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GRAIN STORAGE AND THE MORAL ECONOMY IN MESOPOTAMIA (3000–2000 BC)

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For Kate and Doc

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ABSTRACT

In Mesopotamia, grain was king. Or, to put it more accurately, grain *made* kings. The palace and temple institutions that rose to prominence during the third millennium BC were built on the production, stockpiling, and distribution of grain, and they invested an enormous amount of energy in managing and monitoring the grain supply. I argue that these efforts to control the agricultural economy would also have required a shift in the *moral* economy – that is, a shift in the way that people understood and experienced three interwoven themes: inequality, access to food, and the distribution of risk. As more and more people were drawn into the institutional orbit, many came to depend directly on the disbursement of food from institutional storage facilities. But how many people? What percentage of the population found itself (willingly or unwillingly) within the "magic circle" (Oppenheim 1977: 89) of the institutional storage system?

I argue that the archaeological evidence for grain storage facilities – extra-household facilities, in particular – offers one means of addressing this deceptively simple question. My study is built around a series of site-based case studies drawn from Northern and Southern Mesopotamia. The focus is explicitly quantitative. In each case, I provide a detailed description of the available evidence, but I focus on compiling information about storage capacity. I then perform a series of calculations to estimate the number of people and the percentage of the population that could have been supported with the stored grain. I emphasize the uncertainty involved in these calculations and also the importance of taking the risk-buffering function of grain storage into account. Overall, the evidence that I have collected is extremely diverse and does not map easily onto the idealized image of a centripetally organized storage economy. This mismatch could be explained in a number of ways, but I suggest that we may need to reconsider both the structure and the magnitude of the institutional storage economy.

Chapter 1

Introduction

In ancient Mesopotamia, agriculture was a risky enterprise. Droughts were always expected but could not be predicted with any certainty. Sudden floods destroyed crops in the fields and played havoc with irrigation systems. Swarms of locusts appeared without warning to devour and destroy great swaths of grain. Invading armies burned crops and consumed stocks of surplus provisions. The looming prospect of food shortage was simply a fact of life. Risk management was, therefore, a constant concern – for households, for communities, and for the powerful palace and temple institutions.

I would like to begin by posing a simple question: Who was bearing the risk? That is, who felt the effects of drought, harvest failure, food shortage, and economic collapse? The answer to this question is, of course, not at all simple. In heavily stratified societies like those of Early Bronze Age Mesopotamia (c. 3000 – 2000 BC), risks, benefits, and losses are seldom distributed evenly or, for that matter, fairly across the population. More often than not, those who control the most wealth or who have a monopoly on political power are able to shift the burden of risk onto disenfranchised groups and onto the poorer segments of society. We still have a relatively weak understanding of the distribution of risk and the complex intertwining of risk and power in Early Bronze Age Mesopotamia, but given the wealth of evidence available, we have a lot to gain by focusing more explicitly on this fundamental problem.

Many different angles could be explored, but I have chosen to focus on gastro-politics (Appadurai 1981) – that is, the politics of food – and on the close connection between risk, inequality, and access to food in Mesopotamia. Drawing on work by E. P. Thompson, James C.

Scott, and others, I use the term "moral economy" to refer to this particular domain of social reality, a domain where discourses and beliefs about duties, rights, and responsibilities intersect with the practical demands of securing and maintaining access to a means of subsistence. During the third millennium BC, the moral economy was in flux. Across Mesopotamia, the rapidly expanding palace and temple institutions had become major economic powers, and they were increasingly successful in establishing control over agricultural production and over the allocation of agricultural products. More and more people found themselves dependent, in one way or another, on these institutions, and many people relied directly on institutional food disbursements to meet their day-to-day subsistence needs. The big question is, how many people.

In this dissertation, I argue that the archaeological evidence for grain storage offers one means of addressing this deceptively simple question. Grain was a fundamental dietary staple in Mesopotamia, and the ability to store up grain as a form of insurance had long been one of the most important "risk buffers" available to the inhabitants of the region. Over the course of the third millennium BC, however, grain emerged as a key strategic resource for the expanding palace and temple institutions, and grain storage facilities became highly effective instruments of institutional control and highly charged symbols of economic strength, political authority, and divine sanction. Unfortunately, discussion of grain storage in Mesopotamia has often been conducted at a relatively high level of abstraction, with little attention paid to the actual, physical remains of storage facilities that have been excavated at numerous sites across the region. At the risk of downplaying a number of recent exceptions, I suggest that the study of grain storage practices in Early Bronze Age Mesopotamia is still only in its infancy. A more thorough investigation of the available archaeological evidence is not only long overdue; it is also essential, if we hope to provide an accurate account of institutional construction and the evolving moral economy in Mesopotamia.

My own goal, in approaching the archaeological evidence, has been to establish a baseline, quantitative appreciation for the magnitude of the extra-household storage economy in third millennium Mesopotamia. To do this, I have examined a series of site-based archaeological case studies from Northern and Southern Mesopotamia (Figure 1.1). The sites in question were chosen because they have produced some of the best evidence in the region for extra-household storage facilities, that is, storage facilities that were not located within the confines of residential structures. In each case, I provide a detailed description of the available evidence, but I focus, in particular, on compiling quantitative information about the storage capacity available at each site. I then perform a series of calculations in order to estimate the number of people and the percentage of the resident population that could have been supported with the stored grain. The archaeological evidence is often fragmentary and ambiguous, and my estimates – in contrast with other similar attempts – are explicitly designed to incorporate a significant degree of uncertainty. The results can, therefore, be frustratingly vague, but I argue that this attempt to face up to the ambiguity of the quantitative data is an important first step toward gauging the scope and structure of the storage economy in Mesopotamia.

Chapter 2 lays the groundwork for my study by providing an introduction to grain, storage, and gastro-politics in Mesopotamia. The basic argument can be summed up briefly. Grain was not just the cornerstone of the Mesopotamian diet; it was also a medium of exchange, a standard of value, a potent symbol, and a contested commodity. The storage of grain was, therefore, not just about creating a buffer against risk; the ability to amass stocks of grain and control access to these stocks was increasingly a mark of economic clout and, at the same time, a political statement. It is typically assumed that, during the third millennium BC, large-scale grain storage was a prerogative reserved primarily for the palace and temple institutions and, indeed, that grain storage lay at the very foundation of institutional power. I argue, however, that this assumption has seldom been backed up with a careful examination of the available evidence. Grain storage is typically discussed at a relatively abstract level, often as a stand-in for the concept of "surplus" and three associated themes: exploitation, integration, and resilience. There have been some important recent efforts to dig down below this abstract level by investigating the archaeological and written evidence for storage in more detail, and my own study builds directly on these. My argument is that the archaeological evidence for grain storage, especially when viewed from a quantitative perspective, can provide a valuable means of gauging the scale and the scope of the institutional (and the extra-institutional) storage economy. Taking the argument one step further, I suggest that this attempt to quantify the storage economy has important implications for a relatively underexplored dimension of life in Mesopotamia, what I am calling the "moral economy."

Chapter 3 introduces the quantitative methods employed in Chapters 4–6. This brief chapter begins with a description of the process by which I have used published material (descriptions, dimensions, plans, sections) to estimate the storage capacity of each excavated storage facility. This is a two-step process. First, I have estimated the volume of each storage facility, and then I have converted this volume into a grain storage capacity (i.e. kg of threshed barley). The chapter then moves on to describe the series of calculations that I have used to translate grain storage capacity into an estimate for the number of people that could have been supported with the stored grain and also an estimate for the percentage of the resident population that could have been supported with the stored grain. Many of these calculations incorporate a significant amount of uncertainty and, consequently, end up producing estimates that cover a broad range of values. The chapter closes with a look at some simple statistical methods that I have used to restrict these ranges and highlight the values that are more likely to be correct.

Chapters 4 and 5 are the backbone of my study. In these chapters – dedicated to Northern Mesopotamia and Southern Mesopotamia, respectively – I present a series of case studies, each based on a site with particularly interesting evidence for extra-household grain storage during the third millennium BC. For each site, I begin with a basic description of the site, the periods represented, and the materials excavated. I then provide a more detailed discussion of each excavated storage facility or, at least, each excavated structure or installation that has been interpreted as a storage facility. As far as possible, I then attempt to quantify this archaeological evidence for grain storage – moving from estimates of storage capacity to estimates for the number of people that could have been supported, the total population of the settlement, and the percentage of the population that could have been supported. In each case, the quantitative material is presented in narrative form and also in a series of tables and graphs. Where available, I also include some additional discussion of other relevant evidence (e.g. survey data and cuneiform documents) from each site.

Chapter 6 examines the quantitative data collected in Chapters 4 and 5 with a wider lens in order to highlight similarities and differences between sites and in order to reflect on the broader implications of the data. The chapter is built around a series of simplified, aggregate-level graphs designed to facilitate comparison between sites. The first set of graphs explores storage capacity (volume and kg of grain), and the second, the relationship between storage capacity and population (number of people supported and percentage of population supported). In each case, I draw attention to some of the most significant patterns and discuss their potential implications. In the final part of the chapter, I then reiterate two key methodological points that have emerged in my study – concerning how we deal with uncertainty and how we account for the risk-buffering function of storage – before closing with a look at the evidence for centralized and decentralized forms of grain storage.

Chapter 7 draws the discussion to a close by reiterating three key points. First, the archaeological evidence for grain storage in Mesopotamia is extremely diverse and cannot be easily mapped onto the idealized image of a highly centralized, centripetally organized storage economy that appears in many general accounts. I suggest some possible reasons for this mismatch. Second, a more comprehensive understanding of the storage economy is crucial, not only as a corrective to existing perceptions but also as part of a much-needed focus on the moral economy in Mesopotamia. I have drawn particular attention to two fundamental questions. How many people were dependent on the institutions? And how were these dependents treated in times of crisis? Third, my attempt to quantify the archaeological evidence for grain storage is only a first step. I end the discussion by suggesting several potential paths forward.

Chapter 2

Grain, storage, and gastro-politics in Mesopotamia

Introduction

In Mesopotamia, grain was king, or, to put it more accurately, grain *made* kings. As we learn in a Sumerian text known as the *Debate between Sheep and Grain*, control over grain could be and often was transformed into control over people.

> Whoever has silver, whoever has jewels, whoever has cattle, whoever has sheep shall take a seat at the gate of whoever has grain, and pass his time there. (ETCSL 5.3.2, 190–191)

The states that emerged in Mesopotamia near the end of the fourth millennium BC were fundamentally agrarian states. They were built on the production, stockpiling, and redistribution of grain, and they invested an enormous amount of energy in managing and monitoring the grain supply.

In Mesopotamia, grain was many things at once: food and drink, medium of exchange and standard of value, contested commodity and heavily loaded cultural symbol. I highlight each of these different roles in turn, before focusing in on one particular phase in the "life cycle" of grain. As it made its way from farm to table, grain had to be placed in storage for at least some period of time. A consideration of how this storage was accomplished, where it was accomplished, and under whose authority gets us to the very heart of the rapidly evolving, increasingly centralized political economy of third millennium Mesopotamia. Unfortunately, discussions of grain storage in Mesopotamia have often taken place at a relatively high level of abstraction, with little explicit reference to the archaeological and written evidence. I spend some time describing this abstract perspective on grain storage – highlighting a few particularly salient themes – and then shift gears to examine a number of recent studies that have attempted to bring storage down off of the abstract plane. In the final part of the chapter, I then introduce two related concepts – gastro-politics and moral economy – as a way of situating and setting up my own efforts to quantify the storage economy in Chapters 4–6.

Grain

During the third millennium BC, a number of different varieties of grain were cultivated in Mesopotamia. Cuneiform documents suggest that barley (Sum. še / Akk. *še'um*, *uṭṭetum*) was the most common variety, followed distantly by emmer wheat (Sum. ziz_2 / Akk. *ziz(z)um*), and another kind of (probably free-threshing) wheat, perhaps durum (Sum. gig / Akk. *kibtum*) (Powell 1984: 49–58, 84; Widell et al. 2013: 85–86). The fundamental importance of barley and wheat is confirmed in the archaeological record. At sites across Northern and Southern Mesopotamia, archaeologists have recovered 2-row (*Hordeum distichum*) and 6-row (*Hordeum vulgare*) barley, emmer wheat (*Triticum dicoccum*), and einkorn wheat (*Triticum monococcum*), as well as some other varieties of wheat, including bread wheat (*Triticum aestivum*) and club wheat (*Triticum compactum*) (Potts 1997: 57–62). There is currently no foolproof means of judging the relative contribution that these grains made to the Mesopotamian diet as a whole. Certainly, a wide variety of food products was collected, cultivated, raised, and consumed in Mesopotamia (see e.g. Bottéro 1985; Reynolds 2007; Paulette 2013: 102–103; Widell et al. 2013), but the evidence suggests that grain was, proportionally, the most important staple food and that it provided a basic dietary foundation for most of the region's inhabitants (Powell 2003: 13).

The Mesopotamian vocabulary – in both Sumerian and Akkadian – included terms for a broad range of intermediate or secondary grain products, that is, grains that had been processed and transformed in a variety of different ways. For example, barley was crushed to produce groats (Sum. níg-àr-ra, ar-za-na / Akk. *mundum*), ground into flour (Sum. dabin / Akk. *qēmum*), malted (Sum. munu / Akk. *buqlum*), and baked into special cakes (e.g. Sum. bappir / Akk. *bappiru*) (Stol 1989; Reynolds 2007: 177; Brunke 2011: 40–43, 49–51). These intermediate grain products were sometimes consumed directly, but they also served as ingredients in the production of a range of other foods and drinks.

Flour, for example, was the primary ingredient needed to make bread. Lexical lists record as many as 300 different types of bread; these types could be distinguished from one another according to ingredients (e.g. flours, spices, fruits, oil, milk, beer, and sweeteners), size (ranging e.g. from tiny to very large), or shape (e.g. a head, a hand, or a female breast) (Bottéro 1985: 38). Bread could be either leavened or unleavened (Bottéro 1985: 39; 2004: 47-50; Reynolds 2007: 176). It was produced on a massive scale by institutional bakeries, but it was also produced by local, neighborhood bakers and by households. The cuneiform record tells us relatively little about baking on the household level, but "tannur"-style ovens, essential for the production of unleavened flatbreads, are ubiquitous in the archaeological record, especially in domestic contexts (e.g. Rova 2013: 148–150).

Soups and porridges also played an important role in the Mesopotamian diet – perhaps even more important than bread (Powell 2003: 13) – and these often included grain in one form or another. For example, a unique collection of recipes dating to the Old Babylonian period includes instructions for the cooking of twenty-five different types of broth and eight dishes focused on birds. A number of these recipes include the addition of either flour, spiced grain cakes, bread/cake crumbs, or beer; at least two describe the cooking of flour-based porridges. Another recipe details the cooking and assembly of a complex dish in which small birds were encased within a pastry (Bottéro 2004: 25-35).

The grains and the grain products that featured in these breads, broths, porridges, and pastries were also key ingredients in Mesopotamia's drink of choice: beer. Although beer appears with great frequency in the cuneiform record, our understanding of both the brewing process and the final product is still far from complete. The two most important ingredients were malted barley and a special type of bread or cake, known in Sumerian as bappir (Civil 1964: 76-78; Brunke 2011: 47–51; for an alternative interpretation of bappir, see e.g. Powell 1994: 96–99). These were often joined by emmer wheat and several other grain-based products, as well as date syrup and a variety of flavorings and aromatics. Most students of Mesopotamian beer – šikarologists, as Marvin Powell has memorably labeled them, after the Akkadian word for beer (*šikaru*; Powell 1994: 118-119) – have assumed that the drink bore at least a passing resemblance to our modern versions of beer, at least in terms of alcohol content. Some, however, envision a much milder drink akin to modern *kvass*, a low-alcohol beverage popular in Russia and Eastern Europe (Damerow 2012: 18; cf. Powell 1994: 91-92, 118). In any case, we can be certain that the flavor profile of Mesopotamian beer diverged significantly from those modern beers that include hops, a flavoring agent that was absent in Mesopotamia.

Beer was ubiquitous in Mesopotamia. It was a luxury drink, consumed by the highest echelons of the social hierarchy at elaborate royal banquets and exclusive ritual events. It was even consumed – to the point of intoxication, loss of inhibitions, and violent confrontation – by the gods themselves (Neumann 1994: 326; Michalowski 1994). At the same time, beer was also the drink of the masses. It was served to workers engaged in construction projects and canal-cleaning efforts; it was occasionally distributed as rations; and it was provided to messengers in a special, storable form (Neumann 1994: 324-331; Heimpel 2009: 105–107). It was also included as a part of the bride price during marriage ceremonies, and it was sometimes provided as payment for services rendered by judges and other officials (Neumann 1994: 326-327). The brewing of beer was a highly developed art, celebrated, for example, in the well known Hymn to Ninkasi (goddess of beer) and in a related drinking song (Civil 1964; Sallaberger 2012). Palaces and temples across Mesopotamia maintained their own breweries, staffed by maltsters, brewers, and a range of other specialists. Beer was also produced and served by independent, neighborhood taverns, and it appears to have been produced by many, perhaps most, private households (Stol 1989: 327; Neumann 1994: 324–325). It is not currently possible to arrive at a precise estimate of per-person consumption patterns, but beer was certainly one of the primary forms in which grain was consumed in third-millennium Mesopotamia.

In the most fundamental sense, then, grain was valued because it could be consumed – in the process providing nutrition, pleasure, and intoxication. Grain could also, however, be exchanged. As a low-value, bulk commodity that was always in demand but was also widely available, grain provided a convenient medium for accomplishing small-scale, local transactions. In fact, by at the least the middle of third millennium BC barley had emerged, alongside silver, as the primary medium of exchange in southern Mesopotamia (Powell 1996: 229). Silver circulated primarily within institutional and commercial circuits; it was employed in large-scale transactions and in the exchange of relatively high-value items, such as real estate, humans, and livestock (Widell 2005: 398). For smaller scale transactions in foodstuffs and other day-to-day necessities, barley was a more practical form of currency. Unfortunately, direct evidence for the operation of this local, barley-based exchange system is relatively meager. It is certain, however, that many people in the cities of Mesopotamia – especially those institutional dependents who were remunerated primarily in barley rations – would have relied on this system to meet many of their daily needs (see e.g. Powell 1990: 88; 1999: 14-15; Steinkeller 2004: 95-96; Widell 2005: 8-11).

Paralleling its role as a physical medium of exchange, grain also functioned as an abstract standard of value. That is, thanks to a codified system of grain equivalencies, specific quantities of foodstuffs, raw materials, and even labor time could be converted into corresponding volumes of barley. This accounting procedure allowed institutional scribes to simplify complex tabulations and calculations involving otherwise incommensurable goods and products. For the institutions, therefore, barley provided not only a simple means of compensating dependent workers but also – thanks to its role in the rationing system – a convenient "money of account" (Powell 1996: 227) that allowed input (e.g. "man-hours" or rations paid) and output (e.g. goods produced or services performed) to be compared across administrative domains (Nissen et al. 1993: 49–51; Snell 1997: 129; Englund 2004: 38).

Given its dietary and economic significance, it is hardly surprising that grain was also a multivalent and multilayered symbol. It was closely associated, for example, with the concept of abundance (Sum. hé-gál / Akk. *ḫegallu*; Winter 2007: 119). Only the gods could guarantee abundance and prosperity in the land, and there was no clearer sign of divine favor than the oft-repeated image of grain thriving in the fields and piled up in the storehouses. On the other hand, the absence of grain was an equally clear sign that the gods had retracted or, perhaps, transferred their favor, a situation that demanded the offering of prayers and sacrifices. As representatives of the gods, kings bore ultimate responsibility for ensuring agricultural abundance, and they did not hesitate to draw attention to their successes. Of course, this meant that they were also to blame when crops failed and storehouses were empty – though they were less enthusiastic about pointing this out.

Irene Winter has drawn particular attention to the visual dimensions of this connection between grain and abundance in third-millennium Mesopotamia. Grain appears again and again as a key motif in what Winter calls the "iconography of abundance" (Winter 2007: 118). This set of recurring images – all pointing to notions of abundance, order, stability, and security – was a powerful rhetorical device that provided visual support for the claims being made by the emerging political and religious institutions. Grain's efficacy as a visual symbol was further augmented and enhanced by a series of metaphorical linkages that appear regularly in the written record. A recurring image of anthropomorphized grain stalks raising their heads to the sky is particularly striking. The Debate between Grain and Sheep, for example, provides a vivid example.

> Grain standing in her furrow was a beautiful girl radiating charm; lifting her head up from the field she was suffused with the bounty of heaven. (Black et al. 1998-2006: t.5.3.2, ll. 49-52)

A number of gods and goddesses in the Mesopotamian pantheon were associated with grain in its various forms. Nissaba, for example, was goddess of the grasses (reeds and cereals), and her husband Haia was god of the [grain?] stores. Their daughter Ninlil was goddess of the grain, particularly seed grain. Ninlil's daughter Ezinu was goddess of the green barley that has just emerged from the seed (Jacobsen 1970: 32; 1976: 99). Dumuzi, god of fertility and new life, was worshipped in a number of different forms; one of these, Dumuzi of the Grain, was linked to the power that resides in grain, malt, and beer (Jacobsen 1970: 87–88; Jacobsen 1976: 99).

There was also Ninkasi, goddess of beer, to whom the famous Hymn to Ninkasi – the most detailed account of brewing in Mesopotamia – was addressed (see Civil 1964).

The mention of beer brings up a final point about the symbolic dimensions of grain. In its two most important processed forms, bread and beer, grain was actually considered a fundamental marker of civilization and, indeed, a civilizing force in itself. This is expressed most clearly in a famous passage from the Epic of Gilgamesh. Shamhat, having decided to introduce the wild man Enkidu to the ways of the civilized world, brings him to a shepherd's camp, where he is offered bread and beer. At first Enkidu refuses, but then, urged on by Shamhat, he eats the bread and drinks the beer. Once he has been groomed and provided with clothing, Enkidu's transformation from wild man to man – from uncivilized to civilized – is complete (see George 1999: 13-14).

I have only been able to scratch the surface here, but hopefully it is clear that grain occupied a complex position in the Mesopotamian world. A diverse array of meanings, messages, functions, and practices was assembled and encoded in this deceptively simple foodstuff. This density of cultural associations and potential effects appears with particular clarity in the realm of gastro-politics, that is, in contexts where social transactions involving food were charged with elements of conflict, competition, and unequal power relations (Appadurai 1981: 495). I am thinking, for example, of contexts of redistribution, debt negotiation, feasting, and politico-religious ritual. In all of these contexts (and more), grain was very much a contested commodity, and it could serve simultaneously as food source, economic instrument, diacritical marker, and political tool. As we will see below, this is why a study of grain – and grain storage in particular – provides such fertile ground for exploring the evolving moral economy in Mesopotamia.

Storage

Most general discussions of the Mesopotamian economy make at least a passing reference to grain storage. In fact, centralized storage facilities are often cited as key factors in the emergence of the first cities and states in Mesopotamia. It is, therefore, strange that the actual evidence for storage technologies and techniques has received so little attention. With some notable exceptions (see below), discussions of grain storage are often brief, short on details, and highly abstract. In his classic discussion of the Urban Revolution, for example, V. Gordon Childe repeatedly draws attention to granaries and their role in the centralized mobilization of agricultural surpluses in Mesopotamia.

> Truly monumental public buildings not only distinguish each known city from any village but also symbolize the concentration of the social surplus. Every Sumerian city was from the first dominated by one or more stately temples…. attached to the temples, were workshops and magazines, and an important appurtenance of each principal temple was a great granary ….
>
> Hence in Sumer the social surplus was first effectively concentrated in the hands of a god and stored in his granary …. (Childe 1950: 12)

Childe, however, provides no details about these granaries and how they actually functioned on a day-to-day basis. His references to grain storage are evocative and serve primarily as rhetorical devices; granaries become symbols, metonymic stand-ins, for the concept of surplus. This symbolic link established between storage and surplus is, in fact, a common one and appears to lie at the root of most abstract discussions of the roles and functions of grain storage in Mesopotamia.

The concept of surplus has had an enormous impact, not only on efforts to explain the development of complex society in Mesopotamia but also on the anthropological theorization of socio-political evolution more broadly (e.g. Earle 1997: 203–211; Johnson and Earle 2000: 26–35; Yoffee 2005: 34–38). The concept has certainly proven powerful as a means of characterizing and comparing the macro-scale structure and dynamics of economic systems, but I am often uncomfortable with the connotations of the term "surplus" as used in particular situations. For example, it is undoubtedly the case that the palace and temple institutions in Mesopotamia were able to support non-producing specialists using grain (and other goods) extracted from primary producers. Describing this repurposed and redistributed grain as surplus, however, suggests that it was somehow extra or beyond the basic needs of the producers; this may very well have been the case, but the simple fact that the grain could be taken and "concentrated" in the hands of the institutions is not sufficient proof. In any case, I will not dwell here on the concept of surplus itself. Instead, I will draw attention to the presumed link between surplus and storage and, especially, to how this link has impacted discussions of grain storage in Mesopotamia. The key point is that the roles and functions assigned to grain storage have often depended heavily on how a particular author understands the broader role of agricultural surpluses within the Mesopotamian economy. I will highlight three themes that are regularly associated with the concept of surplus: exploitation, integration, and resilience. These are the abstract touchstones around which discussions of storage in Mesopotamia have tended to cluster.

For the theme of exploitation, we can return to Gordon Childe. One of the most vivid metaphors that appears in Childe's book *Man Makes Himself* (1951) is his description of the Mesopotamian temple as a great bank presided over by a corporation of greedy priests and an imaginary god.

> Naturally enough this imaginary god has found earthly representatives and interpreters glad to administer and to enlarge his terrestrial possessions in exchange for a modest share of his income. The wizards and magicians, guessed at in the Neolithic village, have emerged as a corporation of priests sanctified with divine authority and emancipated from any mundane labors in field or pasture. These interpret the divine will to the toiling masses …. (Childe 1951: 118)

> [E]ach god has an earthly dwelling, the city temple, a material estate, and human servants, the priestly corporation. The oldest decipherable documents from Mesopotamia are, in fact, the accounts of the temple revenues kept by the priests. They reveal the temple as not only the center of the city's religious life, but also the nucleus of capital accumulation. The temple functions as the great bank; the god is the chief capitalist of the land. (Childe 1951: 124)

According to Childe, surplus agricultural goods were collected from the peasants – who scraped by at the "bare subsistence" level – and concentrated in the hands of a "tiny ruling class." The temple granary was the primary locus and the primary symbol of this concentration of wealth and power. Given the enduring influence that Childe has exerted on later scholarship, it is strange that this theme of exploitation has not featured more prominently in subsequent discussions of surplus and storage in Mesopotamia. There appears to be almost unanimous agreement that economic power in early Mesopotamia was built on the appropriation of agricultural surpluses, and it is common to see centralized storage facilities as the material manifestation of this power. Seldom, however, is the focus placed so firmly on exploitation (but see e.g. Pollock 1999: 1–3, 218–223; Liverani 2006: 24–25, 62–64). Instead, it is Childe's emphasis on the connection between surplus and integration that has proven more enduring.

The theme of integration is pervasive in Mesopotamian studies, and it has appeared in a variety of different guises. The common thread is a focus on functional complementarities, systemic interdependencies, and overarching structure. For example, Childe argues that increasing occupational specialization led to the emergence of "an organic solidarity" linking all urban residents to one another, much like the functional interdependence of the cells in an organism (Childe 1950: 16). In one of his early discussions of urbanization in Mesopotamia, Robert McC. Adams develops a similar vision but broadens the scope significantly. According to Adams, it was not only the urban residents who formed an integrated whole; during the urbanization process, the subsistence system itself came to be divided up into distinct, specialized units of production that were not self-sustaining. The relationships established between these complementary units were mediated by the emerging centralized institutions, which, therefore, played a crucial role in facilitating integration (Adams 1966: 47-48, 51).

This vision of the palace and temple institutions as mechanisms of integration has long occupied a prime place in discussions of early Mesopotamia. Following in the footsteps of Anton Deimel and his (in)famous "temple-state" theory, for example, one school of thought has tended to emphasize the absolute dominance of the institutions and their role in fostering social, political, and economic integration (see e.g. Deimel 1931, Schneider 1920, Falkenstein 1974; for critiques, see e.g. Gelb 1971, Foster 1981). In recent years, this perspective is perhaps best exemplified by the work of Piotr Steinkeller. Drawing on his extensive knowledge of the cuneiform source material, Steinkeller has consistently argued that the city-states of southern Mesopotamia were highly structured and highly unified. Each city-state was divided up into a collection of temple communities or temple estates, and these were all joined together into a nested, pyramid-like organizational structure, under the ultimate jurisdiction of the city ruler. According to Steinkeller, this "temple estate" system was "an integrating organizational scheme that brought together economic resources and social groups distributed among different ecological zones." It was a way of dealing with the diversity of the Mesopotamian environment, by creating a "horizontal" economy, analogous to the well-known "vertical" economy of the pre-Colombian Andes (Steinkeller 1999: 290-293).

The influential economic historian Karl Polanyi also drew particular attention to integration and, in particular, to what he called the three basic "forms of integration": reciprocity, redistribution, and exchange (Polanyi 1957: 250–256). For Polanyi, Mesopotamia was one of the classic examples of an economy dominated by redistribution; this meant that integration was achieved primarily through the collection and distribution of goods from an "allocative center." Polanyi only briefly mentioned the "vast storage systems" of ancient Mesopotamia (Polanyi 1957: 254), but it was his sometime collaborator, the Assyriologist A. Leo Oppenheim, who really drew attention to storage as the defining feature of the Mesopotamian redistributive economy. In fact, Oppenheim sometimes uses the term "storage economy" as a substitute for "redistributive economy." In one particularly memorable formulation, he sets up a distinction between the self-contained, self-supporting storage (i.e. redistributive) economy and a private economy conducted by "groups outside the magic circle of the storage system" (Oppenheim 1977: 89). Oppenheim, however, has little to say about the actual storage facilities that occupied the center of this "magic circle." He presents storage as the nexus around which the whole redistributive system revolves – and a symbol of that system – but he only mentions in passing the technologies and techniques that defined and gave shape to this storage economy.

The third theme that regularly appears in discussions of surplus and storage is resilience. It is generally assumed that in Mesopotamia surplus agricultural goods were stored up as a form of insurance against food shortages and other crises. In other words, storage – and grain storage, in particular – served as a risk buffer, providing households and other small-scale groups with some level of resilience in the face of a harsh and unpredictable environment. From a cross-cultural perspective, there is abundant evidence to support such an assumption (e.g. Halstead and O'Shea 1989; Gallant 1991; Forbes and Foxhall 1995). In discussions of Bronze Age

Mesopotamia, however, it is also commonly asserted that the central institutions were able to provide a much more effective form of resilience. Built on the mobilization and reallocation of surplus goods, they were – so the argument goes – more stable than individual households and were *inherently* better equipped to manage economic risk and uncertainty (e.g. Postgate 1992: 299; Powell 1999: 18–19; Westenholz 2002: 26; Stein 2004: 77).

Gil Stein, for example, argues that the palaces and temples of southern Mesopotamia were able to exploit economies of scale that were simply inconceivable on the household level. The size and wealth of the institutional apparatus allowed for more efficient production and more secure long-term investments in agriculture; as a result, the palaces and temples could adopt strategies designed to maximize agricultural output, while absorbing risks that that would have spelled disaster for individual households (Stein 2004: 77). Likewise, Nicholas Postgate argues that the temples provided society with an "economic buffer"; more specifically, "the scale and diversity of their own resources gave them a resilience which imparted an element of stability to the society as a whole" (Postgate 1992: 299).

In the passages just cited, neither Stein nor Postgate refers directly to storage, but Aage Westenholz, making a similar argument, draws a more explicit connection between institutional resilience and storage capabilities.

> The variation in harvests from year to year meant that individual farmsteads were scarcely viable. The average output might be sufficient, but nobody can eat an average. A series of bad years would force the family to sell themselves into slavery. Only large institutions, with sufficient capacity for storage from the good years, could weather the vicissitudes of the climate. (Westenholz 2002: 26)

This quote raises three important issues that, taken together, suggest that we should be hesitant in assuming a direct correlation between the centralized storage of agricultural surpluses and increased resiliency.

First, storage capacity is not what matters. It was not the capacity to store large amounts of grain that enabled the palace and temple institutions to create economies of scale, giving them an economic edge over smaller economic units. It was their ability to mobilize large amounts of grain via taxes, tribute, and control over the basic means of production (e.g. land and labor). As we will see in Chapters 4–6, storage capacity can serve as a rough proxy measure – a preliminary means of assessing the scale and structure of the storage economy. If we wish to understand the *effects* of institutional management, though, what really matters is how the grain made its way into and out of storage facilities; in other words, what really matters are inputs and outputs. For example, where did the grain come from? Who produced it, and how was it collected? Who had access to the stored grain? Through what channels and under what conditions was it reallocated and distributed to consumers?

Second, we need to pay careful attention to the *human scale*. What does it mean to say that "only large institutions … could weather the vicissitudes of the climate" (Westenholz 2002: 26); and what does it mean to say that the temples "imparted an element of stability to the society as a whole" (Postgate 1992: 299)? Asserting that a particular institution or the "society" itself was resilient tells us very little about how actual people fared during bad times. Even when focusing on high-level transformations in the political economy or developments that transpired gradually over the course of centuries, we should always be working to understand the implications for actual people. For example, who suffered most during crisis years? Who barely scraped by? Who prospered? Does institutional resiliency also entail resiliency for dependent households?

Third, the correlation between institutional scale (or the scale of institutional storage facilities) and resiliency should be considered a hypothesis, rather than a simple fact of economics. From a cross-cultural perspective, it is demonstrably not the case that wealthy institutions and centralized planning always lead to higher levels of resiliency. In fact, as authors such as James C. Scott (1998) and Robert McC. Adams (1978) have pointed out, precisely the opposite is often the case. Highly centralized systems and centrally planned projects have often proven much less flexible and more brittle than more decentralized, locally based efforts. If an argument is to be made connecting institutions and resilience in Mesopotamia, it must be carefully demonstrated, not assumed.

There can be little doubt that grain storage in third-millennium Mesopotamia was closely bound up with the themes of exploitation, integration, and resilience. My argument, however, is that we gain little by continuing to discuss storage on this abstract level – by acting as if there is a direct link between surplus and storage and then using this link to infer the function of storage within the Mesopotamian political economy. Fortunately, there have also been a number of attempts to dig down below this abstract level, drawing out detailed evidence for storage technologies and techniques and, consequently, for the complexity of storage practices in Mesopotamia. In some cases, these studies have been short detours or digressions attached to more broadly conceived projects; in other cases, they have been directed explicitly toward storage and the storage economy.

The archaeological evidence for grain storage in third-millennium Mesopotamia has attracted significant attention over the past few decades. This is largely due to a series of rescue excavations undertaken along the middle stretches of the Khabur River in Syria between 1984 and 1997 (for general overviews, see Hole 1991; 1999; Schwartz 1994b; Fortin 1998b; Pfälzner 2002; Akkermans and Schwartz 2003: 218–223; 1984–1997). These excavations uncovered unexpected evidence for the "large-scale" (see Chapters 4–6 for qualifications) storage of grain at a group of small sites, most dating to the first half of the third millennium BC. For example, the sites of Tell al-Raqa'i and Tell 'Atij have featured prominently. At Tell al-Raqa'i, the settlement was clustered around and dominated by a large, circular building that was uncovered in two successive building levels; in Level 4, this building was divided up into a series of irregularly shaped rooms, many of which appear to have been used for the storage of grain. Evidence for storage was also uncovered outside of the circular building (e.g. the silos in the Northwest Area, Levels 3 and 4) and in earlier levels at the site (e.g. the "grill-like structures" in Levels 5-7) (Schwartz and Curvers 1992; Schwartz 1994b). At Tell Atij, structures interpreted as grain storage facilities were also uncovered in multiple occupation levels. These structures included, for example, "grill-plan" buildings, rectangular silos, and a vaulted storeroom with large storage jars in situ (Fortin 1998b).

Although much of the material excavated along the Middle Khabur is still only available in the form of preliminary reports, many of the storage facilities have actually been examined and discussed in great detail. For example, the different types of storage technology employed have been catalogued and compared with types known from the ethnographic, historical, and archaeological literature (e.g. Hole 1991; 1999; Zaccagnini 1993a; Pfälzner 2002). Measurements of storage capacity have been used to estimate the number of people that could have been fed with the stored grain and also the amount of agricultural land that would have been needed to produce the necessary grain (e.g. Hole 1999; Schwartz 1994b; Pfälzner 2002). Indications of change through time in storage practices have been cited as evidence for shifts in community organization and in the regional political economy (Pfälzner 2002).

Several competing models have been proposed to explain the existence of this conspicuous concentration of "large-scale" storage facilities, located in an area that is normally considered environmentally marginal and peripheral to the main centers of human settlement in the region. Pfälzner, building on an earlier discussion by Hole (1999: 275-278), has sorted these models into three groups (2002: 279–280).

1) the export theory
2) the local use theory I: steppe consumption
3) the local use theory II: village consumption

Proponents of the "export theory" argue that the Middle Khabur settlements served primarily as transshipment points, where grain was collected and processed before being shipped onward to the south. Several different scenarios have been proposed. Michel Fortin and Glenn Schwartz, for example, have speculated that the Middle Khabur storage facilities might have been under the control of an expanding city like Mari or, alternatively, that they might have emerged as "gateway communities" to facilitate interaction between the dry farming zone to the north and the irrigated zone to the south (Fortin and Schwartz 2003: 225).

Not everyone, however, is convinced that the Middle Khabur sites were embedded within a regional-scale system of staple mobilization or redistribution. The main proponents of the "local use theory" have been Frank Hole and Peter Pfälzner. Hole argues that the storage facilities were part of an integrated regional economy that placed special emphasis on the herding of sheep and goats. Drawing on ethnographic evidence and on archaeological survey conducted in the steppe to the west of the Khabur, he suggests that the Middle Khabur settlements served as "tethers from which herding people ranged out seasonally." The storage facilities may, therefore, have served a much larger population than that permanently residing in the small riverside villages (Hole 1999:274-280). Pfälzner, on the other hand, sees no need to envision either surplus extraction by an external power or the existence of a larger, more dispersed pastoralist population. He argues that the Middle Khabur storage facilities were well suited to the needs of the local sedentary population and served as a type of "village-based community storage" (Pfälzner 2002: 266-281).

As we will see in Chapters 4 and 5, this much-discussed cluster of storage facilities is only the tip of the iceberg when it comes to archaeological evidence for grain storage in Mesopotamia (for a recent overview, see Van der Stede 2010). The ongoing debate over the interpretation of the Middle Khabur sites does, however, provide an excellent example of the new perspectives that can emerge through detailed analysis of the material remains. It also highlights the ambiguity inherent in the archaeological evidence. In fact, some of the most fundamental disagreements over how to interpret the Middle Khabur storage facilities revolve not around the physical remains themselves but, rather, around disagreements over how we should understand the broader, regional-scale, sociopolitical context; that is, the context within which the storage facilities functioned. Ultimately, this debate underscores how little we actually know about the storage economy in Mesopotamia and how much work remains to be done.

There have been relatively few detailed and systematic attempts to analyze the written evidence for grain storage in Mesopotamia. Storage facilities appear frequently in the cuneiform record – whether explicitly mentioned by name or, as is more often the case, implied as the context for a recorded transaction – but this evidence has only been explored in a piecemeal and often tangential fashion. The problem, ultimately, is that references to storage are scattered across an enormous corpus of texts, many of which provide only highly condensed information written in a kind of administrative shorthand. At the same time, the number of people capable of dealing directly with the primary data – that is, the cuneiform texts themselves – is relatively small. It can only be hoped that the recent, renewed attention to the archaeological evidence for storage will be matched by a corresponding interest in further elucidating the written material. In any case, it is worth considering briefly what the texts have to say – and might potentially have to say – about grain storage in Mesopotamia.

The first point to emphasize is that the "abstract" perspectives on surplus and storage (see above) – which tend to focus, especially, on centralized redistribution – were not pulled out of thin air. The majority of the cuneiform tablets that have been unearthed and studied are administrative records, and many of these are concerned with the institutional redistribution of grain and grain products. The palace and temple institutions were in control of huge tracts of agricultural land – some would say all of the agricultural land – and managed the exploitation of this land through a variety of different arrangements. Harvested grain was collected and shipped toward urban centers and toward institutional storage facilities; in southern Mesopotamia, this was accomplished primarily by boat, and in northern Mesopotamia, primarily by animal traction (Weiss 1986: 94–95; Breckwoldt 1995/1996: 66–75; Wilkinson 2000: 15, Note 13; Widell 2009). The shipments varied in size but could be enormous; one Late Akkadian text, for example, appears to record the shipment of approximately 40,000 liters or 29 metric tons of barley from Nagar (Tell Brak) southward to Sippar (Sommerfeld et al. 2004; Ristvet et al. 2004). Probably the clearest indicator of institutional redistribution, though, is the regular allocation of grain rations. Large numbers of administrative documents from Mesopotamia record the withdrawal of grain from storage facilities (sometimes explicitly mentioned, sometimes not) and the distribution of this grain to institutional dependents (workers, supervisors, officials, etc.).

What about the storage facilities where these transactions took place? Very seldom do cuneiform documents provide direct information about the form of a particular storage facility, its physical layout, or the technologies employed (e.g. to protect the stored grain from moisture and pests or to control access). The broad range of terms used to refer to storage facilities and storage containers certainly suggests that many different types were recognized (see e.g. Salonen 1968: 275–282; Van Lerberghe 1993; Breckwoldt 1995/1996: 75–78; Steinkeller 2007: 190; Brunke 2008; Heimpel 2009: 166–167), but a comprehensive philological treatment of storage terminology is currently lacking (Renger 1994: 178; Steinkeller 2007: 190, Note 4). In Tables 2.1 and 2.2, I have compiled a brief list of Sumerian and Akkadian terms, respectively, with approximate translations and some selected references. It is important to mention that some graphic representaitons of storage facilities have also been preserved. In particular, a series of cylinder seal impressions from the sites of Susa and Chogha Mish in western Iran, all dating to the later part of the fourth millennium BC, depict what are almost certainly domed granaries; in some cases, workers are shown filling sacks nearby or climbing stairs or ladders to empty the contents of sacks or baskets into the granaries (Figures 2.1 and 2.2; Amiet 1961: Pl. 16, 36–37; 1972: 80, Pl. 16, 80–81; Delougaz and Kantor 1996: 143, Plates 35, 38, 44, 131, 133, 149).

The documents also very seldom provide any direct information about storage capacity. A detailed examination of inputs and outputs – that is, deposits and withdrawals of grain – could potentially offer some indication for the size of particular storage facilities, but I do not know of any systematic efforts to collect this kind of information and derive capacity estimates (but see e.g. Visicato 1993; Pomponio and Visicato 1994: 205; Breckwoldt 1995/1996: 66–78; Steinkeller 2007: 190, Note 4). Occasionally, however, we do get some brief glimpses into the methods that scribes and others in Mesopotamia might have used to estimate and/or calculate storage capacity. For example, in his translation of the "agricultural manual" known as the *Farmer's Instructions*, Miguel Civil argues that the phrase "gidru-šè–ná" ("to lay under the stick") refers to the use of a stick to measure the depth and, therefore, the approximate capacity of a grain pile. He also cites evidence suggesting that this method could be used to divide up shares of the grain claimed by different parties (Civil 1994: 32–33, 96–97).

One particularly unique aspect of the written record – as compared to the archaeological record – is the appearance of specific people, who are often mentioned by name (or title/profession) and who can sometimes be tracked across multiple transactions. The "granary supervisor" (Sum. ka-guru$_7$), for example, was an official closely associated with the operation of storage facilities from at least the Early Dynastic period (e.g. Deimel 1931: 84–85) through the Akkadian (e.g. Foster 1982: 90, 95) and Ur III (e.g. Steinkeller 2004: 68–72) periods. A thorough investigation of this official and his changing role through time would be extremely valuable but, to my knowledge, has not been attempted. With reference to the Ur III period, however, Steinkeller has suggested that the ka-guru$_7$ was a high-level government official and was not, in fact, physically present to monitor deposits and withdrawals on a day-to-day basis. A ka-guru$_7$ named Arad, for example, was "the chief official in charge of grain processing, storage, and distribution at Umma" and may have been the brother of the governor of the province (Steinkeller 2004: 68). Arad appears in numerous documents as the official responsible for distributing grain and grain products from a series of storehouses in the city of Umma and in the surrounding countryside. According to Steinkeller's argument, however, this does not mean that he was physically present at those storehouses; to the contrary, the grain transfers in question were almost certainly conducted by others, although with his stamp of approval (Steinkeller 2004: 68-72).

A number of recently published texts from the town of Garshana (near Umma) also provide some interesting details about Ur III grain storage practices and the people involved. Guards, for example, were stationed daily at a storage facility (ganun), their task described as "sitting in the *ganun* storage" (Heimpel 2009: 328). Some texts from Girsu similarly describe guard duty at a storage facility as "sitting by" the ganun (Mander 1994: 99, cited in Heimpel 2009: 328). Many of the texts from Garshana also document the activities of porters (or workers, more generally) engaged in transporting grain from a variety of locales to a storehouse (ganun) and granary (gur_7) at Garshana, often by loading the grain into sacks and shipping it by boat (Heimpel 2009: 308-316). There are even some texts that record the construction of a ganun storage facility, the refurbishment of an old ganun, and "stuccoing the foundation terrace" of a gur_7 or "granary" (Heimpel 2009: 166–167, 170).

There is much to be gained by collecting further information about the people who worked at storage facilities and within other sectors of the redistributive economy. Perhaps more valuable, though, is the possibility of learning more about the people who were contributing grain to storage facilities and the people who were receiving grain through rations, wages, or other means. These are the people who really felt the effects – whether positive or negative – of redistribution.

The cuneiform record also provides a unique perspective on storage systems, that is, spatially extensive networks of storage facilities designed to funnel grain toward cities and into institutional coffers. The Ba'u temple archive from Girsu, for example, references at least 30 storehouses, approximately half devoted solely to grain and the other half functioning as multi-purpose warehouses (Deimel 1931: 84-85; Schneider 1920: 74). So far, though, the most detailed attempt to reconstruct an institutional storage network has been conducted by Piotr Steinkeller as part of his study of the Umma province during the Ur III period. Steinkeller has identified references to at least 85 hamlets or small villages, many of which appear to have been "highly specialized agricultural outposts," consisting of little more than a threshing floor (kisur$_{12}$), a grain silo (guru$_7$ or ì-dub), and perhaps a few houses. These "minimal settlements" were spread out across the countryside as nodes of institutional administration, where grain was collected and partially processed before being shipped onward to Umma and other towns. Some of these rural settlements, also outfitted with threshing floors and storage facilities, appear to have functioned primarily as roadhouses for travelers. Some were more substantial settlements that included large-scale storehouses (gá-nun), palaces (é-gal), temples, and a variety of other facilities. The "quay (kar) of Umma," for example, was an important harbor settlement near Umma that included a weaving establishment and what must have been a major storehouse, perhaps more like a warehouse complex (Steinkeller 2007: 190-193). Although it falls outside the chronological bounds of my own study, I should also mention Tina Breckwoldt's analysis of grain storage systems in the Larsa region during the Old Babylonian period (Breckwoldt 1995/1996).

Gastro-politics and the moral economy

I am framing my own study of grain storage practices in Mesopotamia as a study in gastro-politics (see e.g. Appadurai 1981 and, for Mesopotamia, Pollock 2003). This means recognizing that grain was not only a staple food but also a precious commodity, an edible substance that was symbolically loaded and that was embedded within a complex matrix of social, political, and economic relations. It also means recognizing that transactions involving grain were often politically charged and were often directly tied up in the reproduction of power asymmetries and economic inequalities. I see no reason, however, that use of the term gastro-politics should necessarily imply only contexts of conflict, competition, domination, and coercion. To the contrary, the politics of food was also – and often at the same time – about sharing, mutual aid, the fostering of community, and the cementing of social bonds.

In Mesopotamia, as elsewhere, storage facilities served as focal points in the realm of gastro-politics. Whether managed by urban institutions, local communities, or family groups, storage facilities gave shape to the urban and the rural landscape by dictating the flow of grain and by defining the spaces where grain could be stockpiled, guarded, measured, monitored, and doled out. Storage facilities of all types and sizes were subject to close scrutiny and careful assessment. They were sites of budgeting, decision-making, and planning for the future, and they played host to a range of transactions, including the settling of debts, the paying of taxes, and the receipt of rations. When filled with grain, storage facilities were potent symbols, physical embodiments of economic security, abundance, divine favor, stability, and freedom from want; for those who were denied access, of course, they might also signify something very different.

As we saw in the preceding section, there is still a lot of uncertainty about the overall structure of the storage economy and about the technological infrastructure that supported it. For example, we do not know what percentage of the population relied primarily on large-scale, institutional grain storage, as opposed to community- or household-level storage. We also do not know how these institutional dependents were treated in times of crisis, and we do not know how their experience differed from that of people who were not directly dependent on institutional storage systems. I suggest that these uncertainties are symptomatic of a more general problem. We need a deeper and more comprehensive understanding of the "moral economy" in third millennium Mesopotamia. That is, we need a better understanding of how this society dealt with three fundamental and tightly interwoven themes: inequality, access to food, and the distribution of risk. I certainly do not wish to claim that these themes have not been explored in the literature, but I do think that a more concerted and more explicit effort to chart the shifting contours of the moral economy in Mesopotamia would be extremely valuable. My effort to quantify the archaeological evidence for grain storage is intended to contribute to this broader goal. To set up my own study, therefore, I will spend some time clarifying and explaining my use of the term moral economy.

The term “moral economy” was introduced to modern scholarship by E. P. Thompson in his study of crowd uprisings in 18th-century England (Thompson 1971). Many people have since borrowed the term, in the process stretching its meaning and its range of applicability well beyond Thompson’s original intent (see e.g. Thompson 1993; Edelman 2005; 2012). I will, however, stick relatively closely to Thompson’s usage of the term and to the elaborations developed by James C. Scott in his study of peasant politics in Southeast Asia (Scott 1976). Both authors place food and, in particular, food shortage at the center of their analyses. Thompson, for example, describes the moral economy as follows:

> It is not only that there is an identifiable bundle of beliefs, usages and forms associated with the marketing of food in time of dearth, which it is convenient to bind together in a common term, but the deep emotions stirred by dearth, the claims which the crowd made upon the authorities in such crises, and the outrage provoked by profiteering in life-threatening emergencies, imparted a particular “moral” charge to protest. All of this, taken together, is what I understand by moral economy. (Thompson 1993: 337-338)

For Thompson, in the particular context of eighteenth-century England, the moral economy was a set of traditional discourses, ideologies, and practices that often came into conflict with the emerging discourse of *laissez-faire* political economy. It was a set of concepts, moral precepts, and legal codes that protesting crowds could draw on in their efforts to maintain access to basic foodstuffs and in their struggles against greedy millers, grain dealers, and grain hoarders (among others). This moral economy discourse drew, in particular, on a longstanding "paternalist" vision of the rights and obligations joining rich and poor, producer and consumer, state and subject – a vision at odds with the political economists who were producing passionate arguments in favor of the unfettered market (Thompson 1971; 1993).

In his book *The Moral Economy of the Peasant* (1976), James C. Scott removed the term moral economy from the specific context of eighteenth-century England and applied it to "peasant" societies in general. Empirically, the focus was twentieth-century Southeast Asia, but the argument was intended to be applicable to a broad range of contexts. For Scott, the moral economy is fundamentally about risk; in particular, the risk of subsistence failure. Most peasant households live on a knife's edge, "subject to the vagaries of weather and the claims of outsiders" (Scott 1976: 5), always in danger of failure and collapse. They typically prefer to avoid risk, rather than seek extra profit and expose themselves to potential ruin. Scott argues that this "safety-first" principle is the key to understanding institutionalized patterns of reciprocity, dependency, and exploitation in many precapitalist agrarian societies. Indeed, it is the key to understanding how peasants themselves understand and evaluate exploitation.

> The fact that subsistence-oriented peasants typically prefer to avoid economic disaster rather than take risks to maximize their average income has enormous implications for the problem of exploitation. On the basis of this principle, it is possible to deduce those systems of tenancy and taxation that are likely to have the most crushing impact on peasant life. The critical problem is not the average surplus extracted by elites and the state, but rather whose income is stabilized at the expense of whom. (Scott 1976: vii)

Farmers living near the edge of subsistence will typically favor a system of tenancy or taxation that is flexible and that guarantees them a minimum level of subsistence, even in a year of abnormally low harvests. For example, a proportional tax, which varies with the cultivator's ability to pay in a given year, is likely to be perceived as less exploitative than a system of fixed annual taxation, regardless of the actual amounts involved. As Scott writes, “The test for the peasant is more likely to be ‘What is left?’ than ‘How much is taken?’” (Scott 1976: 7).

Both Thompson and Scott place particular emphasis on understanding the perspectives of the downtrodden; that is, the logic of the crowd and the peasant, respectively. Their detailed analyses make it clear, however, that the moral economy is not somehow insulated, constructed by the poor and for the poor. It is a more complicated production, a realm of continual negotiation and conflict, an evolving project to which rich and poor, elite and commoner, landlord and tenant, state and subject all contribute. At the same time, their analyses make it clear that the moral economy is not solely about ideas, ideologies, and discourses; it is very much grounded in the most fundamental of material realities: food, hunger, life, and death. I suggest, therefore, a rather broad conception of the term moral economy. For me, the moral economy is a culturally specific set of discourses and practices revolving around three deeply entangled themes: inequality, access to food, and the distribution of risk. It is a discursive field made up of contending beliefs and claims about rights, responsibilities, duties, obligations, and entitlements. It is also a field of practice, rooted at the most basic level in the production, distribution, and consumption of food.

For me, then, the moral economy is not a static set of “traditional” values, and it is not a coherent ideology espoused by the peasantry. Instead, it is a complex amalgam, riven with ambiguities and contradictions, and it is always evolving. An examination of specific moral economies over the *longue durée* will typically reveal both periods of relative stasis – when a precarious balance was struck between the conflicting goals, interests, and actions of the parties involved – and periods of transformation. I would like to draw particular attention to these periods of transformation, when even minor shifts in the balance of power could significantly alter the distribution of risk, disrupting or destroying the social safety nets that had been in place.

In Classical Greece, for example, food shortages were dealt with primarily through a system of *euergetism*; that is, wealthy private benefactors were expected to come forward during a crisis and provide aid to those in need (Garnsey and Morris 1989: 104; Gallant 1991: 182-185). Beyond these private benefactions, there was no "comprehensive framework of institutions or laws designed to protect the average citizen-consumer from hunger and starvation" (Garnsey and Morris 1989: 105). Risk management, therefore, rested largely on a paternalist ethic that required – and celebrated – voluntary philanthropic actions by wealthy community members. Gallant argues that this particular form of moral economy, which relied on a sense of communal responsibility and accountability, underwent a transformation beginning in the fourth century BC. As previously independent city-states were drawn into the Hellenistic empire, local elites were increasingly empowered by ties to central authorities and no longer felt accountable to their communities. Local communities, therefore, "lost the leverage" that had previously ensured elite generosity and protection in times of crisis. Wealthy citizens still provided subsistence support but on much less favorable terms. Deprived of traditional forms of insurance and subject to new taxes, tithes, and tribute, peasant households found themselves increasingly driven into extreme poverty and debt (Gallant 1991: 185-196).

This example illustrates several key points. First, the social sanctions and the norms of reciprocity at the core of a particular moral economy may quickly lose their efficacy when faced with major realignments in the configuration of political power. Second, this disruption in the existing moral economy can produce disastrous results for some portions of the population, while working to the benefit of others. Third, institutions often play a central role in mediating between the desires of the wealthy and the needs and demands of the poor. During food crises, the cities of Classical Greece may have looked to private patrons and philanthropists for aid, but this system relied on the distinctive notions of citizenship and mutual aid that accompanied the emergence of the *polis* as a political form (see e.g. Garnsey and Morris 1989).

Throughout history, institutions have been both key players and key battlegrounds in the ongoing struggle to define the contours of the moral economy. The city of Rome, for example, is a particularly interesting case. During the imperial period, the central authorities employed a wide variety of measures to alleviate food shortages in the city. These measures included the setting of maximum prices for grain, the release of grain from centrally managed storage facilities, and the buying of grain from external sources. As in Greece, private benefactors also played an important role (Jongman 2000: 278-279). When it comes to the moral economy, however, one institutional practice is particularly revealing. Beginning in the late first century BC, the majority of the free adult male citizens in the city (200,000, approximately one fifth of the total population) were entitled to a monthly grain ration that provided enough grain to feed two people at basic subsistence level. This massive system of regularized institutional support was financed primarily through taxes levied on the provinces (Jongman 2000: 272-273). It, therefore, provides a glimpse into a distinctive moral economy, one incorporating a strong sense of citizenship and entitlement but also built on high levels of socio-economic stratification and supported by a political economy of military domination and extraction.

The power asymmetries, the social disruptions, and the economic restructurings that followed in the wake of Roman imperial expansion, however, pale in comparison to the shocks produced by European colonial expansion, by the spread of capitalism, and by the emergence of a global economy during the second half of the second millennium AD. Some of the most illuminating studies of the moral economy have explored this dynamic period, when the fault lines separating conflicting visions of the moral economy were often thrown into stark relief. In his studies of food riots in 18th-century England, for example, E. P. Thompson (1971, 1993) brings together evidence for a drawn-out battle – in words and deeds – between proponents of a paternalist model ("traditionalists") and proponents of a *laissez faire* model ("political economists"); that is, between those who believed that institutional intervention in the food supply was often necessary and those who believed that only a free market would arrive at the most effective and efficient solution in times of dearth. It was in the context of this debate that crowd actions – aiming, for example, to set fair prices, to bring hoarders to justice, or to prevent exports – took on a special relevance and efficacy.

Popular uprisings also feature prominently in James C. Scott's (1976) study of the moral economy in colonial-period Southeast Asia (first half of the 20th century). Scott traces a series of peasant rebellions back to their roots in the moral economy. As the region was drawn into the global capitalist economy and as it was incorporated by colonial powers, the "subsistence ethic" that had provided a conceptual framework for the moral economy (see above) lost much of its force. Peasants could no longer count on wealthy patrons and on the state apparatus to provide them with security in times of crisis, and they responded in a variety of ways, one of which was open rebellion. Scott's analysis provides a wealth of useful details about the shifting conditions of dependency over a relatively short period of time in Southeast Asia, but I would emphasize one recurring point. In the context of rapid political and economic transformation, the existing moral economy was thrown into crisis; its conceptual and practical supports were removed – sometimes gradually and sometimes quite suddenly – leading to significant suffering for the poorer segments of society and leading, in some cases, to open conflict between social classes (Scott 1976).

I have spent some time outlining these general perspectives on the moral economy because they provide a crucial backdrop for my study of grain storage in Mesopotamia. As in many of the examples discussed above, the third millennium BC was a time of rapid social, political, and economic change in Mesopotamia. The palace and temple institutions were expanding and were acquiring both dependents and land. They were transforming the agricultural economy and the agricultural landscape, and they were funneling agricultural products toward their own coffers by means of complex redistributive systems. More and more households found themselves dependent on rations, institutional land grants, sharecropping arrangements, and the support of wealthy patrons. Loans and advances were increasingly needed, and debt was endemic. Military conflict and conquest led to several episodes of regional-scale political centralization and economic reorganization. These political dislocations, institutional transformations, and economic restructurings gave rise to new systems of food allocation and new ideologies of authority, entitlement, and obligation.

In other words, the moral economy was in flux. I suggest that we have a lot to gain by focusing more explicitly on this changing moral economy; that is, on the complex and shifting relationships linking risk, inequality, and access to food in third-millennium Mesopotamia. In particular, we need a better understanding of the distribution of risk, the effects of institutional management, and the impacts of economic dependency over the short and the long term. These are all big questions that can and should be tackled from a variety of different angles, using multiple lines of evidence. I have chosen, however, to focus on a very specific data set: the archaeological evidence for grain storage practices. During the third millennium BC, grain storage sat right at the intersection between household and state, reciprocity and redistribution, cooperation and exploitation, domestic economy and political economy in Mesopotamia. This set of technologies and techniques can, therefore, provide unique insight into the shifting contours of the moral economy in third-millennium Mesopotamia.

Discussion and conclusions

In this chapter, I have argued that grain was a precious commodity in third millennium Mesopotamia. It may not have been rare or particularly valuable, but it was the cornerstone of the diet and a key indicator of economic success and security. A deceptively simple "staple" food, grain was inflected with a complex array of meanings and messages, and it was deeply embedded in the realm of gastro-politics. The ability to stockpile grain and dole it out to dependents was a key form of economic power and was, indeed, the driving force behind institutional expansion in Mesopotamia. The increasingly powerful palace and temple institutions were built on complex systems of staple redistribution that revolved, in particular, around management of the grain supply. Grain storage facilities played an important and widely acknowledged role in these systems of institutionally managed redistribution, but the actual evidence for such facilities – and for other storage facilities managed at the household or communal level – has not received enough attention.

I have argued that a more detailed examination of the archaeological evidence for grain storage in third millennium Mesopotamia can provide a crucial new perspective on the intersection of risk, power, and inequality in this society, that is, on the rapidly evolving moral economy. This is not because changes in storage practices can be assumed to reflect changes in a deeper, underlying moral economy. In Mesopotamia, grain storage was an integral part of the technological infrastructure that supported and gave shape to the moral economy, and any effort to establish or maintain control over (or access to) grain supplies was inevitably an active contribution to the fashioning of the moral economy. It should be clear by now that I think we are still in the early stages of understanding the complexities of both the moral economy and the storage economy in Mesopotamia. In the chapters that follow, I begin sketching in the broad outlines of this storage economy by examining some of the best archaeological evidence currently available from both Northern and Southern Mesopotamia. My approach is explicitly quantitative and is designed to explore the connection between grain storage, institutional dependency, and the broader moral economy. Chapter 3 provides an introduction to this quantitative project and the basic methods employed.

Chapter 3

Methods

Introduction

In deciding to focus on quantifying the storage economy, I have deliberately chosen to set aside a number of other equally important factors in order to highlight storage capacity. I did not set out with the intention of restricting my study in this way, but it has gradually become clear to me that the archaeological assessment of storage capabilities in Mesopotamia is a crucial first step that has not been adequately accomplished in the existing literature. As we saw in Chapter 2, my own interest in assessing the quantitative dimension of the storage economy is related to my broader interest in gastro-politics and in clarifying the nature of the moral economy in Mesopotamia. I have tried, in particular, to translate storage capacity estimates into a more accurate assessment of the scope and the effects of institutional dependency. This is a complicated topic and one that cannot possibly be addressed solely with recourse to the messy and often ambiguous archaeological evidence for grain storage. I argue, however, that the archaeological evidence can make an important contribution.

My basic approach can be summed up as follows. I have chosen a series of sites in Northern and Southern Mesopotamia to serve as case studies. My reasons for choosing these particular sites are simple: these sites have produced some of the best archaeological evidence for grain storage in third millennium Mesopotamia. I have certainly left out plenty of other examples that could have served equally well, but I think that the sites examined here provide a reasonable overview of the available evidence. It is important to point out that I have focused exclusively on extra-household storage facilities; that is, I have not examined the evidence for bins, pits, silos, storerooms, and other storage facilities located within the walls of structures that can clearly be interpreted as houses. This is a significant omission, and I would be eager to see a detailed, quantitative study of household-level storage that can be brought into dialogue with the data that I have assembled here.

In Chapters 4 and 5, I provide a detailed description of each archaeological case study, focusing especially on the evidence for grain storage at each site. After describing the excavated remains, I draw on published accounts and on my own measurements (e.g. using published plans) to estimate the maximum storage capacity – in cubic meters and in kilograms of barley – available within each excavated storage unit and within all of the excavated storage units dating to the same time period at a particular site. I then estimate the number of people that could have been fed with the stored grain, and I compare this estimate with site-level population estimates to calculate the percentage of the population that could have been fed with the stored grain. For each case study, I then reflect briefly on the possible implications of these calculations. In Chapter 6, I compare the case studies to one another and use this comparison to draw some broader conclusions about the moral economy and, in particular, about the scope of institutional dependency in Mesopotamia.

One key point needs to be emphasized. In all of my estimates and calculations, I have tried to allow for and incorporate the full range of uncertainty involved. This means allowing for uncertainty about storage volume (e.g. based on different interpretations of the excavated remains) and also about the conversion factors used to translate this storage volume into estimates for the number of people fed and the percentage of the population fed. Among archaeologists, the usual response to such uncertainty is to employ specific values (e.g. averages or best estimates), acknowledging that the resulting calculations are only approximations. While I understand the rationale behind this approach, I am uncomfortable with this papering-over of uncertainty, and I suggest that we can make much stronger arguments by explicitly incorporating uncertainty in our calculations. In my own calculations, I employ ranges of possibility, rather than average values or best estimates. This approach leads inevitably to a significant – and sometimes frustratingly enormous – degree of uncertainty in the results of my calculations, but I have been able to restrict these ranges using some basic statistical methods.

Storage capacity

The starting point for all of my calculations is storage capacity, that is, the maximum amount of grain that could have been stored within any particular storage space. The process of estimating storage capacity can be broken down into two distinct steps: measuring storage volume (m^3) and converting this volume into grain by weight (kg). I will discuss these two steps in turn.

Storage volume

In most of the cases that I have examined, the measurement of storage volume is a matter of measuring (or estimating) the interior volume of a three-dimensional space (e.g. a room, a silo, or a bin). In some cases, I have relied directly on figures provided by excavators in published accounts, but in general I have produced my own measurements (e.g. for area and height/depth) and volume estimates using published plans and/or sections.[1] To measure the interior floor space or area of each storage unit, I have employed a computer application developed by J. P. Thalmann (Area_Utility, Version 1.02, 29/07/2007) as a part of the ARCANE project (Figure 3.1). This application allows the user to upload an image (e.g. a plan provided with scale) and then trace the boundaries of any particular zone (e.g. the interior of a room) on the image. The application then calculates the area of the designated zone. This indispensable tool has allowed me to provide more accurate area measurements than would be possible using simple length and width measurements, as typically reported in primary publications (e.g. room A measures approximately 1 × 2 meters).

Measuring the height or depth of a storage space has generally been more difficult. In some cases, I have used the ARCANE tool to measure the height/depth of storage spaces that appear on published sections. In other cases, I have relied on figures provided by excavators (e.g. for the height or depth of a well-preserved silo). In most cases, however, storage spaces are not preserved to their full, original height or depth, and I have had to rely on very rough estimates (either my own or those suggested by others). This uncertainty about height/depth can have a significant impact on the resulting volume calculations, but I see no clear means of dealing with the problem. As a general rule, where no other information was available, I have relied on a height estimate of 2–3 meters for most storage spaces, whether they were used for bulk storage or for storage in containers.

This leads into a final point about estimating storage volume. It is often unclear whether a particular storage space was used for bulk storage (i.e. filled up completely with grain) or for

[1] For details about volume measurements for any particular storage space, see the notes provided with the storage capacity tables in Chapters 4 and 5.

container storage (i.e. with grain kept in sacks, ceramic vessels, etc.). Although hardly adequate, I have generally relied on a simple rule-of-thumb. If there is no clear evidence for a doorway or another point of entry, I have assumed that a storage space would have been used for bulk storage and would probably have been accessed from above. In these cases, I have employed the total volume estimate for my calculations. If, on the other hand, there is evidence for a doorway or another point of entry, I have assumed that a storage space would have been used for container storage. In these cases, I have generally reduced the total volume estimate by 25% in order to account for the fact that some of this potential storage volume would have been occupied, not by grain, but by walkways, ventilation spaces, and the containers themselves.

Grain by weight

To convert storage volume into a grain storage capacity (i.e. grain by weight), I have assumed that the grain being stored was threshed barley. In actuality, we often cannot even say for certain that a particular storage space was being used to store grain at all, let alone threshed barley in particular. As we saw in Chapter 2, however, barley was by far the most common cereal cultivated in Mesopotamia, and barley is best stored post-threshing. To me, therefore, this is at least a reasonable assumption, and it has the benefit of facilitating comparison between storage facilities and between sites. The uncertainty about whether a particular storage facility was being used to store grain or, instead, some other commodity is more difficult to deal with. Many different types of commodities were kept in storage facilities in Mesopotamia, and we know that many storage facilities, on both the household and the institutional level, were mixed-use facilities, used to store a variety of different products at one time. In the archaeological cases that I have examined, however, it is often impossible to determine exactly which products were being stored. I can only reiterate that my estimates – whether for storage capacity, people fed, or percentage of population fed – are all intended to be maximum estimates; that is, they are all premised on the, admittedly, unrealistic assumption that the storage facilities in question were being used solely to store grain. In many cases, therefore, my estimates may be too high by a significant margin.

Unfortunately, there is significant disagreement in the literature about the conversion factors that should be used to translate storage volume (e.g. cubic meters) into stored grain (e.g. kilograms of threshed barley). I see no clear means of deciding among the various options and have, therefore, employed a wide range of conversions factors. My minimum (1 m^3 = 444.4 kg barley) and maximum (1 m^3 = 934.6 kg barley) values for converting storage volume to threshed barley are drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see, for example, Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), and Gallant (1991: 96-97). As a glance at the storage capacity tables in Chapters 4 and 5 will demonstrate, the wide range of conversion factors that I have employed has a significant impact on the resulting capacity estimates and, indeed, on all subsequent calculations. The importance of this factor should, therefore, be kept in mind.

Storage capacity and population

Building on the storage capacity estimates, I have produced two further sets of calculations, both designed to establish a connection between storage capacity and people. The first set of calculations explores several different methods for estimating the number of people that could have been fed using the stored grain. The second set of calculations compares these number-of-people-fed figures to site-level population estimates in order to estimate the percentage of the population that could have been fed using the stored grain.

Number of people fed

I have used two different methods to estimate the number of people fed. The first is based on average daily caloric needs and the second, on average daily rations. I will discuss these two methods in turn, before outlining some additional factors that have also been taken into account.

The first method requires three calculations: 1) a conversion of grain (kg) into (kilo)calories, 2) a conversion of calories into person-days, and 3) a conversion of person-days into number-of-people-fed. For the first calculation, I have assumed that one kilogram of threshed barley equals 3400–3600 calories (see Schwartz 1994b: Table 2). For the second calculation, I have assumed that one person needs to eat a total of 2000–3000 calories per day (see e.g. Gallant 1991: 63-68; Schwartz 1994b: Table 2). In translating total calories (from the stored grain) into person-days (total number of days for which one person could be supported using the stored grain), however, I have allowed for two different options. The first assumes a diet of 100% grain (i.e. 2000–3000 kcal/day from grain), and the second assumes a diet of 50–75% grain (i.e. 1000–2250 kcal/day from grain). A 100%-grain diet is certainty an unrealistic assumption. Grain was the cornerstone of the diet in Mesopotamia, but many other foods – meat, fish, dairy products, fruits, and vegetables, for example – were also regularly consumed. There is currently no secure means of gauging the relative proportion of these different dietary components (see e.g. Ellison 1981; Reynolds 2007). The advantage of assuming a 100%-grain diet, for purposes of calculation, is that it allows for the possibility that people were receiving more grain than they actually needed to consume and were then trading it for other food items; this appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). In terms of acutal consumption, a diet composed of 50–75% grain is probably a more realistic assumption for the majority of the population. For the third calculation, I have assumed that the stored grain was intended to provide enough food for either one year (365 days) or two years (730 days). To convert person-days into a number-of-people-fed estimate, therefore, I have divided total person-days by either 365 or 730. The distinction between one year and two years is a significant one that I discuss in more detail below.

The second method also requires three calculations: 1) a simple volume conversion, 2) a conversion of storage volume into person-days, and 3) a conversion of person-days into number-of-people-fed. For the first calculation, I have divided my existing volume measurements by 1000 in order to convert them from cubic meters into liters (1 m^3 = 1000 liters). For the second calculation, I have assumed that one person would have received a ration of 1–2 liters of barley per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42). To convert storage volume (liters of threshed barley) into person-days (total number of days for which one person could be supported using the stored grain), I have, therefore, divided the total volume by 1–2 liters. For the third calculation, I have assumed that the stored grain was intended to provide enough food for either one year (365 days) or two years (730 days). To convert person-days into a number-of-people-fed estimate, therefore, I have divided total person-days by either 365 or 730.

For all of my number-of-people-fed estimates, I have also included a separate set of figures that account, in a very approximate manner, for seed and/or spoilage. That is, I have attempted to account for the fact that some percentage of the stored grain will typically need to be saved for seeding the next year's crop and also for the fact that some percentage of the grain will typically be lost to spoilage, pilfering by rodents, etc. (see e.g. Gallant 1991: 97; Schwartz 1994b: Table 2; Forbes and Foxhall 1995: 74). To calculate these figures, I have simply reduced the total storage capacity (whether expressed in m^3 or kg of barley) by 15–25% before proceeding with the rest of the calculations.

To my mind, the distinction between assuming one year's worth of storage and assuming two year's worth of storage (see above) is a fundamental issue that is often overlooked. Among Mesopotamian archaeologists, at least, the tendency has been to convert storage capacity into "number of people fed" estimates by assuming that the stored grain would have been intended to provide food for a single year; that is, by assuming that the storage facilities in question were filled up to the brim and then completely emptied each year. This certainly might have been the case for any particular storage facility (e.g. a single silo), but, when considering the role of storage on a broader scale (e.g. for an entire settlement), it is much more reasonable to assume that some quantity of grain was being kept in storage as a buffer against future crisis. For all of my calculations, I provide two different estimates: one ("1 year") assuming that the grain was intended to be completely consumed over the course of the following year and one ("2 years") assuming that half of the grain was intended for consumption during the following year and half (i.e. another year's worth) was being saved as a risk buffer. In all cases, the 1-year estimate for number-of-people-fed is twice the size of the 2-year estimate; that is a significant difference, especially for some of the larger storage facilities.

Percentage of population fed

In order to estimate the percentage of a settlement's population that could have been fed with the stored grain, I have simply divided the total estimated population by my number-of-people-fed estimates. The resulting percentages are interesting, but they should be considered very tentative for at least two reasons. First, population estimates are notoriously problematic and are usually intended only as very rough approximations (see e.g. Postgate 1994). Where available, I have included population estimates published by others, but in every case I have also included my own estimate, based solely on site size (in hectares) and a population density of 100–200 persons per hectare.[2] Second, it is important to remember that most sites have only been partially excavated. Only in very rare cases is it possible to suggest that the full complement of storage facilities in use at a settlement during a particular time period has been uncovered. My estimates for percentage-of-population-fed are based solely on the specific storage facilities that I have discussed; no attempt has been made to extrapolate from these excavated examples to estimate the total storage capacity available at the site during a particular time period. In the case of some of the smaller sites, it is possible that the excavated sample is large enough that the excavated storage capacity approximates the total storage capacity originally available within the settlement, but this is almost certainly not the case with the larger sites, most of which have only been very partially explored.

[2] For details about the population estimates used for each site, see the site-by-site discussion in Chapters 4 and 5.

Statistical methods

One of the most frustrating things about my effort to take uncertainty seriously and incorporate it within my calculations is the breadth of the results. Uncertainty about storage volume is compounded by uncertainty about converting volume to grain, and this is further compounded by uncertainty about converting grain to calories and calories to the number of people fed. And so on. The resulting estimates, when expressed as a range of possibility, can be extremely broad. I do think that it is important to recognize the full range of possible estimates that are implied by any given set of assumptions, and I have shown these ranges in the tables and graphs provided in Chapters 4–6. It is also important to recognize, however, that the relative likelihood of both the lowest and the highest ends of these ranges occurring – out of the full universe of possible combinations of figures used in the calculations – is extremely low. The middle range values are much more likely to occur and, therefore, offer a more solid basis for interpretation. To highlight these middle range values, I have employed some simple statistical techniques.

These techniques can be broken down into two basic steps. First, I have used Microsoft Excel to run a series of Monte Carlo simulations that model the distribution of the results produced for each calculation. Second, I have excluded the extreme values within each simulated distribution to achieve a "95% confidence" estimate. I will discuss these two steps in turn.

A Monte Carlo simulation offers a simple means of exploring the range of different results that could be produced, given the degree of uncertainty incorporated within a series of interacting variables. As outlined above, I have produced calculations (e.g. estimating the number of people fed) that involve a number of different interacting variables, each of which incorporates a certain degree of uncertainty. These variables include:

Storage volume: range varies by site
Storage volume to threshed barley conversion: 1 m^3 = 444.4–934.6 kg
Threshed barley to calories conversion: 1 kg = 3,400–3,600 kcal
Calories consumed per person per day: 2,000–3,000 kcal
Percentage of calories from grain: 50%–100%
Grain losses to seed and/or spoilage: 0%–25%
Settlement population: range varies by site[3]

My Monte Carlo simulations use a random number generator to simulate the interaction of these variables in different combinations over multiple hypothetical simulation runs, thereby defining a distribution of probable results. For each simulation run, each variable (among those listed above) is assigned a value within the specified range using a random number generator. The following calculations are then performed using these randomly assigned values:

Number of people fed for 1 year
Number of people fed for 2 years
Percentage of population fed for 1 year
Percentage of population fed for 2 years

The simulation is run 200 times to produce an Excel table with 200 results – i.e. a distribution of possible results – for each separate calculation.

The second step is to exclude the more extreme results at the upper and lower ends of each distribution, that is, to exclude the very high and very low values produced through relatively unlikely combinations of the randomly generated variables. To do this, I have placed each set of 200 results in numerical order, and I have excluded the highest 2.5% and the lowest

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[3] It is important to point out that I have not included a variable for daily rations (i.e. 1–2 liters of grain per person per day). This means that the "simplified" estimates employed for summary purposes in Chapters 4–6 are based solely on the number of calories that a person needs per day (rather than the average daily ration).

2.5% of the values in order to define a "95% confidence" range. More specifically, I have defined the upper and the lower limits of my "95% confidence" range by taking the average of the fifth and sixth highest values and the average of the fifth and sixth lowest values. The result is a much tighter range of possibility than would be produced by calculating the highest and lowest possible values produced by my set of interacting and uncertain variables. In my opinion, this "95% confidence" range offers the best of two worlds; it incorporates the full range of uncertainty for each variable, but it excludes the extreme results produced through (relatively) unlikely combinations of these variables. For purposes of graphic display in Chapters 4–6, I have included the "95% confidence" range, the full range, and also the median value (a good indicator of the overall tendency of the distribution) using a "box-and-whiskers" diagram. The box (i.e. the two bars above and below the median, shown with a horizontal line) defines the 95% confidence range, while the whiskers (i.e. the lines extending upward and downward from the box) define the full range of possibility.

CHAPTER 4

NORTHERN MESOPOTAMIA

Tell ‘Atij

Tell ‘Atij is located in northeastern Syria on the east bank of the Khabur River, approximately two kilometers downstream from Tell al-Raqa’i. The site consists of two mounds, a main tell (10 m high, 150 x 40 m at the base, 6-8 x 40 m at the summit) and a secondary tell (2 m high, 200 x 40 m at the base), separated from one another by a 30 meter wide channel (Fortin and Schwartz 2003: 222). Five excavation seasons were conducted at Tell ‘Atij between 1986 and 1993 by a Canadian team (Université Laval) as a part of the broader Middle Khabur salvage project (e.g. Fortin 1989; 1998b; 2003). On the main tell, the excavators uncovered a sequence of thirteen stratigraphic levels, the earliest founded on virgin soil near the beginning of the Ninevite 5 period and the latest dating to the late Ninevite 5 period (Fortin 1990b: 537-554; 1994: 362-376; 1995: 24-36; Fortin and Cooper 1994: 34-45). On the secondary tell, the excavators uncovered graves dating to the Ninevite 5 and Roman periods, as well as domestic structures dating to the Roman or post-Roman period (Fortin 1988: 165-169; 1990a: 243-247; 1990b: 555-560; 1994: 378-381). The site has featured prominently in recent debates over the evidence for grain storage in third millennium Northern Mesopotamia, thanks to the recovery of a series of structures that have been interpreted as large-scale, purpose-built storage facilities. Building on this evidence, the excavators have argued that the site, which was located on an island in the middle of the Khabur river (Fortin 1998a: 231; for doubts about this argument, see Hole 1999: 276-277), functioned as a kind of commercial station or depot, where agricultural goods were collected before being shipped farther southward (e.g. Fortin 1990b: 563-566; 1997: 54-56, 1998b: 17-20).

Storage facilities – or, rather, structures that have been interpreted as storage facilities, though sometimes without clinching evidence – were uncovered on the main tell in three different excavation areas: the northern edge of the summit, the middle of the southern slope, and the center of the summit. Unfortunately, the published reports do not provide detailed information about the stratigraphic connections linking these three areas, if such connections existed. The main stratigraphic sequence (Levels I to XIII) was uncovered in a deep exposure at the center of the summit (Fortin 1990b: 537-554; 1994: 362-376; 1995: 24-36), but the remains uncovered in the other two areas have not been explicitly tied into this sequence, except in the case of a few isolated rooms (Fortin 1994: 368). At the moment, therefore, it is not possible to discuss the evidence for storage in a comprehensive, site-wide, level-by-level fashion. Instead, each of the three excavation areas will be discussed separately.

Near the northern edge of the summit of the main tell (excavation units D6-9, E6-9), the excavators uncovered three groups of rooms that appear to have been dedicated largely to storage (Figure 4.1). The northwestern group (E6-7), also known as the "Northern Granary," included four small mudbrick silos (502, 503, 504, 505), each of which was vaulted for approximately two thirds of its width (Figure 4.2). The excavators suggest that the unvaulted portion of each silo (i.e. the southwestern third of the silo) would have originally been closed off with some kind of removable covering and that the silos could have been accessed from the roof by removing this covering. To the southeast of these silos was a massive mudbrick platform (D8A15) that might have provided rooftop access to the silos (Fortin 1988: 155-159; 1990a: 222). To the west of the platform (D8, E7-9), excavation revealed a group of rooms that had undergone several renovations (Figure 4.3). During the earliest phase, the entire area was occupied by a large, plastered room (548) that may have been used for storage. This room, which provided access to a vaulted tunnel running into the side of the platform, was subsequently subdivided to create three smaller, vaulted rooms, two of which (507, 533) may also have been used for storage. These two rooms were later filled in with bricks in order to increase the surface area of platform D8A15 (Fortin 1988: 159-162; 1990a: 222-225). Since rooms 548, 507, and 533 were all accessed through doorways, I have assumed that, if they were indeed used for grain storage, the grain would not have been stored in bulk but, rather, in containers (e.g. sacks). To the south of the platform (D9), another group of silos was uncovered (Figures 4.4 and 4.5). For purposes of calculation (see below), I have treated three of these (523, 524, 525) as a single silo, divided into three compartments by two arched partition walls (318, 319). This silo and another silo (522) immediately to the west would have been accessed from the roof, while an adjacent room (526) would have been accessed through a doorway and probably would not, therefore, have been used for bulk storage (Fortin 1990a: 226-231). For further details about the storage spaces uncovered in this area near the northern edge of the main tell, see Table 4.1.

Midway down the southern slope of the main tell (excavation units D16-19, E16-19, F16-19, G16-19), a broad horizontal exposure revealed the remains of an assortment of structures, many of them poorly preserved, subject to numerous reconstructions, and apparently built on very different levels (Figure 4.6; Fortin 1988: 162-165; 1990a: 232-236). The excavators sometimes refer to these structures as the “Southern Granary” or “Southern Warehouses,” but – given the differences in elevation and the fact that many of the rooms are not described in detail in the published reports – it is unclear to me whether or not the structures should all be considered part of the same stratigraphic level. In any case, if I understand the reports correctly, the two rooms of interest here can be linked to Level VI in the sequence uncovered at the center of the main tell (see notes for Table 4.2; Fortin 1994: 368). Room 517-517’ (in a later publication, labeled 538-536) was a large rectangular room with plastered walls, internal buttresses along one wall (307), and the possible remains of a stairway in the southern corner. Although the excavators refer to this structure as a “silo,” which suggests bulk storage, three large storage jars were found arranged in a row along the northeastern wall (409). It seems more likely, therefore, that the structure functioned at least partly as a storeroom within which goods were kept in containers (cf. Van der Stede 2010: 325). The crosswall (408) separating 517 (a.k.a. 538) from 517’ (a.k.a. 536) appears to have been added later (Fortin 1988: 162-165). A vaulted corridor (515) led from storeroom 517-517’ (a.k.a. 538-536) into room 516 to the northwest. This room, which was equipped with a mudbrick floor and arched buttresses along one wall (306), may also have functioned as a storeroom (Fortin 1988: 163-165; Fortin 1990a: 232-234). For further details about the storerooms uncovered in this area midway down the southern slope of the main tell, see Table 4.2.

Near the center of the summit of the main mound (excavation units D13-16, E13-15, F13-15, G13-15), a sounding (c. 8 m deep) was excavated down to virgin soil. Within this deep and relatively broad (c. 15 x 15 m, on average) exposure, the excavators identified thirteen distinct occupation levels, the earliest labeled Level XIII and the latest Level I (Fortin 1988: 146-152; 1990a: 238-241; 1990b: 537-553; 1994: 362-376; 1995: 24-38; Fortin and Cooper 1994: 34-45). Many of these levels (Levels XII, IX, VI, V, IV, III, and IIa/b; see Figures 4.7–4.15) included one or more structures that might have been used for storage, but in many cases the evidence for a storage function is somewhat ambiguous. For example, the excavators interpret vaulted ceilings, buttresses, plastered floors/walls, and plastered ledges around the edges of rooms as indications of storage (e.g. Fortin 1990b: 538-541). While each of these features can certainly play a role in storage, I am not completely convinced that their presence, whether alone or in tandem, is sufficient to assign a storage function to a room. I remain skeptical, therefore, about the function of the following rooms: 571 (Level IX); 555b, 558b, 559a, and 561b (Level VI); 555, 558, 559b, and 561a (Level V); 555, 556, and 557 (Level IV); 553 (Level III); 539b and 552 (Level IIb); 539a and 552 (Level IIa) (for an alternative perspective on some of these rooms, see Pfälzner 2001: 310-312; 2002: 271). In my calculations of storage capacity (see below), I have included these rooms, despite my reservations, as a way of estimating the maximum available storage capacity. Because the excavators have generally refrained from speculating about exactly how the goods would have been stored in these rooms, I have assumed that grain would have been stored in bulk within doorless rooms and in bags or other containers within rooms that were accessed via doorways. Within the deep sounding, there were also three structures whose storage function seems more certain. These included two silos (573 and 599) with "grill-plan" foundations in Level XII (Figure 4.7; Fortin 1994: 375-376; 1995: 31-34) and a well-preserved silo (600) with plastered walls, vaulted ceiling, and *in situ* carbonized barley grains in Level IV (Figure 4.15; Fortin 1995: 37-38). For further details about the storage facilities (and possible storage facilities) uncovered in this deep sounding at the center of the summit of the main tell, see Table 4.3.

In their efforts to interpret the remains uncovered at Tell 'Atij, the excavators have drawn particular attention to the ubiquity of storage facilities (relative to other types of architecture) and to the total storage capacity represented by these storage facilities. The basic argument is that the large amounts of grain stored at 'Atij – if that is, indeed, the product that was being stored – would have exceeded the needs of local inhabitants by a significant margin (e.g. Fortin 1990a:

249; 1990b: 563). In fact, the excavators were unable to identify any clear traces of domestic architecture at the site, leading them to suggest that those responsible for managing the storage facilities were actually living elsewhere (Fortin 1998a: 229-236; cf. Pfälzner 2002: 271). Pointing to a number of interesting artifactual finds – including clay calculi, a numerical tablet, a cylinder seal, a collection of stone anchors, and a graphic representation of a sailboat – the excavators argue that Tell ‘Atij was a highly specialized riverine site, a commercial station or depot where grain was being stored in preparation for shipment farther southward, perhaps to the city of Mari (e.g. Fortin 1990a: 248-249; Fortin 1998a: 237-238). Unfortunately, barley grains were only recovered in situ within one of the excavated storage facilities (silo 600, see above) – introducing at least some doubt into the case for large-scale grain storage – and there has been little explicit, quantitative discussion of the actual storage capacities of the various silos and storerooms uncovered at the site (see, however, Fortin and Schwartz 2003: 222-223, which suggests that the four silos at the northern edge of the summit of the main tell could each have held c. 4.5 m^3 or 2 tons of grain, enough to feed two 5-person families for one year).

In Tables 4.4, 4.5, and 4.6, I have used data from the published reports to estimate the maximum storage capacity for each excavated storage structure, including those cases in which a storage function is uncertain or debatable. To summarize very briefly, the three structures uncovered near the northern edge of the summit of the main tell, if used to store threshed barley, could have held a maximum of 12.0 m^3 or 5,333–11,215 kg (Northern Granary), 15.7–23.4 m^3 or 6,977–21,870 kg (rooms west of Platform D8A15), and 15.3–17.1 m^3 or 6,799 - 15,982 kg (rooms south of Platform D8A15). In total these three structures could have held a maximum of 43.0–52.5 m^3 or 19,109–49,067 kg. The two storerooms (516 and 517-517’, i.e. 538-536, both dating to Level VI) uncovered midway down the southern slope of the main tell could have held a maximum of 40.4–60.6 m^3 or 17,954–56,637 kg of threshed barley. The sequence of storerooms excavated in the deep sounding near the center of the main tell, if examined level-by-level, could have held between 14.3–21.4 m^3 or 6,355–20,000 kg of threshed barley (Level III) and 78.0–116.8 m^3 or 34,663–109,161 kg (Level VI), depending on the level. In the absence of more detailed stratigraphic information (e.g. connecting the northern area to the other areas), it seems to me that the highest estimate for site-wide storage capacity at any one point in time can be derived by adding together the estimates for Level VI in both the central and southern areas to reach a total of 118.4–177.4 m^3 or 52,617–165,798 kg of threshed barley.

Table 4.7 provides a detailed look at my estimates for the number of people that could have been fed with the grain stored in each area at Tell ʻAtij. In Table 4.8, I have simplified these estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[1] At a 95% level of confidence, my calculations suggest that the storage facilities uncovered near the northern edge of the summit of the main tell could have held enough grain to support 72–261 people for one year or 36–131 people for two years. The storage facilities uncovered midway down the southern slope of the main tell, on the other hand, could have held enough grain to support 73–280 people for one year or 37–140 people for two years. The sequence of storerooms excavated in the deep sounding near the center of the main tell could – depending on the specific level examined – have held enough grain to support 49–493 people for one year or 24–247 people for two years.

As mentioned above, the excavators have identified no clear evidence – at least in their opinion – for domestic architecture at Tell ʻAtij, leading Fortin to suggest that the people

[1] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 4.8 and the “Statistical methods” section in Chapter 3.

responsible for managing the storage facilities would have been living elsewhere (e.g. Fortin 1998: 237–238). The implication, as far as I can tell, is that Tell ‘Atij was not a settlement at all but was instead a highly specialized grain depot or commercial outpost with no resident population. This seems extremely unlikely to me, and I find Pfälzner’s alternative interpretation – that the structures at the center of the tell may have been domestic in character – to be a reasonable suggestion. Pfälzner does not, however, feel prepared to offer a population estimate for the settlement (Pfälzner 2002: 271). In light of the uncertainty about both the function of the site and its original extent (before being eroded away by the river), I certainly agree that there is no means for reaching a confident population estimate, but I have made a very preliminary calculation, simply to provide some sense for the maximum number of people that might have occupied a site of this size. I have used two different measurements for site size: 1) the maximum extent of the main tell as preserved at the time of excavation (0.52 ha; measured using the plan published in Fortin 1995: Fig. 1, following the 289 m contour) and 2) the approximate area falling within the main tell’s enclosure wall, as hypothetically reconstructed by Fortin (0.24 ha; measured using the plan published in Fortin 1995: Fig. 13). In both cases, I have assumed a population density of 100–200 person/ha, resulting in population estimates of 52–104 and 24–48 people, respectively.

To calculate the percentage of the population that could have been fed with the grain stored at Tell ‘Atij, I have first combined these two population estimates into a single range (24–104 people), and I have then divided this range by the “simplified” number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table 4.9. At a 95% level of confidence, my calculations suggest that the storage facilities uncovered near the northern edge of the summit of the main tell could have held enough grain to support 97–715 % of the population for one year and 48–357 % of the population for two years. The storage facilities uncovered midway down the southern slope of the main tell, on the other hand, could have held enough grain to support 86–664 % of the population for one year and 43–332 % of the population for two years. The sequence of storerooms excavated in the deep sounding near the center of the main tell could have held enough grain to support 81–1,274 % of the population for one year and 41–637 % of the population for two years.

Tell Beydar

Tell Beydar (ancient Nabada) is located in northeastern Syria on the western bank of the Wadi Awaidj, approximately 35 km NNW of the modern city of Hasseke, in the western part of the Khabur Triangle. A typical *Kranzhügel*, the site covers a total area of approximately 22.5–28 hectares (but only 17 ha of settled area) and is divided into three distinct zones by a series of concentric circles. The outermost zone or Lower Town is approximately 600 meters in diameter and is surrounded by a fortification wall[2]. In terms of elevation, the Lower Town sits slightly lower than the level of the surrounding plain, and it has not produced evidence for occupation. A second zone, known as the Upper City, is approximatley 400 meters in diameter, is surrounded by a moat, and rises to a height of approximately 20 meters above plain level. At the center of the site a third zone, the Acropolis, rises a further 7.5 meters above the level of the Upper City (i.e. 27.5 meters above plain level) and is approximately 60 meters in diameter (Lebeau 1997: 7–

[2] Excavation has also uncovered evidence for a 50-hectare lower city, occupied during the Mitanni and Neo-Assyrian periods, beyond the limits of the outer forification wall (Lebeau 1997: 9–11; 2006: 3).

10; 2006: 3–4; Ur and Wilkinson 2008: 307). Over the course of seventeen excavation seasons (1992–2010), a joint Syrian-European mission has uncovered extensive evidence for occupation in the Upper City and the Acropolis: palaces, temples, workshops, warehouses, and domestic quarters, for example (e.g. Lebeau and Suleiman 1997; 2003; 2007; 2010).

The site was occupied from at least the Early Jezirah I period through the Akkadian period and was then reoccupied during the Hellenistic period, but it is the Early Jezirah IIIb remains that really stand out (Figure 4.16; Lebeau 1997: 9–11). During this period, a palace – also known as the Official Block – occupied the Acropolis at the center of the settlement. The palace was flanked to the southwest by a cluster of at least five temples (Temples A–E) and, in the spaces between these temples, architectural blocks that included workshops, warehouses, and other associated facilities. To the southeast of the palace, a massive, rectangular Granary lay alongside one of the roads that led from the Lower Town into the Upper City and, ultimately, to the Acropolis. To the east of the Acropolis was another palatial structure (the Eastern Palace), and, to the northwest, an enigmatic U-shaped structure (perhaps a sheepfold or warehouse?), as well as a collection of private houses. Near the northern edge of the Upper City lay a series of workshops and several more private houses. Given the large percentage of the site that appears to have been devoted to open space (i.e. the entire Lower Town) and to non-residential buildings, it is difficult to reach a firm population estimate for the EJ IIIb settlement, but several possibilities have been suggested: 1,000–2,000 (Sallaberger and Ur 2004: 66), 2,000–3,000 (Lebeau 2006: 19), and 1,700–3,400 (Ur and Wilkinson 2008: 313).

More than 200 cuneiform documents have been recovered from EJ IIIb levels at Tell Beydar (Ismail et al. 1996; Milano et al. 2004). According to these texts, the settlement was known as *Nabada* and served, during the EJ IIIb period, as a mid-level administrative center within a regional state ruled from the city of *Nagar* (Tell Brak) (Sallaberger and Ur 2004: 51–55). The texts provide information about a relatively restricted range of topics (e.g. the organization of labor, sheep/goat herding, and cereal agriculture), but they offer an important perspective on local-level administration, one that is lacking at most other contemporary settlements in northern Mesopotamia. In the paragraphs that follow, I focus first on the archaeological evidence for grain storage at Tell Beydar during the EJ IIIb period and then turn briefly to the written evidence in order to develop a broader perspective on the production and distribution of grain at *Nabada* and in the surrounding region.

The best candidate for a large-scale grain storage facility at Tell Beydar is the Granary or Warehouse uncovered in Area E between 1992 and 1996 (Figures 4.16 and 4.17; see Table 4.10). This freestanding structure[3] was situated in the southeastern part of the Upper City, near one of gateways leading in from the Lower Town. The building was rectangular (c. 26.5 × 7.5 m) and was divided into four rooms of identical size (c. 5 × 5 m) arranged in a line. These four rooms were separated from one another by three corbel-arched crosswalls that would have left a broad, arched passageway (2.4 m wide at floor level, originally 3.5 m or, according to a different estimate, 5 m high) running the entire length of the building (Goddeeris et al. 1997: 107; Sténuit 2003: 243–244). The structure would have been entered from the west through a wide doorway that opened onto a broad street. The walls of the building (c. 1.3 m thick) were constructed of mudbrick and were completely covered in an exceptionally well preserved coating of plaster that had been applied in many separate layers, reaching a total thickness of 3 cm. On the interior wall faces, the plaster was orange; on the exterior wall faces, gray (Sténuit 2003: 243–244). The

[3] In fact, the remains of a private house were found abutting the eastern wall of the Granary (Goddeeris et al. 1997: 110–111; Sténuit 2003: 248–249). The point that I would like to emphasize, however, is that the building was not part of a larger architectural complex.

floor, which was made of beaten earth, sloped down significantly from west to east (c. 1.38 m in total) and sat above a complicated pattern of foundation walls. In the case of the western two rooms (the first and second rooms), the foundation was a variant of the grill-plan foundation known from many other sites, almost certainly designed to provide sub-floor ventilation for the building. In the case of the eastern two rooms (the third and fourth rooms), however, the floor sat directly on a set of wide terracing walls that extended well beyond the limits of the Granary building. These terracing walls were probably not constructed specifically to serve as a foundation for this building but, rather, as a means of stabilizing the slope in this part of the settlement. Because the terracing walls were separated from one another by linear voids, however, they may still have provided some form of ventilation. In any case, potential traces of sub-floor (reed?) matting – which has often been found in association with grill-plan foundations at other sites – was recovered in the second and fourth rooms (Goddeeris et al. 1997: 107–108; Sténuit 2003: 245–247).

No artifacts were recovered *in situ* within the Granary, and no interior installations of any kind were identified. The building had been carefully cleaned out and then filled in with debris (e.g. layers of earth containing sherds, stones, figurines, and clay sealings), mudbrick layers (each consisting of one discontinuous brick course), and small, floating mudbrick walls (Goddeeris et al. 1997: 108–110; Goddeeris 2003: 268–270; Sténuit 2003: 243).[4] Although there is no definitive proof for the function of this building, the excavators suggest that it probably served as a warehouse, perhaps dedicated to the storage of cereals or fodder. This suggestion

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[4] As far as I can tell, the early suggestion of multiple floors within this building (Goddeeris et al. 1997: 107–108) was actually a misunderstanding that was later corrected, when it was realized that these “floors” were actually part of the infilling process (i.e. “floors” were actually layers of mudbrick laid down within the fill, as a means of improving the stability of the fill, which was intended to serve as the foundation for a future construction) (Goddeeris 2003: 269; Sténuit 2003: 245, 249).

seems reasonable, especially given the evidence for a purposefully constructed system of sub-floor ventilation, at least in the western half of the building. Interestingly, however, the excavators also suggest – based, for example, on the lack of evidence for door closures and on the pristine state of the wall plaster – that the building may never have actually been used (Sténuit 2003: 247–249). This would certainly complicate any effort to estimate the number of people (or animals, see below) that could have been fed with the grain stored in the building, but I will assume, for the sake of argument, that this building was actually a functioning granary.

According to the excavators, the Granary would have provided approximately 100 m^2 of usable floor space (out of a total surface area of 201.78 m^2), and the building would have originally reached a height of either 3.5 meters (Goddeeris 1997: 107) or 5 meters (Sténuit 2003: 244), resulting in a total usable volume of either 350 m^3 (my calculation) or 500 m^3 (Goddeeris et al. 1997: 107; Sténuit 2003: 244, 248)[5]. As they point out, it is difficult to estimate the storage capacity of this space, given the absence of information about either the products stored or the method of storage. For the sake of argument, I have assumed (see Table B) that building was used to store grain, and, since the building was accessed through a doorway (rather than from above), I have assumed that the grain was not stored in bulk but was, instead, stored in some form of container (e.g. sacks). I have also allowed for the possibility that the arched passageway would have been left partly free of stored goods, so that the entire length of the building could be accessed.

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[5] The interior space of each of the four rooms measured approximately 5 × 5 m (i.e. 25 m^2), resulting in total of 100 m^2. As excavated, the walls only reached a maximum height of 2.3 meters. In reconstructing the orginal height of the arches in the crosswalls and, therefore, the original height of the building itself, the excavators have provided two different values: 3.5 m (Goddeeris et al. 1997: 107) and 5.0 m (Sténuit 2003: 244). The total usable volume of 500 m^3 calculated by Sténuit (2003: 248) assumes that the building was 5 m high; a height of 3.5 m would reduce this volume to 350 m^3, which is a significant difference.

A second possible storage facility was uncovered closer to the center of the settlement, within the cluster of temples to the southwest of the Official Block (Figures 4.16 and 4.18; see Table 4.10). Excavated between 1997 and 2002, this approximately rectangular structure (c. 19.7 × 9.0 m) lay on the southern side of the street that ran along the southern side of Temple A. To the east, the building abutted Main Street, the road that led directly into the Official Block; to the south, it abutted Temple C; and to the west, a broad courtyard situated outside the entrance to Temple A. Unfortunately, only the mudbrick foundations of the building were preserved, and even these were extremely fragmentary. The plan reconstructed by the excavators consists of six long, narrow rooms, one of which was divided into two smaller rooms by a crosswall. The building was probably entered from the street to the north through the northernmost of these two small rooms (Dezzi Bardeschi and Sténuit 2007: 55–61). According to the excavators, the elongated shape of the rooms suggests a possible storage function (Dezzi Bardeschi and Sténuit 2007: 60); the foundation walls might also conceivably have served as a "grill" foundation for the structure above (Lebeau 2006: 12). The excavators also indicate the presence of plaster basins within the structure (Dezzi Bardeschi and Sténuit 2007: 58), but it is unclear to me exactly where these were located.[6] The argument linking this poorly preserved building with storage – and, even more so, with *grain* storage – must be considered extremely tentative. Bearing this in mind, I have produced (see Table 4.12) two different estimates for the potential storage capacity of the building: one assuming that building was, indeed, divided into a series of elongated rooms

[6] Two plaster basins are mentioned: 32701 in room 12547 and 32704 in room 12548 (Dezzi Bardeschi and Sténuit 2007: 58). Neither of these rooms, however, appears on the plan for the phase under discussion (i.e. Phase 3 of the building to the south of Temple A; Dezzi Bardeschi and Sténuit 2007: Pl. 3–4). In any case, if there were indeed plaster basins within some of the rooms in this building, their presence would seem to argue against bulk storage.

(used for bulk storage) and one assuming that the foundation walls were designed, instead, to provide a grill foundation for a single, enormous storeroom (also used for bulk storage).

Storage was almost certainly taking place in some of the other contexts excavated at Tell Beydar (e.g. in the private houses and perhaps in the U-shaped structure), but one area in particular should be mentioned. To the south of the street that ran along the southern side of Temples B and C, the excavators uncovered a rectangular structure – composed of five separate architectural units – that they sometimes call a “storage building” (Table 4.10; Suleiman 2007: 85–88). Numerous storage jars were recovered from this structure, which certainly does suggest a storage function, but the complex does not appear to have been a dedicated storage facility. Instead, it seems to have been a series of workshops devoted to the processing of various materials, perhaps including food products (Figure 4.16; Lebeau 2006: 12). In fact, on the northern side of the same street, immediately to the west of Temple B, a bakery was uncovered; it consisted of three rooms: one dedicated to the grinding of grain and two dominated by large ovens (Lebeau 2006: 13; Suleiman 2007: 88). Given the difficulty of estimating exactly how much grain storage might have been taking place within this zone of workshops, I have not attempted any calculations.

In Tables 4.11 and 4.12 I have used data from the published reports to estimate the maximum storage capacity of the Granary and the building to the south of Temple A. To summarize very briefly, using the measurements provided by Goddeeris et al. (1997), the Granary could have held a maximum of 262.5 m^3 or 116,655–245,333 kg of threshed barley. Using the measurements provided by Sténuit (2003), the Granary could have held a maximum of 375 m^3 or 166,650–350,475 kg of threshed barley. Using my own measurements, the Granary could have held a maximum of 239.9–342.8 m^3 or 106,612–320,381 kg of threshed barley, if there was no passageway running east-west through the structure. If there was a one-meter-wide passageway running east-west through the center of the structure, the Granary could have held a maximum of 189–270 m^3 or 83,992–252,342 kg of threshed barley. Bearing in mind the many uncertainties involved (e.g. regarding floor plan, function, and possible storage methods), the building to the south of Temple A could have held a maximum of 120.6–180.9 m^3 or 53,595–169,069 kg of threshed barley, if the building was divided into seven rooms, all of which were used for storage. If the building, instead, consisted of a single, large room lying above a grill-plan foundation, then the building to the south of Temple A could have held a maximum of 172.1–258.1 m^3 or 76,481–241,220 kg of threshed barley.

Table 4.13 provides a detailed look at my estimates for the number of people that could have been fed with the grain stored in the Granary and the building south of Temple A. In Table 4.14, I have simplified these estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[7] At a 95% level of confidence, my calculations suggest that the Granary and the building south of Temple A, together, could have held enough grain to support 598–2,971 people for one year or 299–1,485 people for two years.

Lebeau estimates a total population of 2,000–3,000 for Tell Beydar during the Early Jezirah IIIb period (Lebeau 2006: 19). Sallaberger and Ur suggest a much lower estimate of 1,000–2,000, which assumes 100–200 persons/ha and which includes a reduction (apparently, from 17 ha to 10 ha of total settled area) to account for the significant portions of the site dedicated to non-residential architecture (Sallaberger and Ur 2004: 60–62, 66). Ur and

[7] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 4.14 and the "Statistical methods" section in Chapter 3.

Wilkinson, on the other hand, have estimated a population of 1,700–3,400 (i.e. 17 ha, 100–200 persons/ha) but with the proviso that this estimate is not adjusted for the presence of non-residential zones and might, therefore, be too high (Ur and Wilkinson 2008: 307–8, 313). My own estimate, based solely on settled area (17 ha) and a population density of 100–200 persons/ha, is 1,700–3,400 people (i.e. the same as the estimate suggested by Ur and Wilkinson).

To calculate the percentage of the population that could have been fed with the grain stored at Tell Beydar during the EJ IIIb period, I have first combined the four population estimates into a single range of possibility (1,000–3,400), and I have then divided this range by the "simplified" number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table 4.15. At a 95% level of confidence, my calculations suggest that the Granary and the building south of Temple A could have held enough grain to support 25–189 % of the population for one year and 13–95 % of the population for two years.

The cuneiform documents recovered from Tell Beydar do not provide any direct references to storage facilities or storage practices, but they do offer some important information about the structure and scope of the redistributive economy. Many of the texts record the distribution of grain rations – primarily barley but also emmer, wheat, and flour – to lists of people, often grouped together by profession. The lists include agricultural personnel and herders, as well as a wide range of low-level craftsmen, such as potters, basket-weavers, carpenters, and millers (Sallaberger 1996b: 93–99; Van Lerberghe 1996a: 120–121). A single document could record the distribution of monthly rations to as many as 160 or even (approximately) 235 people, resulting in a total outlay of 22 kor and just over 32 kor of grain, respectively (Text numbers 57 and 71; Sallaberger 1996b: 89). Grain was also regularly disbursed as fodder for sheep, goats, equids, and birds (Sallaberger 1996b: 89, 98; Van Lerberghe 1996a: 120–121; 1996b) – an important point to consider when gauging the amount of stored grain that would be needed to support the population of the settlement, a population that clearly included both humans and a range of animals.

The texts do not indicate the precise nature of the institutional body that was responsible for these grain disbursements and the other administrative activities recorded, but they do offer some insight into the structure of the institutional economy. For example, five leading officials appear to have exercised a significant degree of economic control, not only in Nabada itself but also in the surrounding region. The texts reference twelve other settlements that fell within the jurisdiction of these officials and, therefore, within the "province" of *Nabada* (which was itself subordinate to *Nagar*, i.e. Tell Brak). The central institution at *Nabada* may or may not have owned all of the agricultural land in the province, but it certainly took responsibility for managing the labor, tools, and draft animals required for the working of much, if not all, of this land (Sallaberger and Ur 2004: 54–57).

An archaeological survey conducted in the region surrounding Tell Beydar during 1997 and 1998 has also provided important information about agricultural production and economic organization within the *Nabada* province (Sallaberger and Ur 2004: 59–65; Ur and Wilkinson 2008). Here, I will focus on one issue in particular: the production and allocation of agricultural surpluses. By combining evidence for site size with evidence for agricultural sustaining areas, Jason Ur and Tony Wilkinson (2008: 312–315) have been able to make an interesting argument about surplus production in the Beydar region during the mid-late third millennium. They begin by establishing the boundaries of the cultivated zone around each settlement, using the hollow-way system as a guide. More specifically, they argue that hollow-ways – that is, the wide, linear depressions that radiate outward from each site – are the traces of ancient roadways that conducted people and animals into the zone beyond the agricultural fields. The fadeout point of the hollow-ways (at least, those that did not continue onward to other settlements) indicates the approximate outer boundary of the cultivated zone around each settlement. Having used these boundaries to calculate the size of each settlement's agricultural sustaining area, Ur and Wilkinson then compare this data to the amount of land that each settlement would have needed in order to support its resident population. They estimate population using site size (100, 150, or 200 persons/hectare), and, in calculating the land needed to support this population, they assume an annual consumption of 250 kg of grain per person, an average yield of 500 kg of grain per hectare, and a regime of biennial fallowing (i.e. only half of the fields were cultivated each year). The result is a chart and a graph (Ur and Wilkinson 2008: Table 1, Fig. 10) showing the degree to which each settlement was either a surplus producer or a surplus consumer, expressed in hectares of agricultural land.

Two key points emerge from this analysis. First, Beydar itself was a surplus consumer – that is, it was not cultivating enough grain to feed its population – while the other eight settlements analyzed were surplus producers. Second, even taking the additional needs at Beydar into account, the region as a whole was producing a significant surplus. Depending on the precise values used in calculating population, these nine settlements were cultivating between 1,090 and 5,470 extra hectares of agricultural land and producing between 545,136 and 2,734,820 extra kilograms of grain, enough to support an additional population of between 2,181 and 10,939 people. Given that the total population of the region was probably only 6,000–13,000, this is a major surplus (Ur and Wilkinson 2008: 313, Table 1; Sallaberger and Ur 2004: 66). Ur and Wilkinson argue that this level of surplus production would have required an influx of additional labor, perhaps contributed by seasonally transhumant pastoral populations, and they argue further that the surplus grain may have been intended for animal consumption (Ur and Wilkinson 2008: 312–315). This would certainly agree with the texts, which indicate that significant quantities of grain were regularly earmarked as fodder for animals.

Tell Brak

Tell Brak (ancient Nagar) is located in northeastern Syria, northeast of Hasseke, near the junction of the Wadi Jaghjagh and the Wadi Radd in the south-central part of the Khabur Triangle. The site consists of a massive high mound (c. 800 × 600 m, i.e. more than 40 ha, in area and 40 m high) and an extensive Outer Town (90 ha) that incorporates a ring of satellite tells (Oates 1982: 62; Oates et al. 2001: xxvii; Ur et al. 2011). Archaeological work was conducted at Tell Brak in the 1920s by Antoine Poidebard and then in the 1930s (1937–1938) by Max Mallowan (Mallowan 1947). Excavation was then resumed in 1976 by David and Joan Oates and has continued to the present day (with a hiatus beginning in 2010, due to political unrest in Syria), with the assistance of a number of different field directors, including Roger Matthews, Geoff Emberling, Helen McDonald, and most recently Augusta McMahon (see e.g. Oates et al. 1997; Oates et al. 2001; Matthews 2003b; Emberling et al. 1999; Emberling and McDonald 2001; 2003). A survey of the site and the surrounding region was conducted between 2002 and 2006, under the field direction of Henry Wright (Wright et al. 2006–2007; Ur et al. 2011). Tell Brak was occupied from at least the Late Ubaid period (mid-fifth millennium BC) through the Late Bronze Age (late second millennium BC) and then again during the Late Assyrian (possibly), Roman, and early Islamic periods (see e.g. Oates et al. 2001: xxx, Table 1), but I will focus here on the third millennium BC.

Having reached a maximum extent of at least 130 hectares during the Late Chalcolithic period, the settled area at Tell Brak had retreated significantly by the beginning of the third millennium (Ur et al. 2011: 6–9, 17). During the Ninevite 5 period, occupation was restricted to the high mound and has only been uncovered in a few, relatively small exposures (Matthews 2003a; Ur et al. 2011: 9). As at a number of other major sites in the region, there was then a sudden expansion in settled area around 2600 BC, with evidence for occupation not only on the high mound but also across a broad Lower Town, resulting in a total occupied area of approximately 70 hectares. The Lower Town is only visible today as a sherd scatter in the fields to the south of the mound (Ur et al. 2011: 9–12). Extensive remains of “mid-late third millennium” occupation have, however, been uncovered through excavation on the high mound (Figure 4.19). These include a series of houses (Areas CH and ER), a post-Ninevite 5 / pre-Akkadian (ED III) public building (the “Brak Oval,” Area TC), a massive fortified storehouse built by the Akkadian king Naram-Sin (the Naram-Sin Palace), an Akkadian-period ceremonial / administrative / industrial complex to the west (Area SS), and another monumental Akkadian-period complex that included a temple and a sort of caravanserai (Area FS) (see e.g. Oates and Oates 2001a: 379–392). The post-Akkadian period is also represented, for example, in a rebuilding of the Naram-Sin Palace, in some domestic structures built atop the monumental buildings in Areas SS and FS, and in a roughly built complex with evidence for both domestic activities and specialized craft production (the Pisé Building, Area TC) (Oates and Oates 2001a: 392–394; Emberling et al. 2012).

During Brak Phase L (post-Ninevite 5 / pre-Akkadian), the best evidence for grain storage and processing comes from the so-called Brak Oval, an irregularly shaped structure uncovered in Area TC in the southeastern quadrant of the high mound (Figure 4.19). Excavated between 1998 and 2002, this public (i.e non-domestic) building was constructed in at least four stages. The earliest phase (Figure 4.20) consisted of a three-room bakery. The three rooms (Rooms 1–3) were arranged in a line (running northeast-southwest) along a curving exterior wall (on their southeastern side), and each was entered through a separate doorway from the northwest. Room 1 was outfitted with a series of features (e.g. a variety of plastered bins, grinding implements, channels, small storage jars, etc.) that suggest the processing of grain (e.g. into flour and/or dough). Room 2 was lined, along its northeastern and southeastern walls, with seven small, domed ovens and a bin of uncertain function. Room 3 was found empty but, according to the excavators, was probably a storeroom (Emberling et al. 1999: 9–15; Emberling and McDonald 2003: 38–39).

During the second phase (Figure 4.20), a second line of rooms (running east-west) was added to the existing line, so that the two formed a corner in the northeast. Room 0, which lay at this corner, included a well at least 4 meters deep. At least four more rooms extended westward from Room 0, but the excavators have not provided any further information about the function of these rooms (apparently, because they were largely levelled in preparation for the next building phase). Two of the rooms, however, were entered through doorways that opened southward onto the same space as the doorways of Rooms 1–3 (Emberling and McDonald 2003: 39–40).

During the third phase (Figure 4.21), Rooms 0–3 (the bakery) continued in use, but the other rooms from the preceding phase were leveled and replaced by a collection of rooms (Rooms 14–18 and 21) centered around a small courtyard (17). This new suite of rooms, located in the northwestern part of the Area TC exposure, included a small kitchen (Room 14), a reception room (Room 16), and a small storeroom (Room 15); as far as I can tell, though, it is not clear exactly what was stored in this storeroom. The rooms around courtyard 17 were connected with Rooms 0–3 by means of a broad courtyard (the "eastern" courtyard), bounded on all sides and approximately triangular in shape. It is possible that another group of rooms (Rooms 4–5) – probably the ground floor for a tower with a stairway – was also built during this phase, creating another courtyard (the "western" courtyard, separated from the eastern courtyard by a thick wall) to the south of Rooms 14–15 and to the north of Rooms 4–5 (Emberling and McDonald 2003: 39–40).

During the fourth and final phase of the Brak Oval (Figure 4.21), a small, thick-walled room (Room 11) of uncertain function (?) was added in the middle of the western courtyard, while two storerooms (Rooms 7–8) and a large bin were added within the eastern courtyard. Interestingly, the construction of Rooms 7–8 introduced a new circulation pattern in the vicinity of the "bakery." Rooms 2 and 3 could no longer be accessed from the eastern courtyard and were, instead, linked with Rooms 7 and 8 by means of small corridor (6) that opened onto what used to be the western courtyard (now corridor 9). The upshot is that the room furnished with grain processing instruments (Room 1) was no longer easily accessible from the baking room (Room 2), which was itself now tied closely to three storerooms (Rooms 3, 7–8). In the northwestern area (i.e. courtyard 17 and associated rooms), the reception room (Room 16) appears to have been repurposed during this phase. A large bin occupied the northwestern half of the room, and the floor in the southeastern half was covered in a 50-cm-thick layer of grain (Emberling and McDonald 2001: 32; 2003: 40–41; Hald in Emberling and McDonald 2001: 42–45; Hald and Charles 2008: S39). The eastern "wall" of Room 16 was almost entirely taken up by a broad doorway whose lintel was supported on a column. The excavators have suggested that this repurposed reception room, which was open to the elements and therefore unsuitable for long-term storage, was being used on a temporary basis for the storage and cleaning of grain (Emberling and McDonald 2001: 32; 2003: 39–40; see, however, Hald and Charles 2008: S40, who argue that the entire room was being used for storage).

The fire that destroyed the final phase of the Brak Oval appears in contexts across the site and is known as the "Early Dynastic III destruction level." In Area TC, this conflagration preserved a rich archaeobotanical assemblage. Compared with earlier periods (e.g. the Late Chalcolithic), the plant remains from Area TC indicate a shift from a relatively diverse cereal economy toward an overwhelming reliance on hulled barley (Hald and Charles 2008: S39–S40). Partially cleaned barley that had been sieved but not hand-sorted was recovered from the floor of Room 16 (the repurposed reception room), from courtyard 17 immediately to the east, and from Rooms 7 and 8 (associated with the bakery). The other storeroom associated with the bakery (Room 3) was apparently being used, instead, to store pulses, while the grain-processing room (Room 1) produced evidence for concentrations of both barley and glume wheat (Hald in Emberling and McDonald 2001: 42–45; Hald and Charles 2008: S39). Especially interesting is Room 16, where piles of clean barley were recovered immediately adjacent to piles with higher levels of chaff, suggesting that the barley was in the process of being cleaned when the fire broke out (Emberling and McDonald 2003: 39; see, however, Hald in Emberling and McDonald 2001: 42, who argues, instead, that the differences may indicate barley derived from different source fields). It is also worth mentioning that 141 clay sealings were uncovered in association with the final phase of the Brak Oval. Most of these were door sealings, but container sealings and "test strips" were also found. The excavators have argued that the sealings were all deposited as deliberate caches inserted (e.g. for apotropaic purposes) within brickwork or beneath floors during the construction of the final phase of architecture (McDonald in Emberling and McDonald 2003: 41–48).

During the succeeding Phase M (Akkadian), a massive fortified storage facility was constructed at Tell Brak (Figure 4.22; Mallowan 1947: 26–29, 63–68, Plates LXI–LX). Excavated by Max Mallowan over the course of three seasons (1937–1938), this so-called "palace," erected by the Akkadian king Naram-Sin, still provides some of the best physical evidence for an Akkadian expansion into northern Mesopotamia (see e.g. Oates and Oates 2001a: 383–386; Ristvet 2012: 244). The Naram-Sin Palace was located near the southern edge of the high mound, on the eastern side of a modern gully that probably marks one of the main roads leading into the third-millennium city from the southwest. The exterior walls of this enormous mudbrick structure were 10 m thick; the interior walls, 2.3–3.3 m thick. Many of the mudbricks had been stamped with the name of Naram-Sin, prefixed with the divine determinative, which indicates a constrution date relatively late in the king's reign (i.e. after his deification). Only the foundations of the building were recovered, and in many places even these had been obliterated by later activity. Toward the south and the southwest, in particular, the plan of the building has been reconstructed (Mallowan 1947: 63–66). This means that the total number of rooms and, therefore, the total capacity of the building is not entirely certain. At the same time, it is possible that the walls of the missing superstructure did not precisely mimic the foundation walls (e.g. in terms of thickness), which leads to some further uncertainty about capacity.

As reconstructed, the structure would originally have covered a total area of more than 10,000 m^2 (c. 111 × 93 m) and would have included 48 rooms arranged around four large courtyards. It is generally assumed that these rooms, which were long and narrow (2.2 m in width, variable in length), would have functioned as magazines of some kind. The recovery of "considerable" quantities of carbonized wheat and barley grains from three rooms (Rooms 10, 13, and 16) indicates that one of the goods – if not the primary good – stored in the building was grain (Mallowan 1947: 63–64, Plate LX). Several fragmentary tablets found in the building also make reference to grain (and other commodities), alongside lists of men (Gadd 1940: 60–61; Mallowan 1947: 66). Although the evidence is not beyond dispute, it does seem reasonable to conclude that this building served primarily as a centralized storage facility for goods (e.g. agricultural goods) brought in from the surrounding region and, therefore, as a key node of Akkadian administration and redistribution (e.g. Mallowan 1947: 26, 73; Moorey 1964: 94–95; Lloyd 1984: 142; Oates and Oates 2001b: 19). As Mallowan writes, the enormous central courtyard (No. 1) would have functioned "as a reception centre for large numbers of beasts and great quantities of merchandise," where "sacks and bales were unloaded and then distributed to the appropriate store rooms after the scribes at the entrance had checked and listed the goods" (Mallowan 1947: 63). For purposes of quantification, I have assumed that the three rooms to either side of the entrance (Rooms 30–32 and their counterparts to the south) would not have been used for storage. Otherwise, I have assumed that all of the long, narrow rooms were used to store grain, not in bulk but rather in containers of some kind (e.g. sacks). Given the likelihood that other commodities were also stored here alongside grain, my estimate for the grain storage capacity of the building should be considered a theoretical maximum that almost certainly overestimates the actual quantity of grain that would have been kept in the building at any one point in time.

During Phase N (post-Akkadian period), the walls of the Naram-Sin Palace were cut down to foundation level, and a new superstructure was built on the same plan, reusing the original foundations. The new walls were not as well built as those of the preceding phase, and they were typically narrower (by as much as 80 cm) (Mallowan 1947: 68–70, Plate LIX; Oates and Oates 2001a: 392–394). Although this reduction in the width of the walls would have increased the floor space available in the building, the published plans do not provide enough information for a full recalculation of the building's storage capacity during the post-Akkadian period. I have, instead, assumed that approximately the same total storage capacity as during Phase M (Akkadian period) would have been available. On the opposite side of the high mound, an "oval structure" uncovered in Area FS may also have played a role in grain storage during Phase N (Figure 4.23; Oates and Oates 2001b: 71–72). Located immediately adjacent to several residential units, this structure measured approximately 4 × 5 meters internally. Its walls were a maximum of 50 cm thick, were reinforced by four external butresses, each one brick wide, and were preserved to a maximum height of 30 cm. According to the excavators, a recess and a stone step on the northern side of the structure suggest the presence of a wide doorway (1.90 m wide) that would have allowed for the storage of bulky objects, perhaps grain (Oates and Oates 2001b: 71–72). It is unclear to me whether this hypothesized doorway would have provided ground-level access to the structure – implying storage in sacks or other containers – or if it might have provided access from above and, therefore, allowed for the bulk storage of grain (i.e. loose grain). I have, therefore, provided two different sets of calculations.

In Tables 4.17, 4.18, and 4.19, I have used data from the published reports to estimate the maximum storage capacity of these storage facilities dating to Phases L, M, and N at Tell Brak. The extensive excavations at Tell Brak have also uncovered further evidence for storage – e.g., enormous storage jars (Oates and Oates 2001b: 34), clay-lined pits (Charles and Bogaard 2001: 320), and smaller vessels found in domestic contexts (Oates and Oates 2001b: 35–36; Charles and Bogaard 2001: 320) – but I have chosen to focus here on a few examples of large-scale, dedicated storage facilities. To summarize very briefly, the storerooms within the Brak Oval (Phase L, post-Ninevite 5 / pre-Akkadian) could have held a maximum of 28.4–42.5 m^3 or 12,621–39,721 kg of threshed barley during Subphases 1 and 2. During Subphase 3, the storerooms in the Brak Oval could have held 38.0–56.9 m^3 or 16,887–53,179 kg of threshed barley. During Subphase 4, the storerooms in the Brak Oval could have held 71.9–135.0 m^3 or 31,952–126,171 kg of threshed barley. During Phase M (Akkadian), the Naram-Sin Palace could have held a maximum of 1,653.6–2,479.4 m^3 or 734,860–2,317,247 kg of threshed barley. During Phase N (post-Akkadian), the Later Palace, like its predecessor (the Naram-Sin Palace), could have held a maximum of 1,653.6–2,479.4 m^3 or 734,860–2,317,247 kg of threshed barley. The oval structure in Area FS, on the other hand, could have held a maximum of 31.0–46.5 m^3 or 13,776–43,459 kg of threshed barley.

Table 4.20 provides a detailed look at my estimates for the number of people that could have been fed with the grain stored in these structures at Tell Brak. In Table 4.21, I have simplified these estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[8] At a 95% level of confidence, my calculations suggest that the storage facilities dating to Phase L could have held enough grain to support 70–600 people for one year or 35–300 people for two years. The storage facilities dating to Phase M, on the other hand, could have held enough grain to support 3,143–11,850 people for

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[8] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 4.21 and the “Statistical methods” section in Chapter 3.

one year or 1,571–5,925 people for two years. The storage facilities dating to Phase N could have held enough grain to support 2,859–11,965 people for one year or 1,429–5,983 people for two years.

During phases L, M, and N, the settlement at Tell Brak appears to have covered a total area of approximately 70 hectares (Ur et al. 2011: 9–12). I have not been able to locate any published population estimates for the settlement during these periods and have, therefore, had to rely only on my own estimates. I have calculated one estimate (7,000–14,000 people) based solely on site size (70 ha) and a population density of 100–200 persons/ha and another estimate (6,000–12,000 people) that reduces the occupied area to 60 ha in order to account (in a very rough manner) for the significant areas of non-residential space that we know existed within the settlement (especially during Phases M and N).

To calculate the percentage of the population that could have been fed with the grain stored at Tell Brak, I have first combined the two population estimates into a single range of possibility (6,000–14,000), and I have then divided this range by the "simplified" number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table 4.22. At a 95% level of confidence, my calculations suggest that the storage facilities dating to Phase L could have held enough grain to support 1–8 % of the population for one year and 0–4 % of the population for two years. The storage facilities dating to Phase M, on the other hand, could have held enough grain to support 26–141 % of the population for one year and 13–70 % of the population for two years. The storage facilities dating to Phase N could have held enough grain to support 28–142 % of the population for one year and 14–71 % of the population for two years.

Ebla

Tell Mardikh (ancient Ebla) is located in northwestern Syria, approximately 60 km southwest of Aleppo. The site covers a total area of approximately 60 hectares and has been extensively excavated. It is best known as the source of a major archive of cuneiform tablets, recovered from the so-called Royal Palace G and dating to the Early Bronze IVA period (c. 2400–2300 BC). Here, I would like to draw attention to some archaeological evidence for grain storage uncovered within the EB IVA Royal Palace (Phase IIB1) and also within levels dating to the earlier EB III period (2700–2400 BC, Phase IIA). See Table 4.23 for some basic information about the storage facilities uncovered in these levels.

During the EB IVA period (c. 2400–2300 BC, Phase IIB1), the Royal Palace probably would have extended across much of the city's Acropolis, but only the southwestern edge of this structure has been uncovered (Figure 4.24). The best evidence for large-scale storage within the Royal Palace comes from an area known as the Central Unit South or Southern Storehouse, excavated along the southern slope of the Acropolis mound (Figures 4.24 and 4.25; Dolce 1988: 37–38; 1990: 123–124; Matthiae 1987: 143–145, Fig. 6; 2013: 50, Fig. 2.2; Mazzoni 2013: 94, Fig. 5.40). This "storehouse" consisted of two parallel lines of rooms, running east-west and bordered to the south by a thick terrace wall, as well as a single room to the south of the terrace wall. The rooms were irregularly shaped and were furnished with a range of installations, including niches, buttresses, benches, and stepped shelves. Large numbers of ceramic vessels were recovered from this area, many of them stacked along the benches and shelves. The rooms appear to have been used, in part, as temporary storage places for pottery (i.e. for the pots themselves, rather than their contents), but the recovery of vegetal remains, cereal grains, and olive pits suggests that many of the storage vessels were in fact being used to store foodstuffs.

Rita Dolce has calculated a total surface area of 83 m^2 for the rooms within the Southern Storehouse (Dolce 1988: 37–8, Note 12). In order to suggest a possible storage capacity, however, she argues that the 280 storage vessels recovered from the area could have held a total of either 148 hundredweights (6,713–7,518 kg) of wheat or 175 hundredweights (7,938–8,890 kg) of oil (Dolce 1988: 38, Note 14).[9] Dolce also provides a similar calculation for the Central Unit West, an area in the northwestern part of the Royal Palace that appears to have been dedicated to a range of functions, including the processing (e.g. grinding) and storage of grain (Figure 4.24 and 4.26). The vessels recovered from the Central Unit West area could have held a total of either 120 hundredweights (5,443–6,096 kg) of wheat or 142 hundredweights (6,441–7,213 kg) of oil (Dolce 1988: 38, Note 14; 1990: 124–125; see Wachter-Sarkady 2013 for a discussion of archaeobotanical remains from this area). Although Dolce (1988: Note 14) cites the table published by Mazzoni (1988: Tab. 2) as a source for her vessel counts and capacity calculations, it is unclear to me exactly how the calculations were performed. Without further details,[10] it is difficult to evaluate the accuracy of Dolce's vessel-based storage capacity estimates, but they do provide an interesting point of comparison for estimates based solely on room volume.

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[9] According to Dolce, these totals can be broken down into medium and large storage vessels as follows: wheat (medium = 46 hundredweights, large = 101 hundredweights), oil (medium = 54 hundredweights, large = 120 hundredweights) (1988: 38, Note 14). Dolce does not specify the type of hundredweight that she is using. I have, therefore, included a range of possible conversions. One short hundredweight equals 45.36 kg. One long hundredweight equals 50.80 kg.

[10] Some recent publications (Mazzoni 2013; D'Andrea and Vacca 2013) have provided further details about the ceramic assemblage from the Central Unit South – including, for example, information about average vessel capacities – but I still do not understand exactly how Dolce reached her storage capacity estimates.

Table 4.24 shows Dolce's storage capacity estimates for the Central Unit South and the Central Unit West, and Table 4.25 shows my own calculations for the Central Unit South. To summarize, Dolce's estimates (based on storage vessels) imply a storage capacity of 6,713–7,518 kg of wheat for the Central Unit South and a capacity of 5,443–6,096 kg of wheat for the Central Unit West; this suggests a total storage capacity of 12,156–13,614 kg of wheat for the two areas combined. My own calculations (based on room volume) suggest a maximum capacity of 57,372–180,939 kg of threshed barley for the Central Unit South.

Whichever calculations are employed, the Southern Storehouse was large enough to accommodate a significant quantity of grain or other foodstuffs. As Dolce points out, however, even if all of the storage vessels were filled with wheat, it would not have been nearly enough to serve the needs of the entire city (Dolce 1988: 41). This was certainly not the primary grain storage facility for the city or for the Ebla state more broadly. Mazzoni echoes this point and takes the argument a step further. The Royal Palace was "the seat of accumulation and redistribution" for the Ebla state, but only in a theoretical (and administrative) sense. The goods stored within the palace itself would have been intended primarily for internal use. The state warehouses that lay at the center of the redistributive economy should be sought elsewhere in the city or, perhaps, outside of the city (Mazzoni 1988: 92).

EB III (c. 2700–2400 BC, Phase IIA) remains that predate the EB IVA (Phase IIB1) Royal Palace have been uncovered in several different areas. Immediately beneath the Southern Storehouse (i.e. Central Unit South), for example, excavations unearthed a long-lived structure known as Building G2 that may have served an administrative function (Matthiae 1987: 137–138, Fig. 1–2; Dolce 2008: 66). To the northeast of this area, along the southeastern slope of the Acropolis mound, a sequence of six occupation phases dating to the EB III period was uncovered in Area CC (Figure 4.27). Among the remains were a number of small rooms dedicated to grain storage. Rooms L.7256 and L.7287, for example, were especially well preserved (Matthiae 2000: 572–575, Fig. 6–7; Dolce 2008: 66). Excavations beneath the North-West Quarter of the Royal Palace also revealed evidence for two levels of EB III occupation in a structure of uncertain function known as Building G5 (Matthiae 2000: 576–578, Fig. 8; Dolce 2008: 66, Note 14). A large, semicircular, subterranean silo (S.4843) was also uncovered beneath the western part of the Royal Palace, but it is unclear to me exactly where this silo was located and how it relates to Building G5. According to a recent publication, the silo was plastered on the interior with clay and was probably located within a courtyard of some kind. Although no dimensions or plan are provided, the capacity of the silo is estimated as 11–12 m^3. The fill of the silo was composed of a loose and ashy matrix that alternated with more compact material and that included some "debris" and charcoal. The archaeobotanical assemblage was dominated by barley but also included a range of other cereals and pulses, in addition to olive stones, a single pomegranate seed, and a variety of weeds. Very little cereal chaff was recovered. The plastering on the interior, the dominance of cereal grains, the relative scarcity of weeds, and the virtual absence of chaff suggests that the silo was used primarily for the storage of partially cleaned cereal grain (Wachter-Sarkady 2013: 377–378). I have assumed that this is the same silo that is briefly mentioned and shown in a photograph in an earlier publication by Mazzoni (1995: 99, 103), but this assumption may not be correct.

Table 4.26 shows my calculations for the storage capacity of Rooms L.7256 and L.7287 in Area CC and Silo S.4843 beneath the western part of the Royal Palace. To summarize, Rooms L.7256 and L.7287 could have held a maximum of 5.5–9.0 m^3 or 2,444–8,411 kg of threshed barley, and Silo S.4843 could have held 11.0–12.0 m^3 or 4,888–11,215 kg of threshed barley.

Table 4.27 provides a detailed look at my estimates for the number of people that could have been fed with the grain stored in the EB IVA and EB III structures analyzed in Tables 4.24–4.26. In Table 4.28, I have simplified these estimates significantly (for example, focusing solely on my own estimates for the Central Unit South during the EB IVA period), and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[11] At a 95% level of confidence, my calculations suggest that the EB IVA (Level IIB1) storage facilities in the Central Unit South could have held enough grain to support 232–910 people for one year or 116–455 people for two years.

I have not been able to locate any published population estimates for the city of Ebla during the EB III or EB IVA periods. I have, therefore, produced my own very rough estimate, based solely on site size. During the EB IVA period (c. 2400–2300 BC, Phase IIB1), the city appears to have covered a total area of approximately 50 hectares (Matthiae 1997: 180). Assuming a population density of 100–200 persons/ha, this suggests a population of approximately 5,000–10,000 for EB IVA Ebla.

To calculate the percentage of the population that could have been fed with the grain stored at Ebla, I have divided my population estimate (5,000–10,000) by the "simplified" number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table 4.29. At a 95% level of confidence, my calculations suggest that the EB IVA (Level IIB1)

[11] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 4.28 and the "Statistical methods" section in Chapter 3.

storage facilities in the Central Unit South could have held enough grain to support 3–15 % of the population for one year and 1–8 % of the population for two years.

Tell Hajji Ibrahim

Tell Hajji Ibrahim is located on the eastern bank of the Euphrates river in northern Syria, approximately 900 meters from the site of Tell es-Sweyhat. During the later fourth and early third millennia BC, the tiny site of Tell Hajji Ibrahim (0.25 ha, 2.60 m above plain level) appears to have been occupied by a small, fortified facility dedicated to the storage and processing of grain. This facility was constructed on virgin soil during Phase A1 and was then rebuilt along the same lines in Phase A2. The remains of the succeeding Phase B were close to the surface and heavily disturbed, but, given the absence of storage structures, they seem to indicate a shift in function (Danti 1997: 89–91; 2000: 105–145, 305–306). I will briefly describe the Phase A1 and A2 remains and will then outline Michael Danti's efforts to quantify and interpret the evidence for storage at the site.

During Phases A1 and A2, the settlement was occupied primarily (if not entirely) by an "enclosure" that included a one-room house, a walled courtyard, a gatehouse, and a series of structures interpreted as silos (Silos I, II, and III). The only silo dating to Phase A1 was the partially preserved Silo I, a rectangular structure built on massive stone footings that had been filled in and covered with river pebbles. Phase A2, the later of the two phases, was more fully excavated than Phase A1 and, therefore, provides a more complete snapshot of the layout of the enclosure (Figure 4.28). There was one silo (Silo II) at the southeastern corner of the enclosure and one silo (Silo III) at the northwestern corner. Silo II was a rectangular structure built directly on the stone footings of Silo I (Phase A1). Silo III was also rectangular but was not provided with stone footings. Its walls (1.20 m thick, preserved to a height of 60 cm) were built of mudbrick and were covered on the interior and exterior in a thick layer of light-brown plaster. The eastern, southern, and (possibly) northern walls of the silo were provided with niches on the exterior, and the floor was covered in lime plaster (Danti 2000: 107, 111–112, 122–123). No traces of the goods originally stored in the silos were recovered in situ, but large quantities of burnt grain – probably the remains of barley processing (threshing and grinding) – were found on the floor of the nearby house (Danti 2000: 111–112, 115, 122–123).

Danti argues that the three silos at Hajji Ibrahim were standardized in terms of storage capacity. That is, he argues that each silo covered approximately the same interior surface area; this means that grain stocks could be easily monitored and compared with a simple measurement of grain height. On the interior, Silo II measured 2.11 m (N-S) × 1.25 m (E-W) or 2.64 m^2, while Silo III measured 2.20 m (N-S) × 1.20 m (E-W) or 2.64 m^2. Silo I was only partially preserved, but its North-South measurement was approximately equivalent to the East-West measurement of its successor Silo II. In the case of Silos II and III, at least, Danti argues that each could have held 2.64 m^3 of grain per 1 m of height or, stated differently, 1320 liters (i.e. 1320 *sila*) of grain per 0.5 m (i.e. 1 *cubit*) of height. He then reduces this estimate somewhat, to account for the layers of plaster covering the interior walls, and suggests a range of 1200–1300 liters of grain per 0.5 m of height (i.e. 2.4–2.6 m^3 of grain per 1 m of height). If the grain was stored to a depth of 3 m, each silo could have held 7.2–7.8 m^3 or 7200–7800 liters of grain. Danti acknowledges the significant uncertainty involved in converting storage volume (m^3 or liters) to grain by weight (kg), but he suggests the use of middle range value: 1 metric ton (1000 kg) of grain per 2.0 m^3 of storage space (i.e. 500 kg of grain per cubic meter). This means that each silo could have held 3600–3900 kg of grain, and the two silos together could have held 7200–7800 kg of grain. If one person needs 250 kg of grain per year, that would be enough grain to feed approximately 29–31 people (Danti 2000: 49–50, 111–112, 122, 130–132; not all of the values that I have provided here appear in Danti's discussion, but all are directly implied by his argument).

Danti, however, takes the argument one step further and suggests that a significant proportion of the stored grain would have been earmarked as fodder for sheep. He calculates that the two silos together could have held the grain harvested from 39 ha of cultivated land (assuming biennial fallow and a yield of 400 kg/ha). That land would yield 9,360 kg of barley straw (after losses due to shattering), in addition to the barley grain. That is enough straw to provide supplemental winter feed (i.e. 3 months or 90 days) for a flock of 127 producing ewes and their followers, but the straw must be combined with barley grain in order to meet protein requirements. If the necessary barley grain is subtracted from the total in storage, that only leaves enough grain to support a population of 19 people for one year (at 250 kg/person/year). The annual dairy and meat production of the flock would contribute enough food to feed an additional 20–30 people, leading to a total population of 39–49 (Danti 2000: 131–132, 42–64; I have not provided a detailed description for all of Danti's calculations because I have been unable to completely reconstruct some of these calculations.). Danti's argument about fodder – i.e. about the relative balance struck between the feeding of people and the feeding of animals – is part of a broader argument about the role of pastoralism in northern Mesopotamia during the later fourth and early third millennia BC (Danti 2000: 42–64, 302–306). I will not go into the details here, but I do think that we need to consider, in a more general sense, the possibility that at least some of the grain kept in storage facilities was being used as fodder.

Table 4.30 provides some basic information about the three silos excavated at Tell Hajji Ibrahim. Table 4.31 summarizes Michael Danti's capacity estimates for the silos, and Table 4.32, my own capacity estimates. For my own estimates, I have not re-measured the floor space of the silos – whose interior wall faces are difficult to identify on the published plans (Danti 2000: Figs. 4.3–4.4) – but I have recalculated the capacities using my own depth estimates and my own conversion factor for transforming storage volume (m^3) into grain by weight (kg). To summarize my own calculations, Silo II and Silo III could each have held a maximum of 5.28–7.92 m^3 or 2,346–7,402 kg of threshed barley. Together, they could have held a maximum of 10.56–15.84 m^3 or 4,692–14,804 kg of threshed barley.

Table 4.33 summarizes Danti's estimates for the number of people and/or animals that could have been fed with the grain stored in the silos. Table 4.34 then shows my own estimates for the number of people that could have been fed with the stored grain. In Table 4.35, I have simplified my estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[12] At a 95% level of confidence, my calculations suggest that the storage facilities dating to the late 4th or early 3rd millennium BC at Tell Hajji Ibrahim (i.e. Silos II and III) could have held enough grain to support 19–77 people for one year or 10–39 people for two years.

Danti estimates a population of only 8 people for the Phase A2 settlement at Tell Hajji Ibrahim. This estimate assumes, based on the amount of roofed space, that the Main House (36.49 m^2) and another possible house outside the western Enclosure Wall (roofed space unknown) would each have provided enough living space for four people or one nuclear family

[12] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 4.35 and the "Statistical methods" section in Chapter 3.

(Danti 2000: 114, 144, 302–303). For ease of comparison with other sites, I have also calculated an alternative estimate (25–50 people) based solely on site size (0.25 ha, Danti 2000: 106) and a population density of 100–200 persons/ha.

To calculate the percentage of the (human) population that could have been fed with the grain stored at Tell Hajji Ibrahim, I have first combined the two population estimates into a single range of possibility (8–50 people), and I have then divided this range by the "simplified" number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table 4.36. At a 95% level of confidence, my calculations suggest that the storage facilities at Tell Hajji Ibrahim (Silos II and III) could have held enough grain to support 60–541 % of the population for one year and 30–271 % of the population for two years.

Tell Karrana 3

Located in northern Iraq to the north of Mosul, Tell Karrana 3 was excavated between 1984 and 1986 by a German-Italian team as a part of the Eski Mosul (Saddam) Dam salvage project. The site sat atop a natural hill and, according to the excavators, originally covered an area of approximately 1500-2000 m^2, of which about 600 m^2 were investigated. Four stratigraphic levels (Levels 1-4) were identified, stretching continuously from the final part of the Late Uruk period to the early part of the Ninevite 5 period (Zaccagnini 1993b: 15-18), but the most distinctive architectural remains at the site, the so-called "Parallel Wall Structures," were all found within subphases of Level 3. Although both the form – that is, the form of any hypothetical superstructure that may have lain above the parallel walls – and the function of these structures remain uncertain, there is a strong possibility that they played a role in the storage or drying of grain (Wilhelm and Zaccagnini 1993; Zaccagnini 1993a, 1993b). They will, therefore, be the focus here.

Four Parallel Wall Structures (PWS) were uncovered, two in the earlier Level 3c and two in Level 3b-a (Figures 4.29 and 4.30). Each PWS consisted of 3-4 low, narrow mudbrick walls laid parallel to one another and separated by spaces through which air could have flowed for purposes of ventilation. No evidence for a superstructure (e.g. architectural fragments in the fill surrounding the walls) was preserved, but impressions left on the tops of many of the walls indicate that they were once covered by reed floors. The excavators suggest – very cautiously and without direct supporting evidence – that the parallel wall structures at Karrana (and elsewhere) could once have supported superstructures of packed mud, a construction style that might not leave behind clear archaeological traces but that is regularly used in other parts of the world in the construction of granaries. In any case, the recovery of significant quantities of grain on top of and between the walls allows for the possibility that the PWS were used primarily for the storage – the interpretation favored by the excavators – or drying of grain (Wilhelm and Zaccagnini 1993: 21-26; Zaccagnini 1993a: 29, 32). Table 4.37 provides some basic data about each of the four Parallel Wall Structures.

Before attempting to quantify the storage capabilities represented by the PWS at Karrana, it is important to emphasize the degree of uncertainty involved and the assumptions that I have made. First, we cannot be certain that these structures functioned as grain storage facilities. I am assuming, however, that each group of parallel walls would have served as the foundation for a freestanding, enclosed storage structure, the only surviving remains of the superstructure being the impressions left by a reed (and mud?) floor. Second, the only information that we have about the shape of these hypothesized storage structures is the floor plan provided by the parallel walls. For purposes of calculation, I am assuming that the outer edges of the parallel walls represent the maximum extent of the overlying structure; that each structure was approximately rectangular in plan; and that the walls rose at right angles to the foundations, forming a box-like structure. Third, there is no clear evidence for how the grain would have been stored (e.g. in sacks vs. in bulk). I am assuming that the grain was stored in bulk to a height of 2-3 meters.

Table 4.38 provides a very rough estimate of the potential storage capacity represented by each parallel wall structure, and Table 4.39, an estimate of total storage capacity by stratigraphic level. For the PWS that appear on the published architectural plans, I have provided two different capacity calculations: one that takes into account the actual (often, incomplete) extent of the structure as excavated and one that attempts to estimate the full, original extent of the structure. For those that do not appear on the published plans, I have relied on measurements provided by the excavators and, where necessary, on analogy with other, similar structures. To summarize briefly, the two parallel wall structures (PWS I, II) that date to Level 3c, if used to store threshed barley, could have held a maximum of 32.6–48.9 m^3 or 14,487–45,702 kg (as excavated) or 40.4–66.0 m^3 or 17,954–61,684 kg (estimated full extent). The two parallel wall structures from the earlier phase of Level 3b (PWS III/3, IV) could have held a maximum of 32.4–48.6 m^3 or 14,399–45,422 kg (as excavated) or 32.8–54.6 m^3 or 14,576–51,029 kg (estimated full extent). The two parallel wall structures from the later phase of Level 3b (PWS III/2, IV) could have held a maximum of 34.0–51.0 m^3 or 15,110–47,665 kg (as excavated) or 34.4–57.0 m^3 or 15,287–53,272 kg (estimated full extent). The single parallel wall structure dating to Level 3a could have held a maximum of 19.8–48.9 m^3 or 8,799–45,702 kg (as excavated) or 20.4–50.1 m^3 or 9,066–46,823 kg (estimated full extent).

Table 4.40 provides a detailed look at my estimates for the number of people that could have been fed with the grain stored in these structures. In Table 4.41, I have simplified these estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[13] At a 95% level of confidence, my calculations suggest that the storage facilities uncovered in Levels 3c–3a at Tell Karrana could have held enough grain to support 50–298 people for one year or 25–149 people for two years.

If the site-size estimate provided by the excavators (1500-2000 m^2 = 0.15–0.2 hectares) is correct, Tell Karrana 3 was a very small settlement, and a significant proportion of the site (600 m^2 or 30-40%) has been explored through excavation (Zaccagnini 1993b: 15-16). Throughout Level 3 – that is, the level during which the PWS were in use – the northwestern portion of the excavated area was devoted to "living quarters," but much of the remaining area was occupied by the PWS and (in Levels 3b-a) by several pottery kilns. Each PWS appears to have been placed within an open space, probably a courtyard, but little more can be said about their broader spatial context or their relation to the rest of the settlement (Zaccagnini 1993a: 29, 1993b: 21-26). Since we know that a significant proportion of the settlement was occupied by the PWS, rather than by residential structures, I have calculated two different population estimates: one that ignores the presence of the PWS, assuming that the entire site was devoted to residential space (i.e. 0.15–0.2 ha, 100–200 persons/ha, 15–40 people), and one that subtracts the areas occupied by non-residential structures (PWS, courtyards, and kilns; approximately 400–500 m^2) before calculating population (i.e. 0.15–0.2 ha minus 0.04–0.05 ha = 0.1–0.16 ha, 100–200 persona/ha, 10–32 people).

[13] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 4.41 and the "Statistical methods" section in Chapter 3.

To calculate the percentage of the population that could have been fed with the grain stored at Tell Karrana, I have first combined my two population estimates into a single range (10–40 people), and I have then divided this range by the "simplified" number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table 4.42. At a 95% level of confidence, my calculations suggest that the storage facilities uncovered in Levels 3c–3a could have held enough grain to support 173–2,006 % of the population for one year and 87–1,003 % of the population for two years.

Kazane Höyük

Kazane Höyük is located in southeastern Turkey at the northern end of the Harran plain near Urfa. Around the middle of the third millennium BC, the settlement expanded rapidly from approximately 10 ha to 100 ha, making it one of the largest settlements in northern Mesopotamia (Creekmore 2008: 30). Although a number of possible storage facilities have been identified in mid-late third millennium levels at the site (Creekmore 2008: 252), I will focus on the two best examples (Operation 2, Building Units 4 and 5), both excavated by Andy Creekmore as a part of his dissertation research (Figure 4.31). Operation 2, located in the southeastern part of the city's Outer Town, was opened in order to investigate a large, rectangular building identified using gradiometry. Only the southern half of this building (Building Unit 5) was uncovered, but the excavations also uncovered part of another building (Building Unit 4) immediately to the west. Both buildings appear to have been dedicated, purpose-built storage facilities; see Table 4.43 for a summary of the basic features of each building.

Building Unit 5 or the Eastern Structure was a large, one-room building used to store grain in bulk or, perhaps, in perishable containers. Its walls were 1.25–1.40 meters thick, were preserved to a height of almost one meter, and were built of mudbrick on stone foundations (1 m deep). The interior faces of the walls were covered in plaster, as was the beaten earth floor, which had been laid on a layer of cobblestones. No doorway was uncovered within the excavated area, but the gradiometry may indicate an entrance in the northwestern corner. The fill of the building included burned barley, burned mudbricks, several rodent skeletons (presumably, grain thieves), and some rodent droppings. The barley was two-row, hulled barley and had been cleaned prior to storage (Creekmore 2008: 156–158, 252–254). Combining the excavated evidence with the gradiometry data, Creekmore estimates that the structure would originally have covered an external area of approximately 153 m^2 and an internal area of 100 m^2 (Creekmore 2008: 157). If the barley was stored in bulk to a depth of 1.0–2.0 meters, this would result in a storage capacity of 100–200 m^3. Drawing on conversion values suggested by Hole (1991) and Hunt (1987) – and compiled by Schwartz (1994b: Table 2) – Creekmore estimates that this amount of barley could have fed either 102–349 (100 m^3), 154–524 (150 m^3), or 205–699 (200 m^3) people for one year. He also provides "middle values" of 225 (100 m^3), 339 (150 m^3), and 452 (200 m^3) people by averaging Hole and Hunt's conversion values. According to Creekmore's calculations, if the total population of the city was 10,000–20,000 (100 ha, 100–200 persons/ha), even the lowest of these middle values (i.e. 225 people) would represent 1.3–2.2 % of the population of the city (Creekmore 2008: 256–257, Fig. 7.16). These calculations assume that Building Unit 5 was used to store grain in bulk, but, given the possible existence of a doorway in the unexcavated northwestern corner of the structure, we should also consider the possibility that grain was being stored in perishable containers (e.g. cloth sacks) that have not survived (beyond one possible bag sealing, Creekmore 2008: 253, 276).

Building Unit 4 or the Western Structure was a building made up of a hallway on the west (Space 5), an outdoor space on the east (Space 6), and between these a line of at least three storerooms (Spaces 1, 2, and 3) filled with ceramic storage vessels (Creekmore 2008: 158–163). As excavated, the building covered a total area of 90.36 m^2 (8.17 × 11.06 m) and included 43.75 m^2 of internal space. Drawing on the gradiometry data, however, Creekmore estimates that the entire building – which extended beyond the excavated area – would have measured approximately 10 × 20 m on the exterior and would, therefore, have covered a total area of approximatley 200 m^2. The mudbrick walls of the building were not preserved, but the stone foundations were preserved to a width of 1.10–1.30 m and a height of 10–25 cm above floor level. Where exposed, the floors were covered in a mixture of pebbles and chunks of plaster (Creekmore 2008: 158–163, 257). Ceramic storage vessels, packed tightly together (in some cases, perhaps, originally stacked) and smashed in place, were uncovered in Spaces 1, 2, 3, 4 (an addition to the south), and 6. Many of these vessels were not fully excavated but were articulated, drawn, and photographed in situ. It was not, therefore, possible to reach an exact count of the vessels or an exact measurement of their storage capacity, but Creekmore estimates a total of at least 50 large jars (all of a common Early Bronze Age type), 11 medium/small jars, and one cooking pot (see Table 4.43 for his room-by-room estimates). One large jar in Space 6 contained burned barley, and two jars (one medium, one medium/large) included features suggesting the storage of liquids. Otherwise, the contents of the vessels remain uncertain (Creekmore 2008: 258–260).

To reach a provisional estimate for the total storage capacity of Building Unit 4, Creekmore examined three vessels from Lidar Höyük, all of the same type as the large storage jars in Building Unit 4. The three vessels measured 97.45, 144.42, and 223.40 liters. Using these measurements as a theorietical minimum, middle, and maximum, Creekmore estimates that the 50 large storage jars from Building Unit 4 at Kazane could have held 4,872.5 l (4.87 m^3), 7,221 l (7.22 m^3), or 11,170 l (11.17 m^3). If these 50 vessels were all filled with grain and if 100 m^3 of grain is enough to feed 225 people for one year (see above), then the large storage jars in Building Unit 4 could have held enough grain to feed 2, 3, or 4.96 persons for one year (Creekmore 2008: 260–261).

There seems little reason to doubt Creekmore's interpretation of Building Units 4 and 5 as grain storage facilities, an interpretation that is further supported by a study of potters' marks (found on 10 vessels), clay sealings, and a possible accounting device (Creekmore 2008: 264–278). I am less certain about his suggestion that Building Unit 5 was being used for "ready-access storage" (i.e. short-term storage) and Building 4, for "longer-term storage" (Creekmore 2008: 258, 261), but this is certainly possible. In Table 4.44, I have summarized Creekmore's storage capacity estimates for the two structures. Table 4.45 then shows my own storage capacity estimates. For each building and for the two buildings combined (i.e. "total"), I have produced two different sets of calculations. The first, which is probably more accurate, builds on Creekmore's basic measurements (e.g. for floor space, number of storage jars, etc.) but includes some adjustments (e.g. depth of storage) and employs my own conversion factors (e.g. for converting volume to stored grain). The second is based entirely on my own floor space measurements and, for the sake of argument (e.g. to render the estimates comparable to those produced for other sites), ignores both the gradiometry data (i.e. focusing solely on the excavated area) and the storage jars recovered in situ.

To summarize my own calculations, Building Unit 5 could have held a maximum of 200.0–300.0 m^3 or 88,880–280,380 kg of threshed barley (based on total estimated floor space) or, alternatively, 108.6–162.9 m^3 or 48,262–152,246 kg of threshed barley (based on excavated floor space). Building Unit 4 could have held a maximum of 4.9–11.2 m^3 or 2,178–10,468 kg of threshed barley (based on number of large storage jars per room) or, alternatively, 85.1–127.7 m^3 or 37,818–119,348 kg of threshed barley (based on excavated floor space). Together, Building Units 4 and 5 could have held a maximum of 204.9–311.2 m^3 or 91,058–290,848 kg (based on number of large storage jars for BU 4 and total estimated floors space for BU 5) or, alternatively, 193.7–290.6 m^3 or 86,080–271,595 kg of threshed barley (based on excavated floor space).

Table 4.46 shows Creekmore's estimates for the number of people that could have been fed with the grain stored in Building Units 4 and 5, and Table 4.47 shows my own estimates. In Table 4.48, I have simplified my estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[14] At a 95% level of confidence, my calculations suggest that the storage facilities dating to the mid-late third millennium BC (i.e. Building Units 4 and 5) at Kazane Höyük could have held enough grain to support 204–1,483 people for one year or 102–741 people for two years.

Creekmore estimates a population of 10,000–20,000 for Kazane Höyük during the mid-late third millennium BC. This estimate is based on site size (100 ha) and a population density

[14] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 4.48 and the "Statistical methods" section in Chapter 3.

of 100–200 persons/ha (Creekmore 2008: 257). Since Creekmore's method for estimating population matches my own, I have not provided an alternative estimate.

To calculate the percentage of the population that could have been fed with the grain stored at Kazane Höyük, I have divided the total population estimate (10,000–20,000) by the "simplified" number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table 4.49. At a 95% level of confidence, my calculations suggest that the storage facilities dating to the mid-late third millennium BC (i.e. Building Units 4 and 5) could have held enough grain to support 2–11 % of the population for one year and 1–5 % of the population for two years.

Tell Leilan

Tell Leilan (ancient Shekhna) is located in northeastern Syria, 15 km southeast of Qamishli, near the junction of the Wadi Jarrah and the Wadi Siblah in the eastern part of the Khabur Triangle. The site covers a total area of approximately 90 hectares; this includes a 15 hectare Acropolis and a 75 hectare Lower Town. A team from Yale University, under the direction of Harvey Weiss, has been working at the site since 1978 (see e.g. Weiss 1983; 1985; 1990; 1997b; Weiss et al. 1990; Stein and Wattenmaker 2003; Weiss et al. 2002–2003; Ristvet 2005; Weiss et al. 2012). On the Acropolis, they have uncovered a sequence stretching almost continuously from the late Ubaid period to the early second millennium BC. The most extensive exposures on the Acropolis, however, cover a more restricted timespan between the Late Ninevite 5 period (Leilan IIId, c. 2600 BC) and the reign of Shamshi-Adad (Leilan I, c. 1800

BC). More specially, excavations in the Acropolis NW area have uncovered evidence for a sequence of public buildings and associated structures dating between the Late Ninevite period (Leilan IIId) and the Post-Akkadian period (Leilan IIc). Excavations in the Acropolis NE area have uncovered the remains of a major second-millennium BC temple dating to the reign of Shamshi-Adad (Leilan I). In the Lower Town, the excavators have revealed an occupational sequence that stretches from the Late Ninevite 5 period (Leilan IIId) through the time of Shamshi-Adad and his immediate successors (Leilan I). This includes a third-millenium BC domestic area in the Lower Town South (Leilan IIId–IIb), two exposures of the city wall and associated structures along the northern edge of the site (Operations 4 and CG, Leilan IIId-I), and two second-millennium BC palaces (Lower Town Palace East and Lower Town Palace North, Leilan I). Since 1984, the Tell Leilan Regional Survey project has also been collecting evidence for the occupational history of a much broader region surrounding the site.

The Leilan team has used all of this evidence to produce a compelling narrative of urbanization and state formation, followed by collapse, abandonment, and, ultimately, large-scale resettlement at the site and in the surrounding region. Before examining the evidence for grain storage at Tell Leilan, I will sketch in the broad outlines of this narrative. During the first half of the third millennium BC (Leilan IIIa–IIIc, c. 2900–2600 BC), occupation at Leilan was restricted to the 15-hectare Acropolis, and throughout the region settlements were relatively small (under 10 ha) and widely distributed. Then, during the Leilan IIId period (c. 2600–2400 BC), the settlement at Leilan expanded rapidly from 15 hectares to approxiately 90 hectares, and the surrounding region witnessed a process of settlement nucleation and the emergence of a three- or four-tiered settlement hierarchy (Weiss et al. 1993: 998; Weiss et al. 2002–2003: 59; Ristvet 2005: 59). On the Acropolis at Leilan, domestic structures from the preceding period

(Leilan IIIc) were replaced by a building complex (sometimes called a “palace”) that included a large cultic platform and a collection of storerooms. In the newly established Lower Town, houses were laid out along a centrally planned street system, and a massive city wall was constructed. Although the ceramic repertoire (Ninevite 5) changed little from Leilan IIIc into IIId, a shift in glyptic style indicates contact with southern Mesopotamia and, therefore, a possible catalyst for the urbanization and secondary state formation that took place during this period (Weiss 1990: 209–217; Weiss et al. 1993: 996–998; Weiss 1997b: 342–343; Ristvet et al. 2004: 8–10). The succeeding Leilan IIa period (c. 2400–2350 BC) witnessed the consolidation of state power. On the Acropolis, a fortification wall was constructed around the cultic platform, the storerooms, and other associated structures, and in the Lower Town the centrally planned street system continued to dictate the broad outlines of domestic space. Ceramic production underwent a sudden shift toward standardized, mass-produced vessels, presumably a sign of increasing involvement by central authorities (Weiss and Courty 1993: 138–139; Weiss et al. 1993: 998; Weiss 1997b: 343).

According to the excavators’ account, the Leilan IIb period (c. 2350–2250 BC) was marked by a radical transformation in the nature of settlement across the region – a transformation brought about by conquest and incorporation within the expanding Akkadian empire. This included the redistribution of population on a regional scale (e.g. a sudden reduction in the size of second-tier administrative centers), the introduction of a rationing system based on Akkadian standards of measurement, and the intensified production of agricultural surpluses that could be shipped southward to the imperial heartland (Weiss and Courty 1993: 139–141; Weiss et al. 1993: 998–999; Weiss 1997b: 343–344). On the Acropolis at Leilan, a fortified Akkadian Administrative Building – devoted especially to the processing, storage, and distribution of grain – was built and, across the street, a series of structures (not all contemporary) that included a school room, a house, and a massive Unfinished Building (de Lillis Forrest et al. 2007; Weiss et al. 2012: 166–175). In the Lower Town, the fortifications along the city wall were enlarged substantially, and houses continued to be built along the same street system (Weiss 1990: 201–203; Ristvet et al. 2004: 10). During the ensuing Leilan IIc or post-Akkadian period (c. 2250–2200 BC), settlements across the region were either abandoned or significantly reduced in size as part of a much-debated episode of collapse. Leilan and its excavators have featured prominently in the debates surrounding the nature and timing of this episode (e.g. Weiss and Courty 1993; Weiss et al. 1993; Weiss 1996; Weiss et al. 2012). So far, the only evidence for occupation at Leilan during this period is an isolated four-room house on the Acropolis (Weiss et al. 2012: 163–5). This scant occupation was then followed by a long hiatus and, eventually, resettlement during the Khabur period (c. 1950–1700 BC).

In constructing this scenario of state formation, conquest, and collapse, the excavators have placed particular emphasis on the cereal economy and on the management of agricultural surpluses, whether by an emerging local state or by the intrusive Akkadian empire. Grain storage, therefore, occupies a central role in the discussion. Here, I begin with a level-by-level (IIId, IIa, and IIb) description of the archaeological evidence for grain storage at Tell Leilan, before broadening the perspective to examine some other evidence for the organization of the agricultural economy at the site and in the surrounding region.

During the Leilan IIId period, the cultic platform on the Acropolis was bordered to the west by a collection of rooms that the excavators describe as storage rooms (Weiss 1990: 209; 1997b: 343), storerooms (Weiss et al. 1993: 996; Weiss et al. 2002–2003: 59), or large storerooms (Weiss and Courty 1993: 136). This collection of storerooms on the Acropolis, excavated in 1987 and 1989, is one of the key pieces of evidence cited in support of the argument for state formation and centralized redistribution during the Leilan IIId period (e.g. Weiss 1990: 209–213; Weiss et al. 1993: 996). According to my reading of the published accounts, though, few (if any) of these rooms can be shown to have served unambiguously as dedicated storage spaces. If I understand the publications correctly, numerous whole and fragmentary storage vessels were recovered, but it was primarily the retrieval of a large quantity of seal impressions that led the excavators to interpret these rooms as storerooms.

In total, twelve separate rooms were identified[15]: nine (Building 1, rooms 1-9) on the southern side of a broad courtyard and three (Building 2, rooms 1–3) on the northern side (Figure 4.32; see Table 4.50). Storage vessels (whole, broken, or sherds) were found within Building 1 in rooms 1, 3, and 6 and within Building 2 in room 3 (Calderone and Weiss 2003: 195–197), but I see no evidence that any particular room had been filled or lined with storage vessels (as you might expect in a "storeroom") or that any room had been used for bulk storage. More than 80 clay sealings[16] were recovered from the floors of Building 1, from the courtyard surface, and from an ash layer that marked the end of Leilan IIId. These door and jar sealings had been impressed with locally made seals that bore imitations of motifs drawn from contemporary southern Mesopotamia (ED II–IIIa); according to the excavators, the contrast between these motifs and those employed during preceding periods indicates a new form of contact with

[15] Weiss et al. (2002–2003: 59) indicate that a line of three storerooms, dating to late in the IIId period, was uncovered on the western side of the cultic platform, but it is unclear to me whether these storerooms are among the twelve uncovered in 1987 (Calderone and Weiss 2003: 195–197) or are, in fact, an additional finding from a subsequent excavation season (e.g. earlier versions of the three IIa storerooms uncovered in 1993).

[16] Weiss et al. (1993: 996) cite a total of 188 clay sealings, while other publications cite "more than 80" (Weiss 1990: 209; Calderone and Weiss 2003: 194). It is unclear to me whether 188 is a typo or whether it, perhaps, includes additional sealings recovered during the 1989 season that were not a part of count cited elsewhere.

southern Mesopotamia and suggests a possible catalyst for urbanization and secondary state formation in the north (Weiss et al. 1993: 996–997; Weiss 1997b: 343; Calderone and Weiss 2003: 194; Parayre 2003). According to the excavators, the sealings also signify the emergence of a local, centralized administrative entity that was collecting, storing, and redistributing goods on a large scale. In support of this contention, they cite archaeobotanical evidence indicating that barley, emmer wheat, and durum wheat, already threshed and winnowed, were being delivered to the Acropolis, where they were then further cleaned through sieving and hand sorting, before being placed in storage (Weiss et al. 1993: 997; Wetterstrom 2003: 388–389, 393).

During the Leilan IIa period, a massive, mubrick enclosure wall was constructed around the cultic platform and a series of associated structures on the Acropolis. The twelve Leilan IIId "storerooms" on the western side of the cultic platform were replaced by an expanded courtyard. Two rooms were built into the enclosure wall on the northern side of the courtyard (Calderone and Weiss 2003: 198, Fig. 4), but neither appears to have been devoted specifically to storage. Excavations conducted in 1993 (and 1999?), however, uncovered a line of three storerooms along the western face of the platform (see Table 4.51). As far as I can tell, no plan of these storerooms – which abutted "corridors and a courtyard" (Weiss et al. 2002–2003: 64) – has been published, but my assumption is that they were located on the eastern side of the courtyard uncovered during the 1987 and 1989 seasons (i.e. the same courtyard mentioned earlier in this paragraph). One of the storerooms (Room 1) was a "grain bin" with plastered walls and a thick layer ("liters") of carbonized barley covering the floor. In the other two rooms, grain was stored in ceramic vessels; for example, six large storage vessels were recovered from one of the two rooms (Weiss 1997a: 126; Weiss et al. 2002–2003: 60–61, 64).

At some point during the IIa period, these storerooms caught fire, leading to the preservation of a rich archaeobotanical assemblage. Durum wheat and emmer wheat were recovered, but barley was by far the dominant cereal grain. The grain bin, for example, was filled with clean, charred barley (as well as a very small percentage of emmer wheat), apparently the product of a single harvest. A significant amount of barley was also recovered from the floors of the other two storerooms and from the debris scattered across the adjacent corridors and courtyard. The only exception was a large storage jar that was found intact, filled with emmer wheat and barley in a ratio of 3:1 (as well as a significant amount of emmer chaff), apparently the result of accidental mixing during the conflagration. With the exception of this storage jar and the grain bin, the proportions of grain, chaff, and weeds within the archaeotontical assemblage as a whole suggest that partially cleaned grain – especially barley – was being stored in bulk at the northwestern edge of the Acropolis during the Leilan IIa period (Weiss et al. 2002–2003: 60, 64). At the same time, the recovery of sixty clay sealings and two cylinder seals (Weiss et al. 2002–2003: 60) suggests that, as during the IIId period, access to this area on the western side of the cultic platform was being controlled, perhaps by some form of centralized administrative entity.

In the Lower Town South area, during the 1989 season, several period IIa houses were excavated to the west of the sherd-paved street that was in use from Leilan IIId to IIb. One of these houses (Building 8, Phase 7), which abutted the wall running along the western side of the street, included a "storage room" containing ten ceramic vessels (see Table 4.51; Weiss 1990: 203–204, Abb. 10–11). Although the excavators have not provided details about the types or sizes of vessels found in this room, my guess (based on published photos) is that it was a multi-purpose domestic storage space (i.e. not necessarily a room dedicated solely to grain storage).

Preliminary analysis of the archaeobotanical assemblage from one of the houses in this area indicates a contrast with contemporary levels on the Acropolis. During periods IIa and IIb, the inhabitants of the Lower Town South area appear to have been receiving already cleaned grain (especially barley, with very little chaff), perhaps as rations, which they then supplemented with lentils and a range of wild seeds and fruits (Weiss 1991: 706; Weiss et al. 2002–2003: 64, 66).

During the Leilan IIb period – which can be subdivided into the IIb3 (earliest), IIb2, and IIb1 periods – the earlier building complex on the Acropolis (i.e. the IIId–IIa cultic platform, storerooms, etc.) was replaced by a fortified structure that the excavators call the Akkadian Administrative Building or AAB (IIb2–IIb1; Figure 4.33). This building was bordered to the south by an east-west street and, on the southern side of the street, by a sequence of constructions that included a school room (IIb3), a "house" (IIb2–IIb1), and a large Unfinished Building (IIb2–IIb1) (de Lillis Forrest et al. 2007; Weiss et al. 2002–2003: 61–62; Weiss et al. 2012: 166–175). The AAB, which has only been partially uncovered, was equipped with a 15-meter-high glacis on its northern side and, so far, more than 17 rooms, many dedicated to the storage, processing, and distribution of grain. Of particular interest is the "Granary," a 3 × 3 meter feature, built of mudbrick but lined on the the interior (floor and walls) with baked brick (see Table 4.52). The uppermost course of baked brick, as preserved, included a series of holes that the excavators interpret as flues, designed to promote air circulation within the chamber (Weiss et al. 2012: 166-170, Figs. 5, 6, 9; Smith 2012: 230–231). Lenses of cereal grain ash recovered from the interior of the Granary have revealed a mixture of crops, including two-row barley, emmer wheat, bread wheat, durum wheat, and goat grass (*Aegilops)*. The proportion of chaff and weeds, relative to cereal grains, indicates that the crops had been threshed and winnowed but had not been further cleaned prior to storage. According to Alexia Smith, who analyzed the archaeobotanical material, the mixed nature of the sample and the low level of post-harvest cleaning suggest either that the grain was being used as animal fodder or, perhaps, that it had been collected as tax from multiple farmers, who would have had little incentive to clean the grain further (Smith 2012: 230–231).

The rooms surrounding the Granary also appear to have been devoted largely to activities involving grain. To the east, for example, Room 12 included a large ceramic storage jar, a collection of smaller ceramic vessels, a group of tablet blanks (clay balls and flattened clay balls), a clay wetting pan, and a basalt vessel capable of holding exactly two liters (i.e. approximately 2 *sìla*) of grain. Although relatively few archaeobotanical remains were recovered, the excavators suggest that this room may have played a role in grain distribution (Weiss et al. 2012: 169–170, Figs. 5, 10; Smith 2012: 231). The rooms to the north and south of the Granary, on the other hand, produced abundant evidence for the preparation of grain-based foods. The excavations revealed a total of twelve tannurs, many containing plant remains: two-row barley, bread wheat, durum wheat, and goat grass, as well as smaller amounts of lentil and pea. Many also included dung fragments, whose content – a mixture of wild and cultivated species – suggests that at least some proporttion of the city's grain supply was being fed to livestock as fodder (Weiss et al. 2012: 169, Figs. 5, 8; Smith 2012: 228–229). To round out the picture, a small room in Area 5 preserved evidence of crop processing in the form of grinding stones, food preparation vessels, and concentration of goat grass (*Aegilops*) – normally considered a weed or a fodder plant but, in this case, perhaps indicating intentional production for human consumption (Weiss et al. 2012: Fig. 5; Smith 2012: 231).

Across the street to the south of the Akkadian Administrative Building (Figure 4.34), some evidence for grain storage and processing was also recovered within the courtyard and service rooms – sometimes referred to as "residential rooms" or the Akkadian House – that were built up against the northern and northeastern sides of the Unfinished Building (see Table 4.52; Ristvet et al. 2004: 11; de Lillis Forrest et al. 2007; Weiss et al. 2012: 171–172). During the IIb2 period, most of the area was taken up by a large walled courtyard with a small service room attached to its western edge. To the east of this courtyard (or, perhaps, in the eastern portion of this courtyard?), a conical grain bin was uncovered. Measuring 90 cm in depth and between 70 cm (base) and 40 cm (rim) in diameter, this bin was made of 4 cm-thick clay walls and was apparently lined on the interior (base and walls) with reed matting. The top was left open, as was a small opening 6 cm wide and 5 cm high at floor level. The base of the bin was covered in a 10 cm-thick layer of ash and charcoal, and the rest of the interior was filled with a hard, compact deposit that included cereal grains (de Lillis Forrest et al. 2007: 46–49, Fig. 3, 5). I will assume that the excavators are correct in interpreting this installation as a grain bin, but the description (except, perhaps, the reed mat lining) also seems to match the basic features of a tannur-style bread oven (see e.g. Rova 2013: 122–123, Figs. 2, 4, 5).

During the following IIb1 period, this area was again dominated by a large courtyard and was again being used for the processing and storage of food. For example, a square clay storage bin was found sitting on one of the successive courtyard surfaces (Figure 4.34; see Table 4.52). The bin measured approximately 1.15 × 1.20 m and was preserved to depth of 90 cm (60 cm above ground and 30 cm below ground). The walls, 10–15 cm thick (E and W) and 20 cm thick (N and S), were glazed by firing on the interior and showed further signs of burning. Among other items found within the fill of the bin was a seal impression (L99-27) showing "women in the act of storing goods," but I do not believe that an image of this impression has been published. Other finds from the area included two tannurs, several brick platforms, and 15 sling bullets, as well as some clay sealings and fragments of cuneiform tablets. A jar (L99-181) full of burned grain was also recovered from the street to the north (de Lillis Forrest et al. 2007: 50–52, Fig. 6).

In the Lower Town South area, the wide, sherd-paved street continued in use during the IIb period (Phases 4–5) and was flanked (during Phase 5) by six houses, two on the eastern side (Buildings 1–2) and four on the western side (Buildings 3–6). One of the houses on the western side, Building 6, included a collection of "grain storage bins or bread kilns" (Weiss 1990: 200–203, Abb. 7–9; Weiss 2007). No detailed descriptions or dimensions have been published, but a photograph published on the Tell Leilan Project website does show one of the installations excavated in Room 6 (see Table 4.52; Weiss 2007: Fig. 6). As with the "conical grain bin" uncovered on the Acropolis (see above), it seems possible to me that this installation was a tannur, rather than a storage bin (see e.g. Rova 2013: 122–123, Figs. 2, 4, 5). The archaeobotanical assemblage from the Lower Town South included very low quantities of chaff, which suggests that the inhabitants of this part of the Lower Town – as during the IIa period – were receiving pre-cleaned grain (e.g. as rations) and were supplementing it with pulses and a variety of wild plants (Weiss 1991: 706; Weiss et al. 1993: 998; Weiss et al. 2002–2003: 64, 66; Ristvet 2012: 253).

The excavators have also drawn particular attention to the ubiquity of a particular type of ceramic bowl that appears only during the Leilan IIb period. These so-called "sila bowls" were recovered in large quantities and often in the form of "stacked kiln wasters." At least twenty-seven stacks, each containing between two and sixty-nine vessels, were found, as well as large numbers of sherds. The excavators argue that these simple, straight-sided, wheel-made bowls exhibit a trimodal capacity distribution, with the majority clustering around 1 liter (i.e. 1 *sìla*).

They also go further to suggest that these standardized bowls were manufactured in large quantities by the Akkadian state in order to facilitate the distribution of rations. In other words, they can be taken as "an administrative artifact of Akkadian imperialism" (Senior and Weiss 1992; Weiss and Courty 1993: 140–141; Weiss 1997b: 344; Ristvet et al. 2004: 10–11; Ristvet 2012: 248–249).

In Tables 4.53 and 4.54, I have used data from the published reports to estimate the maximum storage capacity of the storage facilities and possible storage facilities excavated in levels IIId and IIb at Tell Leilan. Unfortunately, in a number of cases (e.g. the three storerooms west of the cultic platform during period IIa) measurements, plans, and other details were not available, making it impossible to reach an estimate of storage capacity. To summarize very briefly, during the Leilan IIId period, the rooms on the Acropolis (NW) to the west of the cultic platform (i.e. Buildings 1 and 2) – if these rooms were used solely or primarily for storage, which seems unlikely – could have held a maximum of 27.7–41.4 m^3 or 12,310–38,692 kg (stratum 16 / 16b) or 47.9–72.3 m^3 or 21,287–67,572 kg (stratum 15e-g / 15b/c) of threshed barley. During the Leilan IIb2 period, the Granary (IIb2–1) located on the Acropolis (NW) within the Akkadian Administrative Building could have held a maximum of 7.2–10.8 m^3 or 3,200–10,094 kg of threshed barley. To the south of the street that ran along the southern side of the Akkadian Administrative Building, the conical grain bin (IIb2) could have held a maximum of 0.2 m^3 or 89–187 kg of threshed barley, and the square, clay storage bin (IIb1) could have held a maximum of 0.9 m^3 or 400–841 kg.

Table 4.55 provides a detailed look at my estimates for the number of people that could have been fed with the grain stored in these structures at Tell Leilan. In Table 4.56, I have simplified these estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[17] At a 95% level of confidence, my calculations suggest that the (possible) storage facilities dating to the Leilan IIId period could have held enough grain to support 53–292 people for one year or 26–146 people for two years. The storage facilities dating to the Leilan IIb2 period, on the other hand, could have held enough grain to support 13–54 people for one year or 7–27 people for two years. The storage facilities dating to the Leilan IIb1 period could have held enough grain to support 14–57 people for one year or 7–28 people for two years.

Weiss estimates a total population of 5,400 for Tell Leilan during the period immediately following its expansion from 15 to 90 hectares. Although this expansion was originally believed to have taken place during the transition from the Leilan III to the Leilan II period, it was later recognized that the expansion had actually occurred during the Leilan IIId period. A population of approximately 5,400 can, therefore, be assumed for the Leilan IIId, IIa, and IIb periods. Weiss reaches this estimate by assuming a population density of 60 persons/ha (i.e. 90 ha × 60 persons/ha); more specifically, he argues that the "otherwise reasonable" (e.g. for smaller settlements) estimate of 100 persons/ha needs to be reduced in order to account for the fact that only 40–60% of the site would have been occupied by domestic structures (Weiss 1986: 95, Note 8). For ease of comparison with other sites, I have also calculated my own estimate (9,000–18,000), based solely on site size and a population density of 100–200 persons/ha (i.e. 90 ha, 100–200 persons/ha, 9,000–18,000 people).

To calculate the percentage of the population that could have been fed with the grain stored at Tell Leilan, I have first combined the two population estimates into a single range of

[17] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 4.56 and the "Statistical methods" section in Chapter 3.

possibility (5,400–18,000), and I have then divided this range by the “simplified” number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table 4.57. At a 95% level of confidence, my calculations suggest that the (possible) storage facilities dating to the Leilan IIId period could have held enough grain to support 0–3 % of the population for one year and 0–2 % of the population for two years. The storage facilities dating to the Leilan IIb2 period, on the other hand, could have held enough grain to support 0–1 % of the population for one year and 0–0 % of the population for two years. The storage facilities dating to the Leilan IIb1 period could have held enough grain to support 0–1 % of the population for one year and 0–0 % of the population for two years.

Tell al-Raqa’i

Tell al-Raqa’i is located in northeastern Syria on the east bank of the Khabur River about 12 km downstream from Hasseke. This small site (0.4–0.5 ha, 7 m high) was excavated between 1986 and 1993 by a joint Dutch-American team (University of Amsterdam and Johns Hopkins University) as a part of the Middle Khabur salvage project. The excavators uncovered some Hellenistic material (Level 1), but it is the extensive remains dating to the early-mid third millennium BC (Levels 2–7) that have received the most attention. In particular, the recovery of a series of well-preserved storage facilities has placed Tell al-Raqa’i – alongside a number of other Middle Khabur sites – at the center of a lively debate over grain storage and its role within the political economy of third-millennium northern Mesopotamia (Schwartz and Curvers 1992, 1993/1994; Schwartz 1994b; Hole 1991, 1999; Pfälzner 2002).

Levels 5-7, dating to the early-to-middle Ninevite 5 period, were only glimpsed in a piecemeal fashion where relatively deep excavation proved feasible. Given the limited nature of the exposures, it is perhaps significant that fragments of five "grill" buildings – that is, sets of parallel walls separated by narrow channels – were uncovered (Grill Buildings 1–5; Figures 4.35–4.38; Schwartz and Curvers 1992: 415–416; 1993/1994: 247–248). These architectural features, which occur at numerous sites across Mesopotamia (e.g. Zaccagnini 1993a: 29–32), are typically assumed to have provided sub-floor ventilation for storage facilities. Table 4.58 provides some basic data about the five grill buildings in Levels 5–7 at Raqa'i.

The succeeding Level 4, dating to the mid-late Ninevite 5 period, was also only partially uncovered but has produced the most extensive evidence for grain storage at the site (Schwartz and Curvers 1992: 406–415; 1993/1994: 249–251; Schwartz 1994b: 23–24). During this period, the south-central part of the mound was dominated by the so-called Rounded Building, a subcircular, mudbrick construction (c. 20 m in diameter) that was filled with an irregular assortment of rooms, many of which appear to have functioned as silos (Figure 4.39). Many of these rooms were doorless, requiring entry from above, and a number had been provided with vaulted ceilings (Figure 4.40). The building also included a series of mudbrick platforms and ovens. Although no grain was found *in situ* in a storage context, the excavators have argued that this building functioned primarily as a locus of grain storage and processing. To the northwest of the Rounded Building, the excavators uncovered further evidence for storage, in this case a complex of six or, perhaps, seven semi-subterranean silos (areas 51–53, 56–59; Figure 4.41). On the northern slope of the mound, fragments of another grill building (Grill Building 6) were uncovered (Figure 4.42; Schwartz and Curvers 1993/1994: 250–251, Abb. 74). Table 4.59

provides some basic data about these various storerooms located inside and outside of the Rounded Building.

Level 3, dating to the end of the Ninevite 5 period, was exposed across an area of 1400 m^2 and offers the most complete architectural plan from the site (Figure 4.43; Curvers and Schwartz 1990: 10-18; Schwartz and Curvers 1992: 401–406, 410–411; 1993/1994: 251–252; Schwartz 1994b: 21–23). The Rounded Building continued in use during this period, but, unfortunately, only the northern part of the building was preserved. The only evidence for storage within the Rounded Building was a possible example of grill architecture, consisting of two freestanding parallel walls, each one brick wide (Curvers and Schwartz 1990: 11–12; Schwartz and Curvers 1993/1994: 252). To the northwest of the Rounded Building, three of the semi-subterranean silos from Level 4 (areas 56–58) continued in use (areas 4–6). Otherwise, the settlement included a collection of two-room domestic structures, an industrial area, and a one-room temple set off from the other buildings by a thin retaining wall. Interestingly, the domestic structures often produced no evidence for dedicated, purpose-built storage facilities, which suggests that the inhabitants of the site may have relied heavily on extra-household storage options (Schwartz and Klucas 1998: 204). Table 4.60 provides some basic data about the storage structures uncovered in Level 3. Although some fragmentary architecture was revealed in the succeeding Level 2 – the final phase of third millennium occupation at the site – no evidence for storage was recovered, and the level was dominated by a series of child burials.

Glenn Schwartz has provided a room-by-room assessment of the storage capacity available in Level 4 at Raqa'i (Schwartz 1994b: Table 1; see Table 4.63, which includes Schwartz's volume estimates, some further additions based on information gleaned from other publications, and my attempt to convert these volumes into quantities of stored grain).

Acknowledging the many uncertainties involved, he has also attempted to correlate this storage capacity with the estimated population of the settlement and with the amount of agricultural land available in the surrounding area. In a nutshell (see Tables 4.61 and 4.62 for details), he argues that the rooms within the Rounded Building and the silos to the northwest would have provided a total of approximately 150 m^3 of bulk storage capacity. Depending on the specific figures employed – and assuming that the storerooms were all filled to maximum capacity – these storerooms could have held enough grain to feed between 154 and 524 people for one year. Schwartz estimates that the total population of the settlement would have been only 30–60 persons (based on site size) or 20–50 persons (based on residential space). According to his argument, therefore, the storage capacity available in the settlement would have far outstripped the needs of the inhabitants. He also argues that the inhabitants would have had access to approximately 300 ha of local agricultural land, more than enough to produce the grain needed to fill the storerooms (Schwartz 1994b: 25–28).

Schwartz's argument has been questioned from a number of angles, but I would like to draw particular attention here to the alternative calculations offered by Peter Pfälzner and Frank Hole. Pfälzner suggests that Schwartz has overestimated the number of people that could have been fed with the stored grain, while also underestimating the total population of the settlement (see Table 4.61). Pfälzner's case rests on a few key points. First, it is unlikely that the silos would all have regularly been filled from floor to ceiling with grain stored in bulk. Second, given the broad range of products registered in the archaeobotanical record from the site, it is unlikely that all of the silos would have been used to store grain. Third, given the number of houses excavated at the site (in Level 3), the average size of a nuclear family, and the likelihood that the southern half of the site has eroded away, the total population of the settlement was probably higher than suggested by Schwartz. Taking these factors into account, Pfälzner estimates that the grain stored at the site could have fed between 38 and 125 people for a year, and he estimates that the total population of the settlement would have been between 85 and 200 people. The upshot – in direct contrast with Schwartz's conclusion – is that the storage facilities at Raqa'i would only have accommodated enough grain to meet the needs of the local population (Pfälzner 2002: 267–271).

Hole raises a number of points of criticism, but, in terms of quantification, he focuses on the (in)ability of the local population to produce the quantity of grain (75,000 kg) needed to fill 150 m^3 of storage space (see Table 4.62). His case rests on three points. First, given the estimates for population (30-50) and agricultural land (300 ha) suggested by Schwartz, there would not have been enough local labor to cultivate the land. Second, drawing on an analysis of satellite images, Hole argues that the inhabitants of the settlement would only have had access to about 47 ha of agricultural land, as opposed to 300 ha. Third, Schwartz's calculations do not allow for the possibility that stored grain could have been used as animal fodder. Taking these factors into account, Hole suggests that Raqa'i and the other Middle Khabur settlements may have functioned as "tethers from which herding people ranged out seasonally" (Hole 1999:280); that is, the storage facilities may have served the needs of pastoralists who were not typically resident at the site but, instead, spent much of their time in the nearby steppe (Hole 1999: 275–280).

Tables 4.63–4.68 present my own attempt to encapsulate the broad ranges of uncertainty that we must take into account when approaching the Tell al-Raqa'i storage facilities from a quantitative perspective. Tables 4.63, 4.64, and 4.65 provide a room-by-room tally of storage capacity at Raqa'i (drawing heavily on Schwartz 1994b: Table 1). I have not attempted to recalculate the room-by-room storage volumes published by Schwartz – for example, by returning to the published plans, as in most of the other examples in this chapter – but I have added some storage facilities that do not appear in his table (e.g. those from Levels 5–7 and 3). I have also introduced a broader range of uncertainty into the conversion from storage volume to stored grain by weight (cf. Schwartz 1994b: 25, Table 2).

To summarize briefly, the five grill buildings uncovered in Levels 5–7, if used to store threshed barley, could have held a maximum of 17.8–36.6 m^3 or 7,910–34,206 kg. The broad range covered by this estimate is, in part, a result of variations in the capacity of Grill Building 4 during its Early, Middle, and Later phases. The Rounded Building uncovered in Level 4 could have held 68.5 m^3 or 30,441–64,020 kg of threshed barley during its earlier phase and 119.7 m^3 or 53,195–111,872 kg during its later phase (after five rooms had possibly been transformed into silos). If the silos in the NW Area and Grill Building 6 are added to these figures for the Rounded Building, the total storage capacity at Tell al-Raqa'i during Level 4 would have been 130.9–134.6 m^3 or 58,172–125,797 kg of threshed barley during the earlier phase and 182.1–185.8 m^3 or 80,925–173,649 kg during the later phase. In the succeeding Level 3, the three silos uncovered in the NW Area could have held 28.0 m^3 or 12,452–26,187 kg of threshed barley.

Table 4.66 provides a detailed look at my estimates for the number of people that could have been fed with the grain stored in these structures. In Table 4.67, I have simplified these estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[18] At a 95% level of confidence, my calculations suggest that the storage facilities uncovered in Levels 5–7 at Tell al-Raqa'i could have held enough grain to

[18] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 4.67 and the "Statistical methods" section in Chapter 3.

support 32–174 people for one year or 16–87 people for two years. The storage facilities uncovered in Level 4, on the other hand, could have held enough grain to support 227–887 people for one year or 114–444 people for two years. The facilities uncovered in Level 3 could have held enough grain to support 43–148 people for one year or 21–74 people for two years.

As mentioned above, several different population estimates have been proposed for Tell al-Raqa'i. Schwartz suggests a population of 30–60 in Level 4 (based on occupied area, i.e. 0.3 ha, 100–200 persons/ha) and 20–50 in Level 3 (based on residential space uncovered, i.e. 200–300 m^2, 6–10 m^2 per person) (Schwartz 1994b: 25–28). Pfälzner suggests a much higher estimate of either 85–102 (based on number of houses excavated, 17 houses, 5–6 persons per house) or 170–200 (if the previous estimate is doubled to account for the fact that half of the settlement may have eroded away) (Pfälzner 2002: 269–271). My own very rough estimate is 40–200 people; this is based solely on site size (0.4–0.5 ha or, if half of the site has eroded away, 0.8–1.0 ha) and a population density of 100–200 persons/ha (i.e. 0.4–1.0 ha, 100–200 persons/ha, 40–200 people).

To calculate the percentage of the population that could have been fed with the grain stored at Tell al-Raqa'i, I have first combined these different population estimates into a single range (20–200 people), and I have then divided this range by the "simplified" number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table 4.68. At a 95% level of confidence, my calculations suggest that the storage facilities uncovered in Levels 5–7 could have held enough grain to support 24–386 % of the population for one year and 12–193 % of the population for two years. The storage facilities uncovered in Level 4, on the other hand, could have held enough grain to support 164–2,091 % of the population for one year and

82–1,046 % of the population for two years. The facilities uncovered in Level 3 could have held enough grain to support 32–446 % of the population for one year and 16–223 % of the population for two years.

Telul eth-Thalathat

Located in northern Iraq, about 50 km west of Mosul, the site of Telul eth-Thalathat consists of four large mounds (Tells I–IV) and several lower mounds. Excavations on Tell II (1956, 1957, 1964) uncovered a stratigraphic sequence stretching from the Hassuna period to the Uruk period, and preliminary excavations on Tell I (1965–1966) revealed a series of buildings with arched ceilings that, according to the excavators, probably post-date the Ninevite 5 period. For present purposes, however, the most interesting discovery at the site was the "granary" excavated on Tell V, a low mound between Tells I and II. Dating to the Ninevite 5 period, this large, freestanding, mudbrick construction appears to have been a purpose-built grain storage facility (Fukai et al. 1974: xxix–xxx, 18–25).

The granary was trapezoidal in plan, measuring 16.4 m (southern side) × 6.3 m (eastern side) × 17.8 m (northern side) × 6.0 m (western side) on its exterior (Figures 4.44 and 4.45; Fukai et al. 1974: 18). It was constructed on a buttressed foundation that included 12 "sleeper walls," each approximately 50 cm in height and 44–46 cm (the length of one brick) in width. The sleeper walls ran parallel to one another (and to the short sides of the building) and were separated from one another by open spaces 60–80 cm in width. Many of these open spaces extended through the northern wall of the building and would, therefore, have provided sub-floor ventilation, a feature shared with many other grain storage facilities in Mesopotamia and beyond

(Fukai et al. 1974: 19–21, 23–25, 62–64). A floor made of reeds covered in clay sat directly on the sleeper walls (Fukai et al. 1974: 21–23). The main walls of the building – that is, the four exterior walls and a series of interior partition walls – were built directly on this floor and appear to have been placed without regard for the location of the sleeper walls beneath.

Nine primary partition walls divided the building's interior space into ten rooms of approximately equal size; some of these rooms were then further subdivided by a series of secondary partition walls that were not bonded to the exterior walls or the primary partition walls (Fukai et al. 1974: 22–23). Two doorways, one on the northern side and one on the southern side, provided access to the building from the exterior, but no interior doorways, allowing communication between rooms, were identified. Both the interior and exterior walls were preserved to a maximum height of 1 m above floor level; it is, therefore, possible that window-like entrances, no longer present at the time of excavation, originally provided direct access to the rooms from the exterior and/or communication between rooms. Access could also, theoretically, have been achieved via rooftop entrances (Fukai et al. 1974: 18, 22–24).

A deposit of carbonized grain and ash, 60 cm deep at the maximum, was recovered *in situ* within room R-1. Beneath this deposit, twelve ceramic vessels – six jars, five bowls, and an "obscure piece" – were found sitting directly on the floor of the room, all filled with carbonized grain (apparently, barley). Carbonized grain was also recovered in room R-16b, and ceramic vessels (e.g. "incised small pots") were found in several other rooms (Fukai et al. 1974: 10–11). In the case of room R-15b, a tiny room entered directly from the doorway on the northern side of the building, the presence of jars and bowls is not problematic, since it is unlikely that grain would have been stored in bulk (that is, without the use of containers) within this small entry room. The other examples of *in situ* ceramic finds, however, cast some doubt on or, at least, complicate the excavators' suggestion (with caveats) that the entire building was devoted to the bulk storage of grain (Fukai et al. 1974: 24–25). This is an important point to keep in mind as we examine the potential storage capacity of the structure.

Citing a total interior floor space of 85 m^2, the excavators argue that the granary could have held a maximum of 85–130 m^3 or 65–100 tons of threshed barley (Table 4.69). This calculation, which explicitly ignores the presence of the interior partition walls, assumes that the grain would have been stored in bulk and that it would have been piled up to a height of 1.3-2 m (Fukai et al. 1974: 24–25). A similar estimate has recently been suggested by Véronique Van der Stede, who argues that the structure could have held 130 m^3 or 65,000 kilos of grain, on the assumption that the grain was piled up to a height of 2 m (Van der Stede 2010: 309). In both cases, it is unclear exactly how the volume was calculated. The values published by Fukai et al., for example, would appear to indicate a volume of 110.5-170 m^3 (i.e. 85 m^2 × 1.3 m and 85 m^2 × 2 m), as opposed to 85–130 m^3. Van der Stede does not provide an estimate for the amount of interior space available for storage, but she does state that the total surface area occupied by the building was 82 m^2 (Van der Stede 2010: 305). With grain piled up uniformly to a height of 2 m, this value would result in a total volume of 164 m^3 (i.e. 82 m^2 × 2 m), as opposed to 130 m^3. Perhaps the lower value takes into account the space occupied by the interior and exterior walls of the building and, therefore, unavailable for storage. Table 4.69 shows the estimates of total floor space, depth of stored grain, and total storage capacity (volume and weight) published by Fukai et al. (1974) and Van der Stede (2010), as well as my own attempt to recalculate the capacities (volume) using the area and depth values provided in each publication.

Tables 4.70–4.73 show my own measurements of available floor space, based on the plan published by Fukai et al. (1974: Pl. XLI), my calculations of bulk storage capacity, and my estimate for the number of people that could have been supported using the grain stored in the granary at Telul eth-Thalathat. I see no clear means of estimating the depth of stored grain; as for other sites, I have, therefore, estimated a maximum depth of 2.0–3.0 m, which is a good bit higher than the 1.3–2.0 m suggested by Fukai et al. (1974: 25). The first table (Table 4.70) provides a simple estimate of the building's total volume – disregarding the presence of interior walls – and the amount of grain that could have been stored in bulk within this space. The second table (Table 4.71) provides a room-by-room estimate of the building's bulk storage capacity, taking into account only the primary interior partition walls – that is, the nine walls that divided the structure into ten rooms of approximately equal size. Two different totals are provided: one that includes all rooms in the building and one that includes all rooms except the two that could be entered through doorways from the exterior (which are less likely to have been used for bulk storage). The third table (Table 4.72) provides a room-by-room estimate of the building's bulk storage capacity, taking into account both the primary and the secondary interior partition walls. The assumption here is that the secondary partition walls – which were not bonded to the other walls – may represent a secondary phase in the use of the building that should be distinguished from the phase presented in Table 4.71. Again, two different totals are provided: one that includes all rooms in the building and one that includes all rooms except the two that could be entered through doorways from the exterior (both of which were significantly reduced in size by the secondary partition walls).

To summarize very briefly, if we disregard the presence of the interior partition walls (as the excavators do in their own calculations), the granary at Telul eth-Thalathat could have held a maximum of 110.9–170.6 m^3 or 49,284–159,443 kg of threshed barley. If we do take into account the presence of the interior partition walls – the more realistic assumption – then we can calculate capacity estimates for an earlier phase (primary partition walls only) and a later phase (primary and secondary partition walls). During the earlier phase, the granary could have held a maximum of 96.1–147.8 m^3 or 42,707–138,134 kg (including all rooms) or, more realistically, 75.7–116.4 m^3 or 33,641–108,787 kg (excluding rooms with exterior doorways). During the later phase, the granary could have held a maximum of 83.1–127.8 m^3 or 36,930–119,442 kg (including all rooms) or, more realistically, 79.7–122.6 m^3 or 35,419–114,582 kg (excluding rooms with exterior doorways).

Table 4.73 provides a detailed look at my estimates for the number of people that could have been fed with the grain stored in the granary. In Table 4.74, I have simplified these estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[19] At a 95% level of confidence, my calculations suggest that the granary at Telul eth-Thalathat could have held enough grain to support 185–1,135 people for one year or 93–567 people for two years.

Unfortunately, we know very little about the remainder of the contemporary settlement at Telul eth-Thalathat. Neither the kilns located adjacent to the granary nor the nearby "round construction," which also contained a large kiln, could be assigned a precise date, but they may have been approximately contemporary. Otherwise, a series of trial trenches on Tells I, II, and III and also surface scatters on the western slope of Tell V and in between Tells III and IV all revealed evidence for Ninevite 5 occupation (Fukai et al. 1974: 62-63). It is likely, therefore, that the Ninevite 5 settlement was extensive, but a more precise characterization of the nature of the settlement during this period and, more specifically, during the use-life of the granary will

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[19] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 4.74 and the "Statistical methods" section in Chapter 3.

have to await future work at the site. Given this uncertainty, I have not been able to calculate a population estimate, and I have not, therefore, been able to estimate the percentage of the population that could have been fed using the grain stored in the granary.

Chapter 5

Southern Mesopotamia

Fara

Fara (ancient Shuruppak) is located in southern Iraq, midway between Baghdad and the head of the Gulf. Although it now sits near the center of the alluvial plain, approximately equidistant from the Tigris and the Euphrates, the city once lay directly on a major branch of the Euphrates. The site covers a total area of approximately 220 ha and rises to a maximum of 10 m above plain level (Martin 1988: 12–14). Excavations were conducted at Fara by the Deutsche Orient-Gesellschaft in 1902–1903 (Heinrich 1931) and by the University of Pennsylvania in 1931. The University of Pennsylvania excavations were published long after the fact by Harriet Martin, who also revisited some of the original DOG records and conducted a surface survey at the site (Martin 1972; 1983; 1988). As reconstructed by Martin, the site appears to have been occupied continuously from the Jemdet Nasr or Early Dynastic 1 period – at which point it was already a large (c. 70 ha) settlement – through the Ur III period. There was also some evidence for very sparse occupation during the succeeding Isin-Larsa period and for occupation on several small, adjacent mounds during the 18th century AD (Martin 1988: 113–117). The site is best known as the source of an important corpus of cuneiform documents dating to the ED III period (e.g. Pomponio and Visicato 1994; Visicato 1995, 2001; Krebernik 1998; Martin et al. 2001), but the broader set of physical remains uncovered at the site – e.g. architecture, ceramics, and clay sealings – has also produced valuable insights into the organization and evolution of urban life during the Early Dynastic period (e.g. Martin 1982, 1988; Matthews 1991; Starzmann 2007, 2008). Here, I will focus on the evidence for storage at Fara, beginning with a unique collection of underground silos – I follow Martin in using the term "silo," even if the function of these structures is not completely certain – and then turning to some written evidence for grain storage facilities and grain transfers.

So far, 32 silos have been identified at Fara. These massive, underground, cylindrical constructions were scattered widely across the site but were most common in the northern third of the mound (Figure 5.1; Heinrich 1931: 8; Martin 1988: 110, Fig. 33). The DOG site map shows 30 of these *Ziegelrundbauten* or *Rundkeller*, which are designated by large circles and can be distinguished from what were probably drains, represented by approximately 40 smaller circles (Heinrich 1931: Tafel 1; Martin 1972: 85–86; 1988: 42, 110). The DOG team excavated nine out of the 30 silos but left little documentation beyond some general comments, a rather sparse record of artifactual finds, occasional architectural observations, and several architectural drawings (Andrae 1903: 8-9; Heinrich 1931: 8-9; Martin 1988: 110-112). The University of Pennsylvania team later excavated two more silos (Pit I and Pit II), neither of which had appeared on the DOG map. Only Pit I (Figures 5.2 and 5.3) was illustrated and described in detail by the excavators, but Martin was able to piece together information about the contents of both silos (Martin 1972: 85-95, Figs. 16, 29; 1988: 42-46, Figs. 12-13, 20a-b, Plates XIII and XIVa-b). For details about the silos excavated by the DOG and the University of Pennsylvania, see Table 5.1.

As a general rule, the silos were either round or elliptical in plan, and some narrowed toward the top. Their walls were built of rectangular, baked, plano-convex bricks, arranged in two or three concentric rings (i.e. the walls were 2–3 bricks thick). Within each ring, the bricks were laid in alternating groups of 2–3 oblique courses (in a herringbone pattern) and 2–3 horizontal courses. The bricks were set into mud mortar, and the walls were covered in mud plaster. In some cases (e.g. Pit I), a low bench ran around the base of the silo, but no traces of floors were recovered. Although some evidence for roofing was recovered, the uppermost parts of the silos did not survive intact. Brick rubble found in the fill layers of some silos (e.g. in Pit I) can probably be interpreted as the collapsed remains of the upper portions of the original silo walls, but it is unclear exactly how the silos would have been covered and accessed (Heinrich 1931: 8-9, Tafel 3-4; Martin 1988: 42-47, 110-112, Fig. 20a-b).

When it comes to silo size, there seems to be some disagreement. The DOG reports cite a wide range of variability (2.0–6.5 m) in silo diameter and maintain that some silos reached an absolute depth of 4 m below modern plain level (saying nothing about the depth of the silos themselves) (Andrae 1903: 8; Heinrich 1931: 8). Erich Schmidt, director of the University of Pennsylvania team, records a base diameter of 4.0–3.3 m (E-W) and 4.2–3.5 m (N-S) (perhaps taking the bench into account?), an interior rim diameter of 3.7–3.82 m, and an original depth of 8.0 m (7.08 m, as excavated) for Pit I (quoted in Martin 1988: 42-43). Martin, on the other hand, estimates that the excavated silos were (on average?) approximately 4 m in diameter and 10 m deep, resulting in a maximum capacity of 125 m^3 for each silo (Martin 1988: 47). This uncertainty regarding silo size and, therefore, capacity has been taken into account in my calculations.

As mentioned above, the function of these “silos” is not completely certain. A wide range of objects – pottery, cuneiform tablets, cylinder seals, shells, beads, human burials, animal bones, date pits, etc. – was recovered from successive fill layers within the silos, but these layers all appear to have been deposited after the primary use-life of the structures (Martin 1988: 42–46, 110–112). If they were silos, no clearly *in situ* remains of the goods that they once held have been found, though Martin (1988: 47) suggests that the date seeds, wood, and straw found at the bottom of Pit I could possibly be remnants of the original contents. Andrae proposed that the round structures might have been wells or drainage shafts (1903: 8–9), but the more general concensus is that they probably were, indeed, silos (Heinrich 1931: 9; Martin 1988: 47). This does not mean that they were all used for storing grain, but, for purposes of calculation, I will assume that this was the case. It terms of dating, I will assume, following Martin (1988: 46–47), that the silos were all built during the ED IIIa period and were then gradually filled in beginning during the ED IIIb period.

More than a thousand cuneiform tablets and tablet fragments were recovered at Fara during the DOG and University of Pennsylvania excavations (Martin 2001: 3). Many of these tablets record the transfer of grain into and out of institutional storage facilities, but the storage facilities themselves are only rarely specified by name (or by the official responsible for their operation). Five storehouses (*ganun*), in particular, have been identified in the documentation: *ganun-mah*, *ganun gúr-gúr*, *ganun* $^{(d)}$*ŠEŠ.KI-na*, *ganun me-pa-è*, and *ganun en* (Visicato 1993: 93; Pomponio and Visicato 1994: 205). It is difficult to say anything definitive about the form or the size of these storehouses (cf. Martin 1988: 47; Pomponio and Visicato 1994: 205, note 70), but, in a few cases, the tablets do reference the quantities of grain either withdrawn from or deposited into them. For example, one brief text (WF 55) records the delivery of barley – to be used as seed grain – from two storehouses: 4,482 liters (11 *gur-mah*, 2 *bariga*)[1] from the *ganun-*

[1] It is important to point out that there is disagreement about how the Early Dyanstic units of measurement should be converted to liters. In this paragraph, I have followed Visicato (1993: 83) and Ellison (1981: 38) in assuming that 1 *sìla* equals 0.83 liters, but see Pomponio and Visicato (1994: 32, note 4) for a discussion of the wide range of possibilities. I have also relied on the following equivalencies: 1 *gur-mah* = 480 *sìla* and 1 *bariga* = 60 *sìla*. The four conversions were conducted as follows: 1) 11 *gur-mah* 2 *bariga* = 5,400 *sìla* = 4,482 liters; 2) 9 ½ *gur-mah* 2 *bariga* = 4,680 *sìla* =

mah and 3,884 liters (9 ½ *gur-mah*, 2 *bariga*) from the *ganun gúr-gúr* (Pomponio and Visicato 1994: 205). A large number of tablets provide similar details about the size (and the destination) of grain deliveries but, unfortunately, without a reference to the storehouse(s) from which the grain was disbursed. For example, two texts (WF 84 and WF 85) document the allocation of very large quantities of barley – a total of 252,586 liters (634 *gur-mah*) and 441,278 liters (1,107 ½ *gur-mah*, 1 *bariga*) – to a series of officials, who may have then redistributed the barley as rations (Pomponio and Visicato 1994: 177–181; Visicato 1995: 144).

In Tables 5.2, 5.3, and 5.4, I have attempted to bring this written evidence into dialogue with the archaeological evidence for storage at Fara. The first step is to achieve an estimate for both the individual and the combined storage capacity represented by the silos identified archaeologically at the site. As mentioned above, Martin estimates that each silo –measuring, on average, 4 m in diameter and 10 m deep – would have held a maximum of 125 m^3 of grain (Martin 1988: 47). Citing Martin, Visicato estimates an average silo capacity of 100 m^3 and a maximum of 125 m^3 (Visicato 1993: 83; Pomponio and Visicato 1994: 205, note 70); it is unclear to me how the lower value of 100 m^3 was reached, but this is the value that Visicato employs for his own calculations. As Table 5.2 demonstrates, the difference between an average silo capacity of 100 m^3 and 125 m^3 is significant when these values are used to calculate an estimate for site-wide storage capacity (3,200 m^3 vs. 4,000 m^3). In Table 5.2, I have also included the silo measurements provided by Heinrich (1931: 8) and Schmidt (Martin 1988: 43) and my own estimate of storage capacity (1 silo and 32 silos). Unfortunately, there is no good way to incorporate the range of silo diameters (2.0–6.5 m) indicated in the DOG reports within

3,884.4 liters; 3) 634 *gur-mah* = 304,320 *sìla* = 252,585.6 liters; 4) 1,107 ½ *gur-mah* 1 *bariga* = 531,660 *sìla* = 441,277.8 liters.

this capacity estimate (e.g. because no information is provided about the frequency of specific diameters); instead, I have simply calculated an average diameter (4.25 m). As far as I am aware, the only measurement of silo depth available is that provided by Schmidt for Pit I (7.08 as excavated, 8 m estimated original depth); I have, therefore, assumed a depth of 8 m for all of the silos, but this should be considered very tentative.

To summarize very briefly, if we use Martin's estimate for the average volume of a silo (125 m^3), a single silo could have held a maximum of 55,550–116,825 kg of threshed barley, and the 32 known silos could have held a maximum of 4,000 m^3 or 1,777,600–3,738,400 kg of threshed barley. If we use Visicato's estimate (100 m^3), on the other hand, a single silo could have held a maximum of 44,440–93,460 kg of threshed barley, and the 32 known silos could have held a maximum of 1,422,080–2,990,720 kg of threshed barley. If we use my own estimate for average silo volume (113.4 m^3), which falls between those of Martin and Visicato, a single silo could have held a maximum of 50,395–105,984 kg of threshed barley, and the 32 known silos could have held a maximum of 1,612,639–3,391,476 kg of threshed barley.

Table 5.3 provides a detailed look at my estimates for the total number of people that could have been fed using the grain stored in a single silo and in the full complement of 32 silos. To draw attention to the significant uncertainty involved – and its potential impact on our interpretations – I have shown three sets of calculations: one using the average silo capacity suggested by Martin (125 m^3), one using the value employed by Visicato (100 m^3), and one using my own estimate (113.4 m^3). Given the absence of actual measurements for most of the silos, these calculations should all be taken with a grain of salt. It is also important to bear in mind that more silos probably still await discovery; the total storage capacity available at the site may have exceeded the combined capacity of the 32 known silos by a significant margin. In

Table 5.4, I have simplified my number-of-people-fed estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[2] At a 95% level of confidence, my calculations suggest that the 32 silos at Fara could have held enough grain to support 5,391–19,582 people for one year or 2,695–9,791 people for two years.

Martin estimates a population of 15,000–30,000 for Fara during the ED III period. According to her argument, the site covers a total area of 220 hectares and could, at a population density of 125–250 persons/ha (citing Adams 1965: 24–25), have supported a population of 27,500–55,000. She reduces this estimate, however, in order to account for the fact that only approximately 100 ha of the site appear to have been occupied during the ED III period and to allow for the possible existence of open spaces within the city. To facilitate comparison with other sites, I have also calculated an alternative population estimate (10,000–20,000), which assumes a site size of 100 ha and a population density of 100–200 persons/ha.

To calculate the percentage of the population that could have been fed with the grain stored at Fara, I have first combined the two different population estimates into a single range (10,000–30,000 people), and I have then divided this range by the "simplified" number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table 5.5. At a 95% level of confidence, my calculations suggest that the 32 silos at Fara could have held enough grain to support 26–144 % of the population for one year and 13–72 % of the population for two years.

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[2] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 5.4 and the "Statistical methods" section in Chapter 3.

Can we establish a relationship between the archaeologically recovered silos and the *ganun* mentioned in the written record? Martin and Visicato have both suggested that the storehouses mentioned in the texts might have been larger facilities, each comprising multiple silos. Martin bases her argument on the fact that one text (WF 55) mentions a *gur₇* or silo with a capacity of 2,400 *gur-mah*, which is well beyond the capacity of any single excavated silo (Martin 1988: 47). While her general argument (1 storehouse = 4 excavated silos) could be correct, it seems to be based on a misreading of the text in question – or, at least, a reading that conflicts with that offered more recently by Pomponio and Visicato (1994: 205). According to the latter, the text records a delivery of barley from two *ganun* (see above) of unknown capacity, and it does not reference a *gur₇*. Visicato bases his own argument, not on a comparison of storage capacities but, rather, on a comparison between the number of silos identified archaeologically (32) and the number of *ganun* appearing in the documentary record (5). If these numbers actually reflect past reality (i.e. if they actually represent the full complement of grain storage facilities at the site) – to me, a highly dubious proposition – then each *ganun* would have included 5–6 of the archaeologically recovered silos (Pomponio and Visicato 1994: 205, note 70).

Even if we cannot make a direct connection between the archaeological and the written evidence for storage at Fara, it is still worth considering the broader implications of the quantitative data. Visicato, for example, has made an interesting argument that ties together the archaeologically recovered silos, a series of grain transfer documents, and Martin's population estimates (Visicato 1993: 83–85). He first calculates the total storage capacity of the 32 silos as approximatley 8,000 *gur* of barley, the equivalent of 3.5 million average daily rations (implying a ration of 1.1 *sìla* per person per day) or enough barley to feed 20,000 people for a period of six months (after which time the silos could be refilled with barley from the next harvest). He then calculates the total quantity of barley transacted within the administrative archives from the site as approximately 7,000 *gur*, a figure that corresponds well with the 8,000 *gur* of silo capacity. This correspondence is interesting because Visicato has also argued that most of the transactions involving barley – that is, the transactions that he added up to reach the figure of 7,000 *gur* – can be dated to a period of no more than six months, the length of time between harvests. Furthermore, he points out that a population of 20,000 (i.e. the number of people that could be fed for six months with the grain stored in the silos) fits well within the total population estimate of 15,000–30,000 suggested by Martin (1988: 127). If I understand Visicato's argument correctly, the upshot is, first, that the grain stored in the silos would potentially have been enough to feed the entire population of the city for a period of six months and, second, that this supply of grain was fully under the control of the city's administrative apparatus. The implication, even if not directly stated, is that the entire population of the city was supported by a centrally managed system of staple redistribution.

If correct, this would be a significant finding, but I think we should be skeptical for a number of reasons. First, it is extremely unlikely that the available silo capacity in the city was so closely matched with the agricultural productivity of the fields that the entire complement of silos would have regularly been filled up to the brim following the harvest and then completely emptied in preparation for the next harvest. The more likely scenario is that the maximum storage capacity was seldom reached, perhaps only in exceptionally productive years. Second, it is extremely unlikely that the full volume of grain stored in the silos would have been earmarked for immediate distribution as regular, daily rations. Indeed, one of the texts examined above (WF 55) documents the withdrawal of seed-grain (i.e. grain that was not being used for rations) from two storehouses. At the same time, I think that we must assume that some quantity of grain was being stored as a buffer against future crisis – probably at least enough to cover an additional six months, if not one or two years. Third, there is a significant level of uncertainty involved in some of the values that Visicato employs; even small adjustments in these values can significantly impact the broader implications of the calculation.

Table 5.6 shows Visicato's calculations, as well as my own attempt to produce comparable figures. In both cases, I have included estimates for the number of people that could have been fed with rations for a period of six months, one year, or two years, and I have also converted these values into percentages of the total population of the settlement (10,000–30,000, see above).[3] A few key points emerge from these calculations. Most important, I think, is the issue of time. If the grain stored in the silos was intended to provide sustenance for the population over a period of only six months (i.e. Visicato's assumption), then both sets of calculations indicate that the grain might have been enough to support the entire population of the settlement (perhaps even two times the population). In both cases, it also might *not* have been enough; Visicato's numbers suggest that the grain was enough to feed 67–200 % of the population for six months, while mine suggest 22–219 %. If the grain was intended to provide support for a period of one year, both calculations again indicate that the grain might have been enough to support the entire population of the settlement (but only barely); the ranges are 33–100 % (Visicato) and 11–110 % (Paulette). If the grain was intended to provide support for a period of two years, both calculations suggest that only approximately half of the population could have

[3] Visicato himself only calculated the number of people that could be fed for a six-month period (i.e. not one year or two years), and he did not explicitly discuss the percentage of the population that could have been fed. Where I have expanded on his calculations, the values in the table are shown in italics, rather than normal type.

been fed and perhaps much less than half; the ranges are 17–50 % (Visicato) and 5–55 % (Paulette). To my mind, two years is likely to be closest to the truth. Visicato may be correct in assuming that the silos would have been completely emptied over the course of the six-month period between harvests, but I think it is much more likely that the goal would have been to keep enough grain on hand for the current year and, as a buffer against crisis, for the following year. The other issue that I would like to highlight is the wide range of uncertainty that emerges from these calculations. If there is uncertainty about specific values (e.g. an average silo size of 100 m^3 vs. 125 m^3 or a population of 10,000 vs. 30,000) and if we attempt to incorporate this uncertainty within our calculations, the results may cover a very broad range of possibility (e.g. enough grain to feed 22–219 % of the population). While we should, of course, work to reduce this uncertainty, where possible, the real challenge is developing interpretations that can stand up, even when faced with significant ambiguity.

Tell Gubba

Tell Gubba is located in the Hamrin valley of east-central Iraq, approximately 19 km southwest of Jalula. The site is roughly circular, measures approximately 80 meters in diameter, and rises approximately 8 meters above plain level. Excavations were conducted at Tell Gubba by a Japanese team from Kokushikan University between 1977 and 1980 as a part of the Hamrin Dam Salvage Project (Fujii 1981). The excavators uncovered evidence for seven distinct stratigraphic levels, dating to the Jemdet Nasr (Level VII), Early Dynastic (Levels VI–III), Achaemenid (Level II), and Islamic (Level I) periods (Odani and Ii 1981). Their most striking discovery was a large circular building in Level VII (Jemdet Nasr period), but the clearest evidence for grain storage at the site comes from the succeeding Levels VI–IIIa (Early Dynastic I period), when the round building was replaced by several one-room houses and a dense collection of small-scale storage structures. The function of this small site – especially during the life of the circular building – bas been a subject of much debate, often revolving around the evidence (or lack of evidence) for storage. I will begin here with a discussion of the Jemdet Nasr-period round building, before turning to the very different architectural remains that succeeded it during the Early Dynastic I period.

In Level VII (Jemdet Nasr period), virtually the entire surface of the site was covered by a large round building that had been constructed on virgin soil (Figure 5.4). According to the excavators, this structure was built in at least three distinct phases (Levels VIId–b; but cf. e.g. Margueron 1999: 27–28). During the first phase (VIId), a circular platform (CW1/2), 5 meters in diameter and 3.5 meters high, was erected at the center of the structure. The platform was surmounted by a fireplace, was pierced by a corbel-vaulted tunnel (0.9 m wide, 1.5 m high), and was surrounded by two concentric circular walls (CW3, CW4). These walls were joined to one another and to the platform to form two corbel-vaulted corridors (C2, C3), each of which provided access to a stairway leading upward. The building could be entered through three doorways: one to the southeast, one to the west, and one to the north. The northern doorway was accessed by means of a horseshoe-shaped projection that extended northward from the outer wall (CW4) of the building. A circular moat was dug around the building either during this first phase or the following phase. During the second phase (VIIc), a revetment (CW4') was added to the previous outer wall (CW4), and a new, oval-shaped wall (CW5) was built around the entire structure. Wall CW4' was joined to the new outer wall (CW5) to create another corbel-vaulted corridor (C4), which could be entered from the outside through three doorways and which provided access to three stairways leading upward. Another horshoe-shaped projection – this time, surrounding a well and only accessible from the interior – was also added on the northern side of the structure. During the third phase (Level VIIb), the ground-plan of the structure was further extended by the construction of two more oval walls (CW6, CW7), two unroofed[4] corridors (C5, C6), and a wide circular wall (C8, with associated rooms) beyond the moat. The excavators have not provided much information about Level VIIa (e.g. Odani and Ii 1981: 145), but a plan published by Ii (1993: Fig. 1) seems to suggest that a series of small structures, at least superficically analogous to the "granaries" constructed in Levels VI–IV (see below), were built within the area previously occupied by the moat and also within corridor C6 (Figure 5.5).

According to the excavators, a series of pits beneath the floor in corridors C3 and C4 may have been used for grain storage. These pits measured 0.6–1.2 meters in diameter and 0.6–1.5 meters in depth, and they were shaped "like a flask with a small mouth and a large bottom" (Odani and Ii 1981: 145). The walls and/or floors of some of the pits were lined – according to the publication "piled up" – with mudbrick. The pits were apparently spaced at regular intervals and were concentrated especially in the vicinity of doorways. Unfortunately, these particular flask-shaped pits or "bell-shaped pits" (the more common term for pits of this shape) are not clearly distinguished from other pits on the published plans (e.g. Odani and Ii 1981: Fig. 5–7, 64; Ii 1993: Fig. 1), and no other illustrations or more detailed descriptions have been provided. One of the published plans (Figure 5.6; Odani and Ii 1981: Fig. 5) shows thirteen features marked with a "P" (presumably, for "pit"); for the sake of argument, I have assumed that all of these features were flask-shaped pits, and I have attempted to estimate a range of possible volumes

[4] Others (e.g. Margueron 1999: 27; Émery 2006: 149) have argued, to the contrary, that corridors C5 and C6 were probably roofed.

(see Table 5.9). The excavators also recovered “some big coarse jars standing on the floors” of the corridors and carbonized wheat grains scatttered “[a]ll through the levels of the corridors” (Odani and Ii 1981: 146). They suggest that the corridors themselves – not just the pits below the corridors – were being used at least partly for grain storage. Unfortunately, very little information about the form, size, frequency, and distribution of the large, coarse storage vessels has been published, but the excavators do indicate that many had been impressed around the rim with cylinder seals or other patterns prior to firing (Fujii 1981: Fig. 22, Pl. 13; Odani and Ii 1981: 147, 160). As mentioned above, a plan of Level VIIa (Jemdet Nasr / ED I transition) published by Ii (Figure 5.5; Ii 1993: Fig. 1) also seems to indicate that agglomerations of small rooms, many with parallel wall foundations, had been built within the area previously occupied by the moat and within corridor C6. As far as I can tell, no further information has been provided about these structures, but I have assumed that they were “granaries” like those that would be built during the succeeding Levels VI–IV. Table 5.7 provides some basic information about the pits, corridors, and rooms that may have been used for storing grain within the Level VII round building.

A number of efforts have been made to reconstruct the original appearance of the round building at Tell Gubba (e.g. Trümpelmann 1989: 70–74, Abb. 6; Margueron 1999: 20–39, Fig. 7–8; Émery 2006: 147–152, Fig. 10), and a number of theories have been proposed to explain its purported function. Some see the structure as a fortified, military outpost – in fact, one in a series of such outposts – set up by a polity in the Diyala or elsewhere in Mesopotamia (e.g. Gibson 1981a: 157–161; 1986: 501); others see it as a “headman’s house” (Crawford 1991: 81–82) or, perhaps, the equivalent of a medieval castle sitting astride an important communication route (Margueron 1999: 38–39). Several authors have drawn particular attention to storage as the building's primary function. Trümpelmann, for example, imagines – with little supporting evidence (see e.g. Van der Stede 2010: 290–291) – that the central core of the round building formed the base for a massive cylindrical silo, measuring approximately 3.5 meters in diameter (on the interior, 5.0 m on the exterior) and 7.0–8.0 meters in height. He likens the round building as a whole to one of the multi-purpose warehouses described by Deimel in his study of the pre-Sargonic texts from Girsu (Trümpelmann 1989: 70–74; e.g. Deimel 1931: 84–85). More recently, Renette has argued that the monumental round buildings at Tell Gubba and elsewhere were food storage facilities set up by mobile communities operating along the piedmont of the Zagros. He points, in particular, to the "dark, secluded rooms and/or corridors" as spaces conducive to storage, and he suggests that the sealed storage vessels would have marked the property of particular households – for example, grain and other foodstuffs that could be accessed during periodic visits to the site (Renette 2009: 82–84, 92–94). Given the data currently available, I see no clear means of adjudicating between these competing theories, but I have attempted to contribute some basic quantitative data to the discussion (see below, Table 5.9).

In Level VIIa, the round building was destroyed in a fire. Although the core of the structure continued to serve as a central focus for the settlement, the rest of the building was replaced in Levels VI–IV (Early Dynastic I period) by a radially organized agglomeration of smaller structures (Figure 5.7). Many of these structures appear to have been purpose-built granaries: small rooms (1–3 m on a side) with walls 15–20 cm thick, organized in linear groupings of between one and eight rooms (Figure 5.8; Table 5.8). According to the excavators, most of the granaries, which were grouped around a series of larger, one-room structures, had been provided with foundations that allowed for subfloor ventilation. Usually, these foundations took the form of parallel walls separated by open spaces (10–25 cm wide), which were generally left open on both ends but could also be closed off with pieces of mudbrick. Two of these structures with parallel wall foundations are illustrated in plan and section in the publication (Figure 5.9; Odani and Ii 1981: Fig. 9). In other cases, the rooms had been laid on a foundation the "upper side of which is divided into four or six" (Odani and Ii 1981: 148), but no illustrations of this type of foundation are provided in the publication. The only direct evidence for the goods originally stored in these well-ventilated, cellular structures was "some" carbonized wheat found in the vicinity (Odani and Ii 1981: 148). The total number of granary structures decreased from Level VI into Level IV, as the granaries were replaced by dwellings (Odani and Ii 1981: 149). According to an early report, more than 30 of the small rooms (cf. Odani and Ii 1981: Fig. 8, which seems to show c. 68 rooms, perhaps grouped into c. 34 "granaries") were recovered in Level V, and approximately 10 in each of two subphases of Level IV. Some of the Level IV examples included walls that had been built on a layer of reeds (Postgate and Watson 1979: 172). Unfortunately, as far as I can tell, the only other information provided about the granaries is a plan of the northeastern part of the tell that superimposes Levels VII, VI, and V (Figures 5.7 and 5.8; Odani and Ii 1981: Fig. 8). The granaries are not labeled as such, but my assumption is that all of the small, Level V structures on the plan – that is, all of the structures except the four larger, one-room structures with thicker walls – were granaries. A few similar structures dating to Level VI also appear on the plan and on a published section drawing (Odani and Ii: Fig. 4). No plan is provided for the two phases of Level IV architecture. See Table 5.8 for some basic information about the granaries uncovered in Levels VI–IV.

In Tables 5.9 and 5.10, I have used data from the published reports to estimate the maximum storage capacity available within the round building uncovered in Level VII and the granaries uncovered in Levels V and IV. In the case of the round building, I have provided two sets of calculations, both of which should be considered extremely tentative. First, I have estimated the capacity of the flask-shaped pits found beneath the floor in Corridors C3 and C4. To do this, I have assumed that all of the features marked with a "P" on the published plan (Odani and Ii 1981: Fig. 5) were flask-shaped pits, and I have used the minimum and maximum depths provided in the publication (0.6–1.5 m) to calculate a very rough capacity for each pit. Second, I have calculated the total above-ground volume available within the corridors during each subphase (VIId, VIIc, and VIIb) and have made the almost certainly unrealistic assumption that all of these corridors were filled with containers (e.g. storage jars) holding grain. In the case of the granaries in Level V, I have assumed that all of the small rooms shown in black (i.e. Level V) on the published plan (Odani and Ii 1981: Fig. 5) were granaries. In the case of the granaries in Level IV, no plan or measurements have been published. I have, therefore, simply used the minimum and maximum sizes calculated for the granaries in Level V to estimate a minimum and maximum size for the ten granaries found in each subphase of Level IV. These calculations for Level IV are completely hypothetical.

To summarize briefly, the Level VII Round Building included three different types of possible grain storage facilities: 1) sub-floor, flask-shaped pits, 2) corridors within which grain could have been stored in containers, and 3) purpose-built, above-ground "granaries" with sub-floor ventilation. The flask-shaped pits (P1–P13) beneath the floors of Corridors C3 and C4 could have held a maximum of 3.2–18.4 m^3 or 1,422–17,197 kg of threshed barley. Corridors C3, C4, C5, and C6 could themselves have held a maximum of 687.7–1,031.6 m^3 or 305,614–964,087 kg of threshed barley. The granaries (G1–G30) could have held a maximum of 207.8–311.7 m^3 or 92,346291,315 kg of threshed barley. If we examine the Round Building through time, using the subphases identified by the excavators (VIId–VIIa), the pits (P1–P2) and the corridor (C3) dating to Level VIId could have held a maximum of 39.3–60.5 m^3 or 17,465–56,543 kg of threshed barley. The pits (P1–P13) and corridors (C3 and C4) dating to Level VIIc could have held a maximum of 136.3–218.1 m^3 or 60,572–203,790 kg of threshed barley. The pits (P1–P13) and corridors (C3–C6) dating to Level VIIb could have held a maximum of 690.9–1050.0 m^3 or 307,036–981,283 kg of threshed barley. The pits (P1–P13), corridors (C3–C5), and granaries (G1–G30, four of which lay within corridor C6) dating to Level VIIa could have held a maximum of 494.7–755.7 m^3 or 219,845–706,230 kg of threshed barley.

Although granaries were also constructed during the succeeding Level VI, I was unable to quantify their storage capacity. During Level V, the excavated granaries (Granaries 1–34) could have held a maximum of 210.4–315.6 m^3 or 93,502–294,960 kg of threshed barley. During each of two subphases of Level IV, ten granary "rooms" were in use, but no plans or measurements have been published. If each of these "rooms" was approximately the size of the individual granary rooms (i.e. the rooms that were grouped together to form "granaries") from Level V, the ten rooms could have held a maximum of 8.0–189.0 m^3 or 3,555–176,639 kg of threshed barley. If each of the Level IV "rooms" was approximately the size of the granaries (i.e. groups of rooms) from Level V, the ten rooms could have held a maximum of 12.0–222.0 m^3 or 5,333–207,481 kg of threshed barley.

Table 5.11 provides estimates – again, each a theoretical maximum – for the total number of people that could have been fed using the grain stored in these various structures. In Table 5.12, I have simplified these estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[5] At a 95% level of confidence, my calculations suggest that the storage facilities dating to Level VIId could have held enough grain to support 10–263 people for one year or 5–131 people for two years. The storage facilities dating to Level VIIc, on the other hand, could have held enough grain to support 19–952 people for one year or 9–476 people for two years, and the storage facilities dating to Level VIIb could have held enough grain to support 127–4,343 people for one year or 63–2,171 people for two years. The storage facilities dating to Level VIIa could have held enough grain to support 573–3,365 people for one year or 286–1,683 people for two years, and the storage facilities dating to Level V could have held enough grain to support 386–1,436 people for one year or 193–718 people for two years.

I have not been able to locate a published population estimate for Levels VII–IV at Tell Gubba. I have, therefore, calculated my own very rough estimate, based on a site size of 0.4–0.5 ha. The upper end of this range (0.5 ha) was calculated using the published dimensions of the site (c. 80 m in diameter; Fujii ed. 1981: 141); the lower end (0.4 ha) was measured directly on the published plan (following the contour line between 89.7 and 90.7; Fujii ed. 1981: Fig. 3). Assuming a population density of 100–200 persons/ha, I have estimated a population of 40–100 for Levels VII–IV at Tell Gubba.

To calculate the percentage of the population that could have been fed with the grain stored at Tell Gubba, I have divided the total population estimate by the "simplified" number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table

[5] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 5.12 and the "Statistical methods" section in Chapter 3.

5.13. At a 95% level of confidence, my calculations suggest that the storage facilities dating to Level VIId could have held enough grain to support 16–553 % of the population for one year and 8–277 % of the population for two years. The storage facilities dating to Level VIIc, on the other hand, could have held enough grain to support 27–1,485 % of the population for one year and 14–743 % of the population for two years, and the storage facilities dating to Level VIIb could have held enough grain to support 188–7,581 % of the population for one year and 94–3,790 % of the population for two years. The storage facilities dating to Level VIIa, on the other hand, could have held enough grain to support 663–6,202 % of the population for one year and 331–3,101 % of the population for two years, and the storage facilities dating to Level V could have held enough grain to support 480–2,521 % of the population for one year and 240–1,261 % of the population for two years.

Tell Madhhur

Tell Madhhur is located at the northeastern end of the Hamrin Valley of east-central Iraq. During the Early Dynastic I period (building levels 1 and 2), the settlement (an oval measuring 100 m × 80 m, 2.5 m above modern plain level and 4.0 m below) included a so-called Curved Building and, immediately to the southwest, a series of rectinlinear structures arranged on either side of a street (Figure 5.10; Roaf 1982: 44–45; 1984: 116–118). First constructed during building level 1, the Curved Building was only partially preserved but, if originally circular, would have measured approximately 30 meters in diameter. The preserved portion revealed a thick outer wall and a narrower, concentric inner wall; a series of radial walls divided the space between the two curving walls into four rooms. During building level 2, a rectangular, raised storage bin or "grain store" was constructed within the building's central courtyard. Sitting atop a foundation of 1–2 courses of baked brick, the grain store was provided with a ventilated, parallel-wall substructure: four mudbrick walls separated by air vents that were sealed off in the middle and at each end with mudbricks. Only a few traces of the bin's superstructure – burnt patches of flooring – were preserved, but the excavators suggest that the upper part of the bin would have been built of mudbrick and would have been divided into two storage compartments. No grain was found in situ, but comparison with similar installations at contemporary sites and modern villages in the region suggests to the excavarors that the bin would have been used to store grain (Roaf 1984: 116, Fig. 3). Tables 5.14 and 5.15 provide some basic details about the grain store and an estimate of storage capacity. To summarize, the grain store could have held a maximum of 4.6–6.9 m^3 or 2,044–6,449 kg of threshed barley.

Table 5.16 provides estimates for the total number of people that could have been supported using the grain stored in the grain store at Tell Madhhur. In Table 5.17, I have simplified these estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[6] At a 95% level of confidence, my calculations suggest that the grain store could have held enough grain to support 8–34 people for one year or 4–17 people for two years.

I have not been able to locate a published population estimate for Tell Madhhur during the Early Dynastic I period. I have, therefore, used the published dimensions of the site (an oval measuring 80 × 100 m, Roaf 1984: 110) and my own measurement of site size (0.7 ha; based on the plan published in Roaf 1984: Fig. 1, following the 80 m contour) to estimate a site size of

[6] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 5.17 and the "Statistical methods" section in Chapter 3.

0.6–0.7 ha. Assuming a population density of 100–200 persons/ha, Tell Madhhur could have supported a population of 60–140 people during the Early Dynastic I period.

To calculate the percentage of the population that could have been fed with the grain stored at Tell Madhhur, I have divided the total population estimate by the “simplified” number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table 5.18. At a 95% level of confidence, my calculations suggest that the grain store at Tell Madhhur could have held enough grain to support 8–36 % of the population for one year and 4–18 % of the population for two years.

Tell Razuk

Tell Razuk is located at the northern end of the Hamrin valley of east-central Iraq. During the later part of the Early Dynastic I period, the small settlement (a triangle measuring 170 × 140 × 120 m) was dominated by a large Round Building that the excavators have interpreted as a fortress, a citadel, or, perhaps, an administrative building (Gibson 1981a: 157–158; 1987: 473). Some others (e.g. Margueron 1999: 53; Renette 2009: 92–94; cf. Van der Stede 2010: 298–300) have argued that the primary function of the Round Building was storage. I have not attempted to calculate a hypothetical storage capacity for the entire building, but I would like to draw attention to a series of raised storage bins constructed within the building’s central, unroofed courtyard and immediately outside the building[7]. These bins varied somewhat

[7] A number of other bins and installations that may have played a role in storage were also recovered (e.g. Gibson et al. 1981: 38, 51, 62–63, Pl. 16–18, 32–34, 38), but I have chosen to focus specifically on the

in form and dimensions, but each appears to have included two basic components: a mudbrick bin (height and roofing uncertain) and, below this, a foundation (e.g. parallel walls separated by an open space) that raised the bin above floor-level and provided some degree of ventilation. No clear traces of the goods originally stored in these bins were recovered, but analogy with other contemporary sites and with modern-day villages in the region suggests grain storage as a likely function (Gibson et al. 1981: 35, 49).

The Round Building was in use from Level VI B through Level V A and was then largely abandoned during Level IV (Gibson et al. 1981: 29–65). From the upper (i.e. later) part of Level VI B through Levels VI A, V B, and the lower (i.e. earlier) part of V B, Bin A[8] was in use within the central courtyard (Figure 5.11 and 5.12; Gibson et al. 1981: 35–38; Gibson 1981b: Pl. 7:1, 14, 16–18). This bin was then replaced by Bin B, which was in use from the upper (i.e. later) part of Level V B through the lower (i.e. earlier) part of Level V A (Gibson et al. 1981: 42; Gibson 1981b: Pl. 27, 28:1); during this same stretch of time, Bin C was in use immediately to the northeast of the outer wall of the Round Building (Figure 5.13; Gibson et al. 1981: 48–49; Gibson 1981b: Pl. 27, 30:1). During the lower (i.e. earlier) part of Level V A, Bin E was also constructed within a room immediately to the southwest of the Round Building, but this bin was poorly preserved and was only visible in section view (Gibson et al. 1981: 56; Gibson 1981b: Pl. 11, 32). In the upper (i.e. later) part of Level V A, the bin (Bin B) in the central courtyard of the Round Building was replaced by Bin D, which went out of use in the succeeding Level IV (Figure 5.14; Gibson et al. 1981: 52; Gibson 1981b: Pl. 34). Table 5.19 provides some basic

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raised bins whose form suggests a grain storage function (based, e.g., on analogy with other contemporary sites and modern villages in the region).

[8] The excavators do not provide specific designations for the bins; instead, they typically refer to a bin according to its stratigraphic position (e.g. "bin on Floor 10a, Locus 455"). For ease of reference, I have assigned my own labels for the bins (Bin A, Bin B, etc.).

details about these five, raised storage bins. Table 5.20 then provides storage capacity estimates for Bins A–D and for each successive phase in the use of the Round Building. Table C provides estimates for the total number of people that could have been fed using the grain stored in the bins.

To summarize, Bin A could have held a maximum of 5.2–7.8 m^3 or 2,311–7,290 kg of threshed barley, while Bin B could have held a maximum of 3.4–5.1 m^3 or 1,511–4,766 kg. Bin C could have held a maximum of 5.8–8.7 m^3 or 2,578–8,131 kg, and Bin D could have held a maximum of 3.6–5.4 m^3 or 1,600–5,047 kg. Depending on the level examined, the bins in concurrent use could have held, at the low end, 3.6–5.4 m^3 or 1,600–5,047 kg of threshed barley (V A upper) and, at the high end, 9.2–13.8 m^3 or 4,088–12,897 kg (V B upper, V A lower).

Table 5.21 provides estimates for the total number of people that could have been fed using the grain stored in the raised bins at Tell Razuk. In Table 5.22, I have simplified these estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[9] At a 95% level of confidence, my calculations suggest that the bins uncovered in Levels VI B–V A could, depending on the level, have held enough grain to support 9–64 people for one year or 4–32 people for two years.

I have not been able to locate a published population estimate for Tell Razuk during the Late ED I period. I have, therefore, calculated my own very rough estimate, based on a site size of 0.8–1.7 ha. The lower end of this range (0.8 ha) was calculated using the published dimensions of the site (a triangle with sides measuring 170 × 140 × 120 m; Gibson et al. 1981: 28); the higher end (1.7 ha) was measured directly on the published plan (following the mound’s

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[9] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 5.22 and the “Statistical methods” section in Chapter 3.

outermost contour line; Gibson 1981b: Pl. 4). Assuming a population density of 100–200 persons/ha, I have estimated a population of 80–340 for Tell Razuk during the Late ED I period.

To calculate the percentage of the population that could have been fed with the grain stored at Tell Razuk, I have divided the total population estimate by the “simplified” number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table 5.23. At a 95% level of confidence, my calculations suggest that the storage bins at Tell Razuk could have held enough grain to support 4–44 % of the population for one year and 2–22 % of the population for two years.

Ur

Tell al-Muqayyar (ancient Ur) is located in southern Iraq, approximately 16 km southwest of Nasiriyah. The site is roughly oval in shape (measuring c. 1,200 × 800 m) and is dominated especially by the remains of a ziggurat (now reconstructed) in its northwestern quadrant. Archaeological excavations were conducted at Tell al-Muqayyar by J. E. Taylor (1853–1954), R. Campbell-Thompson (1918), and H. R. Hall (1919), but the most sustained and most extensive excavation campaign (1922–1934) was directed by C. Leonard Woolley under the auspices of the British Museum and the University of Pennsylvania Museum. Woolley uncovered evidence for occupation at the site from the Ubaid period through the Neo-Babylonian period. He focused, in particular, on a series of long-lived monumental structures located within the “temenos” area near the ziggurat (Figure 5.15), but he also unearthed, for example, well-preserved residential areas and a cemetery that included more than 1,850 burials, among them the famous “royal tombs” of the Early Dynastic IIIa period (see e.g. Woolley 1982; Pollock 1997; Zettler 1998a; 1998b). The artifactual assemblage recovered at the site included thousands of cuneiform tablets. Those dating to the Old Babylonian period have received particular attention (e.g. Charpin 1986; Van De Mieroop 1992a; 1992b; Brusasco 1999–2000), but more than three thousand tablets date to the Ur III period (Widell 2003: 3), when the city was the dynastic seat and nerve center for a state that exercised hegemony over a broad territory. An archaeological survey conducted by Henry Wright in 1966 (Wright 1981) has also provided further information about changing patterns of settlement at Ur itself and in the immediately surrounding region.

Before turning to the evidence for grain storage at Ur, it is worth describing the basic sequence of third-millennium occupation at the site in a little more detail. During the Uruk period, a monumental temple platform was constructed in the area that would later house the ziggurat (Woolley 1939: 5–6; 1982: 36–37; Pollock 1997: 288). A new version of this platform was constructed during the Early Dynastic I period (Woolley’s “Archaic II”). The main temple almost certainly lay immediately below the later ziggurat and could not, therefore, be excavated. A number of other constructions (e.g. shrines, kitchens, storerooms, and a thick enclosure wall) were preserved on the platform, but these had been cut down to foundation level in preparation for a subsequent rebuilding effort (see below) (Woolley 1939: 1–5; 1982: 46–47, 113; Wright 1969: 36–39). Approximately two hundred meters to the southeast of the temple platform, the excavators uncovered a garbage dump, where building debris, pottery, clay tablets, and clay sealings – apparently refuse from a nearby (but unexcavated) public building – had accumulated over time. Known as the “Seal Impression Strata” or SIS, this dump was composed of a series of layers, the earlier of which (strata 4–8) Woolley dated to the early part of the Early Dynastic period (i.e. ED I; Woolley 1982: 47–50; Pollock 1997: 289; Zettler 1998a: 21). During the Early Dynastic IIIa period, this area was transformed into a cemetery – the so-called Royal Cemetery – that would continue in use through the post-Akkadian period and that contained a total of at least 1,850 burials (according to Woolley, the original total may have been 2–3 times this number). Among the Early Dynastic IIIa burials in the cemetery were sixteen elaborate, richly furnished, chambered tombs that Woolley christened the Royal Tombs (Woolley 1934; Woolley 1982: 51–103; Pollock 1997: 289; Zettler 1998a). During this same period (Woolley's "Archaic I"), the temple platform to the northwest was rebuilt on the same ground plan as its ED I predecessor. The platform was surrounded by an enclosure wall approximately 11 meters thick and included, according to Woolley's interpretation, six shrines, two kitchens, three large storerooms, several courtyards, and a number of other rooms of uncertain function (Woolley 1939: 7–23; 1982: 46, 113–118; Benati 2013). At this point, Ur was developing into or had already developed into a city-state under the control of a local dynasty. Indeed, by the Early Dynastic IIIb period, the kings of Ur had achieved enough prominence on the regional scale that they appear in the Sumerian King List and are, as a result, referred to as the First Dynasty of Ur.

The city was certainly occupied during the Akkadian period, but the excavated evidence is sparse (Pollock 1997: 289). The Ur III period, on the other hand, is well attested. Under the rule of the Third Dynasty of Ur, the city of Ur was at the peak of its power and lay at the center of a state that encompassed the entirety of southern Mesopotamia and beyond. Although the city itself extended over an area of at least 50 hectares (Pollock 1997: 289), most of the Ur III remains uncovered by Woolley lay within or near the Temenos area. The focal point was the massive ziggurat built by Ur-Nammu, first king of the Ur III dynasty (Woolley 1939: 98–121; 1982: 138–147). The ziggurat lay on a terrace – successor to the earlier temple platforms – that was surrounded by a casemate wall. Immediately to the northwest of the ziggurat was another "kitchen" and a shrine, perhaps dedicated to the god Nanna. Originally, there were probably more structures within the walled ziggurat terrace, but only faint traces were preserved (Woolley 1939: 24–39; 1982: 147–149). The ziggurat terrace could be entered through a monumental doorway in the eastern corner or through another monumental doorway in the northeastern wall, which could be accessed by passing through a massive, walled courtyard surrounded by large chambers. Referencing tablets found within, Woolley called this courtyard complex the Court of Nanna and interpreted it as a "great store-house" where offerings, rents, and tithes were brought before the god, documented by temple scribes, and placed in storage (Woolley 1939: 74–81; 1982: 149–150; Pollock 1997: 289). Among the other monumental structures excavated within the Temenos area were the *Enunmah* (a storehouse), the *Giparu* (residence of the high-priestess of Nanna), and the *Ekhursag* (perhaps a palace). Immediately to the southeast, Woolley also excavated a group of buildings that he described as "mausolea" for the Ur III kings (Woolley 1974; 1982: 160–174; Pollock 1997: 289). Near the end of the third millennium, the Ur III state collapsed, and the city of Ur was destroyed, only to be rebuilt soon afterward by the newly emergent dynasty of Isin (Pollock 1997: 290).

There can be no doubt that centralized grain storage played a fundamental role in the functioning of the Ur III state, with its tightly managed agricultural economy and its regional-scale systems of taxation and redistribution. The preceding states of the Early Dynastic period were, likewise, built on the collection and redistribution of agricultural goods. Archaeologically, the evidence for large-scale storage at Ur during the third millennium derives entirely from the monumental constructions of the Temenos area. I will discuss this evidence first, beginning with the Early Dynastic period and then moving on to the Ur III period (Tables 5.24, 5.25, and 5.26).

After attempting to quantify this physical evidence for storage spaces at Ur, I will then highlight some key points that emerge from the examination of clay sealings and cuneiform tablets found at the site.

As discussed above, during the Early Dynastic I (Archaic II) period, a new version of the Uruk- and Jemdet Nasr-period temple platform was constructed, according to a different plan and orientation. Only the foundations of this structure were preserved, but these same foundations were later reused as a basis for the better-preserved temple platform of the Early Dynastic IIIa/b (Archaic I) period. In both periods, the northern corner of the platform was occupied by three long, parallel rooms that Woolley interpreted as storerooms (Figures 5.16 and 5.17; Tables 5.24 and 5.25). They were located immediately behind the northern "kitchen" and may or may not have been connected to it directly (Woolley 1939: 20, Plates 64, 66, and 67; 1982: 114–115; Benati 2013: 202). Although there was no evidence for the goods that would have been stored in these large storerooms, I have assumed, for purposes of quantification (i.e. to achieve an estimate for maximum storage capacity), that all three rooms were used solely for the storage of grain. In calculating the capacity of these rooms during the Early Dynastic I period (i.e. Archaic II), I have used Woolley's plan of the building's foundations (Woolley 1939: Plates 64 and 67); it should be kept in mind, however, that the walls standing above ground may have been narrower than the foundation walls (Woolley 1939: 2), which would have resulted in more available storage space. In calculating the capacity of these rooms during the Early Dynastic IIIa/b period (i.e. Archaic I), I have used Woolley's "conjectural" reconstruction of the above-ground walls, rather than his plan of the actual excavated remains (Woolley 1939: Plates 64 and 66).

On the eastern side of the Early Dynastic IIIa/b (Archaic I) temple platform, Woolley excavated a line of six rooms that he interpreted as “shrines,” based on analogy with later versions of the ziggurat terrace (Figure 5.17; Woolley 1939: 17–19; 1982: 117; Benati 2013: 202, 209; Table 5.25). These nearly identical rooms opened directly onto the courtyard that would presumably have lain immediately in front of the (unexcavated) main temple, and they backed up onto the southern “kitchen” unit. Few artifacts were found in situ, and the only internal installation recovered was a brick-lined pit cutting the floor of one room (Shrine C). Each room was provided with mudbrick walls and a floor consisting of 14–15 courses of baked brick – the lower courses joined using bitumen mortar and the upper using clay – and then a thick coating of bitumen. This method of floor construction raised the rooms up approximately 0.85 meters above the level of the courtyard to the northwest. Each room had a doorway in its northwestern wall and was accessed from the courtyard by means of three steps. The northeastern-most room (Shrine A), however, also had a doorway in its southeastern wall, which connected up with a bitumen causeway that led across a courtyard and out through the southeastern wall of the temple platform. This room was clearly functioning as passageway, rather than a shrine. Although Woolley’s functional interpretation may be correct for the other five rooms, others have suggested that the “shrines” may instead have functioned as storerooms, their elaborate, raised floors providing protection against moisture and vermin (Mallowan 1968: 38; Benati 2013: 209). The evidence supporting this reinterpretation is certainly not conclusive, but, in my calculations, I have allowed for the possibility that Shrines B–F were not shrines at all but were actually storerooms for grain. Woolley did not excavate beneath these rooms and did not, therefore, identify any evidence for a similar line of rooms dating to the preceding, Early Dynastic I (Archaic II) period (Woolley 1939: 3).

During the Ur III period, the structure most likely to have served as a large-scale storage facility was the *Enunmakh*, located immediately to the east of the ziggurat terrace and southeast of the Court of Nanna (Figures 5.15, 5.18, and 5.19; Woolley 1974: 49–54, Plates 53, 58; 1982: 242–245; Table 5.26). Although Woolley identified some possible traces of earlier versions of this structure, the basic floor plan established during the Ur III period appears to have been maintained relatively unchanged through numerous reconstructions all the way up to the Neo-Babylonian period, when it was significantly redesigned by Nebuchadnezzar (Woolley 1974: 45). The Ur III version was square in plan (57 × 57 m), with exterior walls 2.7 meters thick, and was raised up two meters above the level of the ground outside. At the center of the building was a five-room unit that Woolley interpreted as a sanctuary dedicated to Nanna and Ningal. This unit was surrounded on all sides by a corridor. The remainder of the building was occupied by long, narrow magazine-like rooms and, therefore, probably functioned primarily as a storehouse of some kind. Indeed, many of the cuneiform tablets found in the building deal with temple revenues and with the deposit and withdrawal of goods from temple storage (Woolley 1974: 45–46). As is often the case, it is impossible to say exactly what was stored in the various rooms of the *Enunmakh*, but, for purposes of quantification, I have assumed that all of these rooms were used solely for the storage of grain. I have also included Woolley's hypothetical reconstruction of the northwestern part of the building (i.e. northwest of the sanctuary), which was not preserved (Woolley 1974: Plates 53, 58).

The so-called Court of Nanna, an enormous, walled courtyard that abutted the northeastern entrance to the ziggurat terrace, may also have served as a storage facility (Figure 5.20; Woolley 1939: 74–81, Plate 68; 1982: 149–155; Table 5.26). The courtyard itself measured 43.6 × 65.7 meters, but it was surrounded on all sides by large rooms that had been built into the width of a massive enclosure wall (external dimensions, 79 × 96 m). On the northwestern, southwestern, and southeastern sides of the courtyard, these long, narrow rooms were oriented parallel to the direction of the enclosure wall and were connected to one another. On each side, a single doorway provided access to the line of rooms. On the northeastern side of the courtyard, on the other hand, the rooms were more irregular in shape and could, in most cases, be accessed directly from the courtyard (Woolley 1939: 75). Although the function of the rooms surrounding the Court of Nanna cannot be definitively proven, Woolley – citing cuneiform evidence – interpreted these rooms as "magazines" and the entire complex as "a store-house into which were brought the offerings made to Nanna and the dues paid to him" (Woolley 1982: 149). He suggested that the surrendered goods would have included, for example, cattle, sheep, grain, and cheese, as well as specialty products brought by merchants. For purposes of quantification, I have assumed that all of the rooms would have been used to store grain, an unrealistic assumption but one that allows me to calculate a maximum grain storage capacity for the structure.

The other two monumental buildings excavated within the Temenos area – the *Giparu* and the *Ekhursag* – were not storage facilities per se, but both almost certainly included rooms dedicated to storage (Woolley 1974: 36–39, 43–44, Plates 56–57; 1982: 160–163, 183–193). I will focus here on the *Giparu*, relying, in particular, on Penelope Weadock's functional analysis of this massive structure (Figure 5.21; Weadock 1958; 1975; Table 5.26). Located immediately to the southeast of the ziggurat terrace, the *Giparu* was the official dwelling of the *entu*-priestess, that is, the high priestess of the god Nanna (Weadock 1975: 101). Woolley uncovered some possible traces of an earlier version of the structure, dating to the Early Dynastic period, but this earlier version had been transformed into a foundation terrace and replaced with a completely new construction during the Ur III period (probably during the reign of Ur-Nammu). The Ur III version was then cut down to foundation level and rebuilt on the same plan during the Isin-Larsa period (Weadock 1975: 105–108). Weadock's functional analysis applies to both the Ur III and Isin-Larsa versions of the structure. The *Giparu* was divided into three distinct sections: 1) a temple dedicated to the goddess Ningal, 2) a sanctuary dedicated to the royal cult, and 3) the residence of the *entu*-priestess. There was also a kitchen with associated storerooms and service rooms (Weadock 1975: 114–124). Although there is no evidence that any of the rooms within the complex would have functioned solely as storerooms for grain, I have provided storage capacity estimates for three groups of rooms: a group of storerooms (B 5–8) directly across a corridor from the kitchen, a group of "service rooms" of uncertain function (C 35–41) near the kitchen, and a group of three storerooms (C 29–31) attached to the Ningal temple. In each case, it is possible that one or more of the rooms would have been used, at least in part, to store grain, but the calculations provided almost certainly overestimate the actual quantity of grain stored to a significant degree.

In Tables 5.27, 5.28, and 5.29, I have used data from the published reports to estimate the maximum storage capacity of these possible storage facilities and storerooms excavated at Tell al-Muqayyar / Ur. It is important to bear in mind that none of these spaces can be definitely proven to have been dedicated to storage, and none can be proven to have been dedicated solely to the storage of grain. My capacity estimates should be considered a theoretical maximum, rather than an assessment of the actual quantities of grain likely to have been stored in these structures at any particular point in time.

To summarize very briefly, the three storerooms in the northern corner of the temple platform could have held a maximum of 139.2–208.6 m^3 or 61,860–194,958 kg of threshed barley during the Archaic II period (i.e. Early Dynastic I). During the Archaic I period (i.e. Early Dynastic IIIa/b), the three storerooms in the northern corner of the temple platform could have held a maximum of 274.3–411.3 m^3 or 121,899–384,401 kg of threshed barley. If the five "shrines" (Shrines B–F) on the temple platform were functioning as storerooms, rather than shrines, they could have held a maximum of 162.8–243.9 m^3 or 72,348–227,949 kg of threshed barley. Together, the three storerooms and the five shrines could have held a maximum of 437.1–655.2 m^3 or 194,247–612,350 kg of threshed barley. During the Ur III period, the *Enunmah* could have held a maximum of 1,137.8–1,879.7 m^3 or 505,638–1,756,768 kg of threshed barley. The rooms surrounding the Court of Nanna could have held a maximum of 1,343.6–2,039.0 m^3 or 597,096–1,905,649 kg of threshed barley, and the possible storerooms within the *Giparu* could have held a maximum of 611.5–917.1 m^3 or 271,751–857,122 kg of threshed barley. Together, the storerooms within the *Enunmah*, the Court of Nanna, and the *Giparu* could have held a maximum of 3,092.9–4,835.8 m^3 or 1,374,485–4,519,539 kg of threshed barley.

Table 5.30 provides estimates – again, each a theoretical maximum – for the total number of people that could have been fed using the grain stored in these structures. In Table 5.31, I have simplified these estimates significantly, and I have used some basic statistical techniques to highlight the more plausible, middle-range values.[10] At a 95% level of confidence, my calculations suggest that the storage facilities dating to the Archaic II (ED I) period could have held enough grain to support 270–964 people for one year or 135–482 people for two years. The storage facilities dating to the Archaic I (ED IIIa/b) period, on the other hand, could have held

[10] For details about how I have simplified the estimates and about the statistical techniques employed, see the notes provided with Table 5.31 and the "Statistical methods" section in Chapter 3.

enough grain to support 635–2,934 people for one year or 317–1,467 people for two years, and the facilities dating to the Ur III period could have held enough grain to support 5,644–22,558 people for one year or 2,822–11,279 people for two years.

Wright estimates a site size of 20 ha and a population of 4,000 for Ur during the ED I period and a site size of 50 ha and a population of 10,000 during the ED III period. Both estimates assume a population density of 200 persons/ha (Wright 1969: 27, 39; 1981: 327–330, 338). I have also calculated my own estimates (ED I = 2,000–4,000 people; ED III / Ur III = 5,000–10,000 people), which follow Wright's site size estimates (including his estimate of 50 ha for the Ur III period) but assume a population density of 100–200 persons/ha.

To calculate the percentage of the population that could have been fed with the grain stored at Ur, I have first combined the different population estimates into a single range for each period (ED I = 2,000–4,000; ED IIIa/b = 5,000–10,000; Ur III = 5,000–10,000), and I have then divided this range by the "simplified" number-of-people-fed estimates discussed above. The resulting percentages – again, using some basic statistical techniques to highlight the more plausible, middle-range values – are shown in Table 5.32. At a 95% level of confidence, my calculations suggest that the storage facilities dating to the Archaic II (ED I) period could have held enough grain to support 8–39 % of the population for one year and 4–19 % of the population for two years. The storage facilities dating to the Archaic I (ED IIIa/b) period, on the other hand, could have held enough grain to support 8–45 % of the population for one year and 4–22 % of the population for two years. The storage facilities dating to the Ur III period could have held enough grain to support 75–318 % of the population for one year and 38–159 % of the population for two years.

CHAPTER 6

QUANTIFYING DEPENDENCY

Introduction

As we saw in Chapter 2, it has long been clear that grain storage was essential to the construction and maintenance of institutional power in third millennium Mesopotamia. The palace and temple institutions were in possession of huge tracts of agricultural land and were able to maintain a sizeable dependent labor force by redistributing this land and its products. Institutional dependency took a wide variety of forms and did not necessarily imply absolute subordination or a complete loss of economic autonomy. Many people did, however, rely directly on the centralized redistribution of foodstuffs; that is, they received regular allotments of grain and other goods from institutional storage facilities. The question is, how many people? What percentage of the population found itself within the "magic circle of the storage system" (Oppenheim 1977: 89)? And what were the benefits of institutional dependency? It is often claimed that the palace and temple institutions, by virtue of sheer size, were intrinsically better equipped to deal with environmental risk and uncertainty and, as a consequence, imparted a new level of stability to society as a whole. But we actually know very little about how dependents were treated in times of crisis. In the event of a lean year or a run of lean years, for example, what percentage of the population could realistically have been sustained on the supplies held in institutional storage facilities? And what other options did people have, if any? These are not easy questions to answer, but they draw attention to some fundamental gaps in our understanding of the scope and the nature of institutional organization in early Mesopotamia.

As I have argued in previous chapters, the archaeological evidence for grain storage practices can contribute a unique, quantitative perspective on institutional dependency and, in a more general sense, on the structure of the moral economy. As we saw in the case studies presented in Chapters 4 and 5, the archaeological evidence is always fragmentary, and it is often highly ambiguous and subject to multiple interpretations. For example, it is often unclear exactly what product was being stored, how it was being stored, or who would have had access to it. It is also often difficult to establish a clear institutional affiliation – or a lack thereof – for specific, excavated storage facilities. The archaeological evidence is far from perfect, but I have argued that an examination of storage practices and, in particular, storage capacities can help us to develop a more realistic assessment of the extent and the limits of institutional redistribution in Mesopotamia.

In the present chapter, I begin by examining the quantitative data from Chapters 4 and 5 in the aggregate. To do this, I have simplified the site-specific data significantly so that I can compare the material across sites and highlight points of similarity and contrast. Using a series of graphs to anchor the discussion, I focus first on storage capacity and then explore the connection between storage capacity and population. In the second half of the chapter, I then reflect on a few more general points that have emerged over the course of my effort to develop a quantitative perspective on grain storage in Mesopotamia. In particular, I draw attention to two important methodological issues and then consider the evidence for centralized (and decentralized) forms of storage.

Storage capacity

For each of the archaeological case studies presented in Chapters 4 and 5, I produced a series of storage capacity estimates and compared these figures with other published estimates. Here, I will revisit these storage capacity estimates in order to draw out some general patterns. I begin with a comparison of the capacities available within several different types (very broadly construed) of storage unit. As should be clear by now, throughout the dissertation I have not adopted an explicitly typological approach in my description and analysis of storage facilities. Within preceding chapters, terms like bin, silo, granary, and storeroom are not intended to carry significant descriptive or interpretive weight; as a general rule, I have simply borrowed the terms used by excavators or other commentators. Here, in order to highlight and compare storage capacities, I have divided the archaeological examples into four broad categories: 1) below-ground, bulk storage (e.g. pits or subterranean silos), 2) above-ground, bulk storage (e.g. bins, silos, or storerooms without doorways), 3) above-ground, container storage (e.g. storerooms filled with jars or sacks of grain), and 4) storage complexes (e.g. multi-room storage buildings or collections of storage facilities). For each category, I have produced one graph showing storage volume (m^3) and one showing the amount of grain that could have been stored (kg of threshed barley) (Figures 6.1–6.10).

The goal here is not to plot out and compare every single storage facility discussed in Chapters 4 and 5 but, instead, to provide a synoptic view that allows for macro-scale comparison. To this end, I have simplified the data in several ways. First, where a number of different storage capacity estimates have been suggested for a particular storage unit (e.g. by the excavators or by myself), I have combined these to create a single range of uncertainty (i.e. with the lowest suggested value as the minimum and the highest value as the maximum). Second, where multiple (more than three) storage units of a similar type were identified at a particular site (e.g. the 30 “granaries” uncovered in Level VIIa at Tell Gubba), I have plotted only the smallest (according to minimum value) and the largest (according to maximum value) examples. Third, it is important to mention that some storage units appear in more than one graph. For example, where there is uncertainty about whether a particular storage unit was used for bulk storage or container storage, I have included both possibilities. Also, in a number of cases, storage units appear both as examples of a particular type (e.g. the individual “silos” within the Rounded Building at Tell al-Raqa’i) and as part of a larger storage complex (e.g. the Rounded Building as a whole treated as a single storage facility). For a more detailed look at the storage capacity of specific storage units, see the site-by-site discussion in Chapters 4 and 5.

A few interesting points emerge from an examination of these graphs showing storage capacity by storage type. First, the terms that archaeologists use to refer to storage structures are not a very useful indicator of storage capacity. In the cases that I have examined, for example, a storage unit described as a silo can range in size from 1.7 m^3 (Tell ‘Atij, 522) to 100–125 m^3 (Fara, average silo size); a structure described as a granary can range from 1.0–1.5 m^3 (Tell Gubba, Level VIIa, G6) to 189.0–375.0 m^3 (Tell Beydar, Granary). This lack of a direct correlation between storage type (or storage terminology) and storage capacity is not especially surprising. Terms like bin, silo, granary, magazine, storeroom, and storehouse are typically used in a relatively loose sense as a means of referring to the basic form and/or function of a structure. From a rhetorical perspective, however, these terms can, and often do, imply something more. I am thinking, for example, of Tell ‘Atij, where a group of four silos (502–505, collectively referred to as a “granary”) excavated at the northern edge of the mound are regularly cited –

usually, without quantitative support (but see Fortin and Schwartz 2003: 222-223, with estimates somewhat higher than mine) – as an example of large-scale grain storage at the site. If my own calculations are correct, however, these silos are not very large at all (2.2–3.6 m^3 per silo) and hardly merit the qualifier "large-scale." Another example is Tell Leilan, where a "granary" within the Akkadian Administrative Building is cited as evidence for large-scale, centralized redistribution. My calculations suggest that this granary had a capacity of approximately 7.2–10.8 m^3, a number that pales in comparison to some of the other, truly large-scale facilities excavated in the region. In both cases, there is certainly nothing wrong with using the term silo or granary to refer to the storage facilities in question, but some of the broader interpretations offered seem to depend as much on the connotations of these terms as on the physical remains themselves.

Second, a few general trends can be identified in the graphs. When it comes to maximum storage capacity, bulk storage facilities – that is, the individual storage units (e.g. silos or raised bins) that were used for bulk storage – almost all fall below 50 m^3 in total capacity; in fact, most fall below (often, well below) or in the vicinity of 25 m^3 (Figures 6.1–6.4). The two exceptions are Building Unit 5 at Kazane Höyük, whose use as a bulk storage facility is uncertain, and the subterranean silos at Fara, which really stand out as an example of large-scale bulk storage – especially in light of the fact that there were at least 32 of these silos within the settlement. In the case of storerooms that would have held grain (or other goods) stored in containers, maximum capacity estimates are significantly higher, with a number of examples reaching the 100–200 m^3 range (Figures 6.5 and 6.6). One glaring exception is Corridor 6 (404–606 m^3) at Tell Gubba, but the use of this corridor as a storeroom that would have been filled with storage containers is far from certain. At the same time, a closer examination of the graph reveals that most of the examples falling in the 100–200 m^3 range are storerooms located within monumental architectural complexes: the Naram-Sin Palace at Tell Brak; the Temple Platform, the *Enunmah*, the Court of Nanna, and the *Giparu* at Ur. If we ignore these monumental examples, most of the remaining storerooms fall close to or below 50 m^3 and many below 25 m^3. It is also important to mention here that my estimates for useable storage volume – which assume a 25% reduction in the total volume of a room in the case of container storage (to account for walkways, ventilation spaces, and the containers themselves) – may be too high. At Ebla and Kazane Höyük, the recovery of large numbers of ceramic storage vessels in situ allowed the excavators to calculate capacity estimates using actual vessels, rather than floor space, as a guide. In both cases, their estimates were significantly lower than my estimates.

Among the above-ground, bulk storage facilities that I have examined are numerous examples of what I am calling raised storage bins (Figures 6.7 and 6.8). These relatively modest structures are often preserved only as a raised foundation that is assumed to have provided sub-floor ventilation for a missing superstructure. In many cases, this foundation consisted of a series of parallel walls, leading excavators to label them parallel wall structures, grill-plan buildings, and other similar terms. The prevailing opinion is that these structures would probably have functioned primarily as grain storage facilities, but, in the absence of a superstructure or traces of the stored cereals, this interpretation must often remain only a hypothesis. Among the sites that I have studied, there is significant variability in the formal structure of these raised storage bins, but, when considering storage capacity, I think it is worth treating them together as a single, basic type. Within this general category, I include the four Parallel Wall Structures (PWS I–IV) at Tell Karrana, the six Grill Buildings (Grill Buildings 1–6) at Tell al-Raqa'i, the 64+ Granaries (G1–G30, Granaries 1–34, and others from Level IV) at

Tell Gubba, the Grain store at Tell Madhhur, and the five storage bins (Bins A–E) at Tell Razuk. These storage bins range in capacity from 0.6 to 50.1 m^3 or 267 to 46,823 kg of threshed barley.

The graphs showing storage complexes – that is, multi-room storage structures or groups of closely related storage facilities – are also instructive (Figures 6.9 and 6.10). The complexes at Tell Brak and Ur, in particular, dwarf all of the others. I hasten to point out that, in both cases, the evidence that the buildings in question were used wholly or in part for the storage of grain is far from conclusive. To my mind, though, the Naram-Sin Palace at Tell Brak and the Enunmah (and perhaps the Court of Nanna) at Ur provide the only good examples from third millennium Mesopotamia of the kind of massive, highly centralized, state-sponsored storage facilities that are typically envisioned – whether realistically or unrealistically – as the focal point and the physical embodiment of the redistributive economy. Among the examples that I have studied, a second tier, clustering near the 100–200 m^3 range, is occupied by the Granary and the Building south of Temple A at Tell Beydar, the Central Unit South at Ebla (using an estimate based on floor space, rather than vessels recovered), and Building Units 4 and 5 at Kazane Höyük. The Rounded Building at Tell al-Raqa'i, the Brak Oval at Tell Brak, and the Granary at Telul eth-Thalathat may also belong in this group, depending on which capacity estimates are employed. A third tier of storage complexes hovers closer to the 25–50 m^3 range; this group includes the NW Area at Tell al-Raqa'i, Buildings 1 and 2 on the Acropolis NW at Tell Leilan (neither of which seems to have been devoted exclusively to storage), and the two groups of storage facilities located on the northern edge and the southern slope of the main tell at Tell 'Atij.

The next two graphs explore the total storage capacity available during specific periods at specific sites (Figures 6.11 and 6.12). Again, I have simplified the data significantly (for level-by-level totals for each site, see Chapters 4 and 5). As a general rule, if multiple levels at a site (e.g. Levels VI B–V A at Tell Razuk) can be assigned to the same basic time period (e.g. Late ED I) and if there is relatively little variation in the capacity totals for these levels, I have combined them (i.e. using the lowest and highest values among all of the levels to define the minimum and maximum for purposes of graphing). If, on the other hand, there is significant variation among the levels, I have graphed each level separately (e.g. Levels VIId–V at Tell Gubba). An exception is Tell ‘Atij, for which the excavators have provided little information about the stratigraphic connections linking several different excavation areas; in this case, I have been unable to create level-by-level totals but have, instead, graphed each excavation area separately.

The two graphs highlight a striking disparity in storage capabilities among the sites studied. Both graphs are dominated by four capacity estimates that stand head-and-shoulders above the rest: Fara during the ED IIIa period, Tell Brak during the Akkadian and post-Akkadian periods, and Ur during the Ur III period. At a minimum, the storage capabilities at these sites are two to three times greater than at the other sites studied; in many cases, though, they exceed the other estimates by one or even two orders of magnitude. It is entirely possible that this imbalance can be traced at least in part to the accidents of discovery or, perhaps more likely, to the massive scale on which early excavations were conducted – leading, for example, to the rapid uncovering of monumental architecture at sites like Ur and Tell Brak. At the same time, though, these graphs do help put the oft-invoked term “large-scale” in perspective, at least as it applies to storage facilities. If my calculations are correct, for example, the “large-scale grain storage” (Weiss 2012: 7) taking place within and/or near the Akkadian Administrative Building at Tell Leilan (7.4–11.0 m^3 during Leilan IIb2, 8.1–11.7 m^3 during Leilan IIb1) is a tiny fraction of the storage capacity available within the approximately contemporary Naram-Sin Palace at Tell Brak

(1,653.6–2,479.4 m^3). Likewise, the much-discussed “large-scale grain storage” (Schwartz 1994b: 32) taking place at Tell al-Raqa’i (130.9–185.8 m^3 in Level 4) and other Middle Khabur sites during the middle and later parts of the Ninevite 5 period is miniscule in comparison with the storage capabilities at Fara (3,200–4,000 m^3) during the roughly contemporary ED IIIa period. But what do these differences mean in human terms? How many people could rely on the grain stored within these storage facilities of widely varying capacity?

Storage capacity and population

It is one thing to measure and compare storage capacities, but it is another thing entirely to translate these storage capacity estimates into figures that are meaningful on the human scale, that is, figures that can tell us something about the people who were dependent, in one way or another, on the stored foodstuffs. And this is where significant differences of opinion – or at least significant differences in basic assumptions – have come to light. The most obvious example is the debate surrounding the interpretation of the Middle Khabur storage facilities. As we saw in Chapter 4, for instance, studies drawing on the same (or similar) capacity estimates for Tell al-Raqa’i have reached very different conclusions about the number of people that could have been supported and, building on these figures, have produced diametrically opposed interpretations concerning the function of the storage facilities and the site as a whole.

In my own efforts to estimate the population that could have been supported using the grain stored in particular storage facilities, I have tried, as far as possible, to acknowledge and allow for the many uncertainties involved. The result is “number of people fed” and “percentage of the population fed” estimates that often cover a very broad range of possibility. For a detailed look at my estimates for particular sites and particular storage facilities, see Chapters 4 and 5. Here, I have produced a series of graphs (Figures 6.13a–6.14d) based on the "simplified," site-wide, level-by-level estimates introduced in those earlier chapters. The estimates are displayed using "box-and-whisker" plots, designed to indicate the full range of uncertainty for each estimate (i.e. the whiskers), while also highlighting the more likely "95% confidence" values (i.e. the boxes or bars) and the median for each range (for details about the statistical methods employed, see Chapter 3). When discussing the graphs here, I focus solely on the 95% confidence range.

The first set of graphs (Figures 6.13a–6.13d) shows estimates for the number of people that could have been fed with the grain stored at particular sites during particular periods – if the storage facilities excavated at these sites were all being used to store grain and if they were all filled to capacity. The site-by-site tables provided in Chapters 4 and 5 include more detailed information about these estimates and about how they were calculated. Here, for each site and time period, I am showing two side-by-side estimates; the first assumes that the stored grain was only intended to provide one year's worth of food, while the second assumes that it was intended to provide two year's worth of food (i.e. one year's worth plus an extra year's worth as a buffer against crisis). Because the estimates vary dramatically from site to site, I have produced four different versions of the graph (Figures 6.13a, 6.13b, 6.13c, and 6.13d), adjusting the scale to allow both the very large and very small estimates to be examined.

In terms of macro-scale patterns, these graphs mirror the storage capacity graphs. That is, they are dominated by four examples that stand out from the crowd: Fara during the ED IIIa period, Tell Brak during the Akkadian and post-Akkadian periods, and Ur during the Ur III period. This pattern is hardly surprising, given that the number-of-people-fed estimates are derived directly from the storage capacity estimates. The main difference is a significant broadening of the degree of uncertainty involved, and this degree of uncertainty is amplified, in absolute (as opposed to relative) terms, for the sites with a higher storage capacity. For example, the storage capacity in Level 4 at Tell al-Raqa'i was estimated at 130.9–185.8 m^3 (a range of uncertainty of 54.9 m^3), while the number of people that could have been fed for one year with the stored grain is estimated at 227–887 (a range of uncertainty of 660 people). The storage capacity during the Akkadian period at Tell Brak, on the other hand, was estimated at 1,653.6–2,479.4 m^3 (a range of uncertainty of 825.8 m^3), while the number of people that could have been fed for one year with the stored grain is estimated at 3,143–11,850 (a range of uncertainty of 8,707 people).

One of the most important points to take away from these graphs, however, is the distinction between the number of people that could be fed for one year and the number that could be fed for two years. In terms of calculation, the distinction is a simple matter of dividing by two, but the graphic representation really draws attention to the magnitude of the difference. Especially for the sites with a larger storage capacity, if we allow for the (very likely) possibility that grain was being held in reserve as a risk buffer, our estimates for the number of people that could be fed are dramatically reduced.

These number-of-people-fed estimates really become interesting, though, when we introduce a further variable: the total population of the settlements in question. Population estimates are notoriously problematic and should generally be considered very rough approximations, but they provide an essential means of contextualizing the storage capacity and number-of-people-fed estimates that we have examined so far. For more detailed information about the population estimates that I have employed, see the site-by-site discussion in Chapters 4 and 5.

The key question, when comparing the number-of-people-fed estimates and the population estimates, is what percentage of the population could have been fed with the stored grain. Figures 6.14a–6.14d show my "percentage-of-population-fed" estimates. Because the resulting percentages vary dramatically from site to site (and often from minimum to maximum at a single site), I have produced four different versions of the graph (Figures 6.14a, 6.14b, 6.14c, and 6.14d), adjusting the scale to highlight particular features. Figure 6.14a, for example, displays the full range of variability (i.e. not just the 95% confidence range) for all sites by employing a scale that reaches from 0 to 25,000%, and Figure 6.14b displays the full 95% confidence range by employing a scale that reaches from 0 to 8,000%. These two graphs draw particular attention to a number of examples that stand out above the rest – sites whose storage facilities could potentially (at the maximum) have held enough grain to support close to or significantly more than 1,000% of their estimated population. Several of these examples should, I think, be viewed with some skepticism. The structures uncovered at the center of the mound at Tell ‘Atij, for example, have been interpreted as storage facilities by the excavators, but the evidence is not very convincing. The estimates for Levels VIId–VIIa at Tell Gubba should also be taken with a grain of salt. As discussed in Chapter 5, I have allowed for the possibility that the corridors within the Round Building were being used for storage, but this is far from certain. If these corridors are removed from the calculations (as they are for the minimum estimates shown in the graph, see below), the percentage-of-population-fed estimates are significantly reduced. For the other cases that exceed 1,000% – Tell Karrana, Tell al-Raqa'i (Level 4), and Tell Gubba (Level V) – we should at least consider the possibility that the storage facilities at these sites were capable of storing ten times (or more) the amount of grain needed to feed the resident population. Tell ‘Atij would also belong in this group, if we were to add together the estimates for the Northern edge and the Southern mid-slope, but it is unclear to me whether or not the storage facilities uncovered in these two areas were contemporary with one another.

In Figure 6.14c, I have changed the scale to show only values between 0 and 500% (bars with higher values are cut off at 500%) in order to highlight those estimates that fall below 500%. In fact, I would like to draw particular attention to the sites whose maximum percentage-of-population-fed estimates fall well below 100%. These include Tell Brak (Phase L), Ebla (EB IVA), Kazane Höyük, and Tell Leilan (IIId, IIb2, IIb1) – all very large sites that have been only partially explored through excavation (as opposed to small sites like Tell al-Raqa’i, Tell Hajji Ibrahim, or Tell Karrana, where a much larger percentage of the site’s surface area has been explored). It is hardly surprising that the storage facilities uncovered at these large sites could not have held enough grain to support the entire resident population (i.e. 100%), and I think it is very likely that further excavation would uncover further storage facilities. Here, I simply want to point out that the excavated evidence, as it currently exists, is not sufficient to argue for massive-scale, city-wide, centrally organized redistribution at these sites during the periods in question.

In Figure 6.14d, I have reduced the scale further (0–250%) in order to highlight the minimum estimates for percentage-of-population-fed (i.e. the bottom edge of the 95% confidence bars). The key point to take away from these graphs is that almost all of the minimum estimates (especially the “two year” estimates) fall near or well below the 100% mark. This means that for most sites – even those with maximum estimates reaching well beyond 1,000% – the excavated storage facilities may not have stored enough grain to support the entire population. The two exceptions are Tell Gubba Level VIIa and Tell Gubba Level V, both of which reach near or well beyond 200% for both their one-year and two-year estimates. In both cases, the minimum end of the range is based primarily on the storage capacity of the numerous "granaries" spread across the site; the minimum estimates do not, for example, include the corridors of the Round Building (see above for my doubts about assigning these corridors a storage function). In fact, both of these levels at Tell Gubba were only partially excavated, and it seems likely that even more granaries would be discovered with further excavation. In these two cases, then, I think that we can be very confident in arguing that there was enough – and, perhaps, much more than enough – storage capacity within the settlement to support the resident population for a period of one or two years.

In this section, we have looked separately at my "number of people fed" estimates and my "percentage of population fed" estimates, but it is also important to consider the relationship between these estimates. The much-discussed Middle Khabur sites provide a particularly interesting example. Quantitative discussion of these sites has focused especially on whether or not the grain stored within a particular settlement would have exceeded the subsistence needs of the settlement's inhabitants. My "percentage of population fed" estimates are intended to provide a numerical expression of this discussion and the many uncertainties involved. Among the many interesting sites excavated in the Middle Khabur region, I have only examined Tell al-Raqa'i and Tell 'Atij, but these are the two sites that have featured most prominently in the storage debate. In both cases, my calculations suggest that it is at least possible – though far from certain – that the storage capabilities at these sites went well beyond the needs of the local community. In both cases, however, we also need to consider exactly how much surplus grain might have been available and how many people this grain could have supported.

For Tell al-Raqa'i, my calculations suggest that the storage facilities in Levels 5–7 and Level 3 might (if filled to the brim) have held enough grain for only a small percentage of the total population (12–32 %) or, at the upper end of the spectrum, for several times the total population (193–446 %). The storage facilities in Level 4, on the other hand, might (if filled to the brim) have held enough grain, at the minimum, to support most or all of the population (82–164 %) and, at the maximum, to support 10–20 times (1,046–2,091 %) the total population. In each of these cases, therefore, it is at least possible that some amount of "surplus" grain would have been earmarked for consumption by a broader regional population (e.g. mobile groups, Hole 1999:274-280) or for delivery to a distant urban center (Schwartz 1994b: 28–30).

How much surplus grain are we really talking about, though? And how many people could this surplus grain have fed? For Levels 5–7 and Level 3, my maximum estimates for the number of people that could have been fed with the stored grain range from 74 to 174. If we assume the lowest population estimate for the site (20) and subtract this from the maximum people-fed estimates, we are left with enough surplus grain – that is, extra grain, beyond the subsistence needs of the local community – to feed a maximum of 54–154 people. For Level 4, my maximum estimates for the number of people that could have been fed with the stored grain range from 444 to 887. If we again assume the lowest population estimate for the site (20) and subtract this from the people-fed estimates, we are left with enough surplus grain to feed a maximum of 424–867 people.

Would a city like Mari be willing to invest the resources required to collect, store, and transport this amount of grain over distance? In the case of Levels 5–7 and 3, I find it hard to believe that the surplus would be large enough to justify such an expenditure. In the case of Level 4, the amount of grain might have been large enough, but I hasten to emphasize that the figures that I am using here are based on my maximum estimates for the number of people fed (and a very low population estimate). If the reality was actually closer to the middle or the low end of my estimated range, then I would find it much more difficult to envision Tell al-Raqa'i as part of a regional-scale system of staple mobilization.

For Tell 'Atij, my calculations suggest that the storage facilities uncovered at the northern edge of the summit might (if filled to the brim) have held enough grain to support as little as 48–97 % of the population or as much as 357–715 % of the population. Similarly, the storage facilities uncovered midway down the southern slope might have held enough grain to support as little as 43–86 % or as much as 332–664 % of the population. The structures uncovered in the deep sounding near the center of the summit – many of which may not actually have been storage facilities – might, depending on the level examined, have held enough grain to support as little as 41–81 % of the population or as much as 637–1,274 % of the population. These figures, while certainly not conclusive, at least suggest the possibility that a significant amount of surplus grain was being stored at Tell 'Atij. Again, the question is, how much grain? And how many people could have been fed with this grain?

If we focus only on my maximum estimates for number-of-people-fed, the storage facilities uncovered at the northern edge of the summit could have held enough grain to support 131–261 people. Similarly, the storage facilities uncovered midway down the southern slope could have held enough grain to support 140–280 people. The structures uncovered in the deep sounding near the center of the summit, depending on the level examined, could have held enough grain to support 247–493 people. Given the lack of stratigraphic information relating these three areas to one another, there is no clear means of calculating a total estimate for the site as a whole during any particular level. If, solely for the sake of argument, we simply combine all three estimates into a hypothetical (but almost certainly incorrect) total, then the storage facilities at Tell ‘Atij could have held enough grain to support a maximum of 518–1,034 people. If we assume the lowest population estimate for the site (24) and subtract this from the maximum people-fed estimate, we are left with enough surplus grain to feed a maximum of 494–1,010 people. As was the case with Level 4 at Tell al-Raqa’i, this might very well be enough grain to justify intervention by a distant urban center, but only if my maximum estimates are correct and only if we suspend judgment about a few problematic issues (i.e. stratigraphic correlations and the function of the structures in the deep sounding).

Consideration of Tell ‘Atij, however, also brings up one other interesting point. The excavators have interpreted the site as a commercial station or depot, where agricultural goods were collected and then shipped farther southward. They have also argued that the storage facilities would have been staffed by non-resident administrators and that the site itself may actually have had no residential population whatsoever. If the storage facilities were all dedicated specifically to “commercial” purposes and if at least some of them – as the excavators have argued (Fortin 1998: 236–237; but see Fortin 1995: 36) – were being used for temporary storage, is it possible that my number-of-people-fed estimates are completely irrelevant? That is, is it possible that grain was being moved into and back out of these storage facilities much more often than once a year? If so, then the amount of “surplus” grain moving through these facilities on its way southward might have been much higher than my estimates suggest. I do not see any clear evidence to support such an argument, but it is an interesting possibility to keep in mind more generally. If some of the storage facilities that have been uncovered archaeologically in Mesopotamia were, in fact, temporary storage spaces that saw a relatively fast-paced turnover in their grain inventory, then the typical “number of people fed for one year” estimates produced by archaeologists would not be too high, as I have argued above, but too low. It would also be very hard to achieve any alternative estimates for “people fed” or “percentage of population fed.”

Uncertainty, risk, and centralization

I started the chapter by posing some questions about the structure and scope of institutional dependency in third-millennium Mesopotamia. Ultimately, I think, these can be boiled down to two basic questions: 1) How many people were directly dependent on the stocks of food – grain, in particular – held in institutional storage facilities?, and 2) How were these dependents treated in times of crisis? That is, did the food held in institutional storage facilities provide dependents with a risk buffer in times of crisis? It should be clear by now that I cannot offer definitive answers to these questions. It should also be clear, however, that the archaeological evidence has much to contribute to the discussion and that it can help bring these questions – or, at least, certain dimensions of these questions – into sharper focus.

I would have liked to be able to offer a general model that describes the overall structure of the institutional storage economy and its development over the course of the third millennium. Given the archaeological sample examined here, though, I simply do not think that such a model is currently possible. Instead, I will highlight a series of issues that have emerged in the course of my study – each of which has important consequences for how we interpret the archaeological evidence for grain storage and how we understand the connection between grain storage and the moral economy.

The first issue is, perhaps, obvious at this point, but I think that it deserves to be reiterated. When attempting to quantify the archaeological evidence for storage, the specific values employed – whether direct measurements, rough approximations, calculated averages, or conversion factors – can have a major impact on the conclusions reached. Tell al-Raqa'i provides a particularly good example. As we saw in Chapter 4, several different people have drawn on the same basic estimates for storage capacity to perform a series of calculations whose results suggest (or, at least, are used to support) diametrically opposed interpretations. My own calculations for Tell al-Raqa'i are based, in part, on the figures used in these competing models and are explicitly intended to incorporate disagreement and/or uncertainty about basic assumptions, conversion factors, etc. It should hardly be surprising, then, that my calculations for Tell al-Raqa'i do not provide conclusive support for any one particular interpretation. Even after eliminating the less likely estimates at the lowest and the highest ends of the spectrum (i.e. after restricting our view to the middle 95% range), for example, my estimates for the percentage of the population that could have been fed cover a very wide range (e.g. for Level 4, 164–2,091 % or 82–1,046 %). This is due primarily to the population estimate employed (20–200 people), which incorporates the highest degree of uncertainty (an increase by a factor of 10 from minimum to maximum) about population among all of the sites that I have examined.

As an examination of the storage capacity tables in Chapters 4 and 5 will demonstrate, one of the most significant sources of uncertainty in my own calculations is the broad range of figures (1 m^3 = 444.4–934.6 kg) used to convert storage volume (m^3) into stored grain (kg). At Tell Beydar, for example, a total storage volume of 309.6–633.1 m^3 translates into 137,586–591,695 kg of threshed barley; in other words, at this one step in the calculation, an already significant degree of uncertainty (a maximum that is approximately twice the size of the minimum) is transformed into a much broader range of uncertainty (a maximum that is 4.3 times the size of the minimum). As Tell Razuk demonstrates, the broader the uncertainty in storage volume, the broader the resulting uncertainty in stored grain. For Levels VI B – V A at Tell Razuk, a total storage volume of 3.6–13.8 m^3 (i.e. a maximum that is 3.8 times the minimum) translates into 1,600–12,897 kg (i.e. a maximum that is 8.1 times the minimum). Again, the general point here is simple but, I think, very important. The specific values employed at each step in a calculation can and will have a major impact on the results of the calculation and on any subsequent interpretations. If there is genuine uncertainty about which value should be employed, it is better to acknowledge this uncertainty explicitly and allow it to be expressed within the calculations. The results will certainly be more vague, but they will also be more accurate and, ultimately, more meaningful.

The second issue concerns risk buffers. When interpreting the excavated remains of storage facilities in Mesopotamia, it is common practice to estimate storage capacity and then translate this storage capacity into an estimate for the number of people (the "population") that could have been supported for one year using the stored grain. I have argued, however, that these "one year" estimates ignore one of the fundamental motivations behind grain storage: protection from the risk of future shortage. In both Northern and Southern Mesopotamia, agriculture was a risky enterprise, and periodic crop failure was simply a fact of life. Mesopotamian specialists generally assume and often explicitly state that grain storage would have provided a buffer against crisis on both the household and the institutional level. Interestingly, though, when archaeologically derived storage capacities are transformed into population estimates, this basic fact is often ignored or glossed over. More specifically, underlying many calculations is an assumption that the storage facilities in question would have been filled up following the harvest and then completely emptied over the course of a single year.

If grain storage was functioning as a risk buffer, however, we should be assuming that the goal – if not always the reality – would have been to hold at least an extra year's worth of grain on reserve. That is, we should be assuming that archaeologically recovered storage facilities were intended to hold enough grain to feed the population dependent on those facilities for at least two years. If it could be shown that the institutional powers – the palace and temple organizations – were not intentionally storing up surplus grain as insurance against crisis, this would be a major finding, with important implications for how we understand the role of the institutions and the nature of institutional dependency in third-millennium Mesopotamia. I do not think, however, that most people who produce "one year" storage estimates are actually trying to make such an argument. They are simply relying on an accepted convention. The result is figures that routinely overestimate the size of the constituency for particular storage facilities, making it difficult to achieve an accurate assessment of the scale and scope of the storage economy more broadly.

My solution has been to calculate both one-year (i.e. no risk buffer) and two-year (i.e. one extra year's worth of grain held on reserve) estimates and to compare these side-by-side. In every case, the one-year estimate is exactly twice the size of the two-year estimate, and this difference can have an enormous impact on the conclusions that can be drawn. For example, if the silos excavated at Fara were only intended to provide one year's worth of food for the population, then it is at least possible that the entire population of the city was dependent on the grain stored in these silos; my calculations suggest that the silos could have held enough grain to support 26–144 % of the population for one year. If, on the other hand, the silos were also intended to store an extra year's worth of grain as a risk buffer (i.e. a total of two years' worth), then my calculations suggest that they could only have held enough grain to support 13–72 % of the population. Even at the maximum end of this range, the storage capacity available within the silos would not have been sufficient to support the entire population of the city.

The third issue is centralization. In the case studies that I have examined, I have focused solely on the evidence for extra-household storage facilities, that is, storage facilities that were not located within the physical confines of residential structures. It should be clear, however, that the general category of "extra-household" storage encompasses a significant degree of variation, both in the scale of storage facilities and in their relative centralization. Of course, the degree of centralization in any particular storage system cannot really be judged by examining individual, isolated storage facilities; centralization and decentralization are ultimately about patterning in the distribution of storage facilities and in the flow of grain across the landscape. Both of these things can be difficult to assess using only the partial exposures generally available to the archaeologist. Still, I think it is worth reflecting briefly on the evidence for centralized and decentralized storage systems in Mesopotamia.

Among the facilities that I have examined, the Naram-Sin Palace at Tell Brak stands out as a truly massive storage facility and probably the strongest suggestion of a high degree of centralization. It would be nice if we could compare this example at the periphery of the Akkadian state with some examples closer to the center of Akkadian power, but the archaeological evidence for the Akkadian period in southern Mesopotamia is very weak. An interesting comparison can be made, however, with the Akkadian-period evidence from Tell Leilan, another urban center in northern Mesopotamia. The excavators of Tell Leilan may be correct in arguing for a major reorganization of the agricultural landscape and the redistributive economy – all orchestrated by the expanding Akkadian empire – but, as far as I can tell, direct evidence for large-scale, centralized storage during the Akkadian period has not yet been uncovered at Tell Leilan. According to my calculations, the "Granary" excavated within the Akkadian Administrative Building (and the two small bins excavated to the south of the building) on the Acropolis at Tell Leilan could have held enough grain to feed a maximum of 13–57 people for one year or 7–28 people for two years. This might have been enough to support the administrative staff or perhaps a somewhat broader collection of dependents, but the storage capacity of the Granary is miniscule in comparison with the Naram-Sin Palace at Tell Brak, which could have held enough grain to feed a maximum of 3,143–11,850 people for one year or 1,571–5,925 people for two years. Was the construction of the Naram-Sin Palace primarily a means of establishing control over the local population – for example, by hijacking and restructuring the local redistributive economy – or was it primarily a means of collecting grain and other goods that could then be shipped southward to the heartland of the Akkadian state? Or both? Either way, the scale of the storage facilities excavated at Tell Brak and Tell Leilan suggests the possibility of a very different kind of Akkadian presence in the two settlements and, perhaps, a very different function within the project of Akkadian expansion.

It is hardly surprising that, among my case studies, the other example of large-scale, centralized storage comes from the city of Ur during the Ur III period, when this city lay at the center of a geographically extensive, state-organized redistributive system. I certainly do not wish to claim that all of the possible storage facilities that I examined at Ur were dedicated exclusively to storage or, even more, exclusively to grain storage, but my calculations do provide an approximate sense for the maximum storage capacity that might have been available within the monumental temenos area at Ur. If all of the storerooms that I examined within the *Enunmah*, the Court of Nanna, and the *Giparu* were used for grain storage, they could potentially have held enough grain to feed 5,644–22,558 people for one year or 2,822–11,279 people for two years. There was, therefore, at least the potential for a significant amount of grain storage capacity at the fortified heart of the city – a fact that should be considered alongside Steinkeller's argument for a more decentralized network of small, rural storage facilities in the Umma province during the Ur III period (Steinkeller 2007: 190-193).

Fara provides a fascinating counterpoint to the evidence for large-scale, centralized storage at Tell Brak (Akkadian period) and Ur (Ur III period). During the ED IIIa period, at least 32 massive underground silos were distributed widely – though not in a uniform fashion – across the urban landscape at Fara. Considered in the aggregate, these silos amount to a major investment in bulk storage capacity. Bearing in mind the significant uncertainty involved (e.g. with respect to the dimensions of the silos), my calculations suggest that the 32 silos could have held enough grain to support a maximum of 5,391–19,582 people for one year or 2,695–9,791 people for two years; in other words they could have held enough grain to support a maximum of 26–144 % of the population for one year or 13–72 % of the population for two years. These figures are interesting in themselves, but I think it is also worthwhile to consider the storage capabilities represented by each silo individually. If we simply divide the aggregate estimates by 32, then my calculations suggest that each silo could have held enough grain to support a maximum of 168–612 people for one year or 84–306 people for two years; in other words, each silo could have held enough grain to support a maximum of 0.8–4.5 % of the population for one year or 0.4–2.3 % of the population for two years. As we saw in Chapter 5, the archaeological and written evidence from Fara offers some conflicting information about the degree of hierarchy and centralization within the city. It is certainly possible that the 32 excavated silos were all part of a centrally planned and centrally managed storage system, but we should also consider the possibility that storage was being managed in a more decentralized fashion. In either case, my calculations offer a sense for the size of the group – for example, a kin group, a neighborhood, or an institutional "household" – that might have been dependent on each silo.

The smaller sites that I have examined have also produced evidence for both more and less centralized forms of storage. I am thinking, for example, of Tell al-Raqa'i and Tell Gubba. Approximately equal in size, these two sites have produced very different evidence for grain storage. Tell al-Raqa'i was dominated by a large, circular structure that appears to have been dedicated (at least in Level 4) primarily to storage. To the northwest of this building, several large silos were uncovered, but the domestic structures which occupied the remainder of the site produced very little evidence for storage. However one interprets this evidence – as a collection of shared, communal storage spaces, as an agglomeration of spaces belonging to particular groups, or as the work of a distant urban polity – it certainly represents a concentrated, centralized form of grain storage.

At Tell Gubba, on the other hand, several different levels produced evidence for numerous small, raised "granaries" spread across the excavated portions of the site. On the published plan for Level V, for example, I have identified 34 granary structures, each composed of between one and eight separate "rooms." In total, these granaries could have held enough grain to support a maximum of 386–1,436 people for one year or 193–718 people for two years. Their somewhat haphazard distribution across the settlement, however, suggests a relatively decentralized form of organization. There might, for example, have been some relationship between the granaries and the four, one-room "house" structures in their midst. If each house structure had access to an equal percentage of the storage space available in the granaries – which I certainly cannot prove – then each of these houses could have stored enough grain to support 97–359 people for one year or 48–180 people for two years. These "people fed" numbers exceed the potential occupancy of each house by a significant margin. Perhaps we are seeing hints here of a connection (e.g. via kinship links) with mobile or semi-mobile groups operating across a broader region (see Renette 2010 for a similar argument applied to the Level VII Round Building at Tell Gubba and other structures in the Hamrin), but the evidence is certainly far from certain.

This brief exploration of centralization brings up one final point. From an analytical perspective, quantification is not enough. Throughout this dissertation, I have focused on storage capacity and, in particular, on two questions: "How much (grain)?" and "How many (people)?". These two questions are important, but they are only the tip of the iceberg. Ideally, to really understand the full complexity of storage practices in third millennium Mesopotamia, we would also like to know exactly who was relying on the stored grain, where the grain was coming from, and how it was making its way to consumers. That is, we would like to be able to reconstruct the systems of collection, access, control, distribution, dependency, and entitlement that gave shape to the evolving moral economy. Given the kind of detailed information that is available in the contemporary cuneiform record, these questions are not out of reach, but my goal here has been more restricted: to use the archaeological evidence to establish a baseline, quantitative appreciation for the scale and the scope of the storage economy in Mesopotamia.

CHAPTER 7

DISCUSSION AND CONCLUSIONS

To draw the discussion to a close, I will revisit several issues introduced in Chapters 1 and 2. First is the assumed link between storage and surplus. I have argued that the concept of surplus – whether used as a simple synonym for "extra" or as a more specific term borrowed from economics – has exerted an undue influence on how we think about the role of storage in Mesopotamia. With some important recent exceptions, discussion of storage has often been conducted at relatively high level of abstraction, with little reference to the existing archaeological and written evidence. Although seldom spelled out in any detail, the assumption seems to be that the cereal economy in third millennium Mesopotamia was centripetally organized, with agricultural surpluses flowing inward toward massive, centrally managed, urban storage facilities and then back outward through a process of redistribution. Depending on a particular author's perspective, this systematic circulation of agricultural surpluses – and, by extension, the storage facilities around which it revolved – might be taken as a sign of exploitation by the institutions, integration on an unprecedented scale, or increased resilience in the face of a fickle environment.

I have argued that this abstract perspective on storage is insufficient and needs to be more firmly and more explicitly grounded in the existing evidence. This is, of course, a messy proposition. The written evidence for grain storage has not yet been explored in a systematic manner, and the archaeological evidence that I have assembled here is, as a general rule, fragmentary and ambiguous. I cannot claim that the archaeological sample I have examined is comprehensive or representative, but it does suggest a more complicated situation than is typically envisioned from a more abstract, theoretical vantage point. Why this apparent mismatch between expectations and reality, between our idealized image of the institutional storage economy – based, at least in part, on hints in the written record – and the archaeological evidence?

The simplest answer would be that we are dealing with a sampling problem: the archaeological evidence is there, but it has been missed by excavators. It is certainly true that Near Eastern tells often demand a highly selective excavation strategy and that broad horizontal exposures can often be achieved only for the uppermost stratigraphic levels. Especially in the case of the largest sites, the amount of surface area uncovered by excavators may be only a tiny fraction of the total area covered by the site. Enormous storage facilities could easily remain undetected, even after many years of excavation. At the same time, the conditions of preservation in Mesopotamia often hinder the identification and examination of very small sites, many having been plowed under or covered by alluvium. Entire networks of small-scale, institutionally managed, rural storage facilities, like those identified by Piotr Steinkeller in the texts from Ur III Umma (Steinkeller 2007: 190-193), could easily go completely undetected. Given these sampling issues, it is hardly surprising that Mesopotamia has not produced archaeological evidence for storage on a par, for example, with the well-known Inka storage system (e.g. Levine 1992).

I would suggest, however, that several other factors may also be in play. First, we should bear in mind that institutional expansion does not necessarily require the construction of a brand new, highly standardized, purpose-built infrastructure. The initiation and completion of major construction projects was certainly considered one of the primary responsibilities of kingship in Mesopotamia, and rulers often went out of their way to put their stamp on building projects (e.g., literally, with brick stamps) and to celebrate their accomplishments in this field: new or refurbished temples, expanded irrigation networks, etc. At the same time, however, the expanding states of early Mesopotamia sometimes appear to have co-opted existing systems of administration and staple mobilization, adjusting them to suit their own purposes; we should not be surprised if they also co-opted existing storage facilities or even entire storage systems. It would be nice – from an archaeological perspective – if the Akkadian and Ur III states (or particular temples), for example, each relied on their own distinctive type of purpose-built storage facility or, at least, clearly marked their storage facilities with signs of ownership. My hunch, though, is that we should probably expect a more complicated mixture of new constructions, repurposed buildings, and requisitioned storage facilities built according to local traditions.

Second, we should consider the possibility that institutional storage systems were less centralized than is typically assumed. Palaces and temples were, indeed, physical seats of power, architectural complexes that served as focal points within the urban landscape, central places toward which grain and other goods flowed. They were also, however, diffuse networks of authority and control, complicated amalgams of people and resources distributed broadly across city and countryside. The institutional economy was typically organized and understood not as a single, hyper-centralized entity but, instead, as a multilevel, nested hierarchy of semi-autonomous "households" (see e.g. Gelb 1979; Schloen 2001; Garfinkle 2008; Ur 2014). While there certainly were central storehouses incorporated within, attached to, or associated with the physical seats of institutional power – that is, with the palace and temple complexes – it may not have made logistical sense to move the bulk of the grain harvest into these central storehouses. It is at least possible that the provision of a physical space for storing grain that belonged, ultimately, to the palace or temple was often considered the responsibility of subordinate social or administrative units (e.g. lower level "households" of one sort or another).

Third, the existence of a highly centralized redistributive system does not necessarily imply that the majority of the harvested grain was making its way physically into the city, before being re-allocated to institutional dependents. Steinkeller, for example, has argued that a significant amount of "redistribution" – that is, the officially documented collection, storage, and doling out of grain – actually took place at small, special-purpose, rural hamlets. According to his argument, many documents that appear to record the delivery of grain into centralized storage facilities or the withdrawal of grain from such facilities are administrative fictions based on transactions that actually happened at small storehouses spread out across the agricultural landscape (Steinkeller 2004). This argument is based on documents from the province of Umma, dating to the Ur III period, but it is worth keeping in mind as a more general possibility.

Finally, I think that we need to consider the possibility that fewer people were relying on centrally stored grain supplies than is often assumed. That is, we may need to reconsider the magnitude of the institutionally managed redistributive economy. Many efforts have been made to gauge the extent of the institutional economy and to argue either for or against the existence of a significant degree of extra-institutional economic activity. In the most general sense, there has been a divide between those who envision an all-encompassing, fully integrated institutional economy and those who, to the contrary, see evidence for a multi-sector economy that included a significant degree of private or communal economic activity. Of course, how one answers this question depends crucially on the specific place and the specific time period in question, but it also depends on the type of data employed. There has been a lot of debate, for example, about written evidence for institutional landholdings. The evidence for grain storage, a technology that theoretically lay at the very heart of the redistributive economy, has so far played very little role in these debates. I see my study as a first step toward bringing grain storage and, in particular, the archaeological evidence for grain storage into the discussion.

Centralized storage is regularly cited as a defining feature of the institutional paradigm in Mesopotamia, but it should be clear, I hope, that we still have only a very partial understanding of the storage economy in third millennium Mesopotamia. The same can be said of the moral economy more broadly. I have defined the moral economy as a complicated realm of discourse and practice, where ideas about rights, responsibilities, and entitlements collide with the daily struggle to maintain access to food in the face of an unequal distribution of resources and risks. Mesopotamian specialists have certainly explored many specific aspects of the moral economy in great detail, but I suggest that we should be working toward a more comprehensive view of this fundamental topic. Given the radical series of transformations and ruptures that swept across Mesopotamia during the later fourth and the third millennium BC, we should absolutely expect to see evidence for significant transformations in the moral economy. One of the most striking developments during this span of time was the emergence of institutional organizations that were able to amass substantial holdings of agricultural land and a sizeable dependent labor force. Our perspective on the changing moral economy will depend, to a large extent, on how we understand the scope, the limits, and the effects of institutional power in third millennium Mesopotamia.

I have drawn particular attention to two questions. First, how many people were dependent on the institutions? And, second, how were these dependents treated in times of crisis? The first question is a difficult one that has been debated for many years. My own approach has been to focus on those people who were directly dependent on the distribution of food from institutional storage facilities, that is, people who were receiving grain rations. This approach ignores the many other types and degrees of dependency that we know existed in Mesopotamia – thanks to the testimony of the cuneiform record – but it allows me to focus attention on the simple, but meaningful, distinction between those who relied on institutional storage and those who relied primarily on their own stocks of food. The second question has received much less attention but needs to be addressed, if we hope to develop an accurate assessment of the effects of institutional expansion in Mesopotamia. The most common assumption is that the institutions provided dependents with a buffer against risk and a new level of long-term stability, but neither of these points has been adequately demonstrated and supported with solid evidence. My own quantitative examination of the archaeological evidence for storage has certainly not provided a definitive answer, but it has drawn attention to an important point: our assumptions about the risk-buffering function of institutional (and non-institutional) storage should (but, in the literature, often do not) have a significant impact on our estimates for the number of people that could have been supported with the grain stored in particular storage facilities. This point applies to archaeological studies like mine, but it also applies to similar attempts to derive quantitative information from the written record (e.g. Visicato's analysis of the texts from Fara; see Chapter 5).

I will close with a few thoughts about future work. Certainly, the recovery of new evidence for storage facilities in Northern or Southern Mesopotamia could radically alter the picture that I have sketched here, but there is also significant room for further efforts to revisit and reanalyze the existing archaeological evidence for grain storage. I have examined some of the best evidence currently available, but many other case studies could also have been included. Perhaps more important, my examination of evidence for extra-household grain storage should be balanced with a detailed study of the evidence for household-level storage, that is, storage taking place within the bounds of residential structures. This would be a major project, and it would be subject to many of the same uncertainties and ambiguities that I have confronted. With the rise of the institutions in Mesopotamia, however, the question of household autonomy – that is, the degree to which individual households were able (or even had a desire) to maintain some degree of autonomy in the face of increasing institutional interventions – takes on a particular significance.

The other crucial path forward is more detailed attention to the written evidence for grain storage. As I have indicated numerous times, the abstract vision of a highly centralized Mesopotamian "storage economy" is derived primarily from the cuneiform record, but there have been relatively few attempts to collect and analyze the relevant material. Studies focusing on the operation of particular storage facilities and storage systems, for example, would be particularly valuable, as would attempts to quantify inputs and outputs. The cuneiform record also offers an unparalleled opportunity to track exactly who was contributing and receiving products from institutional storage facilities and, in some cases, when these transactions were taking place. This kind of information offers the possibility of understanding how social inequality was reflected in storage practices and, potentially, how access to stored food was managed from year to year (e.g. during good years vs. bad years). Detailed examination of the written evidence for storage could, therefore, provide fascinating new insight into the changing structure of the moral economy and could help us to understand how different people (e.g. different types of institutional dependent) experienced and managed risk in Mesopotamia during the third millennium BC.

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PSD *The Pennsylvania Sumerian Dictionary*

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APPENDIX 1

FIGURES

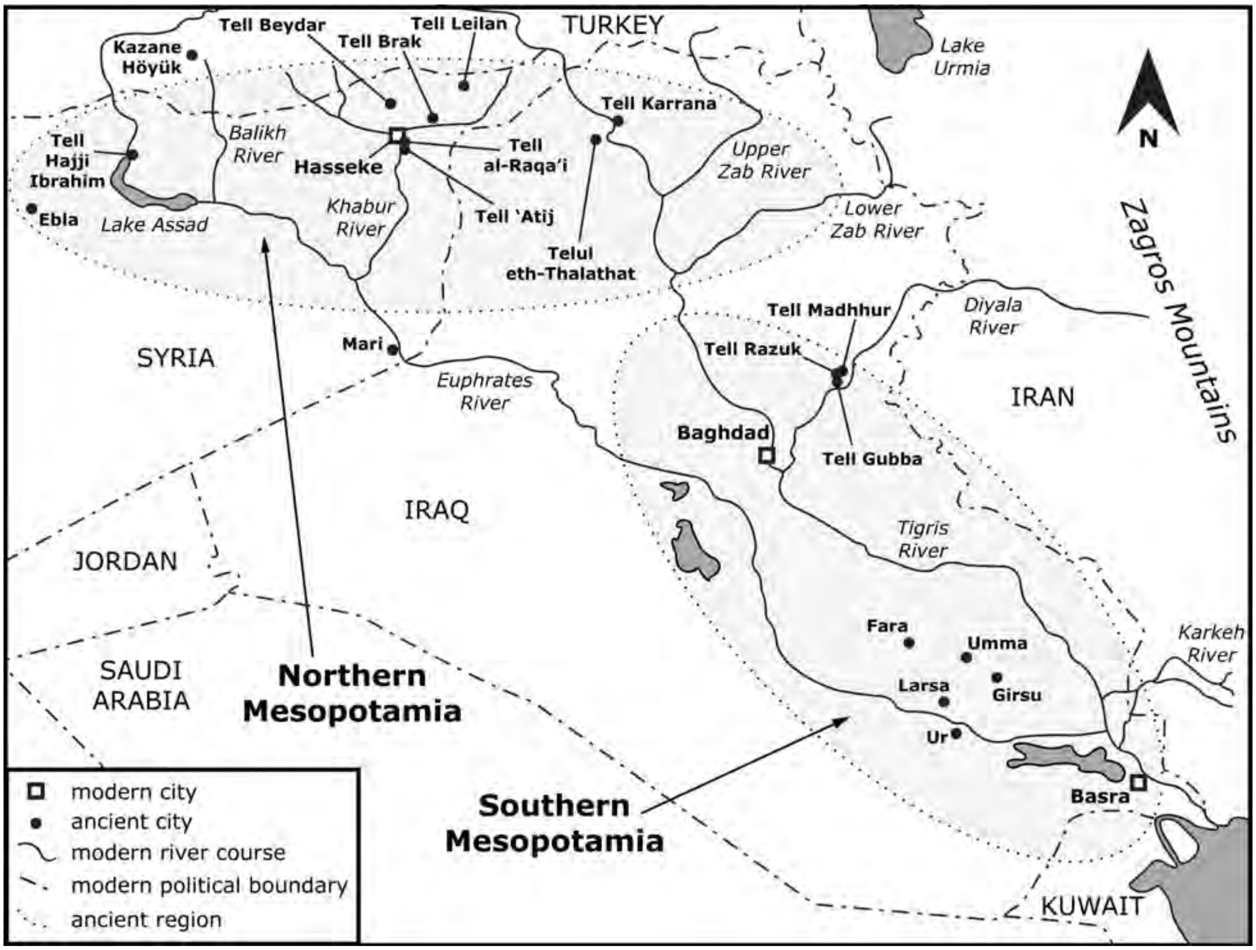


Figure 1.1: Map showing Northern Mesopotamia, Southern Mesopotamia, and sites mentioned in the text.

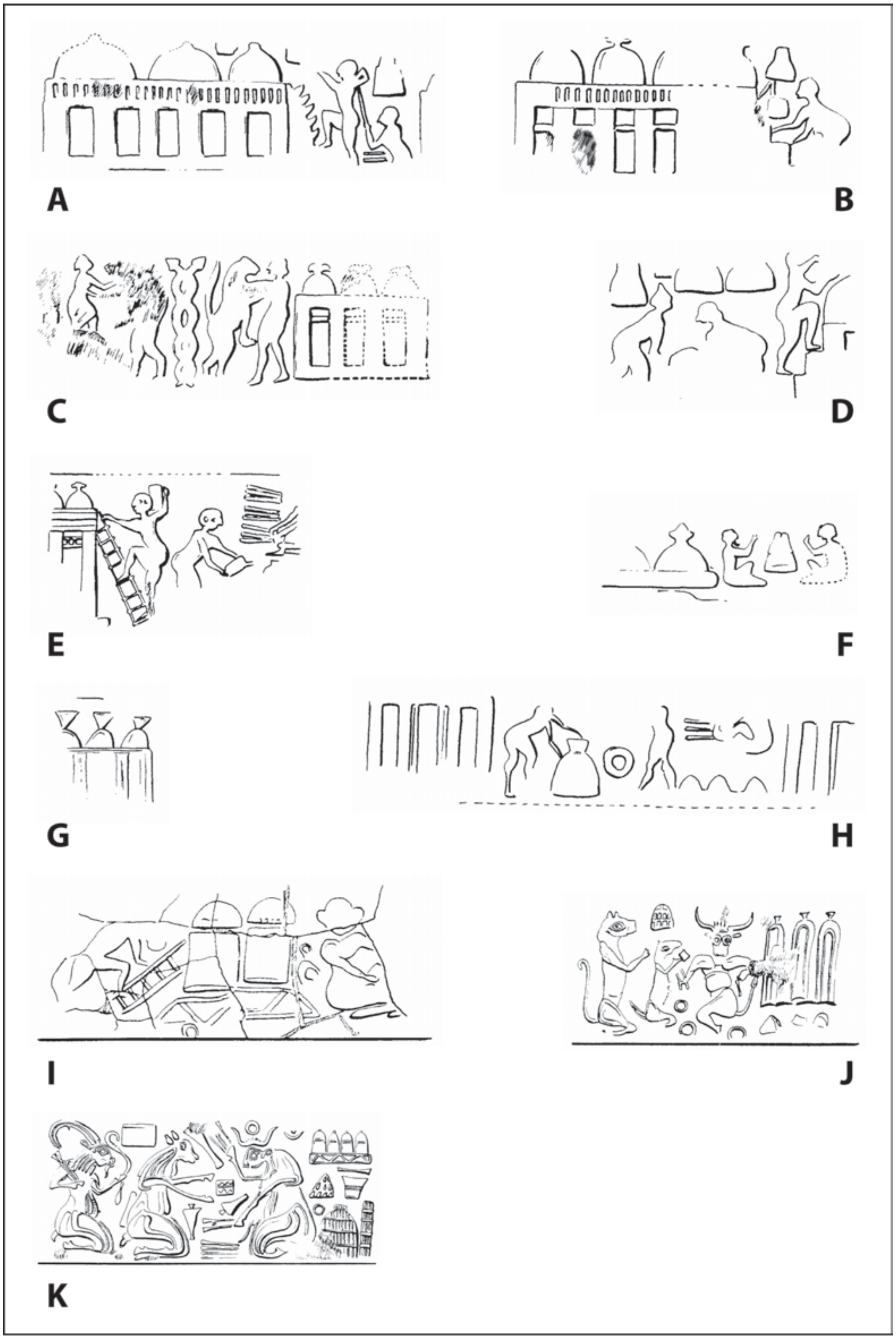


Figure 2.1: Cylinder seal impressions from Susa (later fourth millennium BC) showing domed granaries. (After Amiet 1961: Pl. 16, 36–37; 1972: Pl. 16)

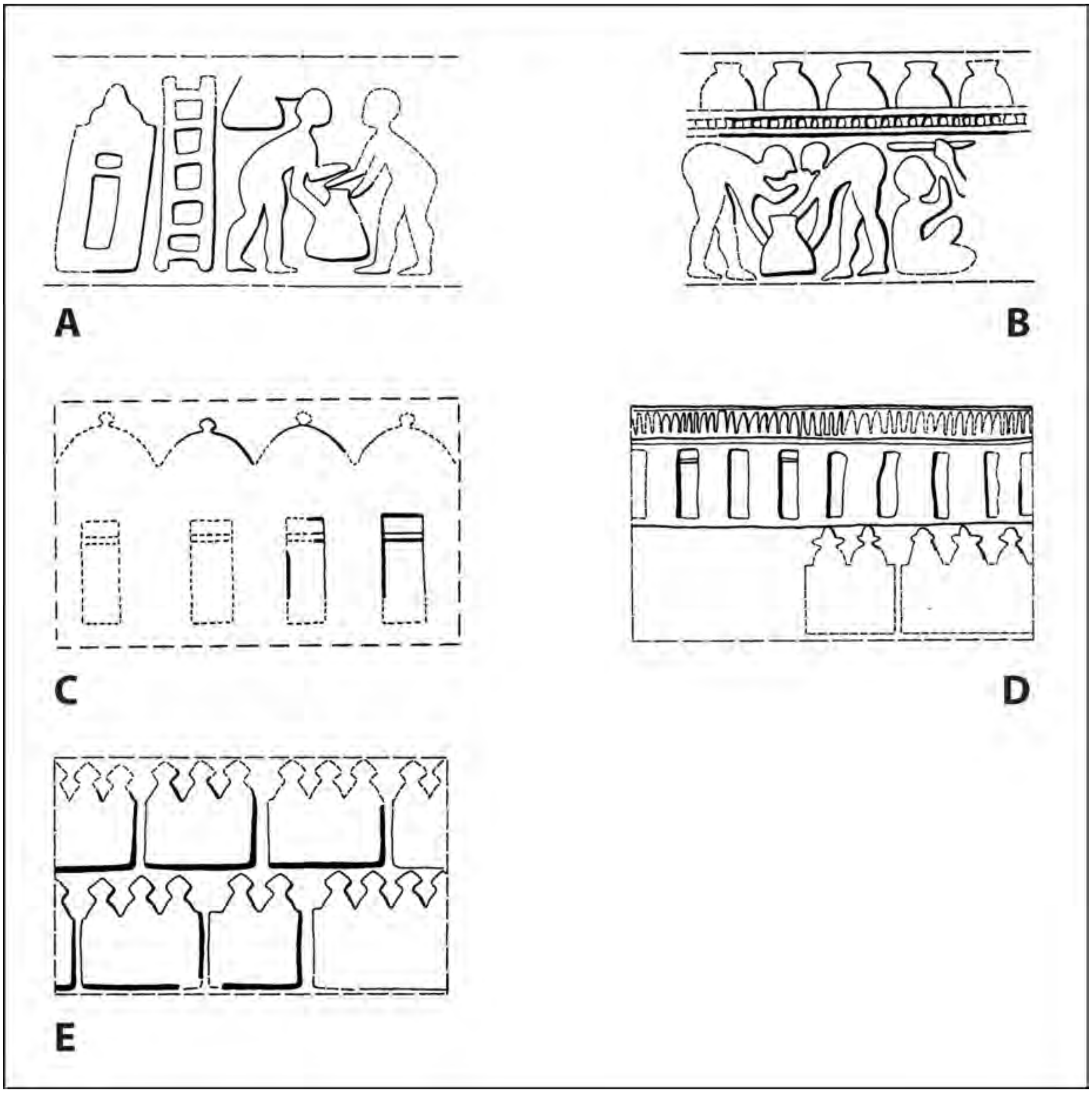


Figure 2.2: Cylinder seal impressions from Chogha Mish (later fourth millennium BC) showing domed granaries. (After Delougaz and Kantor 1996: Pl. 149)

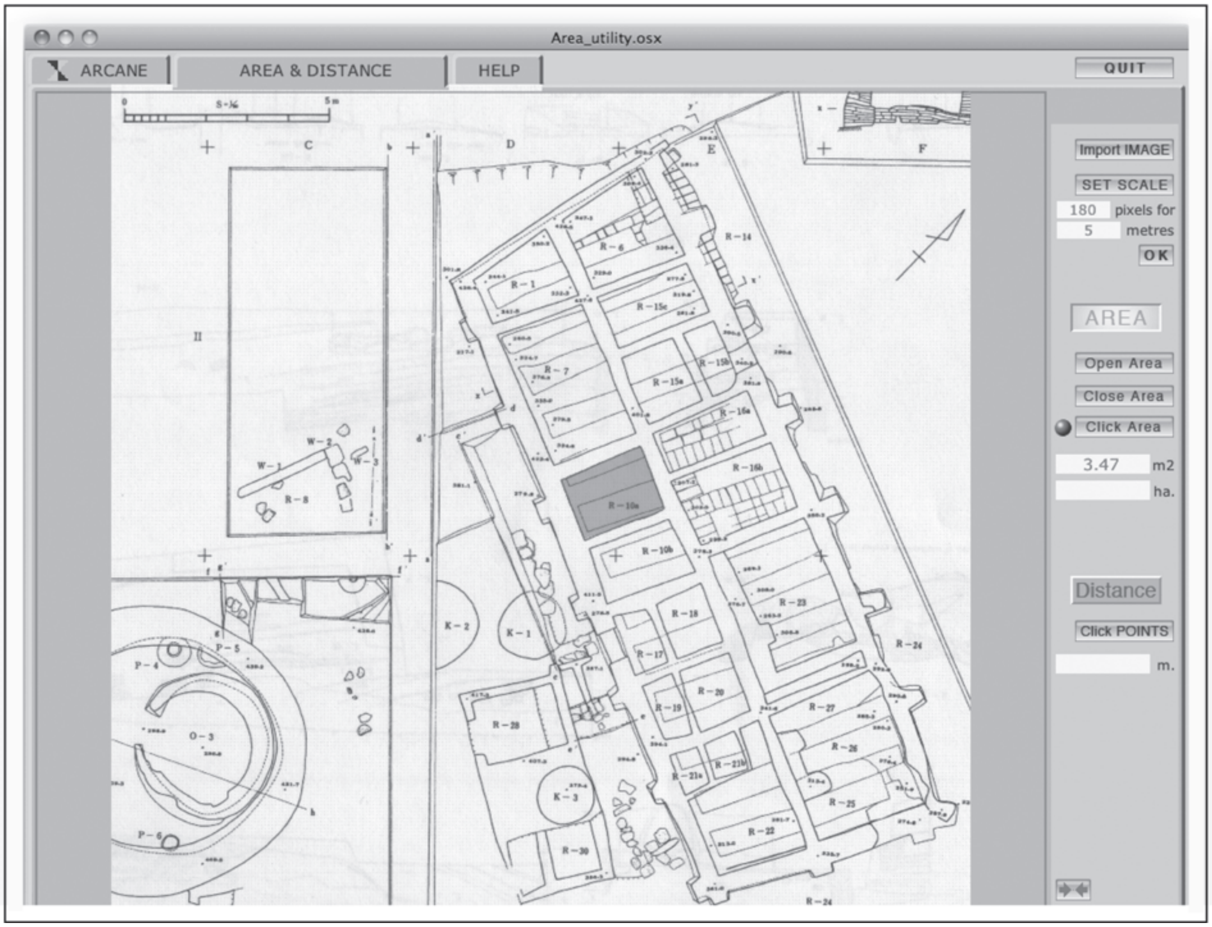


Figure 3.1: Screenshot showing Area_Utility tool (Version 1.02, 29/07/2007) developed by J. P. Thalmann for the ARCANE project.

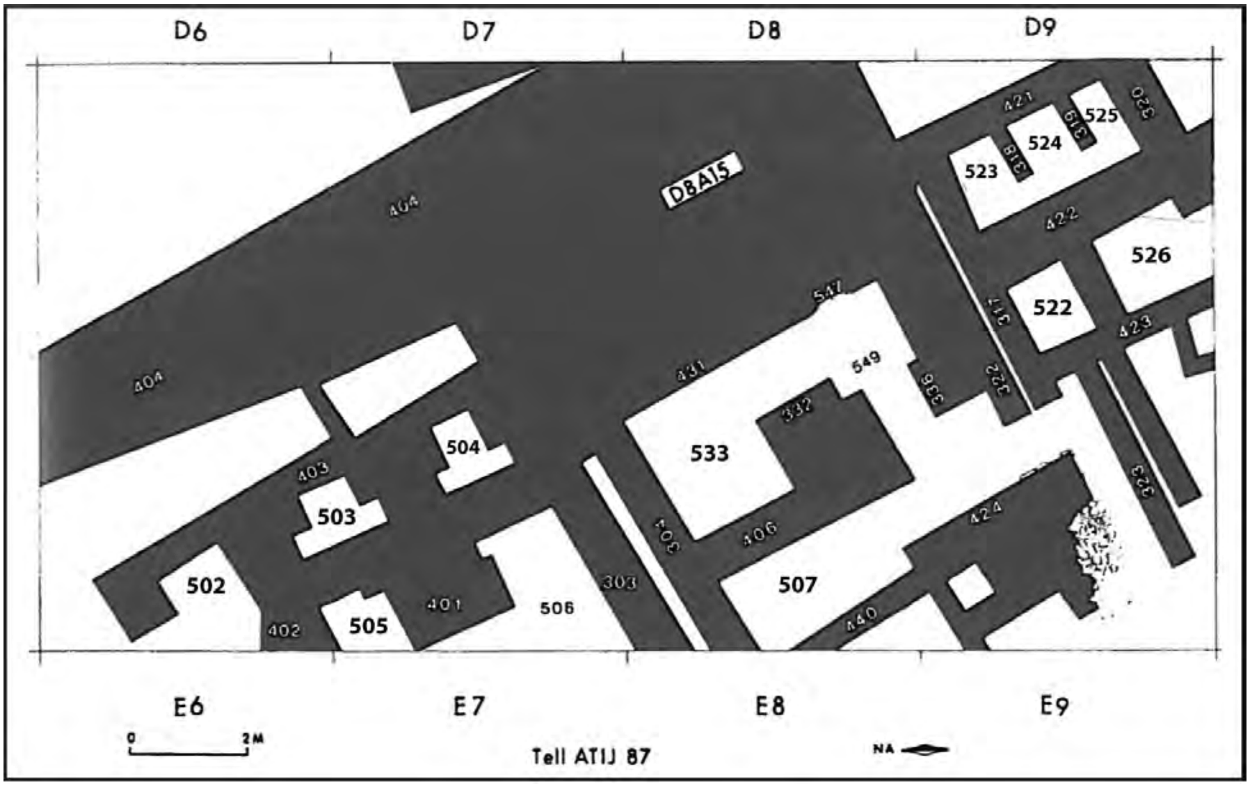


Figure 4.1: Tell ‘Atij, main tell, northern edge. Plan showing silos (502, 503, 504, 505, 522, 523-524-525), mudbrick platform (D8A15), and possible storerooms (507, 526, 533). (After Fortin 1990a: Fig. 2)

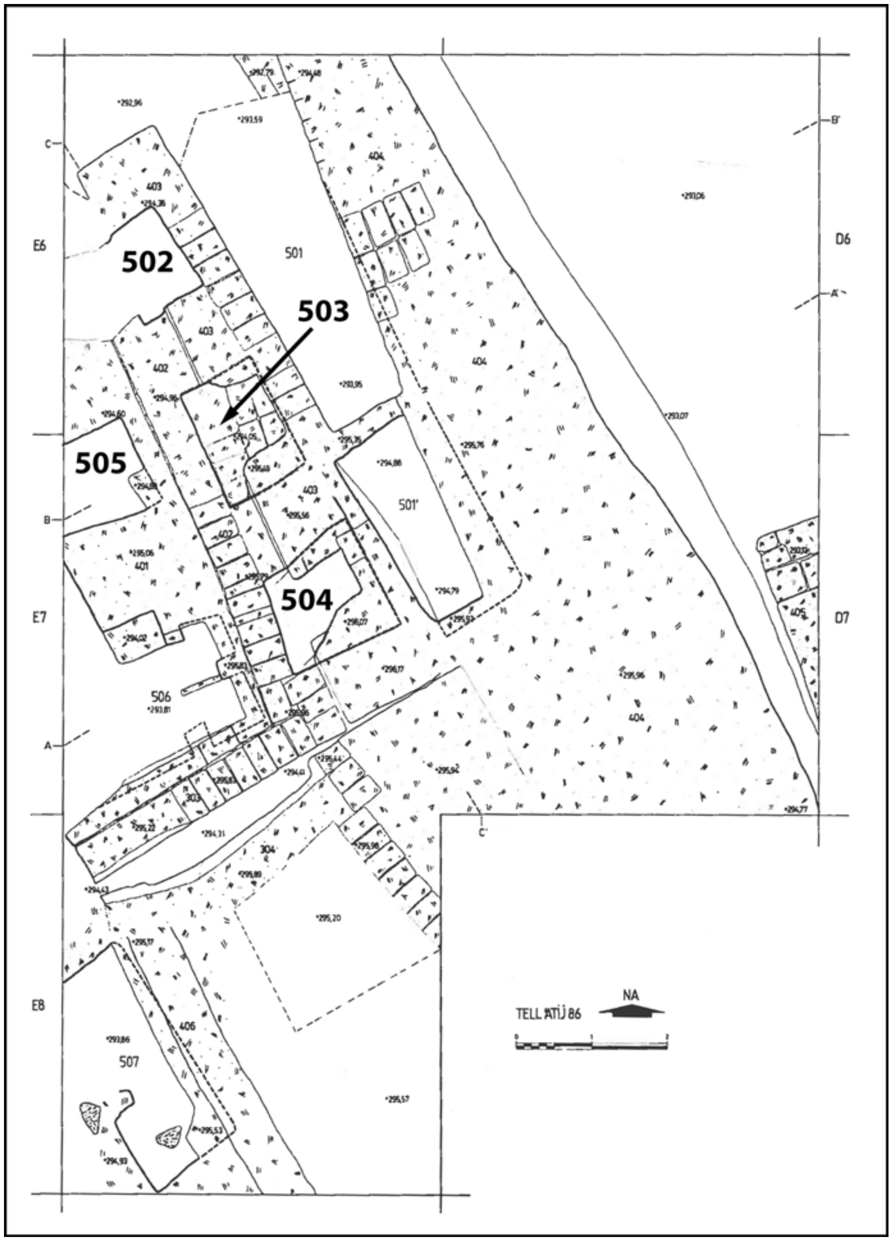


Figure 4.2: Tell ‘Atij, main tell, northern edge. Plan showing silos (502, 503, 504, 505). (After Fortin 1988: Fig. 18)

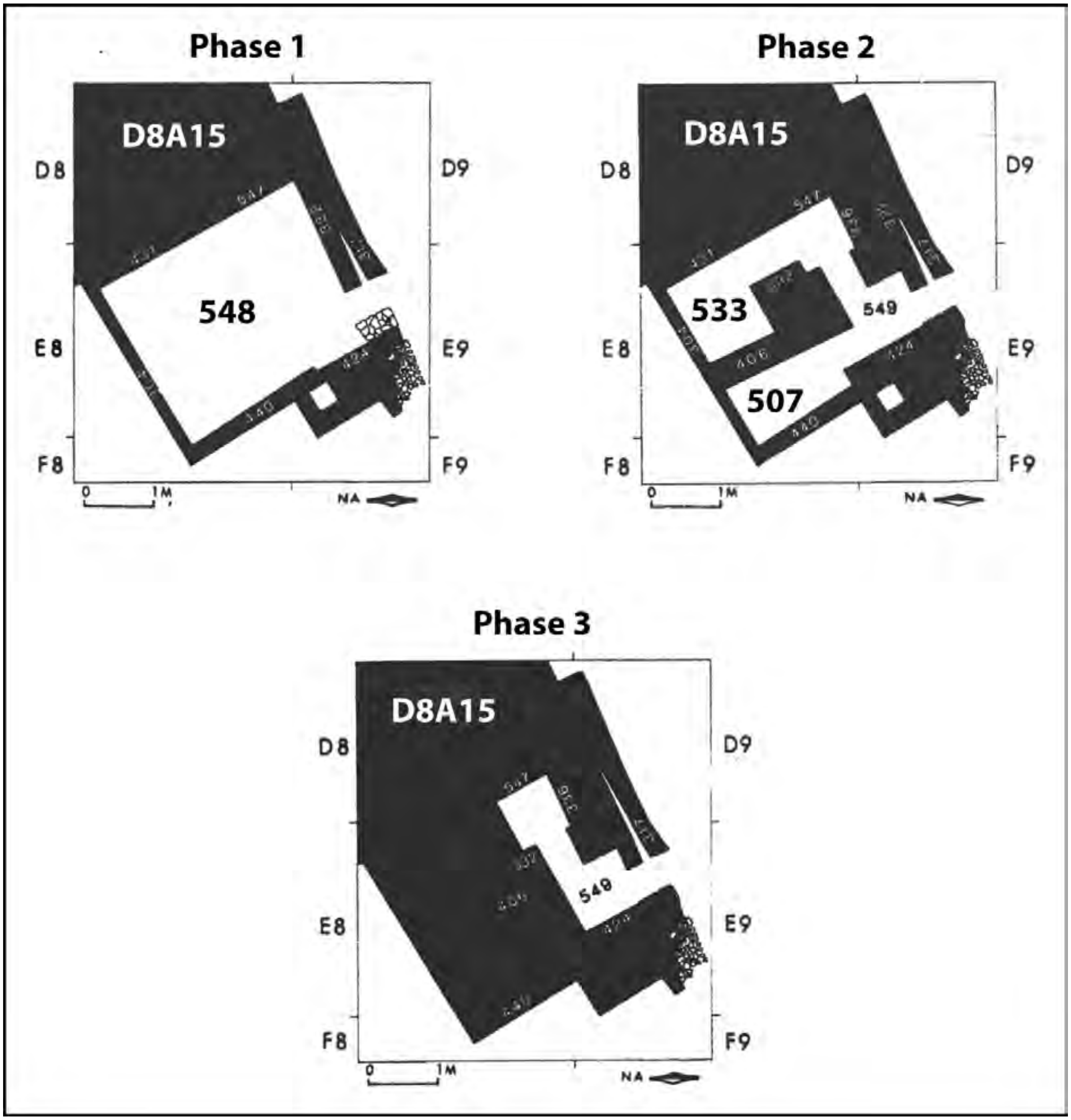


Figure 4.3: Tell ‘Atij, main tell, northern edge. Plan showing possible storerooms (507, 533, 548). (After Fortin 1990a: Fig. 5)

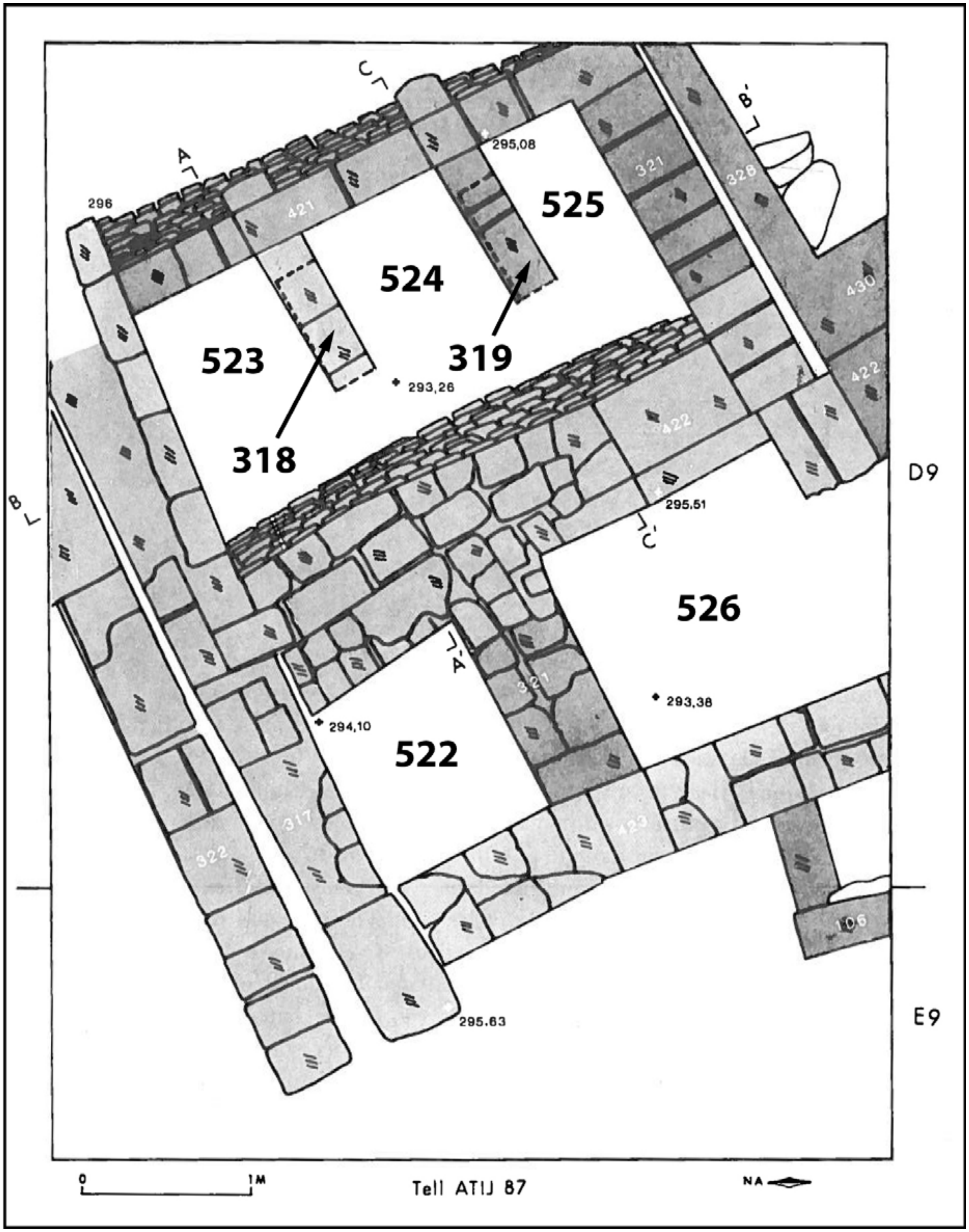


Figure 4.4: Tell ‘Atij, main tell, northern edge. Plan showing silos (522, 523-524-525). (After Fortin 1990a: Fig. 8a)

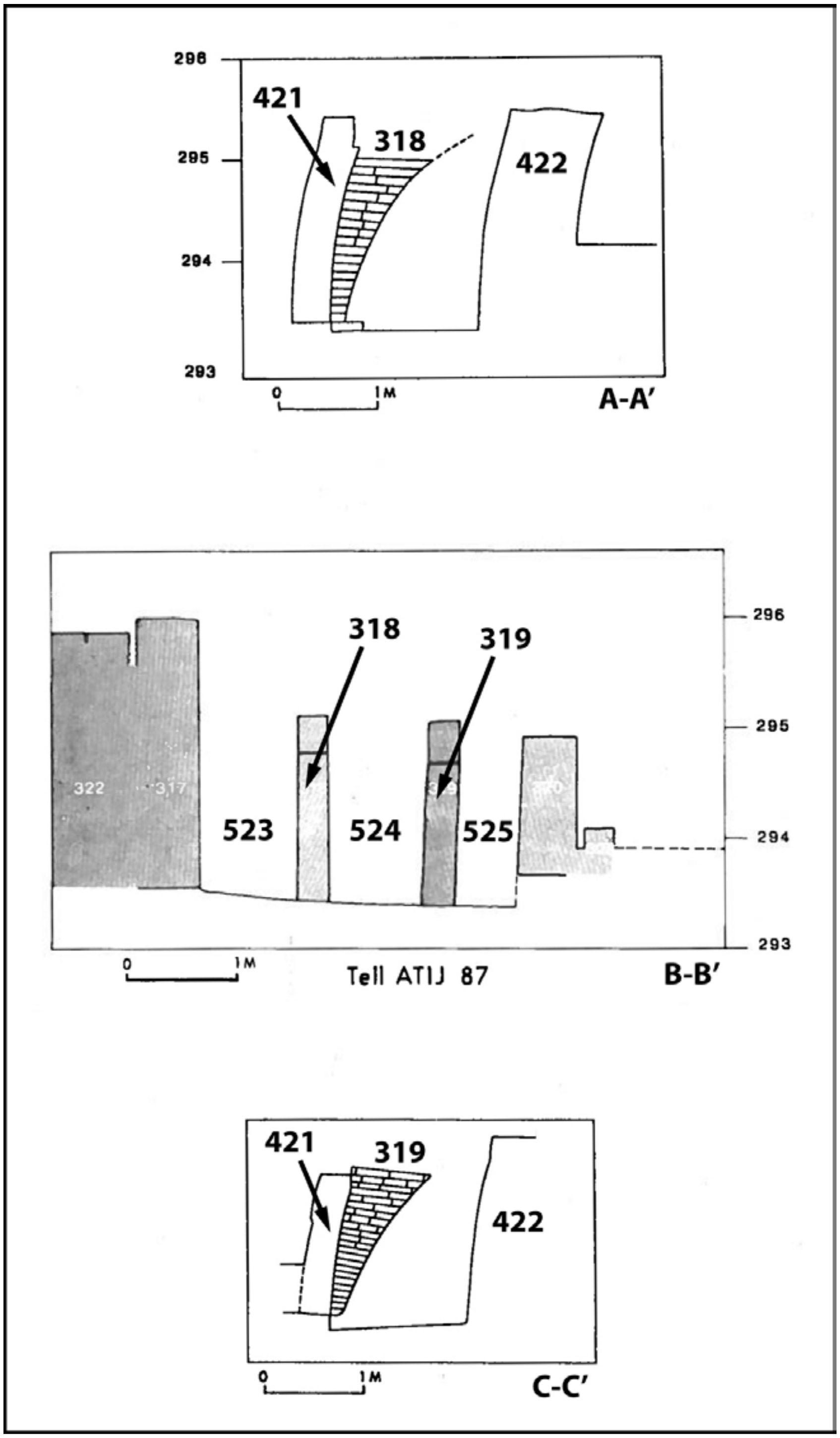


Figure 4.5: Tell ‘Atij, main tell, northern edge. Sections showing silos (522, 523-524-525) and arched partition walls (318, 319). For the location of the sections (A-A’, B-B’, C-C’), see Figure 4.4. (After Fortin 1990a: Fig. 8b)

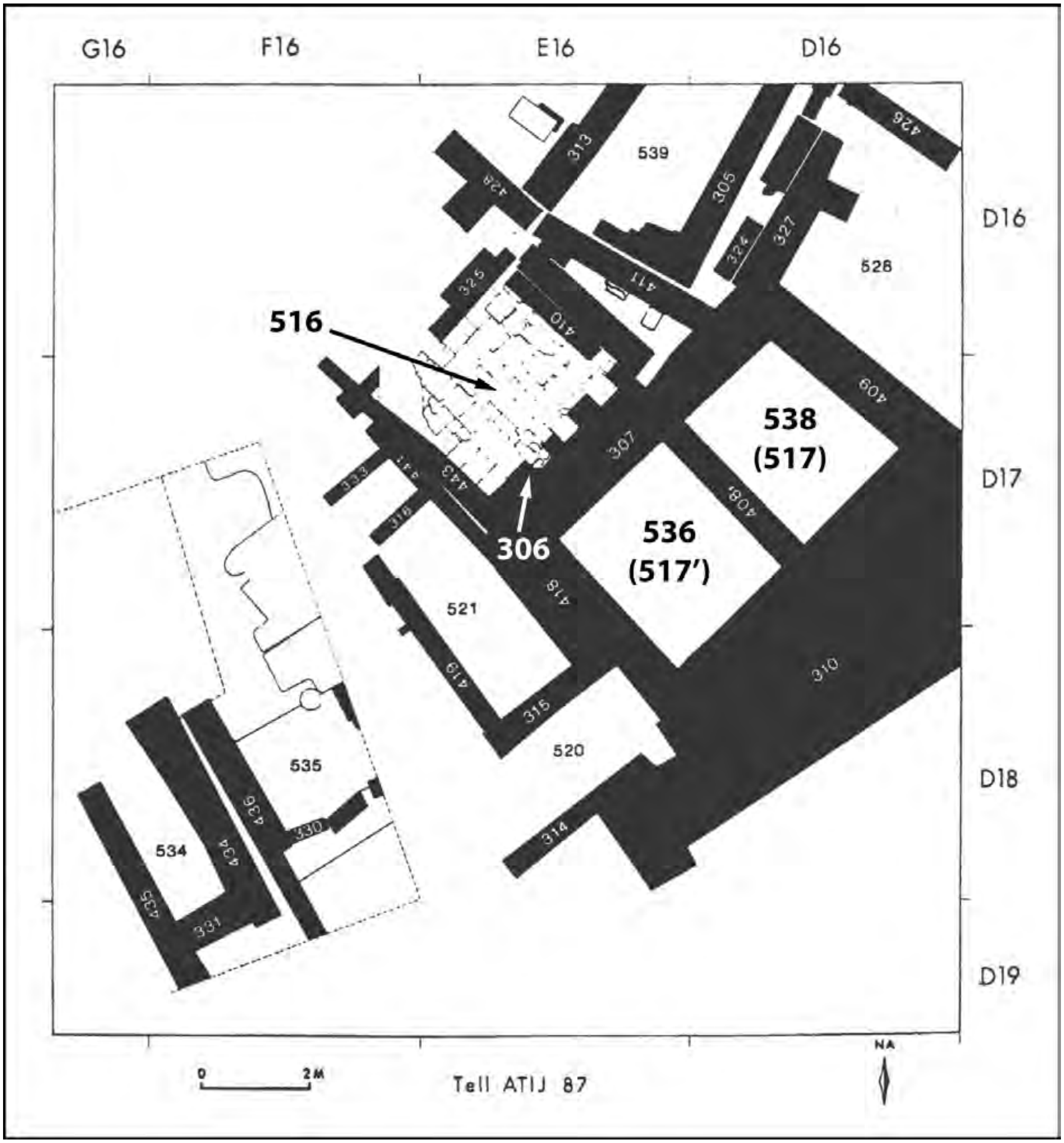


Figure 4.6: Tell ‘Atij, main tell, southern mid-slope. Plan showing storerooms (516 and 538-536). For reasons that are unclear (perhaps a difference in stratigraphic level?), the excavators sometimes refer to rooms 538 and 536, respectively, as 517 and 517’. I have, therefore, added this second set of room numbers (in parentheses) to the current plan. (After Fortin 1990a: Fig. 14)

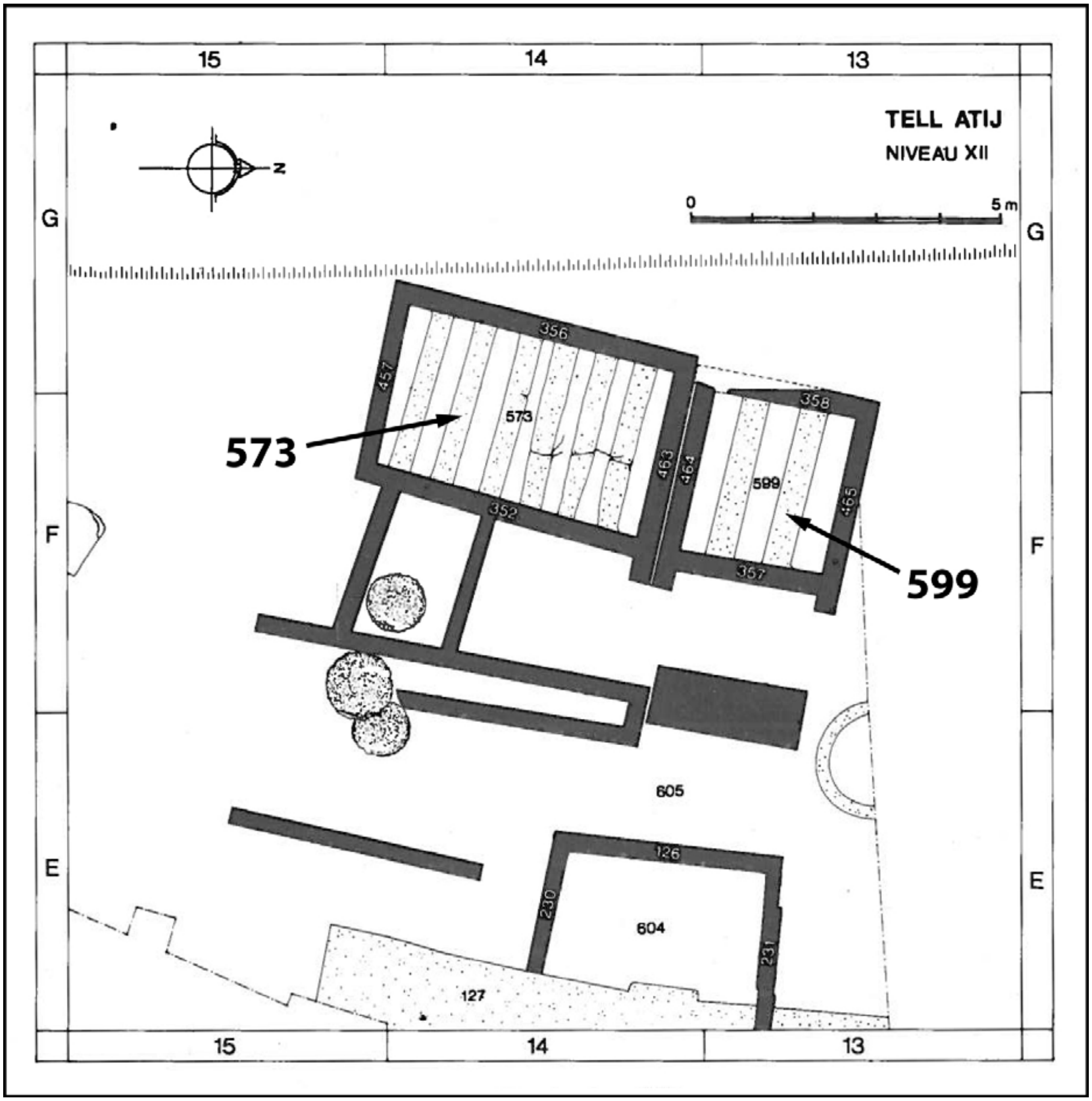


Figure 4.7: Tell ‘Atij, main tell, center, Level XII. Plan showing silos (573 and 599) with “grill-plan” foundations. (After Fortin 1995: Fig. 6)

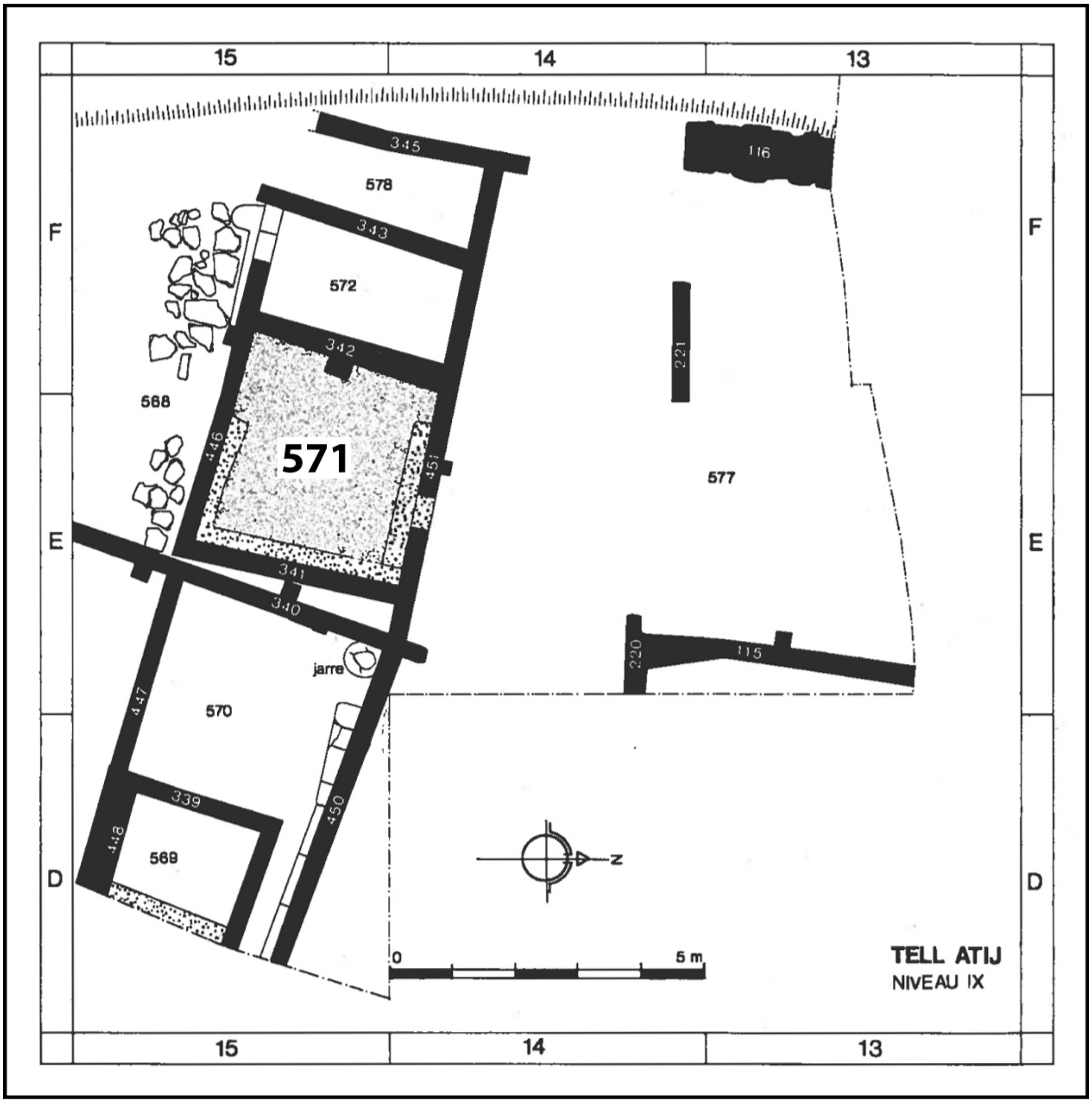


Figure 4.8: Tell ‘Atij, main tell, center, Level IX. Plan showing possible storeroom (571). (After Fortin 1994: Fig. 11)

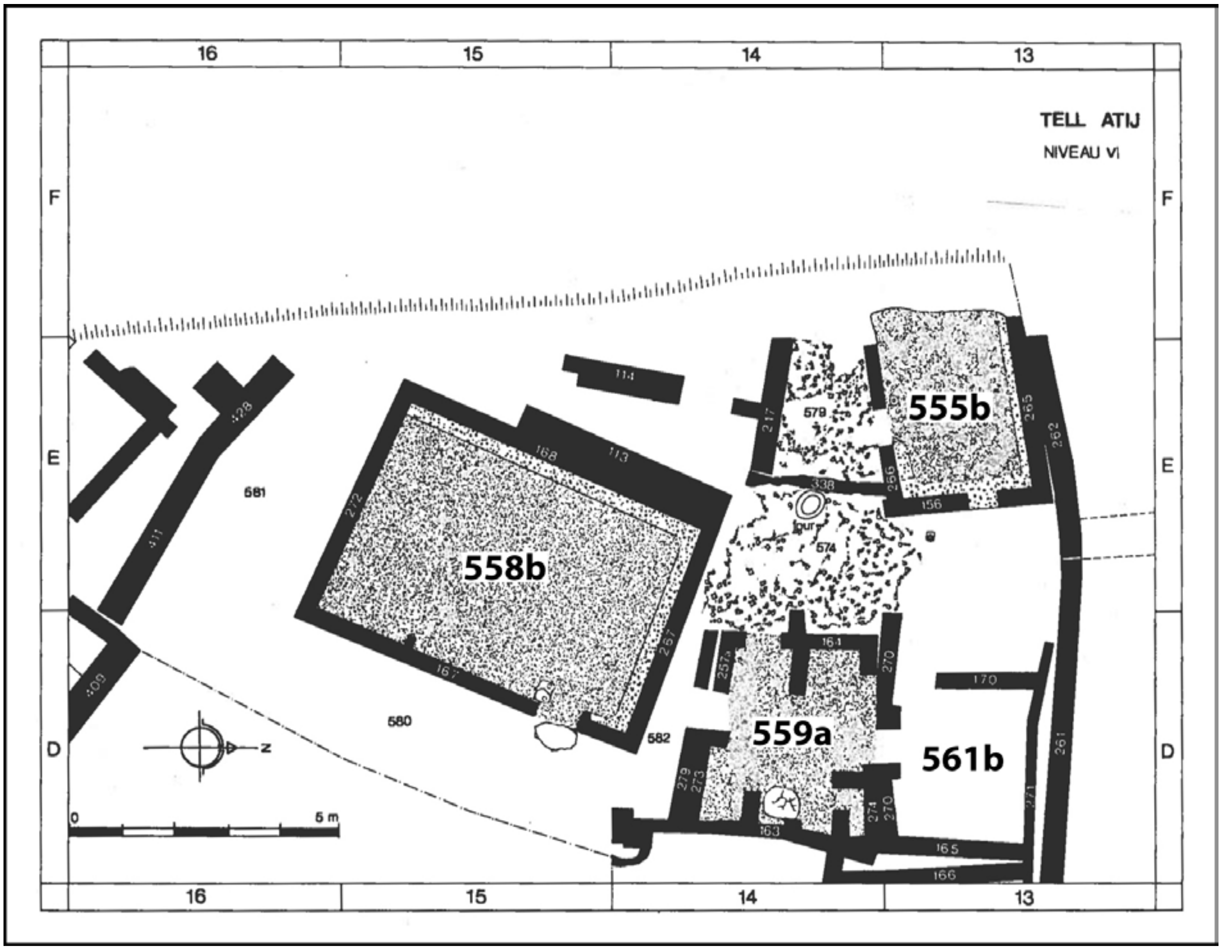


Figure 4.9: Tell ‘Atij, main tell, center, Level VI. Plan showing possible storerooms (555b, 558b, 559a, 561b). (After Fortin 1994: Fig. 3)

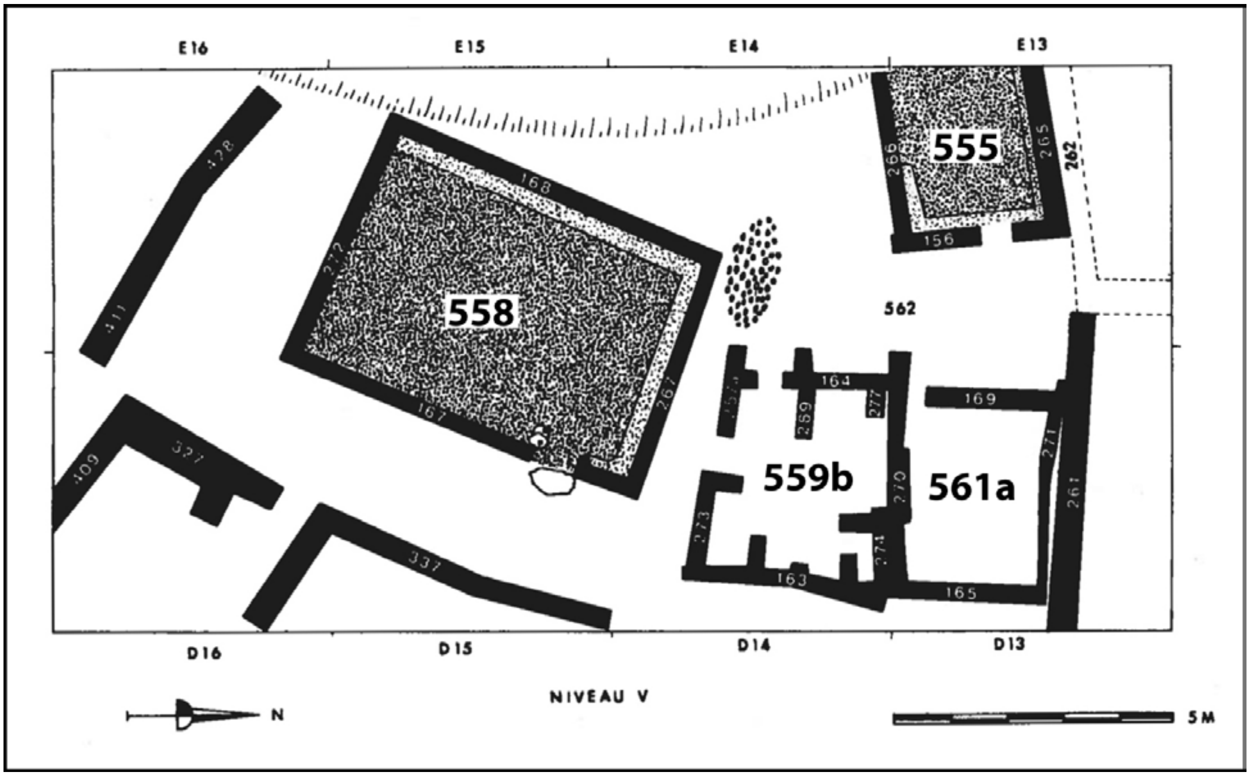


Figure 4.10: Tell ‘Atij, main tell, center, Level V. Plan showing possible storerooms (555, 558, 559b, 561a). (After Fortin 1990b: Fig. 6)

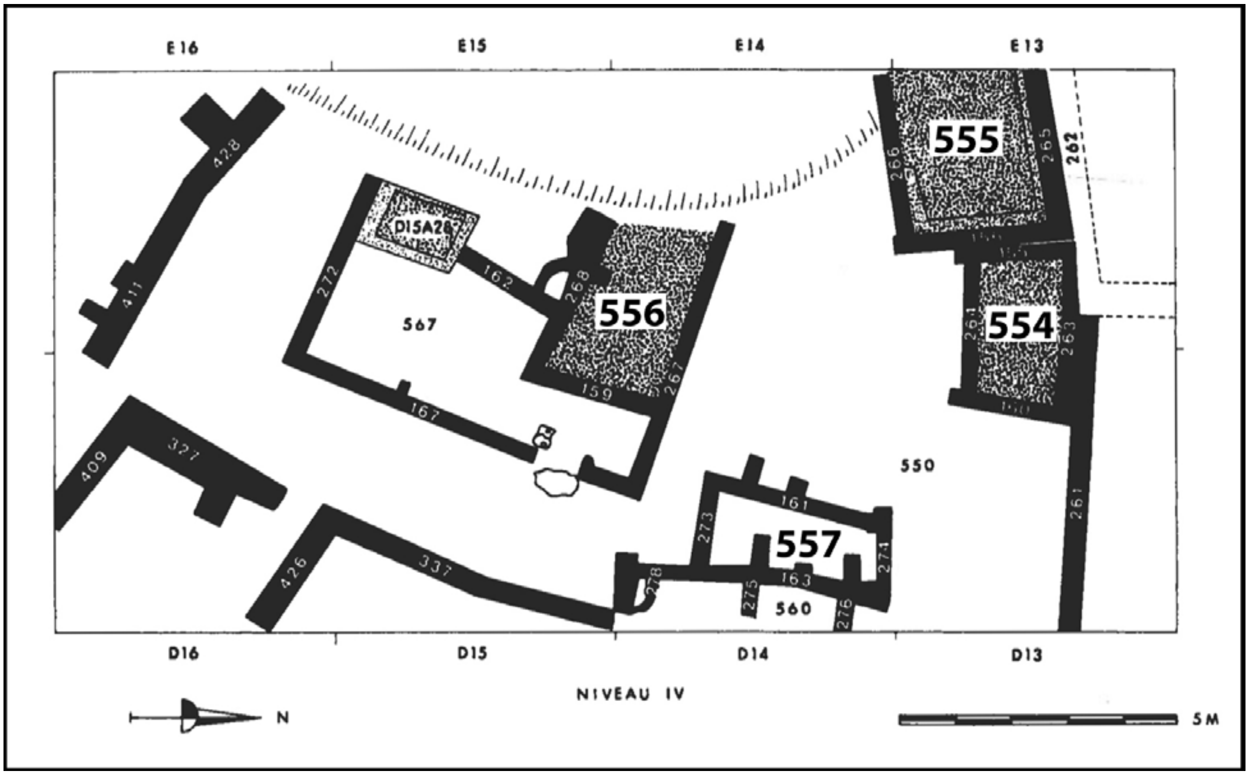


Figure 4.11: Tell ‘Atij, main tell, center, Level IV. Plan showing possible storerooms (554, 555, 556, 557). (After Fortin 1990b: Fig. 9)

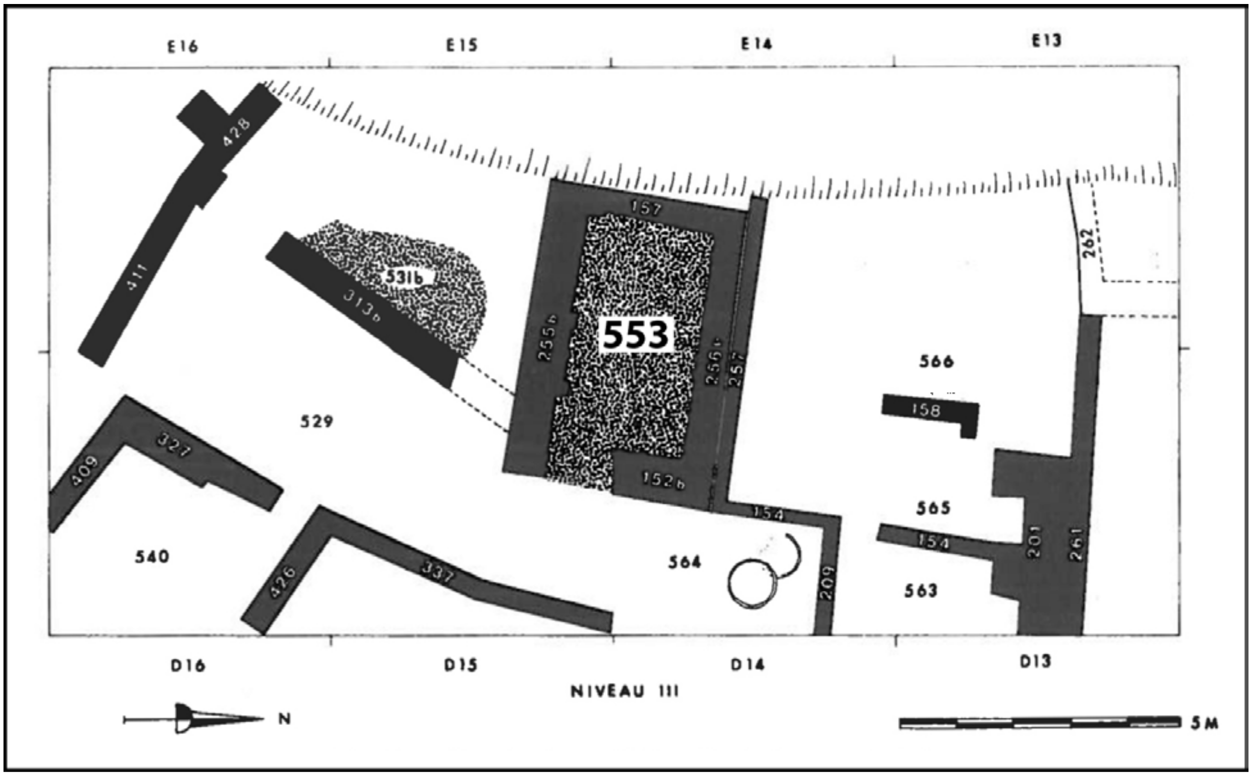


Figure 4.12: Tell ‘Atij, main tell, center, Level III. Plan showing possible storeroom (553). (After Fortin 1990b: Fig. 12)

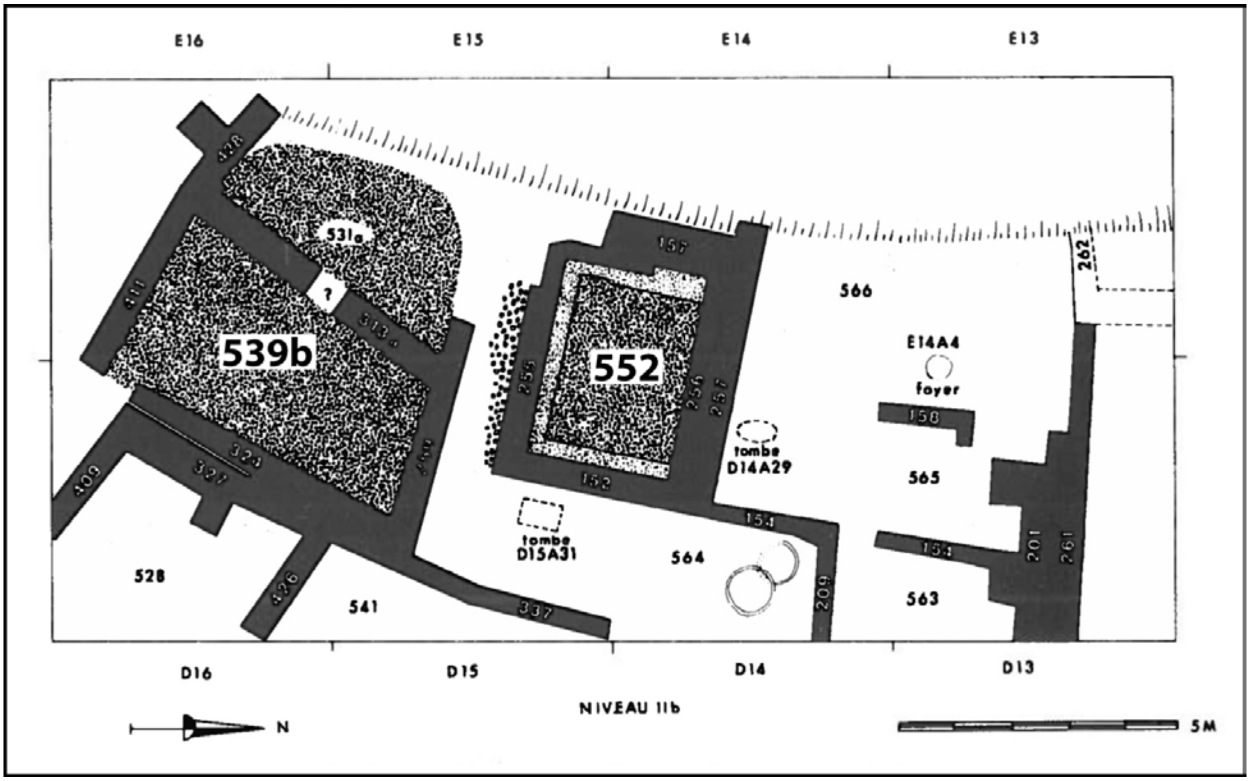


Figure 4.13: Tell ‘Atij, main tell, center, Level IIb. Plan showing possible storerooms (552, 539b). (After Fortin 1990b: Fig. 14b)

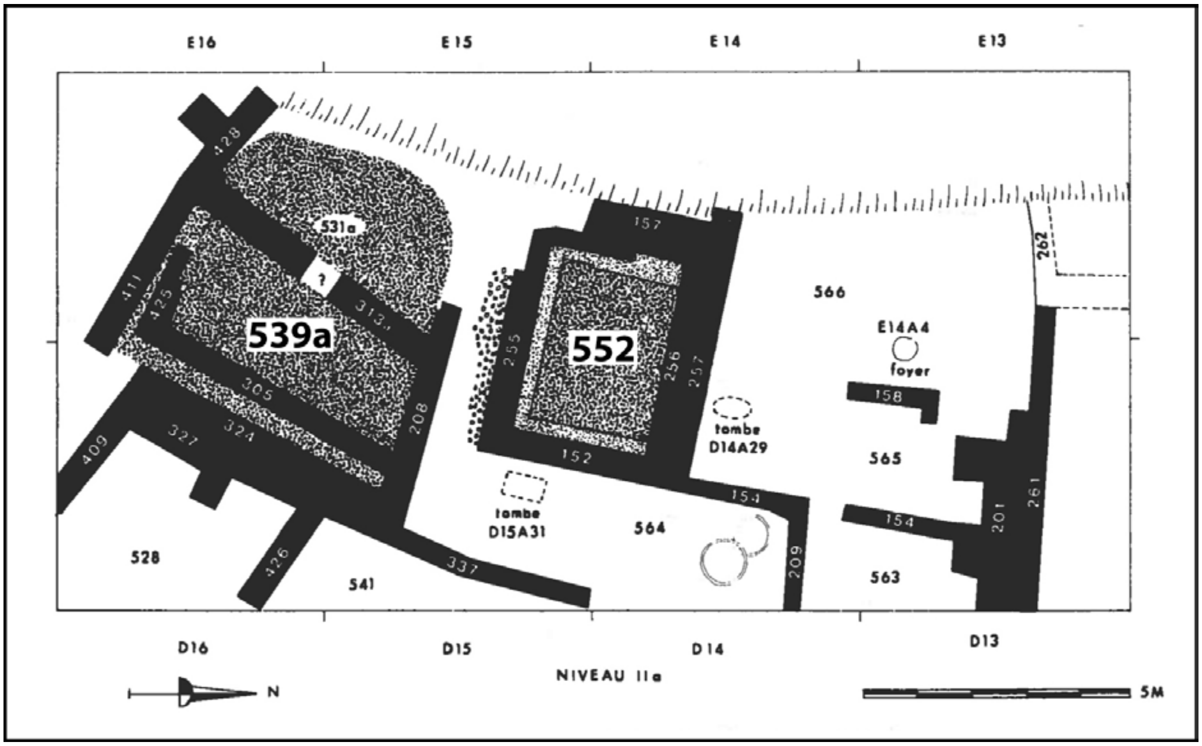


Figure 4.14: Tell ‘Atij, main tell, center, Level IIa. Plan showing possible storerooms (552, 539a). (After Fortin 1990b: Fig. 14a)

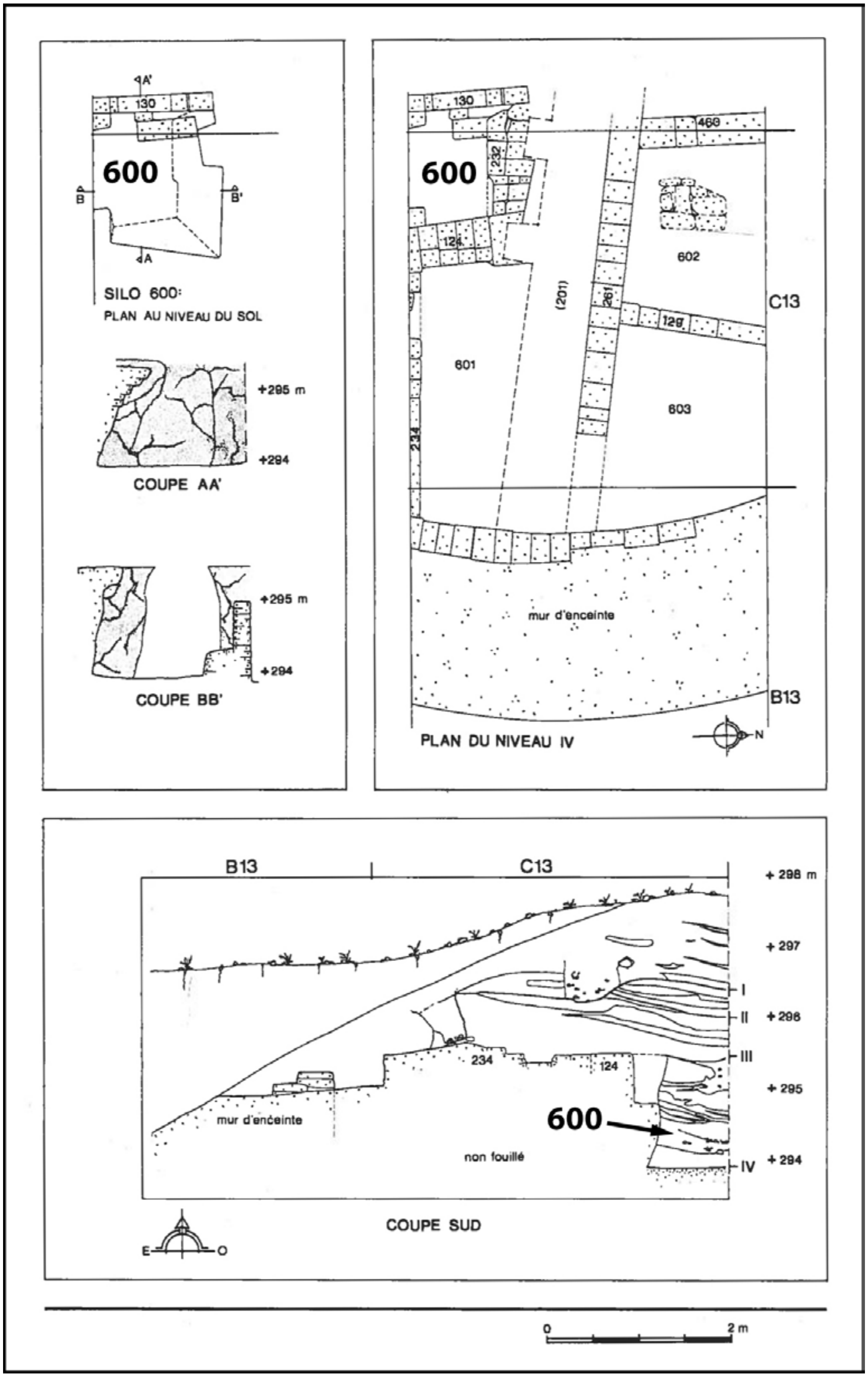


Figure 4.15: Tell ‘Atij, main tell, center, Level IV. Plans (top right and top left) and sections (bottom and center left) showing silo (600). (After Fortin 1995: Fig. 12)

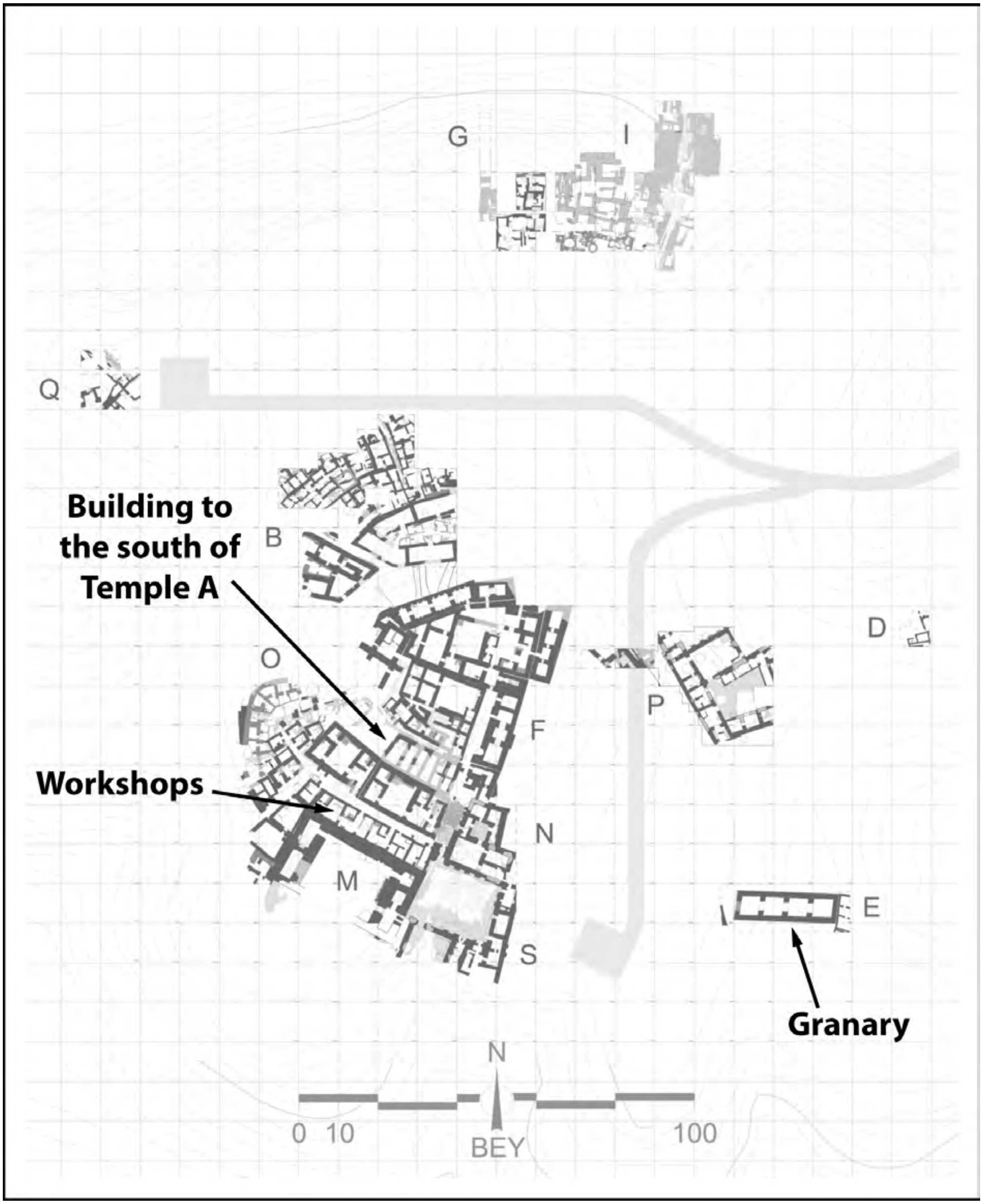


Figure 4.16: Tell Beydar, Early Jezirah IIIb period (and earlier levels). Site plan showing Granary, building to the south of Temple A, and workshops south of Temples B and C. (After Lebeau and Suleiman 2010: 6)

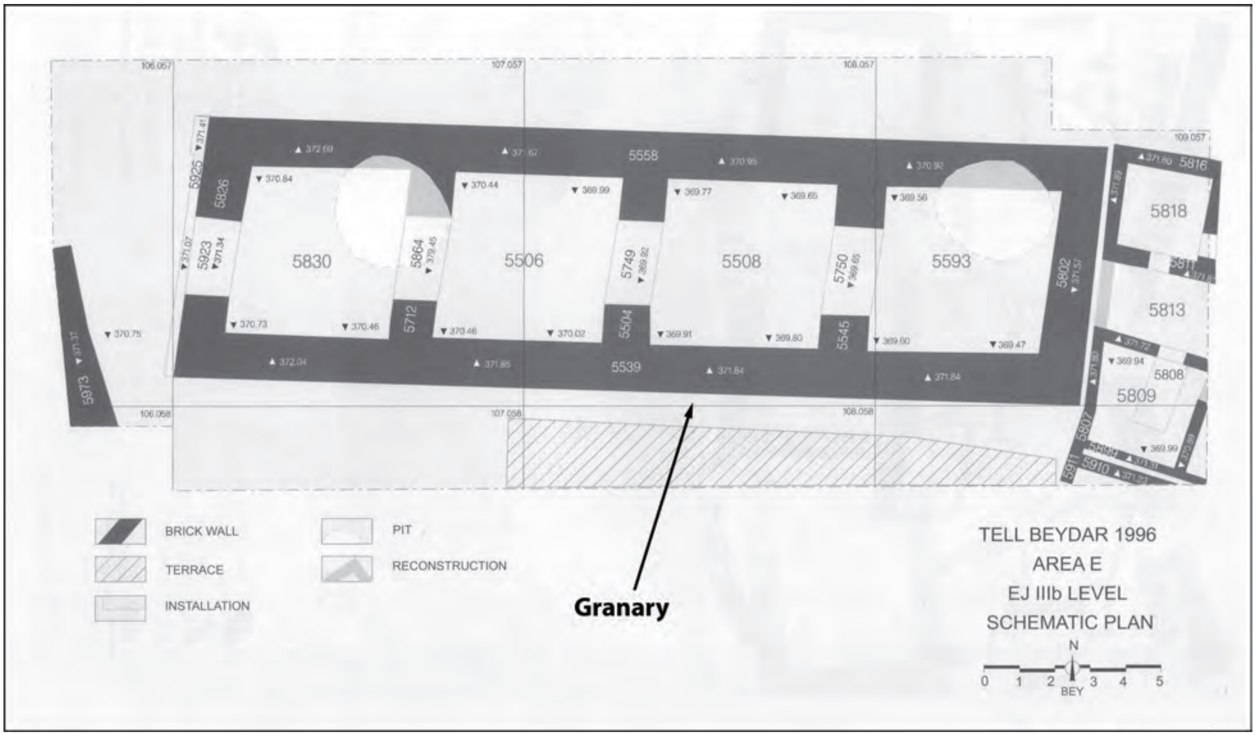


Figure 4.17: Tell Beydar, Early Jezirah IIIb period. Plan showing Granary in Area E. (After Lebeau and Suleiman 2003: Plan 23)

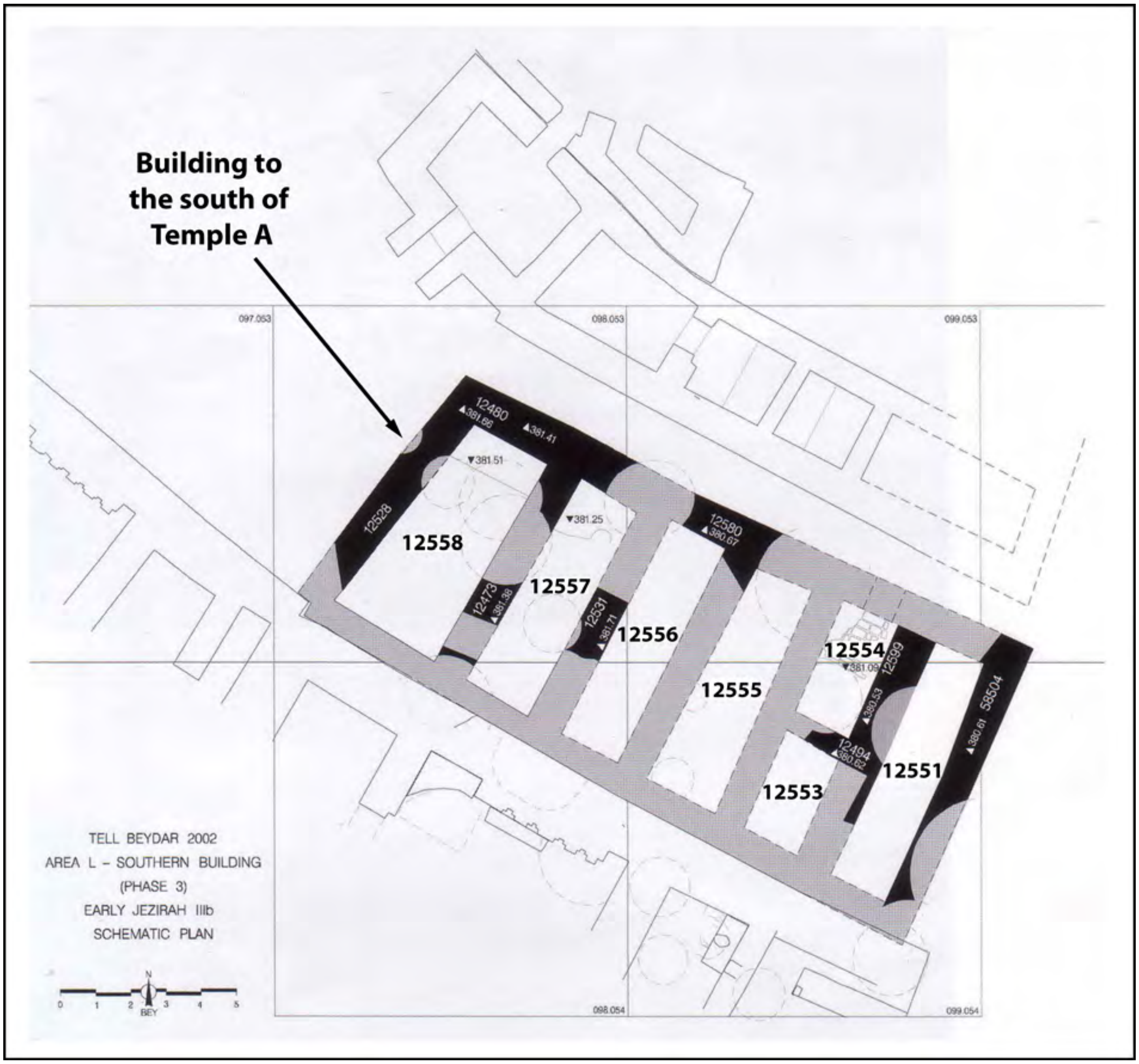


Figure 4.18: Tell Beydar, Early Jezirah IIIb period. Plan showing building to the south of Temple A. (After Dezzi Bardeschi and Sténuit 2007: Pl. 4)

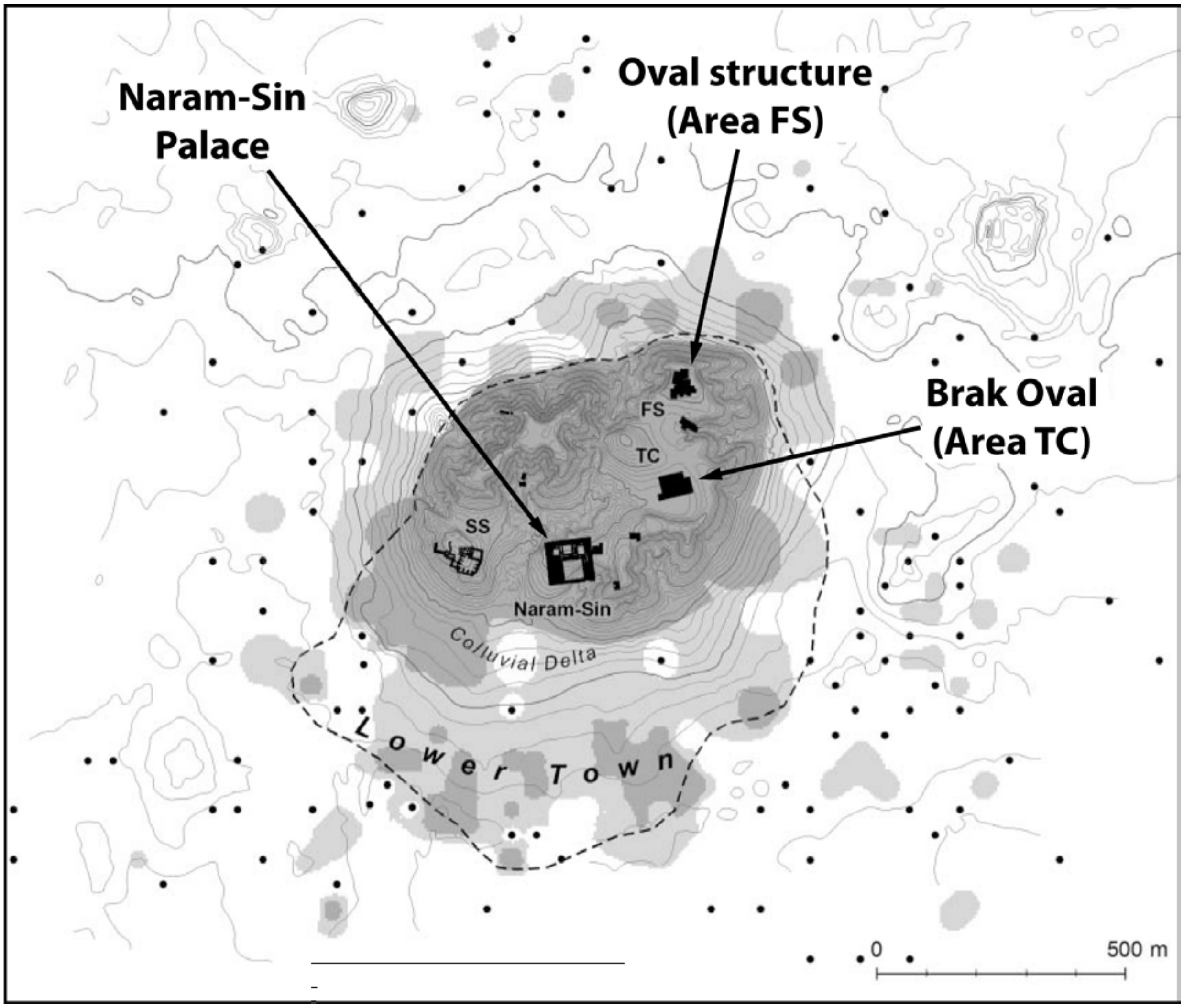


Figure 4.19: Tell Brak, Phases L–N. Site plan showing Brak Oval (Phase L), Naram-Sin Palace (Phases M and N), and Oval structure (Phase N). (After Ur et al. 2011: Fig. 5)

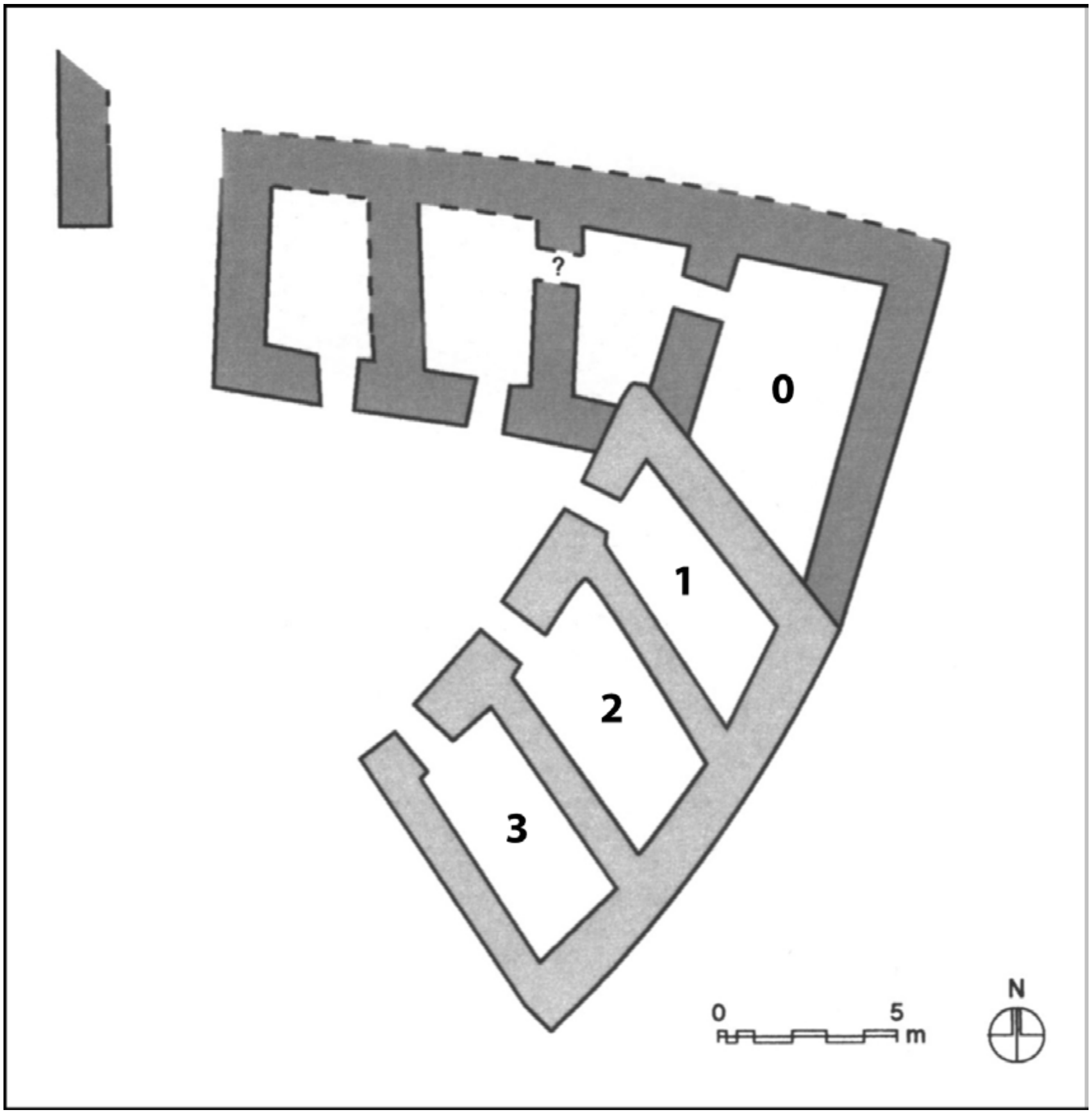


Figure 4.20: Tell Brak, Area TC, Brak Oval, Phase L. Plan showing subphase 1 (light gray) and additional rooms added during subphase 2 (dark gray). (After Emberling and McDonald 2003: Fig. 45)

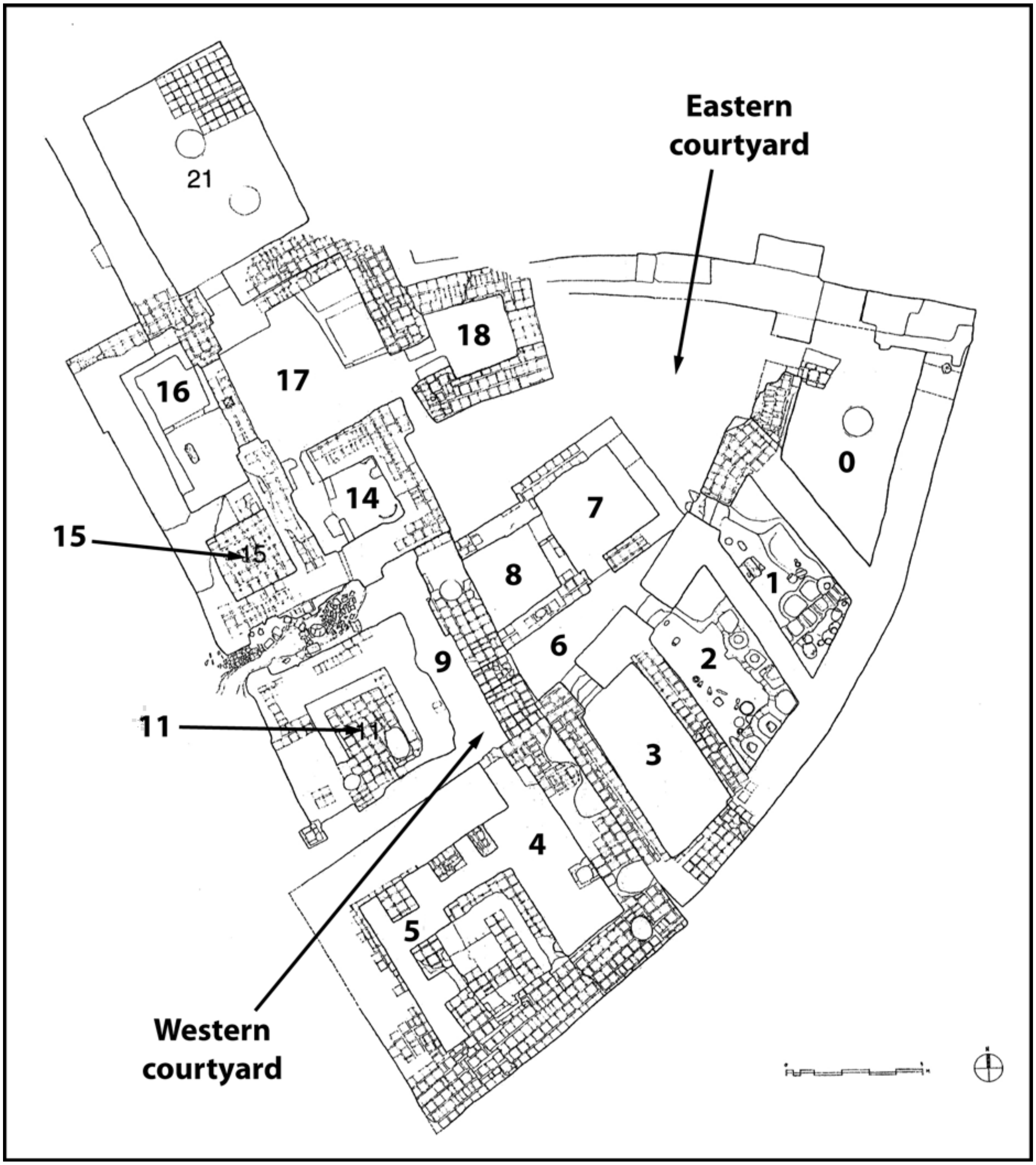


Figure 4.21: Tell Brak, Area TC, Brak Oval, Phase L. Plan showing subphase 3 and additional rooms (6, 7, 8, 9, and 11) added during subphase 4. (After Emberling and McDonald 2003: Fig. 43)

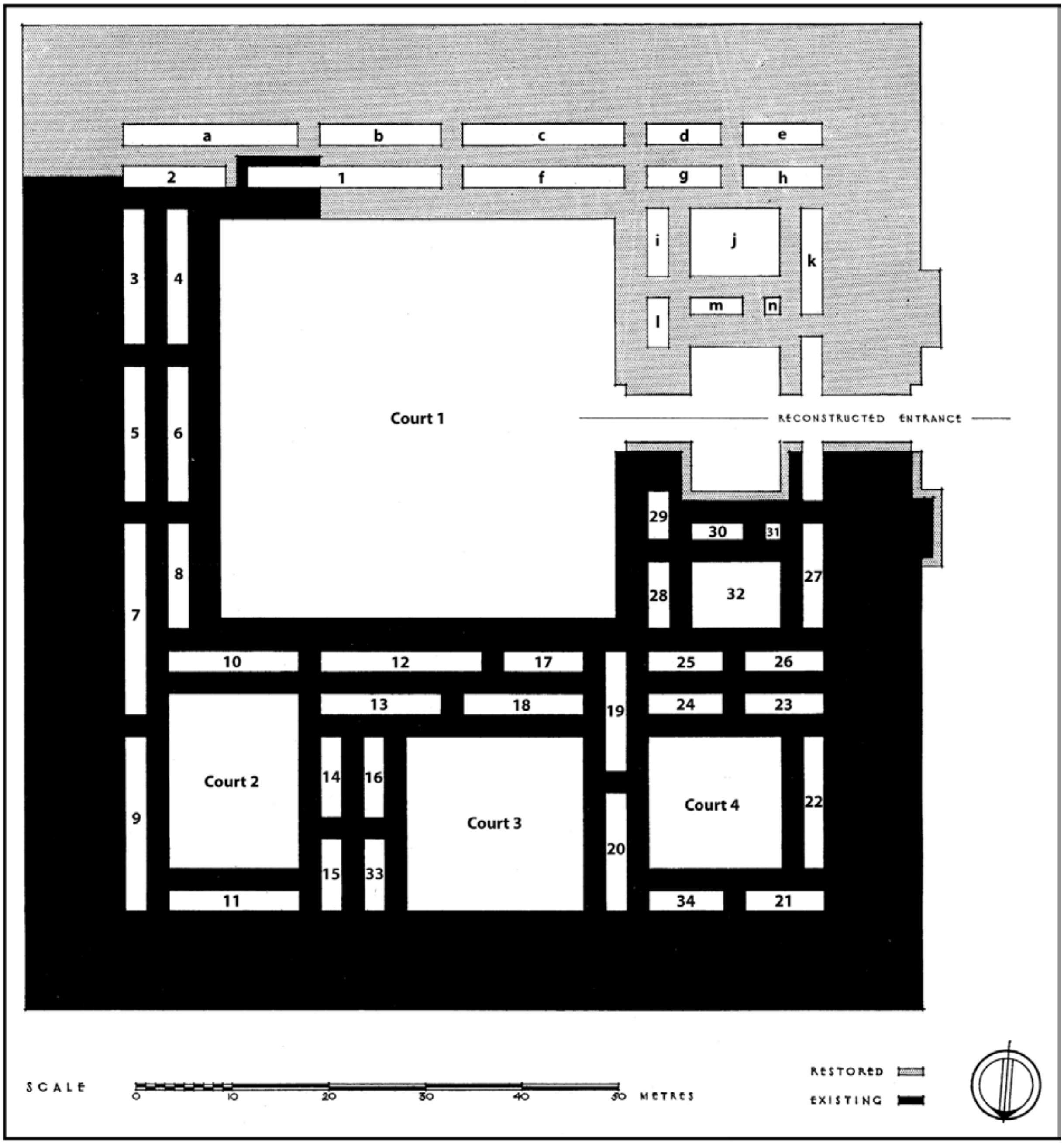


Figure 4.22: Tell Brak, Phase M. Plan showing the Naram-Sin Palace. Room numbers and court numbers were assigned by Mallowan. Room letters (in reconstructed section) are my own addition. (After Mallowan 1947: Plate LX)

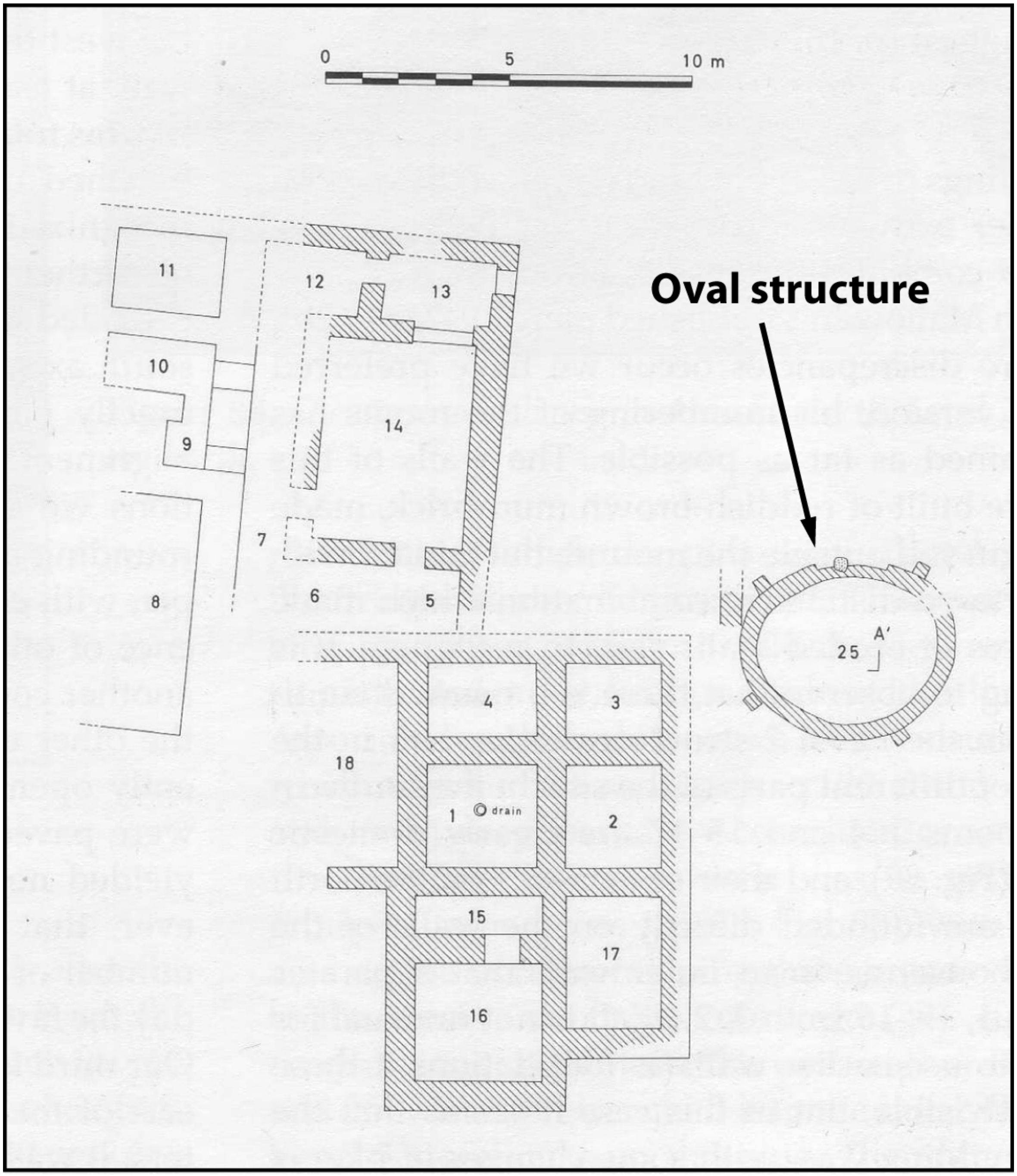


Figure 4.23: Tell Brak, Phase N. Plan showing oval structure in Area FS. (After Oates et al. 2001: Fig. 89)

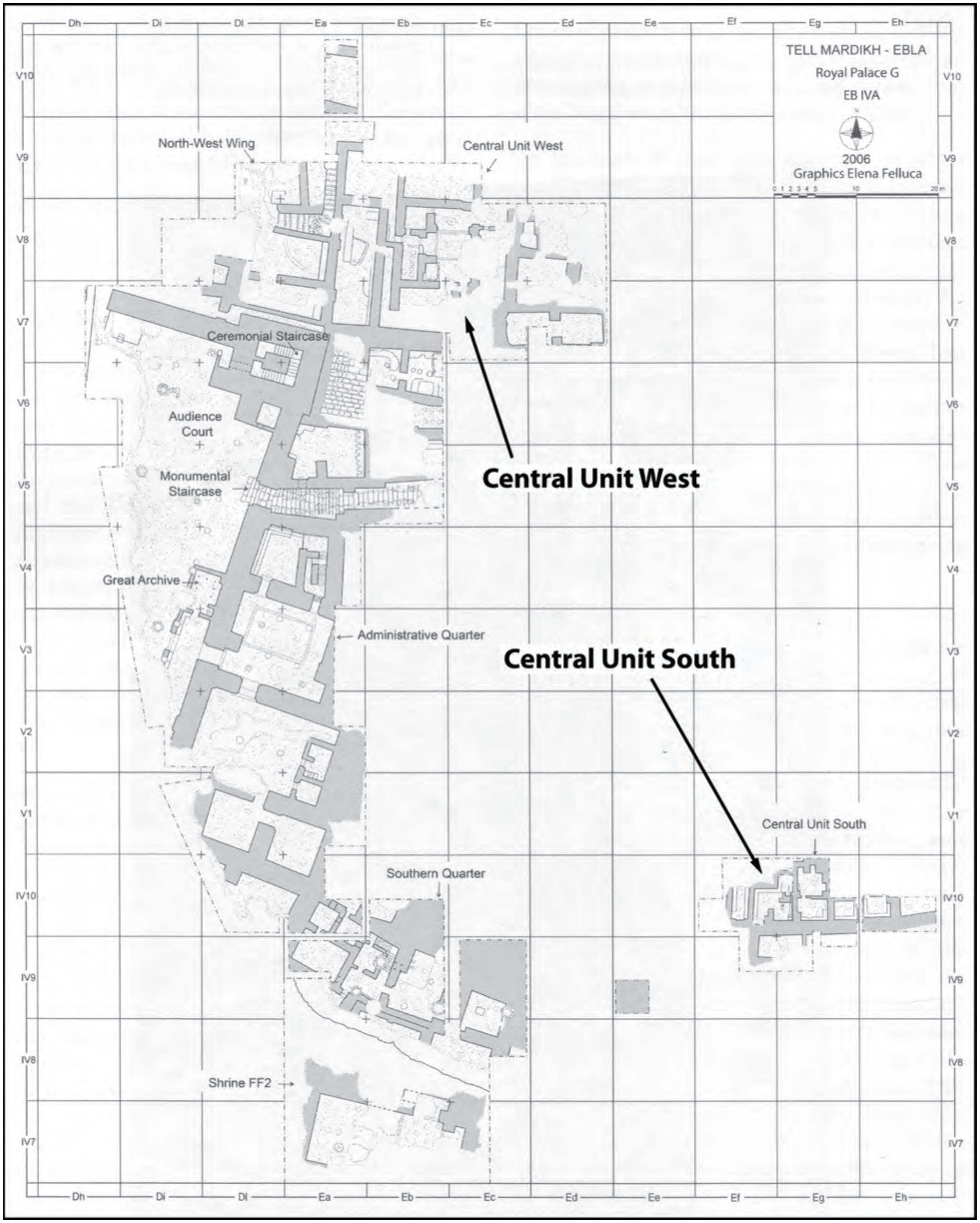


Figure 4.24: Ebla, EB IVA. Plan showing Royal Palace G. (After Matthiae 2013: Fig. 2.2)

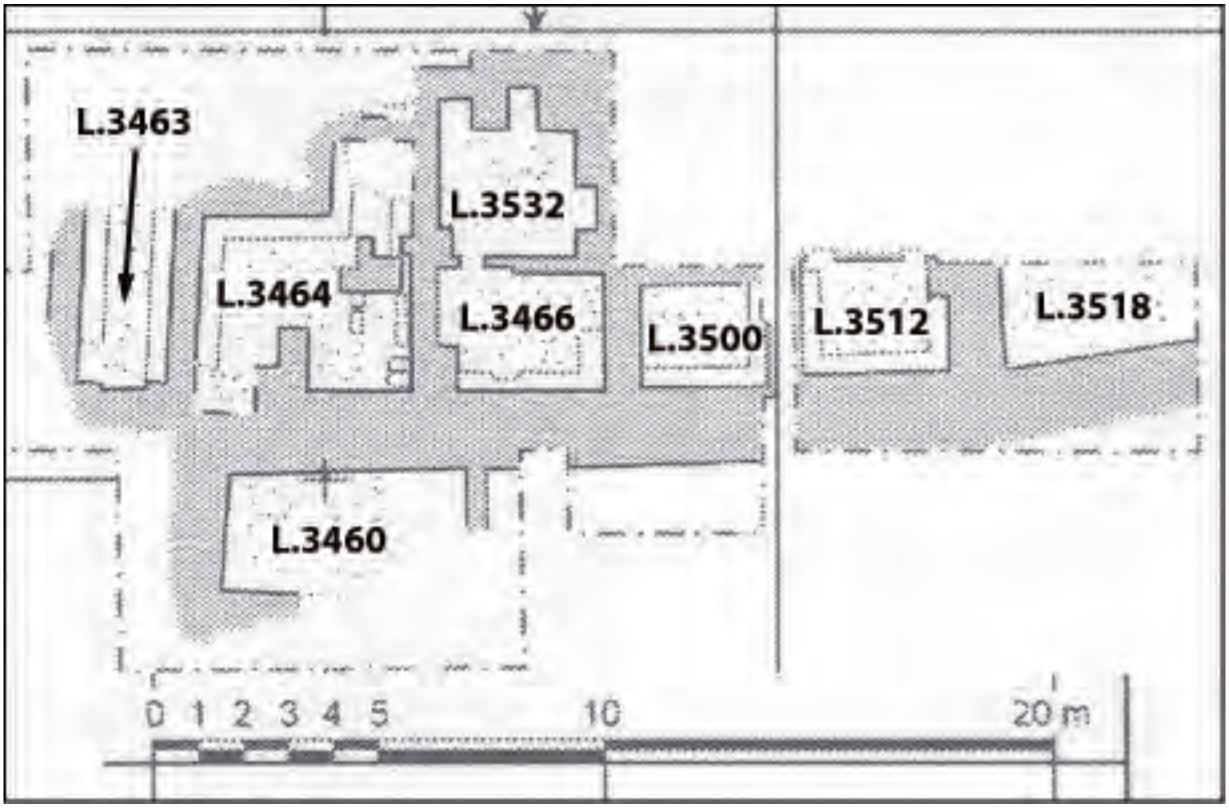


Figure 4.25: Ebla, EB IVA, Royal Palace G. Plan showing the Central Unit South or Southern Storehouse. (After Matthiae 2013: Fig. 2.2)

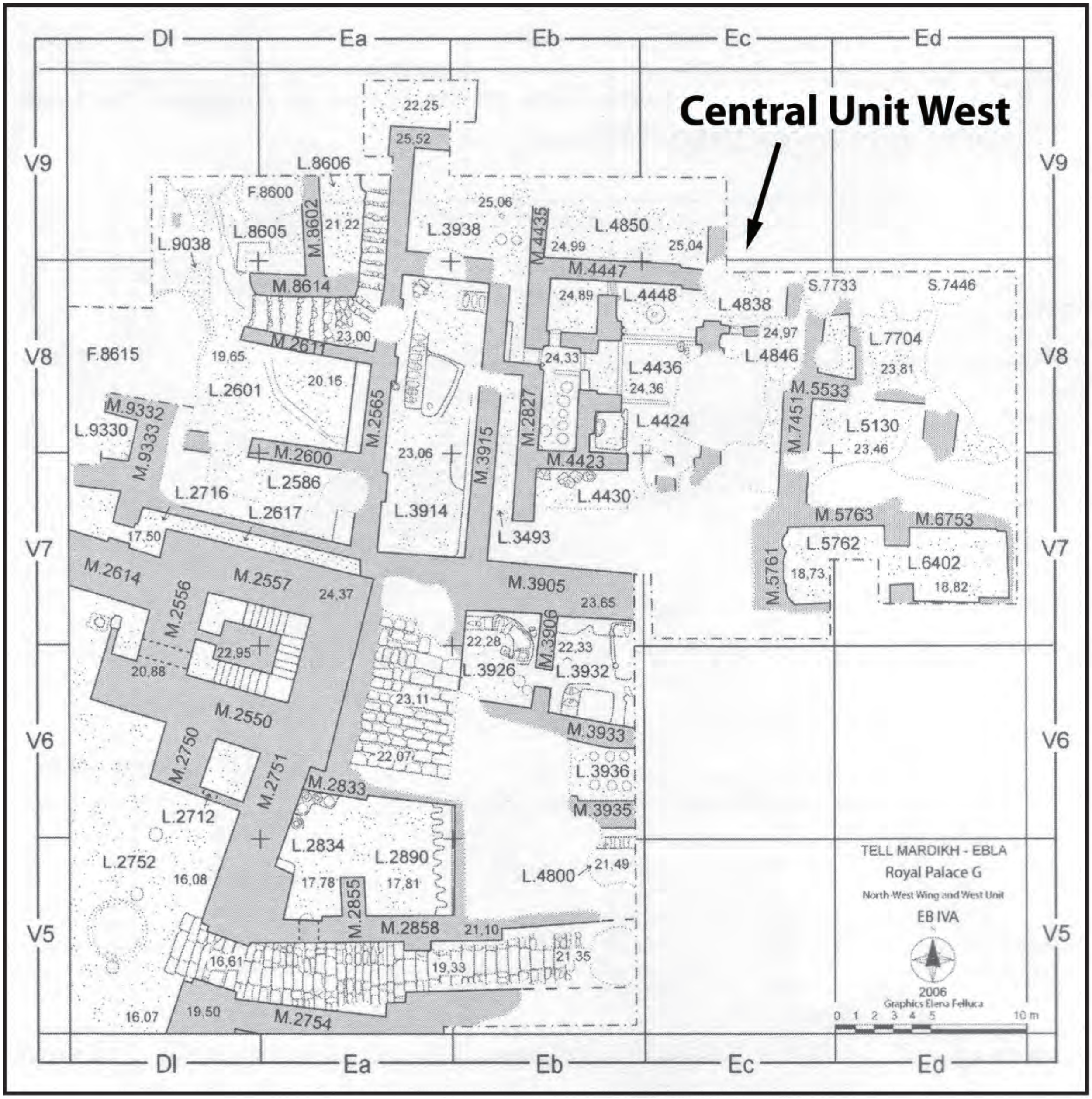


Figure 4.26: Ebla, EB IVA, Royal Palace G. Plan showing the Central Unit West. (After Matthiae 2013: Fig. 2.6)

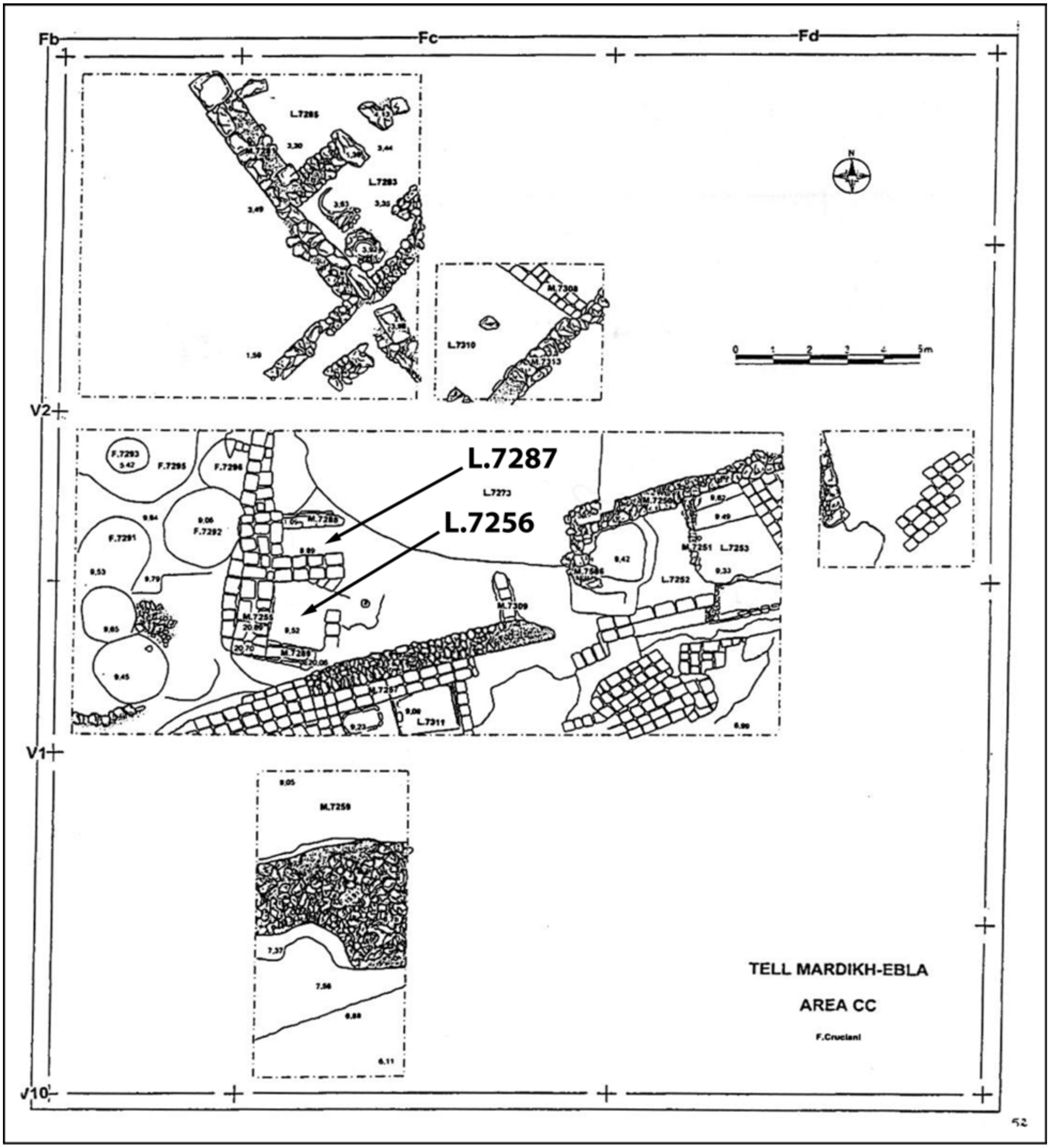


Figure 4.27: Ebla, EB III, Area CC. Plan showing Rooms L.7256 and L.7287. (After Matthiae 2000: Fig. 6)

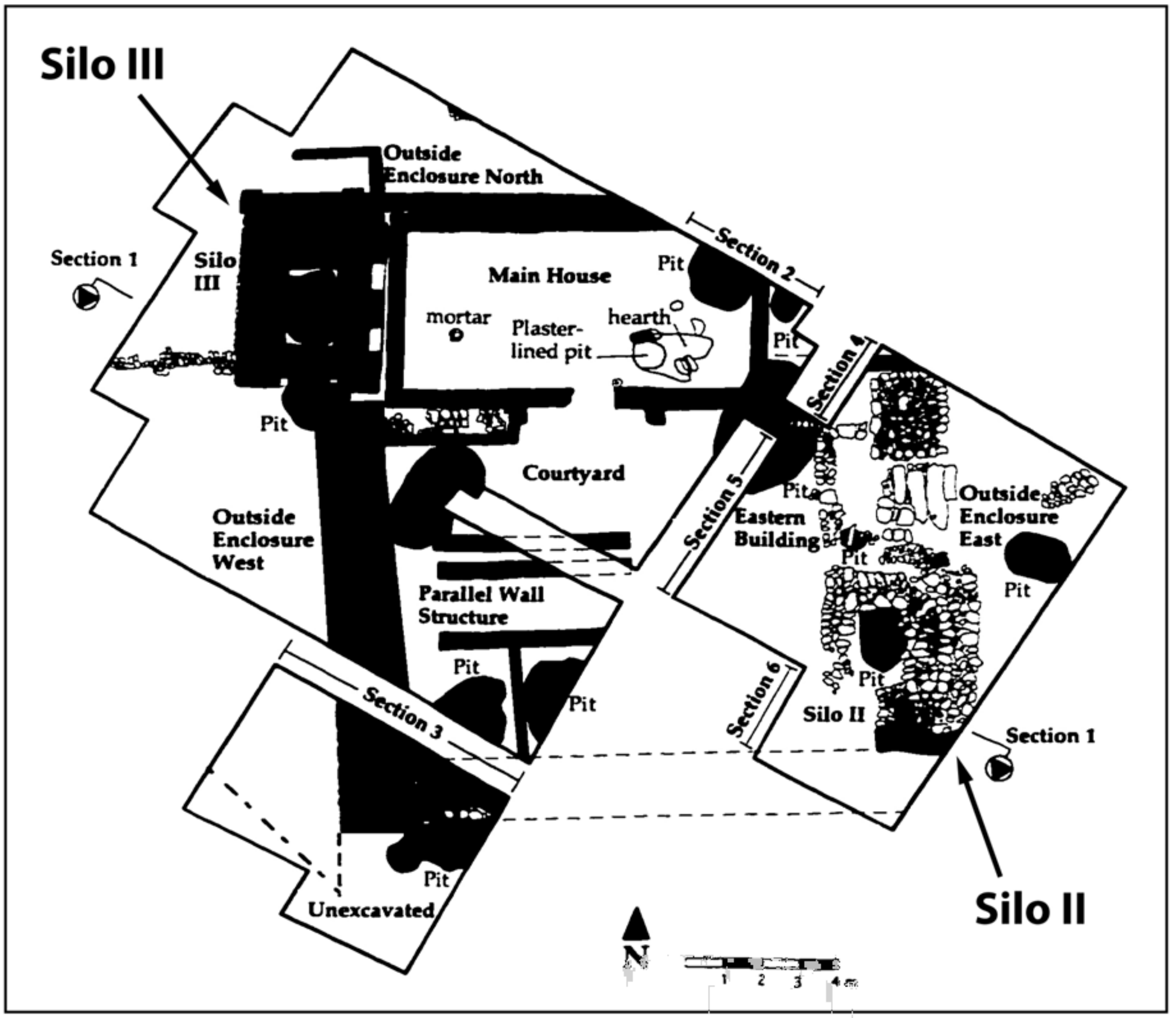


Figure 4.28: Tell Hajji Ibrahim, Phase A2. Plan showing Silo II and Silo III. (After Danti 2000: Fig. 4.4)

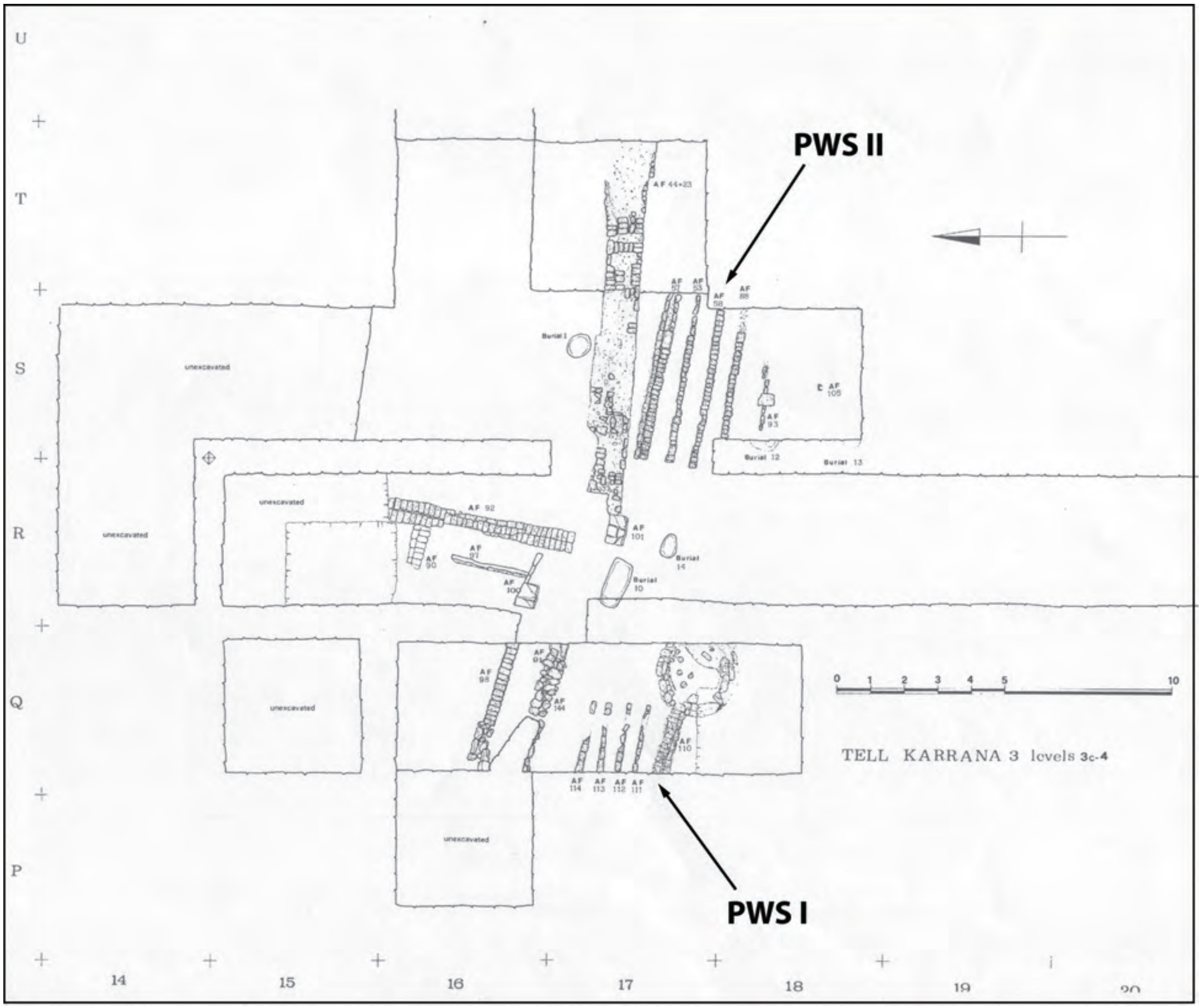


Figure 4.29: Tell Karrana 3, Phases 3c and 4. Plan showing PWS I and PWS II. (After Wilhelm and Zaccagnini 1993: Plate VI)

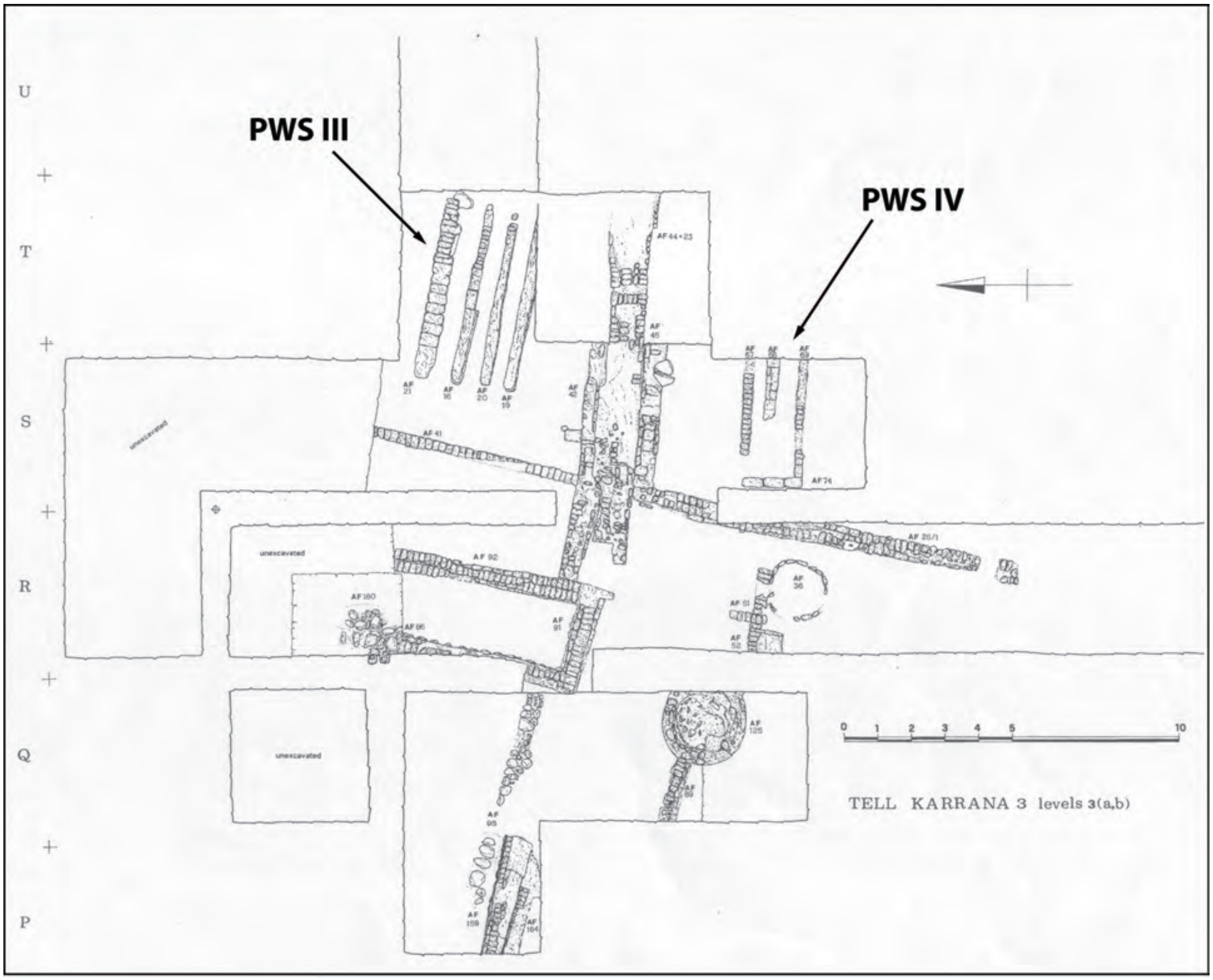


Figure 4.30: Tell Karrana 3, Phases 3b and 3a. Plan showing PWS III and PWS IV. (After Wilhelm and Zaccagnini 1993: Plate V)

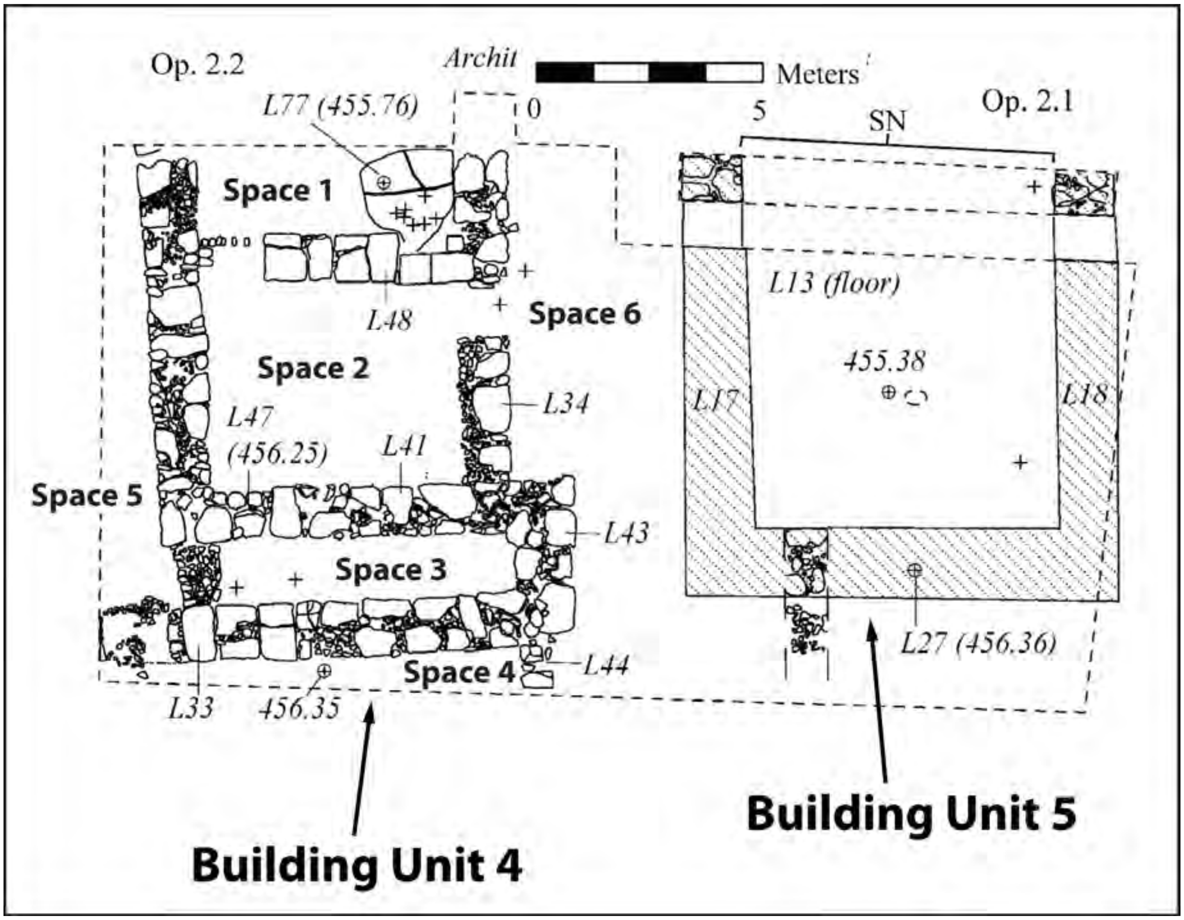


Figure 4.31: Kazane Höyük, mid-late third millennium BC. Plan showing Building Units 4 and 5. (After Creekmore 2008: Fig. 5.8)

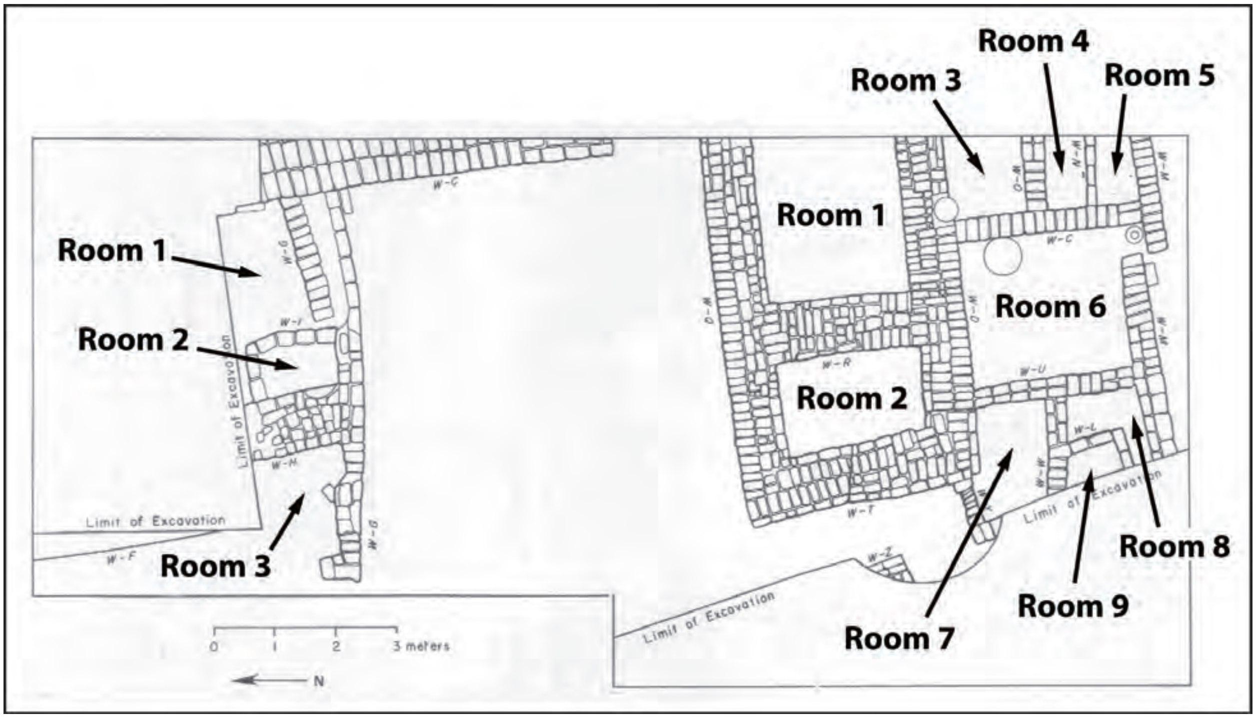


Figure 4.32: Tell Leilan, Acropolis NW, Leilan IIId period. Plan showing possible storerooms west of cultic platform. (After Calderone and Weiss 2003: Fig. 3)

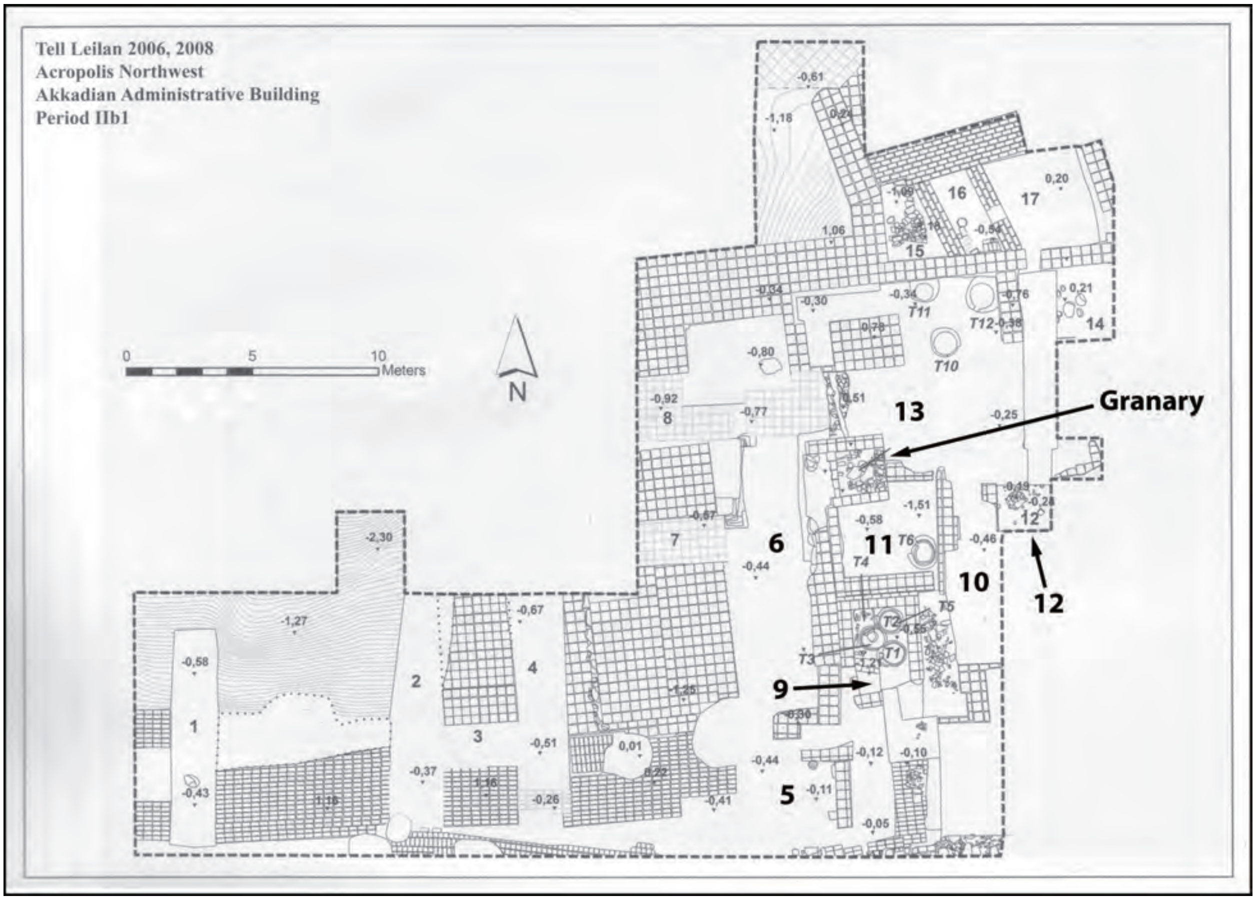


Figure 4.33: Tell Leilan, Acropolis NW, Leilan IIb1 period. Plan showing the Akkadian Administrative Building. (After Weiss et al. 2012: Fig. 5)

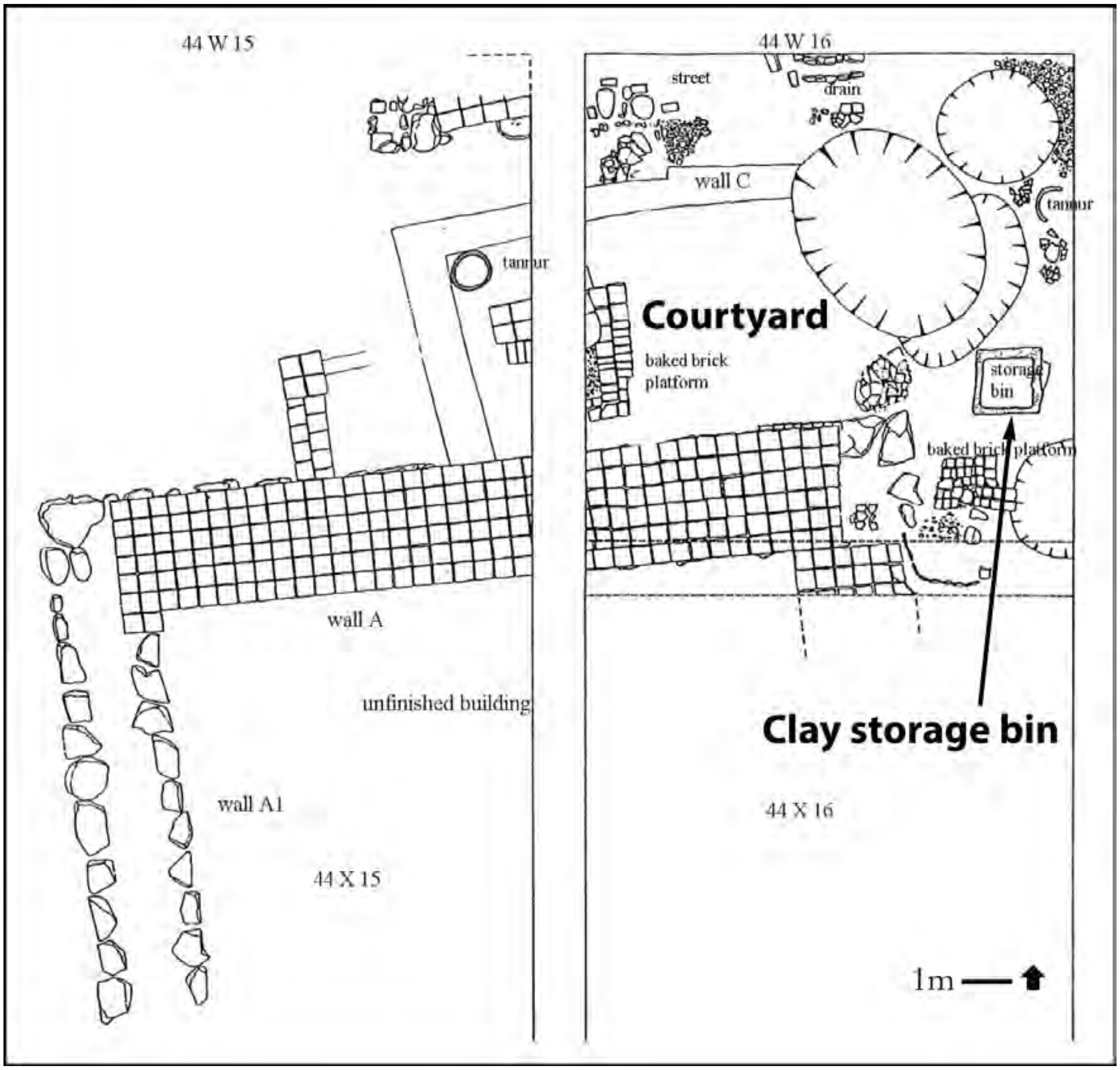


Figure 4.34: Tell Leilan, Acropolis NW, Leilan IIb1 period. Plan showing courtyard and service rooms across the street to the south of the Akkadian Administrative Building (including clay storage bin). (After de Lillis Forrest et al. 2007: Fig. 6)

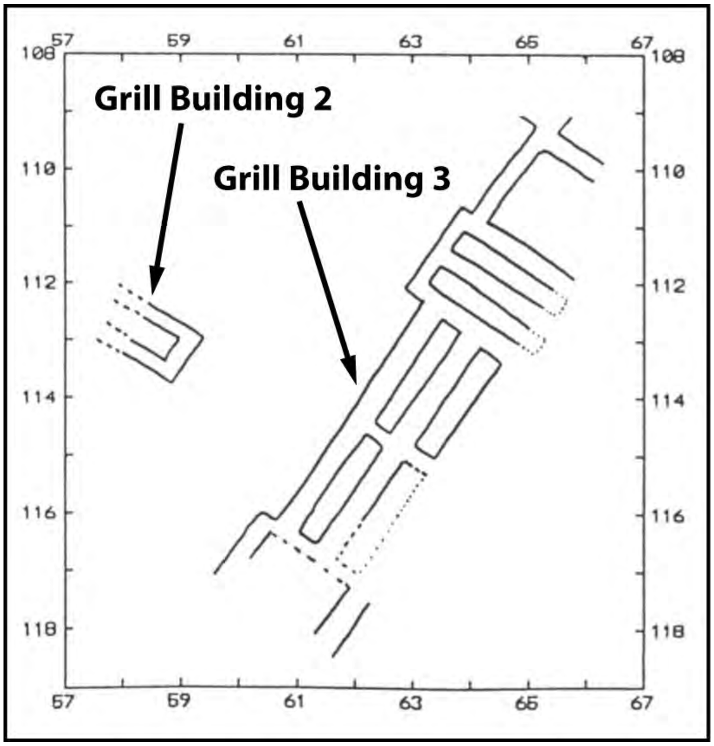


Figure 4.35: Tell al-Raqa'i, Levels 5–7. Plan showing Grill Buildings 2 and 3. (After Schwartz and Curvers 1993/1994: Abb. 66)

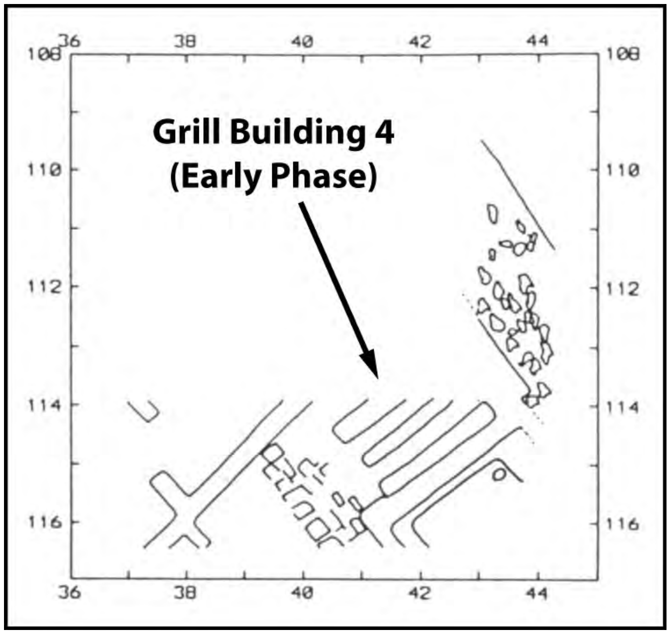


Figure 4.36: Tell al-Raqa'i, Levels 5–7. Plan showing Grill Building 4, Early Phase. (After Schwartz and Curvers 1993/1994: Abb. 67)

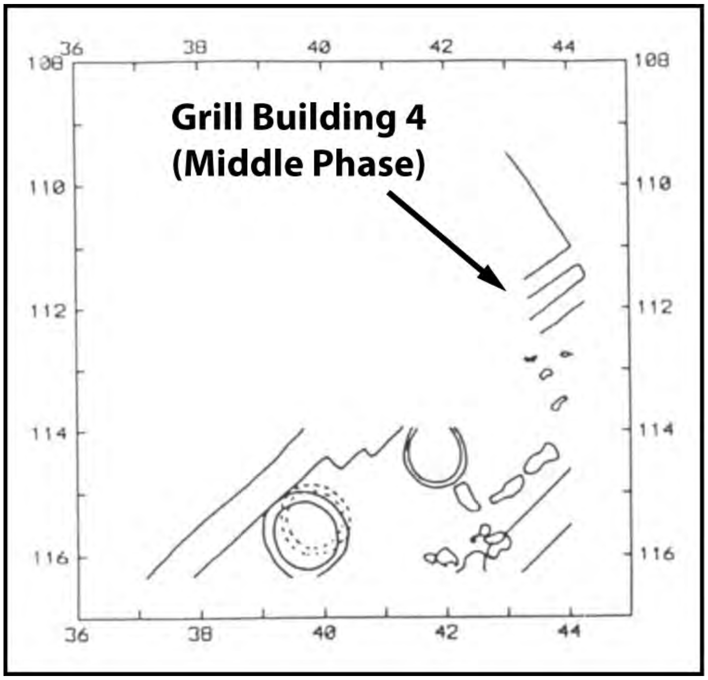


Figure 4.37: Tell al-Raqa'i, Levels 5–7. Plan showing Grill Building 4, Middle Phase. (After Schwartz and Curvers 1993/1994: Abb. 68)

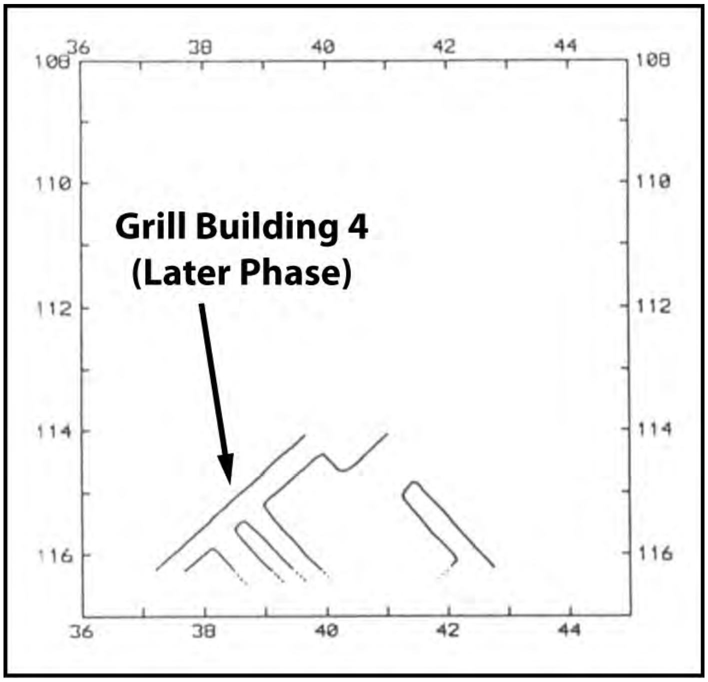


Figure 4.38: Tell al-Raqa'i, Levels 5–7. Plan showing Grill Building 4, Later Phase. (After Schwartz and Curvers 1993/1994: Abb. 69)

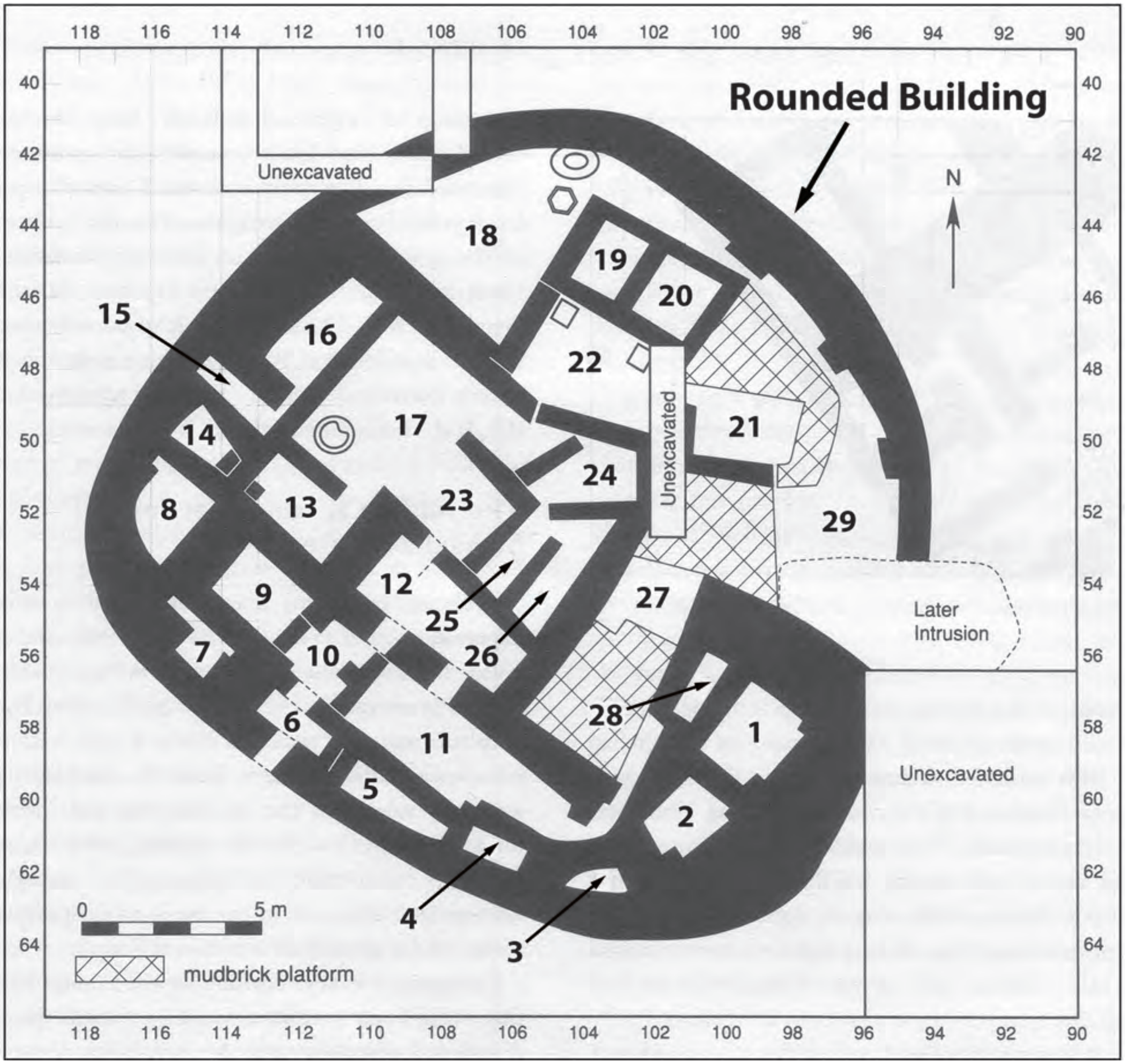


Figure 4.39: Tell al-Raqa'i, Level 4. Plan showing Rounded Building. (After Schwartz 1994b: Fig. 10)

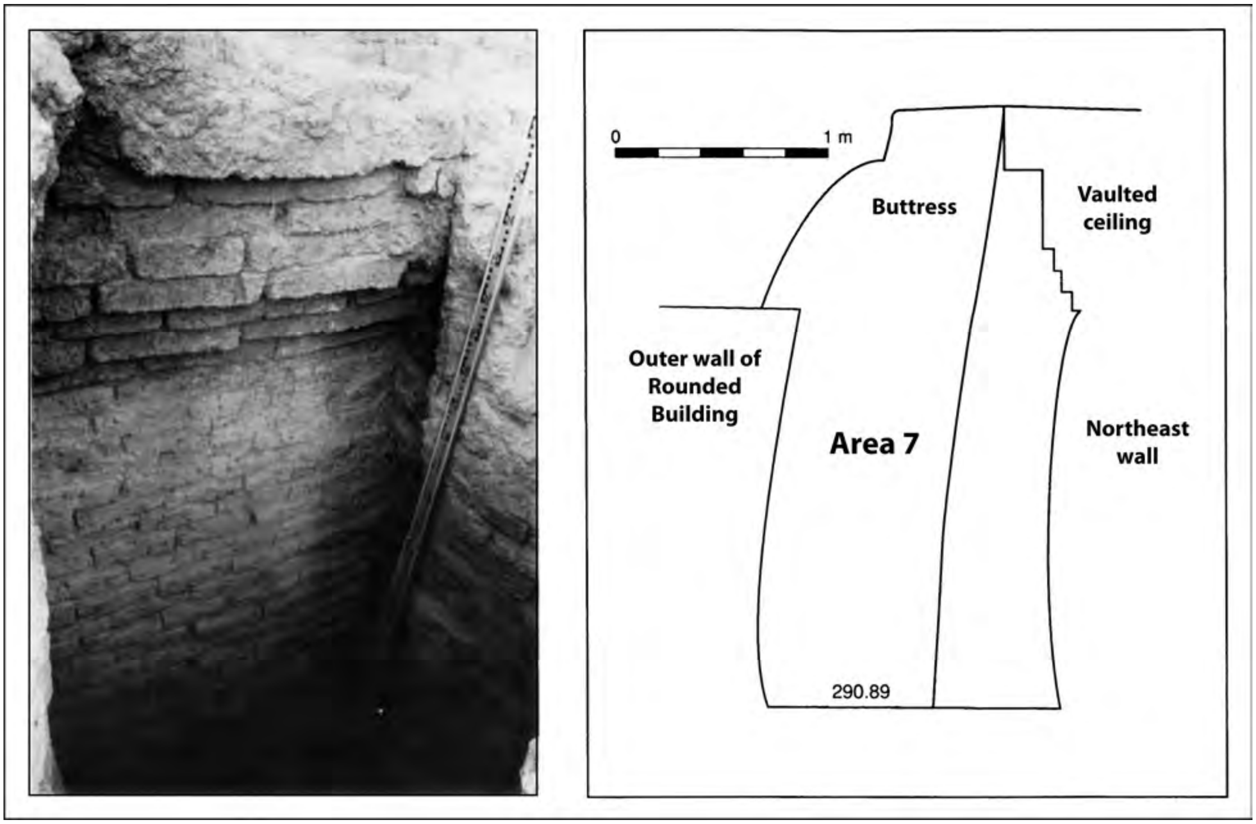


Figure 4.40: Tell al-Raqa'i, Level 4, Rounded Building. Photo (left, facing northeast) and section (right, facing northwest) showing silo with corbel-vaulted roof (area 7). (After Schwartz and Curvers 1992: Figs. 13–14)

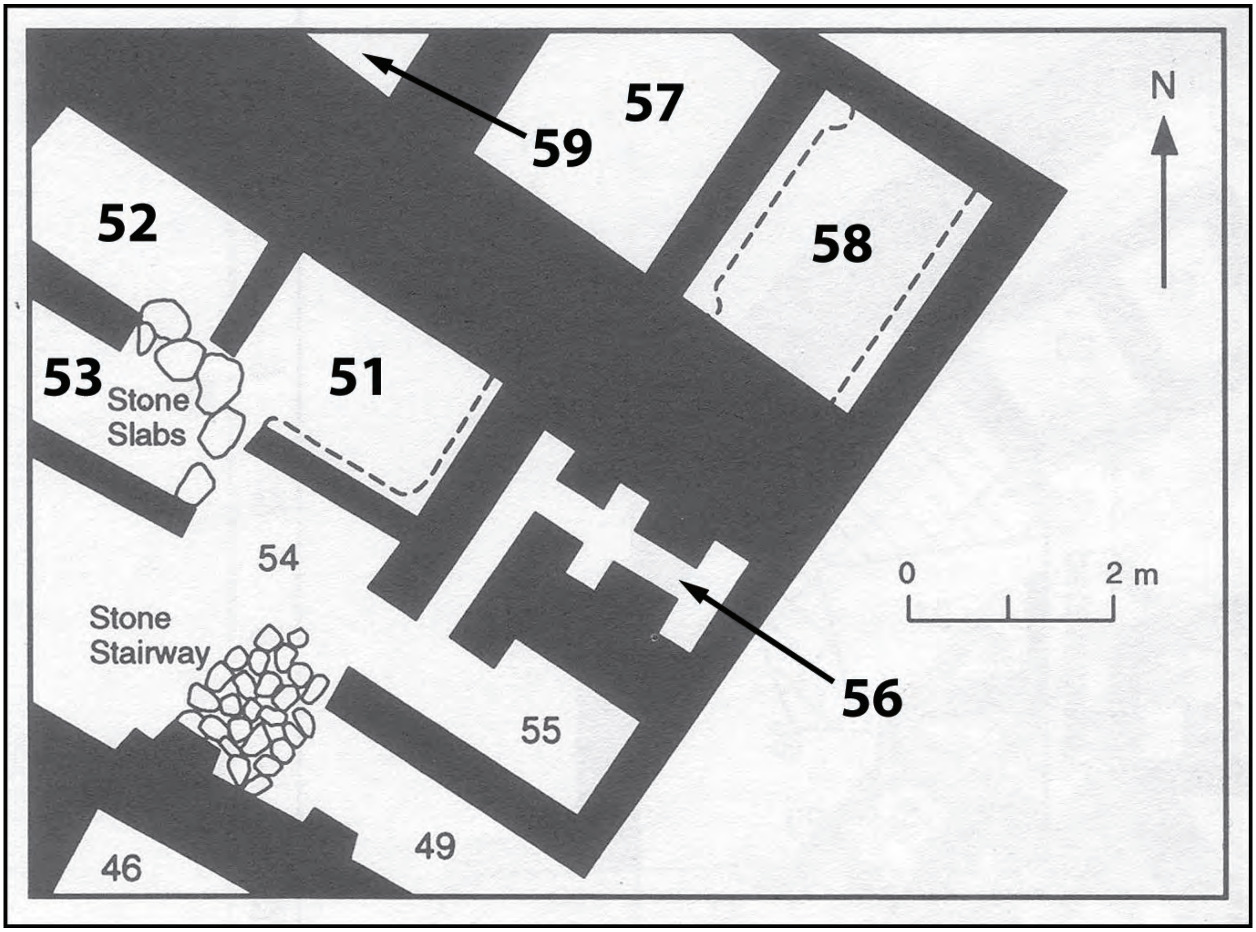


Figure 4.41: Tell al-Raqa’i, Level 4, NW Area. Plan showing semi-subterranean silos (areas 51–53, 56–58, and perhaps 59). (After Schwartz 1994b: Fig. 11)

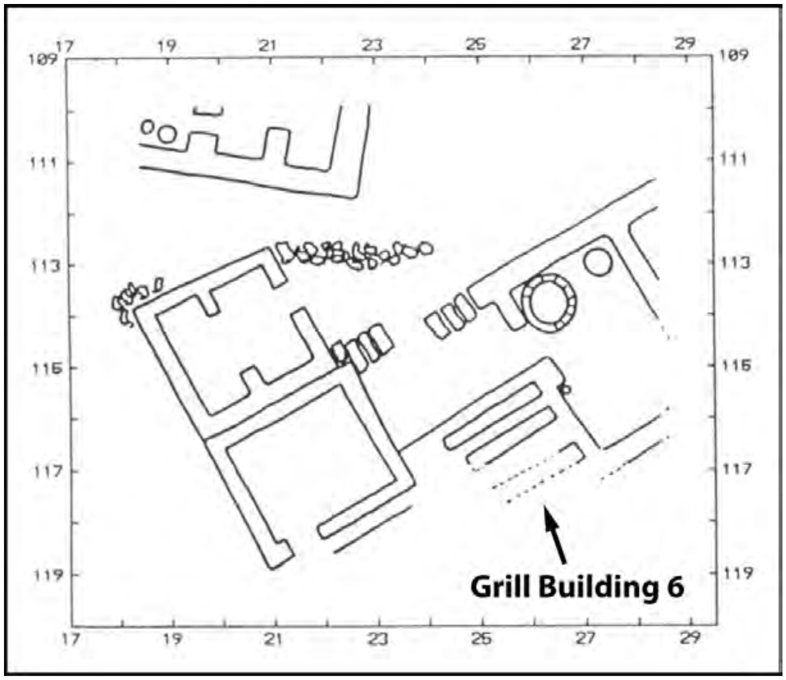


Figure 4.42: Tell al-Raqa'i, Level 4. Plan showing Grill Building 6. (After Schwartz and Curvers 1993/1994: Abb. 74)

Figure 4.43: Tell al-Raqa'i, Level 3. Plan showing excavated area, including silos (areas 4–6) in NW Area. (After Schwartz 1994b: Fig. 9)

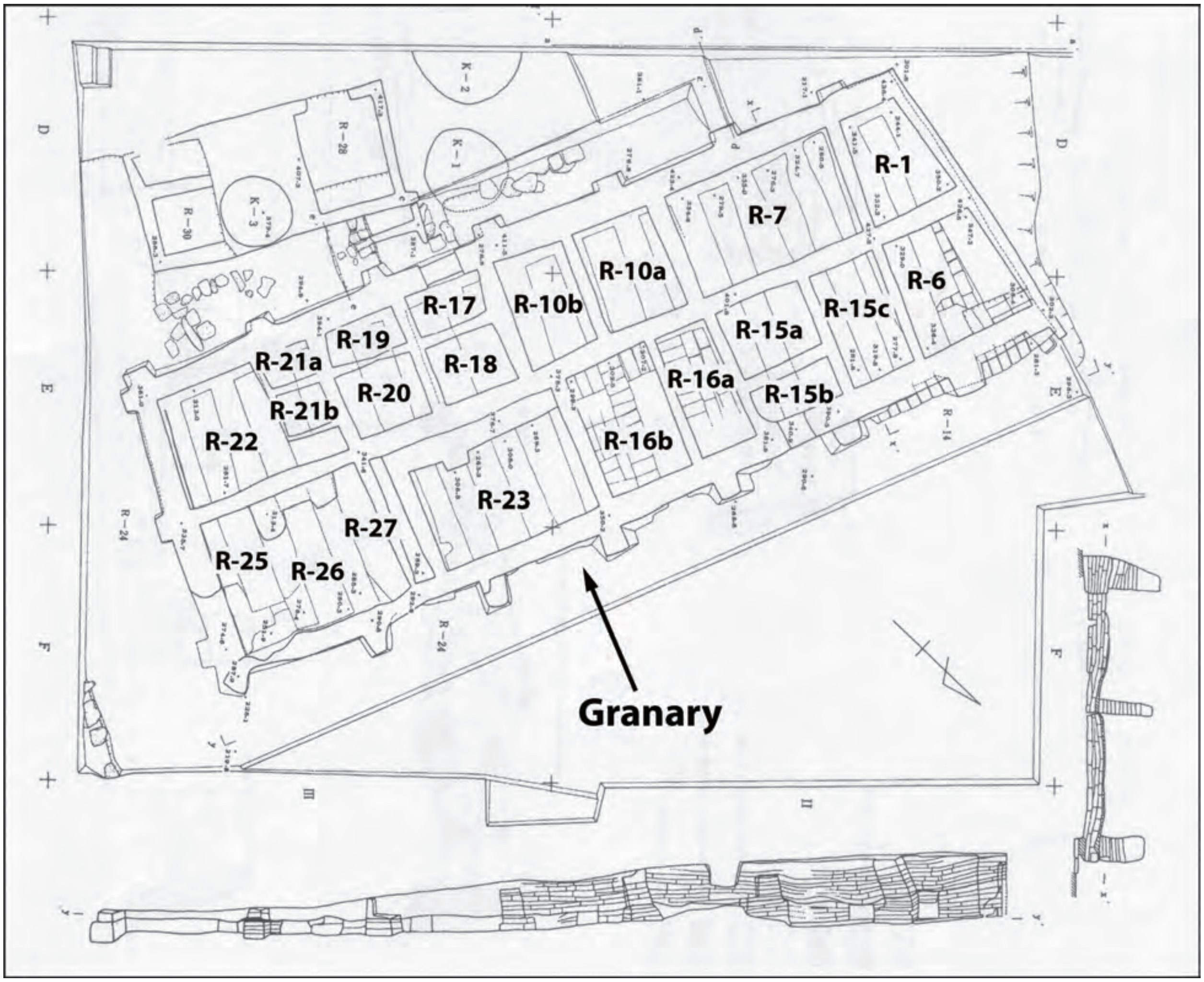


Figure 4.44: Telul eth-Thalathat, Granary. Plan (top; rooms labeled) and sections (bottom and bottom right). (After Fukai et al. 1974: Plate XLI)

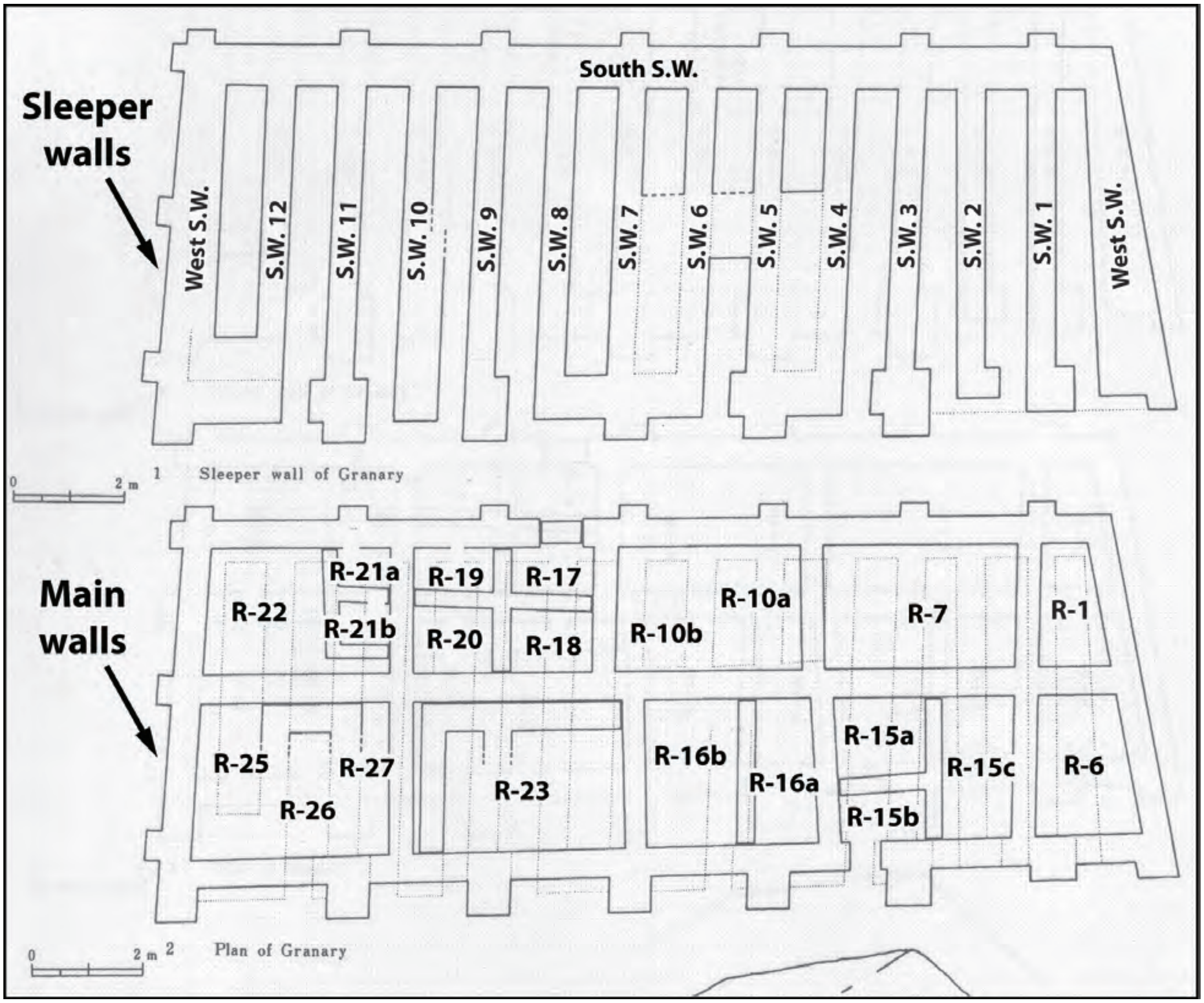


Figure 4.45: Telul eth-Thalathat, Granary. Schematic plans showing sleeper walls (above; sleeper walls labeled) and main walls (below; rooms labeled). (After Fukai et al. 1974: Plate XLVI)

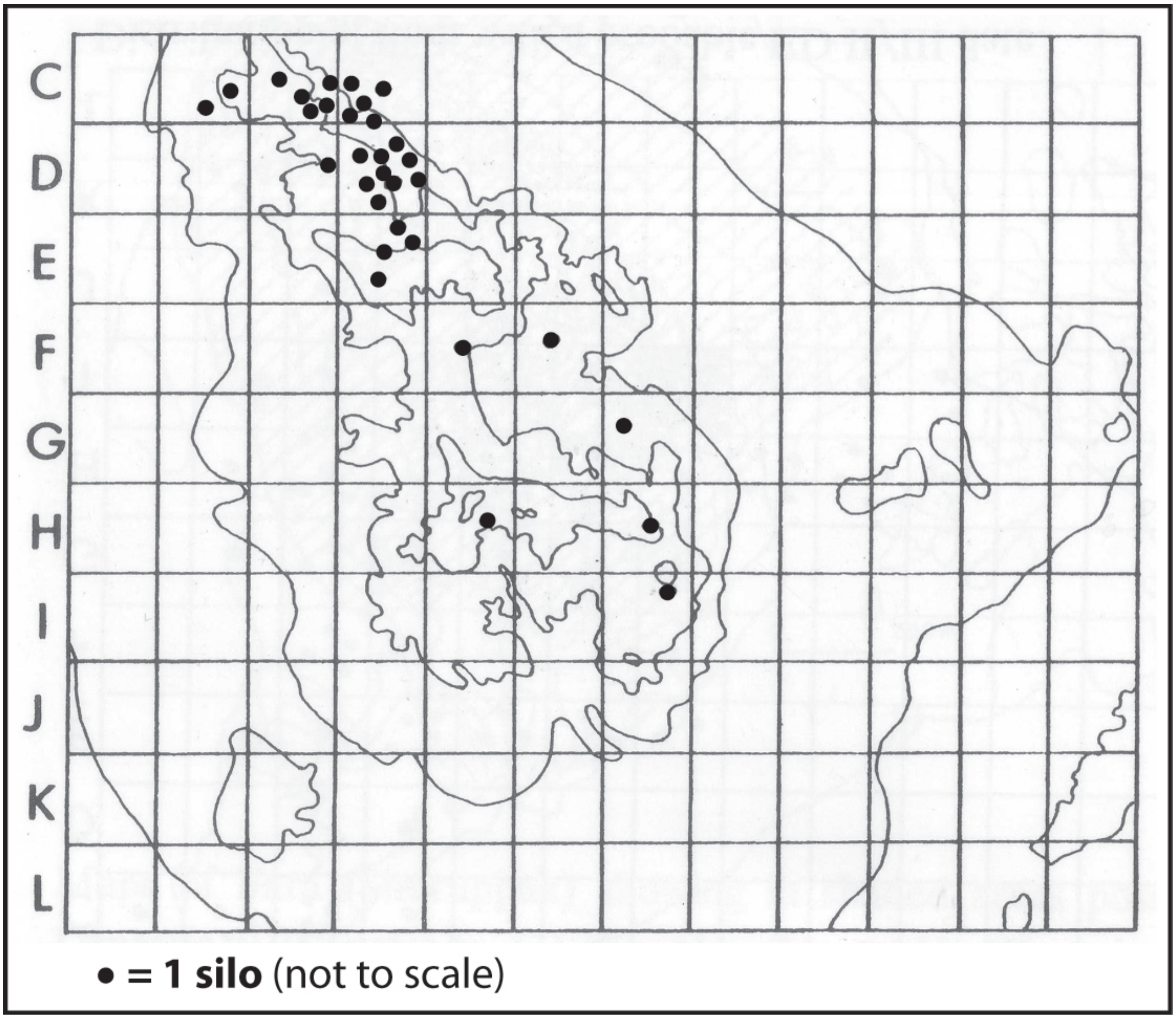


Figure 5.1: Fara. Site plan showing distribution of silos. (After Martin 1988: Fig. 33)

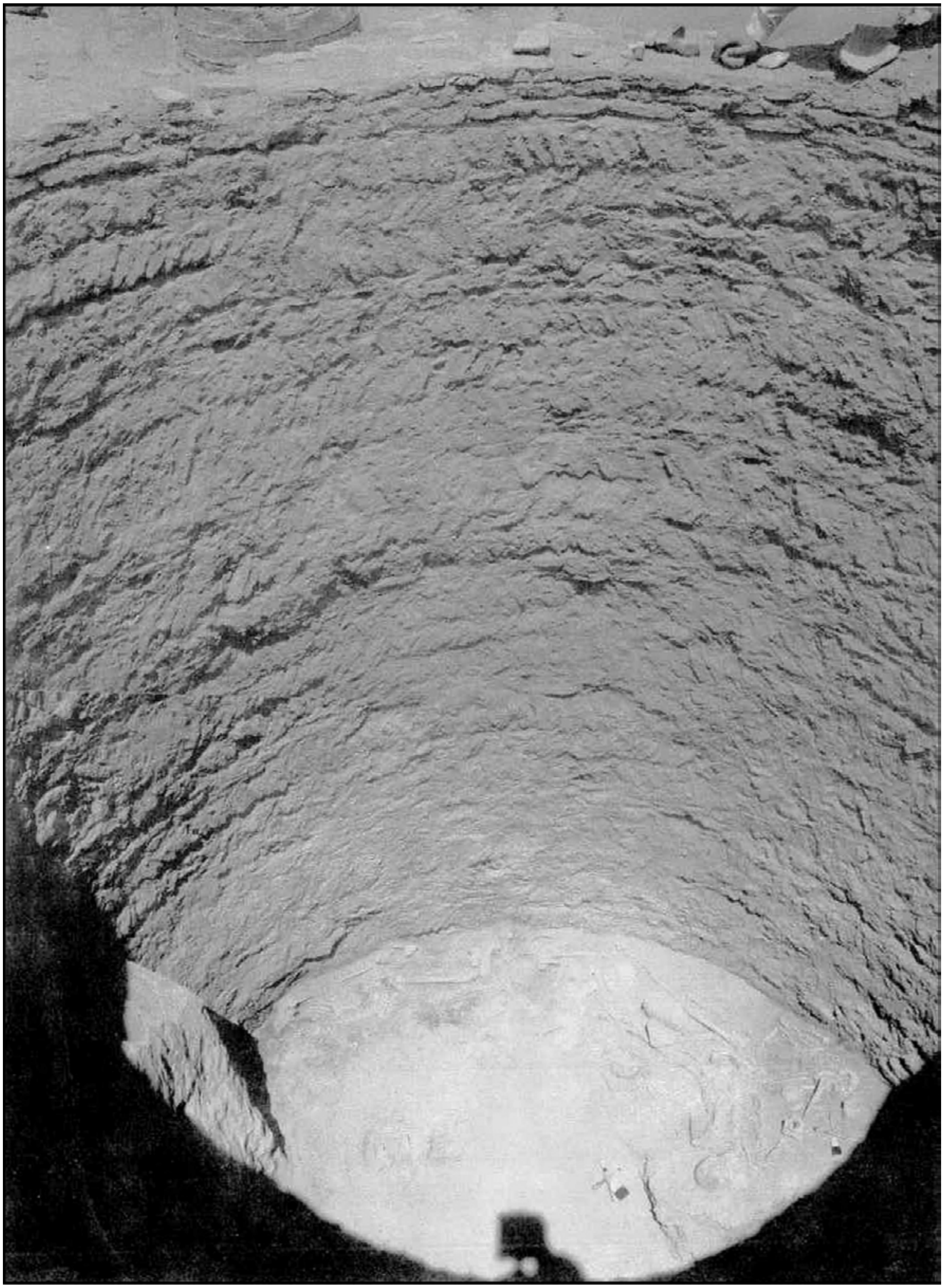
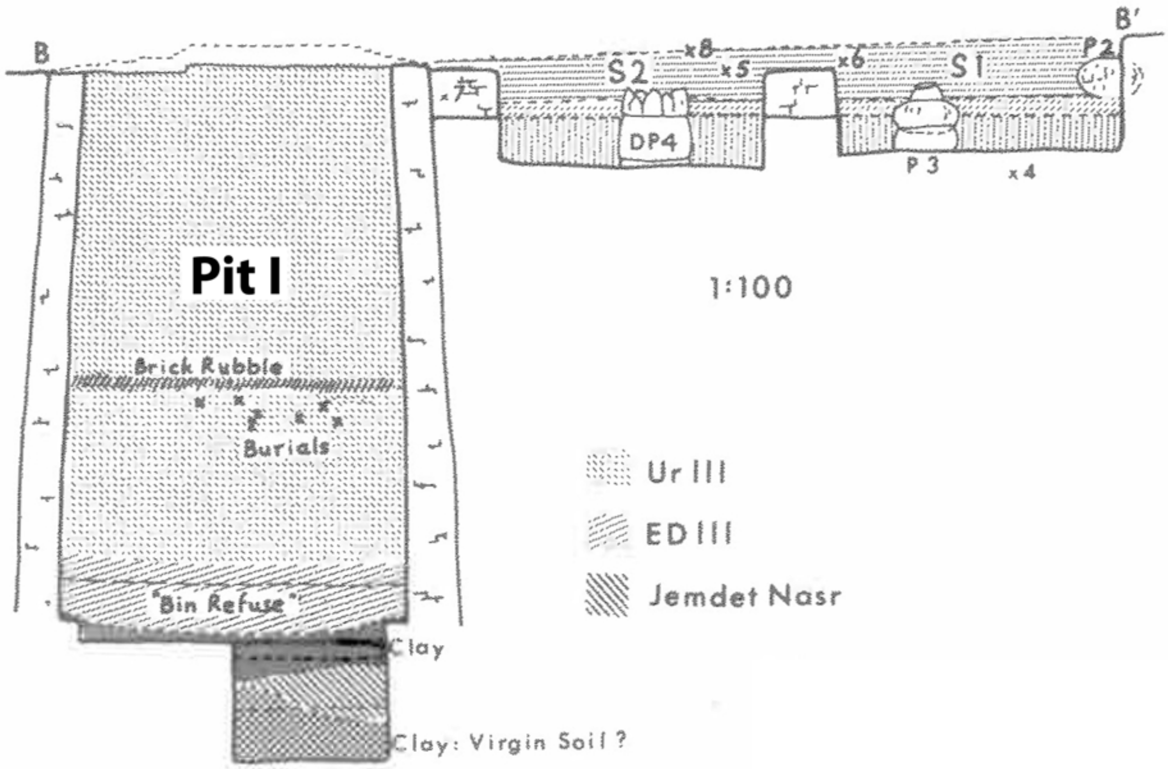


Figure 5.2: Fara. Photo showing silo (Pit I). (After Martin 1988: Plate XIII)



Section B-B' taken through Pit I and FG 43 (after Schmidt).

Figure 5.3: Fara. Section showing silo (Pit I). (After Martin 1988: Fig. 14)

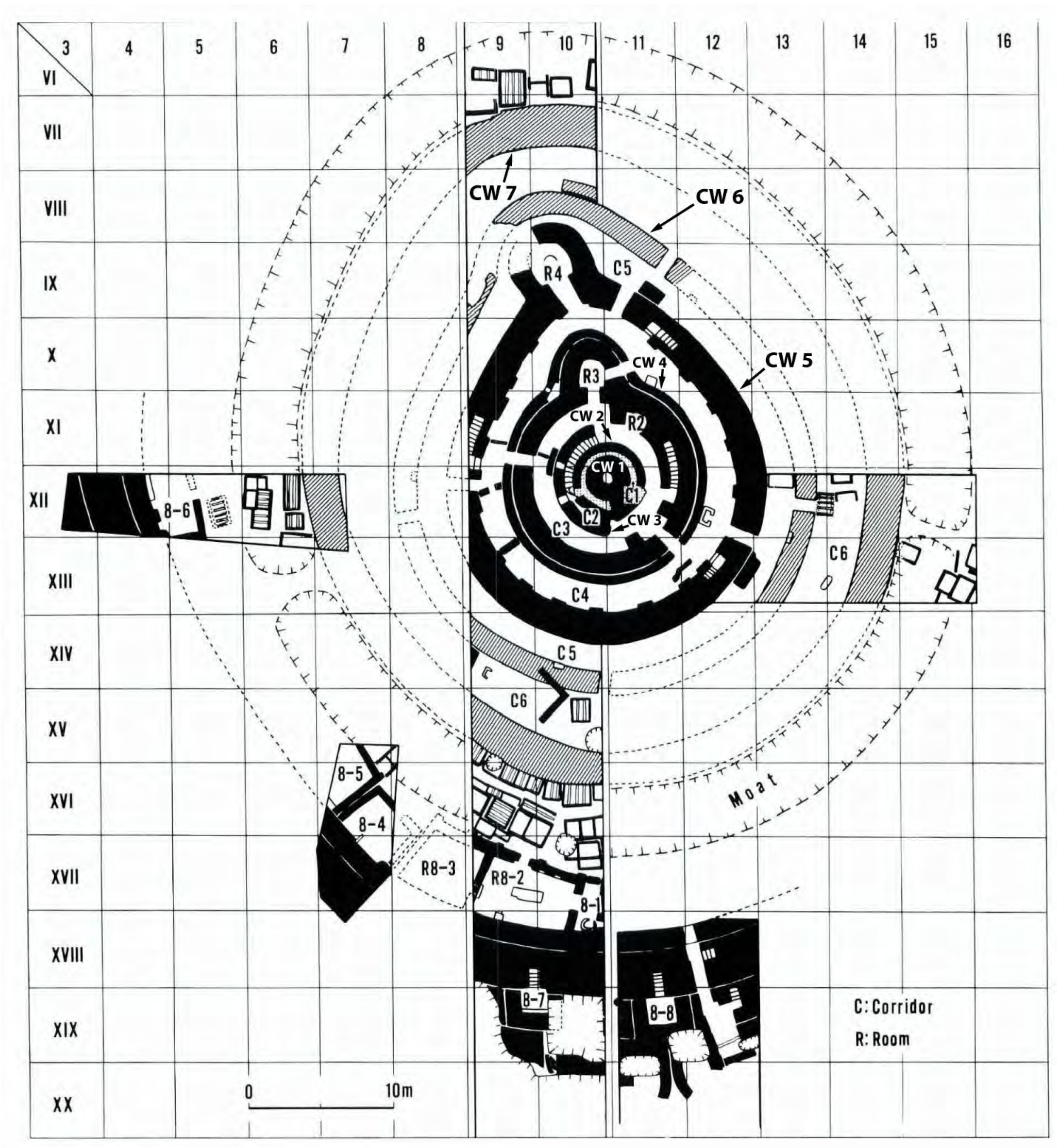


Figure 5.4: Tell Gubba, Level VIIa. Plan showing round building. (After Ii 1993: Fig. 1)

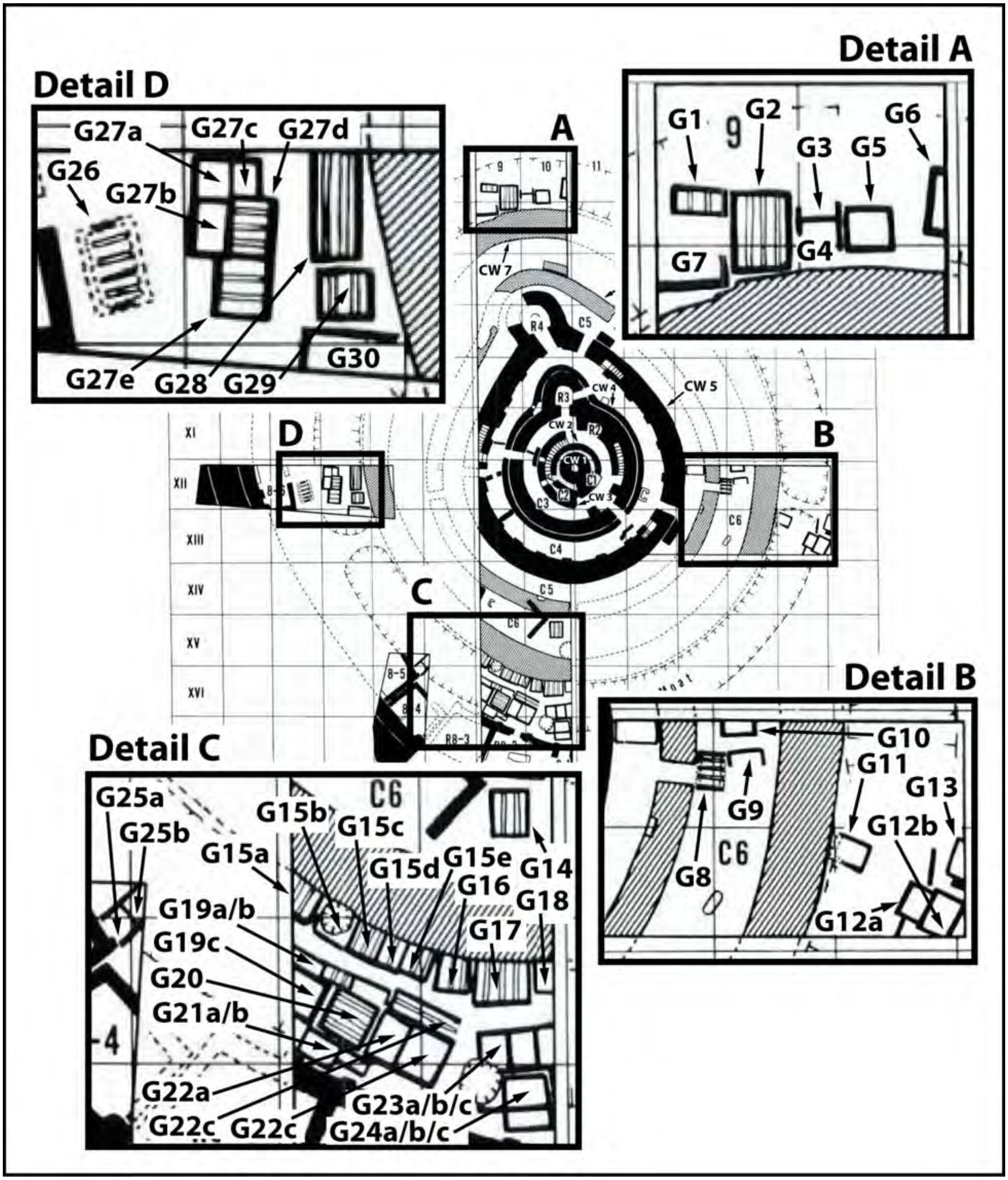


Figure 5.5: Tell Gubba, Level VIIa. Plan showing round building with details (Detail A–D) showing possible "granaries" (G1–G30, my labels). (After Ii 1993: Fig. 1)

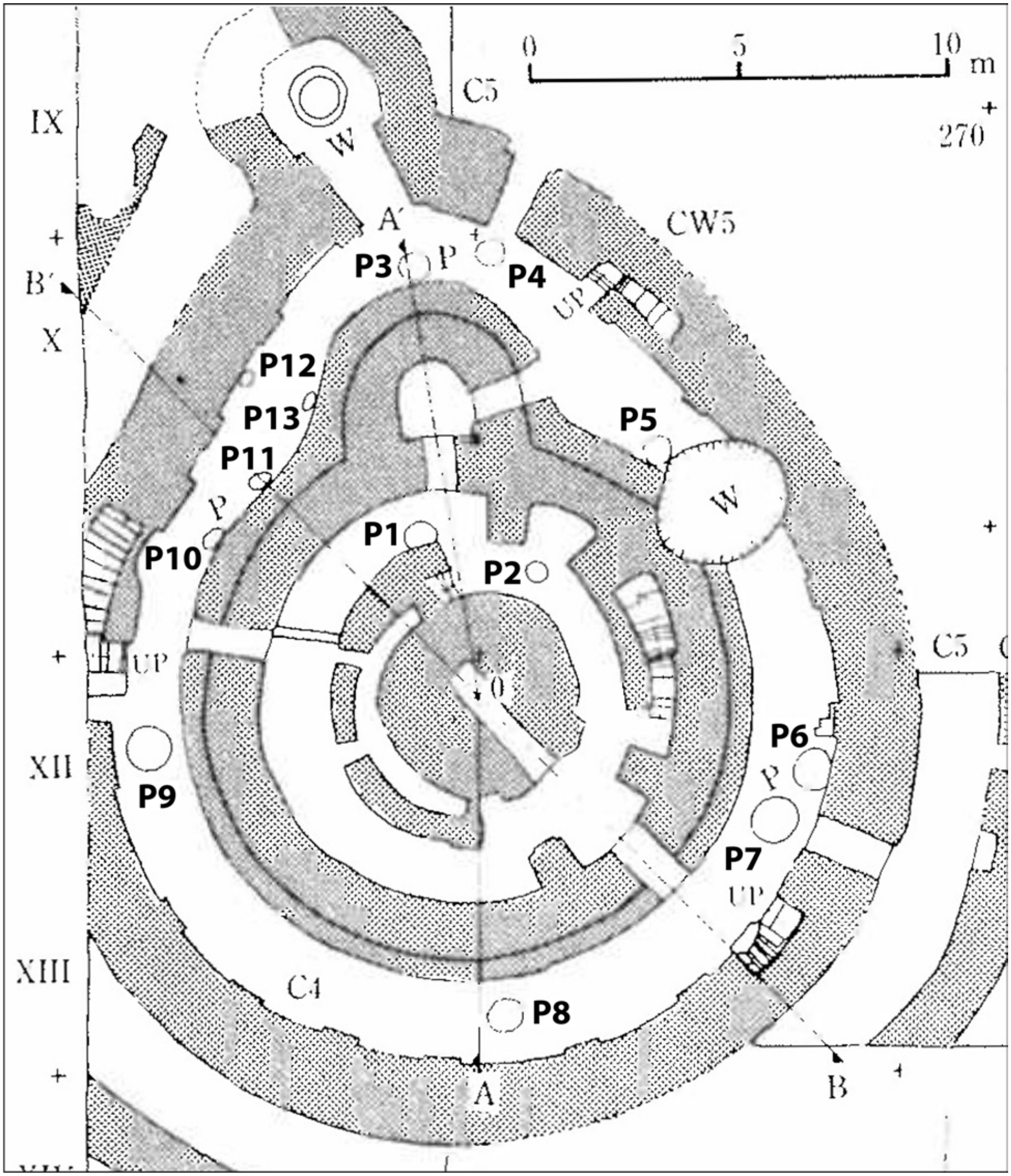


Figure 5.6: Tell Gubba, Level VII, Round building. Plan showing pits (P1–P13, my labels) within corridors. (After Odani and Ii 1981: Fig. 5)

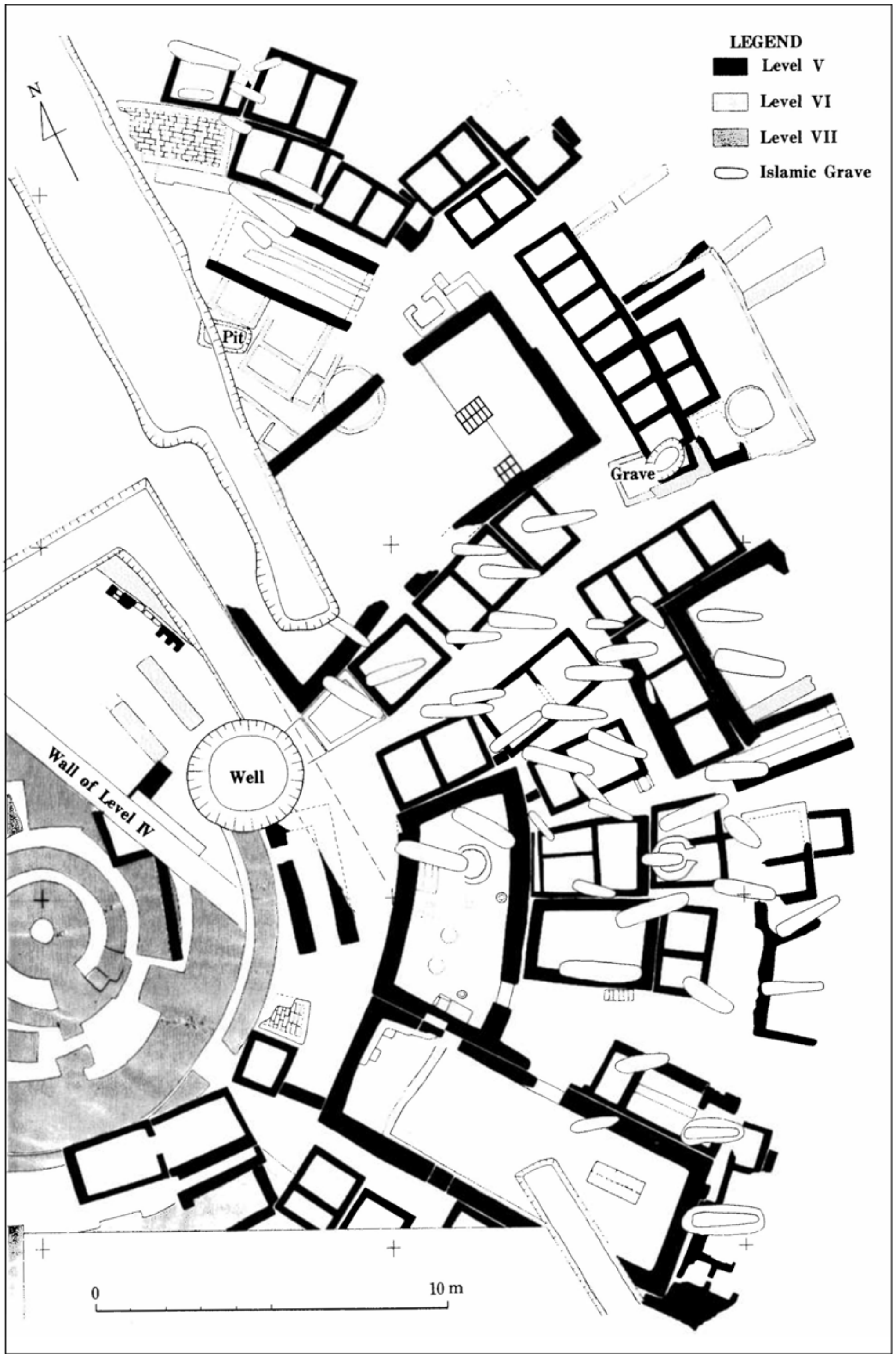


Figure 5.7: Tell Gubba. Plan of Levels VII–V, with Level V structures shown in black. (After Odani and Ii 1981: Fig. 8)

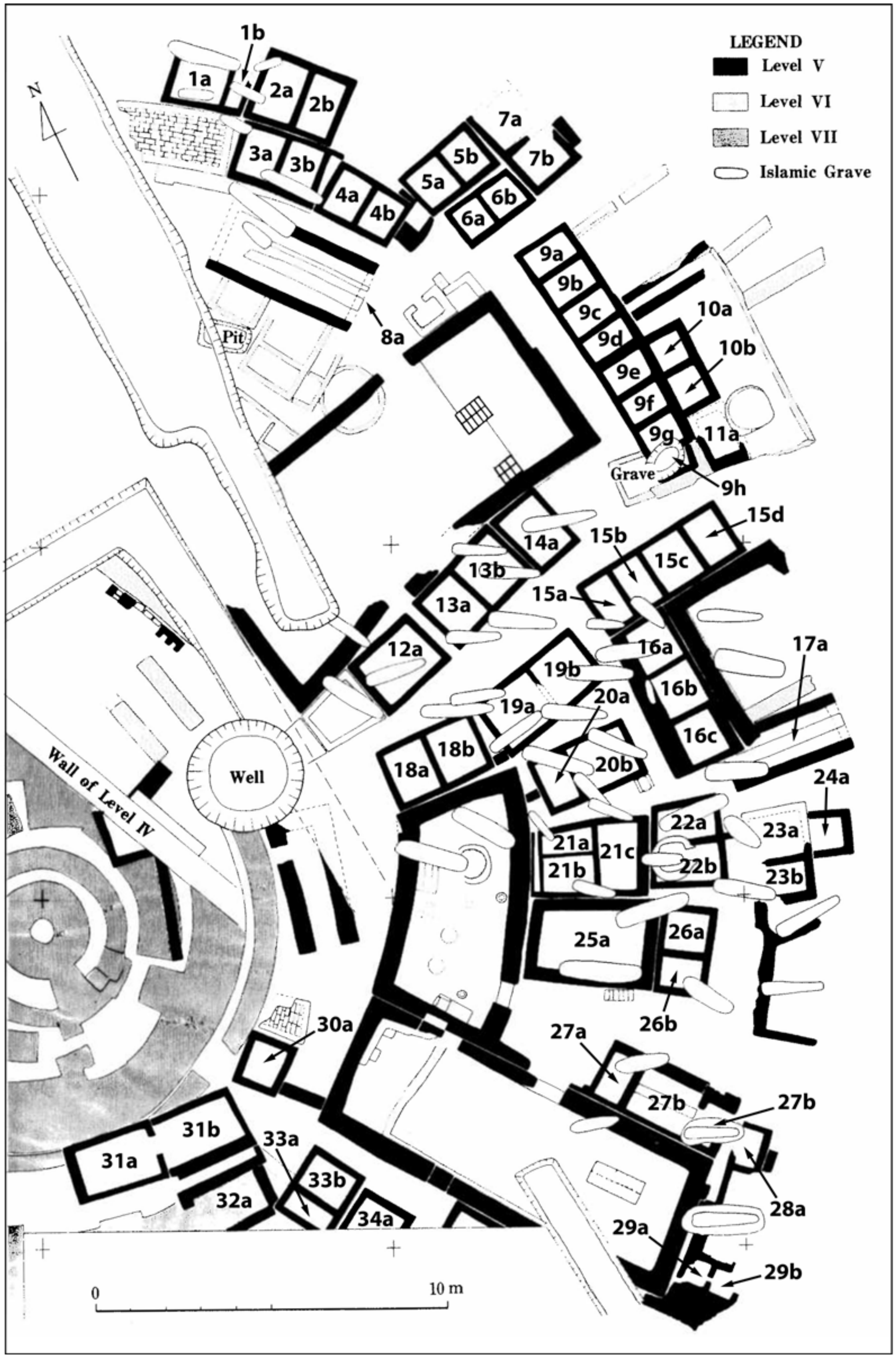


Figure 5.8: Tell Gubba. Plan of Levels VII–V, with Level V structures shown in black and Level V granaries labeled (1–34, my labels). (After Odani and Ii 1981: Fig. 8)

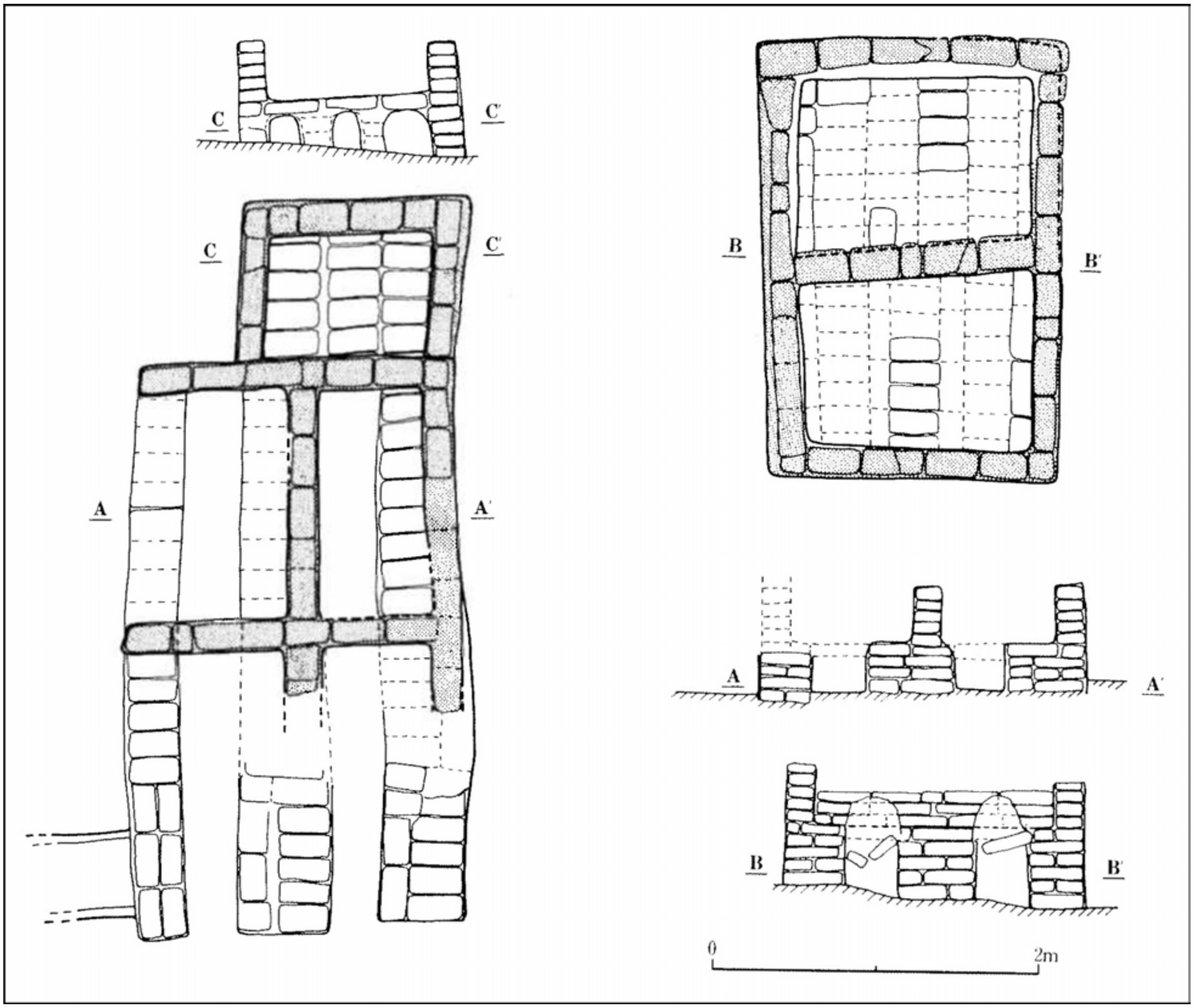


Figure 5.9: Tell Gubba. Plans (bottom left, top right) and sections (top left, bottom right) showing two structures with parallel wall foundations. (After Odani and Ii 1981: Fig. 9)

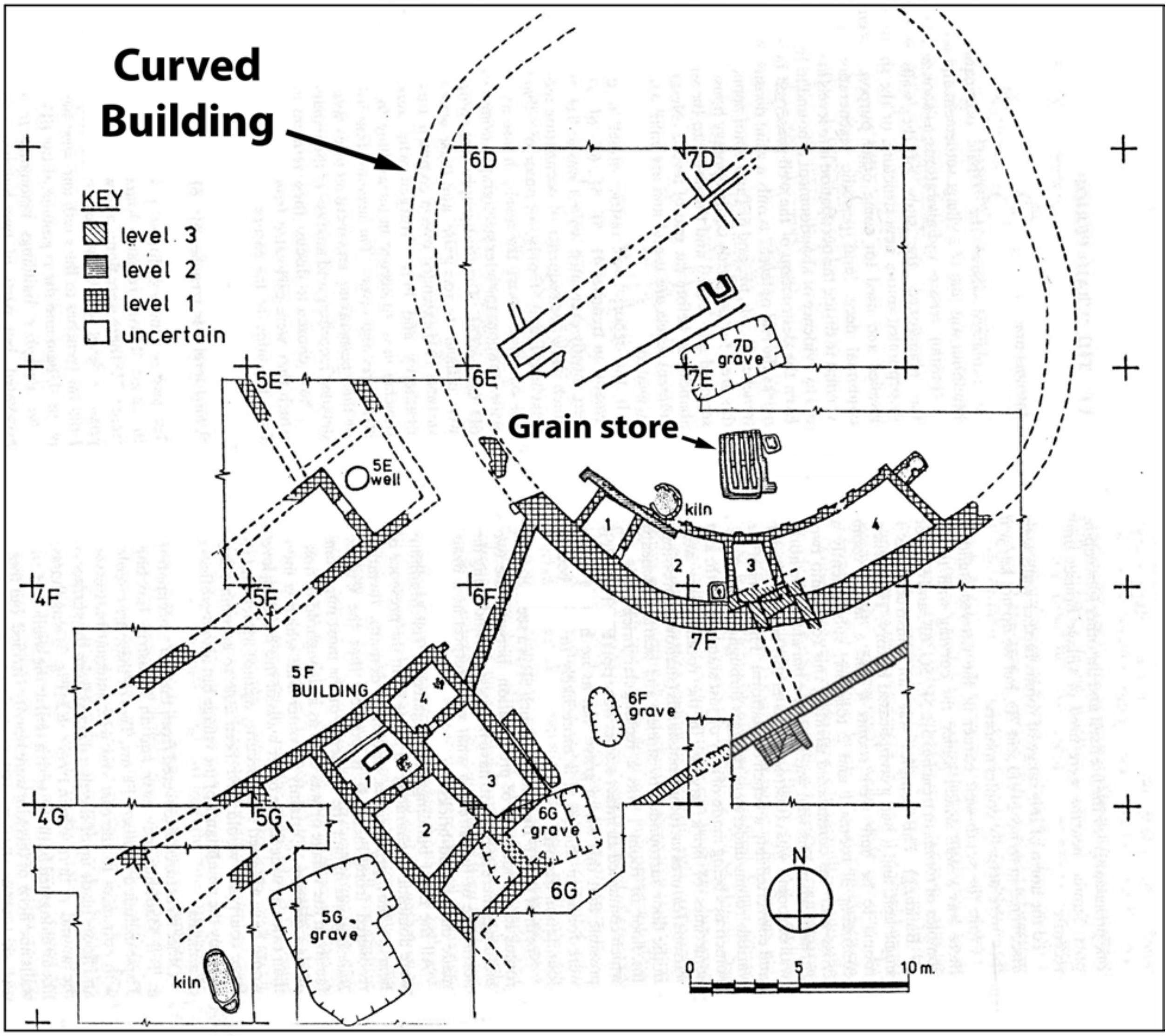


Figure 5.10: Tell Madhhur. Plan showing "grain store" within central courtyard of Curved Building. (After Roaf 1984: Fig. 3)

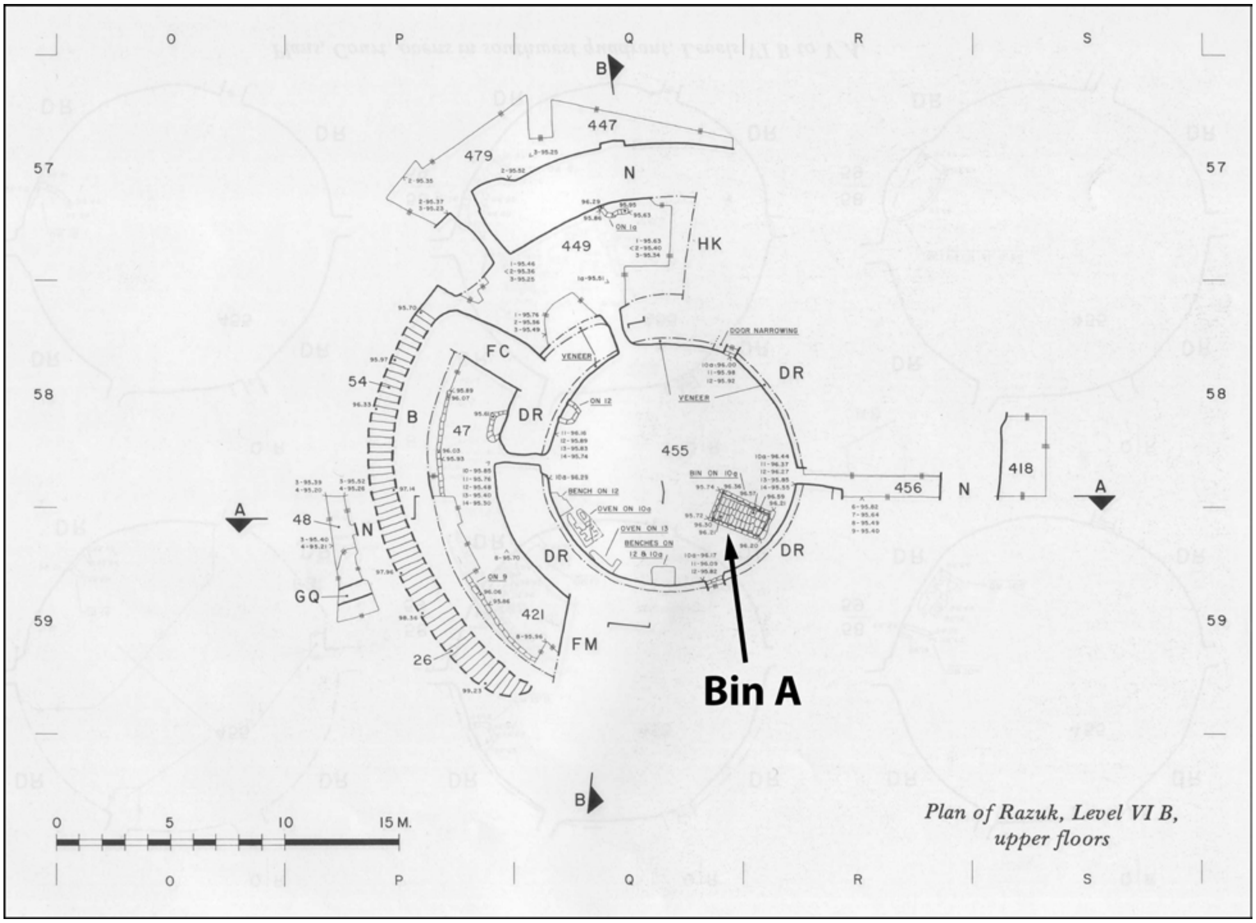


Figure 5.11: Tell Razuk, Level VI B, upper floors. Plan showing Bin A within courtyard of Round Building. (After Gibson 1981b: Pl. 14)

Figure 5.12: Tell Razuk. Photo showing Bin A within courtyard of Round Building. (After Gibson 1981b: Pl. 7:1)

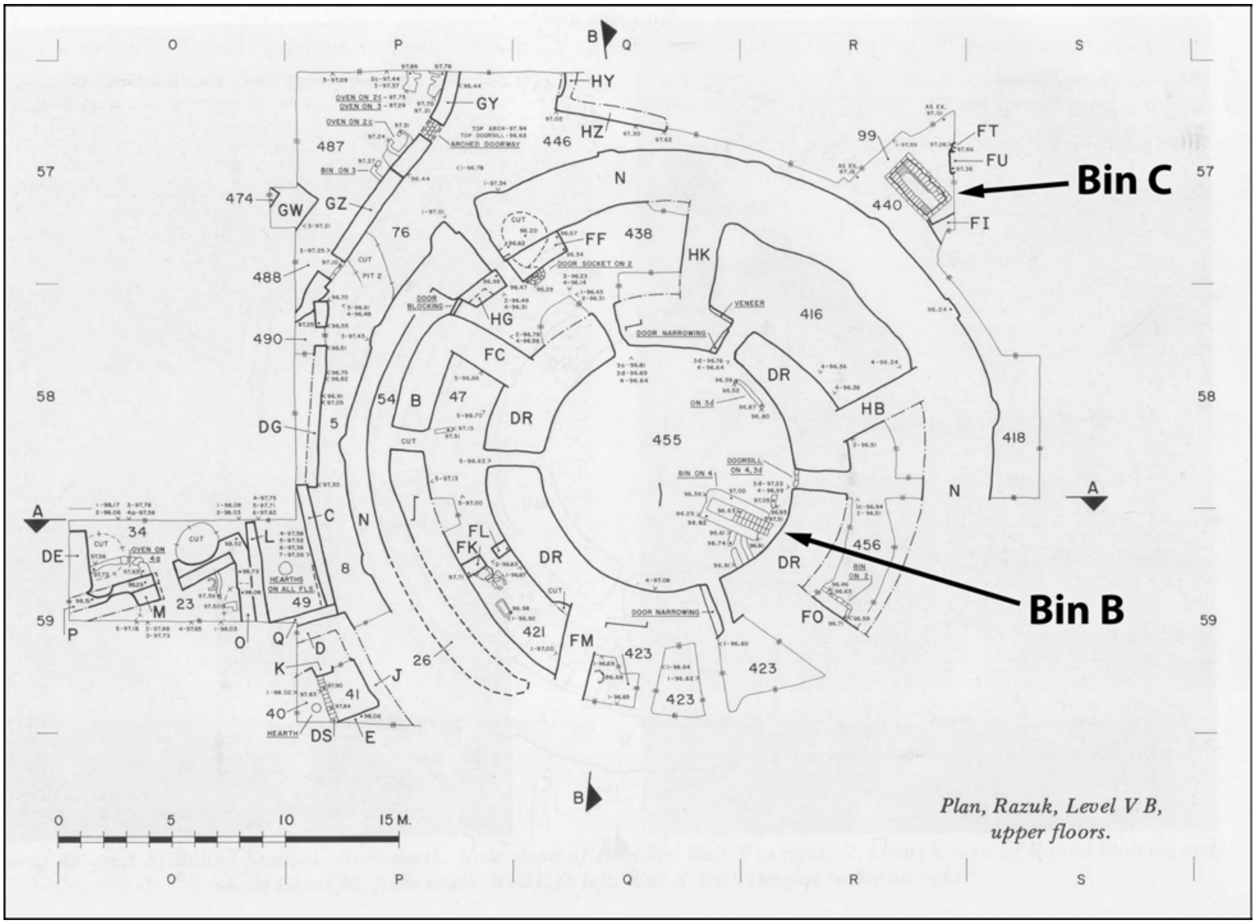


Figure 5.13: Tell Razuk, Level V B, upper floors. Plan showing Bin B within courtyard of Round Building and Bin C northeast of Round Building. (After Gibson 1981b: Pl. 27)

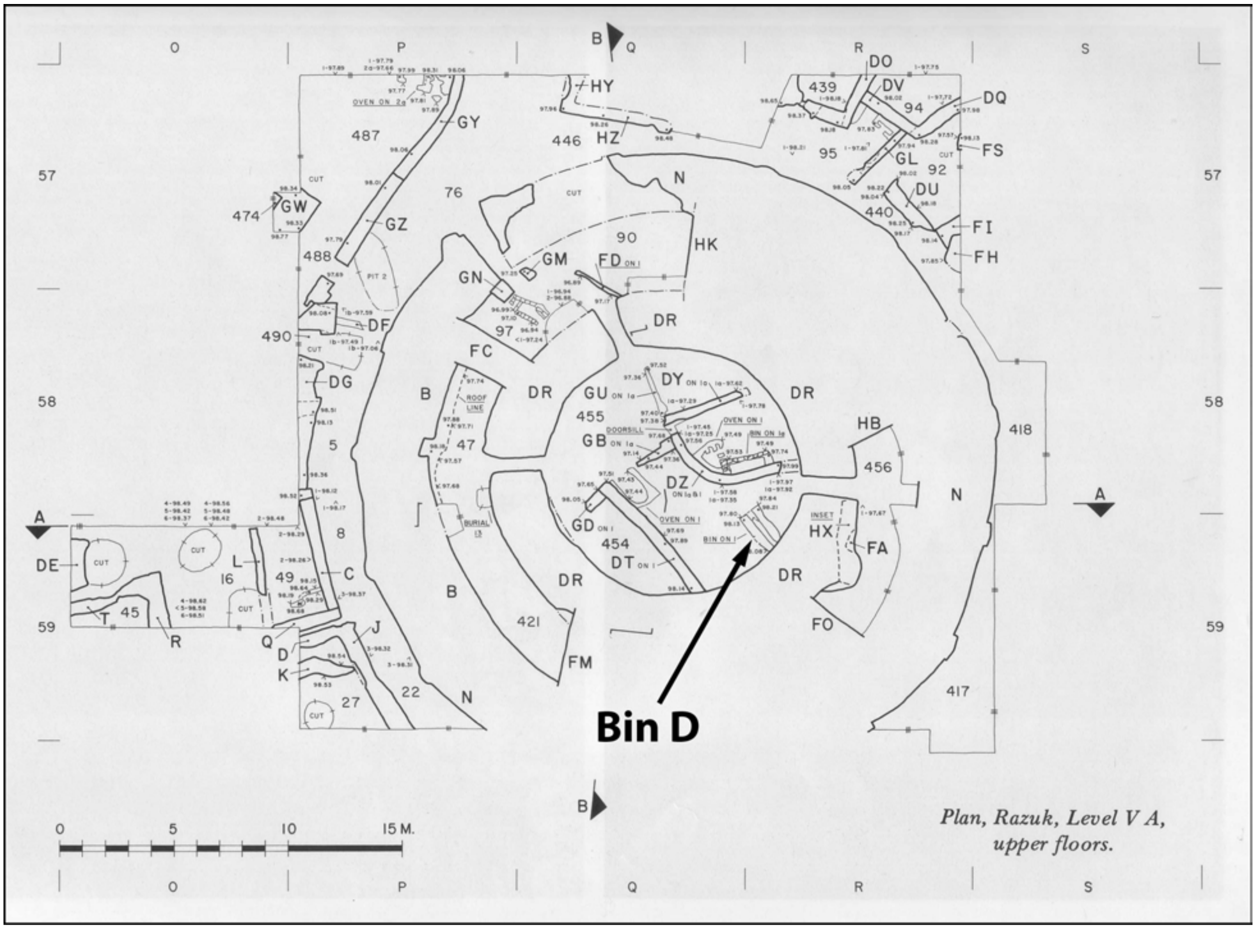


Figure 5.14: Tell Razuk, Level V A, upper floors. Plan showing Bin D within courtyard of Round Building. (After Gibson 1981b: Pl. 34)

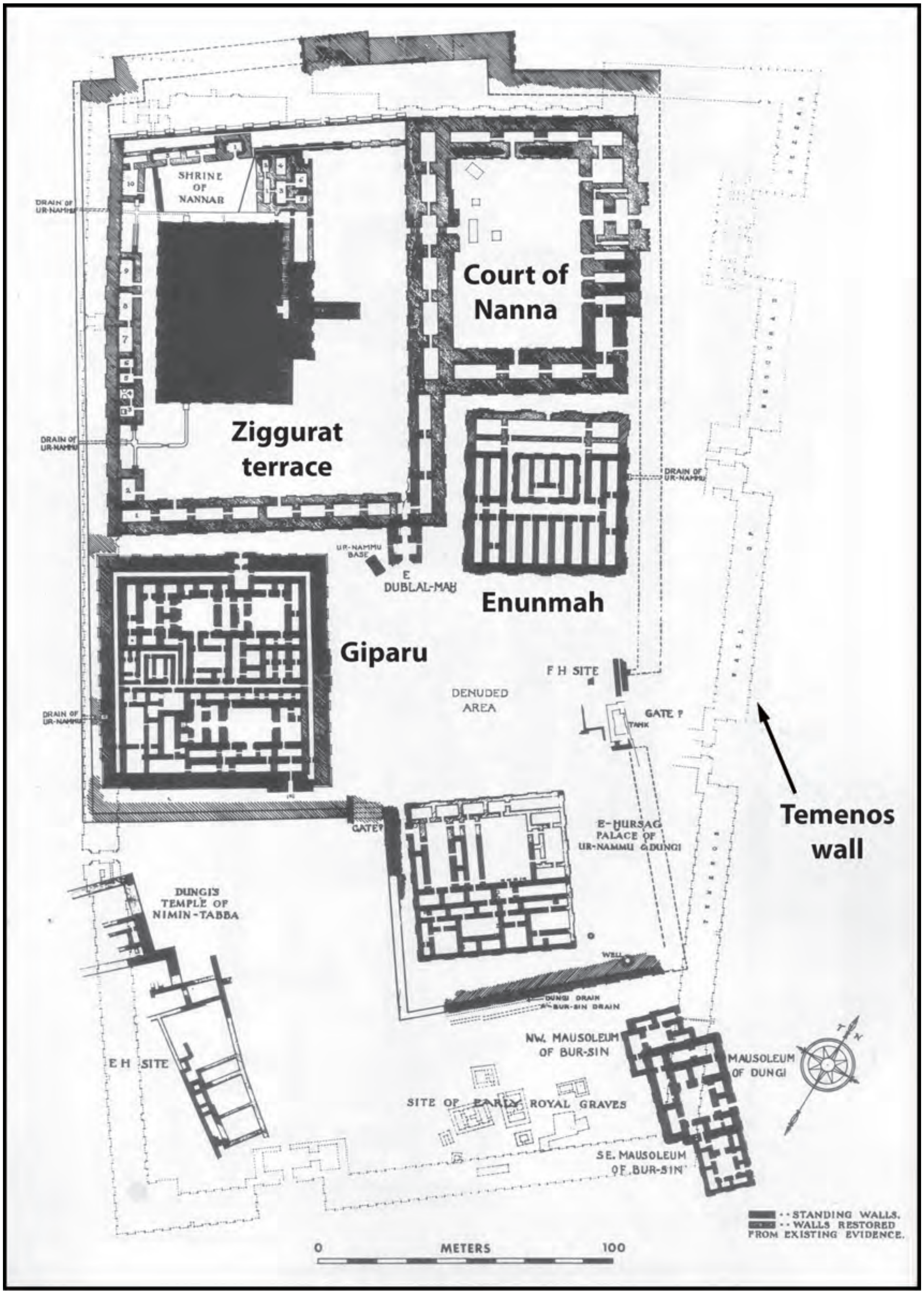


Figure 5.15: Ur, Ur III period. Plan showing Temenos area (including the Court of Nanna, Enunmah, Giparu, and ziggurat terrace). (After Woolley 1974: Pl. 53)

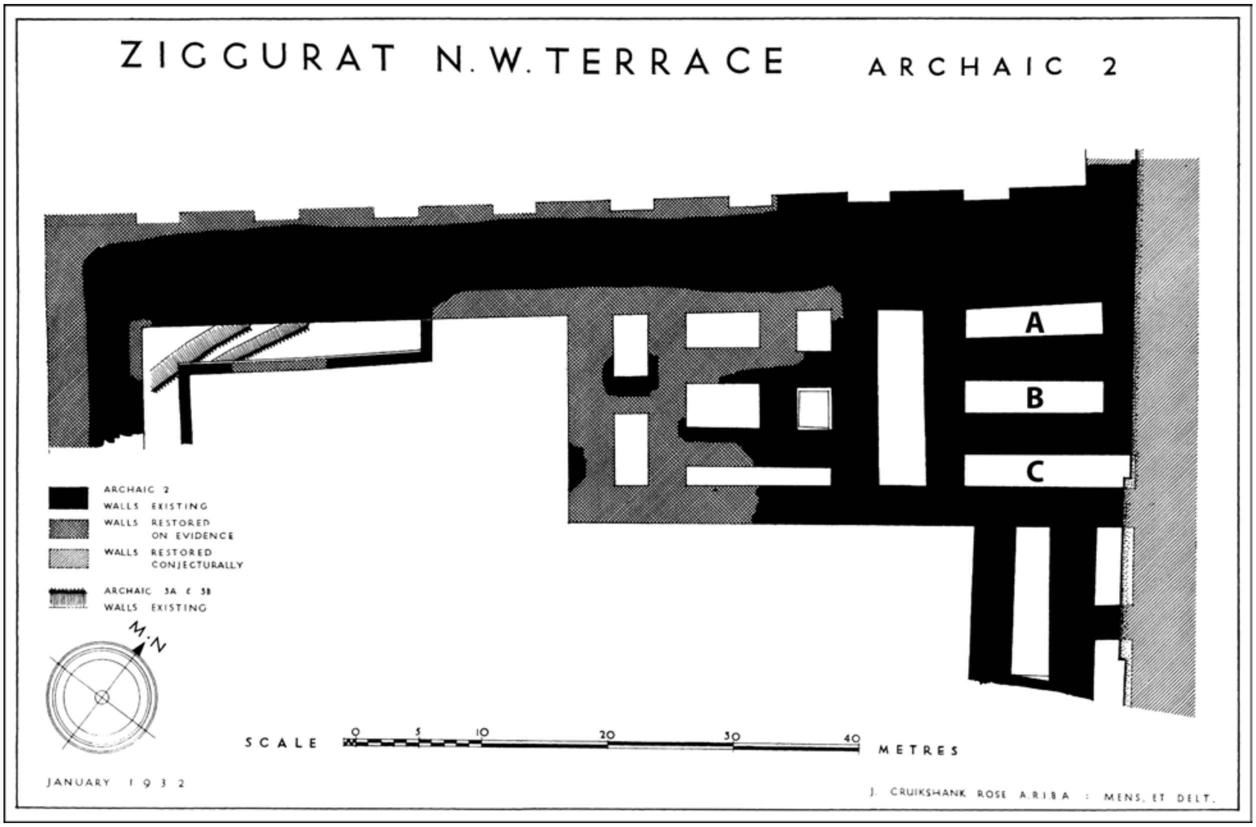


Figure 5.16: Ur, Archaic II period. Plan showing northern portion of temple platform. The three long, parallel storerooms (A–C) are visible on the right side. (After Woolley 1939: Pl. 67)

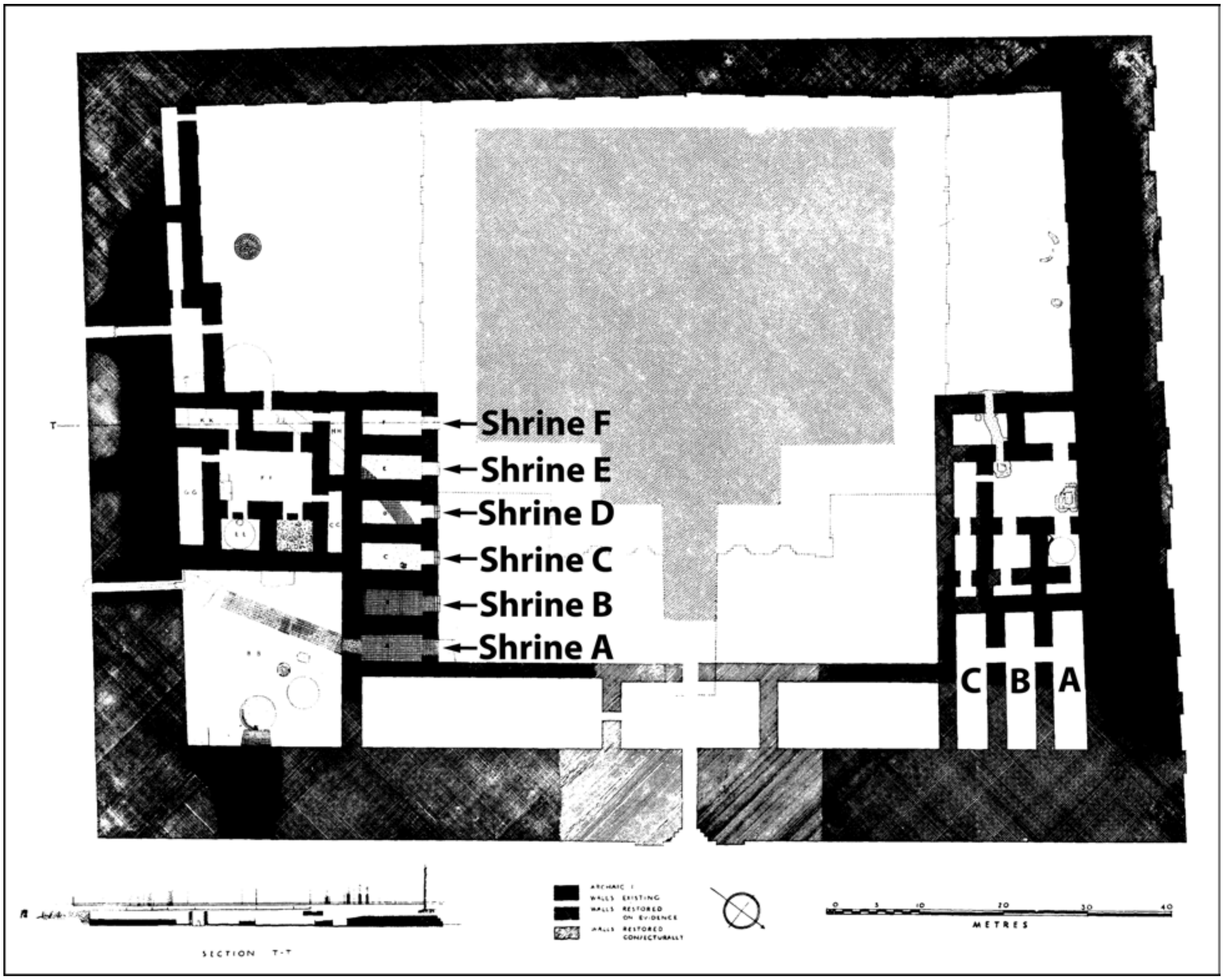


Figure 5.17: Ur, Archaic I period. Plan showing temple platform. The three long, parallel storerooms (A–C) are visible in the bottom right corner, and the six "shrines" (Shrines A–F) are visible just to the left of center. (After Woolley 1939: Pl. 66)

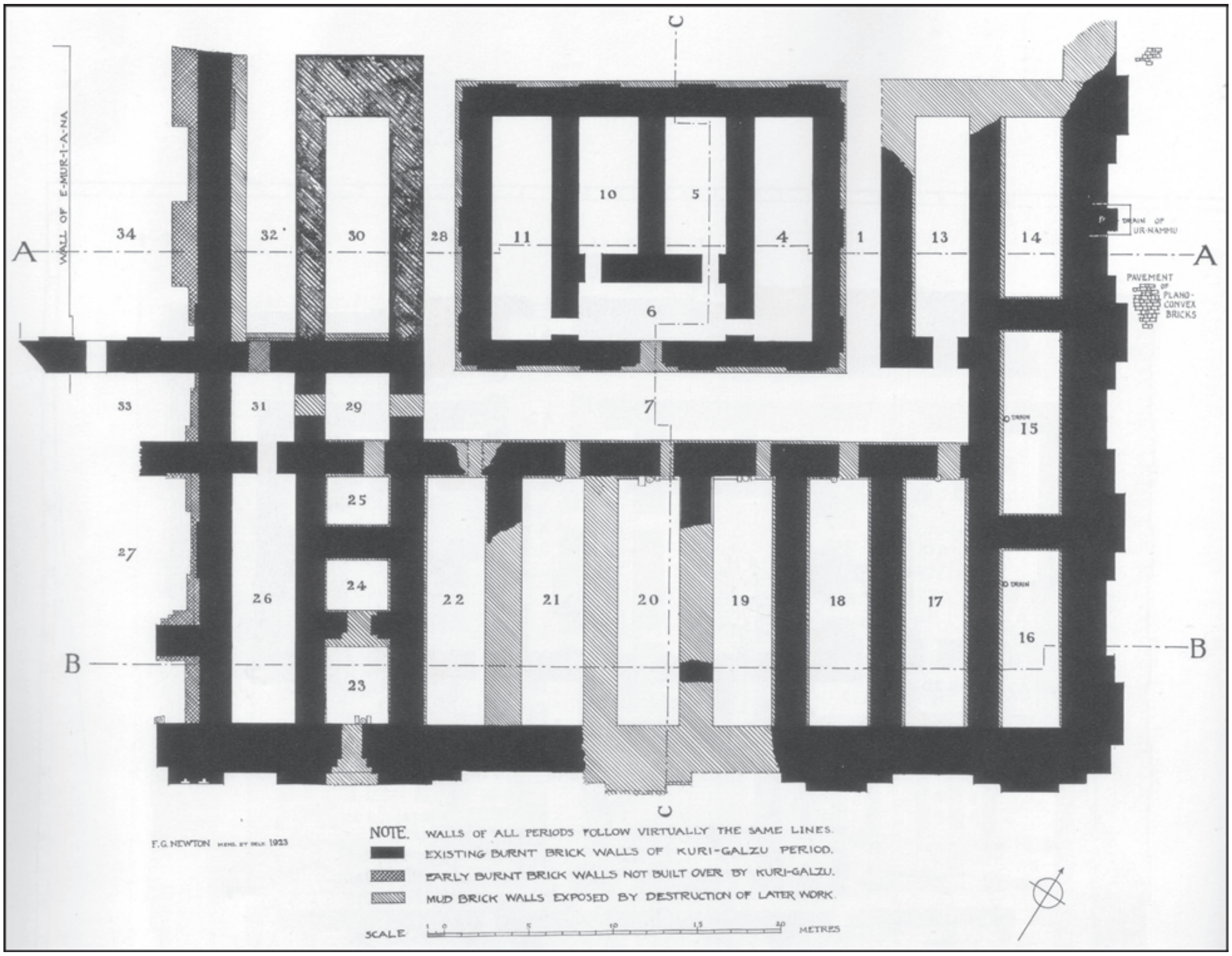


Figure 5.18: Ur. Plan showing the Enunmakh (without Woolley's conjectural reconstruction of the northwestern part of the building and with Woolley's room labels). (After Woolley 1974: Pl. 58)

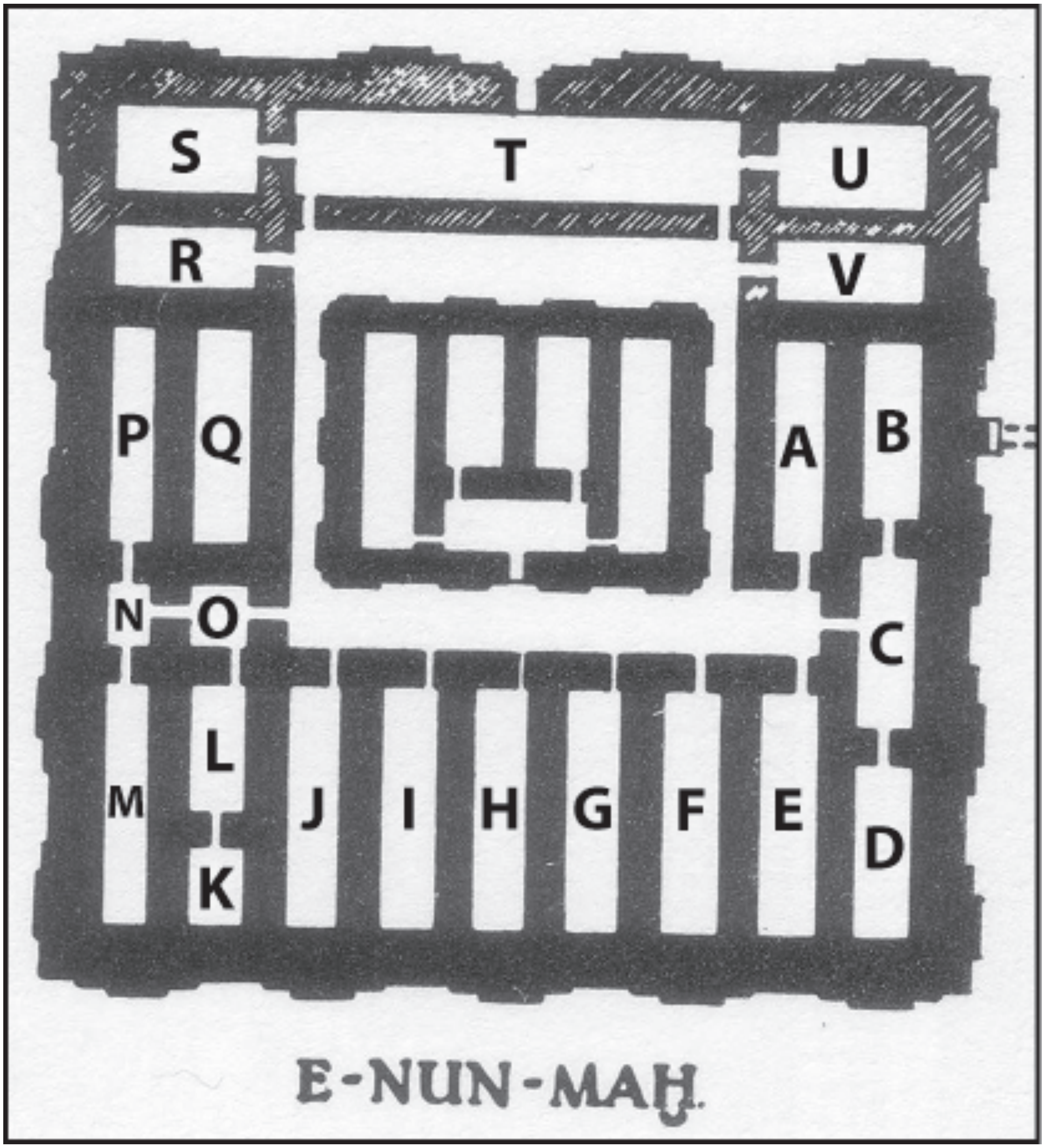


Figure 5.19: Ur. Plan showing the Enunmakh (including Woolley's conjectural reconstruction of the northwestern part of the building and my own room labels). (After Woolley 1974: Pl. 53)

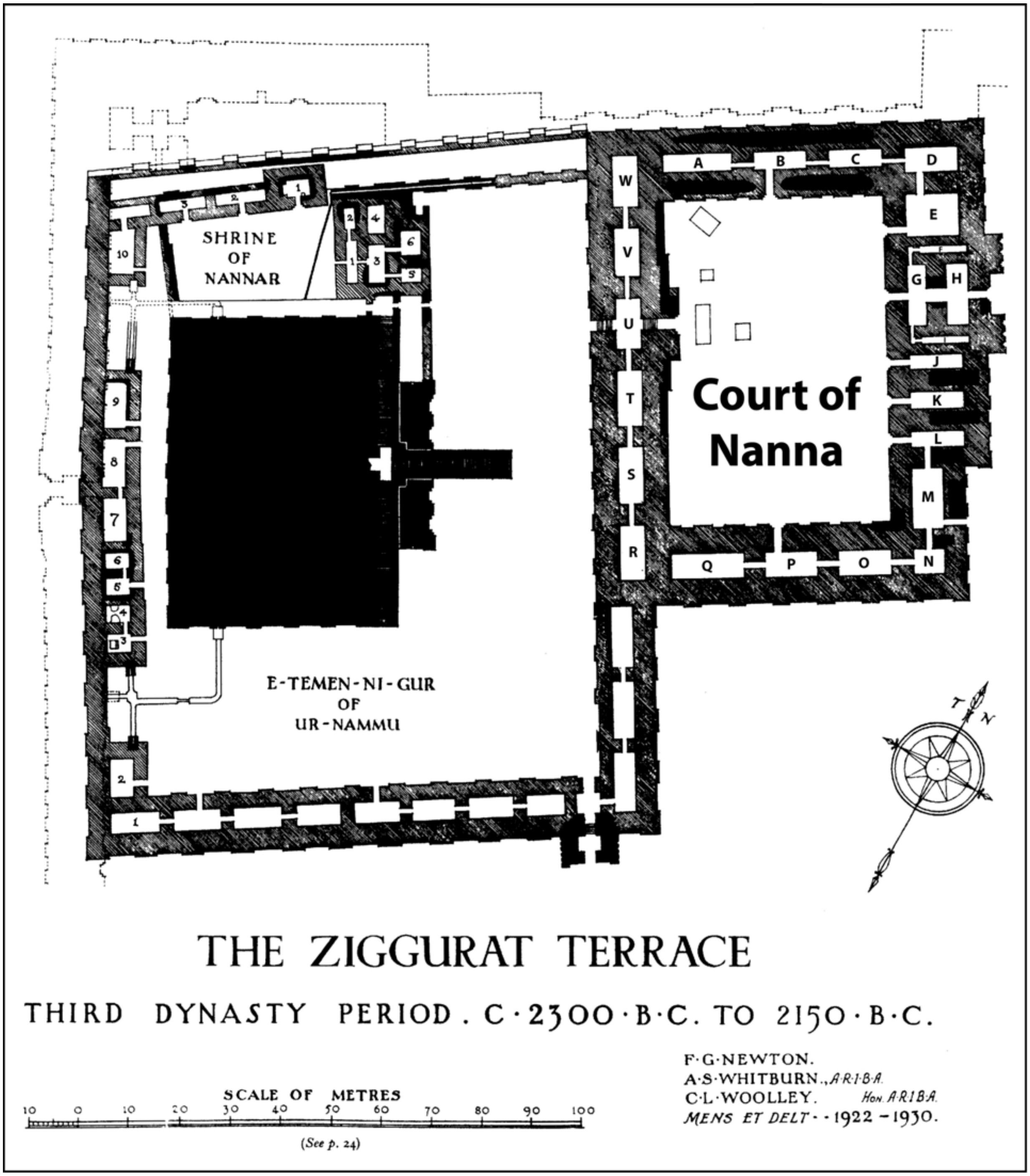


Figure 5.20: Ur. Plan showing the Court of Nanna (with my own room labels). (After Woolley 1939: Pl. 68)

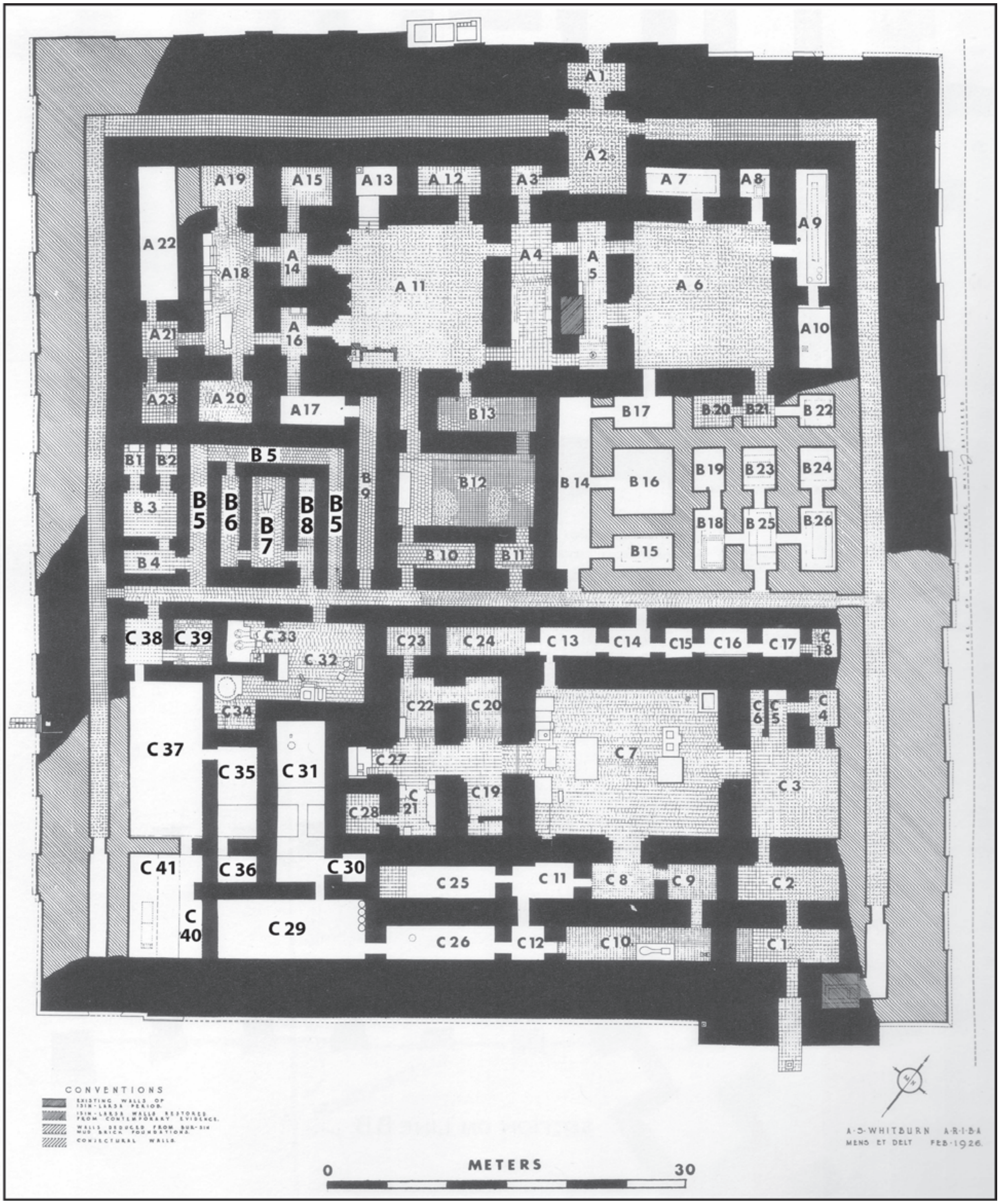


Figure 5.21: Ur. Plan showing the Giparu, including possible storerooms (B 5–8, C 35–41, and C 29–31). (After Woolley 1974: Pl. 57)

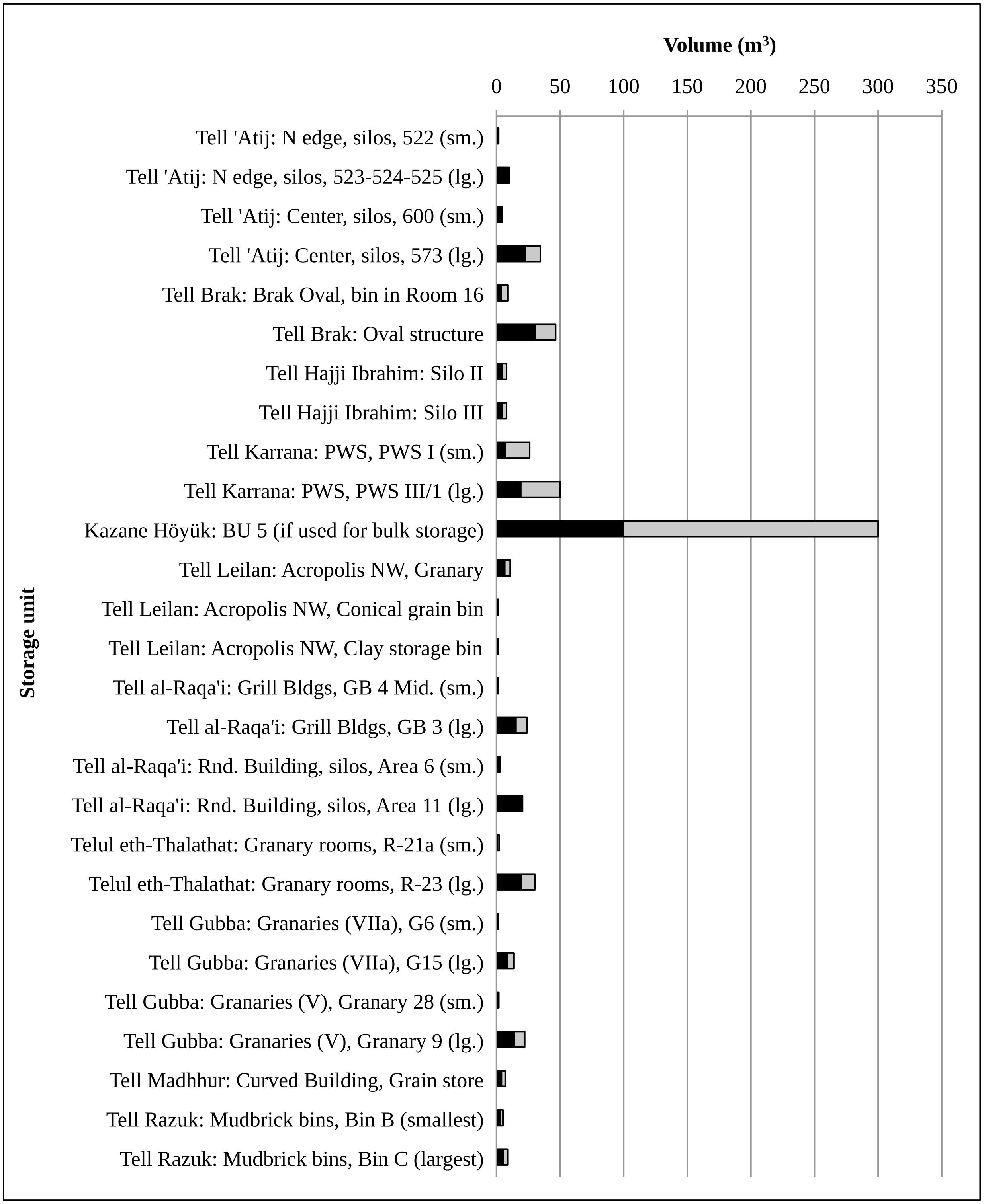


Figure 6.1: Graph showing the storage capacity (m^3) of above-ground, bulk storage units. Where more than three examples were recovered at a site, I have shown only the smallest (sm.) and largest (lg.) examples.

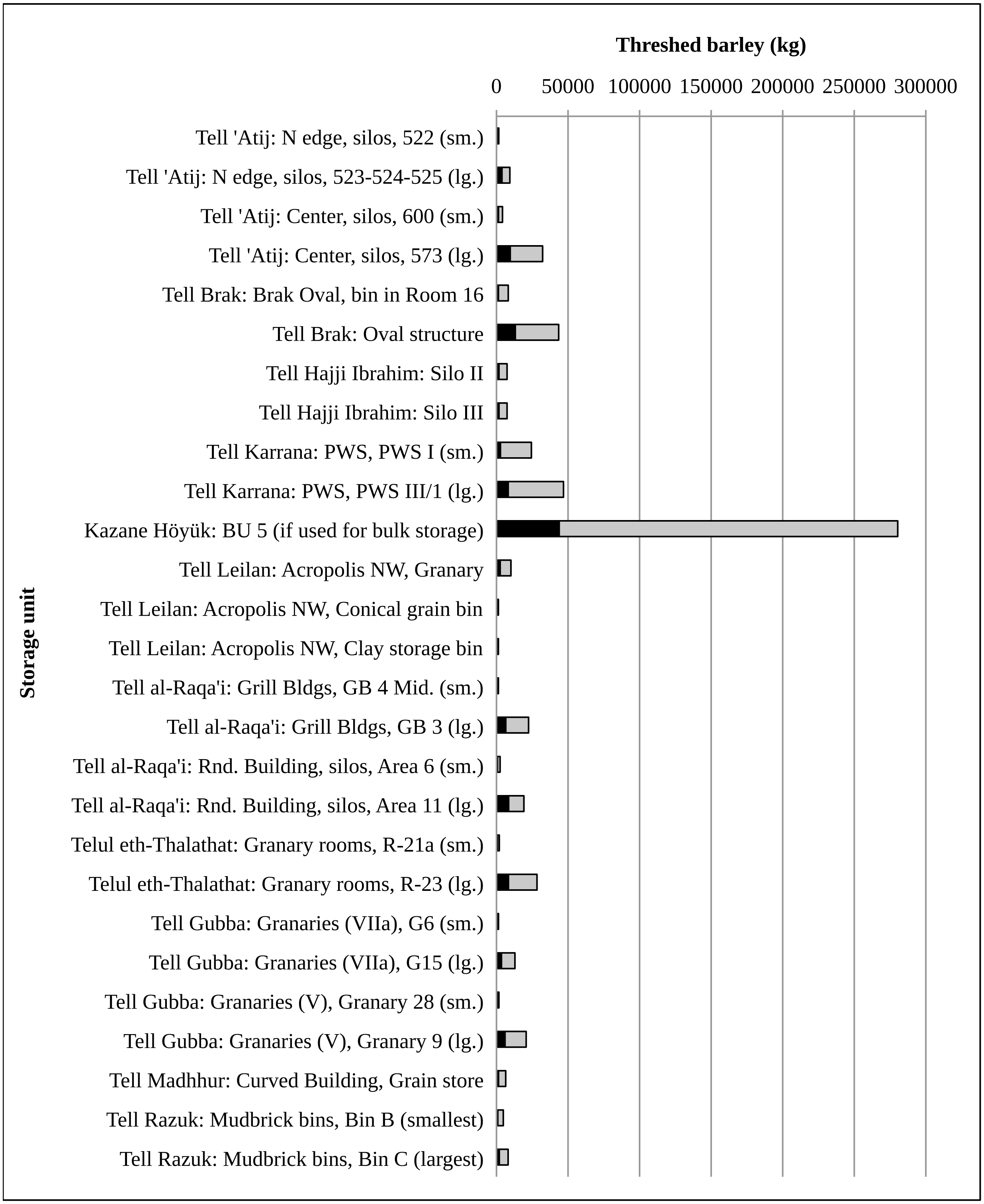


Figure 6.2: Graph showing the storage capacity (kg of threshed barley) of above-ground, bulk storage units. Where more than three examples were recovered at a site, I have shown only the smallest (sm.) and largest (lg.) examples.

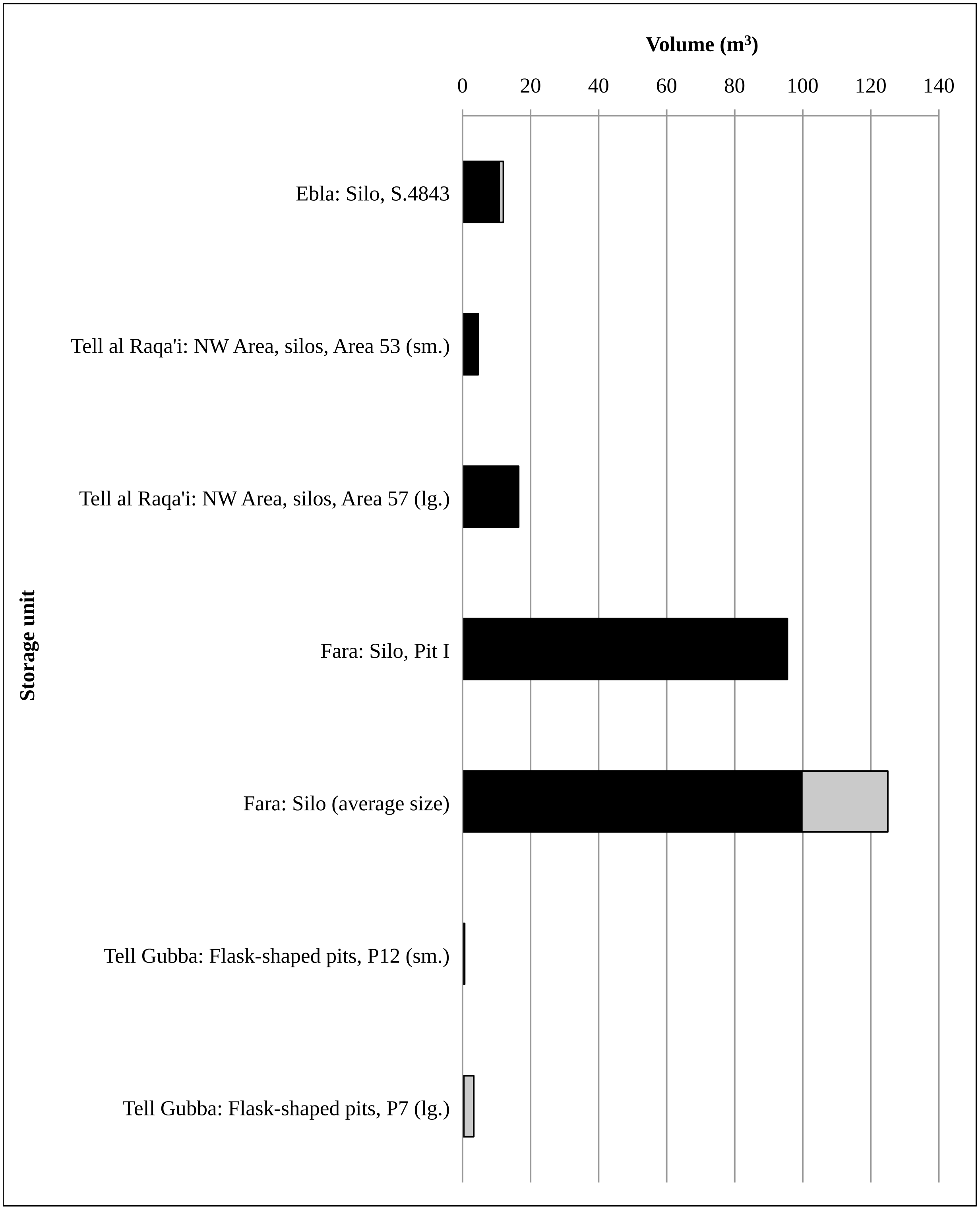


Figure 6.3: Graph showing the storage capacity (m^3) of below-ground, bulk storage units. Where more than three examples were recovered at a site, I have shown only the smallest (sm.) and largest (lg.) examples.

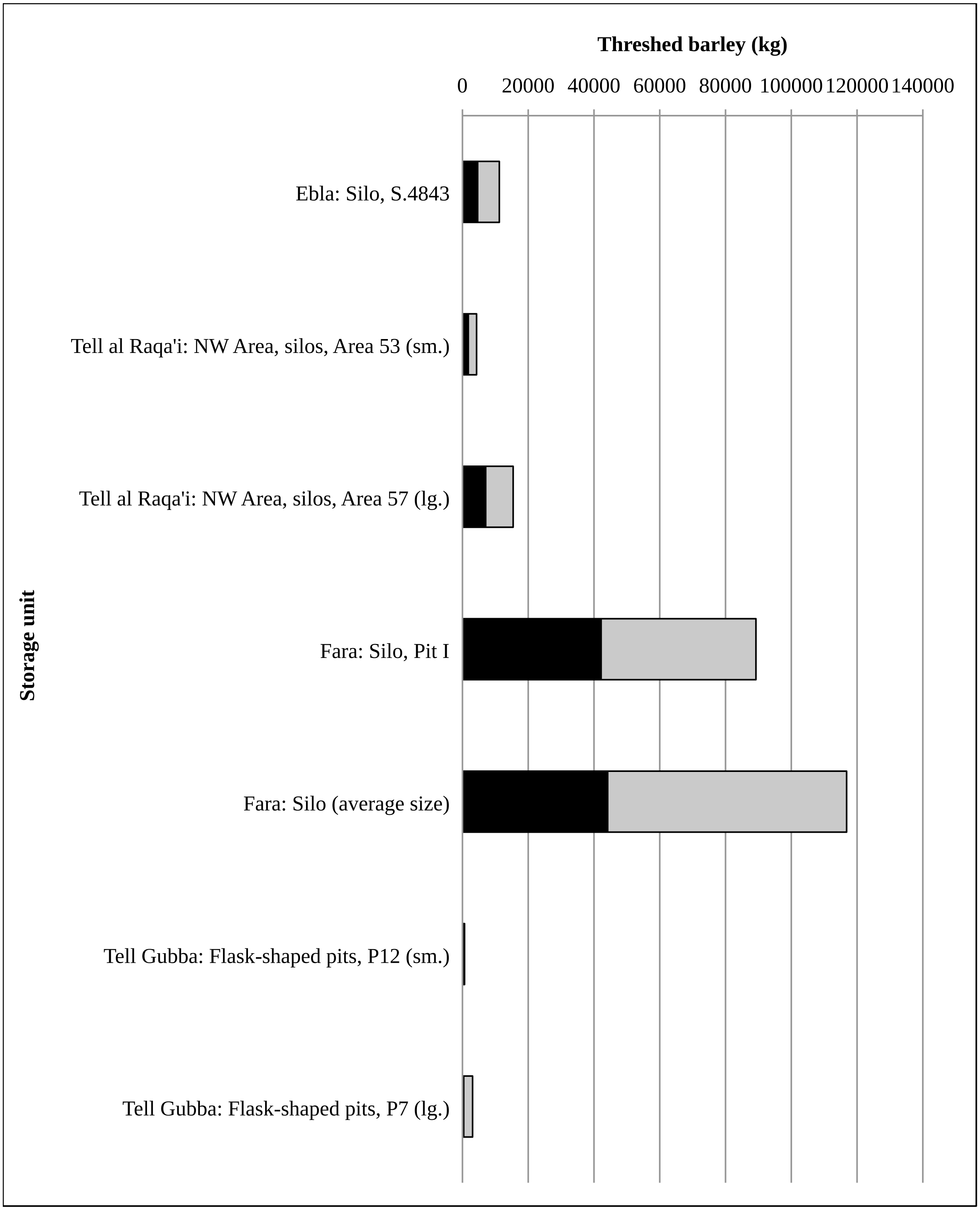


Figure 6.4: Graph showing the storage capacity (kg of threshed barley) of below-ground, bulk storage units. Where more than three examples were recovered at a site, I have shown only the smallest (sm.) and largest (lg.) examples.

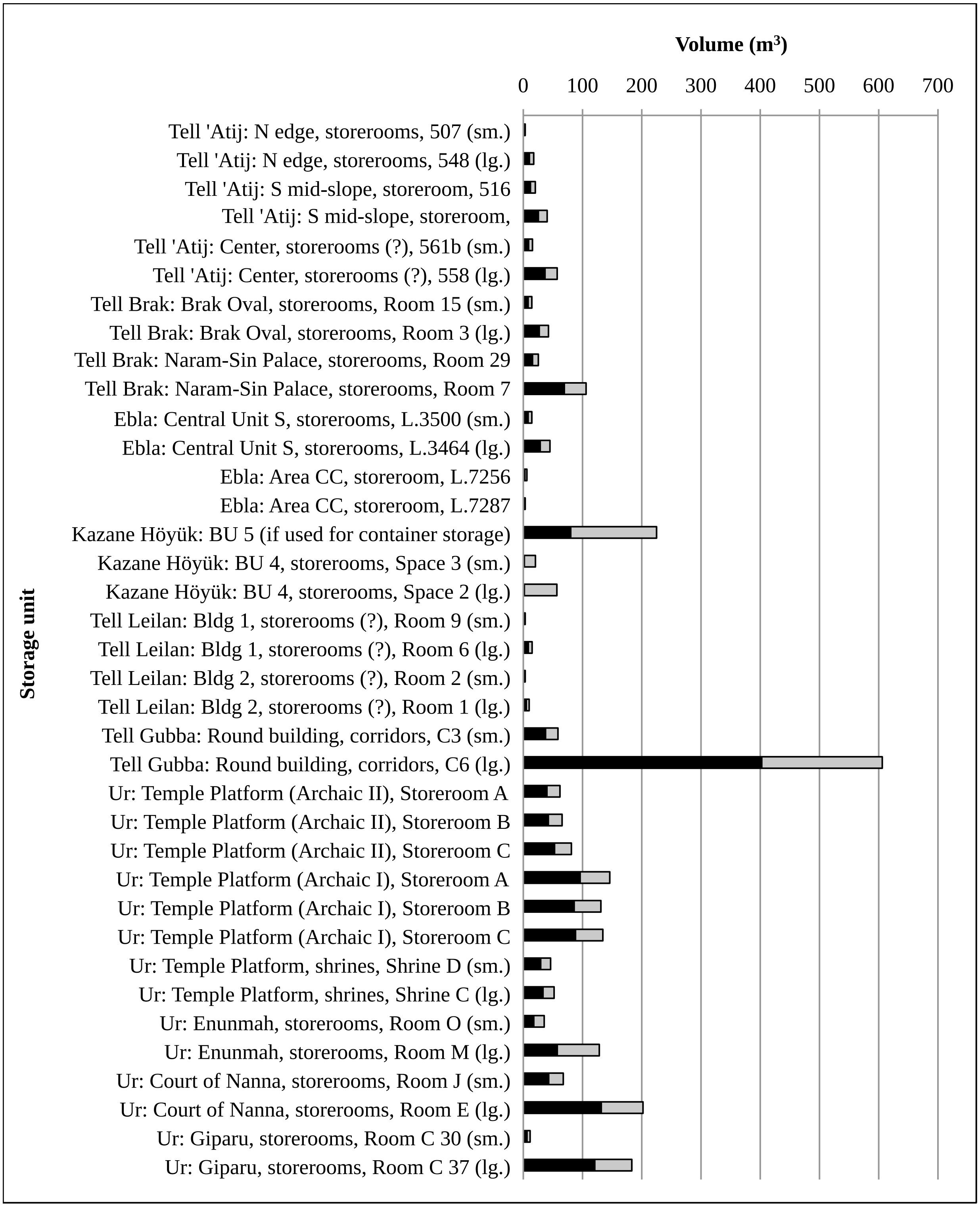


Figure 6.5: Graph showing the storage capacity (m^3) of storerooms that would have held grain in containers. Where more than three examples were recovered at a site, I have shown only the smallest (sm.) and largest (lg.) examples.

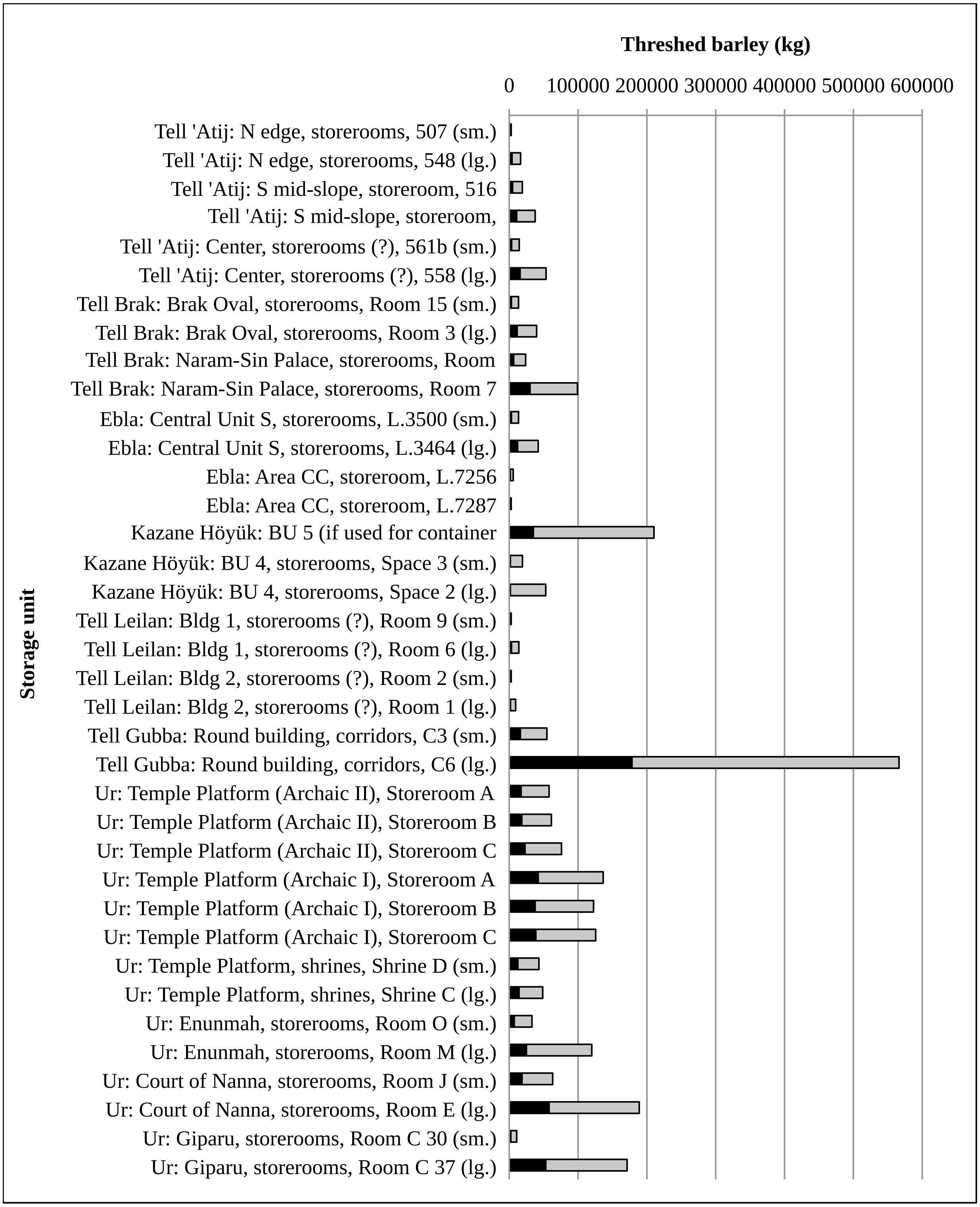


Figure 6.6: Graph showing the storage capacity (kg of threshed barley) of storerooms that would have held grain in containers. Where more than three examples were recovered at a site, I have shown only the smallest (sm.) and largest (lg.) examples.

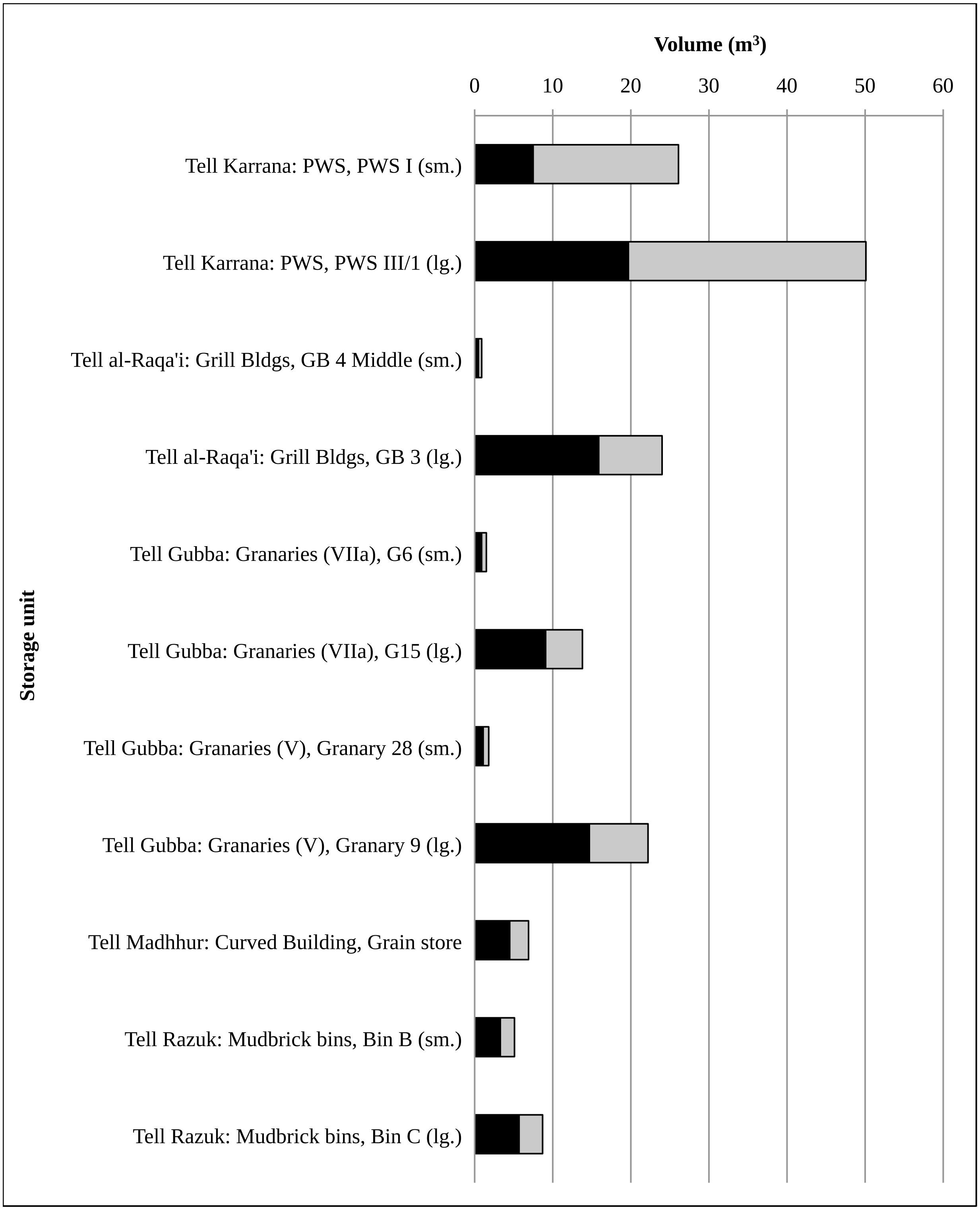


Figure 6.7: Graph showing the storage capacity (m^3) of raised storage bins. Where more than three examples were recovered at a site, I have shown only the smallest (sm.) and largest (lg.) examples.

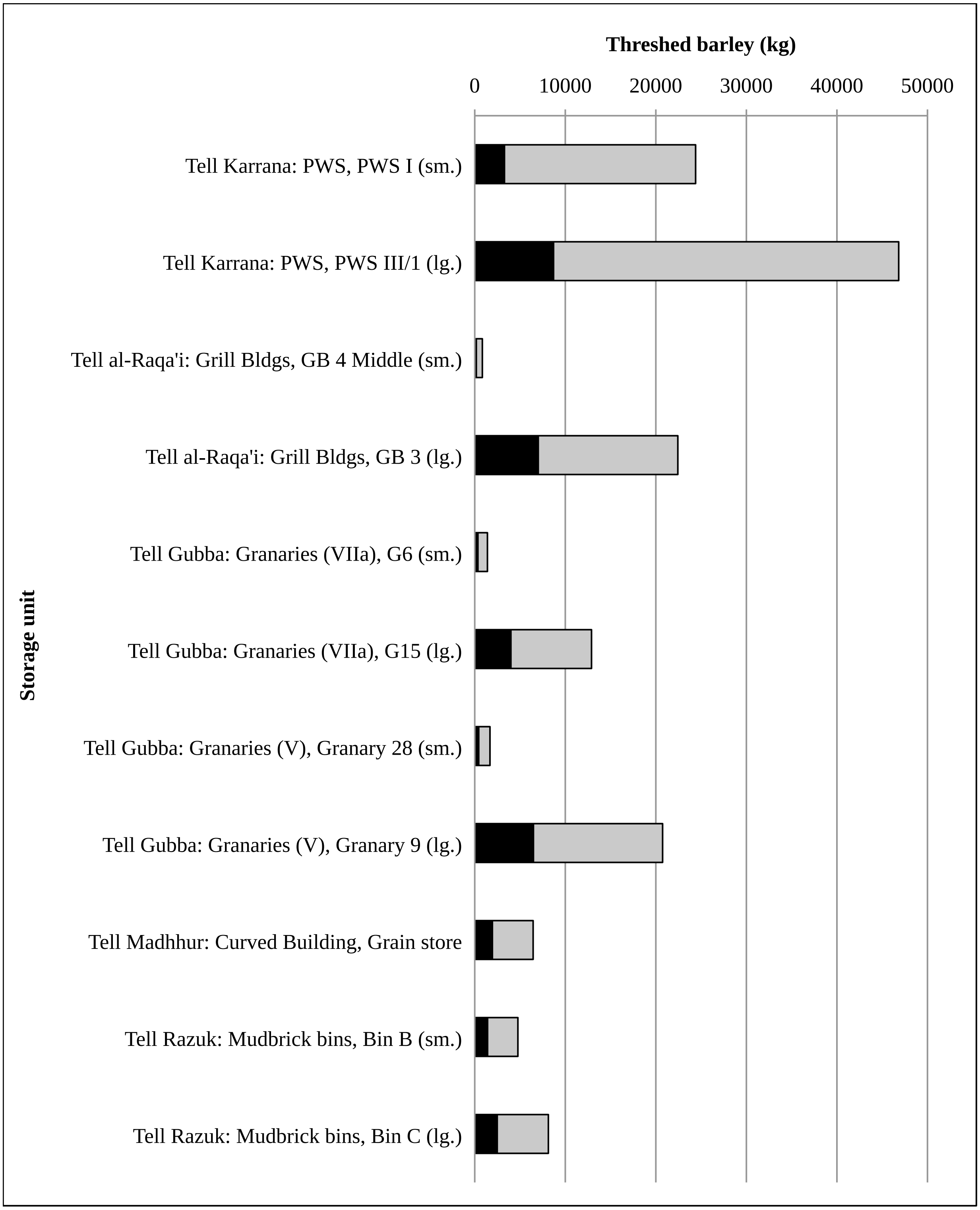


Figure 6.8: Graph showing the storage capacity (kg of threshed barley) of raised storage bins. Where more than three examples were recovered at a site, I have shown only the smallest (sm.) and largest (lg.) examples.

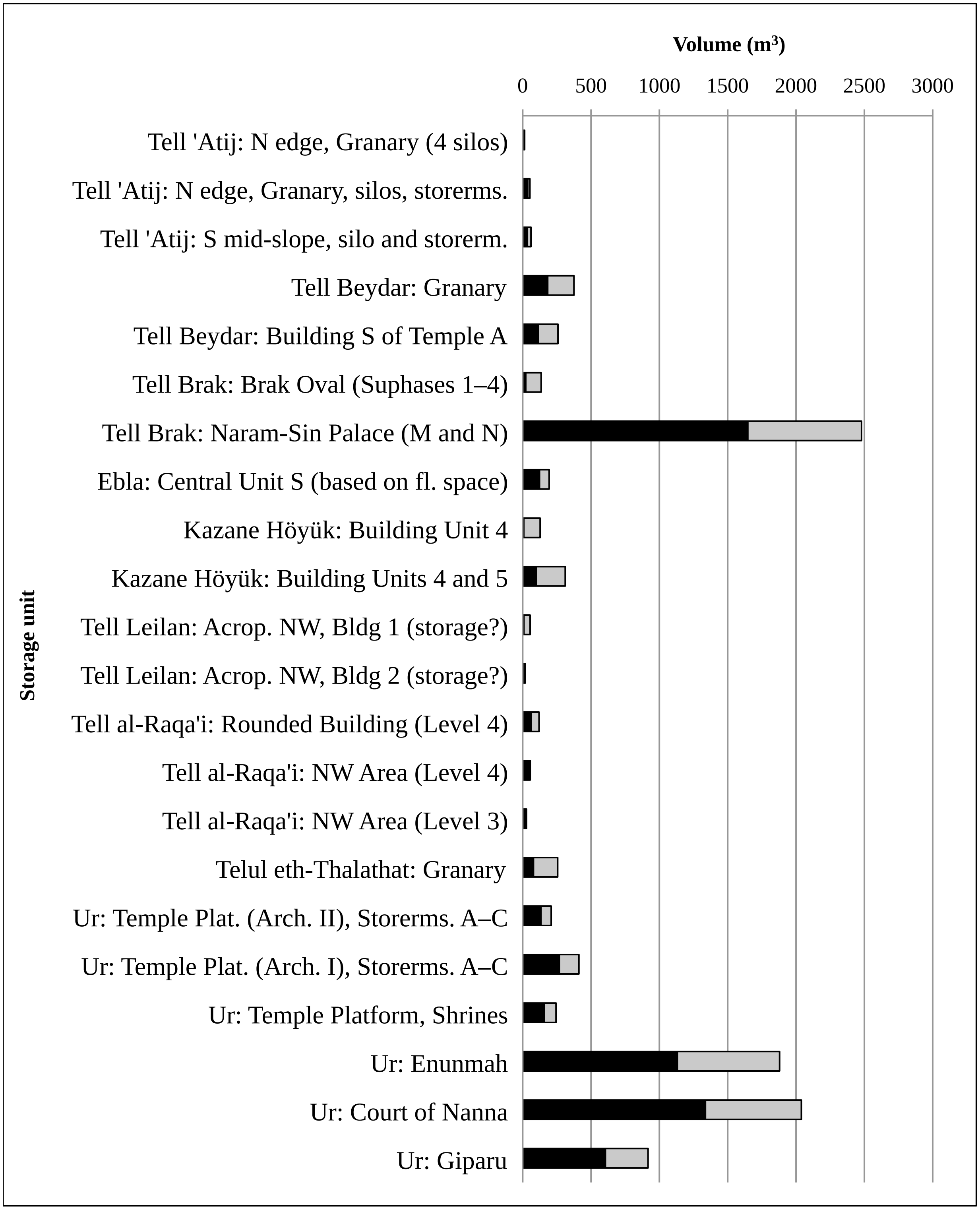


Figure 6.9: Graph showing the storage capacity (m^3) of storage complexes.

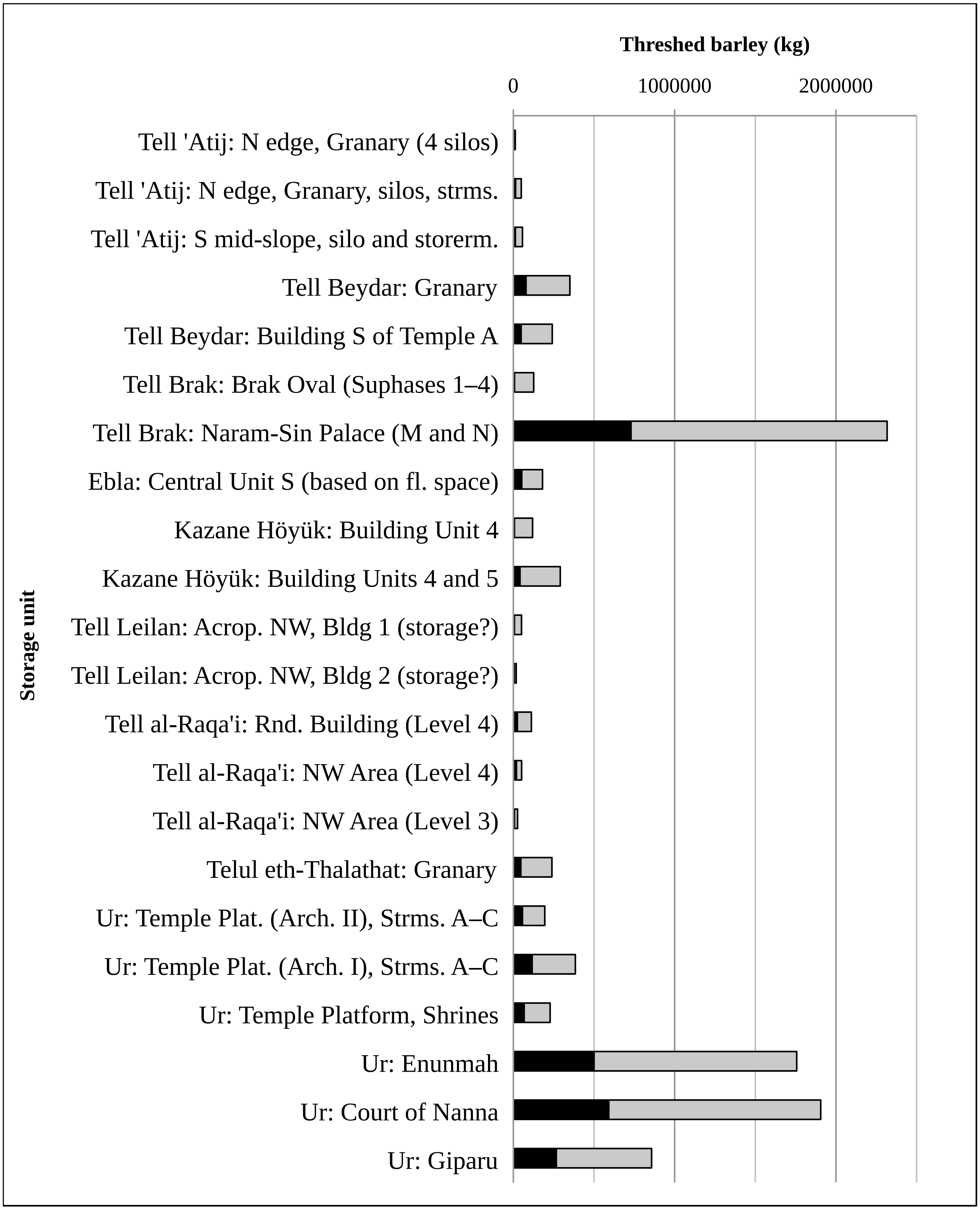


Figure 6.10: Graph showing the storage capacity (kg of threshed barley) of storage complexes.

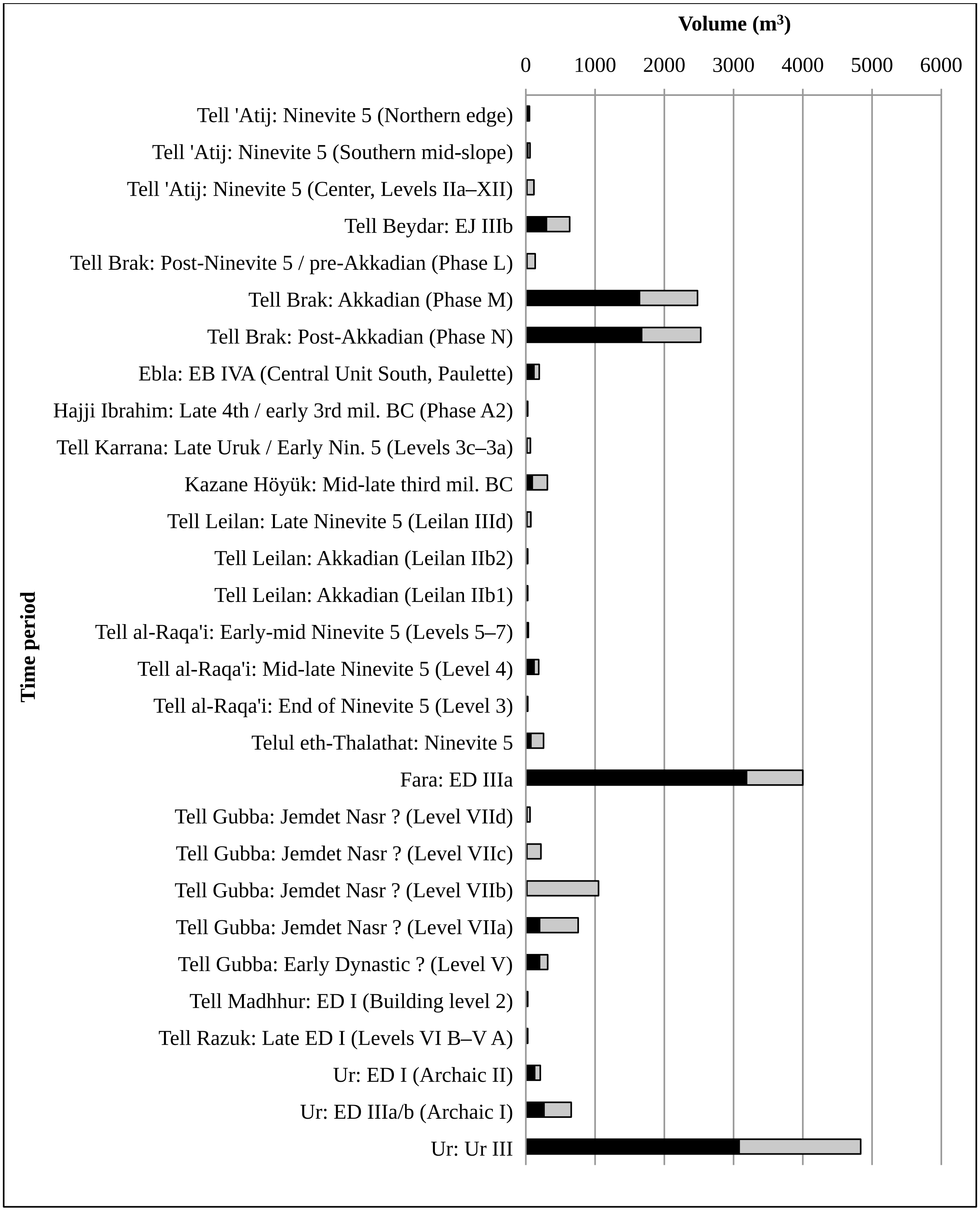


Figure 6.11: Graph showing the storage capacity (m^3) available during specific periods at each site.

Figure 6.12: Graph showing the storage capacity (kg of threshed barley) available during specific periods at each site.

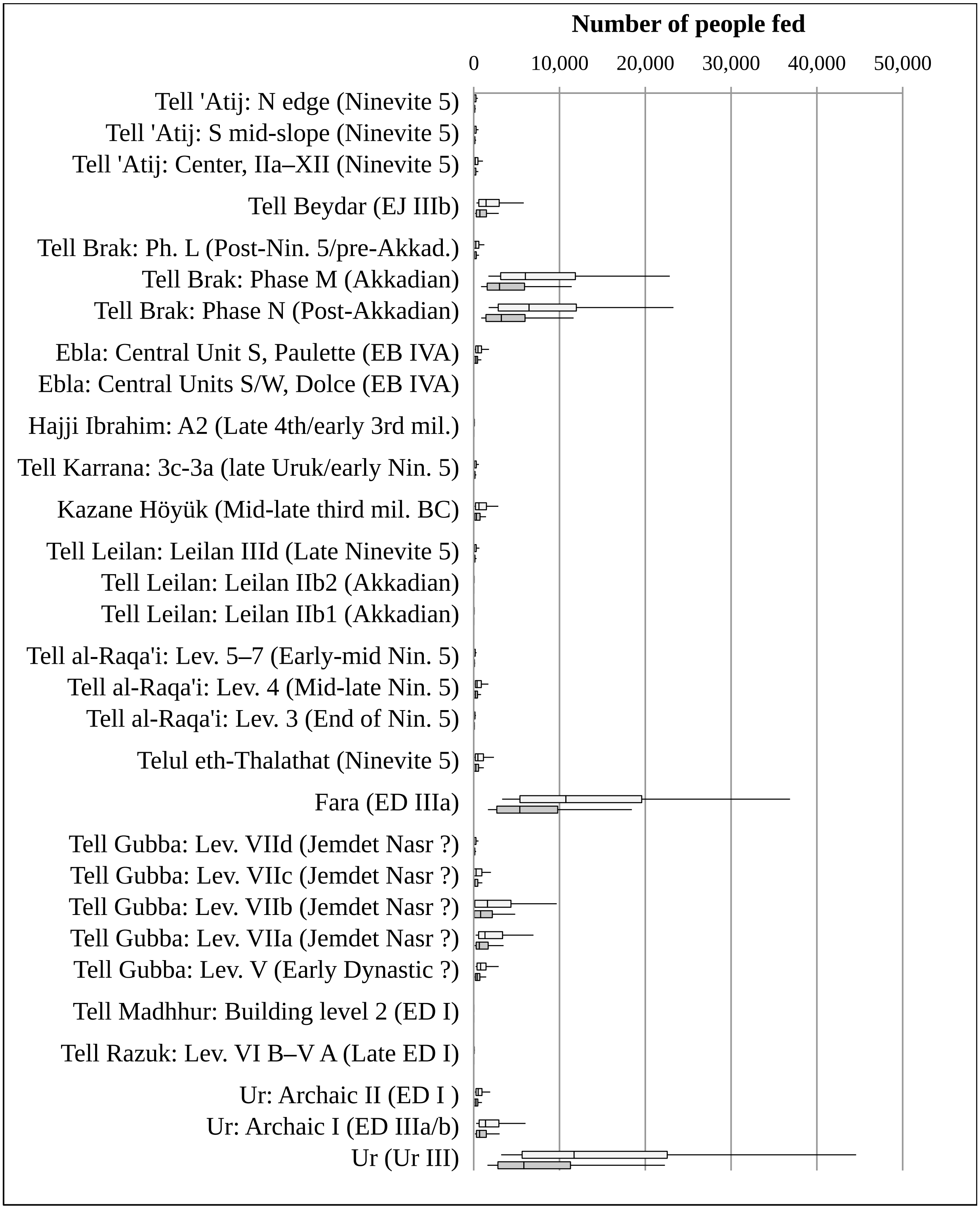


Figure 6.13a: Graph showing the number of people that could have been supported for one year (light gray bars) or two years (dark gray bars) with the grain stored at each site during specific periods. Scale = 0–50,000 people.

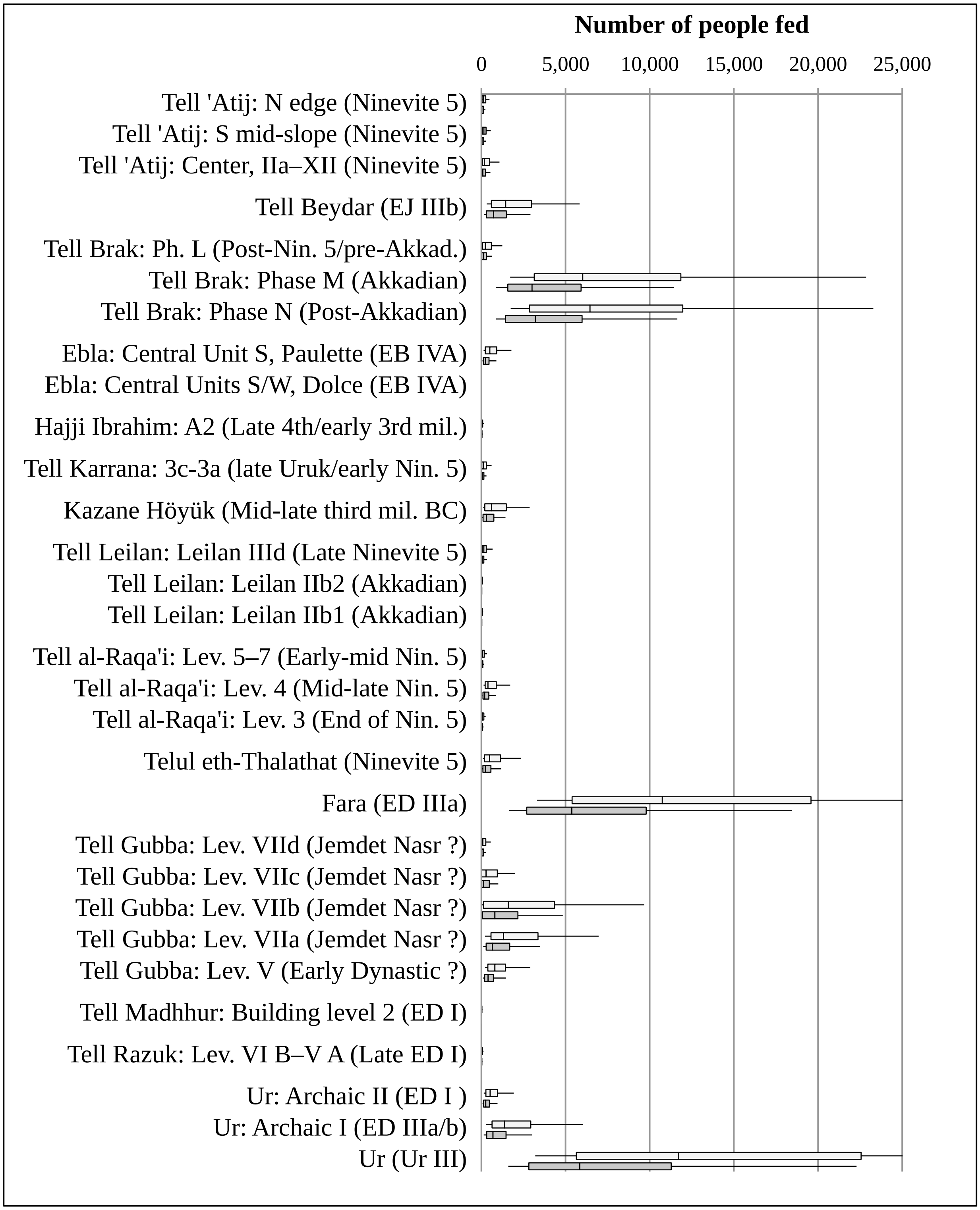


Figure 6.13b: Graph showing the number of people that could have been supported for one year (light gray bars) or two years (dark gray bars) with the grain stored at each site during specific periods. Scale = 0–25,000 people.

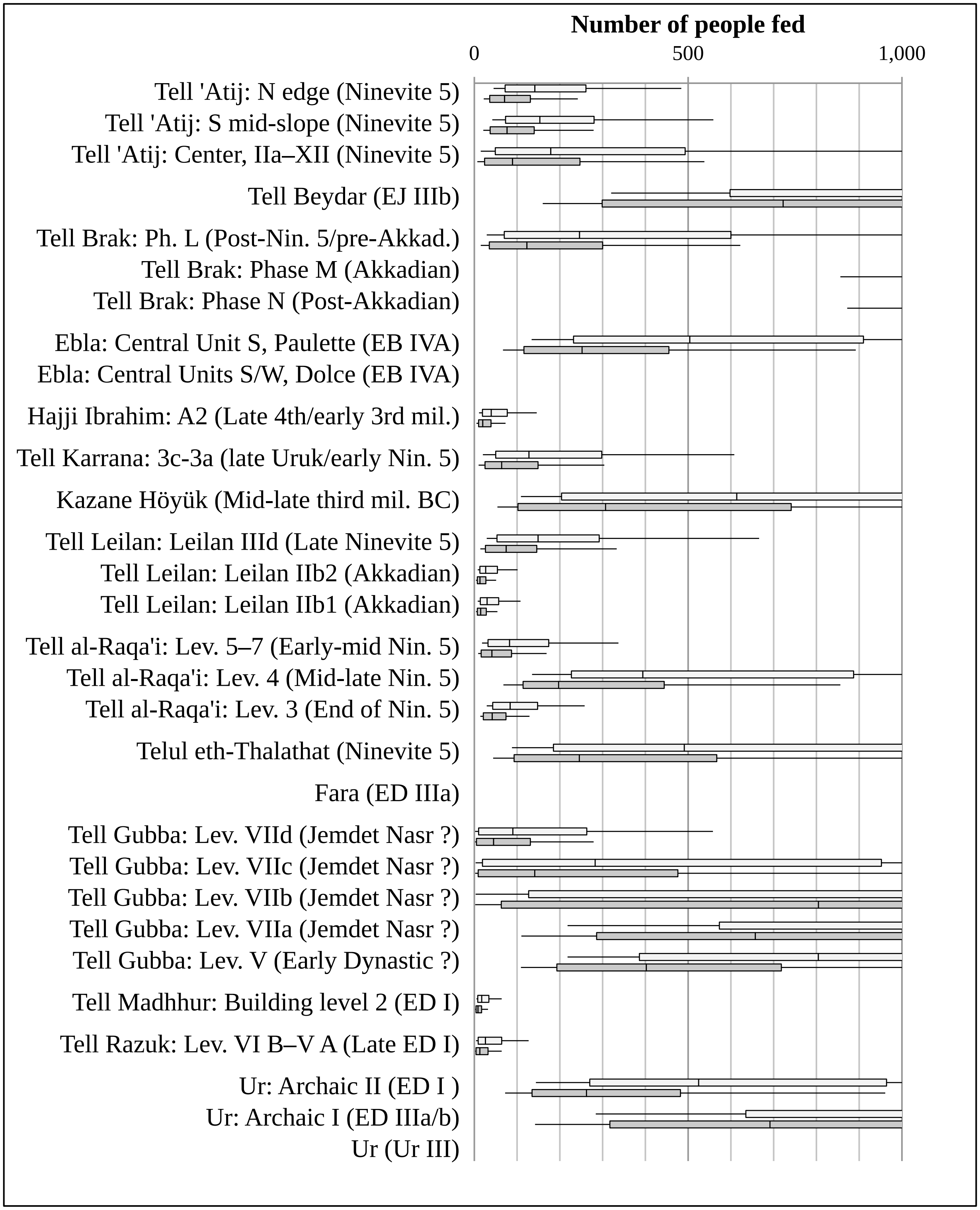


Figure 6.13c: Graph showing the number of people that could have been supported for one year (light gray bars) or two years (dark gray bars) with the grain stored at each site during specific periods. Scale = 0–1,000 people.

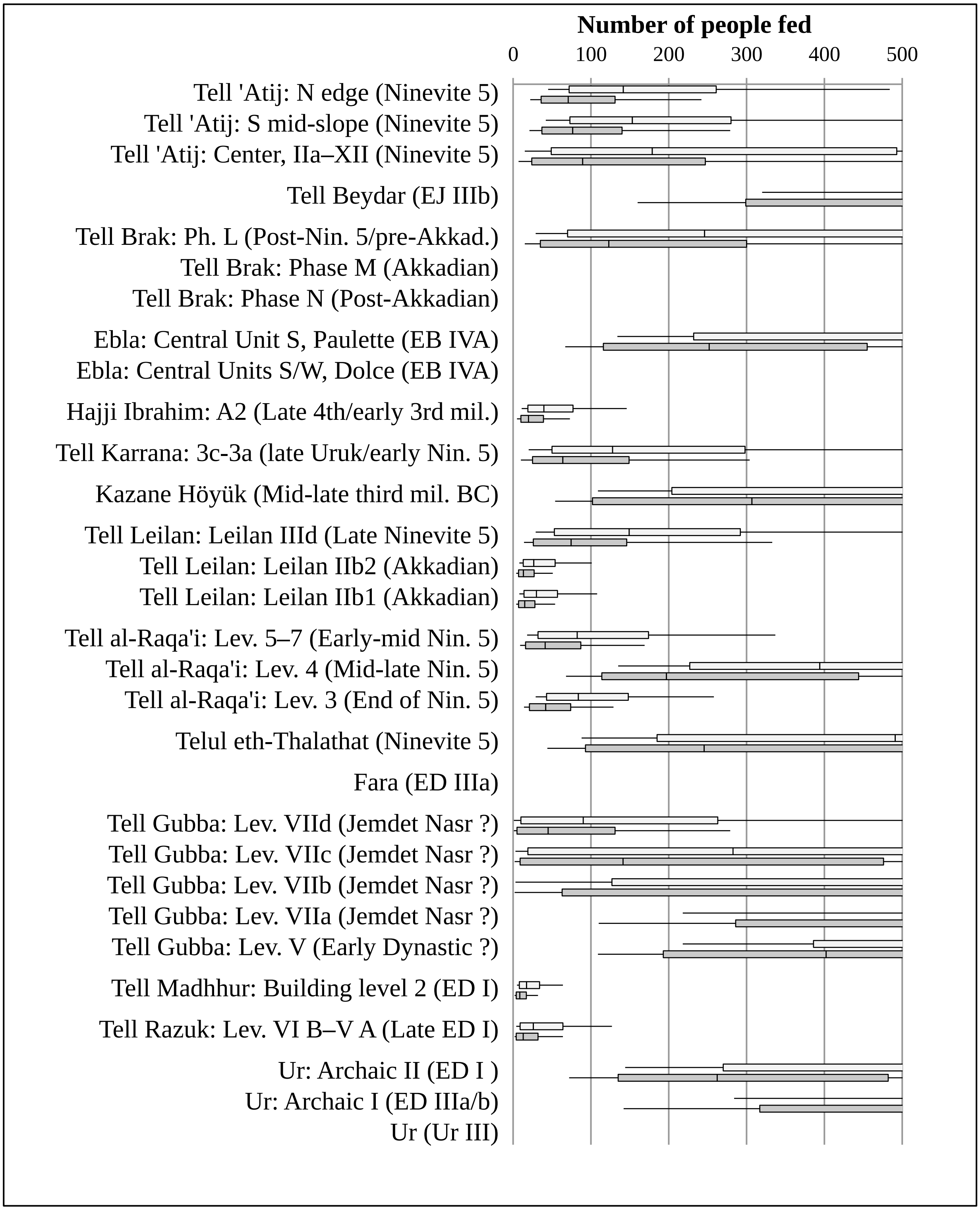


Figure 6.13d: Graph showing the number of people that could have been supported for one year (light gray bars) or two years (dark gray bars) with the grain stored at each site during specific periods. Scale = 0–500 people.

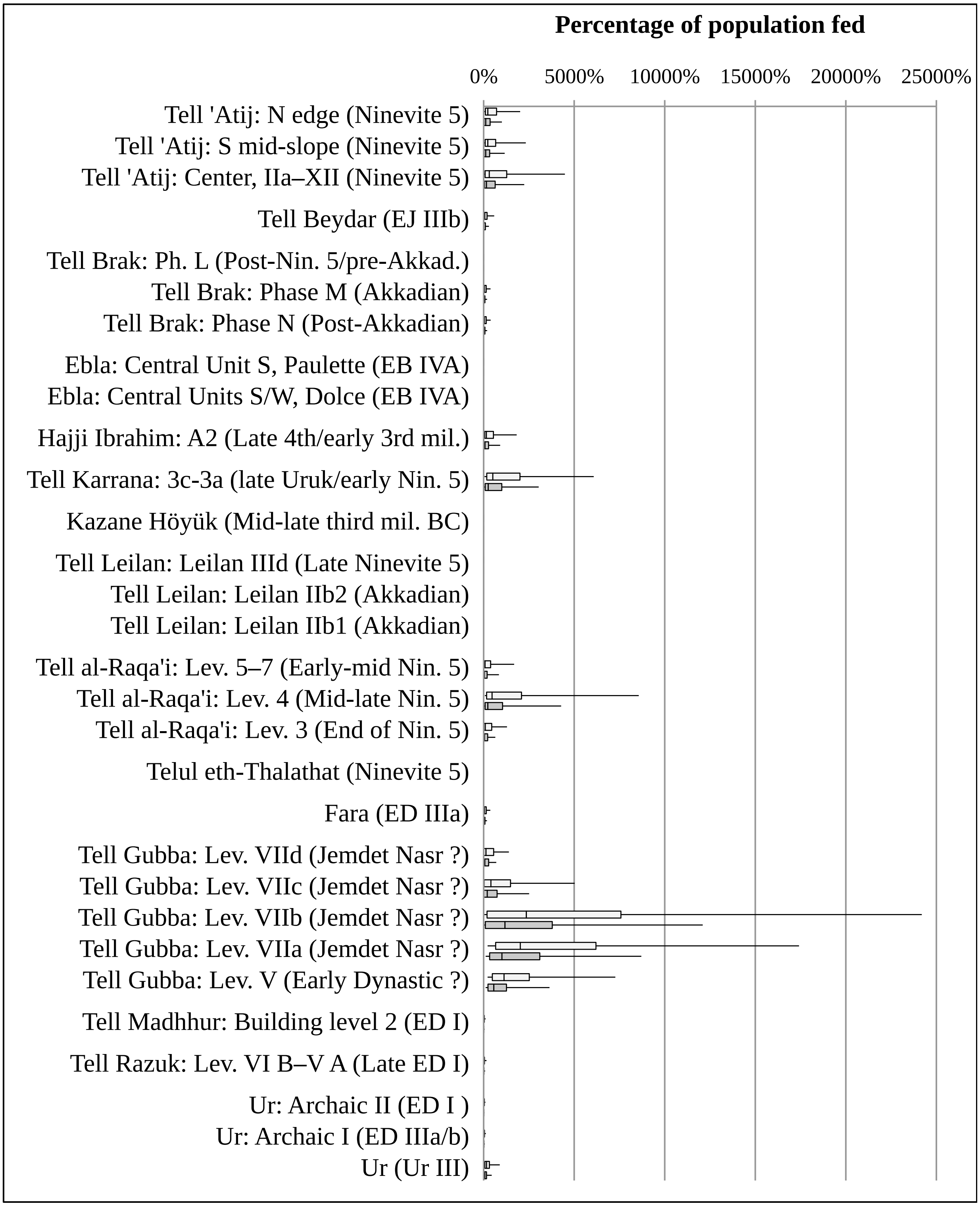


Figure 6.14a: Graph showing the percentage of the population that could have been supported for one year (light gray bars) or two years (dark gray bars) with the grain stored at each site during specific periods. Scale = 0–25,000 people.

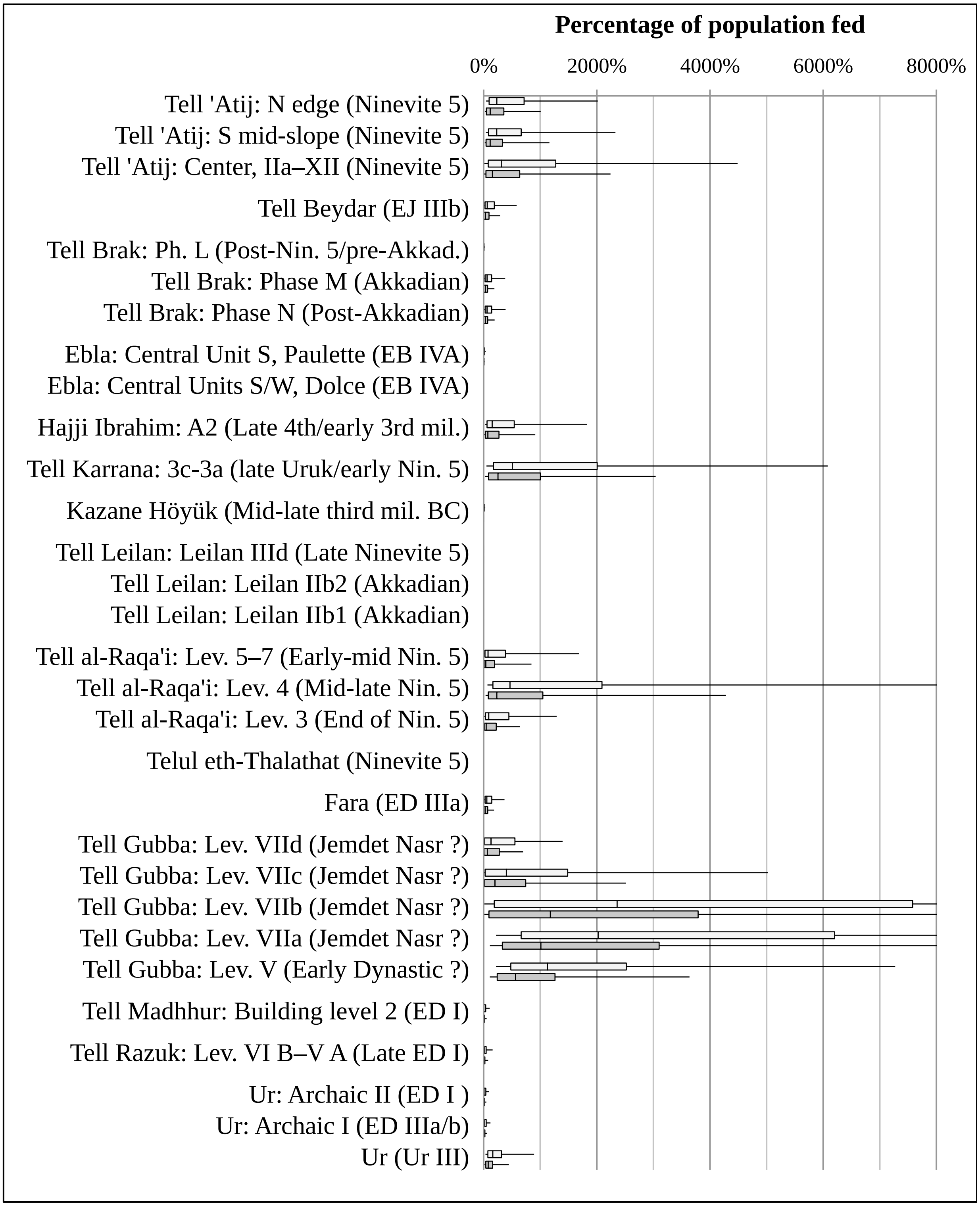


Figure 6.14b: Graph showing the percentage of the population that could have been supported for one year (light gray bars) or two years (dark gray bars) with the grain stored at each site during specific periods. Scale = 0–8,000 people.

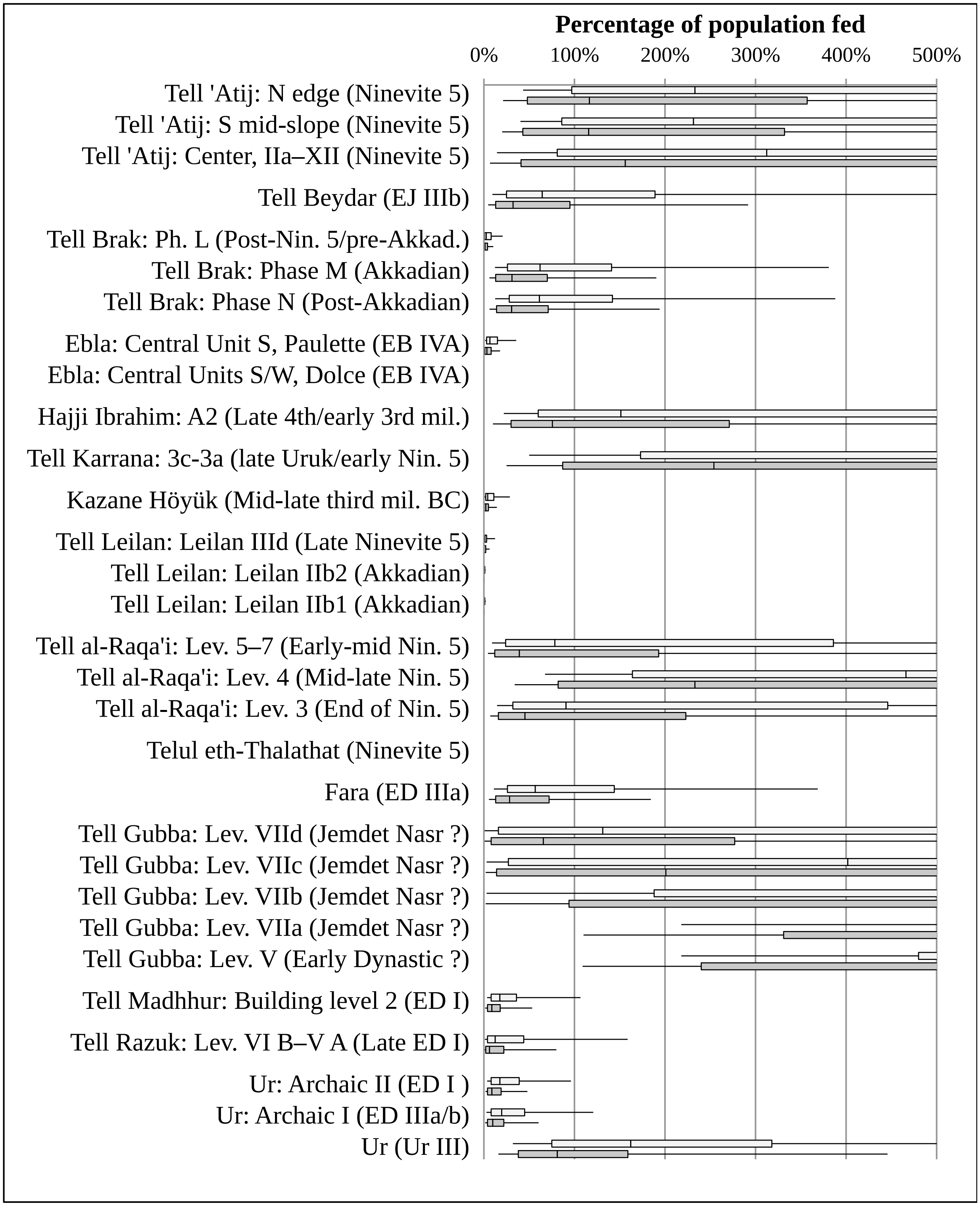


Figure 6.14c: Graph showing the percentage of the population that could have been supported for one year (light gray bars) or two years (dark gray bars) with the grain stored at each site during specific periods. Scale = 0–500 people.

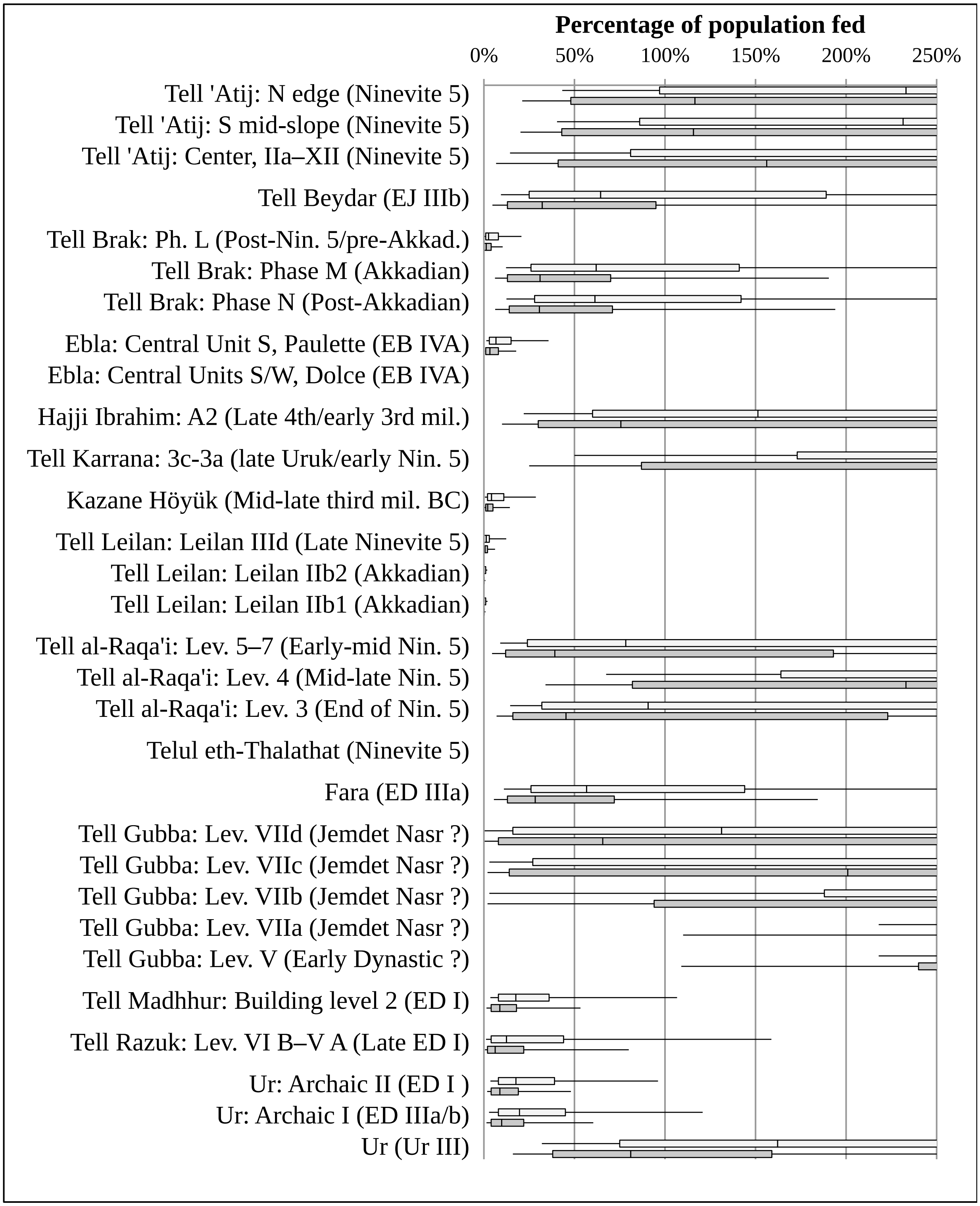


Figure 6.14d: Graph showing the percentage of the population that could have been supported for one year (light gray bars) or two years (dark gray bars) with the grain stored at each site during specific periods. Scale = 0–250 people.

APPENDIX 2

TABLES

Table 2.1 (page 1 of 3)
Storage terminology (Sumerian)

Term (Sumerian)	Equivalencies (Akkadian)	Translation (approx.)	Dictionary reference	Other references
$arah_4$, $arah_3$, $arah_x$	*arahhu, našpaku*	storehouse, granary, storeroom; storage vessel	PSD arah [STOREHOUSE]	
é-gi-na-ab-du_7	*šutummu*	storehouse		Jacobsen 1970: 321–322, Note 5
é-$guru_7$, é-gur_7		grain magazine		Salonen 1968: 276; Deimel 1931: 84
é-ì-dub		storehouse		Breckwoldt 1995/1996: 65
é-ki-lam		magazine		Deimel 1931: 105
é-kišib-ba	*bīt kunukki*	storehouse		Breckwoldt 1995/1996: 75–76; Widell 2002: 397; Van De Mieroop 1992b: 79; Sigrist 2004: 136; Heimpel 2009: 166
é-kú		storehouse		Salonen 1968: 278; Deimel 1931: 84
é-ní-ga		magazine		Charvát 2007: 253; Deimel 1931: 105–106
é-saĝ, ésaĝ	*qarītu, qirītu*	grain-store	PSD esaĝ [STORE]	
é-šutum, é-šu-tum		storehouse	PSD šutum [STOREHOUSE]	Sigrist 2004: 83, 95, 202
é-uš-gíd-da, é-ús-gíd-da	*araḫḫu, arḫu, našpaku, ašlukkatu, ašrukkatu*	storehouse		Jacobsen 1970: 321–322, Note 5, 375, Note 32; Breckwoldt 1995/1996: 75–76; Zettler 1987: 209, Note 25; Harris 1975: 32
erìm, $erim_4$, $erim_5$, $erim_6$	*išittu*	storeroom, treasury	PSD erim [STOREROOM]	
esaĝtur		granary	PSD esaĝtur [GRANARY]	
ganun, gá-nun, é-gá-nun	*ganūnu, ganīnu*	storehouse	PSD ĝanun [STOREHOUSE]	Salonen 1968:276, 278–280; Jacobsen 1970: 321–322, Note 5; Steinkeller 2007: 193; Visicato 1993: 83; Pomponio and Visicato 1994: 205; Harris 1975: 22–23; Sigrist 2004: 131, 154, 202, 208, 210; Deimel 1931: 84; Heimpel 2009: 166–167, 308, 311, 328
ganun-mah		storehouse		Visicato 1993: 83; Pomponio and Visicato 1994: 205; Postgate 1992: 232

Table 2.1 (page 2 of 3)
Storage terminology (Sumerian)

Term (Sumerian)	**Equivalencies (Akkadian)**	**Translation (approx.)**	**Dictionary reference**	**Other references**
gìr		conveyor (agent who managed assessment, packing, and shipment of grain)		Breckwoldt 1995/1996: 70–71
gur_7, $guru_7$	*karû*	grain heap, grain store; grain magazine, silo	PSD guru [STORE]	Salonen 1968: 280–282; Breckwoldt 1995/1996: 76; Steinkeller 2007: 190–193; Steinkeller 2004: 68–73; Widell 2002: 397; Grégoire 1999: 225–226; Sigrist 2004: 26–27, 35, 162–163, 168, 173–174, 176, 180, 187, 246: Heimpel 2009: 170, 308
ì-dub, ni-dub	*išpikū, našpaku*	granary; silo or storage bin	PSD idub [GRANARY]	Salonen 1968: 276, 282; Steinkeller 2007: 190–193; Steinkeller 2004: 68–73; van Driel 2000: 15; Sigrist 2004: 71–72, 80, 129, 159, 165, 182–183, 243; Deimel 1931: 84
im-du_8-a		storage pit		Salonen 1968: 276; Deimel 1931: 84
ka-$guru_7$, ka-gur_7	*kagurrû*	granary supervisor	PSD kaguruk [SUPERVISOR]	Deimel 1931: 84–85; Foster 1982: 90, 95; Steinkeller 2004: 68–72; Sigrist 2004: 26, etc.
ki-sur_{12}, ki-sur-ra, ki-su_7	*maškanu*	threshing floor	PSD kisur [LOCUS]	Steinkeller 2007: 190–193; van Driel 2000: 15; Sigrist 2004: 26–27, etc.

Table 2.1 (page 3 of 3)
Storage terminology (Sumerian)

Term (Sumerian)	Equivalencies (Akkadian)	Translation (approx.)	Dictionary reference	Other references
^{dug}kur-KU.DÙ		container; pithos (large storage vessel for storing oil and sometimes beer, wort, grain, earth, and honey)	PSD kurkudu [CONTAINER]	Sallaberger 1971: 16–17; Sallberger 1996a: 75, 102
lagaš (ŠIR.BUR.LA^{ki})	*nakamtu*	storehouse	PSD lagaš [STOREHOUSE]	
lú-še-íl		grain porter		Breckwoldt 1995/1996: 74
na-kab-tum, na-ga-ab-tum, na-káb-tum		place for fattening livestock?; administrative structure responsible for collection, storage, and distribution of a range of goods	PSD nakabtum [STOCKYARD?]	Sigrist 2004: 268; Brunke 2008
na-kam-tum	*nakkamtu*	storehouse	PSD nakamtum [STOREHOUSE]	
šutum, šutum$_2$, šu-tum, šudum		storehouse	PSD šutum [STOREHOUSE]	Salonen 1968: 282

Table 2.2 (page 1 of 2)
Storage terminology (Akkadian)

Term (Akkadian)	Equivalencies (Sumerian)	Translation (approx.)	Dictionary reference	Other references
araḫḫu, arḫu	é-uš-gíd-da	storehouse, granary	CAD 1, Part II: 220	Jacobsen 1970: 321–322, Note 5, 375, Note 32
ašaḫḫu		storehouse	CAD 1, Part II: 411	
ašlukkatu, ašrukkatu	é-uš-gíd-da		CAD 1, Part II: 450	Jacobsen 1970: 321–322, Note 5; Harris 1975: 32
bīt ašaḫḫātim	é-ús-gíd-da	storehouse		Breckwoldt 1995/1996: 75–76
bīt karê		storehouse	CAD 8: 228	
bīt kunukki	é-kišib-ba	storehouse	CAD 8: 548	
bīt qarīti		storehouse	CAD 13: 133	
ganūnu, ganīnu	ganun, gá-nun	storage room or building	CAD 5: 42–43	Salonen 1968: 278–280; Jacobsen 1970: 321–322, Note 5
ḫuršu, uršu, bīt ḫurši		larder; storehouse	CAD 6: 256	Dercksen 1996: 69–71; Dercksen 2000: 139
isru, esru	esaĝtur	small granary	CAD 7: 204	
išpikū	ì-dub	yield, produce (of a field); storage bin or jar	CAD 7: 258–259	Salonen 1968: 276, 282
kagurrû, kakurrû, kukurrû, kugurrû	ka-gur$_7$	official in charge of grain stores	CAD 8: 35	
karû	gur$_7$	pile of barley (prepared for storage)	CAD 8: 226–227	Salonen 1968: 280–282; Oppenheim 1977: 314–315, 387, Note 26
maknaku, maknakkum		sealed container or room	CAD 10, Part I: 138	Dercksen 2000: 139
maškanu		threshing floor, empty lot; small agricultural settlement	CAD 10, Part I: 369–373	
nakkamtu, nakkandu, nakkantu, nakamtu	lagaš (ŠIR.BUR.LA^{ki})	storehouse, treasury; stores, reserves	CAD 11, Part I: 182–184	Van Lerberghe 1993

Table 2.2 (page 2 of 2)
Storage terminology (Akkadian)

Term (Akkadian)	Equivalencies (Sumerian)	Translation (approx.)	Dictionary reference	Other references
našpaku	é-uš-gíd-da, ì-dub, é-ì-dub	granary, silo, storehouse (for barley, dates, oil); storage jar; stores of barley (?); cargo boat	CAD 11, Part II: 66–70	Jacobsen 1970: 321–322, Note 5; CAD 7: 259; Sallaberger 1996a: 76, 83; Oppenheim 1969: 14–15
natbāku		storage place for barley, granary	CAD 11, Part II: 118	Van Lerberghe 1993; Harris 1975: 46–48, 139–141
qarītu, qirītu	é-sag, ésag	storeroom, granary	CAD 13: 132–133	
rab ḫuršāti		storehouse keeper	CAD 6: 256	
rugbu		loft, upper room (e.g. as storeroom)	CAD 14: 403	
šipku		accumulation, heap (e.g. referring to staples)	CAD 17, Part III: 70–71	
šutummu	é-gi-na-ab-du$_7$	storehouse; treasury	CAD 17: 412–414	Jacobsen 1970: 321–322, Note 5
ūrum		roof (e.g. as a place for storage)	CAD 20: 261	

Table 4.1 (page 1 of 2)
Tell ‘Atij
Main tell, summit, northern edge, all storerooms, basic info.

Designation	Level	Location	Description	Contents
502	?	E6 (Granary)	Silo. Rectangular. Preserved to max. depth of 0.7 m (as measured on section). Probably partially vaulted (NE and SW walls vertical; NW and SE walls arched for 2/3 or their width). Floor and walls covered in gypsum plaster. Probably accessed through the unvaulted 1/3 of the roof (closed off with removable cover?).	Filled with ashy, gray soil that produced large quantities of ceramic sherds. Some semi-complete ceramic vessels found on floors of silos and adjacent rooms, perhaps used for removing stored products (e.g. grain).
503	?	E7 (Granary)	Silo. Rectangular. Preserved to max. depth of 1.3 m (as measured on section). Partially vaulted (NE and SW walls vertical; NW and SE walls arched for 2/3 or their width). Floor and walls covered in gypsum plaster. Probably accessed through the unvaulted 1/3 of the roof (closed off with removable cover?).	
504	?	E7 (Granary)	Silo. Approximately square. Preserved to max. depth of 2.0 m (as measured on section). Partially vaulted (NE and SW walls vertical; NW and SE walls arched for 2/3 or their width). Floor and walls covered in gypsum plaster. Probably accessed through the unvaulted 1/3 of the roof (closed off with removable cover?).	
505	?	E6-7 (Granary)	Silo. Rectangular. Preserved to max. depth of 1.0 m (as measured on section). Probably partially vaulted (NE and SW walls vertical; NW and SE walls arched for 2/3 or their width). Floor and walls covered in gypsum plaster. Probably accessed through the unvaulted 1/3 of the roof (closed off with removable cover?).	
507	?	E8 (W of D8A15)	Rectangular room. Originally vaulted. Interior faces of walls plastered. Accessed via doorway in southern wall. Used for storage?	

Table 4.1 (page 2 of 2)

Tell ‘Atij
Main tell, summit, northern edge, all storerooms, basic info.

Designation	Level	Location	Description	Contents
522	?	D9-E9 (S of D8A15)	Silo. Approximately square. Accessed from roof.	
523-524-525	?	D9 (S of D8A15)	Silo. Approximately rectangular. Divided into three rooms by two small, arched partition walls that created a passage, approx. 2 m high, along wall 422. Partition walls were supported by a revetment and buttresses on the northeastern side of wall 421. Opening in wall 422 to the east may have allowed for air circulation. Accessed from the roof.	
526	?	D9 (S of D8A15)	Rectangular room. Accessed via doorway in southern wall. Openings in wall 423 to the west and wall 422 to the east may have allowed for air circulation. Used for storage?	
533	?	E8 (W of D8A15)	Rectangular room. Vaulted. Accessed via doorway in southern wall. Used for storage?	
548	?	D8-9, E8-9 (W of D8A15)	Rectangular room. Walls covered in *djuss*. Floor plastered. Accessed via doorway in southern wall. Used for storage?	

SOURCES: Fortin 1988, 1989, 1990a

Table 4.2
Tell ‘Atij
Main tell, southern mid-slope, all storerooms, basic info.

Designation	Level	Location	Description	Contents
516	VI [b]	E16-17	Room with arched buttresses along SE wall (306). Mudbrick floor. Floor and walls covered in gypsum plaster. Opening in NE wall (410) led to corridor (515) which passed through an arch in wall 306 and into room 538. Used for storage?	
517-517' (538-536)[a]	VI [c]	D16-17	Large, rectangular silo (?). Internal faces of walls covered in plaster. Three large jars arranged in a line along NE wall (409). Two buttresses against internal face of NW wall (307). Mass of bricks (308) along SW wall (407) might be remains of a stairway. Internal partition wall (408) added after structure had been abandoned for some time, dividing the silo into two separate rooms (517 and 517').	Filled with gray, ashy deposit, up to 2.5 m thick, very rich in ceramics.

SOURCES: Fortin 1988, 1990a, 1994

[a] Fortin 1988 (162-164) refers to this silo as 517 and 517' (to indicate the later division of the silo into two separate rooms), while Fortin 1990a (232-236) appears to refer to the same silo as 538 and 536. The reason for this change in designation is unclear.

[b] Fortin (1994: 368) indicates a stratigraphic connection between room 516 and the Level VI remains uncovered immediately to the north.

[c] Fortin (1994: 368) indicates a stratigraphic connection between warehouse (entrepôt) 538 and the Level VI remains uncovered immediately to the north. I have assumed that this stratigraphic attribution applies to the phase during which rooms 538 and 536 (i.e. 517 and 517') were joined together as a single storeroom or silo (i.e. prior to the insertion of partition wall 408), but this assumption may be incorrect.

Table 4.3 (page 1 of 4)
Tell ʻAtij
Main tell, summit, center, all storerooms, basic info.

Designation	Level	Location	Description	Contents
539	IIa	D15-16, E15-16	Room. Floor space reduced by addition of walls 305 and 425 in Level IIa. One doorway? Plastered floor from Level IIb reused. Used for storage?	
539	IIb	D15-16, E15-16	Room. One (perhaps two) doorways. Floor plastered. Used for storage?	
552	II	D14-15, E14-15	Room. No doorway identified, but must have existed in western wall (157), which was only preserved to foundation level. Floor underwent several transformations: 1) plastered, 2) projection added at base of walls, 3) layer of mudbricks added, 4) plastered. Used for storage?	
553	III	D14-15, E14-15	Room. Massive walls (70-90 cm wide). One doorway. Floor covered in gypsum plaster. Function uncertain.	
554	IV	D13-E13	Silo. Mudbrick floor covered in *djuss* plaster. No doorway. Probably accessed via the roof. Used for storage?	
555	IV	E13-14	Room. Successor to 555 (Level V), which was cleaned and reused. Single doorway (Level V) blocked by construction of room 554 to the east. Western part of room unexcavated. Projection and plastering suggest storage of perishable products. Projection and plastering suggest storage of perishable products.	
555	V	E13-14	Room. Successor to 555b (Level VI). One doorway. Internal wall faces and floor covered in gypsum plaster. Projection (10-15 cm high, covered in plaster) at base of walls would probably have facilitated cleaning of room. Western part of room unexcavated. Projection and plastering suggest storage of perishable products.	Floor cleaned before being reused in succeeding level (IV).

Table 4.3 (page 2 of 4)
Tell ‘Atij
Main tell, summit, center, all storerooms, basic info.

Designation	Level	Location	Description	Contents
555b	VI	E13-14, F13-14	Room. Two doorways. Internal wall faces, floor, and benches (similar to "projections" in other rooms?) at base of walls covered in *djuss* plaster. Projection and plastering suggest storage of perishable products.	
556	IV	D14-15, E14-15	Silo? No doorway. Western part of room unexcavated (eroded away). Floor covered in plaster. Used for storage?	
557	IV	D14	Room with no doorway. Successor to (E half of) room 559b (Level V). Internal wall faces covered in *djuss* plaster. A refuse pit?	Filled with thick, gray, ashy deposit, (perhaps deriving from ovens in adjacent room 560).
558	V	D14-16, E14-16	Room. Successor to 558b (Level VI). One doorway with stone door socket and threshold stone. Internal wall faces and floor plastered. Projection at base of walls. Projection and plastering suggest storage of perishable products.	
558b	VI	D14-16, E14-16	Room. One doorway. Floor sloped down significantly (20 cm) from east to west. Floor and projection at base of walls covered in plaster (according to published plan). Projection and plastering suggest storage of perishable products.	

Table 4.3 (page 3 of 4)
Tell ‘Atij
Main tell, summit, center, all storerooms, basic info.

Designation	Level	Location	Description	Contents
559a	VI	D13-14	Room. Arched buttresses on E and W sides indicate that room was vaulted. Two doorways. Internal wall faces, buttresses, and floor covered in gypsum plaster. Circular cooking oven against eastern wall (perhaps for roasting grain or to heat up the room in order to keep stored goods dry). Plaster and vaulting suggest storage function.	
559b	V	D13-14	Room. Successor to 559a (Level VI). Arched buttresses on E and W sides indicate that room was vaulted. Two doorways. Internal wall faces and buttresses covered in gypsum plaster. Beaten earth floor. Plaster and vaulting suggest storage of perishable products.	
561a	V	D13	Room. Successor to 561b (Level VI). Probably several floors. One narrow doorway. Used for storage?	
561b	VI	D13	Room. Beaten earth floor. Six complete ceramic vessels sitting on floor. Earthen bench in SE corner. Two doorways. Probably for storage.	
571	IX	D14-15, F14-15	Room. One doorway. Floor covered in gypsum plaster. Benches (similar to "projections" in other rooms?) at base of three walls. Excavators suggest that the rooms in Level IX may have served a different function than those in Levels I-VI, but 571 looks very similar to other rooms that were assigned a storage function.	
573	XII	F14-15, G14-15	Silo. No doorway. Interior crosswalls (i.e. "grill" plan) suggest storage function.	
599	XII	F13-14, G13-14	Silo. No doorway. Interior crosswalls (i.e. "grill" plan) with clear traces of reed floor suggest storage function.	

Table 4.3 (page 4 of 4)
Tell ‘Atij
Main tell, summit, center, all storerooms, basic info.

Designation	Level	Location	Description	Contents
600	IV	C13, D13	Silo. Entirely made of mudbrick. Very well preserved. Internal wall faces covered in gypsum plaster. Arched buttresses. Beginnings of corbelled ceiling partly preserved. Carbonized barley grains indicate grain storage function.	Carbonized barley grains.

SOURCES: Fortin 1990b, 1994, 1995

Table 4.4 (page 1 of 3)
Tell ‘Atij
Main tell, summit, northern edge, estimated storage capacity

Designation	Floor space	Depth[g]	Volume	Storage capacity	
				Volume[h]	Barley, threshed[a]
502 (silo)[b]					
(Vaulted zone)	*(0.7 m²)*	*(2.2 m)*	*(1.1 m³)*	*(1.1 m³)*	*(489 - 1,028 kg)*
(Unvaulted zone)	*(0.4 m²)*	*(2.2 m)*	*(0.9 m³)*	*(0.9 m³)*	*(400 - 841 kg)*
Total			2.0 m³	2.0 m³	889 - 1,869 kg
503 (silo)[c]					
(Vaulted zone)	*(1.3 m²)*	*(2.2 m)*	*(2.0 m³)*	*(2.0 m³)*	*(889 - 1,869 kg)*
(Unvaulted zone)	*(0.6 m²)*	*(2.2 m)*	*(1.3 m³)*	*(1.3 m³)*	*(578 - 1,215 kg)*
Total			3.3 m³	3.3 m³	1,467 - 3,084 kg
504 (silo)[d]					
(Vaulted zone)	*(1.6 m²)*	*(2.2 m)*	*(2.5 m³)*	*(2.5 m³)*	*(1,111 - 2,337 kg)*
(Unvaulted zone)	*(0.5 m²)*	*(2.2 m)*	*(1.1 m³)*	*(1.1 m³)*	*(489 - 1,028 kg)*
Total			3.6 m³	3.6 m³	1,600 - 3,365 kg
505 (silo)[e]	1.4 m²	2.2 m	3.1 m³	3.1 m³	1,378 - 2,897 kg
507	1.3 m²	2.0 - 3.0 m	2.6 - 3.9 m³	2.0 - 2.9 m³ [s]	889 - 2,710 kg
522	1.3 m²	1.3 m	1.7 m³	1.7 m³	755 - 1,589 kg
523-524-525 (silo)[f]	4.9 m²	2.2 m	10.0 m³	10.0 m³	4,444 - 9,346 kg
526	2.4 m²	2.0 - 3.0 m	4.8 - 7.2 m³	3.6 - 5.4 m³ [s]	1,600 - 5,047 kg
533	1.3 m²	2.0 - 3.0 m	2.6 - 3.9 m³	2.0 - 2.9 m³ [s]	889 - 2,710 kg
548	7.8 m²	2.0 - 3.0 m	15.6 - 23.4 m³	11.7 - 17.6 m³ [s]	5,199 - 16,449 kg
Total (N Granary) *502, 503, 504, 505*				12.0 m³	5,333 - 11,215 kg
Total (W of Platform) *507, 533, 548*				15.7 - 23.4 m³	6,977 - 21,870 kg
Total (S of Platform) *522, 523-524-525, 526*				15.3 - 17.1 m³	6,799 - 15,982 kg
Grand Total				43.0 - 52.5 m³	19,109 - 49,067 kg

SOURCES: Fortin 1988, 1989, 1990a

Table 4.4 (page 2 of 3)
Tell ‘Atij
Main tell, summit, northern edge, estimated storage capacity

[a] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[b] Silo 502 can probably (on analogy with 503 and 504) be divided into two components: a vaulted zone to the east and an unvaulted zone to the west. This silo was not preserved to its full height. I have, therefore, used the better preserved silo 504 as a guide for calculating its original capacity. In particular, I have assumed that the original height of both the vaulted zone and the unvaulted zone was 2.2 m, and I have assumed that the volume beneath the vault would have equaled approximately 70% of the volume of a hypothetical room with vertical walls and dimensions defined by the floor space of the vaulted zone and the height of the vault. See Note 4 for further details.

[c] Silo 503 can be divided into two components: a vaulted zone to the east and an unvaulted zone to the west. This silo was not preserved to its full height. I have, therefore, used the better preserved silo 504 as a guide for calculating its original capacity. In particular, I have assumed that the original height of both the vaulted zone and the unvaulted zone was 2.2 m, and I have assumed that the volume beneath the vault would have equaled approximately 70% of the volume of a hypothetical room with vertical walls and dimensions defined by the floor space of the vaulted zone and the height of the vault. See Note 4 for further details.

[d] Among the four silos (502, 503, 504, 505) excavated in 1986, silo 504 was preserved to the greatest depth and has, therefore, been used here as a guide for calculating the capacities of the other three silos. 504 can be divided into two components: a vaulted zone to the east and an unvaulted zone to the west. To calculate the maximum storage capacity of the vaulted zone I first used the section drawing published in Fortin 1988 (Fig. 19, C-C') to estimate the original height of the arched vault (2.2 m) and the two-dimensional area (2.3 m^2) encompassed by the arch (i.e. the empty space beneath the arch). I then calculated the area of a hypothetical rectangle with dimensions defined by the maximum width (1.5 m) and maximum height of the arch (2.2 m) and determined that the area beneath the arch (2.3 m^2) occupied approximately 70% of the area of this hypothetical rectangle (3.3 m^2). Assuming that the three-dimensional volume beneath the vault would also equal approximately 70% of the volume of a hypothetical room with vertical walls and dimensions defined by the floor space of the room and the height of the vault, I then measured the total floor space of the vaulted zone (1.3 m^2), multiplied this by the height of the vault (2.2 m), and multipled the result by 0.7 (70%) to estimate the total volume (2.0 m^3) of storage space beneath the vault. To calculate the maximum storage capacity of the unvaulted zone (i.e. the zone with vertical walls), I measured the floor space of the unvaulted zone (0.5 m^2) and multiplied this by the height of the walls (assumed to be equal to the height of the adjacent vault, i.e. 2.2 m).

Table 4.4 (page 3 of 3)
Tell ‘Atij
Main tell, summit, northern edge, estimated storage capacity

[e] Like silos 503 and 504, silo 505 was probably partially vaulted, but the published plans and sections do not provide sufficient information for me to estimate the original extent of the vaulted zone. I have, therefore, simply estimated the original length (1.2 m) and width (1.2 m) of the silo (also unclear in the published plans and sections), multiplied these by one another, and multiplied the result by 2.2 m (on analogy with the estimated original height of silo 504).

[f] I have considered rooms 523, 524, and 525 to be part of a single silo that was divided into three rooms by two arched partition walls (318 and 319). To calculate the volume of the silo, I measured the total floor space (4.9 m^2) and multiplied this by the estimated original height of the walls (2.2 m, i.e. approximately one brick higher than the estimated top of the arch of wall 318) to reach a total volume of 10.8 m^3. I then calculated the volume of partition walls 318 (1.2 m^2 × 0.3 m = 0.4 m^3) and 319 (1.3 m^2 × 0.3 m = 0.4 m^3) by multiplying their cross-sectional area and their width and subtracted these volumes from the total volume (10.8 m^3 - 0.8 m^3) to reach a storage volume of 10.0 m^3.

[g] For rooms 507, 526, 533, and 548, there is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored (whether in bulk, in sacks, or in other containers) to a depth of 2.0–3.0 meters.

[h] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

Table 4.5
Tell ‘Atij
Main tell, southern mid-slope, estimated storage capacity

Designation	Floor space	Depth[a]	Volume	Storage capacity	
				Volume[b]	Barley, threshed[c]
516	9.0 m^2	2.0 - 3.0 m	18.0 - 27.0 m^3	13.5 - 20.3 m^3 [s]	5,999 - 18,972 kg
517-517' (538-536)	17.9 m^2	2.0 - 3.0 m	35.8 - 53.7 m^3	26.9 - 40.3 m^3 [s]	11,954 - 37,664 kg
Total			53.8 - 80.7 m^3	40.4 - 60.6 m^3	17,954 - 56,637 kg

SOURCES: Fortin 1988, 1990a

[a] For both rooms, there is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored (whether in bulk, in sacks, or in other containers) to a depth of 2.0–3.0 meters.

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

Table 4.6 (page 1 of 2)
Tell ‘Atij
Main tell, summit, center, estimated storage capacity

Designation	Level	Floor space	Depth[d]	Volume	Storage capacity Volume[c]	Barley, threshed[a]
539a	IIa	9.5 m^2	2.0 - 3.0 m	19.0 - 28.5 m^3	14.3 - 21.4 m^3 [s]	6,355 - 20,000 kg
539b	IIb	15.3 m^2	2.0 - 3.0 m	30.6 - 45.9 m^3	23.0 - 34.4 m^3 [s]	10,221 - 32,150 kg
552	II	9.4 m^2	2.0 - 3.0 m	18.8 - 28.2 m^3	14.1 - 21.2 m^3 [s]	6,266 - 19,814 kg
553	III	9.5 m^2	2.0 - 3.0 m	19.0 - 28.5 m^3	14.3 - 21.4 m^3 [s]	6,355 - 20,000 kg
554	IV	3.8 m^2	2.0 - 3.0 m	7.6 - 11.4 m^3	7.6 - 11.4 m^3	3,377 - 10,654 kg
555	IV	7.0 m^2	2.0 - 3.0 m	14.0 - 21.0 m^3	10.5 - 15.8 m^3 [s]	4,666 - 14,767 kg
555	V	7.0 m^2	2.0 - 3.0 m	14.0 - 21.0 m^3	10.5 - 15.8 m^3 [s]	4,666 - 14,767 kg
555b	VI	8.4 m^2	2.0 - 3.0 m	16.8 - 25.2 m^3	12.6 - 18.9 m^3 [s]	5,599 - 17,664 kg
556	IV	5.8 m^2	2.0 - 3.0 m	11.6 - 17.4 m^3	11.6 - 17.4 m^3	5,155 - 16,262 kg
557	IV	3.0 m^2	2.0 - 3.0 m	6.0 - 9.0 m^3	4.5 - 6.8 m^3 [s]	2,000 - 6,355 kg
558	V	25.4 m^2	2.0 - 3.0 m	50.8 - 76.2 m^3	38.1 - 57.2 m^3 [s]	16,932 - 53,459 kg
558b	VI	25.1 m^2	2.0 - 3.0 m	50.2 - 75.3 m^3	37.7 - 56.5 m^3 [s]	16,754 - 52,805 kg
559a	VI	8.7 m^2	2.0 - 3.0 m	17.4 - 26.1 m^3	13.1 - 19.6 m^3 [s]	5,822 - 18,318 kg
559b	V	8.6 m^2	2.0 - 3.0 m	17.2 - 25.8 m^3	12.9 - 19.4 m^3 [s]	5,733 - 18,131 kg
561a	V	7.6 m^2	2.0 - 3.0 m	15.2 - 22.8 m^3	11.4 - 17.1 m^3 [s]	5,066 - 15,982 kg
561b	VI	6.9 m^2	2.0 - 3.0 m	13.8 - 20.7 m^3	10.4 - 15.5 m^3 [s]	4,622 - 14,486 kg
571	IX	10.5 m^2	2.0 - 3.0 m	21.0 - 31.5 m^3	15.8 - 23.6 m^3 [s]	7,022 - 22,057 kg
573	XII	11.5 m^2	2.0 - 3.0 m	23.0 - 34.5 m^3	23.0 - 34.5 m^3	10,221 - 32,244 kg
599	XII	6.0 m^2	2.0 - 3.0 m	12.0 - 18.0 m^3	12.0 - 18.0 m^3	5,333 - 16,823 kg
600[b]	IV	2.8 m^2	1.6 m	4.5 m^3	4.5 m^3	2,000 - 4,206 kg
Total	IIa				28.4 - 42.6 m^3	12,621 - 39,814 kg
Total	IIb				37.1 - 55.6 m^3	16,487 - 51,964 kg
Total	III				14.3 - 21.4 m^3	6,355 - 20,000 kg
Total	IV				38.7 - 55.9 m^3	17,198 - 52,244 kg
Total	V				72.9 - 109.5 m^3	32,397 - 102,339 kg
Total	VI				78.0 - 116.8 m^3	34,663 - 109,161 kg
Total	IX				15.8 - 23.6 m^3	7,022 - 22,057 kg
Total	XII				35.0 - 52.5 m^3	15,554 - 49,067 kg

SOURCES: Fortin 1990b, 1994, 1995

[a] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

Table 4.6 (page 2 of 2)
Tell ‘Atij
Main tell, summit, center, estimated storage capacity

[b] The scale provided on the published plan (Fortin 1995: Fig. 12) appears to be incorrect. Instead, I have used the elevations provided on the adjacent section drawings to calculate the scale, and this appears to result in correct measurements (e.g. excavation unit C13 measures 5 × 5 m). Because silo 600 includes a confusing collection of buttresses and evidence for vaulting, I have provided only a very approximate volume calculation (floor space × depth, i.e. 2.8 m^2 × 1.6 m = 4.5 m^3) which almost certainly overestimates the volume of the silo. At the same time, however, my measurement of floor space (2.8 m^2) based on the published plan is significantly smaller than the floor space (6.8 m^2) that is implied by the room dimensions that appear in the text of the publication (3.60 × 1.90 m, Fortin 1995: 37). Perhaps the silo continued further south beyond the boundaries of excavation unit C13, and this continuation was not included on the published plan. If this is the case, then my volume estimate may actually be too low.

[c] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[d] For all of the rooms except 600, there is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored (whether in bulk, in sacks, or in other containers) to a depth of 2.0–3.0 meters.

Table 4.7 (page 1 of 2)
Tell ‘Atij
Number of people that could be fed with stored grain

Designation	**Number of people fed**					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Summit, N edge						
N granary	17 - 55	8 - 28	22 - 111	11 - 55	16 - 33	8 - 16
	(12 - 47)	*(6 - 24)*	*(17 - 94)*	*(8 - 47)*	*(12 - 28)*	*(6 - 14)*
W of platform	22 - 108	11 - 54	29 - 216	14 - 108	22 - 64	11 - 32
	(16 - 92)	*(8 - 46)*	*(22 - 183)*	*(11 - 92)*	*(16 - 54)*	*(8 - 27)*
S of platform	21 - 79	11 - 39	28 - 158	14 - 79	21 - 47	10 - 23
	(16 - 67)	*(8 - 33)*	*(21 - 134)*	*(11 - 67)*	*(16 - 40)*	*(8 - 20)*
Total	*59 - 242*	*30 - 121*	*79 - 484*	*40 - 242*	*59 - 144*	*29 - 72*
	(45 - 206)	*(22 - 103)*	*(59 - 411)*	*(30 - 206)*	*(44 - 122)*	*(22 - 61)*
Southern slope						
Total (Level VI)	56 - 279	28 - 140	74 - 559	37 - 279	55 - 166	28 - 83
	(42 - 237)	*(21 - 119)*	*(56 - 475)*	*(28 - 237)*	*(42 - 141)*	*(21 - 71)*
Summit, center						
Total (Level IIa)	39 - 196	20 - 98	52 - 393	26 - 196	39 - 117	19 - 58
	(29 - 167)	*(15 - 83)*	*(39 - 334)*	*(20 - 167)*	*(29 - 99)*	*(15 - 50)*
Total (Level IIb)	51 - 256	26 - 128	68 - 513	34 - 256	51 - 152	25 - 76
	(38 - 218)	*(19 - 109)*	*(51 - 436)*	*(26 - 218)*	*(38 - 129)*	*(19 - 65)*
Total (Level III)	20 - 99	10 - 49	26 - 197	13 - 99	20 - 59	10 - 29
	(15 - 84)	*(7 - 42)*	*(20 - 168)*	*(10 - 84)*	*(15 - 50)*	*(7 - 25)*
Total (Level IV)	53 - 258	27 - 129	71 - 515	36 - 258	53 - 153	27 - 77
	(40 - 219)	*(20 - 109)*	*(53 - 438)*	*(27 - 219)*	*(40 - 130)*	*(20 - 65)*
Total (Level V)	101 - 505	50 - 252	134 - 1009	67 - 505	100 - 300	50 - 150
	(75 - 429)	*(38 - 214)*	*(101 - 858)*	*(50 - 429)*	*(75 - 255)*	*(37 - 128)*
Total (Level VI)	108 - 538	54 - 269	144 - 1077	72 - 538	107 - 320	53 - 160
	(81 - 458)	*(40 - 229)*	*(108 - 915)*	*(54 - 458)*	*(80 - 272)*	*(40 - 136)*
Total (Level IX)	22 - 109	11 - 54	29 - 218	15 - 109	22 - 65	11 - 32
	(16 - 92)	*(8 - 46)*	*(22 - 185)*	*(11 - 92)*	*(16 - 55)*	*(8 - 27)*

Table 4.7 (page 2 of 2)
Tell ‘Atij
Number of people that could be fed with stored grain

Designation	Number of people fed					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Total (Level XII)	48 - 242 *(36 - 206)*	24 - 121 *(18 - 103)*	64 - 484 *(48 - 411)*	32 - 242 *(24 - 206)*	48 - 144 *(36 - 122)*	24 - 72 *(18 - 61)*
Level VI						
Total	163 - 818 *(123 - 695)*	82 - 409 *(61 - 347)*	218 - 1,635 *(163 - 1390)*	109 - 818 *(82 - 695)*	162 - 486 *(122 - 413)*	81 - 243 *(61 - 207)*

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 4.8
Tell ‘Atij
Number of people that could be fed with stored grain (simplified)

Area	Date	Storage capacity		Number of people fed			
		Volume	Grain	1 year		2 years	
		(m^3)	(threshed barley)	Full range	95% range	Full range	95% range
Summit, N edge[a]	early-mid Ninevite 5	43.0 - 52.5 m^3	19,109 - 49,067 kg	45 - 484	72 - 261	22 - 242	36 - 131
Southern slope[b]	mid-late Ninevite 5	40.4 - 60.6 m^3	17,954 - 56,637 kg	42 - 559	73 - 280	21 - 279	37 - 140
Summit, center[c]	end of Ninevite 5	14.3 - 116.8 m^3	6,355 - 109,161 kg	15 - 1,077	49 - 493	7 - 538	24 - 247

[a] The simplified storage capacity ranges for the northern edge of the summit of the main tell are drawn from Table 4.4 (Grand Total).

[b] The simplified storage capacity ranges for the southern slope of the main tell are drawn from Table 4.5 (Total).

[c] The simplified storage capacity ranges for the deep sounding near the center of the main tell are drawn from Table 4.6 (minimum from Level III, Total; maximum from Level VI, Total).

Table 4.9
Tell ‘Atij
Percentage of the population that could be fed with stored grain

Area	Date	Population	% of population fed			
		(estimated)	1 year		2 years	
			Full range	95% range	Full range	95% range
Summit, N edge	early-mid Ninevite 5	24 - 104	43 - 2,017 %	97 - 715 %	21 - 1,008 %	48 - 357 %
Southern slope	mid-late Ninevite 5	24 - 104	40 - 2,329 %	86 - 664 %	20 - 1,163 %	43 - 332 %
Summit, center	end of Ninevite 5	24 - 104	14 - 4,488 %	81 - 1,274 %	7 - 2,242 %	41 - 637 %

Table 4.10 (page 1 of 2)
Tell Beydar
Storage facilities, basic info.

Designation	Date	Location	Description	Contents
Granary (*entrepôt)*	EJ IIIb	Field E (Upper City, SE part)	Freestanding, rectangular structure (c. 26.5 × 7.5 m). Divided into 4 rooms of equal size (c. 5 × 5 m), arranged in a line (E-W). Near gateway leading into Upper City from Lower Town. Entered from the west through broad doorway in short wall. Arched dividing walls created broad, arched passageway (either 3.5 or 5.0 m high), running entire length of the structure (E-W). Mudbrick walls completely covered in plaster (orange on interior, gray on exterior). Roofing uncertain. No interior installations. Beaten earth floor sloped down from W to E and sat above possible remains of reed mats, which sat above complex foundation: grill-plan beneath western two rooms, terracing walls with intervening voids running at an oblique angle beneath eastern two rooms. Probably intended to be used for (grain) storage, but may never have actually been used.	No artifacts recovered in situ. Structure had been cleaned out and filled in with debris, mudbrick layers, and small, floating mudbrick walls.

Table 4.10 (page 2 of 2)
Tell Beydar
Storage facilities, basic info.

Designation	Date	Location	Description	Contents
Building to the south of Temple A	EJ IIIb	Field L (Acropolis, between Temples A and C)	Approximately rectangular structure (c. 19.7 × 9.0 m). Located on S side of street running along S side of Temple A. Only very fragementary mudbrick foundations preserved. Reconstructed plan consists of six long, narrow rooms (one divided in two by a crosswall) arranged in a line (E-W). Probably entered from the street to the north, but also abutted courtyard (in front of entrance to Temple A) to the west. Long, narrow rooms suggest a storage function. Alternatively, they might be the remains of a grill-plan foundation. Possibly used for (grain) storage.	
Storage Building	EJ IIIb	Field M (Upper City, SW of Temples B and C)	Rectangular structure (33.25 × 6.25 m), composed of at least 16 rooms, divided into 5 architectural units (3–4 rooms each). Located on S side of street running along S side of Temples B and C. Numerous and varied interior installations suggest that each unit functioned as a workshop, perhaps dedicated to food processing. Although storage was taking place, probably not a dedicated storage facility.	Destruction by fire resulted in preservation of vast ceramic repertoire, including many large storage vessels.

SOURCES: Goddeeris et al. 1997; Goddeeris 2003; Sténuit 2003; Lebeau 2006; Dezzi Bardeschi and Sténuit 2007; Suleiman 2007

Table 4.11
Tell Beydar
Granary, estimated storage capacity

Source[a]	Floor space[e]	Depth	Volume (total)	Storage capacity Volume[b]	Storage capacity Barley, threshed[c]
Goddeeris et al. 1997	100 m²	3.5 m	*350 m³*	*262.5 m³ [s]*	*116,655 - 245,333 kg*
Sténuit 2003	100 m²	5.0 m	500 m³	*375.0 m³ [s]*	*166,650 - 350,475 kg*
Paulette[d]					
No passageway	*91.4 m²*	*3.5 - 5.0 m*	*319.9 - 457 m³*	*239.9 - 342.8 m³ [s]*	*106,612 - 320,381 kg*
Passageway (1 m)	*72 m²*	*3.5 - 5.0 m*	*252 - 360 m³*	*189 - 270 m³ [s]*	*83,992 - 252,342 kg*

[a] Values shown in normal type are drawn directly from the publications cited. Values shown in italics are my own estimates and/or calculations.

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[d] I have produced two different sets of calculations. The first (i.e. "no passageway") assumes that all of the available space in the four rooms was used for storage. The second (i.e. "passageway") assumes that a one meter wide passageway -- running from the doorway in the western wall all the way to the eastern wall -- was left free so that the entire length of the structure could be accessed.

[e] Like the excavators, I have not included the spaces beneath the three arched dividing walls in my floor space measurements. This means that we may all, to some extent, be underestimating the total storage capacity of the structure.

Table 4.12
Tell Beydar
Building to the south of Temple A, estimated storage capacity

Designation	Floor space	Depth[a]	Volume (total)	Storage capacity	
				Volume[b]	Barley, threshed[c]
Room 12551	12.2 m^2	2.0 - 3.0 m	24.4 - 36.6 m^3	18.3 - 27.5 m^3 [s]	8,133 - 25,702 kg
Room 12553	5.2 m^2	2.0 - 3.0 m	10.4 - 15.6 m^3	7.8 - 11.7 m^3 [s]	3,466 - 10,935 kg
Room 12554	6.1 m^2	2.0 - 3.0 m	12.2 - 18.3 m^3	9.2 - 13.7 m^3 [s]	4,088 - 12,804 kg
Room 12555	13.5 m^2	2.0 - 3.0 m	27.0 - 40.5 m^3	20.3 - 30.4 m^3 [s]	9,021 - 28,412 kg
Room 12556	12.3 m^2	2.0 - 3.0 m	24.6 - 36.9 m^3	18.5 - 27.7 m^3 [s]	8,221 - 25,888 kg
Room 12557	12.8 m^2	2.0 - 3.0 m	25.6 - 38.4 m^3	19.2 - 28.8 m^3 [s]	8,532 - 26,916 kg
Room 12558	18.3 m^2	2.0 - 3.0 m	36.6 - 54.9 m^3	27.5 - 41.2 m^3 [s]	12,221 - 38,506 kg
Total (7 rooms)[d]	80.4 m^2	2.0 - 3.0 m	160.8 - 241.2 m^3	120.6 - 180.9 m^3 [s]	53,595 - 169,069 kg
Total (1 room)	114.7 m^2	2.0 - 3.0 m	229.4 - 344.1 m^3	172.1 - 258.1 m^3 [s]	76,481 - 241,220 kg

[a] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[d] I have produced two different calculations for total storage space. The first (i.e. "7 rooms") assumes that the structure was divided up into seven rooms (six long narrow rooms, one of which was subdivided by a crosswall), as suggested by the foundations. To reach this total, I have added together the room-by-room floor space measurements shown above. The second (i.e. "1 room") assumes that the structure actually consisted of a single, large room supported by a grill-plan foundation. To reach this total, I have re-measured the floor space enclosed by the exterior walls of the structure. In both cases, because the structure appears to have been accessed through a doorway in the northern wall, I have assumed that the grain was stored in containers, rather than in bulk.

Table 4.13 (page 1 of 2)
Tell Beydar
Number of people that could be fed with stored grain

Designation	**Number of people fed**					
	100% of calories from grain[a] *(minus seed/spoilage)[d]*		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Granary						
Goddeeris et al. 1997	362 - 1,210	181 - 605	483 - 2,420	241 - 1,210	360 - 719	180 - 360
	(272 - 1,028)	*(136 - 514)*	*(362 - 2,057)*	*(181 - 1,028)*	*(270 - 611)*	*(135 - 306)*
Sténuit 2003	517 - 1,728	259 - 864	690 - 3,457	345 - 1,728	514 - 1,027	257 - 514
	(388 - 1,469)	*(194 - 735)*	*(517 - 2,938)*	*(259 - 1,469)*	*(385 - 873)*	*(193 - 437)*
Paulette (no pswy.)	331 - 1,580	166 - 790	441 - 3,160	221 - 1,580	329 - 939	164 - 470
	(248 - 1,343)	*(124 - 671)*	*(331 - 2,686)*	*(166 - 1,343)*	*(246 - 798)*	*(123 - 399)*
Paulette (pswy.)	261 - 1,244	130 - 622	348 - 2,489	174 - 1,244	259 - 740	129 - 370
	(196 - 1,058)	*(98 - 529)*	*(261 - 2,116)*	*(130 - 1,058)*	*(194 - 629)*	*(97 - 314)*
Building S of Temple A						
Total (7 rooms)	166 - 834	83 - 417	222 - 1,668	111 - 834	165 - 496	83 - 248
	(125 - 709)	*(62 - 354)*	*(166 - 1417)*	*(83 - 709)*	*(124 - 421)*	*(62 - 211)*
Total (1 room)	237 - 1,190	119 - 595	317 - 2,379	158 - 1,190	236 - 707	118 - 354
	(178 - 1,011)	*(89 - 506)*	*(237 - 2,022)*	*(119 - 1011)*	*(177 - 601)*	*(88 - 301)*

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

Table 4.13 (page 2 of 2)
Tell Beydar
Number of people that could be fed with stored grain

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 4.14
Tell Beydar
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume	Grain	1 year		2 years	
		(m^3)	(threshed barley)	Full range	95% range	Full range	95% range
EJ IIIb[a]	EJ IIIb	309.6 - 633.1 m^3	137,586 - 591,695 kg	320 - 5,836	598 - 2,971	160 - 2,918	299 - 1,485

[a] The simplified storage capacity ranges for Level EJ IIIb were calculated by adding together the capacity estimates from Table 4.11 (minimum from Paulette, Passageway; maximum from Sténuit 2003) and Table 4.12 (minimum from Total, 7 rooms; maximum from Total, 1 room).

Table 4.15
Tell Beydar
Percentage of the population that could be fed with stored grain

Level	Date	Population	% of population fed			
		(estimated)	1 year		2 years	
			Full range	95% range	Full range	95% range
EJ IIIb	EJ IIIb	1,000 - 3,400	9 - 584 %	25 - 189 %	5 - 292 %	13 - 95 %

Table 4.16 (page 1 of 2)
Tell Brak
Storage facilities, basic info.

Designation	Phase	Subphase	Date	Location	Description	Contents
Brak Oval, Room 3	L	Brak Oval, Subph. 1–4	post-Nin. 5 / pre-Akkadian	TC	Storeroom (probably).	Pulses (Subph. 4).
Brak Oval, Room 7	L	Brak Oval, Subph. 4	post-Nin. 5 / pre-Akkadian	TC	Storeroom.	Partially cleaned barley that had been sieved but not hand-sorted.
Brak Oval, Room 8	L	Brak Oval, Subph. 4	post-Nin. 5 / pre-Akkadian	TC	Storeroom.	Partially cleaned barley that had been sieved but not hand-sorted.
Brak Oval, Room 15	L	Brak Oval, Subph. 3–4	post-Nin. 5 / pre-Akkadian	TC	Storeroom.	
Brak Oval, Room 16	L	Brak Oval, Subph. 4	post-Nin. 5 / pre-Akkadian	TC	Reception room repurposed for cleaning and temporary storage of grain. Broad doorway with lintel supported on central column took up most of E wall. Large bin occupied NW half of room.	Floor in SE half of room covered in 50 cm thick layer of grain (partially cleaned barley that had been sieved but not hand-sorted). Piles of cleaned barley found immediately adjacent to piles with higher levels of chaff (i.e. grain was either in the process of being cleaned or may have come from different source fields).

Table 4.16 (page 2 of 2)
Tell Brak
Storage facilities, basic info.

Designation	Phase	Subphase	Date	Location	Description	Contents
Naram-Sin Palace	M		Akkadian	Naram-S. Palace	Massive fortified storehouse. Exterior walls 10 m thick. Interior walls 2.3–3.3 m thick. Walls built of mudbrick, but only foundations survived. Many mudbricks stamped with name of Naram-Sin. Plan partially reconstructed (S and SW portions). As reconstructed, 48 rooms arranged around 4 large courtyards. Most rooms were long and narrow (2.2 m wide) and would probably have served as magazines.	"Considerable" quantities of carbonized wheat and barley in Rooms 10, 13, and 16. Several fragmentary tablets that make reference to grain (and other commodities), alongside lists of men.
Later Palace	N		post-Akkadian	Naram-S. Palace	Massive fortified storehouse. Walls of Naram-Sin Palace were cut down down to foundation level and rebuilt on the same plan, reusing original foundations. New walls were not as well built and were typically narrower.	
Oval structure	N		post-Akkadian	FS	Granary(?). Measured approximately 4 × 5 m internally. Mudbrick walls 50 cm thick (max.), preserved to max. height of 30 cm, reinforced by four external buttresses (one brick wide). Recess and stone step on northern side might indicate doorway (1.9 m wide).	

SOURCES: Emberling et al. 1999; Emberling and McDonald 2001; 2003; Hald and Charles 2008

Table 4.17 (page 1 of 2)
Tell Brak
Storage facilities, Brak Phase L, storage capacity

Designation	Location	Subphase[e]	Floor space	Depth[a]	Volume (total)	Storage capacity	
						Volume[b]	Barley, threshed[c]
Brak Oval, Room 3	TC	Brak Oval, Subph. 1–4	18.9 m²	2.0 - 3.0 m	37.8 - 56.7 m³	28.4 - 42.5 m³ [s]	12,621 - 39,721 kg
Brak Oval, Room 7	TC	Brak Oval, Subph. 4	11.7 m²	2.0 - 3.0 m	23.4 - 35.1 m³	17.6 - 26.3 m³ [s]	7,821 - 24,580 kg
Brak Oval, Room 8	TC	Brak Oval, Subph. 4	7.9 m²	2.0 - 3.0 m	15.8 - 23.7 m³	11.9 - 17.8 m³ [s]	5,288 - 16,636 kg
Brak Oval, Room 15	TC	Brak Oval, Subph. 3–4	6.4 m²	2.0 - 3.0 m	12.8 - 19.2 m³	9.6 - 14.4 m³ [s]	4,266 - 13,458 kg
Brak Oval, Room 16 *(bin only)*[d]	TC	Brak Oval, Subph. 4	4.4 m²	1.0 - 2.0 m	4.4 - 8.8 m³	4.4 - 8.8 m³	1,955 - 8,224 kg
Brak Oval, Room 16 *(entire room)*	TC	Brak Oval, Subph. 4	15.1 m²	2.0 - 3.0 m	30.2 - 45.3 m³	22.7 - 34.0 m³ [s]	10,088 - 31,776 kg
Total		Brak Oval, Subph. 1			37.8 - 56.7 m³	28.4 - 42.5 m³	12,621 - 39,721 kg
Total		Brak Oval, Subph. 2			37.8 - 56.7 m³	28.4 - 42.5 m³	12,621 - 39,721 kg
Total		Brak Oval, Subph. 3			50.6 - 75.9 m³	38.0 - 56.9 m³	16,887 - 53,179 kg
Total		Brak Oval, Subph. 4			94.2 - 180.0 m³	71.9 - 135.0 m³	31,952 - 126,171 kg

SOURCE: Emberling and McDonald 2003: Fig. 43

[a] There is no clear means of estimating the depth of stored grain. In the case of the bin in Room 16, I have assumed (without evidence) that the walls of the bin may have originally reached a height of 1.0–2.0 meters. In the published plans, however, the bin appears to abut the bench against the soutwestern wall of the room. This suggests to me that the bin may have reached no higher than the top of the bench (presumably, less than 1 meter high), in which case my capacity estimate may be too high. For all of the other storerooms, I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

Table 4.17 (page 2 of 2)
Tell Brak
Storage facilities, Brak Phase L, storage capacity

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[d] In the case of Room 16, it seems likely that only the bin in the northwestern half of the room was being used for storage (i.e. bulk storage of grain), while the other half of the room was being used for the cleaning of grain (Emberling and McDonald 2001: 32; 2003: 39–40). I have also allowed for the possibility, however, that the entire room was being used to store grain (in this case, in sacks or other containers) (Hald and Charles 2008: S40). These two different possibilities account for the range of floor space estimates (and the broader range of capacity estimates) shown for Brak Oval Subphase 4.

[e] The excavators have not officially assigned subphase designations for the four building phases identified in the Brak Oval (Emberling and McDonald 2003: 39–41). For ease of refernce, I have numbered these as Brak Oval Subphases 1–4 (earliest to latest).

Table 4.18 (page 1 of 3)
Tell Brak
Storage facilities, Brak Phase M, storage capacity

Designation[d]	Location	Floor space	Depth[a]	Volume (total)	Storage capacity	
					Volume[b]	Barley, threshed[c]
Room 1	Naram-Sin Palace[e]	44.8 m²	2.0 - 3.0 m	89.6 - 134.4 m³	67.2 - 100.8 m³ [s]	29,864 - 94,208 kg
Room 2	Naram-Sin Palace	27.4 m²	2.0 - 3.0 m	54.8 - 82.2 m³	41.1 - 61.7 m³ [s]	18,265 - 57,665 kg
Room 3	Naram-Sin Palace	33.6 m²	2.0 - 3.0 m	67.2 - 100.8 m³	50.4 - 75.6 m³ [s]	22,398 - 70,656 kg
Room 4	Naram-Sin Palace	33.6 m²	2.0 - 3.0 m	67.2 - 100.8 m³	50.4 - 75.6 m³ [s]	22,398 - 70,656 kg
Room 5	Naram-Sin Palace	33.6 m²	2.0 - 3.0 m	67.2 - 100.8 m³	50.4 - 75.6 m³ [s]	22,398 - 70,656 kg
Room 6	Naram-Sin Palace	33.6 m²	2.0 - 3.0 m	67.2 - 100.8 m³	50.4 - 75.6 m³ [s]	22,398 - 70,656 kg
Room 7	Naram-Sin Palace	47.1 m²	2.0 - 3.0 m	94.2 - 141.3 m³	70.7 - 106.0 m³ [s]	31,419 - 99,068 kg
Room 8	Naram-Sin Palace	26.2 m²	2.0 - 3.0 m	52.4 - 78.6 m³	39.3 - 59.0 m³ [s]	17,465 - 55,141 kg
Room 9	Naram-Sin Palace	43.2 m²	2.0 - 3.0 m	86.4 - 129.6 m³	64.8 - 97.2 m³ [s]	28,797 - 90,843 kg
Room 10	Naram-Sin Palace	30.5 m²	2.0 - 3.0 m	61.0 - 91.5 m³	45.8 - 68.6 m³ [s]	20,354 - 64,114 kg
Room 11	Naram-Sin Palace	30.5 m²	2.0 - 3.0 m	61.0 - 91.5 m³	45.8 - 68.6 m³ [s]	20,354 - 64,114 kg
Room 12	Naram-Sin Palace	37.5 m²	2.0 - 3.0 m	75.0 - 112.5 m³	56.3 - 84.4 m³ [s]	25,020 - 78,880 kg
Room 13	Naram-Sin Palace	30.1 m²	2.0 - 3.0 m	60.2 - 90.3 m³	45.2 - 67.7 m³ [s]	20,087 - 63,272 kg
Room 14	Naram-Sin Palace	18.9 m²	2.0 - 3.0 m	37.8 - 56.7 m³	28.4 - 42.5 m³ [s]	12,621 - 39,721 kg
Room 15	Naram-Sin Palace	16.9 m²	2.0 - 3.0 m	33.8 - 50.7 m³	25.4 - 38.0 m³ [s]	11,288 - 35,515 kg
Room 16	Naram-Sin Palace	18.6 m²	2.0 - 3.0 m	37.2 - 55.8 m³	27.9 - 41.9 m³ [s]	12,399 - 39,160 kg
Room 17	Naram-Sin Palace	18.9 m²	2.0 - 3.0 m	37.8 - 56.7 m³	28.4 - 42.5 m³ [s]	12,621 - 39,721 kg
Room 18	Naram-Sin Palace	27.9 m²	2.0 - 3.0 m	55.8 - 83.7 m³	41.9 - 62.8 m³ [s]	18,620 - 58,693 kg
Room 19	Naram-Sin Palace	27.9 m²	2.0 - 3.0 m	55.8 - 83.7 m³	41.9 - 62.8 m³ [s]	18,620 - 58,693 kg
Room 20	Naram-Sin Palace	29.0 m²	2.0 - 3.0 m	58.0 - 87.0 m³	43.5 - 65.3 m³ [s]	19,331 - 61,029 kg
Room 21	Naram-Sin Palace	18.6 m²	2.0 - 3.0 m	37.2 - 55.8 m³	27.9 - 41.9 m³ [s]	12,399 - 39,160 kg

Table 4.18 (page 2 of 3)
Tell Brak
Storage facilities, Brak Phase M, storage capacity

Designation[d]	**Location**	**Floor space**	**Depth**[a]	**Volume (total)**	**Storage capacity**	
					Volume[b]	Barley, threshed[c]
Room 22	Naram-Sin Palace	30.2 m²	2.0 - 3.0 m	60.4 - 90.6 m³	45.3 - 68.0 m³ [s]	20,131 - 63,553 kg
Room 23	Naram-Sin Palace	17.3 m²	2.0 - 3.0 m	34.6 - 51.9 m³	26.0 - 38.9 m³ [s]	11,554 - 36,356 kg
Room 24	Naram-Sin Palace	16.4 m²	2.0 - 3.0 m	32.8 - 49.2 m³	24.6 - 36.9 m³ [s]	10,932 - 34,487 kg
Room 25	Naram-Sin Palace	17.6 m²	2.0 - 3.0 m	35.2 - 52.8 m³	26.4 - 39.6 m³ [s]	11,732 - 37,010 kg
Room 26	Naram-Sin Palace	18.6 m²	2.0 - 3.0 m	37.2 - 55.8 m³	27.9 - 41.9 m³ [s]	12,399 - 39,160 kg
Room 27	Naram-Sin Palace	24.2 m²	2.0 - 3.0 m	48.4 - 72.6 m³	36.3 - 54.5 m³ [s]	16,132 - 50,936 kg
Room 28	Naram-Sin Palace	17.7 m²	2.0 - 3.0 m	35.4 - 53.1 m³	26.6 - 39.8 m³ [s]	11,821 - 37,197 kg
Room 29	Naram-Sin Palace	11.3 m²	2.0 - 3.0 m	22.6 - 33.9 m³	17.0 - 25.4 m³ [s]	7,555 - 23,739 kg
Room 33	Naram-Sin Palace	16.9 m²	2.0 - 3.0 m	33.8 - 50.7 m³	25.4 - 38.0 m³ [s]	11,288 - 35,515 kg
Room 34	Naram-Sin Palace	17.6 m²	2.0 - 3.0 m	35.2 - 52.8 m³	26.4 - 39.6 m³ [s]	11,732 - 37,010 kg
Room a	Naram-Sin Palace	43.6 m²	2.0 - 3.0 m	87.2 - 130.8 m³	65.4 - 98.1 m³ [s]	29,064 - 91,684 kg
Room b	Naram-Sin Palace	30.5 m²	2.0 - 3.0 m	61.0 - 91.5 m³	45.8 - 68.6 m³ [s]	20,354 - 64,114 kg
Room c	Naram-Sin Palace	40.4 m²	2.0 - 3.0 m	80.8 - 121.2 m³	60.6 - 90.9 m³ [s]	26,931 - 84,955 kg
Room d	Naram-Sin Palace	17.3 m²	2.0 - 3.0 m	34.6 - 51.9 m³	26.0 - 38.9 m³ [s]	11,554 - 36,356 kg
Room e	Naram-Sin Palace	20.2 m²	2.0 - 3.0 m	40.4 - 60.6 m³	30.3 - 45.5 m³ [s]	13,465 - 42,524 kg
Room f	Naram-Sin Palace	40.4 m²	2.0 - 3.0 m	80.8 - 121.2 m³	60.6 - 90.9 m³ [s]	26,931 - 84,955 kg
Room g	Naram-Sin Palace	17.2 m²	2.0 - 3.0 m	34.4 - 51.6 m³	25.8 - 38.7 m³ [s]	11,466 - 36,169 kg
Room h	Naram-Sin Palace	18.9 m²	2.0 - 3.0 m	37.8 - 56.7 m³	28.4 - 42.5 m³ [s]	12,621 - 39,721 kg
Room i	Naram-Sin Palace	17.0 m²	2.0 - 3.0 m	34.0 - 51.0 m³	25.5 - 38.3 m³ [s]	11,332 - 35,795 kg

Table 4.18 (page 3 of 3)
Tell Brak
Storage facilities, Brak Phase M, storage capacity

Designation[d]	Location	Floor space	Depth[a]	Volume (total)	Storage capacity	
					Volume[b]	Barley, threshed[c]
Room k	Naram-Sin Palace	27.4 m²	2.0 - 3.0 m	54.8 - 82.2 m³	41.1 - 61.7 m³ [s]	18,265 - 57,665 kg
Room l	Naram-Sin Palace	12.7 m²	2.0 - 3.0 m	25.4 - 38.1 m³	19.1 - 28.6 m³ [s]	8,488 - 26,730 kg
Total	Naram-Sin Palace	1,101.8 m²		2,203.6 - 3,305.4 m³	1,653.6 - 2,479.4 m³	734,860 - 2,317,247 kg

SOURCE: Mallowan 1947: Plate LX

[a] There is no clear means of estimating the depth of stored grain. Although the walls of the Naram-Sin Palace may have reached as high as 15 meters (Mallowan 1947: 65), I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[d] The published plan (Mallowan 1947: Plate LX) does not provide room designations for the hypothesized (but no longer preserved) rooms in the southern and southwestern parts of the Naram-Sin Palace. For ease of reference, I have labeled these Rooms a–n.

[e] Although it is clear that the Naram-Sin Palace (Phase M) and the Later Palace (Phase N) would have differed slightly in room-by-room and total storage capacity (e.g. due to changes in the width and the exact position of walls), the published plans (Mallowan 1947: Plates LIX and LX) do not provide enough information for me to calculate separate storage capacities for the two buildings.

Table 4.19 (page 1 of 3)
Tell Brak
Storage facilities, Brak Phase N, storage capacity

Designation[d]	Location	Floor space	Depth[a]	Volume (total)	Storage capacity	
					Volume[b]	Barley, threshed[c]
Room 1	Later Palace[e]	44.8 m²	2.0 - 3.0 m	89.6 - 134.4 m³	67.2 - 100.8 m³ [s]	29,864 - 94,208 kg
Room 2	Later Palace	27.4 m²	2.0 - 3.0 m	54.8 - 82.2 m³	41.1 - 61.7 m³ [s]	18,265 - 57,665 kg
Room 3	Later Palace	33.6 m²	2.0 - 3.0 m	67.2 - 100.8 m³	50.4 - 75.6 m³ [s]	22,398 - 70,656 kg
Room 4	Later Palace	33.6 m²	2.0 - 3.0 m	67.2 - 100.8 m³	50.4 - 75.6 m³ [s]	22,398 - 70,656 kg
Room 5	Later Palace	33.6 m²	2.0 - 3.0 m	67.2 - 100.8 m³	50.4 - 75.6 m³ [s]	22,398 - 70,656 kg
Room 6	Later Palace	33.6 m²	2.0 - 3.0 m	67.2 - 100.8 m³	50.4 - 75.6 m³ [s]	22,398 - 70,656 kg
Room 7	Later Palace	47.1 m²	2.0 - 3.0 m	94.2 - 141.3 m³	70.7 - 106.0 m³ [s]	31,419 - 99,068 kg
Room 8	Later Palace	26.2 m²	2.0 - 3.0 m	52.4 - 78.6 m³	39.3 - 59.0 m³ [s]	17,465 - 55,141 kg
Room 9	Later Palace	43.2 m²	2.0 - 3.0 m	86.4 - 129.6 m³	64.8 - 97.2 m³ [s]	28,797 - 90,843 kg
Room 10	Later Palace	30.5 m²	2.0 - 3.0 m	61.0 - 91.5 m³	45.8 - 68.6 m³ [s]	20,354 - 64,114 kg
Room 11	Later Palace	30.5 m²	2.0 - 3.0 m	61.0 - 91.5 m³	45.8 - 68.6 m³ [s]	20,354 - 64,114 kg
Room 12	Later Palace	37.5 m²	2.0 - 3.0 m	75.0 - 112.5 m³	56.3 - 84.4 m³ [s]	25,020 - 78,880 kg
Room 13	Later Palace	30.1 m²	2.0 - 3.0 m	60.2 - 90.3 m³	45.2 - 67.7 m³ [s]	20,087 - 63,272 kg
Room 14	Later Palace	18.9 m²	2.0 - 3.0 m	37.8 - 56.7 m³	28.4 - 42.5 m³ [s]	12,621 - 39,721 kg
Room 15	Later Palace	16.9 m²	2.0 - 3.0 m	33.8 - 50.7 m³	25.4 - 38.0 m³ [s]	11,288 - 35,515 kg
Room 16	Later Palace	18.6 m²	2.0 - 3.0 m	37.2 - 55.8 m³	27.9 - 41.9 m³ [s]	12,399 - 39,160 kg
Room 17	Later Palace	18.9 m²	2.0 - 3.0 m	37.8 - 56.7 m³	28.4 - 42.5 m³ [s]	12,621 - 39,721 kg
Room 18	Later Palace	27.9 m²	2.0 - 3.0 m	55.8 - 83.7 m³	41.9 - 62.8 m³ [s]	18,620 - 58,693 kg
Room 19	Later Palace	27.9 m²	2.0 - 3.0 m	55.8 - 83.7 m³	41.9 - 62.8 m³ [s]	18,620 - 58,693 kg
Room 20	Later Palace	29.0 m²	2.0 - 3.0 m	58.0 - 87.0 m³	43.5 - 65.3 m³ [s]	19,331 - 61,029 kg
Room 21	Later Palace	18.6 m²	2.0 - 3.0 m	37.2 - 55.8 m³	27.9 - 41.9 m³ [s]	12,399 - 39,160 kg

Table 4.19 (page 2 of 3)
Tell Brak
Storage facilities, Brak Phase N, storage capacity

Designation[d]	**Location**	**Floor space**	**Depth**[a]	**Volume (total)**	**Storage capacity**	
					Volume[b]	Barley, threshed[c]
Room 22	Later Palace	30.2 m²	2.0 - 3.0 m	60.4 - 90.6 m³	45.3 - 68.0 m³ [s]	20,131 - 63,553 kg
Room 23	Later Palace	17.3 m²	2.0 - 3.0 m	34.6 - 51.9 m³	26.0 - 38.9 m³ [s]	11,554 - 36,356 kg
Room 24	Later Palace	16.4 m²	2.0 - 3.0 m	32.8 - 49.2 m³	24.6 - 36.9 m³ [s]	10,932 - 34,487 kg
Room 25	Later Palace	17.6 m²	2.0 - 3.0 m	35.2 - 52.8 m³	26.4 - 39.6 m³ [s]	11,732 - 37,010 kg
Room 26	Later Palace	18.6 m²	2.0 - 3.0 m	37.2 - 55.8 m³	27.9 - 41.9 m³ [s]	12,399 - 39,160 kg
Room 27	Later Palace	24.2 m²	2.0 - 3.0 m	48.4 - 72.6 m³	36.3 - 54.5 m³ [s]	16,132 - 50,936 kg
Room 28	Later Palace	17.7 m²	2.0 - 3.0 m	35.4 - 53.1 m³	26.6 - 39.8 m³ [s]	11,821 - 37,197 kg
Room 29	Later Palace	11.3 m²	2.0 - 3.0 m	22.6 - 33.9 m³	17.0 - 25.4 m³ [s]	7,555 - 23,739 kg
Room 33	Later Palace	16.9 m²	2.0 - 3.0 m	33.8 - 50.7 m³	25.4 - 38.0 m³ [s]	11,288 - 35,515 kg
Room 34	Later Palace	17.6 m²	2.0 - 3.0 m	35.2 - 52.8 m³	26.4 - 39.6 m³ [s]	11,732 - 37,010 kg
Room a	Later Palace	43.6 m²	2.0 - 3.0 m	87.2 - 130.8 m³	65.4 - 98.1 m³ [s]	29,064 - 91,684 kg
Room b	Later Palace	30.5 m²	2.0 - 3.0 m	61.0 - 91.5 m³	45.8 - 68.6 m³ [s]	20,354 - 64,114 kg
Room c	Later Palace	40.4 m²	2.0 - 3.0 m	80.8 - 121.2 m³	60.6 - 90.9 m³ [s]	26,931 - 84,955 kg
Room d	Later Palace	17.3 m²	2.0 - 3.0 m	34.6 - 51.9 m³	26.0 - 38.9 m³ [s]	11,554 - 36,356 kg
Room e	Later Palace	20.2 m²	2.0 - 3.0 m	40.4 - 60.6 m³	30.3 - 45.5 m³ [s]	13,465 - 42,524 kg
Room f	Later Palace	40.4 m²	2.0 - 3.0 m	80.8 - 121.2 m³	60.6 - 90.9 m³ [s]	26,931 - 84,955 kg
Room g	Later Palace	17.2 m²	2.0 - 3.0 m	34.4 - 51.6 m³	25.8 - 38.7 m³ [s]	11,466 - 36,169 kg
Room h	Later Palace	18.9 m²	2.0 - 3.0 m	37.8 - 56.7 m³	28.4 - 42.5 m³ [s]	12,621 - 39,721 kg
Room i	Later Palace	17.0 m²	2.0 - 3.0 m	34.0 - 51.0 m³	25.5 - 38.3 m³ [s]	11,332 - 35,795 kg

Table 4.19 (page 3 of 3)
Tell Brak
Storage facilities, Brak Phase N, storage capacity

Designation[d]	Location	Floor space	Depth[a]	Volume (total)	Storage capacity: Volume[b]	Storage capacity: Barley, threshed[c]
Room k	Later Palace	27.4 m^2	2.0 - 3.0 m	54.8 - 82.2 m^3	41.1 - 61.7 m^3 [s]	18,265 - 57,665 kg
Room l	Later Palace	12.7 m^2	2.0 - 3.0 m	25.4 - 38.1 m^3	19.1 - 28.6 m^3 [s]	8,488 - 26,730 kg
Oval structure	FS	15.5 m^2	2.0 - 3.0 m	31.0 - 46.5 m^3	31.0 - 46.5 m^3	13,776 - 43,459 kg
Total	Later Palace	1,101.8 m^2		2,203.6 - 3,305.4 m^3	1,653.6 - 2,479.4 m^3	734,860 - 2,317,247 kg
Total	All	1,117.3 m^2		2,234.6 - 3,351.9 m^3	1,684.6 - 2,525.9 m^3	748,636 - 2,360,706 kg

SOURCES: Mallowan 1947: Plate LX; Oates and Oates 2001b: Fig. 89

[a] There is no clear means of estimating the depth of stored grain. Although the walls of the Naram-Sin Palace may have reached as high as 15 meters (Mallowan 1947: 65), I have assumed that the grain in this building and in the Oval Structure was stored to a depth of 2.0–3.0 meters.

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[d] The published plan (Mallowan 1947: Plate LX) does not provide room designations for the hypothesized (but no longer preserved) rooms in the southern and southwestern parts of the Later Palace. For ease of reference, I have labeled these Rooms a–n.

[e] Although it is clear that the Naram-Sin Palace (Phase M) and the Later Palace (Phase N) would have differed slightly in room-by-room and total storage capacity (e.g. due to changes in the width and the exact position of walls), the published plans (Mallowan 1947: Plates LIX and LX) do not provide enough information for me to calculate separate storage capacities for the two buildings.

Table 4.20 (page 1 of 2)
Tell Brak
Number of people that could be fed with stored grain

Designation	Number of people fed					
	100% of calories from grain[a] *(minus seed/spoilage)[d]*		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Brak Phase L						
Brak Oval 1	39 - 196 *(29 - 167)*	20 - 98 *(15 - 83)*	52 - 392 *(39 - 333)*	26 - 196 *(20 - 167)*	39 - 116 *(29 - 99)*	19 - 58 *(15 - 49)*
Brak Oval 2	39 - 196 *(29 - 167)*	20 - 98 *(15 - 83)*	52 - 392 *(39 - 333)*	26 - 196 *(20 - 167)*	39 - 116 *(29 - 99)*	19 - 58 *(15 - 49)*
Brak Oval 3	52 - 262 *(39 - 223)*	26 - 131 *(20 - 111)*	70 - 525 *(52 - 446)*	35 - 262 *(26 - 223)*	52 - 156 *(39 - 133)*	26 - 78 *(20 - 66)*
Brak Oval 4	99 - 622 *(74 - 529)*	50 - 311 *(37 - 264)*	132 - 1,244 *(99 - 1,058)*	66 - 622 *(50 - 529)*	98 - 370 *(74 - 314)*	49 - 185 *(37 - 157)*
Brak Phase M						
N.-Sin Palace	2,282 - 11,428 *(1,711 - 9,713)*	1,141 - 5,714 *(856 - 4,857)*	3,042 - 22,855 *(2,282 - 19,427)*	1,521 - 11,428 *(1,141 - 9,713)*	2,265 - 6,793 *(1,699 - 5,774)*	1,133 - 3,396 *(849 - 2,887)*
Brak Phase N						
Later Palace	2,282 - 11,428 *(1,711 - 9,713)*	1,141 - 5,714 *(856 - 4,857)*	3,042 - 22,855 *(2,282 - 19,427)*	1,521 - 11,428 *(1,141 - 9,713)*	2,265 - 6,793 *(1,699 - 5,774)*	1,133 - 3,396 *(849 - 2,887)*
Oval structure	43 - 214 *(32 - 182)*	21 - 107 *(16 - 91)*	57 - 429 *(43 - 364)*	29 - 214 *(21 - 182)*	42 - 127 *(32 - 108)*	21 - 64 *(16 - 54)*

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

Table 4.20 (page 2 of 2)
Tell Brak
Number of people that could be fed with stored grain

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 4.21
Tell Brak
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume (m^3)	Grain (threshed barley)	1 year		2 years	
				Full range	95% range	Full range	95% range
L[a]	Nin. 5 / pre-Akkadian	28.4 - 135.0 m^3	12,621 - 126,171 kg	29 - 1,244	70 - 600	15 - 622	35 - 300
M[b]	Akkadian	1,653.6 - 2,479.4 m^3	734,860 - 2,317,247 kg	1,711 - 22,855	3,143 - 11,850	856 - 11,428	1,571 - 5,925
N[c]	Post-Akkadian	1,684.6 - 2,525.9 m^3	748,636 - 2,360,706 kg	1,743 - 23,284	2,859 - 11,965	872 - 11,642	1,429 - 5,983

[a] The simplified storage capacity ranges for Phase L are drawn from Table 4.17 (minimum from Total, Brak Oval, Subphase 1/2; maximum from Total, Brak Oval, Subphase 4).

[b] The simplified storage capacity ranges for Phase M are drawn from Table 4.18 (Total).

[c] The simplified storage capacity ranges for Phase N are drawn from Table 4.19 (Total, All).

Table 4.22
Tell Brak
Percentage of the population that could be fed with stored grain

Level	Date	Population (estimated)	% of population fed			
			1 year		2 years	
			Full range	95% range	Full range	95% range
L	Nin. 5 / pre-Akkadian	6,000 - 14,000	0 - 21 %	1 - 8 %	0 - 10 %	0 - 4 %
M	Akkadian	6,000 - 14,000	12 - 381 %	26 - 141 %	6 - 190 %	13 - 70 %
N	Post-Akkadian	6,000 - 14,000	12 - 388 %	28 - 142 %	6 - 194 %	14 - 71 %

Table 4.23 (page 1 of 2)
Ebla
Storage facilities, basic info.

Designation	Location	Phase	Date	Description	Contents
Room L.3518 Room L.3512 Room L.3500 Room L.3466 Room L.3532 Room L.3464 Room L.3463 Room L.3460	Royal Palace, Central Unit South	IIB1	EB IVA 2400–2300 BC	Collection of storerooms known as the Southern Storehouse. 2 parallel lines of rooms, running east-west and bordered to the south by a thick terrace wall. Also a single room to the south of the terrace wall. Rooms irregularly shaped and furnished with a range of installations, including niches, buttresses, benches, and stepped shelves. Probably used, at least in part, for storage of foodstuffs.	Large numbers of ceramic vessels, many of them stacked along the benches and shelves. Vegetal remains, cereal grains, and olive pits.
Central Unit West	Royal Palace, Central Unit West	IIB1	EB IVA 2400–2300 BC	Area dedicated to a range of functions, including processing (e.g. grinding) and storage of grain.	Large numbers of ceramic vessels.
Room L.7256 Room L.7287	Area CC	IIA	EB III 2700–2400 BC	Two well-preserved storerooms among a number of small rooms dedicated to grain storage. Both apparently entered via doorways.	

Table 4.23 (page 2 of 2)
Ebla
Storage facilities, basic info.

Designation	Location	Phase	Date	Description	Contents
Silo S.4843	Beneath western part of Royal Palace	IIA	EB III 2700–2400 BC	Large, semicircular, subterranean silo. Plastered on the interior with clay. Probably located within a courtyard of some kind. Probably used primarily for storage of partially cleaned cereal grain.	Loose, ashy matrix alternated with more compact material and included some "debris" and charcoal. Archaeobotanical assemblage dominated by barley but also included a range of other cereals and pulses, in addition to olive stones, a single pomegranate seed, and a variety of weeds. Very little cereal chaff recovered.

SOURCES: Dolce 1988: 37–38; 1990: 123–124; Matthiae 1987: 143–145, Fig. 6; 2013: 50, Fig. 2.2; Mazzoni 2013: 94, Fig. 5.40; Matthiae 2000: 572–575, Fig. 6–7; Dolce 2008: 66; Wachter-Sarkady 2013: 377–378; Mazzoni 1995: 99, 103

Table 4.24
Ebla
Phase IIB1 (EB IVA), storage facilities, storage capacity (Dolce)

Designation[d]	**Location**	**Floor space**	**Depth**	**Volume (total)**	**Storage capacity** Volume	**Storage capacity** Grain[c]
Room L.3518	Central Unit South	7.74 m²			280 storage vessels (volume not provided)	*6,713 - 7,518 kg (wheat)*[a]
Room L.3512	Central Unit South	7.20 m²				
Room L.3500	Central Unit South	6.16 m²				
Room L.3466	Central Unit South	9.68 m²				
Room L.3532	Central Unit South	9.36 m²				
Room L.3464	Central Unit South	19.16 m²				
Room L.3463	Central Unit South	8.00 m²				
Room L.3460	Central Unit South	15.12 m²				
Central Unit West	Central Unit West					*5,443 - 6,096 kg (wheat)*[b]
Total	Central Unit South and Central Unit West					*12,156 - 13,614 kg (wheat)*

SOURCE: Dolce 1988: 37–38, Notes 12 and 14

[a] Dolce indicates that the medium-sized jars found in the Central Unit South could have held a total of approximately 46 hundredweights of wheat, while the large jars could have held approximately 101 hundredweights; together these could have held a total of 148 hundredweights (1988: 38, Note 14).

[b] Dolce indicates that the medium-sized jars found in the Central Unit West could have held a total of approximately 26 hundredweights of wheat, while the large jars could have held approximately 94 hundredweights (1988: 38, Note 14).

[c] Dolce measures grain (wheat) by the hundredweight, but she does not specify the type of hundredweight that she is using. I have, therefore, included a range of possible conversions. One short hundredweight equals 45.36 kg. One long hundredweight equals 50.80 kg

[d] In this table, values shown in normal type are drawn directly from Dolce 1988. Values shown in italics do not appear in Dolce 1988, but they are extrapolated directly from information provided there.

Table 4.25
Ebla
Phase IIB1 (EB IVA), storage facilities, storage capacity (Paulette)

Designation	Location	Floor space[a]	Depth[b]	Volume (total)	Storage capacity	
					Volume[c]	Barley, threshed[d]
Room L.3518	Central Unit South	9.0 m²	2.0 - 3.0 m	18.0 - 27.0 m³	13.5 - 20.3 m³ [s]	5,999 - 18,972 kg
Room L.3512	Central Unit South	8.0 m²	2.0 - 3.0 m	16.0 - 24.0 m³	12.0 - 18.0 m³ [s]	5,333 - 16,823 kg
Room L.3500	Central Unit South	6.4 m²	2.0 - 3.0 m	12.8 - 19.2 m³	9.6 - 14.4 m³ [s]	4,266 - 13,458 kg
Room L.3466	Central Unit South	9.5 m²	2.0 - 3.0 m	19.0 - 28.5 m³	14.3 - 21.4 m³ [s]	6,355 - 20,000 kg
Room L.3532	Central Unit South	10.3 m²	2.0 - 3.0 m	20.6 - 30.9 m³	15.5 - 23.2 m³ [s]	6,888 - 21,683 kg
Room L.3464[e]	Central Unit South	20.0 m²	2.0 - 3.0 m	40.0 - 60.0 m³	30.0 - 45.0 m³ [s]	13,332 - 42,057 kg
Room L.3463	Central Unit South	8.0 m²	2.0 - 3.0 m	16.0 - 24.0 m³	12.0 - 18.0 m³ [s]	5,333 - 16,823 kg
Room L.3460	Central Unit South	14.8 m²	2.0 - 3.0 m	29.6 - 44.4 m³	22.2 - 33.3 m³ [s]	9,866 - 31,122 kg
Total	Central Unit South	86.0 m²		172.0 - 258.0 m³	129.1 - 193.6 m³	57,372 - 180,939 kg

SOURCE: Matthiae 2013: Fig. 2.2

[a] I have measured floor space using the plan published by Matthiae (2013: Fig. 2.2). Many of the rooms included benches and other installations, but I have not taken these into account in my measurements.

[b] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[c] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container (in this case, primarily ceramic vessels). In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[d] Minimum and maximum values for converting storage volume to threshed barley (1 m³ = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[e] The plan (Matthiae 2013: Fig. 2.2) seems to show a mudbrick mass of some sort in the eastern part of room L.3464, but I do not know anything further about the nature of this feature. I have, therefore, provided a range of possible floor space measurements; the lower value excludes the mudbrick mass, and the higher value includes it.

Table 4.26
Ebla
Phase IIA (EB III), storage facilities, storage capacity (Paulette)

Designation	Location	Floor space[a]	Depth[b]	Volume (total)	Storage capacity	
					Volume[c]	Barley, threshed[d]
Room L.7256	Area CC	2.7 m²	2.0 - 3.0 m	5.4 - 8.1 m³	4.1 - 6.1 m³ [s]	1,822 - 5,701 kg
Room L.7287	Area CC	0.9 - 1.3 m²	2.0 - 3.0 m	1.8 - 3.9 m³	1.4 - 2.9 m³ [s]	622 - 2,710 kg
Total (Area CC)	Area CC			7.2 - 12.0 m³	5.5 - 9.0 m³	2,444 - 8,411 kg
Silo S.4843	Beneath western part of Royal Palace			11.0 - 12.0 m³	11.0 - 12.0 m³	4,888 - 11,215 kg

SOURCES: Mazzoni 1995: 99, 103; Matthiae 2000: 572–575, Fig. 6–7; Dolce 2008: 66, Note 14; Wachter-Sarkady 2013: 377–378

[a] I have measured the floor space of rooms L.7256 and L.7287 using the plan published by Matthiae (2000: Fig. 6). Each room appears to have been entered by a doorway, but it us unclear to me exactly where the eastern boundary of room L.7287 was located. I have, therefore, allowed for a range of possible floor space measurements for this room.

[b] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[c] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[d] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

Table 4.27 (page 1 of 2)
Ebla
Number of people that could be fed with stored grain

Designation	Number of people fed					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Phase IIB1 (Dolce)						
Central Unit South	21 - 37	10 - 19	28 - 74	14 - 37	-	-
	(16 - 32)	*(8 - 16)*	*(21 - 63)*	*(10 - 32)*	-	-
Central Unit West	17 - 30	8 - 15	23 - 60	11 - 30	-	-
	(13 - 26)	*(6 - 13)*	*(17 - 51)*	*(8 - 26)*	-	-
Total	38 - 67	19 - 34	50 - 134	25 - 67	-	-
	(28 - 57)	*(14 - 29)*	*(38 - 114)*	*(19 - 57)*	-	-
Phase IIB1 (Paulette)						
Central Unit South	178 - 892	89 - 446	238 - 1,785	119 - 892	177 - 530	88 - 265
	(134 - 758)	*(67 - 379)*	*(178 - 1,517)*	*(89 - 758)*	*(133 - 451)*	*(66 - 225)*
Phase IIA						
Area CC	8 - 41	4 - 21	10 - 83	5 - 41	8 - 25	4 - 12
	(6 - 35)	*(3 - 18)*	*(8 - 71)*	*(4 - 35)*	*(6 - 21)*	*(3 - 10)*
Silo S.4843	15 - 55	8 - 28	20 - 111	10 - 55	15 - 33	8 - 16
	(11 - 47)	*(6 - 24)*	*(15 - 94)*	*(8 - 47)*	*(11 - 28)*	*(6 - 14)*

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2). Dolce indicates that her estimates are for "wheat" (Dolce 1988: 38, Note 14), but it is unclear to me whether she means wheat specifically or is simply using "wheat" as a synonym for "grain." For purposes of calculation, I have assumed this "wheat" is threshed barley, but this assumption may skew the results somewhat.

Table 4.27 (page 2 of 2)
Ebla
Number of people that could be fed with stored grain

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2). Dolce indicates that her estimates are for "wheat" (Dolce 1988: 38, Note 14), but it is unclear to me whether she means wheat specifically or is simply using "wheat" as a synonym for "grain." For purposes of calculation, I have assumed this "wheat" is threshed barley, but this assumption may skew the results somewhat.

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42). Dolce, unfortunately, does not provide volume estimates but, instead, only weight (hundredweights) estimates. To calculate the number of rations represented by her weight estimates, I would have first had to convert her weight estimates back into volume using my own conversion factors (rather than her original conversion factors, which are not provided). This operation would not provide an accurate assessment of the storage volume on which her calculations were based. I have, therefore, omitted ration calculations in this case.

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 4.28
Ebla
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume	Grain	1 year		2 years	
		(m^3)	(threshed barley)	Full range	95% range	Full range	95% range
IIB1, Central Unit South (Paulette)[a]	EB IVA	129.1 - 193.6 m^3	57,372 - 180,939 kg	134 - 1,785	232 - 910	67 - 892	116 - 455

[a] The simplified storage capacity ranges for the Central Unit South (Phase IIB1) are drawn from Table 4.25 (Total).

Table 4.29
Ebla
Percentage of the population that could be fed with stored grain

Level	Date	Population	% of population fed			
		(estimated)	1 year		2 years	
			Full range	95% range	Full range	95% range
IIB1, Central Unit South (Paulette)	EB IVA	5,000 - 10,000	1 - 36 %	3 - 15 %	1 - 18 %	1 - 8 %

Table 4.30
Tell Hajji Ibrahim
Storage facilities, basic info.

Designation	Phase	Date	Description	Contents
Silo I	A1	late 4th mil. BC	Silo. Only eastern half preserved. Massive stone footings. Gaps between stones filled with river pebbles. Top of footings covered with layer of pebbles. Succeeded by Silo II.	No artifacts or ecofacts.
Silo II	A2	late 4th / early 3rd mil. BC	Silo. Constructed on partially preserved stone footings of Silo I, but rotated 90 degrees (i.e. long axis N-S).	
Silo III	A2	late 4th / early 3rd mil. BC	Silo. No substantial stone footings. Mudbrick walls (1.20 m thick, preserved 60 cm high, on average) covered on interior and exterior with thick, light brown plaster. Eastern, southern, and (possibly) northern walls niched on exterior. Floor of thick lime plaster.	A handful of ceramic sherds.

SOURCE: Danti 2000: 111–112, 122–123, 131

Table 4.31
Tell Hajji Ibrahim
Storage facilities, storage capacity (Danti)

Designation[a]	Phase	Date	Dimensions (N-S × E-W)	Floor space	Depth[b]	Volume (total)	Storage capacity	
							Volume[c]	Barley, threshed[d]
Silo I	A1	late 4th mil. BC	1.33 × ? m					
Silo II	A2	late 4th / early 3rd mil. BC	2.11 × 1.25 m	2.64 m²	3.0 m	*7.92 m³*	*7.92 m³* *(7.20 - 7.80 m³)*	*3,960 kg* *(3,600 - 3,900 kg)*
Silo III	A2	late 4th / early 3rd mil. BC	2.20 × 1.20 m	2.64 m²	3.0 m	*7.92 m³*	*7.92 m³* *(7.20 - 7.80 m³)*	*3,960 kg* *(3,600 - 3,900 kg)*
Total	A2	late 4th / early 3rd mil. BC					*15.84 m³* *(14.40 - 15.60 m³)*	*7,920 kg* *(7,200 - 7,800 kg)*

SOURCE: Danti 2000: 111–112, 122, 129–131

[a] In this table, values shown in normal type are drawn directly from Danti 2000. Values shown in italics do not appear in Danti 2000, but they are extrapolated directly from information provided there.

[b] Although his examination of Uruk glyptic suggests a depth of 1.46–2.00 m (Danti 2000: 124), Danti estimates a depth of 3 m for each silo when calculating storage capacity (Danti 2000: 131).

[c] Based solely on the interior dimensions of the silos, Danti calculates a storage capacity of 1,320 liters of grain per 0.5 m of depth (i.e. 2.64 m^3 per 1 m of depth). He then reduces this estimate somewhat to account for the layers of plaster that would have covered the interior walls (and also to bring his estimate more in line with the metrology of capacity known from later periods in southern Mesopotamia) and suggests a range of 1,200–1,300 liters of grain per 0.5 m of depth (i.e. 2.4–2.6 m^3 per 1 m of depth). I have included both storage capacity estimates, the former in normal type and the latter within parentheses.

[d] Although citing a wide range of variation in possible values for converting storage volume into grain (1 metric ton of threshed barley = 1.07–2.25 m^3), Danti does not explain his choice of conversion factor (1 metric ton of theshed barley = 2.0 m^3, i.e. 1 m^3 = 500 kg of theshed barley) (Danti 2000: 129).

Table 4.32
Tell Hajji Ibrahim
Storage facilities, storage capacity (Paulette)

Designation[a]	**Phase**	**Date**	**Dimensions** (N-S × E-W)	**Floor space**	**Depth**[b]	**Volume (total)**	**Storage capacity** Volume	Barley, threshed[c]
Silo I	A1	late 4th mil. BC	1.33 × ? m					
Silo II	A2	late 4th / early 3rd mil. BC	2.11 × 1.25 m	2.64 m²	*2.0 - 3.0 m*	*5.28 - 7.92 m³*	*5.28 - 7.92 m³*	*2,346 - 7,402 kg*
Silo III	A2	late 4th / early 3rd mil. BC	2.20 × 1.20 m	2.64 m²	*2.0 - 3.0 m*	*5.28 - 7.92 m³*	*5.28 - 7.92 m³*	*2,346 - 7,402 kg*
Total	A2	late 4th / early 3rd mil. BC					*10.56 - 15.84 m³*	*4,692 - 14,804 kg*

SOURCE: Danti 2000: 111–112, 122, 131

[a] In this table, values shown in normal type are drawn directly from Danti 2000. Values shown in italics are my own estimates and/or calculations.

[b] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters (cf. Danti 2000: 131, for an estimate of 3.0 m).

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

Table 4.33
Tell Hajji Ibrahim
Number of people/animals that could be fed with stored grain (Danti)

Designation[a]	**Phase**	**Date**	**Storage capacity**		**Number of people fed for one year**[b]	**Number of sheep / people fed for one year**[c]
			Volume	Barley, threshed		
Silo II	A2	late 4th / early 3rd mil. BC	*7.92 m^3 (7.20 - 7.80 m^3)*	*3,960 kg (3,600 - 3,900 kg)*	*16 people (14 - 16 people)*	
Silo III	A2	late 4th / early 3rd mil. BC	*7.92 m^3 (7.20 - 7.80 m^3)*	*3,960 kg (3,600 - 3,900 kg)*	*16 people (14 - 16 people)*	
Total	A2	late 4th / early 3rd mil. BC	*15.84 m^3 (14.40 - 15.60 m^3)*	*7,920 kg (7,200 - 7,800 kg)*	*32 people (29 - 31 people)*	127 sheep / 19 people

SOURCE: Danti 2000: 129–131

[a] In this table, values shown in normal type are drawn directly from Danti 2000. Values shown in italics do not appear in Danti 2000, but they are extrapolated directly from information provided there.

[b] Because his argument assumes that the stored grain was used to feed both sheep and people, Danti does not provide calculations for the number of people that could have been fed, if sheep are not taken into account. I have, however, employed his conversion factor (250 kg of grain per person per year, Danti 2000: 131) to calculate this value.

[c] Danti calculates the number of sheep (ewes plus followers) that could have been fed with the stored grain by first calculating the amount of agricultural land that would have been needed to produce enough grain to fill the silos (39 ha, under biennial fallow, 400 kg/ha). He then calculates the amount of straw that could have been produced on that land (9,360 kg, after losses due to shattering), in addition to the grain. 9,360 kg of straw is enough to feed 127 ewes (plus followers) for a 3-month (90 day) period of supplemental feeding, but the straw must be combined with barley grain in order to meet protein requirements. If the necessary barley grain is subtracted from the total in storage, that only leaves enough grain to support a population of 19 people for one year (at 250 kg/person/year).

Table 4.34
Tell Hajji Ibrahim
Number of people that could be fed with stored grain (Paulette)

Designation	**Number of people fed**					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Silo II	7 - 37 *(5 - 31)*	4 - 18 *(3 - 16)*	10 - 73 *(7 - 62)*	5 - 37 *(4 - 31)*	7 - 22 *(5 - 18)*	4 - 11 *(3 - 9)*
Silo III	7 - 37 *(5 - 31)*	4 - 18 *(3 - 16)*	10 - 73 *(7 - 62)*	5 - 37 *(4 - 31)*	7 - 22 *(5 - 18)*	4 - 11 *(3 - 9)*
Total (Silos II and III)	15 - 73 *(11 - 62)*	7 - 37 *(5 - 31)*	19 - 146 *(15 - 124)*	10 - 73 *(7 - 62)*	14 - 43 *(11 - 37)*	7 - 22 *(5 - 18)*

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 4.35
Tell Hajji Ibrahim
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume	Grain	1 year		2 years	
		(m^3)	(threshed barley)	Full range	95% range	Full range	95% range
Phase A2[a]	Late 4th / early 3rd mil. BC	10.6 - 15.8 m^3	4,692 - 14,804 kg	11 - 146	19 - 77	5 - 73	10 - 39

[a] The simplified storage capacity ranges for Phase A2 are drawn from Table 4.32 (Total).

Table 4.36
Tell Hajji Ibrahim
Percentage of the population that could be fed with stored grain

Level	Date	Population	% of population fed			
		(estimated)	1 year		2 years	
			Full range	95% range	Full range	95% range
Phase A2	Late 4th / early 3rd mil. BC	8 - 50	22 - 1,825 %	60 - 541 %	10 - 913 %	30 - 271 %

Table 4.37 (page 1 of 2)
Tell Karrana 3
Parallel Wall Structures, basic info.

Designation	Level	Location	Description	Contents
PWS I	3c	Western Area (Q 17)	4 parallel walls (AF 111, 112, 113, 114), perhaps 5 (AF 110). Walls consist of 2 courses of mudbricks laid in single rows on their short sides, covered with plaster. Total excavated length c. 2 m, but walls continue into western baulk. Distance between walls 33-38 cm.	Large quantities of animal bones and smaller quantities of grain found in spaces between walls.
PWS II	3c	Eastern Area (S 17-18)	4 parallel walls (AF 57, 53, 58, 88). Walls consist of 3 courses of mudbricks laid in single rows on their long sides. Original length c. 3.3 m. In later phase, walls extended to east with bricks laid on short sides, resulting in total length of c. 4.5 m. Distance between walls 40-60 cm. Impressions of reeds in plaster on top of walls indicate that reeds were laid across walls perpendicular to direction of walls.	Significant quantities of carbonized grain found in spaces between walls, along with carbonized remains of a wooden implement (table or shelf?), conical bowl, and lumps of clay with reed impressions.
PWS III/1	3a	Eastern Area (S/T 16)	3 parallel walls (AF 16, 20, 19), perhaps 4 (AF 21). Walls (30 cm wide) consist of 3-4 courses of mudbricks laid alternately as 2 rows of bricks on their short sides and 1 row of bricks on their long sides. Both sides of walls plastered. Fourth wall (AF 21, width 60 cm) added later. Length c. 5.3 m. Distance between walls 45 cm. Distance between secondary wall AF 21 and AF 16 54 cm. PWS III/1 preceded by PWS III/2 and PWS III/3.	Abundant ashes, some bones (including hind leg of cow/bull), and a few ceramic sherds found within compact clay matrix in spaces between walls.

Table 4.37 (page 2 of 2)
Tell Karrana 3
Parallel Wall Structures, basic info.

Designation	Level	Location	Description	Contents
PWS III/2	3b	Eastern Area (S/T 16)	3 parallel walls (AF 16A, 20A, 19A). May have existed simultaneously with PWS III/3 or may have been part of same structure, but definitely survived longer than PWS III/3. Not shown on published plans. Walls consist of 3-4 courses of mudbricks, in some cases plastered on sides. Length c. 5 m. Impressions of reeds visible on tops of walls.	Ash and bones of an equid (possibly onager) and a cow found in spaces between walls.
PWS III/3	3b	Eastern Area (T 16)	3 parallel walls (AF 145, 120, 124). May have existed simultaneously with PWS III/2 or may have been part of same structure, but definitely went out of use before PWS III/2. Not shown on published plans. Walls consist of 2 courses of mudbricks laid on their long sides. Length c. 5 m.	Ash found in spaces between walls.
PWS IV	3b(-a)	Eastern Area (S 18)	3 parallel walls (AF 67, 68, 69) and 1 perpendicular wall (AF 74) delimiting western edge of structure. Parallel walls consist of 1 course of mudbricks laid on their long sides. Perpendicular wall consists of 1 course of very large mudbricks laid on their short sides. Total excavated length c. 3.5 m, but walls continue into eastern baulk. Floor slopes toward southeast.	

Table 4.38 (page 1 of 2)
Tell Karrana 3
Parallel Wall Structures, estimated storage capacity, by PWS

Designation[b]	**Floor space**	**Depth**	**Storage capacity**	
			Volume	Barley, threshed[a]
PWS I				
as excavated	3.8 m²	2.0 - 3.0 m	7.6 - 11.4 m³	3,377 - 10,654 kg
full extent (?)	6.9 - 8.7 m²	2.0 - 3.0 m	13.8 - 26.1 m³	6,133 - 24,393 kg
PWS II				
as excavated	12.5 m²	2.0 - 3.0 m	25.0 - 37.5 m³	11,110 - 35,048 kg
full extent (?)	13.3 m²	2.0 - 3.0 m	26.6 - 39.9 m³	11,821 - 37,291 kg
PWS III/1 *(excluding AF 21)*				
as excavated	9.9 m²	2.0 - 3.0 m	19.8 - 29.7 m³	8,799 - 27,758 kg
full extent (?)	10.2 m²	2.0 - 3.0 m	20.4 - 30.6 m³	9,066 - 28,599 kg
PWS III/1 *(including AF 21)*				
as excavated	16.3 m²	2.0 - 3.0 m	32.6 - 48.9 m³	14,487 - 45,702 kg
full extent (?)	16.7 m²	2.0 - 3.0 m	33.4 - 50.1 m³	14,843 - 46,823 kg
PWS III/2				
approx. (no plan)	9.8 m²	2.0 - 3.0 m	19.6 - 29.4 m³	8,710 - 27,477 kg
PWS III/3				
approx. (no plan)	9.0 m²	2.0 - 3.0 m	18.0 - 27.0 m³	7,999 - 25,234 kg
PWS IV				
as excavated	7.2 m²	2.0 - 3.0 m	14.4 - 21.6 m³	6,399 - 20,187 kg
full extent (?)	7.4 - 9.2 m²	2.0 - 3.0 m	14.8 - 27.6 m³	6,577 - 25,795 kg

SOURCES: Wilhelm and Zaccagnini 1993; Zaccagnini 1993a

[a] Minimum and maximum values for converting storage volume to threshed barley (1 m3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

Table 4.38 (page 2 of 2)
Tell Karrana 3
Parallel Wall Structures, estimated storage capacity, by PWS

[b] Full extent calculated as follows: PWS I (assuming structure width of 1.73 m, as measured on plan, and original wall length of 4-5 m, on analogy with other PWS, floor space = (1.73 m × 4 m) - (1.73 m × 5 m) = 6.9 - 8.7 m^2), PWS II (assuming that walls AF 58 and 88 were originally approx. same length as AF 57 and 53, measurement on plan = 13.3 m^2), PWS III/1 (assuming that wall AF 19 was originally approx. same length as AF 21, 16, and 20, measurement on plan = 10.2 m^2 (excluding AF 21) or 16.7 (including AF 21)), PWS III/2 (according to publication, wall length was c. 5 m, and wall widths were 0.30 m, 0.30 m, and 0.45 m; assuming distance between walls of 0.45 m, on analogy with PWS III/1, floor space = 5.0 m × (0.30 + 0.45 + 0.30 + 0.45 +0.45 m) = 9.75 m^2), PWS III/3 (according to publication, wall length was c. 5 m, and wall widths were 0.30 m; assuming distance between walls of 0.45 m, on analogy with PWS III/1, floor space = 5.0 m × (0.30 + 0.45 + 0.30 + 0.45 +0.30 m) = 9.0 m^2), PWS IV (assuming structure width of 1.84 m, as measured on plan, and original wall length of 4-5 m, on analogy with other PWS, floor space = (1.84 m × 4 m) - (1.84 m × 5 m) = 7.36 - 9.2 m^2).

Table 4.39 (page 1 of 2)
Tell Karrana 3
Parallel Wall Structures, estimated storage capacity, by Level

Level[b]	Floor space	Depth	Storage capacity	
			Volume	Barley, threshed[a]
Level 3c *(PWS I, II)*				
as excavated	16.3 m²	2.0 - 3.0 m	32.6 - 48.9 m³	14,487 - 45,702 kg
full extent (?)	20.2 - 22.0 m²	2.0 - 3.0 m	40.4 - 66.0 m³	17,954 - 61,684 kg
Level 3b, earlier *(PWS III/3, IV)*				
as excavated	16.2 m²	2.0 - 3.0 m	32.4 - 48.6 m³	14,399 - 45,422 kg
full extent (?)	16.4 - 18.2 m²	2.0 - 3.0 m	32.8 - 54.6 m³	14,576 - 51,029 kg
Level 3b, later *(PWS III/2, IV)*				
as excavated	17.0 m²	2.0 - 3.0 m	34.0 - 51.0 m³	15,110 - 47,665 kg
full extent (?)	17.2 - 19.0 m²	2.0 - 3.0 m	34.4 - 57.0 m³	15,287 - 53,272 kg
Level 3a *(PWS III/1)*				
as excavated	9.9 - 16.3 m²	2.0 - 3.0 m	19.8 - 48.9 m³	8,799 - 45,702 kg
full extent (?)	10.2 - 16.7 m²	2.0 - 3.0 m	20.4 - 50.1 m³	9,066 - 46,823 kg

SOURCES: Wilhelm and Zaccagnini 1993; Zaccagnini 1993a

[a] Minimum and maximum values for converting storage volume to threshed barley (1 m3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

Table 4.39 (page 2 of 2)
Tell Karrana 3
Parallel Wall Structures, estimated storage capacity, by Level

[b] Full extent calculated as follows: PWS I (assuming structure width of 1.73 m, as measured on plan, and original wall length of 4-5 m, on analogy with other PWS, floor space = (1.73 m × 4 m) - (1.73 m × 5 m) = 6.9 - 8.7 m^2), PWS II (assuming that walls AF 58 and 88 were originally approx. same length as AF 57 and 53, measurement on plan = 13.3 m^2), PWS III/1 (assuming that wall AF 19 was originally approx. same length as AF 21, 16, and 20, measurement on plan = 10.2 m^2 (excluding AF 21) or 16.7 (including AF 21)), PWS III/2 (according to publication, wall length was c. 5 m, and wall widths were 0.30 m, 0.30 m, and 0.45 m; assuming distance between walls of 0.45 m, on analogy with PWS III/1, floor space = 5.0 m × (0.30 + 0.45 + 0.30 + 0.45 +0.45 m) = 9.75 m^2), PWS III/3 (according to publication, wall length was c. 5 m, and wall widths were 0.30 m; assuming distance between walls of 0.45 m, on analogy with PWS III/1, floor space = 5.0 m × (0.30 + 0.45 + 0.30 + 0.45 +0.30 m) = 9.0 m^2), PWS IV (assuming structure width of 1.84 m, as measured on plan, and original wall length of 4-5 m, on analogy with other PWS, floor space = (1.84 m × 4 m) - (1.84 m × 5 m) = 7.36 - 9.2 m^2).

Table 4.40 (page 1 of 2)
Tell Karrana 3
Number of people that could be fed with stored grain

Designation	**Number of people fed**					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Level 3c *(PWS I, II)*						
as excavated	45 - 225 *(34 - 192)*	22 - 113 *(17 - 96)*	60 - 451 *(45 - 383)*	30 - 225 *(22 - 192)*	45 - 134 *(33 - 114)*	22 - 67 *(17 - 57)*
full extent (?)	56 - 304 *(42 - 259)*	28 - 152 *(21 - 129)*	74 - 608 *(56 - 517)*	37 - 304 *(28 - 259)*	55 - 181 *(42 - 154)*	28 - 90 *(21 - 77)*
Level 3b, earlier *(PWS III/3, IV)*						
as excavated	45 - 224 *(34 - 190)*	22 - 112 *(17 - 95)*	60 - 448 *(45 - 381)*	30 - 224 *(22 - 190)*	44 - 133 *(33 - 113)*	22 - 67 *(17 - 57)*
full extent (?)	45 - 252 *(34 - 214)*	23 - 126 *(17 - 107)*	60 - 503 *(45 - 428)*	30 - 252 *(23 - 214)*	45 - 150 *(34 - 127)*	22 - 75 *(17 - 64)*
Level 3b, later *(PWS III/2, IV)*						
as excavated	47 - 235 *(35 - 200)*	23 - 118 *(18 - 100)*	63 - 470 *(47 - 400)*	31 - 235 *(23 - 200)*	47 - 140 *(35 - 119)*	23 - 70 *(17 - 59)*
full extent (?)	47 - 263 *(36 - 223)*	24 - 131 *(18 - 112)*	63 - 525 *(47 - 447)*	32 - 263 *(24 - 223)*	47 - 156 *(35 - 133)*	24 - 78 *(18 - 66)*
Level 3a *(PWS III/1)*						
as excavated	27 - 225 *(20 - 192)*	14 - 113 *(10 - 96)*	36 - 451 *(27 - 383)*	18 - 225 *(14 - 192)*	27 - 134 *(20 - 114)*	14 - 67 *(10 - 57)*
full extent (?)	28 - 231 *(21 - 196)*	14 - 115 *(11 - 98)*	38 - 462 *(28 - 393)*	19 - 231 *(14 - 196)*	28 - 137 *(21 - 117)*	14 - 69 *(10 - 58)*

Table 4.40 (page 2 of 2)
Tell Karrana 3
Number of people that could be fed with stored grain

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 4.41
Tell Karrana 3
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume (m^3)	Grain (threshed barley)	1 year		2 years	
				Full range	95% range	Full range	95% range
Levels 3c - 3a[a]	Late Uruk / Early Nin. 5	19.8 - 66.0 m^3	8,799 - 61,684 kg	20 - 608	50 - 298	10 - 304	25 - 149

[a] The simplified storage capacity ranges for Levels 3c–3a are drawn from Table 4.39 (minimum from Level 3a, as excavated; maximum from Level 3c, full extent).

Table 4.42
Tell Karrana 3
Percentage of the population that could be fed with stored grain

Level	Date	Population (estimated)	% of population fed			
			1 year		2 years	
			Full range	95% range	Full range	95% range
Levels 3c - 3a	Late Uruk / Early Nin. 5	10 - 40	50 - 6,080 %	173 - 2,006 %	25 - 3,040 %	87 - 1,003 %

Table 4.43 (page 1 of 2)
Kazane Höyük
Storage facilities, mid-late third millennium BC, basic info.

Designation	Building Unit	Operation	Space	Description	Contents
Eastern Structure	Building Unit 5	2.1		One-room, rectangular silo (or storeroom). Only partially excavated. Mudbrick walls (1.25–1.40 m thick, preserved to almost 1 m high) on stone foundations (1 m deep). Interior faces of walls covered in plaster. Beaten earth floor laid on layer of cobblestone and covered in plaster. No doorway excavated, but gradiometry suggests possible entrance in NW corner of structure. Based on excavation and gradiometry, building probably covered external area of 153 m^2 and internal area of 100 m^2. Probably used to store grain in bulk or, perhaps, in perishable containers (e.g. cloth sacks).	Burned barley (2-row, hulled, cleaned), burned mudbricks, rodent skeletons (NISP = 76, MNI = 16), rodent droppings, 2 clay sealings.
Western Structure	Building Unit 4	2.2	General	Storage facility made up of at least 4 rooms, 1 hallway, and 1 external space. Only stone foundations of walls preserved (1.10–1.30 m wide, 10–25 cm above floor level). As excavated, building covered total area of 90.36 m^2 (including 43.75 m^2 of internal space), but entire building may actually have covered area of 200 m^2 (20 × 10 m).	
			Space 1	Storeroom. Extended beyond excavated area. Floor covered in mixture of pebbles and chunks of plaster (5 cm thick). Connected by doorway to Space 2.	At least 10 large, 4 medium, and 2 small storage jars (some upright, some on their side or crushed; one medium jar inside a larger jar, suggesting that they had been stacked). One plaster jar cover or stopper. Several clay sealings.

Table 4.43 (page 2 of 2)
Kazane Höyük
Storage facilities, mid-late third millennium BC, basic info.

Designation	Building Unit	Operation	Space	Description	Contents
Western Structure	Building Unit 4	2.2	Space 2	Storeroom. The top of the debris in the room was articulated, but the debris was not removed. The contents of the room are, therefore, an estimate (e.g. if the jars were originally stacked, there may have been more jars below that were not visible from the top of the debris). Floor covered in mixture of pebbles and chunks of plaster. Connected by doorways to Spaces 1 and 6.	At least 26 large and 4 medium jars (leaving little space in between to move through the room). 2 clay sealings in or beside doorway leading to Space 6.
			Space 3	Storeroom. Long and narrow. Pebble floor. Connected by doorway to Space 5.	7 large storage jars (leaving little room for accessing jars furthest from the entrance).
			Space 4	Southern addition to the Western Structure. Extended beyond excavated area, but gradiometry suggests dimensions of 8 × 10 m, with an interal area of 50 m^2. Thin eastern wall (0.70 m thick) abuts southern wall of Space 3. Floor covered in mixture of pebbles and chunks of plaster. Pit along northern wall contained sherds from large storage jar (probably originally set into floor). Connected by doorway to Space 5.	One large storage jar set into floor (recovered as sherds within pit along northern wall).
			Space 5	Hallway. Extended beyond excavated area, but gradiometry indicates dimensions of 2 × 19 m. Earthen floor. Connected by doorways to Spaces 3, 4, and (possibly) 1.	
			Space 6	Outdoor space between Eastern and Western Structures (but might also have been roofed and/or incorporated within Western Structure). Where exposed, floor of compacted pebbles.	7 large storage jars (standing upright, one containing two-row, hulled barley) and one cooking pot (upturned). Burned mudbrick debris.

SOURCE: Creekmore 2008: 156–163, 252–281

Table 4.44 (page 1 of 2)
Kazane Höyük
Storage facilities, mid-late third millennium BC, storage capacity (Creekmore)

Designation[a]	**Building Unit**	**Space**	**Floor space**	**Depth**	**Volume (total)**	**Storage capacity**	
						Volume (# of large jars)	Barley, threshed
Eastern Structure[b]	Building Unit 5		100.0 m^2	1.0 - 2.0 m	100.0 - 200.0 m^3	100.0 - 200.0 m^3	*44,444 - 100,000 kg*
Western Structure[c]	Building Unit 4	Space 1	23.0 m^2			*1.0 - 2.2 m^3 (10 large jars)*	*444 - 1,100 kg*
		Space 2	24.6 m^2			*2.5 - 5.8 m^3 (26 large jars)*	*1,111 - 2,900 kg*
		Space 3	7.7 m^2			*0.7 - 1.6 m^3 (7 large jars)*	*311 - 800 kg*
		Space 6	?			*0.7 - 1.6 m^3 (7 large jars)*	*311 - 800 kg*
		Spaces 1–3, 6				4.87 - 11.17 m^3 (50 large jars)	*2,164 - 5,585 kg*
Total	Building Units 4–5					104.87 - 211.17 m^3	*46,608 - 105,585 kg*

SOURCE: Creekmore 2008: 157, 160–163, 256–257, 259–261

[a] In this table, values shown in normal type are drawn directly from Creekmore 2008. Values shown in italics do not appear in Creekmore 2008, but they are extrapolated directly from information provided there. The goal is simply to present Creekmore's calculations, so that they can be compared with my own calculations (Table C).

[b] In calculating the storage capacity of the Eastern Structure (Building Unit 5), Creekmore does not use the excavated floor space (i.e. the internal area of the building, as excavated); instead, he estimates the total floor space (100 m^2) of the building (i.e. beyond the excavated area) by drawing on gradiometry data (Creekmore 2008: 157). He also assumes that the grain would have been stored in bulk (i.e. without containers) to a depth of 1–2 m (based on the preserved height of the walls, c. 1 m) (Creekmore 2008: 156, 254, 256). In order to convert storage volume (m^3) to barley, Creekmore, following Hole (1991) and Hunt (1987), assumes that 1000 kg of barley needs 2–2.25 m^3 of storage space (i.e. 1 m^3 of storage space will hold 444.44–500.00 kg of barley). He does not actually show the resulting values (which I have shown here in italics), but these values are implied in his discussion (Creekmore 2008: 256–257, Fig. 7.16).

Table 4.44 (page 2 of 2)
Kazane Höyük
Storage facilities, mid-late third millennium BC, storage capacity (Creekmore)

[c] In calculating the storage capacity of the Western Structure (Building Unit 4), Creekmore does not use floor space (although he does provide floor space measurements and/or estimates for Spaces 1–3, shown here in normal type); instead, he counts (or estimates) the total number of large storage jars uncovered in each Space (i.e. room). Having established a minimum, middle, and maximum value for the volume for these jars (by examining three similar jars from Lidar Höyük), he then calculates a minimum, middle, and maximum storage capacity for the building as a whole (which contained 50 large storage jars) (Creekmore 2008: 258–261). In the table, I have only shown the minumum and maximum (i.e. no "middle"). Creekmore does not calculate a separate storage capacity for each Space, but I have included these calculations in the table (in italics), using his room-by-room count of large storage jars (Creekmore 2008: 159–163). In discussing the storage capacity of the 50 jars, Creekmore does not actually convert storage space (m^3) to barley; instead, he applies a conversion value established in his discussion of Building Unit 5 (the "middle" value, i.e. 100 m^3 of storage space can hold enough barley to feed 225 people for one year) in order to estimate the number of people that could be fed with the stored grain (Creekmore 2008: 261; see Table D). Here, I have included a conversion of storage space into barley (in italics) for each Space and for the building as a whole, by borrowing the conversion values (1000 kg of barley = 2–2.25 m^3 of storage space) used in his discussion of Building Unit 5 (Creekmore 2008: 256–257; see Note 2, above).

Table 4.45 (page 1 of 2)
Kazane Höyük
Storage facilities, mid-late third millennium BC, storage capacity (Paulette)

Designation[a]	**Building Unit**	**Space**	**Floor space**	**Depth**[b]	**Volume (total)**	**Storage capacity**	
						Volume[c]	Barley, threshed[d]
Eastern Structure	Building Unit 5 *(calculations based on total estimated floor space)*[e]		100.0 m^2	2.0 - 3.0 m	200.0 - 300.0 m^3	200.0 - 300.0 m^3 *(150.0 - 225.0 m^3 [s])*	88,880 - 280,380 kg *(66,660 - 210,285 kg)*
Eastern Structure	Building Unit 5 *(calculations based on excavated floor space)*[f]		54.3 m^2	2.0 - 3.0 m	108.6 - 162.9 m^3	108.6 - 162.9 m^3 *(81.5 - 122.2 m^3 [s])*	48,262 - 152,246 kg *(36,219 - 114,208 kg)*
Western Structure	Building Unit 4 *(calculations based on number of large jars per room)*[g]	Space 1 Space 2 Space 3 Space 6 Total	10 large jars 26 large jars 7 large jars 7 large jars 50 large jars			1.0 - 2.2 m^3 2.5 - 5.8 m^3 0.7 - 1.6 m^3 0.7 - 1.6 m^3 4.9 - 11.2 m^3	444 - 2,056 kg 1,111 - 5,421 kg 311 - 1,495 kg 311 - 1,495 kg 2,178 - 10,468 kg
Western Structure	Building Unit 4 *(calculations based on excavated floor space)*[h]	Space 1 Space 2 Space 3 Space 6[k] Total	11.8 m^2 25.2 m^2 9.1 m^2 10.6 m^2 56.7 m^2	2.0 - 3.0 m 2.0 - 3.0 m 2.0 - 3.0 m 2.0 - 3.0 m 2.0 - 3.0 m	23.6 - 35.4 m^3 50.4 - 75.6 m^3 18.2 - 27.3 m^3 21.2 - 31.8 m^3 113.4 - 170.1 m^3	17.7 - 26.6 m^3 [s] 37.8 - 56.7 m^3 [s] 13.7 - 20.5 m^3 [s] 15.9 - 23.9 m^3 [s] 85.1 - 127.7 m^3 [s]	7,866 - 24,860 kg 16,798 - 52,992 kg 6,088 - 19,159 kg 7,066 - 22,337 kg 37,818 - 119,348 kg
Total	Building Units 4–5 (*calculations based on number of large jars and total estimated floor space, respectively)*[i]					204.9 - 311.2 m^3 *(154.9 - 236.2 m^3)*	91,058 - 290,848 kg *(68,838 - 220,753 kg)*
Total	Building Units 4–5 (*calculations based on excavated floor space)*[j]					193.7 - 290.6 m^3 *(166.6 - 249.9 m^3)*	86,080 - 271,595 kg *(74,037 - 233,557 kg)*

SOURCE: Creekmore 2008: 157, 160–163, 256–257, 259–261

[a] I have tried to accomplish two goals in this table. The first is to build on Creekmore's calculations (Creekmore 2008) by borrowing his measurement data (e.g. for floor space and storage jars), adjusting these in places (e.g. his estimates for the depth of storage space), and applying my own conversion values (e.g. for converting storage volume into threshed barley). For each Building Unit and for the Totals at the bottom, the first set of calculations is devoted to this goal. The second goal is to juxtapose Creekmore's measurements with my own, new measurements. To accomplish this, I have used the published plans to measure the interior floor space within the excavated structures, and I have treated these as I have other sites. For each Building Unit and for the Totals at the bottom, the second set of calculations is devoted to this goal.

[b] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters (cf. Creekmore 2008: 254, 256, for an estimate of 1.0–2.0 m).

[c] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[d] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[e] For the first set of calculations for Building Unit 5, I have used Creekmore's estimate for the total interior floor space (100 m^2) of the room (Creekmore 2008: 157), but I have increased the depth from 1.0–2.0 m (Creekmore 2008: 254, 256) to 2.0–3.0 m (to match my calculations for other sites). In the "Storage Capacity" column, I have included an estimate for bulk storage (in normal type) and an estimate for storage in containers (in parentheses and italics). The addition of an estimate for storage in containers seems justified, given the possibility of a doorway in the northwestern (unexcavated) portion of the building (Creekmore 2008: 157).

[f] For the second set of calculations for Building Unit 5, I have used the published plan (Creekmore 2008: Fig. 5.8) to measure the interior floor space of the excavated portion of the building. This leads to a much lower estimate (54.3 m^2) than Creekmore's estimate (100 m^2), which was based partly on gradiometry data. In the "Storage Capacity" column, I have included an estimate for bulk storage (in normal type) and an estimate for storage in containers (in parentheses and italics).

[g] For the first set of calculations for Building Unit 4, I have used Creekmore's estimate for the number of large storage jars in each Space and in the building as a whole, and I have used his minimum and maximum volume estimates for the storage jars. In order to convert storage volume (m^3) to threshed barley (kg), however, I have employed my own conversion values (to match my calculations for other sites).

[h] For the second set of calculations for Building Unit 4, I have not used Creekmore's data regarding storage vessels; instead, I have used the published plan (Creekmore 2008: Fig. 5.8) to measure the interior floor space of each Space that was being used for storage. I have then calculated the total available storage volume and, to account for storage in containers, have reduced this volume by 25 % (see Note 3). This results in a much higher storage capacity estimate than is produced by focusing on the storage jars preserved in situ -- which emphasizes the fact that my calculations for storage in containers (or in bulk) are intended as *maximum* storage capacity estimates. In reality, the actual volume of storage in any particular case may have been much lower.

[i] The first total is based on Creekmore's estimate for the total floor space of Building Unit 5 and Creekmore's estimate for the total volume of the 50 large storage jars identified in situ. In other words, this represents my effort to build on Creekmore's measurements. The storage capacity estimates shown in normal type assume bulk storage of grain in Building Unit 5; those shown in italics assume container storage in Building Unit 5.

[j] The second total is based on my own measurements for the floor space within the excavated portion of Building Unit 5 and the excavated portions of the storage spaces of Building Unit 4 (Spaces 1, 2, 3, and 6). The storage capacity estimates shown in normal type assume bulk storage of grain in Building Unit 5; those shown in italics assume container storage in Building Unit 5

[k] The excavators were unable to establish clear boundaries for Space 6 (Creekmore 2008: 162–163). In calculating the floor space of this area, I have only included the zone where storage jars were recovered in situ (i.e. the zone bounded on the west and south by the walls of Building Unit 4, on the north by the edge of the excavation unit, and on the east by an imaginary line extending northward from the eastern face of the eastern wall of Space 3).

Table 4.46
Kazane Höyük
Number of people that could be fed with stored grain (Creekmore)

Designation	**Building Unit**	**Storage capacity**	**Conversion factors**			**Number of people fed for one year**
			volume = grain	grain per person per	Source	
Eastern Structure	Building Unit 5	100 - 200 m^3	2.25 m^3 = 1000 kg	433 kg	Hole 1991	102 - 205
			2.00 m^3 = 1000 kg	143 kg	Hunt 1987	349 - 699
				222 kg	Hole 1991 / Hunt 1987[b]	225 - 452
Western Structure	Building Unit 4	4.87 - 11.17 m^3	2.00 m^3 = 1000 kg	222 kg	Hole 1991 / Hunt 1987	11 - 25[a]

SOURCE: Creekmore 2008: 256–257, Fig. 7.16

[a] Creekmore actually calculates a range of 2.00–4.96 persons fed per year (Creekmore 2008: 261), but this seems to be a mistake. If, as he suggests, we borrow the "middle-ground figure" achieved during his calculations for Building Unit 5 (100 m^3 of stored grain will feed 225 persons per year, i.e. 1 m^3 will feed 2.25 persons per year), then the range should be 10.96–25.16 persons fed per year (4.87 m^3 × 2.25 persons = 10.96 persons; 11.17 m^3 × 2.25 persons = 25.13 persons). In the table, I have shown the conversion factors that were used to reach the "middle-ground figure" (i.e. 2.00 m^3 = 1000 kg; 222 kg grain per person per year; see Note b).

[b] Creekmore indicates that the conversion values used to calculate a range of 225–452 people fed per year (see Table 7.16, next-to-last row) represent a "middle figure" between the conversion values proposed by Hole (1991) and Hunt (1987). As far as I can tell, the value for converting volume to grain (2 m^3 = 1000 kg) is drawn directly from Hunt, but I am uncertain about the origin of the value for converting grain to people (222 kg per person per year).

Table 4.47 (page 1 of 2)
Kazane Höyük
Number of people that could be fed with stored grain (Paulette)

Designation[c]	**Number of people fed**					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Eastern Structure (Bldg. Unit 5)						
Total estimated floor space	276 - 1,383 *(207 - 1,175)*	138 - 691 *(103 - 588)*	368 - 2,765 *(276 - 2,351)*	184 - 1,383 *(138 - 1,175)*	274 - 822 *(205 - 699)*	137 - 411 *(103 - 349)*
Excavated floor space	150 - 751 *(112 - 638)*	75 - 375 *(56 - 319)*	200 - 1,502 *(150 - 1,276)*	100 - 751 *(75 - 638)*	149 - 446 *(112 - 379)*	74 - 223 *(56 - 190)*
Western Structure (Bldg. Unit 4)						
Number of large jars	7 - 52 *(5 - 44)*	3 - 26 *(3 - 22)*	9 - 103 *(7 - 88)*	5 - 52 *(3 - 44)*	7 - 31 *(5 - 26)*	3 - 15 *(3 - 13)*
Excavated floor space	117 - 589 *(88 - 500)*	59 - 294 *(44 - 250)*	157 - 1,177 *(117 - 1,001)*	78 - 589 *(59 - 500)*	117 - 350 *(87 - 297)*	58 - 175 *(44 - 149)*
Total (Bldg. Units 4 and 5)						
Jars and total est. floor space	283 - 1,434 *(212 - 1,219)*	141 - 717 *(106 - 610)*	377 - 2,869 *(283 - 2,438)*	188 - 1,434 *(141 - 1,219)*	281 - 853 *(211 - 725)*	140 - 426 *(105 - 362)*
Excavated floor space	267 - 1,339 *(200 - 1,138)*	134 - 670 *(100 - 569)*	356 - 2,679 *(267 - 2,277)*	178 - 1,339 *(134 - 1,138)*	265 - 796 *(199 - 677)*	133 - 398 *(100 - 338)*

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

Table 4.47 (page 2 of 2)
Kazane Höyük
Number of people that could be fed with stored grain (Paulette)

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

[e] In this table, I have not included any storage capacity calculations which assume that grain was stored in containers (i.e. not in bulk) within Building Unit 5. This means that the storage capacity estimates that appear in parentheses and italics within Table C have not been converted into estimates for the number of people that could be fed. If I had included these calculations, they would, in each case, have produced smaller values for the number of people fed.

Table 4.48
Kazane Höyük
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume (m^3)	Grain (threshed barley)	1 year		2 years	
				Full range	95% range	Full range	95% range
Mid-late third mil. BC[a]	Mid-late third mil. BC	104.9 - 311.2 m^3	46,608 - 290,848 kg	109 - 2,869	204 - 1,483	54 - 1,434	102 - 741

[a] The simplified storage capacity ranges for the mid-late third millennium BC are drawn from Table 4.44 (minimum from Total, Building Units 4–5) and Table 4.45 (maximum from Total, Building Units 4–5, calculations based on number of large jars and total estimated floor space).

Table 4.49
Kazane Höyük
Percentage of the population that could be fed with stored grain

Level	Date	Population (estimated)	% of population fed			
			1 year		2 years	
			Full range	95% range	Full range	95% range
Mid-late third mil. BC	Mid-late third mil. BC	10,000 - 20,000	1 - 29 %	2 - 11 %	0 - 14 %	1 - 5 %

Table 4.50 (page 1 of 4)
Tell Leilan
Storage facilities, Leilan IIId period, basic info.

Building	Room	Site grid	Location	Stratum	Description[a]	Contents
Building 1	Room 1	44X12	Acropolis NW (W of cultic platform)	16	First phase of Building 1.	Fine ware sherds.
				15e-g	Second phase of Building 1.	2 complete, small jars.
	Room 2	44X12	Acropolis NW (W of cultic platform)	16	First phase of Building 1.	
				15e-g	Second phase of Building 1.	Door sealing (L87-1031) and broken, stone hammer head or mace head.
	Room 3	44X12	Acropolis NW (W of cultic platform)	15e-g	Second phase of Building 1. Partially excavated (in 1987). One floor. According to excavators, used for storage and/or food processing.	"Cooking pot" within niche in wall P was actually used for storage. Two grinding stones on floor.
	Room 4	44X12	Acropolis NW (W of cultic platform)	15e-g (Floor 1)	Second phase of Building 1. Partially excavated (in 1987).	Door sealing (L87-1132) on floor.
				15e-g (Floor 2)	Second phase of Building 1. Partially excavated (in 1987). At Floor 2, room was subdivided by narrow brick wall, creating Room 5 and reducing size of Room 4.	Collapsed hearth on floor. More animal bones than other rooms. Small number of sherds.
	Room 5	44X12	Acropolis NW (W of cultic platform)	15e-g (Floor 2)	Second phase of Building 1. Partially excavated (in 1987). Room created when Room 4 was subdivided by narrow brick wall.	More animal bones than other rooms. Small number of sherds.

Table 4.50 (page 2 of 4)
Tell Leilan
Storage facilities, Leilan IIId period, basic info.

Building	Room	Site grid	Location	Stratum	Description	Contents
Building 1	Room 6	44X12	Acropolis NW (W of cultic platform)	15e-g (Floor 4)	Second phase of Building 1. Four floors (Floors 1-4, latest to earliest), all ashy and black with abundant organic material.	Smaller storage vessel (no. 2) dug into floor (5–10 cm) and 3 decorated sealings (L87-1034, L87-1035, L87-1036).
				15e-g (Floor 3)	Second phase of Building 1. Four floors (Floors 1-4, latest to earliest), all ashy and black with abundant organic material.	Smaller storage vessel (no. 2), jar (in niche), and decorated sealing (L87-1032).
				15e-g (Floor 2)	Second phase of Building 1. Four floors (Floors 1-4, latest to earliest), all ashy and black with abundant organic material.	Large storage vessel (no. 1) and large grinding stone.
				15e-g (Floor 1)	Second phase of Building 1. Four floors (Floors 1-4, latest to earliest), all ashy and black with abundant organic material.	Large storage vessel (no. 1) and grinding stone.
	Room 7	44X12	Acropolis NW (W of cultic platform)	15e-g	Second phase of Building 1. Partially excavated (in 1987). One floor.	

Table 4.50 (page 3 of 4)
Tell Leilan
Storage facilities, Leilan IIId period, basic info.

Building	Room	Site grid	Location	Stratum	Description	Contents
Building 1	Room 8	44X12	Acropolis NW (W of cultic platform)	15e-g (Floor 4)	Second phase of Building 1. Partially excavated (in 1987). Four floors (Floors 1-4, latest to earliest), all ashy and gray with little organic material.	Very little pottery, one sealing (L87-1508).
				15e-g (Floor 3)	Second phase of Building 1. Partially excavated (in 1987). Four floors (Floors 1-4, latest to earliest), all ashy and gray with little organic material.	
				15e-g (Floor 2)	Second phase of Building 1. Partially excavated (in 1987). Four floors (Floors 1-4, latest to earliest), all ashy and gray with little organic material.	Large amount of pottery and complete vessels, one sealing (L87-1030).
				15e-g (Floor 1)	Second phase of Building 1. Partially excavated (in 1987). Four floors (Floors 1-4, latest to earliest), all ashy and gray with little organic material. At Floor 1, room was subdivided by partition wall, creating Room 9 and reducing size of Room 8.	
	Room 9	44X12	Acropolis NW (W of cultic platform)	15e-g (Floor 1)	Second phase of Building 1. Partially excavated. Room created when Room 8 was subdivided by partition wall.	

Table 4.50 (page 4 of 4)
Tell Leilan
Storage facilities, Leilan IIId period, basic info.

Building	Room	Site grid	Location	Stratum	Description	Contents
Building 2	Room 1	44W12	Acropolis NW (W of cultic platform)	16	Partially excavated.	
				15b/c	Partially excavated. In stratum 15b/c, Room 1 was subdivided, creating Room 2 and reducing size of Room 1.	
	Room 2	44W12	Acropolis NW (W of cultic platform)	15b/c	Room created when Room 1 was subdivided.	
	Room 3	44W12	Acropolis NW (W of cultic platform)	16b	Partially excavated. Probably a doorway to the west of wall G.	Several sherds of large storage vessels. Large, corrugated pottery stand on floor.
				15b/c	Partially excavated.	

SOURCE: Calderone and Weiss 2003

[a] The area to the west of the cultic platform on the Acropolis was excavated in 1987 and 1989, but, as far as I am aware, only the 1987 excavations have been published, with some notes about the 1989 season (Calderone and Weiss 2003).

Table 4.51
Tell Leilan
Storage facilities, Leilan IIa period, basic info.

Designation	Site grid	Location	Description	Contents
Room 1	?	Acropolis NW (W face of cultic platform)	Grain bin. Plastered walls.	Thick layer of clean, charred barley (with small % of emmer wheat) covering floor.
?	?	Acropolis NW (W face of cultic platform)	Storeroom. Grain stored in ceramic vessels.	Significant amount of barley on floor. 6 large storage vessels.
?	?	Acropolis NW (W face of cultic platform)	Storeroom. Grain stored in ceramic vessels.	Significant amount of barley on floor.
Large storage jar	?	Acropolis NW (W of cultic platform)	It is unclear whether this vessel was found within one of the three storerooms along the western face of the cultic platform or elsewhere (e.g. in the adjacent corridors or courtyard).	Filled with emmer wheat and barley in ratio of 3:1 and significant amount of emmer chaff.
Area west of cultic platform	44W12, 44X12, etc.	Acropolis NW (W of cultic platform)	Storage zone, including line of three storerooms (see above) and adjacent corridors and courtyard.	60 clay sealings and 2 cylinder seals. Proportion of grain, chaff, and weeds in archaeobotanical assemblage indicates storage of partially cleaned grain.
Building 8, Phase 7, storage room	76E20, 76F20	Lower Town South (W of street)	Storage room within domestic structure.	10 ceramic vessels.

SOURCES: Weiss 1990; Weiss 1997a; Weiss et al. 2002–2003

Table 4.52 (page 1 of 2)
Tell Leilan
Storage facilities, Leilan IIb period, basic info.

Designation	Date	Site grid	Location	Description	Contents
Granary	IIb2–1	44T15, 44T16	Acropolis NW (Akkadian Administrative Building)	Square room, c. 3 x 3 m (exterior?). Built of mudbrick, but lined on interior (floor and walls) with baked brick. Uppermost course of baked brick included series of holes (probably flues, promoting air circulation).	Lenses of cereal grain ash: two-row barley, emmer wheat, bread wheat, durum wheat, and goat grass (Aegilops). Crops had been threshed and winnowed but not further cleaned.
Conical grain bin	IIb2	44W17	Acropolis NW (S of street)	90 cm deep. Between 70 cm (base) and 40 cm (rim) in diameter. Clay walls 4 cm thick. Lined on interior (base and walls) with reed matting. Top left open. Opening 6 cm wide and 5 cm high at floor level. Excavators interpret as grain bin, but also seems to resemble a tannur.	Base of bin covered in 10-cm-thick layer of ash and charcoal. Rest of bin filled with hard, compact deposit that included cereal grains.
Clay storage bin	IIb1	44W16	Acropolis NW (S of street)	Approximately square, c. 1.15 × 1.20 m (exterior). 90 cm deep (60 cm above ground, 30 cm below ground). Clay walls 10–15 cm thick (E and W) and 20 cm thick (N and S) were glazed by firing on interior and showed further signs of burning.	Among other items, seal impression (L99-27) showing "women in the act of storing goods."
Jar (L99-181)	IIb1	44W16	Acropolis NW (street)		Full of burned grain.

Table 4.52 (page 2 of 2)
Tell Leilan
Storage facilities, Leilan IIb period, basic info.

Designation	Date	Site grid	Location	Description	Contents
Building 6, Phase 5	IIb	76E19	Lower Town South (W of street)	House that included a collection of "grain storage bins or bread kilns." No detailed descriptions provided, but image on Tell Leilan Project website shows installation that looks like either a conical storage bin or tannur.	

SOURCES: Weiss 1990: 200–203; Weiss 2007; Ristvet et al. 2004: 11; de Lillis Forrest et al. 2007; Weiss et al. 2002–2003: 61–62; Weiss et al. 2012: 166–175; Smith 2012: 230–231

Table 4.53 (page 1 of 2)
Tell Leilan
Storage facilities, Leilan IIId period, storage capacity

Building	Room[d]	Stratum	Floor space	Depth[a]	Volume (total)	Storage capacity: Volume[b]	Storage capacity: Barley, threshed[c]
Building 1	Room 1	16 / 15e-g	6.3 m²	2.0 - 3.0 m	12.6 - 18.9 m³	9.5 - 14.2 m³ [s]	4,222 - 13,271 kg
	Room 2	16 / 15e-g	3.6 m²	2.0 - 3.0 m	7.2 - 10.8 m³	5.4 - 8.1 m³ [s]	2,400 - 7,570 kg
	Room 3	15e-g	1.9 m²	2.0 - 3.0 m	3.8 - 5.7 m³	2.9 - 4.3 m³ [s]	1,289 - 4,019 kg
	Room 4	15e-g (Floor 1)	1.7 m²	2.0 - 3.0 m	3.4 - 5.1 m³	2.6 - 3.8 m³ [s]	1,155 - 3,551 kg
		15e-g (Floor 2)	0.8 m²	2.0 - 3.0 m	1.6 - 2.4 m³	1.2 - 1.8 m³ [s]	533 - 1,682 kg
	Room 5	15e-g (Floor 2)	0.8 m²	2.0 - 3.0 m	1.6 - 2.4 m³	1.2 - 1.8 m³ [s]	533 - 1,682 kg
	Room 6	15e-g (Floors 1-4)	6.6 m²	2.0 - 3.0 m	13.2 - 19.8 m³	9.9 - 14.9 m³ [s]	4,400 - 13,926 kg
	Room 7	15e-g	2.1 m²	2.0 - 3.0 m	4.2 - 6.3 m³	3.2 - 4.7 m³ [s]	1,422 - 4,393 kg
	Room 8	15e-g (Floors 2-4)	1.9 m²	2.0 - 3.0 m	3.8 - 5.7 m³	2.9 - 4.3 m³ [s]	1,289 - 4,019 kg
		15e-g (Floor 1)	1.1 m²	2.0 - 3.0 m	2.2 - 3.3 m³	1.7 - 2.5 m³ [s]	755 - 2,337 kg
	Room 9	15e-g (Floor 1)	0.5 m²	2.0 - 3.0 m	1.0 - 1.5 m³	0.8 - 1.1 m³ [s]	356 - 1,028 kg
Building 2	Room 1	16	4.4 m²	2.0 - 3.0 m	8.8 - 13.2 m³	6.6 - 9.9 m³ [s]	2,933 - 9,253 kg
		15b/c	2.9 m²	2.0 - 3.0 m	5.8 - 8.7 m³	4.4 - 6.5 m³ [s]	1,955 - 6,075 kg
	Room 2	15b/c	1.0 m²	2.0 - 3.0 m	2.0 - 3.0 m³	1.5 - 2.3 m³ [s]	667 - 2,150 kg
	Room 3	16b / 15b/c	4.1 m²	2.0 - 3.0 m	8.2 - 12.3 m³	6.2 - 9.2 m³ [s]	2,755 - 8,598 kg
Building 1	All rooms	16	9.9 m²		19.8 - 29.7 m³	14.9 - 22.3 m³ [s]	6,622 - 20,842 kg
		15e-g	23.7 - 24.1 m²		47.4 - 72.3 m³	35.8 - 54.3 m³ [s]	15,910 - 50,749 kg
Building 2	All rooms	16 / 16b	8.5 m²		17.0 - 25.5 m³	12.8 - 19.1 m³ [s]	5,688 - 17,851 kg
		15b/c	8.0 m²		16.0 - 24.0 m³	12.1 - 18.0 m³ [s]	5,377 - 16,823 kg
Total	All rooms	16 / 16b	18.4 m²		36.8 - 55.2 m³	27.7 - 41.4 m³ [s]	12,310 - 38,692 kg
		15e-g / 15b/c	31.7 - 32.1 m²		63.4 - 96.3 m³	47.9 - 72.3 m³ [s]	21,287 - 67,572 kg

SOURCE: Calderone and Weiss 2003: 195–198, Fig. 3

Table 4.53 (page 2 of 2)
Tell Leilan
Storage facilities, Leilan IIId period, storage capacity

[a] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[d] I see no clear evidence that any of the rooms included in this chart served as dedicated storage facilities. The storage capacities shown here should be considered a hypothetical case, demonstrating the storage capacity that would have been available if these rooms had been used solely for storage.

Table 4.54
Tell Leilan
Storage facilities, Leilan IIb period, storage capacity

Designation	Date	Floor space	Depth	Volume (total)	Storage capacity	
					Volume	Barley, threshed[d]
Granary[a]	IIb2–1	3.6 m^2	2.0 - 3.0 m	7.2 - 10.8 m^3	7.2 - 10.8 m^3	3,200 - 10,094 kg
Conical grain bin[b]	IIb2	0.3 m^2	0.9 m	0.2 m^3	0.2 m^3	89 - 187 kg
Clay storage bin[c]	IIb1	1.0 m^2	0.9 m	0.9 m^3	0.9 m^3	400 - 841 kg
Total	IIb2			7.4 - 11.0 m^3	7.4 - 11.0 m^3	3,289 - 10,281 kg
Total	IIb1			8.1 - 11.7 m^3	8.1 - 11.7 m^3	3,600 - 10,935 kg

[a] According to the publications (Weiss et al. 2012: 169; Smith 2012: 230), the Granary measured 3 × 3 m (i.e. 9 m^2). This appear to be an estimate for the external dimensions of the structure (erring on the high side). Using the published plan (Weiss et al. 2012: Fig. 5), I estimate the interior dimensions as c. 1.8 × 1.9 m and the total interior floor space as 3.6 m^2. There is no clear means of estimating the depth of stored grain (the height of the ventilation holes might provide some indication, but this height has not been published). I have assumed that the grain was stored to a depth of 2.0–3.0 m.

[b] According to the publication (de Lillis Forrest et al. 2007: 48–49), the conical grain bin was 90 cm high, 70 cm in diameter at the base, and 40 cm in diameter at the rim. Based on comparison with the square storage bin, also described in this same publication (de Lillis Forrest et al. 2007: 50–51), I have assumed that these are the exterior dimenions. Because the walls were 4 cm thick, the interior dimenions would be as follows: 90 cm high, 62 cm in diameter at the base, and 32 cm in diameter at the base. The floor space (at ground level) would, therefore, have been c. 0.3 m^2 (area of circle = $\pi\ 0.31^2 \approx 0.302$), and the interior volume would have been c. 0.2 m^3 (volume of circular truncated cone = $1/3\pi\ (0.31^2 + 0.31 \times 0.17 + 0.17^2)\ 0.90 \approx 0.167$).

[c] According to the publication (de Lillis Forrest et al. 2007: 50–51), the clay storage bin measured 1.15 × 1.20 m (i.e. c. 1.4 m^2) and was c. 90 cm deep. Using the published plan (Le Lillis Forrest et al. 2007: 50), I estimate the interior dimensions as c. 1.0 × 1.0 m (i.e. 1.0 m^2). These measurements match the published measurements, if the publication is describing the exterior dimenions of the structure, which seems to be the case (given that the E and W walls were described as 10–15 cm thick and the N and S walls 20 cm thick). I have, therefore, estimated the interior volume of the bin as 0.9 m^3 (i.e. 1.0 m^2 × 0.9 m).

[d] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

Table 4.55 (page 1 of 2)
Tell Leilan
Number of people that could be fed with stored grain

Designation	**Number of people fed**					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Leilan IIId (Acropolis)						
Building 1 (str. 16)	21 - 103	10 - 51	27 - 206	14 - 103	20 - 61	10 - 31
	(15 - 87)	*(8 - 44)*	*(21 - 175)*	*(10 - 87)*	*(15 - 52)*	*(8 - 26)*
Building 1 (str. 15e-g)	49 - 250	25 - 125	66 - 501	33 - 250	49 - 149	25 - 74
	(37 - 213)	*(19 - 106)*	*(49 - 425)*	*(25 - 213)*	*(37 - 126)*	*(18 - 63)*
Building 2 (str. 16 / 16b)	18 - 88	9 - 44	24 - 176	12 - 88	18 - 52	9 - 26
	(13 - 75)	*(7 - 37)*	*(18 - 150)*	*(9 - 75)*	*(13 - 44)*	*(7 - 22)*
Building 2 (str. 15b/c)	17 - 83	8 - 41	22 - 166	11 - 83	17 - 49	8 - 25
	(13 - 71)	*(6 - 35)*	*(17 - 141)*	*(8 - 71)*	*(12 - 42)*	*(6 - 21)*
Total (str. 16 / 16b)	38 - 191	19 - 95	51 - 382	25 - 191	38 - 113	19 - 57
	(29 - 162)	*(14 - 81)*	*(38 - 324)*	*(19 - 162)*	*(28 - 96)*	*(14 - 48)*
Total (str. 15e-g / 15b/c)	66 - 333	33 - 167	88 - 666	44 - 333	66 - 198	33 - 99
	(50 - 283)	*(25 - 142)*	*(66 - 566)*	*(33 - 283)*	*(49 - 168)*	*(25 - 84)*
Leilan IIb (Acropolis)						
Granary	10 - 50	5 - 25	13 - 100	7 - 50	10 - 30	5 - 15
	(7 - 42)	*(4 - 21)*	*(10 - 85)*	*(5 - 42)*	*(7 - 25)*	*(4 - 13)*
Conical grain bin	0 - 1	0 - 0	0 - 2	0 - 1	0 - 1	0 - 0
	(0 - 1)	*(0 - 0)*	*(0 - 2)*	*(0 - 1)*	*(0 - 0)*	*(0 - 0)*
Clay storage bin	1 - 4	1 - 2	2 - 8	1 - 4	1 - 2	1 - 1
	(1 - 4)	*(0 - 2)*	*(1 - 7)*	*(1 - 4)*	*(1 - 2)*	*(0 - 1)*
Total (IIb2)	10 - 51	5 - 25	14 - 101	7 - 51	10 - 30	5 - 15
	(8 - 43)	*(4 - 22)*	*(10 - 86)*	*(5 - 43)*	*(8 - 26)*	*(4 - 13)*
Total (IIb1)	11 - 54	6 - 27	15 - 108	7 - 54	11 - 32	6 - 16
	(8 - 46)	*(4 - 23)*	*(11 - 92)*	*(6 - 46)*	*(8 - 27)*	*(4 - 14)*

Table 4.55 (page 2 of 2)
Tell Leilan
Number of people that could be fed with stored grain

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 4.56
Tell Leilan
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume (m^3)	Grain (threshed barley)	1 year		2 years	
				Full range	95% range	Full range	95% range
IIId[a]	Late Nin. 5	27.7 - 72.3 m^3	12,310 - 67,572 kg	29 - 666	53 - 292	14 - 333	26 - 146
IIb2[b]	Akkadian	7.4 - 11.0 m^3	3,289 - 10,281 kg	8 - 101	13 - 54	4 - 51	7 - 27
IIb1[c]	Akkadian	8.1 - 11.7 m^3	3,600 - 10,935 kg	8 - 108	14 - 57	4 - 54	7 - 28

[a] The simplified storage capacity ranges for Level IIId are drawn from Table 4.53 (minimum from Total, stratum 16 / 16b; maximum from Total, stratum 15e-g / 15b/c).

[b] The simplified storage capacity ranges for Level IIb2 are drawn from Table 4.54 (Total, Level IIb2).

[c] The simplified storage capacity ranges for Level IIb1 are drawn from Table 4.54 (Total, Level IIb1).

Table 4.57
Tell Leilan
Percentage of the population that could be fed with stored grain

Level	Date	Population (estimated)	% of population fed			
			1 year		2 years	
			Full range	95% range	Full range	95% range
IIId	Late Nin. 5	5,400 - 18,000	0 - 12 %	0 - 3 %	0 - 6 %	0 - 2 %
IIb2	Akkadian	5,400 - 18,000	0 - 2 %	0 - 1 %	0 - 1 %	0 - 0 %
IIb1	Akkadian	5,400 - 18,000	0 - 2 %	0 - 1 %	0 - 1 %	0 - 0 %

Table 4.58
Tell al-Raqa'i
Levels 5-7 (early-mid Ninevite 5), Grill Buildings, basic info.

Designation	Location	Description
Grill Building 1	Below and west of area 1 silo (Level 4)	Two parallel walls (30-32 cm wide) separated by space (30 cm wide), uncovered within 2.1 m^2 unit (below area 1 silo) in 1990. Top of another wall exposed in 1993 (west of area 1 silo, along 101 N-S axis).
Grill Building 2	Below southern entrance to Level 4 Rounded Building (Excavation units 42/114, 42/116, and 60/120)	A single narrow space defined by three walls (each c. 30 cm wide). Separated from Grill Building 3 to the south by an alley.
Grill Building 3	Excavation units 42/114, 42/116, and 60/120	Three groups of parallel walls (30 cm wide). First, oriented NE-SW. Second, oriented NW-SE. Third, heavily damaged, oriented NW-SE. Separated from Grill Building 2 to the north by an alley. Adjacent to probable domestic architecture.
Grill Building 4 (Early Phase)	Excavation unit 36/120 (deep sounding), above virgin soil	Virtually complete grill segment. Three parallel walls (each 2.1 m long, 30 cm wide). Adjacent to probable domestic architecture.
Grill Building 4 (Middle Phase)	Excavation units 36/120 (deep sounding) and 42/114 North (trench along 43 E-W axis)	Heavily damaged. Two parallel walls (30 cm wide) separated by space (30 cm wide). Adjacent to several large ovens.
Grill Building 4 (Late Phase)	Excavation unit 36/120 (deep sounding)	Two parallel walls (30 cm wide), covered with one course of mudbricks (perhaps base of superstructure).
Grill Building 5	Bottom of excavation unit 29/136 (step trench on west slope), on virgin soil	Two parallel walls (30 cm wide), oriented SE-SW, separated by narrow space, uncovered within small exposure (80 cm wide).

SOURCES: Schwartz and Curvers 1992: 415-416; 1993/1994: 247-248

Table 4.59 (page 1 of 2)
Tell al-Raqa'i
Level 4 (mid-late Ninevite 5), storage facilities, basic info.

Designation	Location	Description
Area 1	Rounded Bldg. (SE quadrant)	Silo with corbel-vaulted roof. Depth 4 m. Window (39 × 31-36 cm) in NW wall just below ceiling. Roof supported by vaulted buttress in NE corner of room. Segments of vaulted ceiling preserved in W corner of room. Fill included hundreds of stone balls (3-15 cm diameter).
Area 2	Rounded Bldg. (SE quadrant)	Silo with corbeled vaulted roof.
Area 6	Rounded Bldg. (SW quadrant)	Room with corbeled-arch doorways (later blocked, perhaps to transform room into a silo). Only entry into Rounded Building.
Area 7	Rounded Bldg. (SW quadrant)	Silo with corbel-vaulted roof. Vault (9 brick courses) extending out from NE wall met buttress extending out from SW wall.
Area 9	Rounded Bldg. (SW quadrant)	Room with corbeled-arch doorway (later blocked, perhaps to transform room into a silo). Fill included fragment of painted wall plaster on mudbrick fragment (showing human figure with short skirt).
Area 10	Rounded Bldg. (SW quadrant)	Room with corbeled-arch doorways (later blocked, perhaps to transform room into a silo).
Area 11	Rounded Bldg. (SW quadrant)	Room with corbeled-arch doorway (later blocked, perhaps to transform room into a silo).
Area 12	Rounded Bldg. (SW quadrant)	Room with corbeled-arch doorways (later blocked, perhaps to transform room into a silo).
Area 19	Rounded Bldg. (NE quadrant)	Rectangular mudbrick silo. Adjacent to ovens and mudbrick platform. Square mubrick block to the SW, possibly a step.
Area 20	Rounded Bldg. (NE quadrant)	Rectangular mudbrick silo. Adjacent to ovens and mudbrick platform. Square mubrick block to the SW, possibly a step. Filled with cooking ware sherds.
Area 21	Rounded Bldg. (NE quadrant)	Silo with corbel-vaulted roof. High vault (1.4 m) extending down in gradual incline. Excavation halted due to cracking.
Area 27	Rounded Bldg. (SE quadrant)	Silo with corbeled vaulted roof.
Area 51	NW Area	Semi-subterranean mudbrick silo. Vaulted ceiling with vaulted buttresses in two corners of the room.
Area 52	NW Area	Semi-subterranean mudbrick silo.
Area 53	NW Area	Semi-subterranean mudbrick silo.
Area 56	NW Area	Semi-subterranen mudbrick silo. Dimensions 1.5 × 2.5 m. Reused in Level 3 (Area 6).

Table 4.59 (page 2 of 2)
Tell al-Raqa'i
Level 4 (mid-late Ninevite 5), storage facilities, basic info.

Designation	Location	Description
Area 57	NW Area	Semi-subterranean mudbrick silo. Dimensions 2.2 × 2.5 m. Accessed via arched window just below top (as preserved) of NW wall. Reused in Level 3 (Area 5).
Area 58	NW Area	Semi(?)-subterranean mudbrick silo. Ledge (extra row of mudbricks) projecting from NW and SE walls. Reused in Level 3 (Area 4).
Area 59	NW Area	Semi-subterranean mudbrick silo?
Grill Building 6	N slope of tell (Exc. unit 29/120)	Three parallel walls (c. 30 cm wide, 2.1 m long). Fill between walls green, soft soil. Room to S included tannur and, later, large oven. Door socket against SE wall of grill building might indicate superstructure (no longer preserved) accessed through doorway from room with tannur/oven.

SOURCES: Curvers and Schwartz 1990: 11; Schwartz and Curvers 1992: 406-415; 1993/1994: 250; Schwartz and Curvers 1993/1994: 250-251, Abb. 74; Schwartz 1994b: 23-24

Table 4.60
Tell al-Raqa'i
Level 3 (end of Ninevite 5), storage facilities, basic info.

Designation	Location	Description
Area 4	NW Area	Semi-subterranean, rectangular mudbrick silo. Constructed in Level 4 (Area 58). During Level 3, floor constructed c. 1.5 m above Level 4 floor, with two mudbrick steps leading to Area 5 silo via opening in NW wall (opening later filled in with bricks).
Area 5	NW Area	Subterranean, rectangular mudbrick silo. Dimensions 2.2 × 2.5 m, at least 3 m deep. Accessed via opening in SE wall. Construced in Level 4 (Area 57; originally accessed via arched window in NW wall, which extended 20 cm below adjacent Level 3 surfaces and was filled in during Level 3).
Area 6	NW Area	Semi-subterranean, rectangular mudbrick silo. Dimensions 1.5 × 2.5 m. Two pairs of arched, interior buttresses. Accessed from courtyard (Area 7) via stairway against W wall. Constructed in Level 4 (Area 56).
Grill architecture, Rounded Building	Rounded Bldg. (N half)	Two freestanding parallel walls (one mubrick wide). In later phase, mudbrick floor constructed on top of walls.

SOURCES: Curvers and Schwartz 1990: 11-12; Schwartz and Curvers 1993/1994: 252

Table 4.61
Tell al-Raqa'i
Level 4, Total storage capacity compared with population

	Storage capacity (volume)[a]	**Number of people supported with stored grain**[b] (for 1 year)	**Population of settlement**[c]	**Percentage of population supported with stored grain**[d] (for 1 year)
Schwartz	150 m^3	154 - 524 people	20 - 60 people	257 - 2,620 %
Pfälzner	150 m^3	150 - 500 people	85 - 200 people	75 - 588 %
	37.5 m^3	38 - 125 people	85 - 200 people	19 - 147 %

SOURCES: Schwartz 1994b: 25-28; Pfälzner 2002: 269-271

[a] Schwartz estimates a total volume of approximately 125 m^3 for the silos in the Round Building and the NW Area, as well as an additional 50 m^3, if the rooms in the southwestern part of the Rounded Building were also being used as silos (after the blocking of their doorways). This would produce a total of 175 m^3, but Schwartz employs a value of 150 m^3 for his further calculations (perhaps to account for uncertainty about the use of the southwestern rooms?). Pfälzner provides one calculation using the volume suggested by Schwartz (150 m^3) and one that reduces this value (37.5 m^3) in order to account for the fact that the storerooms may typically have only been half full (i.e. 150 $m^3 \div 2 = 75$ m^3) and that some storerooms may have been used to store products other than grain (i.e. 75 $m^3 \div 2 = 37.5$ m^3).

[b] Schwartz: 150 m^3 = 66,667 kg grain (if 2.25 m^3 = 1,000 kg grain) = 154 people (if each person needs 433 kg grain per year) or, alternatively, 150 m^3 = 75,000 kg grain (if 2.0 m^3 = 1,000 kg grain) = 524 people (if each person needs 143 kg grain per year). Pfälzner: 150 m^3 = 150-500 people (according to Schwartz, values rounded off by Pfälzner) or, alternatively, 37.5 m^3 = 38-125 people (if the values calculated by Schwartz and rounded off by Pfälzner are divided by four).

[c] Schwartz: 0.3 ha (estimated occupied area) × 100-200 persons per ha = 30-60 people or, alternatively, 200-300 m^2 total estimated living space ÷ 10 m^2 (or 6 m^2) per person = 20-30 (or 33-50) people. Pfälzner: 17 houses (excavated in Level 3) × 5-6 persons per nuclear family = 85-102 people or, alternatively, 17 houses (excavated in Level 3) × 5-6 persons per nuclear family × 2 (to account for the unpreserved southern half of the settlement) = 170-200 people.

[d] These percentages are my own calculations, based solely on the values provided in the current table. Schwartz: 154 ÷ 60 = 257 % and 524 ÷ 20 = 2,620 %. Pfälzner: 150 ÷ 200 = 75 % and 500 ÷ 85 = 588 %. Also, 38 ÷ 200 = 19 % and 125 ÷ 85 = 147 %.

Table 4.62
Tell al-Raqa'i
Level 4, Total storage capacity compared with land and labor requirements

	Storage capacity[a]		**Land needed to produce stored grain**[b]	**Population of settlement**[c]	**Land cultivated per person per year to produce stored grain**[d]	**Land available in vicinity of settlement**
	Volume	Grain				
Schwartz	150 m^3	75,000 kg	60 - 250 ha	20 - 60 people		300 ha
Hole				30 - 50 people	1.2 - 8.3 ha	47 ha

SOURCES: Schwartz 1994b: 25-28; Hole 1999: 275-276

[a] Schwartz (1994b: 25-28, citing Hunt 1987): 150 m^3 = 75,000 kg grain (if 2.0 m^3 = 1,000 kg grain). Hole also employs this figure, although elsewhere (1991: 24) he suggests a different conversion factor (2.25 m^3 = 1,000 kg grain), which is also cited by Schwartz (1994b: 25).

[b] Schwartz (1994b: 28): 75,000 kg grain ÷ 1,254 kg grain per ha (yield at pre-Sargonic Girsu, Adams 1981: 86) = 60 ha or, alternatively, 75,000 kg grain ÷ 300 kg grain per ha (yield in modern Biqa' Valley, Marfoe 1979: 5).

[c] For Schwartz's calculation, see Table E. Hole is restating the value calculated by Schwartz but restricting the range somewhat.

[d] This calculation is not provided directly but is implied by Hole (1999: 275): 60 ha ÷ 50 people = 1.2 ha per person or, alternatively, 250 ha ÷ 30 people = 8.3 ha per person. Hole considers this to be an unrealistic requirement, while Schwartz (1994b: 33, Note 6), citing several sources, argues that a range of 1.6 - 4 ha per person per year is common.

Table 4.63
Tell al-Raqa'i
Levels 5-7 (early-mid Ninevite 5), estimated storage capacity

Designation	Interior dimensions[a]	Floor space[b]	Depth[c]	Volume	Storage capacity: Volume	Storage capacity: Barley, threshed[e]
Grill Building 1	?	?	?	?	?	?
Grill Building 2	1.3 × 0.5 m	0.6 m^2	2.0 - 3.0 m	1.2 - 1.8 m^3	1.2 - 1.8 m^3	533 - 1,682 kg
Grill Building 3						
(SE segment)	*(2.2 × 1.1 m)*	*(2.5 m^2)*	*(2.0 - 3.0 m)*	*(5.0 - 7.5 m^3)*	*(5.0 - 7.5 m^3)*	*(2,222 - 7,010 kg)*
(central segment)	*(2.1 × 1.3 m)*	*(2.7 m^2)*	*(2.0 - 3.0 m)*	*(5.4 - 8.1 m^3)*	*(5.4 - 8.1 m^3)*	*(2,400 - 7,570 kg)*
(NW segment)	*(2.1 × 1.3 m)*	*(2.8 m^2)*	*(2.0 - 3.0 m)*	*(5.6 - 8.4 m^3)*	*(5.6 - 8.4 m^3)*	*(2,489 - 7,851 kg)*
Total				16.0 - 24.0 m^3	16.0 - 24.0 m^3	7,110 - 22,430 kg
Grill Building 4 *Early Phase*	2.3 × 1.5 m	3.6 m^2	2.0 - 3.0 m	7.2 - 10.8 m^3	7.2 - 10.8 m^3	3,200 - 10,094 kg
Grill Building 4 *Middle Phase*	1.1 × 0.3 m	0.3 m^2	2.0 - 3.0 m	0.6 - 0.9 m^3	0.6 - 0.9 m^3	267 - 841 kg
Grill Building 4 *Later Phase*	1.4 × 0.3 m	0.4 m^2	2.0 - 3.0 m	0.8 - 1.2 m^3	0.8 - 1.2 m^3	356 - 1122 kg
Grill Building 5	?	?	?	?	?	?

Total *(including Grill Building 4, Early Phase)*[d]		24.4 - 36.6 m^3	10,843 - 34,206 kg
Total *(including Grill Building 4, Middle Phase)*		17.8 - 26.7 m^3	7,910 - 24,954 kg
Total *(including Grill Building 4, Late Phase)*		18.0 - 27.0 m^3	7,999 - 25,234 kg

SOURCE: Schwartz and Curvers 1993/1994: 247-249

[a] As measured on published plans: interior dimensions = approximate dimensions of the area defined by the outermost edges of the outermost spaces between the parallel walls; in other words, the outermost walls defining each grill building are not included in the measurement.

[b] As measured on published plans: floor space = the area defined by the outermost edges of the outermost spaces between the parallel walls; in other words, the outermost walls defining each grill building are not included in the measurement. This value was not reached by multiplying the approximate length and width of each grill building (also included in this table) but was, instead, measured directly on the plans. In the case of Grill Building 4 (Early Phase), whose original extent can be confidently reconstructed (despite the fact that the eastern corner of the building does not appear on the plan), an estimate for the full extent of the original interior space is employed.

[c] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[d] The excavators have not suggested that Levels 5-7 (always discussed together as a unit) can be divided, across the board, into an Early, Middle, and Late Phase. I have, however, provided three different totals in order to account for changes in the volume of Grill Building 4.

[e] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

Table 4.64 (page 1 of 2)
Tell al-Raqa'i
Level 4 (mid-late Ninevite 5), estimated storage capacity

Designation	Location	Floor space	Depth	Volume	Storage capacity	
					Volume	Barley, threshed[c]
Area 1	Rounded Bldg.					
(Lower)		*(5.2 m²)*	*(2.5 m)*	*(13.0 m³)*	*(13.0 m³)*	*(5,777 - 12,150 kg)*
(Upper)		*(4.6 m²)*	*(1.0 m)*	*(4.6 m³)*	*(4.6 m³)*	*(2,044 - 4,299 kg)*
Total				17.6 m³	17.6 m³	7,821 - 16,449 kg
Area 2	Rounded Bldg.					
(Lower)		*(3.7 m²)*	*(2.5 m)*	*(9.3 m³)*	*(9.3 m³)*	*(4,133 - 8,692 kg)*
(Upper)		*(3.4 m²)*	*(1.0 m)*	*3.4 m³*	*3.4 m³*	*(1,511 - 3,178 kg)*
Total				12.7 m³	12.7 m³	5,644 - 11,869 kg
Area 6	Rounded Bldg.	1.6 m²	1.7 m	2.7 m³	2.7 m³	
Area 7	Rounded Bldg.					
(Lower)		*(2.3 m²)*	*(1.9 m)*	*(4.4 m³)*	*(4.4 m³)*	*(1,955 - 4,112 kg)*
(Upper)		*(1.6 m²)*	*(0.7 m)*	*(1.1 m³)*	*(1.1 m³)*	*(489 - 1,028 kg)*
Total				5.5 m³	5.5 m³	2,444 - 5,140 kg
Area 9	Rounded Bldg.	4.5 m²	1.8 m	8.1 m³	8.1 m³	3,600 - 7,570 kg
Area 10	Rounded Bldg.	3.1 m²	1.8 m	5.6 m³	5.6 m³	2,489 - 5,234 kg
Area 11	Rounded Bldg.	8.9 m²	2.3 m	20.5 m³	20.5 m³	9,110 - 19,159 kg
Area 12	Rounded Bldg.	6.2 m²	2.3 m	14.3 m³	14.3 m³	6,355 - 13,365 kg
Area 19	Rounded Bldg.					
(Lower)		*(1.8 m²)*	*(0.1 m)*	*(0.2 m³)*	*(0.2 m³)*	*(89 - 187 kg)*
(Upper)		*(3.2 m²)*	*(1.6 m)*	*(5.1 m³)*	*(5.1 m³)*	*(2,266 - 4,766 kg)*
Total				5.3 m³	5.3 m³	2,355 - 4,953 kg
Area 20	Rounded Bldg.					
(Lower)		*(1.8 m²)*	*(0.1 m)*	*(0.2 m³)*	*(0.2 m³)*	*(89 - 187 kg)*
(Upper)		*(3.2 m²)*	*(1.6 m)*	*(5.1 m³)*	*(5.1 m³)*	*(2,266 - 4,766 kg)*
Total				5.3 m³	5.3 m³	2,355 - 4,953 kg
Area 21	Rounded Bldg.					
(Lower)		*(4.8 m²)*	*(1.0 m)*	*(4.8 m³)*	*(4.8 m³)*	*(2,133 - 4,486 kg)*
(Upper)		*(4.3 m²)*	*(1.4 m)*	*(6.0 m³)*	*(6.0 m³)*	*(2,666 - 5,608 kg)*
Total				10.8 m³	10.8 m³	4,800 - 10,094 kg
Area 27	Rounded Bldg.					
(Upper)		*(4.5 m²)*	*(2.0 m)*	*(9.0 m³)*	*(9.0 m³)*	*(4,000 - 8,411 kg)*
(Lower)		*(3.8 m²)*	*(0.6 m)*	*(2.3 m³)*	*(2.3 m³)*	*(1,022 - 2,150 kg)*
Total				11.3 m³	11.3 m³	5,022 - 10,561 kg
Area 51	NW Area					
(Lower)		*(3.4 m²)*	*(0.1 m)*	*(0.3 m³)*	*(0.3 m³)*	*(133 - 280 kg)*
(Upper)		*(4.4 m²)*	*(2.0 m)*	*(8.8 m³)*	*(8.8 m³)*	*(3,911 - 8,224 kg)*
Total				9.1 m³	9.1 m³	4,044 - 8,505 kg
Area 52	NW Area	3.5 m²	2.0 m	7.0 m³	7.0 m³	3,111 - 6,542 kg

Table 4.64 (page 2 of 2)
Tell al-Raqa'i
Level 4 (mid-late Ninevite 5), estimated storage capacity

Designation	Location	Floor space	Depth	Volume	Storage capacity	
					Volume	Barley, threshed[c]
Area 53	NW Area	2.3 m^2	2.0 m	4.6 m^3	4.6 m^3	2,044 - 4,299 kg
Area 56	NW Area	2.4 m^2	2.0 m	4.8 m^3	4.8 m^3	2,133 - 4,486 kg
Area 57	NW Area	5.5 m^2	3.0 m	16.5 m^3	16.5 m^3	7,333 - 15,421 kg
Area 58	NW Area					
(Lower)		*(3.8 m^2)*	*(1.2 m)*	*(4.6 m^3)*	*(4.6 m^3)*	*(2,044 - 4,299 kg)*
(Upper)		*(5.6 m^2)*	*(1.5 m)*	*(8.4 m^3)*	*(8.4 m^3)*	*(3,733 - 7,851 kg)*
Total				13.0 m^3	13.0 m^3	5,777 - 12,150 kg
Area 59	NW Area	?	?	?	?	?
Grill Bldg 6[b]	N slope	3.7 m^2	2.0 - 3.0 m	7.4 - 11.1 m^3	7.4 - 11.1 m^3	3,289 - 10,374 kg

Total	Rounded Bldg (excluding Areas 6, 9, 10, 11, and 12)[a]		68.5 m^3	30,441 - 64,020 kg
Total	Rounded Bldg (including Areas 6, 9, 10, 11, and 12)		119.7 m^3	53,195 - 111,872 kg
Total	NW Area		55.0 m^3	24,442 - 51,403 kg

Grand Total	Rounded Bldg + NW Area (excluding Areas 6, 9, 10, 11, and 12)		123.5 m^3	54,883 - 115,423 kg
Grand Total	Rounded Bldg + NW Area (including Areas 6, 9, 10, 11, and 12)		174.7 m^3	77,637 - 163,275 kg
Grand Total	Rounded Bldg + NW Area + Grill Bldg 6 (exluduing Areas 6, 9, 10, 11, and 12)		130.9 - 134.6 m^3	58,172 - 125,797 kg
Grand Total	Rounded Bldg + NW Area + Grill Bldg 6 (including Areas 6, 9, 10, 11, and 12)		182.1 - 185.8 m^3	80,925 - 173,649 kg

SOURCES: Schwartz and Curvers 1993/1994: 250-251, Abb. 74; Schwartz 1994b: 25-28, Table 1

[a] During a later phase of Level 4, the doors to Areas 6, 9, 10, 11, and 12 were blocked, perhaps transforming these rooms into silos. To account for this possibility, I have included two totals for the Rounded Building and two Grand Totals.

[b] The floor space measurements for Grill Building 6 should be considered very approximate, and there is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

Table 4.65 (page 1 of 2)
Tell al-Raqa'i
Level 3 (end of Ninevite 5), estimated storage capacity

Designation	Location	Floor space	Depth	Volume	Storage capacity	
					Volume	Barley, threshed[d]
Area 4[a]	NW Area	5.6 m^2	1.2 m	6.7 m^3	6.7 m^3	2,986 - 6,281 kg
Area 5[b]	NW Area	5.5 m^2	3.0 m	16.5 m^3	16.5 m^3	7,333 - 15,421 kg
Area 6[c]	NW Area	2.4 m^2	2.0 m	4.8 m^3	4.8 m^3	2,133 - 4,486 kg
Grill architecture, Rounded Building	Rounded Bldg.	?	?	?	?	?
Total					28.0 m^3	12,452 - 26,187 kg

SOURCES: Curvers and Schwartz 1990: 11-12; Schwartz and Curvers 1992: 410-411; Schwartz 1994b: Table 1; Schwartz and Curvers 1993/1994: 252

[a] The values (floor space and depth) listed for Area 4 have been inferred from published accounts, but the inference may be incorrect. Schwartz (1994b: Table 1) provides two sets of measurements (area, height, volume) for the earlier version of Area 4 (i.e. Area 58, Level 4): Lower (with ledges; height = 1.2 m) and Upper (above ledges; height = 1.5 m, area = 5.6 m^2). Schwartz and Curvers (1992: 410) indicate that the later version of this silo (i.e. Area 4, Level 3) was marked by the construction of a floor approximately 1.5 m above the earlier floor. According to the height measurements provided by Schwartz, this would apparently place the later floor 0.3 m above the earlier ledges and would suggest a height of 1.2 m (i.e. 1.5 - 0.3 m = 1.2 m) and an area of 5.6 m^2 for Area 4. It is unclear to me, however, whether or not this height takes into account the presence of an opening (filled in, at some point, with bricks) in the NW wall leading to Area 5.

[b] The values (floor space and depth) listed for Area 5 (drawn from Curvers and Schwartz 1990: 11) are exactly the same as those provided by Schwartz (1994b: Table 1) for the earlier version of this silo (Area 57, Level 4). This seems to ignore the fact that the arched window in the NW wall of the stucture (which provided access during Level 4) was filled in with bricks during Level 3 (increasing the height of the silo?), but, lacking any way to resolve this issue, I have employed the published values.

Table 4.65 (page 2 of 2)
Tell al-Raqa'i
Level 3 (end of Ninevite 5), estimated storage capacity

[c] Although Curvers and Schwartz (1990: 11) indicate that the interior of Area 6 measured 1.5 × 2.5 m (i.e. 3.75 m^2), I have instead employed the area and height values published by Schwartz (1994b: Table 1) for the earlier version of this silo (Area 56, Level 4). My assumption is that Schwartz has reduced the area in order to account for the presence of the facing buttresses.

[d] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

Table 4.66 (page 1 of 2)
Tell al-Raqa'i
Number of people that could be fed with stored grain

Designation	Number of people fed					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Levels 5-7						
Total (Early GB 4)	34 - 169 *(25 - 143)*	17 - 84 *(13 - 72)*	45 - 337 *(34 - 287)*	22 - 169 *(17 - 143)*	33 - 100 *(25 - 85)*	17 - 50 *(13 - 43)*
Total (Middle GB 4)	25 - 123 *(18 - 105)*	12 - 62 *(9 - 52)*	33 - 246 *(25 - 209)*	16 - 123 *(12 - 105)*	24 - 73 *(18 - 62)*	12 - 37 *(9 - 31)*
Total (Late GB 4)	25 - 124 *(19 - 106)*	12 - 62 *(9 - 53)*	33 - 249 *(25 - 212)*	17 - 124 *(12 - 106)*	25 - 74 *(18 - 63)*	12 - 37 *(9 - 31)*
Level 4						
Rounded Bldg. (Early)	95 - 316 *(71 - 268)*	47 - 158 *(35 - 134)*	126 - 631 *(95 - 537)*	63 - 316 *(47 - 268)*	94 - 188 *(70 - 160)*	47 - 94 *(35 - 80)*
Rounded Bldg. (Late)	165 - 552 *(124 - 469)*	83 - 276 *(62 - 234)*	220 - 1,103 *(165 - 938)*	110 - 552 *(83 - 469)*	164 - 328 *(123 - 279)*	82 - 164 *(61 - 139)*
NW Area	76 - 253 *(57 - 215)*	38 - 127 *(28 - 108)*	101 - 507 *(76 - 431)*	51 - 253 *(38 - 215)*	75 - 151 *(57 - 128)*	38 - 75 *(28 - 64)*
Grill Bldg. 6	10 - 51 *(8 - 43)*	5 - 26 *(4 - 22)*	14 - 102 *(10 - 87)*	7 - 51 *(5 - 43)*	10 - 30 *(8 - 26)*	5 - 15 *(4 - 13)*
Total (Early RB)	181 - 620 *(135 - 527)*	90 - 310 *(68 - 264)*	241 - 1,241 *(181 - 1,055)*	120 - 620 *(90 - 527)*	179 - 369 *(134 - 313)*	90 - 184 *(67 - 157)*
Total (Late RB)	251 - 856 *(188 - 728)*	126 - 428 *(94 - 364)*	335 - 1,713 *(251 - 1,456)*	168 - 856 *(126 - 728)*	249 - 509 *(187 - 433)*	125 - 255 *(94 - 216)*
Level 3						
Total	39 - 129 *(29 - 110)*	19 - 65 *(14 - 55)*	52 - 258 *(39 - 220)*	26 - 129 *(19 - 110)*	38 - 77 *(29 - 65)*	19 - 38 *(14 - 33)*

Table 4.66 (page 2 of 2)
Tell al-Raqa'i
Number of people that could be fed with stored grain

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 4.67
Tell al-Raqa'i
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume (m^3)	Grain (threshed barley)	1 year		2 years	
				Full range	95% range	Full range	95% range
Levels 5-7[a]	early-mid Nin. 5	17.8 - 36.6 m³	7,910 - 34,206 kg	18 - 337	32 - 174	9 - 169	16 - 87
Level 4[b]	mid-late Nin. 5	130.9 - 185.8 m³	58,172 - 173,649 kg	135 - 1,713	227 - 887	68 - 856	114 - 444
Level 3[c]	end of Nin. 5	28.0 m³	12,452 - 26,187 kg	29 - 258	43 - 148	14 - 129	21 - 74

[a] The simplified storage capacity ranges for Levels 5–7 are drawn from Table 4.63 (minimum from Total, including Grill Building 4, Middle Phase; maximum from Total, including Grill Building 4, Early Phase).

[b] The simplified storage capacity ranges for Level 4 are drawn from Table 4.64 (minimum from Grand Total, Rounded Building + NW Area + Grill Bldg 6, excl. Areas 6, 9, 10, 11, and 12; maximum from Grand Total, Rounded Building + NW Area + Grill Bldg 6, incl. Areas 6, 9, 10, 11, and 12).

[c] The simplified storage capacity for Level 3 is drawn from Table 4.65 (Total).

Table 4.68
Tell al-Raqa'i
Percentage of the population that could be fed with stored grain

Level	Date	Population (estimated)	% of population fed			
			1 year		2 years	
			Full range	95% range	Full range	95% range
Levels 5-7	early-mid Nin. 5	20 - 200	9 - 1,685 %	24 - 386 %	5 - 845 %	12 - 193 %
Level 4	mid-late Nin. 5	20 - 200	67 - 8,565 %	164 - 2,091 %	34 - 4,280 %	82 - 1,046 %
Level 3	end of Nin. 5	20 - 200	15 - 1,290 %	32 - 446 %	7 - 645 %	16 - 223 %

Table 4.69
Telul eth-Thalathat
Granary, total bulk storage capacity, as published

	Total floor space	Depth	Storage capacity		
			Volume	Grain (weight)	*Volume (recalculated)*
Fukai et al. 1974	85 m^2 *(total includes interior walls)*	1.3 - 2.0 m	85 - 130 m^3	65 - 100 tons *(threshed barley)*	110.5 - 170 m^3 *(85 m^2 × 1.3 m) - (85 m^2 × 2 m)*
Van der Stede 2010	82 m^2 *(total includes exterior and interior walls?)*	2.0 m	130 m^3	65,000 kg	164 m^3 *(82 m^2 × 2 m)*

SOURCES: Fukai et al. 1974; Van der Stede 2010

Table 4.70
Telul eth-Thalathat
Granary, total bulk storage capacity, disregarding interior walls, my measurements

Designation	Floor space	Depth[b]	Storage capacity	
			Volume	Barley, threshed[a]
Granary (no interior walls)	85.3 m^2	2.0 - 3.0 m	170.6 - 255.9 m^3	75,815 - 239,164 kg

SOURCE: Fukai et al. 1974: Pl. XLI

[a] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[b] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored in bulk to a depth of 2.0–3.0 meters.

Table 4.71
Telul eth-Thalathat
Granary, room-by-room bulk storage capacity, disregarding secondary partition walls, my measurements

Room number (R-)	**Floor space**	**Depth**[b]	**Storage capacity**	
			Volume	Barley, threshed[a]
1	3.3 m²	2.0 - 3.0 m	6.6 - 9.9 m³	2,933 - 9,253 kg
7	7.6 m²	2.0 - 3.0 m	15.2 - 22.8 m³	6,755 - 21,309 kg
10a-10b	7.1 m²	2.0 - 3.0 m	14.2 - 21.3 m³	6,310 - 19,907 kg
17-18-19-20	7.6 m²	2.0 - 3.0 m	15.2 - 22.8 m³	6,755 - 21,309 kg
21a-21b-22	7.6 m²	2.0 - 3.0 m	15.2 - 22.8 m³	6,755 - 21,309 kg
6	5.1 m²	2.0 - 3.0 m	10.2 - 15.3 m³	4,533 - 14,299 kg
15a-15b-15c	8.1 m²	2.0 - 3.0 m	16.2 - 24.3 m³	7,199 - 22,711 kg
16a-16b	7.9 m²	2.0 - 3.0 m	15.8 - 23.7 m³	7,022 - 22,150 kg
23	10.1 m²	2.0 - 3.0 m	20.2 - 30.3 m³	8,977 - 28,318 kg
25-26-27	9.5 m²	2.0 - 3.0 m	19.0 - 28.5 m³	8,444 - 26,636 kg
Total (all rooms)	73.9 m²		147.8 - 221.7 m³	65,682 - 207,201 kg
Total (excluding 17-18-19-20 and 15a-15b-15c)	58.2 m²		116.4 - 174.6 m³	51,728 - 163,181 kg

SOURCE: Fukai et al. 1974: Pl. XLI

[a] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[b] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored in bulk to a depth of 2.0–3.0 meters.

Table 4.72
Telul eth-Thalathat
Granary, room-by-room bulk storage capacity, including secondary partition walls, my measurements

Room number (R-)	Floor space	Depth[2]	Storage capacity	
			Volume	Barley, threshed[1]
1	3.3 m²	2.0 - 3.0 m	6.6 - 9.9 m³	2,933 - 9,253 kg
7	7.6 m²	2.0 - 3.0 m	15.2 - 22.8 m³	6,755 - 21,309 kg
10a	3.5 m²	2.0 - 3.0 m	7.0 - 10.5 m³	3,111 - 9,813 kg
10b	3.1 m²	2.0 - 3.0 m	6.2 - 9.3 m³	2,755 - 8,692 kg
17	1.3 m²	2.0 - 3.0 m	2.6 - 3.9 m³	1,155 - 3,645 kg
18	1.8 m²	2.0 - 3.0 m	3.6 - 5.4 m³	1,600 - 5,047 kg
19	1.2 m²	2.0 - 3.0 m	2.4 - 3.6 m³	1,067 - 3,365 kg
20	2.1 m²	2.0 - 3.0 m	4.2 - 6.3 m³	1,866 - 5,888 kg
21a	0.7 m²	2.0 - 3.0 m	1.4 - 2.1 m³	622 - 1,963 kg
21b	0.8 m²	2.0 - 3.0 m	1.6 - 2.4 m³	711 - 2,243 kg
22	5.6 m²	2.0 - 3.0 m	11.2 - 16.8 m³	4,977 - 15,701 kg
6	5.1 m²	2.0 - 3.0 m	10.2 - 15.3 m³	4,533 - 14,299 kg
15a	2.5 m²	2.0 - 3.0 m	5.0 - 7.5 m³	2,222 - 7,010 kg
15b	1.3 m²	2.0 - 3.0 m	2.6 - 3.9 m³	1,155 - 3,645 kg
15c	3.2 m²	2.0 - 3.0 m	6.4 - 9.6 m³	2,844 - 8,972 kg
16a	2.9 m²	2.0 - 3.0 m	5.8 - 8.7 m³	2,578 - 8,131 kg
16b	4.5 m²	2.0 - 3.0 m	9.0 - 13.5 m³	4,000 - 12,617 kg
23	6.8 m²	2.0 - 3.0 m	13.6 - 20.4 m³	6,044 - 19,066 kg
25	3.0 m²	2.0 - 3.0 m	6.0 - 9.0 m³	2,666 - 8,411 kg
26	1.8 m²	2.0 - 3.0 m	3.6 - 5.4 m³	1,600 - 5,047 kg
27	1.8 m²	2.0 - 3.0 m	3.6 - 5.4 m³	1,600 - 5,047 kg
Total (all rooms)	63.9 m²		127.8 - 191.7 m³	56,794 - 179,163 kg
Total (excluding 17 and 15b)	61.3 m²		122.6 - 183.9 m³	54,483 - 171,873 kg

SOURCE: Fukai et al. 1974: Pl. XLI

[1] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[2] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored in bulk to a depth of 2.0–3.0 meters.

Table 4.73 (page 1 of 2)
Telul eth-Thalathat
Number of people that could be fed with stored grain

Designation	**Number of people fed**					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Granary (no interior walls)						
All interior space	235 - 1,179	118 - 590	314 - 2,359	157 - 1,179	234 - 701	117 - 351
	(177 - 1,003)	*(88 - 501)*	*(235 - 2,005)*	*(118 - 1,003)*	*(175 - 596)*	*(88 - 298)*
Granary: earlier phase						
All rooms	204 - 1,022	102 - 511	272 - 2,044	136 - 1,022	202 - 607	101 - 304
	(153 - 869)	*(76 - 434)*	*(204 - 1,737)*	*(102 - 869)*	*(152 - 516)*	*(76 - 258)*
Excluding rooms with	161 - 805	80 - 402	214 - 1,609	107 - 805	159 - 478	80 - 239
exterior doorways	*(120 - 684)*	*(60 - 342)*	*(161 - 1,368)*	*(80 - 684)*	*(120 - 407)*	*(60 - 203)*
Granary: later phase						
All rooms	176 - 884	88 - 442	235 - 1,767	118 - 884	175 - 525	88 - 263
	(132 - 751)	*(66 - 376)*	*(176 - 1,502)*	*(88 - 751)*	*(131 - 446)*	*(66 - 223)*
Excluding rooms with	169 - 848	85 - 424	226 - 1,695	113 - 848	168 - 504	84 - 252
exterior doorways	*(127 - 720)*	*(63 - 360)*	*(169 - 1,441)*	*(85 - 720)*	*(126 - 428)*	*(63 - 214)*

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

Table 4.73 (page 2 of 2)
Telul eth-Thalathat
Number of people that could be fed with stored grain

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 4.74
Telul eth-Thalathat
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume (m^3)	Grain (threshed barley)	1 year		2 years	
				Full range	95% range	Full range	95% range
Granary[a]	Nin. 5	85.0 - 255.9 m^3	51,728 - 239,164 kg	88 - 2,359	185 - 1,135	44 - 1,179	93 - 567

[a] The simplified storage capacity ranges for the Granary are drawn from Table 4.69 (minimum from Fukai et al.; volume converted into grain using my own conversion factors) and Table 4.70 (maximum from Granary, no interior walls).

Table 5.1 (page 1 of 2)
Fara
Silos, excavated, general info.

Designation	Date	Location	Description	Contents
Pit I	ED III	next to FG 43	Cylindrical silo. Walls 0.40–0.45 m thick, constructed of baked, plano-convex bricks, joined with mud mortar, laid in alternating groups of oblique and horizontal courses. Walls covered in mud plaster. Original top of silo perhaps 1 m higher than preserved top. Low bench (3 horizontal brick courses) encircled base of silo. Clay floor (c. 28 cm thick) reached to top of bench.	Layer of "bin refuse" (wood and straw particles, date seeds, bones, etc.) immediately above clay floor might have been deposited after silo went out of use or might be remains of original contents. Above this were successive layers of fill (ED III, Akkadian, Ur III, and perhaps later). At a depth of 4.5–4.7 m, eight human burials were deposited casually, one at a time, and sealed by brick fragments. Near the top of the silo was a layer of bricks and brick fragments, probably from the original walls of the silo (reaching perhaps 1 m higher than preserved).
Pit II	ED III	near H 47/48/58		Pottery and fragmentary tablets (2).
Silo, Trench I, N. End (="Ziegel Brunen, n. Hügel"?)		CE?		Inscribed gypsum vessel, cylinder seal, sheep figurine, pottery spool, and pottery box.
Silo in Ia		CF	Bench ("Fundamentvorsprung") encircled base of silo.	Sherds, bone splinters, date pits, and fish bones.
Silo in Ie		DF		Cylinder seals (2) and ceramic pig figurine.

Table 5.1 (page 2 of 2)
Fara
Silos, excavated, general info.

Designation	Date	Location	Description	Contents
Silo in Ig		DF	Bricks found at base of silo were probably remains of collapsed roof.	Cylinder seal, cow carved from pebble, gypsum "half conch shell," and necklace of carnelian beads.
Silo in Ik		DF		Small ceramic bowl.
Silo North of IIIb-c House (=Ziegelbau)		FH		Tablets (6), tablet fragments, and seal impressions.
Silo East of Ir		EF		Cylinder seal fragments (2) and copper chisel.
Silo in IIa				
Silo NW of house(s) north of VIIp		SW corner of EF	Elliptical in plan.	

SOURCE: Martin 1988: 42-47, 106, 110-112, Fig. 31

Table 5.2 (page 1 of 2)
Fara
Silos, capacity

Source[f]	Diameter	Depth	Storage capacity		
			Volume	Barley, threshed[g]	Barley (ancient)
Martin (1988)[a]					
1 silo	4.0 m	10.0 m	125 m^3	*55,550 - 116,825 kg*	
32 silos			*4,000 m^3*	*1,777,600 - 3,738,400 kg*	
Visicato (1993)[b]					
1 silo			100 m^3	*44,440 - 93,460 kg*	250 *gur*
32 silos			*3,200 m^3*	*1,422,080 - 2,990,720 kg*	8,000 *gur*
Heinrich (1931)[c]					
1 silo	2.0 - 6.5 m				
Schmidt (Martin 1988)[d]					
1 silo (Pit I)	3.9 m	8.0 m	*95.5 m^3*	*42,440 - 89,254 kg*	
Paulette[e]					
1 silo	*4.25 m*	*8.0 m*	*113.4 m^3*	*50,395 - 105,984 kg*	
32 silos			*3,628.8 m^3*	*1,612,639 - 3,391,476 kg*	

SOURCES: Heinrich 1931; Martin 1988; Visicato 1993

[a] Martin (1988: 45) indicates that the excavated silos were approximately 4 m in diameter and 10 m deep, resulting in a capacity of approximately 125 m^3 ($\pi r^2 h = 3.14 \times (4/2)^2 \times 8 = 125.6$ m^3), but it is unclear to me how she arrived at an average depth of 10 m. As far as I can tell, the only depth that has been published is 7.08 m for Pit I, which Schmidt estimates to have originally reached a depth of approximately 8 m (Martin 1988: 43).

[b] Citing Martin, Visicato indicates an average silo capacity of 100 m^3 and a maximum silo capacity of 125 m^3 (Visicato 1993: 83; Pomponio and Visicato 1994: 205, note 70), but it is unclear to me how he arrived at the value of 100 m^3 (since Martin estimates 125 m^3, see note 1). To reach an estimate of total storage capacity (i.e. a total for the 32 silos), Visicato first converts 100 m^3 (the volume of one silo) into Mesopotamian capacity measures: 100 m^3 = 100,000 l ≈ 125,000 *sìla* (if 1 *sìla* = 0.83 l, then 100,000 l = 120,482 *sìla*) ≈ 250 *gur* (if 1 *gur* = 480 *sìla*, then 120,482 *sìla* = 251 *gur*). He then multiplies 250 *gur* (the capacity of one silo) by 32 to reach a total storage capacity of 8,000 *gur* of barley (Visicato 1993: 83). Finally, he argues that 8,000 *gur* of barley equals approximately 3.5 million daily rations (8000 *gur* = 3,840,000 *sìla*, which implies a daily ration of 1.1 *sìla* per peson per day), enough to feed 20,000 people for a period of 6 months (3,500,000/183 = 19,126). For purposes of comparison, I have also used Visicato's estimate of average silo capacity (100 m^3) to calculate the total volume (m^3) of the 32 silos and the quantity of threshed barley (kg) that could have been stored within a single silo and 32 silos.

Table 5.2 (page 2 of 2)
Fara
Silos, capacity

[c] Heinrich (1931: 8) indicates that the silos ranged from 2.0 to 6.5 m in diameter and that some reached a depth of 4 m below modern plain level. Unfortunately, he provides no information about the depth of the silos themselves.

[d] Schmidt (quoted in Martin 1988: 42–43) actually records a range of values for the diameter of Pit I: 3.3–4.0 (base, E-W), 3.5–4.2 (base, N-S), and 3.7–3.82 (rim, interior). I am assuming that the ranges provided for the silo's base indicate the diameter at the level of the bench (the lower numbers) and above the bench (the higher numbers). To estimate an average diameter for Pit I, I have calculated an average for the rim (3.76) and an average for the base above the level of the bench (4.10) and have then averaged these values to reach a diameter of 3.9 m. Schmidt records a depth of 7.08 m for Pit I (as excavated), but he estimates an original depth of 8.0 m. He does not provide an estimate of silo capacity. I calculated the volume according to the formula for the volume of a cylinder ($\pi r^2 h = 3.14 \times (3.9/2)^2 \times 8 \approx 95.5$).

[e] I see no good way to incorporate the full range of silo diameters (2.0–6.5 m, Heinrich 1931: 8) within my estimate of total storage capacity. Instead, I have opted for an average diameter of 4.25 m. Given the absence of information about the range of silo depths, I have chosen to use Schmidt's (Martin 1988: 43) estimate of 8 m (Pit I). I calculated the volume according to the formula for the volume of a cylinder ($\pi r^2 h = 3.14 \times (4.25/2)^2 \times 8 \approx 113.4$).

[f] Throughout this table, values shown in normal type are drawn directly from the publications cited. Values shown in italics are my own estimates and/or calculations.

[g] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

Table 5.3
Fara
Number of people that could be fed with stored grain

Designation	Number of people fed					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
1 silo						
Martin: 125 m^3	172 - 576 *(129 - 490)*	86 - 288 *(65 - 245)*	230 - 1,152 *(172 - 979)*	115 - 576 *(86 - 490)*	171 - 342 *(128 - 291)*	86 - 171 *(64 - 146)*
Visicato: 100 m^3	138 - 461 *(103 - 392)*	69 - 230 *(52 - 196)*	184 - 922 *(138 - 784)*	92 - 461 *(69 - 392)*	137 - 274 *(103 - 233)*	68 - 137 *(51 - 116)*
Paulette: 113.4 m^3	156 - 523 *(117 - 444)*	78 - 261 *(59 - 222)*	209 - 1,045 *(156 - 889)*	104 - 523 *(78 - 444)*	155 - 311 *(117 - 264)*	78 - 155 *(58 - 132)*
32 silos						
Martin: 4,000 m^3	5,519 - 18,436 *(4,140 - 15,671)*	2,760 - 9,218 *(2,070 - 7,835)*	7,359 - 36,872 *(5,519 - 31,341)*	3,680 - 18,436 *(2,760 - 15,671)*	5,479 - 10,959 *(4,110 - 9,315)*	2,740 - 5,479 *(2,055 - 4,658)*
Visicato: 3,200 m^3	4,416 - 14,749 *(3,312 - 12,536)*	2,208 - 7,374 *(1,656 - 6,268)*	5,887 - 29,498 *(4,416 - 25,073)*	2,944 - 14,749 *(2,208 - 12,536)*	4,384 - 8,767 *(3,288 - 7,452)*	2,192 - 4,384 *(1,644 - 3,726)*
Paulette: 3,628.8 m^3	5,007 - 16,725 *(3,755 - 14,216)*	2,504 - 8,363 *(1,878 - 7,108)*	6,676 - 33,450 *(5,007 - 28,433)*	3,338 - 16,725 *(2,504 - 14,216)*	4,971 - 9,942 *(3,728 - 8,451)*	2,485 - 4,971 *(1,864 - 4,225)*

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that wad earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 5.4
Fara
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume	Grain	1 year		2 years	
		(m^3)	(threshed barley)	Full range	95% range	Full range	95% range
ED IIIa[a]	ED IIIa	3,200.0 - 4,000.0 m^3	1,422,080 - 3,738,400 kg	3,312 - 36,872	5,391 - 19,582	1,656 - 18,436	2,695 - 9,791

[a] The simplified storage capacity ranges for the ED IIIa silos are drawn from Table 5.2 (minimum from Visicato 1993, 32 silos; maximum from Martin 1988, 32 silos).

Table 5.5
Fara
Percentage of the population that could be fed with stored grain

Level	Date	Population	% of population fed			
		(estimated)	1 year		2 years	
			Full range	95% range	Full range	95% range
ED IIIa	ED IIIa	10,000 - 30,000	11 - 369 %	26 - 144 %	6 - 184 %	13 - 72 %

Table 5.6
Fara
Percentage of the population that could be fed with rations

Source[b]	Storage capacity (32 silos)	Daily Rations	Number of people fed with rations (% of population fed)[a]		
			6 months	1 year	2 years
Visicato (1993)[c]	8,000 *gur*	3,500,000	20,000 *(67–200 %)*	*10,000* *(33–100 %)*	*5,000* *(17–50 %)*
Paulette[d]	*3,200,000–4,000,000 l*	*1,200,000–4,000,000*	*6,557–21,858* *(22–219 %)*	*3,288–10,959* *(11–110 %)*	*1,644–5,479* *(5–55 %)*

SOURCE: Visicato 1993

[a] I have assumed a total population of 10,000–30,000 for Fara during the ED III period. The values in parantheses indicate the percentage of the population that could have been fed with the grain stored in the silos (via daily or monthly rations) for a given period of time. For example, if 10,000 people could have been fed for one year, this means that between 33% (i.e. 10,000/30,000) and 100% (i.e. 10,000/10,000) of the population could have been fed for one year.

[b] Values shown in normal type are drawn directly from Visicato (1993). Values shown in italics are my own estimates and/or calculations.

[c] To reach an estimate of total storage capacity (i.e. a total for the 32 silos), Visicato first converts 100 m^3 (the volume of one silo) into Mesopotamian capacity measures: 100 m^3 = 100,000 l ≈ 125,000 *sìla* (if 1 *sìla* = 0.83 l, then 100,000 l = 120,482 *sìla)* ≈ 250 *gur* (if 1 *gur* = 480 *sìla,* then 120,482 *sìla* = 251 *gur).* He then multiplies 250 *gur* (the capacity of one silo) by 32 to reach a total storage capacity of 8,000 *gur* of barley (Visicato 1993: 83). Finally, he argues that 8,000 *gur* of barley equals approximately 3.5 million daily rations (8000 *gur* = 3,840,000 *sìla,* which implies a daily ration of 1.1 *sìla* per peson per day), enough to feed 20,000 people for a period of 6 months (3,500,000/183 = 19,126). Visicato does not himself calculate the number of people that could be fed for 1 year or 2 years. To calculate these values, I simply reduced his (rounded-off) value of 20,000 by 50% (for 1 year) and 75% (for 2 years).

[d] My estimate for total storage capacity (32 silos) uses the single-silo estimates provided by Visicato (100 m^3) and Martin (125 m^3) as lower (i.e. 100 $m^3 \times 32$ = 3,200,000) and upper (i.e. 100 $m^3 \times 32$ = 4,000,000) limits, respectively. To calculate the number of daily rations represented by this range of storage capacities, I have assumed a ration of 1–2 liters of grain per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42); although Visicato does not indicate the exact ration size used in his calculations, the numbers that he provides imply a ration of approxiamtely 1.1 *sìla* per person per day (0.9 liters per person per day, if 1 *sìla* = 0.83 liters). In calculating the minimum number of rations, I have also included a 15–25% reduction (e.g. 3,200,000 l - (3,200,000 l × 0.25) = 2,400,000 l) to account for seed requirements and losses due to spoilage.

Table 5.7 (page 1 of 3)
Tell Gubba
Storage facilities, Level VII, basic info.

Designation	Location	Subphase	Date	Description	Contents
Flask-shaped pits (P1–P2)[d]	Round building, Corridor C3	VIId–a[a]	Jemdet Nasr	Flask-shaped (small mouth, large bottom) pits beneath floor of corridor. In some cases, walls and/or floors lined with mudbricks. According to excavators, probably used for grain storage, drainage, or as "pitfall-like facilities against enemy invasion."	Sandy soil or mubrick fragments. Few finds.
Flask-shaped pits (P3–P13)[d]	Round building, Corridor C4	VIIc–a[a]	Jemdet Nasr	Flask-shaped (small mouth, large bottom) pits beneath floor of corridor. In some cases, walls and/or floors lined with mudbricks. Arranged at regular intervals, especially near doorways. According to excavators, probably used for grain storage, drainage, or as "pitfall-like facilities against enemy invasion."	

Table 5.7 (page 2 of 3)
Tell Gubba
Storage facilities, Level VII, basic info.

<table>
<tr><th>Designation</th><th>Location</th><th>Subphase</th><th>Date</th><th>Description</th><th>Contents</th></tr>
<tr><td>Corridor C3[b]</td><td>Round building</td><td>VIId-a</td><td>Jemdet Nasr</td><td>Corbel-vaulted corridor between walls CW2/3 and CW4. Probably used, at least in part, for storage.</td><td rowspan="4">Large, coarse storage jars with sealed rims found standing on floors (corridor number unspecified); some contained grain. Carbonized grain found scattered "all through the levels of the corridors." Bone objects and spindle whorls in C4.</td></tr>
<tr><td>Corridor C4</td><td>Round building</td><td>VIIc–a</td><td>Jemdet Nasr</td><td>Corbel-vaulted corridor between walls CW4' and CW5. Probably used, at least in part, for storage.</td></tr>
<tr><td>Corridor C5</td><td>Round building</td><td>VIIb–a</td><td>Jemdet Nasr</td><td>Unroofed (according to the excavators) corridor between walls CW5 and CW6. If unroofed, probably not used for storage. If roofed, possibly used (at least in part) for storage.</td></tr>
<tr><td>Corridor C6</td><td>Round building</td><td>VIIb–a</td><td>Jemdet Nasr</td><td>Unroofed (according to the excavators) corridor between walls CW6 and CW7. If unroofed, probably not used for storage until construction of "granary" rooms during subphase VIIa.[c] If roofed, possibly also used (at least in part) for storage during Level VIIb.</td></tr>
</table>

Table 5.7 (page 3 of 3)
Tell Gubba
Storage facilities, Level VII, basic info.

Designation	Location	Subphase	Date	Description	Contents
Granaries (G1–G30)	Round building, Corridor C6 and moat area	VIIa	Jemdet Nasr / ED I transition	Small rooms that appear on the plan of Level VIIa published by Ii (1993: Fig. 1) but that have not been discussed elsewhere in the publications. Many appear to include parallel wall foundations, presumably for purposes of ventilation. Possibly used for grain storage.	

SOURCES: Odani and Ii 1981: 142–147, Fig. 5; Ii 1993: Fig. 1

[a] It is unclear to me to which subphase the flask-shaped pits should be assigned. I have, therefore, assigned them to any subphase during which the corridor in question was in use.

[b] I have not included corridor C2 (Subphases VIId–a), which seems to have been occupied entirely by a staircase (see Ii 1993: Fig. 1).

[c] Although little information has been provided about the nature of the round building during subphase VIIa, I have assumed, based on a plan published by Ii (1993: Fig. 1), that corridor C6 had been at least partially filled in with small "granary" rooms (similar to those built during Levels VI–IV) during this subphase.

[d] On the published plan, pits are marked with a "P" (Odani and Ii 1981: Fig. 5), but they do not appear to have been labeled individually. I have, therefore, labeled them myself, beginning with those in corridor C3 (P1–P2) and then moving on to those in corridor C4 (P3–P13).

Table 5.8
Tell Gubba
Storage facilities, Levels VI–IV, basic info.

Designation	Level	Date	Description	Contents
Granaries	VI	ED I	Small rooms (1–3 m on a side) with walls 15–20 cm thick, organized in linear groupings ("granaries") of between one and eight rooms. Most were provided with foundations (e.g. parallel walls separated by open spaces) that allowed for subfloor ventilation. Probably used for grain storage. There were more of these rooms in Level VI than in Levels V and IV. Some seem to appear (walls shown in white) on the plan published by Odani and Ii (1981: Fig. 8).	Some carbonized wheat found around the structures.
Granaries	V	ED I	Small rooms (1–3 m on a side) with walls 15–20 cm thick, organized in linear groupings ("granaries") of between one and eight rooms. Most were provided with foundations (e.g. parallel walls separated by open spaces) that allowed for subfloor ventilation. Probably used for grain storage. There were fewer of these rooms in Level V (at least 30) than in Level VI, and more than in Level IV. Many appear (walls shown in black) on the plan published by Odani and Ii (1981: Fig. 8).	
Granaries	IV	ED I	Small rooms (1–3 m on a side) with walls 15–20 cm thick, organized in linear groupings ("granaries") of between one and eight rooms. Most were provided with foundations (e.g. parallel walls separated by open spaces) that allowed for subfloor ventilation. Probably used for grain storage. There were fewer of these rooms in Level IV (at least 10 in each of 2 subphases) than in Levels VI and V. They do not appear on any published plan.	

SOURCES: Odani and Ii 1981: 148–149, Fig. 8; Ii 1993: Fig. 1; Van der Stede 2010: 291–292

Table 5.9 (page 1 of 4)
Tell Gubba
Storage facilities, Level VII, storage capacity

Designation	Sub-phase	Date	Location	Floor space[f]	Avg. diam. (floor level)	Depth[a]	Volume (total)	Storage capacity	
								Volume[b]	Barley, threshed[c]
Pit P1[d]	VIId–a	J. Nasr (/ED I)	Cor. C3	0.4 m²	0.7 m	0.6 - 1.5 m	0.2 - 1.3 m³	0.2 - 1.3 m³	89 - 1,215 kg
Pit P2	VIId–a	J. Nasr (/ED I)	Cor. C3	0.2 m²	0.5 m	0.6 - 1.5 m	0.1 - 0.7 m³	0.1 - 0.7 m³	44 - 654 kg
Pit P3	VIIc–a	J. Nasr (/ED I)	Cor. C4	0.5 m²	0.7 m	0.6 - 1.5 m	0.2 - 1.3 m³	0.2 - 1.3 m³	89 - 1,215 kg
Pit P4	VIIc–a	J. Nasr (/ED I)	Cor. C4	0.4 m²	0.6 m	0.6 - 1.5 m	0.2 - 1.0 m³	0.2 - 1.0 m³	89 - 935 kg
Pit P5	VIIc–a	J. Nasr (/ED I)	Cor. C4	0.4 m²	0.7 m	0.6 - 1.5 m	0.2 - 1.3 m³	0.2 - 1.3 m³	89 - 1,215 kg
Pit P6	VIIc–a	J. Nasr (/ED I)	Cor. C4	0.8 m²	0.9 m	0.6 - 1.5 m	0.4 - 2.2 m³	0.4 - 2.2 m³	178 - 2,056 kg
Pit P7	VIIc–a	J. Nasr (/ED I)	Cor. C4	1.0 m²	1.1 m	0.6 - 1.5 m	0.6 - 3.3 m³	0.6 - 3.3 m³	267 - 3,084 kg
Pit P8	VIIc–a	J. Nasr (/ED I)	Cor. C4	0.6 m²	0.8 m	0.6 - 1.5 m	0.3 - 1.8 m³	0.3 - 1.8 m³	133 - 1,682 kg
Pit P9	VIIc–a	J. Nasr (/ED I)	Cor. C4	1.0 m²	1.1 m	0.6 - 1.5 m	0.6 - 3.3 m³	0.6 - 3.3 m³	267 - 3,084 kg
Pit P10	VIIc–a	J. Nasr (/ED I)	Cor. C4	0.2 m²	0.5 m	0.6 - 1.5 m	0.1 - 0.7 m³	0.1 - 0.7 m³	44 - 654 kg
Pit P11	VIIc–a	J. Nasr (/ED I)	Cor. C4	0.2 m²	0.5 m	0.6 - 1.5 m	0.1 - 0.7 m³	0.1 - 0.7 m³	44 - 654 kg
Pit P12	VIIc–a	J. Nasr (/ED I)	Cor. C4	0.1 m²	0.4 m	0.6 - 1.5 m	0.1 - 0.4 m³	0.1 - 0.4 m³	44 - 374 kg
Pit P13	VIIc–a	J. Nasr (/ED I)	Cor. C4	0.1 m²	0.4 m	0.6 - 1.5 m	0.1 - 0.4 m³	0.1 - 0.4 m³	44 - 374 kg
Corridor C3[e]	VIId–a	J. Nasr (/ED I)	Round building	39.0 m² *		2.0 - 3.0 m	78.0 - 117.0 m³	39.0 - 58.5 m³ [s]	17,332 - 54,674 kg
Corridor C4	VIIc–a	J. Nasr (/ED I)	Round building	94.1 m² *		2.0 - 3.0 m	188.2 - 282.3 m³	94.1 - 141.2 m³ [s]	41,818 - 131,919 kg
Corridor C5	VIIb–a	J. Nasr (/ED I)	Round building	150.6 m² *		2.0 - 3.0 m	301.2 - 451.8 m³	150.6 - 225.9 m³ [s]	66,927 - 211,126 kg
Corridor C6	VIIb–a	J. Nasr (/ED I)	Round building	404.0 m² *		2.0 - 3.0 m	808.0 - 1212.0 m³	404.0 - 606.0 m³ [s]	179,538 - 566,368 kg
Granary G1[g]	VIIa	J. Nasr/ED I	Moat	0.9 m²			1.8 - 2.7 m³	1.8 - 2.7 m³	800 - 2,523 kg
Room G1a				*0.9 m²*		*2.0 - 3.0 m*	*1.8 - 2.7 m³*	*1.8 - 2.7 m³*	*800 - 2,523 kg*
Granary G2	VIIa	J. Nasr/ED I	Moat	3.4 m²			6.8 - 10.2 m³	6.8 - 10.2 m³	3,022 - 9,533 kg
Room G2a				*3.4 m²*		*2.0 - 3.0 m*	*6.8 - 10.2 m³*	*6.8 - 10.2 m³*	*3,022 - 9,533 kg*
Granary G3	VIIa	J. Nasr/ED I	Moat	0.5 m²			1.0 - 1.5 m³	1.0 - 1.5 m³	444 - 1,402 kg
Room G3a				*0.5 m² **		*2.0 - 3.0 m*	*1.0 - 1.5 m³*	*1.0 - 1.5 m³*	*444 - 1,402 kg*
Granary G4	VIIa	J. Nasr/ED I	Moat	0.7 m²			1.4 - 2.1 m³	1.4 - 2.1 m³	622 - 1,963 kg
Room G4a				*0.7 m² **		*2.0 - 3.0 m*	*1.4 - 2.1 m³*	*1.4 - 2.1 m³*	*622 - 1,963 kg*
Granary G5	VIIa	J. Nasr/ED I	Moat	1.3 m²			2.6 - 3.9 m³	2.6 - 3.9 m³	1,155 - 3,645 kg
Room G5a				*1.3 m²*		*2.0 - 3.0 m*	*2.6 - 3.9 m³*	*2.6 - 3.9 m³*	*1,155 - 3,645 kg*
Granary G6	VIIa	J. Nasr/ED I	Moat	0.5 m²			1.0 - 1.5 m³	1.0 - 1.5 m³	444 - 1,402 kg
Room G6a				*0.5 m² **		*2.0 - 3.0 m*	*1.0 - 1.5 m³*	*1.0 - 1.5 m³*	*444 - 1,402 kg*
Granary G7	VIIa	J. Nasr/ED I	Moat	1.5 m²			3.0 - 4.5 m³	3.0 - 4.5 m³	1,333 - 4,206 kg
Room G7a				*1.5 m² **		*2.0 - 3.0 m*	*3.0 - 4.5 m³*	*3.0 - 4.5 m³*	*1,333 - 4,206 kg*
Granary G8	VIIa	J. Nasr/ED I	Cor. C6	1.1 m²			2.2 - 3.3 m³	2.2 - 3.3 m³	978 - 3,084 kg
Room G8a				*1.1 m²*		*2.0 - 3.0 m*	*2.2 - 3.3 m³*	*2.2 - 3.3 m³*	*978 - 3,084 kg*
Granary G9	VIIa	J. Nasr/ED I	Cor. C6	0.7 m²			1.4 - 2.1 m³	1.4 - 2.1 m³	622 - 1,963 kg
Room G9a				*0.7 m² **		*2.0 - 3.0 m*	*1.4 - 2.1 m³*	*1.4 - 2.1 m³*	*622 - 1,963 kg*
Granary G10	VIIa	J. Nasr/ED I	Cor. C6	0.5 m²			1.0 - 1.5 m³	1.0 - 1.5 m³	444 - 1,402 kg
Room G10a				*0.5 m² **		*2.0 - 3.0 m*	*1.0 - 1.5 m³*	*1.0 - 1.5 m³*	*444 - 1,402 kg*
Granary G11	VIIa	J. Nasr/ED I	Moat	1.1 m²			2.2 - 3.3 m³	2.2 - 3.3 m³	978 - 3,084 kg
Room G11a				*1.1 m²*		*2.0 - 3.0 m*	*2.2 - 3.3 m³*	*2.2 - 3.3 m³*	*978 - 3,084 kg*
Granary G12	VIIa	J. Nasr/ED I	Moat	2.8 m²			5.6 - 8.4 m³	5.6 - 8.4 m³	2,489 - 7,851 kg
Room G12a				*1.1 m²*		*2.0 - 3.0 m*	*2.2 - 3.3 m³*	*2.2 - 3.3 m³*	*978 - 3,084 kg*
Room G12b				*1.7 m²*		*2.0 - 3.0 m*	*3.4 - 5.1 m³*	*3.4 - 5.1 m³*	*1,511 - 4,766 kg*
Granary G13	VIIa	J. Nasr/ED I	Moat	0.6 m²			1.2 - 1.8 m³	1.2 - 1.8 m³	533 - 1,682 kg
Room G13a				*0.6 m² **		*2.0 - 3.0 m*	*1.2 - 1.8 m³*	*1.2 - 1.8 m³*	*533 - 1,682 kg*
Granary G14	VIIa	J. Nasr/ED I	Cor. C6	1.6 m²			3.2 - 4.8 m³	3.2 - 4.8 m³	1,422 - 4,486 kg
Room G14a				*1.6 m²*		*2.0 - 3.0 m*	*3.2 - 4.8 m³*	*3.2 - 4.8 m³*	*1,422 - 4,486 kg*

Table 5.9 (page 2 of 4)
Tell Gubba
Storage facilities, Level VII, storage capacity

Designation	Sub-phase	Date	Location	Floor space[f]	Avg. diam. (floor	Depth[a]	Volume (total)	Storage capacity	
								Volume[b]	Barley, threshed[c]
Granary G15	VIIa	J. Nasr/ED I	Moat	4.6 m^2			9.2 - 13.8 m^3	9.2 - 13.8 m^3	4,088 - 12,897 kg
Room G15a				*0.9 m^2 **		*2.0 - 3.0 m*	*1.8 - 2.7 m^3*	*1.8 - 2.7 m^3*	*800 - 2,523 kg*
Room G15b				*1.3 m^2*		*2.0 - 3.0 m*	*2.6 - 3.9 m^3*	*2.6 - 3.9 m^3*	*1,155 - 3,645 kg*
Room G15c				*0.9 m^2*		*2.0 - 3.0 m*	*1.8 - 2.7 m^3*	*1.8 - 2.7 m^3*	*800 - 2,523 kg*
Room G15d				*0.7 m^2*		*2.0 - 3.0 m*	*1.4 - 2.1 m^3*	*1.4 - 2.1 m^3*	*622 - 1,963 kg*
Room G15e				*0.8 m^2*		*2.0 - 3.0 m*	*1.6 - 2.4 m^3*	*1.6 - 2.4 m^3*	*711 - 2,243 kg*
Granary G16	VIIa	J. Nasr/ED I	Moat	1.0 m^2			2.0 - 3.0 m^3	2.0 - 3.0 m^3	889 - 2,804 kg
Room G16a				*1.0 m^2*		*2.0 - 3.0 m*	*2.0 - 3.0 m^3*	*2.0 - 3.0 m^3*	*889 - 2,804 kg*
Granary G17	VIIa	J. Nasr/ED I	Moat	2.3 m^2			4.6 - 6.9 m^3	4.6 - 6.9 m^3	2,044 - 6,449 kg
Room G17a				*2.3 m^2*		*2.0 - 3.0 m*	*4.6 - 6.9 m^3*	*4.6 - 6.9 m^3*	*2,044 - 6,449 kg*
Granary G18	VIIa	J. Nasr/ED I	Moat	0.5 m^2			1.0 - 1.5 m^3	1.0 - 1.5 m^3	444 - 1,402 kg
Room G18a				*0.5 m^2 **		*2.0 - 3.0 m*	*1.0 - 1.5 m^3*	*1.0 - 1.5 m^3*	*444 - 1,402 kg*
Granary G19	VIIa	J. Nasr/ED I	Moat	2.0 m^2			4.0 - 6.0 m^3	4.0 - 6.0 m^3	1,778 - 5,608 kg
Room G19a				*0.5 m^2 **		*2.0 - 3.0 m*	*1.0 - 1.5 m^3*	*1.0 - 1.5 m^3*	*444 - 1,402 kg*
Room G19b				*0.4 m^2*		*2.0 - 3.0 m*	*0.8 - 1.2 m^3*	*0.8 - 1.2 m^3*	*356 - 1,122 kg*
Room G19c				*1.1 m^2 **		*2.0 - 3.0 m*	*2.2 - 3.3 m^3*	*2.2 - 3.3 m^3*	*978 - 3,084 kg*
Granary G20	VIIa	J. Nasr/ED I	Moat	1.9 m^2			3.8 - 5.7 m^3	3.8 - 5.7 m^3	1,689 - 5,327 kg
Room G20a				*1.9 m^2*		*2.0 - 3.0 m*	*3.8 - 5.7 m^3*	*3.8 - 5.7 m^3*	*1,689 - 5,327 kg*
Granary G21	VIIa	J. Nasr/ED I	Moat	1.3 m^2			2.6 - 3.9 m^3	2.6 - 3.9 m^3	1,155 - 3,645 kg
Room G21a				*0.9 m^2*		*2.0 - 3.0 m*	*1.8 - 2.7 m^3*	*1.8 - 2.7 m^3*	*800 - 2,523 kg*
Room G21b				*0.4 m^2*		*2.0 - 3.0 m*	*0.8 - 1.2 m^3*	*0.8 - 1.2 m^3*	*356 - 1,122 kg*
Granary G22	VIIa	J. Nasr/ED I	Moat	5.0 m^2			10.0 - 15.0 m^3	10.0 - 15.0 m^3	4,444 - 14,019 kg
Room G22a				*1.4 m^2*		*2.0 - 3.0 m*	*2.8 - 4.2 m^3*	*2.8 - 4.2 m^3*	*1,244 - 3,925 kg*
Room G22b				*2.1 m^2*		*2.0 - 3.0 m*	*4.2 - 6.3 m^3*	*4.2 - 6.3 m^3*	*1,866 - 5,888 kg*
Room G22b				*1.5 m^2 **		*2.0 - 3.0 m*	*3.0 - 4.5 m^3*	*3.0 - 4.5 m^3*	*1,333 - 4,206 kg*
Granary G23	VIIa	J. Nasr/ED I	Moat	2.7 m^2			5.4 - 8.1 m^3	5.4 - 8.1 m^3	2,400 - 7,570 kg
Room G23a				*1.1 m^2*		*2.0 - 3.0 m*	*2.2 - 3.3 m^3*	*2.2 - 3.3 m^3*	*978 - 3,084 kg*
Room G23b				*1.0 m^2*		*2.0 - 3.0 m*	*2.0 - 3.0 m^3*	*2.0 - 3.0 m^3*	*889 - 2,804 kg*
Room G23c				*0.6 m^2 **		*2.0 - 3.0 m*	*1.2 - 1.8 m^3*	*1.2 - 1.8 m^3*	*533 - 1,682 kg*
Granary G24	VIIa	J. Nasr/ED I	Moat	2.7 m^2			5.4 - 8.1 m^3	5.4 - 8.1 m^3	2,400 - 7,570 kg
Room G24a				*0.6 m^2*		*2.0 - 3.0 m*	*1.2 - 1.8 m^3*	*1.2 - 1.8 m^3*	*533 - 1,682 kg*
Room G24b				*1.3 m^2*		*2.0 - 3.0 m*	*2.6 - 3.9 m^3*	*2.6 - 3.9 m^3*	*1,155 - 3,645 kg*
Room G24c				*0.8 m^2*		*2.0 - 3.0 m*	*1.6 - 2.4 m^3*	*1.6 - 2.4 m^3*	*711 - 2,243 kg*
Granary G25	VIIa	J. Nasr/ED I	Moat	1.2 m^2			2.4 - 3.6 m^3	2.4 - 3.6 m^3	1,067 - 3,365 kg
Room G25a				*0.7 m^2*		*2.0 - 3.0 m*	*1.4 - 2.1 m^3*	*1.4 - 2.1 m^3*	*622 - 1,963 kg*
Room G25b				*0.5 m^2 **		*2.0 - 3.0 m*	*1.0 - 1.5 m^3*	*1.0 - 1.5 m^3*	*444 - 1,402 kg*
Granary G26	VIIa	J. Nasr/ED I	Moat	1.7 m^2			3.4 - 5.1 m^3	3.4 - 5.1 m^3	1,511 - 4,766 kg
Room G26a				*1.7 m^2*		*2.0 - 3.0 m*	*3.4 - 5.1 m^3*	*3.4 - 5.1 m^3*	*1,511 - 4,766 kg*
Granary G27	VIIa	J. Nasr/ED I	Moat	3.9 m^2			7.8 - 11.7 m^3	7.8 - 11.7 m^3	3,466 - 10,935 kg
Room G27a				*0.6 m^2*		*2.0 - 3.0 m*	*1.2 - 1.8 m^3*	*1.2 - 1.8 m^3*	*533 - 1,682 kg*
Room G27b				*0.7 m^2*		*2.0 - 3.0 m*	*1.4 - 2.1 m^3*	*1.4 - 2.1 m^3*	*622 - 1,963 kg*
Room G27c				*0.4 m^2*		*2.0 - 3.0 m*	*0.8 - 1.2 m^3*	*0.8 - 1.2 m^3*	*356 - 1,122 kg*
Room G27d				*1.0 m^2*		*2.0 - 3.0 m*	*2.0 - 3.0 m^3*	*2.0 - 3.0 m^3*	*889 - 2,804 kg*
Room G27e				*1.2 m^2*		*2.0 - 3.0 m*	*2.4 - 3.6 m^3*	*2.4 - 3.6 m^3*	*1,067 - 3,365 kg*
Granary G28	VIIa	J. Nasr/ED I	Moat	2.0 m^2			4.0 - 6.0 m^3	4.0 - 6.0 m^3	1,778 - 5,608 kg
Room G28a				*2.0 m^2 **		*2.0 - 3.0 m*	*4.0 - 6.0 m^3*	*4.0 - 6.0 m^3*	*1,778 - 5,608 kg*
Granary G29	VIIa	J. Nasr/ED I	Moat	0.9 m^2			1.8 - 2.7 m^3	1.8 - 2.7 m^3	800 - 2,523 kg
Room G29a				*0.9 m^2*		*2.0 - 3.0 m*	*1.8 - 2.7 m^3*	*1.8 - 2.7 m^3*	*800 - 2,523 kg*
Granary G30	VIIa	J. Nasr/ED I	Moat	1.5 m^2			3.0 - 4.5 m^3	3.0 - 4.5 m^3	1,333 - 4,206 kg
Room G30a				*1.5 m^2 **		*2.0 - 3.0 m*	*3.0 - 4.5 m^3*	*3.0 - 4.5 m^3*	*1,333 - 4,206 kg*

Table 5.9 (page 3 of 4)
Tell Gubba
Storage facilities, Level VII, storage capacity

Designation	Sub-phase	Date	Location	Floor space[f]	Avg. diam. (floor	Depth[a]	Volume (total)	Storage capacity	
								Volume[b]	Barley, threshed[c]
All Pits (P1–P13)				5.9 m^2			3.2 - 18.4 m^3	3.2 - 18.4 m^3	1,422 - 17,197 kg
All Corridors (C3–C6)				687.7 m^2			1,375.4 - 2,063.1 m^3	687.7 - 1,031.6 m^3	305,614 - 964,087 kg
All Granaries (G1–G30)				103.9 m^2			207.8 - 311.7 m^3	207.8 - 311.7 m^3	92,346 - 291,315 kg
Pits	VIId			0.6 m^2			0.3 - 2.0 m^3	0.3 - 2.0 m^3	133 - 1,869 kg
Corridors	VIId			39.0 m^2			78.0 - 117.0 m^3	39.0 - 58.5 m^3	17,332 - 54,674 kg
Total	VIId			39.6 m^2			78.3 - 119.0 m^3	39.3 - 60.5 m^3	17,465 - 56,543 kg
Pits	VIIc			5.9 m^2			3.2 - 18.4 m^3	3.2 - 18.4 m^3	1,422 - 17,197 kg
Corridors	VIIc			133.1 m^2			266.2 - 399.3 m^3	133.1 - 199.7 m^3	59,150 - 186,593 kg
Total	VIIc			139.0 m^2			269.4 - 417.7 m^3	136.3 - 218.1 m^3	60,572 - 203,790 kg
Pits	VIIb			5.9 m^2			3.2 - 18.4 m^3	3.2 - 18.4 m^3	1,422 - 17,197 kg
Corridors	VIIb			687.7 m^2			1,375.4 - 2,063.1 m^3	687.7 - 1,031.6 m^3	305,614 - 964,087 kg
Total	VIIb			693.6 m^2			1,378.6 - 2,081.5 m^3	690.9 - 1050.0 m^3	307,036 - 981,283 kg
Pits	VIIa			5.9 m^2			3.2 - 18.4 m^3	3.2 - 18.4 m^3	1,422 - 17,197 kg
Corridors[h]	VIIa			283.7 m^2			567.4 - 851.1 m^3	283.7 - 425.6 m^3	126,076 - 397,719 kg
Granaries	VIIa			103.9 m^2			207.8 - 311.7 m^3	207.8 - 311.7 m^3	92,346 - 291,315 kg
Total	VIIa			393.5 m^2			778.4 - 1,181.2 m^3	494.7 - 755.7 m^3	219,845 - 706,230 kg

SOURCES: Odani and Ii 1981: Fig. 5; Ii 1993: Fig. 1

[a] There is no clear means of estimating the depth of stored grain within the corridors and granaries. I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% (50%, in the case of the corridors) in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

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Tell Gubba
Storage facilities, Level VII, storage capacity

[d] On the published plan, pits are marked with a "P" (Odani and Ii 1981: Fig. 5), but they do not appear to have been labeled individually. I have, therefore, labeled them myself, beginning with those in corridor C3 (P1–P2) and then moving on to those in corridor C4 (P3–P13). According to the excavators (Odani and Ii 1981: 145), the flask-shaped pits measured 0.6–1.2 m in diameter and 0.6–1.5 m in depth. I have assumed that all of the pits (P1–P13) within corridors C3 and C4 were flask-shaped pits, and I have used the published plan to measure the diameter and the area of these pits at floor level. Most of the pits were not exactly circular. In calculating their diameter, I have, therefore, measured a minimum and maximum diameter and used these to calculate an average diameter. To estimate the volume of these flask-shaped pits ("with a small mouth and a large bottom"), I have calculated the volume of a circular truncated cone ($\frac{1}{3}\pi(r_1^2+r_1r_2+r_2^2)h$), with an upper diameter equal to the average diameter of the pits at floor level and a lower diameter no smaller than the upper diameter and no larger than two times the upper diameter. I have assumed that the depth of the pits was between 0.6 and 1.5 m, as indicated by the excavators.

[e] The storage capacity estimates for the corridors in the Round building should be considered very rough. I used the plan published by Ii (1993: Fig. 1) to measure the total surface area of each corridor and multiplied this area by an estimated storage height of 2.0–3.0 m. I then divided the resulting volume by 2 (i.e. a 50% reduction, as opposed to the 25% reduction that I have used for most other non-bulk storerooms) in order to account for the fact that at least some of the corridors (C3, C4) were vaulted (i.e. the sloping walls would reduce the total volume) and also for the fact that some potential storage volume would have been occupied by walkways, ventilation spaces, and the storage containers themselves (e.g. ceramic vessels).

[f] An asterisk (*) indicates that the feature/room in question was only partially preserved or partially excavated (e.g. because it fell beyond the limit of excavation).

[g] Because the "granary" rooms do not appear to have been accessed via doorways, I have assumed that grain was stored in bulk (i.e. not within separate containers) within all of these rooms.

[h] The plan of subphase VIIa, published by Ii (1993: Fig. 1), shows four granary structures (G8–10, 14) within Corridor 6. In calculating storage capacities for Level VIIa, I have, therefore, assumed that the only storage taking place within Corridor 6 was happening within the granary structures. I have not included the total usable storage capacity of Corridor 6 (i.e. total floor space × 2–3 m depth) in either the "Corridors (VIIa)" or the "Total (VIIa)" estimates.

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Tell Gubba
Storage facilities, Levels VI–IV, storage capacity

Designation	**Level**	**Date**	**Location**	**Floor space**[d]	**Depth**[a]	**Volume (total)**	**Storage capacity** Volume[b]	Barley, threshed[c]
Granary 1	V	ED I	NE Area	1.9 m^2			3.8 - 5.7 m^3	1,689 - 5,327 kg
Room 1a				*1.5 m^2*	*2.0 - 3.0 m*	*3.0 - 4.5 m^3*	*3.0 - 4.5 m^3*	*1,333 - 4,206 kg*
Room 1b				*0.4 m^2*	*2.0 - 3.0 m*	*0.8 - 1.2 m^3*	*0.8 - 1.2 m^3*	*356 - 1,122 kg*
Granary 2	V	ED I	NE Area	3.3 m^2			6.6 - 9.9 m^3	2,933 - 9,253 kg
Room 2a				*1.8 m^2*	*2.0 - 3.0 m*	*3.6 - 5.4 m^3*	*3.6 - 5.4 m^3*	*1,600 - 5,047 kg*
Room 2b				*1.5 m^2*	*2.0 - 3.0 m*	*3.0 - 4.5 m^3*	*3.0 - 4.5 m^3*	*1,333 - 4,206 kg*
Granary 3	V	ED I	NE Area	2.8 m^2			5.6 - 8.4 m^3	2,489 - 7,851 kg
Room 3a				*1.4 m^2*	*2.0 - 3.0 m*	*2.8 - 4.2 m^3*	*2.8 - 4.2 m^3*	*1,244 - 3,925 kg*
Room 3b				*1.4 m^2*	*2.0 - 3.0 m*	*2.8 - 4.2 m^3*	*2.8 - 4.2 m^3*	*1,244 - 3,925 kg*
Granary 4	V	ED I	NE Area	2.1 m^2			4.2 - 6.3 m^3	1,866 - 5,888 kg
Room 4a				*1.1 m^2*	*2.0 - 3.0 m*	*2.2 - 3.3 m^3*	*2.2 - 3.3 m^3*	*978 - 3,084 kg*
Room 4b				*1.0 m^2*	*2.0 - 3.0 m*	*2.0 - 3.0 m^3*	*2.0 - 3.0 m^3*	*889 - 2,804 kg*
Granary 5	V	ED I	NE Area	2.3 m^2			4.6 - 6.9 m^3	2,044 - 6,449 kg
Room 5a				*1.2 m^2*	*2.0 - 3.0 m*	*2.4 - 3.6 m^3*	*2.4 - 3.6 m^3*	*1,067 - 3,365 kg*
Room 5b				*1.1 m^2*	*2.0 - 3.0 m*	*2.2 - 3.3 m^3*	*2.2 - 3.3 m^3*	*978 - 3,084 kg*
Granary 6	V	ED I	NE Area	1.7 m^2			3.4 - 5.1 m^3	1,511 - 4,766 kg
Room 6a				*0.8 m^2*	*2.0 - 3.0 m*	*1.6 - 2.4 m^3*	*1.6 - 2.4 m^3*	*711 - 2,243 kg*
Room 6b				*0.9 m^2*	*2.0 - 3.0 m*	*1.8 - 2.7 m^3*	*1.8 - 2.7 m^3*	*800 - 2,523 kg*
Granary 7	V	ED I	NE Area	3.0 m^2			6.0 - 9.0 m^3	2,666 - 8,411 kg
Room 7a				*1.7 m^2*	*2.0 - 3.0 m*	*3.4 - 5.1 m^3*	*3.4 - 5.1 m^3*	*1,511 - 4,766 kg*
Room 7b				*1.3 m^2*	*2.0 - 3.0 m*	*2.6 - 3.9 m^3*	*2.6 - 3.9 m^3*	*1,155 - 3,645 kg*
Granary 8	V	ED I	NE Area	6.3 m^2			12.6 - 18.9 m^3	5,599 - 17,664 kg
Room 8a				*6.3 m^2*	*2.0 - 3.0 m*	*12.6 - 18.9 m^3*	*12.6 - 18.9 m^3*	*5,599 - 17,664 kg*
Granary 9	V	ED I	NE Area	7.4 m^2			14.8 - 22.2 m^3	6,577 - 20,748 kg
Room 9a				*1.0 m^2*	*2.0 - 3.0 m*	*2.0 - 3.0 m^3*	*2.0 - 3.0 m^3*	*889 - 2,804 kg*
Room 9b				*1.1 m^2*	*2.0 - 3.0 m*	*2.2 - 3.3 m^3*	*2.2 - 3.3 m^3*	*978 - 3,084 kg*
Room 9c				*1.1 m^2*	*2.0 - 3.0 m*	*2.2 - 3.3 m^3*	*2.2 - 3.3 m^3*	*978 - 3,084 kg*
Room 9d				*0.9 m^2*	*2.0 - 3.0 m*	*1.8 - 2.7 m^3*	*1.8 - 2.7 m^3*	*800 - 2,523 kg*
Room 9e				*1.0 m^2*	*2.0 - 3.0 m*	*2.0 - 3.0 m^3*	*2.0 - 3.0 m^3*	*889 - 2,804 kg*
Room 9f				*0.9 m^2*	*2.0 - 3.0 m*	*1.8 - 2.7 m^3*	*1.8 - 2.7 m^3*	*800 - 2,523 kg*
Room 9g				*0.9 m^2*	*2.0 - 3.0 m*	*1.8 - 2.7 m^3*	*1.8 - 2.7 m^3*	*800 - 2,523 kg*
Room 9h				*0.5 m^2*	*2.0 - 3.0 m*	*1.0 - 1.5 m^3*	*1.0 - 1.5 m^3*	*444 - 1,402 kg*
Granary 10	V	ED I	NE Area	1.7 m^2			3.4 - 5.1 m^3	1,511 - 4,766 kg
Room 10a				*0.8 m^2*	*2.0 - 3.0 m*	*1.6 - 2.4 m^3*	*1.6 - 2.4 m^3*	*711 - 2,243 kg*
Room 10b				*0.9 m^2*	*2.0 - 3.0 m*	*1.8 - 2.7 m^3*	*1.8 - 2.7 m^3*	*800 - 2,523 kg*
Granary 11	V	ED I	NE Area	1.0 m^2			2.0 - 3.0 m^3	889 - 2,804 kg
Room 11a				*1.0 m^2*	*2.0 - 3.0 m*	*2.0 - 3.0 m^3*	*2.0 - 3.0 m^3*	*889 - 2,804 kg*
Granary 12	V	ED I	NE Area	2.8 m^2			5.6 - 8.4 m^3	2,489 - 7,851 kg
Room 12a				*2.8 m^2*	*2.0 - 3.0 m*	*5.6 - 8.4 m^3*	*5.6 - 8.4 m^3*	*2,489 - 7,851 kg*
Granary 13	V	ED I	NE Area	4.0 m^2			8.0 - 12.0 m^3	3,555 - 11,215 kg
Room 13a				*1.8 m^2*	*2.0 - 3.0 m*	*3.6 - 5.4 m^3*	*3.6 - 5.4 m^3*	*1,600 - 5,047 kg*
Room 13b				*2.2 m^2*	*2.0 - 3.0 m*	*4.4 - 6.6 m^3*	*4.4 - 6.6 m^3*	*1,955 - 6,168 kg*
Granary 14	V	ED I	NE Area	2.1 m^2			4.2 - 6.3 m^3	1,866 - 5,888 kg
Room 14a				*2.1 m^2*	*2.0 - 3.0 m*	*4.2 - 6.3 m^3*	*4.2 - 6.3 m^3*	*1,866 - 5,888 kg*

Table 5.10 (page 2 of 3)
Tell Gubba
Storage facilities, Levels VI–IV, storage capacity

Designation	Level	Date	Location	Floor space[d]	Depth[a]	Volume (total)	Storage capacity	
							Volume[b]	Barley, threshed[c]
Granary 15	V	ED I	NE Area	5.2 m²			10.4 - 15.6 m³	4,622 - 14,580 kg
Room 15a				*1.1 m²*	*2.0 - 3.0 m*	*2.2 - 3.3 m³*	*2.2 - 3.3 m³*	*978 - 3,084 kg*
Room 15b				*1.1 m²*	*2.0 - 3.0 m*	*2.2 - 3.3 m³*	*2.2 - 3.3 m³*	*978 - 3,084 kg*
Room 15c				*1.7 m²*	*2.0 - 3.0 m*	*3.4 - 5.1 m³*	*3.4 - 5.1 m³*	*1,511 - 4,766 kg*
Room 15d				*1.3 m²*	*2.0 - 3.0 m*	*2.6 - 3.9 m³*	*2.6 - 3.9 m³*	*1,155 - 3,645 kg*
Granary 16	V	ED I	NE Area	4.7 m²			9.4 - 14.1 m³	4,177 - 13,178 kg
Room 16a				*1.6 m²*	*2.0 - 3.0 m*	*3.2 - 4.8 m³*	*3.2 - 4.8 m³*	*1,422 - 4,486 kg*
Room 16b				*1.6 m²*	*2.0 - 3.0 m*	*3.2 - 4.8 m³*	*3.2 - 4.8 m³*	*1,422 - 4,486 kg*
Room 16c				*1.5 m²*	*2.0 - 3.0 m*	*3.0 - 4.5 m³*	*3.0 - 4.5 m³*	*1,333 - 4,206 kg*
Granary 17	V	ED I	NE Area	3.0 m²			6.0 - 9.0 m³	2,666 - 8,411 kg
Room 17a				*3.0 m²*	*2.0 - 3.0 m*	*6.0 - 9.0 m³*	*6.0 - 9.0 m³*	*2,666 - 8,411 kg*
Granary 18	V	ED I	NE Area	3.7 m²			7.4 - 11.1 m³	3,289 - 10,374 kg
Room 18a				*1.8 m²*	*2.0 - 3.0 m*	*3.6 - 5.4 m³*	*3.6 - 5.4 m³*	*1,600 - 5,047 kg*
Room 18b				*1.9 m²*	*2.0 - 3.0 m*	*3.8 - 5.7 m³*	*3.8 - 5.7 m³*	*1,689 - 5,327 kg*
Granary 19	V	ED I	NE Area	4.6 m²			9.2 - 13.8 m³	4,088 - 12,897 kg
Room 19a				*2.4 m²*	*2.0 - 3.0 m*	*4.8 - 7.2 m³*	*4.8 - 7.2 m³*	*2,133 - 6,729 kg*
Room 19b				*2.2 m²*	*2.0 - 3.0 m*	*4.4 - 6.6 m³*	*4.4 - 6.6 m³*	*1,955 - 6,168 kg*
Granary 20	V	ED I	NE Area	3.5 m²			7.0 - 10.5 m³	3,111 - 9,813 kg
Room 20a				*1.1 m²*	*2.0 - 3.0 m*	*2.2 - 3.3 m³*	*2.2 - 3.3 m³*	*978 - 3,084 kg*
Room 20b				*2.4 m²*	*2.0 - 3.0 m*	*4.8 - 7.2 m³*	*4.8 - 7.2 m³*	*2,133 - 6,729 kg*
Granary 21	V	ED I	NE Area	4.7 m²			9.4 - 14.1 m³	4,177 - 13,178 kg
Room 21a				*1.0 m²*	*2.0 - 3.0 m*	*2.0 - 3.0 m³*	*2.0 - 3.0 m³*	*889 - 2,804 kg*
Room 21b				*1.6 m²*	*2.0 - 3.0 m*	*3.2 - 4.8 m³*	*3.2 - 4.8 m³*	*1,422 - 4,486 kg*
Room 21c				*2.1 m²*	*2.0 - 3.0 m*	*4.2 - 6.3 m³*	*4.2 - 6.3 m³*	*1,866 - 5,888 kg*
Granary 22	V	ED I	NE Area	3.5 m²			7.0 - 10.5 m³	3,111 - 9,813 kg
Room 22a				*1.6 m²*	*2.0 - 3.0 m*	*3.2 - 4.8 m³*	*3.2 - 4.8 m³*	*1,422 - 4,486 kg*
Room 22b				*1.9 m²*	*2.0 - 3.0 m*	*3.8 - 5.7 m³*	*3.8 - 5.7 m³*	*1,689 - 5,327 kg*
Granary 23	V	ED I	NE Area	2.9 m²			5.8 - 8.7 m³	2,578 - 8,131 kg
Room 23a				*1.8 m²*	*2.0 - 3.0 m*	*3.6 - 5.4 m³*	*3.6 - 5.4 m³*	*1,600 - 5,047 kg*
Room 23b				*1.1 m²*	*2.0 - 3.0 m*	*2.2 - 3.3 m³*	*2.2 - 3.3 m³*	*978 - 3,084 kg*
Granary 24	V	ED I	NE Area	0.9 m²			1.8 - 2.7 m³	800 - 2,523 kg
Room 24a				*0.9 m²*	*2.0 - 3.0 m*	*1.8 - 2.7 m³*	*1.8 - 2.7 m³*	*800 - 2,523 kg*
Granary 25	V	ED I	NE Area	5.4 m²			10.8 - 16.2 m³	4,800 - 15,141 kg
Room 25a				*5.4 m²*	*2.0 - 3.0 m*	*10.8 - 16.2 m³*	*10.8 - 16.2 m³*	*4,800 - 15,141 kg*
Granary 26	V	ED I	NE Area	2.3 m²			4.6 - 6.9 m³	2,044 - 6,449 kg
Room 26a				*1.3 m²*	*2.0 - 3.0 m*	*2.6 - 3.9 m³*	*2.6 - 3.9 m³*	*1,155 - 3,645 kg*
Room 26b				*1.0 m²*	*2.0 - 3.0 m*	*2.0 - 3.0 m³*	*2.0 - 3.0 m³*	*889 - 2,804 kg*
Granary 27	V	ED I	NE Area	4.2 m²			8.4 - 12.6 m³	3,733 - 11,776 kg
Room 27a				*1.1 m²*	*2.0 - 3.0 m*	*2.2 - 3.3 m³*	*2.2 - 3.3 m³*	*978 - 3,084 kg*
Room 27b				*2.5 m²*	*2.0 - 3.0 m*	*5.0 - 7.5 m³*	*5.0 - 7.5 m³*	*2,222 - 7,010 kg*
Room 27c				*0.6 m²*	*2.0 - 3.0 m*	*1.2 - 1.8 m³*	*1.2 - 1.8 m³*	*533 - 1,682 kg*
Granary 28	V	ED I	NE Area	0.6 m²			1.2 - 1.8 m³	533 - 1,682 kg
Room 28a				*0.6 m²*	*2.0 - 3.0 m*	*1.2 - 1.8 m³*	*1.2 - 1.8 m³*	*533 - 1,682 kg*
Granary 29	V	ED I	NE Area	0.9 m²			1.8 - 2.7 m³	800 - 2,523 kg
Room 29a				*0.4 m²*	*2.0 - 3.0 m*	*0.8 - 1.2 m³*	*0.8 - 1.2 m³*	*356 - 1,122 kg*
Room 29b				*0.5 m²*	*2.0 - 3.0 m*	*1.0 - 1.5 m³*	*1.0 - 1.5 m³*	*444 - 1,402 kg*
Granary 30	V	ED I	NE Area	1.1 m²			2.2 - 3.3 m³	978 - 3,084 kg
Room 30a				*1.1 m²*	*2.0 - 3.0 m*	*2.2 - 3.3 m³*	*2.2 - 3.3 m³*	*978 - 3,084 kg*

Table 5.10 (page 3 of 3)
Tell Gubba
Storage facilities, Levels VI–IV, storage capacity

Designation	Level	Date	Location	Floor space[d]	Depth[a]	Volume (total)	Storage capacity	
							Volume[b]	Barley, threshed[c]
Granary 31	V	ED I	NE Area	6.2 m²			12.4 - 18.6 m³	5,511 - 17,384 kg
Room 31a				*3.0 m²*	*2.0 - 3.0 m*	*6.0 - 9.0 m³*	*6.0 - 9.0 m³*	*2,666 - 8,411 kg*
Room 31b				*3.2 m²*	*2.0 - 3.0 m*	*6.4 - 9.6 m³*	*6.4 - 9.6 m³*	*2,844 - 8,972 kg*
Granary 32	V	ED I	NE Area	2.3 m²			4.6 - 6.9 m³	2,044 - 6,449 kg
Room 32a				*2.3 m²*	*2.0 - 3.0 m*	*4.6 - 6.9 m³*	*4.6 - 6.9 m³*	*2,044 - 6,449 kg*
Granary 33	V	ED I	NE Area	2.2 m²			4.4 - 6.6 m³	1,955 - 6,168 kg
Room 33a				*0.8 m²*	*2.0 - 3.0 m*	*1.6 - 2.4 m³*	*1.6 - 2.4 m³*	*711 - 2,243 kg*
Room 33b				*1.4 m²*	*2.0 - 3.0 m*	*2.8 - 4.2 m³*	*2.8 - 4.2 m³*	*1,244 - 3,925 kg*
Granary 34	V	ED I	NE Area	0.9 m²			1.8 - 2.7 m³	800 - 2,523 kg
Room 34a				*0.9 m² **	*2.0 - 3.0 m*	*1.8 - 2.7 m³*	*1.8 - 2.7 m³*	*800 - 2,523 kg*
Room (estimate)[e]	IV	ED I		0.4 - 6.3 m²			0.8 - 18.9 m³	356 - 17,664 kg
Granary (estimate)	IV	ED I		0.6 - 7.4 m²			1.2 - 22.2 m³	533 - 20,748 kg
Total	V	EDI		105.2 m²			210.4 - 315.6 m³	93,502 - 294,960 kg
Total (if 10 Rooms)	IV	EDI		4.0 - 63.0 m²			8.0 - 189.0 m³	3,555 - 176,639 kg
Total (if 10 Granaries)	IV	EDI		6.0 - 74.0 m²			12.0 - 222.0 m³	5,333 - 207,481 kg

SOURCES: Postgate and Watson 1979: 172–173; Odani and Ii 1981: Fig. 8

[a] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[d] An asterisk (*) indicates that the feature/room in question was only partially preserved or partially excavated (e.g. because it fell beyond the limit of excavation).

[e] An early report indicates that "about 10 small, rectangular rooms with ventilation grids beneath them" were uncovered in each of two subphases of Level IV. The same report indicates that "[m]ore than 30 rooms of a type similar to Level IV were uncovered" in Level V (Postgate and Watson 1979: 172). No plan accompanies this early report, but a later plan shows approxiately 68 small rooms, perhaps grouped into 34 "granaries" (i.e. groups of rooms) dating to Level V. In estimating the storage capacity of the Level IV rooms, which do not appear on any plan, I have used the Level V rooms as a guide. It is unclear to me, however, whether the "10 small, rectangular rooms" uncovered in Level IV are analogous to the "rooms" or the "granaries" (i.e. groups of rooms) uncovered in Level V. I have, therefore, provided two different calculations, both of which are completely hypothetical. The first uses the minumum and maximum sizes of the individual rooms uncovered in Level V to calculate a minumum and maximum capacity for each "room" of Level IV. The second uses the mimumum and maximum sizes of the "granaries" (groups of rooms) uncovered in Level V to calculate a minimum and maximum capacity for each "room" of Level IV.

Table 5.11 (page 1 of 2)
Tell Gubba
Number of people that could be fed with stored grain

Designation	Number of people fed: 100% of calories from grain[a] *(minus seed/spoilage)*[d] 1 year	2 years	50-75% of calories from grain[b] *(minus seed/spoilage)* 1 year	2 years	Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)* 1 year	2 years
Level VIId						
Pits	0 - 9	0 - 5	1 - 18	0 - 9	0 - 5	0 - 3
	(0 - 8)	*(0 - 4)*	*(0 - 16)*	*(0 - 8)*	*(0 - 5)*	*(0 - 2)*
Corridors	54 - 270	27 - 135	72 - 539	36 - 270	53 - 160	27 - 80
	(40 - 229)	*(20 - 115)*	*(54 - 458)*	*(27 - 229)*	*(40 - 136)*	*(20 - 68)*
Total	54 - 279	27 - 139	72 - 558	36 - 279	54 - 166	27 - 83
	(41 - 237)	*(20 - 119)*	*(54 - 474)*	*(27 - 237)*	*(40 - 141)*	*(20 - 70)*
Level VIIc						
Pits	4 - 85	2 - 42	6 - 170	3 - 85	4 - 50	2 - 25
	(3 - 72)	*(2 - 36)*	*(4 - 144)*	*(2 - 72)*	*(3 - 43)*	*(2 - 21)*
Corridors	184 - 920	92 - 460	245 - 1,840	122 - 920	182 - 547	91 - 273
	(138 - 782)	*(69 - 391)*	*(184 - 1,564)*	*(92 - 782)*	*(137 - 465)*	*(68 - 232)*
Total	188 - 1,005	94 - 502	251 - 2,010	125 - 1,005	187 - 597	93 - 299
	(141 - 854)	*(71 - 427)*	*(188 - 1,708)*	*(94 - 854)*	*(140 - 508)*	*(70 - 254)*
Level VIIb						
Pits	4 - 85	2 - 42	6 - 170	3 - 85	4 - 50	2 - 25
	(3 - 72)	*(2 - 36)*	*(4 - 144)*	*(2 - 72)*	*(3 - 43)*	*(2 - 21)*
Corridors	949 - 4,754	474 - 2,377	1,265 - 9,509	633 - 4,754	942 - 2,826	471 - 1,413
	(712 - 4,041)	*(356 - 2,021)*	*(949 - 8,082)*	*(474 - 4,041)*	*(707 - 2,402)*	*(353 - 1,201)*
Total	953 - 4,839	477 - 2,420	1,271 - 9,678	636 - 4,839	946 - 2,877	473 - 1,438
	(715 - 4,113)	*(358 - 2,057)*	*(953 - 8,227)*	*(477 - 4,113)*	*(710 - 2,445)*	*(355 - 1,223)*
Level VIIa						
Pits	4 - 85	2 - 42	6 - 170	3 - 85	4 - 50	2 - 25
	(3 - 72)	*(2 - 36)*	*(4 - 144)*	*(2 - 72)*	*(3 - 43)*	*(2 - 21)*
Corridors	391 - 1,961	196 - 981	522 - 3,923	261 - 1,961	389 - 1,166	194 - 583
	(294 - 1,667)	*(147 - 834)*	*(391 - 3,334)*	*(196 - 1,667)*	*(291 - 991)*	*(146 - 496)*
Granaries	287 - 1437	143 - 718	382 - 2,873	191 - 1437	285 - 854	142 - 427
	(215 - 1221)	*(108 - 611)*	*(287 - 2,442)*	*(143 - 1221)*	*(213 - 726)*	*(107 - 363)*
Total	683 - 3,483	341 - 1,741	910 - 6,966	455 - 3,483	678 - 2,070	339 - 1,035
	(512 - 2,960)	*(256 - 1,480)*	*(683 - 5,921)*	*(341 - 2,960)*	*(508 - 1,760)*	*(254 - 880)*

Table 5.11 (page 2 of 2)
Tell Gubba
Number of people that could be fed with stored grain

Designation	Number of people fed					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Level V						
Total	290 - 1,455	145 - 727	387 - 2,909	194 - 1,455	288 - 865	144 - 432
	(218 - 1,236)	*(109 - 618)*	*(290 - 2,473)*	*(145 - 1,236)*	*(216 - 735)*	*(108 - 367)*
Level IV						
Total (if 10 rooms)	11 - 871	6 - 436	15 - 1,742	7 - 871	11 - 518	5 - 259
	(8 - 740)	*(4 - 370)*	*(11 - 1,481)*	*(6 - 740)*	*(8 - 440)*	*(4 - 220)*
Total (if 10 granaries)	17 - 1023	8 - 512	22 - 2,046	11 - 1,023	16 - 608	8 - 304
	(12 - 870)	*(6 - 435)*	*(17 - 1,739)*	*(8 - 870)*	*(12 - 517)*	*(6 - 258)*

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 5.12
Tell Gubba
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume	Grain	1 year		2 years	
		(m^3)	(threshed barley)	Full range	95% range	Full range	95% range
VIId[a]	J. Nasr/ED I	0.3 - 60.5 m³	0,133 - 56,543 kg	0 - 558	10 - 263	0 - 279	5 - 131
VIIc[b]	J. Nasr/ED I	3.2 - 218.1 m³	1,422 - 203,790 kg	3 - 2,010	19 - 952	2 - 1,005	9 - 476
VIIb[c]	J. Nasr/ED I	3.2 - 1,050.0 m³	1,422 - 981,283 kg	3 - 9,678	127 - 4,343	2 - 4,839	63 - 2,171
VIIa[d]	J. Nasr/ED I	211.0 - 755.7 m³	93,768 - 706,230 kg	218 - 6,966	573 - 3,365	110 - 3,483	286 - 1,683
V[e]	ED I	210.4 - 315.6 m³	93,502 - 294,960 kg	218 - 2,909	386 - 1,436	109 - 1,455	193 - 718

[a] The simplified storage capacity ranges for Level VIId are drawn from Table 5.9 (minimum from Pits, subphase VIId; maximum from Total, subphase VIId).

[b] The simplified storage capacity ranges for Level VIIc are drawn from Table 5.9 (minimum from Pits, subphase VIIc; maximum from Total, subphase VIIc).

[c] The simplified storage capacity ranges for Level VIIb are drawn from Table 5.9 (minimum from Pits, subphase VIIb; maximum from Total, subphase VIIb).

[d] The simplified storage capacity ranges for Level VIIa are drawn from Table 5.9 (minimum from Pits + Granaries, subphase VIIa; maximum from Total, subphase VIIa).

[e] The simplified storage capacity ranges for Level V are drawn from Table 5.10 (Total, Level V).

Table 5.13
Tell Gubba
Percentage of the population that could be fed with stored grain

Level	Date	Population	% of population fed			
		(estimated)	1 year		2 years	
			Full range	95% range	Full range	95% range
VIId	J. Nasr/ED I	40 - 100	0 - 1,395 %	16 - 553 %	0 - 698 %	8 - 277 %
VIIc	J. Nasr/ED I	40 - 100	3 - 5,025 %	27 - 1,485 %	2 - 2,513 %	14 - 743 %
VIIb	J. Nasr/ED I	40 - 100	3 - 24,195 %	188 - 7,581 %	2 - 12,098 %	94 - 3,790 %
VIIa	J. Nasr/ED I	40 - 100	218 - 17,415 %	663 - 6,202 %	110 - 8,708 %	331 - 3,101 %
V	ED I	40 - 100	218 - 7,273 %	480 - 2,521 %	109 - 3,638 %	240 - 1,261 %

Table 5.14
Tell Madhhur
Storage facilities, Early Dynastic I period, basic info.

Designation	Location	Date	Level	Description	Contents
Grain store	Curved Building, central courtyard	ED I	Building level 2	Rectangular storage bin. Baked brick foundation (1–2 courses) below parallel-wall substructure (4 mudbrick walls separated by air vents sealed off in the middle and at each end with mudbricks). Superstructure mostly destroyed, except for some patches of burnt floor; would probably have been made of mudbrick and would probably would have been divided into two storage compartments. Probably used for grain storage.	

SOURCE: Roaf 1984: 116, Fig. 3

Table 5.15
Tell Madhhur
Storage facilities, Early Dynastic I period, storage capacity

Designation	Location	Date	Level	Floor space	Depth[a]	Volume (total)	Storage capacity	
							Volume[b]	Barley, threshed[c]
Grain store[d]	Curved Building, central courtyard	ED I	Building level 2	2.3 m²	2.0 - 3.0 m	4.6 - 6.9 m³	4.6 - 6.9 m³	2,044 - 6,449 kg

SOURCE: Roaf 1984: 116, Fig. 3

[a] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[d] Although very little of the bin's superstructure was preserved, the excavators suggest that it would have been divided into two storage compartments (Roaf 1984: 116). In calculating the volume of the bin, I have, therefore, assumed that it would have been divided down the middle by a narrow mudbrick wall running east-west directly above the line of bricks shown in the published plan as part of the substructure (Roaf 1984: Fig. 3).

Table 5.16
Tell Madhhur
Number of people that could be fed with stored grain

Designation	**Number of people fed**					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Grain store	6 - 32 *(5 - 27)*	3 - 16 *(2 - 14)*	8 - 64 *(6 - 54)*	4 - 32 *(3 - 27)*	6 - 19 *(5 - 16)*	3 - 9 *(2 - 8)*

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 5.17
Tell Madhhur
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume	Grain	1 year		2 years	
		(m^3)	(threshed barley)	Full range	95% range	Full range	95% range
Building level 2[a]	ED I	4.6 - 6.9 m^3	2,044 - 6,449 kg	5 - 64	8 - 34	2 - 32	4 - 17

[a] The simplified storage capacity ranges for Building Level 2 are drawn from Table 5.15 (Grain store).

Table 5.18
Tell Madhhur
Percentage of the population that could be fed with stored grain

Level	Date	Population	% of population fed			
		(estimated)	1 year		2 years	
			Full range	95% range	Full range	95% range
Building level 2	ED I	60 - 140	4 - 107 %	8 - 36 %	1 - 53 %	4 - 18 %

Table 5.19 (page 1 of 2)
Tell Razuk
Storage facilities, Late Early Dynastic I period, basic info.

Designation	Location	Level	Locus	Floor (construction)	Floor (final use)	Description	Contents
Bin A[1]	Round Building, central courtyard	VI B (upper) – V B (lower)	455	on Floor 10a	Floor 5	Mudbrick bin (2.6 × 1.6 m, 40–50 cm high). Raised parapet around edge (preserved as high as 39 cm above rest of bin, but probably originally higher) would probably have supported a roof. Entire outer surface of bin covered in mud plaster (as thick as 8 cm on the top). Upper surface (i.e. floor) of bin sloped downward from SE to NW. Probably used for grain storage. Grain would have been held within raised comparment created by parapet and would have slid downward to the NW, where it could be accessed through (hypothetical) hole in parapet. Hole in NW wall of substructure might have provided sub-floor ventilation, or might simply indicate damage. Replaced by Bin B.	
Bin B	Round Building, central courtyard	V B (upper) – V A (lower)	455	on Floor 4	Floor 3b	Mudbrick bin. Only four courses preserved. Long walls 40 cm thick. Short wall (NW) 18 cm thick, included opening to allow for ventilation (or access to stored grain?). NE part of bin and top of bin not preserved. Bricks on floor of bin covered in mud plaster. Floor sloped down from SE to NW (36 cm over 3 m length). Probably used for grain storage. Replaced Bin A.	Brown, compact fill "very free of ash, sherds and other inclusions." Grindstone found against SE end of bin (on Floor 4).

Table 5.19 (page 2 of 2)
Tell Razuk
Storage facilities, Late Early Dynastic I period, basic info.

Bin C	Open space immediately NE of Round Building	V B (upper) – V A (lower)	99 / 92	below Floor 1 (Locus 99)	Floor 2 (Locus 92)	Mudbrick bin (2.7 × 1.5 m, 1 m high). Reddish brown clay used for mortar and plaster, but top surface (i.e. floor of bin) covered in gray plaster. Raised parapet (5–7 brick courses high) would probably have supported a roof, forming storage compartment. Floor of bin virtually level. Substructure followed slope downward to the NW and consisted of two walls (each 50 cm wide) with 50 cm space between them, presumably to provide ventilation. Air shaft partially blocked with mudbricks (probably to keep out water). Floor above air shaft supported with cantilevered bricks. Probably used for grain storage (until Locus 92, Floor 1, when it may have been used as a hearth).	Some ash and sherds within storage compartment (i.e. within parapet) seem to indicate secondary (Locus 92, Floor 1) use as a hearth. Bottom of air shaft filled with a hard, very compact, gray deposit with traces of charcoal (perhaps indicating occasional subfloor fires to deal with damp conditions).
Bin D	Round Building, central courtyard	V A (upper)	455	on Floor 1		Mudbrick bin (2.0 × 1.0 m, preserved 37 cm high). Only substructure of 2 parallel walls (presumably for ventilation) preserved. Probably used for grain storage.	
Bin E	Within room (walls C, Q, L) WSW of Round Building	V A (lower)	49	on Floor 3		Mudbrick bin. Only visible in section. Destroyed by later pit within excavated area. Based on section drawing (Pl. 11), substructure consisted of 2 parallel walls with intervening open space, presumably for ventilation. Probably used for grain storage.	Interior filled with hard, green striations.

SOURCE: Gibson et al. 1981: 35, 38, 42, 48–9, 52, 57; Gibson 1981b: Pl. 7:1, 11, 14, 16–18, 26–27, 28:1, 30, 34

[1] The excavators do not provide specific designations for the bins; instead, they typically refer to a bin according to its stratigraphic position (e.g. "bin on Floor 10a, Locus 455"). For ease of reference, I have assigned my own labels for the bins (Bin A, Bin B, etc.).

Table 5.20
Tell Razuk
Storage facilities, Late Early Dynastic I period, storage capacity

Designation	Location	Level	Floor space	Depth[a]	Volume (total)	Storage capacity	
						Volume[b]	Barley, threshed[c]
Bin A[d]	Round Building, central courtyard	VI B (upper) – V B (lower)	2.6 m²	2.0 - 3.0 m	5.2 - 7.8 m³	5.2 - 7.8 m³	2,311 - 7,290 kg
Bin B	Round Building, central courtyard	V B (upper) – V A (lower)	1.7 m²	2.0 - 3.0 m	3.4 - 5.1 m³	3.4 - 5.1 m³	1,511 - 4,766 kg
Bin C	Open space immediately NE of Round Building	V B (upper) – V A (lower)	2.9 m²	2.0 - 3.0 m	5.8 - 8.7 m³	5.8 - 8.7 m³	2,578 - 8,131 kg
Bin D[e]	Round Building, central courtyard	V A (upper)	1.8 m²	2.0 - 3.0 m	3.6 - 5.4 m³	3.6 - 5.4 m³	1,600 - 5,047 kg
Total		VI B (upper)	2.6 m²		5.2 - 7.8 m³	5.2 - 7.8 m³	2,311 - 7,290 kg
Total		VI A	2.6 m²		5.2 - 7.8 m³	5.2 - 7.8 m³	2,311 - 7,290 kg
Total		V B (lower)	2.6 m²		5.2 - 7.8 m³	5.2 - 7.8 m³	2,311 - 7,290 kg
Total		V B (upper)	4.6 m²		9.2 - 13.8 m³	9.2 - 13.8 m³	4,088 - 12,897 kg
Total		V A (lower)	4.6 m²		9.2 - 13.8 m³	9.2 - 13.8 m³	4,088 - 12,897 kg
Total		V A (upper)	1.8 m²		3.6 - 5.4 m³	3.6 - 5.4 m³	1,600 - 5,047 kg

SOURCE: Gibson 1981b: Pl. 14, 27, 34

[a] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters, but this may be an overestimate. The excavators, for example, have compared the bins at Tell Razuk to storage bins in use within nearby villages: "It should be noted that in present day villages of the Basin, very similar constructions are used in houses to keep blankets, rugs and other goods from damage through mildew. We were told that foodstuffs may be kept in similar fashion. The storage chambers for grain, however, seem today to be outdoor room-like enclosures, with walls a meter or so high and without doorways. When filled with grain, the enclosures are covered with mats or straw and mud plastered roofs are laid on" (Gibson et al. 1981: 49).

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[d] Although the evidence is not conclusive (e.g. no grain was recovered in situ), I have assumed for purposes of calculation that Bins A–D were all raised, grain storage bins. The bins varied somewhat in form, but each appears to have included two basic components: a mudbrick bin (height and roofing uncertain) and, below this, a foundation that raised the bin above floor-level and provided some degree of ventilation. In each case, I have attempted to estimate the storage capacity of the mudbrick bin. I have not attempted to account for the downward slope of the bin floor within Bins A and B.

[e] Only the parallel-wall foundations of Bin D were preserved. I have used the maximum extent of these walls to calculate the floor space of the (hypothetical) overlying bin, but this probably overestimates the size of the bin, which would have been surrounded by a parapet wall of some kind.

Table 5.21 (page 1 of 2)
Tell Razuk
Number of people that could be fed with stored grain

Designation	Number of people fed					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Bin A	7 - 36 *(5 - 31)*	4 - 18 *(3 - 15)*	10 - 72 *(7 - 61)*	5 - 36 *(4 - 31)*	7 - 21 *(5 - 18)*	4 - 11 *(3 - 9)*
Bin B	5 - 24 *(4 - 20)*	2 - 12 *(2 - 10)*	6 - 47 *(5 - 40)*	3 - 24 *(2 - 20)*	5 - 14 *(3 - 12)*	2 - 7 *(2 - 6)*
Bin C	8 - 40 *(6 - 34)*	4 - 20 *(3 - 17)*	11 - 80 *(8 - 68)*	5 - 40 *(4 - 34)*	8 - 24 *(6 - 20)*	4 - 12 *(3 - 10)*
Bin D	5 - 25 *(4 - 21)*	2 - 12 *(2 - 11)*	7 - 50 *(5 - 42)*	3 - 25 *(2 - 21)*	5 - 15 *(4 - 13)*	2 - 7 *(2 - 6)*
Total: VI B (upper)	7 - 36 *(5 - 31)*	4 - 18 *(3 - 15)*	10 - 72 *(7 - 61)*	5 - 36 *(4 - 31)*	7 - 21 *(5 - 18)*	4 - 11 *(3 - 9)*
Total: VI A	7 - 36 *(5 - 31)*	4 - 18 *(3 - 15)*	10 - 72 *(7 - 61)*	5 - 36 *(4 - 31)*	7 - 21 *(5 - 18)*	4 - 11 *(3 - 9)*
Total: V B (lower)	7 - 36 *(5 - 31)*	4 - 18 *(3 - 15)*	10 - 72 *(7 - 61)*	5 - 36 *(4 - 31)*	7 - 21 *(5 - 18)*	4 - 11 *(3 - 9)*
Total: V B (upper)	13 - 64 *(10 - 54)*	6 - 32 *(5 - 27)*	17 - 127 *(13 - 108)*	8 - 64 *(6 - 54)*	13 - 38 *(9 - 32)*	6 - 19 *(5 - 16)*
Total: V A (lower)	13 - 64 *(10 - 54)*	6 - 32 *(5 - 27)*	17 - 127 *(13 - 108)*	8 - 64 *(6 - 54)*	13 - 38 *(9 - 32)*	6 - 19 *(5 - 16)*
Total: V A (upper)	5 - 25 *(4 - 21)*	2 - 12 *(2 - 11)*	7 - 50 *(5 - 42)*	3 - 25 *(2 - 21)*	5 - 15 *(4 - 13)*	2 - 7 *(2 - 6)*

Table 5.21 (page 2 of 2)
Tell Razuk
Number of people that could be fed with stored grain

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 5.22
Tell Razuk
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume (m^3)	Grain (threshed barley)	1 year		2 years	
				Full range	95% range	Full range	95% range
VI B - V A[a]	Late ED I	3.6 - 13.8 m^3	1,600 - 12,897 kg	4 - 127	9 - 64	2 - 64	4 - 32

[a] The simplified storage capacity ranges for Building Levels VI B – VA are drawn from Table 5.20 (minimum from Total, Level VA, upper; maximum from Total, Level VB upper / Level VA lower).

Table 5.23
Tell Razuk
Percentage of the population that could be fed with stored grain

Level	Date	Population (estimated)	% of population fed			
			1 year		2 years	
			Full range	95% range	Full range	95% range
VI B - V A	Late ED I	80 - 340	1 - 159 %	4 - 44 %	1 - 80 %	2 - 22 %

Table 5.24
Ur
Storage facilities, Archaic II period, basic info.

Designation	Date	Location	Description	Contents
Temple Platform, Storeroom A[a]	ED I	Temenos	Long, narrow room. Only foundations preserved. Probably a storeroom.	
Temple Platform, Storeroom B	ED I	Temenos	Long, narrow room. Only foundations preserved. Probably a storeroom.	
Temple Platform, Storeroom C	ED I	Temenos	Long, narrow room. Only foundations preserved. Probably a storeroom.	

SOURCE: Woolley 1939: 1–5, Plates 64, 67

[a] The three long, narrow rooms arranged parallel to one another and occupying the northern corner of the Archaic II (and Archaic I) Temple Platform are not labeled on the published plans (Woolley 1939: Plates 64, 66, 67). I have, therefore, labeled them Storerooms A (northwestern), B (central), and C (southeastern).

Table 5.25 (page 1 of 2)
Ur
Storage facilities, Archaic I period, basic info.

Designation	Date	Location	Description	Contents
Temple Platform, Storeroom A[1]	ED IIIa/b	Temenos	Long, narrow room. Connected to Storeroom B via doorway in southeastern wall. Probably a storeroom.	
Temple Platform, Storeroom B	ED IIIa/b	Temenos	Long, narrow room. Connected to Storerooms A and C via doorways in northwestern and southeastern walls. Probably a storeroom.	
Temple Platform, Storeroom C	ED IIIa/b	Temenos	Long, narrow room. Connected to Storeroom B via doorway in northwestern wall. Probably a storeroom.	
Temple Platform, Shrine B	ED IIIa/b	Temenos	Room with baked brick floor (15 courses) laid in mud mortar. Traces of bitumen suggest original presence of further courses and a coating of bitumen on top. Accessed via doorway in northwestern wall. Possibly a storeroom.	
Temple Platform, Shrine C	ED IIIa/b	Temenos	Room with baked brick floor (at least 15 courses) and a coating of bitumen on top. Brick-lined pit cut into floor in northeastern part of room. Accessed via doorway in northwestern wall and stairway leading up from courtyard (upper step coated in bitumen). Possibly a storeroom.	
Temple Platform, Shrine D	ED IIIa/b	Temenos	Room with baked brick floor (14 courses) and a coating of bitumen on top. Accessed via doorway in northwestern wall and stairway leading up from courtyard (upper step coated in bitumen). Possibly a storeroom.	
Temple Platform, Shrine E	ED IIIa/b	Temenos	Room with baked brick floor. Accessed via doorway in northwestern wall and stairway leading up from courtyard. Possibly a storeroom.	
Temple Platform, Shrine F	ED IIIa/b	Temenos	Room with baked brick floor and a coating of bitumen on top. Accessed via doorway in northwestern wall and stairway leading up from courtyard. Possibly a storeroom.	

SOURCES: Woolley 1939: 17–20, Pl. 64, 66; Benati 2013: 202, 209

Table 5.25 (page 2 of 2)
Ur
Storage facilities, Archaic I period, basic info.

[1] The three long, narrow rooms arranged parallel to one another and occupying the northern corner of the Archaic I (and Archaic II) Temple Platform are not labeled on the published plans (Woolley 1939: Plates 64, 66, 67). I have, therefore, labeled them Storerooms A (northwestern), B (central), and C (southeastern).

Table 5.26
Ur
Storage facilities, Ur III period, basic info.

Designation	Date	Location	Description	Contents
Enunmah	Ur III	Temenos	Large structure, square in plan (57 × 57 m). Exterior walls 2.7 m thick. Five-room ("sanctuary") unit at center, surrounded on all sides by corridor. Remainder of structure occupied by long, narrow, magazine-like rooms. Storehouse.	
Court of Nanna	Ur III	Temenos	Walled courtyard (internally, 43.6 × 65.7 m; externally, 79 × 96 m) with large rooms built into the wall on all sides. On NW, SW, and SE sides, long, narrow rooms oriented parallel to direction of wall, connected to one another and accessed from the courtyard via a single doorway on each side. On NE side, rooms more irregular in shape, could usually be accessed directly from the courtyard. Many of the rooms probably functioned as storerooms.	
Giparu	Ur III	Temenos	Official dwelling of the entu-priestess. Large structure (76.5 × 79 m) that included Ningal temple, sanctuary to royal cult, residential area, and kitchen. Three groups of rooms possibly dedicated, at least in part, to storage: "storerooms" (B 5-8) across corridor to NW of kitchen, "service rooms" (C 35-41) to S and SW of kitchen, "storerooms" (C 29-31) attached to Ningal temple. Some of these rooms probably functioned as storerooms.	

SOURCES: Woolley 1939: 75, Pl. 68; 1974: 43–44, 49–54, Pl. 53, 57, 58; 1982: 149–155, 242–245; Weadock 1958; 1975

Table 5.27
Ur
Storage facilities, Archaic II period, storage capacity

Designation	Date	Location	Floor space	Depth[a]	Volume (total)	Storage capacity	
						Volume[b]	Barley, threshed[c]
Temple Platform, Storeroom A[d]	ED I	Temenos	27.5 m^2	2.0 - 3.0 m	55.0 - 82.5 m^3	41.3 - 61.9 m^3 [s]	18,354 - 57,852 kg
Temple Platform, Storeroom B	ED I	Temenos	29.1 m^2	2.0 - 3.0 m	58.2 - 87.3 m^3	43.7 - 65.5 m^3 [s]	19,420 - 61,216 kg
Temple Platform, Storeroom C	ED I	Temenos	36.1 m^2	2.0 - 3.0 m	72.2 - 108.3 m^3	54.2 - 81.2 m^3 [s]	24,086 - 75,890 kg
Total					185.4 - 278.1 m^3	139.2 - 208.6 m^3	61,860 - 194,958 kg

SOURCE: Woolley 1939: Plate 67

[a] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[d] The three long, narrow rooms arranged parallel to one another and occupying the northern corner of the Archaic II (and Archaic I) Temple Platform are not labeled on the published plans (Woolley 1939: Plates 64, 66, 67). I have, therefore, labeled them Storerooms A (northwestern), B (central), and C (southeastern).

Table 5.28
Ur
Storage facilities, Archaic I period, storage capacity

Designation	Date	Location	Floor space	Depth[a]	Volume (total)	Storage capacity	
						Volume[b]	Barley, threshed[c]
Temple Platform, Storeroom A[d]	ED IIIa/b	Temenos	64.9 m^2	2.0 - 3.0 m	129.8 - 194.7 m^3	97.4 - 146.0 m^3 [s]	43,285 - 136,452 kg
Temple Platform, Storeroom B	ED IIIa/b	Temenos	58.2 m^2	2.0 - 3.0 m	116.4 - 174.6 m^3	87.3 - 131.0 m^3 [s]	38,796 - 122,433 kg
Temple Platform, Storeroom C	ED IIIa/b	Temenos	59.7 m^2	2.0 - 3.0 m	119.4 - 179.1 m^3	89.6 - 134.3 m^3 [s]	39,818 - 125,517 kg
Temple Platform, Shrine B	ED IIIa/b	Temenos	21.3 m^2	2.0 - 3.0 m	42.6 - 63.9 m^3	32.0 - 47.9 m^3 [s]	14,221 - 44,767 kg
Temple Platform, Shrine C	ED IIIa/b	Temenos	23.1 m^2	2.0 - 3.0 m	46.2 - 69.3 m^3	34.7 - 52.0 m^3 [s]	15,421 - 48,599 kg
Temple Platform, Shrine D	ED IIIa/b	Temenos	20.5 m^2	2.0 - 3.0 m	41.0 - 61.5 m^3	30.8 - 46.1 m^3 [s]	13,688 - 43,085 kg
Temple Platform, Shrine E	ED IIIa/b	Temenos	22.3 m^2	2.0 - 3.0 m	44.6 - 66.9 m^3	33.5 - 50.2 m^3 [s]	14,887 - 46,917 kg
Temple Platform, Shrine F	ED IIIa/b	Temenos	21.2 m^2	2.0 - 3.0 m	42.4 - 63.6 m^3	31.8 - 47.7 m^3 [s]	14,132 - 44,580 kg
Total: Storerooms					365.6 - 548.4 m^3	274.3 - 411.3 m^3	121,899 - 384,401 kg
Total: Shrines					216.8 - 325.2 m^3	162.8 - 243.9 m^3	72,348 - 227,949 kg
Total: All					582.4 - 873.6 m^3	437.1 - 655.2 m^3	194,247 - 612,350 kg

SOURCE: Woolley 1939: Plate 66

[a] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[d] The three long, narrow rooms arranged parallel to one another and occupying the northern corner of the Archaic I (and Archaic II) Temple Platform are not labeled on the published plans (Woolley 1939: Plates 64, 66, 67). I have, therefore, labeled them Storerooms A (northwestern), B (central), and C (southeastern).

Table 5.29 (page 1 of 3)
Ur
Storage facilities, Ur III period, storage capacity

Designation	Date	Location	Floor space	Depth[a]	Volume (total)	Storage capacity	
						Volume[b]	Barley, threshed[c]
Enunmah, Room A[d]	Ur III	Temenos	38.8 - 43.5 m²	2.0 - 3.0 m	77.6 - 130.5 m³	58.2 - 97.9 m³ [s]	25,864 - 91,497 kg
Enunmah, Room B	Ur III	Temenos	35.0 - 35.9 m²	2.0 - 3.0 m	70.0 - 107.7 m³	52.5 - 80.8 m³ [s]	23,331 - 75,516 kg
Enunmah, Room C	Ur III	Temenos	35.0 - 37.0 m²	2.0 - 3.0 m	70.0 - 111.0 m³	52.5 - 83.3 m³ [s]	23,331 - 77,852 kg
Enunmah, Room D	Ur III	Temenos	35.5 - 36.8 m²	2.0 - 3.0 m	71.0 - 110.4 m³	53.3 - 82.8 m³ [s]	23,687 - 77,385 kg
Enunmah, Room E	Ur III	Temenos	49.9 - 52.6 m²	2.0 - 3.0 m	99.8 - 157.8 m³	74.9 - 118.4 m³ [s]	33,286 - 110,657 kg
Enunmah, Room F	Ur III	Temenos	50.3 - 51.1 m²	2.0 - 3.0 m	100.6 - 153.3 m³	75.5 - 115.0 m³ [s]	33,552 - 107,479 kg
Enunmah, Room G	Ur III	Temenos	46.7 - 51.4 m²	2.0 - 3.0 m	93.4 - 154.2 m³	70.1 - 115.7 m³ [s]	31,152 - 108,133 kg
Enunmah, Room H	Ur III	Temenos	44.9 - 55.7 m²	2.0 - 3.0 m	89.8 - 167.1 m³	67.4 - 125.3 m³ [s]	29,953 - 117,105 kg
Enunmah, Room I	Ur III	Temenos	48.1 - 55.1 m²	2.0 - 3.0 m	96.2 - 165.3 m³	72.2 - 124.0 m³ [s]	32,086 - 115,890 kg
Enunmah, Room J	Ur III	Temenos	44.5 - 52.6 m²	2.0 - 3.0 m	89.0 - 157.8 m³	66.8 - 118.4 m³ [s]	29,686 - 110,657 kg
Enunmah, Room K	Ur III	Temenos	15.2 m²	2.0 - 3.0 m	30.4 - 45.6 m³	22.8 - 34.2 m³ [s]	10,132 - 31,963 kg
Enunmah, Room L	Ur III	Temenos	25.7 m²	2.0 - 3.0 m	51.4 - 77.1 m³	38.6 - 57.8 m³ [s]	17,154 - 54,020 kg
Enunmah, Room M	Ur III	Temenos	39.2 - 57.0 m²	2.0 - 3.0 m	78.4 - 171.0 m³	58.8 - 128.3 m³ [s]	26,131 - 119,909 kg
Enunmah, Room N	Ur III	Temenos	9.7 - 16.3 m²	2.0 - 3.0 m	19.4 - 48.9 m³	14.6 - 36.7 m³ [s]	6,488 - 34,300 kg
Enunmah, Room O	Ur III	Temenos	12.7 - 15.7 m²	2.0 - 3.0 m	25.4 - 47.1 m³	19.1 - 35.3 m³ [s]	8,488 - 32,991 kg
Enunmah, Room P	Ur III	Temenos	33.2 m²	2.0 - 3.0 m	66.4 - 99.6 m³	49.8 - 74.7 m³ [s]	22,131 - 69,815 kg
Enunmah, Room Q	Ur III	Temenos	42.7 - 49.5 m²	2.0 - 3.0 m	85.4 - 148.5 m³	64.1 - 111.4 m³ [s]	28,486 - 104,114 kg
Enunmah, Room R	Ur III	Temenos	31.3 m²	2.0 - 3.0 m	62.6 - 93.9 m³	47.0 - 70.4 m³ [s]	20,887 - 65,796 kg
Enunmah, Room S	Ur III	Temenos	42.8 m²	2.0 - 3.0 m	85.6 - 128.4 m³	64.2 - 96.3 m³ [s]	28,530 - 90,002 kg
Enunmah, Room U	Ur III	Temenos	45.3 m²	2.0 - 3.0 m	90.6 - 135.9 m³	68.0 - 101.9 m³ [s]	30,219 - 95,236 kg
Enunmah, Room V	Ur III	Temenos	31.6 m²	2.0 - 3.0 m	63.2 - 94.8 m³	47.4 - 71.1 m³ [s]	21,065 - 66,450 kg
Court of Nanna, Room A[e]	Ur III	Temenos	48.7 - 49.2 m²	2.0 - 3.0 m	97.4 - 147.6 m³	73.1 - 110.7 m³ [s]	32,486 - 103,460 kg
Court of Nanna, Room B	Ur III	Temenos	37.4 m²	2.0 - 3.0 m	74.8 - 112.2 m³	56.1 - 84.2 m³ [s]	24,931 - 78,693 kg
Court of Nanna, Room C	Ur III	Temenos	36.9 - 37.1 m²	2.0 - 3.0 m	73.8 - 111.3 m³	55.4 - 83.5 m³ [s]	24,620 - 78,039 kg
Court of Nanna, Room D	Ur III	Temenos	51.3 - 53.1 m²	2.0 - 3.0 m	102.6 - 159.3 m³	77.0 - 119.5 m³ [s]	34,219 - 111,685 kg

Table 5.29 (page 2 of 3)
Ur
Storage facilities, Ur III period, storage capacity

Designation	Date	Location	Floor space	Depth[a]	Volume (total)	Storage capacity	
						Volume[b]	Barley, threshed[c]
Court of Nanna, Room E	Ur III	Temenos	88.7 - 89.8 m²	2.0 - 3.0 m	177.4 - 269.4 m³	133.1 - 202.1 m³ [s]	59,150 - 188,883 kg
Court of Nanna, Room J	Ur III	Temenos	29.5 - 30.0 m²	2.0 - 3.0 m	59.0 - 90.0 m³	44.3 - 67.5 m³ [s]	19,687 - 63,086 kg
Court of Nanna, Room K	Ur III	Temenos	35.4 - 35.5 m²	2.0 - 3.0 m	70.8 - 106.5 m³	53.1 - 79.9 m³ [s]	23,598 - 74,675 kg
Court of Nanna, Room L	Ur III	Temenos	31.5 - 33.9 m²	2.0 - 3.0 m	63.0 - 101.7 m³	47.3 - 76.3 m³ [s]	21,020 - 71,310 kg
Court of Nanna, Room M	Ur III	Temenos	73.7 - 74.7 m²	2.0 - 3.0 m	147.4 - 224.1 m³	110.6 - 168.1 m³ [s]	49,151 - 157,106 kg
Court of Nanna, Room N	Ur III	Temenos	29.6 - 29.7 m²	2.0 - 3.0 m	59.2 - 89.1 m³	44.4 - 66.8 m³ [s]	19,731 - 62,431 kg
Court of Nanna, Room O	Ur III	Temenos	52.8 - 53.1 m²	2.0 - 3.0 m	105.6 - 159.3 m³	79.2 - 119.5 m³ [s]	35,196 - 111,685 kg
Court of Nanna, Room P	Ur III	Temenos	50.2 - 50.6 m²	2.0 - 3.0 m	100.4 - 151.8 m³	75.3 - 113.9 m³ [s]	33,463 - 106,451 kg
Court of Nanna, Room Q	Ur III	Temenos	69.6 - 71.9 m²	2.0 - 3.0 m	139.2 - 215.7 m³	104.4 - 161.8 m³ [s]	46,395 - 151,218 kg
Court of Nanna, Room R	Ur III	Temenos	54.2 m²	2.0 - 3.0 m	108.4 - 162.6 m³	81.3 - 122.0 m³ [s]	36,130 - 114,021 kg
Court of Nanna, Room S	Ur III	Temenos	56.1 m²	2.0 - 3.0 m	112.2 - 168.3 m³	84.2 - 126.2 m³ [s]	37,418 - 117,947 kg
Court of Nanna, Room T	Ur III	Temenos	54.0 m²	2.0 - 3.0 m	108.0 - 162.0 m³	81.0 - 121.5 m³ [s]	35,996 - 113,554 kg
Court of Nanna, Room V	Ur III	Temenos	46.5 m²	2.0 - 3.0 m	93.0 - 139.5 m³	69.8 - 104.6 m³ [s]	31,019 - 97,759 kg
Court of Nanna, Room W	Ur III	Temenos	49.3 m²	2.0 - 3.0 m	98.6 - 147.9 m³	74.0 - 110.9 m³ [s]	32,886 - 103,647 kg
Giparu, Room B 5	Ur III	Temenos	47.2 m²	2.0 - 3.0 m	94.4 - 141.6 m³	70.8 - 106.2 m³ [s]	31,464 - 99,255 kg
Giparu, Room B 6	Ur III	Temenos	11.6 m²	2.0 - 3.0 m	23.2 - 34.8 m³	17.4 - 26.1 m³ [s]	7,733 - 24,393 kg
Giparu, Room B 7	Ur III	Temenos	21.5 m²	2.0 - 3.0 m	43.0 - 64.5 m³	32.3 - 48.4 m³ [s]	14,354 - 45,235 kg
Giparu, Room B 8	Ur III	Temenos	10.5 m²	2.0 - 3.0 m	21.0 - 31.5 m³	15.8 - 23.6 m³ [s]	7,022 - 22,057 kg
Giparu, Room C 29	Ur III	Temenos	62.5 m²	2.0 - 3.0 m	125.0 - 187.5 m³	93.8 - 140.6 m³ [s]	41,685 - 131,405 kg
Giparu, Room C 30	Ur III	Temenos	5.1 m²	2.0 - 3.0 m	10.2 - 15.3 m³	7.7 - 11.5 m³ [s]	3,422 - 10,748 kg
Giparu, Room C 31	Ur III	Temenos	55.2 m²	2.0 - 3.0 m	110.4 - 165.6 m³	82.8 - 124.2 m³ [s]	36,796 - 116,077 kg
Giparu, Room C 35	Ur III	Temenos	26.2 m²	2.0 - 3.0 m	52.4 - 78.6 m³	39.3 - 59.0 m³ [s]	17,465 - 55,141 kg
Giparu, Room C 36	Ur III	Temenos	7.7 m²	2.0 - 3.0 m	15.4 - 23.1 m³	11.6 - 17.3 m³ [s]	5,155 - 16,169 kg

Table 5.29 (page 3 of 3)
Ur
Storage facilities, Ur III period, storage capacity

Designation	Date	Location	Floor space	Depth[a]	Volume (total)	Storage capacity	
						Volume[b]	Barley, threshed[c]
Giparu, Room C 37	Ur III	Temenos	81.4 m²	2.0 - 3.0 m	162.8 - 244.2 m³	122.1 - 183.2 m³ [s]	54,261 - 171,219 kg
Giparu, Room C 38	Ur III	Temenos	12.6 m²	2.0 - 3.0 m	25.2 - 37.8 m³	18.9 - 28.4 m³ [s]	8,399 - 26,543 kg
Giparu, Room C 39	Ur III	Temenos	12.6 m²	2.0 - 3.0 m	25.2 - 37.8 m³	18.9 - 28.4 m³ [s]	8,399 - 26,543 kg
Giparu, Room C 40/41	Ur III	Temenos	53.4 m²	2.0 - 3.0 m	106.8 - 160.2 m³	80.1 - 120.2 m³ [s]	35,596 - 112,339 kg
Total: Enunmah[f]					1,516.2 - 2,505.9 m³	1,137.8 - 1,879.7 m³	505,638 - 1,756,768 kg
Total: Court of Nanna					1,790.8 - 2,718.3 m³	1,343.6 - 2,039.0 m³	597,096 - 1,905,649 kg
Total: Giparu					815.0 - 1,222.5 m³	611.5 - 917.1 m³	271,751 - 857,122 kg
Grand Total					4,122.0 - 6,446.7 m³	3,092.9 - 4,835.8 m³	1,374,485 - 4,519,539 kg

SOURCES: Woolley 1939: Pl. 68, 77; 1974: Pl. 53, 57, 58

[a] There is no clear means of estimating the depth of stored grain. I have assumed that the grain was stored to a depth of 2.0–3.0 meters.

[b] An [s] following a volume estimate indicates that the grain was probably not stored in bulk but may, instead, have been stored in sacks or some other kind of container. In these cases, I have reduced the total volume of the room or structure by 25% in order to account (in a very approximate manner) for the fact that some of this potential storage volume would have been occupied by walkways, ventilation spaces, and the containers themselves.

[c] Minimum and maximum values for converting storage volume to threshed barley (1 m^3 = 444.4 - 934.6 kg) drawn from Hole (1991: 24) and Reynolds (1974), respectively. For other values, see e.g. Schwartz (1994b: Table 2), Danti (2000: 129), Seeher (2000: 293, Note 105), Gallant (1991: 96-97).

[d] The detailed plan of the Enunmah (Woolley 1974: Pl. 58) does not include Woolley's conjectural reconstruction of the northwestern part of the building. I have used this detailed plan to calculate floor space measurements for most of the rooms in the building (i.e. all except the northwestern rooms), but I have also re-measured all of the rooms in the building (i.e. including the northwestern rooms) using a less detailed plan (Woolley 1974: Pl. 53). Where two different measurements were taken for a single room, I have included both measurements (shown as a range). In some cases, the disparity between the two measurements is significant. Given the relatively coarse resolution of the plans, all measurements in this table should be considered rough approximations.

[e] The detailed plan of the Court of Nanna (Woolley 1939: Pl. 77) does not include the rooms along the southwestern side of the court (i.e. within the wall shared with the ziggurat enclosure). I have used this detailed plan to calculate floor space measurements for most of the rooms in the building (i.e. all except the southwestern line of rooms), but I have also re-measured all of the rooms in the building (i.e. including the southwestern line of rooms) using a less detailed plan (Woolley 1974: Pl. 68). Where two different measurements were taken for a single room, I have included both measurements (shown as a range). Given the relatively coarse resolution of the plans, all measurements in this table should be considered rough approximations.

[f] The totals shown here assume that all of the possible storerooms (many of which may not actually have functioned on a regular basis as storerooms) within these three structures were being used to store grain, exclusively. This is extremely unlikely. These numbers are simply provided as a hypothetical indication of the maximum available storage capacity.

Table 5.30
Ur
Number of people that could be fed with stored grain

Designation	Number of people fed					
	100% of calories from grain[a] *(minus seed/spoilage)*[d]		50-75% of calories from grain[b] *(minus seed/spoilage)*		Typical ration (1-2 liters/day)[c] *(minus seed/spoilage)*	
	1 year	2 years	1 year	2 years	1 year	2 years
Archaic II period						
Storerooms A–C	192 - 961	96 - 481	256 - 1,923	128 - 961	191 - 572	95 - 286
	(144 - 817)	*(72 - 409)*	*(192 - 1,634)*	*(96 - 817)*	*(143 - 486)*	*(72 - 243)*
Archaic I period						
Storerooms A–C	378 - 1,896	189 - 948	505 - 3,791	252 - 1,896	376 - 1,127	188 - 563
	(284 - 1,611)	*(142 - 806)*	*(378 - 3,223)*	*(189 - 1,611)*	*(282 - 958)*	*(141 - 479)*
Shrines B–F	225 - 1,124	112 - 562	300 - 2,248	150 - 1,124	223 - 668	112 - 334
	(168 - 956)	*(84 - 478)*	*(225 - 1,911)*	*(112 - 956)*	*(167 - 568)*	*(84 - 284)*
Total	603 - 3,020	302 - 1,510	804 - 6,040	402 - 3,020	599 - 1,795	299 - 898
	(452 - 2,567)	*(226 - 1,283)*	*(603 - 5,134)*	*(302 - 2,567)*	*(449 - 1,526)*	*(225 - 763)*
Ur III period						
Enunmah	1,570 - 8,664	785 - 4,332	2,093 - 17,327	1,047 - 8,664	1,559 - 5,150	779 - 2,575
	(1,178 - 7,364)	*(589 - 3,682)*	*(1,570 - 14,728)*	*(785 - 7,364)*	*(1,169 - 4,377)*	*(584 - 2,189)*
Court of Nanna	1,854 - 9,398	927 - 4,699	2,472 - 18,795	1,236 - 9,398	1,841 - 5,586	920 - 2,793
	(1,390 - 7,988)	*(695 - 3,994)*	*(1,854 - 15,976)*	*(927 - 7,988)*	*(1,380 - 4,748)*	*(690 - 2,374)*
Giparu	844 - 4,227	422 - 2,113	1,125 - 8,454	563 - 4,227	838 - 2,513	419 - 1,256
	(633 - 3,593)	*(316 - 1,796)*	*(844 - 7,186)*	*(422 - 3,593)*	*(628 - 2,136)*	*(314 - 1,068)*
Total	4,268 - 22,288	2,134 - 11,144	5,690 - 44,576	2,845 - 22,288	4,237 - 13,249	2,118 - 6,624
	(3,201 - 18,945)	*(1,600 - 9,472)*	*(4,268 - 37,890)*	*(2,134 - 18,945)*	*(3,178 - 11,261)*	*(1,589 - 5,631)*

[a] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 100 % of their daily caloric needs from the stored grain. This is an unrealistic assumption, but it allows for the possibility that some portion of the grain was being traded for other food items, as appears to have been the case, for example, when institutional dependents were given monthly grain allocations (see e.g. Waetzoldt 1987: 134; Widell 2005: 397). I have assumed a total daily caloric intake of 2000-3000 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[b] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving 50-75 % of their daily caloric needs from the stored grain. I have assumed a total daily caloric intake of 2000-3000 kcal per person per day and, therefore, a daily caloric intake from grain of 1000-2250 kcal per person per day (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 63-68). I have also assumed that 1 kg of grain (threshed barley) represents 3400-3600 kcal (Schwartz 1994b: Table 2).

[c] The calculations in this column assume that the people who relied on the stored grain for subsistence were receiving a ration of 1-2 liters of grain (barley) per person per day (see e.g. Gelb 1965: 230-233; Ellison 1981: 37-42).

[d] The italicized values in parentheses below each population estimate represent a very rough attempt to account for seed requirements (i.e. grain that was earmarked for seeding the next crop, as opposed to consumption) and the effects of spoilage. To allow for seed and/or spoilage, I have assumed a 15-25 % reduction in the amount of grain available for consumption (see e.g. Schwartz 1994b: Table 2; Gallant 1991: 97; Forbes and Foxhall 1995: 74).

Table 5.31
Ur
Number of people that could be fed with stored grain (simplified)

Level	Date	Storage capacity		Number of people fed			
		Volume	Grain	1 year		2 years	
		(m^3)	(threshed barley)	Full range	95% range	Full range	95% range
Archaic II[a]	ED I	139.2 - 208.6 m^3	61,860 - 194,958 kg	144 - 1,923	270 - 964	72 - 961	135 - 482
Archaic I[b]	ED IIIa/b	274.3 - 655.2 m^3	121,899 - 612,350 kg	284 - 6,040	635 - 2,934	142 - 3,020	317 - 1,467
Ur III[c]	Ur III	3,092.9 - 4,835.8 m^3	1,374,485 - 4,519,539 kg	3,201 - 44,576	5,644 - 22,558	1,600 - 22,288	2,822 - 11,279

[a] The simplified storage capacity ranges for the Archaic II period are drawn from Table 5.27 (Total).

[b] The simplified storage capacity ranges for the Archaic I period are drawn from Table 5.28 (minimum from Total, Storerooms; maximum from Total, All).

[c] The simplified storage capacity ranges for the Ur III period are drawn from Table 5.29 (Grand Total).

Table 5.32
Ur
Percentage of the population that could be fed with stored grain

Level	Date	Population	% of population fed			
		(estimated)	1 year		2 years	
			Full range	95% range	Full range	95% range
Archaic II	ED I	2,000 - 4,000	4 - 96 %	8 - 39 %	2 - 48 %	4 - 19 %
Archaic I	ED IIIa/b	5,000 - 10,000	3 - 121 %	8 - 45 %	1 - 60 %	4 - 22 %
Ur III	Ur III	5,000 - 10,000	32 - 892 %	75 - 318 %	16 - 446 %	38 - 159 %