# Did bad water contribute to the Starving Time?

October 17 2011, by Andrea Davis

Geologists at William & Mary are analyzing a possible contributing cause of the deaths at Jamestown Island during the Starving Time of 1609 and 1610—bad drinking water.

The water, by today's standards of drinkability and even safety, is really bad. The scientists are finding that the Jamestown aquifer water contains high, but varying, levels of arsenic. But arsenic may be far down on a list of problems that include high salinity, various metals and fecal contamination from the colonists' latrines.

The Starving Time nearly eliminated the fledgling colony, killing the majority of the 500 colonists before supplies and reinforcements arrived from England. History indicates that food was scarce for a number of reasons, including a severe drought. The role of the drinking water has

been a matter of scholarly consideration.

Advised by Associate Professor of Geology Gregory Hancock and Assistant Professor of Geology James Kaste, Doug Rowland ’12 is studying water from wells actually used by the colonists. Hancock noted that the colonists dumped refuse in their old wells, creating a concentrated assortment of artifacts for present-day archaeologists.

The three wells inside the fort were filled in years ago, but workers installed PVC piping at all three well sites to allow access to the same shallow aquifer used by John Smith and the Virginia Company. The geologists are comparing the water in the colonists’ wells with 14 new groundwater monitoring wells installed across Jamestown island.

Jamestown fort is on a slight rise of land between the brackish James River and the even more saline (and appropriately named) Pitch and Tar Swamp. There’s a persistent, but unproven, notion that the Spanish had been spiking the colonists’ aquifer with arsenic, but Kaste says they didn’t need to: arsenic is a natural component in the water under Jamestown Island. Rowland explained that he has found arsenic at levels unsafe for consumption in wells outside the fort, but not consistently.

“I’m looking at the concentrations of arsenic in the aquifer, and what variables cause them to fluctuate throughout space and time,” Rowland said. “The World Health Organization says that anything above 10 parts per billion of arsenic in water is unhealthy.”

Kaste and Hancock have been working on this project since 2007, when Hancock first became interested in the arsenic story at Jamestown.

“I had heard the story of the Jamestown fort and how they were having problems, and one of the problems was probably related to drinking water,” says Hancock. “But nobody had really done any kind of

investigation to look at that."

In 2008, Kaste and Hancock worked with two students in the geology department who did senior theses on the groundwater chemistry at Jamestown. It is that prior research and the two professors' continued interest that led Rowland to join the project.

The presence of arsenic is a substantial component of their research, but their analysis is showing that it's only one component of a cocktail of contaminants.

"There's a range of things going on here," Kaste said. "First of all, it's pretty salty and salt has concerns with high blood pressure. Then there's the metals—arsenic of course and iron. It smells pretty sulfur-y today, too."

Kaste explained that they've measured high sulfur levels in most of the wells and says that it likely comes from sulfur-reducing bacteria in the water. In addition, the colonists likely were contaminating their own water through their outhouses, he added. The aquifer's water still presents a elevated fecal coliform count, with the droppings from Jamestown Island's plentiful Canada goose population taking the place of the latrines, Hancock explained.

Rowland goes through a multi-step process to collect a groundwater sample for study. First, he uses a groundwater gauge to find the depth of the water. An instrument known as a YSI probe provides temperature, dissolved oxygen content and conductivity, which he explains is "a proxy for salinity."

Then, he draws the water out of the ground, through a filter apparatus, and into an clean sample bottle. At the geology lab, he uses the department's newest instrument, an atomic absorption spectrometer, to

measure the dissolved arsenic in the sample. Kaste explains that arsenic amounts are determined by the light absorption properties of arsenic vapors introduced to the optical path of the spectrometer.

“Certain elements, when they’re atomized, absorb specific wavelengths of light,” he says. “The more arsenic present, the more light is absorbed. The detector essentially measures light dimming, which is proportional to arsenic concentrations. This technique allows us to determine arsenic concentrations accurately down to one part per billion

Levels of salt and arsenic in the aquifer are controlled by naturally occurring factors, such as precipitation, tidal flow and seasonal variations. The new wells allow the geologists to monitor the changes. For example, when water levels rise in the swamp, wells near the swamp show an increase in salinity before the colonists’ wells do. By taking a multiplicity of samples as natural conditions change, Rowland hopes to project levels of arsenic and salinity in the groundwater during the Colonial period.

“Once we understand how the variables control arsenic, we can back-project and estimate the range of arsenic they may have been consuming,” Kaste said.

For example, summer arsenic levels might be high due to factors such as tidal flow of the James River, which filters into the swamp, as well as precipitation levels during those months.

“As we get further into the summer, certain processes might serve to concentrate arsenic in the aquifer,” Rowland explained. One such process, he said, is evapotranspiration, the process by which heat, air and plants remove water from the earth and return it to the atmosphere.

“There’s usually more evapotranspiration in the summertime,” Rowland

said, “so that might cause a general seasonal trend.”

He said that as precipitation lessens and the weather gets hotter, water is drawn out of the swamp, which can be a source of arsenic to the wells near the fort. Rowland can use such data to hypothesize how the meteorological trends of the past, as documented by colonists like John Smith, might have affected arsenic levels in the groundwater.

“This project has a historical component, in that there’s evidence in historical records of arsenic poisoning that might have led to the poor health of some of the colonists during the Starving Time,” Rowland said.

Archaeological studies reveals that the colonists also collected water near the same swamp that Rowland studies. Hancock explains that the colonists put themselves in danger by collecting water near the swamp.

“The presence of this swamp could be a driver of arsenic production. Generally speaking, you don’t want to drink water near a swamp,” Hancock said.

Provided by The College of William & Mary