Utilizing Soils to Understand Maya Water Management at El Perú-Waka', Guatemala

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Introduction

The ancient Maya civilization thrived in the lowland karst landscapes of Mesoamerica, which includes the Petén region of present day Guatemala. Although the area supported large populations centered around major cities, there were very serious challenges regarding freshwater resource management in the region. These issues include distinct wet-dry seasons which required surface water systems able to safely transmit floodwaters, yet maintain storage over the extended dry season and the difficulty of construction engineering on Vertisols found in the lowland depressions of the region. Our research looks to understand the types of water management practices used by inhabitants of the Classic Maya city of El Perú-Waka' through the evaluation of surface reservoirs within the city core.

This interdisciplinary study suggests that the Maya did not manage all surface water systems the same and that engineering practices were often dictated by environmental factors. Therefore, simplified theoretical models of management should not be applied universally to the highly variable water systems of the ancient Maya.

Study Area

This study was conducted in the Petén region of northern Guatemala (Fig. 1). The region has a humid tropical climate with mean temperatures of approximately 25.5 °C and 1500 mm of annual rainfall. The region has distinct wet-dry seasons, with most precipitation occurring between June-October.

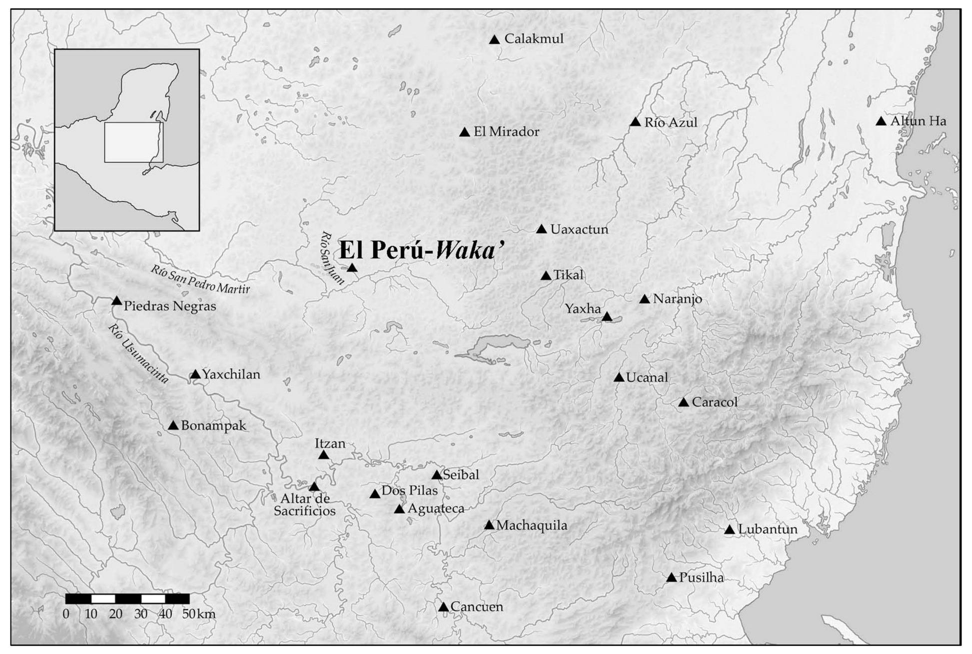

Fig. 1: Overview map showing the location of El Perú-Waka' in northern Guatemala.

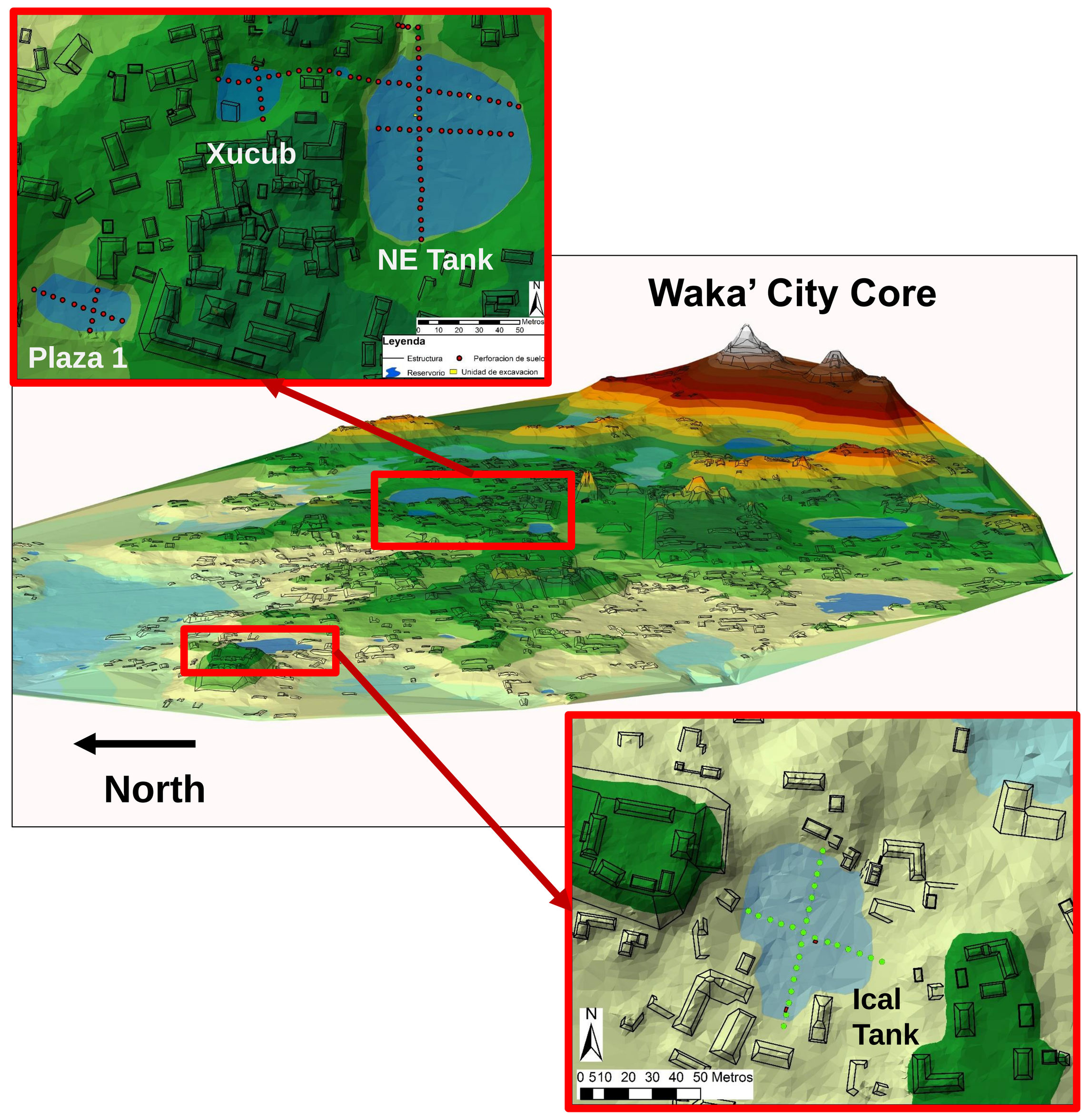

Fig. 2: City core map showing the location of study reservoirs.

Methods

Soils were described in 2016-2017 along transects in four large reservoirs within the Waka' city core (Fig. 2). Soil cores were taken along 9 transects to characterize the Xucub Reservoir, Plaza 1 Reservoir, Northeast (NE) Tank, and Ical Tank. We sampled soils every 5 m along each transect from the upland constructed edges of the reservoirs inward (Figs. 3-5). Soil was removed in approximate 20 cm increments using a hand operated soil bucket auger with clay head attachment (approximate 8.5 cm diameter) and placed in polyvinyl chloride (PVC) half-cores for description. Soil sample depths were checked repeatedly during removal to maintain proper sample depths. Cores were taken to a maximum depth of 200+ cm with auger extensions or until auger refusal on hard surfaces such as limestone blocks, bedrock, or extremely gravelly fill horizons. We described using standard field methods outlined by Schoeneberger et al. (2012). Soil horizons were also tested for the presence of carbonates using dilute hydrochloric acid (10% HCl) on the primary soil matrix. We have completed 134 soil descriptions from auger borings within the Waka' core.

Soil test pits (1x1.5 m and 1x2 m) were also excavated at locations of possible water management structures such as terraces, cut limestone pavement, and constructed flooring (Figs. 6-8). A total of four soil pits have been excavated within the large study reservoirs and two additional pits in smaller residential pools (agudas).

Results: Soil Coring

Fig. 3: Example of a soil transect through the jungle landscape of the NE Tank within the Waka' city core. Evenly spaced (5 m) auger descriptions were important to identify subsurface features of interest and locations for more intensive soil pits (see Figs. 6-8).

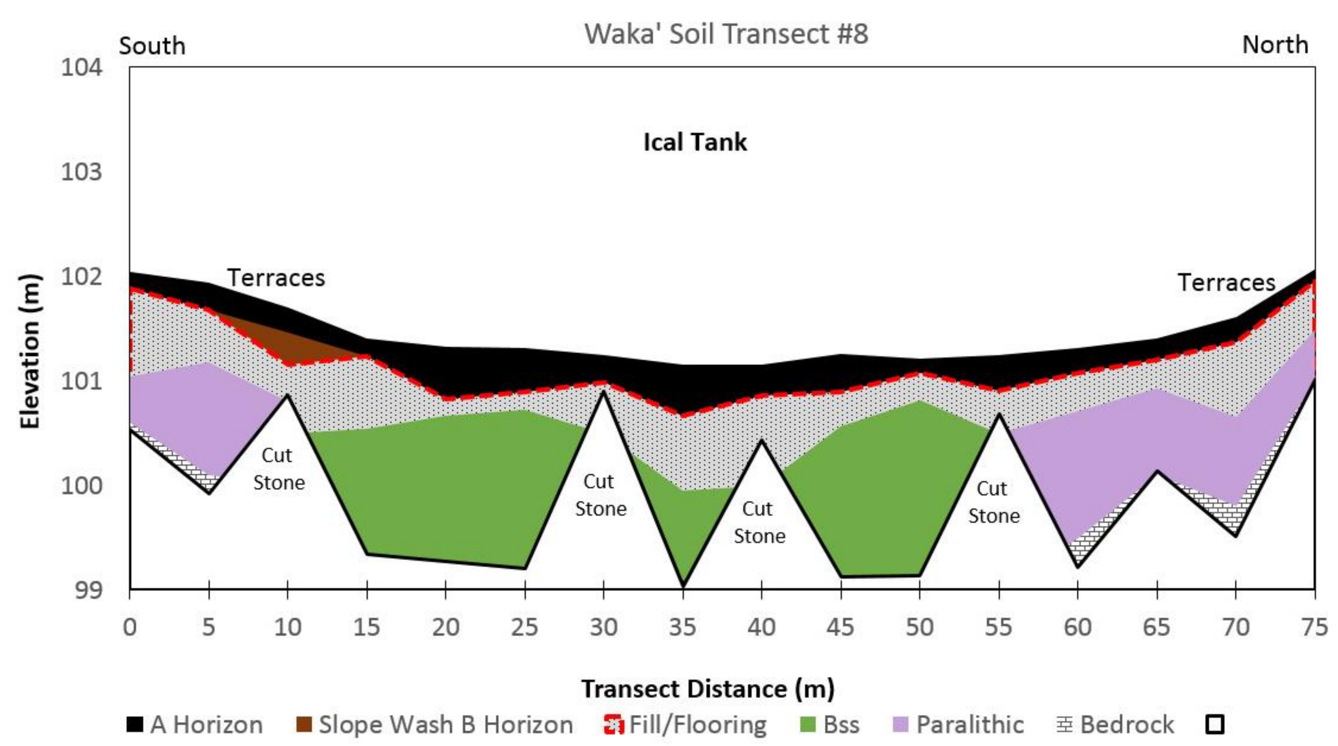

Fig. 4: Example of subsurface data collected from soil coring using bucket augers within the Ical Tank. Descriptions were done every 5 m along perpendicular transects. Materials above the dashed red line represent post-abandonment slope wash deposits and were likely not present within the reservoirs during their time of use.

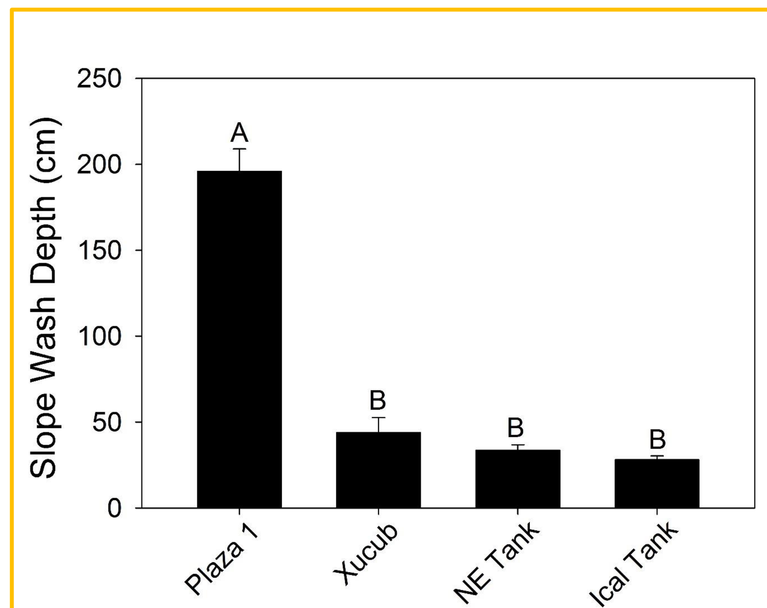

Fig. 5: Depths of post-abandonment slope wash within study reservoirs. Means with different letters are significantly different according to One-Way ANOVA and Tukey's HSD tests.

Table 1: Average water storage volumes by reservoir

	Plaza 1	Xucub	NE Tank	Ical Tank
Current Volume (m^3)	254	264	6212	1652
Minus Slope Wash (m^3)	774	385	7163	2106
Volume Increase	**205%**	**46%**	**15%**	**28%**

Soil data were used to estimate reservoir storage capacity within the Waka' core. Pond volume was calculated for the current soil surface and then corrected for mean post-abandonment slope wash within the reservoir. Volume estimates were based on a modified elliptical cone calculation from Beach et al. (2015):

$$V = H(1/2) \times \pi \times (L/2) \times (W/2)$$

Where V = volume in m^3, H is the maximum reservoir height (m), and L is the length and W is the reservoir width (m).

Results: Soil Pits

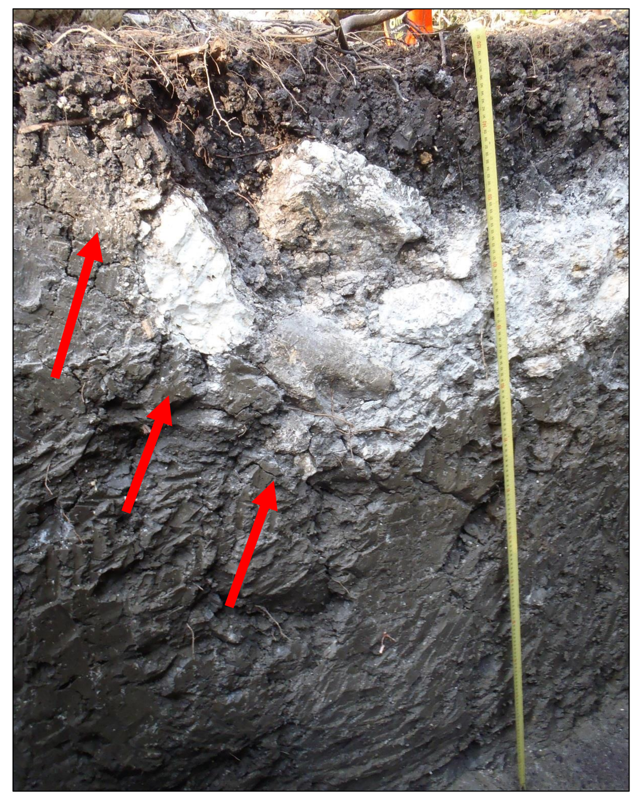

Fig. 6: Expression of Gilgai

The large reservoirs within Waka' contain modified and capped Vertisols. Because of infilling, surface cracks are often absent. However, rings or parallel micro-ridges of cut limestone blocks are common at the surface. We dug pits at these locations and have observed engineered flooring pushed up to the surface via argilliturbation and expressed as gilgai through the cultural surfaces.

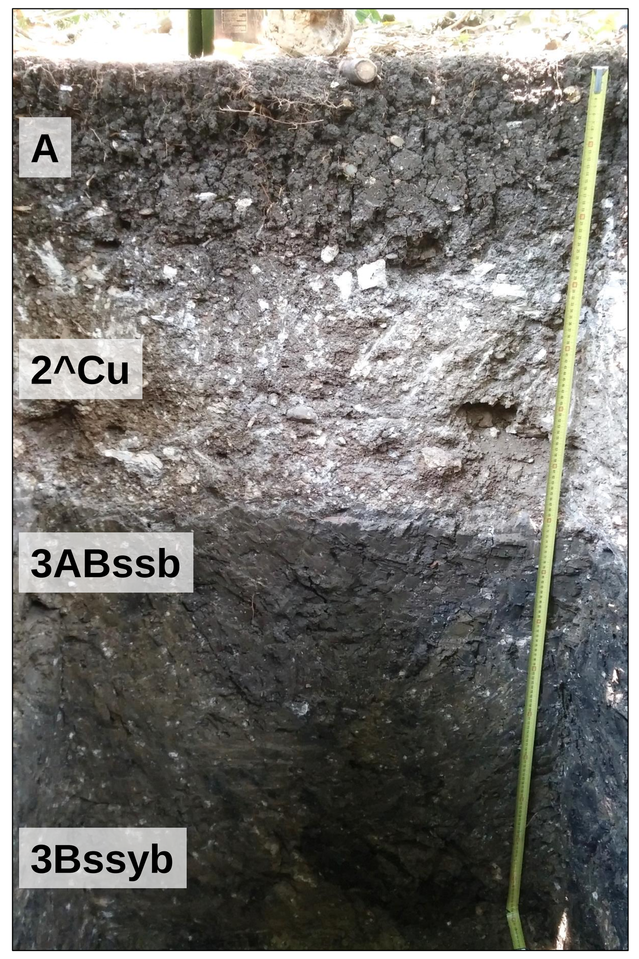

Fig. 7: Floors Over Gypsum

Secondary gypsum crystals were found in the cracks of pre-Maya Vertisols within the NE Tank system. Gypsum deposits were deep in the soils, indicating sulfate-rich ground water in this area (Luzzadder-Beach and Beach, 2008). The NE Tank had extensive flooring over these deposits, possibly to separate fresh rainwater from contaminated ground water.

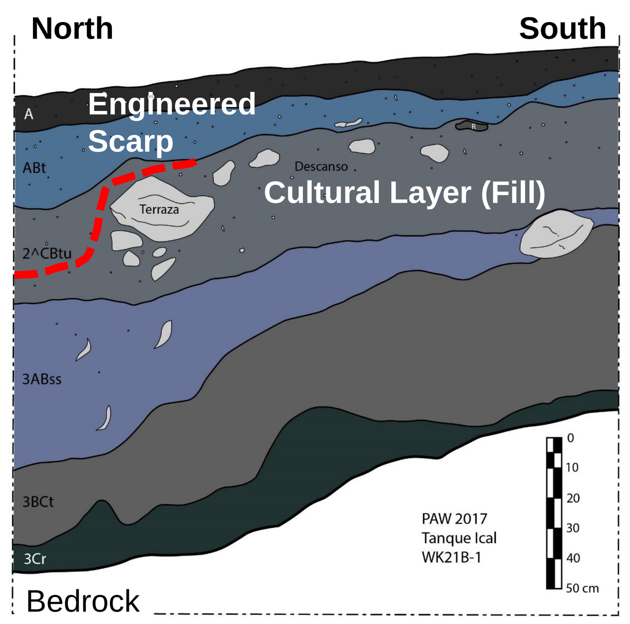

Fig 8: Access Terraces

Surface expression of buried concentric terraces were evident in the larger tank systems. Two excavations across these suspected terraces showed a constructed surface made of cut stone pavers with reinforced retaining walls that step down towards reservoir centers.

Reservoir Summary

- **Plaza 1:** Likely filled storm water basin, no outlet.
- **Xucub:** Minimal management, controlled outlet, access platforms.
- **NE and Ical Tanks:** Extensively modified, controlled inlet/outlets, limestone pavement, flooring over gypsum (NE system only), access terraces, dredging.

On-Going Research

- Use more advanced interpolation methods to estimate water storage, pXRF, and describe additional soil pits in 2018.

Acknowledgements

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