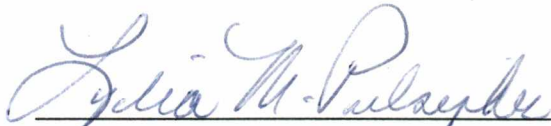
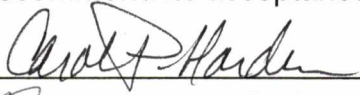


To the Graduate Council:

I am submitting herewith a thesis written by Christopher S. Schultz entitled "The Carriacou Hypothesis: Bottomless Stacked Pots, a Study in Amerindian Freshwater Procurement." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Geography.


Lydia M. Pulsipher, Major Professor

We have read this thesis
and recommend its acceptance:




Accepted for the Council:


Associate Vice Chancellor and
Dean of The Graduate School

**THE CARRIACOU HYPOTHESIS:
BOTTOMLESS STACKED POTS, A STUDY IN
AMERINDIAN FRESHWATER PROCUREMENT**

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Christopher S. Schultz

May, 1996

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DEDICATION

This thesis is dedicated to my wife,

Kathy Harget Schultz

for her invaluable assistance, patience, and love.

ACKNOWLEDGMENTS

First, I must thank Dr. Lydia Pulsipher for her encouragement and tremendous assistance. I thank my committee members, Drs. Carol Harden and Theodore Schmudde for their valuable comments, and the Geography Department for creating and maintaining such an excellent learning environment. Special thanks to Magness "Devil" Alexander, Hezekiah Williams, Junior McMillon, and Margaret "Estemie" Andrews for their assistance and contributions to this project, and to many others on Carriacou and Barbados who offered me their hospitality during the summer of 1995. And I am very grateful for the salinity test Ms. Rose Boll (UT Chemistry Department) developed for my fieldwork. I thank my parents, Marian and Rad Schultz, for giving me the will to reach and achieve my goals, and my relatives and friends for their support along the way. Finally, a special note of appreciation for my wife, Kathy, who helped me to succeed.

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ABSTRACT

Water procurement is difficult for people who live in dry environments. On the small, low islands in the Eastern Caribbean, where drought can be a common occurrence, residents have had to develop numerous techniques to secure and manage their water supply. Some researchers have noted that these droughts occurred in prehistory, and thus must have affected also the indigenous population of the region; but few have chosen to focus much attention on Amerindian freshwater management, and none have adequately explored how they survived on these islands during dry times. My research addresses these issues.

Recently, a number of bottomless clay pottery assemblages have been uncovered in the coastal zones of Carriacou and Barbados, two small, drought-prone islands in the Eastern Caribbean. A folk theory suggests the "potstacks" were used by Amerindians as a freshwater well casing. The purpose of this paper is to examine and test the efficacy of this "Carriacou hypothesis;" in particular, that during

dry times Amerindians dug wells in the island coastal zone to tap into the edge of the freshwater lens, using the potstacks as a well casing.

I study this concept by examining what is known about Amerindian freshwater management in the Eastern Caribbean, and by documenting the extensive use of groundwater and well casings by the people of other arid regions. Then, I ground the Carriacou hypothesis in the hydrologic literature and develop the "Potstack System" theory to explain how it was possible to find fresh near-coast groundwater by digging shallow pits and lining them with collections of bottomless pottery. Finally, I take this system to the field to test its correspondence with the groundwater hydrology of Carriacou and Barbados. Here, I document relevant cultural information, test the depth and salinity of near-coast well water, and dig test pits in my own attempt to find freshwater.

My results show that island residents are well aware of the existence of near-coast freshwater, and that they dig shallow holes to collect it. Well measurements also support the Carriacou hypothesis and the Potstack System, indicating that groundwater becomes fresher with increasing distance from the coast, but that it will lie at a greater

depth below the surface; thus, by striking a balance between depth and salinity in the coastal zone, one can dig shallow pits and procure slightly brackish -- but drinkable -- water. And although I did not find freshwater in my own test pits, I came to appreciate the problems involved with digging wells and the real need for a casing in these circumstances.

I conclude that the Carriacou hypothesis is not an unreasonable explanation for the utility of the Carriacou and Barbados potstacks, and that it provides a window for comparing the water procurement techniques of today to those that may have been used in the past.

FORWARD

CRITICAL THEORY IN PRACTICE

Recently there has been a move in geography toward reevaluating the control a scientist has in manipulating all the stages of the research process. Some geographers question the limitations of quantification and the use of the formal written word as the sole forum for professional research, and they argue that technical language in geographic discourse excludes the discussion from anyone not familiar with a particular group's jargon (see, for example, Mascia-Lees, et al., 1989; Anderson and Gale, 1992; Rodman, 1992; Cosgrove and Domosh, 1994; Duncan and Ley, 1994; and Nast, 1994). These researchers also dispute the artificial -- but traditional -- barriers that separate disciplines and sub-disciplines. "Critical Theory," the common label for this type of thinking, challenges us to question the way research is conducted, how the results are presented, and even the audience for which it is aimed.

I have written my thesis with these concerns in mind. I am using both physical and cultural geography to do a combined study on an aspect of Amerindian freshwater procurement and management. I am also sending copies of this thesis to the Carriacou public library and the Barbados Museum so it can be easily accessible to the island residents. It would not be fair to the people who helped me if they could not read my work. For this reason I wrote the thesis in the first person, with a style that is purposefully free of geographic jargon and technical prose, yet hopefully maintains the professionalism necessary in academic research.

Probably most unconventional in this thesis is that I have written the prologue as a short story and the chapter on my field research as a narrative. The short story allows me to dispense with a lot of distracting technicalities and quickly introduce the essence of my research to the reader. I hope to expose the human side of the bottomless stacked pots, allowing the reader to "bodily occupy" the world 1,500 years ago as a way to place the potstacks in better context. I write my field results as a narrative because I believe the process through which I gathered information was as important as the

raw data that I actually obtained. In this way, I hope to bring the reader closer to the fieldwork, to let her/him “walk through” the events with me and see how I slowly came to construct a theory of current and past freshwater management on Carriacou and Barbados.

As the reader will learn, it wasn’t possible for me to prove that the Carriacou hypothesis was correct, but by employing both cultural and physical methods and perspectives, it was possible to compare my theoretical concepts on how water might have been procured by the Amerindians on Carriacou to the current island water practices. I think the results based on modern techniques lend credence to the Carriacou hypothesis despite the fact that the physical proof is incomplete.

In these ways, I hope to show that academic research can be professional, yet be written for and understood by a larger non-professional audience, and I hope that my type of innovative methods will be more widely accepted in the academic community. Ultimately, I also hope to demonstrate that human and physical geography can be successfully meshed together to provide us with a better understanding of the complex and dynamic world in which we live.

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PROLOGUE

A STORY

On a Caribbean island, one thousand, five hundred years ago...

Attabeira¹ awoke to the early rising sun, as was her habit from early childhood days. She arose before her brothers and sisters, and sometimes even before mother and grandmother. Now that she was the bondmate of a powerful Caonabo, known for having killed a shark with his bare hands, her habit served an especially useful purpose.

As she stepped from the women's hut, Attabeira noted with satisfaction that few others were stirring. She liked the early morning because it was quiet, giving her a chance to be alone before the clans' daily activities sprang to life. Noticing that the wide-mouth rain pots had

¹ This story is based on a review of archaeological literature, my understanding of the Amerindian religion as described in various texts, and ethnographic information obtained on Carriacou during my 1995 field season. Attabeira is named for the Taino (the name now preferred for the Native Americans of the Northeast Caribbean) "mother of waters." Other names mentioned in this story are noted in Wilson (1990). Any reference to religion must be taken in context: Amerindians are thought to have believed everything must be performed within a "context of social and religious cohesiveness" (Stevens-Arroyo, 100). Thus, were religion not invoked prior to an activity, it would be doomed to fail.

not been filled during the night. Attabeira picked up her water jug, knowing that breakfast would have to wait.

“Of all the times for a drought!” she thought.

The clan had located in this place a number of cycles ago. Back then the small stream nearby provided excellent water, and Attabeira had enjoyed the task of fetching water; you could be sure someone at the stream would tell you the latest clan gossip. But now the stream was dry, the drought so intense that even the shallow holes they dug in the stream bed were brackish. This forced everyone to conserve water for only the most basic needs; any water use not related to drinking and cooking became highly restricted.

“Only the potstack wells lend us water now,” the cacique (clan leader) said. “Guarionex should not have taken the food without performing a sacrifice. He angered the water goddess, and now we all must thirst.”

Unless they accepted the collective punishment and suffered through the drought, they would have to move; and moving was an extreme measure everyone resisted. Their current location had many advantages: protection from the intense sun, a calm canoe landing, good

cropland, and a coral reef nearby for excellent fishing. Moving would mean giving up all this. But their first priority was to maintain a dependable supply of freshwater.

For some weeks now they had been using the potstack wells down by the shoreline. Few clan members liked this water; it didn't taste very good, nor was it easy to collect. You had to be careful in drawing water from the well or the hemp rope harness could catch on a pot edge, tip the calabash gourd, and send your precious cargo splashing to the bottom. This irritated other water drawers because your accident stirred up sediment and made for gritty-tasting water. Needless to say, mothers took ample time to teach children how to draw water correctly.

This morning, as Attabeira approached the potstack well she noticed that the lid was lying on the ground beside it. "If anything got in there..." she muttered to herself. Squinting to see the waters' surface six feet down, she found that -- luckily -- there were only a few leaves and twigs floating around. The children most likely had been dropping rocks into the well again. Attabeira imagined them squealing as each stone "kerplunked" into the water. But this was a serious offense: stones, sand, dirt, twigs -- or worse yet, mosquitoes -- could fill up or contaminate the

well. But she couldn't blame them. Attabeira had done the same thing to her own grandfather's potstack. She vividly remembered her father's rebuke after catching her in the act: "If I ever see you doing this again...! Don't you know how hard it is to clean those wells? Do you want to go out and build your grandfather a new one?"

She realized now that he had slightly exaggerated. It wasn't quite *that* hard to build a potstack well, as he had always suggested. When needed, the shaman performed the water ritual, reminding everyone that wells could not give birth to freshwater without special attention. In the coolest part of the night, the men followed the Shaman to the beach, each carrying a number of large clay pots in various stages of disrepair. Then several groups of men chose likely sites just inland of the first line of sand dunes and began to dig holes with shell scoops.

A well maker, chosen for an act of exceptional courage or bravery (such as that done recently by her mate, Caonabo, who had killed a shark thus saving little Behecchio's life), was given the honor of constructing the potstack well. When one of the groups struck good freshwater as they dug through the sand, the shaman with great care, broke out the bottom of a pot and passed it to the well-maker. The well-maker then placed the

inverted bottomless pots at the bottom of the hole and partially filled in sand and dirt around it. As he stacked the other pots in place above the first and filled in sand around the stacks, he had the additional task of making sure the stack was properly aligned so the water drawing vessel could successfully pass through the entire stack down to the water level. The well-maker finished by placing the last pot "rim up" and capping it with a flat clay lid.

Usually this lid kept the small children from playing in the well, but even the heaviest covers failed to stop the most mischievous ones. The shaman always said this type of rule breaking caused undue hardship for the rest of the clan. Attabeira reminded herself to inform the shaman when she returned; during droughts, the clan had an important responsibility to sternly discipline violators of the water customs, even children.

Attabeira took the harness lying nearby and lowered the gourd into the well, carefully drawing water and pouring it into her jug. When she finished, she replaced the lid and balanced the load on her head for the short walk home.



Bottomless stacked pots, found in Harvey Vale, Carriacou, Grenada. (For scale, the small white sign to the left of the potstack is eight inches long)

Source: Carriacou Museum. 1994. Photographs of potstack taken by Dr. Lydia M. Pusipher in March. In possession of the author.

CHAPTER 1

INTRODUCTION

...[T]hey did not know where the Indians found drinking water, although they had fresh water in their houses.

-- Christopher Columbus¹

Barbados that splendid island, my father [Sir Thomas Warner] at his first settling in those parts rejected, for the great want of water...

-- Captain Philip Warner²

Background

This thesis was born of several discussions I had with my advisor, Dr. Lydia M. Pulsipher, in 1994. She knew I was interested in Caribbean water management, and relayed some ideas she picked up while visiting the Carriacou Museum in the Grenadines. There she had seen recently a curious set of Amerindian clay pots recovered in the town of Harvey Vale, a few years previously. Ms. Clemencia Alexander, a member of the Museum staff, described how the pots had been found, paraphrasing the museum sign that accompanied the pot exhibit.

¹ Columbus, C. 1968. *The Journal of Christopher Columbus*. Trans. C. Jane. London: Anthony Blond. p. 48

² Davis, 1887 cited in Barton, 1953:13 (Barton, G.T. 1953. *The Prehistory of Barbados*. Barbados: Advocate Co., Ltd.).

Mrs. Margaret Andrews was constructing a new guesthouse.³ She employed some workers to build a large rainwater cistern,⁴ a vital source of drinking water for the residents of this small, dry Caribbean island. But as the young men dug the foundation, Mrs. Andrews noticed they began to pull up pieces of clay pottery. Aware that Amerindians had occupied the island in prehistoric times, she halted the workers and contacted the Carriacou Museum.

Digging resumed, and with great care they eventually recovered a remarkably complete set of seven clay pots. The pots all lacked bottoms and were found one on top of another, stacked in a column like a tube. In the center of the column they noticed freshwater springing from the earth, even though the hole was only 50 feet from the sea!⁵ Carriacou has a large number of wells that tap island groundwater, so Mrs. Andrews suggested the pots may be an old well casing. The Museum acquired the pots, pieced them together, and put them on display with a sign reading, "Amerindian Freshwater Well Casing."

"We think the pots are of the Barrancoid style, which dates them at approximately 500 AD," Ms. Alexander added. Fascinated by the idea, Dr. Pulsipher snapped pictures of the pots and the explanatory sign before she left.

³ Many island residents open up rooms or houses to rent to vacationers at inexpensive rates.

⁴ In the Caribbean today, cisterns are concrete or plastic containers that collect and store rainwater usually caught on the roof of a dwelling.

⁵ Mrs. Andrews' well is still used for drinking and cooking, although it gets salty from time to time. Currently, the "Amerindian well" at Constant Spring is being cited by Carriacou's Nature Tour and Trails Committee as spouting natural mineral water that "can do wonders for your health" (Brochure, Ade's Dream Guesthouse, 1995), and has been mentioned in a Grenada tourist guide as a must-see for any tourist visiting Carriacou: "No trip would be complete without a stop at the museum, with its rare Amerindian well..." (Kay, 1995:33).

One of her next stops was Barbados, where, by accident, she learned of yet another set of Amerindian clay pots that was found on the south coast at the beach near Maxwell, Oistins Bay. These sounded like what she had just seen in the Carriacou Museum, so Dr. Pulsipher arranged to meet the two people who were studying the pots: Dr. Ronald Hinds of Barbados, who found the pots, and Mrs. Mary Hill Harris of the University of Cambridge, England, who was analyzing their design. The pots were uncovered in 1989 when Hurricane Hugo smashed to pieces a tide wall that protected the Maxwell location. Among the stone and cement block ruins, Hinds stumbled upon the tops of two broken pots (about 5 m from each other) with fragments washing out into the surf. Upon closer examination, a large number of pot sherds were found, each belonging to separate pots. Unlike the stacked Carriacou pots, the broken sherds of several pots were "nested" tightly together,⁶ although again, the bases of these pots had been knocked out and removed, apparently before burial.

⁶ The "nest" that Harris and Hinds (1995) describe, with pot sherds packed quite close together, seems to be a *collapsed* potstack. After a long time, wave action could eventually destroy the well casing and cause it to collapse into the form that Hind's had found.

Citing the "Carriacou hypothesis" developed by Mrs. Margaret Andrews, Dr. Pulsipher suggested to Hinds and Harris that the pots might represent an Amerindian freshwater well casing. The two scientists were intrigued by this explanation, and agreed it merited further exploration. They said they would mention the idea in their papers at an upcoming conference (Hinds and Harris, 1995; Harris and Hinds, 1995). Upon returning to the US, Dr. Pulsipher showed me the pictures of the Carriacou potstack and the Barbados potsherds, and explained the Carriacou hypothesis suggesting the potstacks served as a well casing. She suggested that I take on a study of this hypothesis as a thesis topic. After several discussions with her, I met with University of Tennessee hydrogeologist, Dr. Larry McKay (pers. comm., 1994). I told him about the pots and the theory, and asked whether freshwater could be procured close to the sea. He said "yes," and drew me a diagram of how groundwater hypothetically moved toward the coastline, showing that the water table got closer to the surface the nearer it came to the shore.

"Of course," he said, "if you dig *too* close to the shore you start to pull up salt water."

I reported these findings to Dr. Pulsipher and promptly decided to explore the viability of the Carriacou hypothesis for my thesis research.

Research Objectives and Chapter Outline

The purpose of this research is to link a known physical phenomenon, the existence of fresh coastal groundwater, with a collection of unexplained Amerindian bottomless stacked pots. A folk theory (the “Carriacou hypothesis”) suggests that this artifact assemblage was used as an Amerindian freshwater well casing. In this thesis, I take the Carriacou hypothesis and ground it in accepted physical hydrologic theory, and then test it in the field to see if the pots could actually be used for the purpose suggested.

To support this hypothesis, first I examined the Caribbean archaeological literature relating to Amerindians of that period, specifically looking for references to water as a factor in settlement location, and anything else related to Amerindian domestic water management.⁷ Next, I studied the groundwater dynamics on small dry islands, taking particular

⁷ “Domestic water management” refers to freshwater used for drinking, cooking, cleaning, and other various daily household needs.

note of the development of the freshwater lens and the subsequent interplay between fresh- and saltwater at the coastline. Using this information, I expanded upon the Carriacou hypothesis and developed what I call the "Potstack System" theory to explain how it was possible to find freshwater close to the surface by digging near-coast pits, and how the bottomless stacked pots could have been used to maintain access to the water once it was found. I then went to Carriacou and Barbados during June and July, 1995, to explore the practicability of the Potstack System, digging test pits along the coast, recording depth and salinity levels for near-shore wells, and documenting cultural information showing the extent to which current island residents make use of groundwater in ways that lend credence to the Carriacou hypothesis and the Potstack System.

Chapter 1 presents the problem and its geographical setting. In Chapter 2, I briefly explain the prehistory of the Caribbean islands and discuss the potential available freshwater sources for Amerindian use, documenting the limited available information on domestic water management discussed in the Caribbean archaeological literature. I present a brief discussion of how groundwater has been used in arid

cultures, noting that elsewhere well casings have been constructed and used to access littoral groundwater. In Chapter 3, I explain the groundwater hydrology of small islands, emphasizing the human importance of freshwater lenses. I conclude Chapter 3 by presenting a Potstack System theory to explain how the "potstack well" might have worked along the coast, I compare the Potstack System to current Barbados hydrogeologic information (there is no such information available for Carriacou), and I suggest a method of how to test the Potstack System. In Chapter 4, I discuss my results on Carriacou and Barbados, and present ethnographic data to support the Carriacou hypothesis and the Potstack System. Finally, in Chapter 5, I summarize my conclusions on whether or not the Amerindian bottomless stacked pots could have been used as a freshwater well casing, as suggested by Mrs. Andrews and the Carriacou Museum.

I present this thesis as a possible explanation for the use of the Carriacou potstack (and similar stacks found in Barbados and elsewhere), and as the first step toward developing a general theory of Amerindian freshwater management in the Caribbean.

Recurrent Drought in the Eastern Caribbean

Freshwater is a scarce commodity in much of the Eastern Caribbean, especially on the small, low islands. Although the annual average precipitation is 889-1016 mm (35-40 in) (Beard, 1949), most rain falls between June and December leaving the period from January to May often quite dry; and the actual totals can vary widely from year to year (Beard, 1949; Twist, 1953; Manton and Bonell, 1993). Intense dry spells can last for several years at a time or may come in quick succession with only short wet seasons in between. Thus, the islands are subject to what I call "recurrent drought."

To some extent these days, the droughts affecting especially the small low Eastern Caribbean islands are "self-inflicted:" the result of human changes to the natural island hydrology, rising population, and of rising per capita demand for water due to modern lifestyles. Nearly all the environments on the Caribbean islands have been drastically modified during the last several centuries. Landscape changes were initiated by Europeans when forests were cleared to make way for sugar cane fields, cattle pastures, and building sites (Watts, 1987); and modifications intensify today with the rapid development of paved roads, parking lots,

and concrete buildings. The clearing of the indigenous vegetation increased evaporation and inhibited the absorption of rainwater, while the buildup of impermeable surfaces exacerbated rapid surface runoff. Island hydrologic systems have been radically altered from what existed in the pre-Columbian era; but also human use of water has increased drastically. Some modern citizens of the Caribbean use an estimated 350 liters per capita per day⁸ for drinking, washing, cleaning, and flushing; whereas in pre-Columbian days per capita use might have been about 5 liters per day.⁹ It should be noted further that drought is an imprecise term, representing really just a deviation from what we *perceive* to be "normal" rainfall, and as such is a term based on human expectation.

Nevertheless, recurrent dry spells in the Eastern Caribbean are a natural phenomena -- albeit somewhat intensified by human agency. The quotations at the beginning of this chapter note the scarcity of freshwater even during the initial phases of European colonization. Documents describing the early plantation years cite drought as a common (and expensive!) problem especially on low lying islands (Ligon 1657:28;

⁸ Goodwin's (1984) estimate for Barbados is cited in Falkland and Brunel, 1993.

⁹ Clarke (1993) writes that traditional cultures in Swaziland typically use five liters of water per day, per capita.

Edwards, 1819:485; and Sheridan, 1958:8). It would seem probable that water shortage affected the islands' indigenous peoples (hereafter referred to as Amerindians) in ways that are somewhat similar to those we see today (Barton, 1953; Slight, 1965; Gallagher, 1976; Watts, 1987; Havisser, 1991); namely they had to procure water by catching rainfall or by tapping groundwater.

The question of how Caribbean indigenous peoples may have coped with the scarcity of freshwater in prehistoric times has been only lightly touched on by Caribbean archaeologists (Barton, 1953; Boomert, 1987; Havisser, 1989, 1991; Watters, 1991; Keegan 1992; and van der Valk, 1992). My study of the Caribbean archaeological literature (archaeology is the only science currently doing fieldwork on the human ecology of these Amerindians) reveals that generally archaeologists rarely acknowledge drought as a limiting factor for human settlement and daily life, nor have they inquired much about Amerindian domestic water management. In most studies, archaeologists seem merely to assume sufficient water supplies were available if they find evidence of settlement (see, for example, Rouse and Allaire, 1978; Rouse, 1986, 1992; Rose, 1987; Siegel, 1991). In conversations and correspondence several

Caribbean archaeologists confirmed my suspicion that the story of freshwater use by Amerindians of the Caribbean is yet to be told (Murphy, 1994; Watters, 1994; Havis, 1995).

In this thesis, I assume that Amerindians lived on these islands under climatic conditions that are somewhat similar to those that exist today, and that their biological needs for water were similar to those of today, while their culturally determined needs were somewhat (but indeterminately) less. I then attempt to answer the question, *how did Amerindians secure a dependable freshwater supply when and where surface water was scarce?* I believe explaining the use of the Amerindian potstacks discussed above will partially answer this question.

The Setting

The Lesser Antilles of the Eastern Caribbean are a long chain of high- and low-lying islands spanning approximately 1020 km (637 mi) from Puerto Rico and the US Virgin Islands in the north, to Trinidad and Tobago in the south, lying near the north coast of South America (figure 1-1). This chain lies along the juncture of the Caribbean tectonic crustal plate and the Atlantic Ocean plate, where the confrontation has caused

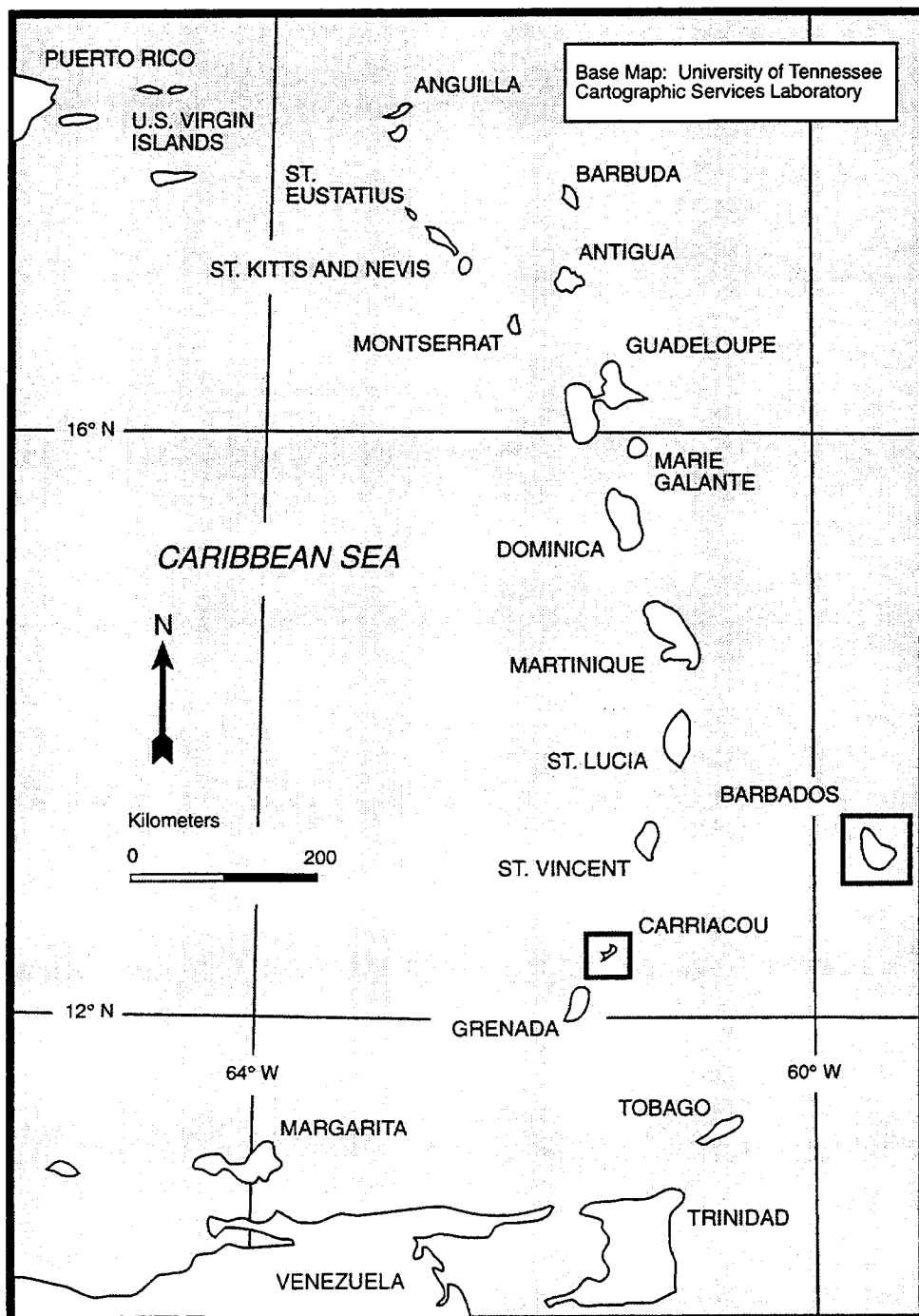


Figure 1-1. Eastern Caribbean: location map

crustal uplift and volcanism, forming two island arcs. The islands of the inner arc, those from St. Eustatious to Grenada, are generally volcanoes that have emerged well above the surface of the ocean and are mountainous, while those of the outer island arc, from Anguilla to Barbados, are comprised of sedimentary deposits on volcanic formations that are below the surface or only a few hundred feet above. The islands of the outer arc are typically under 305 m (1000 ft) in height, many only a few tens of meters (hundreds of feet) above the ocean surface.

Carriacou

Carriacou (figure 1-2), with an area of 34 km² (13 mi²), is one of the larger islands in the Grenadines -- the very small islands dotting the waters between St. Vincent and Grenada. It is located approximately 42 km (16 mi) north-northeast of Grenada (figure 1-1). Carriacou's modern population is 4,671 (Falkland, 1991), resulting in an island density of 137 persons per km² (359 per mi²). The area has a warm, subtropical climate, with a mean annual temperature of 24-27°C (75-80°F) (Beard, 1949). Most vegetation is dry secondary woodland and scrub, with mangrove along the coasts (Beard, 1949). A north-south volcanic ridge nearly

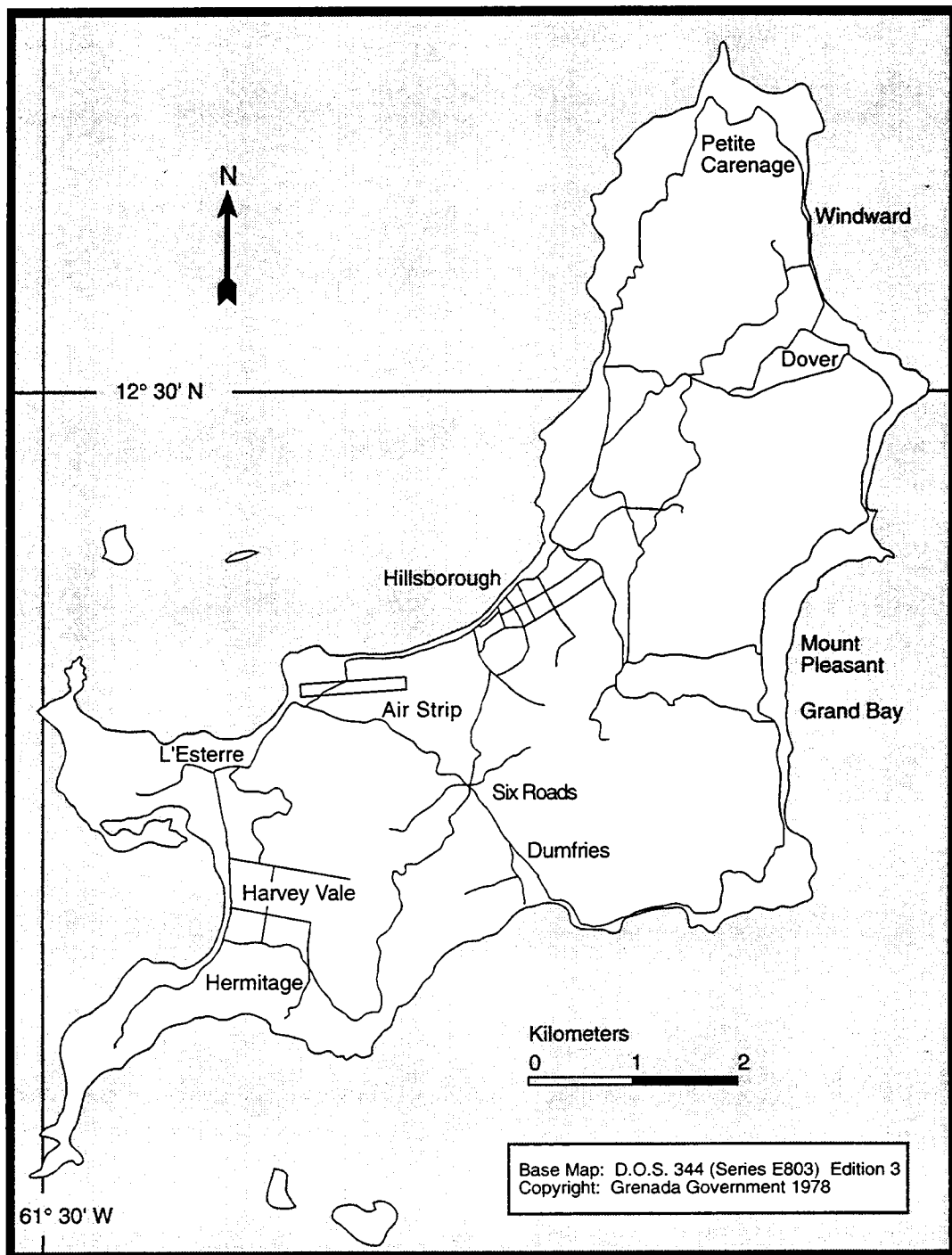


Figure 1-2. Carriacou: map of major roads and towns

divides Carriacou in half lengthwise, peaking at High North (291 m; 955 ft) in the north and at Chapeau Carre (291 m; 954 ft) in the south (figure 1-3). Most of the towns are located within the coastal, low lying valleys between secondary ridges.

According to Beard (1949), Carriacou has about 1,154-1,667 mm (45-65 in) of precipitation per year, while Hill (1977) calculates an annual average of 1,220 mm (48.04 in) of rainfall over a period of 39 years. These precipitation levels are significantly lower than those for the neighboring mountainous island of Grenada, which receives 2,425 mm (95 in) per year (Falkland, 1991). Hill (1977) stresses that rainfall on Carriacou is subject to extreme variations from month to month and year to year (table 1-1). Droughts are common. The rains come in short, intense bursts causing significant runoff, which is the only time the island's streams contain water (Kingsbury, 1960).

Since there are few natural surface water catchments, Carriacou residents obtain their drinking and cooking water primarily by catching the rain on their rooftops and storing it in large concrete cisterns.

Groundwater (locally called "Bohole Water") may be used for drinking during these droughts, but is otherwise used only for showering, cleaning

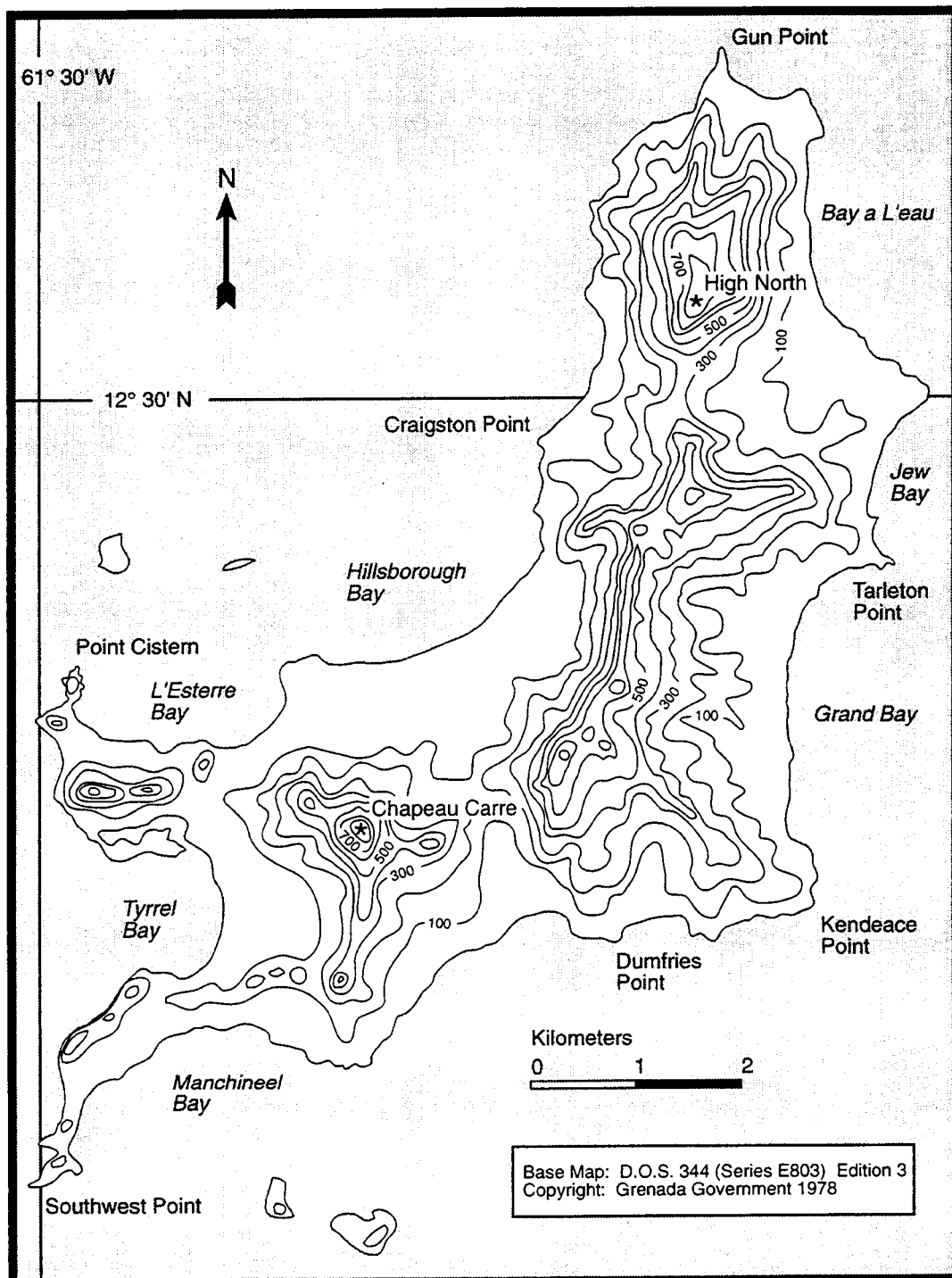


Figure 1-3. Carriacou: topographic map. (100 ft contour intervals)

Table 1-1. Carriacou yearly rainfall variability. (Measurements are in inches)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1920	2.3	.93	1.54	.20	1.83	3.1	7.55	4.72	5.32	6.2	8.6	1.40	43.93
1930	2.8	.67	.46	2.18	1.97	4.0	3.35	2.14	4.62	2.4	3.8	2.96	31.57
1940	2.3	1.59	2.11	.92	.44	3.2	3.58	4.53	6.25	6.1	9.9	3.25	44.26
1950	1.6	2.85	2.24	1.38	4.11	8.8	4.51	7.34	3.71	10.8	8.1	10.65	66.24
1960	1.7	.53	.77	.21	.69	4.1	3.73	5.64	.70	3.6	1.6	2.47	25.88
1970*	1.5	4.82	1.60	1.00	3.77	1.6	4.32	9.95	4.49	9.6	2.6	13.04	58.37

* Figures for Jan. and Feb. are for 1971.

Source: Hill, D.R. 1977. The Impact of Migration on the Metropolitan and Folk Society of Carriacou, Grenada. *Anthropological Papers of the American Museum of Natural History* 54[2]:191-391.

household items, and watering sheep, goats, and cattle. A limited number of pumps and water lines have been constructed, and are located on the street to provide easy access to this groundwater. Artificial ponds have been constructed to provide additional water for animals to drink.

Archaeological evidence reveals Carriacou was occupied by prehistoric Amerindian populations who hunted for fish and shellfish off the island's coast (Richardson, 1975). This may explain how the island got its Indian name, "Kayryouacou," which means land of many reefs (Kay, 1995). The island was not formally occupied by Europeans until the French arrived in the late 17th century, fishing for sea turtle and clearing the tropical dry deciduous forest to grow cotton and sugar cane (Richardson, 1975). The French formally ceded control of Carriacou and Grenada to Great Britain in the Treaty of Paris in 1763. Because of its droughty conditions, Carriacou did not become a sugar "powerhouse" like many of the other islands in the West Indies (e.g. Barbados, see below); but there were some sugar plantations. The modern residents of Carriacou, who call themselves "Kayaks," are the descendants of African slaves brought over by the French and British as laborers for both cotton and sugar plantations. Some are also the descendants of Scottish ship

builders, and continue the tradition today constructing hand-built wooden boats for fishing and shipping activities (Kingsbury, 1960). Today, Carriacou is administered as part of the nation of Grenada, which became independent from Britain in 1974.

Barbados

Barbados, located approximately 210 km (131 mi) to the northeast of Carriacou, is much larger (431 km²; 166 mi²) and has many more inhabitants (250,000) (figure 1-4). The island is one of the most densely populated in the Caribbean, with 580 persons per km² (1,506 per mi²). Its position in the Caribbean is almost due east 160 km (100 mi) of St. Vincent (figure 1-1). The temperature ranges and the general climate of Barbados are very similar to those of Carriacou, 24°-27°C (75°-80°F) (Stanley Associates Engineering LTD, 1978). Most of the land in Barbados is cultivated in sugar cane, except for occasional patches of trees and meadows for grazing (Beard, 1949); little of the original vegetation remains today (Watts, 1966). The island can be easily divided into two distinct physiographic regions (figure 1-5): the extremely weathered Scotland District in the northeast -- made of sedimentary clays

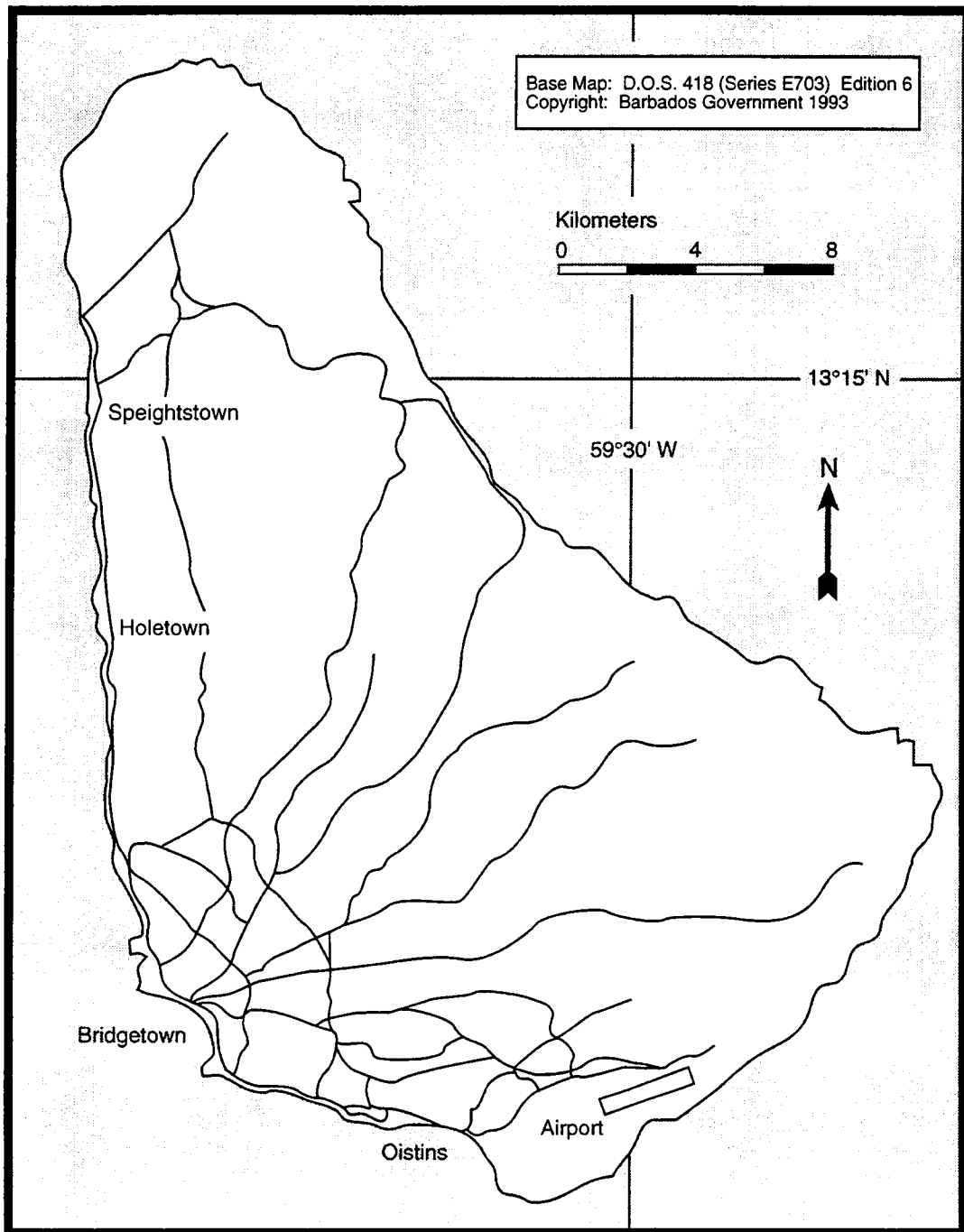


Figure 1-4. Barbados: map of major roads and towns

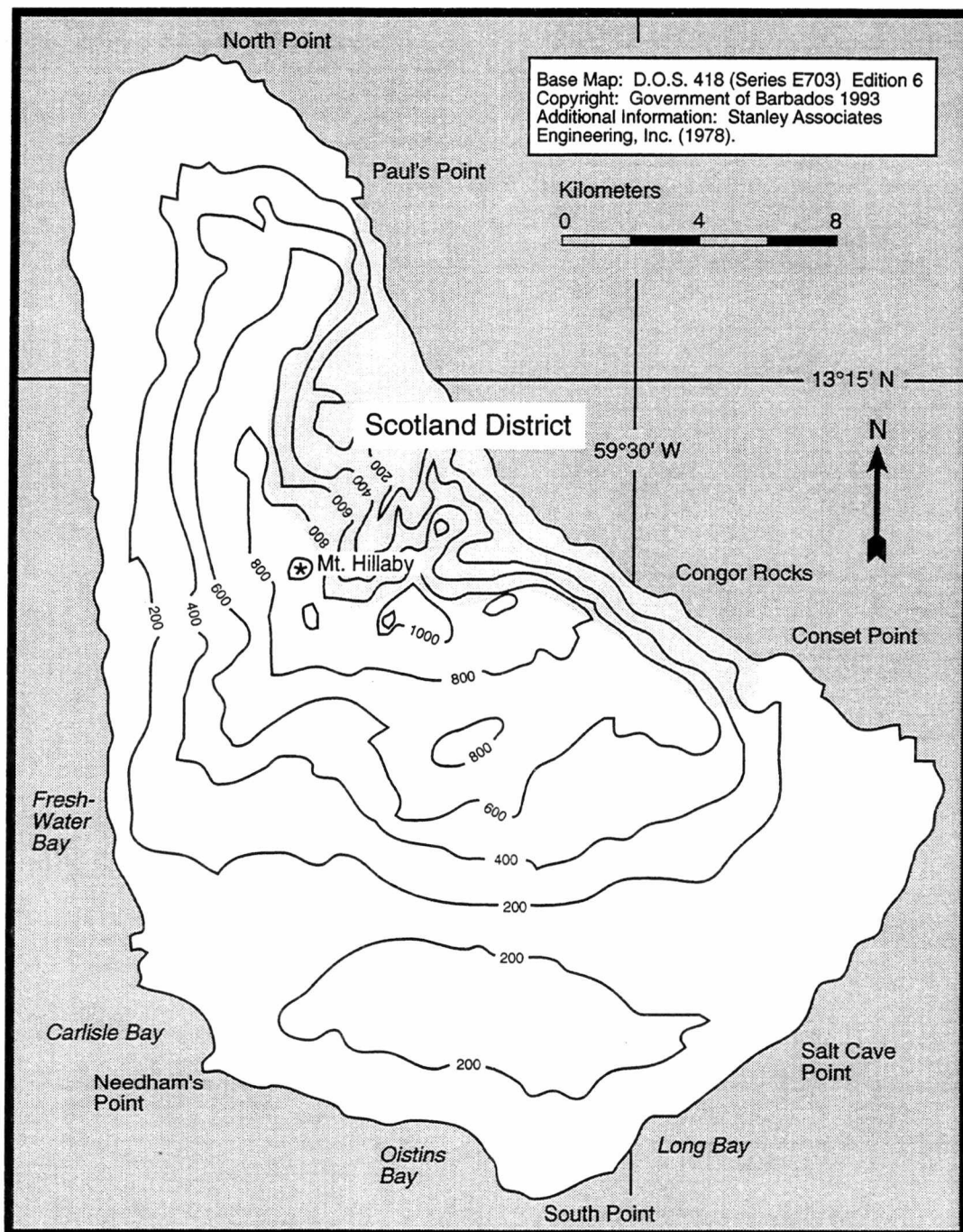


Figure 1-5. Barbados: topographic map. (200 foot contour intervals)

and shales that were folded and faulted many years ago and since eroded -- and the "c-shaped" region of younger sedimentary coral rock, which was uplifted and weathered to form step-like plateaus (Stanley, 1978). Mt. Hillaby 340 m (1116 ft), the highest peak in Barbados, is located in the center of the island, with the rest of the land gently sloping into rolling hills to the north, west, and south, and dropping sharply to the east toward the Scotland District (Stanley, 1978). Low lying areas border nearly every coast, with a narrow band along the West, and broader areas toward the Southwest, South, and Southeast.

The mean annual rainfall for the whole of Barbados is 1524 mm (60 in), but this varies from 1143 mm (45 in) in the lowlands at the coasts, to 2184 mm (86 in) in the high central part of the island (Stanley, 1978). As with most of the Caribbean islands, Barbados has a distinctive wet and dry season, but as table 1-2 shows, the rainfall amounts can be highly variable.

Modern Barbados relies mainly on a sizable groundwater supply, which has filtered through the highly porous coral bedrock cap. Rainwater quickly soaks into the soil and flows deep underground through an extensive network of limestone solution channels. Barbados has a

Table 1-2. Barbados yearly rainfall variability.* (Measurements are in inches)

<i>Month</i>	<i>Monthly Average</i>	<i>Monthly Maximum</i>	<i>Monthly Minimum</i>
Jan.	3.34	11.23	.65
Feb.	2.23	14.35	.27
Mar.	1.92	5.54	.12
Apr.	2.37	9.51	.28
May	3.15	13.44	.43
Jun.	5.24	15.52	.63
Jul.	6.19	19.50	1.93
Aug.	7.18	18.47	2.31
Sept.	7.57	20.46	2.21
Oct.	7.91	23.16	2.77
Nov.	7.65	28.09	1.42
Dec.	4.94	14.30	.99
Annual	59.69		

* Based on island-wide records, 1847-1976 inclusive.

Source: Stanley Associates Engineering, Inc. 1978. *Barbados Water Resources Study*, vol. 3: *Water Resources and Geohydrology*. Edmonton, Alberta.

modern water delivery system, and numerous wells are used to tap groundwater for domestic, industrial, and agricultural purposes. Wells in the center of the island can be extremely deep, but are shallow approaching the coastline. Rainwater catchments are rarely used on the island, although ponds and springs are commonly used for bathing and for the watering of animals.

Barbados, first settled by the British in 1627, was virtually stripped of all indigenous vegetation in early colonial times and then planted in sugar cane. The island became one of the leading producers of sugar in the West Indies during the late 1700's; at this time 65 percent of all sugar exported from the Eastern Caribbean area came from Barbados (Beckles, 1990). Like the "Kayaks" of Carriacou, "Bajans" are the descendants of African slaves. The island was granted independence from Britain in 1966.

CHAPTER 2

AMERINDIANS AND FRESHWATER IN THE EASTERN CARIBBEAN

The presence or absence of water is an extremely important factor in determining the settlement of primitive people, and as they have not the ability to sink wells and make other provision for storage they must of necessity reside near streams or natural ponds.

-- G.T. Barton¹

Since the capture of Montserrat [by the French, there is] a greater demand for water. The casks sunk at Cades Bay (spring) [Antigua] a long time ago are rotten. Purchase as many casks as possible to replace [them].

-- From the Navy Board to the Commissioner of the Antigua Navy Yard, 17 June 1782²

Introduction to Caribbean Prehistory

Much of what we know about Amerindians comes from early colonial accounts such as those of Christopher Columbus (1492), Bartolome de Las Casas (1499), and Ramon Pane (1499), and from the

¹ Barton, G.T. 1953. *The Prehistory of Barbados*. Barbados: Advocate Co., Ltd. p. 13.

² Nicholson, D.V. 1995. Personal Communication with Desmond Nicholson, the founder of the Museum of Antigua and Barbuda, August 3, 1995. It should be noted that in early colonial times Antigua frequently bought water from Montserrat during dry times (Bowen, 1747). My interpretation of this quote is that in 1782, when Montserrat was captured by the French, it was no longer available as a water source.

many journals and letters of European sailors traveling in the West Indies who wrote about their encounters with the indigenous peoples (Nicholl, 1607; Purchas, 1625; Gage, 1648; and Uring, 1726). These accounts provide valuable primary information on Amerindians at the time of the European incursion, and occasionally contain considerable detail; but they must be viewed with some skepticism because of a European tendency to misconstrue information from Amerindians and to judge their ways harshly (Wilson, 1990; Hulme and Whitehead, 1992; Keegan, 1992).

The archaeological record is the other main source of information about the Amerindians (see, for example, Barton, 1953; Bullen and Bullen, 1972; Rouse and Allaire, 1978; Sears and Sullivan, 1978; Allaire 1984; Rouse, 1986, 1992; Hackenberger, 1987, 1988; Drewett, 1989, 1991, 1993; Haviser, 1989, 1991; Rouse and Alegria, 1990; Watters, 1991; Keegan, 1992; Versteeg and Schinkel, 1992; Winter and Wing, 1995). But biases exist here as well for the following reasons. It must be assumed that much of Amerindian material culture was of organic matter that quickly decomposed in the warm Caribbean climate. Hence, much of the tangible evidence of Amerindian daily life has not survived well in the archaeological record. Archaeologists typically find an abundance of crab

remains, fishbones, stone and shell tools, and pottery (all of which are resistant to decay), but very little evidence of the plant material used for food and tools (see discussion in next section). Another bias is that archaeologists must infer a great deal from the very limited number of sites they thus far have been able to excavate. Furthermore, modern archaeologists are creatures of their own experience and may fail to recognize the challenges that Amerindians had to meet, a fact that may explain their failure when studying the drier islands of the Eastern Caribbean to take sufficient note of the daily human need for freshwater and the factors that mitigated against long trips for water procurement.

Using artifact distribution analysis and Carbon 14 dating, archaeologists have been able to determine rough dates for Amerindian occupations in the Eastern Caribbean region that reach back at least 9,000 years (Veloz Maggiolo and Vega, 1982). They also have defined the routes of migration, and some cultural distinctions between groups (Allaire, 1980; Rouse, 1986; Drewett, 1991; Siegel, 1991). Caribbean archaeologists have employed comparative ceramic analysis in studying the quite durable pottery fragments that are very prevalent at Amerindian settlements, and have noticed that pottery styles changed over time

(Meggers and Evans, 1978; Allaire, 1984; Rouse, 1992). By organizing these styles into a matrix, archaeologists have been able to develop a chronology of pottery styles for the Caribbean. New sites can be located within this chronology and dated by comparing the pottery sherds found on that site with those already studied. There are a number of theories about Amerindian migration, of which Siegel (1991) presents a summary, but the most common is the theory developed by Lathrap (1970) and expanded upon by Rouse (1989).

In brief, the first humans are thought to have entered the West Indies around 5,000 BP (Rouse, 1986). The people we are concerned with here are thought to have migrated down the Orinoco River from the central Amazon, eventually reaching the Atlantic/Caribbean coast of South America and entering the West Indies archipelago via Trinidad around 2,000 years ago. These Amerindians were the first of a series of population "waves" that moved north into the Lesser Antilles. Succeeding waves would take over or assimilate into the preceding one (Rouse and Allaire, 1978).

When Europeans arrived in the West Indies, they encountered people who are commonly classified into three separate groups: the

Guanahatebey who were at the Western tip of Cuba, the Arawak (Tainos)³ who inhabited the rest of Cuba, Hispaniola, and the Bahamas, and the Carib who were on the Lesser Antilles.⁴ The Guanahatebey are considered the ancient remnants of the first West Indians, pushed back and crowded by the more technologically "advanced" later waves of the Tainos. The Carib are thought to be a new wave of Amerindians migrating up from the South American mainland shortly before the Europeans arrived in the later fifteenth century (Sauer, 1966; Watts, 1987).

³ "Arawak" is really a term for the language. "The Taino" is a more correct name, and is the one gaining acceptance today to describe these people.

⁴ These divisions are being sharply criticized by some current scholars. Keegan (1992) argues that "conventional views are modern myths...created by scientists, avocationalists, and the public in their efforts to understand a complex history from a limited and biased ethnohistorical database" (3). Wilson (1990) warns us these biases definitely existed, for "Taino culture was viewed through fifteenth-century European eyes, and the written records that survived were often crafted with particular political objectives in mind" (5). And Stevens-Arroyo (1988) shows throughout his book "Cave of the Jagua: The Mythological World of the Tainos," that the Amerindians may have told myths about themselves which the Europeans then accepted as fact. All these stories have been told and retold so many times over the centuries that they have taken on a life of their own -- even though many are unsupported by strong evidence. Until a more credible history can be developed, we can only recognize the flaws inherent in the current one.

Water as a Factor in Amerindian Settlement Location

Archaeology has revealed a lot to us about Amerindians in the Eastern Caribbean. We have an idea of what they ate (Winter and Wing, 1995), the tools they used (Rouse, 1992), how their houses were constructed (Versteeg and Schinkel, 1992), and a few scholars have even speculated on their religion or spirituality (Stevens-Arroyo, 1988). Amerindian settlement patterns are partially understood, such as where they lived and why they might have located in a particular place (Haviser 1989; Drewett, 1991; Keegan 1992). Innumerable factors may have influenced the site selection process, but undoubtedly certain primary factors had to be satisfied before any others were considered. One of these must have been the availability of freshwater. A number of archaeologists have briefly mentioned this fact in their research (Barton 1953:333; Sleight, 1965:230; Sears and Sullivan 1978:22; Haviser 1989:8, 1991:25; Drewett, 1991:178; Watters, 1991:311; Keegan, 1992:68-72; and van der Valk, 1992:22) and the anthropologist Douglas Taylor observed that Caribs on the Dominican Reserve positioned their settlements with respect to freshwater sources and the sea (1992:309); but few Caribbean researchers have examined the role water played in

daily life, or have evaluated the impact that recurrent drought had on Amerindian freshwater management strategies. For this reason, I find it useful to review and re-clarify the dependent relationship human beings have with water.

Our need for freshwater is second only to our need for oxygen, and a primary concern is drinking a sufficient amount of water each day.

There are certain biological tasks our bodies perform that require freshwater; water helps to transmit electrochemical impulses from the brain to other parts of the body, allows us to dispose of biological waste, acts as a cooling agent to regulate body temperature, and works as a cushion to protect our internal organs from harm (Ladell, 1965). Hence, water is lost, excreted, or consumed by our bodies on a daily basis; and while the amount may vary somewhat from person to person, or climate to climate, it has been calculated that an average of 1.8-3.0 liters is lost per day in a tropical environment (White, et al., 1972). Without daily replacement of water lost through natural bodily functions, the central nervous system begins to break down, biological waste begins to poison us, and our body temperature starts to fluctuate wildly. Death follows in 5-

8 days (Ladell, 1965). Hence, it is vital for the healthy human to have a dependable supply of water every day.

Ideally, a freshwater source should be within a minimal walking distance of any human settlement. A long trek raises caloric and water consumption and increases the risk of dropping the water container. Research on present cultures confirms that people generally minimize distance to water (White, et al., 1972). In the Caribbean, although few archaeologists confront the limiting factor of freshwater on Amerindian settlement patterns and human ecology, Jay Havisser (1989), in his reports of Amerindian settlement on Curacao (a low, dry island in the Western Caribbean), *does* acknowledge the daily need for water; but he seems untroubled by his observation that while most Amerindian settlements were close to water, some were as far as two kilometers from a reliable source. Given the escalating loss of water through bodily evaporation and vessel spillage with increasing distance, such observations of the supposed distance between settlement and water source suggest further research on Amerindian freshwater management is necessary.

Sources of freshwater in the prehistoric Eastern Caribbean must have included rainfall catchments (both natural and human-constructed),

streams, and groundwater -- the latter most easily accessed via springs. But perhaps Amerindians of this region also dug wells. There is ample archaeological, historical, and ethnological evidence indicating that people from all over the world have dug for groundwater with simple technologies, especially when surface water became scarce. In the dry American Southwest archaeologists uncovered wells dug 5,000 years ago in ancient lake bed sediments (Green 1962; Smith, et al., 1966; Meltzer, 1987, 1991, 1995). Evans (1951) notes the following:

Although primitive [sic] man [sic] might conceivably have made such excavations for any of various purposes, the available evidence indicates that they were dug for water, and as yet there is no good evidence in support of other possibilities. All of the wells were dug from a barren, wind-scoured surface which indicates a dry climate and implies a paucity or absence of surface water in the area...The wells were all dug from the more deeply eroded parts of the old lake floor where the water table could be encountered at shallowest depth (6).

Wells also were commonly dug in the ancient cities of the Indus Valley, Mesopotamia, and Egypt as well, and were also constructed by the Etruscans, Greeks, and Romans (Forbes, 1955). One Roman author suggested good water supplies could be found by "inspecting the type of soil and observing the vegetation...followed by trials, in which bronze or lead vessels or unburnt clay pots are buried for a short time and inspected

for water" (146).⁵ The Mayans of the dry Yucatan left behind large "walk-in" wells, some of which are still being used today (Matheny, 1982). After observing the Aborigines of the Australian Outback, Gould writes that "[T]he search for water dominates all other concerns... particularly in seasons of severe or even moderate drought" (Gould, 1977:28).

Aborigines cope with this water shortage by digging "native" wells:

A native well is nothing more than a place where it is known to the aborigines that a localized subsurface water table exists. In these places they dig to get water, using wooden digging-bowls and digging-sticks and collecting the water by letting it flow into a large wooden bowl placed at the bottom (78).

And in the Rim Caribbean, Gallagher (1976:19) documents historical and ethnographic evidence showing Amerindians of dry Northwest Venezuela knew to dig beneath the ground for water.

At times people have constructed near-shore freshwater wells. For example, although Eastern Arabians built deep, complex water systems based on their knowledge of groundwater, they also found near-surface freshwater on coastal beaches, sometimes exploiting temporary freshwater lenses that formed "in the calcareous sands of the littoral

⁵ Water could pass through the bodies of unburnt clay pots -- albeit with some difficulty -- but not the bronze or lead vessels. Forbes doesn't explain if the metal pots were perforated or not.

dunes that in places develop parallel to the shore under the influence of alternating sea- and land-breezes" (Wilkinson, 1977:56). Similarly, on the dry Yucatan Peninsula, Mexicans currently dig for water along the beach.

Shallow wells of the Xicalango Peninsula, dug into the sand and clay, and similar wells found at Punta de Cedro, on a low beach ridge at the mouth of the Rio Balchaca, are two ethnographic examples of how water is traditionally obtained in an area where salt and brackish water predominate. These wells are hardly more than simple 1-m-diameter holes in the soil, dug down to where water seeps into them. Fresh water separates from the saline water and migrates to the surface where it can be scooped off. The water is foul tasting and dirty, but it is life sustaining (Matheny, 1982:166).

Further evidence of near-coast freshwater procurement comes from Papua New Guinea where, during dry spells, the islanders of Buka "obtained water for drinking and cooking from...holes dug in beach sands" (Falkland, 1991:220). And, back in the Caribbean, though he provides no physical proof, van der Valk (1992) suggests that during prehistoric times, surface water scarcity on St. Eustatious (a small, dry island in the Eastern Caribbean) must have forced Amerindians to dig for water to survive.

[S]hallow wells near the shore are a good possibility under prehistoric non-extraction conditions, when the groundwater level under the island must have been considerably higher than today [with] water from the freshwater lens running sideways from the coastal cliffs (22).

Hence, considering the widespread use of groundwater by inhabitants of arid regions, some whose methods rely on near-surface coastal water tables, it seems possible that Amerindians in the West Indies may have discovered similar technologies to exploit coastal groundwater during periods of recurrent drought.

“Discovering” Groundwater and Learning to Use It

How did the Amerindians learn about groundwater, and how did they learn to tap into it? There are a number of Amerindian activities that involved digging or turning over the earth, such as digging postholes for house construction (Versteeg and Schinkel, 1992) or digging graves to inter the dead (Drewett, 1991). During either one of these activities, an Amerindian could have “accidentally” hit a high water table, and after tasting it found the water to be fresh.

It is also possible that while using a shallow and shrinking stream or pond, Amerindians dug a hole and allowed it to fill, making it easier to collect the remaining water with the dipper (White, et al., 1972). In time, as the water level dropped below the soil surface, the only water

remaining in the stream would be in the hole. Expanding or deepening the hole would allow more water to be collected.

But a deeper hole invites the chance of pit collapse. This might occur for two reasons: first, the sediment may be composed of a high percentage of sand, which does not pack well, and hence is unsuitable for the construction of vertical walls; second, water-logged material will easily break apart and collapse into the hole. The longer the hole remains open, the more material will fall down into the hole, requiring that the well be cleaned out and the sediment be allowed to settle to the bottom before the water can be collected.

This common problem in extracting water from a water hole may have been solved by the Amerindians using a method commonly found in other cultures: construction of a well casing. Amerindians in the southwest United States used clay as a lining (Green, 1962), while the Mayans used stones and mortar (Matheny, 1982) and the Chinese used bamboo (Manning, 1987). In Europe, some used brick, but in ancient Crete and Mycenae people used "pottery rings," and Roman soldiers were known to stack "old wooden barrels" on top of each other as a casing (Forbes, 1955). These "barrel-wells" are also found in New World

European settlements at Santa Elena (South, 1979) and possibly near English Harbour in Antigua, West Indies (Nicholson, pers. comm., 1995.). In present-day Carriacou, stacked steel drums, their tops and bottoms removed, serve the same purpose.⁶ Other modern methods include cylinders of concrete, metal or plastic.

Bottomless Stacked Pots: A Well Casing?

Other than the bottomless stacked pots discussed here, I have not found any direct evidence linking Amerindians to the construction of wells. But it should be noted that bottomless stacked pottery assemblages have been reported elsewhere in the Caribbean: on Mustique (Hinds and Harris, 1995), St. Lucia (England, 1995), Puerto Rico (Harris and Hinds, 1995), and St. Vincent (Bullen and Bullen, 1972). Steven Hackenberger (1987, 1988) also found two sets of bottomless stacked pots on Barbados other than those at Oistins Bay, one of which contained water. He suggested they have represented a water hole or well, but did not explore the idea further.

⁶ According to Falkland (1991), the use of bottomless steel drums is a common practice on islands where the soil is loose and well casings are necessary.

The Carriacou pots, found at Constant Spring Guest House (figure 2-1), have yet to be formally described in text by a professional archaeologist, but figure 2-2 shows seven pots, supposedly stacked as they were found. The pots all appear to have had their bases knocked out prior to emplacement. The Barbados pots, found on the beach at Maxwell, Oistins Bay (figure 2-3), have been extensively examined by both Dr. Hinds and Mrs. Harris, and are documented in detail elsewhere (Harris and Hinds, 1995). Collectively, the Barbados pots measure between 25-29 cm in height, and 30-49 cm in diameter, with several sherds showing white on red painting and "Barbados incised grooving." Like the Carriacou pots, they also appear to have had their bases knocked out before they were placed in the ground. Archaeologists using comparative ceramic analysis estimate both the Carriacou and Barbados potstacks to be approximately 1,500 years old (Allaire, pers. comm. 1995; Carriacou Museum, 1994; Harris, pers. comm., 1995; Harris and Hinds, 1995), placing them well within the time we know Amerindians lived on these islands.

Both the Carriacou and Barbados pots were found at locations that currently experience beach erosion. Current residents on Carriacou

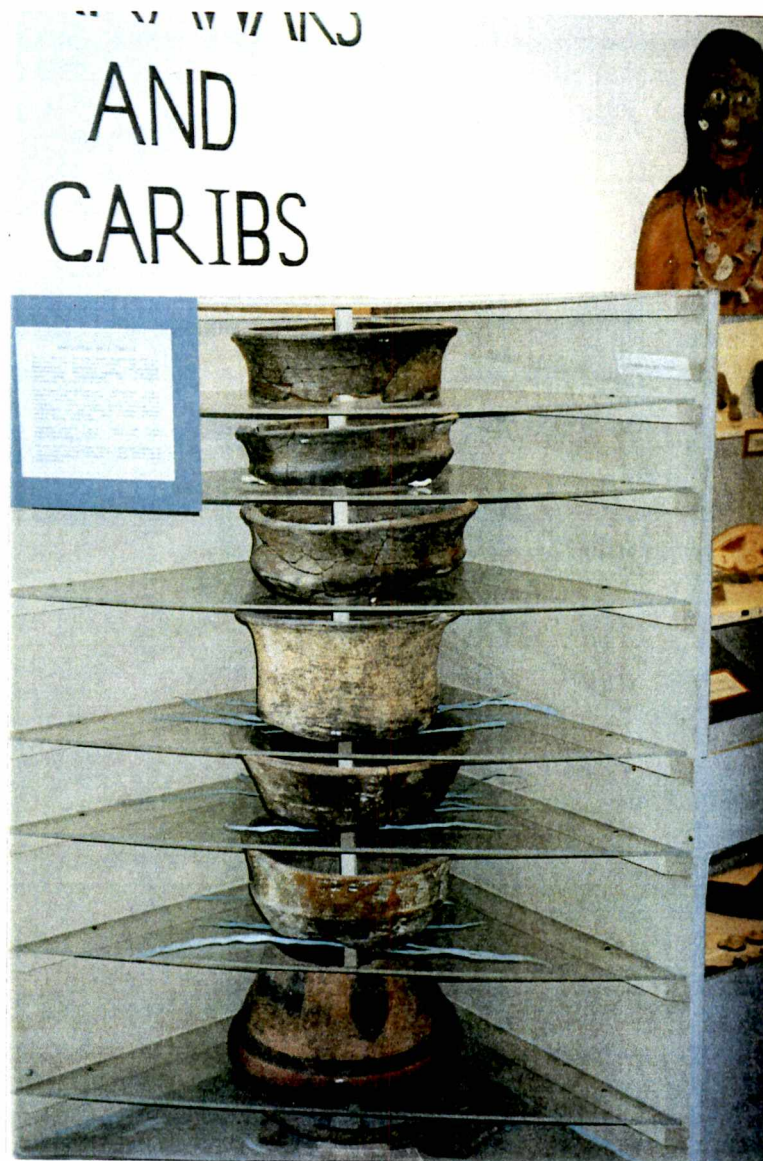


Figure 2-2. Bottomless stacked pots, found in Harvey Vale, Carriacou, Grenada. (For scale, the small white sign to the left of the potstack is eight inches long)

Source: Carriacou Museum. 1994. Photographs of potstack taken by Dr. Lydia M. Pusipher in March. In possession of the author.

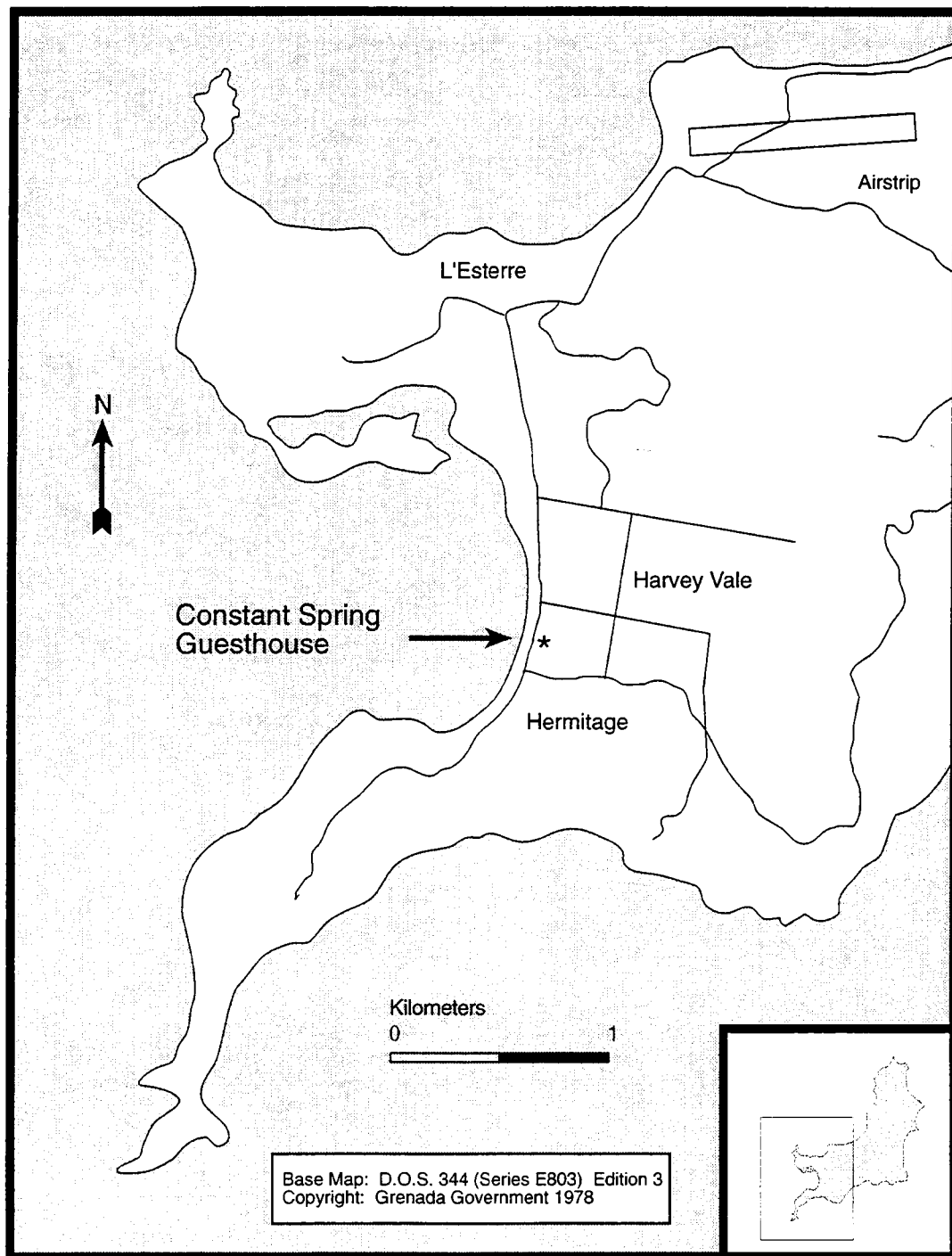


Figure 2-1. Location of Constant Spring Guesthouse, Carriacou

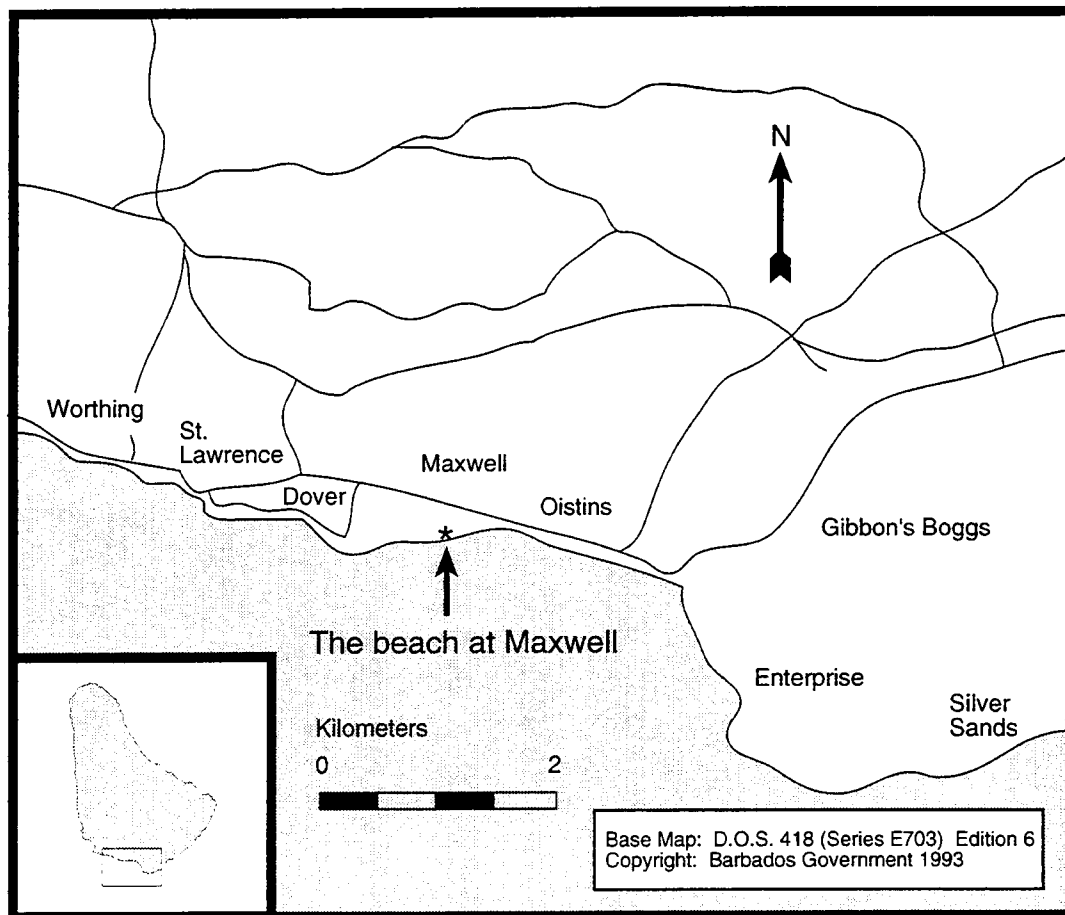


Figure 2-3. Location Map for the beach at Maxwell, Oistins Bay, Barbados

mentioned wave action to be a problem there (Andrews, pers. comm., 1995; Williams, pers. comm., 1995), and I observed that several sea walls were placed along some parts of the island coastline. Several archaeologists have mentioned that sea encroachment has altered the appearance and position of Maxwell Beach at Oistins Bay, Barbados (Barton, 1953; Drewett, 1993), while noting that sea levels have also changed since Amerindian occupation (Hackenberger 1987, 1988). Both of these factors can influence our perceptions of the present-day Barbados coastline, which implies that although the Maxwell sherds were found only a few steps from the ocean, the Amerindians may have originally placed the potstacks tens -- or hundreds -- of meters from the coastline in their day. The same argument could be made for the Carriacou pots.

The significance of the knocked-out bottoms of the pots in question needs further exploration. Careful examination of all of the potstack vessels in Barbados and Carriacou reveals that all pots were made with normal bottoms, and many appear to have been used for other purposes before the bottoms were removed. In most cases, if not all, the bottoms are removed just where the base meets the body-base curve. Hence, the

pot still rests on its original surface (what on a European pot would be called a "foot rim") and could be stacked atop another pot without undo stress to its structure.

If the potstack wells were used consistently and widely, one could assume that the potters would have devised ways of making clay cylinders that fit nicely together more completely and securely than the modified pots. According to pottery experts there is no technical reason why this could not have been done (England, pers. comm., 1995). According to archaeologist Wendy Ashmore (1984), she uncovered six wells constructed of stacked ceramic tubes used by the Mayans in what is today Guatemala. The lowest portion of each stack extended a number of feet into the present water table. More significant for this study, Ashmore also found what might be an older well form, "consisting of wide-mouth jars, their bases knocked out, stacked in a column to form a tube" (148). And, in the Atacamas region of dry coastal Ecuador, Martinez and Pavon (1989) found five "ceramic chimneys" that bear a resemblance to the potstacks reported in this paper. Four of the five stacks were found to contain water, and the authors suggest they may have been used for collection purposes.

Some tentative ideas can be suggested here. That the potstacks were made only of reused pots that were modified by having their bottoms carefully removed is an indication that the potstack wells may have been only occasional or emergency sources of freshwater in the Eastern Caribbean. Furthermore, the fact that similar potstacks with bottoms removed are mentioned elsewhere in the New World suggests that this method of freshwater procurement is very ancient and probably did not originate in the Eastern Caribbean region, perhaps being diffused there from Central of North America.

The next chapter will examine how this potstack system may have worked, describing the groundwater processes involved, and explaining why near-coast freshwater can be found by digging shallow pits.

CHAPTER 3

THE POTSTACK SYSTEM

Nearer the coast, however, [the water table] starts to come within the range of hand-dug wells, because the land surface slopes more rapidly towards the sea than does the phreatic surface.

-- J.C. Wilkinson¹

And the exploring party set off along the shore with Captain Standish marching ahead. The sailors disappeared among the sand dunes to dig for water.

-- Iris Vinton²

In Chapter 1, I discussed how recurrent drought caused water problems in the past, and continues to do so today. In Chapter 2, I showed that groundwater has been used by people all over the world as a reliable source of freshwater during dry spells, and discussed several cases where contraptions similar to the stacked pots were used as freshwater well casings. In this chapter, I plan to examine drought more thoroughly, discussing the Eastern Caribbean climate and the factors that influence island to island precipitation patterns. I then examine

¹ Wilkinson, J.C. 1977. *Water and Tribal Settlement in South-East Arabia: A Study of the Aflaj of Oman*. Oxford: Clarendon Press. p. 48.

² Vinton, I. 1957. *Boy on the Mayflower*. New York: Tab Books, Inc. p. 52.

groundwater dynamics on small islands and present some ideas (called the "Potstack System") to explain how the potstack well could have worked on island coastlines, and compare this system with Barbados hydrogeologic information. The reader will see later that the Potstack System theory is similar to the Carriacou Hypothesis, but goes further to incorporate groundwater science in an explanation of how the Amerindians could have tapped near-coast freshwater using the bottomless stacked pots.

Caribbean Island Hydrology

The climate in the Eastern Caribbean is classified Bsh, hot dry subtropical, according to the Koppen classification system. The weather is dominated by subsiding, rain-inhibiting air associated with the Atlantic subtropical high pressure cell. The seasonal migration of the sun's direct rays makes the high shift north and south, dividing the year into wetter (June-December) and drier (January-May) seasons (Beard, 1949).

Although the average annual precipitation here is 889-1016 mm (35-40 in), it is erratic and in any one place can deviate greatly from the mean (Beard, 1949; Twist, 1953; Stanley Associates Engineering, Inc.,

1978; Maton and Bonell, 1993). Island morphology plays a significant role in rainfall distribution throughout the Eastern Caribbean, since larger islands with relatively high relief can capture a greater mass of rainfall than smaller ones with lower relief (Beard, 1949). Hence, these latter islands are particularly susceptible to drought (Falkland and Brunel, 1993). At times, sparse rainfall and high rates of evaporation result in shrinking supplies of surface water for human use. For this reason, islanders since pre-history probably have had numerous water strategies, including the extraction of groundwater, to adequately supply their daily water needs.

In fact, groundwater as a source has some advantages over other sources, especially in dry times. Groundwater is part of the global interchange of moisture between the sea and land. Water evaporating from the sea and precipitating onto the land eventually cycles back to the sea through various processes of evaporation, transpiration, runoff, and groundwater discharge (Oberlander and Muller, 1987). Groundwater exists beneath the surface in a zone where water has completely filled all the pore spaces in the soil and rock. This mass of water generally migrates slowly down slope until it discharges as a spring or stream

(Manning, 1987), or at the coastline, it may empty directly into the ocean itself (Todd, 1980). Although the rate at which groundwater completes the cycle will vary depending on the hydraulic conductivity of the rock (Heath, 1988), groundwater movement is generally much slower than the processes of evaporation, transpiration, and runoff (which may complete the cycle in minutes or days) and can easily take weeks, months, or years to complete the cycle. The time lapse between influx and outflow dampens fluctuations and allows groundwater to maintain a more consistent flow rate than surface water. Groundwater, therefore, can be very useful to people during dry times (Heath, 1988) and may provide the only freshwater source remaining on islands during extended droughts (Falkland and Brunel, 1993).

On oceanic islands, there is a close relationship between the relatively dense saltwater and light freshwater. If the island bedrock is highly permeable, saltwater may completely infiltrate the island somewhere below sea level, leaving the freshwater to "float" on top, forming a freshwater lens as shown in figure 3-1 (see, for example, Todd, 1980; Matthes, 1982; Rowe, 1984; Cant and Weech, 1986; Custodio, 1987a; Falkland, 1991; and Maidment, 1993). In the homogeneous

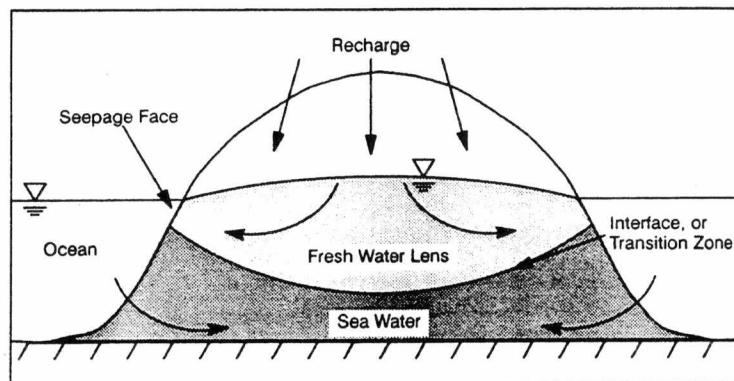


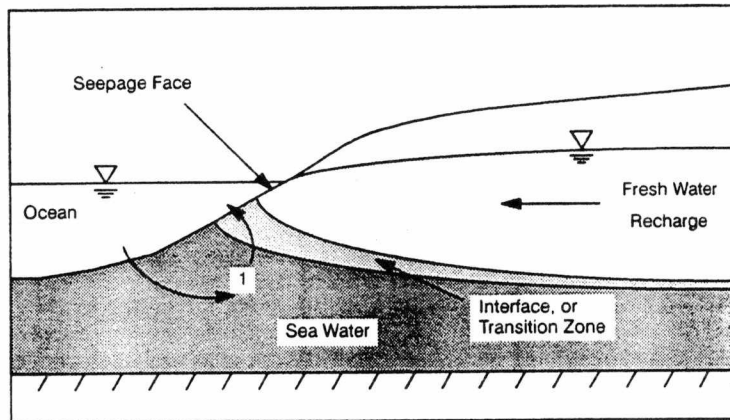
Figure 3-1. Freshwater lens in a homogeneous hypothetical island.

Source: Maidment, D.R., ed. 1993. *Handbook of Hydrology*. New York: McGraw-Hill, Inc.

subsurface of the hypothetical island, the freshwater lens is convex, both above and below sea level, with the top of the lens considered to be the water table. Using sea level as a baseline, the depth to the bottom of the lens can be roughly estimated with the Ghyben-Hertzberg formula, which calculates a depth of 40 ft for every 1 ft the water table is above sea level (Falkland, 1991). Freshwater flows down-gradient (Manning, 1987) toward the coast, thereupon encountering a wedge of dense saltwater (figure 3-2) (Custodio, 1987a). Here, the two water masses mix somewhat, but the freshwater is generally forced to rise toward the island surface by the intruding saltwater wedge. It then intersects the surface and exits as a stream or spring, or remains below ground and discharges directly into the sea (Cooper, 1959).

The Potstack System

Now, using the aspects of groundwater hydrology explained above, I will expand upon the Carriacou hypothesis set forth by Mrs. Andrews and present a theory, called "the Potstack System," which attempts to explain how the Amerindians could have procured freshwater using the bottomless stacked pots. In the Potstack System, it is assumed at the



¹Recirculation of sea water

Figure 3-2. Freshwater flow towards a hypothetical island coastline.

Source: Maidment, D.R., ed. 1993. *Handbook of Hydrology*. New York: McGraw-Hill, Inc.

coastline the slope of the water table is not as steep as the island surface, and the water table comes closer to the surface as it approaches the coast (figure 3-3). I suggest the Amerindians might have dug shallow pits in this area to access the freshwater they knew to be in the shoreline zone. They used the bottomless stacked pots as a well casing to prevent the sandy pit walls from collapsing. Pits dug too close to the shoreline would have filled with undrinkable salty water, while pits dug far inland would have had to be very deep to access the water table. I propose that the Amerindians struck a balance between salinity and depth; they placed their potstack wells in the coastal zone where the water table was accessible at a reasonable level and the water just fresh enough to drink. During very dry times the Amerindians may have been willing to settle for lower quality water if no other supplies were available.

Comparing the Potstack System to Reality -- The Barbados Example

Since the bottomless stacked pots were found on Carriacou and Barbados, it makes sense to seek comparisons between the Potstack System and the groundwater dynamics documented on these two islands.

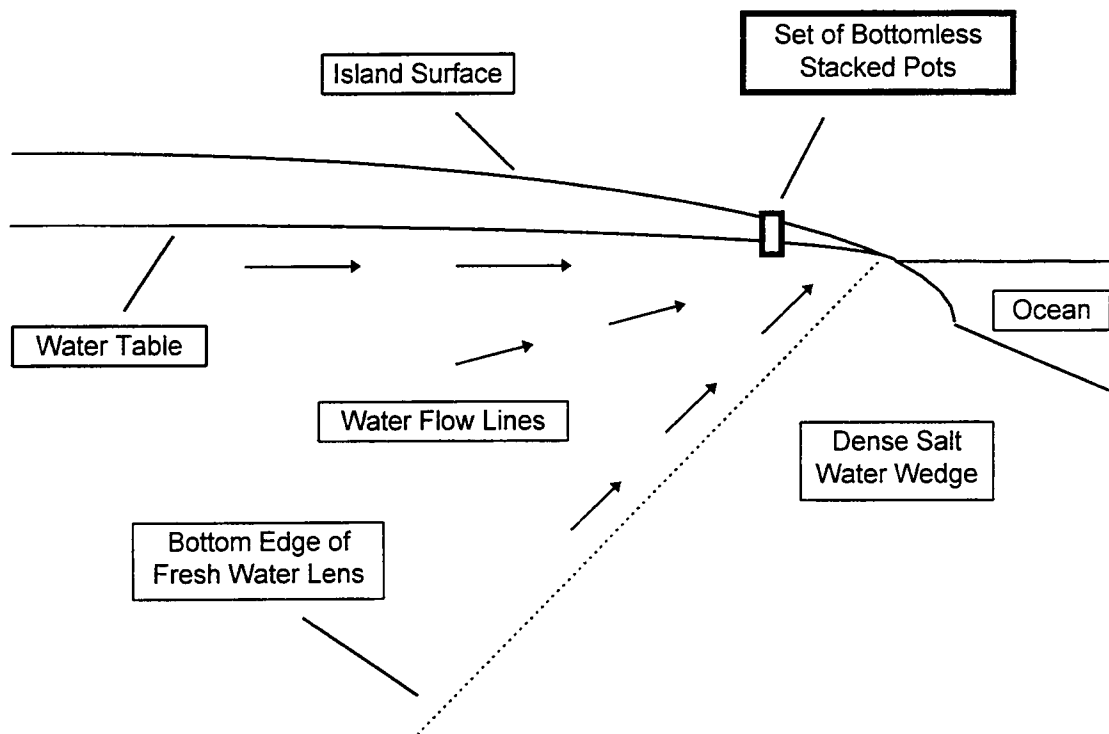


Figure 3-3. The Potstack System (no scale implied).

But Carriacou's hydrogeologic information is very limited, so a discussion of the island's groundwater situation is difficult. Barbados, on the other hand, *has* been studied by geologists and hydrologists, therefore this comparison of the Potstack System with groundwater dynamics will be limited to Barbados.

Nearly all of Barbados is made of sedimentary rock, mostly clays and marls overlain by a very porous coral limestone cap (Drewett, 1989). This lower impermeable bedrock restricts the formation of the freshwater lens to the extent suggested in the hypothetical island shown in figure 3-1. Instead, the rainwater percolates through the upper coral limestone to the impermeable rock layer, where it then flows downslope through fractures and solutions channels atop the clay/marl bedrock (Senn, 1946). Along the coast, the highly porous limestone dips below sea level where a saltwater wedge penetrates inland and "backs up" the freshwater flow, causing it to form a modified freshwater lens as shown in figure 3-4 (Stanley, 1978). Here, the top of the water table is at sea level, and a well dug to this depth will yield water (Senn, 1946). Hence, the shallowest wells exist closest to the coast where the land elevation approaches sea

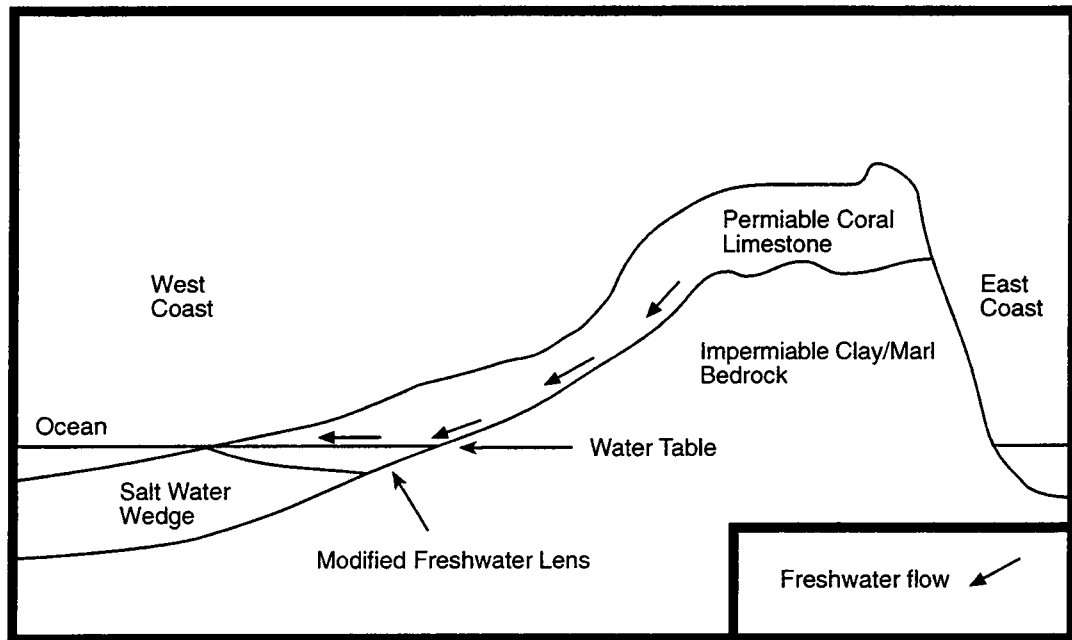


Figure 3-4. Simplified crossection of Barbados

Base drawing: Stanley Associates Engineering, Inc., 1978

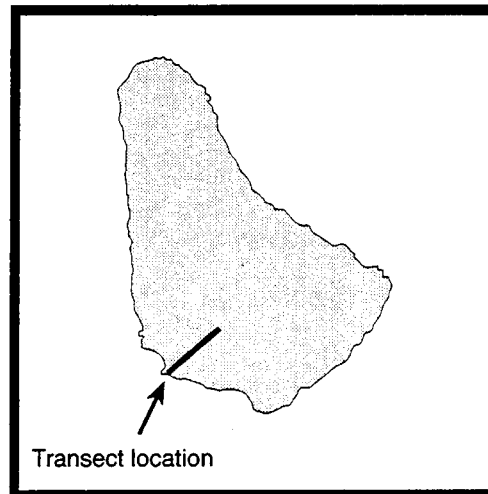
level, and further inland where the land elevation is higher, the wells must be dug much deeper in order to reach the freshwater lens (Senn, 1946).

This description is further supported by a transect survey completed during the 1978 Barbados Water Resources Study by Stanley Associated Engineering, Inc. Among other crosssections, one drawn from a transect along the southwest coast (figure 3-5) is very helpful to compare against my hypothetical Potstack System; it suggests one could sink a 10 ft well within 402 m (1320 ft) of the coast and find drinkable water with a chloride content of only 600 parts per million (according to Falkland, 1991, water with more than a 2,000 parts per million chloride level is considered undrinkable). Such shallow, near-coast well construction on Barbados is confirmed by geologist Alfred Senn (1946), who wrote the following:

In the days before [Barbados] was provided with a water supply system, there were many more wells in use in the coastal districts, where water is found at shallow depth.

On the other hand, examination of figure 3-5 (b) shows that with increasing distance from the coast, one can find fresher water but the wells need to be dug much deeper.

(a)



(b)

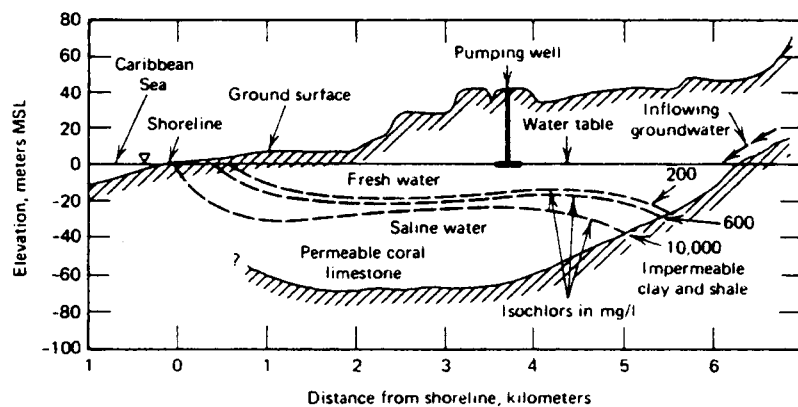


Figure 3-5. Groundwater transect performed by Stanley (1978): location map (a) and cross-section of transect (b). (mg/l = ppm)

Source: (a) Based on information in Stanley (1978). (b) Todd (1980), adapted from drawing by Stanley Associates Engineering, Inc. 1978. *Barbados Water Resources Study, vol. 3: Water Resources and Geohydrology*. Edmonton, Alberta.

Hence, the collected hydrogeological information of Barbados seems to indicate the Potstack System presented above accurately emulates parts of the island's current groundwater dynamics at the coastline. If the Amerindians encountered a similar -- or, more likely, better³ -- groundwater environment on Barbados, they should have been able to access freshwater by digging shallow near-coast pits and then line the well with the bottomless stacked pots.

Testing the Potstack System in the Field

But what is it like on Carriacou? Is the near-coast groundwater there fresh enough to drink? Could the Amerindians have used the theory suggested by the Potstack System to secure reliable freshwater supplies? My fieldwork attempts to answer these questions.

I decided to conduct fieldwork on the islands where the bottomless stacked pots were found (Carriacou and Barbados) to (1) document cultural information that shows the extent to which islanders use

³ Wheeler (1916) notes that intensive destruction of an island's original vegetation increases surface flow and evaporation, while Custodio (1987b) and Todd (1980) write that urbanization also greatly increases runoff. Both of these factors apply in Barbados' case and reduce the total amount of water remaining in the island's water system. Hence, Barbados water system today is bound to be different from Precolumbian times, when the groundwater may have been more accessible using the Potstack System.

groundwater in ways that lend credence to the Carriacou hypothesis and the Potstack System, (2) record depth and salinity of near-coast wells, and (3) dig shallow near-coast pits in an attempt to find freshwater. In the latter case, I dug the holes using a military shovel and tested the salinity of the water with simple chemistry equipment. By constructing a series of pits from the coast inland, I measured the water depth and salinity, expecting to find increasing distance between the surface and the water table and decreasing salinity level with increasing distance from the coast. Results that confirmed this would support the validity of the Potstack System.

By digging my own holes on the islands where the bottomless stacked pots were found, I tried to simulate what I thought the Amerindians had experienced when constructing potstack wells. My technique is based on a methodology called "Idealism," developed by Leonard Guelke in 1974. He suggested that if researchers try to imaginatively put themselves in the place of members of another culture, they may get a better understanding of that culture's ways and practices. In my case, I tried to "bodily occupy" the space the Amerindians lived 1,500 years ago, and attempted to show that (1) freshwater is accessible

using shallow near-coast pits, and (2) a well casing is necessary to prevent collapse of the pit walls. I dug the holes and tested for salinity as previously described, but also installed a set of perforated 1 1/4 in PVC tubes to emulate the bottomless stacked pots.⁴

My fieldwork attempted to show that the Carriacou hypothesis and the more elaborate Potstack System were workable in practice, the results of which are presented in the next chapter.

⁴ I constructed the PVC system by cutting 60 in long 1 1/4 in diameter pipe into more manageable 20 in long pieces, and fitting them together with couplings. I had 12 pieces, enough to build numerous well simulators at the same time and to various depths. I drilled 1/4 in holes into four tubes to allow water to infiltrate into the bottom of the well. It would have been more accurate to test the theory using my own set of bottomless stacked pots, but considering the size and weight of these bulky items, the PVC tubes were much easier to transport. Besides, if the theory held for the PVC it should have also worked for the potstacks.

CHAPTER 4

RESULTS OF FIELDWORK ON CARRIACOU AND BARBADOS

*...a small spring has been discovered in the principal island
Carriacou...by digging; but, being of great value, it is kept locked by
the proprietor.*

- Father Raymond P. Devas¹

Carriacou Fieldwork

Initial encounter

When I arrived in Carriacou on 1 July, 1995, I was surprised to find the island quite green. "Isn't this place supposed to be dry?" I thought at first, but soon I learned the rainy season had begun a few weeks earlier. A quick taxi ride to town took me to my guest house.

Since I hadn't eaten for a while, I went outside and walked along the main street of Hillsborough looking for a restaurant. Upon seeing "Kayak's Bar and Grill," I stepped inside, and was greeted by a young man about my age who handed me a menu and asked if I wanted

¹ Devas, 1964, cited in Hill, 1977:205 (Hill, D.R. 1977. The Impact of Migration on the Metropolitan and Folk Society of Carriacou, Grenada. *Anthropological Papers of the American Museum of Natural History* 54[2]:191-391).

anything to eat. I nodded, picked something from the menu, and took a seat at one of the tables. He accepted the drink I offered him, picking two from the refrigerator and sitting down across the table from me. After several minutes of conversation I learned his name was Hezekiah Williams (pers. comm., 1995), or "Kiah," for short.

He asked what I was doing on Carriacou, assuming I came from one of the yachts and was on the island for a vacation. I shook my head and told him that I was here to do some work. "Yeah, right," he said, laughing. I explained that I was an American scientist, a graduate student, and wanted to conduct research on Carriacou's groundwater. At that, he looked at me with renewed interest, asked some detailed questions, and concluded by stating, "Then, I have someone you need to meet."

Meeting "the Devil"

I met Kiah at the restaurant the next day, 2 July, 1995, where we caught a "transport" (minibus) south into the small village of Harvey Vale. He told me there was a gentleman here who knows a lot about wells and groundwater, and might be able to help me. "His name is Magness

Alexander," Kiah told me, "but everyone calls him Devil." I quickly pushed aside any negative thoughts, hopped out of the minibus, paid the driver, and followed Kiah across the road.

Standing under the large wooden frame skeleton of a boat was a tall, muscular man. Kiah introduced me as a friend of his, and said that I was interested in learning about groundwater on Carriacou; "Maybe he'll write a book someday!"

Devil (Alexander, M., pers. comm., 1995) was wary of "scientists," but since I was Kiah's friend, he relaxed and agreed to show me around. We followed him across the road through the woods, arriving at what Devil called "Digpond" (figure 4-1). It was a small artificial water hole, dug by a backhoe. I was told the pond walls frequently collapsed, requiring continual maintenance to keep it clean and accessible as a water supply for the cattle and other animals.

I asked, "Is this water drinkable?"

Devil scooped some of the water in his hand and tasted it, declaring that yes, indeed, you could drink it. He offered me some. I declined, explaining that as a scientist I needed to test this water accurately. I pulled out a small glass vial and filled it with the Digpond

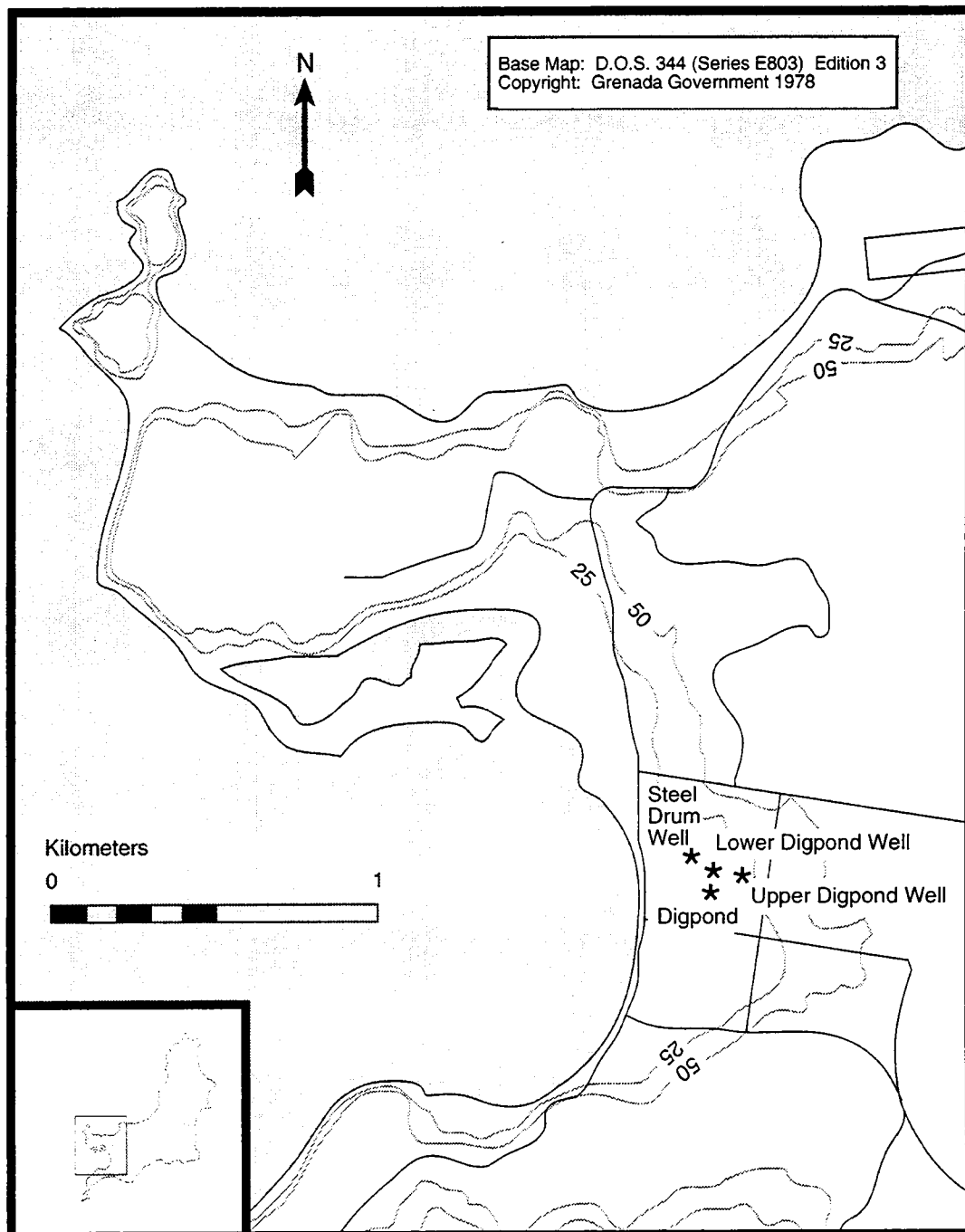


Figure 4-1. Carriacou wells visited while meeting Magness Alexander ("the Devil")

water. "I'll take this back to the guesthouse," I said, "where I can chemically test the salt content of the water." I explained how a chemistry graduate student had trained me to use silver nitrate as an indicator of water salinity. "The silver reacts with the salt to form a solid, which I can then compare against some known salt solutions."² (I later tested the water salinity and found it to be 1,000 parts per million (ppm) of chloride. I considered 2,000 ppm undrinkable, so Devil's taste test had been right!)

Devil impatiently smoked a cigarette as I wrote a few things down in my notebook. Kiah told me he had lots of things that he could show me, so I finished what I was doing and I quickly followed Devil and Kiah to a well that was nearby.

Evidently this well was also used for watering cattle, for a steel drum, cut in half length-wise, lay on the ground to act as a trough. I

² The method was developed by Ms. Rose Boll, a University of Tennessee chemistry graduate student. Since the largest percentage of salt in seawater is sodium chloride, the chloride can be used as reliable indicator of water salinity. The chemical reaction is as follows: silver nitrate (liquid) reacts with sodium chloride (in solution) to form silver chloride (a solid). The solid silver chloride collects at the bottom of the vial and can be compared with known standard salt solutions of 20, 200, 1,000, 2,000, 5,000, 10,000, and 20,000 parts per million (ppm) of chloride. Two thousand is considered potable (fresh enough to drink) while 20,000 is considered pure sea water (Falkland, 1991). After collecting a number of water samples, I took them back to the guest house and used an eye-dropper to place 10 drops of silver nitrate into each vial. I did the same to the seven vials of standard salt solutions, comparing them together and recording the results.

gathered another sample, this time using my miniature collection device (made of fishing line, a weight, and a plastic cap) because the water level was fairly deep. I would come back later³ to measure the water depth on my own; I didn't want to tax Devil's patience, and besides, Kiah had to get back to work. This well -- that I call "Lower Digpond" -- turned out to be 2.7 m (8.8 ft) deep, with a chloride content of 2,000-5,000 ppm (figure 4-1).

We then walked through the bushes and came upon another well, covered by a piece of corrugated metal. Devil lifted it for me and I collected a sample, labeling the vial "Upper Digpond Well" (figure 4-1). Since this well was not as close to the coast as Lower Digpond Well, I expected the water level to be further from the surface with a lower water chloride content (as predicted by the Potstack System described in the previous chapter). I came back later and found the water to be 5.9 m (19.3 ft) below the surface, with a 200-1000 ppm chloride level. Both measurements were expected and support the theory behind the Potstack System.

³ At times I did not measure the depth and salinity of a well during my first visit; in these cases, I came back and conducted my experiments at a later date.

Our last stop turned out to be the most enlightening. Located in the middle of a shallow dried up pond, Devil showed us a rusty steel drum (figure 4-1). It stuck out of the ground a few feet, and had four pieces of wood holding it in place. When we got to the drum, I looked inside and saw that it was only one of several others which were stacked on top of each other, and there was water a number of feet below the surface. This was a well casing made of bottomless stacked steel drums! I stared at Kiah and said, "I really must thank you for introducing me to your friend," explaining that this well closely resembled the bottomless stacked pots found at Constant Spring just 457 m (1,500 ft) from our present location. Devil told me the pond had dried up during the dry season, and the land owner had to dig a pit to get to the lowered water table. To keep the sides of the well from collapsing, he removed the tops and bottoms out of these steel drums and put them into the ground. I explained how I thought the Amerindians had used the pots for the same purpose. They agreed that the hypothesis seemed reasonable.

When I came back later to take measurements, I found the water level of the steel drum well 2.4 m (8 ft) below the surrounding landscape.

I took two separate chloride measurements, which both yielded readings of 2,000 ppm. The well water was drinkable, but just barely.

I thanked both Kiah and Devil for their help and repaid them by buying a round of drinks at the rumshop nearby. Soon afterward, Kiah and I caught the next transport back to Hillsborough.

Table 4-1 summarizes measurements of the three wells I tested this day,⁴ and lists them by increasing distance from the ocean. As predicted by the Potstack System, near-coast water will have a higher salt content and lie fairly close to the surface; on the other hand, wells farther from the ocean will have better tasting groundwater, but one will have to dig deeper to access it.⁵

⁴ Digpond is excluded from this table because I want to limit my discussion to only wells. Ponds are likely to be filled by surface runoff, so testing of these do not give an accurate picture of groundwater position and salinity.

⁵ I arrived on Carriacou just after the end of the dry season, so the near-coast wells I tested on this day, 2 June 1995, may not always be this salty. Limited precipitation reduces groundwater recharge and the freshwater flow toward the sea, which allows the saltwater wedge to penetrate further inland (Custodio, 1987a). As the wet season progresses, we should see a decrease in the water salinity as the saltwater wedge gets pushed coastward.

Table 4-1. Wells measured while "Meeting the Devil."

<i>Name of water source</i>	<i>Distance from coast, m (and ft)</i>	<i>Water depth below surface, m (and ft)</i>	<i>Water chloride content (ppm)*</i>
Steel Drums	182.9 (600)	2.4 (8.0)	2,000
Lower Digpond	228.6 (750)	2.7 (8.8)	2,000-5,000
Upper Digpond	335.3 (1,100)	5.9 (19.3)	200-1,000

* Potable water = 2,000 ppm or less.

I had a conversation with Devil later that week, and he made a telling statement about Carriacou wells: although you could find fresher, better-tasting water farther from the ocean, you would have to dig much deeper to access it. No one would spend time working on a deep well when you can simply find water closest to the surface "over deah [there]," near the coast.

Education in a "transport"

On our way back to Kayak's, Kiah seemed pretty happy that he and Devil could provide so much help. He was glad to answer some additional questions. Since all these wells and ponds we saw were for the animals, I asked, what water do *you* drink? He said that everyone in Carriacou drinks rainwater; each house roof is outfitted with gutters to

deliver the rain into a large concrete cistern. "First thing people are concerned about with their house is building the stuff to collect freshwater. Without freshwater, nobody can live," Kiah said.

Kiah told me that no one drinks the "Bohole" water (the water from the ground) because it doesn't taste as good as rainwater. "It's too heavy," he said.⁶ So they only use it to wash things and to give to the animals. Sometimes they have a very bad dry season and the cisterns run low. Only then would they use the bohole water to drink. "But isn't the rainwater from the cisterns dirty?" I asked. He said no; all the solids from the rooftop fall to the bottom of the cistern, and the water is drawn and filtered from the upper part. One of his friends later told me that they put fish in the cisterns (called "millions") to kill the mosquito larvae.

We got back to the restaurant, and Kiah suggested I take a rainwater sample from their tap. I did so, and it was 200 ppm.⁷ I then took a sample from the "bohole" water pump outside the restaurant, and it was 1,000 ppm. "No wonder you drink the rainwater," I commented, "it is very fresh."

⁶ I would find that this heavy vs. light distinction is consistently used on Carriacou to classify brackish vs. freshwater.

⁷ These are not included in a table since they were not well measurements.

Meeting Mr. Guadeloupe

Later that night, I came back to sit outside with the restaurant clientele and I struck up a conversation with Mr. Godwin "John" Guadeloupe (pers. comm., 1995), a construction contractor. He heard about what I was doing, and told me he was interested in getting a hydraulic drill in order to dig deep wells. "The deepest we can go right now is 18 feet," he said, mentioning the caterpillars like the one I saw at Digpond. John told me the construction industry is booming on Carriacou because many emigrants, who had been working in the United States, Europe, or on some of the other Caribbean islands, are coming back to stay on Carriacou permanently (see Richardson, 1974, for a discussion on Carriacou migration). These new people will undoubtedly tax the current water supply, so water extraction and well drilling will certainly be a profitable venture in the future. John said that if he could purchase a drill now, he might be able to corner the market.

If well construction is limited to a depth of 5.5 m (18 ft), as Mr. Guadeloupe suggests, all recently dug wells, therefore, must be located in areas where the water table is within the range of that equipment. I examined the most recent Carriacou topographic map (D.O.S., 1978) and

noticed that of 21 wells noted on the map, 62 percent are located at less than 7.6 m (25 ft)⁸ above sea level and 86 percent at less than 15.2 m (50 ft) above sea level. Since these low points on Carriacou are along the coast, most wells are therefore positioned close to the ocean.

Table 4-2. Near-coast wells listed on 1978 Carriacou topographic map.

<i>Description</i>	<i>Number</i>	<i>Percent</i>
Wells located < 7.6 m (25 ft)* above sea level	13	62
Wells located < 15.2 m (50 ft)* above sea level	18	86
Total number of wells shown on map	21	100

* Map contours are in feet.

The Carriacou Museum and Junior's walk

Before I left the restaurant for home, Junior McMillon (pers. comm., 1995), the restaurant owner's son, told me that if I stopped by during his school lunch break the next day, he'd take me to the church well by his school. I agreed.

While I was waiting for Junior the next morning, 4 July, 1995, I decided to visit the Carriacou Museum. Lydia Pulsipher's friend and Museum employee, Clemencia Alexander (pers. comm., 1995), gave me a

⁸ The contours on the Carriacou topographic map are in 25 ft increments.

tour. And, coincidentally, the first exhibit she showed me was the set of bottomless stacked pots. I asked about how to get to Constant Spring Guest House (where the potstack had been found), and Clemencia gave me directions.

She also showed me two other pieces of pottery that had been found without their bases intact. "Is this also a well casing?" I asked. No, she said. Although the pots were found stacked on top of each other, they were dragged out of the surf during low tide, so the Museum didn't think it was an Amerindian well. I silently disagreed: beach erosion could have easily changed the Carriacou coastline. When the Amerindians were here 1,500 years ago, the pots may have been in a better location to tap fresh groundwater.

I thanked Clemencia and went to meet Junior. He took me up the street to the church well he had mentioned (figure 4-2), where I found it to be 3.8 m (12.4 ft) deep with a salinity of 1,000 ppm. Walking around the block to the Botanical Gardens, Junior showed me a nearby pond that had been re-excavated a few weeks previously (figure 4-2). He said the recent dry season had been so bad that the government was forced to dig out many of the ponds with heavy equipment. After the pond dries up,

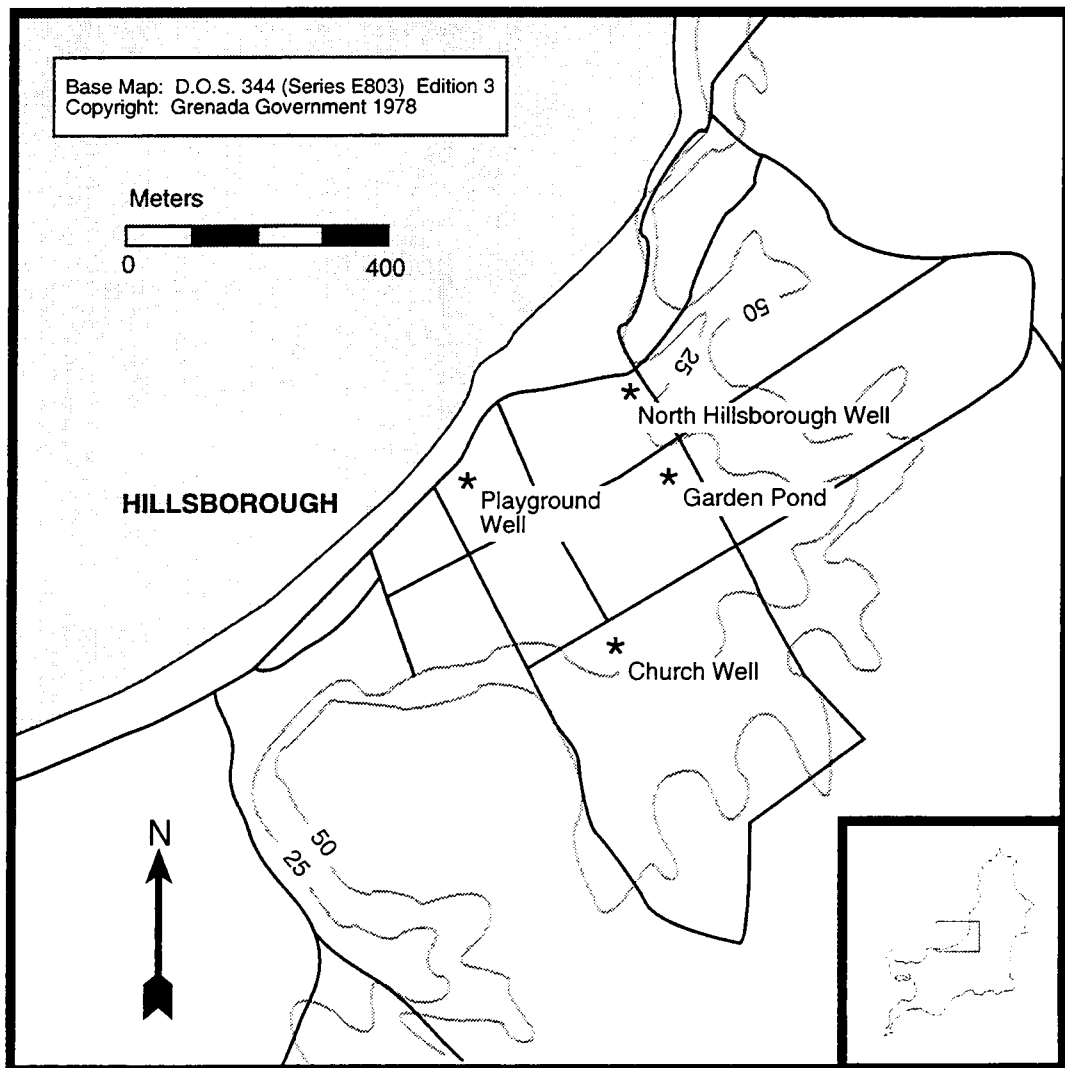


Figure 4-2. Water sources visited in Hillsborough

they simply dig down a few more feet until water “springs back up again.”

This water had a green film on it (which Junior blamed on the tree leaves) but it tested only 20 ppm, presumably drinkable.

The church well is very far from the coast (381 m; 1,250 ft), and as I expected, had a relatively deep water table and low salt content. Later in the week I tested a well towards the north of Hillsborough (figure 4-2), and found that although it was closer to the ocean (152.4 m; 500 ft) and saltier (5,000 ppm), it was much *deeper* (5.9 m; 19.3 ft) than the church well. I expected this well water to be closer to the surface. I examined the topographic map and found that the “North Hillsborough” well seemed to be located at a higher elevation, which probably explains why the water is further from the surface.

A few days later I found a near-coast well (65.5 m; 215 ft) in the playground behind my guesthouse (figure 4-2). Initial comparisons between this well (Playground well) and the far-coast Church well seemed to support the Potstack System; the depth below the surface changed from 2.4 m (7.8 ft) to 3.8 m (12.4 ft). I then expected to see a subsequent rise in salinity at the near-coast well, but instead found both to have 1,000 ppm of chloride.

Without having studied the hydrogeology of Carriacou, I cannot provide the definite explanation for this difference; however, the hydrogeologic literature leads me to suggest several ideas. The Playground well is much closer to the beach, so the soil at this location may be made of a higher percentage of sand. As noted by Custodio (1987a), Manning (1987), and Falkland (1991), sandier soil has a higher infiltration capacity which allows for more of the rainfall to enter the groundwater system. This water recharge could push the saltwater wedge seaward (Custodio, 1987a) allowing for relatively fresher water to be drawn from the near-coast well. Also, since the Playground well is located in a grassy area, the vegetation can slow down overland flow and increase groundwater recharge (Hausenbuiller, 1985; Dunne, 1988; and Falkland, 1991). Regardless, the data in Table 4-3 suggest the relationship between coastal proximity, water depth and salinity may not be a simple and direct one.⁹

⁹ As mentioned previously, all ponds are excluded from this examination, so I do not list them in the tables.

Table 4-3. Measurements from wells in Hillsborough, along the west coast of Carriacou.

<i>Name of water source</i>	<i>Distance from coast in m (and ft)</i>	<i>Water depth below surface, m (and ft)</i>	<i>Water chloride content (ppm)*</i>
Playground	65.5 (215)	2.4 (7.8)	1,000
N. Hillsborough	152.4 (500)	5.9 (19.3)	5,000
Church	381.0 (1,250)	3.8 (12.4)	1,000

* Potable water = 2,000 ppm or less.

“Estemie” and the Constant Spring Guest House

After I left Junior, I took a transport to Harvey Vale for a visit to the Constant Spring Guest House and Mrs. Margaret Andrews who, according to the Museum plaque, had originated the Carriacou hypothesis. As I stepped into the courtyard I noticed a hand painted sign on the back of the wall: *Constant Spring: Site of Ancient Indian Well. Excavated by M. Andrews and C'cou Society. Pots on Display Museum Hillsb.* I ordered a drink from the bar and sat down to rest at the picnic table.

Soon the bartender and I began talking and I found out that she was Margaret Andrews (1995). “But call me Estemie,” she said. I let her know I was researching the bottomless stacked pots she had found. Estemie explained the story (related at the beginning of this thesis) and

showed me the well that had be constructed, which was made of several cement cylinders stacked on top of each other and covered with a large wooden disk. She said the disk helped keep stuff from falling into the well. I nodded in agreement.

Kiah had once explained to me the usefulness of a well lid; it was a barrier against dirt, leaves, and mosquitoes, but also children. "They like to walk by wells," he said, "and throw pebbles and stones into it. They like to hear the 'kerplunk.' The problem is, they fill it up." Watching Estemie's daughter's son scramble about the place, I could see how the children around here might be tempted to throw things into the well. But I figured they could just as easily climb over the edge and fall inside, so the lid must act as a safety device as well.

I asked to take a few measurements, and Estemie agreed. I found the well was approximately 17.4 m (57 ft) from the ocean, and 2.2 m (7.1 ft) deep, but had an extremely high chloride level of 10,000 ppm! I was little shocked, because I was led to believe this was a freshwater well. Then Estemie explained that when the rain stops and dries out the island, the water gets a little salty. If I stayed a couple more weeks into the wet season, I'd see the well would be fresh again. I take this to mean that

during the dry season, declining groundwater allows the saltwater wedge to move inland and the salinity of the well increases. With the beginning of the rainy season, the groundwater recharges and the saltwater wedge gets pushed back, and the salinity declines.

Table 4-4. The well at Constant Spring Guest House, on 4 July, 1995.

<i>Name of water source</i>	<i>Distance from coast, m (and ft)</i>	<i>Water depth below surface, m (and ft)</i>	<i>Water chloride content (ppm)*</i>
Constant Spring	17.4 (57)	2.2 (7.1)	10,000

* Potable water = 2,000 ppm

Digging pits A and B near Constant Spring

I decided to dig my first series of pits near Constant Spring Guesthouse along an imaginary transect that lay perpendicular to the shore. According to the Potstack System, I should find an increasing distance between the surface and the water table and a decreasing salinity with increasing distance from the coast. I chose pit "A" 1.5 m (5 ft) from the ocean (figure 4-3) to guarantee an initial 20,000 ppm measurement at the beginning of my pit series. I found water at 0.4 m

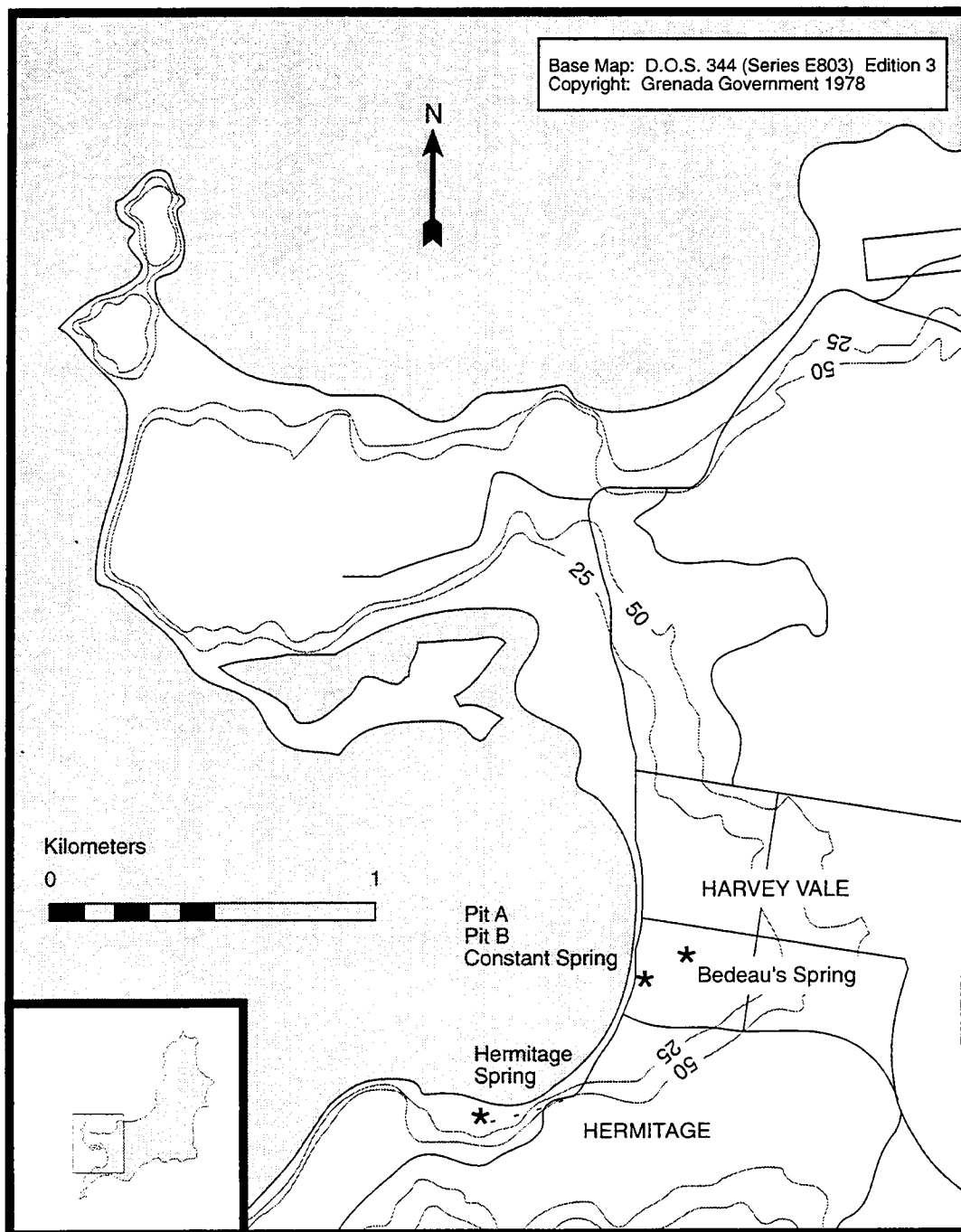


Figure 4-3. Harvey Vale and Hermitage sites mentioned in text

(1.3 ft), sampled the water, and inserted a PVC tube into the hole for later testing. As expected, I later found the chloride level to be 20,000 ppm.

I looked for an appropriate location for pit "B" and immediately noticed that in my haste to start digging, I hadn't realized a transect here at Constant Spring would be nearly impossible to follow; there was a road between the well and the beach, and the rest of the property was covered in concrete. The only possible location for the next pit would be on the steep road bank that sloped down to the beach. I chose to dig pit "B" 4.9 m (16 ft) inland (figure 4-3), but concluded a third pit would have to be located on the other side of the road, but off to either side of the transect. As the reader will come to learn, I met Devil again soon after digging pit "B" and never got back to digging a third Constant Spring pit; and Devil later showed me a location on the other side of the island which I thought would be a better place to dig a series of pits.

As I dug pit "B," I realized that sand kept falling in on me. The way I prevented this was to construct numerous "steps" in the side of the pit walls -- which, incidentally, helped me get back out of the deepening hole. Yet I still had partial wall collapse from time to time, and the digging became increasingly difficult. After a while, a native "Kayak" named John

Bedeau (pers. comm., 1995) stopped by, and was wondering what I was doing. We talked for a while and he became very interested in my work, excited to meet a "real scientist," as he put it. I got back to work and soon completed the pit after hitting water, whereby John helped me take measurements (the pit was 1.2 m -- 4.1 ft -- deep, with a chloride level of 10,000-20,000 ppm) and install the PVC pipe.

I was getting tired, but John insisted on showing me a nearby well called, coincidentally, "Bedeau's Spring." It had been recently dug using a small backhoe and wasn't too far from Constant Spring (figure 4-3). Measurements showed a depth of 2.3 (7.6 ft) and chloride level of 2-5,000 ppm. It was located 182.9 m (600 ft) from the ocean. Since I would not dig another pit in this area (for the reasons discussed previously), these four locations represent the extent of my first digging session.

After digging and installing the PVC pipes in pits A and B, I had to wait for the water level to go down before I got an accurate reading (I "filled up" the hole when I installed the pipe, so the water naturally rose slightly at first). When I returned, I found there to be 0.1 m (0.29 ft) of water in pit A and 2 inches in pit B, so the depths-to-water from the surface were 0.3 m (1.1 ft) and 1.2 m (3.8 ft) respectively. By comparing

pits A and B with Constant Spring and Bedeau's Spring, we can get a general picture of the groundwater situation in a small section of Harvey Vale. As expected, I found a measurable drop in chloride with distance: from 20,000 ppm in pit A to 2,000-5,000 ppm in Bedeau's Spring.¹⁰ There was also an increasing distance between the surface and the water table, from 0.3 m (1.1 ft) to 2.3 m (7.6 ft) at the same locations. These measurements support the Potstack System.

Table 4-5. Measurements of test pits and springs in Harvey Vale.

<i>Name of water source</i>	<i>Distance from coast, m (and ft)</i>	<i>Water depth below surface, m (and ft)</i>	<i>Water chloride content (ppm)*</i>
Pit A	1.5 (5)	0.3 (1.1)	20,000
Pit B	4.9 (16)	1.2 (3.8)	10,000-20,000
Constant Spring	17.4 (57)	2.2 (7.1)	10,000
Bedeau's Spring	182.9 (600)	2.3 (7.6)	2,000-5,000

* Potable water = 2,000 ppm

¹⁰ Since Bedeau's Spring was uncovered, fresh rainwater captured by the well could alter the chloride content. However, this may be offset by increased evaporation. Most of the wells I tested on Carriacou were open. I conclude that with such a small water surface area for most of these wells, the primary determinant of salinity must be that of the groundwater.

The Hermitage Trek

Soon after we got back on the road, John and I ran into Devil. He said there were some places he wanted to take me, and if I wanted, we could leave immediately. Tired after digging two pits, I was going to decline his offer, but then again thought it might be in my best interest to take advantage of hospitality whenever it was offered. So John and I followed Devil south back through Harvey Vale to Hermitage, then skirted the coast of Tyrrel Bay to a shallowly dug pit (that I call "Hermitage Spring") which was 1.4 m (4.5 ft) deep and approximately 58.5 (192 ft) from the sea (figure 4-3). I could see where the walls of the pit had collapsed, reminding me of the problems I had just encountered at pit B. Over time, I could easily visualize the hole filling itself in unless the owner installed a set of large cement cylinders like Estemie had at Constant Spring.

I took out my equipment to take a sample, but was discouraged by John and Devil. They promised I could get a rough estimate of the salt content if I would "just taste it." I reluctantly did so, and was surprised to find they were right; it wasn't completely saltwater, but it certainly wasn't

fresh either. Chloride tests later proved the water at Hermitage Spring was 10,000 ppm.

On the way back, Devil asked me to meet him the next day. He wanted to take me to a place called "Point Cistern," where freshwater supposedly springs from a hole in the rocks. We set a time and then I said good-bye to John and Devil. I was tired but eager to start the next day.

Table 4-6. Measurements of spring sampled during the Hermitage Trek.

<i>Name of water source</i>	<i>Distance from coast, m (and ft)</i>	<i>Water depth below surface, m (ft)</i>	<i>Water chloride content (ppm)*</i>
Hermitage Spring	58.5 (192)	1.4 (4.5)	10,000

* Potable water = 2,000 ppm

The Point Cistern Trek

When I caught up with Devil in the morning (6 July, 1995), we took off immediately. He said we needed to "make a move" if we were going to get back at a reasonable time -- evidently Point Cistern was a long way off. During the walk we stopped to see one of his friends so I could test his backyard well which was 609.6 m (2,000 ft) from the coast (figure 4-4).

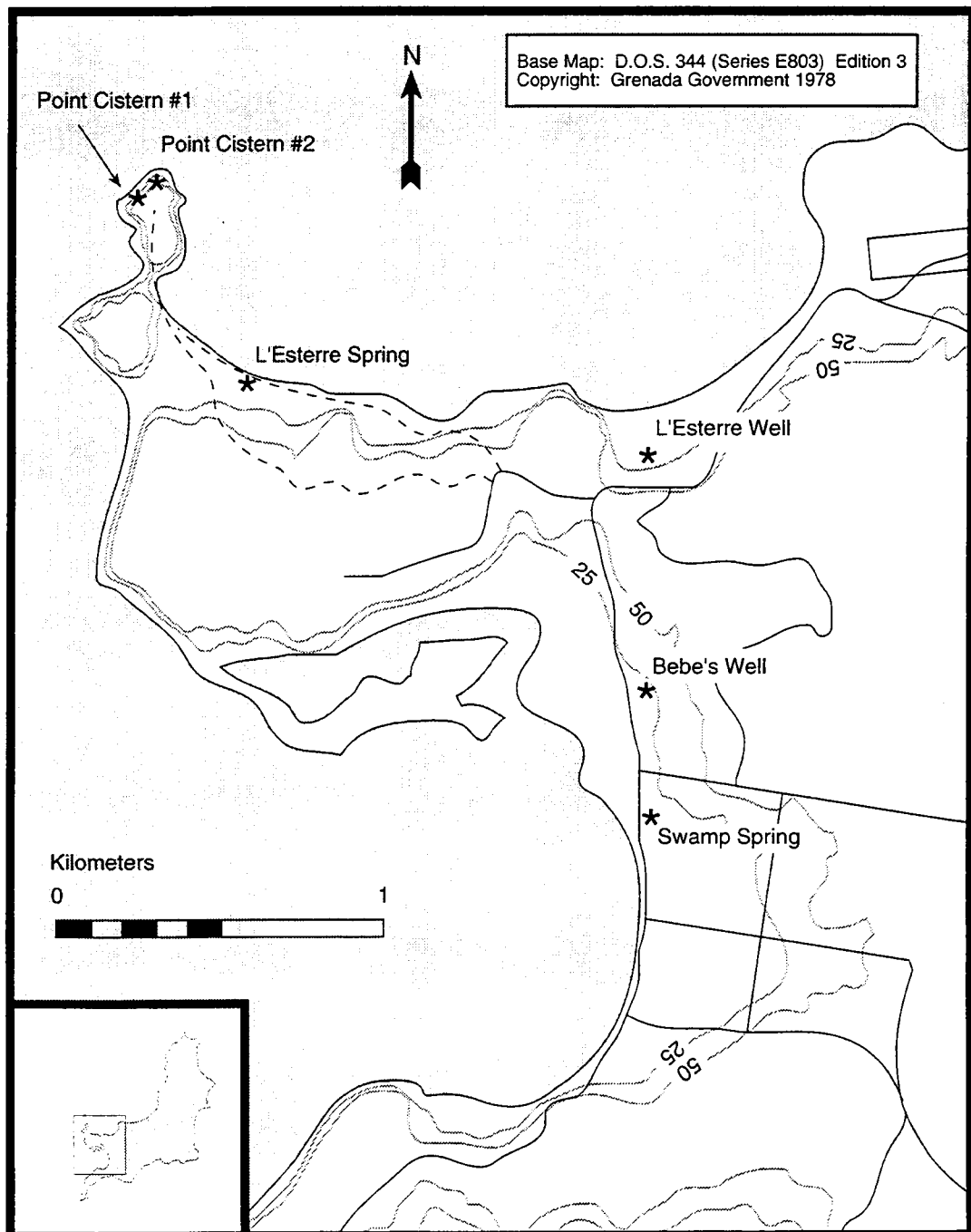


Figure 4-4. Sites visited during the Point Cistern trek

Devil got permission from "Bebe" and as we went back behind the house, he explained how it used to be a pond but kept filling in. Bebe finally dug it out and installed a cement casing to keep the sides from further collapsing. "Now, water springs back up," he said. I did my routine tests (the depth was 1.8 m -- 6 ft -- and the chloride was 1,000-2,000 ppm), and we were off again.

We marched north up the hill toward L'Esterre, turned west, went up another hill and cut to the northwest into the thickets. The trek to Point Cistern was over rigorous terrain, making for a long and difficult hike. Devil told me "everybody knows Point Cistern," yet they find it to be strange since the freshwater is so close to the sea. And it *is* drinkable, he emphasized: fishermen use it to drink and cook, and he said that "if boat break down and you thirsty, come here to get water to drink." As I wrote furiously in my notebook, he often stopped to re-clarify certain points, wanting to make sure I fully understood his meaning.

Eventually we got to a thin peninsula, and I stayed on top while Devil scampered down the northwest cliff-face to confirm the location of the water supply. When he yelled, I followed him, careful to follow his exact path of descent. We found ourselves at the bottom of the cliff,

about 10 feet from the crashing surf, but separated from it by a high mass of rocks. This was an unlikely spot for a freshwater source, but Devil insisted we had arrived. I looked around and saw that the seaward facing rock had sheared off the mainland, collapsing and settling to form the present landscape. A three to four foot crack remained between the rocks, and it was in here that Devil was pointing.

There was water at the base between the rocks. Devil tasted it and told me it was fresh, though admitting it was a little brackish. I tasted it too. He was right! Tests confirmed a chloride level at "Point Cistern #1" of 2,000-5,000 ppm (figure 4-4). But why was this relatively fresh water source this close to the sea? I examined the cracks in the cliff-face and figured freshwater must have dripped down from above and collected into this natural catchment. The water got a little saline from the ocean's salt spray.

But Devil seemed irritated; he didn't think this was the "right one," rather there must be another catchment around close. We searched for a while and, indeed, found another catchment higher on the cliff to the east, perhaps 15.2-22.9 m (50-75 ft) above the sea. "Point Cistern #2" appeared to be more of a cave than a rainwater catchment (figure 4-4).

The water came from inside the cave, and discoloration on the cliff below suggested that water frequently flowed over the lip at the cave entrance. Devil and I tasted the water and found it was very good! (Chloride testing later proved it to be 200-2,000 ppm.) Considering the quality and quantity of water here, we presumed this must be the "right" Point Cistern.

On our way back, Devil and I took a different route, this time walking along the coast at L'Esterre Bay where we stumbled upon a pond (figure 4-4) that was only 7.6 m (25 ft) from the sea! I hastily pulled out a glass vial to get a sample, but taste tests proved it was far from drinkable (L'Esterre Pond chloride: 20,000 ppm). Nevertheless, Devil wanted to see if there was some fresh groundwater further inland, and he took my military shovel to dig a hole approximately 24.7 m (81 ft) from the shore (L'Esterre Spring, figure 4-4).

This was the first time I saw someone else dig a hole, and I was surprised to see that he did it differently than I had. Instead of using the shovel in the traditional two-fisted method, he grasped the back handle with one hand and thrust the blade into the ground, twisting it with one motion to separate the soil, and scooping it out by hand with another. Then he waited. "I'm looking for the vein," he said, explaining that water

below the ground flows in veins, like in the human body. When you dig a pit you have to tap into the vein, sort of how a nurse draws blood out of your arm. I silently disagreed: I thought you simply dug a hole, and the level at which you eventually hit water was the water table. I would be proved wrong.

Devil stared into the hole intently, waiting for water to dribble out of the pit wall. He saw some, pointed it out to me, and dug diagonally into that part of the wall. After a few minutes of false starts he found his "vein," and I learned first-hand why they call these springs -- the water truly springs from the ground! It filled up the hole perhaps a quarter of the way, and Devil tasted it, instructing me to get a sample. Alas, after all that work it was too brackish to drink (L'Esterre Spring depth: not recorded; chloride: 20,000 ppm).

The "vein" Devil tapped needs further examination. Without having studied them, I can only assume that since soil and rock have variable permeabilities (see, for example, Todd 1980; Hausenbuiller, 1985; Custodio 1987a; Manning, 1987; and Heath, 1988), the amount and speed through which the water flows will be dependent upon these

properties. The variability of soil and rock composition and distribution translates into variable water access by well diggers.

After filling the hole, we continued our hike along the coast, then turned south and scrambled up a steep slope. Emerging at the top of the hill, I realized we were in L'Esterre village. I asked Devil if he wanted to rest and he nodded, taking us to Uncle Tom's rum shop. He walked -- I stumbled -- into the shop and quickly ordered two beers. He then enthusiastically began to tell Uncle Tom (pers. comm., 1995) what we had been doing. During the conversation, the bartender informed me that when he was younger, he and his friends would play out around Point Cistern, and would always go to that place to get a drink. "So that's been there a while?" I asked. Oh yes, he said. And the water never goes dry either -- even during the worst dry season. "The only problem is that it's very difficult to get a bucket of water back from Point Cistern."

After a few drinks, we left Uncle Tom and stopped by to see the L'Esterre village well (figure 4-4), which was 1.5 m (5 ft) deep with a 2,000 ppm chloride level, before heading back to Harvey Vale. On our walk back, I thanked Devil, telling him how much I appreciated his time and assistance. He said we weren't done. If I came back tomorrow, he'd take

me across the island to show me many other wells. Naturally, I agreed to come back.

Suddenly, he grabbed my shovel and was off in the woods digging another hole (Swamp Spring figure 4-4). I followed. Devil was digging on fairly damp soil, so we both knew water must be nearby. But I was beginning to learn more about where salt and freshwater could be found, and suggested the water would probably be pretty salty at this location. He agreed, but he wanted to try it anyway. Devil dug this hole in the same way as the last one, but it took longer for him to find the "vein." Eventually he tapped a weak one at 0.5 m (1.8 ft), and tasted it to be salty (Harvey Vale Swamp: 10,000-20,000 ppm). We finished our walk to Harvey Vale, where Devil cleaned off my shovel for me and I hailed a transport to take me back to Hillsborough.

As I spent more time with Devil, I became aware that his understanding of groundwater dynamics was fairly accurate. He knew rainwater came from the mountain and "penetrates the soil," as he puts it. I asked Devil one time how he knew where to dig for water. He offered me an example. If you pour water on a hill, where does the water go? Down the hill. If you want to find water, you don't dig at the top of the hill,

but at the bottom: "I don do anything by guess. I jus watch to see if look like water over deah [there]." He correctly told me that "heavy rains cause it [the water table] to rise up," and that long dry spells force the water to sink lower, deeper into the soil.

Table 4-7 shows the now distinctive increase in distance between the surface and the water table and decrease in salinity with greater coastal distance.¹¹

Table 4-7. Mainland water sources found during the Point Cistern Trek.

<i>Name of water source</i>	<i>Distance from coast, m (and ft)</i>	<i>Water depth below surface, m (and ft)</i>	<i>Water chloride content (ppm)*</i>
L'Esterre Spring	24.7 (81)	(not measured)	20,000
Swamp Spring	76.2 (250)	0.5 (1.75)	10,000-20,000
L'Esterre Well	121.9 (400)	1.5 (5)	2,000
Bebe's Well	609.6 (2,000)	1.8 (6)	1,000-2,000

* Potable water = 2,000 ppm

Table 4-8 is given for the convenience of the reader. Although Point Cistern does not conform to the Potstack System, it does suggest there are many other water supplies that might have been used by the Amerindians in the Eastern Caribbean that need to be examined further.

¹¹ L'Esterre Pond is excluded from the table for reasons discussed previously.

Table 4-8. Peninsula water sources found during Point Cistern Trek.

<i>Name of water source</i>	<i>Distance from coast, m (and ft)</i>	<i>Water depth below surface, m (and ft)</i>	<i>Water chloride content (ppm)*</i>
Point Cistern #1	3.0 (10)	n/a	2,000-5,000
Point Cistern #2	0.0**	n/a	200-2,000

* Potable water = 2,000 ppm

** As this was located on a cliff overlooking the ocean, it is virtually "on" the coast.

The Trek across Carriacou

I did not know that when I met Devil the next morning (7 July, 1995), our hike was going to be an 11 hour march across the central backbone of Carriacou, over to the Southeast part of the island, and up much of the windward coast (see figure 4-5 for a map of the whole trip). First we headed east over the mountain, turning northeast when we reached the top. Hiking to Six Roads, we then turned southeast to Dumfries. There we saw the Lime Factory well which was 228.6 m (750 ft) from the coast, and 1.2 m (4 ft) deep with a chloride level of 1,000-2,000 ppm (figure 4-5).

A walk through an old cemetery brought us to the coast, where we eventually found what looked to be two old colonial wells (figure 4-5). By now I wasn't surprised to find that they were located in the bottom of a

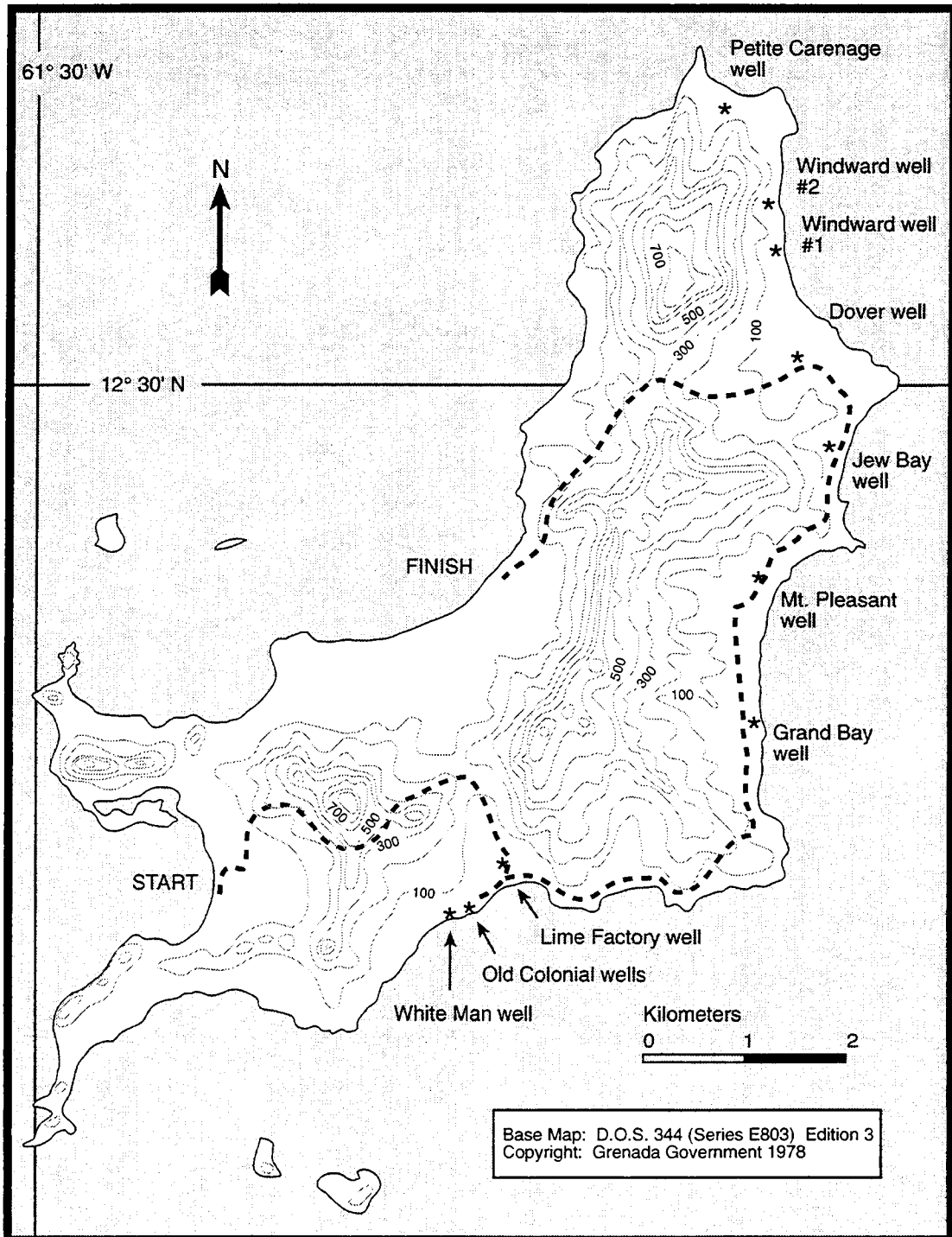


Figure 4-5. Sites visited during the Trek across Carriacou. (Includes wells along the northeast coast, as mentioned in text)

dried up stream bed; the water should be relatively close to the surface here. Devil thought there was an operating well close by, and after consulting the topographic map, we found the one he was talking about (figure 4-5). He said it was called "White Man Well," and like the other now-defunct wells, it was located at the bottom of a dried up stream bed.¹² I was surprised to find White Man with a low salt content of 1,000-2,000 ppm (depth: 2.2 m; 7.3 ft), even though it was about 62.2 m (204 ft) from the sea! Intrigued, I began to wonder if this wouldn't be a better place to dig a series of test pits than at the Constant Spring location. Later I decided to do just that.

We left White Man and walked north along the windward coast, first stopping at a well in Grand Bay (figure 4-5). This well was on a steep rise only 25 m (82 ft) away from the sea, with a depth of 4.3 m (14 ft) and a chloride level of only 2,000-5,000 ppm! After leaving Grand Bay, we visited wells at Mount Pleasant, Jew Bay, and Dover (figure 4-5). The Mount Pleasant well was farther away (144.8 m; 475 ft) from the sea than Grand Bay or White Man, so I expected lower chloride levels. Tests

¹² Over time, the channel of the stream has shifted to the southwest, so now the well appears to be sitting on a slight rise. But I don't think this was the case when it was originally constructed.

confirmed 1,000-2,000 ppm, with a depth of just 2.4 m (7.8 ft). The Jew Bay well was not shown on the Carriacou topographic map, even though it was fairly large.¹³ The water level was 3.6 m (11.8 ft) below the surface, with a chloride level of 2,000-5,000 ppm. The Dover well tested with a very low salinity of 200-1,000 ppm, and had a depth of 3.6 m (11.8 ft).

We left Dover well and hiked the long march home in the dark. Finally we got to my guest house, and I gave Devil some money for a transport back to Harvey Vale, thanking him very much for his tremendous help. For the first time, he seemed as tired as I was!

The closest well to the sea is at Grand Bay, and as expected, it has the highest chloride content. I found no appreciable chloride change between the White Man and Lime Factory well water, even though the distance-to-coast increased from 62.2 m (204 ft) to 228.6 m (750 ft). Dover well is extraordinarily fresh, with a 200 ppm chloride content. The Jew Bay well is odd, though, with a relatively high salinity of 2,000-5,000 ppm where other wells of similar distance from the sea had 1,000-2,000

¹³ "Well" might not be the best word to describe this feature: I didn't accurately measure its size, but estimated the Jew Bay well to be 15.2 m (50 ft) long and 9.1 m (30 ft) wide. I met Mr. Winston Flary (pers. comm., 1995), from Windward, Carriacou, who told me this well was built by slaves in 1710 for John Monroe, esq. (1753 d.). He called it "The Negro Well." The plans for the great house (located next to the well) are supposedly in Scotland.

ppm levels. I think evaporation might be the cause: the well's size exposes a larger surface area, and with few overhanging trees provides fairly limited shade. The proportional evaporation rate might be higher than at other locations, even though the larger surface area collects more rainwater. More likely, though, the differences can be attributed to variations in the water flow rates through rock and soil with different hydraulic conductivities.

Table 4-9. Wells sampled during the Trek across Carriacou.

<i>Name of water source</i>	<i>Distance from coast, m (and ft)</i>	<i>Water depth below surface, m (and ft)</i>	<i>Water chloride content (ppm)*</i>
Grand Bay	25 (82)	4.3 (14)	2,000-5,000
White Man	62.2 (204)	2.2 (7.3)	1,000-2,000
Mt. Pleasant	144.8 (475)	2.4 (7.8)	1,000-2,000
Jew Bay	152.4 (500)	3.6 (11.8)	2,000-5,000
Lime Factory	228.6 (750)	1.2 (4.0)	1,000-2,000
Dover	243.8 (800)	3.6 (11.8)	200

* Potable water = 2,000 ppm

Later that week I went out to check some of the wells in the northeast part of the island that Devil and I had not visited (figure 4-5). Windward wells #1 and #2 are perhaps 400 m (1,312.4 ft) from each other, and on the west (landward) side of the road. Since #2 is further

from the coast -- 68.6 m (225 ft) vs. 30.5 m (100 ft) -- I expected it to be a deeper well and have a lower salt content. Results shown in Table 4-10 confirm this assumption. But although the Petite Carenage well is farther from the coast and has a lower salinity than the Windward wells, its water level is much closer to the surface. Perhaps a very large rainwater catchment basin upslope could account for this difference.

Table 4-10. Well measurements from Carriacou northeast coast

<i>Name of water source</i>	<i>Distance from coast, m (and ft)</i>	<i>Water depth below surface, m (and ft)</i>	<i>Water chloride content (ppm)*</i>
Windward #1	30.5 (100)	3.4 (11.2)	2,000-5,000
Windward #2	68.6 (225)	3.9 (12.8)	2,000
Petite Carenage	213.3 (700)	2.5 (8.2)	1,000-2,000

* Potable water = 2,000 ppm

Digging pits C, D, E, and F at White Man well

I returned to White Man well (figure 4-5) to dig a series of pits along a transect within the dried up stream bed. As related earlier in the chapter, I originally thought the water table could be found by digging straight down through increasingly saturated soil until I encountered a well defined water level. Devil had shown me that my original idea seemed to

be incorrect. Pits "C-F" did not work out the way I had predicted either. Instead, I found a small trickle of water from a "vein" that slowly seeped out from the pit wall. Deepening the hole did not seem to increase the water discharge rate. Rather, pursuing (digging into) the "vein" slightly increased the water flow. When I left the pit alone and came back later, I found the water had collected in the bottom of the pit, rising to a particular level.

I thought I needed to dig much deeper, perhaps 1.8-3.0 m (6-10 ft), to hit the water table that I was expecting to find. But Devil had insisted that this was the way all wells worked -- the digger must tap a "vein." Although I did not have a chance to observe well construction personally, Devil's belief was confirmed by another person, John Gabriel (pers. comm., 1995), whom I met while I was constructing the White Man pits. He showed me the holes in the White Man well casing that allowed the "vein water" to infiltrate the well. Every now and then, John explained, the veins get clogged and the owners throw lit dynamite "caps" into the well to blow them back open.

When digging "C" I got to a depth of 0.4 m (1.3 ft). A vein started to seep in at 0.3 m (0.9 ft), eventually filling the pit up to 0.1 m (0.3 ft) below

the surface. Pit "D" was similar: I dug the pit to 1.0 m (3.3 ft) in a vain attempt to find a saturated soil layer and the water table. Instead, a vein seeped in at 0.7 m (2.3 ft) eventually filling the hole to 0.5 m (1.6 ft) below the surface. Pit "E" was 0.8 m (2.5 ft) deep, but the water slowly collected and rose a few inches to a final depth of 0.7 m (2.2 ft) below the surface. In pit "F" I encountered extremely rocky soil and reached a depth of 0.9 m (2.8 ft), but was unable to find water.

As noted in Table 4-11, all four pits were dug along a transect from the shore; at 8.8 m (29 ft), 27.4 m (90 ft), 41.5 m (136 ft), and finally 57.9 m (190 ft). Three of the four pits contained water. I expected to find a significant drop in water salinity since the nearby White Man well had water with 1,000-2,000 ppm chloride, but instead found water samples from all three pits to be salt water. Supporting the Potstack System, however, was the increasing distance between the water and ground surface, from 0.1 m (0.3 ft) to 0.7 m (2.2 ft) between pits C and E, to a depth of 2.2 m (7.3 ft) at the White Man well itself.

Table 4-11. Measurements of pits dug at White Man well.

<i>Name of water source</i>	<i>Distance from coast, m (and ft)</i>	<i>Water depth below surface, m (and ft)</i>	<i>Water chloride content (ppm)*</i>
Pit C	8.8 (29)	0.1 (0.3)	20,000
Pit D	27.4 (90)	0.5 (1.6)	20,000
Pit E	41.5 (136)	0.7 (2.2)	20,000
Pit F	57.9 (190)	n/a**	n/a**
White Man	62.2 (204)	2.2 (7.3)	1,000-2,000

* Potable water = 2,000 ppm

** Not applicable; water was not found.

The end of my work on Carriacou

My days on the island would soon be over. I spent the rest of my time going back to test some of the wells mentioned earlier in the chapter. I thanked all my friends, knowing that I would not have been able to learn as much about Carriacou groundwater without their help. I packed my bags and with the next plane, flew to Barbados.

Barbados Fieldwork

Problems from the beginning

Although the fieldwork on Carriacou was successful in supporting the Carriacou hypothesis, I had yet to find freshwater on my own. Hence,

when I arrived on Barbados (15 July, 1995) for my one week stay, I was committed to finding an acceptable place to dig. I thought the most efficient way to pick a site was to contact someone in the government who knew something about the groundwater supplies. Since this island is larger and more “industrialized” than Carriacou, I was optimistic I’d find what I needed. I was wrong.

I spent most of my time on Barbados calling and re-calling various officials. Days passed as I tried to set up an appointment to see someone who could provide me with some leads. Nothing happened. Finally, I made contact with Mr. David Croney (pers. comm, 1995), a former employee for the Barbados government in the Environmental Management division. I explained my research and he became very interested, immediately providing me with some contacts.

Dr. Mwansa and the freshwater anecdotes

On 21 July, I met with Dr. John Mwansa (1995), the project manager for the “Water Resources Management and Water Loss Studies,” which is an 18 month program working on evaluating Barbados’ quantity, quality, and distribution of water, and the reuse of wastewater.

He would surely have the answer to my problem -- all I wanted was current information on salinity and coastal groundwater levels. I could merely examine the groundwater maps his project had constructed and dig in coastal locations where there was freshwater close to the surface. But my hopes were soon dashed. Dr. Mwansa told me he'd be able to give me all that information, but I'd have to wait a few months: the project had only started the week I arrived on the island. Instead, he gave me the titles of two rare documents (Senn, A. 1946. *Report of the British Union Oil Company Limited on Geological Investigations of the Ground-Water Resources of Barbados, B.W.I.*; and Stanley Associates Engineering, Inc. 1978. *Barbados Water Resources Study, vol. 3: Water Resources and Geohydrology*. Edmonton, Alberta.) that have information on Barbados groundwater resources. "I doubt they have exactly what you're looking for, but they might help," he said. Dr. Mwansa said he would rather not lend me his personal copies, for they were the only ones he had and needed them for work. He suggested I might be able to find them when get back to the United States.

Dr. Mwansa apologized and I thanked him for his time. Getting up to leave, he stopped me and said, "But you know, I seem to remember

Nick Sealy tell a story that seemed related to your work.” Mr. Sealy was the former General Manager of the Barbados Water Authority, and had talked about freshwater bubbling up through the sea near the Oistins police station (figure 4-6). And when Mr. Sealy was a small child, he and his friends had often gone swimming at the beach and frequently drank the freshwater coming right out of the sand.

I heard similar stories repeated by some other Barbados residents. I met Mr. Woody Richardson (pers. comm., 1995), who -- 22 years ago -- was the former Superintendent of the Barbados Water Works (the old name of the current Water Authority). He said that sometimes at Paradise Beach, on Freshwater Bay (figure 4-6), you can “dig in the sand and drink freshwater from it if you are thirsty.” Mr. Cassious St. John (pers. comm., 1995), of the Barbados Agriculture and Marketing Association, said he and his friends would play in the freshwater that came out of the ground at South Point (figure 4-6). And some friends of mine, Mr. Jeff Griffeth (pers. comm., 1995) and Mr. Derek Southerland (pers. comm., 1995), said that the water table on the Barbados west coast is so close to the surface the fresh groundwater can “come right out of the beach sand.” They said

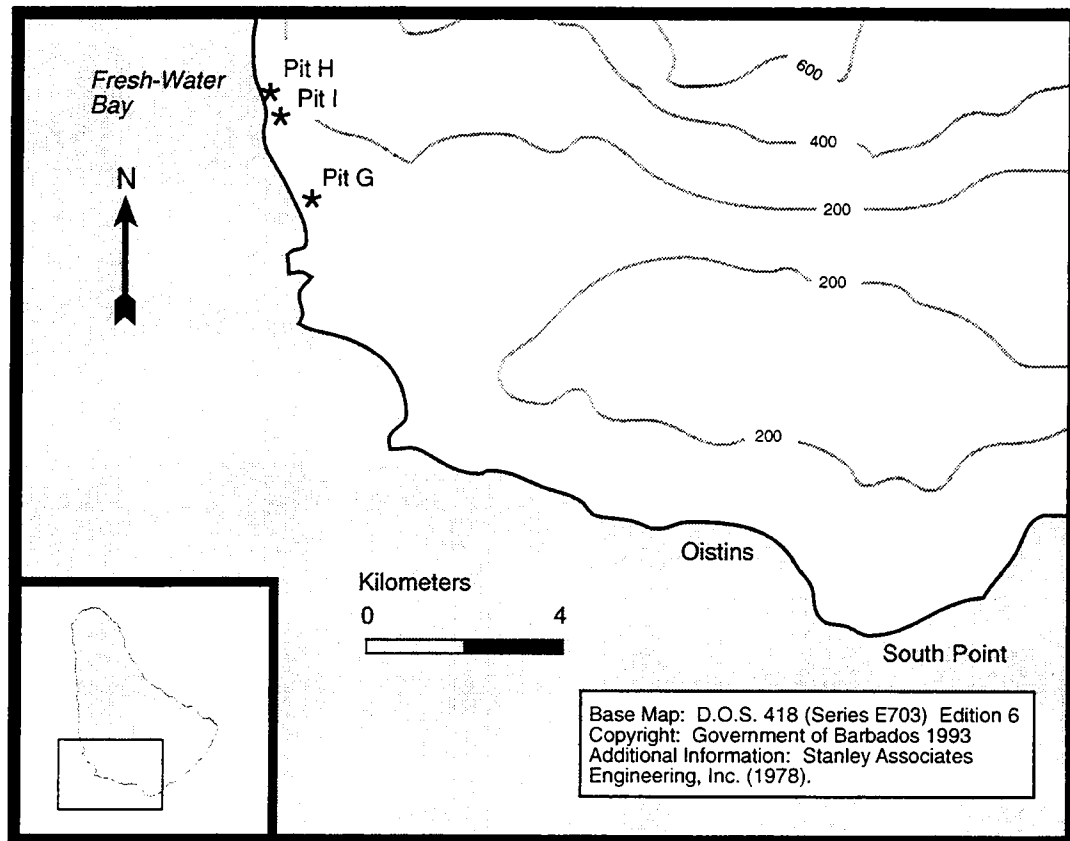


Figure 4-6. Barbados: southwest coast. (Includes locations of pits, as mentioned in text)

when swimming you can tell freshwater is discharging into the sea because it feels colder than the surrounding ocean water.

Digging pits G, H, and I at Brandons and Freshwater Bay

Given my limited ability to find information on Barbados coastal well water levels, I decided to trust these anecdotes and dig a couple of pits on the western coast. I went out with Mr. St. John and dug pit “G” in a swampy area at Brandons, approximately 63.1 m (207 ft) from the ocean (figure 4-6). After going through 0.5 m (1.5 ft) of soil we quickly encountered sand, and at 0.6 m (2.1 ft) found water! Later tests showed it had a salinity of 5,000 ppm -- undrinkable, but the freshest water collected so far during my excavations.

I dug my last two pits on Paradise Beach, Freshwater Bay. I expected to dig along another transect here, so I located Pit “H” only 6.7 m (22 ft) from the coast (figure 4-6). The walls often collapsed and I wasted valuable time re-digging the hole, but I eventually dug to 1.7 m (5.5 ft) and found water (20,000 ppm). Since I still hadn’t found freshwater, I decided digging along a transect would take too long (my time on Barbados was getting very short) and chose one last pit (“I”) in the

bottom of a dried up stream bed (figure 4-6). This one was farther from the ocean (48.5 m; 159 ft) than the last pit, and after digging 1.7 m (5.7 ft) I started pulling up very saturated sand. I began to think I would finally find freshwater! I tried to dig deeper, but shortly realized that too many rocks and boulders prevented me from going any farther. Only a backhoe could clear out the rest of the hole.

Table 4-12. Measurements of pits along the Barbados southwest coast.

<i>Name of water source</i>	<i>Distance from coast, m (and ft)</i>	<i>Water depth below surface, m (and ft)</i>	<i>Water chloride content (ppm)*</i>
Pit G	63.1 (207)	0.6 (2.1)	5,000
Pit H	6.7 (22)	1.7 (5.5)	20,000
Pit I	48.5 (159)	1.7 (5.7)	n/a**

* Potable water = 2,000 ppm

** Not applicable; water was not found.

The end of my work on Barbados

I left Barbados without finding freshwater. But what I learned about modern water practices from the residents of Carricou and Barbados lent credence to the Carriacou hypothesis and the Potstack System *despite* the fact that I had not found freshwater myself. I'm convinced additional

groundwater information and further digging would yield the results I had been seeking.

Conclusions

Fieldwork shows that digging for near-shore freshwater is not only feasible, but a common practice among Carriacou residents. In fact, the absence of deep drilling equipment forces them to dig only shallow wells. They know a water table exists close to the surface near the sea, and subsequently locate their wells within a relatively short distance from the island coastline, striking a balance between water depth and salinity.

Most of the wells seem to follow a particular pattern, being positioned in low, flat areas along the coast, at the mouth of a large drainage basin, or sometimes in the channels of intermittent streams (see figures 4-7 and 4-8). These are optimal locations that take advantage of the natural drainage of surface and subsurface water, and mimic the way East Africans access valley springs below their settlement areas (White, et al., 1972).

My measurements of the Carriacou wells and test pits show that, in general, the Potstack System presented in Chapter 3 is an accurate

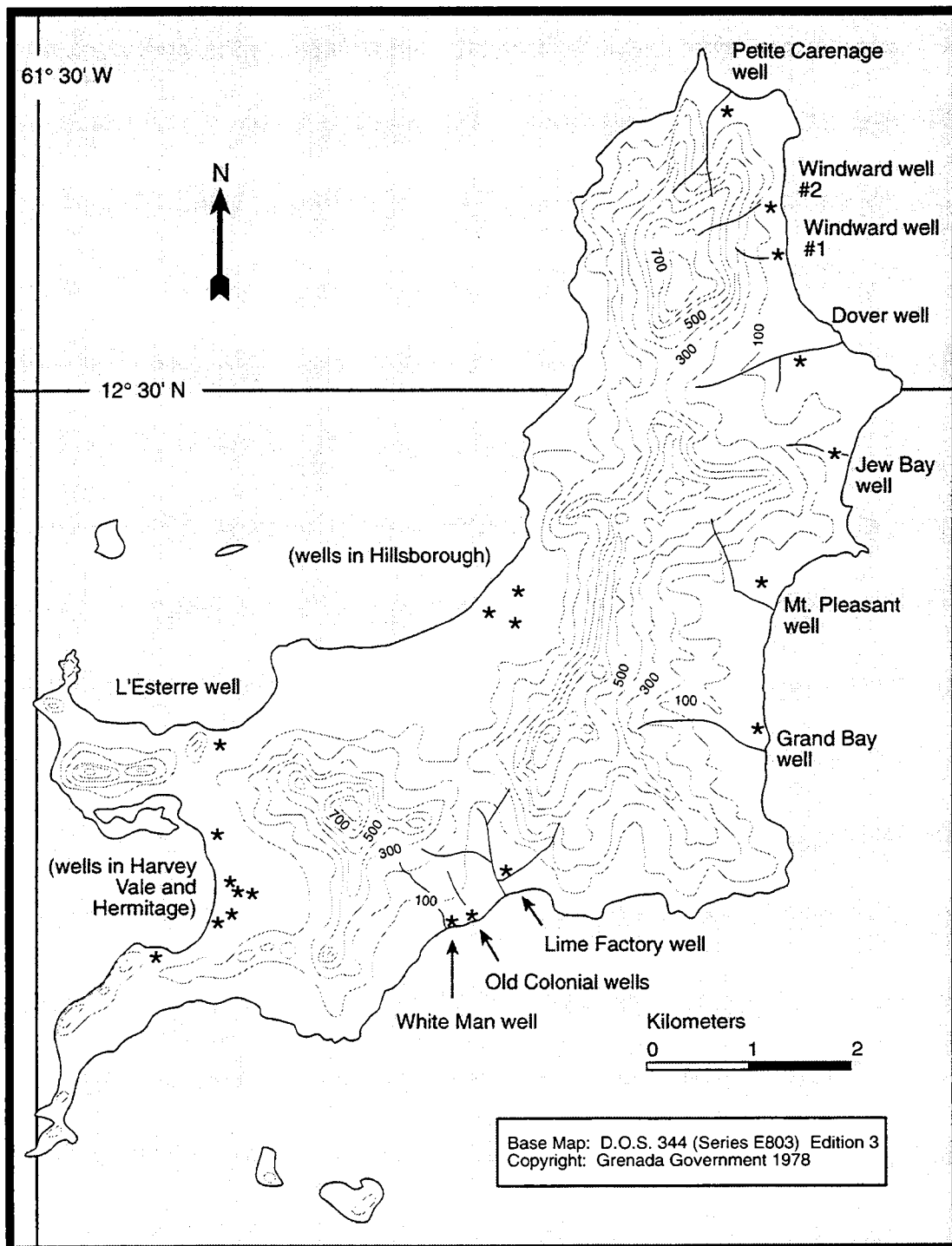


Figure 4-7. Topographic map showing all the wells visited during Carriacou fieldwork. (Relevant intermittent streams shown)



Figure 4-8. White Man well, facing southeast. (Intermittent streambed is at far right)

Source: Schultz, C.S. 1995. Photograph of White Man well, Carriacou, Grenada, West Indies. In possession of the author.

representation of reality: fresher subsurface water is found deeper below the surface with increasing distance from the shoreline (table 4-13).

However, this only holds true for wells close to one another. A distance of 100 m (328.1 ft) from the coast may be an acceptable location to tap freshwater in one place, but on the other side of the island it may be necessary to move 300 m (984.3 ft) away to find water with the same salinity. As noted earlier, these spatial differences could be caused by permeability variations in the soil and rock, type and amount of vegetation covering the surface, and/or basin catchment size.

I did not find drinkable water in my test pits; the one at Brandons, Barbados (pit G) was closest with a chloride level of 5,000 ppm. Rather, my personal experience in pit construction made me recognize the problems associated with wells and appreciate the need for a well casing - especially to prevent pit collapse. In my treks over Carriacou, I found that deeper, machine-dug uncased wells exhibited similar, if not more dramatic, wall collapse. I suspect the freshwater tables on Carriacou and Barbados have changed since prehistoric times, drawn down by high use, disappearance of indigenous vegetation, and increase in impermeable

Table 4-13. Summary of measurements on Carriacou and Barbados. (Sorted by order noted in text and distance from coast).

<i>Name of water source</i>	<i>Distance from coast, m (and ft)</i>	<i>Water depth below surface, m (and ft)</i>	<i>Water chloride content (ppm)</i>
CARRIACOU			
<u>Harvey Vale</u>			
Steel Drum Well	182.9 (600)	2.4 (8.0)	2,000
Lower Digpond Well	228.6 (750)	2.7 (8.7)	2,000-5,000
Upper Digpond Well	335.3 (1,100)	5.9 (19.3)	200-1,000
<u>Hillsborough</u>			
Playground Well	65.5 (215)	2.4 (7.8)	1,000
N. Hillsborough Well	152.4 (500)	5.9 (19.3)	5,000
Church Well	381.0 (1,250)	3.8 (12.4)	1,000
<u>Constant Spring</u>			
Pit A	1.5 (5)	0.3 (1.1)	20,000
Pit B	4.9 (16)	1.2 (3.8)	10,000-20,000
Constant Spring	17.4 (57)	2.2 (7.1)	10,000
Bedeau's Spring	182.0 (600)	2.3 (7.6)	2,000-5,000
<u>Hermitage Trek</u>			
Hermitage Spring	58.5 (192)	1.4 (4.5)	10,000

Table 4-13. (continued)

<i>Name of water source</i>	<i>Distance from coast, m (and ft)</i>	<i>Water depth below surface, m (and ft)</i>	<i>Water chloride content (ppm)</i>
<u>Point Cistern Trek Mainland</u>			
L'Esterre Spring	24.7 (81)	(not measured)	20,000
Swamp Spring	76.2 (250)	0.5 (1.75)	10,000-20,000
L'Esterre Well	121.9 (400)	1.5 (5)	2,000
Bebe's Well	609.6 (2,000)	1.8 (6)	1,000-2,000
<u>Point Cistern Trek Peninsula</u>			
Point Cistern #1	3.0 (10)	n/a	2,000-5,000
Point Cistern #2	0.0 (0.0)	n/a	200,2,000
<u>Trek across Carriacou</u>			
Grand Bay Well	25.0 (82)	4.3 (14)	2,000-5,000
White Man Well	62.2 (204)	2.2 (7.3)	1,000-2,000
Mt. Pleasant Well	144.8 (475)	2.4 (7.8)	1,000-2,000
Jew Bay Well	152.4 (500)	3.6 (11.7)	2,000-5,000
Lime Factory Well	228.6 (750)	1.2 (4.0)	1,000-2,000
Dover Well	243.8 (800)	3.6 (11.7)	200
<u>Carriacou northeast coast</u>			
Windward Well #1	30.5 (100)	3.4 (11.2)	2,000-5,000
Windward Well #2	68.6 (225)	3.9 (12.8)	2,000
Petite Carenage Well	213.3 (700)	2.5 (8.2)	1,000-2,000

Table 4-13. (continued)

<i>Name of water source</i>	<i>Distance from coast, m (and ft)</i>	<i>Water depth below surface, m (and ft)</i>	<i>Water chloride content (ppm)</i>
<u>White Man</u>			
Pit C	8.8 (29)	0.1 (0.3)	20,000
Pit D	27.4 (90)	0.5 (1.6)	20,000
Pit E	41.5 (136)	0.7 (2.2)	20,000
Pit F	57.9 (190)	n/a**	n/a**
White Man Well	62.2 (204)	2.2 (7.3)	1,000-2,000
BARBADOS			
<u>Barbados west coast</u>			
Pit G	63.1 (207)	0.6 (2.1)	5,000
Pit H	6.7 (22)	1.7 (5.5)	20,000
Pit I	48.5 (159)	1.7 (5.7)	n/a**

* Potable water = 2,000 ppm or less

** Not applicable; water was not found.

Source: All measurements made by Christopher S. Schultz during June-July, 1995, fieldwork.

surfaces. The latter two factors reduce the amount of rain that recharges the groundwater by increasing surface runoff.

When placed in context, I can understand why Mrs. Andrews thought the bottomless stacked pots might have been an Amerindian well casing. From her perspective, near-coast freshwater wells are used all the time, so when she found freshwater springing up through the bottomless stacked pots, it was easy for her to visualize the Amerindians 1,500 years ago using a water collection technique so common in her own day. It is even a possibility that the knowledge she carries was passed down, generation to generation, from the early days of contact between African-Carriacou people and Amerindian-Carriacou people.

Finally, the bottomless stacked pots closely resemble a steel drum well Devil showed me in Harvey Vale. I suggest these two features may be related, with the modern use of steel drum casings deriving from earlier technology that may be traced back to European stacked barrels or even Carriacou stacked pots.

CHAPTER 5

SUMMARY

Freshwater procurement is a necessity for all humans. We all need water to drink, prepare our food, and accomplish numerous daily household tasks. In a dry environment, however, finding and maintaining the freshwater supply is a significant challenge. The Eastern Caribbean is one of these environments where recurring drought is a notable problem, especially for those people on the small, low lying islands. Hence, current island residents have been forced to develop multiple strategies to secure reliable freshwater supplies. But although researchers suggest recurring drought also afflicted the prehistoric indigenous peoples of this region, little research has been done on how the Amerindians managed their freshwater. My intention here has been to address this issue.

In my research, I explored the general method of tapping groundwater with lined wells for dry time water supply, specifically examining the possibility that bottomless stacked pots found on Carriacou and Barbados were freshwater well casings (as suggested by the

Carriacou hypothesis). I believe the Amerindians used these wells to tap into the edge of the island freshwater lens primarily during times of recurring drought.

In Chapter 1, I examined the phenomena of recurring drought in the Eastern Caribbean, and provided a geographic setting for the two islands in question. Chapter 2 gave a brief archaeological background of the Amerindians in the region, where I highlighted the lack of attention archaeologists have paid toward human domestic water management on small dry islands in the Eastern Caribbean. I then collected evidence documenting how groundwater has been used as a reliable water supply for various peoples throughout the world. In Chapter 3, I discussed the groundwater hydrology of small islands, emphasizing the human importance of the "freshwater lens." I presented the Potstack System theory as a way to explain how fresh groundwater can be accessed at island coastlines, and then I compared the System to what is known about Barbados hydrogeology (similar Carriacou information not being available). I suggested three ways to go about testing the efficacy of the Carriacou hypothesis and the Potstack System; and in the Chapter 4 narration, I described my results, documenting the ways current islanders

procure and manage freshwater. I tested the depth and salinity of near-coast wells, and then dug my own pits as a way to re-create the Amerindian experience of constructing coastal wells.

My documentation of current water practices proved particularly helpful. Over time, I slowly learned about the islanders' rather accurate understanding of groundwater dynamics, and I found that their procurement methods provide strong evidence supporting the Carriacou hypothesis and the Potstack System. When I completed my fieldwork, I left with no doubt that one can find fresh groundwater by digging shallow coastal wells.

Water depth and salinity measurements of many near-coast Carriacou wells generally supported the theory behind the Potstack System. With increasing distance from the coast, I found a relative increase in distance between the water table and the surface, and a decrease in water salinity. These results suggest that water tables can be accessed most easily in the coastal areas with low elevation, but there the water quality will be low. The greater the distance from the sea the fresher the water is likely to be, but factors such as soil and rock permeability and vegetation coverage also affect salinity and depth

readings. By balancing the two factors, one can find water fairly close to the surface with a reasonably tolerable salt content, as evidenced by many of the Carriacou wells. However, only wells within the same general area best exhibit this latter relationship; broad, across-island comparisons are inaccurate because of various differences in place-to-place morphology that influence the local availability of water.

My attempt to recreate Amerindian well digging was educational. Although I, myself, did not find freshwater using the method employed, I have a better understanding of where and how to construct shallow wells - - especially the need for a well casing to prevent pit-wall collapse.

Future Research

1. To complete this study it would be interesting to construct and test a potstack well over the course of several years to see how well it withstands use and seasonal changes in groundwater/seawater interactions. Another attempt should be made to dig for near-coast freshwater on Carriacou and Barbados. I'm convinced that by pinpointing near-surface water tables prior to pit construction, one would be able to

successfully simulate the Amerindian potstack method. The new Barbados water resources project should prove helpful in this regard.

It would also be useful to explore further the fact that the potstacks appear to have been made with old pots. As stated above, this suggests the technique was only used as an emergency strategy during extremely dry times. If the method were used more consistently, the Amerindians might have developed a better clay structure for the well casing. Similar assemblages found in the future should be examined carefully for dating purposes and to document any technical improvements. Very likely this method was only for emergencies when the Amerindians were willing to tolerate a saltier water supply from the coastal wells until better sources such as springs and running streams became available again.

2. It would be useful to explore more the possible links between the Eastern Caribbean potstacks and those found in Mexico and Ecuador. That these types of assemblages were found outside the Eastern Caribbean implies cultural diffusion rather than independent invention. Those researchers interested in diffusion might consider looking at the

bottomless stacked pots as a type of marker of technological diffusion and possibly of migration patterns.

3. I am especially interested in seeing the whole question of Amerindian freshwater procurement and management in the Eastern Caribbean explored more fully by historical geographers and archaeologists. Such research is essential to a comprehensive understanding of the human ecology of those who lived in this region before the age of European expansion.

I find that the bottomless stacked pots uncovered on Carriacou and Barbados, and elsewhere in the Caribbean, provide a window for comparison between the island peoples of prehistory and today regarding their similar attempts to resolve the universal human problem of water procurement. This thesis is the first step in a study of freshwater procurement and management by Amerindians in the Eastern Caribbean. It is also an attempt to demonstrate that "Critical Theory" can be used in geographic practice and that human and physical geography can be

successfully linked to provide researchers with additional tools to examine the world around us.

REFERENCES

REFERENCES

- Alexander, C. 1995. Carriacou Museum staff member. Personal communication during Museum tour, 4 July, Hillsborough, Carriacou, Grenada.
- Alexander, M. 1995. Resident of Carriacou, Grenada. Personal communication through 2-14 July.
- Allaire, L. 1980. On the Historicity of Carib Migrations in the Lesser Antilles. *American Antiquity* 45[2]:238-245.
- Allaire, L. 1984. A Reconstruction of Early Historical Island Carib Pottery. *Southeastern Archaeology* 3[2]:121-133.
- Allaire, L. 1995. Professor of Anthropology, University of Manitoba. Personal communication at the International Congress for Caribbean Archaeology, 27 July, Basse Terre, Guadeloupe, French West Indies.
- Anderson, K. and Gale, F. 1992. *Inventing Places: Studies in Cultural Geography*. Melbourne: Longman Cheshire, Wiley Halsted Press.
- Andrew, T. 1995. Owner of Uncle Tom's rum shop, L'Esterre, Carriacou, Grenada. Personal communication 6 July.
- Andrews, M. 1995. Owner of Constant Spring Guesthouse, Harvey Vale, Carriacou, Grenada. Personal communication through 4-11 July.
- Ashmore, W. 1984. Classic Maya Wells at Quirigua, Guatemala: Household Facilities in a Water-Rich Setting. *American Antiquity* 49[1]:147-153.
- Barton, G.T. 1953. *The Prehistory of Barbados*. Barbados: Advocate Co., Ltd.
- Beard, J.S. 1949. *The Natural Vegetation of the Windward and Leeward Islands*. Oxford: Oxford University Press.
- Beckles, H. 1990. *A History of Barbados: From Amerindian Settlement to Nation-State*. New York: Cambridge University Press.

- Bedeau, J. 1995. Resident of Carriacou, Grenada. Personal Communication in Harvey Vale, 5 July.
- Boomert, A. 1987. Notes on Barbados Prehistory. *Journal of the Barbados Museum and Historical Society* 38[1]:8-43.
- Bowen, E. 1747. *A New and Accurate Map of the Island of Antigua or Antego*. Providence: Manuscript in the John Carter Brown Library, Providence.
- Brochure, Ade's Dream Guesthouse. 1995. Hillsborough, Carriacou, Grenada.
- Bullen, R.P. and Bullen, A.K. 1972. *Archaeological Investigations on St. Vincent and the Grenadines, West Indies*. The William L. Bryant Foundation, American Studies. Report Number 8.
- Cant, R.V. and Weech, P.S. 1986. A Review of the Factors Affecting the Development of Ghyben-Hertzberg Lenses in the Bahamas. *Journal of Hydrology* 84:333-343.
- Carriacou Museum. 1994. Photograph of potstack taken by Dr. Lydia M. Pulsipher in March. In possession of the author.
- Clarke, R. 1993. *Water: the International Crisis*. Cambridge: MIT Press.
- Columbus, C. 1968. *The Journal of Christopher Columbus*. Trans. C. Jane. London: Anthony Blond.
- Cooper, H.H., Jr. 1959. A Hypothesis Concerning the Dynamic Balance of Fresh Water and Salt Water in a Coastal Aquifer. *Journal of Geophysical Research* 64[4]:461-467.
- Cosgrove, D. and Domosh, M. 1994. Author and Authority: Writing the New Cultural Geography. In *Place/Culture/Representation*, ed. J. Duncan and D. Ley, pp. 25-38. New York: Routledge.
- Croney, D. 1995. Former employee at Environmental Management division in the Barbados government. Personal communication through 19-23 July.
- Custodio, E. 1987a. Saltwater and Freshwater Inter-relationships under Natural Conditions. In *Groundwater Problems in Coastal Areas*, ed.

- E. Custodio and G.A. Bruggeman et al., pp. 14-96. Fleurus, Belgium: UNESCO.
- Custodio, E. 1987b. Effects of Human Activities on Saltwater-Freshwater Relationships in Coastal Aquifers. In *Groundwater Problems in Coastal Areas*, ed. E. Custodio and G.A. Bruggeman et al., pp. 97-111 Fleurus, Belgium: UNESCO.
- Davis, N.D. 1887. *The Cavaliers and Roundheads of Barbados, 1650-1652*. Georgetown, British Guiana: Argosy Press.
- de Las Casas, B. 1967. *Las Casas: In Defense of the Indians*. Trans. and ed. S. Poole. Dekalb: Northern Illinois University Press.
- Devas, R.P. 1964. *The Island of Grenada: 1650-1950*. St. George's, Grenada: Justin James Field, O.P. Bishop.
- Directorate of Overseas Surveys. 1978. *1:25,000 scale topographic map of Carriacou, Grenada, West Indies (D.O.S. 344; Series E803)*. Southhampton, England: Ministry of Overseas Development.
- Directorate of Overseas Surveys. 1993. *1:50,000 scale topographic map of Barbados, West Indies (D.O.S. 418; Series E703)*. Southhampton, England: Ministry of Overseas Development.
- Drewett, P.L. 1989. Prehistoric Ceramic Population Lifeways and Adaptive Strategies on Barbados, Lesser Antilles. In *Early Ceramic Population Lifeways and Adaptive Strategies in the Caribbean*, ed. P.E. Siegel, pp. 79-118. BAR International Series 506.
- Drewett, P.L. 1991. *Prehistoric Barbados*. London: Institute of Archaeology, University College London.
- Drewett, P.L. 1993. Further Contributions on Prehistoric Barbados, Including the First Evidence for Preceramic Peoples. *Journal of the Barbados Museum and Historical Society* 41:99-112.
- Duncan, J. and Ley, D. 1994. Introduction: Representing the Place of Culture. In *Place/Culture/Representation*, ed. J. Duncan and D. Ley, pp. 1-21. New York: Routledge.

- Dunne, T. 1988. Description of Runoff Processes. In *Perspectives on Water: Uses and Abuses*, ed. D.H. Speidel, L.C. Ruedisili, and A.F. Agnew, pp. 66-72. New York: Oxford University Press.
- Edwards, B. 1819. *The History, Civil and Commercial, of the British West Indies*, vol. 1. Reprinted by AMS Press, Inc, New York, 1966.
- England, S. 1995. Visiting Historical Archaeologist, University of Virginia. Letter to the author, 28 February.
- Evans, G.L. 1951. Prehistoric Wells in Eastern New Mexico. *American Antiquity* 17[1]:1-9.
- Falkland, A., ed. 1991. *Hydrology and Water Resources of Small Islands: A Practical Guide*. Paris: United Nations.
- Falkland, A.C. and Brunel, J.P. 1993. Review of Hydrology and Water Resources of Humid Tropical Islands. In *Hydrology and Water Management in the Humid Tropics: Hydrological Research Issues and Strategies for Water Management*, ed. M. Bonell, M.M. Hufschmidt, and J.S. Gladwell, pp. 135-163. New York: Cambridge University Press.
- Flary, W. 1995. Carriacou cattleman. Personal communication 12 July, at the Jew Bay well, Carriacou, Grenada.
- Forbes, R.J. 1955. *Studies in Ancient Technology*. Leiden: E.J. Brill.
- Gabriel, J. 1995. Resident of Carriacou. Personal communication, 10 July, at White Man well, Carriacou, Grenada.
- Gage, T. 1648. *A New Survey of the West Indies*, 2nd edn. London: J. Sweeting. 1655.
- Gallagher, P. 1976. La Pitia: An Archaeological Series in Northwestern Venezuela. *Yale University Publications in Anthropology*, Number 76.
- Goodwin, R.S. 1984. Water Resources Development in Small Islands: Perspectives and Needs. *Natural Resources Forum* 8[1]:63-68.
- Gould, R.A. 1977. Puntutjarpa Rockshelter and The Australian Desert Culture. *Anthropological Papers of the American Museum of Natural History* 54[1]:1-188.

- Green, F.E. 1962. Additional Notes on Prehistoric Wells at the Clovis Site. *American Antiquity* 28[2]:230-234.
- Griffeth, J. 1995. Bajan pilot for Leeward Islands Air Transport (LIAT). Personal communication 25 June through 1 June, in St. Johns, Antigua.
- Guadeloupe, G. 1995. Owner of G and G Construction. Personal communication at Kayak's Restaurant, 2 July, Hillsborough, Carriacou, Grenada.
- Guelke, L. 1974. An Idealist Alternative in Human Geography. *Annals of the Association of American Geographers* 14:193-202.
- Hackenberger, S. 1987. *Archaeological Investigations at Four Amerindian Sites, Barbados, West Indies, 1986*. Typescript, Barbados Museum.
- Hackenberger, S. 1988. An Abstract of Investigations by the Barbados Museum, 1986. *Journal of the Barbados Museum Historical Society* 38[2]:155-162.
- Harris, M.H., and Hinds, R. 1995. Pottery from Maxwell, Barbados. In *Proceedings of the Fifteenth International Congress for Caribbean Archaeology*, ed. R.E. Alegria and M. Rodriguez, pp. 511-522. San Juan, Puerto Rico: Centro de Estudios Avanzados de Puerto Rico y el Caribe.
- Harris, P. 1995. Research Affiliate at the Florida Museum of Natural History. Personal communication at the International Congress for Caribbean Archaeology, 27 July, Basse Terre, Guadeloupe, French West Indies..
- Hausenbuiller, R.L. 1985. *Soil Science: Principles and Practices*, 3rd ed. Dubuque: Wm. C. Brown Publishers.
- Haviser, J.B. 1989. A Comparison of Amerindian Insular Adaptive Strategies on Curacao. In *Early Ceramic Population Lifeways and Adaptive Strategies in the Caribbean*, ed. P.E. Siegel, pp. 3-28. BAR International Series 506.

- Haviser, J.B. 1991. The First Bonaireans. *Reports of the Archaeological - Anthropological Institute of the Netherlands Antilles*, Number 10, Curacao.
- Haviser, J.B. 1995. Archaeologist at the Institute of Archaeology and Anthropology of the Netherlands Antilles in Curacao, Netherlands Antilles. Personal communication with Dr. Lydia M. Pulsipher (Professor of Geography, Department of Geography, University of Tennessee) at the Society of Historical Archaeology meeting, Washington, D.C., 17 January.
- Heath, R.C. 1988. Ground Water. In *Perspectives on Water: Uses and Abuses*, ed. D.H. Speidel, L.C. Ruedisili, and A.F. Agnew, pp. 73-89. New York: Oxford University Press.
- Hill, D.R. 1977. The Impact of Migration on the Metropolitan and Folk Society of Carriacou, Grenada. *Anthopological Papers of the American Museum of Natural History* 54[2]:191-391.
- Hinds, R., and Harris, M.H. 1995. Pottery from Mustique. In *Proceedings of the Fifteenth International Congress for Caribbean Archaeology*, ed. R.E. Alegria and M. Rodriguez, pp. 459-469. San Juan, Puerto Rico: Centro de Estudios Avanzados de Puerto Rico y el Caribe.
- Hulme, P. and Whitehead, N.L. 1992. Introduction. In *Wild Majesty: Encounters with Caribs from Columbus to the Present Day*, ed. P. Hulme and N.L. Whitehead, pp. 1-6. Oxford: Clarendon Press.
- Kay, F. 1995. The Art of Pottering in Carriacou. *The Greeting Tourist Guide* 8[1]:32-35.
- Keegan, W.F. 1992. *The People Who Discovered Columbus: The Prehistory of the Bahamas*. Gainesville: University Press of Florida.
- Kingsbury, R.C. 1960. Carriacou: An Old World in the New. *The Journal of Geography* 59[9]:399-409.
- Ladell, W.S.S. 1965. Water and Salt (sodium chloride) Intakes. In *The Physiology of Human Survival*, ed. O.G. Edholm and A.L. Bacharach, pp. 235-291. New York: Academic Press.

- Lathrap, D.W. 1970. *The Upper Amazon*. London: Thames and Hudson.
- Ligon, R. 1657. *A True and Exact History of the Island of Barbados*. Reprinted by Frank Cass and Co. Ltd., London, 1970.
- Maidment, D.R., ed. 1993. *Handbook of Hydrology*. New York: McGraw-Hill, Inc.
- Manning, J.C. 1987. *Applied Principles of Hydrology*. Columbus: Merrill Publishing Company.
- Manton, M.J. and Bonell, M. 1993. Climate and Rainfall Variability in the Humid Tropics. In *Hydrology and Water Management in the Humid Tropics: Hydrological Research Issues and Strategies for Water Management*, ed. M. Bonell, M.M. Hufschmidt, and J.S. Gladwell, pp. 13-98. New York: Cambridge University Press.
- Martinez, C.M.H. and Pavon, J.A.. 1989. Chimeneas Ceramicas: Un Rasgo Cultural de Significacion Controvertida. In *Proceedings of the Forty-Sixth International Congress of Americanists*, edited by J.F. Bouchard and M. Guinea, pp. 147-162. BAR International Series 503.
- Mascia-Lees, F.E., Sharpe, D. and Ballerino Cohen, C. 1989. The Postmodernist Turn in Anthropology: Cautions from a Feminist Perspective. *Signs: Journal of Women and Culture in Society* 15[1]:7-33.
- Matheny, R.T. 1982. Ancient Lowland and Highland Maya Water and Soil Conservation Strategies. In *Maya Subsistence: Studies in Memory of Dennis E. Puleston*, ed. K.V. Flannery, pp. 157-178. New York: Academic Press.
- Matthess, G. 1982. *The Properties of Groundwater*. Trans. J.C. Harvey. New York: John Wiley and Sons.
- McKay, L. 1994. Professor of Geology, University of Tennessee, Knoxville. Personal communication at the University of Tennessee, 5 May, Knoxville, Tennessee.

- McMillon, J. 1995. Employee at Kayak's Restaurant (and the son of John Caesar, the restaurant owner). Personal communication, 4 July, in Hillsborough, Carriacou, Grenada.
- Meggers, B.J. and Evans, C. 1978. Lowland South America and the Antilles. In *Ancient Native Americans*, ed. J.D. Jennings, pp. 543-591. San Francisco: W.H. Freeman and Company.
- Meltzer, D.J. 1987. Prehistoric Water Wells on the Southern High Plains: Clues to Altithermal Climate. *Journal of Field Archaeology* 14:9-28.
- Meltzer, D.J. 1991. Altithermal Archaeology and Paleoecology at Mustang Springs, on the Southern High Plains of Texas. *American Antiquity* 56[2]:236-267.
- Meltzer, D.J. 1995. Modelling the Prehistoric Response to Altithermal Climates on the Southern High Plains. In *Ancient Peoples and Landscapes*, ed. E. Johnson, pp. 349-368. Lubbock: Museum of Texas Tech University.
- Murphy, R. 1994. Graduate student at the Department of Anthropology, Trent University, Canada. Letter to the author, 31 August.
- Mwansa, J. 1995. Project Manager for the Water Resources Management and Water Loss Studies. Personal communication in Hastings, 21 July, Christ Church, Barbados.
- Nast, H. 1994. Women in the Field: Critical Feminist Methodologies and Theoretical Perspectives. *The Professional Geographer* 46[1]:54-72.
- Nicholl, J. 1607. *An Houre Glasse of Indian Newes, or A True and Tragical Discourse, Shewing the most Lamentable Miseries, and Distressed Calamities Indured by 67 Englishmen, which were Sent for a Supply to the Planting in Guiana in the Yeare. 1605*. London: Nathaniell Butter.
- Nicholson, D.V. 1995. Founder of the Museum of Antigua and Barbuda, St. Johns, Antigua. Electronic mail to the author, 3 August.
- Oberlander, T.M. and Muller, R.A. 1987. *Essentials of Physical Geography Today*, 2nd ed. New York: Random House.

- Pane, R. 1974. *Relacion Acerca de las Antigüedades de los Indios*. Trans. J.J. Arrom. Mexico: Siglo XXI.
- Purchas, S. 1625. *Purchas His Pilgrimes*, 20 vols. Glasgow: James MacLehose. 1905-1907.
- Richardson, B.C. 1974. Labor Migrants from the Island of Carriacou: Workers on the Margins of the Developed World. *Proceedings of the Association of American Geographers* 6:149-152.
- Richardson, B.C. 1975. The Overdevelopment of Carriacou. *The Geographical Review* 65[3]:390-399.
- Richardson, W. 1995. Former Superintendent of the Barbados Water Works. Personal communication in Worthing, 21 July, Christ Church, Barbados.
- Rodman, M.C. 1992. Empowering Place: Multilocality and Multivocality. *American Anthropologist* 94[3]:640-656.
- Rose, R. 1987. Lucayan Lifeways at the Time of Columbus. In *Proceedings of the First San Salvador Conference, Columbus and His World*, ed. D.T. Gerace, pp. 321-339. Fort Lauderdale: CCFL Bahamian Field Station.
- Rouse, I and Alegria, R.E. 1990. Excavations at Marie de la Cruz Cave and Hacienda Grande Village Site, Loiza, Puerto Rico. *Yale University Publications in Anthropology*, Number 80.
- Rouse, I, and Allaire, L. 1978. Caribbean. In *Chronologies in New World Archaeology*, ed. R.E. Taylor and C.W. Meighan, pp. 431-481. New York: Academic Press.
- Rouse, I. 1986. *Migrations in Prehistory: Inferring Population Movement From Cultural Remains*. New Haven: Yale University Press.
- Rouse, I. 1989. Peoples and Cultures of the Saladoid Frontier in the Greater Antilles. In *Early Ceramic Population Lifeways and Adaptive Strategies in the Caribbean*, ed. P.E. Siegel, pp. 383-403. BAR International Series 506.
- Rouse, I. 1992. *The Tainos: Rise and Decline of the People who Greeted Columbus*. New Haven: Yale University Press.

- Rowe, M. 1984. The Freshwater "Central Lens" of Bermuda. *Journal of Hydrology* 73:165-176.
- St. John, C. 1995. Employee at the Barbados Agriculture and Marketing Association. Personal communication through 20-22 July.
- Sauer, C.O. 1966. *The Early Spanish Main*. Berkeley: University of California Press.
- Schultz, C.S. 1995. Photograph of White Man well, Carriacou, Grenada, West Indies. In possession of the author.
- Sears, W.H. and Sullivan, S.O. 1978. Bahamas Prehistory. *American Antiquity* 43[1]:3-25.
- Senn, A. 1946. *Report of the British Union Oil Company Limited on Geological Investigations of the Ground-Water Resources of Barbados, B.W.I.*
- Sheridan, R.B. 1957. Letters from a Sugar Plantation in Antigua, 1739-1758. *Agricultural History* 31[3]:3-23.
- Siegel, P.E. 1991. Migration Research in Saladoid Archaeology: A Review. *The Florida Anthropologist* 44[1]:79-91.
- Sleight, F.W. 1965. Certain Environmental Considerations in West Indian Archaeology. *American Antiquity* 31[2]:226-231.
- Smith, C., Runyon, J., and Agogino, G. 1966. A Progress Report on a Pre-Ceramic Site at Rattlesnake Draw, Eastern New Mexico. *Plains Anthropologist* 11:302-313.
- South, S. 1979. Exploring Santa Elena. *National Geographic Society Research Reports* 20:703-715.
- Southerland, D. 1995. Bajan pilot for Leeward Islands Air Transport (LIAT). Personal communication 25 June through 1 July, St. John's, Antigua.
- Stanley Associates Engineering, Inc. 1978. *Barbados Water Resources Study, vol. 3: Water Resources and Geohydrology*. Edmonton, Alberta.

- Stevens-Arroyo, A.M. 1988. *Cave of the Jagua: The Mythological World of the Tainos*. Albuquerque: University of New Mexico Press.
- Taylor, D. 1992. Anthropologist of the Caribs. In *Wild Majesty: Encounters with Caribs from Columbus to the Present Day -- An Anthology*, ed. P. Hulme and N.L. Whitehead, pp. 306-316. Oxford: Clarendon Press.
- Todd, D.K. 1980. *Groundwater Hydrology*. New York: John Wiley and Sons.
- Twist, T.F. 1953. Weather of the Eastern Caribbean. *Weather* 8:303-304.
- Uring, N. 1726. *A History of the Voyages and Travels of Nathaniel Uring*. London: J. Peele.
- van der Valk, B. 1992. The Physical Environment of Golden Rock. In *The Archaeology of St. Eustatius: The Golden Rock Site*, ed. A.H. Versteeg and K. Schinkel, pp. 14-30. Amsterdam: The Foundation for Scientific Research in the Caribbean Region.
- Veloz Maggiolo, M. and Vega, B. 1982. The Antillean Preceramic: A New Approximation. *Journal of New World Archaeology* 5[2]:33-44.
- Versteeg, A.H. and Schinkel, K., ed. 1992. *The Archaeology of St. Eustatius: The Golden Rock Site*. Amsterdam: The Foundation for Scientific Research in the Caribbean Region.
- Vinton, I. 1957. *Boy on the Mayflower*. New York: Tab Books, Inc.
- Watters, D.R. 1991. Archaeology of Fountain Cavern, Anguilla, West Indies. *Annals of the Carnegie Museum* 60[4]:255-319.
- Watters, D.R. 1994. Associate Curator, Section of Anthropology, Carnegie Museum. Letter to the author, 6 September.
- Watts, D. 1966. *Man's Influence on the Vegetation of Barbados, 1627-1800*. University of Hull Publications, Occasional Paper No. 4.
- Watts, D. 1987. *The West Indies: Patterns of Development, Culture and Environmental Change since 1492*. New York: Cambridge University Press.

- Wheeler, L.R. 1916. The Botany of Antigua. *The Journal of Botany* 54:41-52.
- White, G.F., Bradley, D.J., and White, A.U. 1972. *Drawers of Water: Domestic Water Use in East Africa*. Chicago: The University of Chicago Press.
- Wilkinson, J.C. 1977. *Water and Tribal Settlement in South-East Arabia: A Study of the Aflaj of Oman*. Oxford: Clarendon Press.
- Williams, H. 1995. Employee at Kayak's Restaurant, Hillsborough, Carriacou, Grenada. Personal communication through 2-14 July.
- Wilson, S.M. 1990. *Hispaniola: Caribbean Chiefdoms in the Age of Columbus*. Tuscaloosa: The University of Alabama Press.
- Winter, J. and Wing, E. 1995. A Refuse Midden at the Minnis Ward Site, San Salvador, Bahamas. In *Proceedings of the Fifteenth International Congress for Caribbean Archaeology*, ed. R.E. Alegria and M. Rodriguez, pp. 423-433. San Juan, Puerto Rico: Centro de Estudios Avanzados de Puerto Rico y el Caribe.

VITA

I, Christopher Scott Schultz, was born in North Hornell, New York, on February 18, 1971. I attended public schools in Gettysburg, Pennsylvania, where I graduated in the top quintile from Gettysburg Senior High School in 1989. I immediately continued my education at Shippensburg University of Pennsylvania. During the summer of 1991, I was an intern at the Environmental Management Division of Letterkenney Army Depot (in Chambersburg, Pennsylvania), and during the summer of 1992 I was an intern at the Center for Rural Pennsylvania (in Harrisburg, Pennsylvania). I graduated magna cum laude in 1993 from the University Honors Program, and earned a Bachelor of Arts degree in Geoenvironmental Studies.

Soon after graduation, I moved to Knoxville where I entered the Masters of Science program in the Department of Geography, University of Tennessee. I received a departmental teaching assistantship in both Physical and Human Geography as well as a research assistantship with Dr. Lydia M. Pulsipher. I received grants from the *W.K. McClure Fund for the Study of World Affairs* and the *Stewart K. McCroskey Memorial Fund*

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My wife, Kathy Harget Schultz, and I were married in June, 1994, and we currently live in Knoxville as she pursues a Masters degree in Social Work. We plan to eventually move back to the south-central Pennsylvania region.