

Irrigation and Drainage in the Early Ptolemaic Fayyum

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WHEN ALEXANDER THE GREAT of Macedon took Egypt from the Persians in 332 BCE he initiated a foreign regime which was to have an important effect on the landscape and productive capacity of the country. With him, as later with Napoleon, there came army engineers. In this case, however, they may already have had recent experience in drainage work back home, where Lake Copais in Boeotia and the area around Olynthus in Macedon had recently been drained and successfully turned over to agricultural use.¹ This was to prove important experience for the development of Egypt. Following the conquest and Alexander's subsequent death in 323 BCE many Greeks and Macedonians settled in Egypt, where Alexander's general Ptolemy son of Lagos became the first of a new dynasty of pharaohs. It is with developments in the Fayyum under the first three Ptolemies that this study is concerned.

Control of the Nile flood, with the irrigation and drainage works that this necessitates, has always been of crucial importance for whoever controls the land of Egypt. Starting with the Ptolemies, and continuing under the Romans, we have a new source of evidence for the study of this control—that is, a mass of administrative papyri. That the first papyrus ever to reach Europe in more recent times was concerned with irrigation works is a striking example of the centrality of the subject. That papyrus, known as the *Charta Borgiana* (*SB I 5124*), was bought by a Danish traveller (Niels Schow) and sent as a gift to Cardinal Stefano Borgia in 1778. Dating from 192, it lists those men from El-Lahun (Ptolemais Hormou) at the Fayyum mouth who were sent as *corvée*

¹ See Hammond and Griffith (1979), 658–60, on the Macedonian experience.

labour to work in February and March on the dykes around Tebtunis in the south Fayyum.² The Charta Borgiana was reported to have been found in a box, but earlier under the Ptolemies it was primarily the new practice of using papyrus in recycled form for mummy casing that is responsible for the mass of documents that has survived to the present. Bound with lime, this 'cartonnage' has preserved a wealth of administrative waste paper, which enables us to trace the effect of the new rulers on the old civilisation of Egypt. Other papyri have been found through excavation—mainly from the rubbish tips of ancient Egypt, but sometimes as personal papers collected together in a box or jar or, in the case of literary or religious texts, buried together with their owners.

The papyri used here are primarily from cartonnage, those from the cemeteries of Ghoran, now in the Sorbonne collection, and more especially those from Gurob, excavated by Petrie in 1887 and 1889 and published as the Petrie Papyri (see Map 2). The Petrie Papyri include a set of papers from two successive engineers—Kleon and his deputy, later his successor, Theodoros—who worked in the Fayyum under Ptolemies II and III in the 250s and 240s BCE. These papers are a mix of personal and public documents but it is mainly official correspondence, the records of contracts with which these engineers were involved, and their accounts, that I want to look at here.³ In addition to these Petrie Papyri, a cache of personal documents (not cartonnage) from much the same period, known as the Zenon Archive, contains much of interest for our enquiry. Zenon served as manager for a large estate of 10,000 *arouras* (c. 2,750 hectares) at Philadelphia on the eastern edge of the Fayyum which belonged to Apollonios, finance minister of Ptolemy II; the archive to which Zenon's name is given is an important source for the period.⁴ That these papyri, dating from a couple of generations after Alexander's conquest, are among the earliest of all surviving Ptolemaic papyri is mainly due to the practice already mentioned of recycling waste paper, which appears only to have started under Ptolemy II. The earliest period of Ptolemaic rule for this reason remains a mystery, though in the Fayyum both the names of villages (such as Berenikis named after Berenike, the wife of Ptolemy I) and the early development of Talit and the Gharraq basin in the south suggest that the early third century BCE was already a period of important activity.⁵ What the Zenon Papyri show, therefore, is an ongoing concern with the development of the irrigation system of the Fayyum basin, and with the settlement and exploitation of the land so reclaimed.

In discussing the papyrological documentation for irrigation and drainage works it is important to acknowledge the limits to this evidence. That the Nile

² On the rediscovery of papyri, see Turner (1980), 17–41.

³ See further, Bouché-Leclercq (1908); Lewis (1986), 136–45.

⁴ See further, Rostovtzeff (1922); Préaux (1947); Orrieux (1985); Clarysse and Vanderpe (1995); ch. 6, p. 125, below; Appendix A for area equivalents.

⁵ For the Talit survey, see Kirby and Rathbone (1996).

has shifted its course must have affected the hydrological configuration of the area,⁶ and as Hanbury Brown remarked in 1892, to understand the history of the Fayyum 'would seem to require an alliance between a palaeontologist, an archaeologist, an Egyptologist, a geologist, and a hydraulic engineer'.⁷ This study is the historical reconstruction of a papyrologist and, whereas there are some aspects which papyri can illuminate, the overall picture is not to be found in the scraps that survive. Though individual names and sections of canals are known, from the papyri it is not possible to draw up a full map of the canal system from the period of Ptolemaic expansion. For the system as a whole, there is probably more to be learned from survey archaeology, combined perhaps with selective excavation, than from the documents alone.⁸ What the papyri do provide, in contrast, is some of the human involvement in the system, the organisation and economics of the irrigation system as it grew in this second main period of Fayyum development,⁹ and some of the techniques employed both in reclamation and in the regular upkeep during what was a period of extensive and generally successful development in the area. These are the aspects I want to concentrate on here.

First, therefore, we may briefly consider the administrative organisation which lay at the base of the early Ptolemaic development of the Fayyum. In the fallout that followed the death of Alexander the Great and the ensuing competition with other successor kingdoms, the new rulers of Egypt were concerned to exploit the wealth of their country. In Egypt wealth always came from the Nile, and the successful reclamation of new land would not only enable the king to reward and settle his troops — an important consideration in a world where fighting men were in heavy demand — but would also increase the long-term yield of his kingdom. So there were compelling reasons behind the development of the Fayyum under the first three Ptolemies. In essence, this development consisted of a mix of drainage and new irrigation, the construction of new dykes, new canals and drains, and the agricultural development of areas previously uncultivated. As suggested below (ch. 6, p. 125), the change of the Fayyum's name from the Marsh to the Arsinoite nome (named after Arsinoe, the sister-wife of Ptolemy II) marked more than simply an act of royal recognition; the older name was now, on the whole, obsolete.¹⁰

By the reign of Ptolemy III there were three main districts established for the

⁶ Butzer (1976), 33–8; Thompson (1988), 12, at Memphis the Nile now flows more than 3 km further east.

⁷ Brown (1892), 56, with reference especially to Lake Moeris.

⁸ See Rathbone (1996).

⁹ The earlier period of development in the 12th Dynasty was mainly under Amenemhet III (1854–1808 BC); one of his pyramids stands at Hawara.

¹⁰ An area of papyrus marshland (*drymos*) along the western edge of the Fayyum, west of the Bahr Nezla, continued into the Roman period, when it became imperial property, *P.Mil.* 6 (6 CE).

Fayyum, the Polemon to the south, the Themistos to the north-west and Herakleides to the north-east, named after their development officers.¹¹ However, in the first generations of Macedonian development of the area it was a series of smaller units named 'nomarchies' which appear to have been the significant operational units, at least for works of irrigation and drainage. Seven such nomarchies are recorded from the mid-third century BCE, and the activities of various nomarchs — of Maimachos, Aristarchos, Diogenes, and others — are reasonably well documented.¹² These nomarchs were the officials who controlled local supplies of irrigation equipment and, under the overall authority of the engineer (*architekton* in Greek), oversaw on the ground both regular maintenance of the drainage and irrigation system and emergency measures.¹³ Under them were those named 10,000—aroura men (*myriarouroi*) and the local village officials — the village headmen (*komarchai*) and perhaps the village scribes (*komogrammateis*).¹⁴ So, when Theodoros replaced Kleon as chief engineer 'in charge of the protection of the dykes and the sluices', the announcement of his appointment was sent to the financial officers (*oikonomoi*), the nomarchs, royal scribes, policemen, *myriarouroi*, village headmen, and village scribes.¹⁵ When there were problems with the flood it was the nomarchs who moved into action, and it was the engineer who organised them. The river had reached the dykes, strengthening work was needed, so the engineer Theodoros called for help: the nomarchs should send along all their donkeys.¹⁶ That these animals were needed for the transport of reinforcement materials is known from other texts — for the transport of reeds of various kinds (*thrya* or *kalamoi*) and a further material carried in bundles known by its Egyptian name of *anouchi*.¹⁷ Nomarchs were actively involved also in the provision of corvée labour¹⁸ and, on occasion, they might themselves take on the contract for work that was needed.¹⁹ The details of such contracts will be discussed below.

First, however, I want briefly to consider the evidence for reclamation pro-

¹¹ The area of the Small Marsh, Mikra Limne, became incorporated in the Herakleides division.

¹² Information from Clarysse, cf. Héral (1992), 150; seven is a minimum number.

¹³ *P.Petrie* II 39 (h) = III 49 lists the nomarchs' central supplies of irrigation and agricultural equipment, including baskets, wooden planks, large and small bends for water-channels (*ankones*), poles, and tamarisk planks; *P.Petrie* II 13 (20) = III 42 G (8), wood supplies.

¹⁴ See Héral (1992), 152–3.

¹⁵ *P.Petrie* II 42 (a) = III 43 (1).

¹⁶ *P.Petrie* II 9 (1) = III 43 (8), undated. *P.Petrie* II 37 = III 44 (2) verso ii c, Aristarchos has agreed to bring 50 donkey-loads of *anouchi* a day; how much the others bring needs controlling.

¹⁷ *Thrya*: *P.Petrie* III 39 ii.4, 15, 21, monthly account; 44 (2) i. 4; II 26 = III 64 a (3). 8, (4). 5, payment records. *Kalamoi*: *P.Petrie* III 44 (4), for the gap (*dialemma*) at Bousiris. *Anouchi*: *P.Petrie* III 41 verso 2, alternative methods of payment debated — by the load or the number of bundles; 43 (2) iv. 16, deeply fixed stakes covered with rope and faced with *anouchi*, verso iv. 11, 14, cladding for (tamarisk) brushwood revetment; 44 (2) i. 4, with *thrya* for reinforcement, verso i. 12, iii. 12.

¹⁸ *SB* V 8243. 4.

¹⁹ *P.Petrie* III 37 (a) i. 4–6 (258–257 BC), Nikon's agent; 43 (2) iv. 45, Horos, verso v. 7, Aristarchos.

jects in the area. In the third edition of his monumental work on Egyptian irrigation published in 1913, William Willcocks (now in conjunction with Craig) ends by suggesting some ways in which land reclamation may best be brought about.²⁰ 'Let plots of 10,000 acres of waste land . . . be handed over without payment of any kind to approved companies, to level, drain and provide with villages and pumping installations'. I wonder if he knew he had been preceded in this idea by Ptolemy II in the first half of the third century BCE? The land unit in Ptolemaic Egypt was the *aroura* (see Appendix A) and it was in plots of 10,000-*arouras* that the Ptolemies reclaimed the Fayyum. The best known 10,000-*aroura* plot is that already mentioned, granted to Apollonios and managed by Zenon at Philadelphia (Darb Girza) in the eastern Fayyum, but the title of those officials known as *myriarouroi* shows that this was not the only such reclamation project.

In the case of Apollonios' estate an important text has survived which details the work involved in setting it up. This text is translated in Appendix B and provides important information both on the enterprise itself and on the organisation of the labour involved. First to note is the division of the plot, called a *perichoma*, which is actually sketched out on the papyrus, with its four surrounding dykes and cross-dykes (and presumably drains) which split it up into forty smaller basins each of 250 *arouras* (10×25 *schoenia*), or, in practice, into ten long plots running east-west of 1,000 *arouras* each (10×100 *schoenia*). These internal divisions, also named *perichomata*, were numbered 1 to 5 North and 1 to 5 South (see Appendix B, Figure 5.1);²¹ this form of division is perhaps to be traced elsewhere, as in the numbered *perichomata* of Kerkeosiris in the south Fayyum. What, however, appears on the papyrus as a matter of straight lines on a map in practice had to take account of the contours of the land, the ravines unsuitable for cultivation (ll.26–31), and of where there were earlier dykes in place (ll.31–36). This was not the first attempt to irrigate the area and here, as elsewhere, earlier dykes were incorporated into the new system.²²

Details are provided in the text of the size of the dykes and canals and the enterprise is costed in terms of the cubic capacity of the earth to be shifted; the unit for this is a *naubion* (*naubia* in the plural), elsewhere termed *aoilia* (most probably its Egyptian name). The cost of shifting dirt, the amount for 4 drachmas (a tetradrachm or stater—the normal silver currency unit, which was often actually paid in bronze), differed according to the season. Here alternative rates are recorded, 70 *naubia* for 4 drachmas before the harvest, but only 50 *naubia* expected for this remuneration when the weather grew warmer after the harvest period. In the end the compromise figure agreed for the project was an average

²⁰ Willcocks and Craig (1913), 837.

²¹ References in *P.L.Bat.* 20, pp. 254–6; this account owes much to Pestman's excellent edition.

²² *P.Petrie* III 37 (257 BCE), with several references to the old dyke of Attinas, which needed supplementary work (*epibole*) on top.

60 naubia for 4 drachmas; this was the normal rate that is found elsewhere.²³ Other rates recorded in different texts are 80 naubia in October,²⁴ or 75 in December,²⁵ 56 in late June,²⁶ and at the height of the summer (late June to late September) only 40 aolia / naubia to four drachmas.²⁷ The amount shifted per man / day ranged from 1.25 to 3 aolia / naubia,²⁸ and calculations made might take account of rest-days, one day off in ten according to *P.Petrie* III 40. This work was not well paid. There were 6 obols to a drachma and 1–2 obols was a standard daily wage. At 3 naubia a day a worker would make just over one obol a day, at the lower end of the regular scale.

The next point of interest raised by this account is the scale of such projects, the number of men involved. In the present case, on the final figures adopted²⁹ and pay at 1 obol a day, 51,600 working days are involved. With a force of five hundred men the project could have been completed in three and a half months— from late January, perhaps, to mid-May— if all, that is, ran smoothly. Other projects were even larger in scope. One proposal made to the finance minister Apollonios by an ambitious contractor envisaged a far larger project than the 10,000 arouras here. He proposed the employment of 15,000 men with 5,000 shovels to bank round an area he describes as an island (*nesos*); the cost (10 talents, with 6 talents for equipment) would be met from the sale of the emmer harvest.³⁰ At the 60-naubia rate the 10 talents on labour might involve the shifting of 900,000 naubia or, again on the pattern of the earlier text, earth for almost 70,000 arouras or almost 20,000 hectares. Fifteen thousand men would represent some 64 per cent of the total adult civilian male population of the nome and, although paid, such workers most probably formed part of a *corvée* system.³¹ Whether this project was ever put into effect remains unknown but the proposal is of interest in showing the grand scale of these projects in the early years of the new regime.³²

The provision of tools, for which allowance was made in this last proposal,

²³ *P.Petrie* III 37 (a) ii. 9; (b) iv. 15–16 (257 BCE); *UPZ* II 157. 8 (242–241 BCE); as 60 aolia: *P.Petrie* III 45 (2). 8; *P.Petrie* II 4 (11) = III 42 D (2). 4 (254 BCE).

²⁴ *P.Petrie* III 43 (2) ii. 25 (246 BCE).

²⁵ *P.Petrie* III 43 (2) verso iii. 2 (246 BCE).

²⁶ *P.Petrie* III 45 (4). 1–4.

²⁷ *P.Petrie* III 40. iii. 8 and elsewhere in the text.

²⁸ *P.Petrie* III 40, rates from 1.25 to 2.75 aolia; 43 (2) verso iii. 4, 3 aolia.

²⁹ See Appendix B, lines 41–4.

³⁰ Clarysse (1988), 78 (*SB V* 8243 + new frag.). My calculations differ somewhat from those of Clarysse, but in any case the reclamation project proposed here is enormous.

³¹ *P.Lille* I 10 (253–230 BCE), with new fragments (to be republished by Clarysse and Thompson in *Counting the People* (forthcoming)), records a total tax-paying civilian population for the nome of 49,584 (23,614 males). *UPZ* II 157. 6–7 (242–241 BCE), from the Theban area, implies 30 naubia as the annual norm for dyke work; soldiers, and probably others, could pay an alternative tax, and some were exempt.

³² *P.Hal.* I 15. 5–6 records a military settlement on a *nesos* at Pharbaitha, which may be the same.

was normally a central responsibility. Tools were kept in a special depot,³³ and in surviving contracts the exact number of shovels to be used is often specified; these were provided at the treasury's expense and charges only levied if they were not returned at the same weight as they went out.³⁴ Such was 'the usual practice'.³⁵ The widespread use of iron in Egypt was a Ptolemaic development and many texts show how precious this metal remained.³⁶

A further feature of the system illustrated by this and other texts is the hand-to-mouth nature of it all. Cash was short and officials needed to use whatever they could find to pay for the work that was needed. The proposal made to Apollonios was that he should finance the large enterprise from the sale of the emmer crop. Elsewhere the expense of unforeseen work in cleaning out sand from a new canal that had silted up in the south Fayyum might be set against the local salt-tax,³⁷ and in a somewhat later contract the sale of oil-seed was used to meet the cost of extensive repairs.³⁸

So far our subject has been new reclamation and drainage work. The nature of the regular work of irrigation and how it was arranged is also to be seen both from official records and from the contracts that survive.³⁹ Work projects were contracted out and the officials involved in the process, which was primarily an oral one only followed later by a written record, were the financial controller (*oikonomos*), the nome engineer and the royal scribe for the nome. Details of the work were listed in the written contract. One Petrie papyrus provides a typical example, involving the removal of various bridges, the revetment of the lower sections with brushwood, replacement of the bridges, special reinforcement near a bend, problems at corners, wooden stakes driven in to a cubit's depth for reinforcement at foundations (probably made of stone), and more general work on revetment with the use of ropes and different materials for cladding.⁴⁰ All the regular upkeep and annual renewal required for an irrigation system to function is to be found specified in these contracts. Provision was made for the tools that were needed, both shovels and water-raising machines (*organa*), and payment arrangements were specified—half the sum to be paid

³³ *P.Petrie* II 5 (a) = III 42 B (5). 2, *skeuophylakion*.

³⁴ *P.Petrie* III 42 F (c). 9–10, sufficient machines and shovels; 43 (2) i. 11–13, 20 shovels; ii. 32–33, 13 shovels; iv. 31–34, sufficient shovels; verso v. 5–6, 100 machines and shovels (246–245 BCE).

³⁵ *PSI* V 488. 18 (257 BCE).

³⁶ E.g. *P.Petrie* II 13 (1) = III 42 C (12). 9–10 (255 BCE), quarrymen threaten to pawn their tools.

³⁷ *P.Petrie* II 4 (11) = III 42 D (2) (254 BCE); any extra cash should be used for ropes and wooden stretchers for the bridges.

³⁸ *P.Petrie* III 43 (2) i. 1–5 (246 BCE).

³⁹ *P.Petrie* III 37 (a) and (b), work from early July to late September; 39, an account of reeds provided mid-June to mid-August; 40, spending on earthworks; 43 (2), an important collection of contracts (246–245 BCE); *PSI* V 488. 16–17 (257 BCE), the *oikonomos* and the *architekton*.

⁴⁰ *P.Petrie* III 43 (2) iii = *Select Papyri* II 348.

on signing the contract, the remainder later. Penalty clauses specified a 50 per cent surcharge for non-completion and provision for passing the contract on if its terms were not fulfilled. The contractor was required to provide acceptable sureties and the royal administration made every effort to protect itself from fraud and incompetence — not always with success.

The timetable of work on the dykes was, as always in Egypt until the present century, concentrated in the period after the harvest and the start of the flood in late July, and on into the main flood period. Once the flood began to rise then there was always urgency about continuing repairs that were needed and extra work on dykes that were weak. The pattern of work that is shown in the third-century BCE texts may be seen in Appendix C, where information from different years has been amalgamated to provide an overview.⁴¹ Work on the dykes continued throughout the period of the flood (late July–late December, with the waters at their height in the three months September–November). There were dyke guards out on duty,⁴² the engineers on constant call and under pressure,⁴³ and the male population of the area on red alert. It was an annual ritual, in which the protection of the waters was the duty of all, from the pharaoh down through the officials on the ground to the ordinary peasant who depended on the silt of the Nile — the blood of Osiris — for the fertilisation of his fields.⁴⁴

This survey ends with emergencies and some use of comparative material, always important for the historian of Egypt. Breaches in the dykes were a fact of life, a regular occurrence, and a matter of constant concern. So, when on 22 March 257 BCE a certain Harmais wrote to Zenon about building up the dykes surrounding Memphis down-river on the Nile to the height of 12 cubits, it was breaches in this embankment that he wished to prevent.⁴⁵ In the Fayyum, when the main sluice gates collapsed and the barrier broke there was urgent need of tamarisk wood for repair.⁴⁶ A further set of fragmentary letters, preserved in draft form and unfortunately lacking any certain date, clearly belongs to the period of the flood and the influx of water to the Fayyum.⁴⁷ The first draft mentions the flood — something has been washed away by rough water; as much as possible is required, together with reeds. In the next letter the author, perhaps

⁴¹ This is not a complete collection; for further detailed discussion, see Bonneau (1993).

⁴² *P.Cairo Zen.* II 59296. 15–18 (250 BCE), dyke guards paid 2.5 drachmas a month.

⁴³ In *P.L.Bat.* 20, Suppl. C (11 Oct. 257 BCE), Apollonios' representative pulls rank on the engineer Kleon in an attempt to get his help: 'If, however, you do not come, we shall be compelled to write to Apollonios that his land alone in the *Limne* is not irrigated'.

⁴⁴ Coronation oath: Thompson (1988), 146–7; appointment oath of an *antigraphheus* ('to manage the dyke works uprightly and with justice, neither to peculate myself, nor allow others to do so'): *P.Petrie* III 56 (b). 9–11.

⁴⁵ *PSI* V 488.5, *ekregmata*; cf. *P.Lond.* VII 2054. 4–11, gravel perhaps used in this work. At this period Memphis, now 3 km west of the river, lay close by the Nile.

⁴⁶ *P.Petrie* III 48. 3–6, *ptosis ton thyron, diaphragma*.

⁴⁷ *P.Petrie* II 37 (5) = III 44 (2); 14 Pauni was originally read for the date on verso ii b. 1 (now replaced by 'to Paues'); this would date the dossier to early August.

Kleon or Theodoros, writes that the sluice gates had been raised,⁴⁸ the one at the quayside and the other at Ptolemais (which is El-Lahun at the entrance to the Fayyum). One of the gates at Ptolemais had been opened on the 11th and another, following instructions, on the 12th of an unspecified month, so that all four gates were now in action; the dyke that ran by the great granary at Poa needed watching. The next letter has a somewhat sharp tone to it. Its recipient was asked to check that the earth said to have been thrown up at Psenaryo really was in place. It was crucial that, as the water came through, it was not lost down a gorge; this was no time for exaggerated claims. Then on the back comes a letter on the need for brushwood reinforcement around the sluices at Ptolemais;⁴⁹ the force of the water had opened most of the gates and the flow had turned towards the northern part of the great barrage;⁵⁰ anouchi was needed for urgent reinforcement. In the next text the writer mentions a dyke at Pseonnophris, and again, refers to the initiative he had shown in opening the sluice gates at Ptolemais; there was no justification for the criticism he would seem to have received. The location of these concerns is clearly the area at the entrance to the Fayyum, with the main Fayyum sluices, the great barrage formed by the Lahun dyke wall, part of which is still in place today, and the gorge the water might turn to flow down the start of the Bats Drain or one of its feeders.

The final letter to mention is from the papers of the nomarch Aristarchos rather than those of the engineers, from the cemetery of Ghoran rather than that of Gurob.⁵¹ Again the text is fragmentary, but its subject-matter is similar. It also illustrates the role that literacy played in everyday life; even in times of crisis officials put pen to papyrus and used the written word to communicate with one another. On 19 October 247 BCE the engineer Theodoros wrote to Aristarchos about a breach that had been found in the dyke. Aristarchos should attend (with others); the water should be let out and for the next three days a watch should be kept on the dykes by men with shovels, baskets, and jars for lifting the water. The young soldiers, the *myriarouros* and dyke guards were to be involved. Fires were to be lit and two individuals were to keep watch day and night. Further instructions had been forwarded to others and shovels called for. If action did not take place immediately Aristarchos had reason to fear for his neck. To understand the full import of this and my earlier texts, I quote from a lecture given

⁴⁸ For raising, cf. *P.Petrie* II 13 (16) = III 44 (1). 5–6, 13; III 44 (3). 3–5, at Theogonis.

⁴⁹ There was a stone quayside at Ptolemais (*ekbateria*) and work there is recorded on the legs (*skele*) of the sluice (*aphesis*), *P.Petrie* III 39 i. 12–13, ii. 9–10, iii. 9–10; cf. *P.Petrie* II 13 (18a) = III 42 G (7) a. 9–12, for problems in transporting stone from the Nile across to the locks (*katakleides*) at Ptolemais.

⁵⁰ *P.Petrie* II 37 = III 44 (2), verso ii a, *ta megala zeugmata*; the great barrage must be that across the Lahun gap, on which see Ball (1939), 213. The relation to this of the barrage, *ochyroma*, in *P.Petrie* II 13 (3) = III 42 C (8). 1–2, is not clear, cf. Appendix C, 11 January.

⁵¹ *SB* XII 10844 (19 October 247 BCE), re-edited by Héral (in her Leuven thesis); Pseonnophris recurs in this text.

to the Khedival Geographical Society in Cairo in 1904 by Sir William Willcocks.⁵²

The terror reigning over the whole country during a very high flood is very striking. The Nile banks are covered with booths at intervals of 50 metres. Each booth has two watchmen, and lamps are kept burning all night. Every dangerous spot has a gang of 50 or 100 special men. The Nile is covered with steamers and boats carrying sacks, stakes, and stone; while the banks along nearly their entire length are protected by stakes supporting cotton and Indian corn stalk, keeping the waves off the loose earth of the banks. In a settlement of a culvert in the Nile bank north of Mansourah in 1887 I witnessed a scene which must have once been more common than it is today. The news that the bank had breached spread fast through the village. The villagers rushed out on to the bank with their children, their cattle, and everything they possessed. The confusion was indescribable. A narrow bank covered with buffaloes, children, poultry, and household furniture. The women assembled round the local saint's tomb beating their breasts, kissing the tomb and uttering loud cries, and every five minutes a gang of men running into the crowd and carrying off the first thing they could lay their hands on wherewith to close the breach. The fellaheen meanwhile, in a steady, business-like manner, plunged into the breach, stood shoulder to shoulder across the escaping water, and with the aid of torn-off doors and windows and Indian corn stalks, closed the breach. They were only just in time.

For 'cotton' and 'Indian corn stalks' read 'reeds' and 'anouchi' and for 'buffaloes' read 'oxen' or 'cows'. Otherwise the description could well apply to the problems that Kleon and Theodoros faced when the flood came high and their new barrages, canals, and dykes were under threat or breached. There can be few better examples of the unchanging nature of the dangers inherent in the flood of the Nile, and the importance to Egypt of the work of the engineer of drainage and irrigation.

Appendix A Equivalencies

Length

1 regular cubit (7 palms of 7.5 cm)	= 52.5 cm
1 large cubit (7 palms of 7.877 cm)	= 55.125 cm
1 schoenion (100 regular cubits)	= 52.5 m
100 schoenia	= 5.25 km

⁵² Willcocks (1904), 29–30; he proceeds to record threats of Ismail Pacha in 1887—that a responsible official and his engineer should be thrown into the breach.

Area

1 aroura (100×100 regular cubits) = 0.27 hectare
10,000 arouras (100×100 schoenia) = 27,500 hectares

Volume

1 naubion ($2 \times 2 \times 2$ large cubits) = 1.34 m^3
or ($2.1 \times 2.1 \times 2.1$ regular cubits) = 1.34 m^3

Coinage

6 obols = 1 drachma
4 drachmas = 1 stater or tetradrachm
6,000 drachmas = 1 talent

Appendix B
Land Reclamation Project

P.Lille I 1 = Papyrologica Lugduno-Batava 20, Supplement A (ed. P.W. Pestman)

Introduction

Report of Stotoetis to Apollonios in the month of Phaophi, Year 27, which is the same as the Egyptian year [November/December 259 BCE], when . . . was *oikonomos* and Diodoros was *antigraphheus*.

Plan

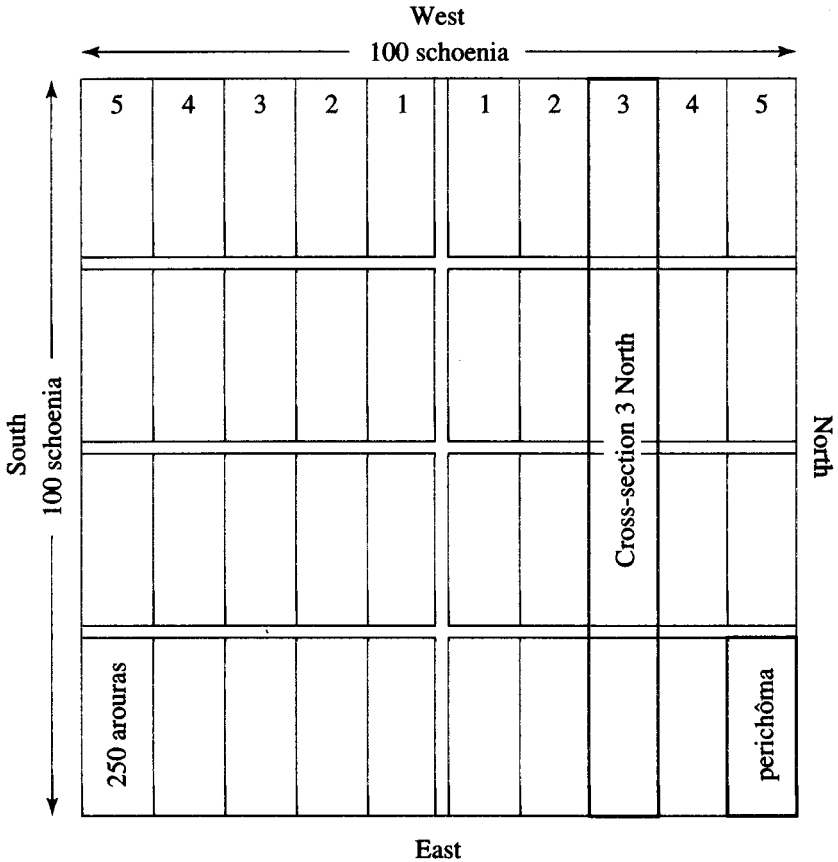


Figure 5.1 Block diagram of 10,000 aroura reclamation project.

Works (lines 1–8)

Perimeter of the 10,000 arouras: 400
schoenia dykes (*chomata*) 4
Within these from south to north, 25
schoenia apart, dykes (*chomata*) 3
In addition from east to west,
10 schoenia apart,
cross-dykes (*diapleurismoí*) 9
16

Total, within the 10,000 arouras:
40 basins (*perichomata*), each of
250 arouras measuring 25 by
10 schoenia, as shown in the block
diagram (*plintheion*)

16 dykes of 100 schoenia each:
1,600 schoenia to be excavated

Measurements (lines 8–13)

Excavation (*orygma*) required:
4 cubits wide by 2 cubits deep
Estimate for the length of the dykes:
1,600 schoenia at 86 naubia a schoenion
naubia 137,600

Canals (*hydragogoí*) in addition to the
existing 4, 4 further canals at 100
schoenia:
400 schoenia at 86 naubia a schoenion
naubia 34,400
naubia 172,000

Cost (lines 14–15, 24–25)

- 1 If completed during the winter, at 70
(naubia) a stater (= 4 drachmas):
1 talent 3,834 drachmas
Rate per aroura: 1 drachma
- 2 If not completed before the harvest, at
50 (naubia) a stater (= 4 drachmas):
2 talents 1,760 drachmas
Rate per aroura: 1 drachma
2.25 obols

Additional expenditure (lines 26–31)

And for the areas nearby it will be
necessary to add on [the cost] for the
difference in height with the adjacent
dykes. This will be let out as soon as we
know the extent of the land involved and
the length of the dykes in these areas.
Arising from the lie of the land, part of
the area involved—up to 1,000 arouras—
is in a ravine to be skirted round and
therefore involving little expense; this
saving can be used to compensate for
greater expense elsewhere.

When there are dykes already in
existence, the cost of as many of these as
can be used by the farmers [i.e. the
workers] is to be deducted from what
they get; they should follow the line of
existing dykes so nothing is redundant.
Likewise for the channels (*dioryges*)
which feed into the embankments
(*perichoseis*), in cases where they
naturally run alongside the dykes
(*chomata*). As for the annual expenditure
which is customarily provided for [repairs
on] the existing canals and dykes,
inspection must be made by the engineers
and the royal scribes and, when they have
reported, payment is to be made. . . *frag.*

Plan finally adopted (lines 41–44)

Following further inspection of the
enclosed basin (*perichoma*) [Apollonios]
decided to make the dykes, but to
excavate to a width of 3 rather than
4 cubits, giving 64.5 (naubia) to a
schoenion.

Rate: 60 naubia for 4 drachmas.

Action followed (lines 44–48)

Apollonios left on 7 Hathyr [1 Jan. 258
BCE]. I [Stotoetis] sailed with him as far
as Phylake and there disembarked. I
reached Touphis on the 8th, the village of

the Syrians on the 9th, Ptolemais on the 10th, the Labyrinth on the 11th [5 Jan.] and there I found the scribes; they took over the instructions and we proceeded to the city [i.e. Krokodilopolis, capital of the province].

Overall cost (not provided)

On the assumption that the smaller width

(3 not 4 cubits) was applied also to the canals:

Dykes: 1,600 schoenia at 64.5 naubia =
naubia 103,200

Canals: 400 schoenia at 64.5 naubia =
naubia 25,800
naubia 129,000

at 60 naubia for a stater (4 drachmas): 1
talent 2,600 drachmas

Appendix C Calendar for Irrigation Work in the Fayyum According to Third-century BCE Papyri

Cereal harvest in the Fayyum: April–June
Egyptian year starts 1 Thoth = late
October in mid-third century BCE

June–July?

in the 60 days after the harvest:
proposal for large-scale reclamation
project, *SB V 8243 + P.Mich. inv.*
3098, ed. Clarysse (1988)

June–October

use of reeds; heaviest use in mid-
June to mid-August, *P.Petrie III 39*

Late June–Late September

account of money spent on shifting
earth, with 40 *aoilia* for 4 drachmas,
P.Petrie III 40

June

12 contract for work on foundations and
dykes, reinforcement with brush-
wood, *P.Petrie III 42 F (a)*

late earth shifting at 56 *aoilia* for 4
drachmas, *P.Petrie III 45 (4)*. 1–4

July

3 supplementary work on old dyke of
Attinas, *P.Petrie III 37b*

4 supplementary work on old dyke of
Attinas, *P.Petrie III 37b*

5 dyke work, *P.Petrie III 37b*

19 payment for making of mud bricks
under control of Kleon, engineer,
P.Petrie III 42 E (1)

22 payment starts of dyke guards for 5
months at 2.5 drachmas a month,
P.Cairo Zen. II 59296. 15–18 (250
BCE)

payment starts of dyke guards for 2
months, *P.Cairo Zen. II 59296*. 28–29

August

4 work on new dyke, *P.Petrie III 37a*

7 need to clear silt from drain leading
from Tebetnou and Samareia to
Kerkeesis (dug the previous year);
work to be financed by charge on
the salt-tax; wooden stretchers for
bridges and ropes requested, *P.Petrie*
III 42 D (2)

13 new dyke and supplementary work
on old dyke of Attinas, *P.Petrie III*
37a

- 14 30 ropes ordered for construction of sluice gates at Sebennytos, to be finished before the water is let through (*aphesis*), *P.Petrie* III 42 C (10)
- 16 work on canal, at Psenaryo, *P.Petrie* III 42 E (2)
- 17 new dyke from royal road, *P.Petrie* III 37b
- 20 new dyke, *P.Petrie* III 37b
- 26 closing of sluice gates; one gate, perhaps at Ptolemais (El-Lahun), to be closed, *P.Petrie* III 42 B (1)

September

- 3 new dyke, *P.Petrie* III 37b (two references)
- 6 new dyke, *P.Petrie* III 37a
- 13 new dyke from Kerkion, *P.Petrie* III 37b
- 28 supplementary work on old dyke, *P.Petrie* III 37a
- 29 dyke by Simon's lands, *P.Petrie* III 37b
- 29 supplementary work on old dyke of Attinas, *P.Petrie* III 37b

October

- 8 contract to clear sand from feeder channel to the canal at Hephaistias, running alongside the rocky area, for purposes of irrigating land of settled cavalry; 23 shovels to be provided, *P.Petrie* III 43 (2) ii (245 BCE)
- 11 problems in irrigating part of Apollonios' estate; Kleon asked for urgent help with work on the sharp bends (*ankones*); he had passed by on way to Mikra Limne, *P.L.Bat.* 20, Suppl. B (257 BCE)
- 14 water in canal has only risen a cubit; request to open gates (*thyrai*); Zenon to Kleon, *P.L.Bat.* 20, Suppl. B
- 15 new dyke, *P.Petrie* III 37a
- 15 mention of sluice gate from the

Montila (canal), *P.Petrie* III 42 C (14)

- 17 *diakommata* of the great canal (side-cuttings for sluices?), *P.Petrie* III 37a
- 19 breach (*ekregma*) in dyke; watch to be kept for next three days with shovels, baskets, and irrigation jars; the young men, area official (*myriarouros*) and dyke guards to be on alert with fires lit night and day in all danger spots; death threat in case of failure, *SB* XII 10844 + unpublished PhD (Leuven) of Héral, cf. Héral (1992), 152

November

- 1 work (on dyke) from Hephaistias to Nautys, *P.Petrie* III 42 G (10)

December

- 6 concern with stone-cutting in advance of king's visit, *P.Petrie* III 42 G (4) (254 BCE), cf. Clarysse (1980) 85–6
- 18 work on the landing place (?at El-Lahun) for king's forthcoming visit, *P.Petrie* III 42 C (3) (254 BCE)
- 21 contract for large-scale work on ditches and dykes in various parts of the Fayyum; 100 men shifting 3 *aoilia* a day to be completed within 40 days; cross-pieces to be left across the full width, *P.Petrie* III 43 (2) verso ii
- 28 need to appoint dyke guards; completion of Kleon's dyke; irrigation of some land; a duct to bring water through into the lake; revetment of dyke (or banks?); wells, *P.Petrie* III 42 C (17)

January

- 11 collapse of wall to south of dam

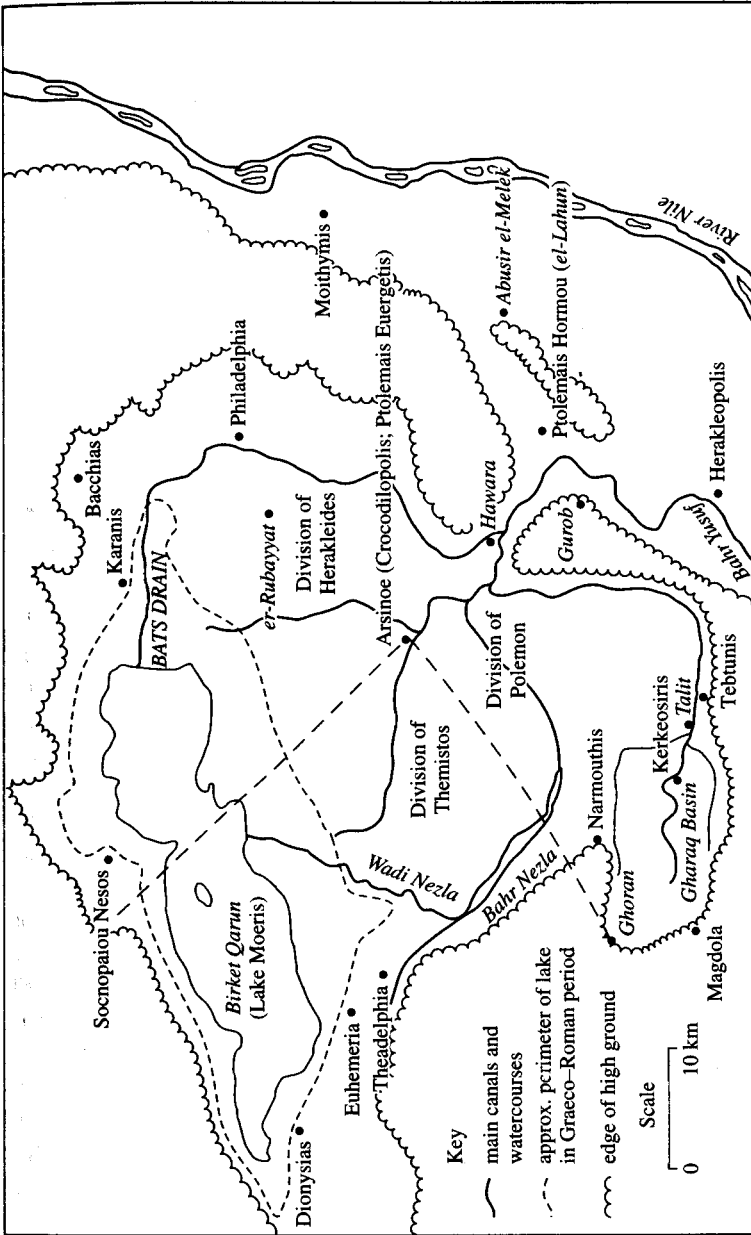
- (*ochyroma*, perhaps at El-Lahun), *P.Petrie* III 42 C (8), with Bouché-Leclercq (1908), 134–5; already a problem on 18 August with the western end in danger of collapse, *P.Petrie* III 42 C (9)
- 17 contract for work on dyke (*potamos*) at Berenike Nea; to clear sand; to complete cross-dyke; to reinforce dyke with tamarisk; making use of anouchi; 100 machines and shovels to be provided without charge, *P.Petrie* III 43 (2) verso iii
- March*
- 1 problems with a canal, *P.Petrie* III 42 D (1)
- 22 dykes at Memphis to be raised to 12 cubits against breaches (*echregmata*), *PSI* V 488 (257 BCE); cf. *P.Lond.* VII 2054. 4–11, gravel in connection with work
- May*
- 5 work on canal south of Kleon's canal; perhaps a new project since a land surveyor is involved, *P.Petrie* III 45 (1)

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Map 2. The Arsinoite Nome (Fayyum)