Creating Space Through Water Management at the Classic Maya Site of Palenque, Chiapas, Mexico

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hereby submit this as part of the requirements for the degree of: Master of Arts

in Anthropology

It is entitled Creating Space Through Water Management at the Classic Maya Site of Palenque, Chiapas, Mexico

Approved by:

Barry L. Isaac

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I would like to thank, first and foremost, Dr. Edwin Barnhart. Without his belief in me as a young undergraduate in 1997, none of this would have been possible. His encouragement and friendship has spurred growth both academically and emotionally. He also generously allowed me access to the PMP’s mapping data and software that made this thesis possible. I would also like to thank my committee chair, Dr. Vernon Scarborough, whose unsurpassed knowledge of water management has guided me throughout my tenure here at the University of Cincinnati. Dr. Barry Isaac and Dr. Nicholas Dunning have also been greatly appreciated for their insightful comments and direction. Finally, I would like to thank LeAndra Luecke for her impressive editing and loving support and encouragement. Thank you, baby.

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Chapter 1
Introduction

Many water management features were identified during the survey conducted by the Palenque Mapping Project, directed by Edwin Barnhart and under the auspices of Mexico’s Instituto Nacional de Antropología e Historia (INAH), the Foundation for the Advancement of Mesoamerican Studies Inc. (FAMSI), and the Precolumbian Art Research Institute (PARI). These features included aqueducts, bridges, dams, drains, walled channels, and pools. The Maya built such features in order to manage the perennial waterways located throughout the site. With nine separate watercourses found in Palenque, we can say that water was widely incorporated into the city plan. The presence of such copious rushing water enabled the Palenqueños to create a unique system of water management anomalous to that of other Maya Lowland sites (French 2000, 2001; Morales, Stuart, and French 2001; Scarborough and Gallopin 1991).

The focus of my thesis is the investigation of the elaborate water management system found in Palenque. What functions did features such as the subterranean aqueducts serve? I shall demonstrate that many of Palenque’s water management features were multi-functional and highly sophisticated.

Flood and erosion control are two of the functions performed by the aqueducts. As the water descended from the steep mountains and entered the level plaza, flooding along with erosion would have been common. Maudslay (1889-1902) visited Palenque in the dry season, prior to the refurbishing of the Palace aqueduct’s entrance, and stated that the main plaza completely flooded three times during his stay. Today, with the maintenance of the aqueduct system, the main plaza is highly unlikely to flood even during the rainy season. By forcing the stream below the plaza floor, the aqueducts act as storm drains.

Built on a narrow escarpment surrounded by steep hills, sheer cliffs, and deep arroyos, Palenque suffered a scarcity of livable terrain. The flat topography that did exist in the site was often burdened with natural waterways. In response, the residents of Palenque constructed several subterranean aqueducts, covered preexisting streams, and by doing so, they increased the size of their plazas in order to create surface areas large enough to maintain normal civic life within a major Maya center.

The importance of the pre-Columbian plaza is revealed through a comprehensive examination of plazas, both archaeologically and ethnographically (Low 2000). The ethnographic information supplies an ethnoarchaeological foundation by demonstrating the importance of plazas today in Latin American communities. This thesis exemplifies a method of interpreting the past by combining water management issues with architectural functions within an ancient Maya community.

The maps presented in the thesis are courtesy of Edwin L. Barnhart and the Palenque Mapping Project. All photos are by the author.

Chapter 2
Palenque

A Brief History

Palenque, located in Mexico's southernmost state of Chiapas (Map 2.1), is one of the best-preserved Maya sites. The Palenqueños built their city on a narrow escarpment tucked away in the mountains and overlooking the plains of Tabasco. There were many advantages to choosing this particular area, defense being one. To attack the city from the east, west, or south, adversaries would have been confronted with a series of steep and treacherous mountains. Alternatively, an assault from the north would have been detected early, due to the panoramic view Palenque had of the plains. Aside from the attributes of its defensive location, Palenque had many natural springs. The presence of fresh water is inviting for any civilization, but for the Maya, it was symbolic, as well. Palenque's natural topography mimics a place of creation, referred to in the *Popol Vuh*, where waters are flowing out of the mountains: "The channels of water were separated; their branches wound their ways among the mountains" (Tedlock 1985:74). A place such as this must have been

Map 2.1 Map of the Maya Region (Weaver 1981)

emblematic to the ancient Maya.

The founder of the Palenque dynasty was K’uk’ B’ahlam I. At the age of 33, he acceded to the throne on 8.19.15.3.4 - 1 K’an 2 K’ayab (March 11, 431). An era of rapid development followed and continued for 368 years. K’inich Janahb’ Pakal was the catalyst who shaped Palenque into a center of prestige, beauty, and power. On 9.9.2.4.8 - 5 Lamat 1 Mol (July 29, 615), at the age of 12, Pakal acceded the throne of Palenque. Born on 9.8.9.13.0 - 8 Ahaw 13 Pop (March 26, 603), Pakal was the son of Lady Sak K'uk' and her consort, K'an-Mo'-Balam (Schele and Mathews 1998:95). It is speculated that Pakal's father, K'an-Mo'-Balam, was a foreigner. Although succession was normally through the male line, Pakal inherited the throne through his mother, who served as ruler for a short time.

This unprecedented event of inheritance caused Pakal to not only change the historical rules of succession through the father, but to justify it, as well. To begin the process, Sak-K'uk' first had to be declared the equivalent to the first mother of gods and kings at the beginning of the present creation. The first mother was a deity to the mother of the three major gods in the *Popul Vuh*. Then, Pakal stated that he had been born on the very day of the calendar that coincided with that of the goddess's birth. Thus, Pakal and the goddess were of the same divine substance. Pakal inherited the throne from his mother because this was what had happened at the beginning of creation: Authority had been transmitted through both males and females (Schele and Freidel 1990).

Pakal led his people to war during the first thirty-five years of his reign. Several of the wars were fought on the premise of revenge, as cities such as Calakmul and Bonampak (Map 2.1) had savaged Palenque in the twenty years prior to Pakal's succession (Schele and Mathews 1998:95). The second half of his reign was much more concerned with peace and city growth. It started with a visit from Nun-Bak-Chak, the exiled king of Tikal, shortly after his loss to Calakmul. Nun-Bak-Chak arrived in Palenque on 9.11.6.16.19 - 2 Cauac 12 Chen (August 16, 659) (Schele and Mathews 1998:97). Pakal considered this visit to be one of the highlights of his reign as evident by its mention as a momentous event upon his sarcophagus lid (ibid.). Along with his shift from war to peace and prosperity, Pakal began a renaissance of building that remade the face of the city. Pakal's interests in the arts peaked around year 675, when at the age of seventy-two he began construction on his own tomb. He spent the next eight years overseeing the construction of what came to be the Temple of the

Inscriptions. Pakal died on 9.12.11.5.18 - 6 Etz’nab 11 Yax (October 1, 684), and his body was placed deep inside the Temple of the Inscriptions (Map 2.4). The tomb door was sealed and the tunnel that leads from the top of the temple was filled with earth and offerings. Pakal's tomb would remain sealed for the next 1250 years.

The throne was then acceded by Pakal’s son, K’inich Kan B’ahlam II (aka Chan Bahlum). In an attempt to carry on his father’s construction legacy, Chan Bahlum built the Cross Group (Map 2.4). This expansion east of the Arroyo Otulum (Map 2.4) likely led to the construction of the Palace aqueduct. The presence of a stream at this location naturally divides the site center. In part, the purpose of the aqueduct was to unite the Palace (Map 2.4) and Temple of the Inscriptions with Chan Bahlum’s Cross Group. Without excavation, it is difficult to determine specific dates of construction for the aqueduct.

After Chan Bahlum, the city of Palenque was ruled by five different kings. The last ruler was Wak Kimi Janahb’ Pakal, whose accession date, 9.18.9.4.4 - 7 K’an 17 Muwan (November 17, 799), was found inscribed on a pot. This is the latest dated text found in Palenque. Like other Classic Maya sites in Mesoamerica, Palenque was abandoned for reasons not fully understood.

Rediscovery to Present

The first official acknowledgment of the ruins in Palenque is found in a letter written by Ramón Ordoñez y Aguiar to the president of the Real Audiencia of Guatemala in 1773 (Gonzáles 1986). Historical research sheds light on a much earlier discovery by Fray Pedro Lorenzo de la Nada (ibid.). In 1560, Fray Domingo de Azcona invited Fray Pedro to work with the Indians in and around the present-day city of San Cristóbal de las Casas. Fray Pedro worked closely with the Chol and Tzeltal Indians for six years before visiting the present-day Palenque area. During this time, he became fluent in their native languages. He traveled to the Lacandon jungle to assist the Indians by setting up a new town 8 km southeast of the ruins near the Chacamax River. Fray Pedro named this new town Palenque, meaning, according to Spanish dictionaries, “palisade or stockade of wood.”

Miguel Angel Fernández, the head archaeologist during the 1930s, comments in his field reports that “the natives of the area referred to Palenque [ruins] by the name of Otolum” (Gonzáles 1986:5). This name is a word of Chol origin, derived from: *otot* (house); *tul* (strong); *lum*, (land)—and together meaning “strong house land” or “fortified place” (Gonzáles, citing Becerra 1980:243).

Thus, a strong affinity exists between the words “Palenque” and “Otolum”.

Fray Pedro Lorenzo de la Nada is the only person in the early history of Palenque’s rediscovery who could have named the town after the ruins. He had a firm enough grasp of the Chol language to search for a similar Spanish translation (ibid.). The word Otulum is still used in the ruins today as the name of the precious stream that flows through the site’s center.

Palenque experienced its first excavations in 1832, by Count Frederick Waldeck. This eccentric character lived atop one of the temples for two years during his stay (Trujillo 1974). That temple has been rightly named the Temple of the Count. A lithographer, Waldeck produced beautiful illustrations of the site. Many of his drawings depict Palenque like a great Mediterranean civilization, sparking great interest back in Europe.

In 1840, Patrick Walker and John Caddy journeyed to Palenque. While working in British Honduras (Belize), Walker and Caddy learned of a large-scale scientific examination of ancient Maya cities that was to be conducted by an American team led by John Lloyd Stephens and Fredrick Catherwood. Britain did not have the resources to support an expedition of such magnitude. “England, despite her reputation for scientific research, was about to become outdone by a representative of that upstart colony to the north" (Pendergast 1967:30). The British knew Stephens and Catherwood were traveling to Copan first and thought it possible to precede them to Palenque. Indeed, Walker and Caddy arrived in Palenque two weeks prior to Stephens and Catherwood. Caddy created a number of remarkable sepia sketches of buildings and sculptures. He published his work promptly in 1840, a full year before Stephens.

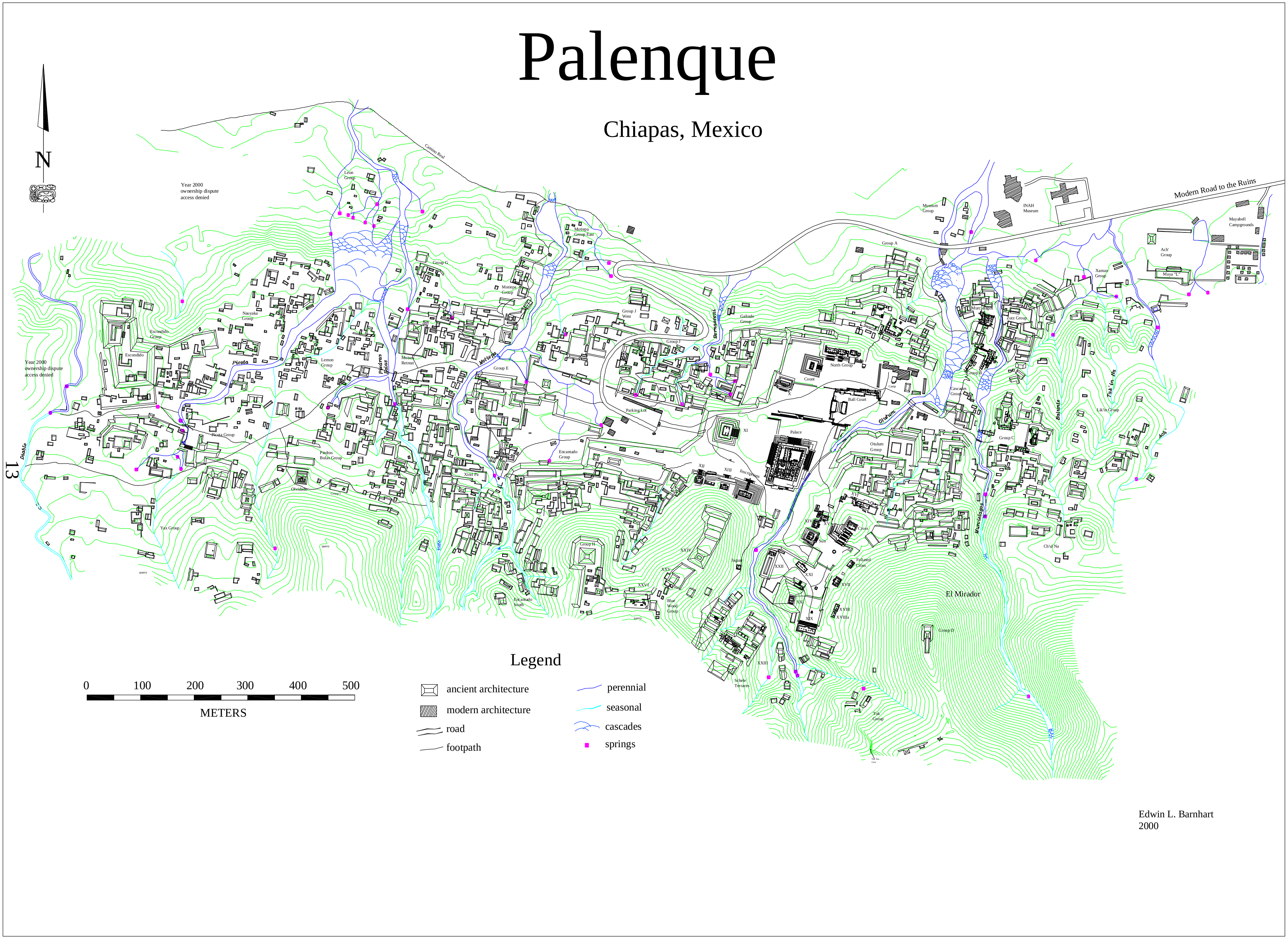
During his expedition through Central America in 1890-1891, Alfred P. Maudslay explored the ruins of Palenque. His report on the site occupies the entire fourth and last volume of *Biologia Centrali-Americana*. "It contains plans of the ruins, photographs and drawings of all the buildings and sculptures known at that time" (Saville 1926:153).

In 1923, the Dirección de Antropología of the Mexican Government sent an expedition to Palenque (Blom 1926:168). Frans Blom was asked to develop a rough map to determine the extent of the site's size and density. The data collected from this expedition are still used today by archaeologists. Blom's map was the most thorough survey conducted of Palenque until August 2000.

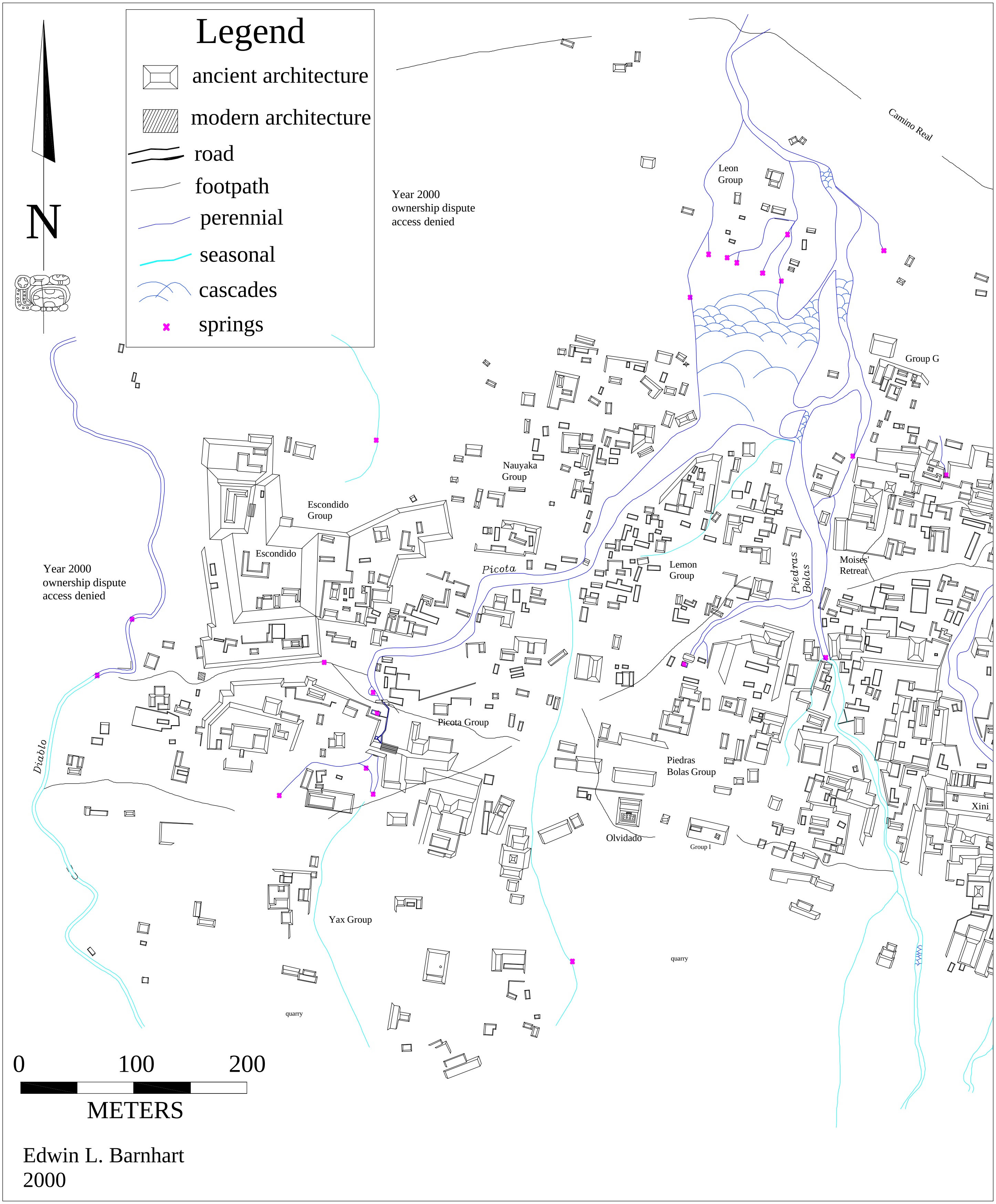
The Proyecto Grupo de las Cruces began in May 1997. It was a continuation of archaeological investigations conducted over the last one hundred years. The project was integrated into the Proyecto Palenque, which functioned for a season as the Proyecto Especial Palenque, directed by Archaeologist Arnoldo Gonzáles Cruz. Proyecto Grupo de las Cruces was a joint venture of the Pre-Columbian Art Research Institute (PARI) from San Francisco, California and Mexico’s Instituto Nacional de Antropología e Historia (INAH).

The purpose of the project was to utilize all available resources to bridge gaps in the archaeological record and increase understanding of the communal and dynastic histories, as well as the architectural diversity of Palenque. A complete map of Palenque was needed for a better understanding of the site’s density and architectural multiplicity. In 1998, Edwin Barnhart and team began the task of creating the first complete structural and topographical map of Palenque (Map 2.2).

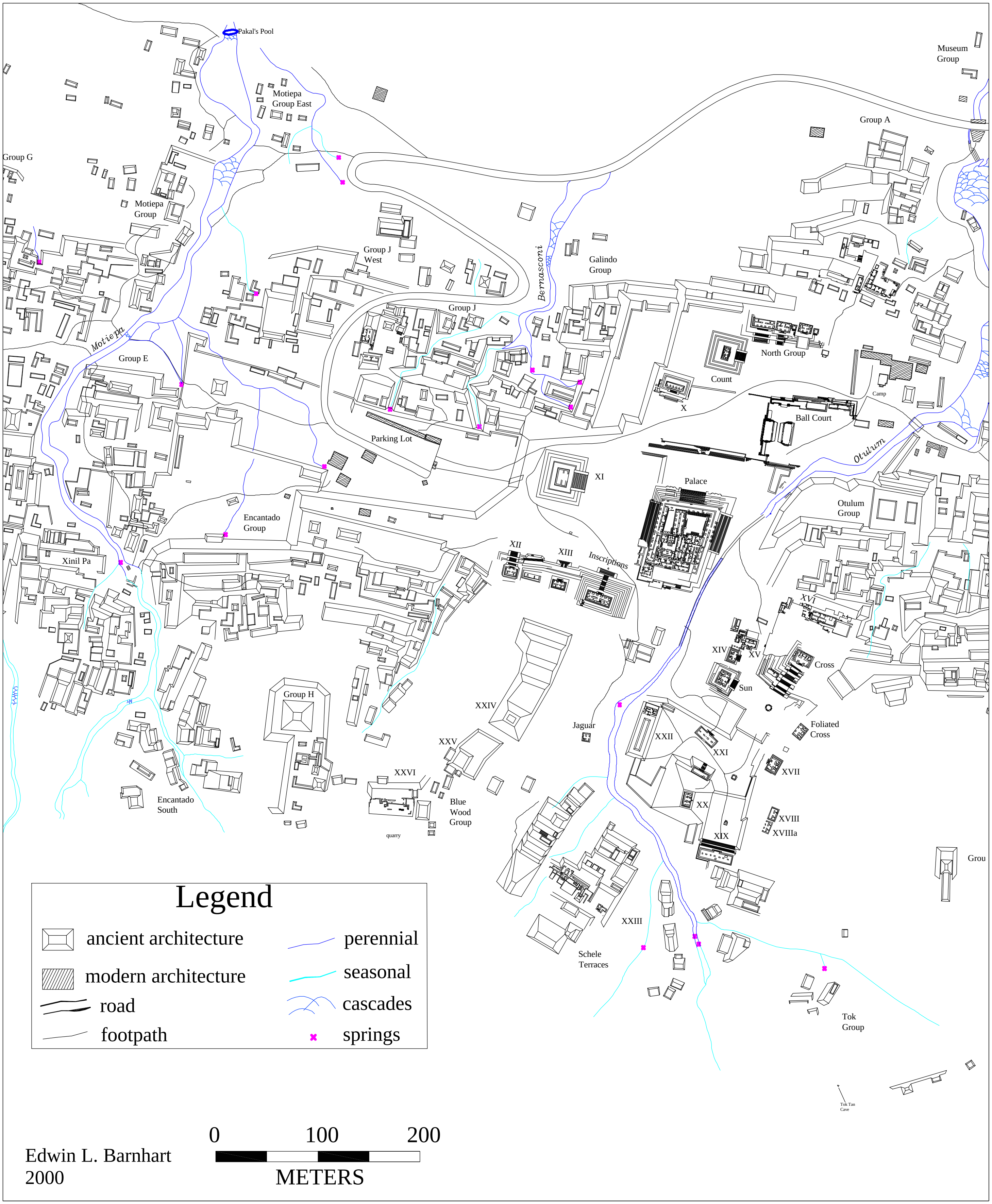
The Palenque Mapping Project (PMP) was sponsored by Florida’s Foundation for the Advancement of Mesoamerican Studies, Inc. (FAMSI). Throughout a 3-year period, the PMP mapped a total of 1481 structures within a 2.2 square kilometer area. An earlier map published by Robertson (1983) portrays only 329 structures. The new data



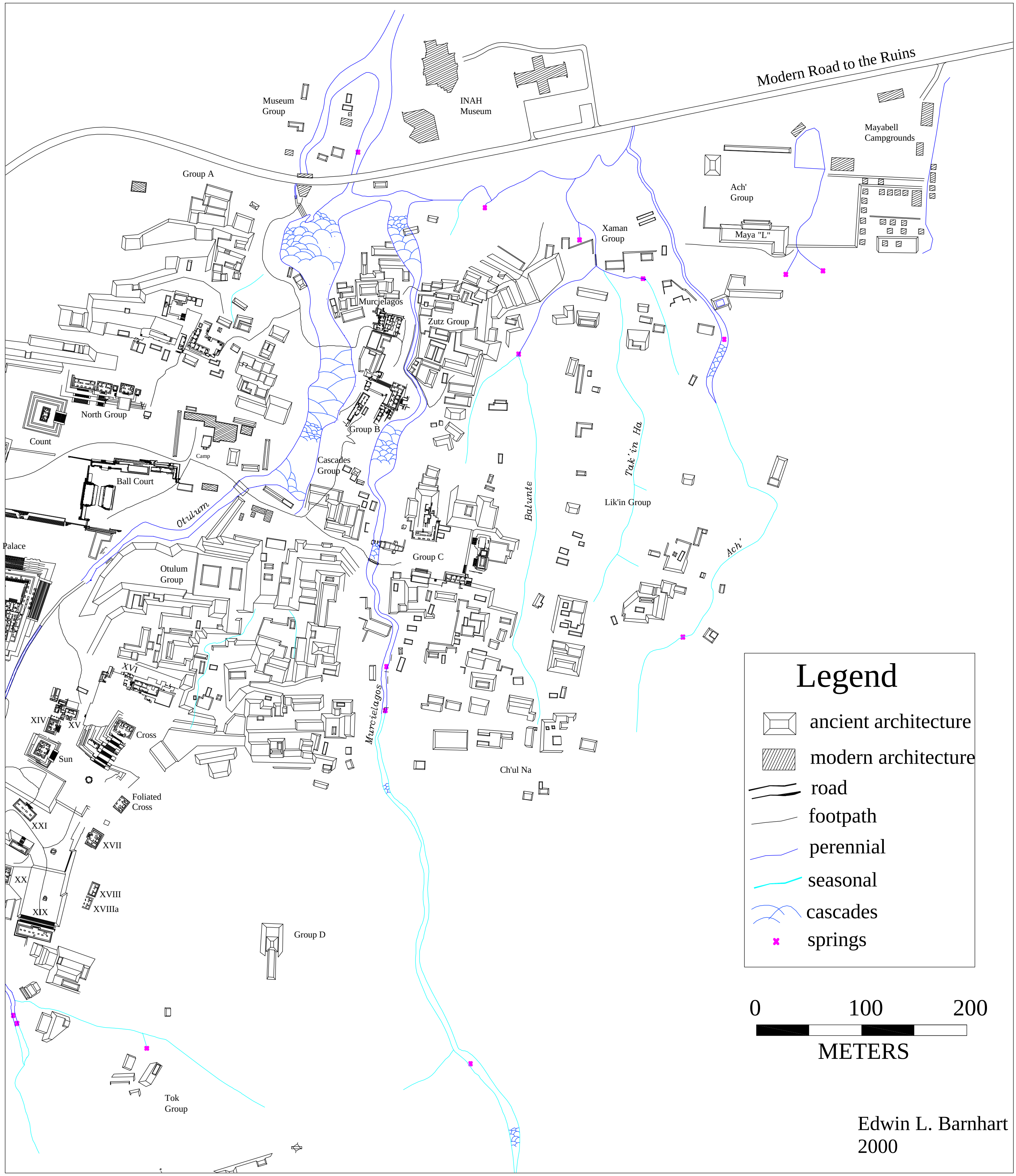
Map 2.2 The PMP 2000 Map



Map 2.3 Palenque West



Map 2.4 Palenque-center



Map 2.5 Palenque East

generated by the PMP more than triples the known size of Palenque.

While as a survey assistant to Barnhart, my duties included an initial pedestrian survey to sketch a rough layout of topography and architecture, the operation of the survey instrument (a *GTS-211D* total station), and the recording and documentation of all water management features encountered throughout the site. The duration of my fieldwork was approximately 13 months over a 3-year period. It must be noted that none of my fieldwork was conducted during Palenque’s rainy season. The majority of the research was performed between the months of April and August.

Chapter 3
The Water Systems

The watercourses in Palenque (Map 3.1) generally run in a northerly direction. Beginning in the mountains, the spring-fed streams flow toward the plains of Tabasco. There are 56 known springs that supply nine separate watercourses that move through the site’s interior. The arroyos are home to Palenque’s many different water management features, as defined below.

Aqueduct:	a covered channel for conveying water either under or above-ground.
Drain:	a small, covered channel for removing water.
Bridge:	a structure spanning a watercourse or arroyo to afford passage for pedestrians.
Walled Channel:	a watercourse or arroyo managed with walls of cut stone.
Pool:	a small manufactured body of confined water.
Dam:	a barrier of stone to obstruct the flow of water.

Spring: a small stream of water flowing naturally from the earth.

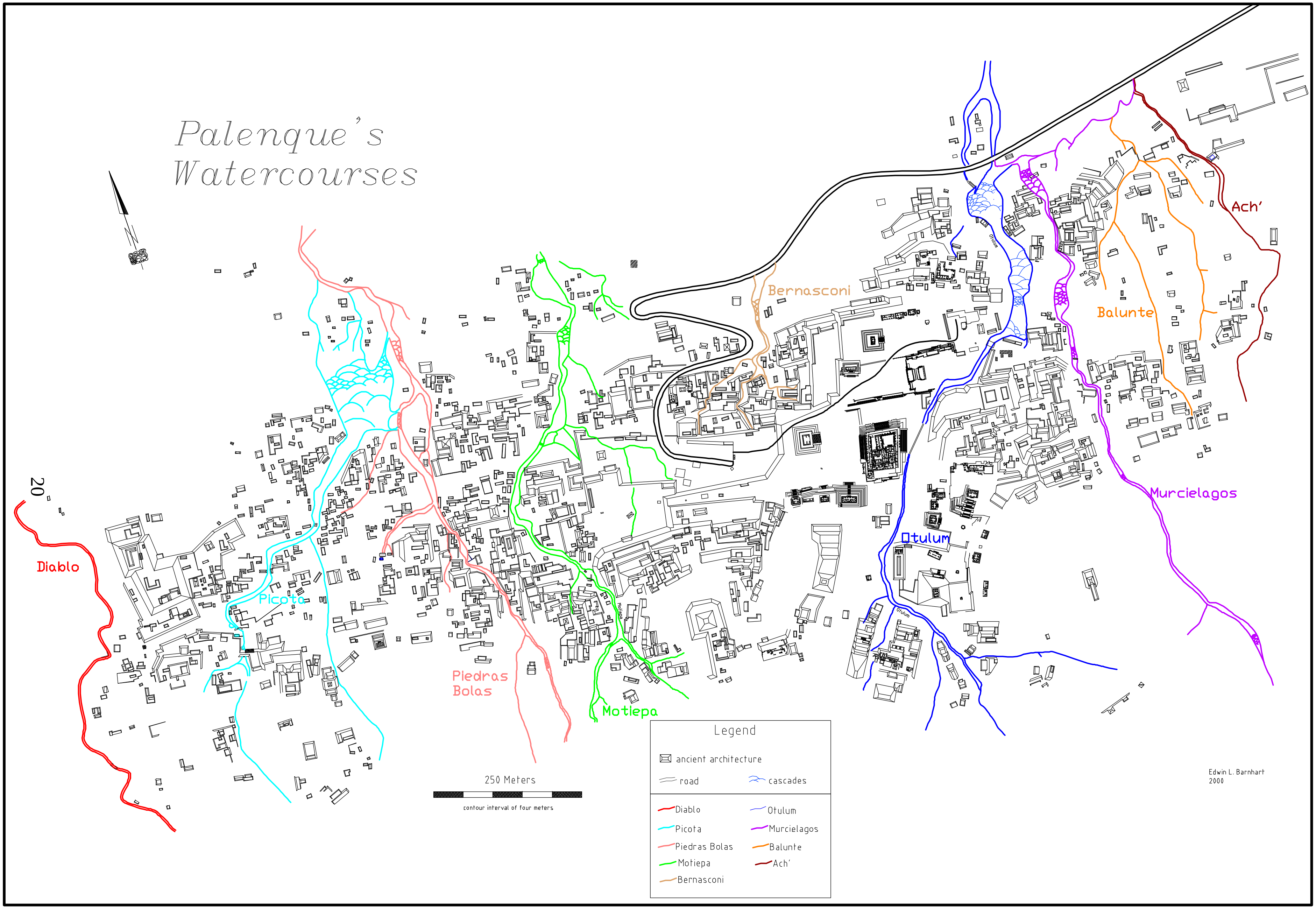
Each water management feature and spring was assigned a specific name and number (Appendices A & B). The name conveys the group of structures associated with the feature, as well as its type. The number refers to the feature's location within the group of structures. The number system runs south to north and west to east, the same direction as the water flow. For example, an aqueduct located in the southwest corner of the Picota Group would carry the name P-A1.

P	-	A	1
Picota Group	-	Aqueduct	Position

The abbreviations for the water features are as followed:

A = Aqueduct
D = Drain
B = Bridge
P = Pool
C = Walled Channel
DM = Dam
S = Spring

The watercourses are separated by name and are discussed fully below. I will begin explaining each stream at its source or entry into the site. A detailed description of the arroyo and its features will be given as we move with the flow of water. The description of each stream will terminate upon its exit from the site boundary. The waterways are in order of appearance, from west to east.

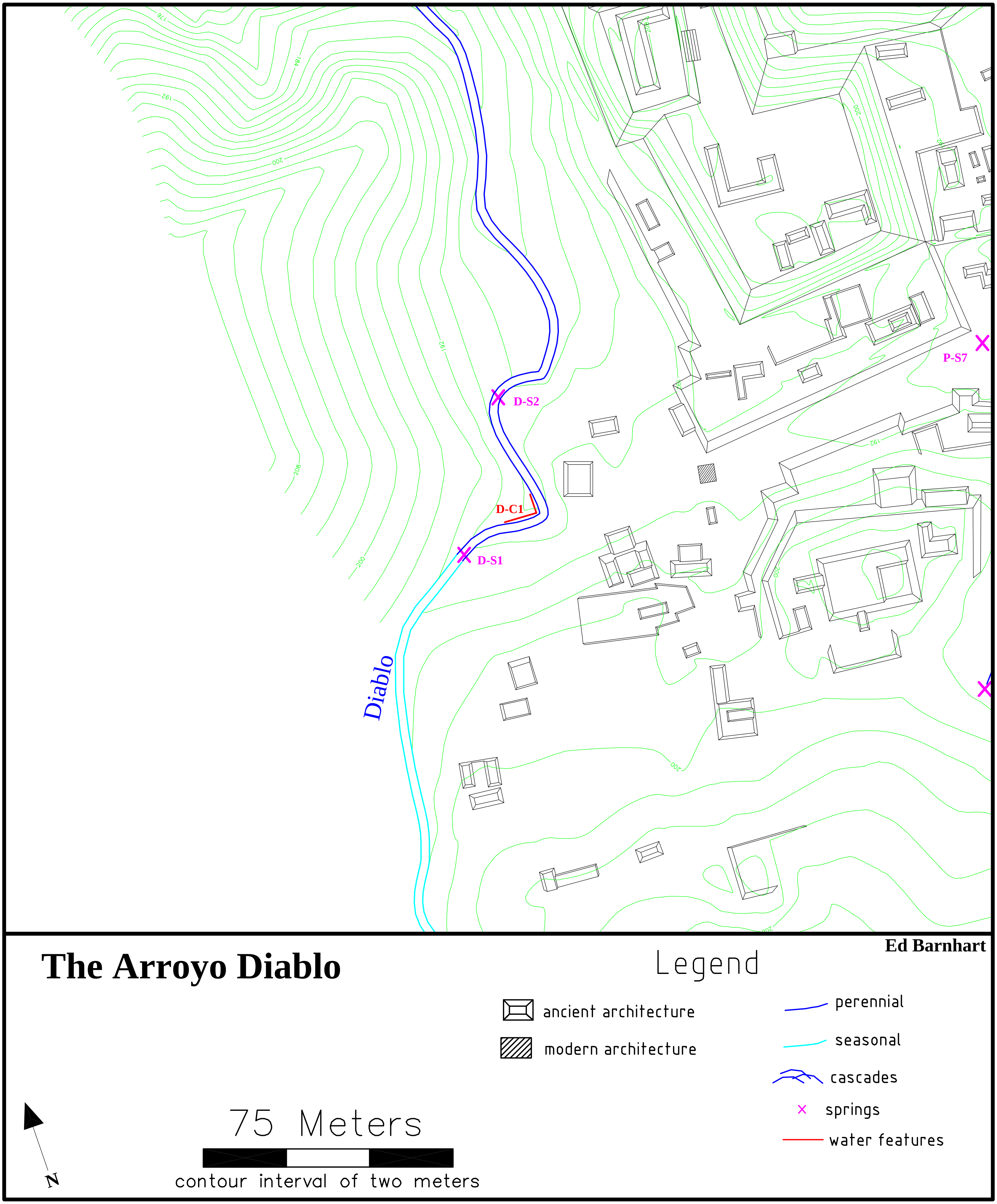


Map 3.1 Palenque's Watercourses

The Arroyo Diablo (Map 3.2)

The Arroyo Diablo begins at 220 meters in elevation and stretches 610 meters down Palenque’s western border. The initial 316 meters (not shown) of the arroyo remain dry from June to August. The Diablo’s first perennial spring, D-S1, marks the temporary termination of the parched portion of the arroyo. A few meters to the north of the spring, evidence of a walled channel exists. The wall, D-C1, extends for approximately 7 meters and is in poor condition. Similar to other architecture found in the west, the stones used in the construction of the wall are extremely large in size, measuring approximately 75cm to 1m in length. As the stream winds forward, it passes the second spring, D-S2. A local farmer has modified the spring by partially damming the flow of water with small stones. The Diablo becomes a trickle as it flows further north and soon becomes dry. At this point, the channel grows in depth and width, suggesting it is a major waterway during the rainy season. During the dry season, the Diablo remains dry and is absent of water management features as it exits the site boundary.

Map 3.2



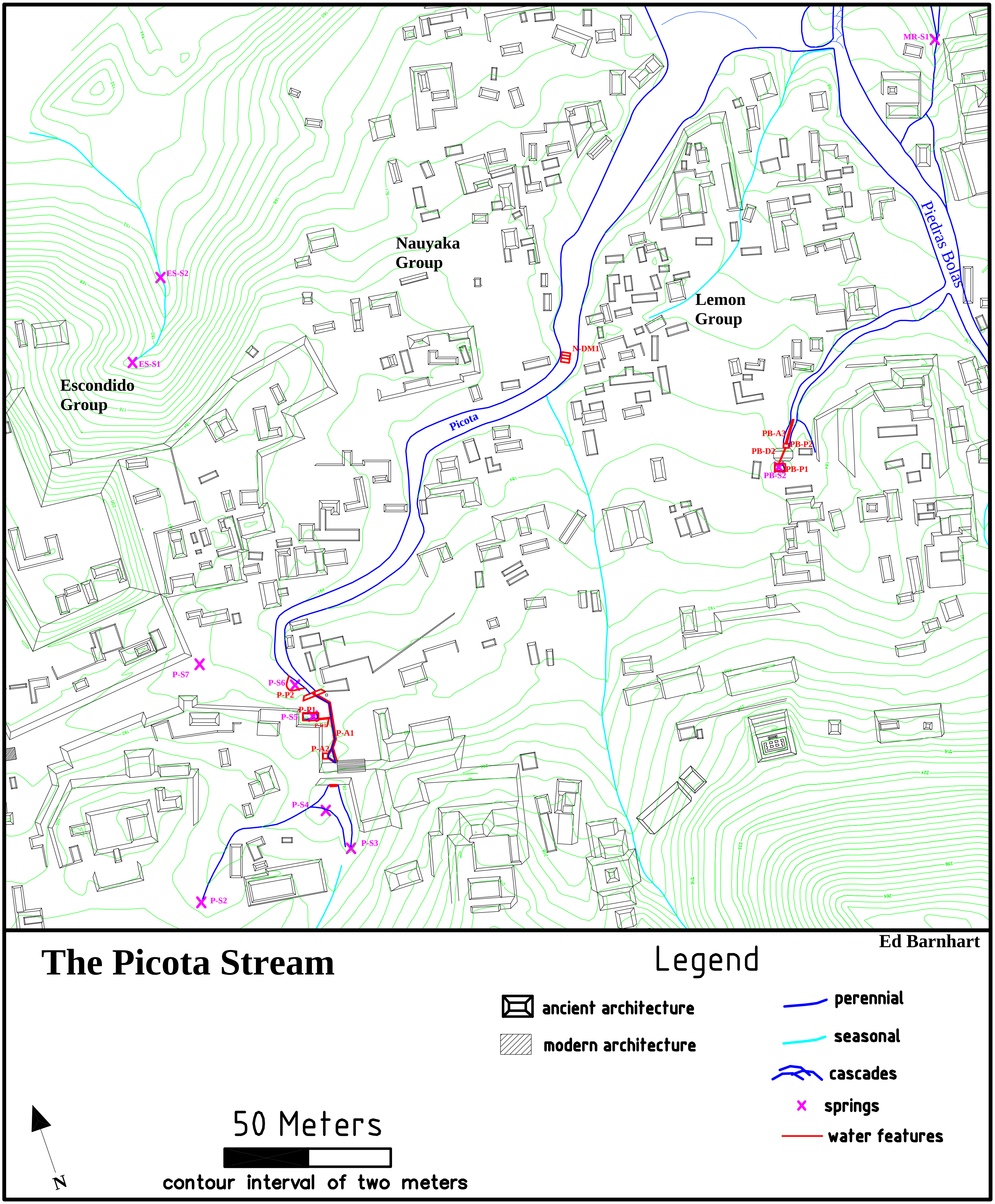
D-S2
D-C1
D-S1
P-S7
Diablo
The Arroyo Diablo
Ed Barnhart
Legend
ancient architecture
modern architecture
perennial
seasonal
cascades
springs
water features
75 Meters
contour interval of two meters
N

The Picota Stream (Map 3.3)

The Picota Stream is Palenque's most complex water system. The watercourse received its name from Palenque's only standing stela, mapped by Frans Blom in 1923(Blom 1925:184). Beginning with an abundance of springs in and around the Picota Complex, the stream stretches 675 meters through the western portion of the site while experiencing a 99-meter decline in elevation. After a series of spectacular cascades, the Picota collides with the Piedras Bolas Stream, and together they exit the site boundary some 90 meters later.

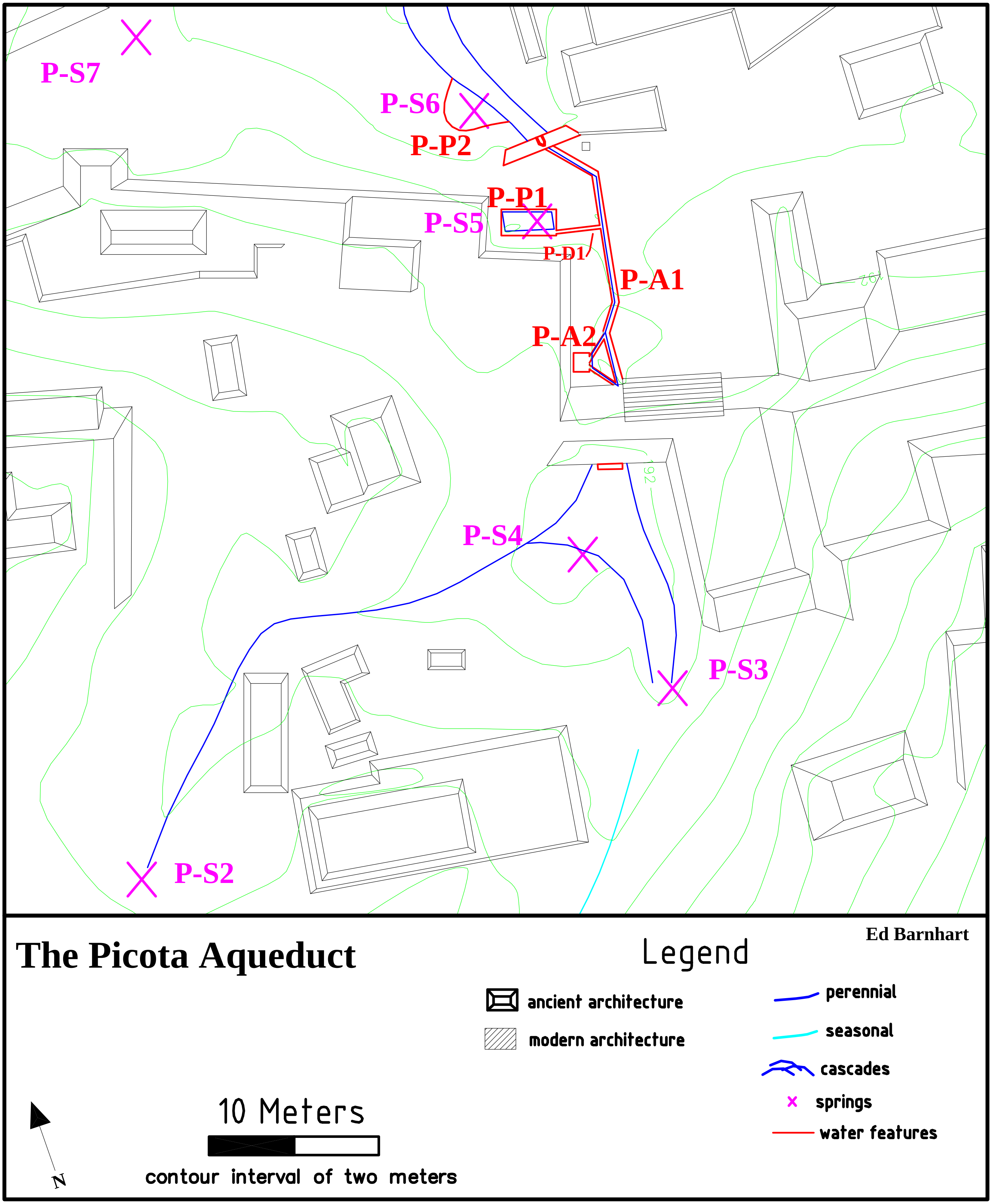
The Picota Stream is fed by a total of 14 separate springs, 12 of which are perennial. The three springs that create the headwaters of the Picota are P-S2, P-S3, and P-S4 (Map 3.3). P-S2 has been modified with cut stones stacked in a crude circle. The stones create a small pool approximately 1 meter in diameter and appear to be modern. Local farmers many times place cut stones in a circular pattern around the spring to assist the flow of water. As the waters from the three springs merge together, they enter P-A1, the Picota's first water feature (Map 3.4).

Map 3.3



Nauyaka
Group
Lemon
Group
Escondido
Group
Picota
Piedras Bolas
ES-S2
ES-S1
MR-S1
N-DM1
PB-P2
PB-D2
PB-P1
PB-S2
P-S7
P-S6
P-P2
P-P1
P-S5
P-A1
P-A2
P-S4
P-S3
P-S2
The Picota Stream
Ed Barnhart
Legend
ancient architecture
modern architecture
perennial
seasonal
cascades
springs
water features
50 Meters
contour interval of two meters
N

Map 3.4


P-S7
P-S6
P-P2
P-P1
P-S5
P-D1
P-A1
P-A2
P-S4
P-S3
P-S2
The Picota Aqueduct
Ed Barnhart
Legend
ancient architecture
modern architecture
perennial
seasonal
cascades
springs
water features
10 Meters
contour interval of two meters
N

P-A1 travels 7 meters beneath a structure and is then joined by P-A2, which delivers water from a small, pool-like feature located 4 meters to the west of P-A1. The waters join together, continuing 18 meters through P-A1 in a northerly direction at an elevation of 189 meters. The aqueduct then takes a 45-degree turn west, followed by a wide turn back to the east, where the water is then released into its natural channel. P-A1’s exit is magnificent example of Palenque’s architectural beauty (Fig. 3.1).

The Picota Group’s best-preserved pool is P-P1, situated 10 meters to the west of P-A1 (Map 3.4). Positioned on an east-west plane, P-P1 measures 7.2m x 2.8m and is approximately 3 meters in depth. The pool is similar in size, shape, and design of those found in the Piedras Bolas (Map 3.6) and the Ach’ (Map 3.14). Without excavation, it is difficult to assess the function of the pools. Spring P-S5 is situated in the southwest corner and serves as one of the Picota’s perennial water sources. The overflow drain, P-D1, transports the water to P-A1 and is positioned in the southeast corner. P-D1, measuring 30cm x 30cm, is fully functional and in excellent condition (Fig. 3.2). P-P2 is located just to the west of P-A1’s exit. It

Figure 3.1 – A view of P-A1’s exit.

Figure 3.2 – The interior of P-D1.

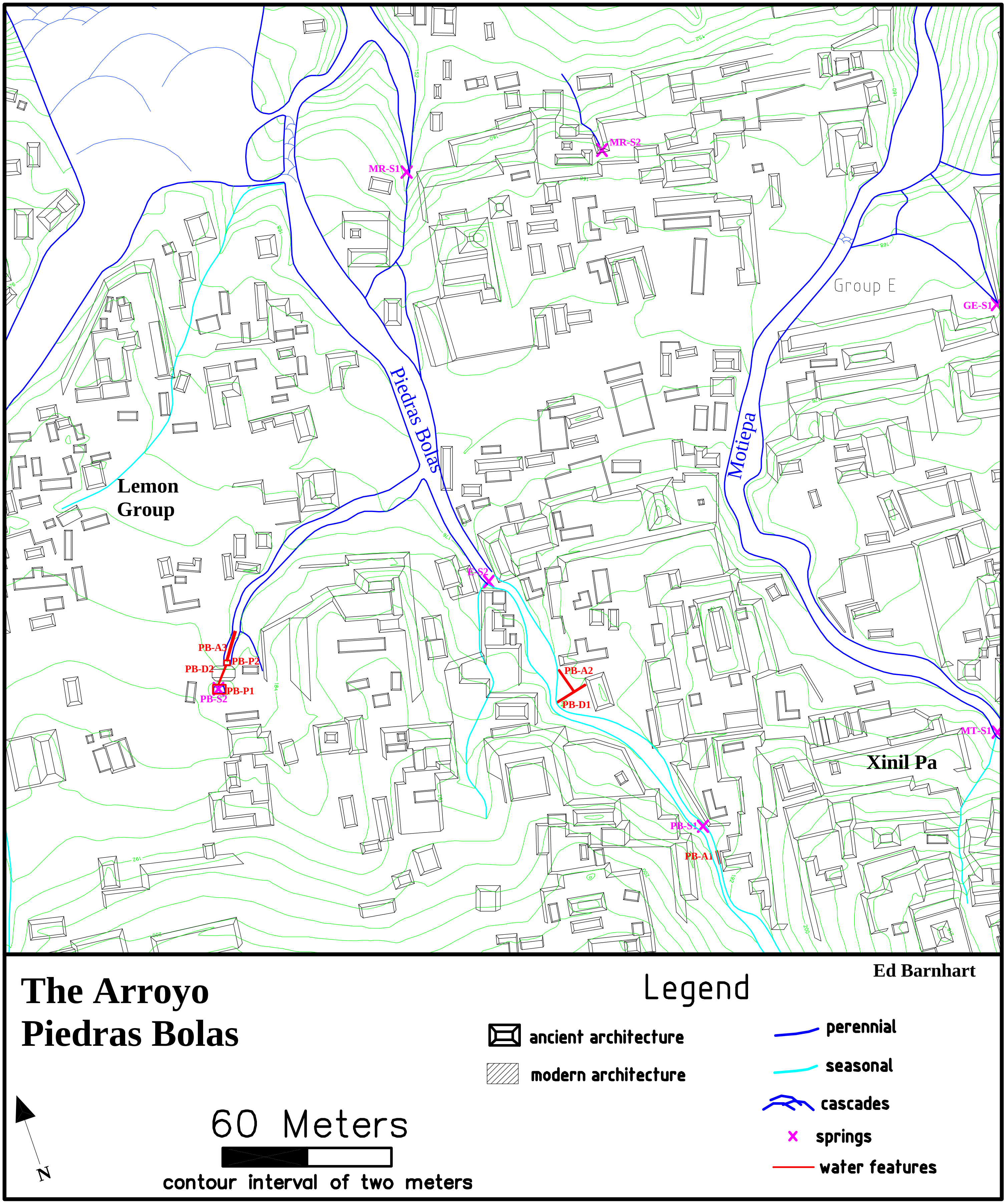
resembles P-P1 in design, but preservation is poor. The dimensions of P-P2 are roughly 7.5 m x 4.5 m. Spring P-S6 is found in P-P2's southwest corner.

As the Picota Stream continues in a northeasterly direction, it creates the borders between the Picota and Escondido groups, as well as the Nauyakas and Lemon groups (Map 3.3). As it enters the Nauyakas Group, a dam-like feature (N-DM1) emerges. N-DM1 measures approximately 4m x 2m and acts as a dam by obstructing the flow water. After passing N-DM1, the Picota Stream widens and begins to drop in elevation more abruptly. Soon the Picota enters the cascades, where it joins the waters of the Piedras Bolas, and together they ornament one of Palenque's most pristine areas of forest. It is in this area where many of the Picota's springs are located, seven emerging from the karstic earth in and around the Leon Group.

The Arroyo Piedras Bolas (Map 3.5)

The source of the Piedras Bolas is unknown because the arroyo extends beyond the site boundary to the south. The seasonal arroyo enters the site periphery at an elevation of 238 meters. With its three aqueducts, two pools, and two drains, the Piedras Bolas appears to have been managed quite extensively during the Classic period. A lengthy

Map 3.5



Piedras Bolas
Motiepa
Lemon Group
Group E
Xinil Pa
MR-S1
MR-S2
GE-S1
MT-S1
PB-A3
PB-P2
PB-D2
PB-P1
PB-S2
PB-A2
PB-D1
PB-S1
PB-A1
The Arroyo Piedras Bolas
Ed Barnhart
Legend
ancient architecture
modern architecture
perennial
seasonal
cascades
springs
water features
N
60 Meters
contour interval of two meters

stretch of the stream is littered with numerous cut stones, suggesting a possible walled channel. The Piedras Bolas travels 610 meters through the site, where it then, as stated earlier, combines with the Picota at the edge of the Palenque escarpment and jointly cascades north into the plains.

The most unique water management feature found in Palenque is PB-A1, located at an elevation of 189.28 meters. This is the first aqueduct that the Piedras Bolas encounters as it flows north from the mountains. The true entrance to PB-A1 is unknown, but a collapse of roof stones revealed its interior. The main chamber of PB-A1 measures 1.20m in height by 80cm in width. This chamber extends 4 meters from the collapsed roof, at which point the aqueduct abruptly decreases in size by entering another chamber measuring 46cm x 46cm (Fig. 3.3). The smaller chamber then continues for 2.5 meters before terminating (Fig. 3.4). Today, due to the collapse, very little water passes through PB-A1. The majority of the water flow has been forced to the west of the aqueduct (Fig. 3.5). During the rainy season, a large quantity of water surges through the Piedras Bolas. When fully functional, PB-A1 would have created a considerable amount of water pressure by forcing

Figure 3.3 – A view from inside PB-A1. Notice the decrease in size of the chamber.

Figure 3.4 – PB-A1’s exit (note the 22cm water bottle for scale).

Figure 3.5 – PB-A1 located just to the left of the cascades.

a square meter of water into a half-square meter chamber. The purpose of having water pressure at this location is unknown, but it might have taken water up and out of the arroyo to a residential group or possibly created a fountain. After exiting PB-A1, the Piedras Bolas winds between the Xinil Pa’ and Piedras Bolas Groups.

The next water feature, PB-D1, is associated with structure X19. PB-D1 originates at the edge of the structure and flows west toward the Piedras Bolas. Its complete length is unknown, because only a small section is exposed due to collapse. The drain is situated 70cm below the surface and measures 50cm x 30cm. Positioned perpendicular to PB-D1 is PB-A2, this aqueduct is functional but its source is unknown. By peering south into PB-A2 from its exit, one sees what appears to be a wall blocking the flow of water (Fig. 3.6). I hypothesize that the aqueduct does not end at the wall, but rather takes a 90-degree turn to the west and brings water from the Piedras Bolas. Project members searched for an entrance into PB-A2 from a westerly direction but found none. Without excavation, it is difficult to learn of PB-A2’s origin. Upon exiting the aqueduct, the water joins, or rejoins, the Piedras Bolas. It is here that an unusually heavy volume of cut stones is found strewn

Figure 3.6 – The interior of PB-A2.

throughout the streambed (Fig. 3.7), suggestive of a prior walled channel. The stone debris continues for approximately 80 meters. A small tributary then joins the Piedras Bolas.

The origin of the tributary is PB-S2, located 125 meters to the west of the Piedras Bolas. Similar to P-S5, PB-S2 is found in the southwest corner of a pool (Map 3.6). The pool, PB-P1, is like the Picota's P-P1 in construction and appears to function the same way (Fig. 3.8). The overflow drain, PB-D2, is designed to bring the water from PB-P1 to PB-P2. The drain is 9.75 meters in length and fully intact. Although the water from PB-P1 flows into PB-P2 today, it does so without the overflow drain. The water from PB-S2 has found a path of least resistance by eroding the northeast corner of PB-P1 and naturally tunneling into PB-P2. The water then enters PB-A3 and flows east toward the Piedras Bolas. The aqueduct, PB-A3, extends for 9.75 meters before releasing the water into the natural tributary.

As the Piedras Bolas continues northward, it forms the boundaries of the Lemon Group and Moisés' Retreat (Map 2.3). The Piedras Bolas receives an abundance of water from spring MR-S1, one of Palenque's most plentiful perennial springs.

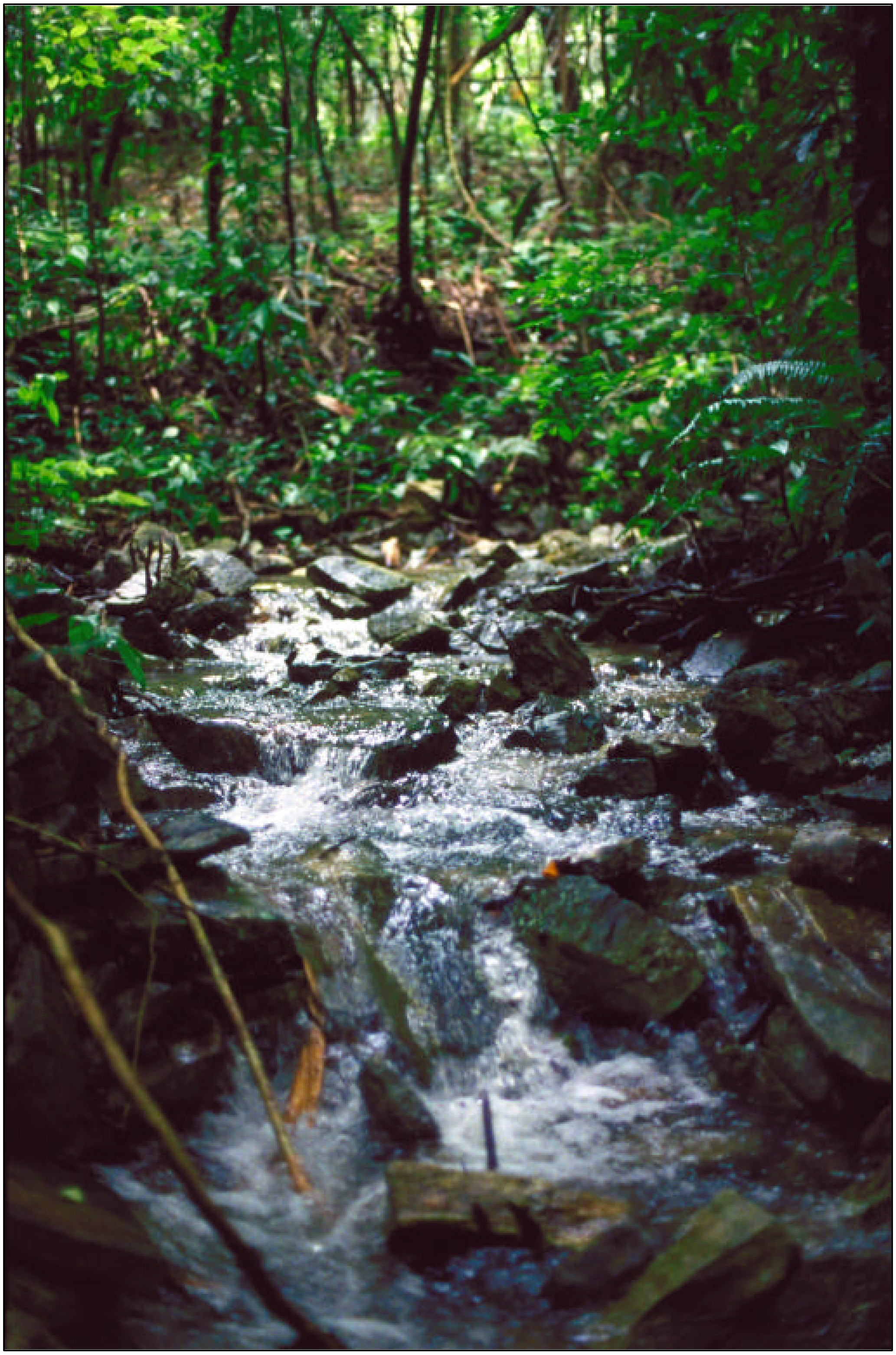
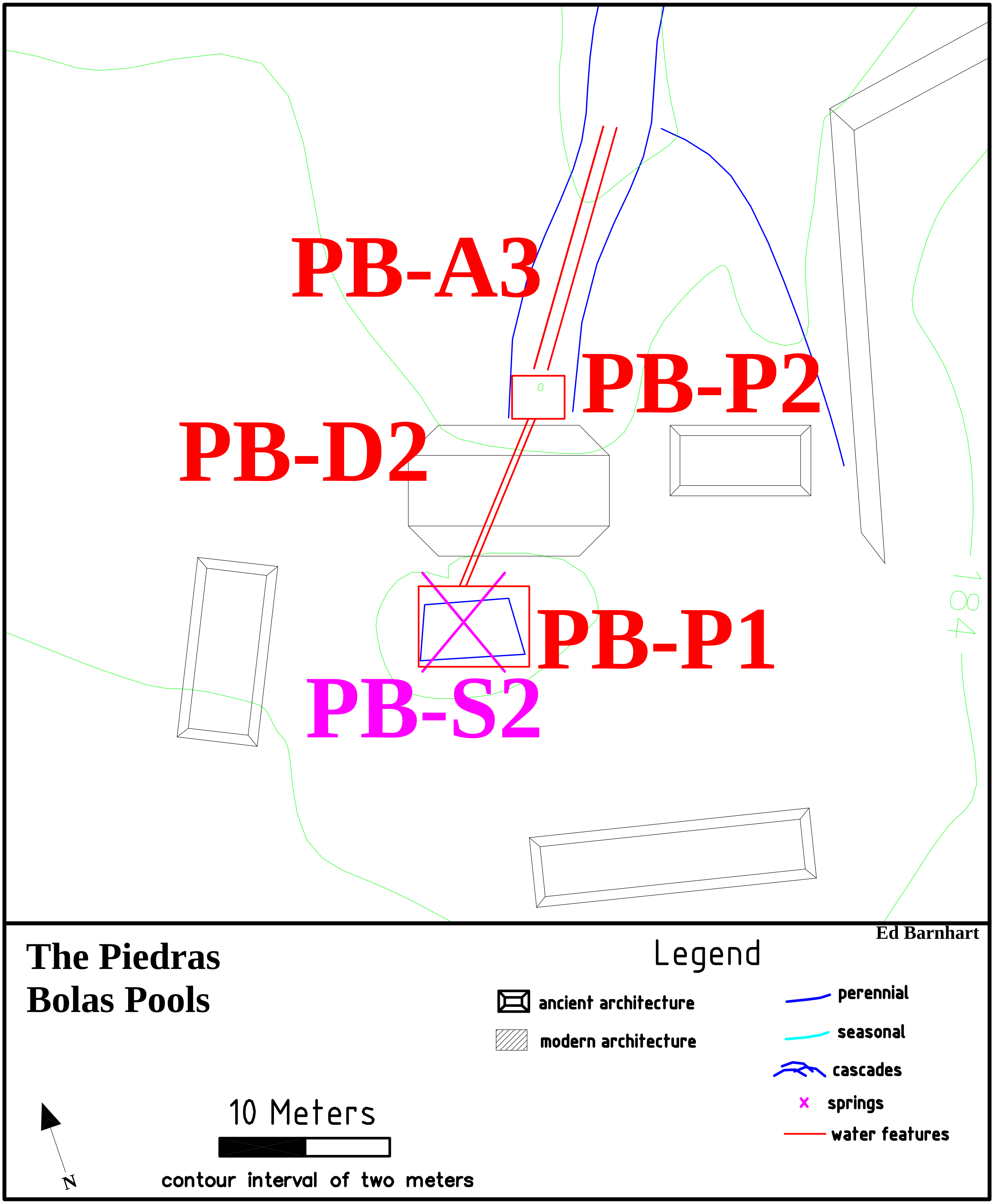


Figure 3.7 – The Piedras Bolas littered with cut stone.

Map 3.6



PB-A3
PB-P2
PB-D2
PB-P1
PB-S2
184
Ed Barnhart
The Piedras Bolas Pools
Legend
ancient architecture
modern architecture
perennial
seasonal
cascades
springs
water features
10 Meters
contour interval of two meters
N

Figure 3.8 – A view of PB-P1. The overflow drain is on the left edge of the photo.

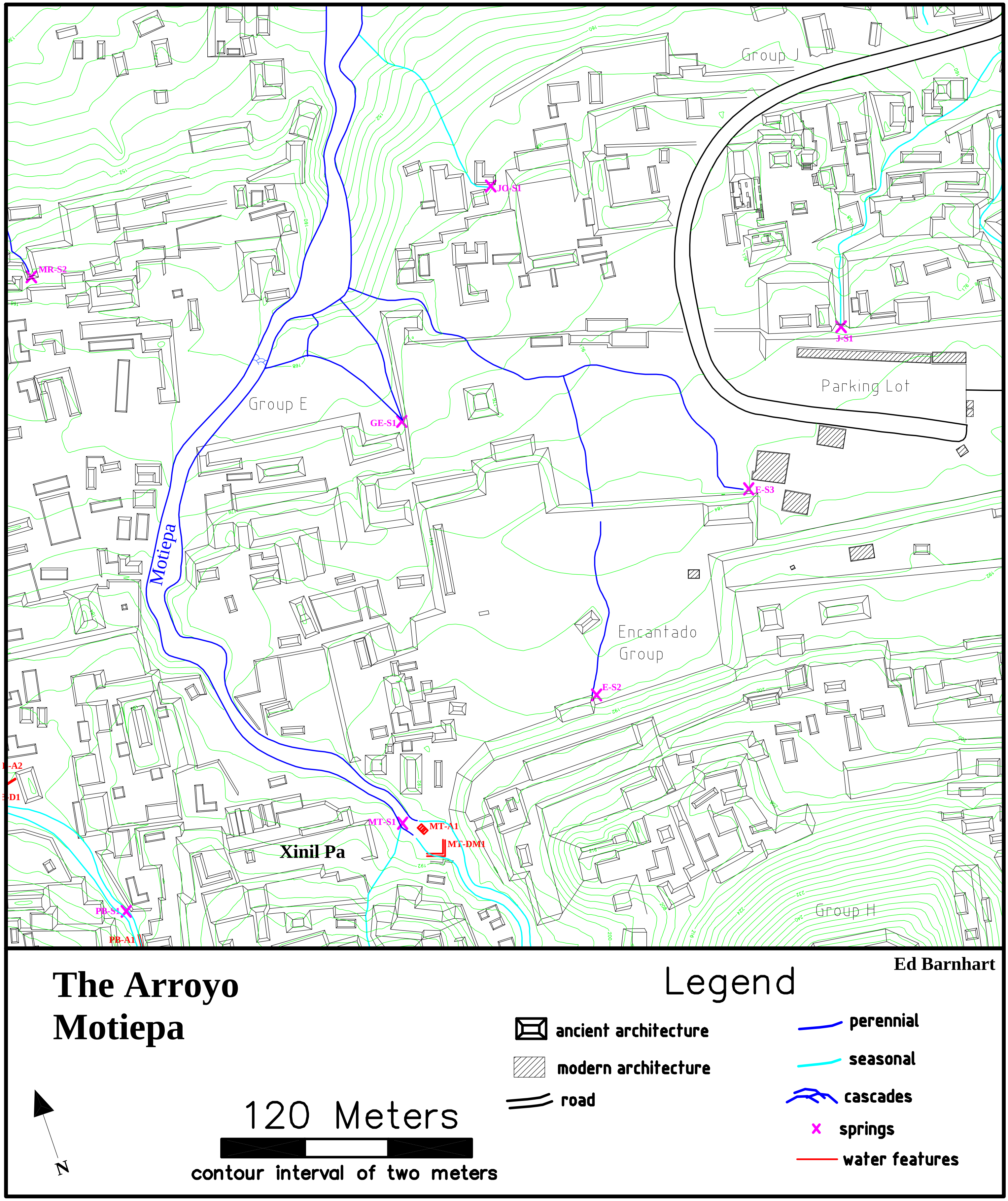
At this juncture, the Piedras Bolas merges with the Picota, and together they spill over the precipice.

The Arroyo Motiepa (Map 3.7)

The Arroyo Motiepa is similar to the Piedras Bolas in that its origin is unknown. It enters the site boundary at an elevation of 216 meters. The Motiepa is fed by seven springs within the site boundary, six of which are perennial. The stream spans a distance of 800 meters to the north before leaving the site. Throughout its course, it assists in creating boundaries for Encantado Group, Encantado South, Xinil Pa’, Group E, Moisés’’ Retreat, Group J, Motiepa Group, and Motiepa East Group (Map 2.4).

There are two major water management features located on the Motiepa stream. First, the water collides with Palenque’s finest dam, MT-DM1 (Fig. 3.9), which measures 8.18 meters in length, 1 meter in width, and roughly 1 meter in height. Today, MT-DM1 remains operational by slowing the flow of water in the Motiepa. The second feature is MT-A1, located 8 meters northwest of MT-DM1 (Fig. 3.10). This feature is classed as an aqueduct, for lack of a better term. Due to heavy calcification, positive identification is difficult. MT-A1 is at an

Map 3.7



Group J
JO-S1
MR-S2
J-S1
Parking Lot
Group E
GE-S1
E-S3
Motiepa
Encantado
Group
E-S2
MT-S1
MT-A1
MT-DM1
Xinil Pa
PB-S1
PB-A1
Group H
Ed Barnhart
The Arroyo
Motiepa
Legend
ancient architecture
modern architecture
road
perennial
seasonal
cascades
springs
water features
120 Meters
contour interval of two meters
N

Figure 3.9 – Water flowing over MT-DM1.

Figure 3.10 – MT-A1 showing heavy calcification forming on all sides.

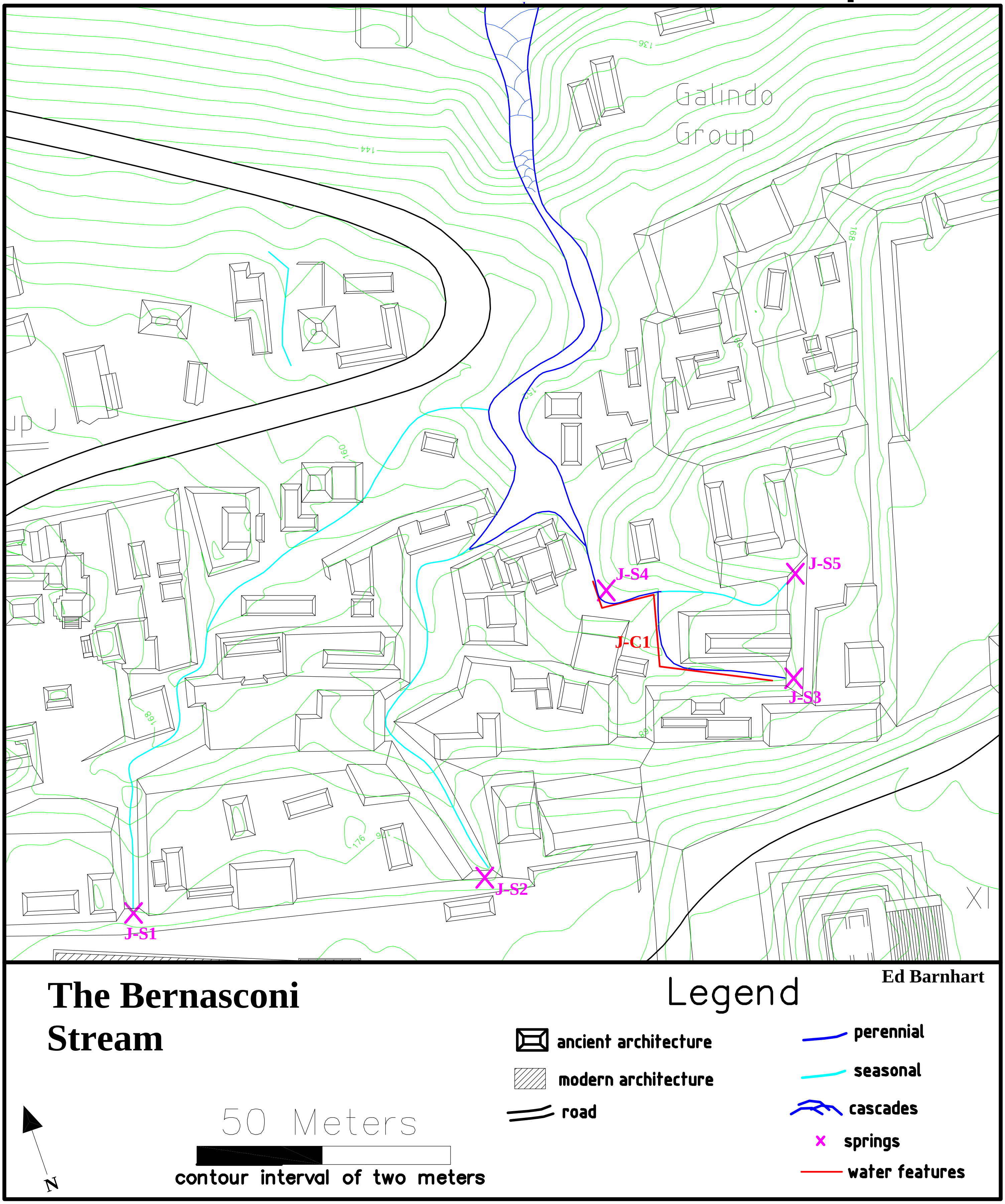
elevation of 189.17 meters and measures 4.5m x 1.5m. Large cut-stone slabs create the roof of the structure. Standing atop the aqueduct, one can clearly hear the sound of rushing water. The source of the water from within is unknown. The water exits through two small holes found on its west side. These holes were presumably drains at one time, but the dense calcification makes identification difficult. Spring MT-S1 is located approximately 1 meter to the west of MT-A1.

As the Motiepa continues through the site, it becomes sterile of cultural modification. While traveling northward, it is joined by the waters from E-S2, E-S3, GE-S1, and JO-S1, before cascading over the Motiepa Falls. The Motiepa then passes between the Motiepa Group and the Motiepa Group East prior to crossing the Camino Real. Immediately after the trail, the water cascades once more and falls into Pakal's Pool (Map 2.4).

The Bernasconi Stream (Map 3.8)

The Bernasconi is the only watercourse in Palenque that originates solely from within a residential group. Three separate spring-fed arroyos meander through Group J before merging together as one and exiting the site. This is Palenque's shortest waterway, measuring roughly 300

Map 3.8



Galindo Group
J-S4
J-S5
J-C1
J-S3
J-S2
J-S1
XI
The Bernasconi Stream
Ed Barnhart
Legend
ancient architecture
modern architecture
road
perennial
seasonal
cascades
springs
water features
N
50 Meters
contour interval of two meters

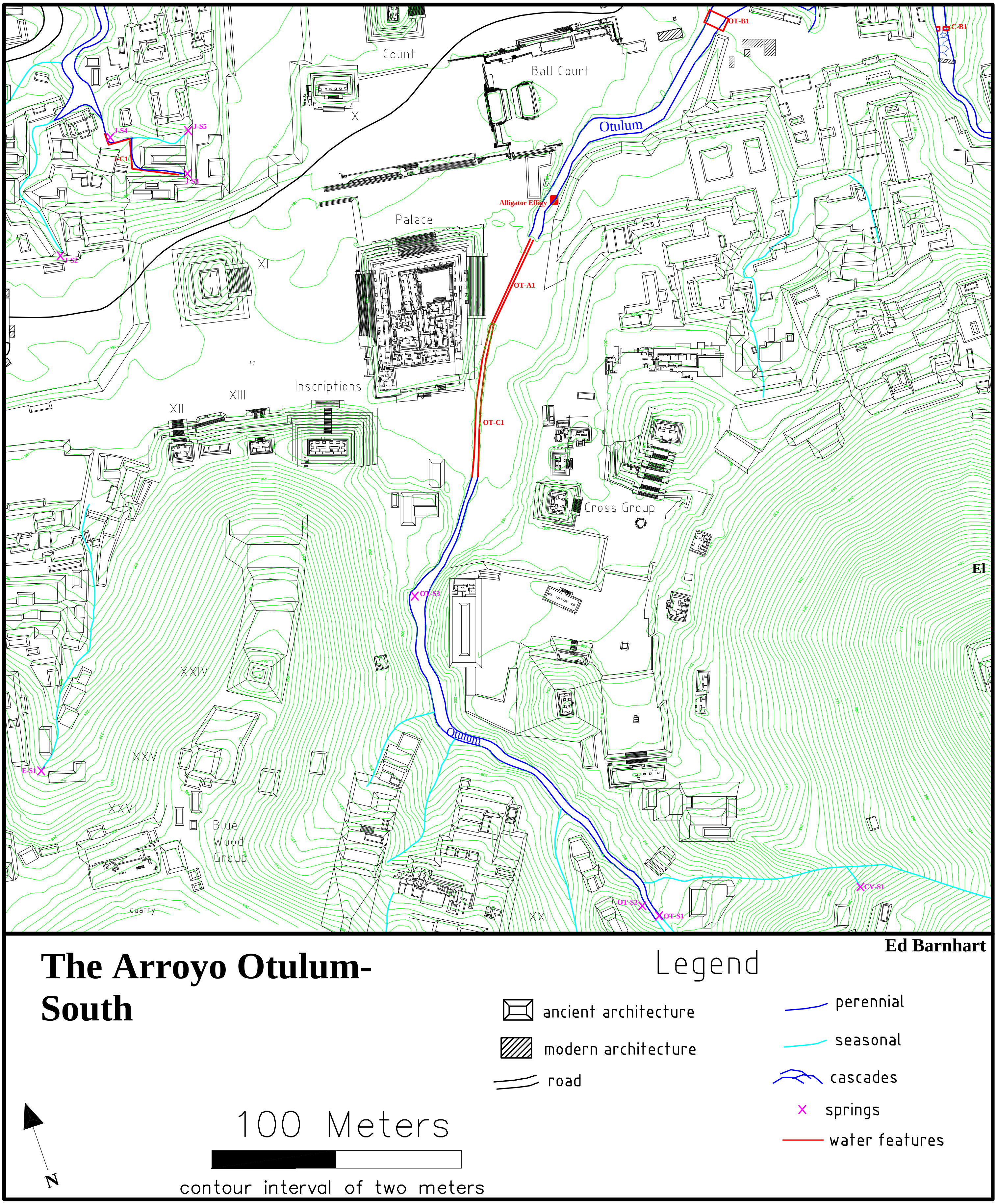
meters in length. The split arroyo located in the far east side of Group J is managed by a walled channel, J-C1. The exact dimensions of these walls are unknown due to their poor condition.

The Arroyo Otulum (Maps 3.9 & 3.10)

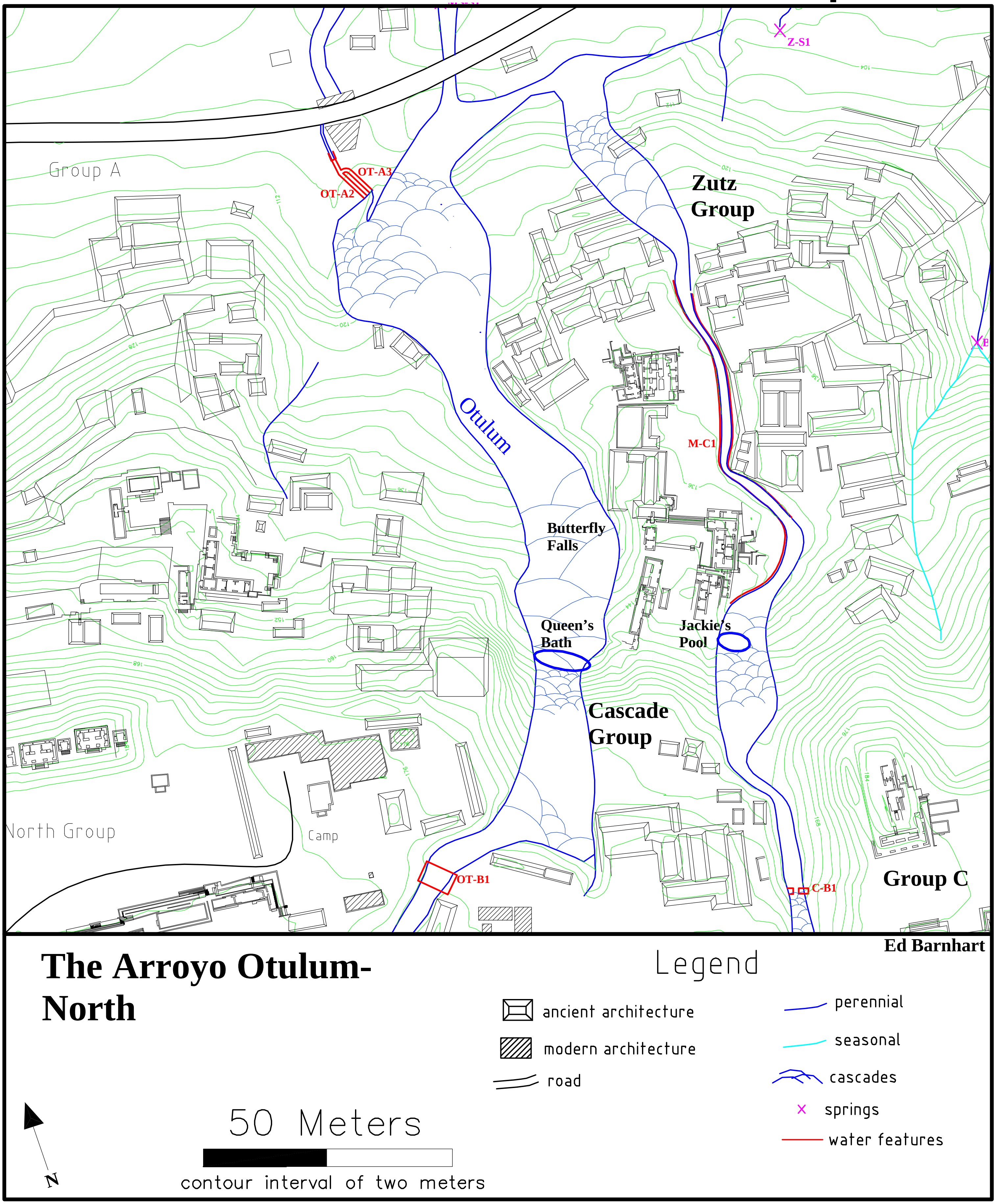
The Otulum is Palenque’s longest and most impressive stream. Its perennial waters flow through the site’s center by way of an extraordinarily constructed aqueduct. Subsequent to passing under Palenque’s only fully functional bridge (OT-B1), the Otulum tumbles over a remarkable series of cascades. These waterfalls include the Queen’s Bath (Map 3.10), a popular swimming hole for tourists and locals alike. The water then runs into a pair of aqueducts before exiting the site’s boundary.

Before the perennial waters of the Otulum begin, a seasonal arroyo climbs to an elevation of 240 meters to the south. The perennial flow of the stream begins with springs OT-S1 and OT-S2, the true headwaters of the Otulum. The stream meanders in a northerly direction, forming the natural boundary of the Cross Group’s western edge (Map 3.9). At this point, a seasonal tributary extending from the Schele Terraces (Map 2.4) joins the Otulum. The stream collects more water at OT-S3 before entering the walled

Map 3.9


Count
Ball Court
X
Otulum
Alligator Effigy
Palace
XI
OT-A1
OT-B1
C-B1
J-S4
J-S5
J-C1
J-S3
J-S2
Inscriptions
XIII
XII
OT-C1
Cross Group
El
OT-S3
XXIV
XXV
E-S1
XXVI
Blue
Wood
Group
quarry
Otulum
XXIII
OT-S2
OT-S1
CV-S1
Ed Barnhart
The Arroyo Otulum-South
Legend
ancient architecture
modern architecture
road
perennial
seasonal
cascades
springs
water features
100 Meters
contour interval of two meters
N

Map 3.10



The Arroyo Otulum-North

channel, OT-C1 (Fig. 3.11).

The OT-C1 stretches 97 meters before entering the OT-A1. It is believed that this walled channel was actually an aqueduct during Classic times. Maps of Palenque created by early explorers illustrate that the Otulum did not then flow through OT-A1. Blom stated that the aqueduct was “blocked by its fallen roof”(Blom 1925:173). The collapse forced the Otulum to flow just to the east of the aqueduct and cut a new streambed. Blom’s map clearly shows that the diversion of the stream began at the same location where the walled channel begins today. During the 1950s, archaeologists began to clean out the debris and rebuild the walls. After the collapse was cleared, the water from the Otulum split in two directions. The stream once again flowed through the aqueduct but continued to flow into its new channel. Not until 1985 did archaeologists decide to block off the side flow of the Otulum and force all of the water back into the aqueduct. The new channel was filled with earth, and no trace is left of it today.

The PMP has discussed the possibility that OT-A1 at one time extended further south, to the edge of OT-C1, but the dimensions of the channel are too wide to support a

Figure 3.11 – The Otulum flowing through OT-C1.

corbelled arch. It is possible that the workers in the 1950s were forced to build the walled channel wider than its original foundation due to erosion. Excavations within the Otulum would clarify this point. Evidence revealing a narrower foundation for the channel would suggest that OT-A1 extended another 97 meters to the south.

The intact section of OT-A1 is in excellent condition and carries the Otulum 58.5 meters beneath the floor of the plaza (Fig. 3.12). It resides at an elevation of 187.50 meters. There is evidence of three separate construction phases of OT-A1. It appears that the Maya of Palenque continued lengthening the aqueduct by continuing construction to the south. The earliest building phase of the aqueduct extends southward from the exit approximately 40 meters. This section is OT-A1's best-preserved area, consisting of large cut-stone support beams found in the corbelled arch. The second phase stretches roughly 10 meters and lacks the support beams. The vault on the east side is under stress and is sagging. OT-A1's third phase extends the remaining 8 meters before the entrance but appears to have continued another 10 meters prior to the collapse. This is uncertain, though, because the archaeologists of the 1950s widened the wall artificially in this area.

Figure 3.12 – An interior view of Palenque’s best-preserved aqueduct, OT-A1. Notice the stone support beams found in the corbelled arch.

After the stream exits OT-A1, a wall on the east side continues for 27 meters. The water then passes an extraordinary work of art, positioned 1 meter above the flow of water--an enormous alligator effigy (Fig. 3.13). It measures 3.44m in length, 1.10m in height, and 86cm thick, or about 3.50 cubic meters. When the Otulum was fully maintained by the Maya and clear of all debris, the water level would have been substantially higher. This is also true today throughout the rainy season. During times of higher water levels, the alligator would have appeared to be floating atop the waters of the Otulum (Stephen D. Houston, personal communication, 2000).

The stream then snakes slightly eastward, passing the ball court and approaches OT-B1, the Otulum Bridge (Fig. 3.14), which measures 10.25m x 10.25m and is in superb condition. Today, tourists and workers use the bridge on a daily bases. The water passes through a corbelled arched opening directly in the middle of the bridge (Fig. 3.15). The passage is about 1 meter in width. After passing beneath the bridge, the water begins to cascade over the falls and into the Queen’s Bath (Map 3.10). The water then topples through a multiple number of small pools that have been nicknamed the Butterfly Falls (Map 3.10).

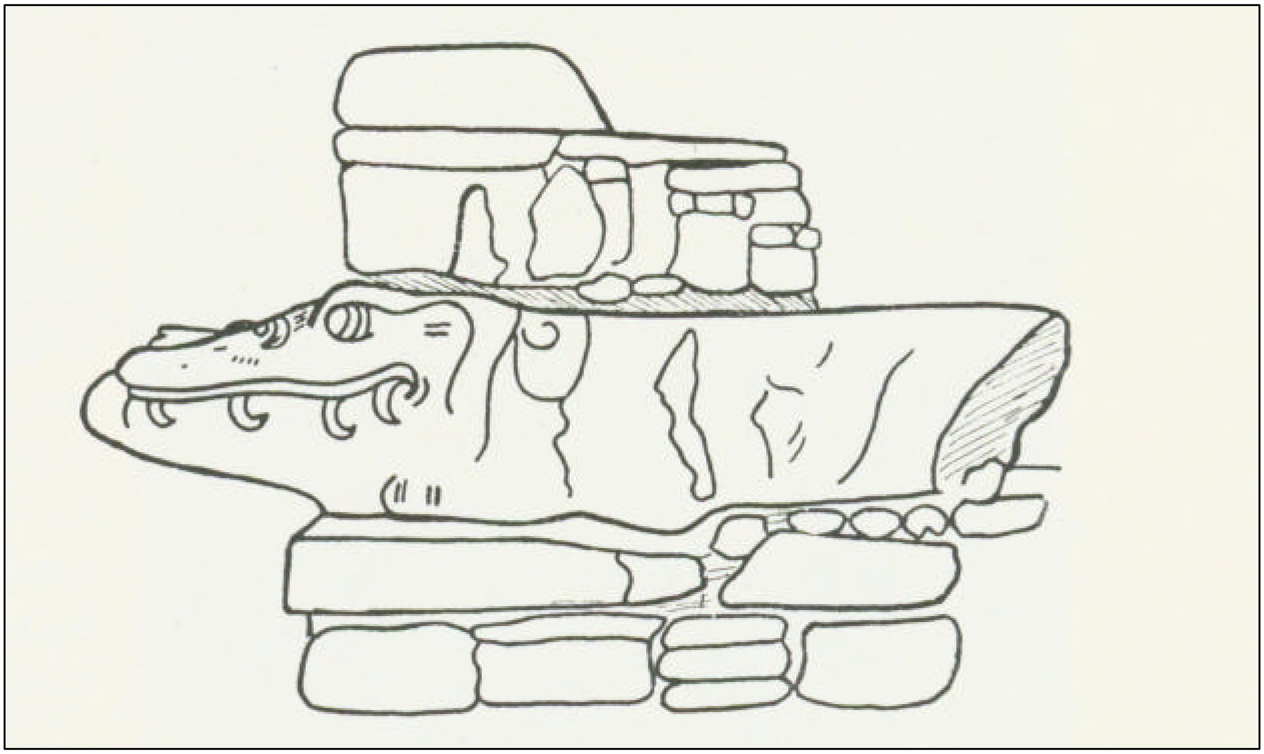


Figure 3.13 – The carved alligator found at the exit of OT-A1. Frans Blom sketched this representation in 1923 (Blom 1926).

Figure 3.14 – Palenque’s only fully functional bridge, OT-B1.

Figure 3.15 – The vaulted channel that allows for water passage beneath the bridge.

At an elevation of 110 meters, the stream gathers in a small and shallow natural pool and then enters a set of parallel aqueducts (Maps 3.10 & 3.11). OT-A2 has been obstructed from view by a large tree that grows directly atop the entrance. The Otulum waters still manage to find their way into the aqueduct. OT-A2 travels north at a bearing of 27 degrees for 19.4 meters before exiting into the natural streambed (Fig. 3.16). The second aqueduct, OT-A3, is heavily calcified and partially collapsed. Despite the damage, the majority of the water flows through this feature. Both aqueducts have similar dimensions, averaging 1.10 meters in height and 80cm in width. The entrance of OT-A3 contains a set of peculiar niches (Fig. 3.17). One is located on the west wall, while the other faces it on the east wall. It is possible that they served as a holding device for a sluice gate of some kind. Following the niches, the aqueduct becomes badly damaged. The water continues through OT-A3 at a bearing of 27 degrees for 13.6 meters. At this point, the aqueduct changes direction with a rapid curve to the west. OT-A3 feeds into OT-A2 and the waters rejoin, exiting together. The Otulum then passes under the road and through the Museum Group and departs the site in a northeasterly direction.

Map 3.11

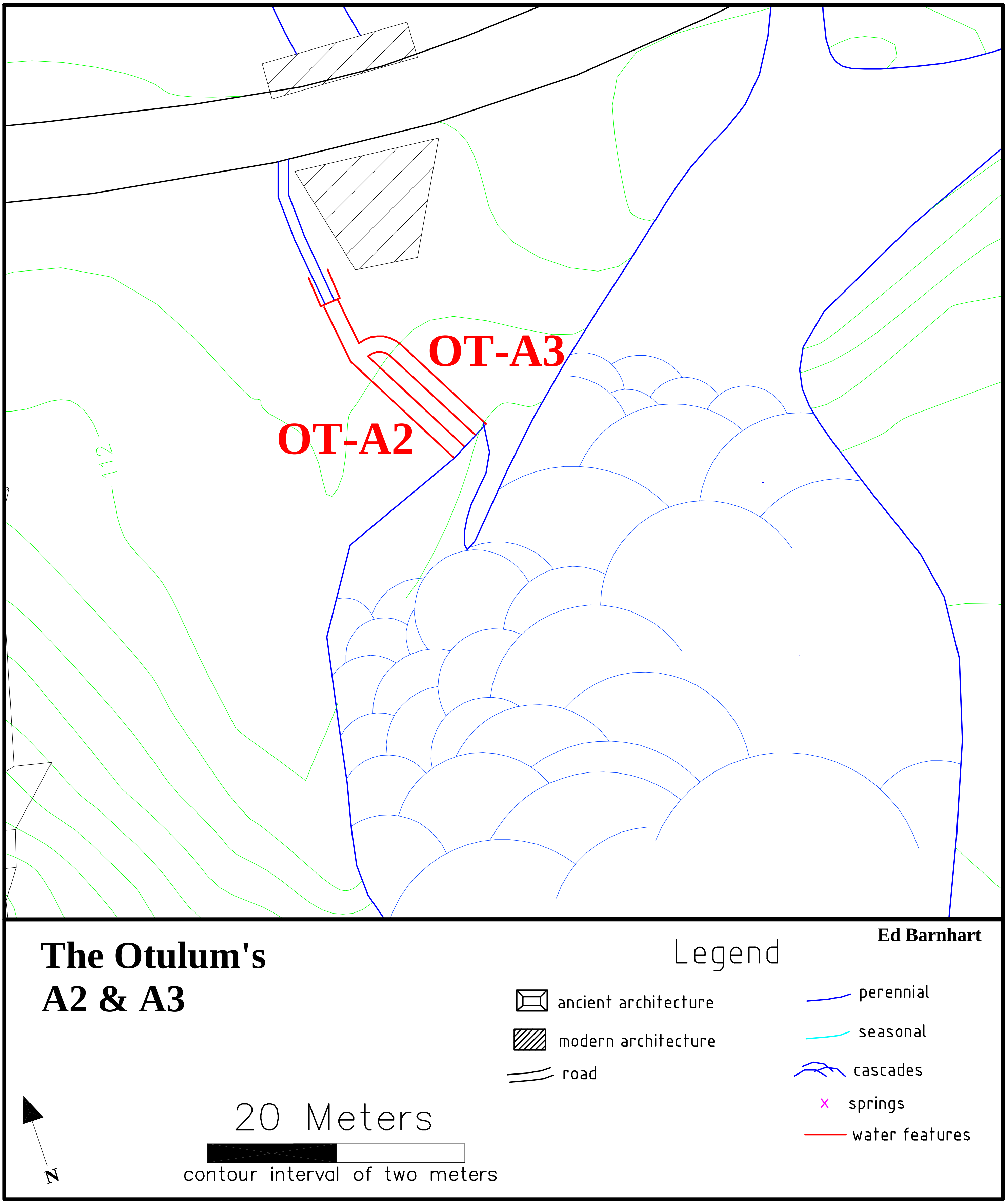

OT-A3
OT-A2
112
The Otulum's
A2 & A3
Ed Barnhart
Legend
ancient architecture
modern architecture
road
perennial
seasonal
cascades
springs
water features
20 Meters
contour interval of two meters
N

Figure 3.16 – The interior of OT-A2, showing the exit of OT-A3 on the left.

Figure 3.17 – One of the niches at the entrance of OT-A3.

The Arroyo Murciélagos (Map 3.12)

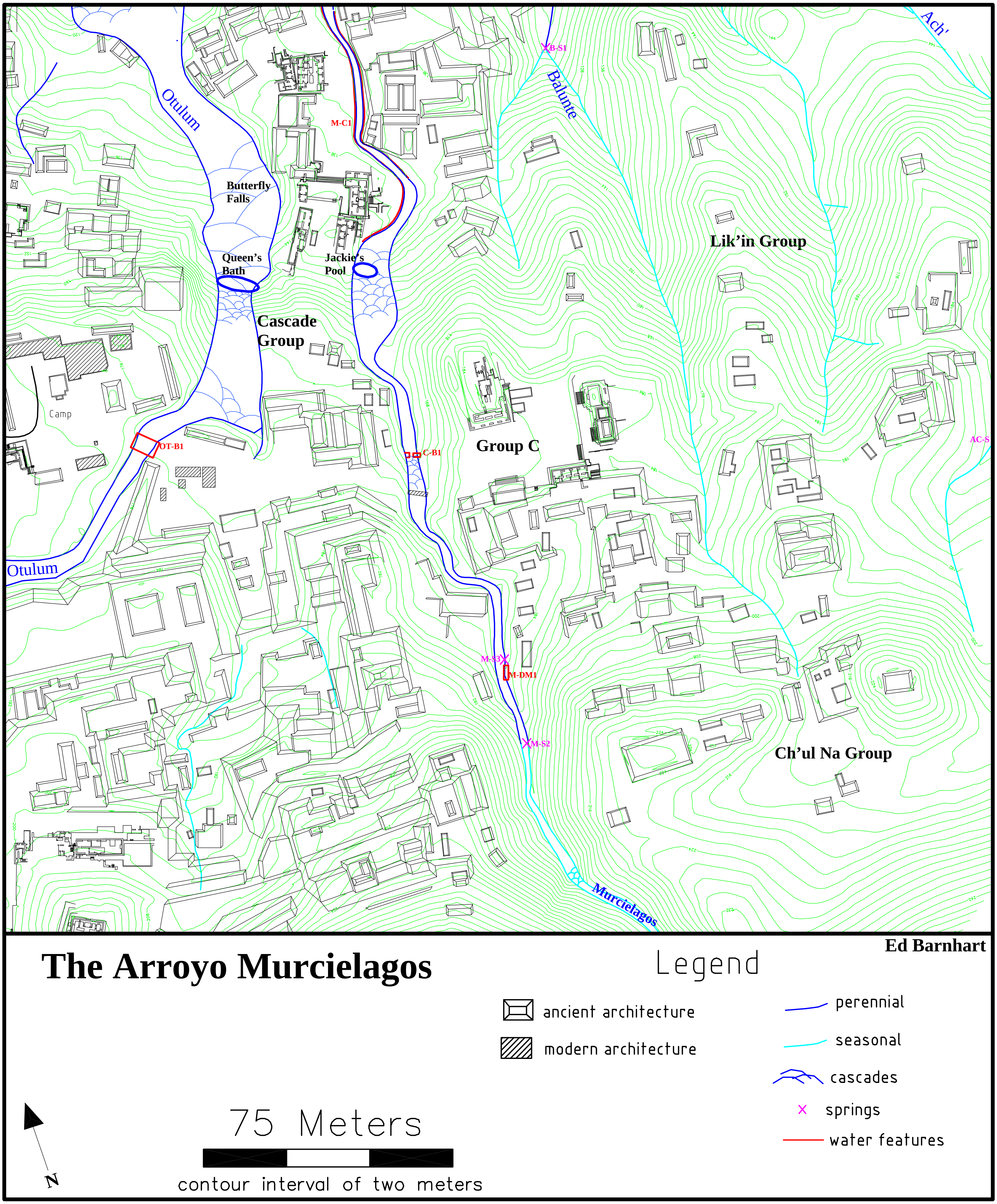
The Arroyo Murciélagos begins at an elevation of 305 meters, the highest in the site. As it stretches 980 meters through the eastern region of the ruins, it drops 200 meters in elevation before reaching the plains to the north. Its southern section runs to the east of El Mirador. This area consists of steep canyon walls and treacherous cliffs.

The water flow in the southern region is seasonal. Spring M-S3, the Murciélagos' only known perennial water source, begins just to the west of Group C at an elevation of 181.58m. This spring is in proximity to a dam-like feature, M-DM1, which measures 3.5m x 3m and appears to serve as a water catchment device. Today, the majority of the water flows to the west of M-DM1.

As the arroyo winds forward, it travels beneath a modern bridge that enables tourists to visit Group C. Immediately thereafter, the stream cascades down 7 meters to the base of C-B1. Prior to its collapse, it measured roughly 3.5 meters in height and contained a corbelled arch measuring 2.3 meters in width. C-B1 connected the Cascade Group with Group C (Fig 3.18).

The Cascade Group seems to be built atop calcified cascades. By its location, this construction suggests that

Map 3.12



The Arroyo Murcielagos

the ancient Maya of Palenque closed this section of the falls by directing all water into the present Otulum stream. This redirection of water made it possible for them to build the Cascade Group and Group B.

As the Murciélagos stream continues, it cascades into Jackie’s Pool. It then flows through M-C1, a series of partially intact canal walls extending some 130 meters toward the plains. At this point, the Murciélagos cascades a final time before flowing under the modern road and exiting the site boundary.

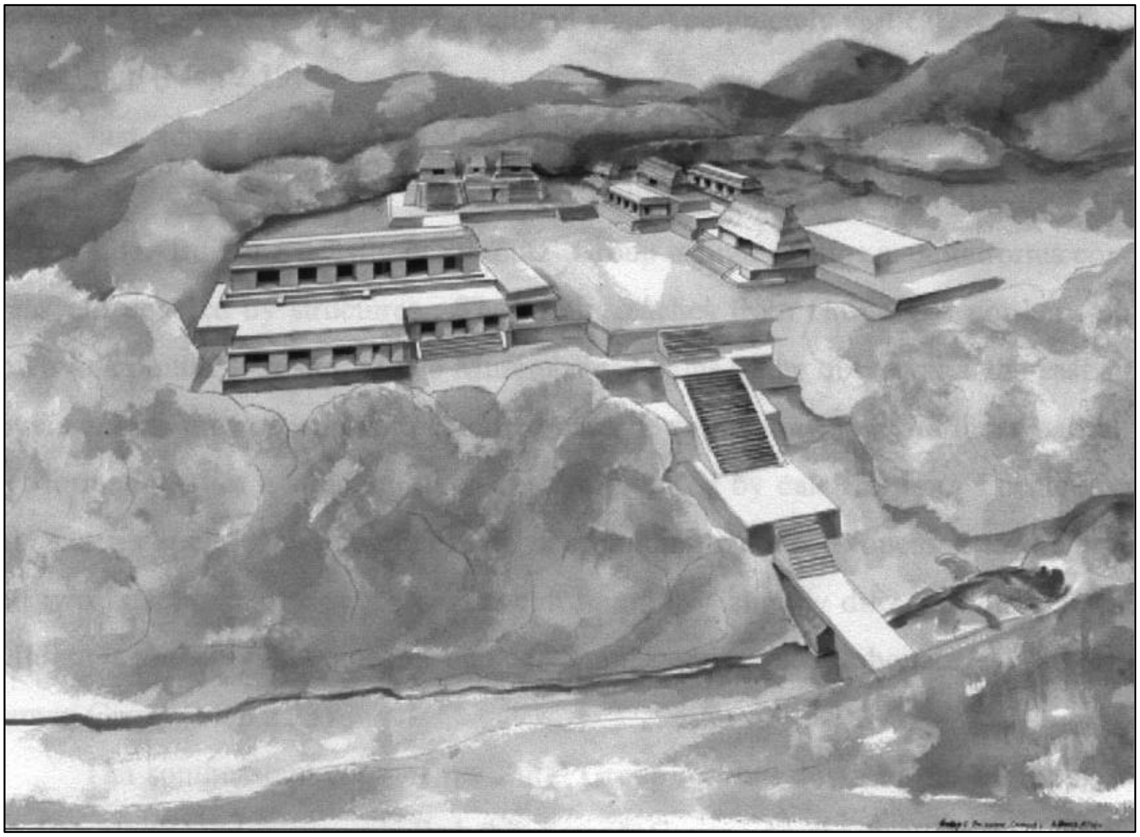
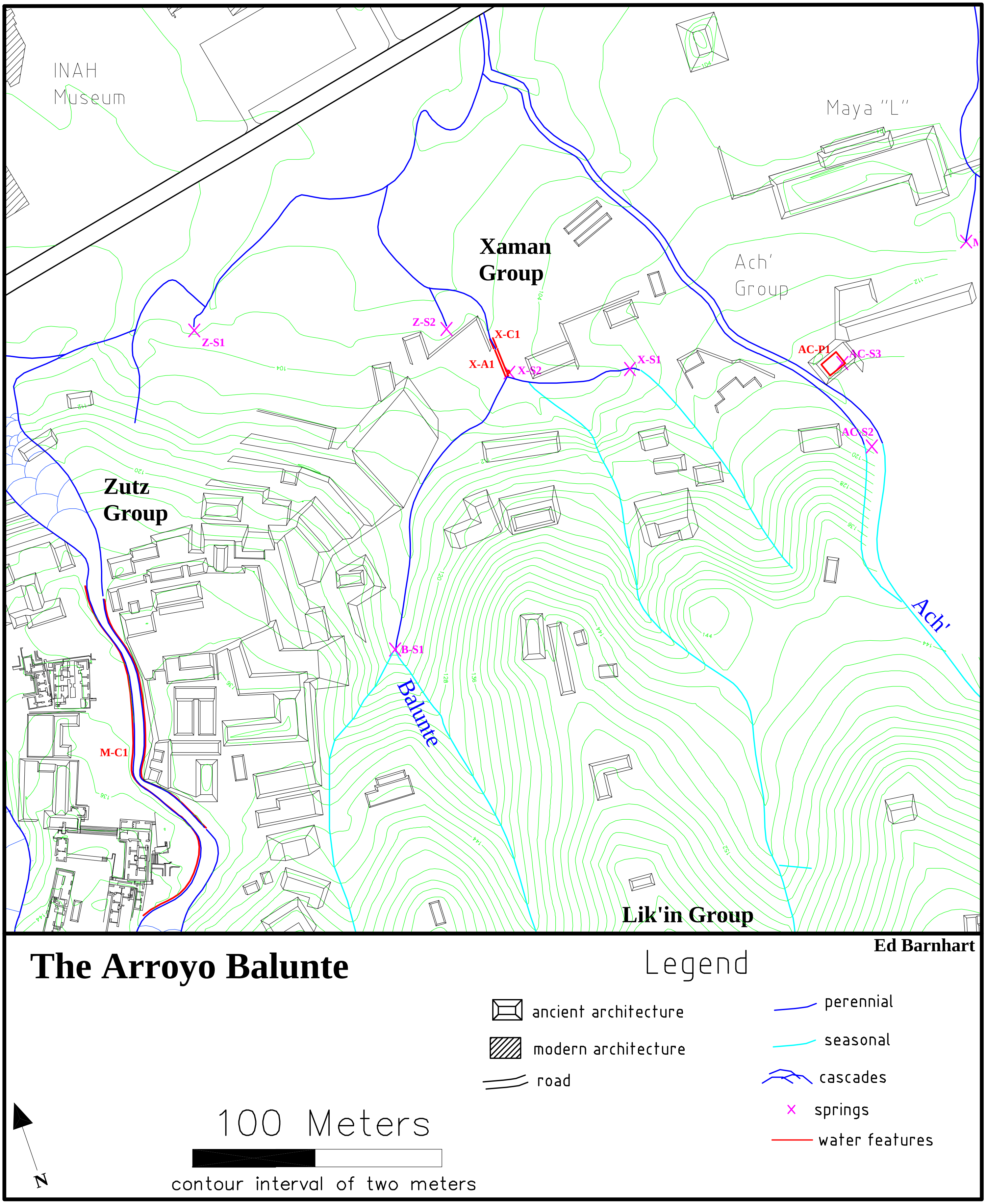


Figure 3.18 – Reconstruction drawing of Group C. Notice C-B1 in the right foreground (Méndez 2000).

The Arroyo Balunte (Map 3.13)

The Arroyo Balunte begins at an elevation of 208 meters, separating Group C and the Ch’ul Na Group. The arroyo remains dry as it snakes between the Lik’in, Zutz’, and Xaman groups. B-S1 is the Balunte’s first perennial spring and is located at 114 meters in elevation. Before entering X-A1 (Fig. 3.19), the stream’s only aqueduct, the Balunte is joined by a small perennial tributary fed by spring X-S1. These two watercourses enter the 11.48-meter aqueduct and together continue in a northerly direction. Once inside X-A1, the stream collects more water from spring X-S2. This spring was previously housed in a corbelled chamber that is connected to the east wall of X-A1. The chamber was probably about 1.5 meters in length, but this is difficult to know for certain, due to its total collapse. After leaving X-A1, the stream passes through X-C1, a section of a walled channel that extends 5.5 meters to the north. Soon the Balunte merges with a series of small drainage ditches and eventually leaves the site by flowing under the modern road.

Map 3.13



The Arroyo Balunte

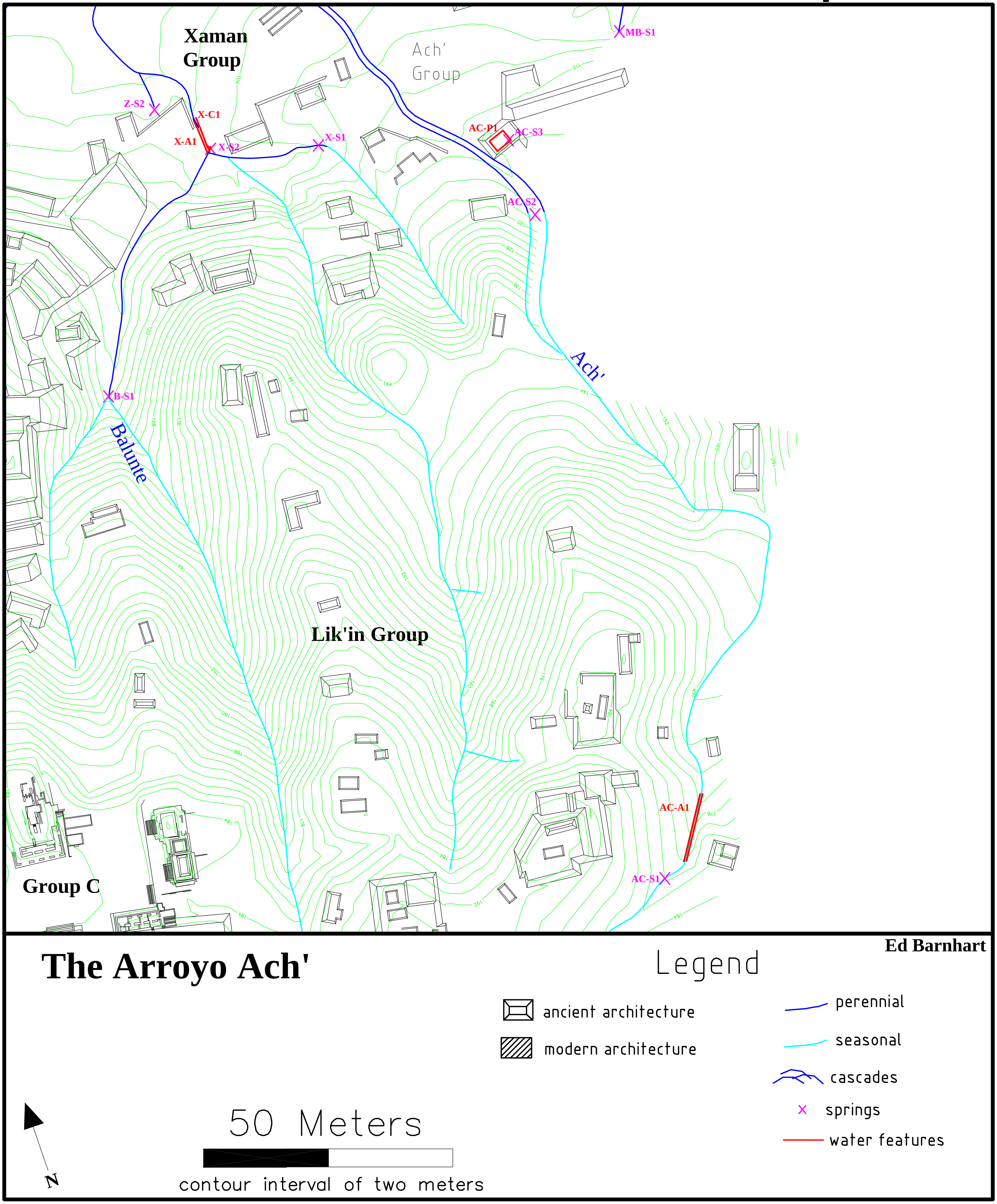
Figure 3.19 – The interior of X-A1.

The Arroyo Ach’ (Map 3.14)

The Arroyo Ach’ serves as much of Palenque’s eastern boundary. Beginning at an elevation of 198 meters, the Ach’ stretches through the site for 554 meters. As the arroyo continues north, it passes its first seasonal spring, AC-S1. The first water management feature emerges some 110 meters further downhill. In this area, the topography becomes relatively flat, without a discernible streambed. The arroyo reemerges some 33 meters to the northeast. Upon closer inspection, evidence of architecture was found at the points of disappearance and return of the arroyo, strongly suggesting the existence of a collapsed aqueduct beneath the surface of the Ch’ul Na Group (Map 2.5).

The arroyo remains seasonally dry during its first 386 meters. The Ach’ collects water from its first perennial spring, AC-S2, at an elevation of 120 meters. As the stream flows toward the north, it passes Palenque’s fifth pool, AC-P1. Measuring 5.25m x 5.25m, AC-P1 is in good condition. The walls are intact but the floor is littered with thick sedimentation. The earth inside the pool remains saturated and muddy during the dry season, suggesting the presence of a weak perennial spring beneath the pool. Pools P-P1, P-P2, and PB-P1 were all constructed atop springs as well. As the stream continues, it creates the borders for the Xaman and Ach’ groups. Like all the watercourses in the eastern portion of the site, the Ach’ maintains a northerly direction and exits the site by flowing beneath the modern road.

Map 3.14


Xaman Group
Ach' Group
MB-S1
Z-S2
X-C1
X-A1
X-S2
X-S1
AC-P1
AC-S3
AC-S2
Ach'
B-S1
Balunte
Lik'in Group
AC-A1
AC-S1
Group C
Ed Barnhart
The Arroyo Ach'
Legend
ancient architecture
modern architecture
perennial
seasonal
cascades
springs
water features
N
50 Meters
contour interval of two meters

Chapter 4
Conclusion

Flood Control

Flood control was one function performed by the aqueducts at Palenque. From August to November, Palenque receives 45 percent (977mm) of its annual rainfall (SARA 1999)(Fig. 4.1). This substantial concentration in precipitation causes the streams in the mountains to expand in size as they rush swiftly downhill toward the level escarpment. The abrupt change in declination causes the streams to slow, forcing the water level to rise and flood the plaza and residential areas. Maudslay (1889-1902) visited Palenque during the dry season of 1895, prior to the current maintenance of the Palace aqueduct (OT-A1)(Map 3.8), and stated that the Main Plaza completely flooded three times during his stay. His fieldwork was conducted between February and April, when the average rainfall reaches only 159mm. Prior to 1950, the entrance to the Palace aqueduct was completely collapsed, causing the Otulum to flow a few meters to the east in a new streambed. Maudslay’s account, along with the damaged entrance, provides a view of how the Main Plaza would function during heavy rains without the assistance of the aqueduct. By

Palenque’s Annual Average Rainfall

Month	mm of Rainfall
Jan	88.9
Feb	55.6
Mar	55.6
Apr	48.1
May	185.2
Jun	307
Jul	188.9
Aug	244.4
Sep	440.7
Oct	292.6
Nov	144.4
Dec	114.8
TOTAL	2166.2

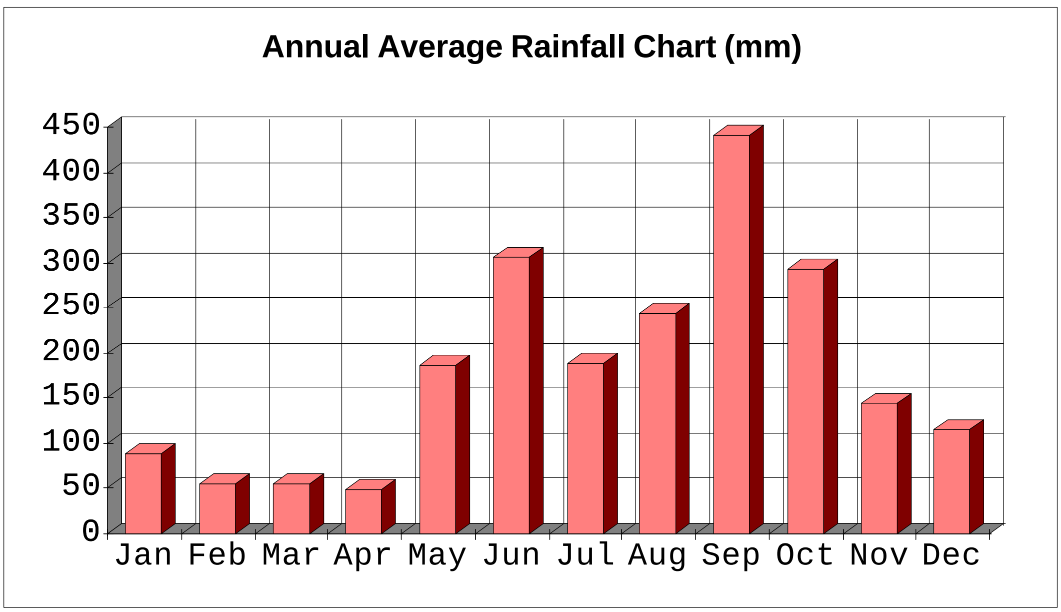


Figure 4.1 – Palenque’s Annual Average Rainfall Charts 1985-1995

forcing the flowing water of the streams below the surface of the plaza, the city planners were able to decrease the risks of plaza and residential flooding.

Erosion

Another problem Palenque's city planners must have faced, along with seasonal flooding, was erosion. Without proper water control features in place, erosion would have been a crisis, not just for the elite but also for the larger number of urban residents living outside the city's center. In order to minimize land loss and residential disruption from erosion, a partial canalization of all nine waterways was implemented. Construction of these walled channels and/or aqueducts outside of the center suggests what Barnhart (2001:95) refers to as "public works." These public works encompass all monumental constructions that served the needs of the general populous or the community at large. The sophistication of the water management features is evidenced by the fact that the majority of them are still intact and functioning after more than 1200 rainy seasons.

Creating Space

Palenque's control of nine separate waterways generated from 56 recorded springs provided an ample supply of water for an expanding civilization. With this great quantity of water came an unforgiving landscape consisting of steep hills, sheer cliffs, and deep arroyos posing challenges for city growth. Thus, the obstacle for the city planners of Palenque would not be water insufficiency, but rather a paucity of habitable terrain. This adversity of inhospitable land led the ancient Palenqueños to develop the second most densely populated city in the Maya region (Barnhart 2001:93), along with a phenomenal subterranean aqueduct system.

Although many of the site's residential groups were constructed on the terraced hillsides, the plazas and public centers were created atop a narrow limestone escarpment measuring approximately 1.7 km east-west by 260m north-south. While the escarpment does continue further to the west, evidence of pre-Hispanic settlement declines abruptly. The constricted limestone shelf provided limited space for such occasions as religious or political ceremonies, public markets, or city expansion.

The majority of civic activities in Mesoamerica occurred in large, level, open spaces located within the city’s center--plazas. These areas were designed for public use and provided a setting for everyday urban life where daily interactions, economic exchange, and informal conversations occurred, and created a socially meaningful space within the city (Low 2000:33). These communal interplays are thought to be the threads that create the natural “human whole” (Arensberg 1961; Redfield 1955) that serves as a society’s principal unit of biological and cultural reproduction (Yaeger and Canuto 2000:2). Murdock (1949) also strongly emphasized the importance of interaction among community members, claiming it as a necessary condition of the community’s existence.

The modern Latin American plaza can provide insight into the Precolumbian plaza via ethnoarchaeology. Many scholars share the belief that the grid-plan town with a central plaza found throughout Latin America is a European creation, but Low (2000) presents suggestive evidence that counters this assumption. She explains that the redesign of Spanish cities in grid-plan during the mid-16th century under the rule of Philip II was in part stimulated by the urban-design experiments of the New World. By overlooking the Precolumbian architectural and archaeological record, many historians have constructed a Eurocentric view of the evolution of the New World urban form. Town centers of

European cities such as Córdoba and Madrid, rebuilt many years after the colonization process began, mimic the design of the newly created plazas of the Spanish-American New World. Low’s implication that the colonial plaza and grid-plan design found in Latin America was more an indigenous than Spanish creation only adds validity to the ethnographic research of plazas as ethnoarchaeological data.

Today, throughout Latin America, plazas are locations within cities where communal activities take place. The church as well as the government offices of a city are typically found on the borders of the plaza, where the majority of public religious and political gatherings occur. The design of most Mesoamerican plazas exhibits a similar layout, where the grandest of temples coupled with a palace or elite residential structure characteristically create the borders of the plaza.

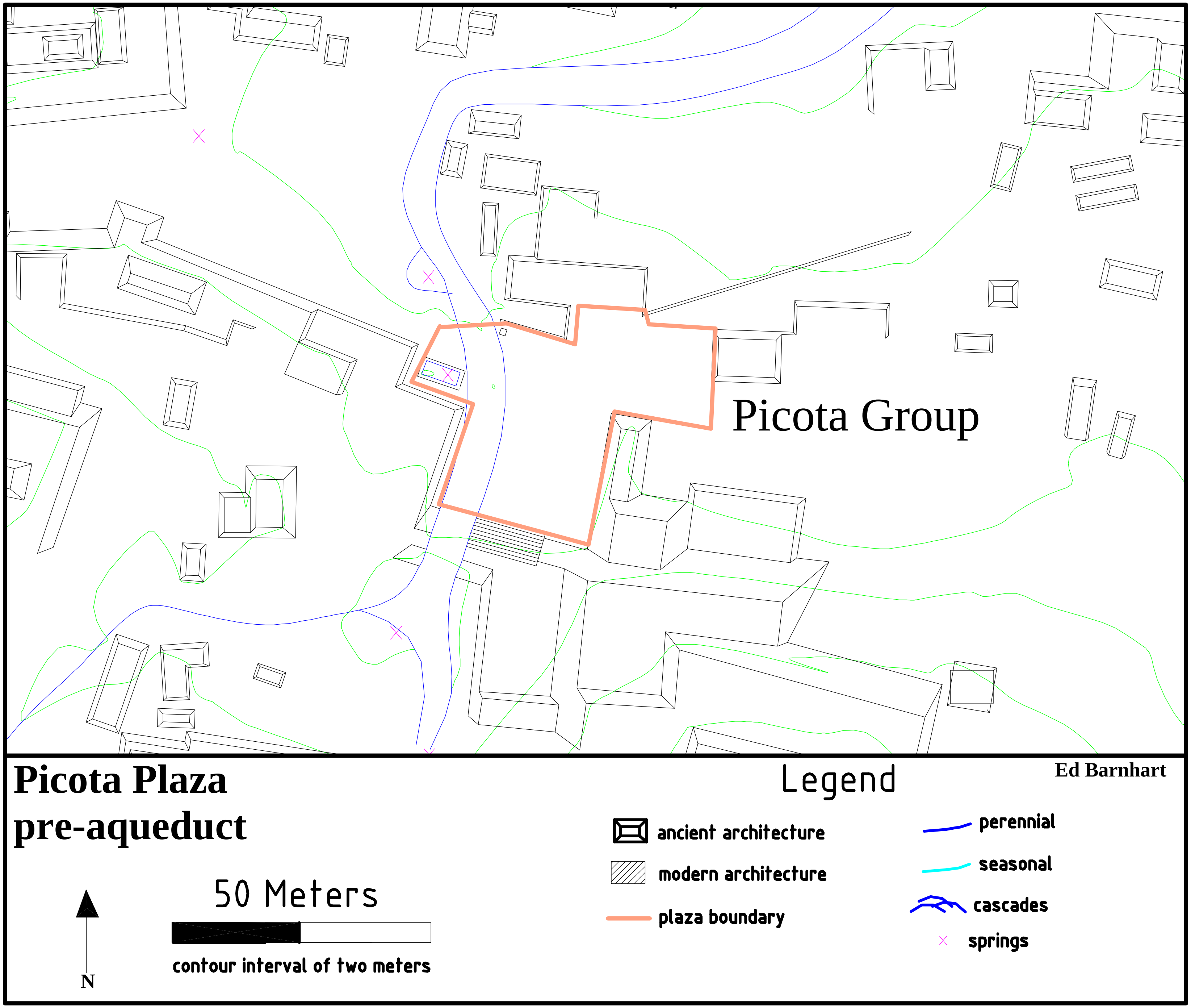
At Palenque, contributing to the dilemma of building on its confined plateau were the spring-fed streams that naturally marred and divided the landscape. Andrews (1975) claimed that this irregular natural terrain caused many problems for the city’s builders, who were forced to do a considerable amount of reshaping of the existing ground form to maintain a semblance of visual order in the over-all layout of the city. To simultaneously control flooding and erosion and also bridge the divided areas to expand civic space, the Maya of Palenque covered portions of the preexisting streams by constructing elaborate subterranean aqueducts that guided the stream beneath plaza floors. The two plazas of concern here are the Picota Plaza (Maps 4.1 & 4.2) and the Main Plaza (Maps 4.3 & 4.4).

The Picota Plaza, located 1 km due west of the site center, contains approximately 1477 m^2 of surface and houses the Picota stream beneath its floor. In order to estimate how much surface space was gained by channeling the stream underground, the average width of the Picota arroyo was calculated by systematically measuring its width where canalization was absent; an average width of 7.23 m was established. This figure was then multiplied by 47 m, the length of the Picota aqueduct (P-A1), to arrive at an estimate of 340 m^2 of surface area created by covering the stream (Figure 4.2). The construction of P-A1 allowed the Maya of Palenque to increase their plaza size by 23 percent (Maps 4.1 & 4.2). Apart from plaza expansion, the absence of the aqueduct would have prevented the construction of the structure and staircase built on the south side.

	plaza size (m^2)	**average arroyo width** (m)	**Aqueduct length** (m)	**land generated** (m^2)	**% increase**	**land gained opposite streamside** (m^2)	**total % gained**
Picota Plaza	1477	7.23	47	340	23	na	23
Main Plaza	33421	6.27	154	971	3	6547	23

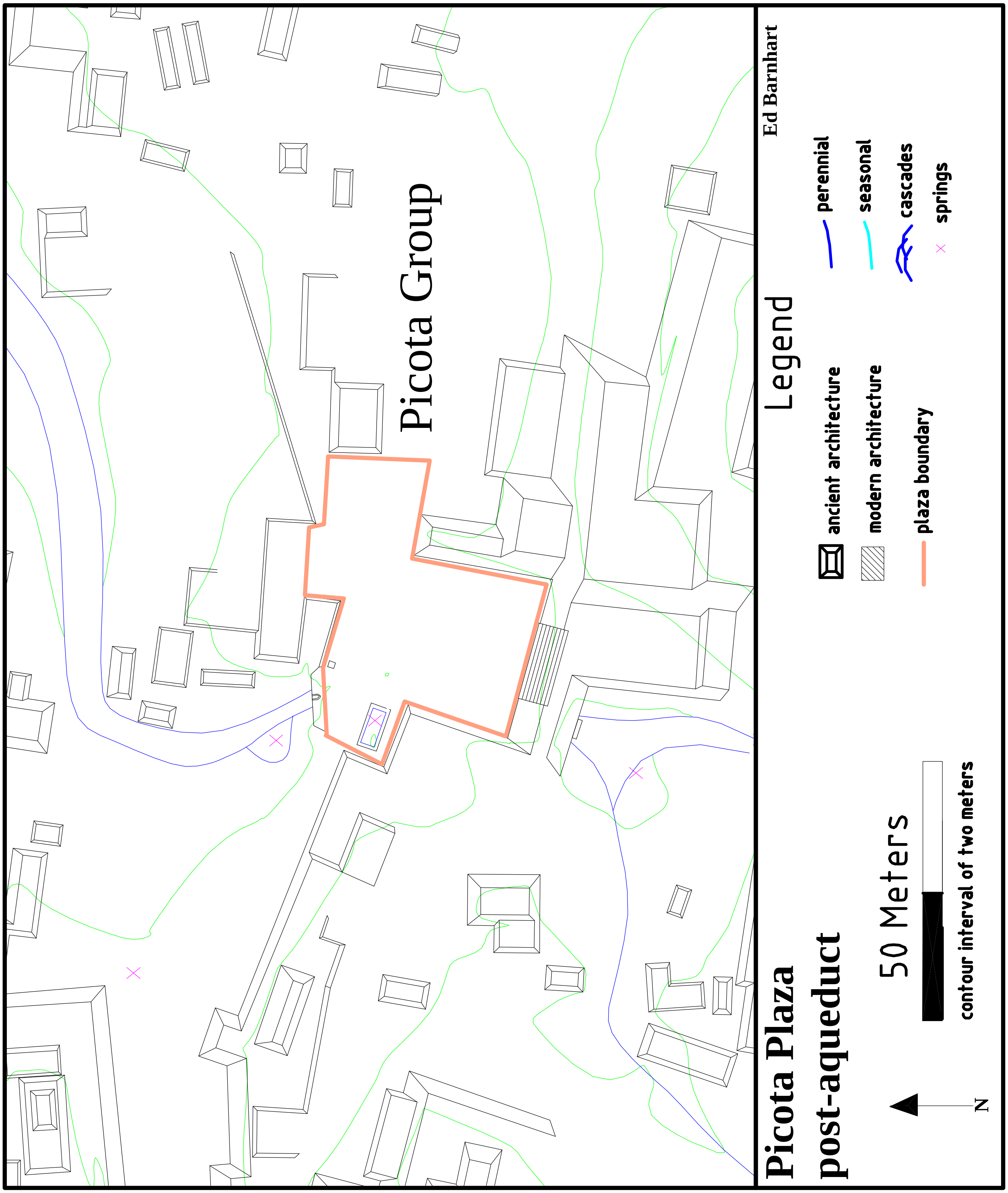
Figure 4.2 – Plaza expansion calculations

Map 4.1



Picota Group
Picota Plaza
pre-aqueduct
Ed Barnhart
Legend
ancient architecture
modern architecture
plaza boundary
perennial
seasonal
cascades
springs
50 Meters
contour interval of two meters
N

Map 4.2

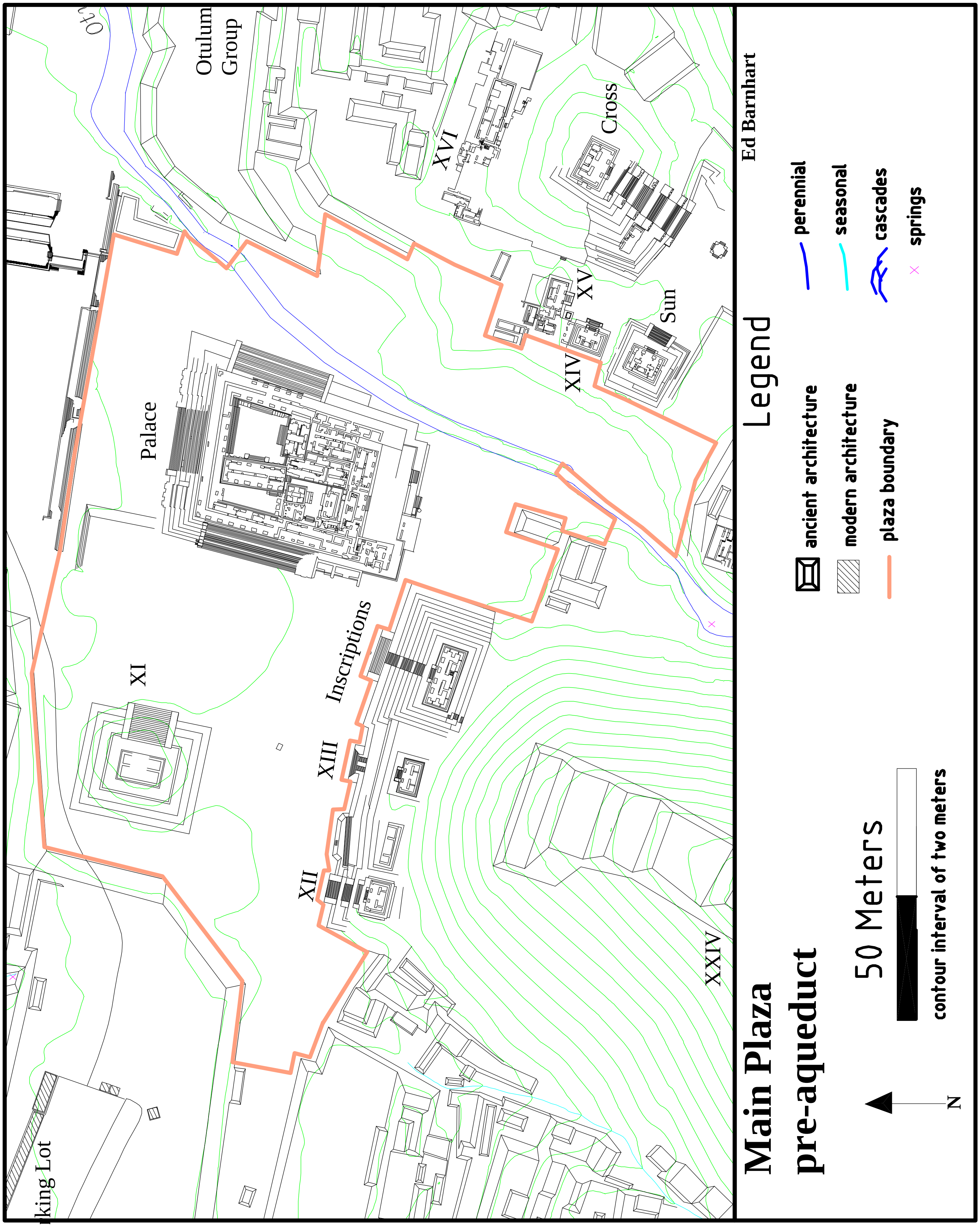

Picota Group
Picota Plaza
post-aqueduct
Legend
ancient architecture
modern architecture
plaza boundary
perennial
seasonal
cascades
springs
Ed Barnhart
50 Meters
contour interval of two meters
N

Main plazas are one of the most important elements of a Maya center. The counterweight to mass is void, and the Maya valued the plazas as much as the structures that surrounded them (Miller 1999:23). Larger buildings demand larger plazas, so the plazas required expansion as a city grew and buildings became larger. Due to the irregularities of Palenque's topography, expansion required inventiveness.

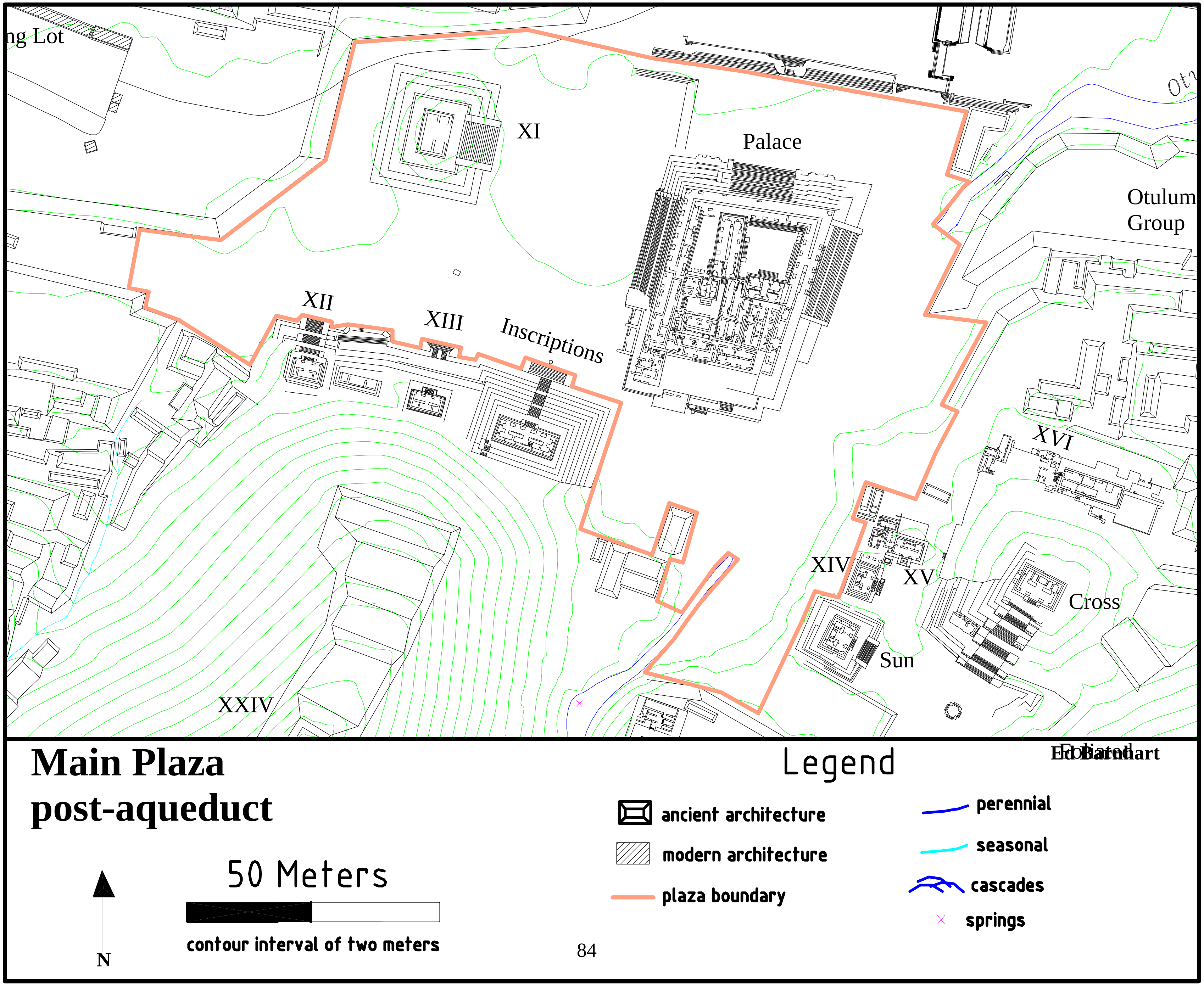
The Palace was constructed on the banks of the Otulum stream in order to utilize the open space on its west side. On the east side, the city planners constructed a subterranean aqueduct beneath the plaza floor. Due to variations in materials and architectural styles, the aqueduct appears to have been implemented in four separate stages, with each stage creating more space to the south side of the plaza (Maps 4.3 & 4.4).

By covering 155 m of the Otulum, only 971 m^2 of surface area was actually created, which is a mere 3 percent of the total plaza size. But, 6547 m^2 of surface area was gained by bridging together the area to the east of the Otulum. The land produced by the aqueduct, along with the level terrain east of the Otulum, increased the size of the Main Plaza by 23 percent. Today, Palenque's Main Plaza is partially divided by the Otulum stream, due to the collapse of the Palace aqueduct’s southern portion.

Map 4.3


Otulum
Group
Cross
XVI
XV
Sun
XIV
Palace
XI
Inscriptions
XIII
XII
XXIV
king Lot
Ed Barnhart
Legend
perenial
seasonal
cascades
springs
ancient architecture
modern architecture
plaza boundary
Main Plaza
pre-aqueduct
50 Meters
contour interval of two meters
N

Map 4.4


Main Plaza
post-aqueduct
Legend
ancient architecture
modern architecture
plaza boundary
perenial
seasonal
cascades
springs
50 Meters
contour interval of two meters
N
84
Palace
XI
XII
XIII
Inscriptions
XIV
XV
XVI
Cross
Sun
Otulum
Group
XXIV
ng Lot

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Appendix A. Water Features

The Arroyo Diablo (Map 3.1)

Water Feature	Dimensions	Length	Elevation
Walled Channel			
D-C1		7m	191.00m

The Picota Stream (Map 3.2)

Water Features	Dimensions	Length	Elevation
Aqueducts			
P-A1		46.7m	189.90m
P-A2		3.67m	189.99m
Pools			
P-P1	7.2m x 2.84m		187.87m
P-P2	7.8m x 4.8m		186.23m
Drains			
P-D1		7.14m	
Dam			
N-DM1		4m x 2m	179.38m

The Arroyo Piedras Bolas (Map 3.4)

Water Features	Dimensions	Length	Elevation
Aqueducts			
PB-A1		6.35m	189.28m
PB-A2		6.66m	181.98m
PB-A3		9.75m	180.00m
Pools			
PB-P1	5.25m x 2.75m		180.97m
PB-P2	3m x 3m		179.93m
Drains			
PB-D1	30cm x 50cm	4.5m	
PB-D2		9.75m	

The Arroyo Motiepa (Map 3.6)

Water Features	Dimensions	Length	Elevation
Aqueduct			
MT-A1	4.5m x 1.5m		189.17m
Dam			
MT-DM1	8.18m x 1m		189.91m

The Bernasconi Stream (Map 3.7)

Water Feature	Dimensions	Length	Elevation
Walled Channel			
J-C1		Roughly 50m	159.00m

The Arroyo Otulum (Map 3.8 & 3.9)

Water Features	Dimensions	Length	Elevation
Walled Channel			
OT-C1		96.5m	
Aqueducts			
OT-A1		58.5m	187.50m
OT-A2		19.40m	110.83m
OT-A3		13.60m	110.83m
Bridge			
OT-B1	10.25m x 10.25m		173.80m

The Arroyo Murciélagos (Map 3.11)

Water Features	Dimensions	Length	Elevation
Walled Channels			
M-C1		13.5m	136.77m
M-C1		81.00m	132.99m
Dam			
M-DM1			183.83m
Bridge			
C-B1		4m	163.52m

The Arroyo Balunte (Map 3.12)

Water Features	Dimensions	Length	Elevation
Aqueduct			
B-A1		11.48m	103.31m
Walled Channel			
B-C1		5.5m	102.03m

The Arroyo Ach' (Map 3.13)

Water Features	Dimensions	Length	Elevation
Aqueduct			
AC-A1		33.00m	164.37m
Pool			
AC-P1	5.25m x 5.25m		113.54m

Appendix B. Springs*

The Arroyo Diablo (Map 3.1)

Springs	Architecture	Perennial	Elevation
D-S1	-	+	191.51m
D-S2	-	+	188.17m
ES-S1	-	-	162.26m
ES-S2	-	+	152.75m
4 springs	**0 with architecture**	**3 perennial**	

The Picota Stream (Map 3.2)

Springs	Architecture	Perennial	Elevation
P-S1	-	-	235.94m
P-S2	+	+	196.44m
P-S3	-	+	192.65m
P-S4	-	+	191.24m
P-S5	+ P-P1	+	187.87m
P-S6	+ P-P2	+	186.23m
P-S7	-	-	187.91m
L-S1	-	+	132.49m
L-S2	-	+	117.72m
L-S3	-	+	125.49m
L-S4	-	+	116.86m
L-S5	-	+	116.64m
L-S6	-	+	116.69m
L-S7	-	+	106.49m
14 springs	**3 with architecture**	**12 perennial**	

* + present
 - absent

The Arroyo Piedras Bolas (Map 3.4)

Springs	Architecture	Perennial	Elevation
PB-S1	-	-	188.00m
PB-S2	+ PB-P1	+	180.97m
PB-S3	-	+	176.70m
MR-S1	-	+	157.73m
MR-S2	+ terrace	-	163.43m
G-S1	-	+	112.05m
6 springs	**2 with architecture**	**4 perennial**	

The Arroyo Motiepa (Map 3.6)

Springs	Architecture	Perennial	Elevation
MT-S1	-	+	188.14m
E-S2	+ terrace corner	+	187.48m
E-S3	-	+	178.99m
GE-S1	+ wall	+	171.80m
JO-S1	+ JO97	-	167.71m
ME-S1	-	+	135.08m
ME-S2	-	+	133.97m
7 springs	**3 with architecture**	**6 perennial**	

The Bernasconi Stream (Map 3.7)

Springs	Architecture	Perennial	Elevation
E-S1	-	+	228.52m
J-S1	-	-	175.66m
J-S2	+ wall	-	173.71m
J-S3	-	+	165.73m
J-S4	-	+	158.71m
J-S5	-	-	166.32m
6 springs	**1 with architecture**	**3 perennial**	

The Arroyo Otulum (Map 3.8 & 3.9)

Springs	Architecture	Perennial	Elevation
CV-S1	-	-	260.03m
ST-S1	-	-	212.12m
OT-S1	-	+	210.49m
OT-S2	-	+	208.73m
OT-S3	-	+	193.16m
MS-S1	-	+	101.29m
6 springs	**0 with architecture**	**4 perennial**	

The Arroyo Murciélagos (Map 3.11)

Springs	Architecture	Perennial	Elevation
M-S1	-	-	238.56m
M-S2	-	-	188.90m
M-S3	+ wall	+	181.58m
3 springs	**1 with architecture**	**1 perennial**	

The Arroyo Balunte (Map 3.12)

Springs	Architecture	Perennial	Elevation
B-S1	-	+	114.48m
Z-S1	-	+	100.90m
Z-S2	-	+	100.68m
X-S1	-	+	103.73m
X-S2	+ B-A1	+	103.62m
5 springs	**1 with architecture**	**5 perennial**	

The Arroyo Ach' (Map 3.13)

Springs	Architecture	Perennial	Elevation
AC-S1	-	-	178.42m
AC-S2	-	+	120.40m
AC-S3	+ AC-P1	-	113.54m
MB-S1	-	+	105.85m
MB-S2	-	+	106.99m
5 springs	**1 with architecture**	**3 perennial**	