SUPPLYING THE ROMAN EMPIRE

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Organization of the water supply for the Trajanic frontier fort in the Nabataean settlement of Hawara (Southern Jordan)

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A Nabataean king, probably Aretas III, founded the settlement of Hawara in the Hisma desert about 41 km south of Petra (as the crow flies) in the late 1st century BC (fig. 1). Despite the low rate of precipitation – *c.* 80 mm/year – and the high pan evaporation rate – *c.* 3,400 mm/year – the settlement flourished through the harvesting of winter run-off water guided to cisterns and agricultural fields (Oleson 2010; Oleson *et al.* 2015). The settlement also enjoyed the output of a 27 km long, ground-level aqueduct that brought spring water from the al-Shara escarpment. The population of Hawara, essentially a colony of Petra, was intended to exploit the relatively fertile soil of the surrounding plains and to service the caravans passing along the adjacent King's Highway. Soon after the conquest of the Nabataean kingdom and the foundation of the *Provincia Arabia* by Trajan in AD 106, Roman engineers built a fort at the north edge of the settlement centre, renamed Hauarra, as part of their strategy for control of this new frontier area (Oleson *et al.* 2015; Oleson 2019). The fort was designed for a garrison of about 500 soldiers and their mounts, probably a mix of auxiliary soldiers and detachments from the *Legio III Cyrenaica* (fig. 2).

The supply of water to the fort would have been a primary concern for the Roman occupying force, but their engineers moved away from the adaptable, multi-facetted Nabataean system and made use of only the aqueduct. The pre-existing system made use of run-off irrigation, cisterns and reservoirs fed by run off, along with the spring-fed aqueduct (Oleson 2010). The deviation from the original system brings up interesting questions about competition, collaboration, and innovation in the changed social environment of Roman Hauarra. Despite the significantly increased demand the Roman garrison placed on the Nabataean water-supply system, the built-in adaptability of the original system allowed continued growth of the civilian settlement alongside the fort. In fact, the Nabataean system continued to function until the aqueduct ceased to flow in the mid-8th century, 300 years after the fort was abandoned. The rest of the system has continued in use by the local Bedouin up to the present (fig. 3).

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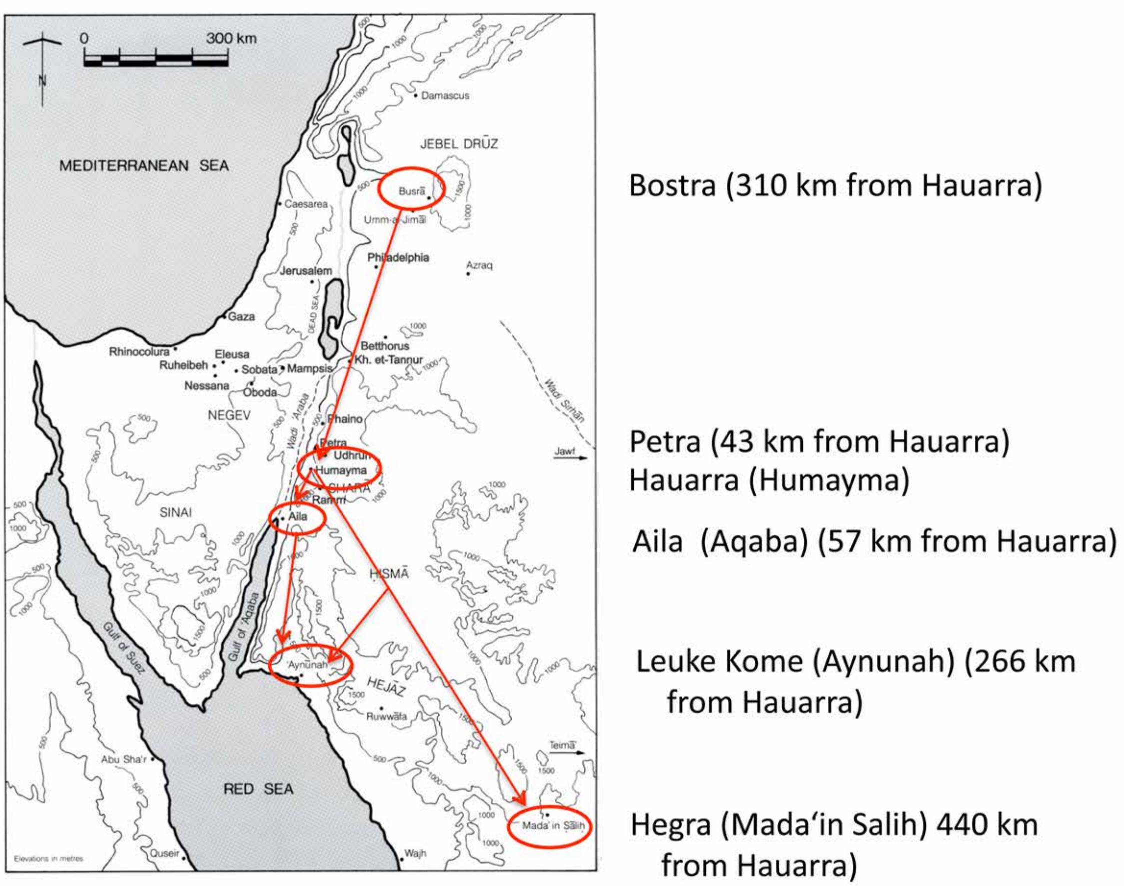

Figure 1. Map of early *Provincia Arabia* fort sites with distances.

What techniques did the Nabataean settlement use to supply itself with water? The most spectacular feature was a 27 km long aqueduct system that brought to the settlement centre water from three springs on the al-Shara escarpment, 15 km to the north (Oleson 2010, 74-114). This was probably a royal project. Although the design is the same as that seen in other Nabataean aqueducts, the Hawara aqueduct is by far the longest example. Water was collected in basins adjacent to the springs, then admitted to channels that ran along the ground. Where possible, the channels were cut in the soft local bedrock, but about 90 % of the Hawara system was built of conduit blocks cut from the local stone. These were laid on a simple gravel foundation and held in position by rubble packing framed by blocks on both sides. The conduits were covered with stone slabs set on a layer of mortar, to prevent evaporation and pollution.

The tall arches that carried portions of Roman aqueducts elsewhere in the Empire in response to changes in the topography were not used by the Nabataean engineers. Although walls several metres high occasionally carried the Nabataean channels across small gullies, for the most part careful surveying of the aqueduct course and small-scale excavation of low obstacles allowed effective channel flow at slopes as low as one percent. The aqueduct system at Hawara discharged its water into a large shallow pool (27.6 × 17 m, depth 1.34 m) with a capacity of 633 m^3. The overflow water then spilled into a downstream conduit that supplied a bath building and possibly some cisterns in the town centre (Oleson 2010, 181-198) The aqueduct and pool were spectacular, but the backbone of Hawara's water-supply system was the collection of run-off water from occasional winter rains. Three reservoirs and more than 50 cisterns in the settlement centre and the surrounding region were located below natural or enhanced run-off fields (Oleson 2010, 115-154 and 175-216). On average, these run-off systems provided a reliable supply of water. Most cisterns were cut down into a levelled rock surface and provided with slab roofs carried on cross arches, to prevent evaporation and pollution. Other parts of the Nabataean system were agricultural terraces and retention dams. There were at least three retention dams on the outskirts of Hawara, designed to hold back large pools of run-off water (Oleson 2010, 115-154). Since these pools were too large to be shielded from the sun, the water would have been of low quality and probably used only to water livestock.

Figure 2. Aerial view of fort (Aerial Photographic Archive of Archaeology in the Middle East, APAAME_20160919_DLK-0081, www.humanities.uwa.edu.au/research/cah/aerial-archaeology).

When the Roman garrison arrived at Hawara, they found this system in operation. The fort was constructed on a rise at the north edge of the Nabataean settlement centre, laid out on a five-degree slope allowing drainage of rainwater and grey water (Oleson 2009; 2019; Oleson *et al.* in press). A large reservoir was built just inside the northwest corner of the fort, fed by a Roman branch channel of typical Nabataean design connected to the aqueduct, which passed within 60 m of the northwest corner tower (fig. 4). The branch conduit passed through the northwest corner tower and emptied into the northwest corner of the adjacent reservoir (29.4 × 14.2 m, 3.0 m deep) with a capacity of 1,275 m^3. Depending on the season, the aqueduct probably discharged between 53 and 470 m^3 per day, but we do not know what proportion was taken for the fort. No overflow channel or outflow pipe was found in the reservoir, but there were masonry platforms inside the southeast and southwest corners that probably supported individuals operating *shadufs*, a water-lifting device typical of the ancient Near East and still in use in parts of the world today (Oleson 1984, *passim*) (fig. 5). The operator, standing on the platform, pulled down on a pole carrying a waterproof basket, which was dipped in the reservoir. The upper end of the pole was attached by a rope loop to a long, counterweighted pole that pivoted on an upright support. As the pole was pulled down, the counterweight was lifted. Once the basket was filled with water, the counterweight was allowed to descend and lift the basket to the level of a catch basin into which the operator emptied the water. The arrangements for the catch basins at Hauarra have not survived, but 10 m down the slope toward the *praetorium* there is a stone channel leading toward the *principia* and a terracotta pipeline leading into the *praetorium*, where it serviced the needs of the commander and his family, including a pool with a spouting water display. Another stretch of the pipe system was found further down slope beneath the sidewalk adjacent to the *via principalis dextra*, but more excavation is needed to define the distribution system in detail. Two structures it may have served are a lavatory and a brewery (Oleson & Sherwood 2022; Oleson *et al.* in press).

While designing the fort and its reservoir, it is likely that the Roman occupiers simply commandeered access to the Nabataean aqueduct water, which previously had served the whole community. Furthermore, at some point in the 2nd or 3rd century the Romans also took control of the remaining aqueduct discharge into the Nabataean pool 80 m west of the southwest tower, to serve a Roman military bath 120 m further downhill (Oleson 2010, 223-230; Reeves *et al.* 2017, 105-122). The previous simple

Figure 3. View of Nabataean aqueduct to Hauarra, from north.

overflow discharge from the pool had been carried toward the town centre by a typical Nabataean conduit system, identical to that of the supply aqueduct. The Roman adaptation exchanged the free overflow and communal access to a closed system in which water was released through a pipe inserted through a hole excavated at the base of the south wall of the pool. The flow was controlled by a large bronze stopcock locked behind a gate, which fed a system of lead piping laid within the Nabataean conduit blocks that conducted the water to a Roman military bath on the site of an earlier Nabataean structure. The stopcock, precisely one Roman foot long (0.296 m), is the largest of the small number of Roman stopcocks found in the Near East and is significantly larger than the average Roman stopcock (Oleson 2010, 333-334). This is a clear indication that Roman technology and Roman habits superseded the Nabataean collaborative social arrangements.

The exclusive focus of the Roman engineers at Hauarra on use of the Nabataean aqueduct to feed a reservoir inside the walls, to the exclusion of the other elements of the existing, time-proven water-supply system for the Nabataean town, is in many ways surprising. Why did the garrison not simply draw fresh spring water from the nearby pool at the end of the Nabataean aqueduct, or construct large cisterns fed by run-off water? Although aqueducts were a standard feature of Roman urban water-supply systems, there are very few examples of Roman forts supplied with water by an aqueduct or pipeline, much less by an aqueduct 27 km long. A dam captured spring water that flowed through a 360 m long channel toward the *Betthorus* (El-Lejjun) fort and *vicus*, but no evidence for a reservoir was found inside the walls (Parker 2006, 241-243, fig. 3.2), and the conduit may have had nothing to do with the fort. The obvious issue with an aqueduct supply system is vulnerability to sabotage by the local population or invading forces. In the largely arid lands along the eastern frontier of the Roman Empire, Roman forts and *castella* normally depended on small reservoirs or cisterns outside the walls, fed by adjacent springs or by run-off from winter rains. While dependence on basins outside the fort exposed soldiers to attack, as several Roman inscriptions attest (*e.g.* at Khirbet Umm el Menara, Kennedy 2004, 71-72), garrisons were trained to confront threats, and the water supply itself remained relatively immune from disruption.

Modest cisterns are occasionally found within Roman forts, but so far field research has not revealed large reservoirs within their walls, even in desert regions, apart from Hauarra and *Castra Albana* (see below). There are reservoirs outside the forts at Bostra (Kennedy & Riley 1990, 124-125, fig. 72), Quweira (Kennedy 2004, fig. 19.6C; Oleson 2010, 457-458), Qasr et-Telah (Kennedy 2004, fig. 20.10C), probably *Adrou/Adroa* (Udhruh) (Kennedy & Falahat 2008, 151-152), and Jerusalem (as restored by Weksler-Bdolah 2021, 304-307). There is a small cistern inside the walls of *Praesidium* (Khirbet al-Khalde), fed by a pipeline from a spring 800 m up the mountain slope (Kennedy 2004, 200, figs. 19.10, 19.9C; Kennedy & Bewley 2004, 190-191; Oleson 2010, 457-460), but this may have been intended to serve a small bath possibly located in the fort's north corner. There is a spring inside the walls of the fort at *Palmyra*, but no reservoir has been exposed (Lenoir 2011, fig. 28). There are reservoirs outside the walls of the *castella* at Khan at-Trab and Khan as-Samat (Lenoir 2011, fig. 50), Khan el-Qattar (Kennedy & Riley 1990, 204), Khan el-Manqoura (Kennedy & Riley 1990, 182-183), Deir el-Qinn (Kennedy 2004, 77-79), Umm el-Quttein (Kennedy & Riley 1990, 142; Kennedy 2004, 82), Umm el-Jimal (Kennedy & Riley 1990, 185; Kennedy 2004, 85-87, fig. 9.10C), Qasr el-Hallabat (Kennedy & Riley 1990, 25; Kennedy 2004, 96-98; Kennedy & Bewley 2004, 177), Qasr Bshir (Kennedy 2004, fig. 14.9C; Kennedy & Bewley 2004, 184-186), Da'janiya (Kennedy & Riley 1990, 173; Kennedy & Bewley 2004, 184; Kennedy 2004: 170, fig. 16.7), and *Ariddela* (Gharandal) (Kennedy 2004, 211, fig. 20.6). Qasr el-Azraq took its water from the large adjacent spring pools (Kennedy & Riley 1990, 180; Kennedy 2004, 57-58). Although the interior areas of many Roman forts in the

Figure 4. Reservoir inside Roman fort, from south.

Figure 5. Shaduf platform at southeast corner of reservoir.

Near East have not been extensively excavated, one would expect a reservoir as large as that in the Hauarra fort to be visible to even superficial survey or to aerial photography.

It is striking to realise that the Hauarra fort appears to be almost unique throughout the whole Roman Empire in depending on a large reservoir within its walls. Many Roman forts and *castella* drew on modest reservoirs or cisterns outside the ramparts, and cisterns are occasionally found within forts, but we have so far identified only one fort with an internal reservoir comparable to that at Hauarra. The reservoir in the *Castra Albana*, the fort built by Septimius Severus for the *Legio II Parthica* at Albano Laziale, 24 km south of Rome, is even larger than that at Hauarra: 45.50/47.90 m x 29.62/31.90 m (150 × 100 *pes monetalis*, capacity 10,132 m^3) (Chiarucci 1988, 35). But the *Castra Albana* is essentially an urban fort, and the reservoir probably was built originally for the Villa of Domitian and later reused when the fort was built on top of the villa site. No other Roman fort has a reservoir within its walls equivalent to the Hauarra and *Castra Albana* reservoirs. The remarkable arrangement of the water supply at Hauarra is an important clue to the role of the fort in the Roman administration of *Provincia Arabia* in the early 2nd century.

Why did the Hauarra fort need such a large reservoir inside the walls? The 1,275 m^3 of water would have represented a six-month supply for the likely garrison size: *c.* 500 men and the mounts for a portion of that number. The fort's location in a sparsely settled desert area far from any disputed or vulnerable frontiers should have been relatively secure. An unexpected, long-term siege would have been highly unlikely, particularly at the hands of the regional nomadic tribes often cited erroneously as a defining hazard along the eastern frontier (*e.g.* Parker 1986, 123-148). The theory that the forts along the Arabian frontier were designed to control the movement of Bedouin tribes is now largely discarded (*e.g.* Graf 1997). The Hisma region was certainly more secure than the frontier in *Syria* or *Mesopotamia*, where reservoirs and large cisterns were nevertheless routinely located outside the fort walls. A striking example of this arrangement is *Bostra*, the principal fort in the province (Kennedy & Riley 1990, 124-125, fig. 72). It seems likely that the Hauarra fort played an unconventional role in Trajan's plans for the region. The plan of the fort is also atypical, representing the earliest known example of a Roman fort with projecting towers around its entire circumference.

The Hauarra fort is one of only three forts known to have been built in *Provincia Arabia* immediately following the Roman annexation: the other two are at *Bostra* and *Hegra* (Kennedy 2004; Parker 1986; 2006; 2009; Fiema 2020, 2022). The documented forts were all placed in widely separated zones of the new province, at locations where the Romans felt the need to establish a major strongpoint: *Bostra* at the north edge of the new province, in the populous and fertile region near *Syria*; Hauarra 310 km to the south of *Bostra* in the Hisma Desert, halfway between Petra (41 km to the north as the crow flies) and the important port at *Aila* (Aqaba, 57 km to the southwest); and at *Hegra* (Mada'in Saleh, Medain Saleh) 440 km southeast of Hauarra along trade routes at the southeast boundary of the province. An important strategic question for Trajan was how to move troops safely along the *Via Nova* and associated desert tracks to protect the southern portion of the *Provincia Arabia*.

Although relatively small, the settlement of Hauarra was nevertheless a significant habitation centre in the context of the sparsely populated southern part of the *Provincia Arabia*, and it was located at a crossroads where one could pass on to a variety of important trading points. A direct route led southeast for 40 km to the small settlement at Nabataean Iram and continued for another 400 km to the important Nabataean centre of *Hegra* on the southern border of the province and at the threshold of *Arabia Felix*. This was an important entry point for the Arabian incense trade. From Hauarra there was also a road connection on the *Via Nova* to the important Nabataean trading port of *Leuke Kome* on the Red Sea, probably modern Aynuna (Nappo 2010; Juchniewicz 2017). From Hauarra, the route led first 57 km to *Aila* on the Gulf of Aqaba, then 209 km via the coastline and the Wadi 'Ifal through the mountains to *Leuke Kome*.

If we consider the strategic needs of Trajan and his generals, we can reconstruct the reasons for selection of the small Nabataean settlement of Hawara for the second largest fort in his new province after that at the provincial capital *Bostra*, 310 km to the north. *Hawara* (Hauarra) is approximately equidistant between the only two substantial habitation centres in the region, Petra and *Aila* (Aqaba). The location of a major fort at Hawara/Hauarra made possible the rapid deployment of military forces to either Petra or *Aila* by way of the *Via Nova*, or to Hegra, without spreading available forces too thin by dividing them between the two main settlements. Arabia's legionary headquarters at *Bostra*, which a legionary's letter of AD 107 described as eight days' journey from Petra, was too far away to have projected a quick response to a crisis in the south (P.Mich 466; Kennedy 2004, 175-176).

In addition to road connections, Hauarra also had the important advantage of a significant, reliable water supply under military control, held in a large reservoir within the fort walls. This supply was much more than the hypothetical 500-strong garrison stationed at Hauarra needed, so it was most likely designed to provide water both for troops being transferred through the fort, and for reserve supplies to be carried by military columns making the estimated 13-day trip to *Hegra*, or the shorter trip to *Leuke Kome*. The *shadufs* installed in the reservoir could have lifted large amounts of water to fill containers provided to troops bound for the desert roads. Among many other sources, Strabo (*Geographica* 16.4.24) comments on Aelius Gallus' use of camels to carry water for his campaign in 26/25 or 25/24 BC from *Leuke Kome* south into the Arabian Peninsula. As a successful, experienced general, undoubtedly aware of the disastrous outcome of Aelius Gallus' campaign, Trajan would have focused on the supply of water to troops on the march through the Hisma Desert (Moss 2015). Even the soldiers crossing the river Danube in the early scenes of the Column of Trajan carry individual water bags as part of their baggage (Volken 2008), and water barrels loaded on wagons appear in later scenes (Del Giacco *et al.* 2017).

The crucial importance of sufficient supplies of water features in many accounts of Roman campaigns in the Near East. Flavius Josephus (*De Bello Iudaico* 7.278) also comments on the need to transport water from a distance (perhaps by boat from springs at Ein Gedi, Jericho, and Ein Boqeq) to support the troops besieging Masada in AD 73-74 (Magness 2009, 84). In 53 BC, Crassus and his army were drawn away from the Euphrates by the Arab chieftain Ariamnes to a spot where deep sand and the lack of water and shade debilitated the army (Plutarchus *Crassus* 22.1). Corbulo suffered the same fate in *Mesopotamia* in AD 59 (Tacitus *Annales* 14.24; Oleson & Reeves forthcoming).

The presence of a large reservoir inside the walls of the Hauarra fort is strikingly atypical for Roman forts in both the Near East and the Roman West. The motivation for this remarkable arrangement was the on-going role of this crossroads fort as a secure centre for the distribution of water to troops on their way into the desert. The reservoir thus helps us understand better the importance of the Hauarra fort in Trajan's strategy for control of the southern *Provincia Arabia*.

Abbreviation

P.Mich: *Michigan papyri*

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