ARTICLES

WATER AND LAND AT THE ANCIENT MAYA COMMUNITY OF LA MILPA

Vernon L. Scarborough, Matthew E. Becher, Jeffrey L. Baker, Garry Harris, and Fred Valdez, Jr.

The Late Preclassic to Classic period (400 B.C.–A.D. 900) Maya community of La Milpa, Belize, has recently revealed an ancient water and land-use system. As demonstrated at other southern Maya Lowland sites, the Maya created a microwatershed to store and convey water during the four months of seasonal drought. In addition to water conservation measures associated with reservoirs, deliberate channelization, diversion weirs, and postulated fields, the importance of rainy-season erosion control is indicated. Given the ancient population densities identified in the Maya area, coupled with the seasonal scarcity of water, we posit a "skill-oriented" economy.

La comunidad maya de La Milpa, Belice, del horizonte Preclásico al horizonte Clásico (400 A.D.–900 D.C.) ha revelado recientemente un antiguo sistema de manejo de agua y tierra. Como se ha demostrado en otros sitios mayas de las tierras bajas meridionales, los mayas crearon una micro-divisoria de aguas para acumular y distribuir agua durante los cuatro meses de sequía. Además de medidas de conservación de agua asociadas con estanques, canalización, presas de desviación y campos de cultivo, se analiza la existencia de control de erosión durante la temporada de lluvias. Dadas la densidades poblacionales antiguas identificadas en el área maya y la escasez estacional de agua, proponemos la existencia de una economía "orientada a la destreza."

The southern Lowland Maya of present-day upper Central America represent one of the earliest and most developed semitropical civilizations in the New World (Figure 1). In addition to towering pyramids, hieroglyphic writing, and sophisticated craft specialists, the Maya had sizable population densities. By A.D. 700 the southern Maya Lowlands register some of the largest populations in the Western Hemisphere before modern times (Rice and Culbert 1990). Given the complexity of Maya civilization, how is it that an environment defined by karstic landforms, thin soils, seasonal drought, and the disturbing absence of permanent natural water sources accommodated statecraft? An answer lies in the longevity of the civilization, and the slow, incremental changes that the Maya made in altering the landscape (Scarborough 1993a, 1994a).

A key variable for understanding Maya land use and related forces of production is water management. In the Maya area, water is the independent variable upon which economic development depends. Because sizable drainages did not exist, the utilization of classic irrigation technology was impossible. However, landscape modifications over many generations designed to improve access to water and extend the period of its availability produced an extremely productive environment.

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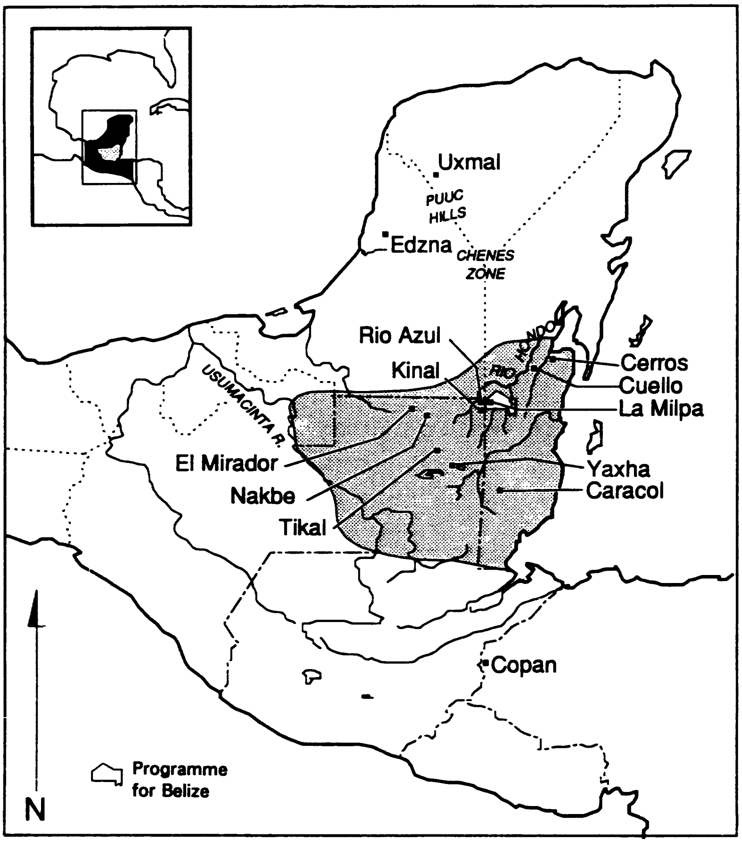

Figure 1. Map of Maya Lowlands. The sites identified are those with known water management features. The southern Maya Lowlands are represented by the shaded zone.

Background

In this early complex society, only a limited number of previously unavailable techniques could significantly improve productivity. Developments in stone-tool technologies, for example, did not evolve significantly following the early domestication process, and few cropping methods were probably added to the inventory of techniques available to farmers after the Middle Formative (Angulo 1993). Three modifications could have been made to the land to significantly enhance production: (1) additional water and/or its diversion, (2) fertilizer, and (3) pest and weed control. Although a crude understanding of pest control may have been practiced by way of intercropping (Gliessman 1984; Gliessman et al. 1981), and composting was surely practiced at the kitchen garden level, sophisticated chemical additives have little influenced this portion of the Maya area until recently. However, the management of water in the prehispanic past prepared the land for production levels beyond those in current use.

In the recent book, *The Rice Economies*, Bray (1986) discusses the relationship of agricultural economies based on "mechanical" technologies drawing from a European model in which labor productivity is increased by the substitution of animals and later machines for humans. When human labor is scarce or more attractive nonfarm-related employment abundant, advances in technology are made to increase the productivity of the labor force. Economies of scale evolve from this strategy. However, when land is scarce and labor abundant, Bray suggests that productivity is defined by enhancing the land base and intensifying the exploitation of resources at a much reduced scale. The mode of production emphasizes the household and immediate community and their association with the small, yet intensively cropped, plot. Seen as an Asian model, it is characterized as "skill-oriented" and dependent on sophisticated agricultural knowledge at the local level. Decisions about the land are made at the household or village level, and the intensity of the tasks performed necessitates the exchange of skilled agricultural labor between households. Although Bray's dichotomy between "mechanical" vs. "skill-oriented" economies emphasizes the unique requirements of wet-rice as opposed to wheat, barley, oats, and rye of an early Middle East and subsequent European agricultural adaptation (Harlan 1992), it illuminates the economic organization of the swamp-dwelling lowland Maya.

For years the Maya have been examined as a civilization according to a model drawn from the earliest states elsewhere in highland Mexico or even the first Old World centers along the semiarid reaches of principal waterways. But the environmental backdrop of the Maya Lowlands is wet-dry forest and seasonally inundated swamp balanced on a limestone foundation, an environment like few others in the New World. To deny this fact, or simply to gloss over its existence, is to obscure severely Maya economic organization. Swamps alone comprise over 30 percent of the southern Maya Lowlands and were a major resource for the origin and development of Maya civilization (Adams 1980; Flannery 1982; Harrison and Turner 1978, 1983; Pohl 1985, 1990).

Another feature that has been dismissed is that the Maya likely had a huge population. It was not concentrated or nucleated at a single city or set of principal cities, but rather population was dispersed across an area of approximately 250,000 km^2. At A.D. 700, more people with shared customs and similar languages were grouped on the Yucatan Peninsula than elsewhere in Mesoamerica (cf. Justeson 1986:438; Kaufman 1976:111; Mathews 1992:5; Rice and Culbert 1990; Turner 1990).

Numerous settlement studies have shown the extent of occupation in the Maya Lowlands and the apparent focus of the Maya on scattered village life. Why was this spatial separation important? Drennan (1988) has suggested that it permitted a type of intensification unlike that reported in highland Mexico, an intensity associated with focused concern over land. Given the densities indicated, land would appear to have been at a premium in the Lowlands. Nevertheless, accretional land development by way of a skill-oriented economy altered the landscape, and slowly raised the carrying capacity that, through time, accommodated a growing population.

We do not know the precise land-use balance on which the Maya were subsisting, but our recent identification of water management practices at the swamp margins of the southern Maya Lowlands suggests that careful timing and attention were demanded for watering fields and providing for domestic needs (Scarborough 1993a; Scarborough, Connolly, and Ross 1993, 1994; Scarborough and Gallopin 1991). The site area of La Milpa within the Programme for Belize landholdings of northwestern Belize provides a case study for the complexity of the ancient water system and the interrelationship between water and land management: a skill-oriented economy (Scarborough et al. 1992).

Survey and Reconnaissance at La Milpa

Water management has been reported from several sites in the Maya area, principally associated with Late Preclassic occupation (Matheny 1976, 1986; Matheny et al. 1980, 1983; Scarborough 1983, 1991a). Unlike the "concave" microwatershed adaptations of the Late Preclassic, La Milpa characterizes a Classic Period "convex" microwatershed (Scarborough 1993a). The builders of La Milpa positioned the site on a natural hill to utilize best the quarried surface for construction fill and the resultant reservoir and rainwater catchment surfaces. The "convex" topographic relief accommodated greater control of runoff across this artificial microwatershed than is apparent at earlier Late Preclassic communities (e.g., Cerros, Edzna, etc.), the latter dependent on natural slope-margin runoff carried into a low-lying site

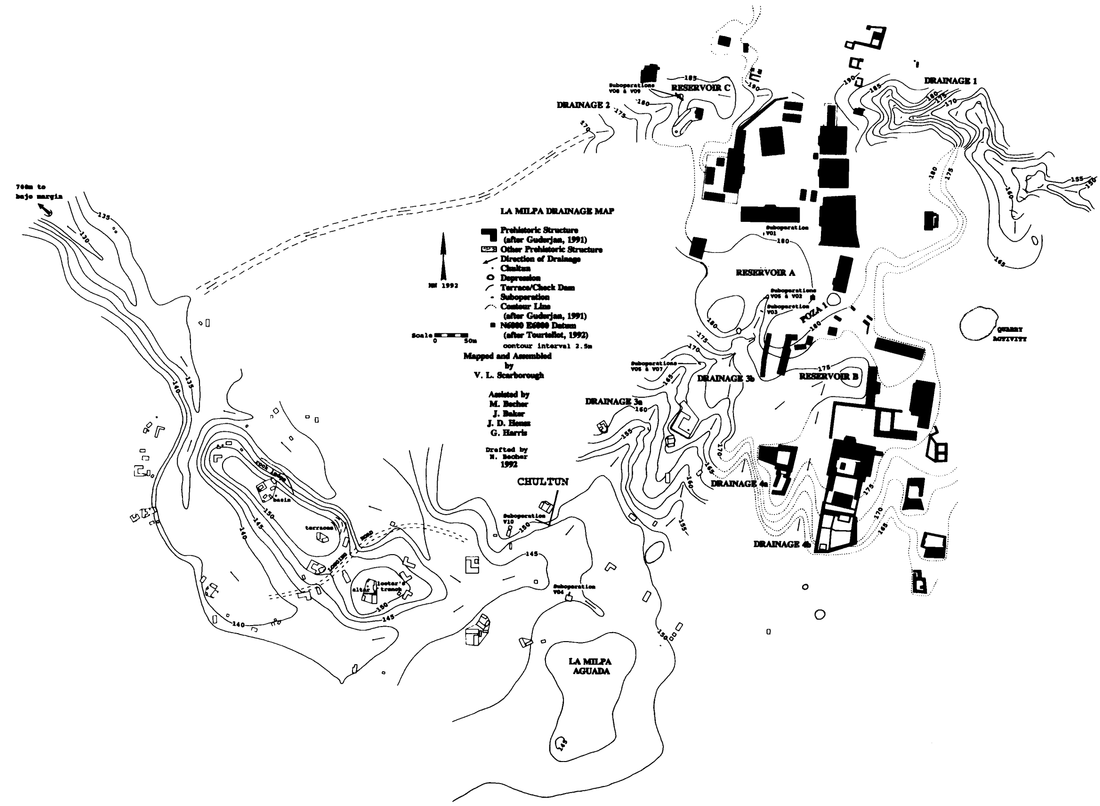

Figure 2. La Milpa Drainage Map.

center. The site center of La Milpa occupies the summit of the highest hillock (180 m asl) within a 2 km radius in an incised cone karst setting.

La Milpa illustrates the sophistication of a reservoir-based water system dating primarily to the Late Classic period. Although these data strongly suggest the complexity of an urban water management scheme, they are preliminary findings requiring additional field investigations.[1] La Milpa lies 25 km northeast of Kinal, Peten, Guatemala, a site of comparable size, with a sophisticated reservoir management adaptation (Scarborough et al. 1993, 1994). As is the case throughout much of the southern Maya Lowlands, no permanent sources of water are known in immediate proximity to La Milpa. The Rio Bravo lies 9 km to the southeast, and the only reported spring/well is located 4 km east/northeast.[2] Further, droughtlike conditions prevail for four months of the year. Rainfall data spanning a period of five years collected from Chan Chich Lodge located 40 km to the south of La Milpa indicate that 87 percent of the annual precipitation falls during the months of June through January (Thomas Harding, personal communication 1992).

Some of the largest structures at La Milpa were constructed during the Late Preclassic period (Guderjan 1991; Norman Hammond, personal communication, 1992). Nevertheless, the major occupation and building activity at La Milpa remains Late Classic. During the 1992 field season, we conducted controlled drainage survey across 75 ha at La Milpa inclusive of the central plaza zone mapped by Guderjan (1991) (Figure 2). Although Tourtellot's (Tourtellot et al. 1993) completed map will eventually permit better population estimates, our preliminary assessment indicates a density of 250 mounds/km[2] within the central southwest quadrant of the site (500 x 500 m).[3] A density of 410

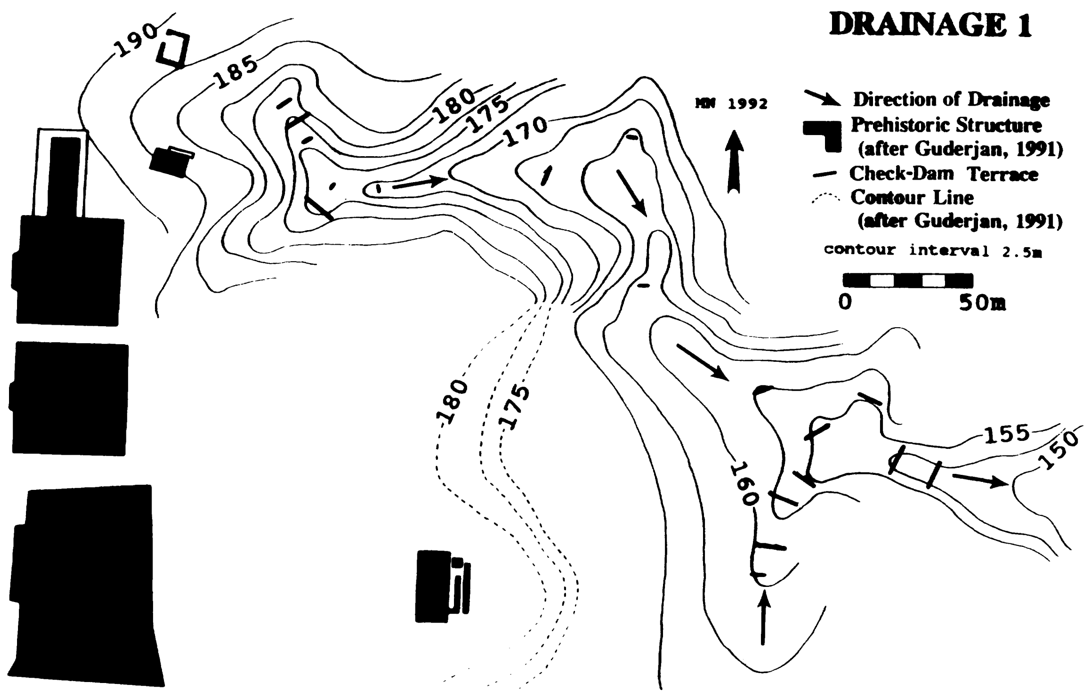

Figure 3. Contour Map of Drainage 1 with Check-Dam Terraces.

mound/km^2 was recorded in the area to the far west and outside the central 1 km^2. These densities are comparable to those from other Classic-period Maya sites in the northeastern Peten (Culbert and Rice 1990), and indicate a clear absence of community boundary or density "drop-off" within the immediate site perimeter.

Drainages and Related Features

Four principal drainages issuing from the elevated central precinct at La Milpa were mapped. The topography at the site is severe, being most rugged to the east. Except for the northeastern-most drainage (Drainage 1), each of the three remaining drainages flowing west (Drainage 2), south (Drainage 3), and southwest (Drainage 4) is defined by a head-end reservoir. The latter three drainages converge, then terminate, in a small *bajo*—seasonal, internally drained swampland—(less than 1 km^2) located 2 km west of the Main Plaza at La Milpa (Figure 2). Drainage 1 issues into a larger bajo (30 km^2) lying 3 km northeast of the same central precinct.

Drainage 1

The northeastern drainage at La Milpa carries very little runoff from the Main Plaza, though it defines its margin (Figure 3). Three of the largest structures at the site (Structures 1, 2, and 3) prevent drainage from flowing in this direction and the associated Main Plaza appears canted in the opposite way (Gair Tourtellot, personal communication 1992).

Drainage 1 is the most incised drainage at the site, having a slope gradient of nearly 10 percent (Figures 3 and 4). The walls of the arroyo are composed of a series of natural terraces approximately 1–3 m wide and geologically formed in the exposed bedrock. In the course of the channel, 18 possible check-dam terraces were identified and mapped. Unlike the side walls of the drainage, these features were deliberate with vertical bedding planes and best defined at or immediately below the confluence of minor drainages feeding into Drainage 1.[4] These locations were generally associated with broader areas of level ground than elsewhere in the channel,

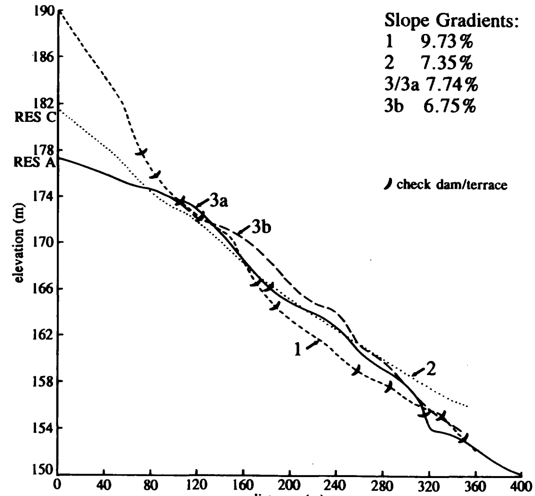

Figure 4. Slope Gradient of La Milpa Drainages. Vertical exaggeration is 1:10.

perhaps suggesting that dry-season agricultural plots were maintained.

The check-dam terraces were constructed to take advantage of natural bedrock outcrops with small, limestone boulders placed on top of the underlying bedrock in many cases. These features were seldom more than two courses high and ranged between 4 and 15 m in length, with a particularly well-constructed set of check-dam terraces descending from a feeder channel near the end of the mapped zone (Figure 3). Nevertheless, many of the check-dam terraces were in severe disrepair, having been "blown out" by years of cascading runoff. No cut stone was identified in the construction, though no formal excavation was carried out in the drainage.

The function of the check-dam features in Drainage 1 is unclear. They surely trapped soil and related debris, and may have provided a small agricultural yield during the dry season when the volume of water contained in the channel was reduced. Nevertheless, an alternative explanation suggests that the check dams functioned primarily to slow the erosive effects of the drainage across this most precipitous northeastern portion of the site (cf. Dunning and Beach 1993). Over the first 150 m of Drainage 1, the slope gradient is 13 percent—almost twice the incline of the other drainages at La Milpa. Given the arroyo's proximity to the major architecture at the site, controlling the degrading effect of wet-season runoff was an end in itself.

Drainage 2

Drainage 2 was identified as a primary drainage at the site based on Tourtellot's observation that most of the runoff from the main plaza flowed into it (Figures 2 and 4). The gradient was gentle when compared to the other drainages, slightly greater than 7 percent within our mapped perimeter, but having a projected gradient of less than 6 percent over its entire length.

An examination of Guderjan's map (1991) above Drainage 2 shows that a parapet wall (less than a meter high) extends from the north end of Structure 9 toward the northeast and the north side of the ballcourt Structures 11 and 12. This somewhat aberrant wall alignment functioned less as a defensive structure and more likely as a plaza runoff diversion weir. It prevented the premature movement of water from the plaza into Drainage 2 by directing flow toward the narrow northern neck of the Main Plaza. This constricted area was defined by the near head-end convergence of Drainages 1 and 2. The weir was constructed to prevent accelerated erosion and uncontrolled runoff into Drainage 2 (Figure 2).

Approximately 100 m west of the end of the diversion feature was a stone dam. Initially the dam was identified as a check dam (Guderjan 1991), but subsequent mapping and excavation indicate a more substantial function. The surficial appearance of the feature suggests an extended single course alignment of stones, 17.5 m long and abutting on both sides of the constricting bedrock walls of the channel's course at this location (Figure 5). The area above the dam was markedly wider than at the dam location, suggesting the presence of an ancient reservoir.

The ill-defined appearance of Reservoir C[5] may be a consequence of post-abandonment downcutting associated with uncontrolled runoff issuing from the unmaintained central

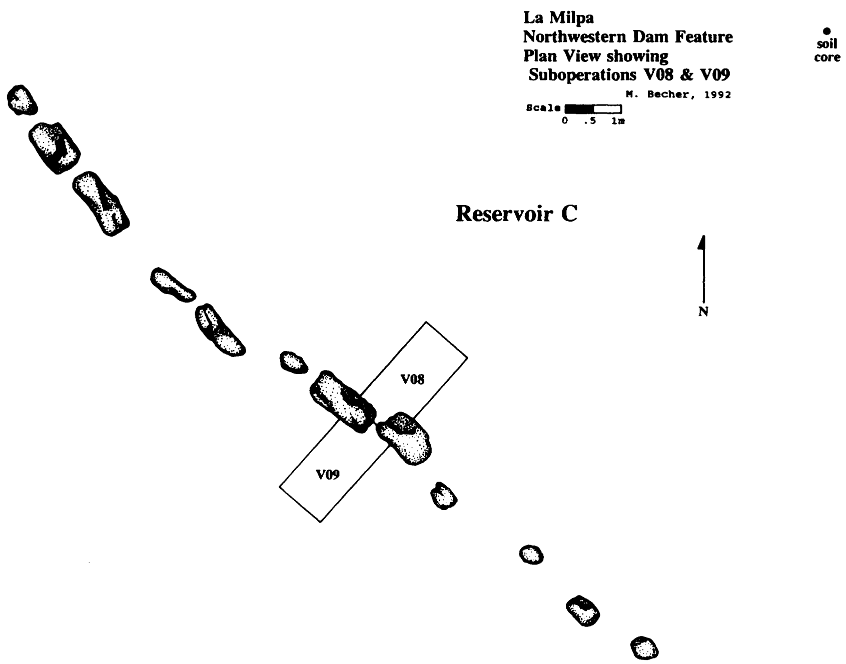

Figure 5. Plan View of Northwestern Dam Feature.

precinct at La Milpa. A soil core was excavated to rubble fall or bedrock, positioned 11 m above the dam, and centrally located within the present channel course. Rock was encountered less than a meter below the surface. The constricted character of the arroyo channel at this location would allow the dam construction to climb at least another meter, though the original height of the dam is difficult to reconstruct. It is possible that a portion of the feature was supported by a sizable timber superstructure anchored in the exposed rubble foundation. The width (thickness) of the dam is unknown.

The scoured condition of the reservoir is further attested by the dam itself. Excavation data indicate that 1.5 m diameter stone slabs were placed vertically into a wet-laid marl and rubble fill support matrix (Suboperation V08 and V09)(Figure 6). The 1.4 m of vertical construction ballast defining the fill behind the stone slabs represents the mass necessary to support the volume contained by Reservoir C. It is likely that the downcut channel

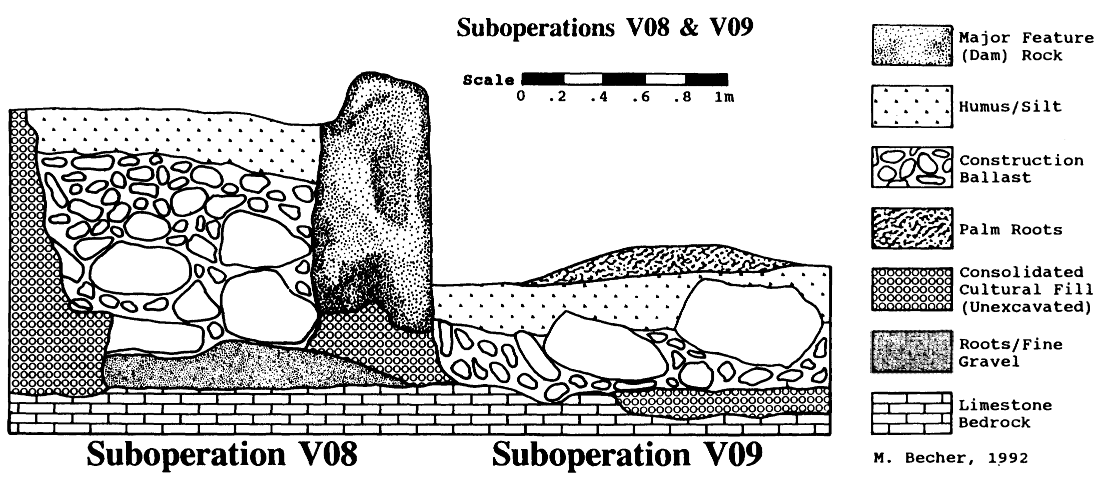

Figure 6. Profile of Northwestern Dam Feature (Southeast Wall Exposure of Suboperation V08 and V09).

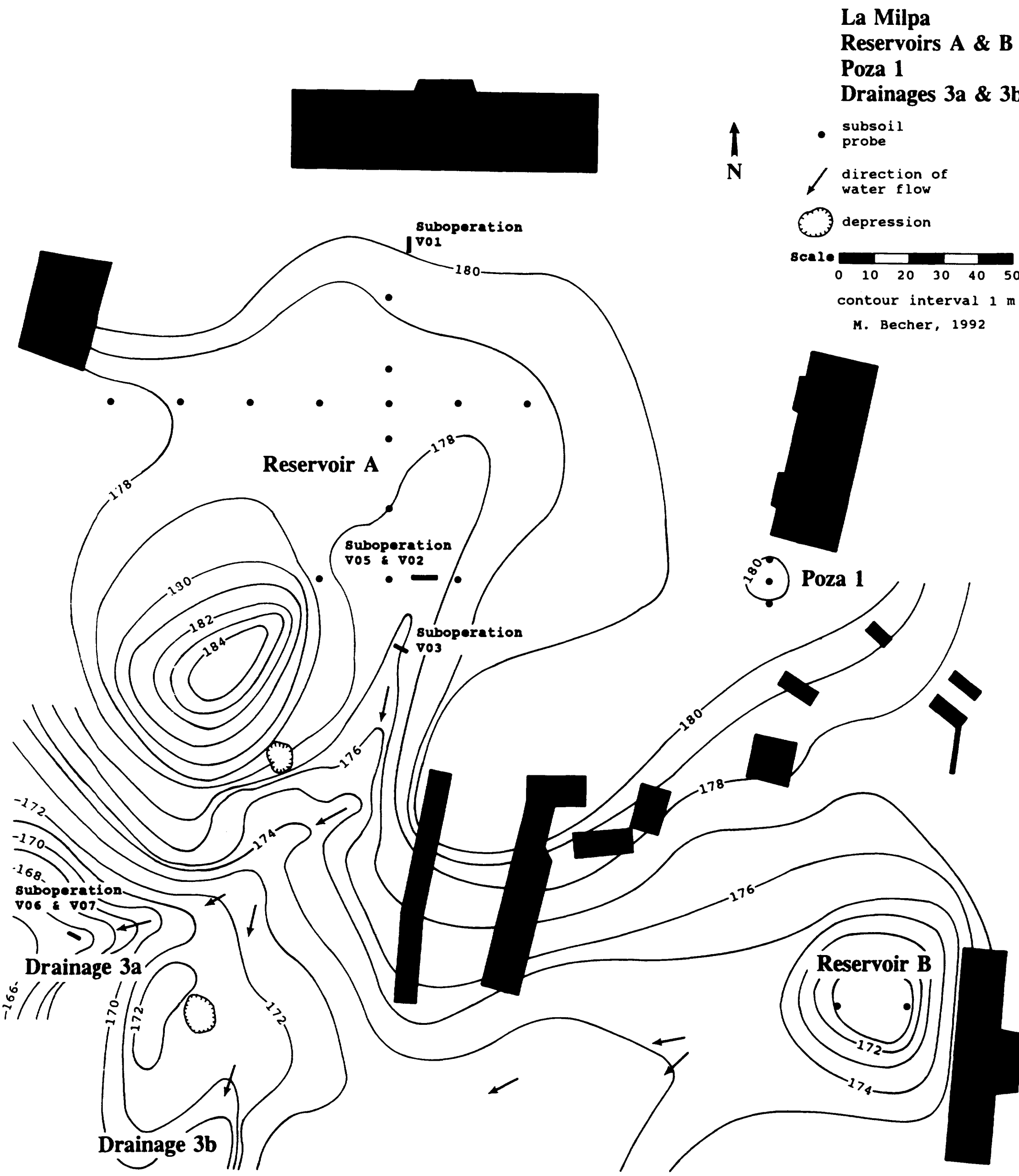

Figure 7. Contour Map of Reservoirs A and B, Drainages 3a and 3b, and Poza 1.

presently knifing through the dam area has removed additional boulder courses as suggested by large outcropping stones immediately below the feature.

No sluice gates for the dam were identified, in part because the feature was in severe disrepair. The dam appears to be a Late Classic period construction, given the datable debris retrieved from the basal reaches of the construction fill. Unlike other dams reported in the Maya area—in the Cayo District, Belize (Healy 1983), and at Copán, Honduras (Turner and Johnson 1979)—no cut stone is identifiable, and the La Milpa alignment is two to four times longer, respectively.

The area below the dam continues at the same "washed out" gradient as that above the feature. A pace and compass survey down Drainage 2 and below the dam found the channel to intersect with the main bajo drain-

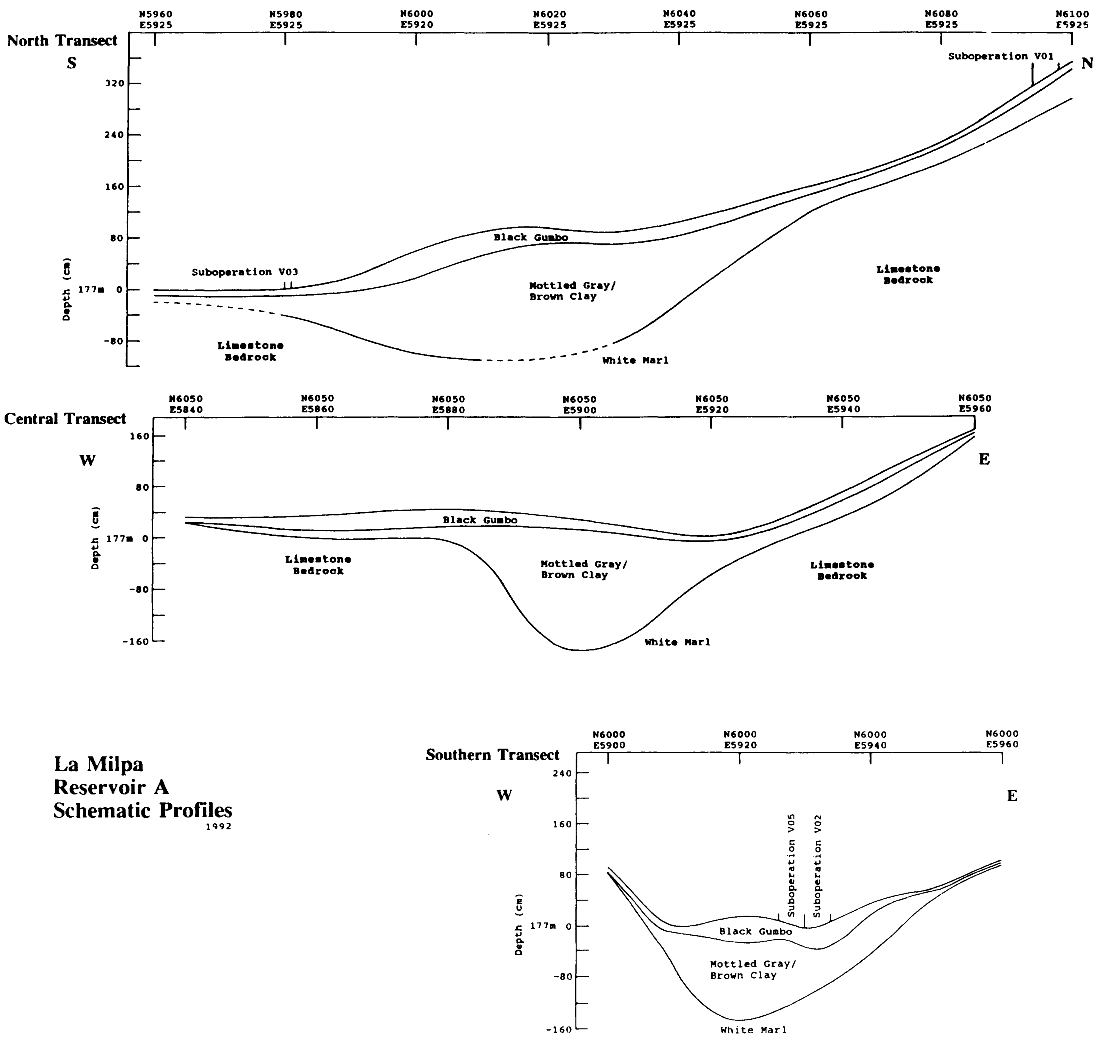

Figure 8. Schematic Profile of Reservoir A retrieved from soil coring transects. Vertical exaggeration is 1:10.

age to the far west (see below), approximately 600 m west. Level fieldlike zones were encountered along the channel's course outside the 1 km² area defining central La Milpa.

Drainage 3

Drainage 3 issues from Reservoir A and bifurcates approximately 70 m south of the slight earthen embankment defining the present southern margin of the reservoir (Figures 2 and 7). This drainage and reservoir received the greatest attention of all the drainages examined because of their location, size, and complexity.

Reservoir A encloses an area of 4,240 m² to a maximum depth of over 2 m. It is bounded most immediately by Structure 8 to the north, segregating the reservoir from the remainder of the Main Plaza. Nevertheless, a sizable quantity of runoff from the plaza must have flowed into Reservoir A, probably around the east end of Structure 8 and between this structure and the massive Structure 3. An excavation unit was placed near the reservoir's margins and below Structure 8 to determine the history of the reservoir relative to the main plaza (Suboperation V01). Unfortunately, this trench was located too high on the banks of the reservoir to provide an unambiguous depositional history (Figure 8). Nevertheless, a soil-coring operation coupled with the discernable stratigraphy from

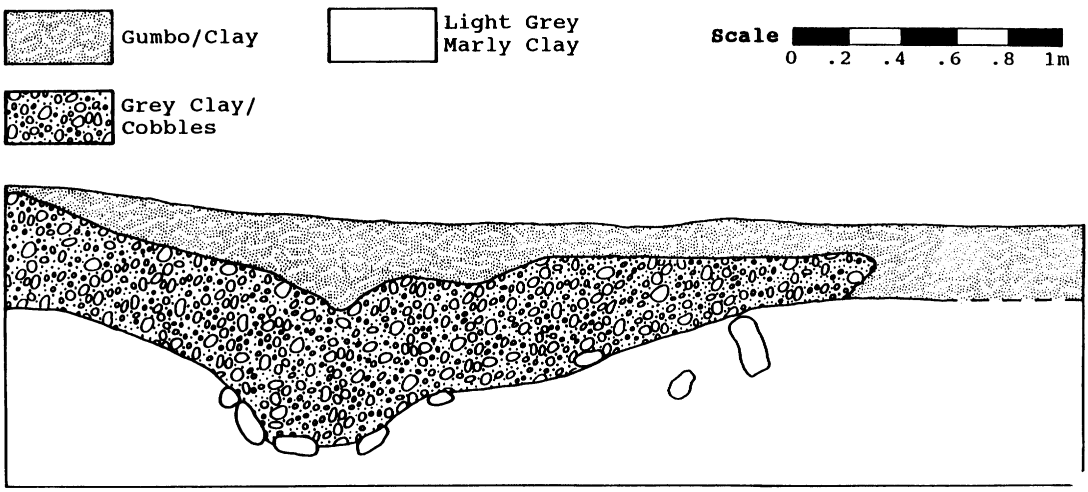

Figure 9. Profile of Reservoir A Berm Channel (North Wall Exposure of Suboperation V02).

the above trench indicates that the reservoir was partially lined by a naturally deposited clay sealant following Late Preclassic quarry efforts in producing the tank and the stone and earthen fill for the adjacent monumental architecture. The reservoir was subsequently used during the Late Classic period. The soil-coring operation further permitted an accurate characterization of the shape and volume of the feature revealing a capacity of 3,180 m^3 (Figures 7 and 8).

The principal drainage outlet for Reservoir A is a slightly perceptible earthen berm at the southern head of Drainage 3. Excavations into the berm suggest that a sluice was positioned at this location, a lazy U-shaped channel 2.5 m wide by .7 m deep cut into the deliberately deposited underlying clay (Suboperation V02) (Figure 9). Considerable sedimentation and bioturbation affected the matrices. Given the limestone quarrying necessary for the erection of monumental architecture in the central precinct at La Milpa, it remains curious that earthen fill was used for the dam. It is likely that the accumulated sediments in the reservoir area were initially scraped away and relocated to the dammed area, in part to expose the underlying limestone for quarrying. This scenario suggests the importance placed on establishing a water source for the construction site, while at the same time allowing the removal of limestone. Too, by keeping the limestone moist, its softened state would allow greater ease of removal.

The post-abandonment infilling matrices within Reservoir A rise to a maximum height of 1.6 m and a cross-sectional width of at least 40 m (Figure 8). The actual elevation of the original dam was higher judging from the other contours in the reservoir. Nevertheless, Dunning's (1992) assessment of the core at N6000 E5940 immediately east of the dam suggests the presence of buried plaster floors overlying the same sediment construction fill identified from the deepest core, N6000 E5920, within the dam itself (Figure 8). If these are floors, they may represent landings from which access to the sluices controlling the release of water were made. Given their depressed location relative to the greater body of Reservoir A, however, these paved surfaces may be the preserved remnants of basal sluice channels themselves, issuing from the tank into Drainage 3.

Located 20 m south of the dam is a well-defined segment of the original drainage channel (Suboperation V03) (Figure 10). Although visible on the surface, subsequent excavation indicates that the 1.6 m wide by .9 m deep channel was lined by eroded buttress stones.

Approximately 70 m south/southwest of the earthen berm, the drainage splits—one branch to the southwest (Drainage 3a) and

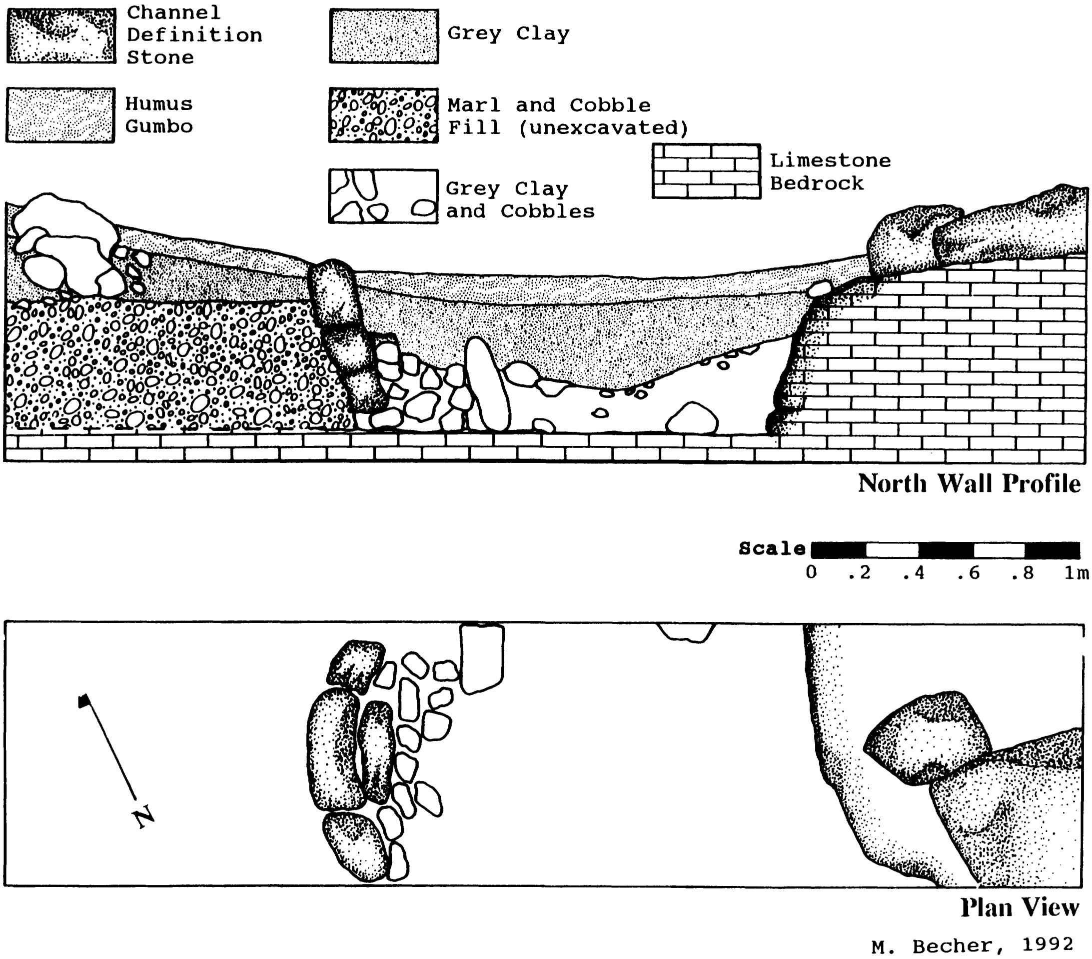

Figure 10. Plan and Profile of Drainage 3 (North Wall Exposure of Suboperation V03).

the other to the south (Drainage 3b). A natural ridge supporting a sizable housemound group separates the two branches. No clearly defined switching station or related diversion feature was identified at this juncture, but given the scoured appearance of the upper drainage, it is unlikely that such a feature would survive following a millennium of abandonment. The gradients of the two drainages were similar, although Drainage 3a was steeper (7.74 percent) than Drainage 3b (6.75 percent) (see Figure 4).

Two crude, small check-dam terraces, each less than 5 m long, were identified along the course of Drainage 3a. Both check dams were in disrepair and constructed by placing a single course of small boulder-size stones on the outcropping bedrock. One of these features was excavated.

At a location 370 m southwest of the earthen berm, the gradient of Drainage 3a leveled. This area was recently used as a milpa locality and was likely a field zone during the Maya occupation of the site. The field area extends over 7 ha with 14 small housemounds dispersed within it. A low-lying *chultun*—a constricted orifice, subterranean chamber—was mapped and excavated (Suboperation V10) (Figures 11 and 12) within the extended margins of Drainage 3a approximately 460 m from the earthen berm of Reservoir A. It was positioned immediately below a ridge-top plazuela group possibly associated with its own immediate courtyard chultun.

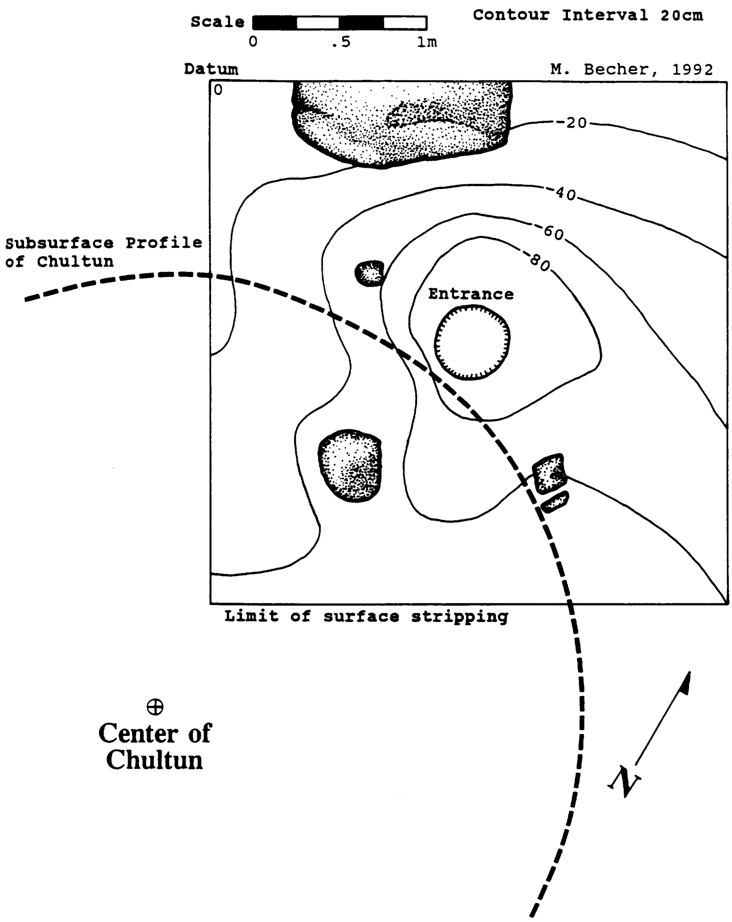

Figure 11. Plan of Cistern Chultun (Suboperation V10).

The excavated chultun was a bell-shaped feature with no sill or related partition, dating to the Late Classic period. It was 2.0 m high, 5.0 m in diameter, with a capacity of 25 m^3. The circular vertical entry shaft (45 cm in diameter) was partially defined and protected from uncontrolled surface drainage by a quarried projection of bedrock and supplemental rubble. Although the interior walls of the cavity revealed no water-impermeable plaster, the feature resembled the chultun cisterns of northern Yucatan (McAnany 1990) more than the food storage pits usually associated with the southern Maya Lowlands (Dahlin and Litzinger 1986; Puleston 1971; Reina and Hill 1980; Scarborough et al. 1994) based on the feature's location, shape and capacity.[6] It appears to have been recharged by way of the drainage it flanks during the wet season, while not taxing the water supply of the reservoir system during the dry season.

Drainage 3b extends for 270 m from its separation from Drainage 3a until it debouches onto the above-mentioned field area. Associated with this drainage, but in the field zone, is a diminutive channel oriented northwest/southeast (see La Milpa Aguada). It was initially interpreted as the remains of a logging road, but excavations (Suboperation V04) (Figure 13) at the foot of a housemound flanking the channel and the channel itself suggest that the ditch dates to the Late Classic period. A possible stone diversion feature was also examined. Dunning's (1992) preliminary evaluation of auger samples taken from the field area reveals elevated phosphate levels indicative of ancient agricultural activity.

The field flat zone was drained by the chan-

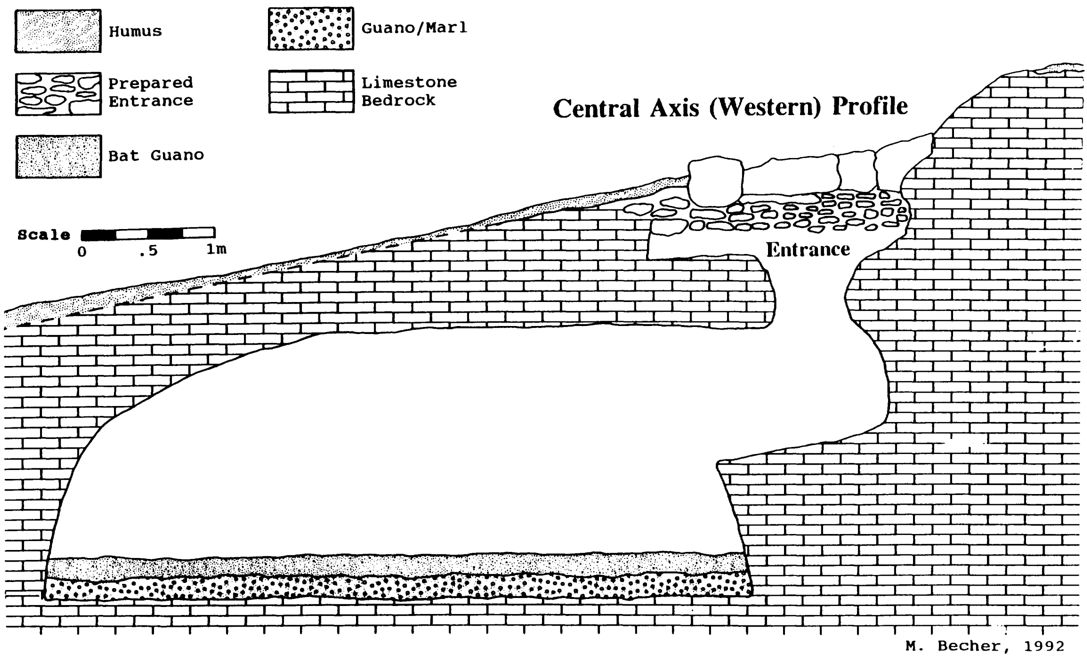

Figure 12. Profile of Cistern Chultun (Suboperation V10).

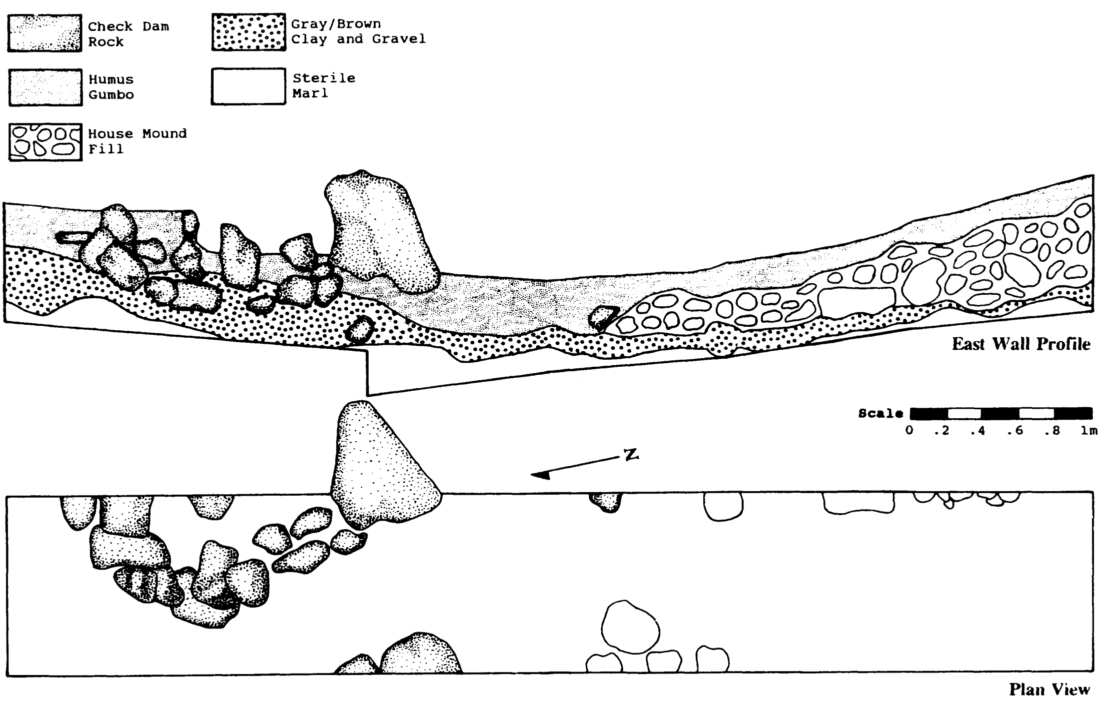

Figure 13. Plan and Profile of Diminutive Ditch within the Field Flat Area (Suboperation V04).

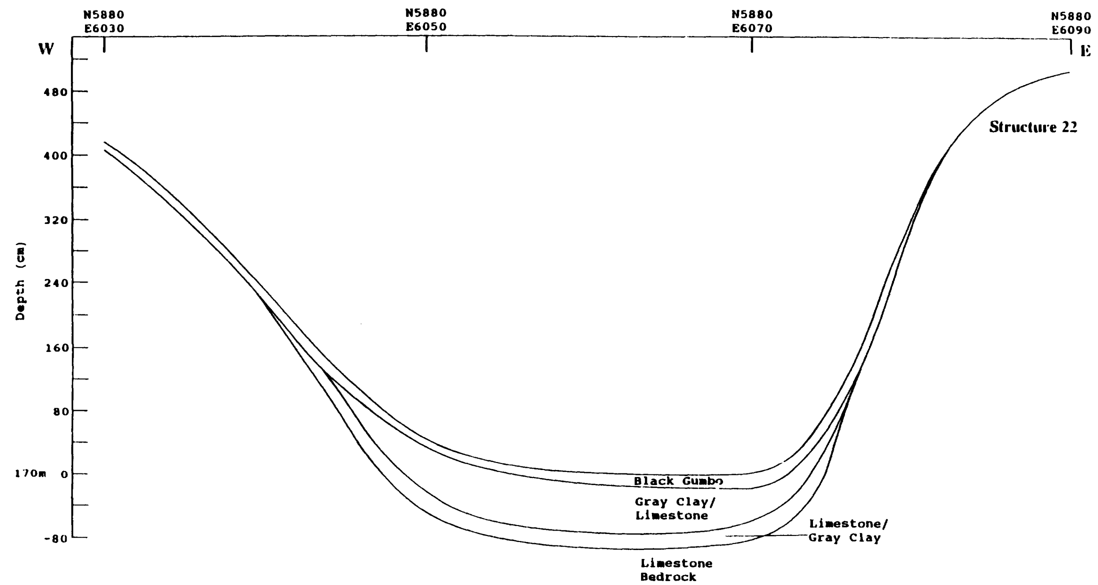

Figure 14. Schematic Profile of Reservoir B retrieved from Soil Coring Transects. The vertical exaggeration is 1:5.

nels identified. If reservoir stores were released expeditiously during the dry season, additional agricultural yields were likely. The bifurcated character of the drainage suggests that Drainage 3a, draining most directly into the Far West Drainage (see below), was used to channel rainy-season overflow away from the field flat zone. Drainage 3b permitted the controlled watering of the field zone from Reservoir A during the dry season. The presence of check dams along Drainage 3a, if functioning as erosional control features (see Drainage 1), and the absence of these features along the slightly more gentle gradient of Drainage 3b, may indicate that a greater uncontrolled volume of water flowed down Drainage 3a than Drainage 3b.

Drainage 4

Drainage 4 is the least well documented of the principal drainages identified at La Milpa. It is actually two drainages, Drainage 4a to the west and Drainage 4b to the east, separated by Courtyard Structures 69–75 and the ridge on which these features are placed (Figure 2).[7] The head end of the bifurcated drainage is defined by Reservoir B, a relatively deep tank. Reservoir B was systematically grid surveyed and cored, revealing a surface area of 2,165 m^2 and a depth of 5.2 m (Figure 14).[8] The approximate volume of the reservoir was 5,975 m^3, with a diminutive catchment area immediately north of the tank and possibly to the east off of Plaza B as defined by Structures 20–24 (see Guderjan 1991: map).

The precise manner by which water was released from Reservoir B to Drainage 4 is not known (Figure 4). In fact, it is possible that Reservoir B did not function as a holding tank for subsequent release of water into the drainage area. Time did not permit a more refined examination of the flat to the west and south of the reservoir.[9] Nevertheless, we conjecture that water was retained in Reservoir B for dry season release into Drainages 4a and 4b, a reconstruction modeled after Reservoir A and Drainages 3a and 3b.

La Milpa Aguada

The large *aguada*—a natural clay- and silt-laden sink—immediately south and southwest of the central 1 km^2 defining La Milpa is the only aguada identified during the 1992

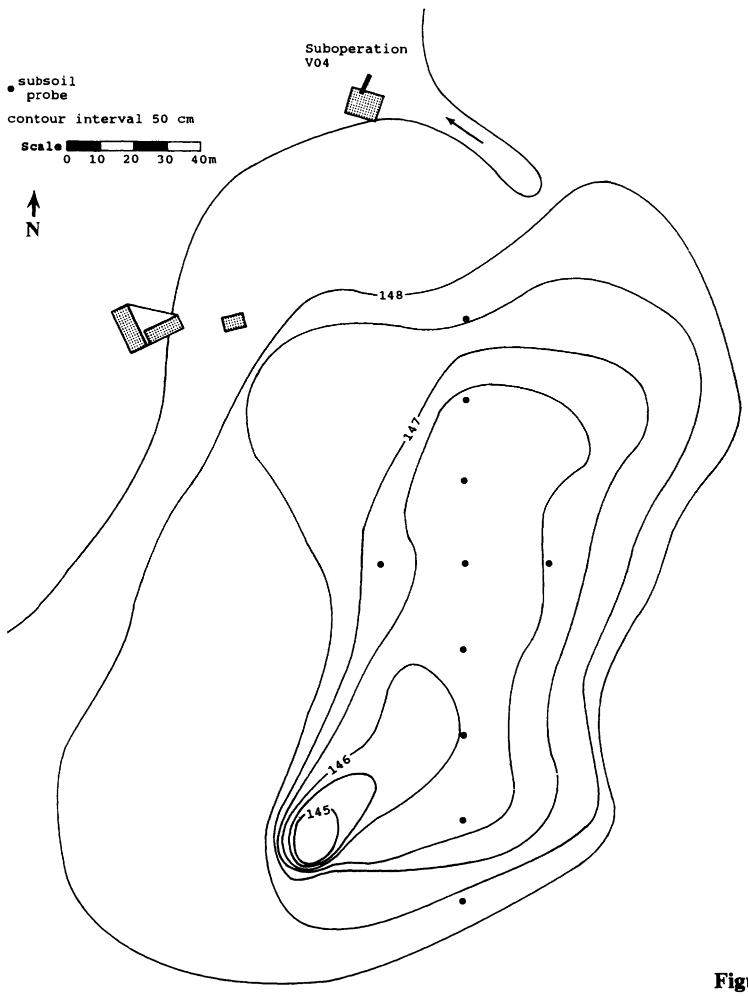

Figure 15. Map of La Milpa Aguada.

field season (Figure 2). Reports of another aguada to the west of the site center were not confirmed. La Milpa Aguada was radially mapped and cored at 25 m intervals, revealing an ancient paleosol at a maximum depth of 1.6 m below the present infilled surface and a surface area of 11,335 m^2 (Figure 15). Investigations were possible because the depression was nearly dry in early April. The basin is partially recharged by way of Drainages 3 and 4.

Although no formal excavation was conducted in the aguada, the tank was probably slightly modified to improve water retention. The southwestern margin of the aguada appears deliberately raised and the core samples retrieved from the bottom of the basin reveal a kaolin clay lining, although the latter now appears to have a natural origin (Nicholas Dunning, personal communication 1992).

The cores associated with La Milpa Aguada provide a cross-sectional history of the depression and surrounding field flat zone (Figures 15 and 16). Dunning's analysis of the central core, N5404 E5663, indicates that the matrices below 130 cm are representative of an ancient paleosol affected by seasonal aridity as evidenced by soil cracking. Nevertheless, the water-retaining character of the depression probably made it an attraction for pioneer populations, if even for half the year. The infilling gray clays overlying the natural paleosol suggest Maya activity at the edge of the aguada.

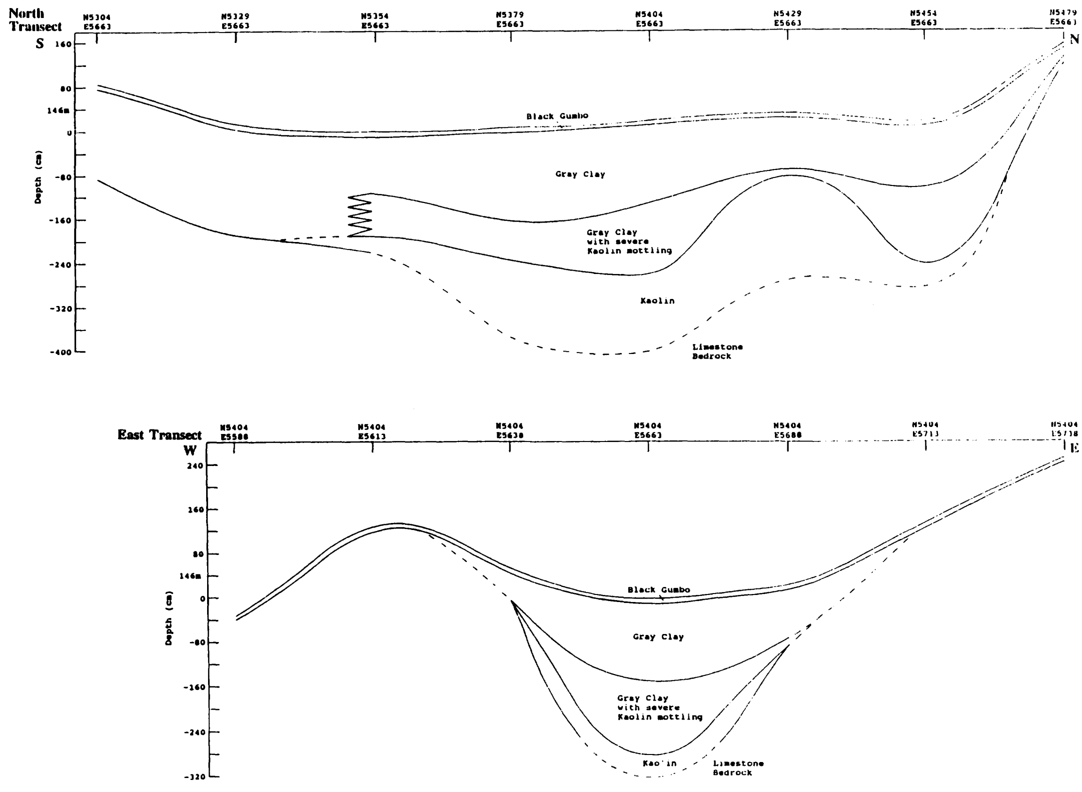

Figure 16. Schematic Profile of La Milpa Aguada retrieved from soil coring transects. The vertical exaggeration is 1:10.

Pollen analysis of the same central core at approximately the same depth reveals a marked frequency of woody charcoal and a similarly striking absence of fungi, both indicative of vegetational clearance around the aguada's margins (Travspore 1993). The burning of ancient adjacent fields in this context implies the presence of intensive swidden agricultural practices, routinely watered by Drainage 3. The high frequencies of *Concentricystes* cysts, a green-algal fossil abundant in "oxbow lakes and other nearby river ponds that are regularly flushed" (Travspore 1993), also represented in the same samples as the charcoal, suggest that the fields were "regularly flushed" by controlled channelization.

The North Transect core sample through the center of the aguada indicates a natural undulation in the basal profile (Figure 16). The rise in the profile at N5429 E5663 may have acted as a natural silting tank embankment given that Drainages 3 and 4 lie immediately to the north and probably partially debouched into the aguada. Although this latter depression is nearly 50 m wide along this coring transect, we have little control over its east–west dimensions. The north–south long axis of the aguada is 175 m.

The East Transect reveals the same sediment history (Figure 16), though the cross-section perpendicular to the North Transect indicates a maximum surface width of 70 m. The banks of the feature climb considerably higher, but the maximum surface-capacity width of the aguada is conditioned by the lower elevations associated with the south end depicted in the North Transect.

Surface drainage into the aguada is principally from the northeast margin of the basin. Nevertheless, shallow subterranean aquifer movement may influence the recharge rate of the aguada from runoff volume carried into the field flat zone and allowed to percolate into these neighboring soils. The northern Drainages 3 and 4 are most responsible for saturating the field flat zone. The filtering action of the soil and porous limestone may have lessened the quantity of impurities that might contaminate the water source after wetting the field flat zone. No well-defined outlet for the aguada was discovered.

The Far West Drainage

Lying below and northwest of La Milpa Aguada, the Far West Drainage was mapped to better discern the relationship between the primary drainages flowing to the south and west at La Milpa (Drainages 2, 3, and 4) and the small bajo terminus approximately 2 km from the Main Plaza as defined by the drainage course (Figure 2). Because the greater La Milpa catchment represents the principal source and watershed for the bajo, water levels in the bajo are hypothesized to have been partially controlled. The Far West Drainage was the linkage between the controlled reservoir and channel release system at the site core and apex and the hypothesized fields in the low-lying bajo.

The increased density and complexity of the structures recorded in the Far West Zone (410 mounds/km^2), as compared to the density of structures associated with the ridges and flat areas in proximity to Drainages 3 and 4, may suggest the significance placed by the Maya in the former zone on the water resource. Although we have little information about the settlement density outside the primary drainage network at La Milpa, the figures from other sites in the southern Maya Lowlands indicate densities of one-half to one-third that represented in the Far West Zone (Culbert and Rice 1990). The recent survey sample carried out at the nearby and environmentally comparable Terminal Classic site of Kinal, Peten (25 km to the southwest), records core site densities of 128 structures/km^2 (Scarborough et al. 1994), further accenting the density of occupation in the Far West Zone at La Milpa.

Although the course of the water flow from Drainages 3 and 4 appears to converge immediately west of the field flat zone, the Far West Drainage again splits around a saddle-top ridge oriented to the northwest. The ridge is densely covered with sizable structures. The gradient around the outcrop is slight, perhaps indicating the presence of additional agricultural plots within the broad course of the drainage. Beyond the ridge, and the convergence once again of the West Drainage, the gradient steepens and the channel course becomes incised. Settlement density appears to drop off as the increasingly incised channel flows toward the bajo located 700 m west of the margins of the map, although this observation may be a consequence of limited survey beyond the margins of the drainage.

Drainage 2 entered the Far West Drainage 150 m northwest and below the saddle-top ridge from the east. It is at this confluence that the channel becomes most incised, cutting 2 m deep across a 10-m-wide course in some locations. There is reason to believe that the erosion of the channel at this location has accelerated since the abandonment of the site area. Given a controlled release of water during the dry season and a well-checked and diverted drainage system during the rainy season, considerably less scouring of the channel's course originally occurred. A possible "hanging" canal/channel segment was noted in the incised walls of the Far West Drainage below our survey lines suggesting post-abandonment downcutting. It was not excavated.

In addition to the housemounds and the drainage course itself, the survey located a small area of possible contour terracing; narrow, single-course alignments located on the northeast margins of the saddle defining the saddle-top ridge. If aboriginal, they may have been constructed for erosional control, although other landscaping functions are clearly possible. In the area west of the aguada and south of the southeast knoll, another single-course alignment was mapped within the present channel course. Consisting of five small, vertically bedded, boulder-size stones, the alignment ran into and slightly askew of parallel with the channel. Although the feature was not excavated, it has the classic appearance of a diversion weir, suggesting that some of the level ground associated with the Far West Drainage was agricultural.

Four of the six chultuns identified by the water survey appear in the Far West Zone associated with elevated housemounds. Unlike the excavated chultun in Drainage 3a, these features were located above the drainage channel and in immediate proximity to a house structure. Our recent excavation of a chultun positioned in a similar location at the nearby site of Kinal (Scarborough et al. 1994) and the function of similarly placed chultuns at other southern Maya Lowland sites suggest that these specific features were not used in water storage.

Outside the mapped area, at the immediate margins of the small bajo, is a damlike plug at the terminus of the Far West Drainage. The feature is approximately 1 m high and 10 m wide, filling the U-shaped drainage course at this location. The feature was not excavated, although it appears to be constructed of unconsolidated cobble-size angular limestone. Because of a present-day logging operation identified nearby, its origin remains suspect.

A very brief reconnaissance into the bajo did not allow the identification of agricultural fields. Given the amount of debris carried by the uncontrolled post-abandonment drainages at La Milpa and the postulated downcutting associated with the lower end of the Far West Drainage, considerable infilling has occurred. It is possible that ancient fields lie buried by the volume of matrix carried into this basin. It should be noted that the damlike plug at the terminus of the Far West Drainage suggests that recent sedimentation into the bajo would have to crest this feature before entering the depression. Although this explanation remains plausible, it may prove that the damlike structure has a recent origin.

Summary of La Milpa Hydraulic Activity

La Milpa's water system is a composite of two significant, temporally separated construction periods. The Late Preclassic period probably represents the initial and explosive investment in monumental architecture and watershed manipulation. However, most of the water-related features identified are a modification of these earlier Formative achievements by Late Classic builders. Given the difficulties in dating water systems, it remains unclear precisely how much energy Late Preclassic architects invested in the landscape at La Milpa.

Although the results of the water survey are preliminary, they strongly suggest the complexity of the water system at La Milpa. As demonstrated at other Maya sites, the Maya created a microwatershed at La Milpa to accommodate the four months of seasonal drought (Scarborough 1993a). In addition to the water conservation measures associated with reservoirs, deliberate channelization, diversion weirs, and the fields themselves, the importance of rainy-season erosion control is indicated at La Milpa.

Our best evidence for a water management system revealed in microcosm comes from the channel segments Drainage 3a and 3b. Reservoir A would be filled to capacity from the Main Plaza area enclosed by the 185 m contour line (80,000 m^2) following only one substantial downpour.[10] If less than one-quarter of the monumental architecture and paved surfaces in this area shed water into the reservoir, coupled with the catchment surface area of the reservoir itself, it would require 13 cm of rainfall to recharge the depression completely. Given very low evaporation rates and negligible seepage rates associated with paved or exposed bedrock surfaces, over 3,000 m^3 of water could be released during the dry season to the hypothesized fields below. Together with diminutive and expedient ditching, cropping in the field zone above La Milpa Aguada was likely.[11] Non-agricultural water requirements may have been satisfied by chultun cisterns of the type discussed above and recharged during the rainy season.

The word "irrigation" is seldom incorporated in a discussion of the Maya Lowlands. Nevertheless, the finds from La Milpa permit the term a place in the economic and ecological literature treating the Maya. The dichotomy between intensive raised-field agriculture and extensive swidden does not accommodate the type of land use presented here. Maya centers were many things. One neglected function was their gravity-fed, water management systems and the immediate agricultural ends to which they were put.

The preparation of the paved central precinct surfaces, in part designed to collect precipitation, required careful planning and coordinated effort. The emphasis at La Milpa and some other Late Classic sites was on landscape gradient relationships rather than horizontal grid or radial models of town planning (cf. Kostof 1991). The perceived "randomness" sometimes associated with Maya settlement patterns may be a consequence of a Western bias toward urban planning and an inability to appreciate the verticality associated with settlement and water management (Scarborough 1993b).

The natural topography strongly influenced the location of reservoirs and the drainages selected for modification. A principal factor in the choice and planning of a Maya town or city within the southern Maya Lowlands was the feasibility of channeling runoff from elevated pavements into reservoirs, modified drainages, and ultimately onto level field and household plots. Water resources that could maintain a large site center were as important as trade networks and political alliances in the geographical positioning of a community.

Conclusion

The southern lowland Maya represent one of the earliest semitropical civilizations on earth. Given the lack of permanent sources of water, the Maya labored to modify their landscape to best enhance the needs of the population. Elsewhere, this development is argued to have been an accretional change, incremental alterations to the surface of the land (Scarborough 1993a, 1993c, 1994a).

La Milpa represents one such site. As with many large Classic period communities, La Milpa reveals a well-defined Late Preclassic construction and occupation investment. Unfortunately, excavations have not yet isolated the precise extent of Late Preclassic occupation. Nevertheless, pioneer populations were probably drawn initially to La Milpa Aguada, as an upland water source, during an extended portion of the year. Late Preclassic landscape engineering significantly altered the surfaces at La Milpa. By the Late Classic period the water system had evolved into a highly efficient and well-organized component of the overall community.

The sophistication of the water management investment at La Milpa suggests the skill-oriented economic adaptation of the Maya within the southern lowlands. The design, construction, and maintenance of the system required focused scheduling and a flexibility inherent in a water system dependent on the vagaries of seasonal rainfall. This adaptability, in part, promoted the construction of larger pavement surfaces and catchment areas for the collection of water through time. The tempo, intensity, and organization of this activity are different than among complex societies deriving their water requirements from readily accessible rivers, streams, or major springs (Scarborough 1993c, 1994b).

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Notes

[1] A recent unpublished critique of the water management system at La Milpa (Tourtellot 1993; Tourtellot and Rose 1993) circulated following the completion of our report to National Geographic Society (Scarborough et al. 1992) and the revised version of this article. We recognize the preliminary nature of our evidence, but remain convinced of the artificial character of the water management investment.

[2] Our field camp was located 100 m from the ancient well supplying the drinking, cooking, and bathing needs of approximately 100 persons inclusive of the personnel at the Rio Bravo Research Station. Christened Poza Maya, it was first reported by Guderjan (1991:76) and is associated with a small housemound group. The stone-lined shaft of the well descends 4.2 m and is 2.5 m in diameter. It was excavated immediately above a small ponding spring, presumably to prevent contamination of the source. The open surface of the ponding spring receives runoff debris during heavy rains. Field consultation with James Ashby of Mission Geoscience indicates that the discharge rate for the well is 9.8 gal/min.

Although the discharge rate for the well is strong, drawing water by hand with fragile clay pots would prevent the well from supplying the needs of a large population. Nevertheless, it remains curious that a larger housemound density is not associated with the feature, given the premium on water.

[3] Mound or structure counts are based on individual building remains rather than collective household loci such as patio groups.

[4] James Ashby, a geologist with hydrologic expertise, examined the check-dam terraces and confirmed their artificial construction. Nicholas Dunning has recently

corroborated the human origin of these features. Nevertheless, Gair Tourtellot—principal surveyor and codirector for the La Milpa Archaeological Project—reserves judgment on their artificial appearance until additional testing can be performed (Tourtellot and Rose 1993).

[5] Tourtellot has questioned the capacity of Reservoir C given the location of the low-lying Structures 184 and 185 resting only 1.5–2.0 m above the extant height of the dam. However, until these structures are excavated and shown not to be water-related features and demonstrated to be coeval with the water management system, debate will continue. We do realize that the burden of proof in substantiating the water management argument is our responsibility, but until more time and energy are made available to test our reconstruction, some important data sets must remain mute. Most problem-oriented research in archaeology is influenced by the question of how much well-marshalled information is enough to convince an audience of peers. Given that water management systems in the southern Maya Lowlands have been neglected as a research interest, it will be some time before enough significant data are presented from meaningful contexts to convince everyone. Nevertheless, water management systems dating to the Classic period are coming to light elsewhere, permitting the timeliness of this report.

[6] The mouth of the chultun was positioned approximately 1 m above the immediate course of Drainage 3a. Given the rainy-season overflow hypothesized for Drainage 3a, the chultun's location slightly above the main course of the channel may have reduced the amount of silt and related debris carried into the cavity. A simple stone diversion weir or wooden flume located higher than the mouth of the cistern and connected to the Drainage 3a would have redirected overflow into the cistern. No such features were identified, however.

The lateral offset entrance and landing suggest the necessity to enter the chultun routinely. Although sedimentation was reduced by the cistern's position away from the course of the drainage, considerable amounts of debris still would be expected. Surface excavations around the mouth of the chultun indicate a high incidence of clayey soil and the broken remains of large jars, a predictable condition associated with periodic dredging or maintenance, and water use. Comparisons to cistern chultuns in the northern Yucatan where they are abundant, but awkwardly accessible to their interiors, indicate the controlled and limited catchment surfaces responsible for their recharge. Unlike the La Milpa cistern, runoff was collected from the paved surfaces of the immediate household. Here, water access from above was easy, but cleaning and maintenance of the chultun was more difficult.

[7] The structure numbering system was initiated by Thomas Guderjan and is a simple numerical progression based on time of discovery.

[8] Tourtellot has reexamined the dimensions of this feature, suggesting a shallower depth by well over a meter. We defer to his elevational readings and will make the necessary volumetric correction when these data are made available formally. Although these new figures will reduce the amount of water available, we do not believe that they significantly affect the character of our argument.

[9] Tourtellot indicates the apparent absence of a connecting surface channel that would allow Reservoir B to spill into Drainage 4. Precisely how Reservoir B was discharged remains an enigma, although underground drains have been reported at other sites (Scarborough 1991b).

[10] Wright et al. (1959:17) state, "Falls of rain are often of an intense kind; 5 inches [12.7 cm] in 24 hours is experienced not infrequently."

[11] Wilken (1987:159) observes that in Chilac near Tehuacan, Puebla, a canalized spring permits each member of the community at least one share of water or 1.3 x 10^6 liters (1 m^3 = 1,000 liters). This is adequate to irrigate plots of nearly 1 ha. The entire area associated with the field flat above La Milpa Aguada is 7 ha, indicating that Reservoir A could only partially water this area. Nevertheless, if Reservoir B released its water volume via Drainage 4, then the complete field area could be adequately moistened. This estimate is believed low, given the elevated water table associated with the nearby aguada as well as the lower evaporation rates in the Maya Lowlands.

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