

limit cause a site to be in violation. Field blanks were taken at least once per day to determine any source of bacterial contamination coming from field sampling protocol. All of the blanks came back below the detection limit, showing no bacterial contamination in the field sampling procedure.

Precipitation data were obtained from three National Oceanic and Atmospheric Administration rain gages located in Pine Grove Furnace State Park, in the southwest portion of the watershed; in Shippensburg, just outside the northwestern watershed boundary; and in Harrisburg, just outside the eastern watershed boundary. These three rain gages recorded daily rainfall totals and were the closest available sites to the Yellow Breeches Creek Watershed that had a continuous rainfall record for all of the sampling periods. The data

Table 2. Water Quality Standards and Aquatic Life Tolerances

Parameter	Limit	Reference Code
Temperature	> 25 degrees	a,d
Dissolved oxygen	< 4 mg/l	a,e
Conductivity	> 800 mmhos/cm	c
pH	< 5	b,d
Alkalinity	< 20 mg/l	a,e
Total fecal coliform	Geometric mean of 200 CFUs/100ml during recreation season or a single sample result of 400 CFUs/100 ml; 2000 CFUs/100 ml during non-recreation season	a
<i>E. coli</i>	Geometric mean of 126 CFUs/100 ml or a single sample maximum of 298 CFUs/100 ml for moderate full body contact recreation	f
Enterococci	Geometric mean of 33 CFUs/100 ml or a single sample maximum of 78 CFUs/100 ml for moderate full body contact	f

from the three locations were averaged together to get an estimated daily rainfall value for the watershed.

Reference Code & References

- a. <http://www.pacode.com/secure/data/025/chapter93/s93.7.html>
- b. Gagen and Sharpe (1987) and Baker and Schofield (1982)
- c. http://www.uky.edu/WaterResources/Watershed/KRB_AR/wq_standards.htm
- d. <http://www.hach.com/h2ou/h2wtrqual.htm>
- e. http://sites.state.pa.us/PA_Exec/Fish_Boat/education/catalog/pondstream.pdf
- f. EPA recommended criteria, Ambient Water Quality Criteria for Bacteria - 1986

RESULTS

Of the 11 sampling sites, 6 were on the mainstem Yellow Breeches Creek, which included sites from the headwaters to the mouth (Figure 4). Results are organized from upstream to downstream with the tributaries discussed in the order in which they enter the mainstem. Tributaries sampled included Mountain Creek, Dogwood Run, Trout Run, Stony Run, and Cedar Run. Numbers following the stream abbreviation denote river mile distance from mouth to sampling site.

BY SAMPLING LOCATION

Yellow Breeches Creek 51.6

The most upstream sampling point was YLBR 51.6, located along Rehoboth Road near New Lancaster, Cumberland County. The majority of the 12-square-mile drainage area to this site is forested; however, the adjacent land use is agricultural crop land. Bacteria levels exceeded the geometric mean for each of the three indicator bacteria in August, but there were no other steady state violations at this site (Table 3).

A majority of the single sample exceedances were in August at this site

Table 3. Steady State Violations at YLBR 51.6

Month	<i>E. coli</i>		Enterococci		Fecal coliform	
	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)
August 2006	126	305	33	337	200	462

for all three indicator bacteria types, with the exception of one enterococci violation in November. Overall, 25 percent of the fecal coliform samples and 21 percent of the *E. coli* and enterococci samples exceeded their single sample maximum limits at YLBR 51.6.

Stream flow at YLBR 51.6 was quite variable with very low flows of only 0.2 cubic feet per second (cfs) in the summer and up to 40 cfs after rain events. There was a general trend of decreasing levels of bacteria with increasing stream flow. This suggests that there is some relatively constant source of bacteria contamination that becomes more concentrated at low flow and is diluted at higher flows. Possible sources of con-

tamination for this site could be improperly functioning septic systems, as it is a very rural area with no public sewer service, and cattle access to the stream, which was observed several times during sampling. The data for this site did not show any increase in bacteria levels after a rainfall event.

Yellow Breeches Creek 40.7

The next downstream mainstem site was YLBR 40.7, located along West Yellow Breeches Creek Road east of Montsera, Cumberland County. This site drains 46.8 square miles of primarily agricultural land, with some low density residential areas. YLBR 40.7 is located within a stream reach that is impaired

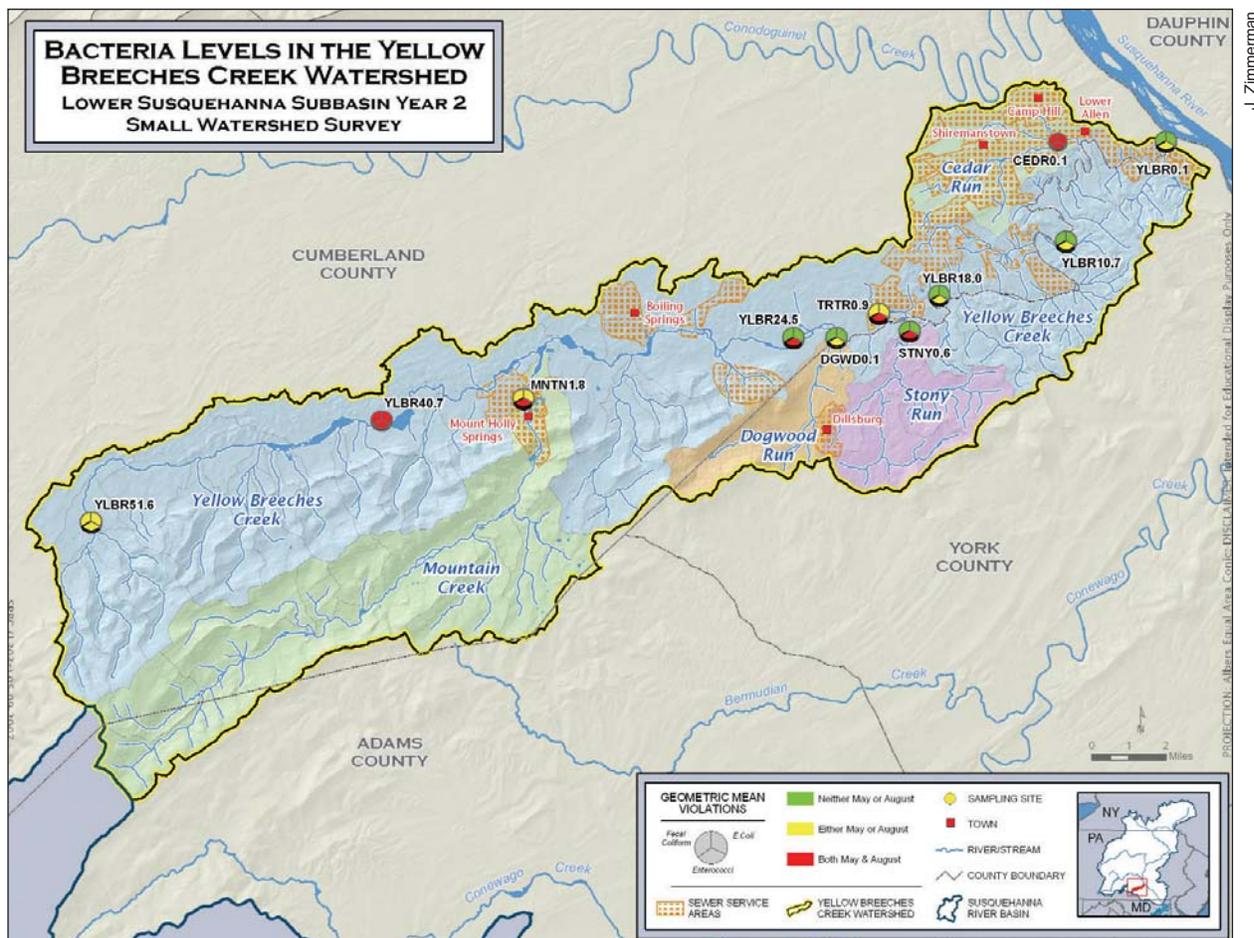


Figure 4. Bacteria levels in the Yellow Breeches Creek Watershed.

for human health by poly-chlorinated biphenols (PCBs) and is located downstream of the Huntsdale State Fish Hatchery. Located adjacent to the stream at this site is a small farm pond that is home to numerous species of waterfowl, which were present during each sampling event.

The geometric mean values for all three of the indicator bacteria were exceeded at YLBR 40.7 during the May and August sampling events. Also, there was an additional violation for enterococci in November (Table 4).

Single sample maximums were exceeded in 54 percent of the enterococci samples, 21 percent of the fecal coliform samples, and 17 percent of the *E. coli* samples. Stream discharge measurements at YLBR 40.7 ranged from 35 cfs to 64 cfs, and there was no clear correlation between stream flow and the concentration of any of the indicator bacteria types. Bacteria levels were quite variable for all three indicator bacteria throughout

the range of flows. Waterfowl may be a prime source of bacterial contamination at this site. However, faulty septic systems may also be a problem, as there is no public sewer service in this area.

Table 4. Steady State Violations at YLBR 40.7

Month	E. coli		Enterococci		Fecal coliform	
	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)
May 2006	126	157	33	78	200	238
August 2006	126	400	33	490	200	537
November 2006	126	NV	33	76	2,000	NV

NV = no violation

Mountain Creek 1.8

Mountain Creek, the largest tributary to the Yellow Breeches Creek, is 20.7 miles long and drains a 46-square-mile area. The sampling site on Mountain Creek, MNTN 1.8, was located near the mouth in Mt. Holly Springs along Route 34 in Cumberland County. Mountain Creek enters the Yellow Breeches Creek about seven miles downstream of YLBR 40.7 and flows in a generally southwest to northeast direction. The area directly surrounding this sampling location is mainly low density residential development. However, the majority of the land upstream draining into Mountain Creek is forested. Much of this forested land is within Mischeaux State Forest and Pine Grove Furnace State Park, which is located in the headwaters of Mountain Creek. This sampling site is downstream of a National Pollutant Discharge Elimination System (NPDES) discharge from Mt. Holly Springs Municipal Authority as well as two other private industrial discharges.

In Mountain Creek, steady state violations existed for all three indicator bacteria during the month of August as well as an enterococci violation in May (Table 5).

There were also numerous single sample maximum violations in Mountain Creek for each indicator bacteria. The greatest percentage (42 percent) of total samples exceeded the single sample maximum for enterococci. *E. coli* and fecal coliform single samples exceeded the single sample limit 4 percent of the time. Discharge measurements in Mountain Creek ranged from 17 cfs to 80 cfs, and there was a general trend of higher levels of indicator bacteria at lower flows. Similarly to YLBR 51.6, there may be a consistent source of bacteria contamination going into Mountain Creek that is more concentrated in lower flows and more dilute at higher flows. The surrounding residential development in Mt. Holly Springs is served by a public sewer system; however, the majority of the Mountain Creek Watershed is not.

Table 5. Steady State Violations at MNTN 1.8

Month	<i>E. coli</i>		Enterococci		Fecal coliform	
	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)
May 2006	126	NV	33	54	200	NV
August 2006	126	149	33	629	200	260

NV = no violation

Yellow Breeches Creek 24.5

On the mainstem Yellow Breeches Creek, sampling site YLBR 24.5 was located along Park Place Road near Williams Grove, Cumberland County. This section of the Yellow Breeches Creek is 9.5 miles downstream of Mountain Creek and is directly downstream of a treated sewage discharge from South Middletown Township Municipal Authority. The primary land use in the 142-square-mile drainage area is forest with a minimal amount of agricultural lands and residential development.

The two geometric mean violations at YLBR 24.5 were for enterococci in May and August. There were no steady state violations for *E. coli* and fecal coliform (Table 6).

Single sample maximums also were exceeded only for enterococci, which had 25 percent of samples over the 78 cfu/100 ml standard. *E. coli* and fecal coliform had no exceedances for geometric means or single sample maximums. Stream flows at this location ranged from 87 cfs to 217 cfs, but there was no correlation between stream flows

Table 6. Steady State Violations at YLBR 24.5

Month	Enterococci	
	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)
May 2006	33	58
August 2006	33	134

and levels of the bacteria indicators. Bacteria concentrations were quite varied along most of the flow regime; however, at the highest flows, all of the indicator bacteria were relatively low. This suggests that bacteria contamination from runoff is not a major problem at this location. This was one of the least bacteria-contaminated sites in the upper reaches of the Yellow Breeches Creek Watershed.

Dogwood Run 0.1

Dogwood Run enters the Yellow Breeches Creek from the south near the town of Williams Grove, Cumberland County, and is about 1.5 miles downstream



Yellow Breeches Creek along Park Place Road.

of YLBR 24.5. The sampling site, DGWD 0.1, was located at the mouth of Dogwood Run along Creek Road. Dogwood Run flows generally in a south to north direction and is about six miles in length. Just upstream of the sampling site on Dogwood Run is a large spring complex that accounts for about one-third of the flow at the sampling site during low flow periods. The entire mainstem of Dogwood Run was designated as impaired for recreational uses by an unknown source of pathogens in 2004 by PADEP. Dogwood Run drains nine square miles and includes Dillsburg Borough, York County, on the east, and mostly forest and agricultural land on the west. Dillsburg is serviced by a public sewer system, but the NPDES discharge for the Dillsburg Borough Municipal Authority discharges only wastewater and industrial waste, not treated sewage, into Dogwood Run (NPDES PA 0024431).

Dogwood Run had the fewest monthly violations of any sampling site in the entire Yellow Breeches Creek Watershed, with only one violation for enterococci, during the month of August (Table 7). Single sample maximums were exceeded in Dogwood Run only for enterococci, as 30 percent of the samples taken were greater than 78 cfu/100 ml. The flow in Dogwood Run ranged from 5 cfs to 48 cfs, but there was no clear trend between discharge rate and bacteria concentrations. However, at the highest flows, all of the indicator bacteria concentrations were relatively low. Of the streams sampled, Dogwood Run was the least impacted tributary in the entire watershed in terms of bacteria contamination.

Table 7. Steady State Violations at DGWD 0.1

Month	Enterococci	
	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)
August 2006	33	210

Trout Run 0.9

Trout Run is a small tributary to the Yellow Breeches Creek that drains 3.5 square miles near Grantham, Cumberland County. Trout Run joins the mainstem Yellow Breeches Creek from the north, downstream of Dogwood Run. The surrounding land use for Trout Run is primarily low density residential. Trout Run is a spring-fed tributary, and the water quality

the allowable single sample limits for recreation. Due to the substantial contribution of spring water in Trout Run, the discharge was fairly consistent over the year, ranging from 4 cfs to 8.7 cfs. Bacteria enter the groundwater system from many of the same sources that contaminate surface water, but through slightly different processes. Fecal contamination seeps into groundwater from the land surface or from underground sources, such as

Table 8. Steady State Violations at TRTR 0.9

Month	E. coli		Enterococci		Fecal coliform	
	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)
May 2006	126	NV	33	43	2,000	NV
May 2006	126	NV	33	127	200	NV
August 2006	126	265	33	380	200	312
November 2006	126	NV	33	75	2,000	NV

NV = no violation

at sampling point TRTR 0.9 was reflective of that characteristic, with a constant temperature and flow throughout the year. Trout Run flows in a northwest to southeast direction and is about two miles long.

In Trout Run, geometric mean values for enterococci exceeded the standard of 33 cfu/100 ml in all four of the sampling periods. This site was the only location to exceed any criteria during the February sampling period. In August, fecal coliform and *E. coli* also exceeded geometric mean standards (Table 8).

Single sample maximum criteria were exceeded in Trout Run in 71 percent of all the enterococci samples collected. In addition, 12.5 percent of all the *E. coli* and fecal coliform samples collected exceeded

biosolid land application, sewage lagoons, unlined sanitary landfills, improperly functioning septic tank systems, and leaking underground sewer lines (USGS, 2006). A majority of the residential areas in Trout Run Watershed are connected to public sewer lines.



Trout Run, a tributary to the Yellow Breeches Creek.

Stony Run 0.6

Stony Run is another tributary to the Yellow Breeches Creek, and the sampling site STNY 0.6 was located near the mouth of the creek northwest of Siddonsburg, York County, along Stony Run Road. Stony Run drains 12.5 square miles of mostly agricultural land, with some forested land in the headwaters. It flows generally in a south to north direction, is approximately eight miles in length, and joins the Yellow Breeches Creek downstream of Trout Run and just upstream of YLBR 18.0. This sampling site was downstream of a small wastewater treatment plant. In Stony Run, there were steady state enterococci violations in May, August, and November, but no violations for *E. Coli* or fecal coliform (Table 9).

Table 9. Steady State Violations at STNY 0.6

Month	Enterococci	
	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)
May 2006	33	57
August 2006	33	369
November 2006	33	150

There were numerous single sample violations in Stony Run as well. The single sample maximum for enterococci is 78 cfu/100 ml, and in Stony Run, this value was exceeded in 54 percent of the samples collected. The single sample maximum for *E. coli* (235 cfu/100ml) was exceeded in eight percent of the samples. Discharge in Stony Run ranged between 0.6 cfs and 36 cfs; however, there was no correlation between stream flow and any of the indicator bacteria levels. There were high bacteria concentrations at low flows and at high flows. Potential sources of bacteria to this site include faulty septic systems, agriculture, and residential runoff.

Yellow Breeches Creek 18.0

The next site downstream on the mainstem Yellow Breeches Creek was YLBR 18.0, located at Market Street near Bowmansdale, Cumberland County. YLBR 18.0 drains 177 square miles of the Yellow Breeches Creek Watershed and is downstream of the discharge for Upper Allen Township Municipal Authority. The primary land use in the surrounding area is low density residential development along with some pasture land. This site is also downstream of the three tributaries mentioned previously: Dogwood Run, Trout Run, and Stony Run.

Bacteria concentrations at YLBR 18.0 exceeded the geometric mean standard for enterococci in August and November. There were no steady state violations for *E. coli* or fecal coliform (Table 10). Forty-two percent of the enterococci samples and four percent of the *E. coli* samples exceeded single sample maximums. Stream flow ranged from 131 cfs to 304 cfs at this site, but there was no trend between bacteria levels and stream flow.

Table 10. Steady State Violations at YLBR 18.0

Month	Enterococci	
	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)
August 2006	33	194
November 2006	33	66

The November 2, 2006, sampling results showed very high concentrations of all three indicator bacteria at the lower three sites on the mainstem Yellow Breeches Creek, starting with YLBR 18.0. The concentrations were more than 10 times greater than any

other sample throughout the year, and were the highest on that day at this site in Bowmansdale (YLBR 18.0). There was a significant rainfall two days prior to sampling; however, similar amounts of rainfall other times of the year did not cause these same elevated levels of bacteria. There were no reported problems at any of the upstream sewage treatment plants, so it was unlikely to be a point source problem. Possible causes include runoff from newly applied manure or biosolids, increased septic system failure due to saturated ground conditions, or a combination of these. These high levels of bacteria appear to have been an anomaly for this stretch of the Yellow Breeches Creek.

Yellow Breeches Creek 10.7

The next downstream site was YLBR 10.7, located at Sheepford Road, near Rossmoyne, Cumberland County. This site drains 194 square miles, and the adjacent land uses to the site are primarily forested and pasture land, with some low density residential development. Enterococci concentrations at YLBR 10.7 exceeded the geometric mean criteria during the August and November sampling periods. There was also a violation for *E. coli* during the month of November, but there were no geometric mean violations for fecal coliform at this sampling location (Table 11).

The single sample maximum of 78 cfu/100 ml for enterococci was exceeded in 29 percent of the samples, with a maximum value of 2900 cfu/100 ml.

Table 11. Steady State Violations at YLBR 10.7

Month	<i>E. coli</i>		Enterococci	
	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)
August 2006	126	NV	33	150
November 2006	126	145	33	194

NV = no violation



Yellow Breeches Creek at Sheepford Road.

Additionally, eight percent of all samples collected were above the single sample maximum standard of 298 cfu/100 ml for *E. coli*. Stream discharge ranged from 129 cfs to 346 cfs, and there was no correlation between flow and concentration of any indicator bacteria. This site also was affected by the elevated bacteria levels first observed upstream at YLBR 18.0 on November 2, 2006. Possible sources of bacteria contamination at this site include faulty septic systems or agricultural inputs.

Cedar Run 0.1

Cedar Run enters the Yellow Breeches Creek about four miles upstream of the mouth and is the most degraded tributary in the watershed. The sampling site on Cedar Run, CEDR 0.1, is at the mouth near Eberly's Mill, Cumberland County. Cedar Run flows generally in a southwest to northeast direction, and the mainstem is about 7.3 miles long. According to the Coldwater Conservation Plan for the watershed, the 13.8-square-mile drainage area for Cedar Run contains greater than 50 percent impervious surface and the land use is primarily high density development (Alliance for the Chesapeake Bay and Pennsylvania Environmental Council, 2005). A large majority of Cedar Run Watershed is serviced by public sewer systems.

Cedar Run had the most combined geometric mean exceedances of any of the

sampled locations in the Yellow Breeches Creek Watershed, with 8 of the 12 (67 percent) geometric mean values exceeding the standards throughout the year. Enterococci exceeded the geometric mean limit in May, August, and November. *E. coli* and fecal coliform exceeded the geometric mean limits in May and August (Table 12).

Single sample maximums were exceeded routinely in Cedar Run for all three

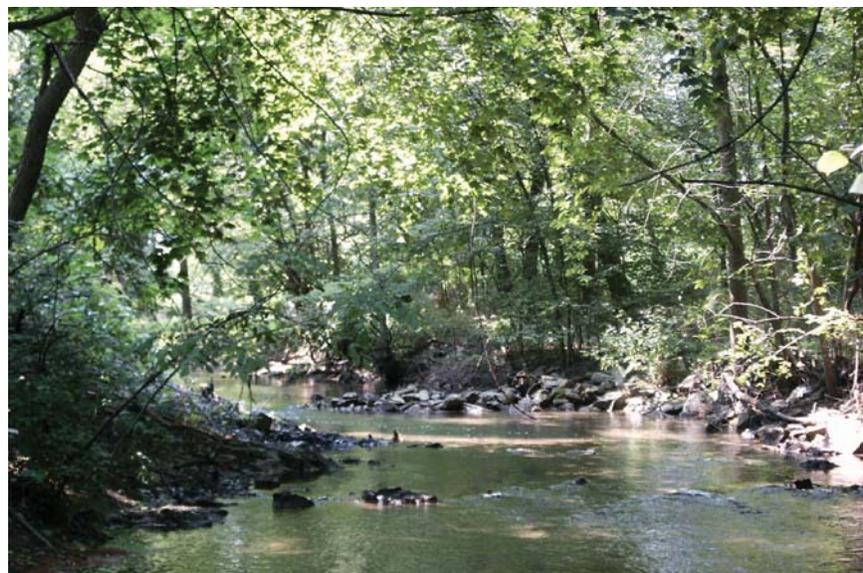
indicator bacteria. Enterococci values exceeded the 78 cfu/100 ml limit 62 percent of the time with a maximum single sample value of 4,100 cfu/100 ml. *E. coli* standards were exceeded in 42 percent of the samples, with a maximum value of 920 cfu/100 ml.

The flow in Cedar Run was variable over the course of the sampling period, ranging from 2 cfs to 31 cfs. There was no discernible trend between higher flows and increasing bacteria levels. However, at the highest flows, the bacteria levels were below the detection limit. This suggests that there are constant sources of bacteria contamination coming from this urbanized watershed, not just impacts related to wet weather events.

Table 12. Steady State Violations at CEDR 0.1

Month	<i>E. coli</i>		Enterococci		Fecal coliform	
	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)
May 2006	126	229	33	187	200	334
August 2006	126	428	33	993	200	833
November 2006	126	NV	33	209	2,000	NV

NV = no violation



Cedar Run near Eberly's Mill.

Yellow Breeches Creek 0.1

The Yellow Breeches Creek empties into the Susquehanna River at New Cumberland, Cumberland County. YLBR 0.1 is located just upstream of the mouth of the Yellow Breeches Creek at Bridge Street, and drains the entire 219-square-mile watershed. This site is downstream of Cedar Run and is located in an area dominated by high density residential development, a majority of which are connected to public sewer systems. Bacteria levels at YLBR 0.1 were relatively low with the only two steady state violations occurring in August and November for enterococci (Table 13).

Table 13. Steady State Violations at YLBR 0.1

Month	Enterococci	
	Geometric mean standard (cfu/100ml)	Calculated geometric mean (cfu/100 ml)
August 2006	33	70
November 2006	33	75

Single sample maximums were never exceeded for *E. coli* or fecal coliform at YLBR 0.1. However, 38 percent of all samples collected for enterococci exceeded the single sample maximums. Discharge measurements ranged from 135 cfs to 333 cfs at the mouth of the Yellow Breeches Creek, and, except for the unusually high value on November 2, 2006, there was a general trend of decreasing bacteria concentrations with increasing stream flows. On the mainstem, this site was the least affected by bacteria contamination, and even the two steady state violations for enterococci were not as elevated as at other sites in the watershed.

FOR THE ENTIRE WATERSHED

Using the USEPA-recommended criteria for steady state concentrations over a 30-day sampling period, there were 8 geometric mean violations (18 percent) for *E. coli* and 26 geometric mean violations (59 percent) for enterococci throughout the year (Figure 5). However, the current method of determining recreational water quality impairment in Pennsylvania uses fecal coliform as the indicator bacteria. The results of fecal coliform analysis in the Yellow Breeches Creek showed a similar number of geometric mean violations as did the *E. coli* analysis. Geometric mean standards for fecal coliform were exceeded seven times (16 percent) throughout the sampling period (Figure 5). The geometric mean violations for fecal coliform occurred only during the recreation season, when the standard is 200 cfu/100 ml. During the rest of the year, the geometric mean standard is 2,000 cfu/100 ml, and this value was not exceeded in the Yellow Breeches Creek Watershed during any of the sampling periods.

During the recreation season (May-September), 5 of the 11 sampling sites exceeded the geometric mean standard for *E. coli* and fecal coliform during at least one of the months (Figure 4). In addition, all 11 of the sampling sites exceeded the geometric mean standard for enterococci for at least one of the months.

The other element of the USEPA-recommended criterion is based on single sample maximums, which were exceeded in the Yellow Breeches Creek 28 times (11 percent) for *E. coli* and 113 times (43 percent) for enterococci (Figure 6 and Figure 7). The current single sample regulations for fecal coliform in Pennsylvania apply only to the recreation season, and this maximum value of 400 cfu/100 ml was exceeded

24 times, which is 9 percent of the samples (Figure 8). There were other very high single sample values outside of the recreational season that are not considered violations under current PADEP regulations. For single sample violations during the recreation season, there were 23 for *E. coli*, 24 for fecal coliform, and 84 for enterococci.

The above data are based on classifying the Yellow Breeches Creek as being a “moderate use, full body contact” stream due to the large amount of recreational use associated with the watershed. This is the second most stringent level in the USEPA-recommended standards, only after designated beach areas. Additionally, there are two other recreational use categories designated in the USEPA recommendations; “light use, full body contact,” and “infrequent use, full body contact.” These categories can be used in streams that are used less frequently for “full body contact recreation,” but still need to be monitored. At both these lower levels, the acceptable concentration of indicator bacteria is higher, reflecting a greater risk to human health, which is theoretically balanced out by fewer recreational users. Table 14 shows the percentage of samples that exceeded the recommended single sample maximums for each recreational use classification on each tributary as well as on the mainstem Yellow Breeches Creek. There are numerous violations of even the least protective standards, which correspond to the highest level of risk, especially for enterococci in the Yellow Breeches Creek (Table 14). More than 40 percent of all enterococci samples violated the “infrequent use, full body contact” criteria at three sampling locations. This is significant given the research correlating enterococci with increased

For single sample violations during the recreation season, there were 23 for E. coli, 24 for fecal coliform, and 84 for enterococci.

incidences of gastroenteritis and the large number of people who use the Yellow Breeches Creek for recreational purposes.

Numerous other studies have tried to link indicator bacteria concentrations with basic water chemistry parameters such as temperature, conductivity, and turbidity, with little success (Cinotto, 2005; Ohio EPA, 2006). The same held true in the Yellow Breeches Creek; there was no clear correlation between any field parameter and bacteria concentrations. Water quality informational data collected during each sampling visit was similar at all of the mainstem sites except YLBR 51.6. All other mainstem sites had an average pH between 7.3-7.6, average conductivity between 214-306 uS/cm, and an average alkalinity of between 84-112 mg/l. Conversely, the average conductivity at YLBR 51.6 was 29 uS/cm, the average pH was 5.1, and the average alkalinity was 1.8 mg/l. Alkalinity and pH at YLBR 51.6 exceeded water quality standards numerous times throughout the sampling period.

Field chemistry for the tributaries entering the Yellow Breeches Creek was quite varied. Mountain Creek had similar characteristics to YLBR 51.6, with lower pH, alkalinity, and conductivity. This likely is due to natural conditions based on the geology of much of the drainage area. The field chemistry in Cedar Run reflects the urban setting of this watershed. It is characterized by high conductivity and the highest average temperature of any of the sampled locations. The high alkalinity in Cedar Run likely is due to the underlying carbonate geology. Dogwood Run had an average temperature of 11.7°C and never rose above 17°C, which probably was due to the spring influence directly upstream of the sampling site. Trout Run had a fairly high conductivity and a high alkalinity, both of which are likely related to the spring water that comprises this stream. The average temperature was higher in Trout Run than in Dogwood Run, even though both are spring fed, because the Trout Run sampling site was farther from the spring source. Stony Run had a moderate

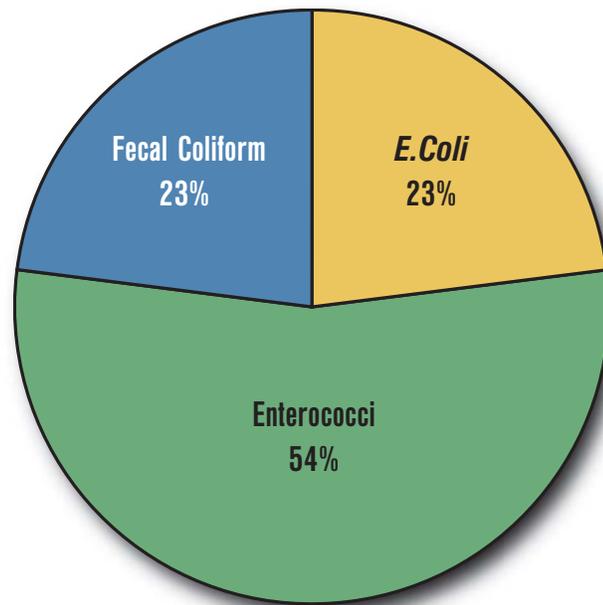


Figure 5. Percentage of Geometric Mean Violations for Indicator Bacteria in the Yellow Breeches Creek Watershed During the Recreational Season.

alkalinity, conductivity, and pH.

Generally, the prevailing theory regarding recreational water quality is that bacteria levels rise in streams and rivers following rain events, specifically due to runoff originating from urban and agricultural areas. Several studies

was the driest sampling period, with only 0.7 inches of rain on average across the Yellow Breeches Creek Watershed for the entire month. The August sampling period bacteria results showed more than double the number of geometric mean violations and almost

Generally, the prevailing theory regarding recreational water quality is that bacteria levels rise in streams and rivers following rain events, specifically due to runoff originating from urban and agricultural areas.

by the USGS have attempted to correlate indicator bacteria concentrations with rainfall, runoff, and wastewater practices. These studies have shown that fecal indicator bacteria concentrations can be highly unpredictable along urban streams and can exceed recreational water quality standards even in the absence of significant rainfall (USGS, 2006). Bacteria data from the Yellow Breeches Creek were extremely variable, and showed no consistent patterns following a rain event or during low-flow months in the summer.

During the 2006 sampling, August

three times as many single sample maximum violations. If urban or agricultural runoff contributed the primary source of bacteria contamination after storm events, this would not be the case. In this study, there was no correlation between bacteria concentrations and amount of rainfall on the day of sampling, one day before sampling, or two days before sampling. It appears that throughout the Yellow Breeches Creek Watershed, there are continuous inputs of bacteria contamination that are more concentrated in low flows, and more dilute during high flows.

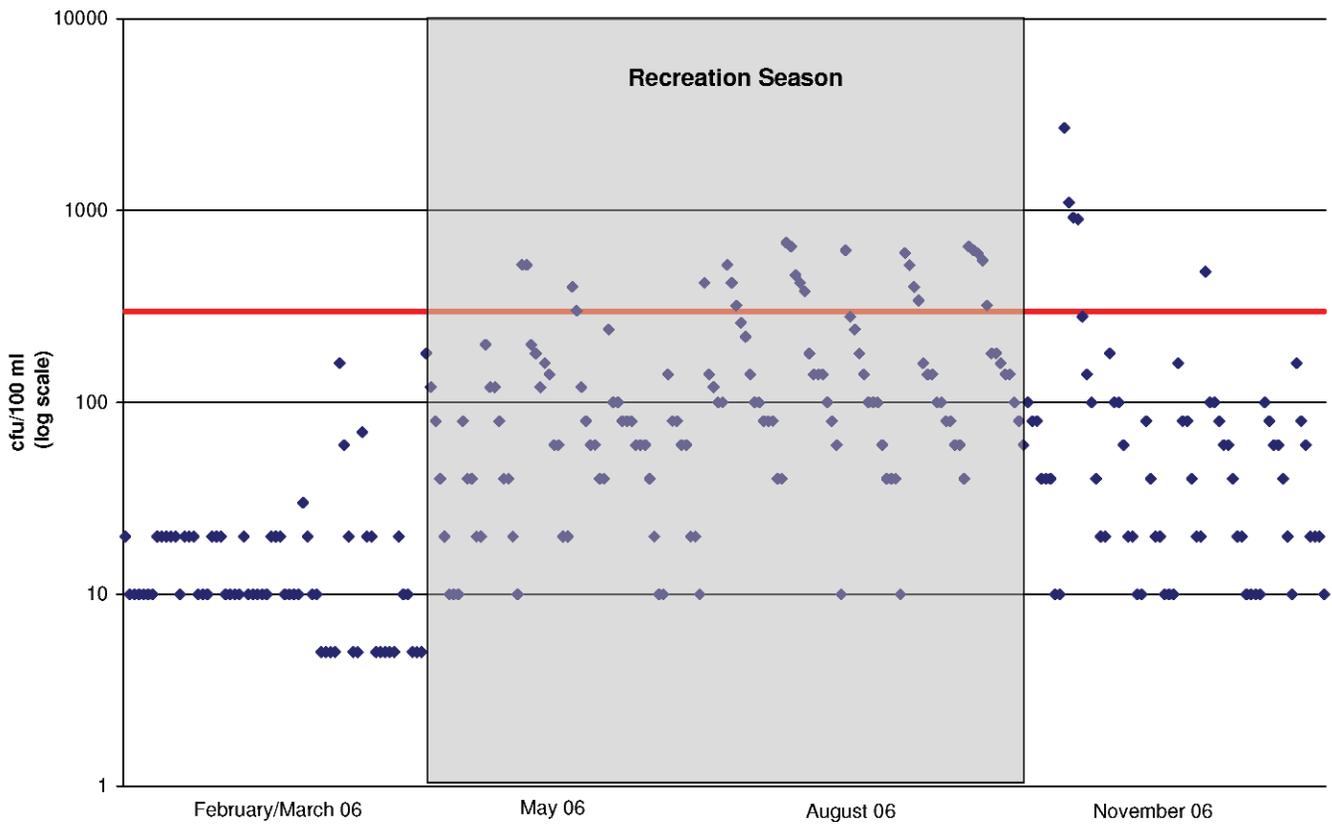


Figure 6. Single Sample *E. Coli* Concentrations
(red line indicates EPA recommended single sample maximum)

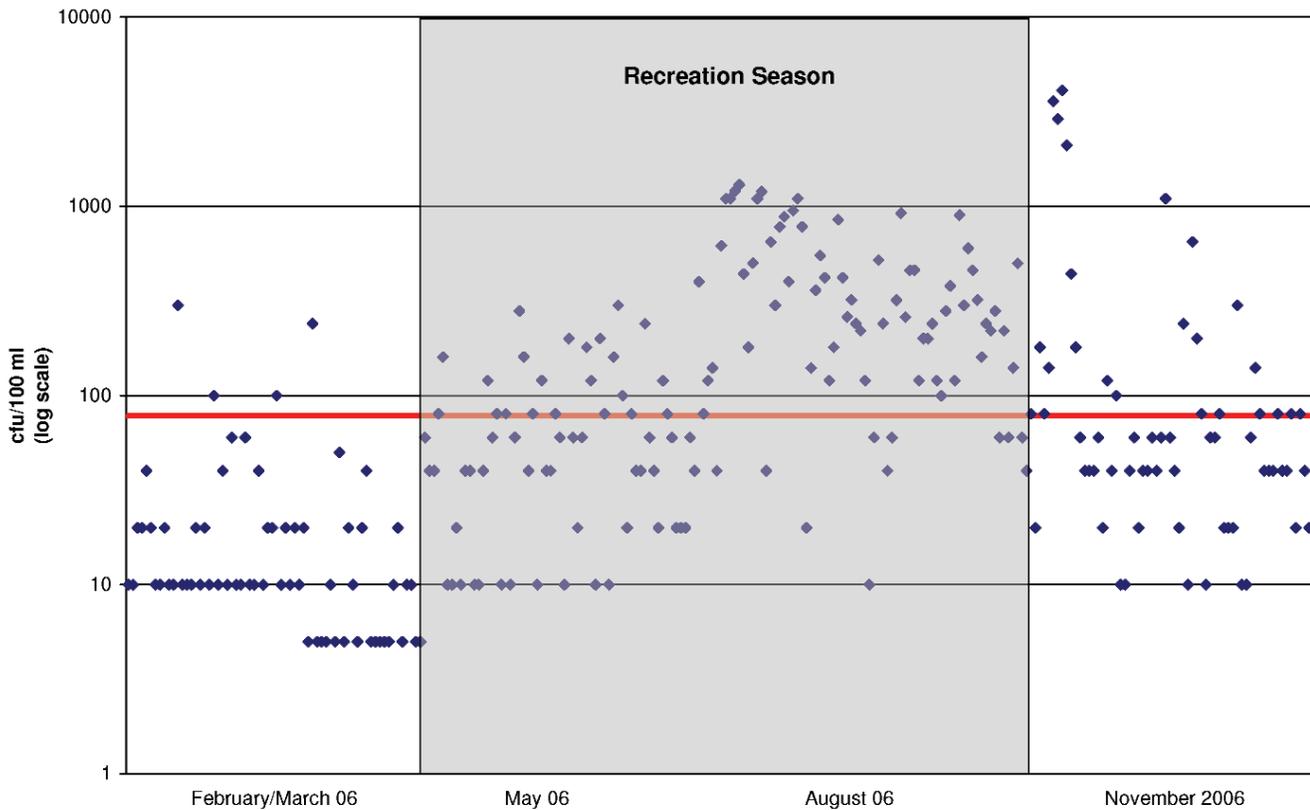


Figure 7. Single Sample Enterococci Concentrations
(red line indicates EPA recommended single sample maximum)

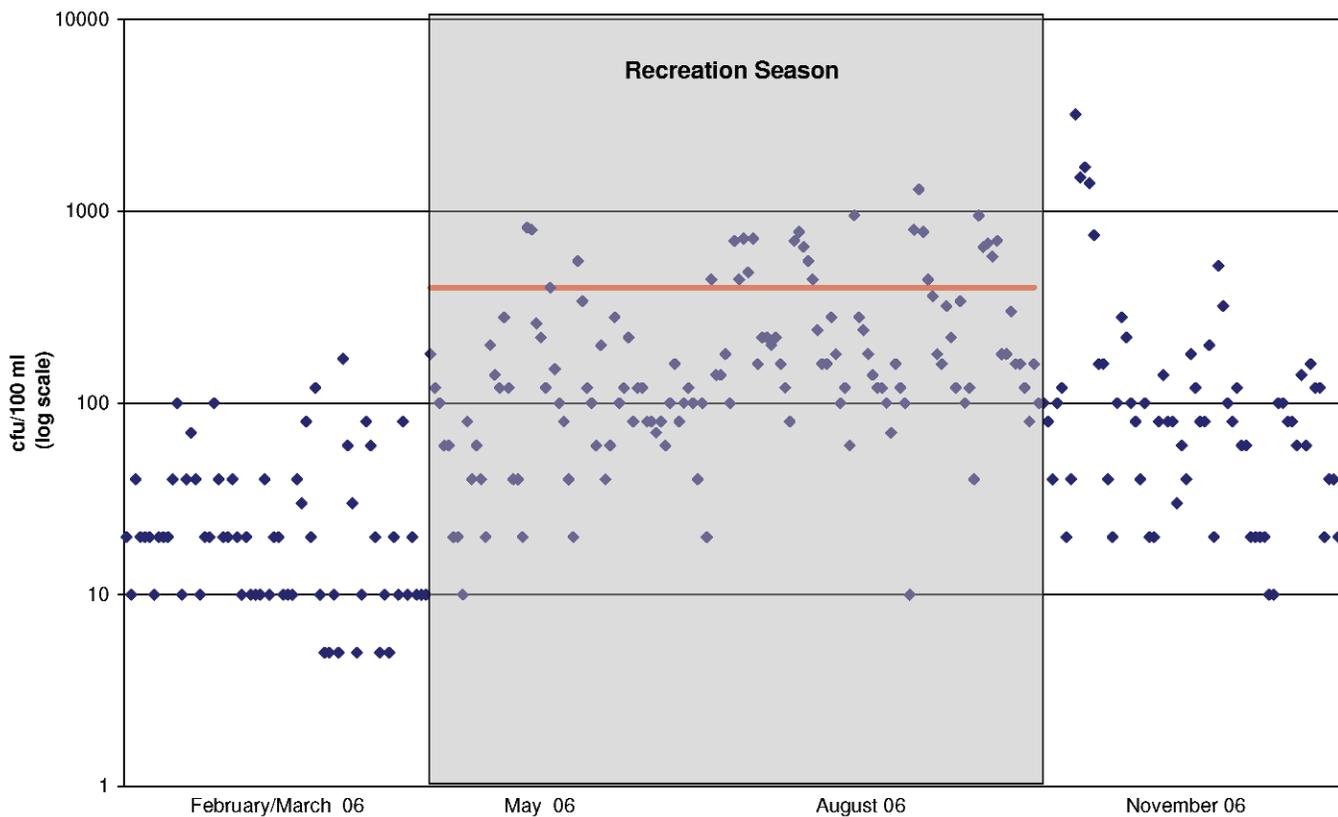


Figure 8. Single Sample Fecal Coliform Concentrations
(red line indicates current PADEP standards for single sample maximum for May-September)

Table 14. A Comparison of Samples Exceeding Standards at Various Risk Levels

PA DEP Standard for May-September Only			EPA Recommended Criteria						
Watershed	Sample size	Fecal Coliform	E. coli			Enterococci			
		Percent >400 CFU/100 ml	Percent >298 CFU/100 ml (Moderate use full-body contact)	Percent >409 CFU/100 ml (Light use, full body contact)	Percent >575 CFU/100 ml (Infrequent use, full body contact)	Percent >78 CFU/100 ml (Moderate use full-body contact)	Percent >107 CFU/100 ml (Light use, full body contact)	Percent >151 CFU/100 ml (Infrequent use, full body contact)	
Cedar Run	24	41.7	41.7	33.3	12.5	62.5	62.5	62.5	
Stony Creek	24	0	8.3	4.2	0	54.2	50	41.7	
Trout Run	24	12.5	12.5	12.5	4.2	70.8	50	41.7	
Dogwood Run	24	0	0	0	0	29.2	25	20.8	
Mountain Creek	24	4.2	4.2	4.2	4.2	41.7	25	25	
Yellow Breeches Mainstem	144	6.9	8.3	5.6	4.2	35.4	27.8	20.1	
All Samples	264	9.1	10.6	8	4.2	42.8	34.5	28.4	