John Peter Oleson
Department of Greek and Roman Studies
University of Victoria
Victoria B.C. Canada V8W 3P4

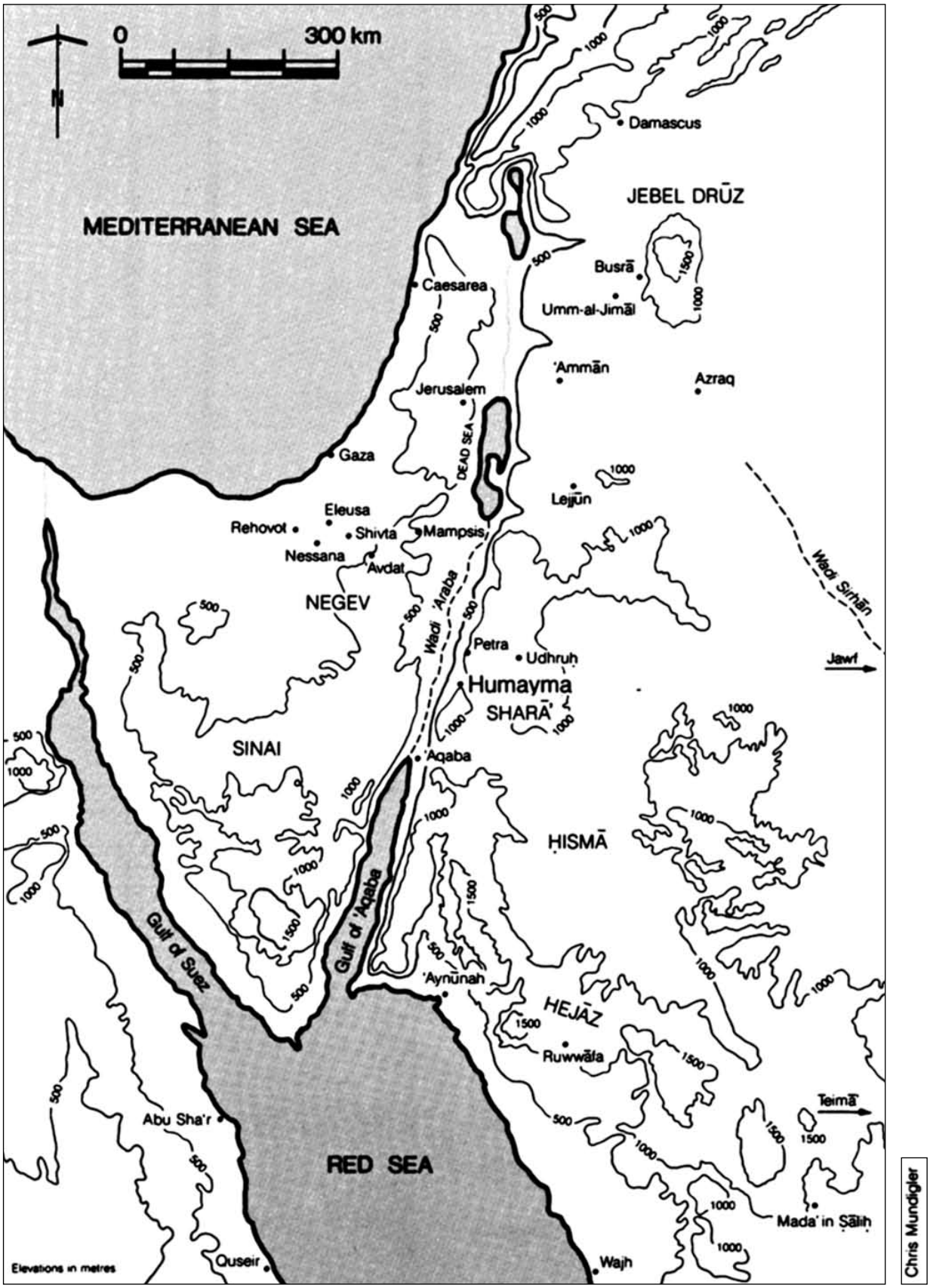
John Peter Oleson

Trajan's Engineers and the Roman Fort at al-Ḥumayma (Ancient Ḥawara, Jordan)

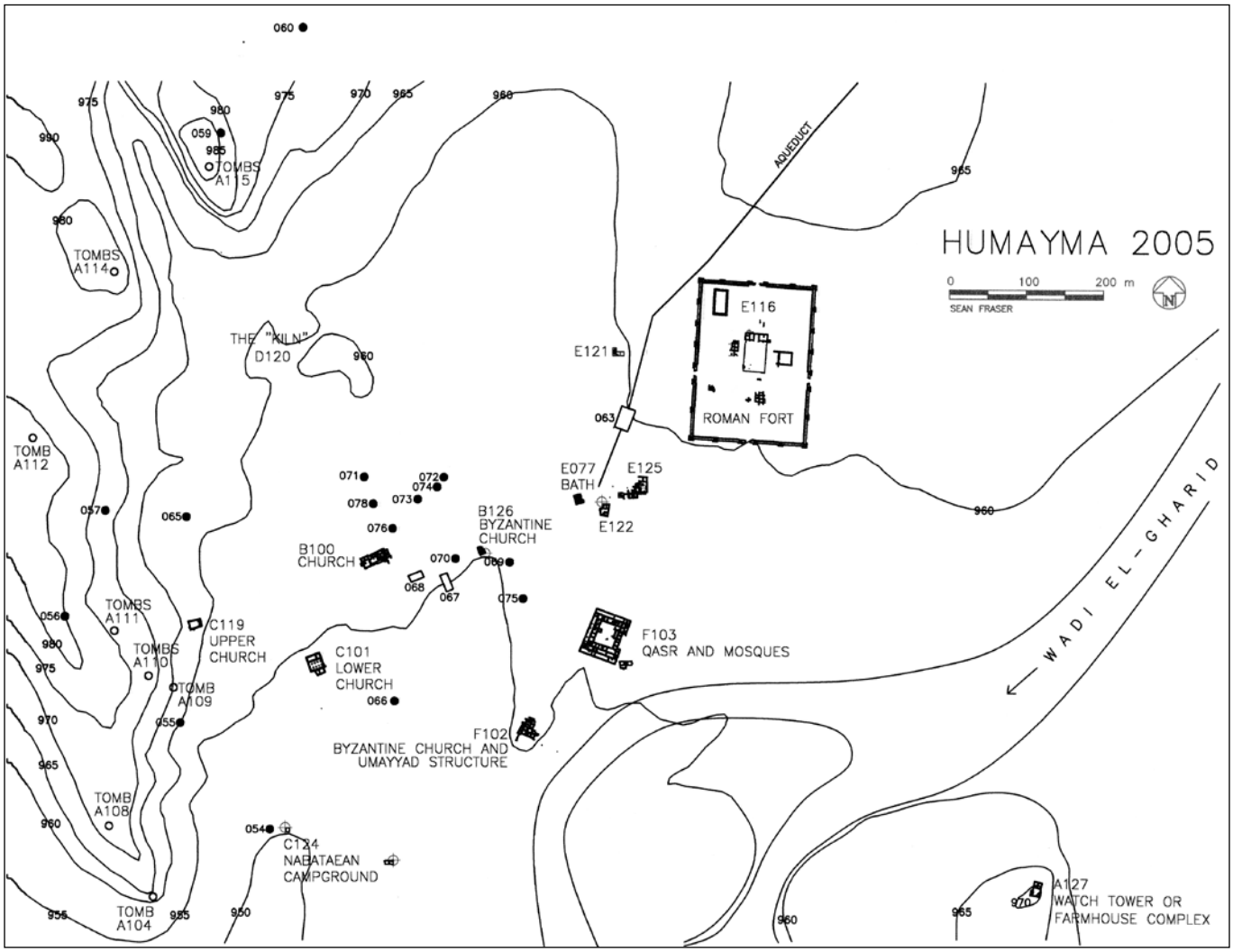
As is well known, the Romans began to intervene directly in the Nabataean kingdom and Nabataean sphere of interest during the 60s BC, in the course of Pompey's reorganization of Syria and the surrounding regions (Bowersock 1983: 28-44). During the reign of Augustus, the expedition of Aelius Gallus also involved intervention in the kingdom, according to Bowersock, perhaps even brief suppression of the kingship around 3BC. Some forces from the army of L. Vitellius may have entered the kingdom as well, before being recalled at the news of Tiberius's death in 37 (Bowersock 1983: 54-58, 65-68). The final blow came after the death of Rabbel II in 106, when the emperor Trajan's forces annexed the kingdom as the Provincia Arabia. Although the literary and numismatic evidence is ambiguous about the conditions of this take-over, the archaeological remains suggest that the occupation was accompanied by widespread violence (Kennedy 1980; Freeman 1996; Schmid 1997, 2000: 139-46; Oleson 2004: 354-55). Various explanations have been proposed for this annexation, and there were undoubtedly more than a few motives. In any case, for the first time, the Romans fortified and extensively garrisoned the region of the former kingdom and improved lines of communication by constructing or rebuilding roads, in particular the *Via Nova Traiana* (Graf 1995, 1997). Much is still obscure about the transition from Nabataean to Roman rule and the early years of the new province, but it is clear that teams of military engineers must have been involved. The well known *Papyrus Michigan* 466, for example, a letter home by a new recruit stationed near Petra in March 107, mentions quarrying undertaken for road work (Speidel 1977: 691-94). Some milestones and honorific building inscriptions mentioning Trajan have been found (Bowersock 1983: 81-86; Graf 1995, 1997), and the legionary fort at Bostra, the capital of the new province, should date to this period (Parker 2000: 124; Kennedy 2004: 217-18). So far, however, there has been little close analysis of the strategy followed by the presumably imported Roman engineers, the direct motivations for their activities, and the procedures they followed in planning and constructing the infrastructure of Roman occupation.

The Roman fort at al-Ḥumayma, Nabataean Hawara, Roman Ḥawara, is the earliest large Roman fort in Jordan so far excavated and reliably dated, and one of the few surviving principate forts in the entire region (FIGS. 1-2) (Oleson *et al*. 2003, 2008; Parker 2000; Kennedy 2004: 193-98). Ceramic and numismatic evidence reveal that the fort was constructed immediately after the events of AD 106. A gap in the coin record suggests the fort was abandoned during Diocletian's reworking of the military centres along the *Via Nova Traiana*, but it was re-occupied, most likely by a military unit, under Constantine. Final abandonment occurred late in the fourth century. The historical context makes it likely that the fort was manned by a detachment from the Legio III Cyrenaica, and an inscription from a shrine in the *vicus* documents the presence of members of that legion in the fort in the mid-third century (Oleson *et al*. 2002). It is also possible that a detachment of the Legio VI Ferrata was stationed at Ḥawara at some point (Kennedy 1980; Freeman 1996).

Although the fortification walls and interior structures were plundered for building materials in the Byzantine and Early Islamic periods, for the most part the plans of both the original structures and their later phases of use can be easily determined (FIG. 3). Excavations directed by Oleson since 1993 have documented the dimensions and design of the fort and its interior road network,



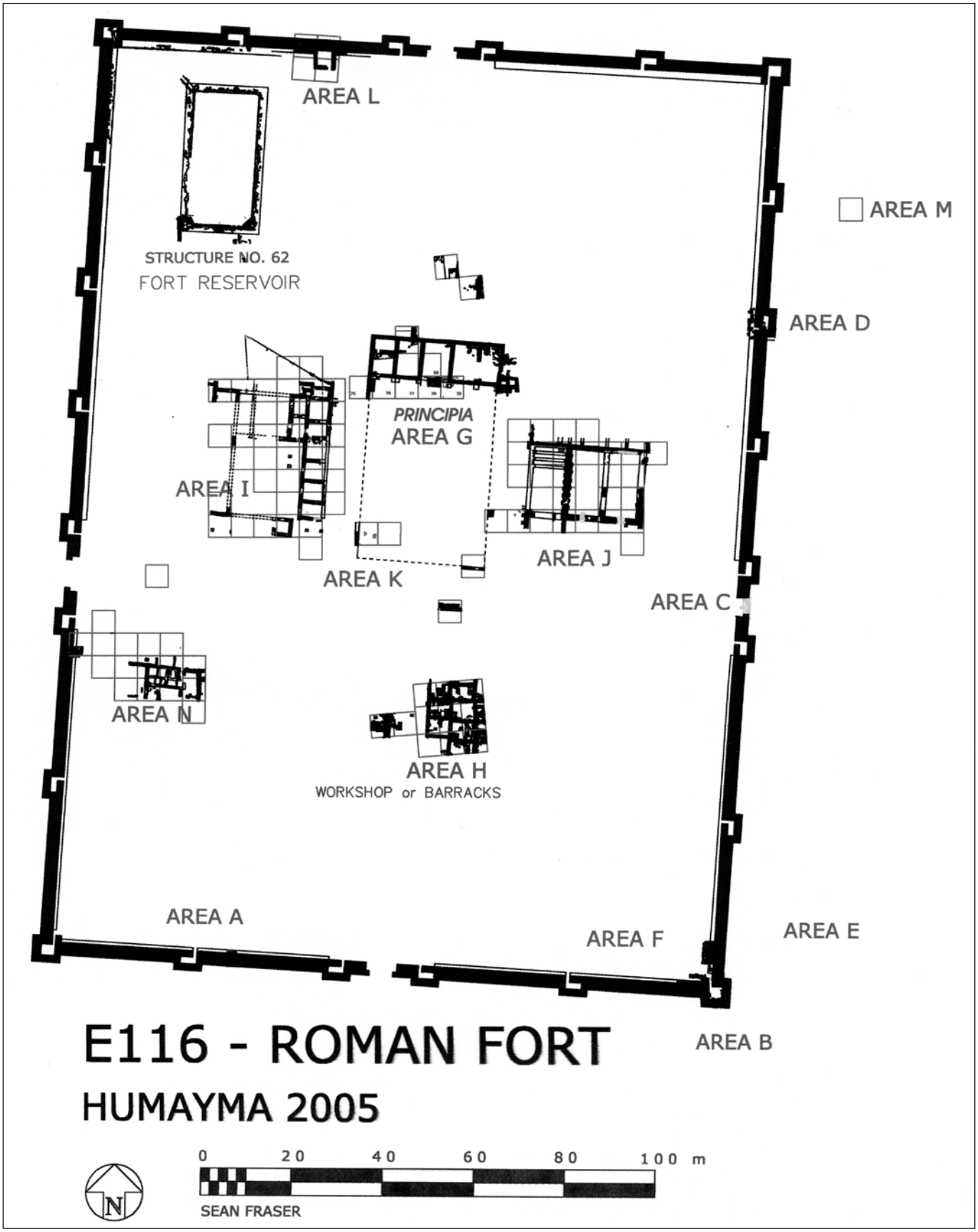
1. Ḥawara/al-Al-Ḥumayma, Locator map.



2. Ḥawara/al-Al-Ḥumayma, plan of settlement.

along with the plans of the most important interior structures: *principia, praetorium, horreum,* barracks, workshops, and possibly a stable (Oleson *et al*. 1995, 1999, 2003, 2008). A latrine has also been identified, along with a pressurized pipeline for water supply, and an extensive network of drains. This paper discusses several issues raised by the location and plan of the fort, as a contribution to our understanding of the process of the occupation of the Provincia Arabia: first, the strategic and tactical reasons for the location of the fort; second, the planning procedures behind the overall layout of the fort; and, third, the design and execution of its individual interior structures. I will show that the structures and their arrangement correspond for the most part to a modular system based on rational totals of Roman feet, and I will compare the archaeological data with Roman period literary sources relating to the planning of fortifications.

Location is always a major consideration in military architecture, and in strategic terms the placement at Nabataean Ḥawara of the main military unit between Petra and Ayla makes a great deal of sense (FIG. 1). This settlement, although small, was the main population and market centre in the Ḥismā, it was located on the main north-south route — renovated as the *Via Nova Traiana* — and at the junction of tracks leading southeast towards the sanctuary in Wādī Ramm, and beyond into the Ḥijaz. There were close connections between Hawara and both Petra 80km to the north and Ayla 80km to the south, on the Red Sea. A Nabataean aqueduct brought spring water to the settlement, supplementing numerous cisterns storing run-off from precipitation, and the loessal soil within the run-off area allowed the production of grain. Ro-



3. Ḥawara/al-Al-Ḥumayma, plan of fort and excavated structures.

man control of this site was crucial to their occupation of the southern portion of the kingdom, and the fort undoubted served as the regional administrative centre (Oleson 2001; Isaac 1990: 205).

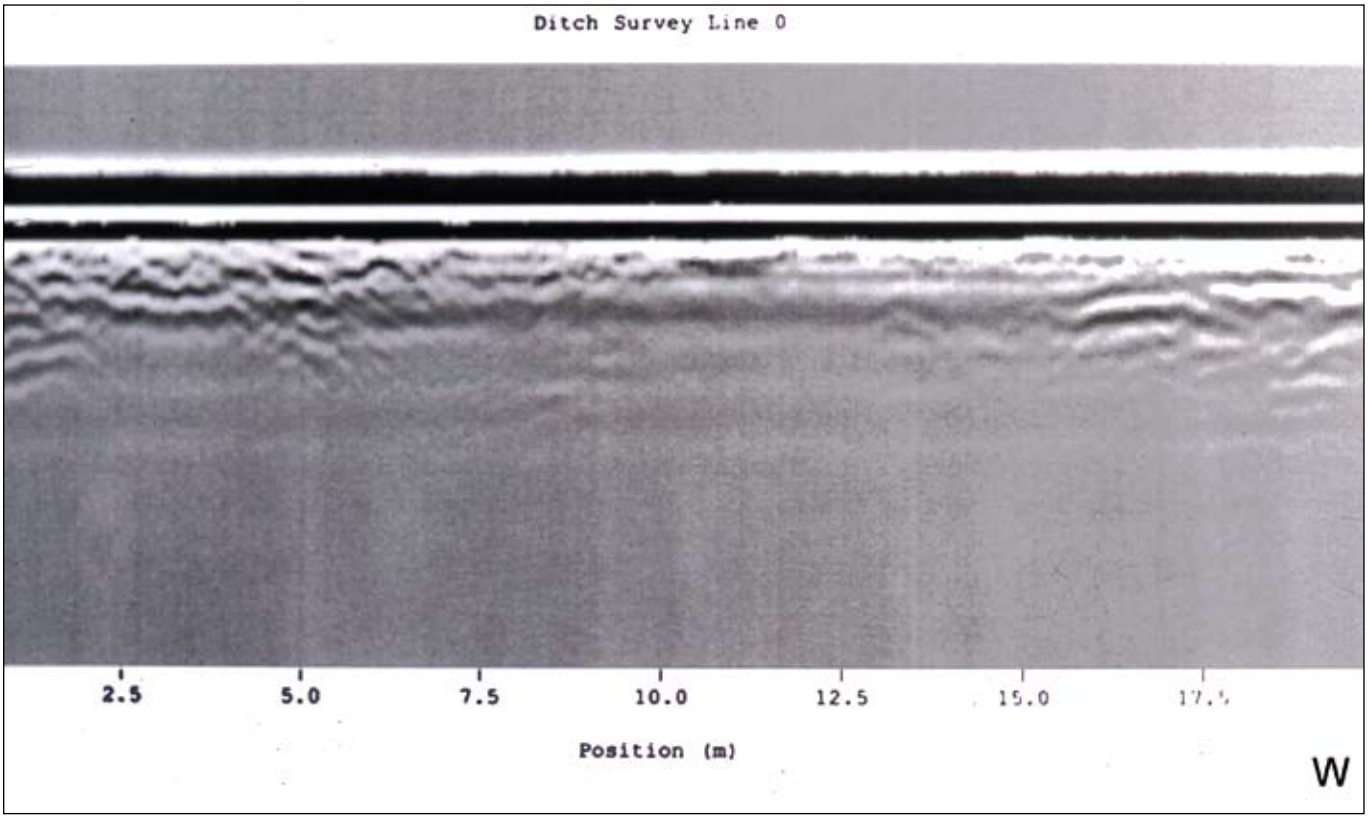
In the local context, tactical considerations are equally important. The fort was laid out on a gentle, southern-facing slope above and 100m northeast of the Nabataean settlement (FIG. 4). The site has no natural defences, but it was close enough to the Nabataean aqueduct to draw water from it by means of a branch channel, and the *Via Nova* probably passed by just outside the west gate. The view directly to the north was blocked by a hill, but from the fort there was a clear view south to the *castellum* at Quweira and to the southeast nearly as far as Wādī Ramm. A detached, semicircular earth mound — in Latin *titulum* — outside the north gate reinforced it against assault from the level plain on that side (Oleson *et al*. 2003: 53). Evidence is less clear for the presence of *titula* at the other three gates, but geophysical survey recently revealed the presence of a ditch (*fossa*) 5m outside the walls, ca.

4. Ḥawara/al-Al-Ḥumayma, aerial view of fort from south (Photo: D. Kennedy, with permission).

1m deep and 3m across, with a V-shaped cross-section (Oleson *et al*. 2008) (FIG. 5). Spoil from the ditch was probably used along with rubble as fill in the stout, block-faced fortification wall. In addition to the 24 projecting towers, there were platforms at several points inside the wall for artillery (FIG. 6). The 4.7m drop from the north gate to the south gate allowed for the controlled removal of runoff through a system of drains below the main roads, and for the internal distribution of water through a system of terracotta pipes fed by the reservoir at the high, northwest corner of the fort. The fort dominated the civilian settlement visually, a permanent reminder to both local inhabitants and passing travellers of the iron fist of Roman occupation.

Roman architects, particularly military architects, paid careful attention to design, materials, and construction procedures, and the fort at Ḥawara was no exception. The general plan of the fort clearly was laid out in multiples of the Roman *pes monetalis*, 0.296m in length, and it was oriented within a few degrees of true north. Throughout this paper, when I refer to "feet" I intend this Roman foot (abbreviated as "RF"), rather than the English foot of 0.3048m (FIG. 3). Here are the main dimensions of the fort in Roman feet: width 500 RF, length 700 RF; walls 10 RF thick; 4 corner towers 20 RF on a side, projecting 6 RF out from the wall, and 20 intermediate wall towers also 20 RF wide projecting 6 RF; the east and west gates are 400 RF south of the north wall and are 15 RF wide. The interior of the reservoir measures 50 by 100 RF, and 10 RF deep. The main north-south road (*via praetoria*)

6. Ḥawara/al-Al-Ḥumayma, ballista platform against fort wall.



5. Ḥawara/al-Al-Ḥumayma, GPR definition of ditch around fort, looking south.

and the peripheral road inside the fort (the *intervallum*) were both 27 RF wide. The principal east-west road (*via principalis*) is less well documented, but may have been 30 RF wide. All the roads so far identified within the fort were originally paved with stone slabs. The Roman surveyors usually achieved an accuracy of better than one percent, but errors or adaptations might be made in executing a theoretical design might be made in any Roman construction project (Wilson-Jones 2000: 11-14, 202).

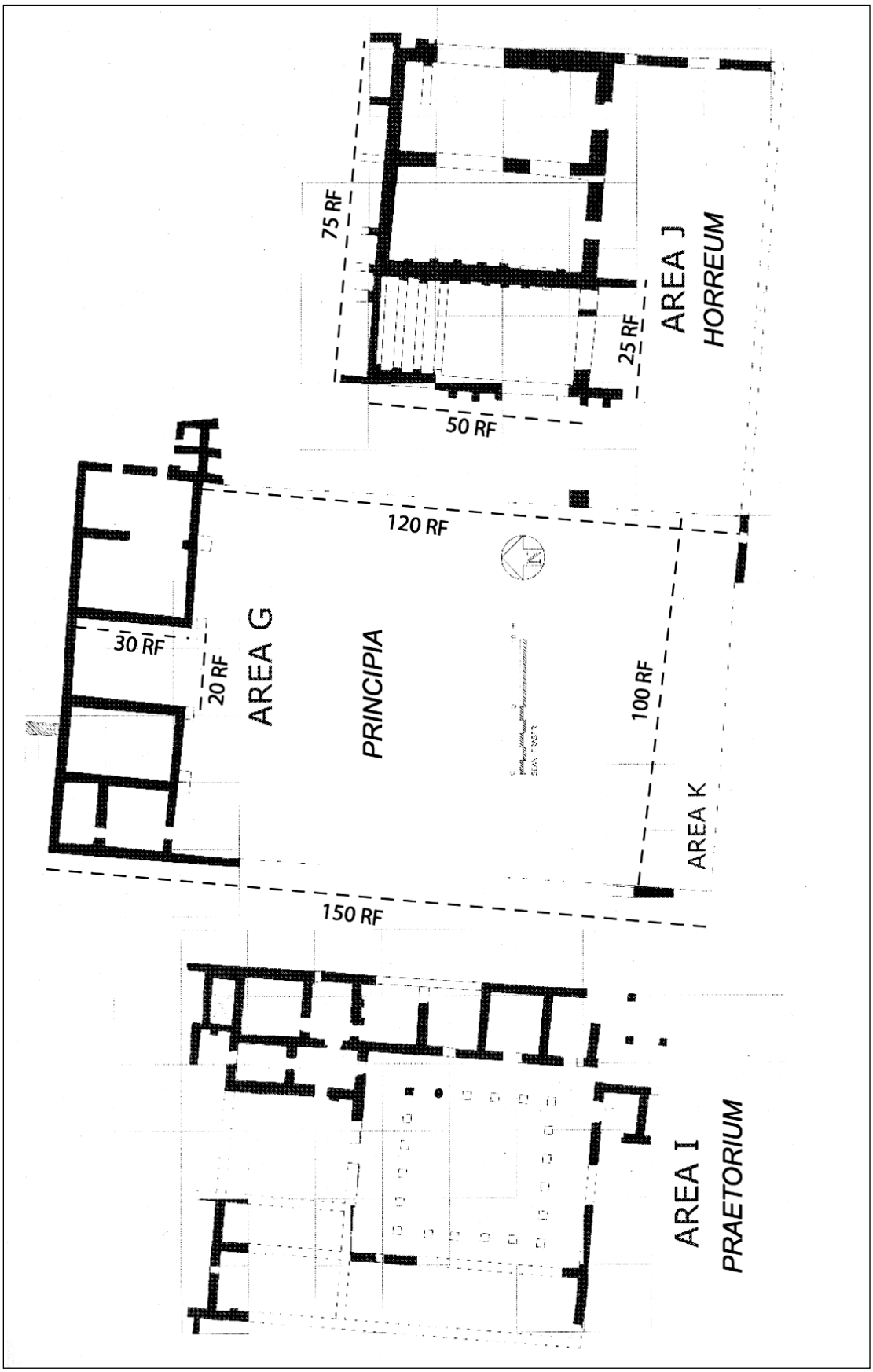
The same attention to rational numbers of the module was applied to the design of the buildings inside the fort. Only three structures — the *principia, praetorium,* and *horreum* — have so far been excavated comprehensively enough to allow convincing reconstruction of the plans and procedures used by the engineers. All three structures belong to the first phase of the fort, but they continued in use in one way or another through the end of occupation (FIG. 7).

The *horreum*, or granary (often referred to in Latin as the plural *horrea*), is located immediately east of the *principia*, or headquarters building, in the northeast quadrant of the fort. This structure is identified as the granary because of the following plan and construction features, which are shared with granaries at other Roman forts: heavy, buttressed walls, long narrow interior rooms roofed with stone slabs carried on cross arches; floors carefully paved with bricks or thick stone slabs; careful arrangement for drainage; and the predominance in this location of fragments of storage wares (Johnson 1983: 142-57; Richardson 2004; Parker 2006: 235-40). The location of the structure near the central administrative area is paralleled in most other Roman forts, and there are no other suitable locations available within the fortification walls for such an important structure. Given the isolated and environmentally marginal location of Ḥawara, the provision of food and other supplies for a unit of 500 men, baggage animals, and mounts would have been logistically very challenging (Richardson 2004). The items making up the standard Roman military diet have been estimated to weigh 1.4kg per person per day (Davies 1971, 1989: 193; Johnson 1983: 195-202), so the unit of approximately 500 men suggested by the size of the Ḥawara fort would have required approximately 700kg of foodstuffs daily. Any mounts housed in the fort would have required further supplies: 3kg of grain per day for a pack animal, 5.5kg/day for a horse (or twice this amount of high quality pasturage) (Shirley 2001: 109). Storage of at least three months supply of food, probably totalling more than 100 metric tons, was essential to the function of the outpost.

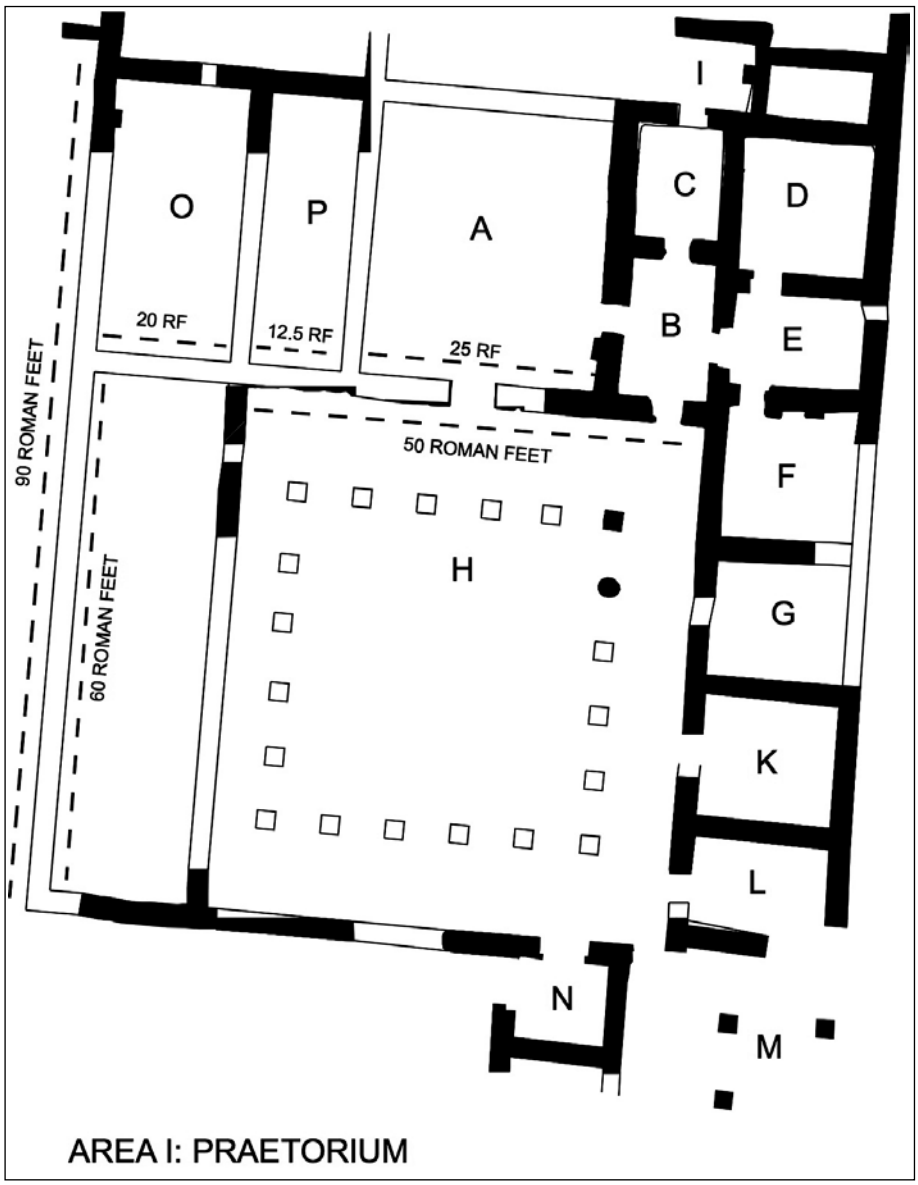
A few details of the south end of the structure require further excavation, but it looks as if the engineers laid out the main portion of the *horreum* as a rectangle 75 RF wide from east to west, and 50 RF long (FIG. 7). This space was then subdivided into three large rooms 25 RF wide and 50 RF long, each with a door 5 RF wide in the centre of the south wall. The walls were built straddling the survey lines, and they vary in width. The storage area was roofed with heavy slabs carried on cross arches.

While the *horreum* was crucial for subsistence, the *principia* was the central administrative structure in a fort, where the unit's gods and standards were kept and the commander's decisions passed on to the officers and men assembled in the courtyard (FIG. 7). As in most Roman forts, the engineers laid this structure out on the centre line of the fort, on the same orientation as the fortification walls, and facing south on to the *via principalis*. The benchmark (*gromae locus*; see below) for the original survey probably was set up on what became the centre line of the *principia*, on the line of its south wall, with a clear view to the sites of the four gates, two-thirds of the distance from the north wall to the south entrance. The engineers laid out a rectangle 100 RF wide and 175 RF long. A cross wall placed 30 RF from the north wall defined space for four offices and the central shrine, subdivided by four party walls 20 RF apart. There may have been a colonnade around the resulting parade ground. Several statue bases drew attention to the façade of the office area.

The *praetorium*, or commander's residence, is the third of these central structures. The planning procedure can be reconstructed in more detail for this structure, given its better preservation, greater complexity, and more complete excavation (FIG. 8). A square was laid out at the appropriate orientation, 90 RF on a side; an east/west line was then laid out across the square, 60 RF north of the south side. Two further lines were then laid out north/S, 20 RF in from the east and west sides. These lines defined a central courtyard 60 RF long north to south, and 50 RF wide. The long rectangles framing the east and west sides of the courtyard were then each divided into rooms theoretically 15 RF wide and 20



7. Ḥawara/al-Al-Ḥumayma, plan of central structures in fort.



8. Ḥawara/al-Al-Ḥumayma, plan of *praetorium* in Roman feet.

RF deep. Five long, rectangular rooms were laid out across the northern third of the structure, all 30 RF long, oriented north/south: two outside rooms 20 RF wide (possibly subdivided in length); two at the northeast and northwest corners of the courtyard, 12.5 RF wide; a grand central room 25 RF wide.

The present measurements of the structure vary slightly from these ideals, depending on whether the walls were constructed with the outer or inner face on the surveyed line, or the medial line of the wall itself. The walls in the *praetorium* — built for the most part of rubble set in mud, with occasional use of blocks at corners and doorways — range in thickness from 0.64-0.70m (2.16-2.36 RF), but the design width was probably 2 RF. The addition of plaster after construction and during renovation, and the gradual dissolution of the fabric after abandonment have thickened them. As built, the outside, north/south dimensions of the *praetorium* are just over 93 RF (27.16m), suggesting that one east/west wall was built outside the surveyed line, and the other straddling it. Similarly, the courtyard is just over 50 RF wide (14.88m), but only 58 RF long (17.16m). In this case, the north/south walls and one east/west wall were built outside the survey line, but the other east/west wall was built inside it. The doors range around 5 RF in width.

As in the *horreum*, most rooms in the *praetorium* had flat slab roofs supported by cross arches, while some of the smaller rooms may have been roofed with poles and palm thatch covered with an

impermeable roof plaster.

The engineers who laid out the fortifications and interior buildings of the fort at Ḥawara were following a long tradition that specified the designs and procedures to be used. Sketches or even verbal descriptions may have been sufficient, given the standardized plans, and with the *groma* to survey right angles and the measuring chain or pole to determine distances (Lewis 2001: 20-1, 59-60, 120-33), the team could have quickly laid out the wall lines on the ground with coloured flags and pegs — as described by Polybius (below, 6.26.10-34.6). Execution seems a little more haphazard, as walls were sometimes built on top of the theoretical wall line, or to one side or the other. These variations from the ideal may have been intentional, as the builders tweaked a standard plan to deal with practical problems involving the site or available materials; the construction teams may also have varied in competence and attention to detail. In any case, consideration of the process of design provides a better understanding of these structures.

It is instructive to compare some of the procedures reconstructed above with the few surviving Greek and Latin sources that describe the procedures for laying out Roman marching camps: a description in Polybius' *History*, dating to the mid-second century BC (6.26.10-34.6); a description in Josephus' *Jewish War* (3.76-84) of the 70s AD; the *de munitionibus castrorum* of Pseudo-Hyginus, dating to the early second century AD; and a few details in Vegetius' *Epitoma rei militaris*, written in the late fourth century (1.21-25, 3.8). These sources all describe temporary or seasonal marching camps, in which the central structure is the commander's tent, termed the *praetorium*. In permanent forts the central building was the *principia*, which took over the administrative functions of the commander's tent, while the *praetorium*, to one side, assumed the residential function.

Although Polybius describes an early form of the Roman marching camp, and the details of the design remain subject to controversy, the characteristics of symmetry, proportion, logical organization, and standardization are already clear. A site from which the camp can best be overseen is selected for the commander's tent and marked with a flag. A square 200 RF on a side is marked out with this flag at the centre. The rest of the camp is laid out around this square, with consideration of local conditions, such as the best direction from which to take water and forage.

"When the army on the march is near the place of encampment, one of the tribunes and those centurions who are specially charged with this duty go on in advance, and after surveying the whole ground on which the camp is to be formed, first of all determine from the considerations I mentioned above where the consul's tent should be placed… (see 6.27). When they have decided on this, they measure out first the area of the *praetorium*, next the straight line along which the tents of the tribunes are erected, and next the line parallel to this, starting from which the troops form their encampment… All this is done in a very short time, as the marking out is quite an easy matter, all the distances being fixed and familiar. Then they plant flags, one in the spot intended for the consul's tent, another on the side of it they have chosen for the camp, a third in the middle of the line on which the tribune's tents will stand, and a fourth on the other parallel line along which the legionaries will encamp. These latter flags are crimson, but the consul's is white. On the ground on the other side of the *praetorium* they plant either simple stakes or flags of other colours. After this they go on to lay out the streets and plant stakes in each street" (Polybius, *History* 6.41; Loeb edition).

There are striking parallels between this straightforward procedure and the modern use of variously coloured flags in laying out building sites, or lawn irrigation systems. Polybius, of course, wrote 250 years before the fort was built at Ḥawara, but the procedures are simple and logical. Josephus was equally impressed by this Roman innovation.

"This camp is not erected at random or unevenly; they do not all work at once or in disorderly parties. If the ground is uneven, it is first levelled; a site for the camp is then measured out in the form of a rectangle. For this purpose the army is accompanied by a multitude of workmen and of tools for building. The interior of the camp is divided into rows of tents. From outside, the circuit gives the appearance of a city wall and is furnished with towers at regular intervals; and in the spaces between the towers are placed…every variety of artillery engines, all ready for use… The camp is intersected by streets symmetrically laid out. Precisely in the centre is the headquarters of the commander (*stratégion*), resembling a small temple" (*Jewish War* 3.76-83; Loeb edition).

The location, design, and even some of the de-

tails of the Ḥawara fort correspond well with the specifications provided by Pseudo-Hyginus, *de munitionibus castrorum*. This work, whose author and original title are unknown, is now felt to have been written by a military engineer active in the east during Trajan's reign (Lenoir 1979: 113-33). Given their chronology and the eastern context, the texts in Josephus and Pseudo-Hyginus are particularly relevant to Ḥawara. Here is a selection of the more striking passages from the *de munitionibus castrorum*.

"As for selecting a location for laying out the fort, sites that rise up a gentle slope from a field are the best. In this arrangement the north gate (*porta decumana*) is at the highest point, so that the rest of the fort lies below it. The south gate should always face the enemy (56).

The spot at the entrance to the *praetorium*, at the middle of the *via principalis* is called the "benchmark" (*gromae locus*) because the troops meet there; also, because when the measurements are called out the *groma* is positioned over a metal stake set in this very spot, at the intersection of the line of sight to each gate (12).

The main ditch, [should have a] cross-section either "sloped" or "Punic". That one is called "sloped" whose sides incline downward from its greatest breadth and meet at a narrow point at the bottom… They should be given a width of at least 5 feet and a depth of at least 3. Similarly, let there be a ditch 60 feet outside the gates, equal to them in width; on account of its short length this is called "the nametag" (*titulum*)… Likewise there should be a mound in front of the main gates, as along the ditches, at "the nametag" (*ad titulum*)" (49-50).

In hostile country one should remember to… build platforms for ballistae around the gates, at the corners, and in place of towers" (58) (translation adapted from Miller and Devoto 1994).

The late fourth century author Vegetius says relatively little about camps, and he expresses a different, much later tradition than the authors already quoted. Nevertheless, a few of his comments are relevant.

"Camps are considered more practical if their length is a third part more then their width. The surveyors (*agrimensores*), however, should calculate a module of measurement in feet, so that the army be enclosed according to its size… A mound is built up like a wall. The centurions measure this with 10-foot poles lest some dig less or cause mistakes through laziness" (3.8; translation Stelten 1990).

The design standards, personnel, procedures, and tools mentioned in these sources help us to reconstruct the activities of Trajan's engineers at Ḥawara early in the second century and to understand better the structures we find there. This approach has not yet been applied to the other Roman forts excavated in the region, although many British scholars have applied modular analysis to Roman forts in Britain and northern Europe (Connolly, Davison, Van Driel-Murray 1989; Evans 1994; Henderson 1991; Richardson 2000; Shirley 2000, 2001; Taylor 2000). Even a selection of a few results based on metric dimensions of fortifications published in Kennedy 2004 (and a few other publications), some of them approximate, will give an idea of the promise of this approach in the region.

Bostra: Trajanic legionary fort; 440 x 360m (Kennedy 2004: 218) = 1500 x 1200 RF.

Ad-Diyāthah: fort, century AD 300; 71.7 x 51.7m (Kennedy 2004: 219) = 250 (?) x 75 RF.

Dayr al-Kahf: fort, after AD 306; 60 x 60m (Kennedy 2004: 72) = 200 x 200 RF.

Al-Lajjūn: legionary fort, century AD 300 (Parker 2006: fig. 3.4); c. 238 x 192m = 800 x 650 RF.

Tall 'Abara: marching camp? Trajanic? (Kennedy 2004: 180); c. 150 x 120m = 500 x 400 RF.

Aṣ-Ṣadaqa: auxiliary fort, second century (Kennedy 2004: 187); c. 120 x 80m = 400 x 275 RF?

Beer Sheva: auxiliary (?) fort, third century (Fabian 1995: 237); 180 x 117.5m = 600 x 400 RF.

In this context there is space only to introduce one remaining problem: the fort at Ḥawara seems to be the earliest documented example — by nearly a century — of a Roman fort with towers projecting from the wall rather than built against the inside face (Gregory 1986, 1996a, 1996b). The Trajanic fort at Bostra has been said to follow the same design, but excavation is needed to prove it. Gregory suggested that the Romans adopted projecting towers for their forts in the east in response to their common custom of billeting troops in walled cities in that region, in contrast with the marching camps customary in the more sparsely populated western provinces. But since towers appear on the fort at Hawara, which is otherwise very western in design, at the very beginning of the Roman occupation of Nabataean, it seems more likely that the towers are a response by Trajan's engineers to the greater experience of their eastern opponents with siege techniques against walled cities with projecting towers.

The greater tactical sophistication of the forces opposing Rome in the Near East, and the character of their offensive and defensive armament, fostered the use of projecting towers. Among other advantages, projecting towers would have allowed more effective deployment of hand carried ballistae, while larger torsion catapults were mounted on intermediate platforms, as at Ḥawara (Rihill 2007: 91-105). The descriptions quoted above do not clarify whether the camp towers should project from the wall, but it may not be accidental that Josephus describes a Roman camp as having "the appearance of a city wall…and furnished with towers".

Roman engineers, both civil and military, were famous for their skills, and the Roman Empire could not have survived without the infrastructure they created. There is still much to be learned about their activities in the Provincia Arabia, whether in the design and construction of forts, or of roads, aqueducts, and drains.

References

Bowersock, G. 1983. *Roman Arabia*. Cambridge, MA: Harvard University Press.

Connolly, P., Davison, D. and Van Driel-Murray, C. 1989. *The Barracks of the Roman Army from the 1st to 3rd Centuries A.D.: a Comparative Study of the Barracks from Fortresses, Forts and Fortlets with an Analysis of Building Types and Construction, Stabling and Garrisons*. 3 vols. British Archaeological Reports, Intl. Ser. S472. Oxford: BAR.

Davies, R.W. 1971. The Roman Military Diet. *Britannia* 2: 122-42.

—— 1989. *Service in the Roman Army*. Edinburgh: Edinburgh University Press.

Evans, E. 1994. Military Architects and Building Design in Roman Britain. *Britannia* 25: 143-64.

Fabian, P. 1995. The Late Roman Military Camp at Beer Sheba: A New Discovery. Pp. 235-40 in J.H. Humphrey (ed.), *The Roman and Byzantine Near East: Some Recent Archaeological Research*. JRA Suppl. 14. Ann Arbor: JRA.

Freeman P. 1996. The Annexation of Arabia and Imperial Grand Strategy. Pp. 91-118 in D. L. Kennedy (ed.), *The Roman Army in the East*. JRA Supp. 18. Ann Arbor: JRA.

Graf, D. 1995. The *Via Nova Traiana* in Arabia Petraea. Pp. 241-67 in J.H. Humphrey (ed.), *The Roman and Byzantine Near East: Some Recent Archaeological Research*. JRA Suppl. 14. Ann Arbor: JRA.

Graf, D. 1997. The Via Militaris and the Limes Arabicus. Pp. 123-33 in W. Goernman *et al*. (eds.), *Roman Frontier Studies 1995: Proceedings of the XVIth International Congress of Roman Frontier Studies*. Oxbow Monograph 91. Oxford: Oxbow.

Gregory 1986. Not 'Why not Playing Cards?' but 'Why Playing Cards in the First Place'. Pp. 169-75 in P. Freeman and D.L. Kennedy (eds.), *The Defense of the Roman and Byzantine East*. British Archaeological Reports, Intl. Series S297. Oxford: BAR.

—— 1996a. *Roman Military Architecture on the Eastern Frontier, A.D. 200-600*. Amsterdam: Hakkert.

—— 1996b. Was There an Eastern Origin for the Design of Late Roman fortifications? Some Problems for Research on Forts of Rome's Eastern Frontier. Pp. 169-210 in D. L. Kennedy (ed.), *The Roman Army in the East*. Journal of Roman Archaeology, Suppl. 18. Ann Arbor: JRA.

Henderson, C.G. 1991. Aspects of the planning of the Neronian Fortress of legio II Augusta at Exeter. Pp. 73-83 in V.A. Maxfield and M.J. Dobson (eds.), *Roman Frontier Studies, 1989. Proceedings of the XVth International Congress of Roman Frontier Studies*. Exeter: University of Exeter Press.

Isaac, B. 1990. *The Limits of Empire: The Roman Army in the East*. Oxford: Oxford University Press.

Johnson, A. 1983. *Roman Forts of the 1st and 2nd Centuries AD in Britain and the German Provinces*. London: Adam & Charles Black.

Kennedy, D.L. 1980. Legio VI Ferrata: The Annexation and Early Garrison of Arabia. *Harvard Studies in Classical Philology* 84: 282-309.

—— 2004. *The Roman Army in Jordan*. 2nd ed. London: Council for British Research in the Levant.

Lenoir, M. 1979. *Pseudo-Hygin: Des Fortifications du Camp*. Paris: Les Belles Lettres.

Lewis, M.J.T. 2001. *Surveying Instruments of Greece and Rome*. Cambridge: Cambridge University Press.

Miller, M.C.J. and Devoto, J.G. 1994. *Polybius and Pseudo-Hyginus: The Fortification of the Roman Camp*. Chicago: Ares.

Oleson, J.P. 2001. King, Emperor, Priest, and Caliph: Cultural Change at Hawara (Ancient al-Ḥumayma) in the First Millennium AD. *SHAJ* 7: 569-80.

—— 2004. "Romanization" at Hawara (al-Humayma)? The Character of "Roman" Culture at a Desert fortress. *SHAJ* 8: 353-60.

Oleson, J.P. *et al*. 1995. Preliminary Report of the Humeima Excavation Project, 1993. *ADAJ* 39: 317-54.

Oleson, J.P. *et al*. 1999. Preliminary Report of the al-

Humayma Excavation Project, 1995, 1996, 1998. *ADAJ* 43: 411-50.

Oleson, J.P. *et al*. 2002. New Dedicatory Inscriptions from Humayma (Ancient Hawara), Jordan. *Zeitschrift für Papyrologie und Epigraphik* 140: 103-21.

Oleson, J. P. *et al*. 2003. Preliminary Report of al-Humayma Excavation Project, 2000, 2002. *ADAJ* 47: 37-64.

Oleson, J. P. *et al*. 2008. Preliminary Report on Excavations at Humayma, Ancient Hawara, 2004 and 2005. Forthcoming in *ADAJ* 52.

Parker, S.T. 2000. Roman Legionary Fortresses in the East. Pp. 121-38 in R. J. Brewer (ed.), *Roman Fortresses and their Legions: Papers in honour of George C. Boon,* London: Society of Antiquaries.

Parker, S.T. 2006. *The Roman Frontier in Central Jordan: Final Report on the Limes Arabicus Project, 1980-89*. 2 vols. Washington D.C.: Dumbarton Oaks.

Richardson, A. 2000. The Numerical Basis of Roman Camps. *Oxford Journal of Archaeology* 19: 425-37.

Richardson, A. 2004. Granaries and Garrisons in Roman Forts. *Oxford Journal of Archaeology* 23: 429-42.

Rihill, T. 2007. *The Catapult: A History.* Yardley PA: Westholme.

Schmid, S. 1997. Nabataean Fine Ware Pottery and the Destruction of Petra in the Late First and Early Second Century AD. *SHAJ* 6: 413-20.

Shirley, E.A.M. 2000. *Construction of the Roman Legionary Fortress at Inchtuthil*. BAR British Series, 298. Oxford: BAR.

Shirley, E.A.M. 2001. *Building a Roman Legionary Fortress*. Brimscombe Port: Tempus.

Speidel, M.P. 1977. The Roman Army in Arabia. Pp. 687-730 in H. Temporini, W. Haase (eds.), *Aufstieg und Niedergang der römischen Welt* II.8. Berlin: De Gruyter.

Stelten, L.F. 1990. *Flavius Vegetius Renatus, Epitoma Rei Militaris. Edited with an English Translation*. New York: Peter Lang.

Taylor, D.J.A. 2000. *The Forts on Hadrian's Wall. A Comparative analysis of the form and construction of some buildings*. BAR British Series, 305. Oxford: BAR.

Wilson-Jones, M. 2000. *Principles of Roman Architecture*. New Haven: Yale.