SENNACHERIB'S NORTHERN ASSYRIAN CANALS: NEW INSIGHTS FROM SATELLITE IMAGERY AND AERIAL PHOTOGRAPHY

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In discussions of the agricultural economies of ancient Mesopotamia, scholars commonly make a sharp distinction between intensive irrigation in the south and extensive rain-fed farming in the north (Weiss 1986; Bagg 2000: 283). In popular as well as academic publications Babylonia is strongly associated with canals, and when one thinks of large state-sponsored initiatives the massive integrated network of canals built by the Sasanian rulers of southern Mesopotamia (Adams 1978) normally springs to mind first. However, since the mid-nineteenth century archaeology and epigraphy have documented the great irrigation schemes of the Neo-Assyrian kings. The inscriptions of Sennacherib in particular refer proudly to his great network of canals, and often describe them in the context of luxurious gardens and parks. The inscriptions make mention of the waters’ use for vegetable garden plots and, less frequently, for grain fields above and below Nineveh.

The two classic studies of Neo-Assyrian canal systems by David Oates (1968) and Julian Reade (1978) were the first to consider the economic implications of the canals for Assyrian urbanism through syntheses of archaeological, textual, and iconographic data. After estimating the ancient populations for the two Assyrian capitals, Oates concluded that neither Ashurnasirpal’s Upper Zab canal for Nimrud nor Sennacherib’s system of canals for Nineveh would have been sufficient to sustain these cities’ massive populations without contributions from beyond their immediate agricultural hinterlands (Oates 1968: 47–9, 52). Although Reade’s own field observations greatly expanded the quantity of Sennacherib’s known canals, he still agreed with Oates’ assessment, stating that “it is hard to avoid the conclusion that these canals were luxuries, constructed without serious regard for any requirements of the Assyrian economy” (Reade 1978: 174; see also Wilkinson 2003: 130). These luxuries would have included elaborate parks and gardens both outside the city and on or near the citadel itself (Lumsden 2000; Stronach and Lumsden 1992; Reade 1998; Dalley 2001–2). Several studies have considered the ideological value of large and innovative engineering projects for the legitimisation of the Assyrian king. Ariel Bagg (2000: 223–4) has recently suggested that the later stages of canal building were undertaken as a demonstration of technical expertise, far in excess of practical irrigation needs, and also as a sort of field school to train Assyrian engineers. In yet another instance of Assyrian emulation of Babylonian culture, Sennacherib may have been consciously attempting to build his capital in the image of the well-irrigated cities typical of the Chaldaean urban landscape (Brinkman 1995: 29).

The motivations and intentions of Sennacherib, his designers and engineers were undoubtedly complex, and all of the above interpretations are surely correct to some degree. I intend, however, to return to the focus to the economic aspect of the canal system. It is this aspect which is explicit in the royal inscriptions. Sennacherib’s inscription at Khinis describes the agricultural conditions he wished to alleviate; he watered Nineveh’s fields “which through lack of water had fallen into neglect and were covered with spiders’ webs, while its people, ignorant of artificial irrigation, turned their eyes heavenward for showers of rain” (Jacobsen and Lloyd 1935: 36 and fn. 27).

Although the inscriptions accurately emphasize the agricultural function of the canal network, they suffer from the urban bias typical of all royal inscriptions. As will be shown in this study, the system had the potential to benefit an area of northern Assyria much greater than just the hinterland of the capital. Despite the Nineveh-centric tone of Sennacherib’s inscriptions, his canal network was probably intended to benefit this broader area from its inception. A thorough and critical review of the iconographic and epigraphic evidence for the canals has recently appeared

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Previous archaeological studies of Assyrian canals have been based heavily on ground observation, often in the form of brief and informal visits by archaeologists excavating elsewhere in the Mosul area. For decades, ethnic tensions and government security concerns in northern Iraq prevented systematic landscape studies in the rural areas where we find most traces of Assyrian canals (e.g., Boehmer 1997: 249). Since the conflicts of 1991 and 2003, fieldwork on the ground has been almost impossible. Therefore this study has relied predominantly upon two remote-sensing data sources. The first is a set of aerial photographs taken in the Spring of 1955, a complete copy of which is held by the British School of Archaeology in Iraq.¹ They have been used previously by Tony Wilkinson as part of his survey of archaeological sites and landscape features of the Iraqi North Jazira (Wilkinson and Tucker 1995) and by David Stronach in a topographical study of Nineveh (Stronach 1995).

The second source is a group of photographs from two recently declassified American intelligence satellite programmes which have been acquired and processed by the University of Chicago Oriental Institute’s Center for the Archaeology of the Middle Eastern Landscape (CAMEL) since 1998. The CORONA programme, the United States’ first intelligence satellite, was in operation from 1959 to 1972.² It was designed to cover large surface areas in order to verify Soviet missile strength during the Cold War (Day et al. 1998). The photographs were declassified by executive order in 1995 and have been publicly available since 1998. David Kennedy (1998) initially recognized their relevance to Near Eastern archaeology, and they have begun to be used for systematic studies of archaeological landscapes (Philip et al. 2002; Ur 2003). A more recent declassification in August 2002 has made imagery from the KH-7 (also called GAMBIT) programme available. This “spotter” satellite, in operation from 1963 to 1967, produced high-resolution imagery of targets that had already been identified from CORONA photographs. Its best ground resolution improved from 1.2 m to 0.6 m over the course of the programme. Coverage was much more limited than CORONA; only urban centres and Soviet Bloc military installations were targeted. Mosul was one such urban centre (Fig. 1); as a result, photographs of Nineveh and the Kisiri canal from four KH-7 missions could be used in this study. Declassified imagery from all of these programmes can now be previewed and ordered on the Internet through the United States Geological Survey’s website.³

These two sources have several advantages over more recent satellite imagery. Most importantly, they have the advantage of higher resolution. Modern digital sensors such as LANDSAT (30 m), ASTER (15 m) and SPOT (10 m) are generally of too low a resolution to detect most sites and landscape features. The sources used in this study also have the benefit of age. In the Mosul area, the landscape of the mid-1950s to early 1970s had yet to be transformed by the Eski Mosul dam project, associated irrigation schemes, and the dramatic expansion of Mosul and other towns, not to mention the cumulative effects of thirty subsequent years of mechanized agriculture. Finally, these are photographs, and as such their interpretation is much easier for non-specialists than multispectral images, which often use energy wavelengths that the human eye cannot see.

These photographs were scanned and registered in the UTM zone 38 coordinate system by reference to ortho-rectified SPOT imagery.⁴ When these images are combined with a digital elevation model (DEM) in a Geographic Information System database, they are powerful tools

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¹ I owe thanks to Harriet Crawford, Chairman of the BSAI, for allowing me access to this resource, and to Augusta McMahon for assisting me in Cambridge with the scanning process.
² CORONA encompassed several “keyhole” camera systems (KH-1 through KH-6); this study employed imagery from only those missions using the highest resolution system (KH-4B, missions 1101-1117). All CORONA photographs reproduced in this study are courtesy of the United States Geological Survey.
⁴ This process has been described elsewhere (Ur 2003). Accurately rectified SPOT images can be downloaded from the website of the U.S. National Geospatial-Intelligence Agency (NGA) at http://geoengine.nima.mil/geospatial/SW_TOOLS/NIMAMUSE/webinter/rust_roam.htm.
for the recognition of archaeological sites and landscape features. All canal courses in this study were reconstructed through analysis of multiple photographs of the same area in different seasons; feature identification is heavily dependent on ground conditions at the time the photograph was taken. Any given canal segment could have been visible in one image but completely invisible in others. By overlaying the different satellite missions and aerial runs, it has been possible to extract information from them to arrive at a composite reconstruction that is in part visible in all of them but rarely completely visible in any single frame. Finally, through reference to the DEM, the feature's relationship to the slope could be determined. Features which ran perpendicularly or obliquely to the slope were likely to be canals, whereas features running parallel to the slope were probably natural drainage. Using these methods, almost all previously identified canal traces of Sennacherib's canal system have been recognized and accurately mapped, and several previously unreported canals can be added to the network as well.

Climate and geography of northern Assyria
To study Assyrian canals properly, it is necessary to have an understanding of the physical realities of the landscape with which the Assyrian engineers had to contend (Beaumont et al. 1988: 19–34). The Zagros Mountains were formed starting in the late Tertiary period by the collision of the
Arabian and Eurasian continental plates; since then their erosional products have formed alluvial fans and plains to the southwest. Rainfall on average exceeds the minimum necessary for rain-fed crops but shows a high degree of year-to-year variability. Precipitation comes to the area in the form of moist westerly winds which move across Assyria until they hit the foothills of the Zagros. There the rise in elevation causes the winds to shed their moisture, which then drains west into the Tigris in rivers and seasonally flowing wadis. The relatively steep gradient causes these drainages to cut into the plain, which makes them difficult to redirect for irrigation outside the narrow river and wadi floodplains.

Although the foothills have generally thin soils and few arable valleys, the plain north and east of Mosul has a high agricultural potential, with soils that average two to four metres in depth (Buringh 1960: 218). Sennacherib’s canal system was an ingenious attempt to redirect springs, rivers and wadis onto such soils and thus to remake the hydrology of Assyria in a form which was much more amenable to human control. Such control would have reduced the inherent risks that come with unpredictable annual rainfall.

The four stages of Sennacherib’s Nineveh canals (Fig. 2)

In 704 BC, Sennacherib ascended the throne of Assyria upon the death of his father Sargon in battle. He promptly relocated the imperial capital from Khorsabad to the long-established town of Nineveh which he then set about enlarging. In addition to building the walls of the city and constructing palaces and temples on its old tell, he undertook the creation of an elaborate water supply system, as had Ashurnasirpal for Nimrud and Sargon for Khorsabad (Bagg 2000: 95–102, 147–54).
Although his later inscriptions make them appear as a unified whole, Sennacherib’s canals appear to have been constructed in phases. Modern scholars have fashioned a four-stage timeline for its implementation, based on the fact that some stages are mentioned in earlier historical accounts than others (Jacobsen and Lloyd 1935: 31–41; Oates 1968: 49–51; Reade 1978; Bagg 2000: Table 5).^5^

Stage 1: The Kisiri canal (Fig. 3)

The earliest hydraulic engineering project was undertaken in or shortly before 702 BC, when workmen used iron pickaxes to cut a canal “from the border of the city of Kisiri to the plain about Nineveh” (Luckenbill 1924: 98; Frahm 1997: 60).^6^ The description of the canal appears

^5^There are some uncertainties; for example, the third stage may have been simultaneous with the fourth (Oates 1968; Reade 1978, 2000).

^6^Sennacherib’s “improvement” of the Tebitu, which was undercutting the foundations of the older palace on Kuyunjik (Luckenbill 1924: 95–6), may predate his work on the Kisiri canal. However, the Tebitu (if it is a proper name) was probably just the large meander in the Khosr next to the old mound (Reade 1978: 61; Bagg 2000) and was independent of the larger irrigation projects. Archaeological traces of this stabilization have been found in two places within the city walls (Scott and MacGinnis 1990: 68–9, Pl. XII).
after a description of a luxurious park with exotic trees and immediately following a description of the division of the land above Nineveh for orchards. Jacobsen assumed that the Kisiri canal would have watered the park (Jacobsen and Lloyd 1935: 34), but there is no explicit connection between them in the text (Reade 1978: 66). There is, however, a close connection between the division of fields so “that (they might) plant orchards” and the waters of the Kisiri canal which were caused to “flow through those orchards in irrigation-ditches” (Luckenbill 1924: 97–8). This does not exclude the use of water from the Kisiri canal for Sennacherib’s exotic parks and gardens, but it does indicate that the economic benefit to the citizenry was of primary importance, at least in the context of his royal inscriptions.

Jacobsen proposed to identify the town of Kisiri with Tell Intnha, primarily because its distance from Nineveh (16 km) is roughly equivalent to the length of 1.5 伯里 that Sennacherib claims for this canal. Reade argued that this linear distance was too far, given the tendency of Assyrian canals to meander along the natural contours of the terrain; he argued for an identification with an ancient dam, now known as al-Shallalat, near the village of Beybokh (Fig. 3; Reade 1978: 64; colour photograph in Reade 1983: 68).

Because of its proximity to Mosul, the land on either bank of the lower Khosr River has been much altered since the end of the Assyrian empire. However, the course of the Kisiri canal can be reconstructed almost in its entirety from its surviving traces. At al-Shallalat, satellite photographs reveal a dark line parallel to the Khosr immediately below the proposed ancient dam, which runs along the right bank (Fig. 4a). Although it has been reused recently near the canal head, this was probably the original point of departure of the Kisiri canal. For a kilometre the canal ran close beside the Khosr itself, but turned to the southwest upon reaching the basin of a sizable tributary wadi. It looped around this drainage at the village of Sayid Lar, and then turned to the south. At this point, it was running over a kilometre from the Khosr itself.

In its middle stretch, the Kisiri canal appears to have been heavily excavated into the hillside, causing it to remain visible as a distinct soil mark (Fig. 4b). A parallel channel, possibly some sort of distributary, is apparent to the east, closer to the Khosr (for position see Fig. 3). At the southern part of this stretch, the canal appears to have forked. The eastern branch descended toward the northern corner of the city wall. This segment has a relatively steep gradient, and it may have been a natural wadi which the Assyrian engineers utilized. Before rejoining the Khosr, however, it was diverted south to the corner of the city wall. Water from this branch would have supplied the various luxury gardens either at the base of the citadel or perhaps even on top of it (Dalley 1994).

The western branch of the Kisiri canal is fragmentary, but it appears to have turned west into a broad gully (Fig. 3, dashed line). Water from this branch would have been available to irrigate fields on the Tigris floodplain. Although the upper and middle stretches of the Kisiri canal have escaped development to date, the two branches of the lower segment appear to be lost for archaeological investigation. In an ASTER April 2002 image, roads and housing developments can be seen to cover both forks of the lower Kisiri canal. The grading and foundation construction behind these projects has probably obliterated any traces of the lower Kisiri canal which had survived to recent decades.

In total, the Kisiri canal stretched for 13.4 km, and closely adhered to the natural contours of the terrain. From al-Shallalat to the fork above the city wall, it descended 11 m over 11.6 km. This relatively shallow gradient of 95 cm per kilometre probably would have resulted in much siltation, requiring continuous maintenance, as shown by the eroded spoil banks that make the canal visible on satellite photographs.

Between Kisiri and the city wall of Nineveh, the Kisiri canal could have irrigated a maximum area of 11.8 km². Some of the canal’s waters would have been used on the Tigris floodplain north

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7 A 伯里 is generally reckoned at 10.8 km (Powell 1989). The variant of 3 伯里 in an earlier text has been dismissed as an early exaggeration which was later corrected (Reade 1978: 61 n. 36; disputed in Frahm 1997: 45); it can also be dismissed on purely geomorphological grounds.

8 Thus the Neo-Assyrian 伯里 would have been 8.93 km. This is probably spurious accuracy, as the 伯里 was a time-specific unit used to convey sense of long distances (Powell 1989).

9 This would appear substantially less than the 25 km² irrigated by Ashur-nasirpal’s Upper Zab canal (Oates 1968: 47), but that figure included part of the Tigris floodplain, which has been left out of the Kisiri calculation.
and west of the city, but because the river has moved since the seventh century BC, it is not possible to estimate the irrigated area.

Stage 2: The Mount Musri canals

The second stage of Sennacherib’s scheme is also thus far attested only by texts. As early as 694, inscriptions describe how Sennacherib enlarged the openings of several springs at the base of Mount Musri (modern Jebel Bashlqa), created reservoirs, and diverted their flow via canals into the Khosr (most recently Frahm 1997: 87–9 [T 12]; Bagg 2000: 344–5 [Text Nr. 42]). The text mentions springs near the towns of Dur-Ishtar, Shibaniba, and Sulu, of which the second can be identified with Tell Billah (Finkelstein 1953). Several scholars have noted that the logical point of confluence of canals from this area with the Khosr would be via the Wadi Gamtar, in the vicinity of the village of al-Jila (Jacobsen and Lloyd 1935: 36; Reade 1978: 70–1), which has long since been subsumed within the urban fabric of Mosul.

Springs in this area are numerous and recognizable on satellite imagery today by associated irrigated fields; they were probably even more numerous a century ago. Of the four major springs which are visible in aerial and satellite photographs, the two above Khorsabad (at Barima and Fadhiliya) flow through natural channels into the Khosr above Kisiri (Fig. 5). If these two were part of his scheme, Sennacherib’s work may have been limited to enlarging the spring’s mouth or

10 British maps of 1919 display many more springs which were not being used for irrigation in the 1960s, which suggests that they had ceased to flow.
creating reservoirs; one such enlargement at Bashiqa was described by Lady Drower and quoted by Reade (1978: 69–70). The spring east of Tepe Gawra at ‘Ain Bahr would also join the Khosr naturally but at a point below the Kisiri canal head. On the other hand, the springs at Bashiqa, above ancient Shibaniba, would flow via the Wadi Shur directly into the Tigris below Nineveh. It is presumably this spring, if any, that would have required major canal excavation in order to move its waters into the Kisiri system.

Even without major irrigation works, the plain below Dur-Sharrukin and Shibaniba was certainly a major breadbasket region for Nineveh, given its proximity, soils, and high rainfall. Irrigation would have raised the yields and reduced the risks in an already productive region. This was recognized in antiquity: the road from Nineveh to Shibaniba passed through a city gate called “The Choicest of Grain and Flocks are ever within it” (Finkelstein 1953: 117–18; Frahm 1997: 191).

The undulating plain between Billa, Khorsabad, and Nineveh is marked by the traces of many canals, almost all in fragmentary and disjointed patterns. Most of the spoil banks have the sharp signatures of contemporary or recently abandoned canals; others, however, have begun to meander, which suggests some antiquity.

Complicating matters is the presence of hollow ways on the plain (Altaweel 2004). These are depressed linear features up to a hundred metres in width which form when the continuous passage of people and animals causes the path to sink (Wilkinson 1993). On CORONA imagery, hollow ways and canals have very similar signatures (Ur 2003), but they can be distinguished by reference to topography: canals attempt to maintain a constant elevation, whereas hollow ways ignore local topographical differences (Wilkinson 1993: Fig. 6). Analysis of CORONA imagery on the plain

Fig. 5. Topography and springs of the plain below the Jebel Bashiqa. Gray shades are in 25 m intervals.
below Jebel Bashiqa has documented many hollow ways, including a direct route between Nineveh and Tell Billa.

Because water from the spring at Bashiqa would have had to cross a major watershed to enter the Khoor basin, we might expect to see at least one massive earthwork of the sort found in the third stage Northern System (see below). Analysis of aerial and CORONA photographs of this watershed has not yet revealed canals of that magnitude.

Without ground observations, it is difficult to suggest dates for the disconnected segments that can be seen. It is likely that the canals of the Musri system have been obscured, damaged, or destroyed by subsequent land use on this long-settled plain. Small irrigation systems based around a single spring, such as those in the Khorsabad area in the 1950s and 1960s (Fig. 6), can be organized at the local level without recourse to a higher political level. Sennacherib probably unified a number of such local networks as part of his Musri canal system, and it is likely that after the collapse of imperial administration, it decomposed into its original components. It is possible that elements of the early seventh-century system continued in use, perhaps even up to the present. However, disentangling them from later networks would be nearly impossible, particularly without field work.

Stage 3: The Northern System (Fig. 7)

The final two stages of the system are true engineering accomplishments on an even grander scale than the first two. The third stage, often referred to as the “Northern System”, is actually a  

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\footnote{Such irrigation autonomy has been documented ethnographically in southern Iraq (Fernea 1970) and proposed for Urartian irrigation (Zimanski 1985:96).}
series of canals which have been hypothesized to be part of a single system although their interconnectivity has not yet been established. David Oates, based on his ground observation of a massive canal between the Wadi Bandwai and the Wadi al-Milh in 1957–8, initially recognized the first segment. Another canal, already shown on Felix Jones’ map of 1852, would have taken the expanded flow of the Wadi al-Milh at least as far as Tarbisi (the modern village of Sharif Khan) along the left terrace edge of the Tigris (see Fig. 2, and Oates 1968: 49–52).

Julian Reade has proposed that the Northern System actually began even further above Bandwai, based on his observations along a canal near the village of Faida (Reade 1978; see also Boehmer 1997). Because the Faida canal and several other northern Assyrian canals are associated with carved reliefs, he hypothesized that the well known reliefs further to the north at Maltai (Bachmann 1927) might also mark a canal head, one that would join either the Faida canal near Girepan or flow down to the Wadi Bandwai on the north side of the Jebel al-Qosh (see Reade 2002: Fig. 1).

Although the reliefs at Maltai, Faida, and Bandwai have been dated to Sennacherib on stylistic grounds, there are no unequivocal inscriptions relating to the Northern System. In its current state of reconstruction, it is a product of modern scholarship rather than a documented ancient entity. This situation is due to our poor knowledge of the historical geography of the Trans-Tigridian area north of Nineveh: the canals of the Northern System are probably among the eighteen canals listed on the so-called Bavian inscription, which summarizes all four stages of Sennacherib’s hydrological work (Reade 1978). Definite identifications for these places can only come through insessional evidence.

In the following sections, I will summarize the evidence for the canals of the Northern System as gleaned from CORONA and aerial photographs, those already identified as well as those which
have been hypothesized. Future archaeological survey, excavation, and epigraphic study will be necessary to connect these canals to Sennacherib’s canal building inscriptions.

**Maltai.** CORONA and aerial photographs reveal a very prominent earthwork on the plain between Maltai and the town of Girepan to the south (Fig. 8). This is the first of three major cross-watershed canals on the plains along the left bank of the Tigris above Nineveh, in this case connecting the basins of the Rubar Dohuk and the Rubar Faidia. Its overall width of 80 m can be explained by the volume of earth excavated through the watershed and subsequent dredging of silts; the actual channel was certainly much narrower. By using the topography as a guide, traces of a canal can be detected north of this earthwork, leading from the area of Maltai to this large earthwork. Unfortunately, a recent track winds along the probable course of the canal, obscuring much of it.

The water source (or sources) for the Maltai canal is difficult to determine from remote sensing alone. One possibility is that the waters of the Rubar Dohuk were diverted into the canal. Given the elevation of the documented cross-watershed canal in Fig. 8, the Assyrian engineers would have had two options. They could have constructed a weir at a point two kilometres upstream from the area of the reliefs and brought a channel along the left bank of the river; this approach was adopted for the Khinis system, discussed below. A second option would have been to raise the water to the level of the canal by installing an impound dam across the river beneath the reliefs. There is no trace of a dam or a left-bank canal in the imagery, although either could have been destroyed by strong floods or robbed out. On the other hand, the ‘Ain Gasara spring, which was characterized as “eine starke Höhlenquelle”, is situated somewhat above the level of the river (Bachmann 1927: 23 and Abb. 17); it would have been relatively simple to redirect its flow around the western end of the Jebel. This was the engineers’ strategy for the Faidia canal (described below).
and probably also for the as yet undetected elements of the Mount Musri system. The width of the Malta canal is excessive for an exclusively spring-fed canal; such canals tend to be much narrower. A Hellenistic canal of similar size was fed by the Balikh River (Wilkinson 1998). The Assyrian engineers probably made use of both the spring and the river in supplying the Malta canal with water.

The Malta canal appears to have deposited its waters into a natural wadi which flows south toward the twelve-hectare mound of Girepan (Fig. 9). At present, there appear to be no obvious traces of a continuation of this canal to the east beyond this wadi as hypothesized by Reade (2002: Fig. 1), and his suggestion that a canal from Malta might join the Wadi Bandwai on the north side of the Jebel al-Qosh is unlikely on purely topographic grounds. However, it is entirely possible that such canals could have been obscured by the later local canals and terraced fields which line the southern slopes of the Jebel.

The area between Malta and Girepan is not yet fully understood. Another large earthwork, parallel to but shorter than the first, crosses the Rubar Dohuk watershed to the west (Fig. 8). Connected to this second earthwork are two dark linear features which run along either side of the crest of the Rubar Dohuk-Rubar Faida watershed, toward the southwest (Fig. 9). If these were canals, they would be excellently placed to distribute water to large areas of the lower Rubar Dohuk basin on the south side of the river and the Rubar Faida basin west of Girepan.\footnote{13}

\textit{Faida.}\ Southeast of Girepan Reade identified a former spring on the northern side of the Jebel al-Qosh which appears to have fed a canal beneath it (Reade 1978: 159–163; Boehmer 1997). The 3.2 m wide canal was chiselled through the natural bedrock strata, which were uplifted by the
ground observations, but it does appear improbable.\footnote{12}

Such an extensive set of canals would necessitate a large water supply, and would suggest that the Rubar Dohuk, rather than Ain Gasara alone, was the source for the Malta canals.
formation of the Jebel al-Qosh. Below the spring, the canal could be traced to the village of Faida and beyond, accompanied by carved reliefs placed at intervals along its course.

Although flowing in the early twentieth century, at the time of Reade’s first visit in April 1973 the spring had dried up, and consisted of only a circle of rocks (Reade 1978: 159). For this reason, it cannot be located with certainty on the imagery. Again, the imagery and topography allow us to test Reade’s hypothesis that a canal from Maltai would be linked to the Faida canal. Large-scale water lifting would have been required to connect the wadi at Girepan with the Faida canal. Thus, it is very likely that the spring on the north side of the Jebel al-Qosh was the initial source for the Faida canal.

Since it fell out of use, the bed of the Faida canal has filled with sediment, which traps run off moisture and promotes vegetation growth. As a result, it appears as a dark line, making its way to the west along the 435 m contour, whereas the highly reflective bare bedrock is white (Fig. 10). The lines of the bedrock strata and the canal have a similar signature on the imagery, but can be differentiated by their direction: gully erosion has caused the upended geological strata to appear to point down the wadis, while the canal’s need to maintain a constant elevation causes its course to run into the wadis.

With the imagery available at present, it is not possible to trace the Faida canal to Bandwai. This may be due to poor preservation, but it is possible that the Faida canal was never intended to reach Bandwai. At several points along the canal, there appear to be distributaries extending

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14 A July 1919 map of this area shows a flowing spring at a point one third of a mile southwest of the village of Khanamah. Unfortunately the scale of this map is too small to suggest a precise point on the CORONA or aerial photographs.
Fig. 11. Alternative reconstructions of the canal head at Bandawai. a. Weir in the wadi gorge at or above Shiru Maliktha, feeding canals; b. Dams across the Wadi Bandawai and a left bank tributary.

Outward along the downslope side; others, such as the one photographed by Reade (1978: Fig. 10b), must have existed but are too small to appear on the aerial photographs. Those that are visible on the imagery appear as thin dark lines running parallel to natural gullies or down spurs, where their gradient would be gentle enough to manage the water without scouring the canal bed. Such oikotimes demonstrate that the canal’s water was intended at least in part for local irrigation on the southern slopes of the Jebel.

The evidence of the Maltai and Faida canals suggests that considerable effort was expended to bring water into the area around the western end of the Jebel al-Qosh. Archaeologically, we know almost nothing of ancient settlement in this region, but the mound beneath the village of Girepan has produced stamped bricks of an unnamed Assyrian king (Place, cited in Reade 1978: 160). Reade has proposed that here might be found the provincial centre Taalmus. Whether or not this identification is correct, the fact that it was the beneficiary of two canals makes it clear that this was an economically (and probably also politically) important area.15

Bandawai. Ten kilometres to the east of Faida, the Wadi Bandawai emerges from a gorge in the midst of the Jebel al-Qosh. At the point of emergence is a badly defaced rock relief known locally as Shiru Maliktha, which is certainly Nea-Assyrian and probably to be attributed to Sennacherib (al-Amin 1948; Shukri 1954; Reade 2002). In 1957–8, David Oates recorded a massive overland canal which carried water from the Wadi Bandawai to the Wadi al-Milh. Closer to Bandawai village, he identified a smaller cut as the canal head (Oates 1968: 49–52, Pls. IVa-b).

Both the source of the Bandawai canal’s water and the means of getting it to the canal head have proven difficult to establish. The GIS data sources assembled here offer several alternatives for understanding this area (Fig. 11). The upper end of Oates’ cross-watershed canal has an elevation of roughly 428 m; therefore, assuming siltation and post-use erosional infilling, we can take the 425 m contour as a base elevation. This is, incidentally, slightly lower than the elevation

13 A letter to Sargon mentions canal digging by hundreds and possibly a thousand men in the area of Talmus (SAA 165, Parpola 1987). Perhaps canal digging in this area under

Sargon was completed by, and credited to, Sennacherib? If the identification of Girepan is correct, this letter supplies further evidence for longstanding irrigation in this region.
of the Faida canal at its last identified position. If a weir was constructed at this elevation in the gorge, it could have fed a left-bank canal which would have flowed past the base of Shiru Maliktha, or possibly through a tunnel along the eastern bank of the wadi (Fig. 11a). An aqueduct may have traversed the gully on the south side of Bandwai village to bring water to Oates' canal head. From this point, a canal may have made its way around the eastern side of the wadi drainage to reach the head of the large canal.

An alternative reconstruction would place one or more dams across the wadi to the southwest of the village (Fig. 11b). A first dam on the Wadi Bandwai would have raised the water to the level of the canal head, which would have served as a sluice. The resulting reservoir would have extended up to the foot of Shiru Maliktha. A second dam would have impounded water in a drainage basin further south in order to raise it to the level of Oates' large canal. This reconstruction would have the benefit of capturing the run-off from the land east of the wadi. Firm evidence for the two reconstructions, which are not mutually exclusive, would require ground observation.

Oates' Bandwai-Milh canal is the second large cross-watershed earthwork in the Northern System, and it is an impressive sight on satellite imagery (Fig. 12). As below Maltai, a great deal of excavation (approximately 15–20 m depth) was necessary to lower the canal through the Bandwai-Milh watershed. This excavation, in conjunction with later maintenance, resulted in massive spoil banks which cast deep shadows in the imagery.

16 Julian Reade photographed a possible tunnel emerging from below Shiru Maliktha, and within the Wadi Bandwai gorge (2002: Figs. 3, 15–16).
Tell Uskoğ: The most commonly used map of the Bandwai canal depicts it flowing into a right bank tributary of the Wadi al-Milh and then flowing south to the Tigris (Oates 1968: Fig. 4; Reade 2002: Fig. 1). An assessment of CORONA imagery shows that it actually connected to a more northerly Milh tributary. This would be a minor point if not for the third major cross-watershed earthwork in the Northern System, a previously unrecognized canal which shifted water from the Wadi al-Milh into a wadi tributary of the Khors above the town of Tell Uskoğ. The Uskoğ canal departs from the Wadi al-Milh above the conjunction with the right-bank tributary used in earlier reconstructions. With this correction, water from Bandwai could have been redirected all the way to the canal head at Kisiri in an integrated network of canals.

The Tell Uskoğ canal (Figs. 7 and 13) is not as visually impressive as the Bandwai canal; it appears to have required less excavation, and its lower spoil banks have probably meant that it has eroded more at the hands of subsequent ploughing. However, the two canals are topographically and morphologically similar. Like Bandwai, the Tell Uskoğ canal originated in a narrow gorge. The northernmost certain traces of the canal cut through the left bank of the Wadi al-Milh to reach a parallel wadi which emerges from the same hills 1,300 m to the east (see Fig. 7). This wadi was probably crossed via an aqueduct which brought the water to the start of another segment of canal which made its way along the 340 m contour. As at Bandwai, it is necessary to reconstruct either dams across the two wadis, or an aqueduct across the second smaller wadi. However, no traces of aqueducts or dams are visible on the photographs.

After two kilometres, this canal went up and around another smaller wadi to reach the head of the large cross-watershed earthwork (Fig. 13). This feature is roughly 70 m wide and stretched for some 1,500 m before emptying into the natural drainage which today leads to the town of Tell Uskoğ.

Given the association of canals and carved reliefs seen already at Maltai, Faida and Bandwai, it is likely that similar reliefs were carved in the gorge near the canal head or at points along the canal with suitable rock outcrops nearby. The Uskoğ canal is located close to longstanding population centres, so it is possible that defacement similar to that of Shurú Malikhta has kept any such reliefs from being noticed or recognized as ancient.

Tarbisu: Previous reconstructions have relied on a canal along the left bank of the Tigris to transport water from the Wadi al-Milh to the area of ancient Tarbisu, now the modern village of Sharif Khan, 8 km northwest of the Nergal Gate. A Tigris canal to Tarbisu is not mentioned in any of Sennacherib’s inscriptions but this one does appear to be integrated into the Third Stage of the system. According to Oates’ hypothesis, it originated at the point where the Wadi al-Milh joins the Tigris, and ran along the edge of the left river terrace (See Fig. 2).

This canal has been eradicated in several places by the movement of the Tigris within its floodplain, but its general course can be followed on CORONA and aerial photographs. Compared to the more convincingly dated canals, the Tarbisu canal shows differences in morphology and design. At thirty meters wide, it is broader than the Faida and Khinis canals (see below) but narrower than the three cross-watershed earthworks. The Tarbisu canal is also much more linear than the other canals. Despite their excavated depth, the cross-watershed earthworks of the Northern System still curve around easily avoided topographic high points, and the courses of the smaller Faida and Khinis canals are almost wholly dictated by the local topography. The Tarbisu canal, on the other hand, is rigidly linear; its engineers even chose to cut through a terrace spur into the floodplain northwest of Rashidiya (Fig. 14). Finally, the spoil banks of the Tarbisu canal are much more defined than those of the other canals, which might indicate that there has been less time since its abandonment for erosion to wear them down.16

17 The topography of the watershed east of the Wadi al-Milh probably required only 4 or 5 m of excavation, whereas the Bandwai-Milh canal may have required excavation to 15–20 m.

18 This width was measured from the aerial photographs of 1955 and represents the distance between the tops of the spoil banks rather than actual channel width, which would require excavation to determine.

19 Note the start of a structurally similar canal along right bank of the Tigris, at the bottom of Fig. 14. In the aerial photographs, this canal can be traced along the edge of the western river terrace for over 2 km. No date for this canal can be suggested.
These points suggest that the Tarbisu canal is of a different, probably more recent, age than the rest of the Northern System and, with the addition of the Uskof canal to the Northern System, it is not necessary to include it in our reconstruction in order to connect Bandwai with Nineveh. However, its context of a large river floodplain differs substantially from the river-terrace plains of the other Neo-Assyrian canals discussed here; this difference in geomorphological context could explain some of the differences in canal morphology. If the Tarbisu canal had been reused after the abandonment of the rest of the Northern System, the subsequent maintenance would explain the lesser erosion of the spoil banks. At present, it seems best to leave open the possibility that both canals may have been part of the Northern System. The Tarbisu canal would have irrigated the fields on the Tigris floodplain upstream from Nineveh, and the Uskof canal would have supplemented the already substantial waters of the Khosr.

Before concluding this overview of the Northern System, it is worth discussing the issue of the ultimate destination of the waters collected by Sennacherib’s canals. In several inscriptions, he claims to have “directed their course into the Khosr River” or that he “added [the waters] to the Khosr forever” (Luckenbill 1924: 115; Jacobsen and Lloyd 1935: 36). Such a statement is included in the Bavian inscription, which is considered to be the latest and most complete summary of the four stages. Most researchers who have previously written on Sennacherib’s canal system have taken this statement literally.

Real difficulties emerge when attempting to reconcile the visible traces of several segments of the Northern System with this statement. Although with some misgivings, Oates (1968) included
the Tarbisu canal in the Northern System in order to move water at least to the area of Nineveh, if not actually into the Khosr. When faced with similar interpretive difficulties with regard to the Musri system, Reade proposed that the second stage canals watered the left bank of the Khosr, rather than actually joining the Khosr itself (Reade 1978: 72).

Similar problems are now apparent with regard to the uppermost elements of the Northern System. Neither the Maltai nor the Faida canals can be linked with the lower elements of this stage which can be shown to have flowed to the Khosr. There appear to be three solutions to this problem. The most simple would be that there existed physical connections between the Maltai and Faida canals which have not been recognized on the ground or in remote sensing imagery. This is possible for the stretch of land between Faida and Bandwai but it is unlikely for the Maltai canal. A second possibility is that the Maltai and Faida canals were constructed after the Khinis system and are not among the eighteen canals of the Bavian inscription which were added to the Khosr. A final possibility is that the phrase in question was not to be taken literally; the canals all flowed in the general direction of Nineveh and the Khosr but were not all intended actually to reach these places. In this case, these passages in the canal inscriptions would be typical of the strong focus on Nineveh in all Sennacherib’s royal inscriptions, despite the fact that most of the canals themselves are quite distant from the capital.

I owe this idea to Julian Reade, who emphasized to me that there are no extant royal inscriptions from the last eight years of Sennacherib’s reign.
One fact is certain: not all the waters were added to the Khosr. An unknown portion was devoted to local irrigation in areas much closer to the canals' sources, as we have already described at Faida and will also see along the Khinis canal.

Stage 4: The Khinis System (Fig. 15)

Elements of the fourth stage have been known since Layard made his acrobatic investigation of the inscriptions at Khinis in 1850. The general outline of the canal's route was established in the 1930s, when Seton Lloyd and Thorkild Jacobsen took a holiday from their work at Khorsabad to investigate rumours of inscriptions at Jerwan. In the context of their excavations at the aqueduct, they located this canal on the ground in several spots, and were able to reconstruct unvisited segments through information from local informants (Jacobsen and Lloyd 1935: 28–31).

The Khinis System is unique amongst Sennacherib's northern Assyrian canals because it preserves two important building inscriptions in situ. The “Bavian Inscription”, carved into the gorge near the village of Khinis, includes a description of the excavation and inauguration of the fourth stage and an overview of the other three (most recently Bagg 2000: 347–54). A shorter inscription
Fig. 16. Aerial photograph (Spring 1955) of the Gomel gorge near Khinis (Run 14 No. 7451).

on the aqueduct at Jerwan describes the feature and mentions some local place names (Jacobsen and Lloyd 1935: 20–1).

The catchment of the Khinis system is the Atrush River basin, which covers a 525 km² area in the mountains of northern Iraq. This is actually a smaller area than the Khostr catchment above al-Shallalat, but it receives a much higher annual rainfall. At present there is minimal vegetation to slow ground run-off, and it is possible that this was the case already in the first millennium BC (Wilkinson 2003).

In the gorge just northeast of the village of Khinis, Sennacherib’s canal began at a weir across the river, which survives as large irregular boulders in the river bed (Fig. 16). In addition to the Bavian Inscription, the western wall of the gorge is covered by Neo-Assyrian reliefs (Bachmann 1927). The dam fed a canal along the right bank of the Gomel River. As along the Faida canal, the Assyrian engineers were faced with the uplifted natural bedrock strata through which they chiselled an open canal bed; however, one particularly hard stratum was tunnelled through, rather than removed entirely (Jacobsen and Lloyd 1935: Pls. XXXIV–XXXV). A natural spring to the north of the village was probably also diverted into the canal.22

In the 1950s and 1960s, small networks of canals irrigated the lands on both banks of the Gomel below the gorge, particularly the fields around the Khinis/Khanusa mound. These canals have obscured the traces of the Assyrian works immediately outside of the gorge. Nonetheless, the probable course of Sennacherib’s canal can be seen on aerial photographs and CORONA

21 A fragmentary prism reconstructed by Frahm (1997: 89–101 [T 13]) probably mentions this stage as well.
22 This was probably the “waters of Khanusa” of the Jerwan inscription, Khanusa being the ancient settlement beneath the modern village of Khinis (Bachmann 1927: 2; Jacobsen and Lloyd 1935: 20–21).
imagery starting two kilometres below the dam, where it ran due south, following the Gomel tightly until it reached the perennial river which flows down from the vicinity of Shaykh 'Adi. At this point it is unclear whether the canal ran up and around the contours or went straight across, but certainly there must have been an unrecognized aqueduct over this watercourse. At almost 40 km², its catchment is nearly four times the size of the catchment of the intermittent stream at Jerwan (12 km²). If the Assyrian engineers felt that the wadi at Jerwan warranted such an investment, surely this much more substantial stream would have deserved the same.\(^{23}\)

The canal continued along the right bank of the Gomel, following the contours, to trace a course along the east flank of a low hill. When the Gomel emerges onto the plain south of this hill, the canal turned west along its southern flank. It wove in and out of several small drainages before it crossed an aqueduct at Jerwan (Jacobsen and Lloyd 1935). At the western end of this plain, it turned south to loop around another low hill. Along these hills, the canal behaved exactly as at Faida: the natural contours dictated its course, and Jacobsen and Lloyd describe it as a “perfectly level and obviously artificial” terrace cut into the hillside (1935: 30). Small off-takes can be seen running down spurs and parallel to but above the natural wadis (Fig. 17).\(^{24}\) Within this plain, the current wadi courses are suspiciously straight, particularly along its western edge; it is

\(^{23}\) If this stream is the “waters of Gammagura”, as proposed by Jacobsen (Jacobsen and Lloyd 1935: 21), then the Jerwan inscription claims that its waters were also added to the Khinis canal, and we should therefore seek some sort of weir upstream from that canal.

\(^{24}\) It is quite possible that the removal of the canal’s fill at these off-takes would reveal reliefs, as already documented at Faida.
possible that they were deliberately straightened as part of the overall irrigation scheme, or that they in fact represent former distributaries which "captured" the natural run-off after the Khinis system went out of use.\footnote{In an analogous process, hollow ways have been known to capture run-off flow (Wilkinson 1993: 553-4; Ur 2003: 106).}

In its final segment, the Khinis canal turned north and then west again to cross the plain below ‘Ain Sifni in two parallel channels, prior to dropping into the Khosr basin near Shifshirin (Fig. 18).\footnote{CORONA and aerial photograph analysis of this segment leads to two corrections on existing maps of the Khinis system. The canals ran around the village of Kandalah to the north, rather than through it (contra Jacobsen and Lloyd, who appear to have relied on local informants rather than personal observation for this particular area). They were, however, correct that the canal debouched into the Khosr tributary at Shifshirin, although more recent reconstructions have assumed it flowed into the Shubabon River, a Khosr tributary to the south of Shifshirin (Outs 1968; Reade 2002).} Like the plain below the Jebel Bashiqa, this area is a complex palimpsest of irrigation landscapes, due to a strong spring at ‘Ain Sifni. Canals from this spring fan out to the south across the plain. These canals have a range of morphologies; some are clearly modern and were in use at the time of the satellite and aerial photographs, while others are long out of use. While it is always difficult to date canals, especially without ground survey, it is likely that at least some of these canals can be attributed to the Neo-Assyrian period since several appear to articulate with the main Khinis canal.\footnote{Since these canals would divert water from the spring at ‘Ain Sifni into the Khosr, we should assume that one or more of them are among the eighteen canals listed in the Bavarian Inscription. It is likely that the ancient names of some of the numerous unsurveyed settlements in this area, many of which are clearly visible on CORONA satellite photographs, are also mentioned in that inscription.}

Furthermore, several offtakes appear to originate from the Khinis canal to water the fields on the north side of the Dilujah River.

A range of explanations for the parallel channels of the Khinis canal between ‘Ain Sifni and Kandalah can be proposed. The southern channel might have been a distributary canal. One of
the two may have been intended as a solitary canal but had to be replaced by the second to correct an error of design. Finally, the second channel may have been a replacement when the first was damaged by a flood.\(^{28}\) The topographic evidence favours the first explanation, as the southern channel is two to three metres lower than the northern channel; it would be difficult for water entering this channel from any point to flow over the watershed and into the Khosr river basin.

In total, the Fourth Stage stretched 90 km from Khinis to Kisiri. The natural riverbed of the Khosr River accounted for the final 34 km, but the initial 55 km required excavation. With the inclusion of the one certain aqueduct at Jerwan, which Lloyd estimated might have incorporated more than two million stones (Jacobsen and Lloyd 1935: 6), and probably at least one other as yet undocumented aqueduct, the magnitude of this undertaking begins to become clear.

_Some generalizations about Sennacherib’s canals_

Having reviewed the new insights that remote-sensing data sources provide for reconstructing Sennacherib’s canal system, it is possible to make some generalizations about several aspects of the canals’ morphologies and design.

Sennacherib tapped both rivers and springs to feed the canals. He addresses springs in particular in his inscriptions, most clearly in the descriptions of the Musri system. Springs are an important source of irrigation water today, but it is likely that they were even more important in the seventh century BC. Spring flow is closely related to vegetation: if ground cover is abundant, surface run-off will be arrested and absorbed into the ground where it will recharge the water tables that feed the springs. However, if there is little or no vegetation, run-off will flow on the surface, sometimes in violent and episodic floods, the water tables will not be refilled and the springs will dry up (Wilkinson 2003). In other parts of the ancient Near East, settlement expansion into the highlands and accompanying deforestation occurred under stable empires, for example in the Amuq valley during the Hellenistic and Roman periods (Wilkinson 1999; Casana 2003); it is quite likely that similar stability under Assyrian rule promoted comparable expansion and deforestation, which would have resulted ultimately in the drying up of springs. The process may be continuing at an accelerated pace: a 1919 map of the Jebel Bashiq shows many more active springs than are visible on recent satellite photographs (Fig. 5).

Assyrian canals were not limited to tapping springs, however. Archaeological evidence for the diversion of rivers into canals via weirs is well documented at al-Shallalat/Kisiri and Khinis; such a strategy is almost certain at Banduwai and Tell Uskof, and probable at Maltai. If it was possible for Ashurnasirpal to dam the Khazir (or possibly even the Upper Zab) two centuries earlier (Oates 1968; Davey 1985), then the Wadis Banduwai and al-Milh and the Rubar Dohuk should have been within the technological capacities of Sennacherib’s engineers.

The canals were not fed solely by their initial sources. We know this from both texts and the surviving traces of the canals. Inscription B on the aqueduct at Jerwan states that not only the waters of the Pulpuliya (the Gomel) but also the waters of Khanusa (probably the spring-fed creek north of Khinis village) and the waters of Gammagara (probably the stream from Shaykh ‘Adi) were added to the Khinis canal (Jacobsen and Lloyd 1935: 20). In the Northern System, the diverted waters of the Wadi Banduwai did not just cross the Wadi al-Milh into the Tell Uskof canal; the system had the opportunity to add the waters of the Milh basin above that point.\(^{29}\) On a more local level, the canals appear to have tapped small springs and minor gullies as they ran across the natural terrain. In connection with the Faida canal Boehner (1997: 248–9 and Taf. 44,2) noted concentrations of stones along the canals within the gullies that he interpreted as the remains of features designed to move the waters across to the opposite side of the gully. Such stone features would also have captured the run-off of the Jebel al-Qosh and added it to the canal. Examination of CORONA and aerial photographs along the lower Khinis canal system suggests a similar pattern of run-off collection (Figs. 17–18). Indeed, the aqueduct at Jerwan is the only known example of an Assyrian canal deliberately avoiding the addition of run-off.

\(^{28}\) I owe this suggestion to T. J. Wilkinson.

\(^{29}\) Admittedly, we have no idea of the percentage of the total flow of any of these watercourses that was actually diverted into the canals.
### Table 1. The four stages of Sennacherib’s canal system; years based on Bagg 2000: Table 5.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Year</th>
<th>Length (km)</th>
<th>Gradient (m/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Kisir Canal</td>
<td>702</td>
<td>13.4</td>
<td>0.95 (al-Shallalat-fork)</td>
</tr>
<tr>
<td>2. Musri System</td>
<td>694</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Northern System</td>
<td>ca. 690</td>
<td>46.4 (total)</td>
<td></td>
</tr>
<tr>
<td>Maltai</td>
<td></td>
<td>4.2</td>
<td>4.0</td>
</tr>
<tr>
<td>Faida</td>
<td></td>
<td>9.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Bandwai</td>
<td></td>
<td>5.0</td>
<td>0.8–1.0 (earthwork)</td>
</tr>
<tr>
<td>Uskop</td>
<td></td>
<td>4.4</td>
<td>1.2 (earthwork)</td>
</tr>
<tr>
<td>Tarbisi</td>
<td></td>
<td>23.1</td>
<td>0.6</td>
</tr>
<tr>
<td>4. Khinis Canal</td>
<td>ca. 690–688</td>
<td>55.0</td>
<td>0.9 (Gomel-Jerwan)</td>
</tr>
</tbody>
</table>

In crossing the terrain, Sennacherib’s canals adhered very closely to the natural contours. This meant that the total distance of excavated canal was often substantially greater than the straight-line distance; apparently the Assyrian engineers felt that the cost of cutting additional lengths of canal was less than the cost of cutting through topographic impediments. Even when deep excavation was unavoidable, as in the case of the three massive cross-watershed earthworks of the Northern System, the attempt to minimize the depth of excavation meant that such canals still meandered rather than followed a straight line.\(^3^0\)

It now is possible to propose tentatively a design gradient to which the Assyrian engineers may have attempted to adhere (Table 1). In general, it appears that a slope of one metre per kilometre was considered the ideal. Such a gradient may have been shallow enough to minimize scouring but steep enough to avoid excessive aggradation of silts in the canal bed, although we cannot be certain in the absence of data on canal depth and bed shape. Most of the extant canals conform to this gradient, with two exceptions. The large earthwork at Maltai plunged down toward Girepan at four times the steepness of the average Assyrian canal, and the Tarbisi canal along the Tigris had a much lower gradient than the rest. As we have seen, the Tarbisi canal has further characteristics that distinguish it from the other canals, but it is more difficult to explain the sharp slope of the Maltai canal, which must have flowed at a dangerous rate and eroded its banks without some means of slowing the waters. However, these gradient figures should be considered to be approximations. The coarse resolution of the DEM means that the elevation value is an average of the 30 × 30 m area within each pixel. In most cases the canal bed may have been metres lower. Furthermore, since their abandonment these canals have been infilled by wind- and waterborne sediments; we are measuring the elevations of the surface traces of these features, rather than the actual ancient beds.

At several points it has been proposed that we must reconstruct dams or aqueducts where evidence for them no longer exists. Stone constructions in close proximity to later urban cities have a tendency to be robbed for building materials; the most famous example is the mining of the stones of the Old Kingdom pyramids to build Cairo (Lehner 1997: 41). However, it is difficult to argue that dams at Bandwai or on the Wadi al-Milh have been entirely reused when Neo-Assyrian structures much closer to Mosul, such as al-Shallalat and especially the dams at al-Jila (Thompson and Hutchinson 1929), have survived.\(^3^1\)

If dams were used, it is possible that the Assyrian engineers chose not to build them of stone. Floods were common and may have been exacerbated by elevated surface run-off due to deforestation; one such flood necessitated a major repair on the Jerwan aqueduct during its period of use (Jacobsen and Lloyd 1935: 9–10). Elsewhere in the Near East in the first millennium BC, dam builders recognized these realities and chose to live with them, thus adopting a flexible strategy in the face of such inevitabilities. For example, the massive dam that formed the economic backbone of the kingdom of Marib in Yemen was constructed of earth; when floods came, the earthen dam proved to be easier to repair or reconstruct than a stone structure (Brunner and Haefner 1986).

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\(^3^0\) The sole exception to this rule is the Tarbisi canal, discussed above.

\(^3^1\) One could argue that al-Shallalat remained useful and thus was more valuable intact, but the dams at al-Jila were not part of an irrigation scheme (see discussion in Bagg 2000: 194–5).
Achaemenid dams (references in Boehmer 1997: 245) were similarly built. If the Assyrian engineers adopted an analogous strategy, the hypothesized dams feeding the Bandwai and Uskof canals may long since have eroded away.

A final point to be made about Assyrian dams is that they are as rare in the textual evidence as they are in the archaeological record. Clearly the inscriptions’ composers saw the canals as the significant element of Sennacherib’s large irrigation schemes; in this sense they may have been emulating royal canal-building inscriptions of Babylonia, where natural levee formation meant that extracting water from rivers was not a great technical challenge but simply a function of gravity. Even the aqueduct at Jerwan, considered to be a great advance in the history of hydraulic engineering (Dalley 2001–2: 451–2), is not mentioned in writing anywhere except on its own façade.32 Again the answer may lie in the urban bias of the royal inscriptions of the time; these built elements of the agricultural infrastructure, as impressive as they might be to us, were still distant from the eyes and minds of Nineveh’s elite.

The function of Sennacherib’s canal network

Scholars such as David Oates and Julian Reade have rightly drawn attention to the likelihood of grain field irrigation in the immediate hinterland of Nineveh. It is certainly true that Sennacherib’s canal network was ultimately focused on his capital, but it is likely that its benefits of increased yield and risk reduction were spread across a broader expanse of northern Assyria.

Local irrigation systems

Perhaps due to the near exclusive emphasis on his capital city in Sennacherib’s inscriptions, the possibility that the canal network might have been used to irrigate land anywhere other than Nineveh and its hinterland has been ignored in previous studies. For example, Bagg (2000) interprets the Khinis system as above and beyond the level of practical necessity, since the fields near Nineveh would have been more than adequately watered by the other three stages; the Khinis system was a sort of training exercise for Assyrian engineers (Bagg 2000: 223–4).

Such an interpretation would be understandable if all of the water (from dams, various springs, and run-off) collected by the Khinis canal were ushered directly to the area of Nineveh. However, water was being extracted from this canal at least from the point where it diverged from the Gomel, and it probably also watered the right bank of that river beneath the gorge. Uncertainty about the volume of water from the various inputs versus the volume of water extracted for irrigation means that we cannot estimate the Khinis system’s contribution to the Khosr, but it may have been substantial from the springs at ‘Ain Sifni alone. Overall, given the length of the Khinis canal and the area of arable land below it on the right bank of the Gomel and in the Daluqah basin, it is possible that this seemingly remote corner of northern Assyria was an even more productive irrigation landscape than the Kisiris-irrigated banks of the Khosr.

We have already discussed similar local offtakes from the Faida canal that appear very similar in morphology and design to the Khinis offtakes. This local system, when combined with the Malatzi canal and its possible southwestern extension, would make the area of Girepan another well-watered agricultural landscape at some distance from Nineveh. To date, it has proven impossible to demonstrate similar local systems on the Jabel Bashina plain and near the Bandwai and Milhi floodplains, probably because later landscape features have erased or obscured earlier ones; however, it is likely that such canal networks existed and were fed by Sennacherib’s canal system.

The main canals appear to be solidly attributed to Sennacherib, but the dating of the various local irrigation offtakes above Kisiris is not so certain. His inscriptions do not explicitly mention irrigation from his canal system near places other than Nineveh and its hinterland.33 Therefore it may be that distant upstream irrigation was a post-Sennacherib or even post-Assyrian alteration of a system originally designed solely to bring water to Nineveh. This may have been a later
Fig. 19. Neo-Assyrian settlement in the eastern Upper Khabur basin/Iraqi North Jazira region, based on Wilkinson and Tucker (1995: Fig. 41) and Ur (2002: Fig. 16).

official decision to spread the benefits of irrigation to outlying parts of Assyria, or it may have represented infringement on the system by local people, perhaps as the imperial administration weakened. Both processes may have been at work.

There is evidence, however, that local irrigation around provincial centres was part of the original design of the canals, from the time of Sennacherib. Some evidence that off-takes were officially sanctioned comes from the Faida canal, where one off-take was cut into the downslope side of the canal, directly opposite a panel of reliefs (Reade 1978: Fig. 10b). The association of sluice and relief was hardly coincidental: anyone opening the sluice gate would have been confronted with the symbols of Assyrian kingship and its divine legitimacy. The reliefs were a powerful reminder to the local farmer that he had the Assyrian king to thank for his irrigation water, and by extension his livelihood.

Northern Assyrian rural settlement

The agricultural beneficiaries of these hydro-engineering projects are difficult to describe at our current state of archaeological knowledge. No systematic archaeological surveys in the northern Assyrian core around Nineveh and Nimrud have been published; our current archaeological knowledge is based primarily on anecdotal information from travellers or from archaeologists who made brief visits. These observations are heavily biased toward the very obvious high-mounded sites (i.e. tells). In fact, Neo-Assyrian settlement on tells is rare and limited to imperial or elite settlement in the Jazira; more typically, settlement at this time was in extensive lower towns near now-abandoned tells or on small low mounds (Wilkinson and Barbanes 2000: 411–21). This latter type of site is not generally noticed except by intensive full-coverage archaeological surveys.

A hint of rural settlement in the Empire may perhaps be gained from a dry-farming outlying area to the west (Fig. 19). Surveys near the Tigris-Euphrates watershed (Wilkinson and Tucker 1995; Ur 2002) have documented a process by which a highly nucleated settlement pattern in the mid to late third millennium BC was replaced by a very full landscape of small dispersed villages.

34 The publication of recent surveys by the Iraq Department of Antiquities in Mosul may change this situation in the future.
or estates, which appear to have evenly divided up the agricultural land (Wilkinson and Barbanes 2000; Wilkinson et al. 2004). A similar pattern of abundant small low sites appears on the CORONA and aerial photographs used in this study, especially in the areas with evidence of local irrigation (e.g. the Girepan area, the plain below Jerwan, and the ‘Ain Sifni-Daluja basin), but without proper ground control it cannot be determined which of these sites were contemporary with the canal systems.

Wilkinson and Barbanes (2000) suggest that the evenly dispersed settlement pattern of the Jazira could be the product of a deliberate imperial policy of territorial acquisition and resettlement, but note that voluntary sedentarization of Aramean tribes might also be a factor. The latter is much less likely on the plains of the northern Assyrian core.

The Neo-Assyrian canals, alongside the policy of physical resettlement of captured populations, appear to have been part of a deliberate plan to remake the demography and economy of the Assyrian heartland. One of Sennacherib’s first major projects upon his accession was the construction of the city wall of Nineveh, which encloses some 750 ha (Stronach 1994). This size was surely in excess of the spatial needs of its population at the time, and hints at an underlying plan. The Kisiri canal was installed shortly thereafter.

Sennacherib soon established himself among Assyrian kings as the most prolific deporter of captured populations. Almost half a million persons are counted as deportees in his inscriptions, and their most common destination was Assyria and its capital cities (Oded 1979: 20–1, 28). These persons were transplanted as entire households or villages in order to keep them in the same economically productive social groupings that had served them so well in their former lands (Oded 1979: 23–5). Assyrian cities such as Nineveh were populated in this manner, and at the same time the agricultural labour necessary to support these populations was efficiently distributed across the landscape.

If a dispersed pattern similar to what has been recovered in the Jazira were to be documented in the Assyrian heartland, it would represent a very efficient distribution of agricultural labour in an extensive dry-farming landscape. With the reliable and properly timed application of water (i.e., irrigation), such a landscape of settlement would have not only reduced the uncertainty of rainfed agriculture by offsetting shortfalls in soil moisture, but would have also been even more productive in that winter grain production could have been intensified, the need for biennial fallow would have been reduced, and water-intensive summer vegetable crops would have been more feasible. Such a distribution of labour and water might explain why it is only in the early first millennium BC, in the contexts of irrigation projects for Nimrud and Nineveh, that we see the re-emergence of urban agglomerations on a scale not seen since the end of the third millennium.

The conclusions of this paper must remain preliminary, pending ground confirmation. Aerial photography is a powerful tool but remote observation alone can never be considered the last word. As the expansion of Mosul and the extension of modern agricultural systems continue at an ever greater pace, we are losing more and more of this fragile landscape. Let us hope that the remains of Sennacherib’s great engineering accomplishment, and the settlements that benefited from it, can be further documented soon, before old aerial photographs and satellite images become our only surviving records.

Acknowledgements

This is an expanded version of a paper presented at the 49e Rencontre Assyriologique Internationale in London (July 2003), as part of Tony Wilkinson’s “Landslapes of Greater Nineveh” session. I must thank Tony Wilkinson, Henry Wright and Joan Oates for their comments, and John Larson for assisting me with photographs from the Oriental Institute’s work at Jerwan. My greatest debt is to the two pioneers of the Assyrian landscape, Julian Reade and the late David Oates. Both were kind enough to dust off memories of decades-old field trips to provide ground control for my interpretations. The comments and photographs they provided were of enormous help. David was unfailingly supportive and encouraging of this project and of my involvement with the Brak survey; his presence at Tell Brak will be sorely missed.
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