

The Friends of the Shenandoah River's
2018 Summer *E. coli* Testing Project at Public Access
and Recreational Use Areas on the Main Stem, North
Fork, and South Fork of the Shenandoah River



Friends of the Shenandoah River
1460 University Drive
Winchester, Virginia 22601
540.665.1286
friendsofshenandoahriver@gmail.com
www.fosr.org



Friends of the Shenandoah River's water-quality testing laboratory located on the campus of Shenandoah University in Winchester, Virginia. Preparation of water samples for the detection and enumeration of *Escherichia coli* bacteria (*E. coli*) concentrations using the IDEXX Colilert-18 test with the Quanti-Tray/2000.

Written by Karen Andersen, Laboratory and Program Director
With contributions from
Molly Smith, Laboratory Assistant
and the Friends of the Shenandoah River Board of Directors
February 2019

Table of Contents

Introduction:	2
Results of the FOSR’s 2018 Summer <i>E. coli</i> Testing Project at Public Access and Recreational Use Sites on the	
Main Stem Shenandoah River.....	6
North Fork Shenandoah River.....	10
South Fork Shenandoah River.....	12
Opequon Creek – Potomac Watershed	15
Continuation of this vital public service	16
FOSR’s 2018 Summer <i>E. coli</i> Testing Project Data Table	17
Supplemental Information:	
S1.1 What is Coliform Bacteria.....	18
S1.2 Health Effects from Exposure to Waterborne Pathogens.....	19
S1.3 Role of Coliforms in Detecting Contamination in Water.....	19
S2.1 EPA BEACH Act.....	20
S2.2 Monitoring of Beach Waters in Virginia	20
Map with the <i>E. coli</i> Testing Project sites identified is located on inside back cover	

Introduction:

The Friends of the Shenandoah River (FOSR) has been operating, maintaining, and funding a science-based volunteer citizen scientist water-quality monitoring program for three decades. The program includes in-house analysis of water samples. The FOSR operates a Virginia Department of Environmental Quality level III accredited water-quality lab in a space that is generously provided by Shenandoah University, via a partnership that began in 1994, on its main campus in Winchester, Virginia. A staff of two operates the FOSR's lab, and a team of dedicated volunteer citizen-scientists is essential to the success of this program. In the scientific, environmental, and educational community, the work performed by the FOSR's lab is held in high regard.

The value of the FOSR's data increases with the years of the record and is crucial to understanding and resolving critical water quality issues plaguing the Shenandoah River. This long-term data also shows trends in water quality. While these data have exceptional value to the Virginia Department of Environmental Quality (DEQ) at the State level and the Environmental Protection Agency (EPA) at the Federal level; it does not provide, according to general public perception, information considered important to their well-being or relevant to their everyday activities.

The Shenandoah River, also known as "Daughter of the Stars," is a true gem for both tourists and residents of the watershed. The river appeals not just to the outdoor enthusiast, but also to someone seeking a tranquil spot to enjoy. Those that visit often leave feeling recharged and can't wait to return. It is not just local guides and outfitters that depend upon the river's recreational industry for their financial well-being; local communities need the Shenandoah for their water supply as well.

In the spring of 2017, local newspapers, television stations, and radio stations raised public concern with the coverage of a report by the Environmental Integrity Project titled *Water Pollution from Livestock in the Shenandoah Valley: Virginia's System of Manure Management Fails to Protect Waterways and Needs to be Strengthened*. The report states; "Tubing and rafting are popular on the Shenandoah River and its tributaries, but high *E. coli* bacteria levels are common in part



*Tubing and rafting are popular on the Shenandoah River and its tributaries, but high *E. coli* bacteria levels are common in part because of manure runoff. Virginia fails to warn people to avoid contact with these contaminated waters, even when bacteria levels are more than 100 times the recreational limit.*

Figure 1: Environmental Integrity Project report, image and excerpt <http://www.environmentalintegrity.org/reports/water-pollution-from-livestock-in-the-shenandoah-valley/>

because of manure runoff. Virginia fails to warn people to avoid contact with these contaminated waters, even when bacteria levels are more than 100 times the recreational limit.”

As a result of this report and the media coverage that followed, the public became alarmed about the potential health risks described. Local and state agencies, including DEQ and the Virginia Department of Health, as well as environmental organizations, such as the FOSR, received phone calls and emails from individuals inquiring about current water-quality conditions and related potential health risks. After receiving inquiries from concerned parents, schools canceled outdoor educational activities that would have taken place in streams. There was a notable drop in tourism related to visitors to the Shenandoah River. This had a detrimental impact on businesses and recreational outfitters throughout the watershed.

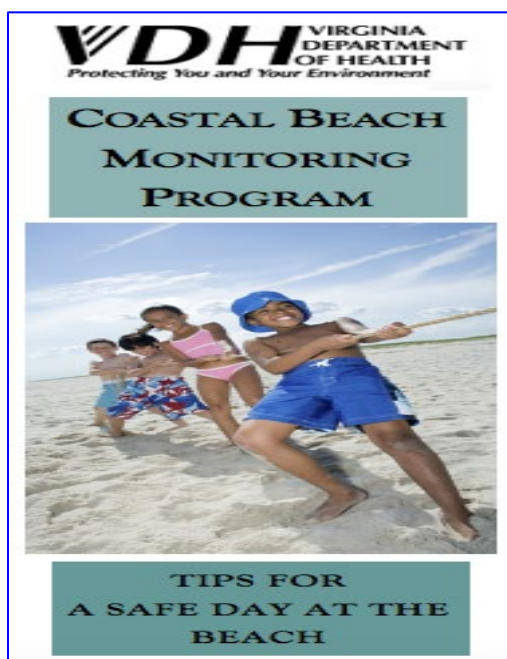


Figure 2: Cover of VDH Beach Monitoring Brochure
http://www.vdh.virginia.gov/content/uploads/sites/12/2017/05/VABeach_brochure_FINAL.pdf

Since 1976, in accordance with the EPA’s 2000 Beaches Environmental Assessment and Coastal Health Act (BEACH Act), branches of the Virginia Department of Health perform weekly testing for levels of bacteria in the coastal waters at public beach areas from May through September¹. When bacteria levels exceed health standards set by the EPA the public is notified and advisories are posted at the particular beach site. Swimming advisories remain in effect until samples show that bacteria are within acceptable levels. (Refer to page 20 for more details about the EPA Beach Act.)

Despite this recognition of the responsibility to inform the public of potential health risks when engaging in water contact recreational activities at Virginia beaches, no such programs exist for the freshwater rivers and tributaries of Virginia even at state recognized public access and recreational use areas.

In response to the public concerns about exposure to reported increased bacteria levels in the Shenandoah River, the FOSR launched a project that began in 2017 to test the *Escherichia coli* bacteria (*E. coli*) levels in the Shenandoah River at public access and recreational areas. Initially, the project started with three sites selected on the Main Stem of the Shenandoah River in Clarke County, Virginia that were tested from May through August. The FOSR implemented the same once a week testing methodology used by the Virginia Department of Health for the public coastal beaches of Virginia. The goal of FOSR’s summer *E. coli* testing project is to provide frequent, real-time accredited *E. coli* concentration results for river recreation users to make their own informed decision about potential associated health risks when recreating in the areas of the river tested.

¹<http://www.vdh.virginia.gov/virginia-beach/environmental-health/>

In a freshwater system, the water-quality data represents a snapshot of the water quality on the date, time, and under the conditions that the water sample was collected. As documented in this report, *E. coli* levels are fluid, meaning that the concentration of *E. coli* changes. Such changes are influenced by many factors, including;

- changes in the volume of flow caused by
 - local and regional rain events that flush contaminants from the land surfaces into the streams and rivers
 - water withdrawal and drought
- runoff from urban, suburban, rural and agriculture lands
- illicit discharge, failing septic systems, contaminated groundwater
- wildlife, livestock, pets, and humans

The FOSR's lab utilized the IDEXX Colilert-18 method for detecting and quantifying the most probable number of *E. coli* present in water. This is an EPA and DEQ approved method for several types of regulated waters including ambient freshwaters used for recreation.² The maximum detectable limit of this method allows for the documentation of bacteria levels in water samples that are about 10 times DEQ's water-quality standard for freshwater beach advisories or closures with a single sample maximum of 235 CFU/100ml.³ There is the possibility for those samples that measure >2,419.6 MPN/100 mL that the actual *E. coli* level is many times higher. Detection of *E. coli* bacteria in the water indicates recent fecal contamination as well as a possible presence of other disease-causing microorganisms or pathogens. As the level of *E. coli* bacterium increases so does the potential health risk from exposure to pathogenic organisms. DEQ's standard is based on the EPA criteria that states that an estimated 36 out of 1000 people will experience illness when exposed to *E. coli* levels of 235 CFU/100mL while engaging in primary recreational water activities.⁴ (*Additional information about Escherichia coli (E. coli) bacteria can be found on page 18*)

Thanks to generous funding received to continue the project, in 2018 the FOSR expanded its *E. coli* testing project to include a total of fifteen sites located on the North Fork, South Fork, Main Stem of the Shenandoah River and Opequon Creek. The project was launched the first week of May and continued through the last week of September.

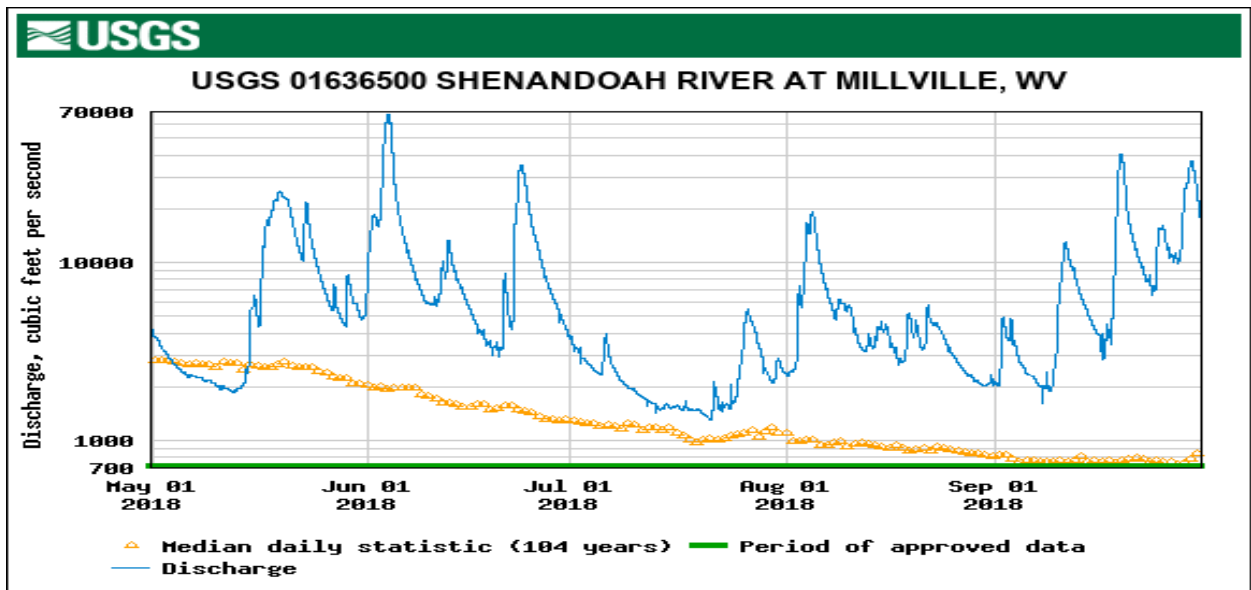
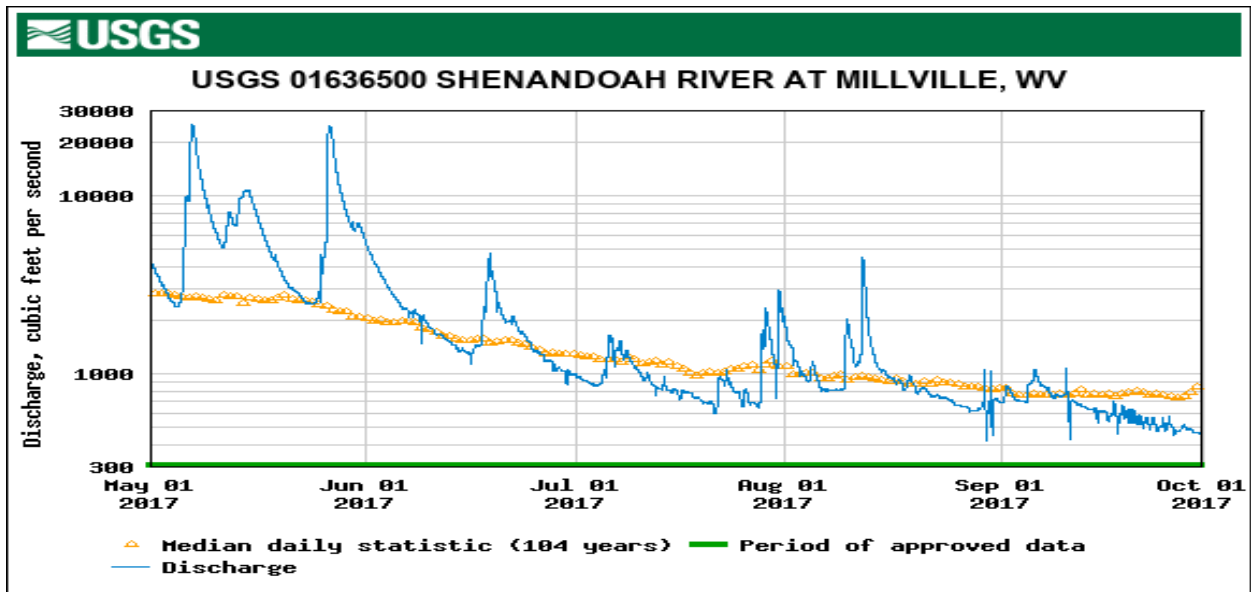
2018 was the wettest year on record for dozens of localities in Virginia. Many areas in the Shenandoah River watershed experienced more than 60 inches of rain leading to overland runoff, saturation of storm-water systems, and strained wastewater treatment facilities. Many of the water samples during the project period were collected during elevated flows, even at and above flood levels. These elevated flows are correlated with increased *E. coli* concentrations as seen in the data from this project. Despite this, on several occasions when performing the water sample collection at high flows, people were recreating in the river.

² Standard Methods for the Examination of Water and Wastewater; 9223 B-2004 Colilert-18®

³ 9VAC25-260-170. Bacteria; Other Recreational Waters <https://law.lis.virginia.gov/admincode/title9/agency25/chapter260/section170/>

⁴ OFFICE OF WATER 820-F-12-058 "Recreational Water Quality Criteria," <https://www.epa.gov/sites/production/files/2015-10/documents/rwqc2012.pdf> pg. 44

Below are graphs generated from the USGS’s discharge data collected from the USGS gauge located on the Main Stem of the Shenandoah River at Millville, West Virginia.⁵ This gauge measures the combined flow from both the North and South Forks of the river that makes up the Main Stem. The discharge is measured in cubic feet per second (CFS). CFS is equal to a volume of water one foot deep and one foot wide flowing a distance of one foot in one second. One CFS is equal to 7.48 gallons of water flowing each second. These graphs illustrate the measured discharge in 2017 and 2018 during the same period. In 2017 the highest measured discharge was approximately 25,000 CFS were as in 2018 the highest discharged measured was approximately 70,000 CFS.



⁵ <https://waterdata.usgs.gov/usa/nwis/uv?01636500>

FOSR’s 2018 Summer *E. coli* Testing Project at Public Access and Recreational Use Sites on the Main Stem, South Fork, and North Fork of the Shenandoah River

Main-stem of the Shenandoah River

The 2018 Summer *E. coli* testing project included six sites on the Main Stem of the Shenandoah River, three of the sites were in Clarke County and the other three in Warren County.

TABLE 1: 2018 Summer <i>E. coli</i> testing project sites located on the Main Stem Shenandoah River	
SITE ID	SITE DESCRIPTION/LOCATION
FC08	Main Stem Shenandoah River at Castleman's Ferry public boat ramp, Route 7 bridge
FC05	Main Stem Shenandoah River at Lockes Landing public boat landing
FC01	Main Stem Shenandoah River at Berry's public boat ramp, Route 50 bridge
FW35	Main Stem Shenandoah River at Morgan's Ford low water bridge public boat landing below the confluence with Manassas Run
FW35MID	Main Stem Shenandoah River at Morgan's Ford low water bridge mid-width of river
FW36	Manassas Run upstream of the confluence with Main Stem Shenandoah River, just upstream of the public boat landing

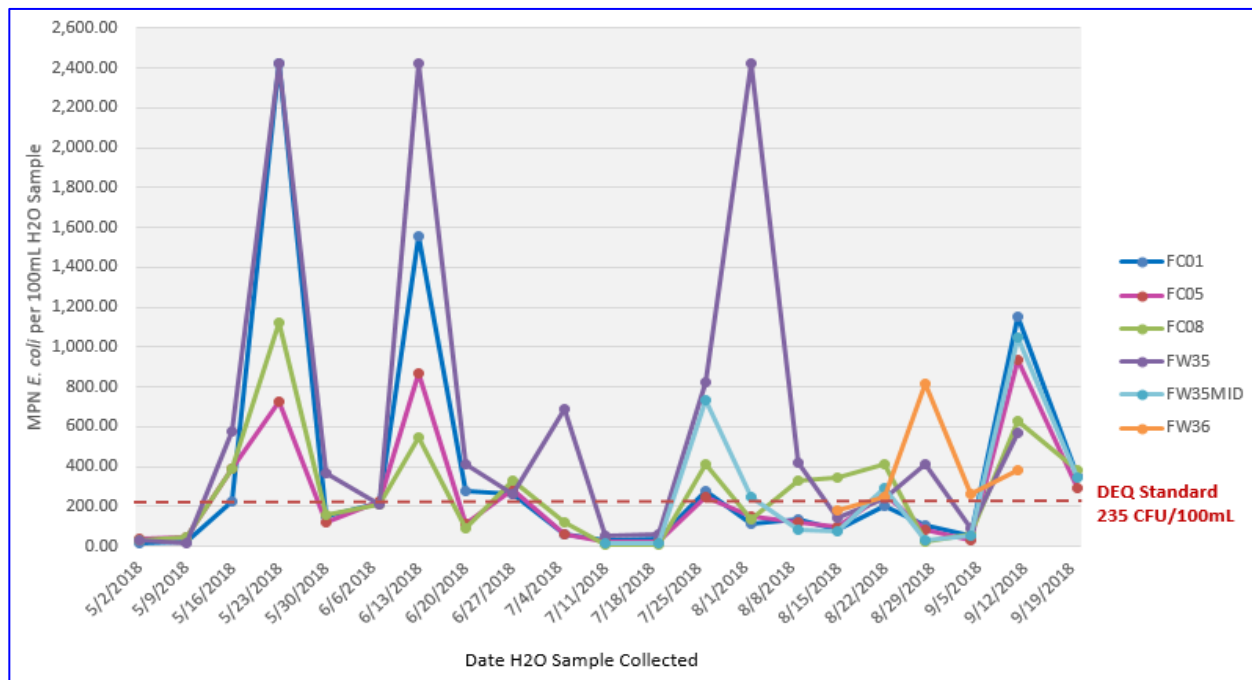


Figure 3: *E. coli* levels at sites on the Main Stem Shenandoah River. Results reported as 2,419.6 MPN/100mL exceeded the method limit of 2,419.36 MPN/100mL. The red line represents the DEQ water-quality standard for freshwater beach advisories or closures with a single sample maximum of 235 *E. coli* colony forming units 100 per milliliters of water sample (CFU/100ml)¹ See Table 5 for complete set of the data for the Summer 2018 *E. coli* Testing project.



Figure 4: A typical scene at Lockes Landing in Clarke County on any given warm day. Potentially well over 10,000 people use Lockes Landing every year as a place to come to enjoy the river.

In both 2017 and 2018, the designated project sites in Clarke County were located at Route 50 Berry’s Boat Ramp, Lockes Landing, and Route 7 Castleman’s Ferry boat ramp. Many individuals, families, and civic groups frequent these sites to enjoy the offerings of the Shenandoah River. Thousands of people, potentially well over 10,000, use Lockes Landing every year as the start to their tubing trip down the river.

The FOSR’s 2017 Summer *E. coli* project data showed that at Route 50 Berry’s Boat Ramp and Lockes Landing 3 out of the 13 times tested *E. coli* levels exceeded the DEQ water-quality standard for freshwater beach advisories or closures with a single sample maximum of 235 CFU/100ml. At Route 7 Castleman’s Ferry boat ramp, of the 13 times tested, the *E. coli* level exceeds the standard once.

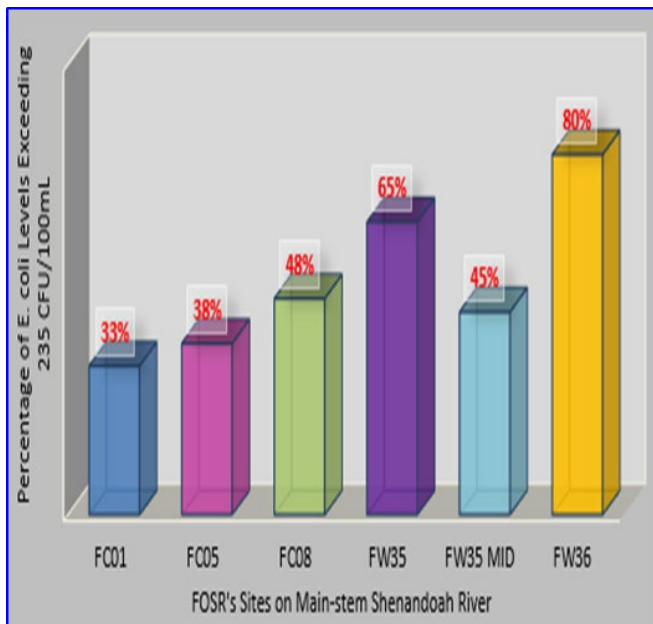


Figure 5: Total percentage of times out of the number of times tested, the *E. coli* levels at each site on the Main Stem of the Shenandoah River exceeded DEQ Standard of 235 CFU per 100mL H₂O sample in 2018.

The FOSR’s 2018 Summer *E. coli* project data for the three sites tested in Clarke County showed an increase in potential health risk from exposure to pathogens due to more frequent elevated *E. coli* levels. At Route 50 Berry’s Boat Ramp (FC01) for 7 of the 21 times tested, or 33% of the time, the measured *E. coli* levels exceeded the standard. The site at Lockes Landing (FC05) exceeded the standard 38% of the time and Route 7 Castleman’s Ferry boat ramp (FC08) exceeded the standard 48% of the time. (See Figure 5 and Table 5)

During the 21 weeks the testing was performed, at Route 50 Berry’s Boat Ramp (FC01) the *E. coli* levels ranged from 15.8 to >2,419.6. (Refer to Table 4) For three consecutive testing dates the *E. coli* levels measured 224.7 on May 16, >2,419.6 on

May 23, and 151.5 on May 30. This leads to the question, **“at what point, for how long, and how often was the *E. coli* level greater than the standard, with it increasing the risk of exposure to pathogens?”** Another example is the period from June 7 to June 27. On June 7th, the *E. coli* concentration was 214.2, the 13th it was 1553.1, the 20th it was 275.5 and on June 27th, 260.3. One-week later on July 5, the *E. coli* concentration was 57.6. Then the next two weeks, on the days tested, the *E. coli* levels measured were 32.7 and 37.4. On July 26 the *E. coli* concentration increased significantly to 275.5. Similar occurrences are seen in the data for the last three weeks tested.

The *E. coli* levels ranged from 23.5 to 932.0 at Lockes Landing (FC05). (Table 5) During the same three-week period from May 16 to May 30, the *E. coli* levels measured 387.3, 727.0, and 117.8 respectively. At this site, the *E. coli* levels showed greater fluctuation from one week to the next. For example, on July 19 the *E. coli* concentration was 23.5. One week later it was 247.2. Similarly, on September 4 the *E. coli* level was 30.9 and the following week on September 11 it was 30 times greater at 932.0.



Figure 6: Shenandoah River at Castleman's Ferry boat ramp, Route 7 in Clarke County (FC08).

For Route 7 Castleman's Ferry boat ramp (FC08) the *E. coli* levels ranged from 9.8 to 1,119.9 MPN/100mL. (Table 4). For the three testing dates from May 16 to May 30 for this site the *E. coli* levels were 387.3, 1119.9, and 156.5. The measured *E. coli* levels at this site went from extremes, one week with the lowest measured *E. coli* concentration at this site of 9.8, and then one week later the *E. coli* concentration increased 42 times to 410.6. Again, raising the question, **“for how long, and how often, between testing periods did the *E. coli* level exceed the standard?”** (Table 5)

In 2018, two sites were added on the river at the Morgan's Ford Road low water bridge in Warren County; one site was in the shallows close to the boat ramp (FW35), the other was at mid-width of the river (FW35MID). A third site was added on Manassas Run (FW36) upstream of the confluence with the Shenandoah because it was found to be a very popular recreational site, especially with families. These three sites are popular with fishermen, boaters, paddlers, and people just enjoying playing in the river and stream. The site in the river shallows the *E. coli* levels exceeded the DEQ standard for 13 out of the 20 times tested. The *E. coli* levels exceeded the standard at mid-river 5 out of the 11 times tested. At the site on Manassas Run where kids were observed playing in the water, the *E. coli* levels exceeded the standard 4 out of 5 times. (See Figure 5 and Table 5)

During the 21 weeks the testing was performed it was only on a rare occasion when people were not observed enjoying themselves in the shallows of the river close to the boat ramp (FW35). At this site the *E. coli* levels ranged from 18.5 to >2,419.6 on three occasions. (Table 5) On May 16 the *E. coli* level was 579.4, May 23 it was >2,419.6, and on May 30 the *E. coli* concentration was 365.4. For the four testing dates from June 13 to July 5, the *E. coli* levels exceeded the standard each of the times tested ranging from 2,419.6 to 261.3.

To test whether the *E. coli* levels were similar mid-width of the river as those measured in the shallows, site FW35MID was added. The *E. coli* levels at this site ranged from 17.3 to 1050.0. When comparing the *E. coli* levels measured at site FW35 to those at FW35MID, 8 out of 10 times the *E. coli* levels at FW35 were higher. To determine the source of the higher *E. coli* readings at FW35 led to the addition of a site on Manassas Run, FW36. Manassas Run flows into the Shenandoah River just above the boat landing. Of the five times tested, the *E. coli* levels at FW36 exceeded the standard four times and ranged from 178.5 to 816.4. Also, four of the times tested, the *E. coli* concentrations were greater than those measured at FW35.

**“Do it again daddy,
do it again!”** the
children called out.

On August 9, 2018, while performing the water sample collection a father and his children were playing in the Shenandoah River shallows downstream of the confluence with Manassas Run (FW35). They were playing a game they called “shampoo.” The father, while holding the children by their legs, dunked them head first into the river water. The children screamed and giggled with delight, anxiously waiting for their next turn while exclaiming, “Do it again daddy, do it again!” At the time that this was occurring the measured *E. coli* levels were 419.6 CFU/100mL, exceeding the DEQ Standard of 235 CFU/100mL. The week before the *E. coli* levels at the site were greater than 2,419.6 CFU/100mL. This is another example of how vital the need is to provide current data to keep the public informed about potential health risks. (See Figure 5 and Table 5)

North Fork of the Shenandoah River

The FOSR’s 2018 Summer *E. coli* testing project included three sites on the North Fork Shenandoah River in Shenandoah County.

TABLE 2: 2018 Summer <i>E. coli</i> testing project sites located on the North Fork Shenandoah River	
SITE ID	SITE DESCRIPTION
FSMB	NF Shenandoah River at Meems Bottom
FSDR	NF Shenandoah River at Deer Rapids public boat landing
FSSP	NF Shenandoah River at Strasburg Park public boat landing

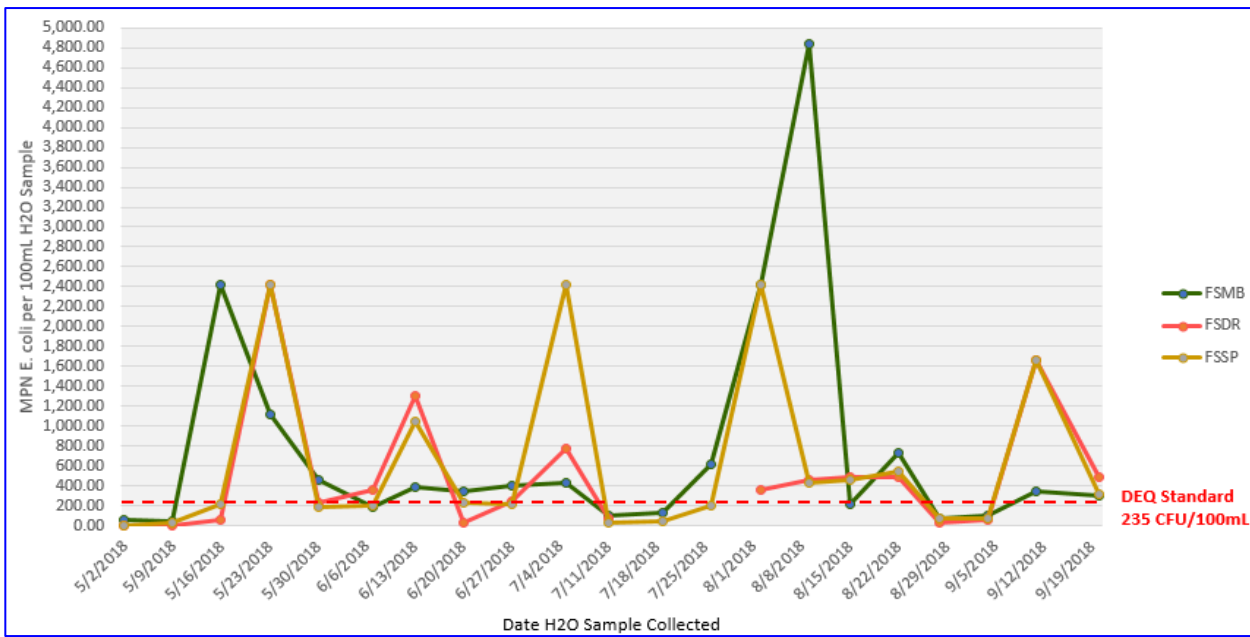


Figure 7: *E. coli* levels at sites on the North Fork Shenandoah River. Results reported as 2,419.6 MPN/100mL exceeded the method limit of 2,419.36 MPN/100mL. On 08.09.2018, the **FSMB** H₂O sample was diluted, the result exceeded the maximum limit of 4,839.2 MPN/100mL. The red dash line represents the DEQ water-quality standard for freshwater beach advisories or closures with a single sample maximum of 235 *E. coli* colony forming units 100 per milliliters of water sample (CFU/100ml)¹ See Table 5 for complete set of the data for the 2018 Summer *E. coli* Testing project.

The North Fork Shenandoah River at Meems Bottom (**FSMB**) located near Mount Jackson in Shenandoah County is a popular tourist attraction with its historic covered bridge. The covered bridge at Meems Bottom is featured on several websites such as Virginia is for Lovers at Virginia.org and TripAdvisor. The bridge is also featured in the 2019 Virginia Travel Guide and State Map and appeared in the Great Day Trips issue of the Northern Virginia Magazine. When visiting the site, tourists and locals, enjoy relaxing in the tranquility of the river. During the 21 weeks the testing was performed, the *E. coli* levels at this site ranged from 43.5 to >4,839.2, and exceeded the state standard 13 times, that is 62% of the times tested. (See Figure 7, 8, 9 and Table 5)

The North Fork Shenandoah River at Deer Rapids (**FSDR**) is a popular area for fishing and paddling. At this site the DEQ Standard of a single sample maximum of 235 *E. coli* CFU/100mL was exceeded 63% of the time, or 12 out of 19 times tested. (Figure 8) The *E. coli* levels ranged from 3.0 to >2,419.6 (Table 5).

At Strasburg Park, the North Fork Shenandoah River adds a natural attraction for the water enthusiasts visiting the park. On several occasions during water sample collection people were engaging in recreational activities that included playing in the river, catching bugs and minnows, swimming, fishing and paddling. The *E. coli* levels in the North Fork Shenandoah River off the public boat ramp in Strasburg Park (**FSSP**) ranged from 6.2 to >2,419.6, exceeding the standard 10 out of the 22 times tested, 43% of the time. (Figure 8) From August 2 to August 22 the *E. coli* levels constantly remained high; measuring >2,419.6 on August 2, 437.4 on the 9th of August, 461.1 on the 15th, and then on August 22 the levels were 544.6. (Table 5)

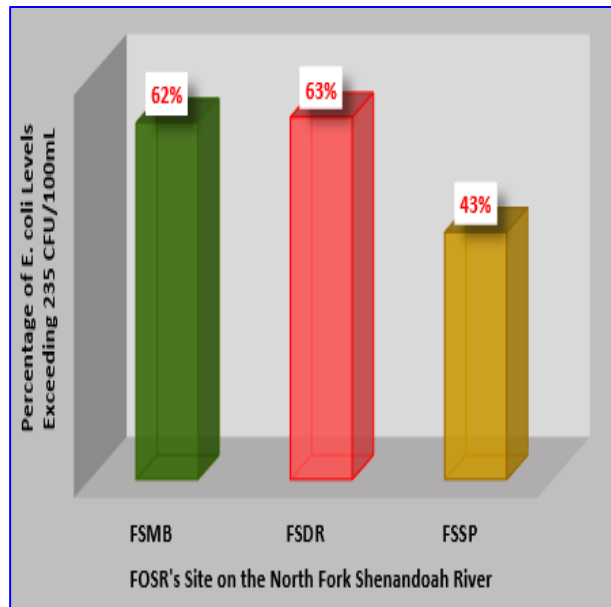


Figure 8: Total percentage of times out of the number of times tested, the *E. coli* levels at each site on North Fork Shenandoah River exceeded DEQ Standard of 235 CFU per 100mL H₂O sample.



Figure 9: The North Fork Shenandoah River at Meems Bottom Covered Bridge (**FSMB**)

South Fork of the Shenandoah River

The FOSR's 2018 Summer *E. coli* testing project included five sites on the South Fork Shenandoah River. Three of the sites were in Warren County and two in Page County.

TABLE 3: 2018 Summer <i>E. coli</i> testing project sites located on the South Fork Shenandoah River	
SITE ID	SITE DESCRIPTION
FW14	SF Shenandoah River at Front Royal public boat landing, Luray Ave.
FWAGSP	SF Shenandoah River at Raymond R. "Andy" Guest Jr., Shenandoah River State Park
FWIH	SF Shenandoah River at Indian Hollow public boat launch off Indian Hollow Road
FP03	SF Shenandoah River at White House public boat landing
FP02	SF Shenandoah River at Newport public boat ramp downstream of Riverside Campground/ Kite's Store

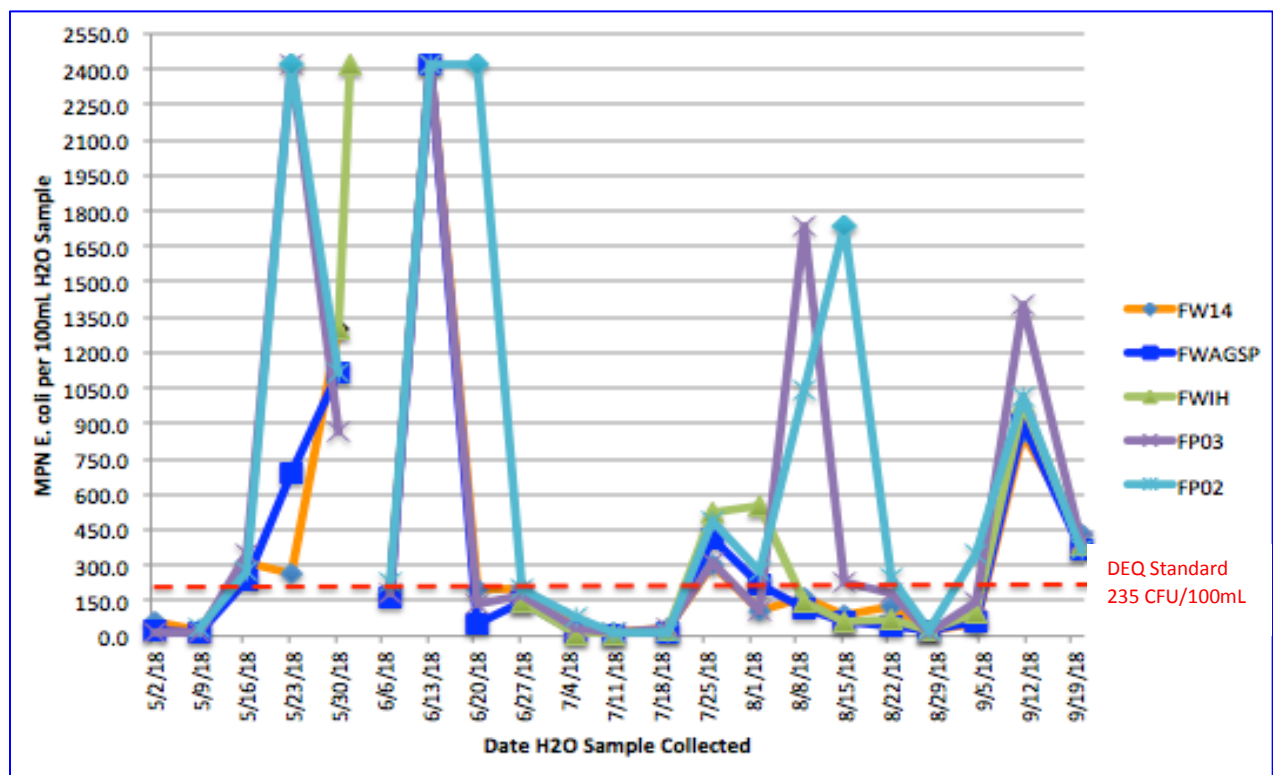


Figure 10: *E. coli* levels at sites on the South Fork Shenandoah River. Six of the *E. coli* levels exceeded the method limit of 2,419.36 *E. coli* CFU/100mL. The red dash line represents the DEQ water-quality standard for freshwater beach advisories or closures with a single sample maximum of 235 *E. coli* colony forming units 100 per milliliters of water sample (CFU/100ml)¹ See Table 5 for complete set of the data for the 2018 Summer *E. coli* testing project.

The South Fork Shenandoah River at the public boat landing off Luray Avenue in Front Royal, Virginia, **FW14**, is a very popular site with local community members and visitors partaking in many water related recreational activities. It's only on a rare occasion on a summer evening when there is not at least one person at the boat landing. Outfitters and other excursion groups use this site as a put-in and take-out site for paddlers. At this site, the *E. coli* levels ranged from 17.1 to >2,419.6. The *E. coli* levels exceeded the DEQ standard 7 out of the 21 times tested, which is 33% of the time. (Figure 12 and Table 5)

In 1994 the Shenandoah River Raymond R. "Andy" Guest Jr. State Park was established. The park offers 5.6 miles of river frontage along the South Fork, riverfront camping, cabins, picnic areas, picnic shelters, abundant wildlife, and trail systems for hikers, cyclists, and equestrians. Recently two additional attractions have been made available at the park, a zip-line and tube rentals. Despite the designation as a State Park, the river that flows through the Park carries the contaminants from many sources. Out of the 21 times tested, the *E. coli* levels at the **FWAGSP** site exceeded the standard 7 times.



Figure 11: Kayakers on the South Fork of the Shenandoah River at Shenandoah River Andy Guest State Park (**FWAGSP**)

The other three sites on the South Fork included in the project, Indian Hollow Public Boat Launch (**FWIH**), White House Public Boat Landing (**FP03**), and Newport Public Boat Ramp (**FP02**), are popular with paddlers, boaters, anglers, and those just out to enjoy the river. All three of these sites are located near campgrounds. Indian Hollow Public Boat Launch (**FWIH**) offers portage for outfitters. At this site, **FWIH**, the *E. coli* levels exceeded the standard 6 of the 15 times tested. The *E. coli* levels exceeded the standard 38% of the time, 8 out of the 21 times tested, at White House Public Boat Landing (**FP03**). Of the five sites tested on the South Fork, site **FP02**, Newport Public Boat Ramp, exceeded the DEQ standard of 235 *E. coli* CFU/100mL most often, 13 out of the 20 times tested, or 65% of the time. Three of those 13 times, the *E. coli* concentration exceeded the method detectable limit of 2,419.6 MPN/100mL of water sample. (Figure 12 and Table 5)

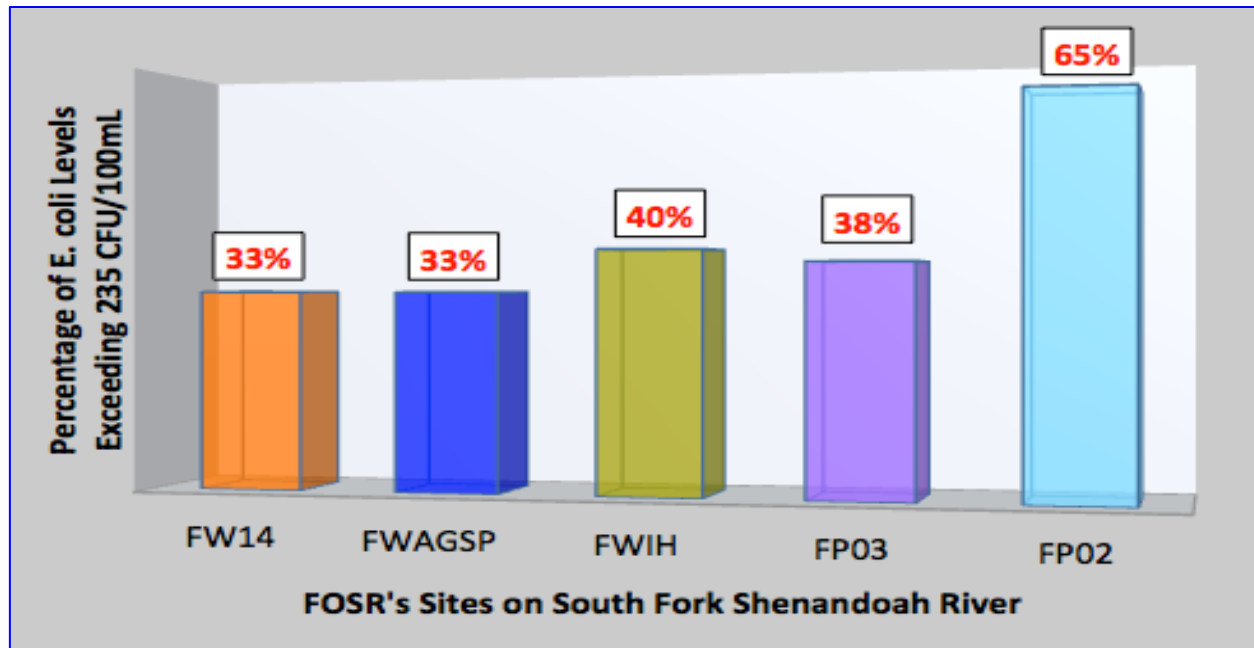


Figure 12: Total percentage of times out of the number of times tested, the *E. coli* levels at each site on South Fork Shenandoah River exceeded DEQ Standard of 235 CFU per 100mL H₂O sample.

Opequon Creek – Potomac Watershed

TABLE 4: 2018 Summer <i>E. coli</i> testing project sites located on the Opequon Creek	
SITE ID	SITE DESCRIPTION
FCOC	Opequon Creek at Neill Road ford

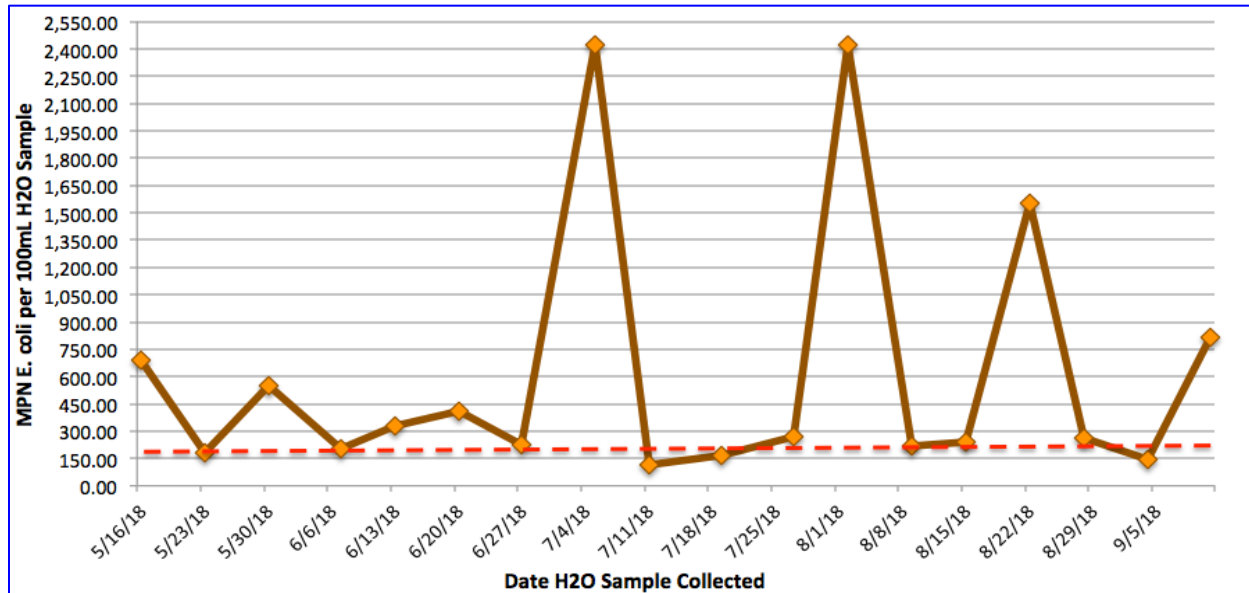


Figure 13: *E. coli* levels at site on Opequon Creek, **FCOC**. Two of the *E. coli* levels measured at this site exceeded the method limit of 2,419.36 *E. coli* CFU/100mL. The red line represents the DEQ water-quality standard for freshwater beach advisories or closures with a single sample maximum of 235 *E. coli* colony forming units 100 per milliliters of water sample (CFU/100ml)¹ See Table 5 for complete set of the data for the 2018 Summer *E. coli* Testing project.

Water is withdrawn from the Shenandoah River watershed, treated and used as a source of drinking water in Frederick County, then treated again prior to being discharged into the Opequon Creek. This site on the Opequon, **FCOC**, is flanked by residences and downstream of the Opequon Water Reclamation facility. On a few occasions when collecting the water samples, people were observed playing in the creek. At this site the *E. coli* levels exceed the standard 11 out of the 18 times tested or 61% of the time.

Starting on July 27 through September 11, with two exceptions, on the day and time the water sample was collected the *E. coli* levels exceeded the standard and ranged from 238.2 to >2,419.6. The two exceptions being on August 9 when the *E. coli* level measured 215.2, however the week previous on August 2, the *E. coli* concentration was greater than 2,419.6 and the week following, on August 15, the *E. coli* measured 238.2. The second time was on September 4 when the *E. coli* level was 148.3. The previous week, on August 28, the *E. coli* level was 261.3, and the following week, on September 11, increased to 813. (See Figure 14, Table 5)

Continuation of FOSR's vital public service:

The FOSR's Summer *E. coli* testing project is a tool that empowers individuals to assess one's potential exposure to harmful pathogens associated with *E. coli* levels before engaging in river recreational activities.

As documented in this project, *E. coli* levels are fluid, meaning that the concentration of *E. coli* changes. These fluctuations of *E. coli* levels exemplify the need for frequent testing. It is equally important to have the information when current *E. coli* levels are below the standard as well as when the levels exceed the standard.

FOSR is hoping to continue the Summer *E. coli* testing project with the following enhancements:

- Expand the program to include many more public access recreational sites in the Shenandoah River watershed. However, the expansion would require both strategically located FOSR's satellite bacteria testing labs and the recruitment of volunteers, interns and hiring of additional lab personnel.
 - ✓ In order to adhere to the method protocols for water sample holding time and posting of data within 20 – 22 hour window, the samples need to be processed for testing on the same day as collection. This limits the geographic area and number of sites that can be covered. The addition of satellite labs with partners such as JMU, Blue Ridge Community College, and environmental organizations like the Friends of the Middle River would allow for greater coverage of the watershed.
 - ✓ In addition, an increase in the frequency of monitoring to 2, 3 or even 4 times a week.
 - ✓ Implement testing during and following rain events.
- Create an App for mobile devices so that the *E. coli* project data can be easily accessible. This could provide recreational users a tool (accredited level III water-quality data) to make an informed decision about the potential health risks.
- Design and install kiosks at the monitored recreational sites with QR codes that citizens can scan for the most recent FOSR's *E. coli* testing data results. The kiosks could also include vital education and prevention information related to potential health risks exposure as outlined by the Virginia Department of Health.

Friends of the Shenandoah River's 2018 Summer Quantitative E. coli Test Results at public recreational use sites on the Main Stem, South Fork and North Fork of the Shenandoah River



These results provide a snapshot of the E. coli bacteria concentrations at the designated sites on the date, time, and under the conditions that the water samples were collected.

SITEID	SITEDescription	5/2	5/9	5/16	5/23	5/30	6/1	6/7	6/13	6/20	6/27	7/5	7/11	7/19	7/26	7/27	8/2	8/9	8/15	8/22	8/28	9/4	9/11	9/20
FC08	Main-stem Shenandoah River at Castleman's Ferry public boat ramp, Route 7 bridge	31.5	48.0	387.3	1119.9	156.5	209.8	547.5	90.8	325.5	344.8	410.6	131.4	325.5	344.8	410.6	20.3	60.2	627.0	379.0				
FC05	Main-stem Shenandoah River at Lockes Landing public boat landing	39.3	43.5	387.3	727.0	117.8	228.2	886.4	111.2	285.1	247.2	247.2	24.1	23.5	247.2	247.2	151.5	122.3	99.0	269.3	81.3	30.9	932.0	292.0
FC01	Main-stem Shenandoah River at Berry's public boat ramp, Route 50 bridge	15.8	25.9	224.7	>2419.6	151.5	214.2	1553.1	275.5	260.3	275.5	275.5	32.7	37.4	275.5	275.5	115.3	135.4	83.3	201.4	101.7	52.1	1155.0	355.0
FW35	Main-stem Shenandoah River at Megan's Ford low H2O bridge public boat landing below confluence with Manassas Run	29.2	18.5	573.4	>2419.6	365.4	209.8	2419.6	410.6	261.3	686.7	686.7	50.4	61.3	821.2	821.2	>2419.6	419.6	142.1	238.2	410.6	88.2	565.0	
FW35MID	Main-stem Shenandoah River at Megan's Ford low H2O bridge mid width of river												17.3	18.5	730.8	730.8	248.1	85.7	77.6	290.9	27.9	49.6	1050.0	345.0
FW36	Manassas Run upstream of confluence with main-stem Shenandoah River, just upstream of public boat landing																							
FW14	SF Shenandoah River at Front Royal public boat landing off Lurray Ave.	63.7	24.3	307.6	261.3	1299.7	186.0	>2419.6	198.9	201.4	38.3	38.3	17.1	32.3	298.7	298.7	105.0	161.6	90.9	125.9	22.8	52.9	857.0	432.0
FWAASP	SF Shenandoah River @ Raymond R. "Anely" Guest Jr., Shenandoah River State Park	26.2	13.2	238.2	686.7	1119.9	167.0	>2419.6	55.6	145.0	13.2	6.3	14.6	410.6	410.6	410.6	214.3	115.3	59.1	45.7	19.9	65.0	906.0	364.0
FWIH	SF Shenandoah River at Indian Hollow public boat launch off Indian Hollow Road																							
FP03	SF Shenandoah River at White House public boat landing	12.0	16.0	344.8	>2419.6	866.4	178.5	>2419.6	137.6	172.3	37.3	37.3	18.5	32.3	307.6	307.6	104.3	1732.9	224.7	178.5	18.7	146.7	1401.0	399.0
FP02	ramp downstream of Riverside Campground/ Kie's Store																							
FSMB	NF Shenandoah River at Meems Bottom	58.3	43.5	>2419.6	1119.9	461.1	183.5	387.3	344.8	410.6	410.6	435.2	98.8	127.4	615.2	615.2	>2419.6	>4839.2	218.7	727.0	77.1	101.4	345.0	305.0
FSDR	NF Shenandoah River at Deer Rapids public boat landing	3.0	7.4	53.7	>2419.6	235.9	365.4	1299.7	35.5	248.9	770.1	770.1	No	67.7	Access	Access	365.4	457.5	488.4	488.4	37.9	57.3	1655.0	487.0
FSSP	NF Shenandoah River at Strasburg Park public boat landing	6.2	25.9	224.7	>2419.6	186.0	1046.2	209.8	1046.2	228.2	218.7	>2419.6	24.6	39.5	203.4	203.4	>2419.6	437.4	461.1	544.6	71.2	69.7	1664.0	313.0
FOCC	Opequon Creek @ Neill Road ford																							

STATE WATER CONTROL BOARD 9 VAC 25-260
Virginia Water Quality Standards.

Statutory Authority, § 62.1-44, 15.3a of the Code of Virginia. WITH AMENDMENTS EFFECTIVE January 6, 2011

For beach advisories or closures, a single sample maximum of 235 E.coli CFU/100 ml in freshwater and a single sample maximum of 104 enterococci CFU/100 ml in saltwater and transition zones shall apply.

Red indicates that the Standard criteria, no more than 10% of the total samples in the assessment period shall exceed 235 E.coli CFU/100 ml, has been exceeded. <http://law.lis.virginia.gov/admincode/title4/agency25/chapter260/section170>

Supplemental Information:

S1.1 What is Coliform Bacteria?

There are different types of bacteria; *coliforms* are a family of a strain of bacteria. The most common is the rod-shaped microorganism total coliform that is naturally found throughout the environment. Fecal coliforms are a group of coliform bacteria that are found in the intestines of warm-blooded animals, including people, where they live and reproduce. *Escherichia coli*, commonly referred to as *E. coli*, is a single species of fecal coliform bacteria. Most strains of the *E. coli* bacterium are harmless. However there are strains of *E. coli* (i.e. *E. coli* O157:H7) that can cause serious illnesses.

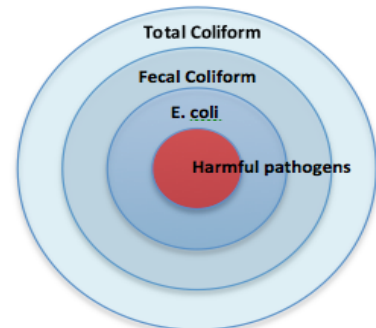


Figure 1. **Coliform bacteria**
The smaller the subset of coliform, the more accurate as an indicator for the presence of pathogens.

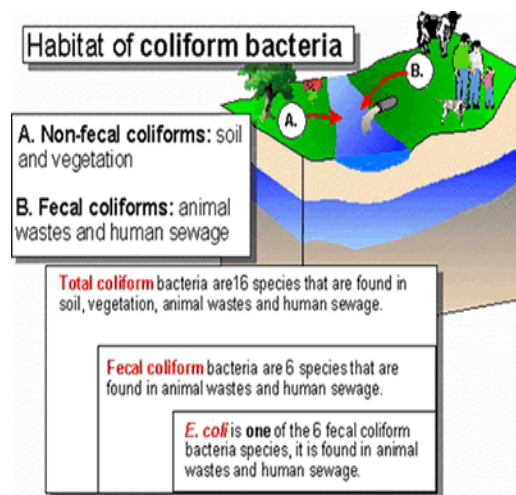


Figure 2. Fecal matter entering a waterbody

If fecal coliform is detected in the water, it indicates that there was recent fecal contamination in the water systems. Detection of *E. coli* bacteria in the water indicates recent fecal contamination as well as a possible presence of other disease-causing microorganisms or pathogens. As the level of *E. coli* bacterium increases the potential health risk from exposure to pathogenic organisms also increases.

Potential sources of contamination from fecal matter include sewers, septic systems, wastewater treatment facilities, wildlife, pets, fertilizer such as manure, and livestock.

S1.2 Health Effects from Exposure to Waterborne Pathogens

Signs and symptoms of exposure to waterborne diseases may include;

- Gastrointestinal illnesses such as
 - gas
 - abdominal cramping
 - diarrhea
 - nausea, which may result in vomiting
 - loss of appetite
- Urinary tract infections
- Respiratory infections
- Conjunctivitis (pink eye)

- Exposure to open wounds by the waterborne pathogens can cause infections of the wound that may result in extended, and sometimes painful, healing time.
- In rare cases developing a life-threatening form of kidney failure called hemolytic uremic syndrome

In mild to moderate cases, one may not associate their symptoms with recent water related recreational activities especially if the symptoms do not manifest until three or four days later. Also, not all people will be affected to the same degree; young children, the elderly, and those with weakened immune systems are at a higher risk of experiencing illness and more serious complications caused by harmful *E. coli* bacteria and associated pathogens. In extreme circumstances, even in otherwise healthy persons, exposure to harmful strains of *E. coli* and other pathogens can and do result in death either from the organism itself or complications from the exposure.

S1.3 Role of coliforms in detecting contamination in water

Testing water for specific harmful bacteria and pathogens is complex, time-consuming and expensive. For this reason, coliform bacteria are used as water quality indicators, or “indicator organisms” for these main reasons:

- Coliforms respond to environmental conditions similar to many pathogens.
- The presence of coliforms, more specifically *E. coli*, in water may be associated with and an indicator of the presence of pathogenic bacteria contaminating the water.
- The analysis of water samples for coliforms, including *E. coli*, is relatively simple, economical and efficient.
- Water sample test results for *E. coli* levels can be read after an incubation period of 18 – 22 hours.



Figure 3. IDEXX Quanti-Tray under 365nm UV light, the presence of *E. coli* indicated by fluorescing wells.

S2.1 Environmental Protection Agency BEACH Act

To protect beachgoers, on October 10, 2000, the Beaches Environmental Assessment and Coastal Health Act (BEACH Act) was signed into law, amending the Clean Water Act (CWA). The BEACH Act required the Environmental Protection Agency (EPA) to develop performance criteria for testing, monitoring, and notifying public users of possible coastal recreation water problems.⁶

The BEACH Act was then amended to require states, territories, and tribes that have coastal recreation waters to adopt new or revised water quality standards by April 10, 2004, for pathogens and pathogen indicators for which EPA has published criteria under CWA section 304(a). An additional amendment authorized EPA to award grants to states, territories, tribes, or local governments to develop and implement beach monitoring and assessment programs.

S2.2 Monitoring of Beach Waters in Virginia

In Virginia, from May through September local branches of the Virginia Department of Health (VDH) perform weekly testing for levels of *E. coli* bacteria at forty-six public beach areas on the Chesapeake Bay and the Atlantic Ocean. When bacteria levels exceed Virginia’s Water Quality Standard for saltwater and transition zones a swimming advisory is issued.⁷ VDH swimming advisories remain in effect until results from additional testing are below the State Standards.

VDH utilizes several public notification methods to inform the public when a swimming advisory has been issued, including:



Figure 4. Image of warning sign posted by VDH

- Posting an advisory sign in plain view at the swimming location;
- Issuing a local press release;
- Publishing swimming advisories at public coastal beaches on the VDH website: (<http://www.vdh.virginia.gov/environmental-epidemiology/beach-monitoring/>);
- Informing local businesses (e.g., rafting companies) and local government officials
- Providing additional information as requested.

Despite the recognition of the responsibility to inform the public of potential health risks when engaging in water contact recreational activities at Virginia beaches, no such programs exist for the freshwater rivers and tributaries of Virginia even at state recognized public access and recreational use areas.

⁶ <https://www.epa.gov/beaches/learn-epas-role-protecting-beaches>

⁷ <http://www.vdh.virginia.gov/environmental-epidemiology/beach-monitoring/>

