

Sustainable Water Resources in Rural Haiti

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"The factors that determine an outbreak of cholera, epidemic or pandemic are complex and ecological,"

Dr. Stephen Jay, professor of medicine and public health at the Indiana University School of Medicine in reference to the recent Haitian Cholera epidemic

I would argue they are also geological

Haiti Demographics

- Population is about 8-10 million.
- Roughly 1/3 of the population lives in the largest city, Port au Prince.
- The entire country is about the size of Maryland.
- As of 1990, only about 39% of the residents had access to clean water and only 25% had access to sanitation.



Maryland



Haiti

Water Resources of Haiti

- In cities, drinking water is treated and sold in bags and bottles.
- Rural Haitians often walk 1-5 miles to get untreated water.
- Springs are contaminated resulting in dysentery and child mortality.
- The World Health Organization (WHO) reported in 2006 that the mortality rate for children under age 5 in Haiti is 15 times higher than in the United States.



Haitian child drinking a “bag” of water



Spring emerging along bedding in a shale unit

Shallow Karst (limestone) Aquifers

- Karst Aquifers
 - Open fissures
 - Shallow
 - Very little attenuation or filtering of pathogens



Source: Reynolds et al., 2008

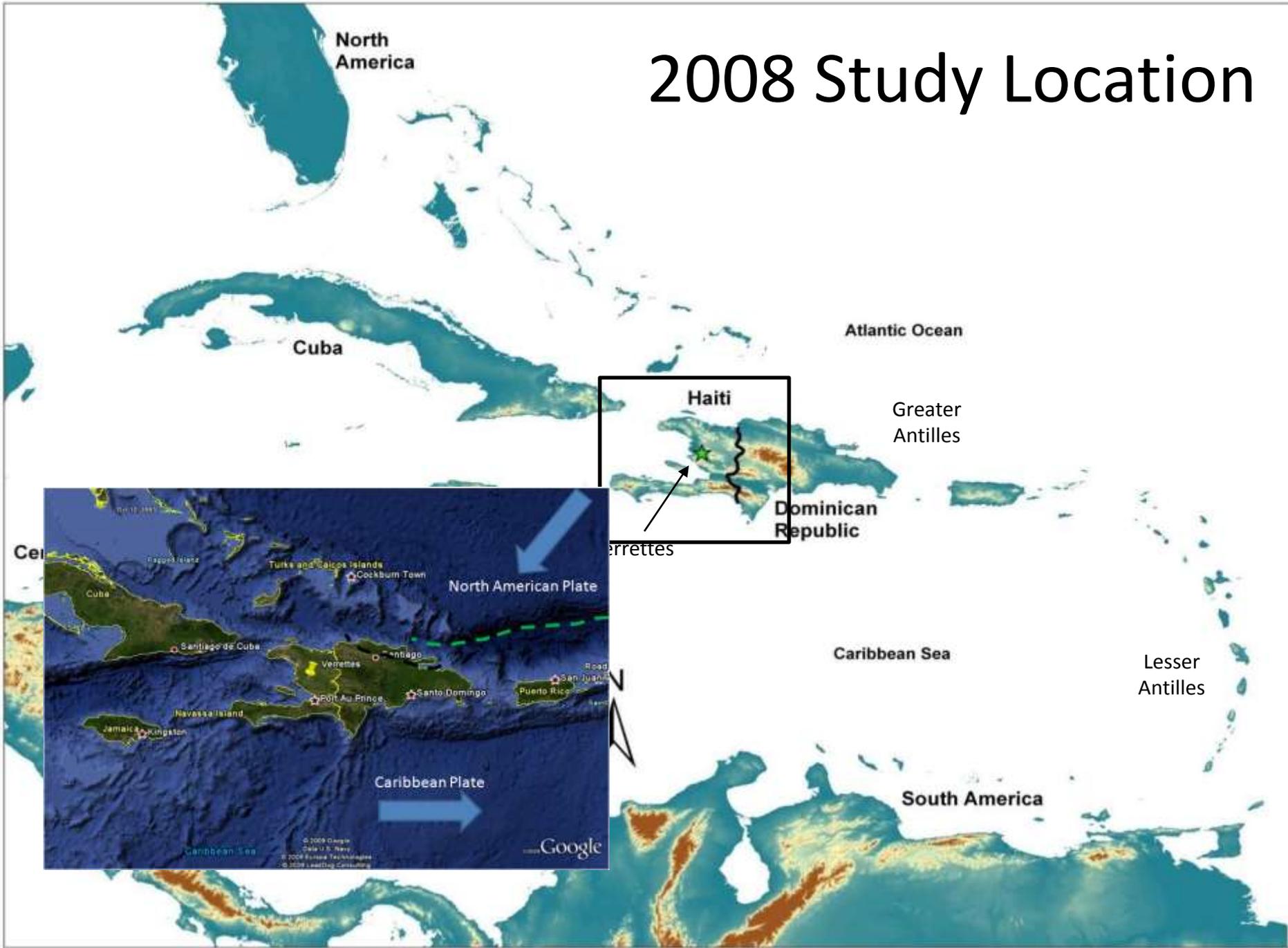
Karst aquifers and bacteria

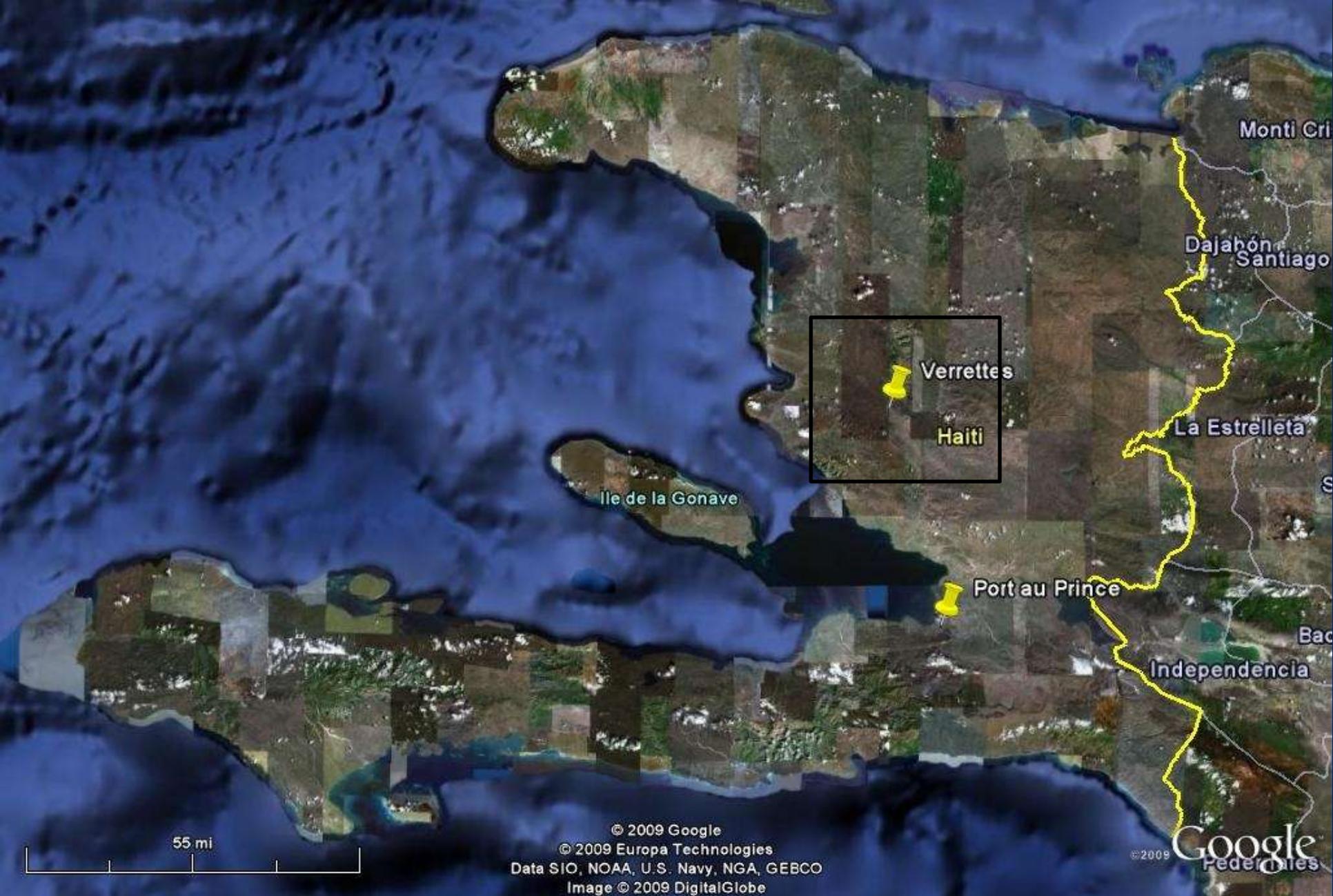


Source: Reynolds et al., 2008

- Bacteria can travel long distances very quickly
 - > 14 km, with a velocity of about 250 m/h (Batsch et al. (1970)).
- Bacteria are often associated with particulates in the ground (soil and organic material that move with water).
 - Groundwater pathogens may be more persistent and difficult to inactivate (Mahler, 2000).
 - Outbreaks can reoccur when rain events mobilize particulates and attached pathogens
- Bacteria in karst settings are often protected from many of the predators that graze on free-floating bacteria (Harvey et al., 1984)

2008 Study Location





Monti Cri

Dajahón
Santiago

Verrettes

Haiti

La Estrélléta

Ile de la Gonave

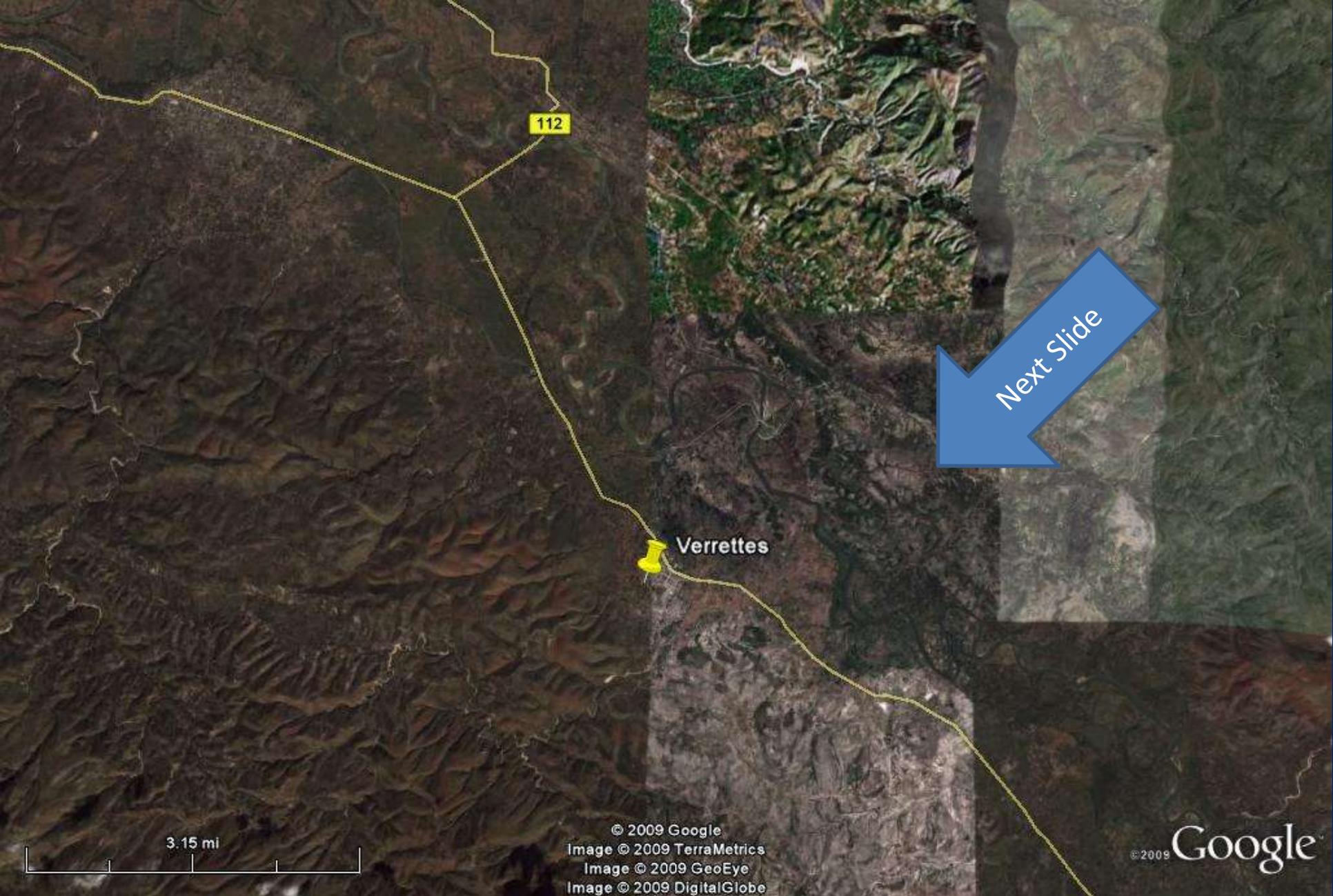
Port au Prince

Independencia

55 mi

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112

Verrettes

Next Slide

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109

Verrettes

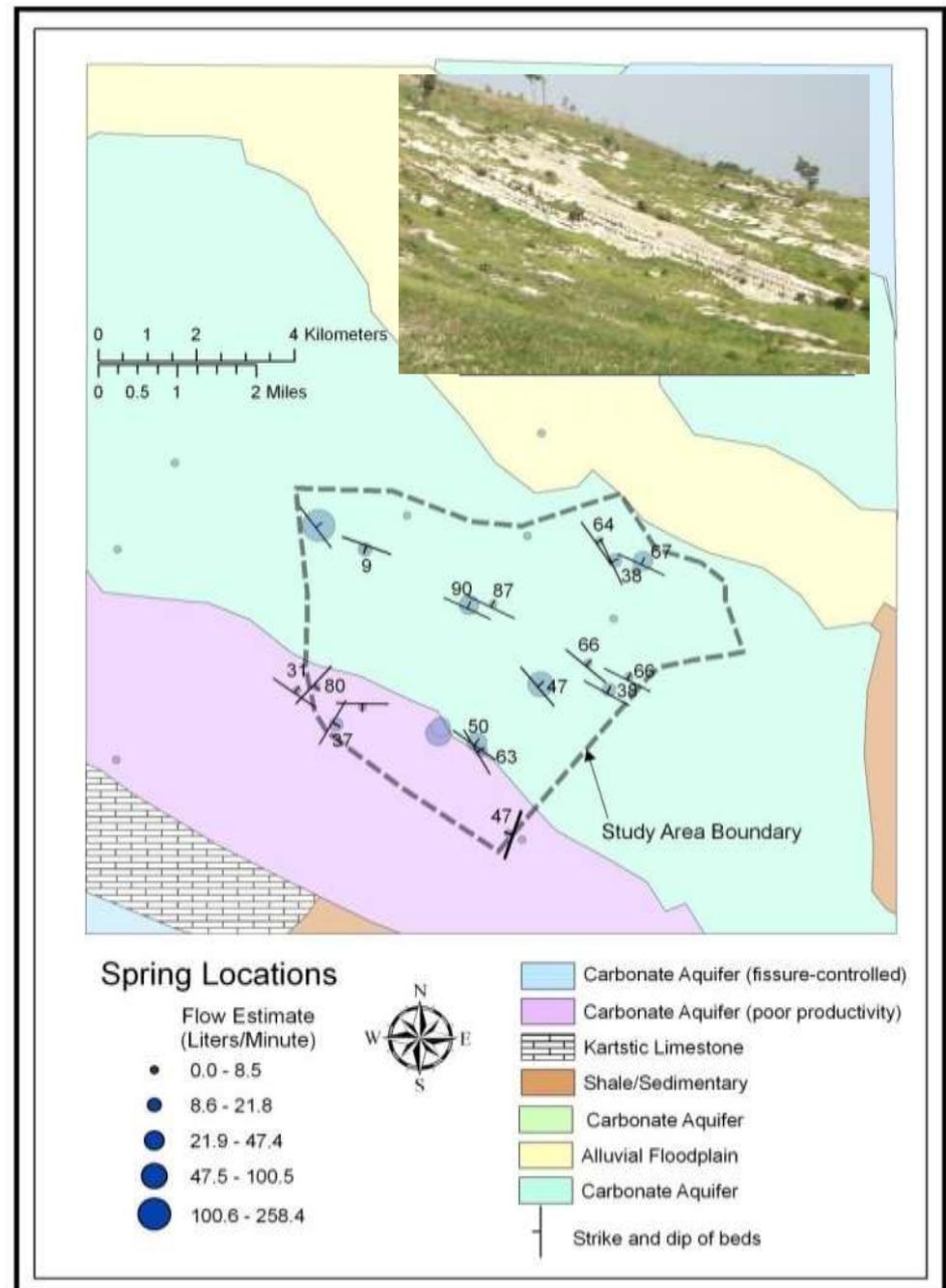
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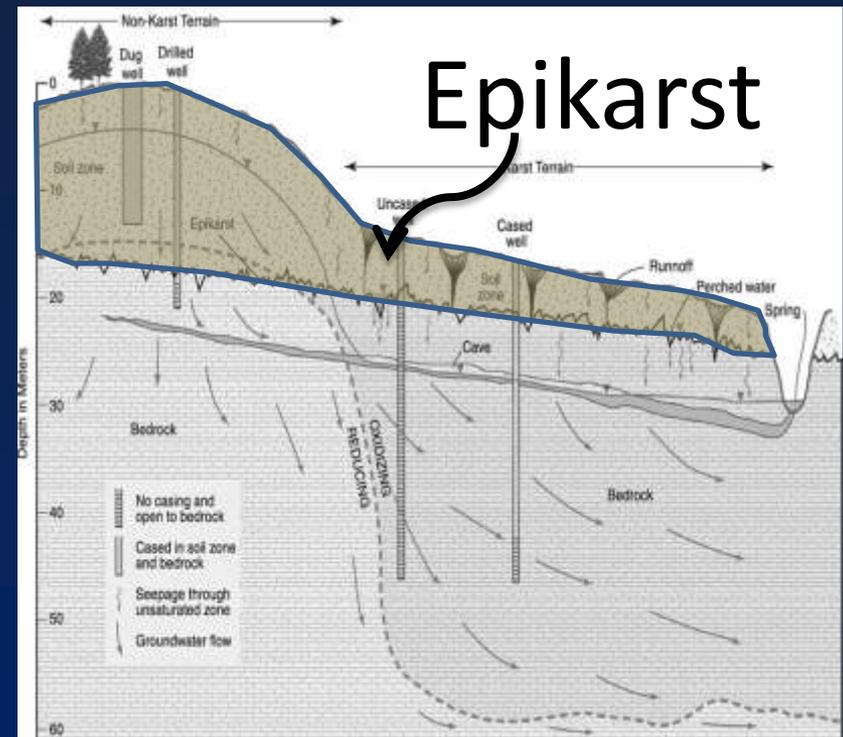
Study area geology and hydrology

- Fractured limestone with karst features and karst aquifers.
- Minor shale and other sedimentary rocks provide confining beds.
- NW-trending bedding and faulting.



Epikarst is present in most karst settings

- Epikarst in most karst settings serves as an important filter for pathogens
- Epikarst is missing in many locations in Haiti



Modified from Kelly et al., 2009

Limestone exposed where epikarst is absent



Student Andrew Sisson standing on Pinnacle Karren

Limestone dissolution without soil cover



Solution pitting near pinnacle karren

2008 Spring Sampling Project

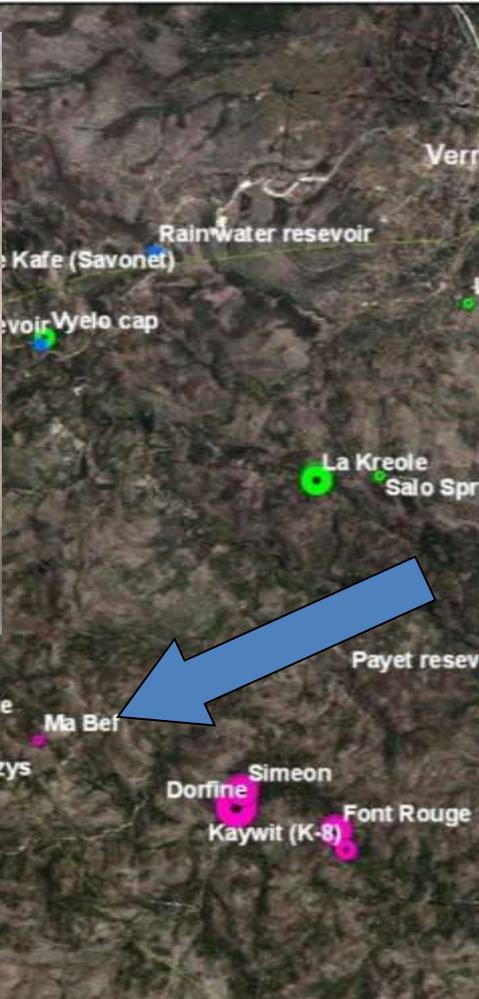
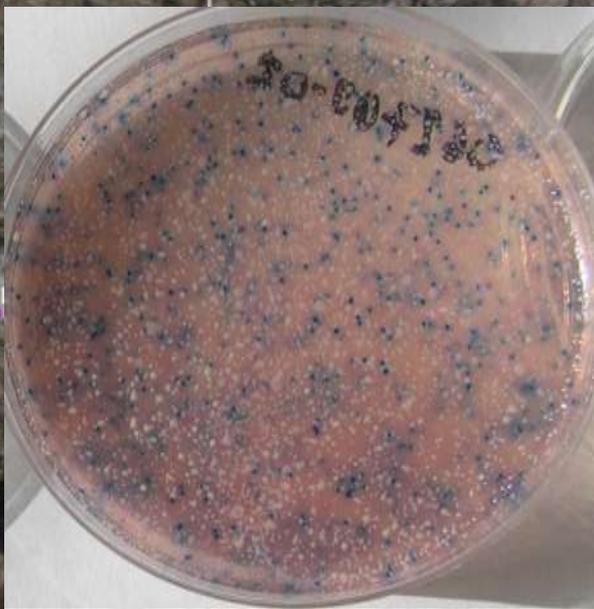
- What is the level of bacterial contamination in springs in the mountains of rural Haiti?
 - 27 springs were located, sampled, and water flow was measured.
 - E-coli and other fecal coliform bacteria were cultured.
 - Capped, uncapped, and treated water from springs was sampled.



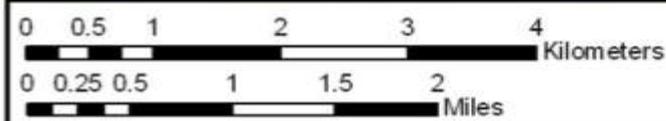
Concrete spring capping



Uncapped spring frequented by animals



Coliform Coliscan	Coliform HAS	E-coli Coliscan	E-coli HAS
~100	75	>1000	7



Verrettes Haiti Spring Project

Map Prepared by: Andrew Sisson

8/01/08



Solar water filter

- Filters can become a breeding ground for bacteria.



Solar-powered water filter



Child with a bloated belly from bad water

Coliform Coliscan	Coliform HAS	E-coli Coliscan	E-coli HAS
~900	Too numerous to count	>100	Too numerous to count

2008 Results

- WHO standard > 1 coliform bacteria per 100 ml is unsafe.
- HAS standard > 10 E-coli or coliform bacteria per 100 ml is unsafe.
- groundwater temperature was high.
- There was no correlation between water quality parameters and bacteria counts.

	E-coli Only	Total Coliform	Total Coliform HAS Standard
HAS Samples	35 %	71 %	57 %
Coliscan Kit	80%	100 %	100 %

Geology + cultural practices = unsafe spring water



Cow resting on fractured limestone

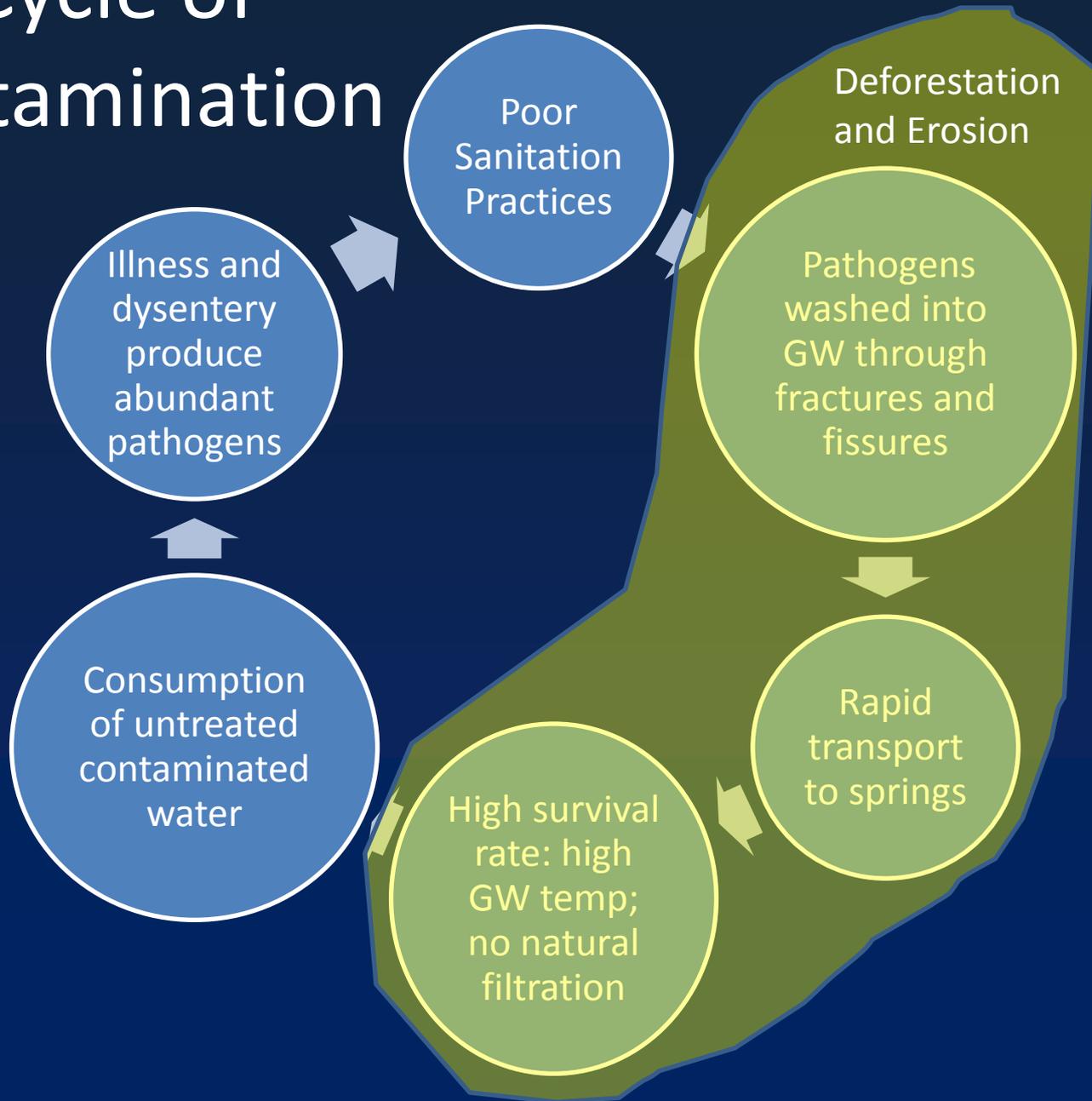


Donkey tied near a capped spring



Spring water emerging from a fissure

Cycle of Contamination



Future Work

- Sample many more springs using a more rigorous e-coli protocol.
 - Field-based bacterial analysis with a PROFILE[®] 1 Bioluminometer.
 - More quantitative determination of e-coli and coliform bacteria using IDEXX quanti-tray methods
- Sample more treatment systems and water sources to identify “hot spots”
- Sample substrates in springs and karst conduits to determine if they are harboring bacteria.

Pathway to sustainable water in Haiti

Make sure that the sources of water are clean:

1. Restore the macro and micro ecosystems.
2. Address sanitation practices and provide education on best practices to reduce bacterial loading.

Provide clean water through treatment:

1. Make sure treatment methods are maintained.
2. Provide training for Haitians on proper use and maintenance of water treatment systems.
3. Test systems regularly to make sure they are effective.

Questions ?

