Eastern Sigillata A or local fragments. In addition, these layers are sealed beneath a road layer (lot 2003–27).



Figure 5. Early road surfaces preserved between the later structures, the stone channel, and the western curb wall. View from the south.

Photo I. Ioannidou and L. Bartzioti

residential-type Roman wall painting adhering to the wall.<sup>12</sup> This building is here designated the Building with Wall Painting. Although both structures bear little significance for the road's stratigraphy, they play a role in our interpretation of the city planning of the district, which we discuss below.

A third building, dubbed the Late Augustan Building, was unearthed directly adjacent to the road on its west side (Figs. 3, 6, 7); this building provides important chronological evidence for the road. Excavation revealed two rooms enclosed by three Roman walls, each preserved in a single course of cobble foundations that abutted the north face of an earlier Hellenistic east-west wall of heavier boulders. Presumably, a fourth wall formed the eastern side of the building, but it did not survive later construction activity in the area. The floors of the building or other deposits from the time of its habitation were likewise completely removed by later activities, and thus it is not possible to propose a function for the building. However, excavation recovered a significant ritual foundation deposit from the construction phase of the building. After setting the cobble foundations, several objects were placed within a shallow depression dug against the walls of the northeast corner of the east room and backfilled. Within the deposit (lot 2001-33), excavators unearthed a coin (coin 2001-136, Fig. 8) and a lamp (lamp 2001-1, Fig. 9) buried under a tortoise (Fig. 10). The lamp provides a Late Augustan terminus post quem for the construction.<sup>13</sup> Shortly thereafter the walls were dismantled to make room for construction in the next phase of the road.

12. We thank Sarah Lepinski for helping us realize the complexity and importance of this structure.

13. The lamp is Broneer type XVI with glazed buff fabric, similar to lamp 1981-11 from manhole 1981-3, which dates to the Late Augustan era; see Slane 2005, p. 40, fig. 9:5. Special thanks to Kathleen Slane for identifying this lamp. The coin is a Greek Imperial Anonymous type A dating to 44/40 B.C. It was identified by Orestes Zervos and further explained to us by Michael Ierardi.

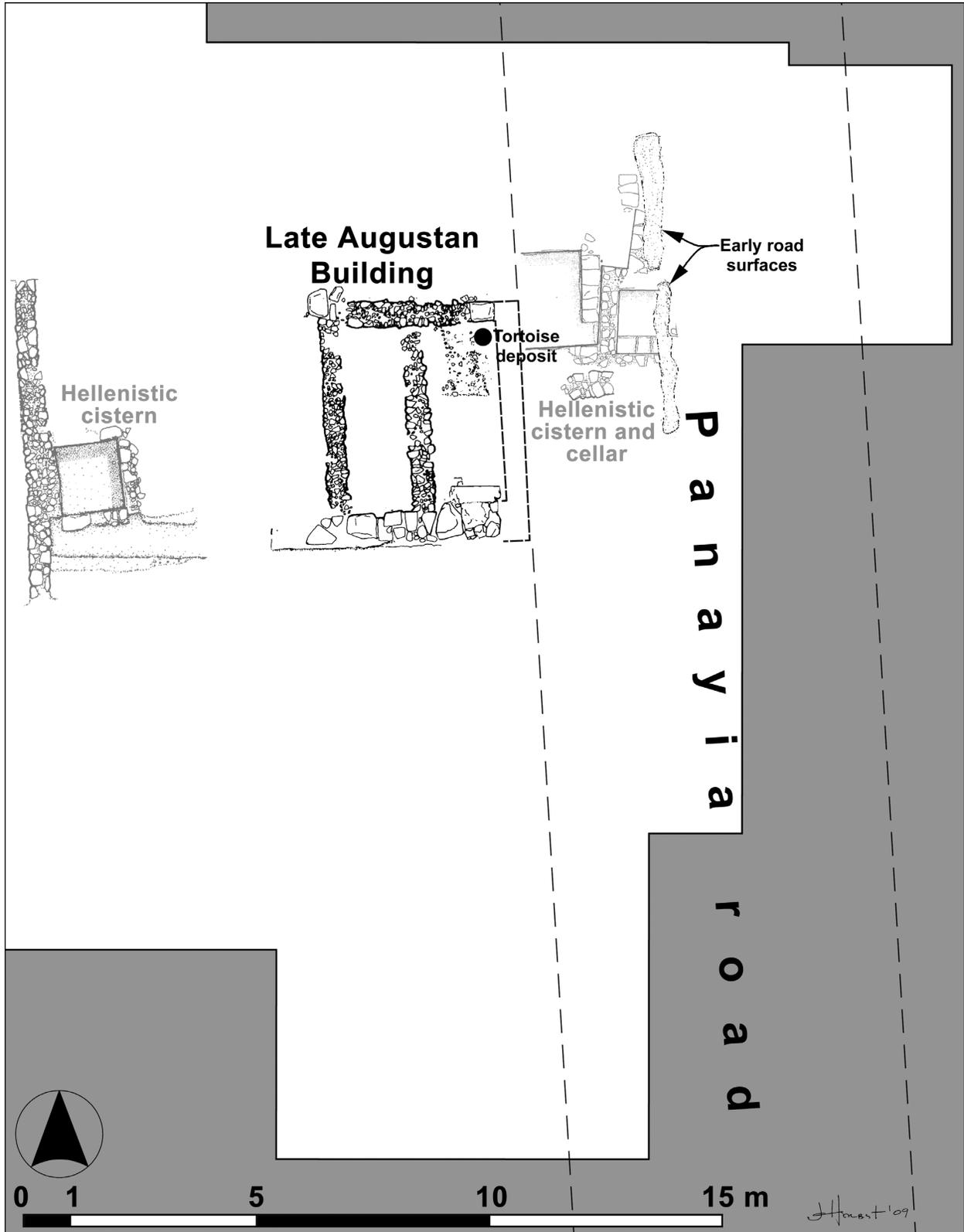


Figure 6. State plan of phase 1 of the road. Scale 1:125. J. A. Herbst

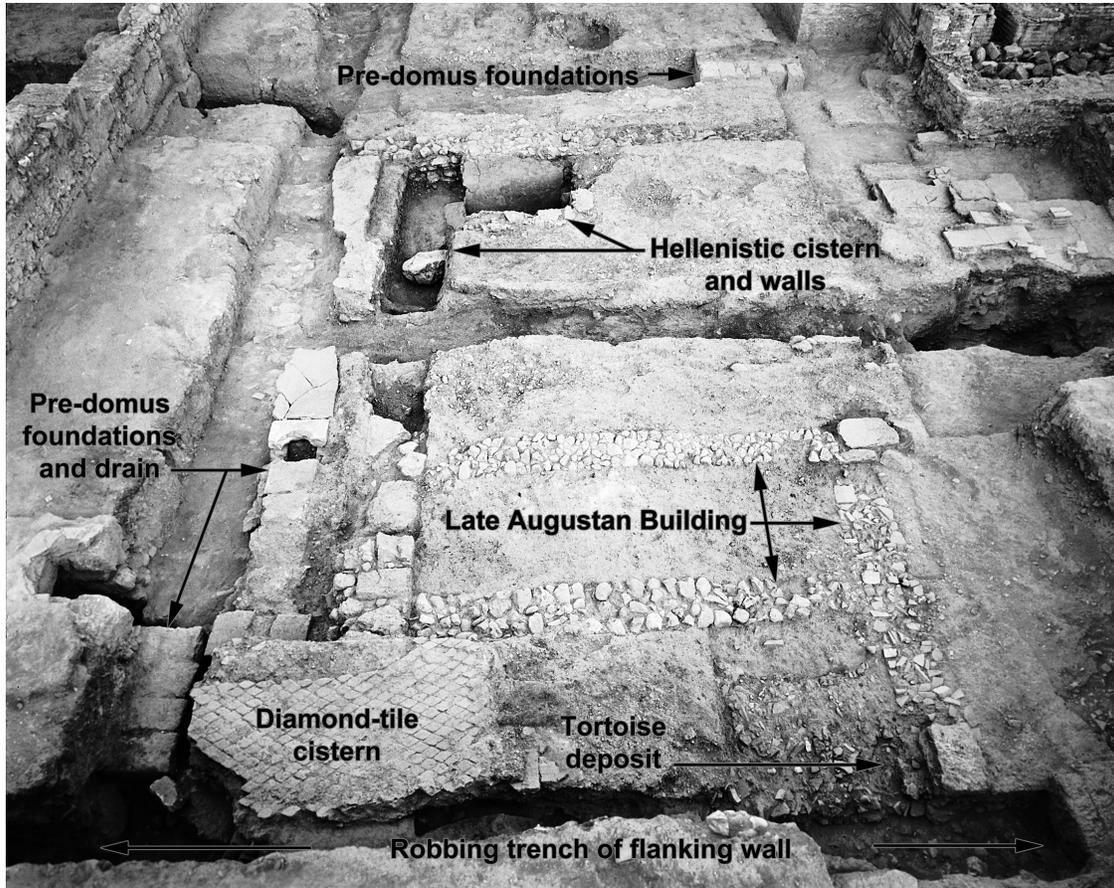


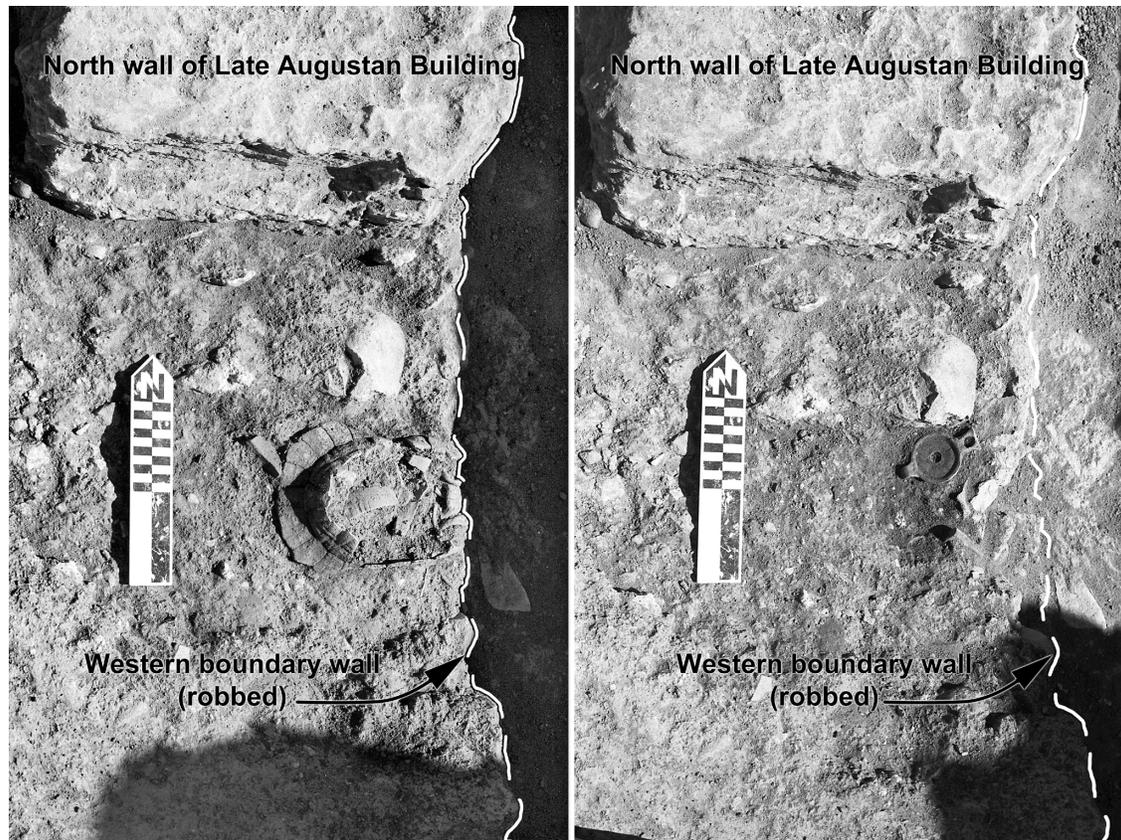
Figure 7. Hellenistic and Roman structures west of the road, including the Late Augustan Building and the tortoise foundation deposit. View from the east. Photo I. Ioannidou and L. Bartzoti



Figure 8. Corinth coin 2001-136, Greek Imperial Anonymous type A dating to 44/40 B.C. Scale 1:1. Photos I. Ioannidou and L. Bartzoti



Figure 9. Corinth lamp 2001-1, Broneer type XVI. Scale 1:2. Photo I. Ioannidou and L. Bartzoti



## PHASE 2: FLANKING WALLS, LATE 1ST TO MID-2ND CENTURY

During phase 2 both sides of the road were framed by buildings, and the road itself received its first water- and waste-management installations. Large-scale construction on the west side of the road marks the beginning of phase 2, in the late 1st century. The in-situ remains include a series of isolated heavy ashlar foundations that were largely disturbed; the number of structures, their function, and their specific plans are all unclear.<sup>14</sup> Excavation recovered a considerable number of monochromatic painted plaster fragments, which were preserved mainly in the construction fills of later superimposed structures.<sup>15</sup> Although poorly preserved, the heavy foundation walls and the fresco fragments suggest a handsomely decorated and substantially built complex. During this phase, several spaces with earthen floors, roughly constructed tile hearths, and domestic assemblages are located west of the road (Fig. 3: B13–B15), separated from it by a substantial north–south wall that acts as the western flanking wall.<sup>16</sup> At the same time a similar wall was constructed to flank the east side of the road.

Both of the walls flanking the road were heavily constructed, deeply founded, and sizable enough for the load-bearing requirements of a multi-story structure. The walls were built using 0.90-m-wide cobble foundations set into a trench, with a toichobate course of 0.76-m-wide ashlar surmounted by upper courses of random ashlar that range in width between 0.50 and 0.60 m (Fig. 4: strata 2, 3; Figs. 11–13). The construction trenches

Figure 10. Broneer type XVI lamp found under the remains of a tortoise, before (*left*) and after (*right*) removal of the tortoise. Photos courtesy Corinth Excavations

14. One enigmatic structure is a small, partially preserved tile floor with six hypocaust-like pillars. We include the features in our description for phase 2, although they may continue in use into phase 3. Thus, we include the features in the illustrations for both phases (Figs. 11, 17).

15. Lepinski 2008, pp. 31–32.

16. These spaces continue in use into the 4th century.

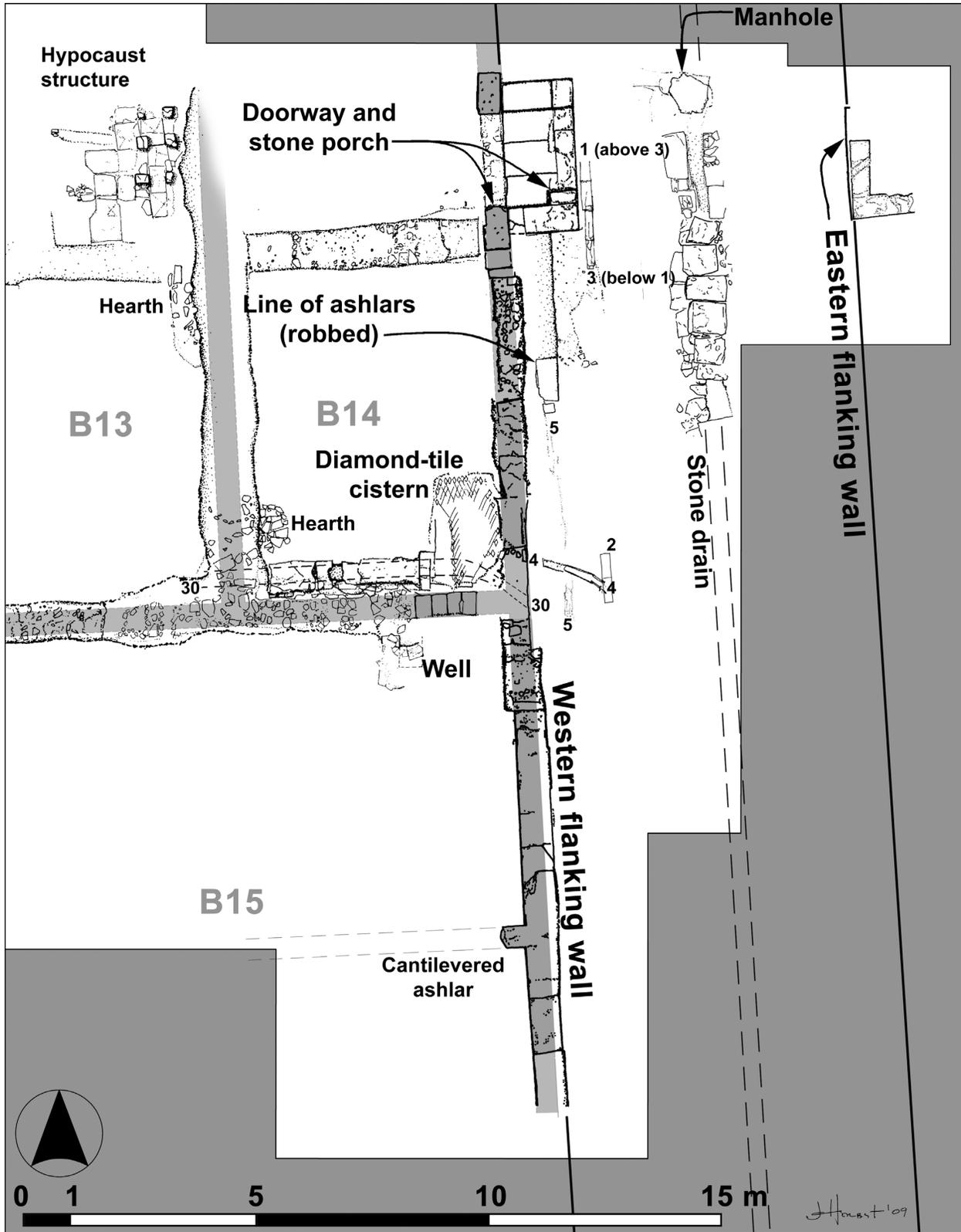
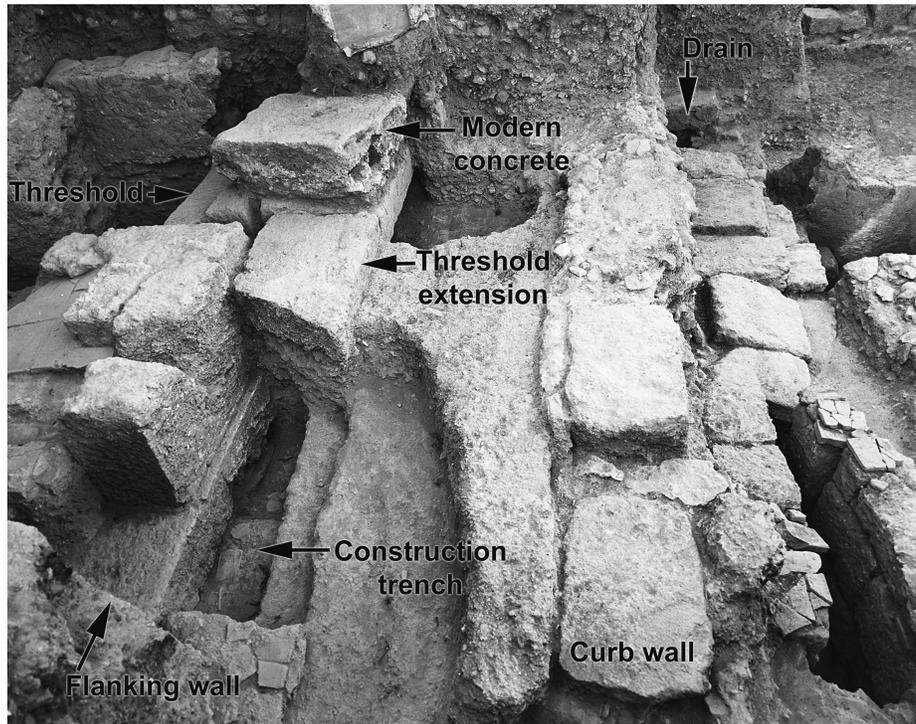


Figure 11. State plan of phase 2 of the road. Scale 1:125. J. A. Herbst



Figure 12 (*left*). Western flanking wall and its construction trench, which cut through the Hellenistic wall at lower left. View from the north. Photo courtesy Corinth Excavations

Figure 13 (*below*). Eastern sidewalk showing flanking wall. Other visible features include the threshold extension of phase 4 and the curb wall of phase 3. The phase 2 stone drain is in the roadbed at right. View from the north. Photo I. Ioannidou and L. Bartzoti



(Fig. 4: stratum 4) and the foundations for the walls (west wall: lots 2004-45, 2004-46, 2004-471; east wall: lot 2004-5) cut through the earliest road layers, and the western wall cut through destruction layers of the Late Augustan Building as well as the tortoise deposit. Construction presumably also removed the eastern wall of the Late Augustan Building and destroyed any feature, such as a stone or earlier wall, that may have served as a boundary marker between property and street in phase 1. The flanking walls define the first known boundaries for the road, fixing its width at 7.4 m.

Two features are integral to the western flanking wall. In the northern end of the excavated area, two large upright orthostates serve as jambs for a 2.04-m-wide doorway. The base of the southern jamb sits at 93.43 masl, which is a probable threshold level in this phase and a small step above the road. Rooms B13 and B14 to the west of the doorway rest at a lower elevation, two or three steps below the surface of the road; they contained two hearths and domestic assemblages dominated by cooking pottery and floor surfaces. A second feature at the southern end of the area is a single ashlar block set perpendicular to and cantilevered from the western face of the wall. This may represent the last remaining stone of a bonded crosswall, although other traces of this wall, such as construction or robbing trenches, have been obliterated by subsequent construction. There is also a doorway in the eastern flanking wall of the road, but the date of its installation is unknown.

After the flanking walls were built, the elevation of the roadbed remained fairly constant, rising only a few centimeters to ca. 92.45 masl. Water- and sewage-management systems were dug through road surfaces and installed: three water-supply lines (lines 1-3; for line 1, see Fig. 4: stratum 6) on the west side of the road, and a stone drain (Fig. 4: stratum 9) slightly east of center.<sup>17</sup> Each supply line was composed of round, wheel-made, ceramic pipe segments, which were sealed with lime mortar.<sup>18</sup> They were placed on the western side of the road and oriented to the road's natural slope down from south to north. The stone drain was constructed with walls of limestone ashlar and stone cover slabs (lot 2004-24) just east of the center of the street. For most of its excavated length, the walls of the drain are 0.38 m apart, but they narrow to 0.12 m near the southernmost excavated point. An undated manhole (manhole 2003-1) at the northern end provided access for maintenance (Fig. 14). Other maintenance required the removal of the drain's cover slabs several times during its lifetime (Fig. 4: stratum 10).

Two additional major constructions occurred early in this period, soon after the stone drain was installed: an east-west drainage channel (Fig. 15) and a stone porch extending from the doorway at the north (Fig. 16). The east-west drainage channel (line 30: lots 2003-44, 2004-15) carried its contents from an unidentified source west of the road and deposited them into the stone drain in the center of the road. To construct this feature, builders tunneled under the road surface and through the western flanking wall to join the stone drain.

At about the same time, a raised limestone porch was built in front of the doorway against the western flanking wall.<sup>19</sup> The porch was set on top of road layers that date to the late 1st century (Fig. 4: stratum 7b). The lack of a construction trench on the southern edge of the porch makes it

17. All pipe segments are stored in lot 2007-47.

18. Lots 2004-20, 2003-77, and 2003-33 include material from the construction of lines 1, 2, and 3, respectively. Lot 2003-32 contains material from the fill of the robbing trench of line 3.

19. Lot 2002-7 includes the material that revealed the porch floor.



Figure 14. Manhole for the stone drain of the road. View from the north. Photo courtesy Corinth Excavations

clear that the porch was built on top of the road and not set into it from a higher level.<sup>20</sup> To facilitate this construction, three courses of ashlar stonework raised the level of the doorway's threshold to 93.00 masl. Five ashlar slabs formed the floor of the porch. A second course of ashlars was set on top of the floor at the porch's northern and southern edges in line with the orthostate jambs of the doorway, creating steps to the north and south of the floor and further elevating the porch from the road. A single stone remains of the raised eastern edge, and a preserved bed of mortar on the floor indicates that the rest of the blocks along that edge had been robbed. One of the ashlars incorporates floor and curb in a single block, indicating that the edging and floor were all part of a single construction event.

To the south of the porch and abutting it, a curious structure was found in the form of a robbing trench and a single unrobbed limestone ashlar block. It is reasonable to reconstruct two or three more ashlars in the line of the robbing trench, which lay parallel to the western flanking wall. Given the structure's scanty remains, it is difficult to suggest a function, but a bench or platform would be appropriate, given its position along the flanking wall and its length of 3.63 m (measured from the southern end of the in-situ ashlar to the northern end of the robbing trench). A pebble and cobble surface was found abutting the ashlar block, the robbing trench, and the porch.

At the end of phase 2, in the middle of the 2nd century, an east–west pipeline (line 4) was installed. This line is notable not only for its orientation but also for being the first instance of a pi-shaped line in this section

20. The fills that abut the north end of the porch were left unexcavated because they were beyond the limits of excavation, and the original deposits against the eastern edge were disturbed by the installation of line 3.

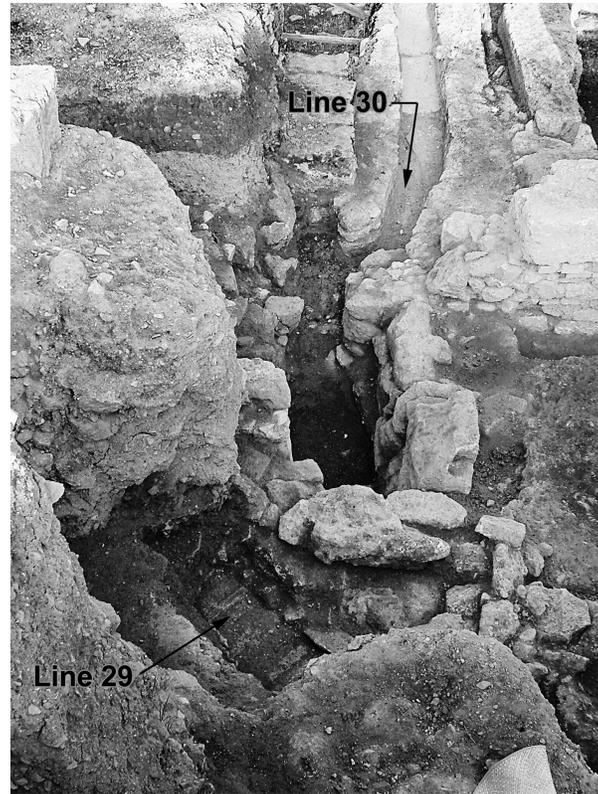


Figure 15. A series of drains (lines 29, 30) cut through the western flanking wall to empty into the stone drain. View from the east. Photo J. Palinkas



Figure 16. First-century limestone porch and the western curb wall. View from the southeast. Photo I. Ioannidou and L. Bartzoti

of the road; there are only two other examples of this type in the road.<sup>21</sup> The pi-shaped line carried water from an unknown source westward into a cistern located above the south wall of the Late Augustan Building. The cistern had a floor built of diamond-shaped terracotta tiles set into cement (Fig. 7), which was constructed against the western face of the road's western boundary wall.<sup>22</sup> A round supply pipe (line 5), this one oriented in the more typical north–south direction, was installed during the middle decades of the 2nd century (Fig. 4: stratum 12).

### PHASE 3: CONSTRUCTION OF SIDEWALKS, MID-2ND TO MID-3RD CENTURY

During the second half of the 2nd century, a radical change in the spatial structure of the road took place with the installation of curb walls, which elevated and formally divided the sidewalks from the roadbed (Fig. 4: strata 13, 14; Fig. 17).<sup>23</sup> With the introduction of the curbs, the road became ca. 2.20 m wide, the western sidewalk ca. 2.75 m wide, and the eastern sidewalk ca. 2.45 m wide (Fig. 13). In constructing the curb walls, builders packed cobbles and rubble into a wide and deep foundation trench and placed a single course of limestone ashlar blocks upon them.<sup>24</sup> The fills in the construction trenches on either side of the western curb date to the mid-2nd century.<sup>25</sup> When first installed, the western curb rose to a height of ca. 0.15 m above the sidewalk. Soon, however, sidewalk layers accumulated until the sidewalk surface became nearly even with the top of the curb wall. The eastern curb had similar rubble foundations, with one course of ashlar blocks preserved; a second course is likely to have surmounted the first.<sup>26</sup> The eastern foundation trenches did not provide conclusive dating evidence for the wall's construction. However, the similarity in construction of the walls and their elevations indicates that the curb walls are contemporary. A second course of ashlars was later added to the western curb to prevent the surfaces from covering it (Fig. 4: stratum 19). The second course stood as a visible boundary marker for nearly a century, at first ca. 0.40 m tall, but sidewalk layers eventually rose to cover them.

With the introduction of the curbs, two important changes in the strata took place. First, the sidewalks and road surfaces began to have distinctly different soil depositions. The sidewalk area continued to build up in thin layers (0.01–0.10 m) of fairly hard-packed soil or clay with small pebbles, but the road layers became thicker (0.10–0.20 m), with very hard-packed fills,

21. Segments from line 4 were not saved and could not be included in the catalogue of pipes.

22. By the late 2nd to early 3rd century, the cistern was backfilled. Later, before the construction of the domus, the walls of the cistern were robbed.

23. The sidewalks were thus added long after the plan of the Roman city had been formalized. As noted by Romano (2003, p. 288, n. 53), the sidewalks and roads, which were the

responsibility of the city to maintain, were not included within the surveyed area of the insulae.

24. Other than their height, the ashlars do not have uniform dimensions: H. 0.45, W. 0.60–0.66, L. 0.75–1.10 m. The construction of the first course of the western curb wall cut through the fill of line 8. Materials from the foundation trenches for the western curb are included in lots 2002-12 and 2004-17, and materials from the foundations

themselves in lots 2003-23 and 2004-16.

25. Lots 2004-17, 2002-12, 2003-23, and 2004-16 contain material from foundation trenches for the western curb wall. The material of the foundations for the west curb is lot 2004-17.

26. The preserved block from the eastern curb wall is 0.88 m long, 0.58 m wide, and 0.40 m high.

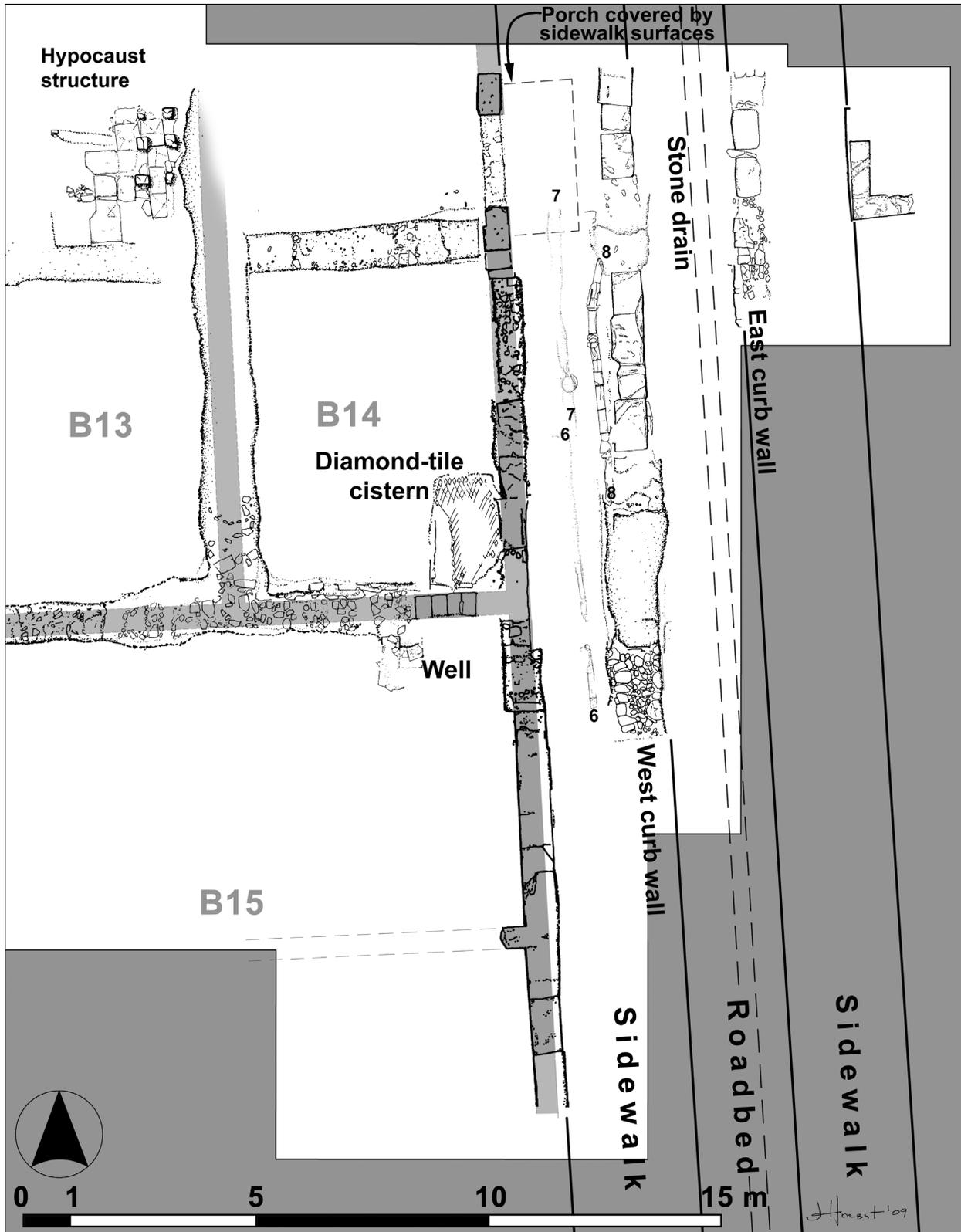


Figure 17. State plan of phase 3 of the road. Scale 1:125. J. A. Herbst

which included large pebbles and cobbles. Second, the sidewalk and road layers continued to rise steadily over time, but they also began to develop unevenly, with the sidewalks gradually becoming significantly higher than the road, and the western sidewalk rising higher than the eastern sidewalk.

Three new water-supply lines (lines 6–8) were installed into the western sidewalk during this phase.<sup>27</sup> These were all composed of round terracotta segments and oriented north–south. Two of these pipelines provide valuable information on the mechanics of water supply in the road. First, although most of line 7 was robbed in antiquity, excavators found a reused amphora body with its toe broken off, interrupting the path of the line.<sup>28</sup> The amphora functioned as a settling basin, which allowed suspended sediment and other particles in the water to settle out, delivering a cleaner water supply. Second, some segments of line 6, preserved to the southeast of line 7, included different forms and ceramic fabrics.<sup>29</sup> This mix could indicate that road engineers used two different types of segments in the same line at the time of installation, or that line 6 may have had a later repair, which was not detected during excavation.<sup>30</sup>

Later in the 2nd century, the sidewalk surfaces began to cover the porch at the northern end of the road. To protect the entrance, the threshold was raised 0.41 m by the addition of five blocks and a leveling course of cement and tile between the jambs (Fig. 4: strata 16, 17).

Beginning in the early 3rd century, the elevation of the western sidewalk increased until soil began to cover its curb (Fig. 4: stratum 17). As a result, the threshold was raised once again with the addition of another course of stones, which was later removed (Fig. 4: stratum 37).<sup>31</sup> Even without the physical division of the two curb walls, the road and sidewalk strata continued to exhibit distinctly different thicknesses, elevations, and matrices. At this time, the road matrix included clumps of iron, which often had expanded and rusted to incorporate pebbles and pottery fragments.

#### PHASE 4: LATER ROAD DEVELOPMENT, MID-3RD TO MID-4TH CENTURY

Phase 4 coincides with the broad reconstruction within the insula west of the road, which introduced a large Roman domus. East of the domus and adjacent to the road, several separate spaces continued in use (Fig. 3: B13–B15; Fig. 18).<sup>32</sup> Although later removal of the walls and subsequent overbuilding have left the domus in fragmentary condition, it was, without doubt, richly assembled and ornately decorated. Included within its walls

27. Lot 2003-20 contains material from the construction trench for line 8.

28. The amphora is saved as lot 2007-47:42. We thank Kathleen Slane for identifying it as a Dressel 6 type.

29. Lines 13, 19, and 20 also mix segments from two different groups.

30. The construction sequence of laying a pipe made repairs difficult to detect in separating the stratigraphy.

The trenches for the pipelines were cut and then backfilled with the same soil, and packed continuously by traffic on the sidewalks. Soil that was removed and replaced during the process of repair was the original construction soil and thus indistinguishable during excavation.

31. It is also possible that the doorway was completely blocked. This

higher threshold or blocking was robbed by the second half of the 13th century.

32. The construction date for the domus is based on the latest coin sealed beneath its construction levels. The coin (coin 1999-200) belongs to Valerian I (253–260). See Sanders 2005, p. 420, and Stirling 2008, p. 127, n. 83, for the chronology of the structure.

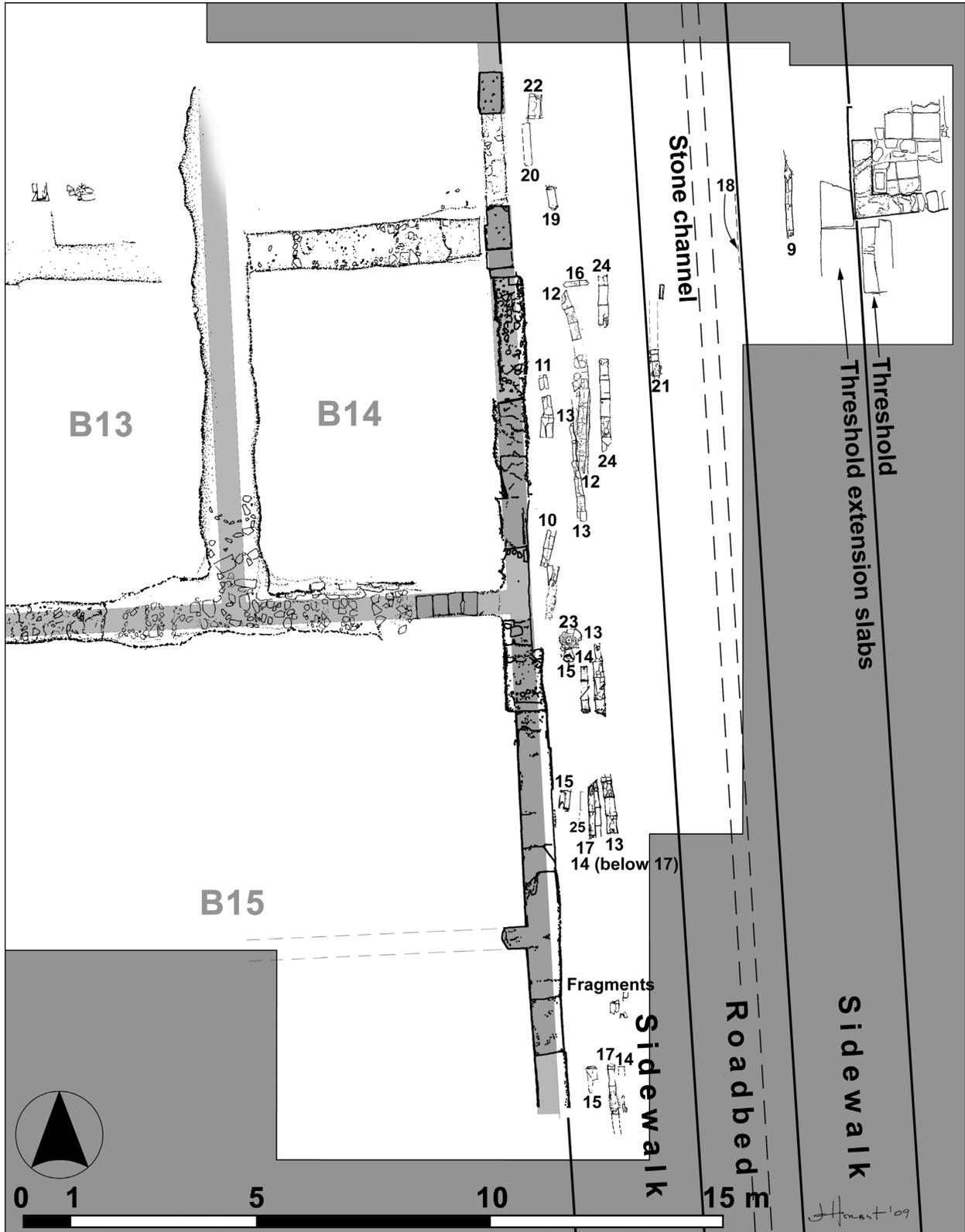


Figure 18. State plan of phase 4 of the road. Scale 1:125. J. A. Herbst



were two peristyle courts (Fig. 3: A1, A10), a fountain and pool rooms with marble and mosaic floors (A2, A8), elegant pictorial wall paintings, and a collection of small-scale sculptures that possibly indicate a domestic shrine.<sup>33</sup> The differing assemblages of material culture and a separate water-supply network in the domus indicate activities distinctly different from those in the rooms along the road (B13–B15).

During this phase, the roadbed and sidewalks continued to develop asymmetrically. Although it was not long before sidewalk layers completely covered the western curb, the eastern curb remained visible because the eastern sidewalk was maintained at a lower elevation (Fig. 4: stratum 23). From this time on, the eastern sidewalk had an elevation 0.40–0.70 m below the rest of the road. The ever-increasing elevation of the road surface would have necessitated the addition of at least one and probably two courses to the eastern curb wall to retain the roadbed. Unfortunately, however, direct evidence for these additional courses has not survived (Fig. 4: stratum 40). At this time the limestone porch went out of use, for it was completely covered by the earthen sidewalk (Fig. 19; Fig. 4: stratum 24). Across the road on the eastern sidewalk, limestone slabs were laid against the street's boundary wall in front of a doorway, creating a threshold and porch for a building.<sup>34</sup> Two of the slabs are preserved, but

**Figure 19.** Road showing western sidewalk strata with pipelines passing over the now-obscured porch. View from the south. Photo I. Ioannidou and L. Bartzioti

33. For a fuller discussion of the domus, see Sanders 2005, pp. 420–426. For studies of the sculptures, see Stirling 2008; for the wall paintings from the pre-domus and domus, see Lepinski 2008; for mosaics, see Sweetman and Sanders 2005.

34. The remainder of the building continues beyond the limits of the Panayia Field and remains unexcavated.

there may have been as many as three, set symmetrically on either side of the threshold (Fig. 4: block 22). Subsequent sidewalk layers immediately began to accumulate against the slabs, and a 3rd-century water-supply line (line 9) was installed next to them.

Also during this phase, several new round water-supply lines (lines 10–17, 19, 20, 22, 23) with north–south orientation were introduced into the sidewalks, particularly the western sidewalk (Fig. 4: 23, 29). One of these (line 23) included an amphora settling basin, although the remainder of the pipe had been robbed in antiquity.<sup>35</sup> Two more lines, one round (line 18) and one pi-shaped (line 21), were installed atypically in the road rather than in the sidewalk, although they were placed close to their respective curb walls. Thus, line 21 lay just to the east of the western curb and line 18 lay just to the west of the eastern curb. While the placement of these lines in the roadbed was not standard, they were located along the edges, and the maintenance of the lines would have disturbed the flow of traffic on the road itself as little as possible.

One result of the constantly rising levels of the sidewalk and roadbed was visible in the threshold of the doorway to room B14. The threshold was once again raised to accommodate the increased elevation of the sidewalk and road. The pace of construction on the street continued steadily until the early to mid-4th century, when the latest preserved road and sidewalk surfaces and two more water lines (lines 24, 25) were installed. Perhaps the extensive development of the street during this phase and the construction of the domus indicate a quickening of building activity in the second half of the 3rd century in this part of the city.

#### PHASE 5: LATER HISTORY OF THE ROAD, LATE 4TH TO 12TH CENTURY

When fire destroyed the domus in ca. 370, the nature of the road in the Panayia Field began to change.<sup>36</sup> Instead of the discrete layers that had previously constituted the road, deeper fills began to accumulate over the road and sidewalks. These fills were distinguished from the road layers of earlier phases by their larger and more frequent pebble and tile inclusions, perhaps the result of waste brought by demolition and ruin of the domus that spilled over into the street. This was an important signal during excavation that careful maintenance of the road was no longer taking place. On average, these fills were ca. 0.30–0.50 m thick, in contrast to road layers, which were, on average, 0.10–0.20 m thick (Fig. 4: strata 25a, 25b).

Only two water-supply lines and one drain (Fig. 20: lines 26, 27, 31) were installed during these years. Composed of the same cooking-ware fabric, these supply lines were installed on either side of the road. Each is oriented northeast to southwest. Line 26, a pi-shaped line, was installed through the western curb wall, and line 27 was installed through the eastern

35. The settling basin is saved as lot 2007-47:43. We thank Kathleen Slane for identifying the amphora as likely to be an African type, but with a fabric inconsistent for the type.

36. See Slane and Sanders 2005, p. 246; Stirling 2008, p. 127. There is ash and burned debris on the floors of the domus. Coins in these destruction levels support this date.

boundary wall to supply the structure to the east. Line 31 is a drain constructed with rubble walls and a tile floor and cut through the eastern flanking wall.

Two earthquakes, in ca. 365 and 375, are described by literary sources.<sup>37</sup> These references coincide with archaeological and epigraphical evidence of destruction and rebuilding in the city. The Panayia Field seems also to have been the site of significant destruction, but without immediate rebuilding.<sup>38</sup> After a period of abandonment in the 5th century, a new domestic apsidal structure was constructed reusing some of the domus's mosaics, and located about 40 m west of the road.<sup>39</sup> In the 6th century, several pits and other such intrusions heavily disturbed the road, although its path was still respected. Line 28, pi-shaped and with cover tiles, was the last line installed in the road.<sup>40</sup> At its southern end, it is oriented northwest–southeast, but at its northern preserved end, it curves more emphatically toward the west-northwest. The lifespan of this line was short: it was heavily disturbed by a series of pits dating to the 6th century.

The upper courses of the eastern flanking wall were robbed in the 6th century. The road was left without formal divisions from the adjoining property, but, at the same time, its path was unobstructed. Stones from the eastern boundary wall and the domus were used in the construction of one or both of the 6th-century buildings in the Panayia Field: the bath and the long building (Fig. 20).<sup>41</sup> The small freestanding bath was constructed some 10 m from the road, and the partially exposed long building was built against the road's western boundary wall.<sup>42</sup> Both buildings were oriented to the Roman grid. Interestingly, the bath with its small-capacity plunge pools did not draw water from the road.<sup>43</sup> The long building also included a tile-lined drainage channel with cover tiles (line 29), which emerged from the easternmost basement room and continued in a northeasterly direction to the stone drain in the road (Figs. 15, 21).<sup>44</sup> North of the long building and postdating its construction are several burials along the road with an east–west orientation.<sup>45</sup> While the road was no longer carefully maintained, and its utility as an artery for water and waste management was dwindling, these activities suggest that it was still an important topographical landmark in the neighborhood, and most likely still a traffic route.

In the 9th or 10th century, the bath and long building were dismantled, and fills began to accumulate in the road's stone drain.<sup>46</sup> While the small

37. The primary source for the earthquake in ca. 365 is Ammianus Marcellinus (26.10.15–19), while the primary source for the earthquake of ca. 375 is Zosimos (4.18). For discussion of the literary accounts, as well as archaeological and epigraphical evidence, see Robinson 2001, pp. 124–127; Brown 2008, pp. 91–94, 100–106. For further discussion and reassessment of these earthquakes, see Sanders 2004, pp. 170–172; see also Rothaus 2000, pp. 17–21. The date of the 375 earthquake is being reevaluated by Charles

Williams in the context of the East Theater Street excavations.

38. As Stirling (2008, p. 127) noted, the fire that destroyed the domus could have been the result of an unrecorded earthquake.

39. Sanders 1999, p. 444. As Sanders (2005, p. 426) has reported, a coin on this building's earliest preserved floor dates to ca. 450.

40. Construction of line 28 cut through fill dating to the 5th century; packing to the sides of and below the pipe dated to the 3rd–5th century.

41. For the bath, see Sanders 1999; 2005, pp. 426–427.

42. For the long building, see Sanders 2005, p. 428.

43. Perhaps a nearby well, such as well 1999-1, was enough to supply its needs (Guy Sanders, pers. comm.).

44. The origin point of the drainage channel is unknown, but it is likely that it served the long building.

45. See Sanders 2005, p. 428. The latest of the graves dates to the 7th century.

46. Slane and Sanders 2005, p. 246.

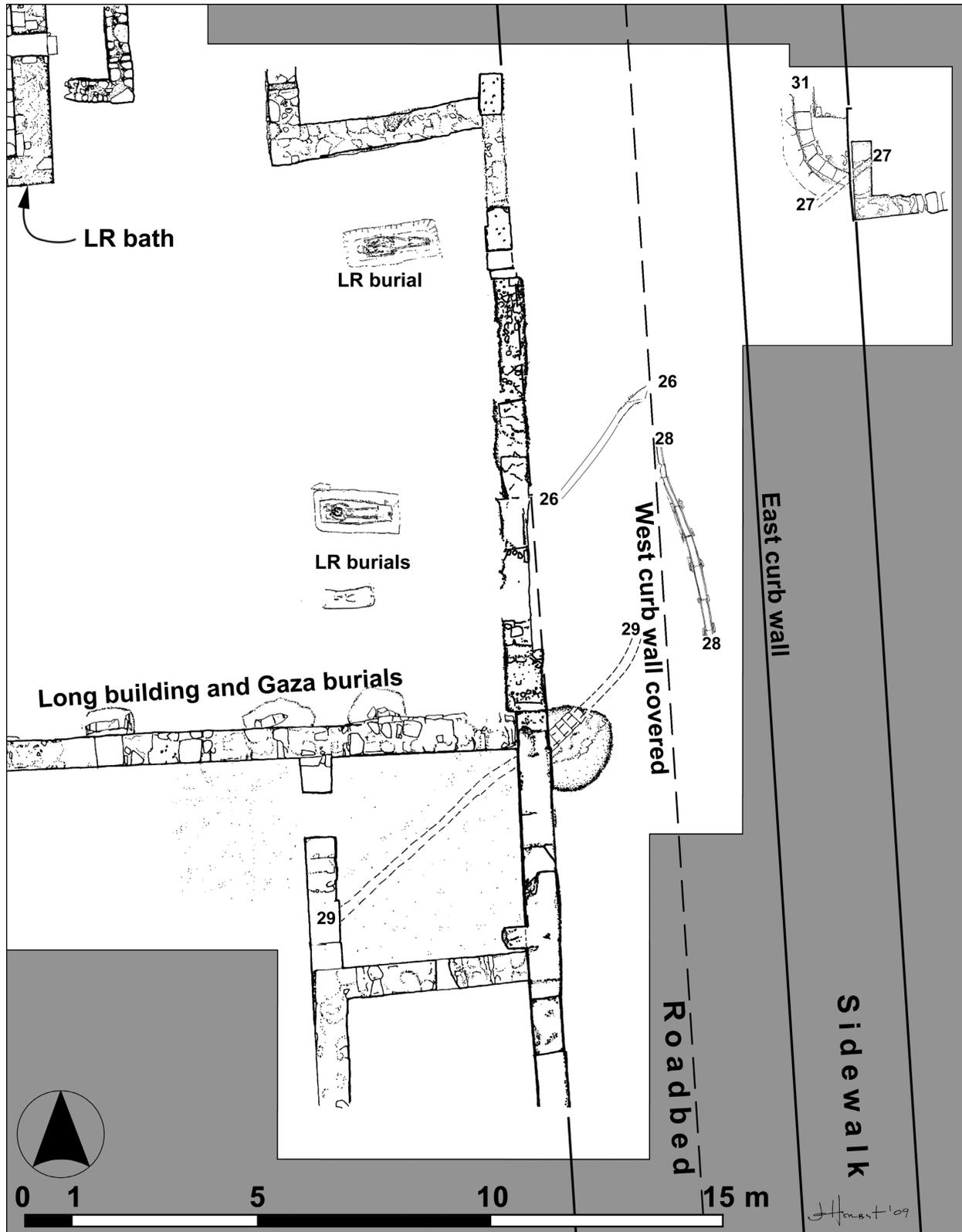


Figure 20. State plan of phase 5 of the road. Scale 1:125. J. A. Herbst



Figure 21. West sidewalk looking toward the long building and line 29. View from the northeast. Photo I. Ioannidou and L. Bartzoti

amount of fill excavated inside the drain dated no later than the 5th century (Fig. 4: stratum 33), it is clear that this date does not represent the time when the drain went out of use.<sup>47</sup> Not only did the stone drain connect with the drainage channel from the long building, but regular maintenance of the drain also continued until the 9th or 10th century (Fig. 4: stratum 34). At that time the manhole for servicing the drain was allowed to close.

The last documented activity in the road was the removal of stones from the remaining curb and flanking walls, perhaps beginning in the 11th century (Fig. 4: strata 36, 39, 40). The lower courses of the eastern flanking wall were robbed in the 11th century, the western curb wall in the 12th century, and the western flanking wall as late as the 13th century.

## URBAN AND SPATIAL CHARACTER: THE STREETScape

From the detailed archaeological history, a local picture of changing urban fabric emerges around this small portion of road in the Panayia Field. To highlight this development in the following summary, we have visualized the experience of a user on the road at critical moments in its development when spatial changes had the greatest impact. This experiential approach raises questions regarding boundaries, public and private space, civic maintenance, ownership, and urbanization in this part of the city.

In the Late Augustan period, or early phase 1, the properties adjacent to the road contained several small, freestanding, lightly constructed buildings that dotted the landscape. The road itself was amply wide for

47. Fills inside the water channel are saved in lot 2003-21.

two-way traffic. Although there may have been a simple wall or stone demarcating the road from the properties, any indication of an early boundary established by the *agrimensores* was destroyed by later construction.<sup>48</sup> In its first decades of existence, the unambiguous spatial quality of the road experienced by pedestrians and wheeled traffic was wide and open, with largely unobstructed views of the landscape around it. In these early phases, the road was an artery that skirted the center of the city without requiring passage through the forum. Indeed, the close proximity to the forum and to the limestone-paved decumanus to the north would suggest that this area was highly trafficked.

Later in the 1st century, accompanying major construction of the insulae that flanked the road, there was a marked transformation in both the user's experience and the structure of the street front. The walls flanking the street were heavily founded, load-bearing, and constructed with strength to support multiple stories. High, solid structures eliminated any view of the surrounding area. Consequently, the open feeling of the road in the preceding phase changed to one of enclosure, with the user's attention shifting inward. Uniform monumental architecture, such as colonnaded walkways, never adorned the facades, as it did on the Lechaion Road.<sup>49</sup> Instead, idiosyncratic vernacular elements punctuated the street front, such as the limestone porch of phase 1 with its small bench or platform on the west side and the threshold extension of phase 4 on the east side. These features suggest that local inhabitants were personalizing public space to suit their own needs. The limestone porch is an interesting case, for its raised edges certainly kept wheeled traffic from crossing it. Inhabitants were thus not only personalizing "public" street space, they were also controlling it. As more buildings were constructed along the roads, demand increased for clean water. At the same time, the roofs of those structures directed more water into the streets. Accordingly, soon after the flanking walls were built, the street's earliest utility systems were installed. A stone channel provided waste management and water runoff, while the first ceramic pipelines provided a clean supply of water. From a pedestrian's point of view, this was certainly a welcome change that alleviated messy and muddy street conditions. Along with the water lines and drains, workers acting in the role of *aquarii*, or plumbers, emerged as additional figures in the streetscape, hindering traffic by digging up the roadbed, implementing repairs, and installing new lines.<sup>50</sup> Life on the street reflected the urbanization accompanied by widespread construction during this phase.

The road in the Panayia Field is unusual in that it never received limestone paving, as did many near the forum in the late 1st century.<sup>51</sup> While limestone paving was ostentatious and impressive, it was also expensive,

48. For Roman surveyors, see Romano 1993, p. 21.

49. *Corinth* I.1, p. 138.

50. While a professional cadre of *aquarii* may have existed in Corinth, water technology was simple enough that it could perhaps have been handled by a general contractor using a team of slaves or workmen with relatively little training. We thank one of the anony-

mous *Hesperia* reviewers for making this suggestion.

51. See Williams, MacIntosh, and Fisher 1974, pp. 32–33, for a date of the third quarter of the 1st century for the paving of the Lechaion Road. As mentioned above, Robinson's excavations south of the South Stoa are currently being reexamined, but see Robinson 1965, p. 290, and 1966, p. 133,

for 1st-century dates for the decumanus and cardo in that area. The paved east–west street that terminated at the theater received paving in the second half of the 1st century; see Williams and Zervos 1982, p. 128. The road east of the Julian basilica was paved at the end of the 1st century or later; see *Corinth* I.5, p. 51.

heavy to transport, and labor intensive, requiring the work of masons. Earthen paving, on the other hand, was an economical choice for a heavily trafficked road. Wheel ruts and potholes in earthen paving were simply filled in and tamped down using unskilled labor. The unpaved surface would also have facilitated the installation and maintenance of the large set of water pipes and channels throughout the lifespan of the road.

In the mid-2nd century, curbs divided the street, separating pedestrian and wheeled traffic. The curbs drastically narrowed the roadbed, limiting wheeled traffic to a single direction and forcing pedestrians to navigate high steps to cross the street. As a narrower, one-way street, the road may have become a less important, less trafficked artery within the city grid at this time.<sup>52</sup> On the one hand, sidewalks restricted wheeled traffic, but on the other hand, their presence may have invited more pedestrians and been conducive to other types of activities. While the motive behind the alteration is unclear, it is tempting to see the narrower road and new sidewalks as a sign of the maturing needs of a growing and ever-more-urban district of Corinth.

Besides traffic flow, other practical advantages related to water management lay behind the installation of curbing. First, when the drainage system became inundated during the torrents common in Ancient Corinth, raised sidewalks allowed pedestrians to stay drier, while permitting runoff to flow down into the roadbed. Second, sidewalks provided an area for the installation of an ever-increasing number of ceramic pipelines where their construction and maintenance would not hamper wheeled traffic.<sup>53</sup> After the curb construction, the two sidewalks began to develop unevenly, with the east side carefully maintained at its original elevation and the west side allowed to rise dramatically with the road. The rising western sidewalk resulted in costly modifications to the road, with additional courses of stone added to the curbs. Subsequently it was necessary to raise the threshold of the doorway. Reasons for this peculiarly lopsided growth are elusive, for the construction was seemingly an expensive solution, the benefits of which are unclear.<sup>54</sup>

The curbs were not a permanent feature of the streetscape, for within decades the western curb was covered by the surface of the sidewalk. Without the physical impediment of the curb, it is likely that greater freedom returned to the use of the road, with pedestrian traffic mixing with wheeled. The greatest number of supply-pipe and drain lines was installed in the road and its sidewalks between the mid-3rd and mid-4th century. With the increased number of lines, construction and maintenance of the utility lines must have been a constant activity along the street.

Following the conflagration of the domus in ca. 370, when the rooms adjacent to the road (B13–B15) were dismantled and the domus left in disrepair until the 6th century, the road retained the same form, with the single eastern curb wall dividing traffic, but with the flanking walls partially standing. The domus fire seemed to mark the beginning of a slow process of counter-urbanization in the area of the road. In the 6th century, the dismantling of the insula walls provided construction material for the long building and another structure to the north built against the western boundary wall. Behind the remnants of the walls, burials were placed in the

52. Cf. Poehler 2006, p. 72. At Pompeii, the greater number of wheel ruts in two-way streets indicates that such streets were more important than one-way streets.

53. Cf. Poehler 2006, p. 57. One benefit of high curbs at Pompeii was controlling water runoff.

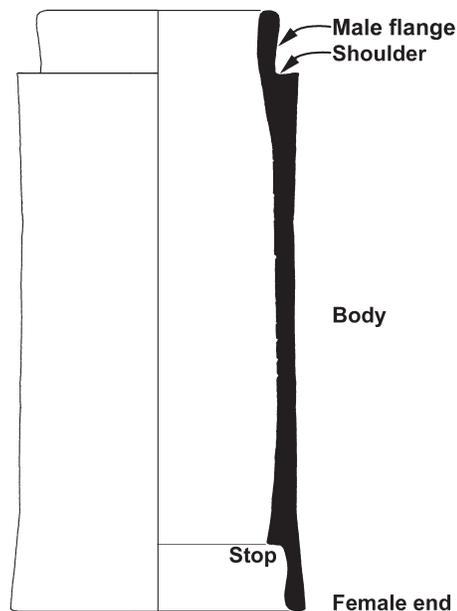
54. In other parts of the city, there are parallels for road and sidewalk surfaces rising in different ways at different times. For instance, Robinson (1965, p. 290) reported a similar and seemingly odd treatment of later road levels for the paved *cardo* leading south from the South Stoa: "By the 12th century the ground level had changed considerably and while the southern extremity of the Roman paving was still exposed, the northern portion [nearer the South Stoa] was buried under at least a meter of earth." Farther west, the paved roadbed of the *decumanus* south of Temple E was covered with earth in the Late Roman period, while the limestone paving of the sidewalk adjacent to it remained uncovered until the Byzantine period; see Williams and Zervos 1987, p. 3.

area between the structures and the bath. With the loss of the large-scale architecture of the insulae, the experience of the street front changed, and a more open feeling was restored. Perhaps the Late Roman structures and the activities that went on inside them served to keep the area structured and working. Further pits, fills, and the robbing of the walls toward the end of the road's maintenance indicate liberation from the narrow passages that dictated traffic and the visual impediments of the boundary wall. Yet the remaining courses of the insula walls still delimited the road. Finally, in the 12th century, with the further robbing of the flanking and curb walls, the space was left without formal demarcation, although the general path was respected. The experiential history of the road had come full circle: once again it was a wide and open path, as it had been in its earliest phase.

## PIPELINES

Segmented terracotta pipelines were a vital portion of the hydrologic cycle in Roman Corinth. Buried beneath the road surface, the pipelines were paradoxically a large part of the experience of the road due to the activity and investment in water and waste systems. With 27 pipelines installed within the confined space of the sidewalks and the road, there must have been repeated installations and repairs, with new replacement lines often cutting through older, obsolete ones. As such, the degree of preservation of individual lines is variable: some lines extended unbroken over several meters, with more than a dozen segments preserved, but many more lines are represented by only a few segments or less. In one case, a pipeline is represented by a nearly empty robbing trench, which contained only a settling basin and fragments of pipe (line 7). The pipelines introduce significant aspects of Roman water and waste technologies, such as the relationship of form and function in different types of pipes, construction practices for laying pipe, maintenance, and, more elusively, possible water sources and final destination of the lines. In addition, the number of wheel-made pipelines is sufficient to allow us to propose a typological sequence covering five centuries.

Two types of pipe—square pi-shaped and round—were installed in the road in the Panayia Field, each offering various benefits that suggest their suitability for use as supply- or drain-lines. Round, wheel-made pipes were the predominant type, accounting for 24 lines, while only three examples were found of inverted pi-shaped channels with cover tiles. Round pipes, which had considerably less exposed joint per segment, created a tighter and cleaner system. Because they formed a closed system, round pipes were more difficult to open and maintain when clogged. Pi-shaped lines with removable cover tiles allowed for easier maintenance without compromising the integrity of the conduit (Fig. 22). However, the pi-shaped lines were more prone to leaking and considerably more permeable to dirt, roots, and other intrusions. Each segment had considerably more joined surface area and pieces that were sealed with lime mortar. Consequently, the advantages and disadvantages of each form suggest their function: the round pipes were more suitable for conducting clean, constantly flowing



water, which was free of clog-causing substances, and the pi-shaped channels were more appropriate for carrying waste or fluids that increased the likelihood of clogging and maintenance.

Typical construction practices and features emerged from the body of material gathered from the pipelines. All the lines were composed of terracotta segments joined by lime mortar. Terracotta pipe was the more economical and healthy alternative to lead, according to Vitruvius (8.6.10), who also advised that the joints of terracotta pipes be sealed with a mixture of quicklime and oil (8.6.8).<sup>55</sup> Hard, white lime mortar is preserved on the male and female ends of a great number of examples noted below. Both round and pi-shaped types employed a joining system in which a narrowed male flange fit into a female opening (Fig. 23).<sup>56</sup> Because constricting the male end would reduce the flow, the female end of the round pipes was sometimes widened to counteract this effect. The widening of the female end was often manifest as a step or stop, but just as often the female end was simply wider.

Builders laid each series of pipe into a trench, which was usually shallow, and backfilled it. Most of the lines in the road ran reasonably straight over their preserved lengths. Elbow joints and similar shapes were unnecessary in long runs of piping, for the tolerance of the joints provided enough “play” to allow for minor directional changes in each segment of the lines.<sup>57</sup> Line 27, for instance, traced an S-curve without special joints. Once the pipeline was functional, water was not conducted through the pipes by pressure, but rather, the pipelines sloped down toward the north, allowing gravity to direct the water.<sup>58</sup> Thus, most of the pipelines from the road have a north-south

Figure 22 (left). Pi-shaped segment 28.2 with cover tile 21.3. Photo J. A. Herbst

Figure 23 (right). Generic round pipe segment with part names designated. Drawing J. A. Herbst

55. Linseed oil is added to quicklime as a plasticizer and for additional waterproofing. Because linseed oil dries, it was chosen over other oils, such as olive.

56. Vitruvius (8.6.8) noted that the male end is tongue-shaped, or *lingulatus*.

57. Landon 1994, p. 371.

58. Repair holes in several segments, covered with pieces of tile, indicate that the pipes could not have conducted water through pressure. See also n. 60, below, for discussion of the need to relieve pressure in the lines at intervals.

Thus, both in theory and in practice, the pipelines were not pressurized. Landon (1994, p. 368) noted that a gradient of 0.114% (a fall of 0.04 m over a length of 35.00 m) is enough to allow water to flow through the pipes without added pressure.

orientation, with only one example with an east–west orientation (line 4) and one northeast–southwest (line 26).

Several problems existed in the technology of water supply, as indicated by the frequency of lines that cut through earlier obsolete ones and by the number of repairs and patches in the round lines. Corinth's ancient water system, like its modern counterpart, was plagued by excessively hard water, due to minerals picked up from the ever-present subsurface marl. These minerals gradually constricted water flow.<sup>59</sup> Scaly lime accretions, often nearly 0.01 m thick, were found on the insides of many of the round pipelines from the road. It is doubtful that Roman technology had a solution for hard water. Thus, when a line succumbed to increasingly narrow flow due to scale, the line had to be replaced. Two seemingly unrelated problems—insoluble sandy particulates in the water and a buildup of pressure that could cause leakage in sealed lines—were solved by placing settling basins at intervals along the length of the pipeline. Settling basins simultaneously slowed the water flow, allowing sandy particles to drop out, and allowed pressure to escape through its lid, which could be accessed for cleaning the basin.<sup>60</sup> Settling basins were uncovered along two of the round pipelines (lines 7, 23) in the form of amphoras with holes broken in the sides, into which pipe segments were sealed with lime mortar.

These various issues meant that pipeline maintenance was a constant activity on Corinth's roads. To clean out the pipes, holes were broken into the tops of segments, the blockage was removed, and the hole was covered with a ceramic fragment and mortar (lines 3, 8, 11, 12, 20; Fig. 24). Another way to repair a water pipe was to remove clogged or damaged segments and replace them with new segments. There seemed to be little concern for matching replacement segments to the fabric or dimensions to the original line. Two lines include narrow- and wide-diameter segments (lines 10, 11) mixed in a single line, while other examples include segments from multiple typological groups (lines 6, 20). Occasionally, pipelines were partially or entirely removed from the road, perhaps because they were deemed beyond repair or because a newer, more efficient water pipeline was installed (lines 5–7, 23). It is clear that repairs were done as needed, with the primary focus on improving the function of the pipes, and not on aesthetics or form.

Other technological questions regarding water supply, such as the origin and destination of the water, are more difficult to answer. Specific sources of water for the road's supply lines are unknown. During the first two centuries of the Roman colony, sources for the pipelines included the springs, wells, and cisterns for which Corinth was famous.<sup>61</sup> The line of the road in the Panayia Field is found nearly midway between two known natural water sources, Hadji Mustafa and Kakavi, important springs that are high enough on the slopes of Acrocorinth to have supplied water to the forum.<sup>62</sup> Because of the distance between the road and the springs, and because much of the city on the upper terrace relied so heavily upon these two springs, it is perhaps more likely that cisterns and other sources fed the water lines. After the mid-2nd century, the Hadrianic aqueduct augmented Corinth's water supply and most certainly played a role in the ever-increasing number of water lines that were installed in the road.<sup>63</sup> Line 4 is the only conduit with a known terminus: the diamond-tile cistern.

59. Landon 2003, p. 44, nn. 6, 7.

60. For water systems built of aqueducts, lead pipe, and terracotta pipe, Vitruvius (8.6.6–9) suggests the insertion of vents, or *κοιλία*, at low points to relieve pressure and air that would destroy joints in the pipe or even the stone of an aqueduct channel.

61. Landon 2003, pp. 54–55.

62. Landon 1994, pp. 174–178. Measured perpendicularly to the line of the road, Hadji Mustafa is ca. 430 m to the west and Kakavi is ca. 460 m to the east.

63. Biers 1978; Landon 1994, pp. 342–365; 2003, pp. 55–57; Lolos 1997.



Figure 24. Line 8 showing holes broken in the pipe, which was then covered with tiles. View from the north. Photo J. Palinkas

Other roads in Corinth similarly incorporated water pipes and drains: the east–west road north of the Great Bath on the Lechaion Road, the road east of the Julian basilica, the decumanus south of Temple E, and the Lechaion Road. No other road, however, is known to have had so many lines spanning such a broad chronological range.<sup>64</sup>

Excavation of the lines from the road in the Panayia Field has greatly increased the number of known examples of pipes from the Roman period in Corinth. Previously, Roman pipes were thought to have had generally uniform characteristics: a concave, slightly biconical exterior body shape with wider ends, narrower at the center, and lacking stops at the female end.<sup>65</sup> However, the pipes from the Panayia road demonstrate a more complex variety of distinguishing traits across time. Because the corpus is tightly sequenced chronologically, we are able to propose several typological groups.

64. See De Cou 1897, p. 498 (road north of the Great Bath on the Lechaion Road); *Corinth* I.5, p. 51 (road east of the Julian basilica); n. 2, above (decumanus south of Temple E); Hill

1927, pp. 75–77 (Lechaion Road).

65. See Landon 1994, p. 370. Landon uses this general description of Roman pipes to offset the Hellenistic pipes in his corpus, which were usually

consistent in their exterior diameter or cylindrical; at the female end they were “carefully cut back to form a neat, sharp-edged socket or sleeve,” or, in our terminology, a stop.

## PIPELINE SEQUENCE GROUPS

The round pipelines have been catalogued and divided into three main groups, A–C, based on formal composition, ceramic fabric, and chronology (Fig. 25). Pi-shaped lines compose a fourth division, group D. A general description of the characteristics of each group follows below. The ceramic fabrics and a detailed catalogue of typical pipe segments are presented in the appendix, along with a table summarizing selected pipe measurements and other data (Table 1).<sup>66</sup> Individual pipe segments are named with two numbers separated by a period: the first number is the designated number of the line as referred to in the text and on the phase plans, and the second number is a sequential number of a given segment. For example, the entry named 6.2 is the second segment from line 6. The segment numbers are random and no notations were made in the field regarding which segments were adjacent in a given line.

### GROUP A

Group A consists of the earliest Roman round wheel-made pipes dating to the late 1st century. They are long, narrowly proportioned pipes with thick walls varying from 0.016 to 0.020 m. The body is cylindrical and sometimes uneven or slightly undulating. The male flange tapers slightly from the shoulder, constricting toward the lip. The lip at the male end is square or sharp at the exterior and beveled toward a rounded interior. The shoulder at the male end is sharp but not square to the body or the male flange: the shoulder slopes, forming a slightly obtuse angle with the body and flange. The female end has a stop, and the lip is beveled to mirror the male shoulder. These are the largest and heaviest pipes. The segments range from 0.680 to 0.784 m in length and 0.165 to 0.180 m in exterior diameter; they weigh between 10.1 (est.) and 16.70 kg. Group A pipes are found in lines 1, 2, and 3 and use ceramic fabric types 1 and 2a.

Development of wheel-made water pipes after group A follows two paths, both resulting in smaller, lighter segments: shorter, larger-diameter, thick-walled pipes with stopped flanges at the female end (group B); and narrow-diameter, thin-walled pipes without stops (group C).

### GROUP B

Pipes in group B have a chronological range from the early 2nd century to at least the late 3rd century. They are short-segmented, thick-walled, large-diameter pipes. Most have a stop at the female end. The bodies of this pipe group are consistently concave and shaped like an hourglass. The diameter ranges from 0.170 to 0.250 m, while the length varies from 0.395 to 0.493 m; the segments weigh between 4.9 (est.) and 8.8 (est.) kg. Early-2nd-century pipes of this group have sloping rather than square shoulders. Later shoulders are perpendicular to the body of the pipe. Another possibly diagnostic feature occurring from the mid-2nd century to the mid-3rd century is that the stop is pinched up on the interior of the pipe, as in segments 6.1, 12.1, and 13.3, rather than built up out of the body as in the other examples. Group B pipes come from lines 5, 11, 12, 22, and some segments from lines 6, 10, 13, 15, and 20. Fabric types 2b, 2c, and 2d are represented in this group.

66. In all, our database contains descriptions for 151 pipe segments or fragments. Of these, 26 significant pipe segment descriptions are presented in the catalogue and 91 segments are summarized in Table 1. Measurements in the following descriptions of groups A–D are intended to serve as a general guideline for field identification, combining actual dimensions and estimated (est.) restored measurements.

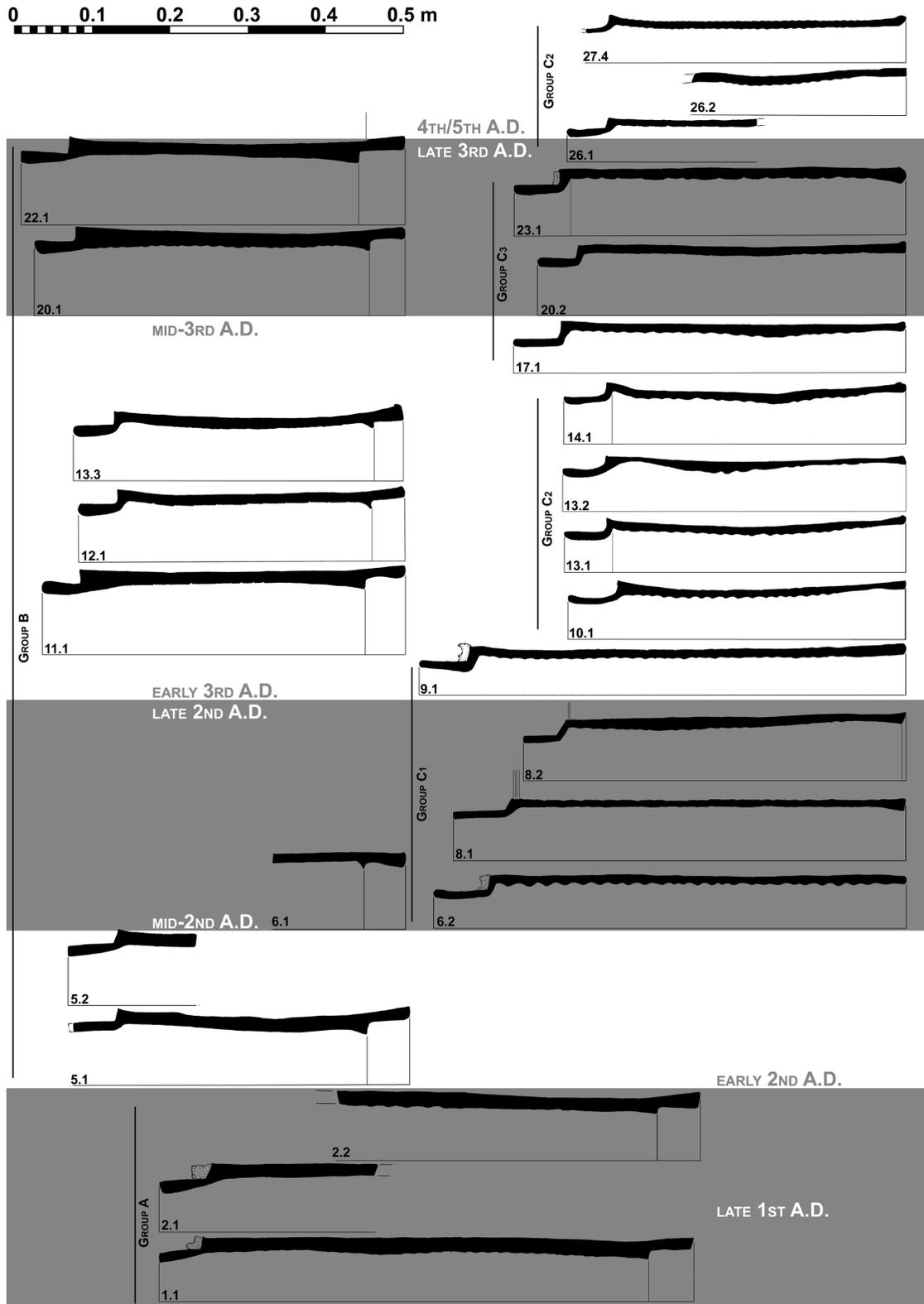


Figure 25. Timeline showing typological groups of the round pipelines from the Panayia road. J. A. Herbst

## GROUP C

Divided into three subgroups, group C pipes are narrowly proportioned and mostly thin-walled water pipes, which lack a stop at the female end. All examples exhibit at least some finger ribbing on their interior surfaces, and heavy, sharp finger ribbing is a nearly exclusive characteristic of this group.<sup>67</sup>

Group C1 ranges chronologically from the mid-2nd to the early 3rd century, consisting of long, narrow, thin-walled cylindrical pipes. These are visibly smaller in all dimensions than group A pipes. Segment length varies from 0.554 to 0.634 m, maximum exterior diameter ranges from 0.129 to 0.170 m, and the wall thickness is between 0.008 and 0.015 m. The thin walls keep the weight of the pipes light, between 3.6 (est.) and 6.8 (est.) kg. Group C1 shares the characteristic sloping shoulder with other late-1st- to late-2nd-century lines. The male flange lip can be square (Fig. 25: 8.1, 8.2), like many early examples from other groups, or rounded (Fig. 25: 6.2, 9.1), as seen in many later pipes. The female lip can be beveled inward (Fig. 25: 8.2), like examples from group A, as well as rounded or square (Fig. 25: 6.2, 9.1). The transition between the body and the male flange is not built up on the interior. Examples come from lines 8 and 9, and most segments are from line 6. Fabric groups 2b, 2d, and 4 are represented in this group.

Group C2 spans a broad period from the early 3rd to the 4th/5th century. The pipes are short, lightweight, and thin-walled, with a concave, hour-glass-shaped body. This group closely resembles group B in body shape and segment length, but it lacks a stop at the female end and is much smaller in diameter. Sizes range from 0.115 to 0.247 m in diameter, and 0.232 to 0.453 m in preserved length. Wall thickness varies between 0.009 and 0.019 m, and the pipes weigh 2.1 (est.) to 4.5 (est.) kg. The male flange rim can be cylindrical, but more often it flares out to a round lip, while the transition from the flange rounds out to the shoulder, which is square where it joins the body of the pipe. At the interior this transition can be built up (Fig. 25: 10.1, 13.2) or not (Fig. 25: 13.1, 14.1). The rim of the female end is thickened slightly, and the lip often has an exterior groove (Fig. 25: 13.1, 13.2) or an impression where the lip is thickened outward (Fig. 25: 14.1). In this group are lines 11, 13, 14, 26, and 27, and some segments from line 10. The fabric groups represented include 2c, 2d, and 3, and some of the latest examples from C2 were fabricated using a cooking-ware ceramic, fabric group 6.

Group C3 pipes originate from strata that date from the mid- to late 3rd century. They are larger in diameter and more thickly walled pipes than the rest of Group C, but they still characteristically lack a stop on the female end. These closely resemble group C2, but the bodies are longer with a less concave, more cylindrical shape. Measurements range from 0.133 to 0.196 m for exterior diameters, from 0.440 to 0.507 m in length, from 0.012 to 0.019 m in wall thickness, and from 4.4 (est.) to 5.5 (est.) kg in weight. The male flange is cylindrical with a rounded lip. Some examples exhibit a very slightly sloping shoulder but not to the degree seen in group A, early group B, and group C1 pipes. The rim of the female end is thickened in various ways. It can be thickened inside and out to a round lip (Fig. 25: 17.1), thickened outward to a mostly square lip (Fig. 25: 20.2), or thickened inward to a round lip (Fig. 25: 23.1). Lines 17, 23, and some segments from line 20 constitute group C3. Fabric groups 2d, 3, and 4 are represented.

67. Indeed, it is difficult to understand why such deep ridges were acceptable on the interior pipe surfaces. Surely they would have hampered the speedy water flow and perhaps increased the instances of clogging.

## GROUP D

The pi-shaped lines of group D (Fig. 22) cover a period from the early 2nd to the later 4th/5th century. Most demonstrate a consistent width along the length of each segment, with the exception of 28.2, which flares more widely at its female end. The thicknesses of the walls and base vary slightly, the walls undulate slightly, and finger grooves are often preserved on the walls and base; these features are consistent with the fact that the pi-shaped pipes were handmade. The ends of the pipes are generally square. A few of the cover tiles that surmounted the pi-shaped lines are preserved. Segments range from 0.683 to 0.730 m in length, with wall thicknesses between 0.015 and 0.038 m, and from 2.75 (est.) to 9.7 (est.) kg in weight. Lines 21 and 28 make up group D, which were often constructed of fabric 5.

## THE PANAYIA FIELD AND CENTURIATION

Exploration of the evolving spatial character and hydrologic technologies of the Panayia Road contributes to the understanding of this district of Roman Corinth at a local or human scale, while the position of the road provides information germane to issues of design at an urban scale. The addition of this new *cardo* with both sides definitively located refines our knowledge of centuriation, the gridded division of the countryside around a newly established colony. Ancient sources report that the Greek city was destroyed by Mummius in 146 B.C. and that a Roman colony was subsequently established by Julius Caesar in 44 B.C.<sup>68</sup> There remain, however, questions about precisely when and how the city was planned. Since the mid-1980s, researchers have proposed several gridded centuriation systems. A variety of analytical methods have amassed layer upon layer of data from field reconnaissance, topographical surveys, archival maps and plans, aerial photographs, and GIS. From this data, no fewer than six centuriation schemes have been proposed, often with a dazzling array of overlapping skewed grids. Mary Walbank asserted that the colony was founded in harmony with traditional Roman practices and rituals, and that the city was not simply a continuation of the Greek plan.<sup>69</sup> Her plan presented major Roman roads largely within the confines of the Classical city walls. Walbank also argued that evidence from a *lex agraria* dating to 111 B.C. indicates that the city was measured and boundaries were established, but that this does not constitute centuriation as early as this date. In another study, P. N. Doukellis argued that Corinth was centuriated twice, once before the colony's foundation, and again in 44 B.C.<sup>70</sup> His plan identified roads from these two grids outside the urban center in the plain north of the city.

Finally, over the course of field seasons from 1988 to 1997, the Corinth Computer Project (CCP) directed by David Romano produced the most detailed plan, combining topographical survey of ancient roads and monuments with archival maps and plans, "shadow lines" from modern features, and low-level and aerial photographs and satellite images.<sup>71</sup> Romano's analysis indicated three systems. One scheme, from the *lex agraria*, is visible in the northern part of the city. A second grid within the city center

68. Sources that highlight the destruction by Mummius include Strabo 8.6.23; Diod. Sic. 32.4.5; Paus. 2.2.2; and Cic. *Leg. agr.* 1.2.5, 2.19.51. Sources that describe Corinth as having been rebuilt or refounded by Julius Caesar include Strabo 8.4.8, 8.6.23, 17.3.15; Diod. Sic. 32.27.1; App. *Pun.* 136; Paus. 2.3.1; and Dio Cass. 43.50.3.

69. Walbank 1986; 1997; 2002, p. 251.

70. Doukellis 1994.

71. Romano 1993, 2000, 2003, 2005, and 2006.

was established in 44 B.C., the *Colonia Laus Iulia Corinthiensis*. Later, in the Flavian period, Corinth was refounded as the *Colonia Iulia Flavia Augusta Corinthiensis*, producing another orientation. From the various plans, the second CCP plan predicted several roads in the vicinity of the Panayia Field, and thus the excavations have produced useful information for the centuriation of Corinth.<sup>72</sup>

The road in the Panayia Field sits within the gridded system of centuriation, in which the colony of 44 B.C. was organized into *insulae* separated by *cardines* and *decumani*. Within the CCP “drawing board” plan, the road in the Panayia Field is the fourth north–south road east of the Lechaion Road and is designated as *cardo IV east*.<sup>73</sup> The streets in the plan are numbered with reference to the *decumanus* and the Lechaion Road as the *cardo maximus* (Figs. 1, 3). Since the existence of the other *cardines* east of the Lechaion Road is speculative, however, we are reluctant to assign this name. The excavated portion falls in the block between the *decumanus I south* and the *decumanus II south*. The CCP plan correctly predicted the road’s general location and accurately depicted its relative width among a series of wide *cardines* that occur every fourth *insula* in the eastern part of the city. A broad avenue of 25 Roman feet, the width of the Panayia road, puts it well above the 12-foot average in the city.<sup>74</sup>

In addition to the Panayia road, the CCP plan restored four other roads, two *cardines* and two *decumani*, in the immediate vicinity of the Panayia Field (see Figs. 1, 3). The *cardines* occur at intervals of one *actus* (ca. 35.52 m), and the *decumani* delimit two *actus* blocks (ca. 72 m). Excavation, however, was unable to confirm the existence of any of these.

Two *cardines* were predicted in the area west of the road in the Panayia Field. First, *cardo II east* was predicted approximately 75 m west of our excavated road, along the western edge of the Panayia Field.<sup>75</sup> Excavations conducted near the western property line did not uncover a road. However, it may lie under the modern road to the west of the property.<sup>76</sup> Second, *cardo III east* was predicted one *actus* west of our road, which should have been visible in the excavations to the north and south of the rectangular concrete pool belonging to the *domus*. Again, however, excavation of a sequence of Hellenistic through Late Roman levels revealed no road. South of the concrete pool, the pre-*domus* and *domus* phases cut deeply, removing the earlier Roman, Hellenistic, and Classical horizons, leaving only the deepest structures and deposits untouched, such as the Geometric graves and a cobble-and-pebble path dated to the Hellenistic period.<sup>77</sup> To the north of the concrete pool, a fuller stratigraphic sequence is preserved, but once again no road was discovered.

72. The plan proposed by Romano for the colony of Corinth in 44 B.C. is presented in several publications, most recently Romano 2003, pp. 285–293; 2005, pp. 30–46.

73. The term “drawing board” plan is used because “it appears from the archaeological evidence that although the urban colony was originally de-

signed to be of a certain size and shape, and to have contained a specific number of *cardines* and *decumani*, the original, or ‘drawing board,’ plan may not have been entirely carried out” (Romano 2003, p. 285).

74. Romano (2003, p. 285) noted the 12-foot average.

75. The 74.58 m distance is based

on two *actus* plus the 12-Roman-foot width of *cardo III east*.

76. Romano (2003, p. 284, fig. 17.3) indicates that the line of the modern road may coincide with the ancient one.

77. See Pfaff 2007 for a discussion of the Geometric horizon in the Panayia Field.

Dating to the Hellenistic period, more of the same cobble-and-pebble path was found sitting above a deeply founded stone drain. These features are oriented about 12° west of north, well off the Roman grid, and they flank a building of the same early period and general orientation. Although the subsequent Early Colony Building, built over a Hellenistic building, interestingly coincides with the eastern edge of the predicted *cardo III east* (Fig. 3), no road surfaces were found and no feature existed to create a boundary for the road's west side.<sup>78</sup> Farther south, the Building with Wall Painting, belonging to the same phase as the Early Colony Building, projects out into the predicted path of *cardo III east*. Later, during the pre-domus period, construction leveled the Early Colony Building and left in its place deeply founded walls dating to the 1st century. Two of these 1st-century walls run east–west across the path of the proposed *cardo III east*. The Hellenistic channel continued in use and was repaired at least once before the domus was constructed. Later, builders tapped the channel to drain the domus's concrete pool and built a manhole over it. Although the placement and orientation of the Early Colony Building might suggest that there was an intention to build *cardo III east* at the time of the foundation of the colony, the road was never established. If plans for this road ever existed, they were most definitely abandoned by the 1st century A.D. for large-scale construction. Additionally, utilities that might have been housed within the possible road were never built. The inhabitants of the area simply reused the Hellenistic drain.

Later phases of habitation also obscured the locations of two *decumani* that were expected to intersect the Panayia Field. First, the position of the *decumanus* that runs south of the *temenos* of Temple E and the forum is well established in several places across the city.<sup>79</sup> From this evidence, the *decumanus* should be found along the northern edge of the Panayia Field, immediately south of the site of the Old Panayia Church (Fig. 1). However, the density of burials in a 17th-century cemetery south of the church site rendered excavation of the entire north half of the property uneconomical.<sup>80</sup> A second *decumanus*, designated *decumanus I south*, was anticipated to bisect the property two *actus* south of the major *decumanus* (Figs. 1, 3). In that area, excavation uncovered a sequence that jumped from the Hellenistic period immediately to the domus horizon. The domus's rectangular concrete pool, other deeply founded walls, and associated floors cut away Early Roman strata, leaving only the remains of three Hellenistic cisterns. No remains of a Roman road were found. Therefore, either the road was planned and again covered by Roman construction, or it was never planned at all.

In addition to what was proposed by the CCP, two other possible locations for *decumani* occur at one-*actus* and three-*actus* intervals south of the major *decumanus*. The area one *actus* south of the major *decumanus* remains incompletely explored, once again due to the 17th-century cemetery. Farther south, three *actus* from the *decumanus*, lies the southern wall of the mosaic-court room (Fig. 3: A2) of the domus, which contains a threshold. Although the threshold might be an entrance onto a road, that is unlikely, for this room is located in a central part of the house. To the

78. Coinciding alignments from the CCP “drawing-board” plan should not be surprising, for crop marks or contours were used as evidence for this road. These may have indicated a wall or other structure instead of a road. See Romano 2003, p. 284, fig. 17.3.

79. See n. 2, above.

80. A six-week season in an area that was only a small portion of the cemetery yielded 86 burials; see Rohn, Barnes, and Sanders 2009.

west and east of the mosaic-court room lie rooms A1 and A6, which both seem to continue south of the three-*actus* line, outside the property line and into an unexcavated area. Thus, the interior space of the house very likely continues farther to the south. It remains possible, however, that the threshold in the southern wall of room A2 led to a vestibule, which in turn opened onto a street.

## CONCLUSIONS

Because roads play many roles in the built environment, they speak to broad themes of city organization and planning, and local themes of specific spatial development. Excavation of the road in the Panayia Field provides important evidence for its chronological development, precise spatial location, and the chronological sequencing of its water pipes. The excavation offers insight into local urban and architectural development, exploration of a possible “drawing board” city plan, and engineering solutions for circulation, water supply, and waste management.

Several decades after the Roman foundation of the colony at Corinth in 44 B.C., the first of the road’s hard-packed surfaces was laid, and from this time on, development of this artery of transportation was increasingly complex and ordered. In the 1st century A.D., when many of Corinth’s streets received limestone paving, the road in the Panayia Field was formally defined with heavy flanking walls but remained unpaved throughout its use. Construction of sidewalks further structured the road with the separation of pedestrian and wheeled traffic in the mid-2nd century. In addition to conducting traffic aboveground, the road provided a necessary conduit for 31 underground pipelines and channels that provided water for uses such as drinking, fountains, and public baths, and drainage of waste and water runoff. These utilities demonstrate many aspects of Roman hydrological engineering. The ceramic pipelines themselves are situated in a well-dated chronological sequence from the late 1st to the 5th century.

The road in the Panayia Field is also notable for its location outside the forum, in a district with residential character. Within this context, the process of urbanization began within a couple generations after the foundation of the road. The character of the built environment moved from sparsely built, independent buildings, populating the open landscape, to solid multistoried complexes that covered much if not all of the city block. Calling yet again on the evidence of the water and waste lines within the road, the growing number of pipes and channels into the 3rd century reflects greater demand for these conveniences by an increasingly urban community. Architectural expression along the street front was individual and idiosyncratic rather than uniform and monumental, as noted by small porches, thresholds, the bench structure, and different heights of the sidewalks on the two sides of the street. Such modifications are in keeping with the residential nature of the neighborhood, for changes seem to have been made both by private owners to satisfy their own needs and by large municipally driven works such as sidewalk curbs. After a late-4th-century

fire consumed the domus, decaying and dismantled structures slowly reversed the process of urbanization into the 6th century, when maintenance of the road ended.

Finally, excavations in the Panayia Field have begun to fix the edges of a city block in this part of Corinth. Since there is little question surrounding the location of the major decumanus south of the forum and none regarding the road in the Panayia Field, the north and east sides of the block are now established. The western cardo of the block has not been found and may lie just under the modern road to the west of the property. This would accord with a block width of at least two *actus*. Similarly, a decumanus that formed the southern edge of the block has been elusive. This leaves the north–south dimension of the insula in question, to be located one or three *actus*, or perhaps more, from the decumanus. This uncertainty supports the conclusion that implementation of the Roman city grid was ultimately more complex than any of the proposed plans. Circumstantial factors such as topography and, in the case of the Panayia Field, the presence of large urban structures most certainly caused revisions and modifications to ideal geometries.

Despite the Panayia road's status as a secondary artery, its excavation has important implications for urbanism in Corinth. Unlike a city such as Pompeii, where the evidence of an entire urban grid has been preserved, at Corinth, regional survey methodologies have shed light on what an urban design plan may possibly have been. Excavation uncovers fixed locations for those regional applications and offers an impression of what the urban fabric actually was at any given time. Throughout its history the road in the Panayia Field was an important utilitarian route. Its excavation has shifted our focus from the broad, colonnaded, paved avenues of the city, where change occurred slowly, to the changing urban character of the everyday, ordinary, neighborhood street.

# APPENDIX

## PIPE SEGMENTS FROM THE PANAYIA ROAD

This appendix contains detailed data for many of the 151 pipe segments that were examined and catalogued from the road in the Panayia Field. Descriptions of ceramic fabrics are followed by a catalogue and table of individual pipe segments that refer to the fabric groups. The fabric descriptions conform to the system used by Sanders in his publication of the Late Roman bath in the Panayia Field, a system that was developed by archaeologists with a background in geology and petrology.<sup>81</sup> Numbers highlighted in bold refer to segments that are catalogued below and illustrated in Figure 25. The catalogue and Table 1 contain detailed information, descriptions, and measurements of select pipe segments organized by the sequenced groups discussed above (pp. 317–320).

### FABRIC DESCRIPTIONS

Fabric 1: Hard, pale brown to very pale brown (Munsell 10YR 6/3 to 10YR 8/4) gradually lightening toward the surface. The break is smooth and conchoidal. Frequent medium to very large spherical angular mudstone; rare small spherical angular terracotta fragments; rare large to very large spherical subrounded white inclusions; and few medium to very large spherical subrounded voids.

Examples: segments **1.1**, **1.2**.

Fabric 2a: Medium hard to hard reddish yellow to yellowish red (5YR 6/8 to 5YR 5/6) with a smooth conchoidal break. Rare small to very large spherical subrounded white inclusions and few small to very large spherical subrounded voids.

Examples: segments **1.3**, **2.1**, **2.2**, **3.1**.

Fabric 2b: Medium hard to hard, light brown to reddish yellow (7.5YR 6/4 to 5YR 6/6). Rough or smooth conchoidal break. The core is generally more red. Few medium to very large spherical white inclusions, which may be subrounded or angular; rare medium to very large spherical angular terracotta fragments; and rare medium to very large voids.

Examples: segments **5.1**, **5.2**, **6.3**, **6.4**, **8.1**, **8.2**, **8.3–11** **10.4**, **11.1**, **15.1**.

81. Sanders 1999, pp. 477–478.

Fabric 2c: Medium hard to hard, reddish yellow to pink (5YR 6/6 to 5YR 6/8) with a rough or smooth conchoidal break. The surface chroma is less saturated than the core. Rare small to very large spherical or tabular subrounded white; few medium to very large spherical angular terracotta fragments; few medium to very large pebbles; and few medium to very large spherical and tabular subrounded voids.

Examples: segments 13.6, 13.8.

Fabric 2d: This clay displays a wide range of hardness and color based on firing. In general, powdery or smooth brown to reddish yellow with a considerable number of small white inclusions and a notable but not large number of small pebble inclusions, occasionally with some mica or terracotta fragments. Although reddish yellow (5YR 6/8 to 7.5YR 7/6) predominates, pink (5YR 7/4 to 7.5YR 8/4) and brown (5YR 6/4 to 7.5YR 5/6) are also common. The break has a conchoidal tendency that feels smooth or powdery. Common small and rare large to very large white inclusions; rare medium to very large spherical subrounded pebbles; occasionally some terracotta fragments, mica, or black inclusions; and few fine voids.

Examples: segments 6.1, 6.2, 6.5, 6.6, 6.9, 9.1, 10.3, 12.1, 12.2–9, 20.1, 20.2, 20.3–10, 22.1, 26.2, 26.3.

Fabric 3: Hard clay with a smooth feel and yellowish red to strong brown (5YR 5/8 to 7.5YR 5/6). Few small platy or spherical pieces of mica; few small and rare large to very large white inclusions; few small to medium pebbles and terracotta fragments.

Examples: segments 10.1, 10.2, 11.2, 11.3, 13.1, 13.2, 13.4, 13.5, 13.7, 13.9, 13.10, 14.1, 17.1.

Fabric 4: Soft to medium hard, very pale brown to pale yellow (10YR 7/3 to 5Y 8/3) with a hackly break and a powdery or rough feel. Rare medium to very large terracotta fragments, rare medium to very large spherical subrounded pebbles, and also in some cases medium to very large spherical subrounded white inclusions or small spherical rounded black inclusions.

Examples: segments 6.8, 6.10, 23.1, 23.2.

Fabric 5: Hard yellow to reddish yellow (10YR 7/6 to 5YR 7/6) with conchoidal break and smooth feel. Few medium to very large white and rare small spherical rounded black inclusions.

Examples: segments 21.1, 28.2, 28.4, 28.5.

Fabric 6: Hard brown (7.5YR 4/4 to 7.5 YR 5/4) “cooking-ware” clay with granular break and a rough feel. Frequent medium spherical subrounded pebbles and few medium spherical angular white inclusions.

Examples: segments 27.1–3, 27.4.

## CATALOGUE

## GROUP A

1.1 Fig. 25

L. 0.680; est. L. 0.052 (male flange); Diam. 0.178 (female exterior); Diam. 0.149 (female interior); Diam. 0.121 (male exterior); est. Diam. 0.092 (male interior); est. Th. 0.020 (male end wall); Th. 0.016 (female end wall); D. 0.055 m (stop); Wt. 15.50 kg.

Both ends preserved; slightly undulating body; impressed finger groove just below shoulder; cylindrical male flange, rim with square lip; female end rim flares slightly outward to square inwardly beveled lip with a stop; extremely thick calcium deposits on interior; lime mortar preserved on shoulder, halfway up male flange, and on female mouth.

2.1 Fig. 25

P.L. 0.278; L. 0.061 (male flange); est. Diam. 0.125 (male exterior); Diam. 0.093 (male interior); Th. 0.016 m (male flange); Wt. 0.95 kg.

Only male end preserved; body shape cannot be determined; flange partly preserved, tapered with beveled sharp shoulder, rim inwardly thickened to a lip with round interior and square exterior; thick lime mortar preserved on shoulder and 3 cm up flange; thin calcium deposit over interior.

2.2 Fig. 25

P.L. 0.465; est. Diam. 0.180 (female exterior); Th. 0.019 (female end); D. 0.054 m (stop); Wt. 2.30 kg.

Only female end preserved; body shape cannot be determined; stop partially preserved; end flares outward to a square lip that is beveled inward; heavy calcium deposit over interior; lime mortar on female end.

## GROUP B

5.1 Fig. 25

P.L. 0.432; p.L. 0.053 (male flange); Diam. 0.190 (female exterior); Diam. 0.160 (female interior); p.Th. 0.016 (male flange); Th. 0.015 (female end); D. 0.052 m (stop).

Both ends preserved; slightly concave body; male end with very sharp square shoulder; male flange cylindrical with lip not preserved; female end with stop; female rim is inwardly thickened to inner round with outer square lip; no lime mortar preserved; thick calcium deposit on interior.

5.2 Fig. 25

P.L. 0.165; L. 0.056 (male shoulder); Diam. 0.141 (male exterior); Diam. 0.116 (male interior); Th. 0.013 m (male flange); Wt. 1.50 kg.

Only male end preserved; body shape cannot be determined; end with very sharp square shoulder; flange cylindrical with slightly rounded and inwardly beveled lip; no lime mortar preserved; thick calcium deposit on interior.

6.1 Fig. 25

P.L. 0.348; Diam. 0.200 (female exterior); Diam. 0.165 (female interior); Th. 0.020 (female end); D. 0.049 m (stop); Wt. 2.05 kg.

Only female end preserved; concave body; end has a sharp pinched stop; rim is inwardly thickened with a round lip; lime mortar on lip; smooth grooves on the inside; patches of thick calcium deposit.

11.1

Fig. 25

L. 0.471; L. 0.054 (male flange); Diam. 0.231 (female exterior); Diam. 0.201 (female interior); Diam. 0.190 (male exterior); Diam. 0.157 (male interior); Th. 0.015 (male flange wall); Th. 0.015 (female end); D. 0.051 m (stop); Wt. 7.00 kg.

Both ends partly preserved; slightly concave body; repair hole; male shoulder is sharp and square with cylindrical male flange with slightly inward-thickened rim to squared and inwardly beveled lip with slightly rounded edges; female with stop; inwardly thickened rim with squared and beveled lip; interior edge of lip slightly rounded; interior with very narrow shallow ridges; smooth exterior; lime mortar on female end and on male shoulder.

12.1

Fig. 25

L. 0.422; L. 0.048 (male flange); Diam. 0.194 (female exterior); Diam. 0.159 (female interior); Diam. 0.150 (male exterior); Th. 0.015 (male flange); Th. 0.018 (female end); D. 0.043 m (stop); Wt. 4.55 kg.

Both ends partly preserved; concave body with sharp shoulder at male end and inwardly flaring rim with round lip; female end with square lip with a stop; calcium deposit over interior and exterior; lime mortar shoulder preserved 1.5 cm up flange and on female lip; smooth, irregular, shallow ridges on interior; smooth exterior.

13.3

Fig. 25

L. 0.417; L. 0.050 (male flange); Diam. 0.198 (female exterior); Diam. 0.156 (female interior); Diam. 0.142 (male exterior); Diam. 0.113 (male interior); Th. 0.015 (male flange); Th. 0.020 (female end); D. 0.040 m (stop); Wt. 5.50 kg.

Both ends preserved; concave body; female end with stop with outwardly thickened rim and squared lip; male flange has cylindrical exterior with thickened interior rim and round lip, square shoulder; male flange preserves lime mortar on shoulder; lime mortar also on female end; exterior smooth, interior without finger ridges; thin calcium deposit on interior.

20.1

Fig. 25

L. 0.476; L. 0.052 (male flange); est. Diam. 0.220 (female exterior); est. Diam. 0.200 (female interior); est. Diam. 0.195 (male exterior); est. Diam. 0.165 (male interior); Th. 0.017 (male flange); Th. 0.015 (female end); D. 0.051 m (stop); Wt. 8.05 kg.

Both ends preserved; concave body; female end with stop; thin calcium deposits over one side of interior; lime mortar preserved at both ends; male end with inwardly thickened rim with round tapered lip; female end with round lip.

22.1

Fig. 25

L. 0.493; L. 0.057 (male flange); Diam. 0.228 (female exterior); Diam. 0.196 (female interior); Diam. 0.188 (male exterior); Diam. 0.161 (male interior); Th. 0.015 (male flange); Th. 0.018 (female end); D. 0.061 m (stop); Wt. 6.25 kg.

Both ends partly preserved; body slightly concave; male flange with cylindrical exterior with inwardly turned rim and squared lip; female end with stop and slightly outward-flaring rim with square lip, cylindrical on interior; lime mortar preserved on male shoulder and female lip; thin calcium deposits all around.

**GROUP C1****6.2**

Fig. 25

L. 0.605; L. 0.070 (male flange); Diam. 0.136 (female exterior); Diam. 0.115 (female interior); Diam. 0.082–0.099 (male interior); Th. 0.009 (male flange); Th. 0.013 m (female end); Wt. 3.85 kg.

Both ends preserved; body of cylinder undulates; lime mortar preserved at male shoulder and small amount on female end; heavy ridge marks on interior with calcium deposits thick on the interior; male flange flares slightly outward to rounded end; female side is straight with rounded end; male shoulder flares outward slightly; male end is oval.

**8.1**

Fig. 25

L. 0.576; L. 0.065 (male flange); Diam. 0.157 (female exterior); Diam. 0.125 (female interior); Diam. 0.115 (male exterior); Diam. 0.094 (male interior); Th. 0.010 (male flange); Th. 0.014 m (female end); Wt. 5.40 kg.

Both ends preserved; cylindrical body; male flange is cylindrical with square lip; male shoulder sharp with two parallel grooves inscribed in body; female end rim flares slightly inward to a squared lip; heavy (up to 1 cm) calcium deposit on one side; mortar preserved at male shoulder and halfway up flange; mortar on female end; part of male flange adhering to female end; light, narrow finger ridges on interior; smooth narrow ridges on exterior.

**8.2**

Fig. 25

L. 0.595; L. 0.051 (male flange); Diam. 0.170 (female exterior); Diam. 0.142 (female interior); Diam. 0.113 (male exterior); Diam. 0.094 (male interior); Th. 0.011 (male flange); Th. 0.015 m (female end); Wt. 6.55 kg.

Both ends preserved; cylindrical body; cylindrical male flange, slightly inward-thickened rim with square lip; female end flares slightly outward with square but slightly beveled lip; interior has very shallow, smooth finger ridges and is filled with irregular calcium deposits; exterior smooth with sharply beveled shoulder on male end and single shallow groove inscribed just below shoulder; lime mortar preserved on male shoulder and about 1 cm up male flange; also preserved on female end; oval hole cut in top, possibly for repair.

**9.1**

Fig. 25

L. 0.634; L. 0.067 (male flange); Diam. 0.134 (female exterior); Diam. 0.110 (female interior); Diam. 0.090 (male exterior); Diam. 0.071 (male interior); Th. 0.010 (male flange); Th. 0.014 m (female end); Wt. 3.55 kg.

Both ends preserved; slightly concave body; male flange is cylindrical with square lip; female end rim flares slightly inward to a rounded lip; heavy (up to 1 cm) calcium deposit on one side; mortar preserved at male shoulder and a third of the way up flange and into mouth of female side; part of male flange adhering to female end; light narrow finger ridges on interior; smooth narrow ridges on exterior.

**GROUP C2****10.1**

Fig. 25

L. 0.436; L. 0.040 (male flange); est. Diam. 0.135 (female exterior); Diam. 0.118 (male exterior); Diam. 0.102 (male interior); Th. 0.018 (male end wall); Th. 0.012 m (female end wall); Wt. 3.25 kg.

Both ends partly preserved; concave and undulating body; male end with sharp square shoulder with shallow, impressed groove just below it; male flange tapers slightly in to inwardly round, outwardly square lip; female end flares outward at a

shallow groove to a rounded lip with shallow groove; shallow, widely spaced ridges on interior; shallow ridging on exterior; thin but occasionally clumpy calcium deposit on interior; lime mortar on female end, male shoulder, and 0.010 m up male flange.

## 13.1

Fig. 25

L. 0.439; L. 0.052 (male flange); Diam. 0.247 (female exterior); Diam. 0.226 (female interior); Diam. 0.109 (male exterior); Diam. 0.092 (male interior); Th. 0.009 (male flange wall); Th. 0.011 m (female wall); Wt. 2.60 kg.

Both ends preserved; concave body; male end with sharp square shoulder with groove; female end without a stop, with rounded lip; deep, narrowly spaced sharp ridging on interior; exterior smooth; thick calcium deposit on interior; lime mortar on male shoulder and on female end; female end is oval.

## 13.2

Fig. 25

L. 0.433; L. 0.054 (male flange); est. Diam. 0.155 (female exterior); est. Diam. 0.125 (male exterior); Th. 0.011 (male flange); Th. 0.011 m (female end); Wt. 1.05 kg.

Both ends preserved; oval pipe with undulating body; sharp square shoulder on male end with a partly preserved male flange with cylindrical inwardly thickened rim with round lip; female rim has rounded lip and incised groove at outer edge of lip; sharp, narrowly spaced finger grooves on interior; smooth exterior; lime mortar on shoulder and female end; very thin calcium deposit on interior; self-slipped on interior and exterior.

## 14.1

Fig. 25

L. 0.234; Diam. 0.151 (female exterior); Diam. 0.131 (female interior); Diam. 0.112 (male exterior); Th. 0.011 m (female end); Wt. (not recorded).

Both ends preserved; female end of joining segment attached; concave body; shoulder sharp and squared; male flange tapers inward to inwardly thickened rim with round lip; female end has outwardly thickened rim with rounded lip and groove on outer edge; interior with deep, irregularly spaced ridges; exterior has been smoothed; heavy lime deposit over interior; lime mortar on both ends; female end on second segment with lip that appears beveled rather than smooth.

## 26.1

Fig. 25

P.L. 0.245; L. 0.054 (male flange); Diam. 0.086 (male exterior); Diam. 0.67 (male interior); Th. 0.011 m (male flange); Wt. 0.65 kg.

Only male end preserved; body shape cannot be determined; male flange narrows toward end, rounded lip flares outward slightly; sharp male shoulder flares outward slightly; very light calcium accretion on interior; no lime mortar present.

## 26.2

Fig. 25

P.L. 0.310; Diam. 0.120 (female exterior); Diam. 0.100 (female interior); Th. 0.010 m (female end); Wt. 1.50 kg.

Only female end preserved, without flange or stop; body not cylindrical but either concave or undulating along its length; light thin calcium deposit on interior; trace drop of lime mortar on end; distinct finger-sized ridge marks on interior; squared rim.

## 27.4

Fig. 25

P.L. 0.415; Diam. 0.122 (female exterior); Diam. 0.104 (female interior); p.Diam. 0.087 (male exterior); p.Diam. 0.078 (male interior); Diam. 0.127 (male shoulder); Th. 0.010 (female end); Th. 0.004 m (male flange); Wt. 1.75 kg.

Both ends preserved; cylindrical body flaring slightly at the female end and male shoulder; male flange only partly preserved without rim; shoulder is sharp and thickened outward; female rim is outwardly thickened with a round lip; no evidence of mortar preserved on either end; even, pronounced ridging on interior, smooth ridging on exterior.

### GROUP C3

#### 17.1

Fig. 25

L. 0.506; L. 0.062 (male flange); Diam. 0.133 (female exterior); Diam. 0.109 (female interior); Diam. 0.072 (male interior); Th. 0.010 (male flange); Th. 0.012 m (female end); Wt. (not recorded).

Both ends partly preserved; very slightly concave body; male shoulder is sharp and slightly beveled; cylindrical flange with slightly inward-thickened rim and squared lip; female end slightly thickened with round lip; interior with shallow, regularly spaced finger ridges; smooth exterior; lime mortar heavy on shoulder; also a small amount on female end.

#### 20.2

Fig. 25

L. 0.470; L. 0.051 (male flange); Diam. 0.189 (female exterior); Diam. 0.161 (female interior); Diam. 0.147 (male exterior); Diam. 0.124 (male interior); Th. 0.014 (female end); Th. 0.014 m (male flange); Wt. 4.20 kg.

Both male and stopless female ends preserved; slightly concave body; thin calcium deposits over interior; lime mortar preserved at female end and male-end shoulder; male end round and flares slightly outward; body preserves break hole that is perhaps a repair; shoulder at male end is sharp; female end with square lip and outwardly thickened rim.

#### 23.1

Fig. 25

L. 0.507; L. 0.058 (male flange); est. Diam. 0.160 (female exterior); Diam. 0.129 (male exterior); Diam. 0.108 (male interior); Th. 0.012 (male flange); Th. 0.019 m (female end); Wt. 3.15 kg.

Both ends partly preserved; cylindrical body; sharp square shoulder; mostly cylindrical male flange with inwardly thickened rim with round lip; female side thickened on inside and outside to round lip; interior with wide, deeply spaced finger grooves; exterior with smooth, regularly spaced shallow grooves; no calcium deposit on interior; lime mortar preserved only on shoulder.

### GROUP D

#### 28.1

L. 0.690; W. 0.102 (female exterior); W. 0.086 (male exterior); W. 0.062–0.050 (male interior); Th. 0.020 (bottom at one end); Th. 0.022 (bottom at other end); Th. 0.025–0.019 (side); H. 0.074–0.054 m (interior side); Wt. 3.85 kg.

Both ends preserved; width of pipe is consistent along its length, although the walls undulate slightly; all preserved ends are fairly square; bottom and two side slabs built up during manufacture, for there are finger presses along outside edges and both sides; inner bottom has been smoothed by finger strokes; lime mortar preserved inside and along lip of one side; other side with lime mortar preserved at lip.

TABLE 1. PIPE SEGMENTS

<i>Pipe Group</i>	<i>Segment Number</i>	<i>Preservation</i>	<i>Fabric Group</i>	<i>Weight (kg)</i>	<i>Length (m)</i>	<i>Male Interior Diameter (m)</i>	<i>Female Exterior Diameter (m)</i>
A	1.1	97%	1	15.50	0.680	0.092	0.178
	1.2	95%	1	9.55	0.684	0.100	0.165
	1.3	99%	2a	11.20	0.711	0.103	0.173
	2.1	—	2a	0.95	0.278*	0.093	—
	2.2	—	2a	2.30	0.465*	—	0.180
	3.1	100%	2a	16.70	0.784	—	0.176
B	5.1	—	2b	—	0.432*	—	0.190
	5.2	—	2b	1.50	0.165*	0.116	—
	6.1	—	2d	2.05	0.348*	—	0.200
	6.3	80%	2b	3.00	0.454	0.092	0.170
	10.3	—	2d	—	0.465	—	0.243
	10.4	—	2b	1.15	0.156*	—	0.250
	11.1	80%	2b	7.00	0.471	0.157	0.231
	12.1	85%	2d	4.55	0.422	—	0.194
	12.2	—	2d	—	0.350*	—	0.170
	12.3	80%	2d	4.75	0.411	0.114	0.202
	12.4	45%	2d	2.55	—	—	—
	12.5	90%	2d	6.05	0.406	0.115	—
	12.6	93%	2d	4.95	0.403	0.120	0.201
	12.7	100%	2d	7.30	0.402	—	—
	12.8	97%	2d	4.80	0.395	0.113	0.199
	12.9	95%	2d	5.40	0.417	0.118	0.192
	13.3	99%	—	5.50	0.417	0.113	0.198
	15.1	—	2b	—	0.458*	0.164	0.230
	20.1	99%	2d	8.05	0.476	0.165	0.220
	20.8	—	2d	0.04	0.341*	—	0.239
	22.1	75%	2d	6.25	0.493	0.161	0.228
	C1	6.2	95%	2d	3.85	0.605	0.082–0.099
6.4		—	2b	1.60	0.450*	—	0.145
6.5		40%	2d	1.10	0.325*	0.078	—
6.6		—	2d	1.10	0.278*	0.081	—
6.7		—	—	0.70	0.171*	—	0.134
6.8		—	4	—	0.610	0.085	0.135
6.9		40%	2d	2.30	0.484*	—	0.129
6.10		—	4	3.05	0.473*	0.075	—
8.1		95%	2b	5.40	0.576	0.094	0.157
8.2		96%	2b	6.55	0.595	0.094	0.170
8.3		92%	2b	4.45	0.631	0.102	0.162
8.4		95%	2b	4.40	0.595	0.094	0.162
8.5		99%	2b	4.75	0.574	0.095	0.159
8.6		80%	2b	4.80	0.622	—	0.162

TABLE 1—*Continued*

<i>Pipe Group</i>	<i>Segment Number</i>	<i>Preservation</i>	<i>Fabric Group</i>	<i>Weight (kg)</i>	<i>Length (m)</i>	<i>Male Interior Diameter (m)</i>	<i>Female Exterior Diameter (m)</i>
C1	8.7	45%	2b	2.65	0.541*	—	0.161
	8.8	65%	2b	3.10	0.584*	—	0.157
	8.9	20%	2b	1.30	0.506*	—	—
	8.10	95%	2b	5.00	0.554	0.095	0.157
	8.11	20%	2b	1.05	0.195*	—	—
	9.1	90%	2d	3.55	0.634	0.071	0.134
	9.2	45%	—	2.05	0.526*	—	0.141
	9.3	—	—	1.00	0.270*	0.083	—
	9.4	95%	—	3.40	0.618*	—	0.132
C2	10.1	80%	3	3.25	0.436	0.102	0.135
	10.2	—	3	3.00	0.386*	—	0.159
	11.2	70%	3	3.15	0.432	0.095	0.155
	11.3	90%	3	3.25	0.372	—	0.150
	13.1	95%	3	2.60	0.439	0.092	0.247
	13.2	35%	3	1.05	0.433	—	0.155
	13.4	80%	3	3.35	0.443*	—	0.154
	13.5	25%	3	1.55	0.403	—	0.160
	13.6	30%	2c	2.40	0.410	0.114	0.200
	13.7	50%	3	2.25	0.453*	0.104	—
	13.8	—	2c	1.50	0.209*	—	—
	13.9	30%	3	1.40	0.430	—	0.170
	13.10	30%	3	1.20	0.441	—	0.150
	14.1	—	3	—	0.440	—	0.151
	26.1	—	—	0.65	0.245*	0.067	—
	26.2	—	2d	1.50	0.310*	—	0.120
	26.3	40%	2d	2.45	0.307*	—	—
27.1	40%	6	1.15	0.300*	0.090	—	
27.2	—	6	0.90	0.270*	—	—	
27.3	35%	6	0.60	0.232*	—	0.115	
27.4	80%	6	1.75	0.415*	0.078	0.122	
C3	17.1	—	3	—	0.506	0.072	0.133
	20.2	95%	2d	4.20	0.470	0.124	0.189
	20.3	75%	2d	3.35	0.418*	—	0.196
	20.4	97%	2d	4.55	0.440	0.121	0.186
	20.5	98%	2d	4.55	0.464	0.118	0.188
	20.6	80%	2d	3.55	0.464	0.120	0.185
	20.7	25%	2d	1.80	0.228*	—	0.190
	20.9	85%	2d	4.70	0.490	0.105	0.170
	20.10	30%	2d	3.00	0.390*	0.125	—
	23.1	55%	4	3.15	0.507	0.108	0.160
	23.2	50%	4	3.35	0.375*	0.100	—

TABLE 1—*Continued*

<i>Pipe Group</i>	<i>Segment Number</i>	<i>Preservation</i>	<i>Fabric Group</i>	<i>Weight (kg)</i>	<i>Length (m)</i>	<i>Male Interior Diameter (m)</i>	<i>Female Exterior Diameter (m)</i>
D	21.1	—	5	4.00	0.625*	0.056	0.108
	21.2	—	—	1.90	0.241*	0.050	0.107
	21.3	100%	—	2.75	0.301*	—	0.164
	21.4	100%	—	2.75	0.256*	—	—
	<b>28.1</b>	85%	—	3.85	0.690	0.062	0.102
	28.2	—	5	—	0.546*	0.092	0.134
	28.3	99%	—	8.95	0.683	0.095	0.167
	28.4	95%	5	4.15	0.730	0.065	0.079
	28.5	95%	5	9.20	0.710	0.074	0.185

Boldface numbers refer to pipe segments included in the catalogue; with the exception of **28.1**, all are illustrated in Figure 25. No attempt was made to estimate the portion of a preserved segment if the entire shoulder or the stop was not present. An asterisk (\*) indicates the preserved length. For segments of square lines from group D, widths instead of diameters are given.

## REFERENCES

- Biers, W. B. 1978. "Water from Stymphalos?" *Hesperia* 47, pp. 171–184.
- Brown, A. R. 2008. "The City of Corinth and Urbanism in Late Antique Greece" (diss. Univ. of California, Berkeley).
- Corinth = Corinth: Results of Excavations Conducted by the American School of Classical Studies at Athens*
- I.1 = H. N. Fowler and R. Stillwell, *Introduction, Topography, Architecture*, Cambridge, Mass., 1932.
- I.5 = S. S. Weinberg, *The Southeast Building, the Twin Basilicas, the Mosaic House*, Princeton 1960.
- XX = C. K. Williams II and N. Bookidis, eds., *Corinth, the Centenary: 1896–1996*, Princeton 2003.
- De Cou, H. F. 1897. "A Roman Building in Corinth: A Report of the Excavations of 1896: Trench XIV," *AJA* 1, pp. 495–506.
- Doukellis, P. N. 1994. "Le territoire de la colonie romaine de Corinthe," in *Structures rurales et sociétés antiques. Actes du colloque de Corfou (14–16 mai 1992)* (Annales littéraires de l'Université de Besançon 508), ed. P. N. Doukellis and L. G. Mendoni, Paris, pp. 359–390.
- Hill, B. H. 1927. "Excavations in Corinth, 1926," *AJA* 31, pp. 70–79.
- James, S. 2010. "The Hellenistic Pottery from the Panayia Field, Corinth: Studies in Chronology and Context" (diss. Univ. of Texas, Austin).
- Landon, M. E. 1994. "Contributions to the Study of the Water Supply of Ancient Corinth" (diss. Univ. of California, Berkeley).
- . 2003. "Beyond Peirene: Toward a Broader View of Corinthian Water Supply," in *Corinth* XX, pp. 43–62.
- Lepinski, S. 2008. "Roman Wall Paintings from Panayia Field, Corinth, Greece: A Contextual Study" (diss. Bryn Mawr College).
- Lolos, Y. 1997. "The Hadrianic Aqueduct of Corinth (with an Appendix on the Roman Aqueducts in Greece)," *Hesperia* 66, pp. 271–314.
- Pfaff, C. A. 2007. "Geometric Graves in the Panayia Field at Corinth," *Hesperia* 76, pp. 443–537.
- Poehler, E. E. 2006. "The Circulation of Traffic in Pompeii's *Regio VII*," *JRA* 19, pp. 53–74.
- Richardson, R. B. 1897. "The Excavations at Corinth in 1896," *AJA* 1, pp. 455–480.
- Robinson, B. A. 2001. "Fountains and the Culture of Water at Roman Corinth" (diss. Univ. of Pennsylvania).
- Robinson, H. S. 1961–1962. "Corinth Excavations (1961)," *ArchDelt* 17, B', pp. 61–63.
- . 1965. "Excavation at Ancient Corinth, 1959–1963," *Klio* 46, pp. 289–305.
- . 1966. "Excavations at Corinth," *ArchDelt* 21, B' 1, pp. 133–141.
- Rohn, A. H., E. Barnes, and G. D. R. Sanders. 2009. "An Ottoman-Period Cemetery at Ancient Corinth," *Hesperia* 78, pp. 501–615.
- Romano, D. G. 1993. "Post-146 B.C. Land Use in Corinth, and Planning of the Roman Colony of 44 B.C.," in *The Corinthia in the Roman Period: Including the Papers Given at a Symposium Held at the Ohio State University on 7–9 March, 1991* (*JRA* Suppl. 8), ed. T. Gregory, Ann Arbor, pp. 9–30.
- . 2000. "A Tale of Two Cities: Roman Colonies at Corinth," in *Romanization and the City: Creations, Transformations, and Failures. Proceedings of a Conference Held at the American Academy in Rome to Celebrate the 50th Anniversary of the Excavations at Cosa, 14–16 May, 1998* (*JRA* Suppl. 38), ed. E. Fentress, Portsmouth, R.I., pp. 83–104.
- . 2003. "City Planning, Centuriation, and Land Division in Roman Corinth: *Colonia Laus Iulia Corinthiensis* and *Colonia Iulia Flavia Augusta Corinthiensis*," in *Corinth* XX, pp. 279–301.
- . 2005. "Urban and Rural Planning in Roman Corinth," in *Urban Religion in Roman Corinth: Interdisciplinary Approaches* (Harvard Theological Studies 53), ed. D. N. Schowalter and S. J. Friesen, Cambridge, Mass., pp. 25–59.
- . 2006. "Roman Surveyors in Corinth," in *Proceedings and Addresses of the American Philosophical Society* 150:1, March 2006, pp. 62–85.
- Rothaus, R. M. 2000. *Corinth, the First City of Greece: An Urban History of Late Antique Cult and Religion* (Religions in the Graeco-Roman World 139), Leiden.
- Sanders, G. D. R. 1999. "A Late Roman Bath at Corinth: Excavations in the Panayia Field, 1995–1996," *Hesperia* 68, pp. 441–480.
- . 2004. "Problems in Interpreting Rural and Urban Settlement in Southern Greece, A.D. 365–700," in *Landscapes of Change: Rural Evolutions in Late Antiquity and the Early Middle Ages*, ed. N. Christie, Aldershot, pp. 163–194.
- . 2005. "Archaeological Evidence for Early Christianity and the End of the Hellenic Religion in Corinth," in *Urban Religion in Roman Corinth: Interdisciplinary Approaches* (Harvard Theological Studies 53), ed. D. N. Schowalter and S. J. Friesen, Cambridge, Mass., pp. 419–442.
- Slane, K. W. 2005. "Corinth: Italian Sigillata and Other Italian Imports to the Early Colony," in *Early Italian Sigillata: The Chronological Framework and Trade Patterns. Proceedings of the First International ROCT-Congress, Leuven, May 7 and 8, 1999* (*BABesch* Suppl. 10), Louvain, pp. 31–42.
- Slane, K. W., and G. D. R. Sanders. 2005. "Corinth: Late Roman Horizons," *Hesperia* 74, pp. 243–297.
- Stirling, L. M. 2008. "Pagan Statuettes in Late Antique Corinth: Sculpture from the Panayia Domus," *Hesperia* 77, pp. 89–161.
- Sweetman, R., and G. D. R. Sanders. 2005. "A New Group of Mosaics from Corinth in Their Domestic Context and in the Context of the Colony," in *La mosaïque gréco-romaine IX. Actes du IX<sup>e</sup> Colloque international pour l'étude de la mosaïque antique et médiévale organisé à Rome, 5–10 novembre 2001* (*CÉFR* 352), ed. H. Morlier, Rome, pp. 359–369.

- Walbank, M. E. H. 1986. "The Nature and Development of Roman Corinth to the End of the Antonine Period" (diss. Open University).
- . 1997. "The Foundation and Planning of Early Roman Corinth," *JRA* 10, pp. 95–130.
- . 2002. "What's in a Name? Corinth under the Flavians," *ZPE* 139, pp. 251–264.
- Williams, C. K., II, J. MacIntosh, and J. E. Fisher. 1974. "Excavation at Corinth, 1973," *Hesperia* 43, pp. 1–76.
- Williams, C. K., II, and O. Zervos. 1982. "Corinth, 1981: East of the Theater," *Hesperia* 51, pp. 115–163.
- . 1983. "Corinth, 1982: East of the Theater," *Hesperia* 52, pp. 1–47.
- . 1984. "Corinth, 1983: The Route to Sikyon," *Hesperia* 53, pp. 83–122.
- . 1985. "Corinth, 1984: East of the Theater," *Hesperia* 54, pp. 55–96.
- . 1986. "Corinth, 1985: East of the Theater," *Hesperia* 55, pp. 129–175.
- . 1987. "Corinth, 1986: Temple E and East of the Theater," *Hesperia* 56, pp. 1–46.
- . 1988. "Corinth, 1987: South of Temple E and East of the Theater," *Hesperia* 57, pp. 95–146.
- . 1989. "Corinth, 1988: East of the Theater," *Hesperia* 58, pp. 1–50.

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