INTRODUCTION
Since the first European settlers crossed the Blue Ridge into the Great Valley Province, the karst terrain’s fertile soils, large springs and ready supply of carbonate rock as a source of high-quality building stone encouraged the development of the region’s most significant towns and cities. Without exception, every urbanized area in the Great Valley from Pennsylvania to Eastern Tennessee is in karst terrain, and in many cases these areas of population have continued their growth to the present day. Berkeley County in West Virginia, and the city of Martinsburg (the county seat) are prime examples of this continued growth and development. This field trip will visit sites of geological and cultural interest, spanning time from the 18th through the 21st centuries, including the 18th century cave and tunnel system in Martinsburg, a 19th – early 20th century historic limestone quarry, and a modern large-lot subdivision where the first karst management plan ever written for a site in the Eastern Panhandle of WV is being used to guide the development process.

Figure 1. Field Trip Route
STOP 1. The Shepherd’s Cove Subdivision

Geological Setting - The Shepherd’s Cove subdivision is underlain entirely by the Stonehenge Limestone of the Beekmantown Group, dating from the Lower Ordovician geologic period. As is typical for the Great Valley Region, the local bedrock strikes consistently from northeast to southwest. A named overthrust fault (the “Rockymarsh Fault”) lies to the east of the site. This fault marks an area where, during the Appalachian Orogeny (260 Ma), the older rocks lying in the east of the property were pushed against and over the younger rocks to the west resulting in the fracturing of the deformed strata. A series of broad upward (anticlinal) and downward (synclinal) folds were formed in the rocks to the west of the fault, which were subsequently subjected to dissolution by mildly acidic groundwater as it migrated through the open fractures and fissures caused by the faulting and folding. Initially, these solution conduits were located entirely below the water table (phreatic), but as the Potomac River cut down through the adjacent bedrock it would eventually leave a portion of the site’s formerly phreatic conduit system high and dry (at least that part above the river’s base level). Over time the base level of the river would drop relative to the site’s general elevation, producing a steep groundwater gradient near the river. Thus, surface water migrating through the conduit system began to carry soil fines and residual sediments downward through the karst “drain pipes”, producing the numerous sinkholes and air-filled voids (caves) that we see today.

Surface Karst Features - The subject site is considered a “mature” karst landscape, with the relatively planar ground surface marked by karst surface features, the most common of which are cover collapse sinkholes where the overlying soil and residual sediments resulting from the dissolution of the limestone have been carried deep into the karst system by the action of surface water and groundwater. The site has over 80 of these sinkholes, based on 2-foot contour interval maps provided by the project’s civil engineer and LIDAR (Fig. 4). Not unexpectedly, these sinkholes become more numerous, deeper and steeper-walled as one proceeds from Scrabble Road towards the river.

Nearly all of the sinkholes at the site are circular to subcircular in cross-section, do not appear to be actively swallowing surface soil and do not show tension cracking in the soil along their parapets. The majority of sinkholes are soil-bottomed, with mature trees and vegetation growing within them; however, some have small, open conduits (throats) at their base. Bedrock is exposed in the walls of many of the sinkholes.

Several small caves occur at the site, opening in the bluffs along the Potomac River and further south within the body of the site. None of these caves have been surveyed or mapped. The most remarkable onsite cave from a historical perspective is the so-called “Devils Chimney”, originally described in Samuel Kercheval’s 1833 book “History of the Valley of Virginia” as:

Figure 2. Geology of Shepherd’s Cove. R-ed-dashed line is the approximate boundary. (Dean, et al., 1987)
“...the place where the owner used to raise the devil with the help of a black servant.”

The cave’s location was subsequently “lost”, with the most recent cave survey (Gulden & Johnson, 1984) only stating that “it was not checked” by the West Virginia Speleological Survey (WVaSS). There are plans by the survey to map this cave in the future, now that it has been positively located. The cave’s “fireplace-like opening” along the riverbank is nearly 20-feet high (Fig. 3), and several subordinate passages open into it, one of which can be followed as a hands and knees crawl for over 30 feet.

![Figure 3. The Devil’s Chimney as seen from the Potomac River. The cave is formed along the axis of an anticlinal fold in the Stonehenge Formation. Several horizontal passages lead off the “fireplace-like” opening, the only vertical passage being the actual “chimney” which extends up to the surface.](image)

It is notable that the largest “sinkhole”, located just north of the power line cut near the center of the site, is possibly the collapsed portion of a shallow cave passage (i.e. an unroofed cave). Unlike most of the site sinkholes, the collapsed structure has a sinuous path that appears to shadow the site’s fracture patterns, with the main “passage” running parallel to the strike of the bedrock.

**Hydrology** – With the exception of the Potomac River, there are no natural surface water bodies at Shepherds Cove, either perennial or intermittent, present on the site. Field examination of the various sinkholes and subsidence structures indicate that all the sinkholes and site soils drain efficiently, as there is no evidence of flooding, sedimentation, or pooled water. No wetland vegetation was observed at any area apart from the bank of the Potomac River.

Based on contour mapping and published hydrological studies of Berkeley and Jefferson Counties, the site is internally drained. Groundwater contour mapping indicates that the focus of local subsurface drainage proceeds along the axis of the site from southwest to northeast, running parallel to the direction of the fracture lineaments along which the sinkholes have developed. Drainage is towards the Potomac River. There are a series small caves and open voids clearly visible in the bluffs along the Potomac River at the site’s northern border. These openings are all lined with spongy deposits of flowstone, suggesting that they
represent abandoned spring mouths. As the river excavated its channel, the older springs were left high and dry, but may still briefly carry water after heavy rains or snow melts as evidenced by the presence of waterborne silt deposits within them. At least four of these drains empty into the fireplace-like opening of the Devil’s Chimney, which probably was at one time a larger, perennial spring.

Groundwater flowing beneath the site probably enters the subsurface in a broad upland area lying 2 to 3 miles to the southwest. Near the southern border of the property along Scrabble Road, the average groundwater elevation is inferred to be at least 50-feet below the surface (Hobba, 1976). The groundwater elevation is assumed to drop rapidly as it approaches the river bank, which occurs at EL 320-feet on the site’s northern boundary. However, measurements of the groundwater elevation in this area have not been conducted. Most likely, the groundwater emerges in one or more springs just north of the northern property line. These springs may have been slightly above the river’s average surface elevation during prehistoric times, however, the impoundment created by Dam #4 during the construction of the C&O Canal has raised the level of this portion of the Potomac over 10-feet, submerging the springs. It is of note that local residents often swim in this section of the river due to its depth and lack of submerged objects, and have noted “cold spots” along the base of the bluff, suggesting that subsurface springs may yet exist in this area.

Figure 4. LIDAR imagery of the Shepherds Cove area. Red dashed line is the approximate site boundary. (Imagery courtesy of Dan Doctor, USGS)

The Shepherd’s Cove Karst Management Plan – Mr. Leonard “Len” Frenkil, the developer and owner of Shepherd’s Cove, sought to create an environmentally responsible community utilizing the highest standards of natural resource management. The purpose of the management plan developed for the site was to provide a framework to this end (Denton, 2006). Some of the desirable effects of this plan were to:
- Maintain naturally vegetated buffers to ensure a metered, biofiltered recharge to karst groundwater in the areas of the site underlain by carbonate rocks (Stonehenge Limestone) both improving the on-site water quality and restricting the formation of cover-collapse sinkholes by maintaining a healthy leaf-litter/topsoil and root-mass layer;
- Provide habitat for wildlife;
- Reduce noise within the subdivision;
- Provide visual “sight-line” screening of the developed area from surrounding properties and roads.

In this regard, the following recommendations were incorporated to include various elements of karst watershed protection and forestland best management practices.

Vegetation and Clearing
1. All sinkholes and subsidence structures should be left in an undisturbed state with every effort made to maintain the pre-existing natural vegetative cover. The margin (parapet) of the sinkholes should be established based on the last closed contour apparent from the 2-foot contour map created by the project civil engineer.
2. If a structure or roadway falls within the parapet of a sinkhole (as defined in #1 above), the area surrounding the structure should be left in an undisturbed, natural state. However, every effort should be made to exclude any structures or roadways from sinkhole areas.
3. Clearing of vegetation should be limited to footprint approved structures and a buffer of 15-feet from the structure. Elsewhere, no trees larger than 6-inches at breast height (ABH) shall be cut. No trees larger than 3-inches ABH shall be cut within 30-feet of Swiftwater Road or adjoining lot lines without approval of the HOA.
4. Dead, damaged or dying trees that are close enough to structures to present a danger if they fall should be removed. Standing dead trees, dead woody shrubs, or dead brush can also be removed by the property owner. Owners may be allowed to collect deadfall for use as firewood, and to help reduce the fuel mass that can contribute to forest fires.
5. At least three or five standing, dead snags per acre should be left in place to provide food and nesting/den areas for wildlife, particularly cavity-nesting birds and animals.

Site Development and Structure Placement
6. Blasting shall be strictly prohibited.
7. If any sinkholes should form during construction, a professional engineer or geologist with experience in karst issues should be contacted to observe the structure and provide recommendation and oversight for remediation.
8. All underground utilities to be excavated in native soils (as opposed to engineering fill) should be planned so that they do not intercept the karst features or their footprints. Dikes of clay or other materials should be built across all trenches for planned utility lines falling within the 100-foot zone around sinkholes. These dikes should be placed at 20-foot intervals, or less; or at such intervals as directed by a PE or PG.
9. We recommend the developer and/or homebuilder to engage the services of a professional geologist (PG) and/or professional engineer (PE) to develop a location and inspection plan to ensure the structural stability of all buildings and roads proposed to fall within 100-foot of the discernable edge of the existing sinkhole. This plan shall identify the tests that will be completed to determine the subsurface conditions, which may include, but are not limited to: core drilling, electrical resistivity, microgravity, soil bearing tests, or any other tests as recommended by the PE.
10. A limited number of roadway culverts may be necessary to maintain unimpeded overland flow of stormwater from the upgradient sections of sinkhole drainages to their central depressions, particularly during heavy precipitation events. Nevertheless, these culverts should be placed only in areas where it is deemed by a professional engineer that there is a high probability that stormwater may pool on the upgradient side of the roadway. It is notable that both NRCS soil survey data review and onsite observation suggests that the site soils are not prone to flooding or surface pooling.
Chemical Contaminants
11. No oil, gasoline, pesticides, or other hazardous and/or regulated substances shall be poured onto the ground or released anywhere within the development.
12. Roads should be treated during winter exclusively with gravel or cinders. De-icing solutions, salt, or other chemical road treatment agents should not be used.
13. Lawn-care services shall not be allowed.

General
14. Restrictive covenant should be placed in any land transfer documents for the subdivision lots, wherein the responsibilities of the grantee are clearly stated regarding the property’s natural resources.
15. Visitation to on-site caves should be monitored and controlled in order to conserve critical habitats of cave-dwelling biota.

STOP 2. Nestle Quarry
Geological and Historical Setting - The Nestle Quarry (historically known as the “Nessle” Limestone Quarry) was first opened during the steel-making boom of the late 19th and early 20th century, where a serendipitous bend in the Potomac River exposed the west limb of an anticline developed in the valuable Middle Ordovician New Market Limestone (Fig. 5).

Figure 5. Geology of the Nestle Quarry area. Onm = New Market Limestone (Dean et al., 1987)
The nearly pure calcium carbonate New Market Limestone was used extensively in the steel-making process as a fluxing compound. In fact, the strike of the New Market Limestone can be traced by noting the locations of the various limestone quarries in the Shenandoah Valley.

Figure 6. The cliffs of the “Stones River” Limestone prior to the development of the quarry. (Photo courtesy of Bruce Cubbage)

Figure 7. Pack mules used to haul limestone from the quarry floor. Figure 8. Ore train of the “Pittsburgh Limestone Company”.

The quarry was opened by the United States Steel Company in the late 19th century, and at its height reportedly employed 375 men. The quarry closed for good in 1931, since:

“...the best of the available limestone had been mined over that operation was becoming expensive because of that and that big quarries owned by company in the Pennsylvania-Ohio limestone section were nearer to the steel plants and required less freight money to bring the stone to the furnaces.” (from Daily Mail, Hagerstown MD 1931)

Nessle Quarry was also famous for being the site of what was reportedly one of the largest blasts ever performed in the United States, where thousands of tons of explosives were detonated simultaneously, tearing down an enormous portion of the cliff face. The event was reportedly filmed by “moving picture machines” as a “big news happening”.

**Karst Geology** – Nessle Quarry is the site of 16 known caves, the majority of which are small. However, two of the caves are significant in size with development of speleothems and complex hydrology (Fig. 9). The historic Nestle Quarry Cave is located along the current access road, and it contains several hundred
feet of passage, several sizable rooms and a stream. The stream resurges from a small cave at the base of the old quarry face. A second large cave (Lower Nestle Quarry Cave) has an entrance in the old quarry face, and was intercepted during the historic quarrying operations. It has 740-feet of passage, areas of well-developed formations and a siphon pool at its far end where it reaches the depth of the phreatic water table.

![Maps and profiles of the Nestle Quarry and Lower Nestle Quarry caves.](Gulden & Johnson, 1984)

In addition to the many caves, the Nestle Quarry area is marked by the presence of numerous large, well-developed cover-collapse sinkholes, many of which have open or clogged throats at their base. Perhaps one of the most significant (and dangerous) of these is Turtle Soup Pit (Fig. 10), a vertical cave that opens from the base of a large sinkhole near the intersection of the quarry access road and Nestle Quarry Road. The pit is a classic “natural trap”, in that its 2-foot wide throat “bells out” to over 5-feet in diameter. The pit is 20-feet deep, and there is a small side passage leading off to the northeast which pinches out rapidly and cannot be followed past that point.
The side passage at the base of the pit follows the strike of the anticlinal fold which brought the New Market Limestone to the surface at the quarry. It's of note that the sinkholes marking the surface of much of the site (Fig. 11) have developed along a set of conjugate fractures that along which the passages in the site caves have developed.
Modern Development – Nestle Quarry underwent development as a custom-built luxury home subdivision in the 21st Century. A series of homes have been built along both sides of Nestle Quarry Road, many of which are perched at the edge of the existing quarry headwall. The entire area has become significantly naturalized since the quarry was abandoned in 1931. The moderator of the field trip, Robert Denton, has provided guidance for the safe placement of several homes along the quarry walls, and also performed the karst survey work which supported the approval of the Nestle Quarry Subdivision by Manor House Builders in 2006. More recently in 2014, Mr. Denton while working for GeoConcepts Engineering, provided geotechnical and foundation design support for the construction of a custom-built cantilever-style home dubbed “Hawk’s Nest”. Perched on the quarry headwall, with spectacular views of the Potomac River’s bluffs and valley, the Hawk’s Nest home was designed to blend in with the natural environment by engaging the efforts of a team of geotechnical, architectural, and structural engineer and engineering geologists.

Figure 12. The completed Hawk’s Nest home.

STOP 3. The Caves at Norborne Cemetery
Geological and Historical Setting – In late 2011, a student from Martinsburg High School first reported the existence of several cave entrances at the base of a large sinkhole located in a wooded area at the northwest corner of the historic Norborne Cemetery in Martinsburg, WV. Stormwater draining from the Martinsburg High School property, and surrounding sites, had been draining for many years to a closed depression at this same location. However, a combination of heavy snowmelt in 2010, plus the effects of a 5-inch rainfall from Tropical Storm Lee in 2011, resulted in the rapid deepening of the closed depression at the cemetery, forming a sinkhole over 25-feet in depth with several exposed “throats” at its base which were large enough to admit a human being, and therefore classifiable as caves. The caves were entered by the students who first reported them to the Tri-State Grotto of the National Speleological Society, but to our knowledge have never been formally explored or surveyed.
The caves are located in the east limb of a plunging anticline, formed by the Rockdale Run Formation and near the contact with the Pinesburg Station Dolomite, both of the Beekmantown Group and dating from the Early Ordovician Geologic Period (Fig. 13). Reportedly, they are all relatively short passages that run parallel with the strike of the bedrock, however the true extent of the caves is unknown. There are a number of other small caves known in this area of Martinsburg, all of which were intercepted during quarrying activities during the 20th century. Not surprisingly, the active Italcementi Quarry located just to the southwest of the Norborne site has intercepted numerous caves during its operations.

Figure 13. Geology of the Martinsburg Sites. **Obrr** = Rockdale Run Formation, **Obps** = Pinesburg Station Dolomite, **Omc** = Middle Ordovician Carbonate Units (includes the New Market Limestone and the Chambersburg Formation), **Om** = Martinsburg Formation (WVGES, 1968).
Caves are known to exist beneath both the cities of Martinsburg and Charles Town (Jefferson County). Although none of the caves in Martinsburg were ever developed as a tour cave, two caves in the Charles Town area have been open for tours in historic times. Perhaps the most famous of these was “Lakeland Caverns” in Charles Town, also known simply as “Charles Town Cave”. The cave consisted of a single, relatively roomy passage, which extended from a vertical drop located beneath the former site of the Liberty Street Café.

Lakeland Caverns featured a boat trip on the cave’s subterranean lake, which gave the cave its name. Unfortunately, the cave is now closed, and when it was last entered around a decade ago the air within the cave was found to be contaminated with petroleum vapors, possibly emanating from dissolved-phase contaminants in the lake water. A heat-exchange unit which supplied the café above was also located in the cave, and this may have contributed to the degradation of the cave’s environment as well. Lakeland Caverns is located in the Cambrian age Elbrook Limestone.
Harper’s Ferry Caverns was the second tour cave operating in Jefferson County. The cave was located west of town in the Bolivar Heights area. The cave itself was unique in that half of it was originally open to the sky, and was roofed over to create a “cave”. It is located in the carbonate facies of the Waynesboro Formation, dating from the Cambrian geologic period.

STOP 4. The Martinsburg Cave Tunnels  
Geological and Historical Setting – In 1770s, Adam Stephens, a prominent Martinsburg citizen built a log cabin with a stone foundation over the entrance to a natural cave located in the Middle Ordovician Chambersburg Formation (Mozier, 2014). Stephens would go on to become a general in the Revolutionary War. After the war’s end, he would demolish the cabin and in 1789 would sponsor the
construction of a stately home on the foundation of the original cabin. The General Adam Stephens House is now is a historic site owned and administered by the City of Martinsburg.

![Figure 18. Entrance to the tunnel system and caves in the basement of the Gen. Adam Stephens House.](image)

The reason why Stephens chose to build his cabin over the cave is still unclear, but it was possible that they chose this location to take advantage of the year round 54°F temperature of the regional cave air to maintain a stable atmosphere in a root cellar beneath the cabin. A cavern room was discovered behind a brick wall in an adjoining property on E. King Street which was probably used for the same purpose. Other purposes could have been to use the cave to escape or hide from attacks by Native American war parties during the French and Indian War, but attacks ceased in 1768, so it’s unlikely the cave was used for this purpose. Nevertheless, stories over the years have added credence to the existence of a cave and tunnel system. It was said that a woman in Martinsburg treated the wounds of both Confederate and Union soldiers, and after nursing them back to health, the tunnels were used to allow them to escape town. Newspaper accounts from 1901 to 1904 tell of a gang of young men who would steal from the railroad, and then when pursued would simply “disappear”. A resident finally revealed the presence of the tunnels, leading to the capture and arrest of the gang. Around 1930 another story emerged of a residential tenant who was removed some floor boards beneath the kitchen of a home, and found a natural cave with skeletons in it. From the 1930s through the 1950s there were numerous accounts of mischievous youngsters who would go from house to house through the tunnels, popping up and scaring people. And then disappearing back into the system. Thus, the cave entrances beneath various houses were filled in with trash, rocks and soil. As the entrances were filled, and houses over the caves were demolished, the stories of the cave and tunnel system became relegated to an urban legend.

Nevertheless, stories remained of the caves. In the 1990s when the chamber was discovered behind the brick wall in the King Street house, excavations were begun as there were stories that this cave was connected to the Stephens house by the tunnel system. To date the excavation at the East King Street house has been deepened to 40 feet below the surface, revealing two sets of stairs. It’s thought that the actual entrance to the cave and tunnel system may be as far down as 70-feet below the surface.
In the late 1990s there were several unsuccessful attempts to locate the entrance to the reputed cave beneath the Adam Stephens House. A breakthrough came in 2002 at a Founders Day gathering, when some local Martinsburg residents suggested the presence of a cellar room beneath the kitchen of the house in which the cave entrance was said to be. The basement room was found, and in it was a soil-filled cavern entrance, which the Tri-State Grotto of the NSS has been excavating since that time. Hundreds of cubic feet of loose soil, trash, and even some horse bones have been removed from the tunnel, which now extends as a steeply sloping cave passage over 40 feet from the formerly hidden basement room. It is hoped that eventually the dig will break into the air-filled passages of the former cave and tunnel system.

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Hobba, W. A., 1976, Ground Water Hydrology of Berkeley County, WV, USGS and the Berkeley County Court.

# Generalized Stratigraphic Chart for West Virginia

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**Note:** No vertical scale implied

(This chart uses current WVGES terminology and supercedes stratigraphic unit names used in older publications.)

**Map-29A  2014**
SELECTED REFERENCES


