A MARVEL OF MAYA ENGINEERING

WATER MANAGEMENT AT TIKAL

BY PETER D. HARRISON

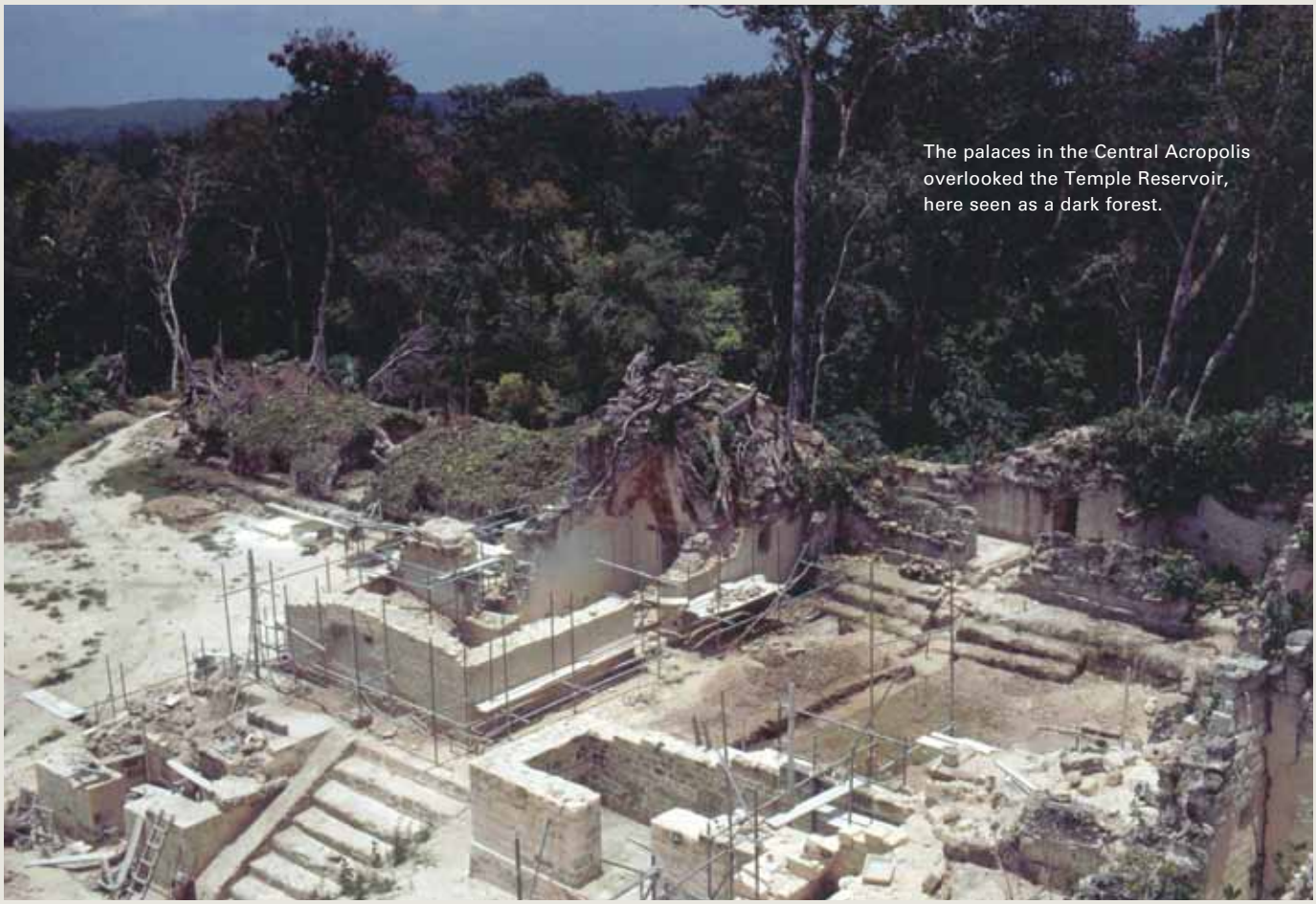
Temple III at Tikal rises out of the jungle, west of the Central Acropolis, in this early photograph from the site.

Peter D. Harrison

Maya structures are often described as great feats of engineering. Perhaps no site in the Maya Lowlands illustrates this more than the ancient city of Tikal in Guatemala. When the University of Pennsylvania Museum of Archaeology and Anthropology first excavated at Tikal between 1955 and 1969, the investigation of tombs, palaces, and temples was considered not only the epitome of adventure, but also a foray into scientific discovery. By the 1970s it was recognized that these remarkable examples of architectural engineering were not the only accomplishments of this ancient civilization.

Tikal was clearly an elite city with kings and a royal court, as demonstrated by the extant architecture, but this was only one indication of its success. The Maya also recognized the necessity of bringing water into their city, storing it for future use, and moving it to where it was needed. To insure survival, this may be one of the most important achievements of any society, ancient or modern.

At early Tikal, a group of palaces called the Central Acropolis constituted the seat of the royal court from the Preclassic Period (800 BCE–250 CE) until the time of depopulation and cessation of construction (900–1000 CE), a phenomenon identified as the Lowland Maya Collapse.



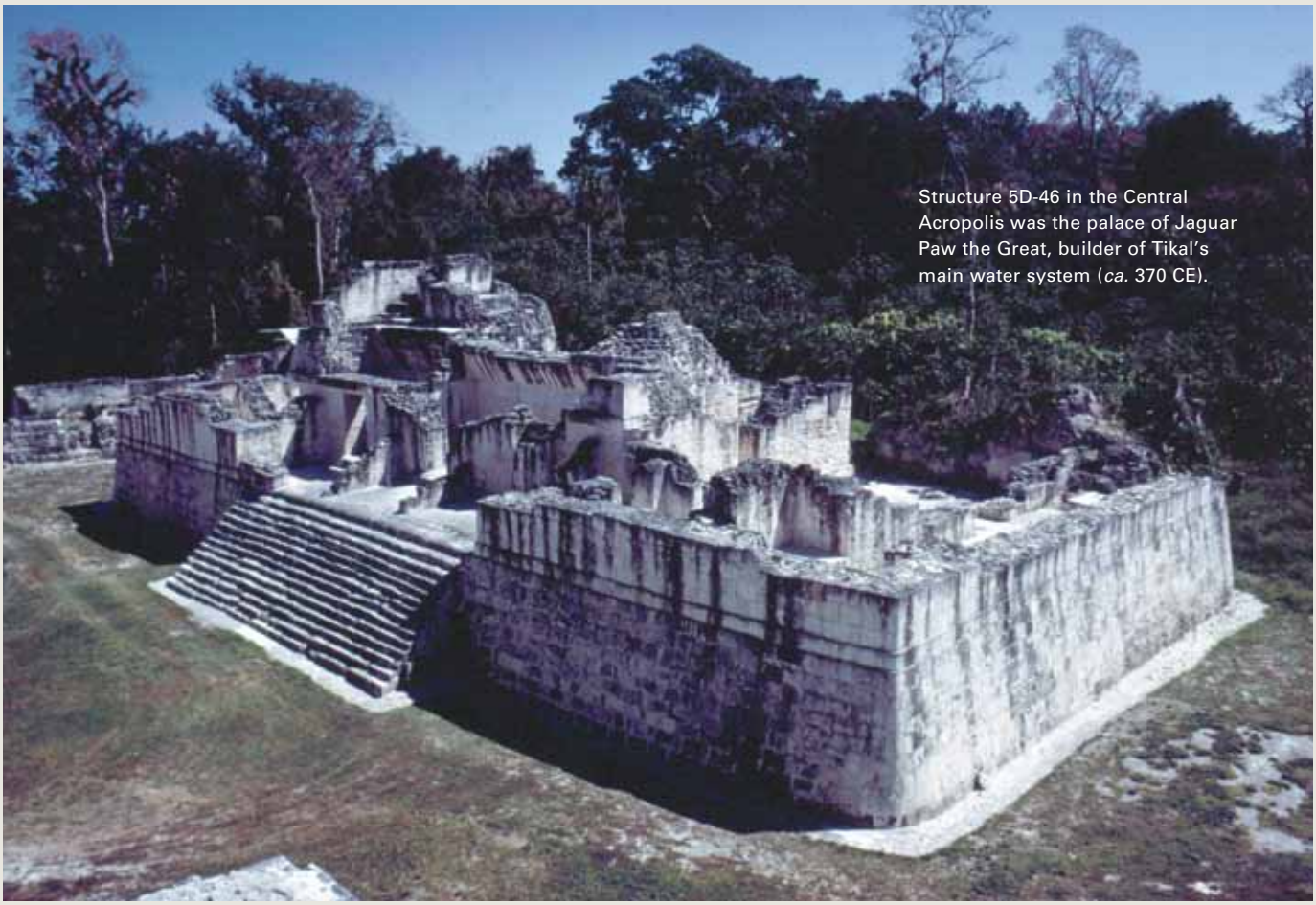
The palaces in the Central Acropolis overlooked the Temple Reservoir, here seen as a dark forest.

Tikal is located in northern Guatemala. This regional map of the Maya area shows Tikal and selected cities of interaction.

As the site expanded and the population increased, the Central Acropolis grew in height, as one building was constructed upon another. On its south side a man-made ravine was created where rock was quarried to build part of the Acropolis. The dense vegetation in this ravine hid many secrets for nearly a millennium, but excavations in the area, which took place from 1962 until 1964, determined that the ravine was a water reservoir and the focus of water collection and control during the Early Classic Period, *ca.* 250–600 CE. (During the 1960s, dating relied mainly on the ceramics that were recovered and identified, with Early Classic pieces being the most prevalent here.)

During my excavations in the Central Acropolis from 1962 to 1969, I investigated the ravine because it seemed so intimately connected to the royal court high above it. Since completing my work, others have taken up the mantel of investigating water control at Tikal, curious about how such a large population dealt with the need for water. A recent study by a team from the University of Cincinnati, including my friend and colleague Vern Scarborough and his student Gary

Peter D. Harrison (top), Lauren Liedel after Peter D. Harrison, *The Lords of Tikal*, Thames and Hudson (map)



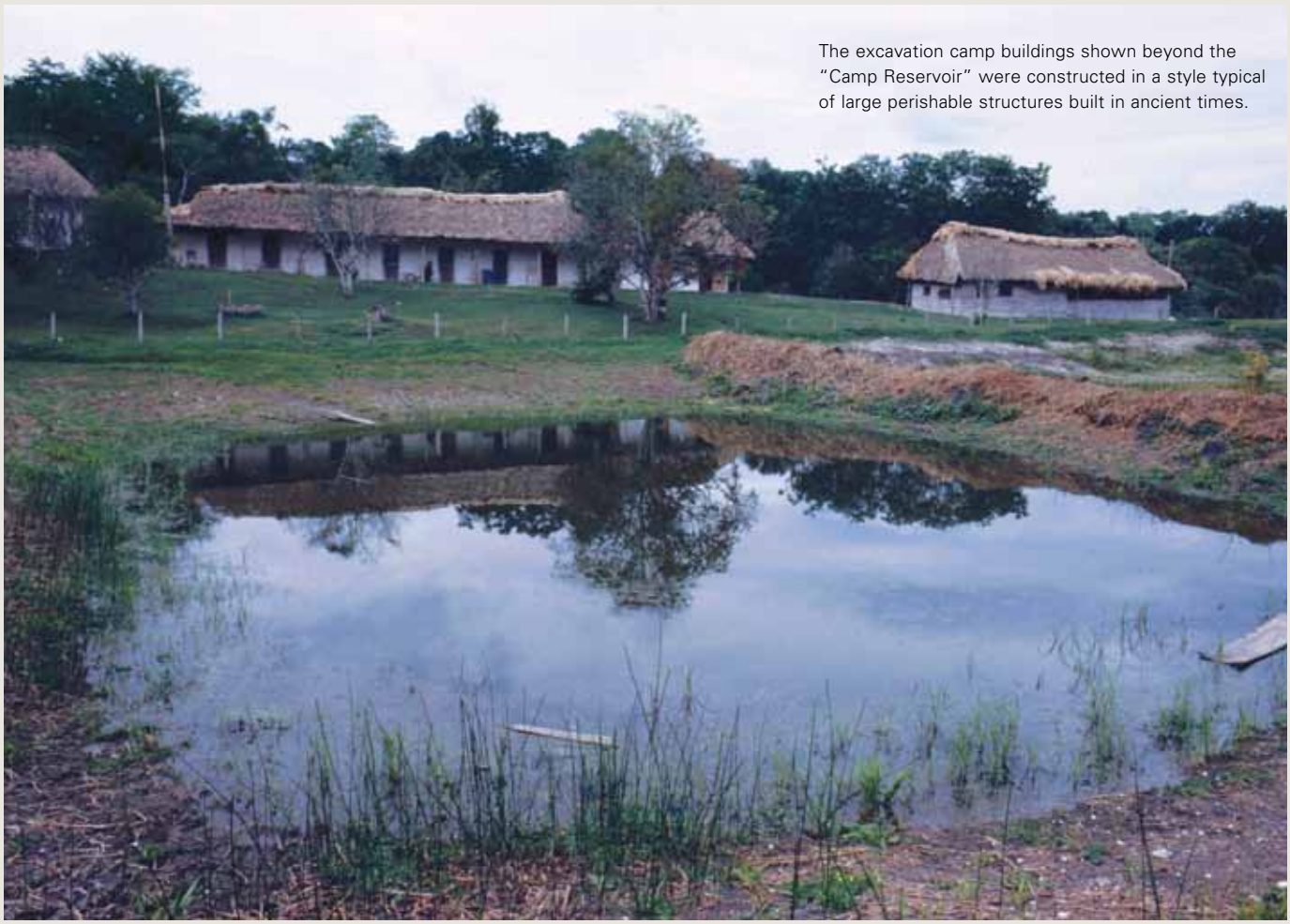
Structure 5D-46 in the Central Acropolis was the palace of Jaguar Paw the Great, builder of Tikal's main water system (*ca.* 370 CE).

Gallopin, surveyed numerous water-holding "tanks" at Tikal. One of the goals of this project was to determine how the water supply had developed and how it was associated with power and control among the Maya elite. Using radiocarbon dating, the team was able to extract the first solid date for construction of the main water system, *ca.* 370 CE, which places its use in the Early Classic Period. This date falls within the 18-year reign of the ruler Jaguar Paw the Great (Chak Tok Ich'aak I in Mayan), who was either 9th or 14th in the dynastic succession at Tikal, depending upon which scholar's work you follow. A palace structure in the Central Acropolis, designated 5D-46, has been identified as the house, or residential palace, of this same ruler. Jaguar Paw the Great was interested not only in the geometric relationships of architecture within the royal court but also in the science of engineering. His achievements indicate that he was a pragmatic and versatile ruler.

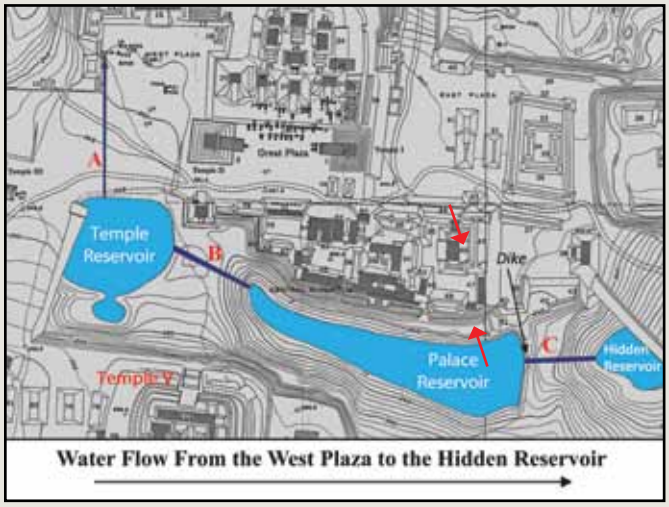
The east boundary of the ravine is formed by a dike, with a walkway connecting the north and south sides of the ravine. Excavation revealed that the lower portion of the dike was made of bedrock. The top portion of the dike was artificial,

In this photograph from 1959, the palace structure is seen at the top of the staircase above the royal kitchen.

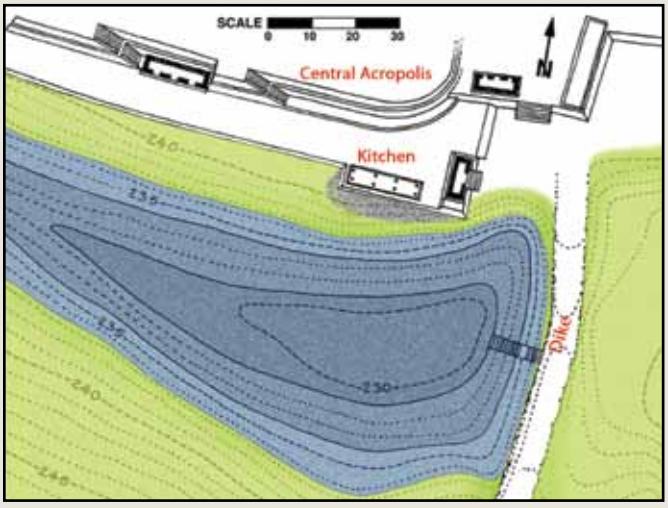
Peter D. Harrison



The excavation camp buildings shown beyond the "Camp Reservoir" were constructed in a style typical of large perishable structures built in ancient times.



The reservoir system adjacent to the Central Acropolis had three connective canals. Canal A drained the West Plaza into the Temple Reservoir, Canal B connected the Temple Reservoir to the Palace Reservoir, and Canal C crossed the dike through a spillway into the Hidden Reservoir. The upper red arrow points to 5D-46, the palace of Jaguar Paw the Great. The lower red arrow points to the kitchen.



The plan of the Palace Reservoir shows absolute elevations of water levels in shades of blue. Note the kitchen location delineated with eight postholes.

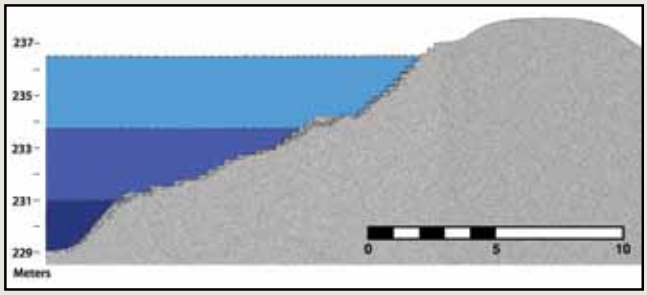
Peter D. Harrison (top), Amalia Kenward (bottom left), David Morgan (bottom right)

built by the Maya to create not only a passage to the south side but also to serve as an overflow sluiceway for water when the reservoir was full. The upper level of the reservoir was equal to the constructed elevation of the lowest terrace fronting the high walls that supported the Central Acropolis (237 m above sea level).

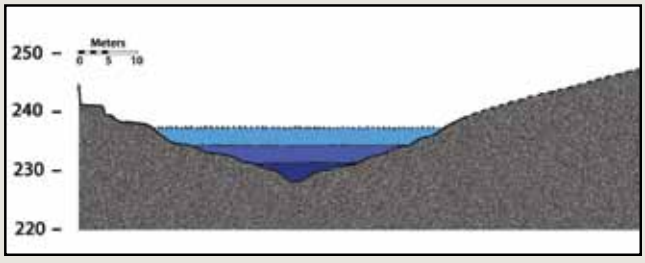
The great central water system created by Jaguar Paw the Great was a complex work of engineering. It began with a collection canal (A) sloping north to south from near the west edge of the West Plaza, behind Temple II of the Great Plaza. The illustration on page 22 shows the layout of the entire system as it flows north to south into the Temple Reservoir, and overflows from there via canal B into the Palace Reservoir, the largest such body of water at Tikal. When the Palace Reservoir overflowed in the wet season, water sluiced over the top of the dike and eastward into the Hidden Reservoir. From there channels guided water flow farther eastward to end up in a small tank called the Camp Reservoir, named because the University of Pennsylvania Project camp was deliberately constructed beside this ancient water supply.

The Maya at Tikal were masters of observation in many fields. As the engineers of the water management system monitored the seasonal patterns and amounts of rainfall, they accordingly created the system of water retention with large and small water basins. During the 1960s investigations in the Palace Reservoir, the Penn Museum excavated a long trench extending from the lowest present soil level eastward up to the top of the dike. Stone slabs (*lajas*) were found at the deepest levels, and Scarborough also found them in other reservoirs. These slabs formed the base of the holding tank of the Palace Reservoir and were sealed in thick black clays that did not allow water to seep through the bottom. These clays were imported from about one km to the east, from the great wetlands that bounded the city in that direction.

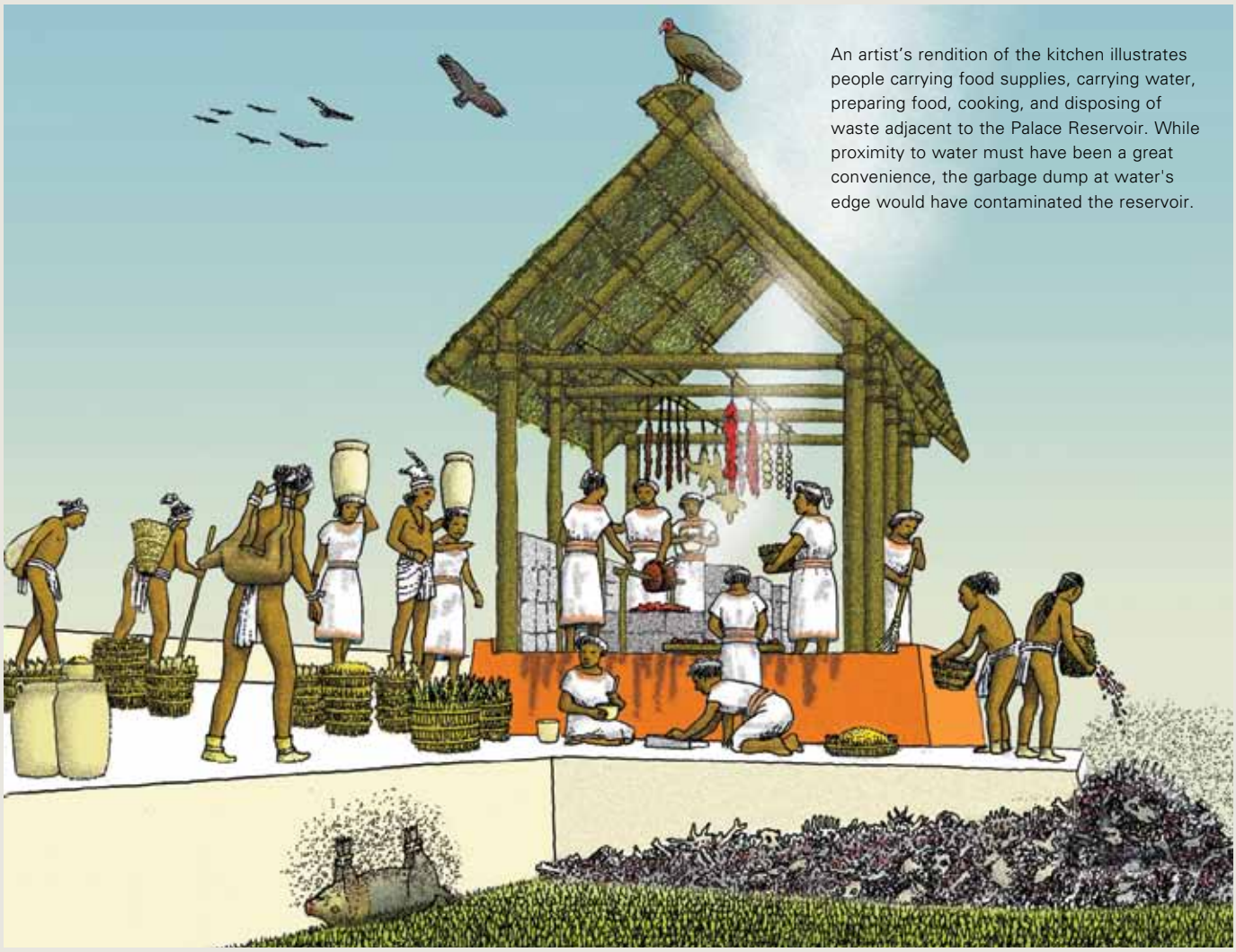
The west face of the excavated dike was also revealing. A staircase was discovered running from the highest point of the dike down to the lowest level of sediment; it was constructed with three platforms: at the top, the bottom, and near the middle. These platforms coincided with notches in the bedrock cut by water farther west in the reservoir, marking levels that were sustained for long periods of time. These markers allowed a reconstruction of the size of the reservoir at the three contained water levels or capacities recognized by the Maya: the highest, the lowest, and the median. It is assumed that repeatedly eroded natural levels were created by rainfall and marked by the Maya with platforms. The uppermost level (at 237 m above sea level) was determined by the construction height of the man-made dike.



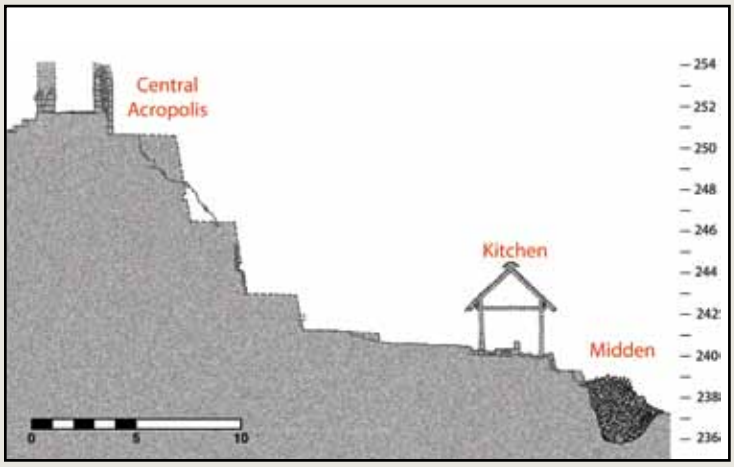
Top, Guatemalan archaeologist Jose Leva stands on the dike stairway in a 1962 photograph. Middle, a profile of the Palace Reservoir, looking north of the dike stairway, indicates three water levels. Bottom, the north-south cross-section of the Palace Reservoir illustrates bedrock indentations.



Peter D. Harrison (top), David Morgan (middle), Jesse Byrd (bottom)



An artist's rendition of the kitchen illustrates people carrying food supplies, carrying water, preparing food, cooking, and disposing of waste adjacent to the Palace Reservoir. While proximity to water must have been a great convenience, the garbage dump at water's edge would have contaminated the reservoir.



An eastern profile shows the Central Acropolis, the royal kitchen, and the kitchen midden. Distance from kitchen to serving rooms (see drawing on page 26) must have created logistical problems with food service reminiscent of those in the French Palace of Versailles.

Over time, Tikal's system of water collection underwent several changes that negatively affected its efficiency. The collection canal (A) that had brought relatively clean water into the Temple Reservoir part of the system during the Early Classic Period was covered and rendered inoperative by the construction of a temple building (5D-11) in the Late Classic Period (600–950 CE). The second problem occurred when a royal kitchen (described below) was built on the lowest terrace, or platform, south of the Central Acropolis; garbage accumulated adjacent to the Palace Reservoir, which surely contaminated the water when it was at its highest level. The ancient Maya did not appear to understand the problems that could be caused by impure water.

The excavations in the Palace Reservoir led to the discovery of Structure 5D-131, a kitchen buried under

David Morgan and Terry Rutledge (top), David Morgan (bottom)

This 1962 photograph of the excavation of the kitchen foundation walls looks south. The reservoir ravine, here filled with dense vegetation, lies beyond the kitchen.

the collapse debris from the Acropolis above. This building was constructed on the platform's edge, just above the high water line of the reservoir and close to the base of two grand staircases leading to the palaces above. The two long rooms of the kitchen were divided by one wall with low masonry exterior walls, presumably intended to protect cooking fires from wind and rain. Postholes dug into the bedrock supported a pole-and-thatch structure similar to Maya kitchens today, only larger. Shape and excavation details revealed three fire pits in the north room, while the south room, closer to the water's edge, was likely used for food preparation and presentation prior to its transport via staircase to the palaces above.

The reconstruction of the full kitchen illustrates the mechanics of water transport, food preparation, cooking, and garbage disposal. An enormous midden piled against the walls supporting the kitchen platform at the water's edge contained all the detritus of ancient Maya kitchens: organic food remains, fragments of utilitarian and ceremonial vessels, *manos* and *metates* used for food preparation, and bone—both animal and human (see sidebar). Lower levels in the midden contained Early Classic (250–600 CE) and Late Classic (600–950 CE) ceramics. Apparently the location was very popular from the time the Palace Reservoir was built until the culture collapsed at Tikal.

The water management system at Tikal can surely be called a marvel of Maya engineering. After careful observation and calculation, holding tanks were constructed and monitored. Beginning with a collection canal, water was stored and made available as needed. Access to the water was limited by easily

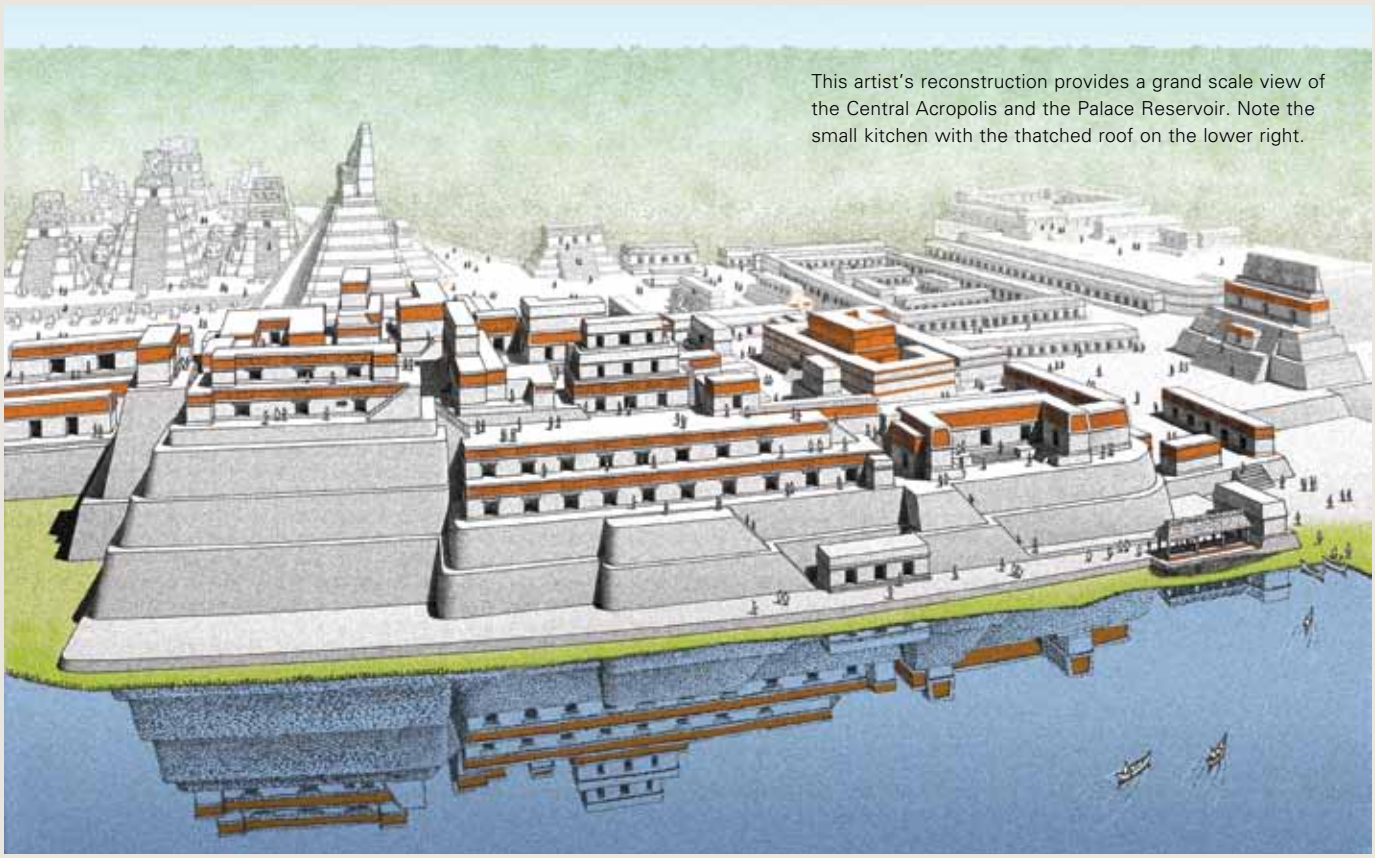
Peter D. Harrison

MIDDEN FINDS

The most surprising finds in the kitchen garbage dump were fragmented, burned, and gnawed human bones, recovered among burned animal bones. The human remains included both skulls—broken and burned on the interior—and fragments of long bones. The human bones from the midden are still under study and have not yet been published, so the cause of the gnawing has not been established. Finds of human bone in the kitchen midden appear to be restricted to the Eznab phase of the Early Postclassic Period (*ca.* 900–1000 CE for Tikal) which preceded the Lowland Maya Collapse. Evidence of human skeletal remains is also found at several other middens at Tikal, all of the same late date, in both the Central Acropolis and the East Plaza.

What does the presence of burned human bone in a midden suggest? It may be evidence of ceremonial human sacrifice or perhaps the execution of prisoners captured in warfare. The deposit could also indicate that cannibalism was practiced at Tikal. Cannibalism has been proposed in other culture areas of the Americas. In the American Southwest, it was thought to be a response to diminished water and food supplies, and attendant intra-population conflict.

As shown in this 1959 photograph, modern Maya kitchens are built as structures separate from the residential buildings. Note the smoke emerging through the thatch roof.



This artist's reconstruction provides a grand scale view of the Central Acropolis and the Palace Reservoir. Note the small kitchen with the thatched roof on the lower right.

guarded stairs at both east and west limits of the waterway. The accessibility of water to the kitchen that served the Central Acropolis must have been a luxury for its date in world history. However, the ongoing quality of the water as a consumable resource has to be questioned. The deteriorating conditions of the Palace Reservoir, with its adjacent garbage dump, surely included bacterial contamination, proliferation of mosquitoes, and diminishing amounts of water. The presence of reeds and perhaps "farmed" fish may have helped clean the water. However, in the midst of plenty and even luxury, the engineers were unable to anticipate the demise of the system they built.

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The author at Tikal in 1959.

Acknowledgments

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For Further Reading

Gallopin, Gary G., *Water Storage Technology at Tikal Guatemala*. University of Cincinnati M.A. thesis, 1990.

Harrison, Peter D., *The Central Acropolis, Tikal, Guatemala: A Preliminary Study of the Functions of Its Structural Components during the Late Classic Period*. University of Pennsylvania Ph.D. dissertation, 1970.

Harrison, Peter D. *The Lords of Tikal: Rulers of an Ancient Maya City*. London: Thames and Hudson, 1999.

Scarborough, Vernon L., and Gary G. Gallopin. "Water Storage Adaptation in the Maya Lowlands." *Science* 251 (1991): 658-662.

Scarborough, Vernon L., and Barry L. Issac, eds. "Aspects of Water Management in the Southern Maya Lowlands." *Economic Aspects of Water Management in the Prehispanic New World*. Greenwich, Conn.: JAI Press Inc. (1993): 71-119.

Turner, Christy G., II, and Jacqueline A. Turner. *Man Corn: Cannibalism and Violence in the Prehistoric American Southwest*. Salt Lake City: University of Utah Press, 1999.