

## Technical Note

To: Blake Perkins, Hoboken Historical Museum and Cultural Center  
From: Saad Cheema; Dane Pehrman  
CC: File  
Date: January 7, 2011  
Re: Geotechnical Condition and Water Quality Analysis for Sybil's Cave

---

### 1.0 PURPOSE

The purpose of this Technical Note (TN) is to present a geotechnical condition evaluation associated with the reopening of Sybil's Cave located in Hoboken, New Jersey. This man-made cave has been in existence for several hundred years. The location of Sybil's Cave is presented on Figure 1.

### 2.0 BACKGROUND

Most of the man-made caves and rock shelters in New Jersey are less than fifty feet long. The larger examples are almost always found in either limestone or marble; the smaller examples can be found in a variety of different rock types. Sybil's Cave (also known as Castle Point Mine) is located in the USGS (15-minute) Jersey City quadrangle (40° – 44.7' N 74° – 01.5' W) within serpentine rock Formation as mentioned in "Caves of New Jersey" Bulletin 70 published by the Department of Environmental Protection, New Jersey Geological Survey.

A spring located inside Sybil's Cave was a major attraction in Hoboken in the 19th century. The cave opened in 1832, was shut in the 1880s due to New Jersey Health Department concerns regarding water quality, and was subsequently filled with dirt, concrete, and serpentine rock fragments during the 1930's.

The cave was reopened in October 2008 by the Mayor of Hoboken, and a new arch was built at the entrance. The cave is approximately 17 feet wide and 19 feet deep and contains four pillars (2 feet by 2 feet square) and a spring water cistern. The entrance of the cave is a horse-shoe shape about 9 feet wide at the base and 13 feet at the center/springline. The square shaped cistern opening is located in the center of the cave. A plan view of the cave is presented on Figure 2.

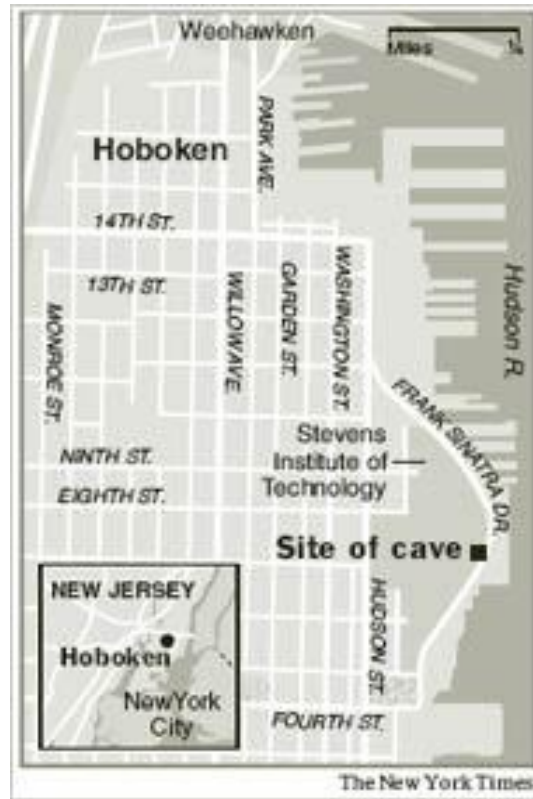


Figure 1: Location Map - Sybil's Cave

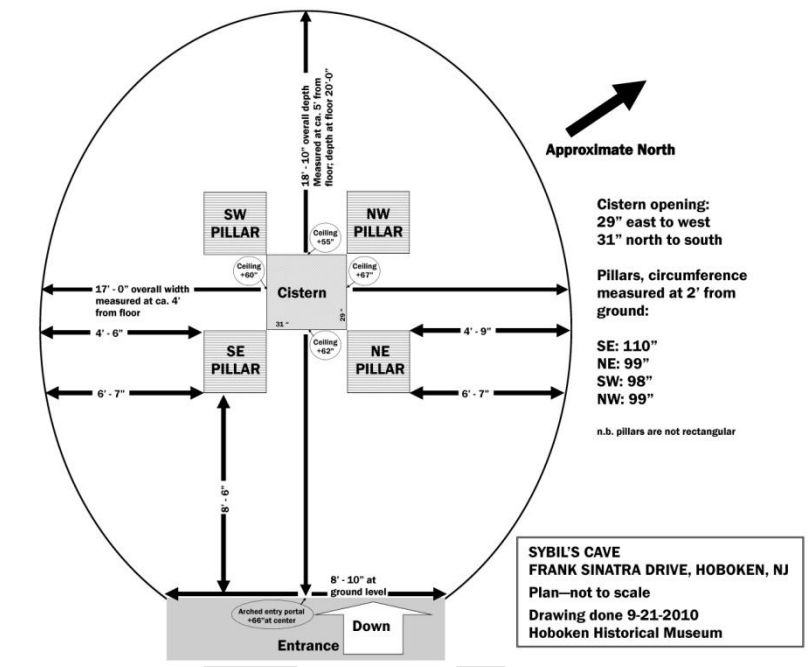


Figure 2: Plan View Sketch of Sybil's Cave (Not on Scale)

### 3.0 GEOLOGICAL DATA ANALYSIS AND REVIEW

New Jersey can be divided into four physiographic provinces (as shown in Figure 3); the Coastal Plain Province, the Piedmont Province, the Highland Province, and the Valley and Ridge Province. Sybil's Cave is located in Hudson County within the Piedmont Province consisting of sandstones, argillites, shales, serpentine, and conglomerates with basaltic lava flows and diabase intrusions. Sybil's Cave was excavated in a prominent bluff of grayish green serpentine rock located between the City of Hoboken and the Hudson River.

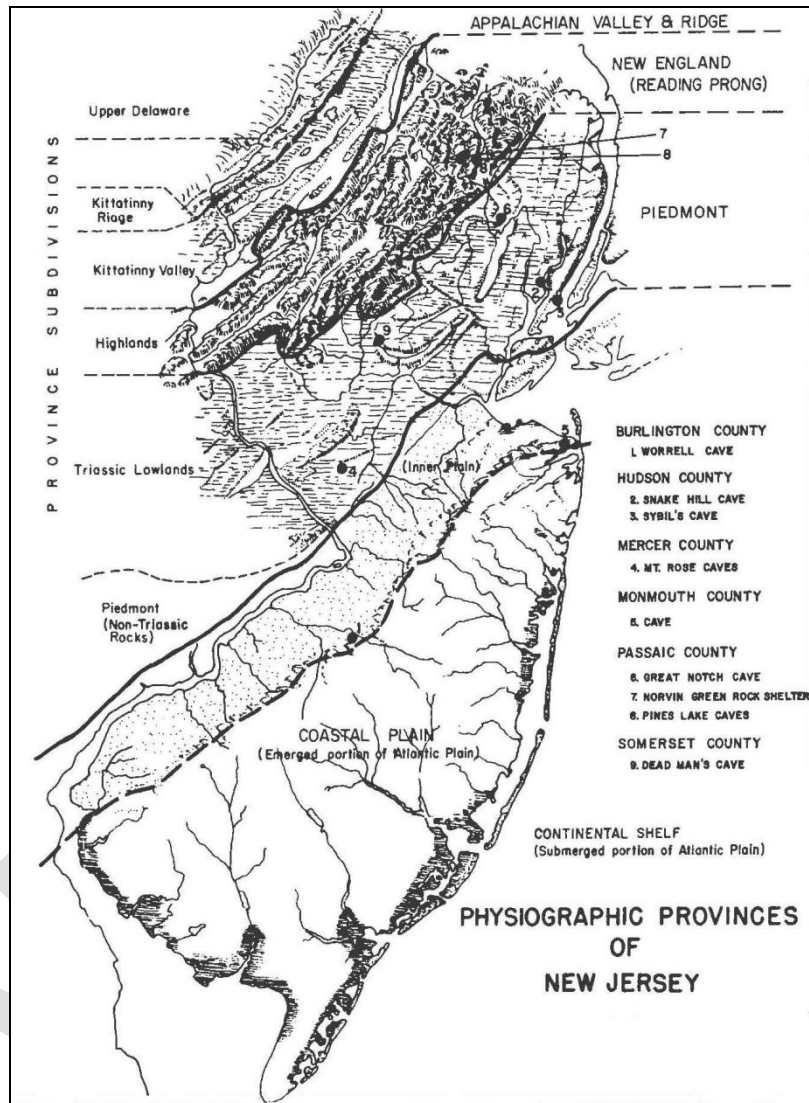


**Figure 3: Physiographic Provinces of New Jersey (NJ Geological Survey)**

A site visit was undertaken by Mr. Robert Foster and Mr. David Webster (Hoboken Historical Museum) , and Mr. Saad Cheema (Black & Veatch) on March 12, 2010. Based upon visual inspection of the cave in the field, rock mapping, evaluation of rock samples, and desk study literature review the following general observations can be made.

1. The rock around the opening of the cave is dipping at a high angle (60 to 70 degrees) and is highly fractured as shown in Figure 4 and Figure 5.
2. The pillars that are supporting the roof of the cave appeared to be under stress and show evidence of spalling at the roof/pillar interface as shown in Figure 6.

3. The rock debris present on the floor indicates that roof of the cave has been spalling over time as shown in Figure 7.
4. The rock samples collected during the site visit indicate the presence of a serpentine rock type which is sometimes associated with asbestos content. This rock character may warrant further investigation.
5. The rock face at the cave portal comprises of highly weathered fractured rock including soil that was highly unstable and wet at the time of site visit. Figure 8 shows the rock face at the cave entrance in a dry condition (photo not taken during site visit).



**Figure 4: Highly fractured bedrock (steeply dipping) around the cave portal.**



**Figure 5: Highly weathered and fractured rock around the Cave portal.**



**Figure 6: Cave rock pillar showing evidence of spalling**



**Figure 7: Rock debris/spalling on the floor near rock pillar**



**Figure 8: Rock condition at cave entrance (dry condition).**

Based on the observations made during the site visit Black & Veatch recommends that Sybil's Cave remains closed for public access. The rock conditions within the cave need to be stabilized to ensure additional spalling and rock block instability does not occur in future.

#### **4.0 WATER QUALITY ANALYSIS**

A sample of surface water was collected on December 15, 2010 from the natural cistern inside Sybil's Cave. This cistern is approximately 3 feet in depth. The sample was collected at a depth of approximately 2 inches below water surface. Table 1 presents the field parameters measured from the water sample using a calibrated handheld water quality meter (YSI 6820 MP).

| pH   | Temp (C) | Specific Conductance (mS/cm) | Turbidity (NTU) | Dissolved Oxygen (mg/L) | Oxygen Reducing Potential (mV) |
|------|----------|------------------------------|-----------------|-------------------------|--------------------------------|
| 7.83 | 7.32     | 1.142                        | 1.4             | 3.9                     | 214.2                          |

These field parameters were within typically normal limits for surface water in similar environments. This cistern water sample was sent via FEDEX, along with a trip blank, to TestAmerica's laboratory in Edison, NJ and King of Prussia, PA for water quality analyses. Coliform bacteria were analyzed at the Brandywine Science Center in Kennett Square, PA. The cistern water sample and the trip blank were analyzed for the following parameters:

- Volatile organic compounds by EPA method 8260B

- Total metals by EPA Method 200.7
- Total metals by EPA Method 200.8
- Total metals by EPA Method 7470A
- General Chemistry using standard methods 2130B, 2540C, 4500-Cl C, 4500-F C, 4500-H
- Nitrogen, Nitrate-Nitrite using method 353.2
- Coliform bacteria using the Colient™ method.

Samples were analyzed on December 17. Detailed analytical results are attached in Appendix A. A summary of the results from the cistern water sample is as follows:

- Volatile organic compounds were not detected
- Several metals were detected including:
  - antimony (1.4 ug/L),
  - arsenic (1.0 ug/L),
  - barium (38 ug/L),
  - chromium (1.6 ug/L),
  - copper (3.3 ug/L),
  - lead (1.1 ug/L), and
  - selenium (4.3 ug/L).
  - No other metals, including mercury, were detected.
- Total dissolved solids were measured at 940 mg/L.
- Chloride was measured at 400 mg/L
- Nitrate-Nitrite as Nitrogen was measured as 6.6 mg/L
- Over 200 coliform bacteria per 100 ml of water was detected.

These results were compared to the Federal and NJ State Primary and Secondary Drinking Water Standards as of February 2005 (current) as outlined in the Federal Safe Drinking Water Act regulations [40 CFR Parts 141, 142, 143] and the New Jersey Safe Drinking Water regulations [N.J.A.C. 7:10-1 et seq.]. None of these compounds exceeded the primary standards. Chloride (secondary standard of 250 mg/L) and total dissolved solids (secondary standard of 500 mg/L) both exceeded secondary standards, which are aesthetic standards. Coliform bacteria does not have a standard; however, in practice, coliform bacteria should not be present in potable sample.

## 5.0 RECOMMENDATIONS

The following recommendations are suggested in order to allow Sybil's Cave to be re-opened for public access.

1. The cave should be renovated by providing internal and external rock support such as rock bolts and shotcrete.
2. A local geotechnical firm (Jenny Engineering Corporation – 2 Edison Pl, Springfield NJ 07081 Tel:973-379-6699, or Dawn Underground Engineering INC – 10 Village Court, Hazlet NJ 07730 Tel:732-739-8840) should be hired to monitor the rock stability conditions of the cave over

time in order to further evaluate the condition of the cave from a rock mass stability standpoint.

3. Due to the presence of coliform bacteria in the cistern water, people should not be permitted to drink water from the cistern however, there are not other health concerns associated with the water and other than ingestion, direct contact would not be expected to present a significant health risk.

A set of photographs (taken during the site visit) showing the conditions at Sybil's Cave are attached for information.

DRAFT

Appendix A  
Detailed Water Quality Sample Results