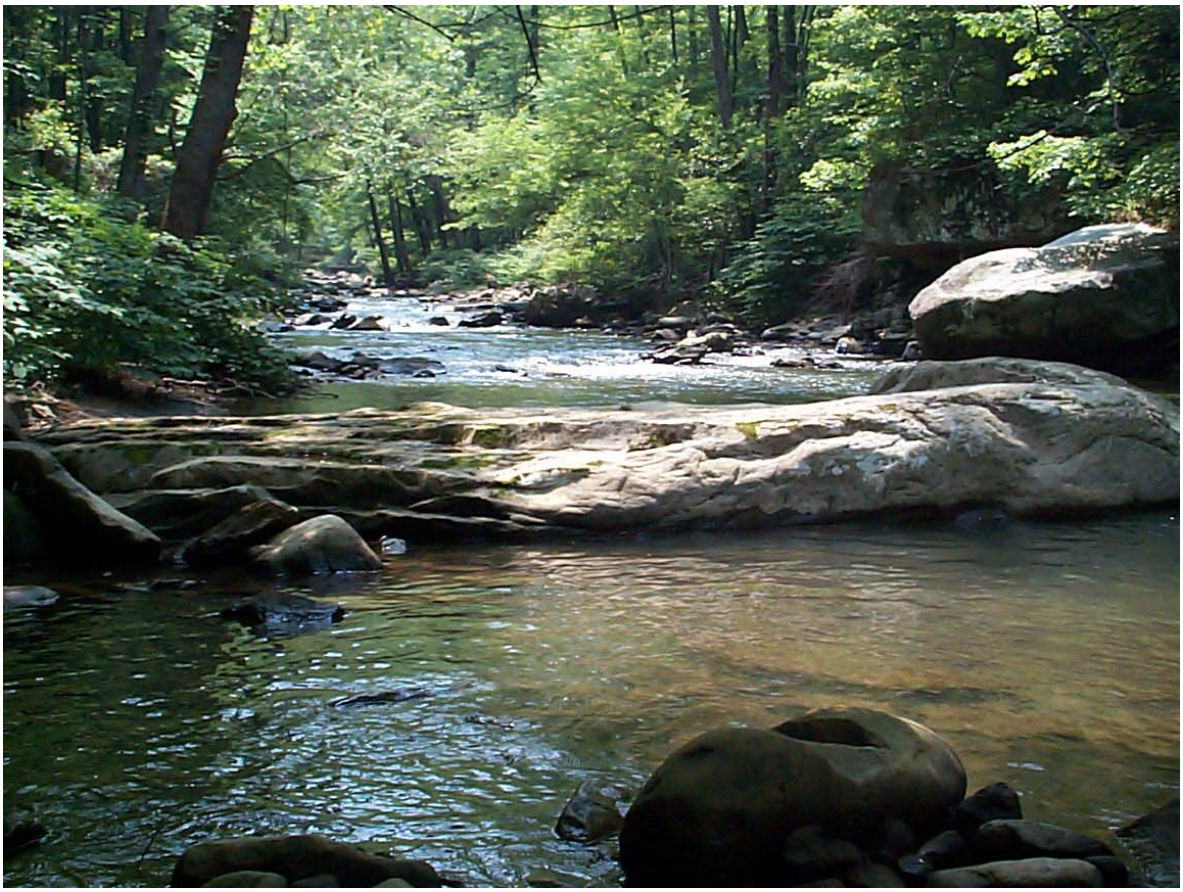
New River Gorge National River
Bluestone National Scenic River
Gauley River National Recreation Area

National Park Service
U.S. Department of the Interior

Water Quality Monitoring During 2009 For New River Gorge National River



Jesse M. Purvis

2010

New River Gorge National River was established by Public Law (PL) 95-625 on November 10, 1978. The park was created to conserve and interpret outstanding natural values and objects, and to preserve an important segment of the New River as a free-flowing stream for the benefit and enjoyment of present and future generations.

Water Quality Monitoring During 2009 for New River Gorge National River

Jesse M. Purvis

United States Department of the Interior
National Park Service
Glen Jean, West Virginia

2010

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EXECUTIVE SUMMARY

This report presents the results of baseline water quality monitoring for New River Gorge National River during 2009. **Baseline monitoring is designed to produce a long-term estimate of average conditions.** Storm event monitoring, but no baseline monitoring, was conducted in Bluestone National Scenic River and Gauley River National Recreation Area during 2009. Storm event monitoring results will be presented in a separate report.

New River Gorge National River provides some of the most popular water-based recreation in the eastern United States., and supports the most significant and highest quality warm water fishery in West Virginia.

Appalachia has a long history of impoverishment. Today this is reflected in infrastructure that is often less than adequate. Sewage treatment is absent or woefully substandard in many areas, including the vicinity of New River Gorge National River. Early surveys of water quality near the park identified fecal pollution from inadequate sewage treatment as the most significant water quality issue. To address this the National Park Service instituted a water quality monitoring program to determine the extent of the problem as it might affect park resources. This report describes the continuing results of this program.

The National Park Service uses the data gathered from this effort to inform the public, regulators and decision makers of the extent of sewage-related water quality problems surrounding the three parks. We believe this effort has led to a better informed public, and the commitment of effort and funding that are working towards improving local water quality.

For more information about the water quality monitoring program, or other park aquatic resource issues, please contact the author at 304-465-0508.

ACKNOWLEDGEMENTS

Access or assistance was provided by the United States Army Corps of Engineers (Bluestone Dam); United States Geological Survey (West Virginia Water Science Center); West Virginia Department of Environmental Protection; ACE Adventure Center, CSX Corporation, the Nuttall Estate, and Dennis Richmond.

Completing this report benefited from many specialists, interns, and volunteers at New River Gorge National River. Lisa Wilson and Kathy Oney completed the field and laboratory work and checked and entered the data. Andy Steel produced the maps.

Additional thanks are extended to other staff at New River Gorge National River, volunteers, and other individuals whom I may have neglected to mention.

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INTRODUCTION and METHODS

WATER QUALITY MONITORING PROGRAM

This report summarizes baseline water quality monitoring efforts by the National Park Service (NPS) in New River Gorge National River (NRGNR) in 2009. This work continues an effort focusing on fecal coliform bacteria, an indicator of sewage pollution, that began in 1980. A previous report (Wilson and Purvis 2003) summarizes the history of NPS water quality monitoring for the park.

Fecal coliform bacteria live in the lower gut of warm-blooded animals and are excreted with the feces. Fecal coliforms are not necessarily pathogenic (disease-causing). However, other microorganisms that are pathogenic also live in the lower gut and are also excreted with the feces. Fecal coliforms are relatively easy to detect, and thus serve as an indicator of fecal pollution, and hence potential pathogenic conditions related to sewage pollution. Fecal coliforms are the basis for the West Virginia standard for primary contact recreational waters. This standard is that fecal coliforms not exceed 200 per 100 milliliters (200 FC/100ml) of water (West Virginia Water Resources Board 1998). This standard is based on the geometric mean (a kind of average) of at least five samples a month. Alternately, waters should not exceed 400 FC/100ml in more than 10% of samples taken in a month.

The study area is described in previous reports (e.g. Wilson *et al*. 2006). New River Gorge National River is part of the Kanawha-New River watershed (Fig. 1). The New River begins in the North Carolina and flows generally north for 250 miles through Virginia and West Virginia. The New River joins the Gauley River at Gauley Bridge, West Virginia to form the Kanawha River. The Kanawha River flows northwest to the Ohio River at Point Pleasant, West Virginia. New River Gorge National River includes 53 miles of the New River, beginning at Hinton and ending near Fayetteville.

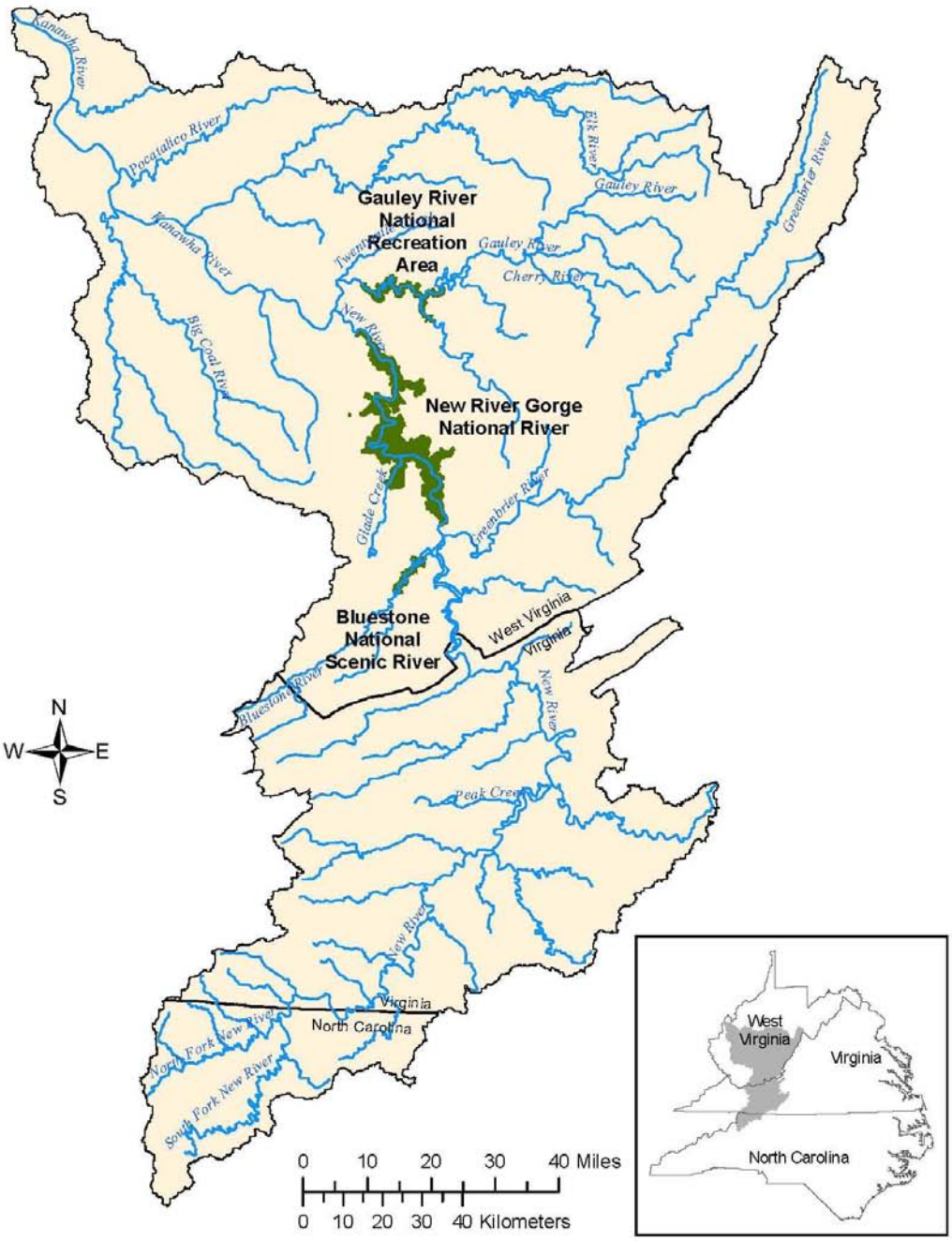

Figure 1. Location of New River Gorge National River in Kanawha-New River watershed

Several reports summarize earlier water quality monitoring efforts (West Virginia Department of Natural Resources 1988, 1989; Wood 1990a, b, c; Schmidt and Hebner 1991; Hebner 1991b; Sullivan 1993b, c; Gibson 1993; Purvis and Wilson 1999; Wilson and Purvis 2000, 2003, Wilson *et al*. 2006, Purvis and Wilson 2007, Purvis 2009).

CHANGES SINCE 2007

Examination of previous data indicated that many streams were well sampled, but others were poorly sampled. To fill in these data gaps, beginning in 2007 we added 12 streams in NRGNR to our monitoring program. In order to add these streams, some well sampled streams were temporarily dropped from the monitoring schedule.

During 2009 data were collected only at 24 sites in NRGNR (Fig. 2). Three of these sites were on the New River and 21 sites were on tributaries. No baseline data were collected from Bluestone National Scenic River or Gauley River National Recreation Area.

Water samples were collected between May and October and analyzed for fecal coliform bacteria by NPS staff at the NPS Water Quality Laboratory at park headquarters according to standard methods (e.g. Bordner *et al*. 1978, American Public Health Association 1992). Details on these routines are described in an earlier report (Wilson *et al*. 2006).

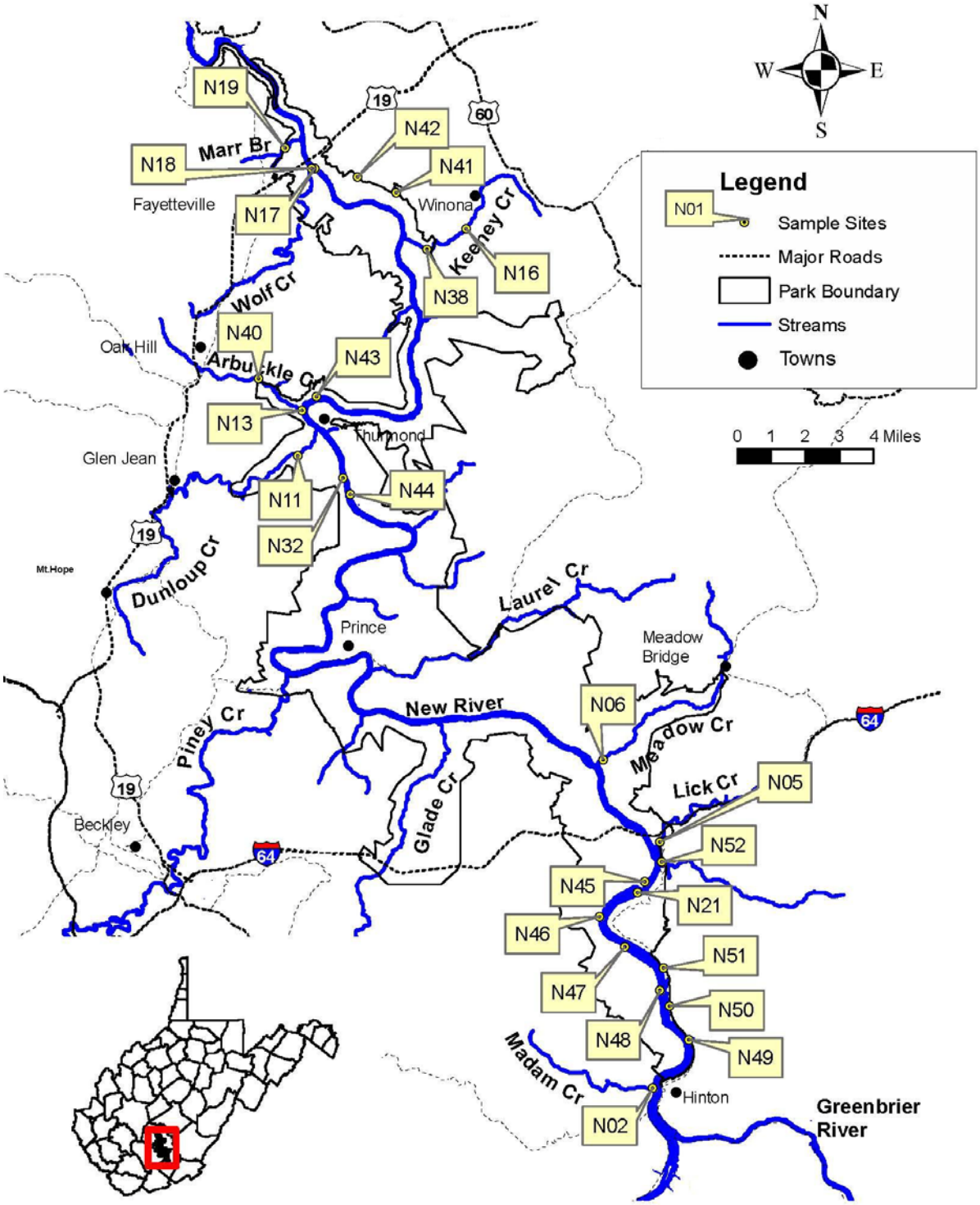

Figure 2. New River Gorge National River water quality monitoring sites.

RESULTS

This section is organized in a downstream direction, except that mainstem information is presented first, followed by information from the tributary streams.

One page is provided for the results from each sampling site. At the top of the page is the site name, followed by a unique site number. These are the same numbers used in Fig. 2. Underneath the names is a color-coded box containing a quick summary of site water quality based on our monitoring, both in the period covered by this report, and since monitoring began at the site.

These sites do not exceed the West Virginia standard more than 10% of the time, either historically or in 2009.
These sites exceed the West Virginia standard more than 10% of the time but no more than 25% of the time, either historically or in 2009.
These sites exceed the West Virginia standard more than 25% of the time, either historically or in 2009.
These sites were recently added to the monitoring program, so reliable estimates of their water quality are not yet available.

Following the boxes is a brief description of the sample location, and its relation to other sampling locations and U. S. Geological Survey (USGS) stream gages. These gages include (with USGS number):

- Hinton (New River at Hinton; 03184500),
- Thurmond (New River at Thurmond; 03185400),

Stream gage data is published annually by the USGS. The 2009 data is available at http://wdr.water.usgs.gov/wy2009/search.jsp.

A short paragraph describes the range and average values of fecal coliform bacteria density during 2009. Three averages – the (arithmetic) mean, the geometric mean and the median – are used to describe the data. The (arithmetic) mean is the average with which

most readers will be familiar. It is calculated by adding the values for all the samples and dividing by the number of samples. The geometric mean is often used in cases where one or a few samples have a much greater value than most of the other samples. Such extreme values often occur in fecal coliform data. Geometric means are calculated by taking the logarithm of each value, adding these logarithms, dividing the total by the number of samples, and then taking the anti-logarithm of this result. Note that for samples where the fecal coliform density was determined to be 0 FC/100ml, I substituted a value of 0.1 FC/100ml when calculating geometric means since the logarithm of 0 is undefined. The median of a set of samples is the value with an equal number of values greater than it and less than it. The median is often more useful when the sample size is small and the sampled population is not normally distributed (*i.e.* does not produce the traditional bell-shaped curve).

The different averages can give quite different results. For five samples with values of 10, 12, 18, 20, and 540, the arithmetic mean would be 120, the geometric mean 29.7 and the median 18. For some sample sets, the averages ae very close. If the sample set is 10, 12, 14, 18 and 20, the mean would be 14.8, the median 14, and the geometric mean 14.3. For data sets with an even number of samples, the median is calculated by taking the arithmetic mean of the two samples closest to the middle. For example, if the sample data are 10, 12, 14, 16, 18, and 20, the median would be 15 (arithmetic mean of 14 and 16).

A bar graph shows fecal coliform bacteria densities for each sample. Blue bars indicate samples with bacteria density up to 200 FC/100ml, yellow bars indicate samples with bacteria density greater than 200 but not more than 400 FC/100ml, and red bars indicate samples with bacteria density greater than 400 FC/100ml. The sample fecal coliform bacteria density value is noted above each bar. Note that some graphs have a logarithmic axis for FC/100ml because of the range of values encountered.

For sites added to the monitoring program in 2007, the bar graphs show all data collected.

NEW RIVER MAINSTEM

New River below Sandstone Falls, site N21

None of the six samples (0%) collected in 2009 exceeded 200 FC/100 ml (Fig. 3).

Since 1993, 12 of 118 samples (10%) have exceeded 200 FC/100 ml.

In 2009 fecal coliform bacteria density ranged from 13 to 48 FC/100 ml (mean 30, geometric mean 25, median 30).

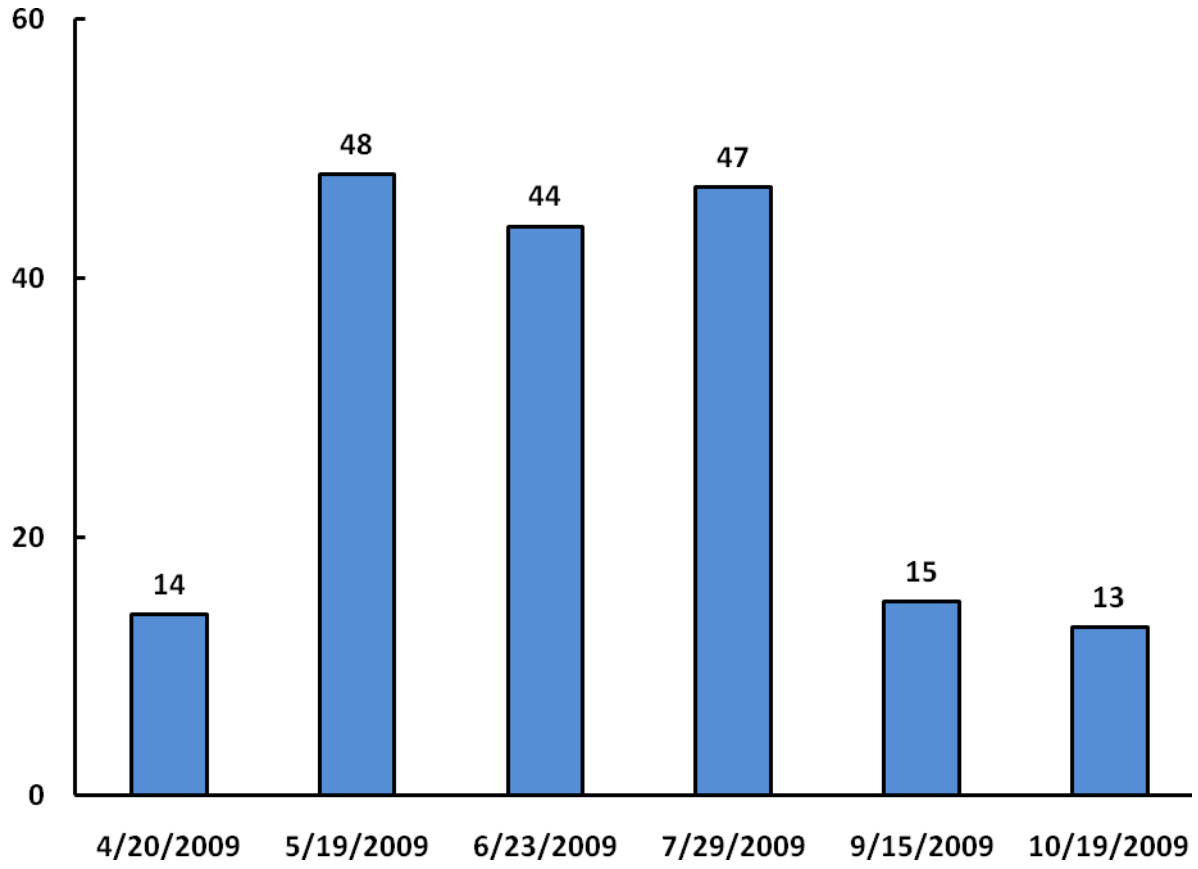

Figure 3. Fecal coliform bacteria density (FC/100ml) at New River below Sandstone Falls (N21) site during 2009.

New River at Stonecliff, site N32

Two of the six samples (33%) collected in 2009 exceeded both 200 FC/100 ml and 400 FC/100ml (Fig. 4).

Since monitoring began at this site in 2007, three of 16 samples (19%) have exceeded 200 FC/100ml

In 2009 fecal coliform bacteria density ranged from 2 to 405 FC/100 ml (mean 163, geometric mean 57, median 75).

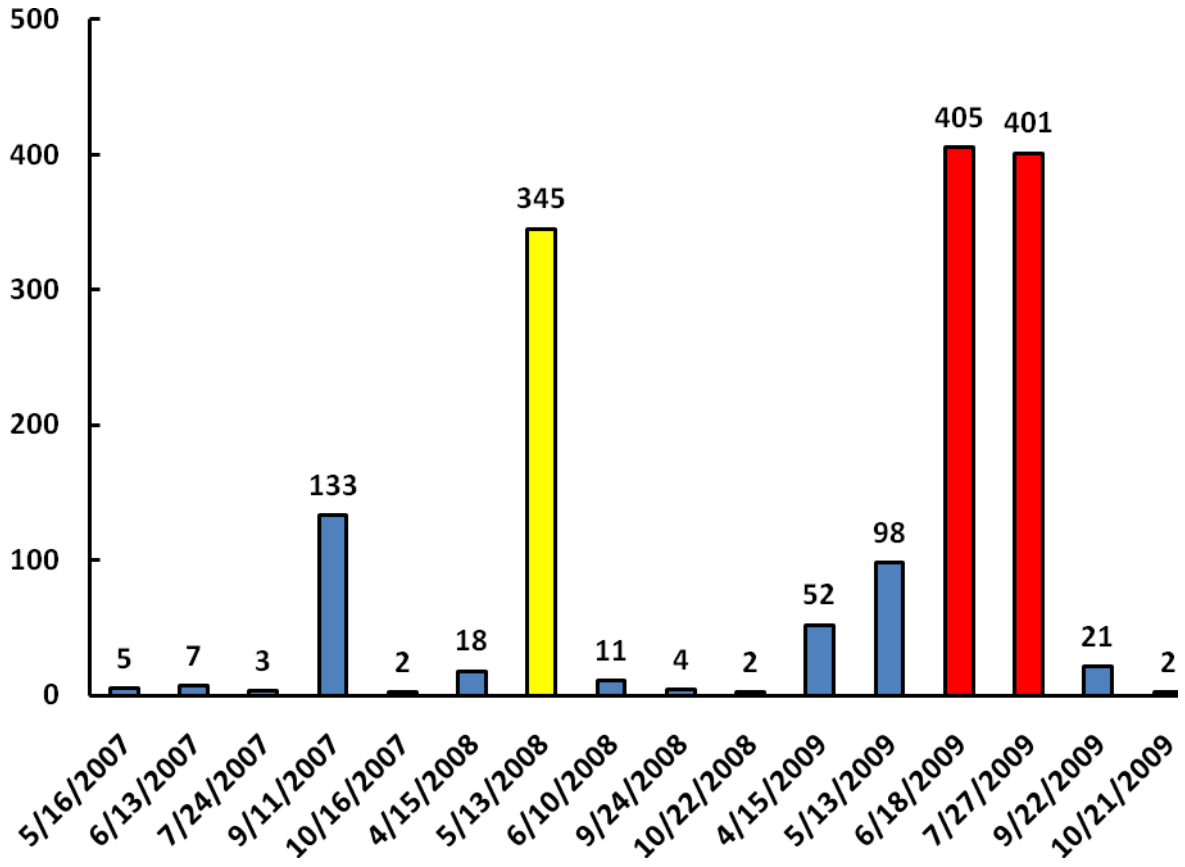

Figure 4. Fecal coliform bacteria density (FC/100ml) at New River at Stonecliff (N32) site during 2007-2009.

New River above Wolf Creek, site N17

None of the six samples (0%) collected in 2009 exceeded 200 FC/100 ml (Fig. 5).

Since 1990, 16 of 147 samples (11%) have exceeded 200 FC/100 ml.

In 2009 fecal coliform bacteria density ranged from 2 to 64 FC/100 ml (mean 18, geometric mean 10, median 11).

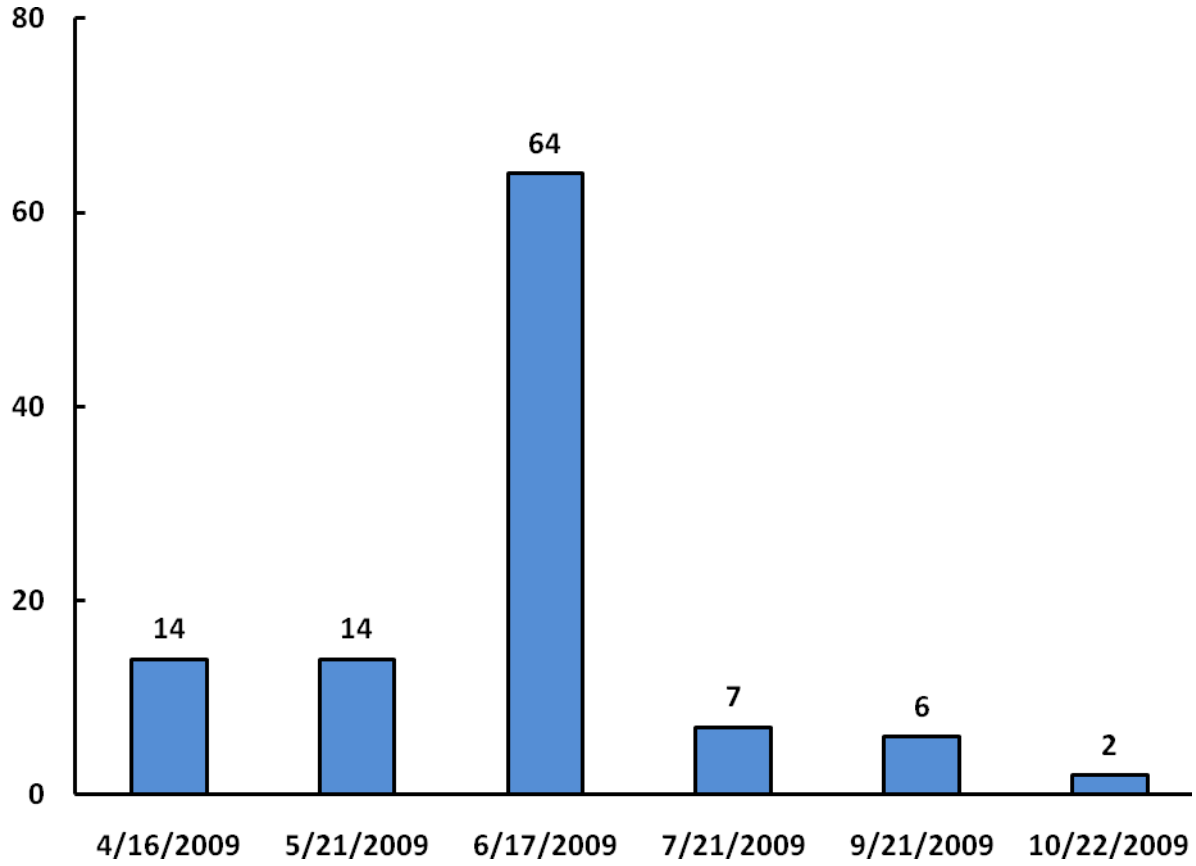

Figure 5. Fecal coliform bacteria density (FC/100ml) at New River above Wolf Creek (N17) site during 2009.

NEW RIVER TRIBUTARIES

Madam Creek, site N02

Four of the six (67%) samples collected in 2009 exceeded 200 FC/100 ml and for three (50%) of the samples exceeded 400 FC/100ml (Fig. 6).

Water quality at this site is unsatisfactory for contact recreation. Since 1990, 122 of 138 samples (88%) exceeded 200 FC/100 ml.

In 2009 fecal coliform bacteria density ranged from 88 to 1000 FC/100 ml (mean 450, geometric mean 316, median 412).

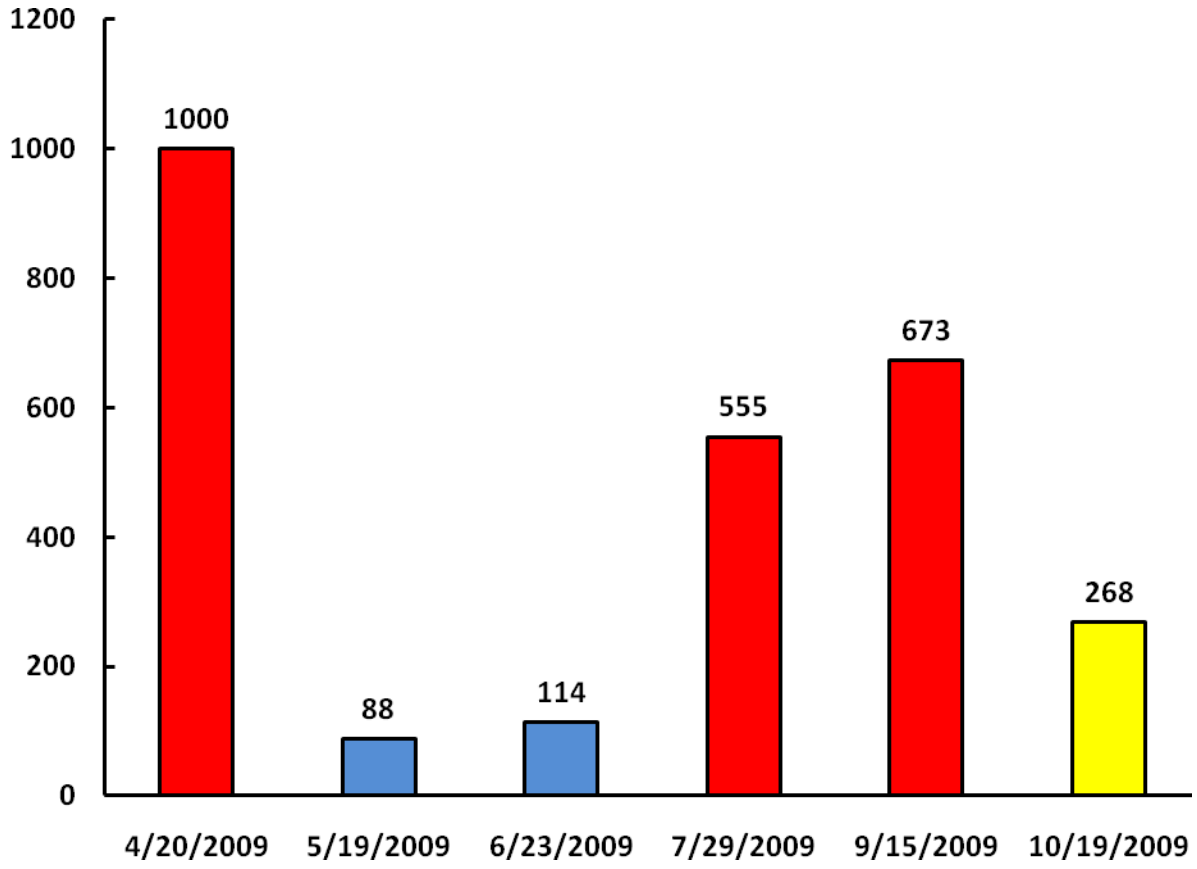

Figure 6. Fecal coliform bacteria density (FC/100ml) at Madam Creek (N02) site during 2009.

Tug Creek, site N49

Four of the six (67%) samples collected in 2009 exceeded 200 FC/100 ml and three (50%) exceeded 400 FC/100ml (Fig. 7).

Since monitoring began in 2007, 13 of 16 samples (81%) have exceeded 200 FC/100 ml and nine samples (56%) have exceeded 400 FC/100ml.

Water quality at this site is unsatisfactory for contact recreation.

In 2009 fecal coliform bacteria density ranged from 70 to 600 FC/100 ml (mean 315, geometric mean 234, median 313). While the 2009 values were lower than in 2007-8, water quality at this site is still unsuitable for contact recreation. Note than the value for 10/30/07 was changed from a previous report due to a re-evaluation of the data.

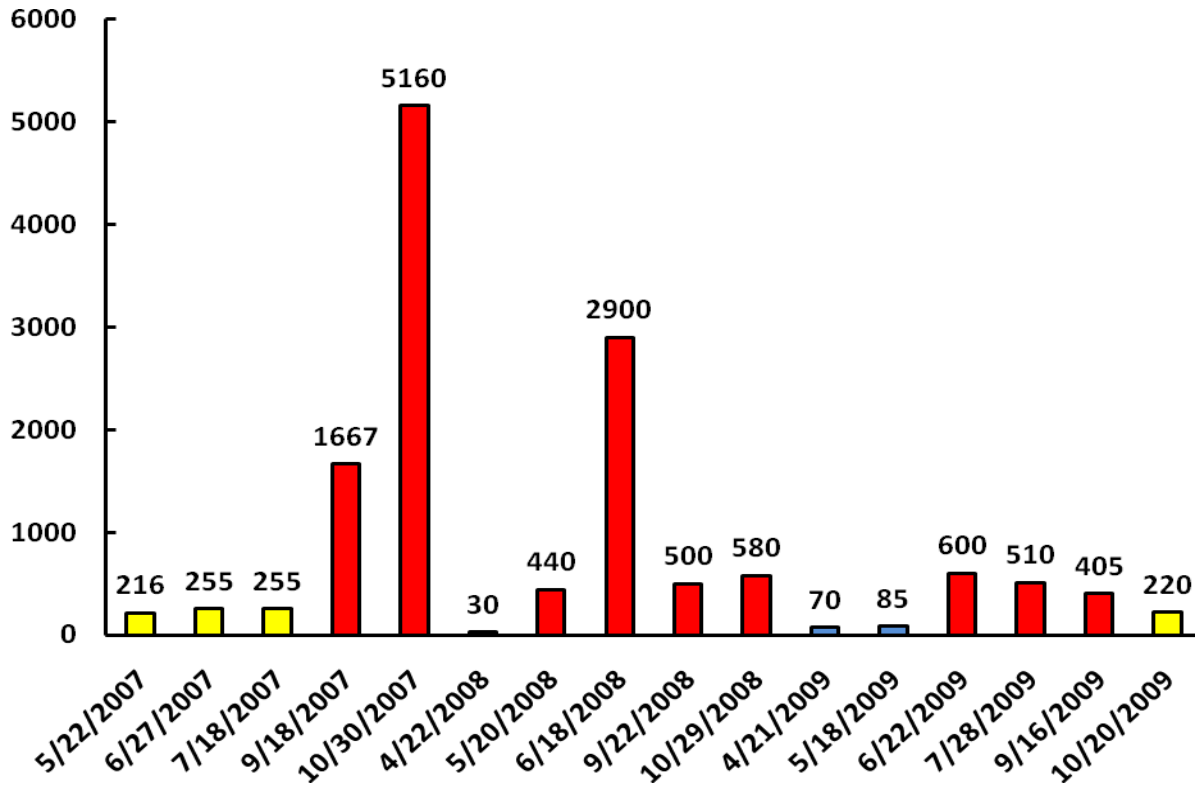

Figure 7. Fecal coliform bacteria density (FC/100ml) at Tug Creek (N49) site during 2007-2009.

Brooks Branch, site N50

Three of the six (50%) collected in 2009 exceeded 200 FC/100 ml and two (33%) exceeded 400FC/100ml (Fig. 8).

Since 2007, nine of 16 samples (56%) have exceeded 200 FC/100 ml and six (38%) exceeded 400FC/100ml.

Water quality at this site is unsatisfactory for contact recreation.

In 2009 fecal coliform bacteria density ranged from 28 to 600 FC/100 ml (mean 240, geometric mean 124, median 163). Note than the value for 5/22/07 was changed from a previous report due to a re-evaluation of the data.

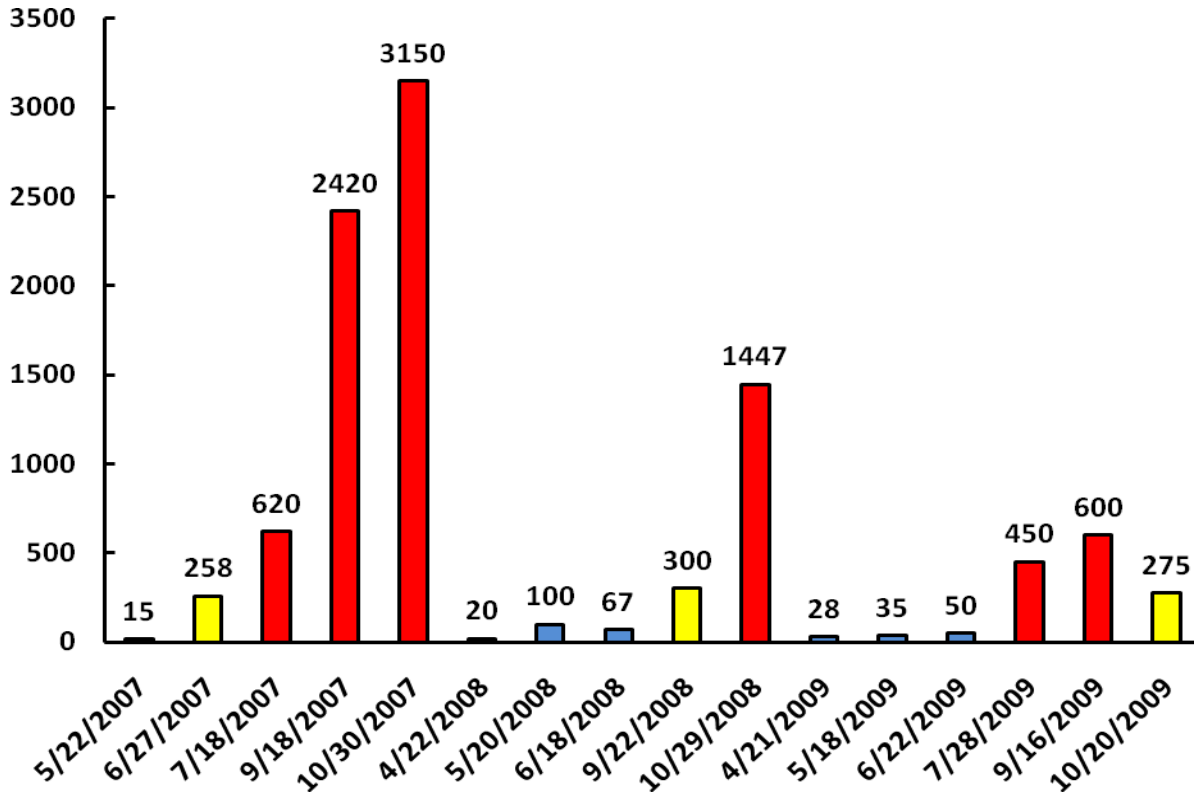

Figure 8. Fecal coliform bacteria density (FC/100ml) at Brooks Branch (N50) site during 2007-2009.

Big Branch, site N48

None of the five samples (0%) collected in 2009 exceeded 200 FC/100 ml (Fig. 9).

Since 2007, one of 11 (9%) of the samples exceeded 200 FC/100 ml.

In 2009 fecal coliform bacteria density ranged from 10 to 109 FC/100 ml (mean 43, geometric mean 29, median 40). In spite of its name, this rather small stream often dries up in the summer.

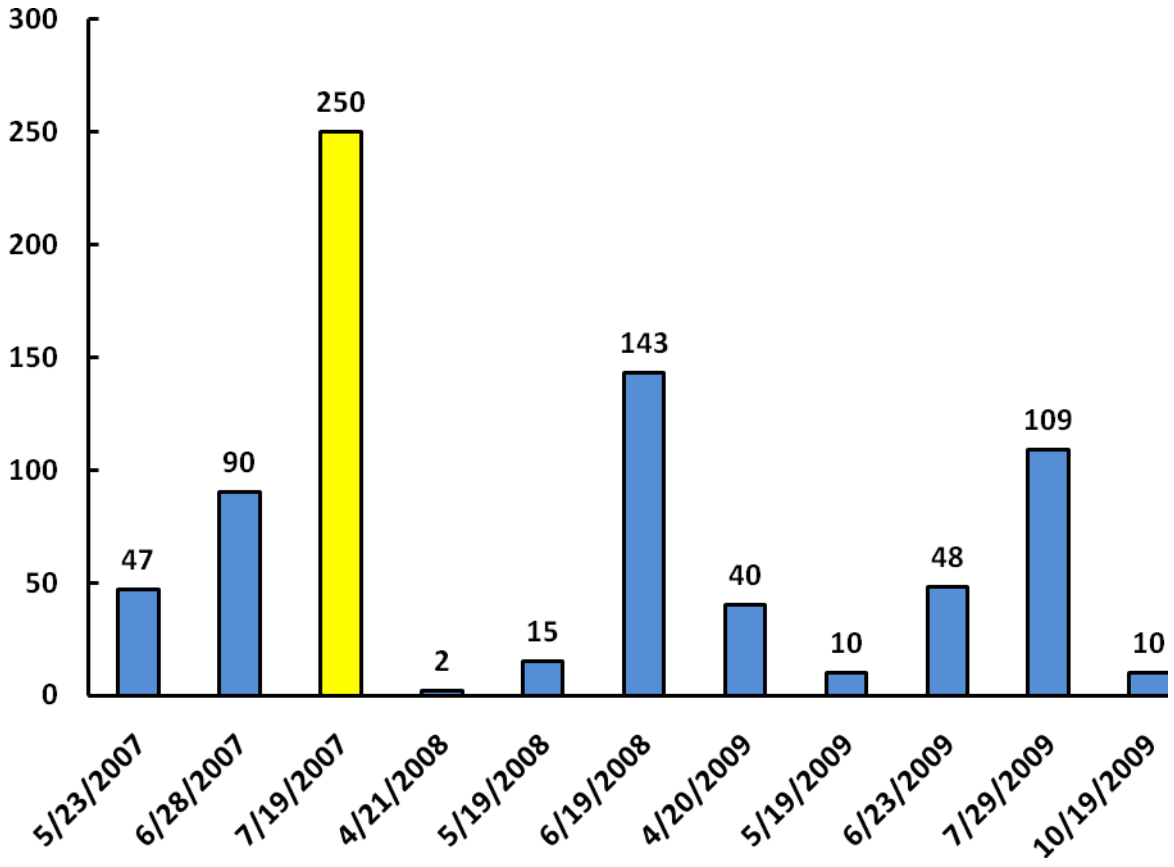

Figure 9. Fecal coliform bacteria density (FC/100ml) at Big Branch (N48) site during 2007-2009.

Owens Branch, site N51

Four of the six samples (67%) collected in 2009 exceeded 200 FC/100 ml , and three (50%) exceeded 400 FC/100ml (Fig. 10).

Since 2007, seven of 14 samples (50%) exceeded 200 FC/100ml, and three (21%) exceeded 400 FC/100ml.

In 2009 fecal coliform bacteria density ranged from 130 to 780 FC/100 ml (mean 458, geometric mean 357, median 448). These results are noticeably higher than was observed in 2007-2008.

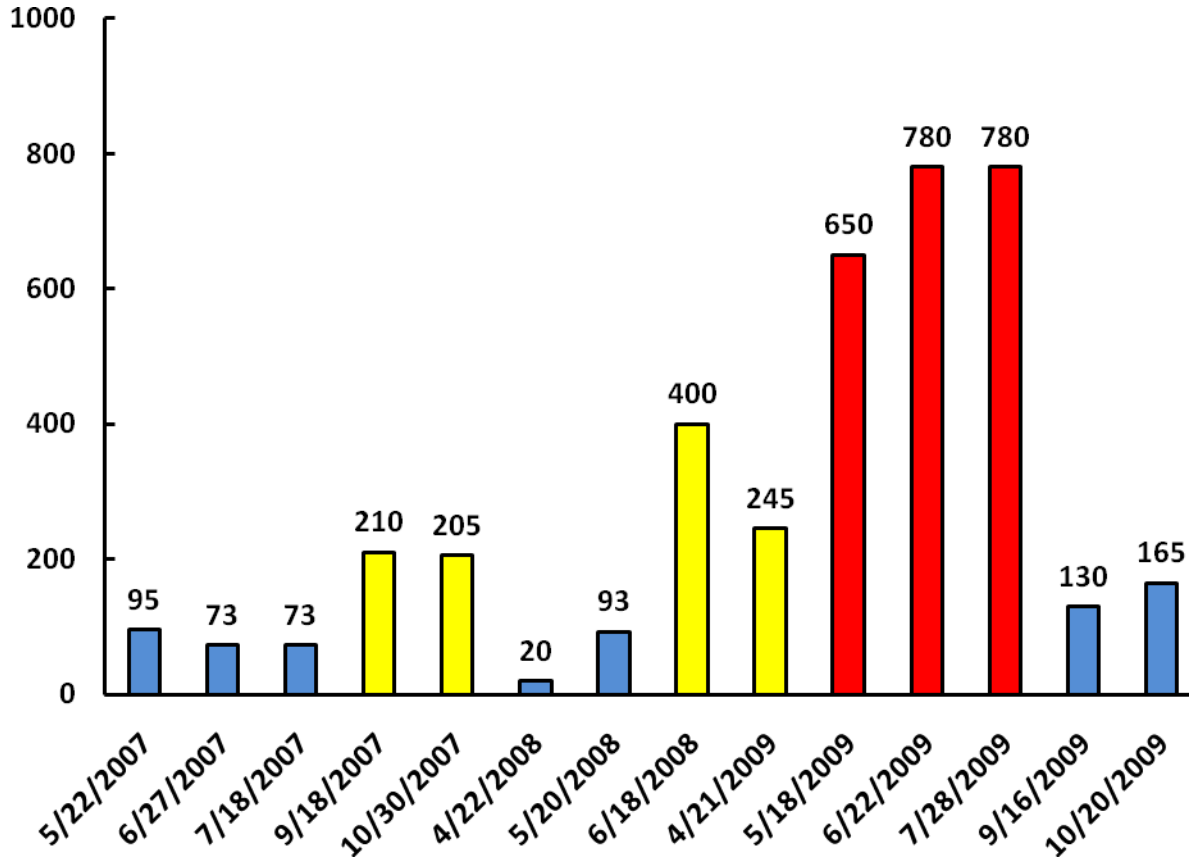

Figure 10. Fecal coliform bacteria density (FC/100ml) at Owens Branch (N51) site during 2007-2009.

Kates Branch, site N47

One of the nine samples (11%) collected in 2007 and 2008 exceeded 200 FC/100 ml (Fig. 11).

Since 2007, three of 15 samples (20%) exceeded 200 FC/100ml, and one sample (7%) exceeded 400 FC/100ml.

Water quality at this site is marginal for contact recreation.

In 2009 fecal coliform bacteria density ranged from 40 to 403 FC/100 ml (mean 150, geometric mean 107, median 80).

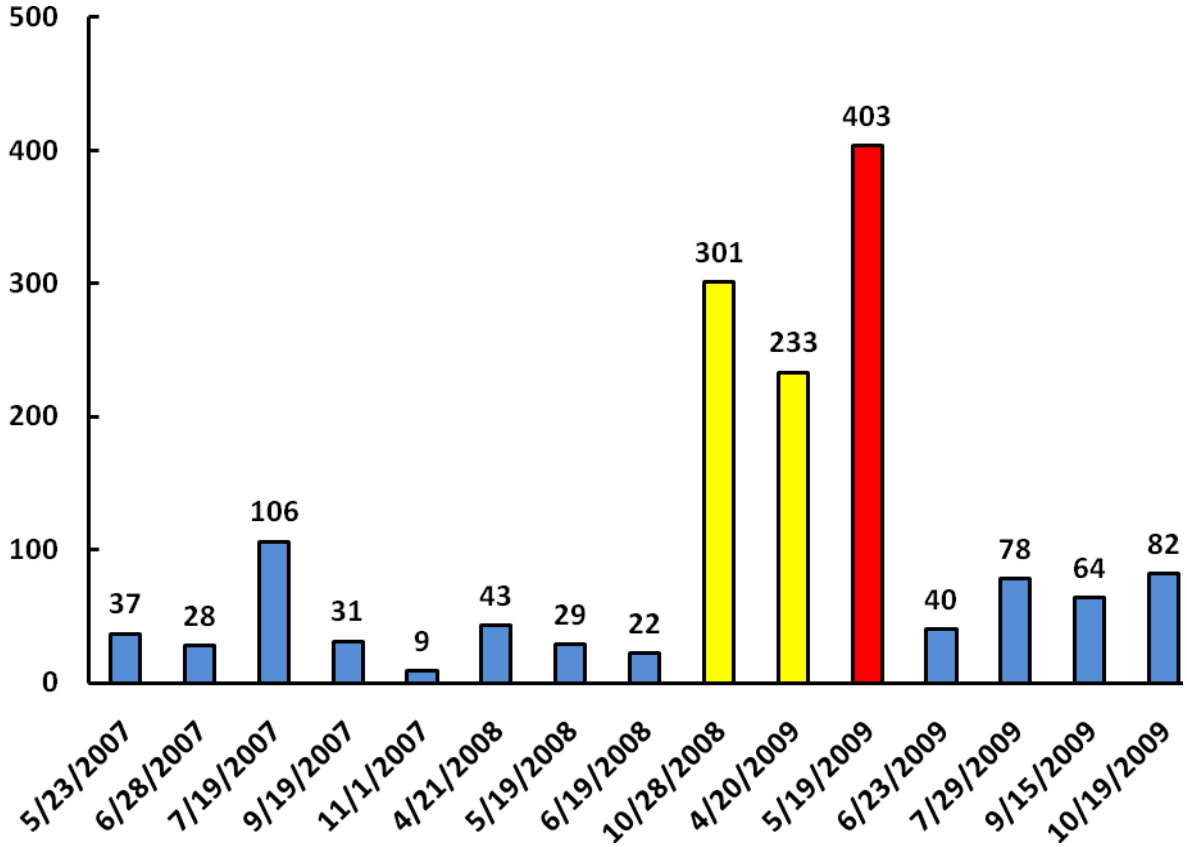

Figure 11. Fecal coliform bacteria density (FC/100ml) at Kates Branch (N47) site during 2007-2009.

Fall Branch, site N46

None of the six samples (0%) collected in 2009 exceeded 200 FC/100 ml (Fig. 12).

Since 2007, none of the 16 samples (0%) have exceeded 200 FC/100ml.

Bacterial water quality at this site appears to be excellent and wholly suitable for water contact recreation.

In 2009 fecal coliform bacteria density ranged from 10 to 74 FC/100 ml (mean 35, geometric mean 29, median 34).

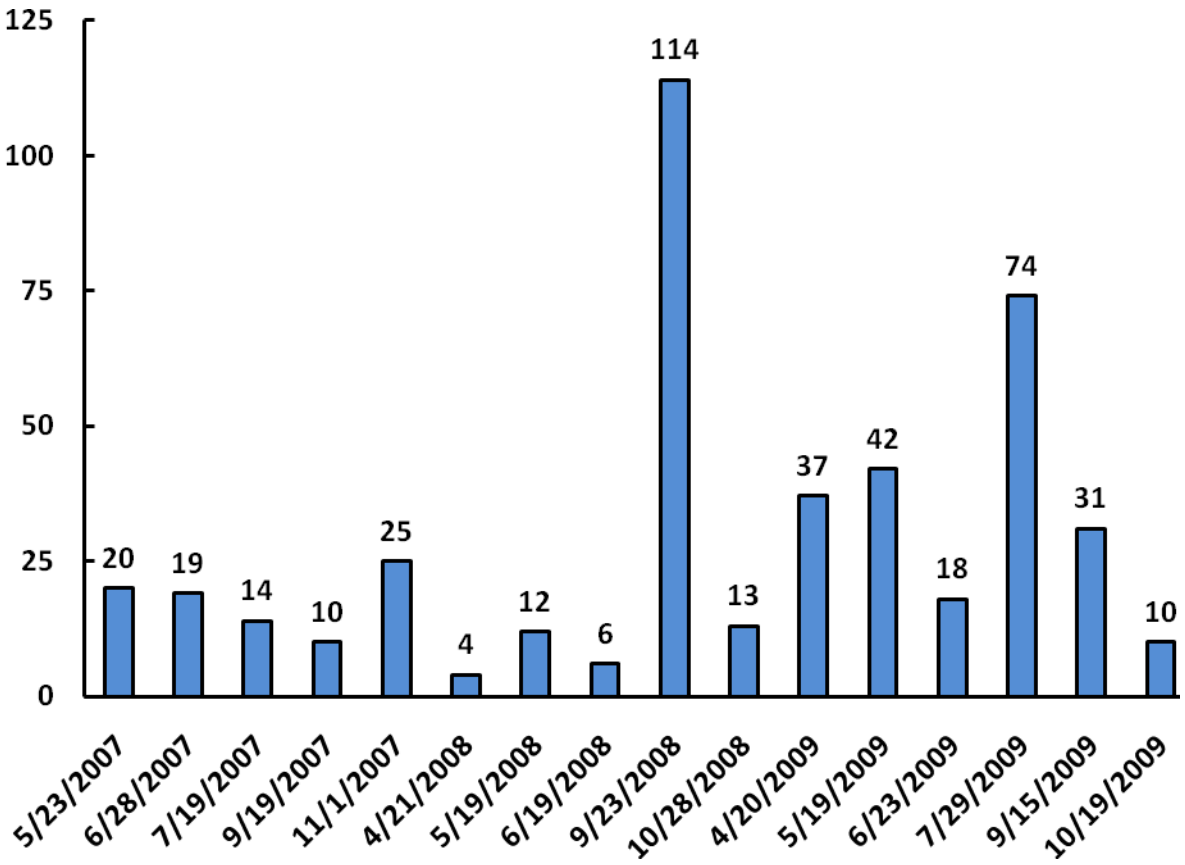

Figure 12. Fecal coliform bacteria density (FC/100ml) at Fall Branch (N46) site during 2007-2009.

Sandstone Falls Creek, site N45

Two of the five samples (40%) collected in 2009 exceeded 200 FC/100 ml (Fig. 13).

Since 2007 four of ten samples (40%) have exceeded 200 FC/100ml, and one sample (10%) exceeded 400 FC/100ml.

In 2009 fecal coliform bacteria density ranged from 45 to 2420 FC/100 ml (mean 610, geometric mean 209, median 175). This small stream dried up in the summer of each year.

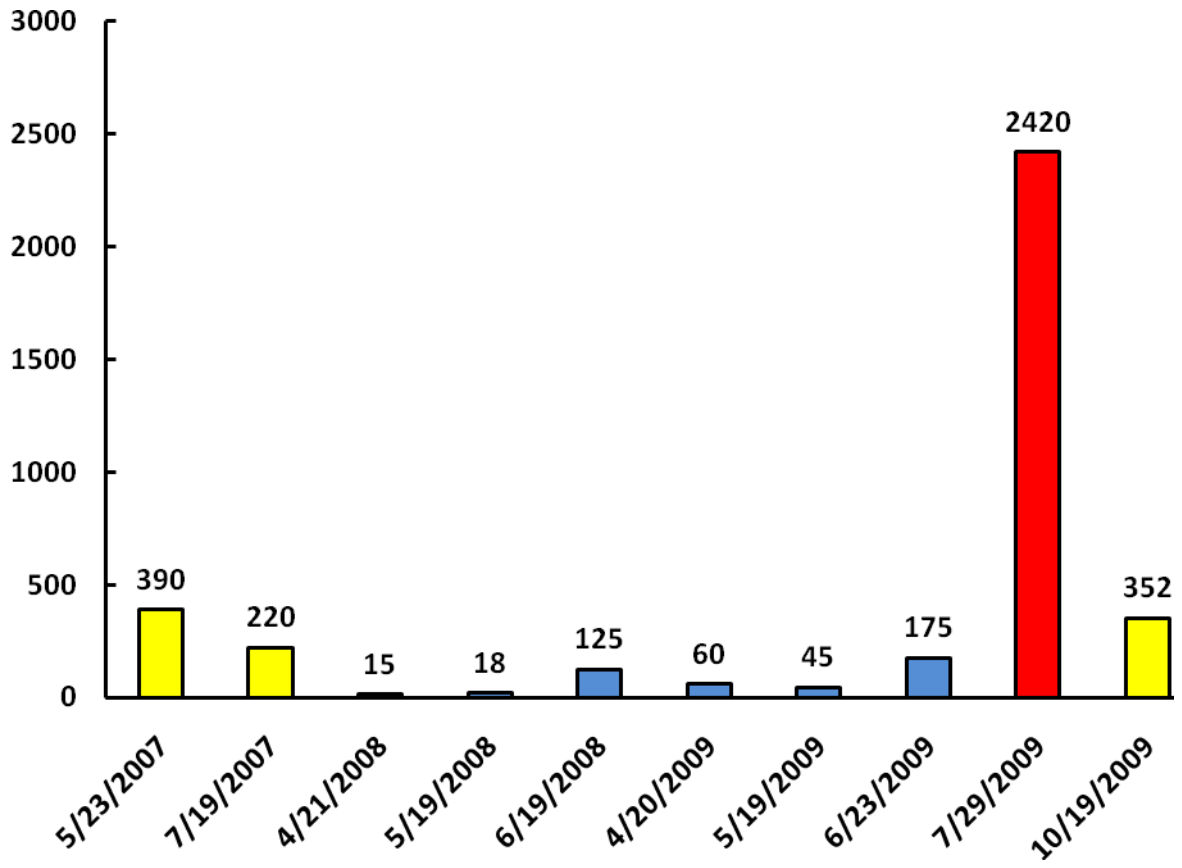

Figure 13. Fecal coliform bacteria density (FC/100ml) at Sandstone Falls Creek (N45) site during 2007-2009.

Laurel Creek near Sandstone, site N52

In 2009 one of six samples (17%) exceeded both 200 and 400 FC/100ml (Fig. 14).

Since 2007, two of 16 samples (12.5%) exceeded both 200 and 400 FC/100 ml.

In 2009 fecal coliform bacteria density ranged from 18 to 517 FC/100 ml (mean 178, geometric mean 117, median 145).

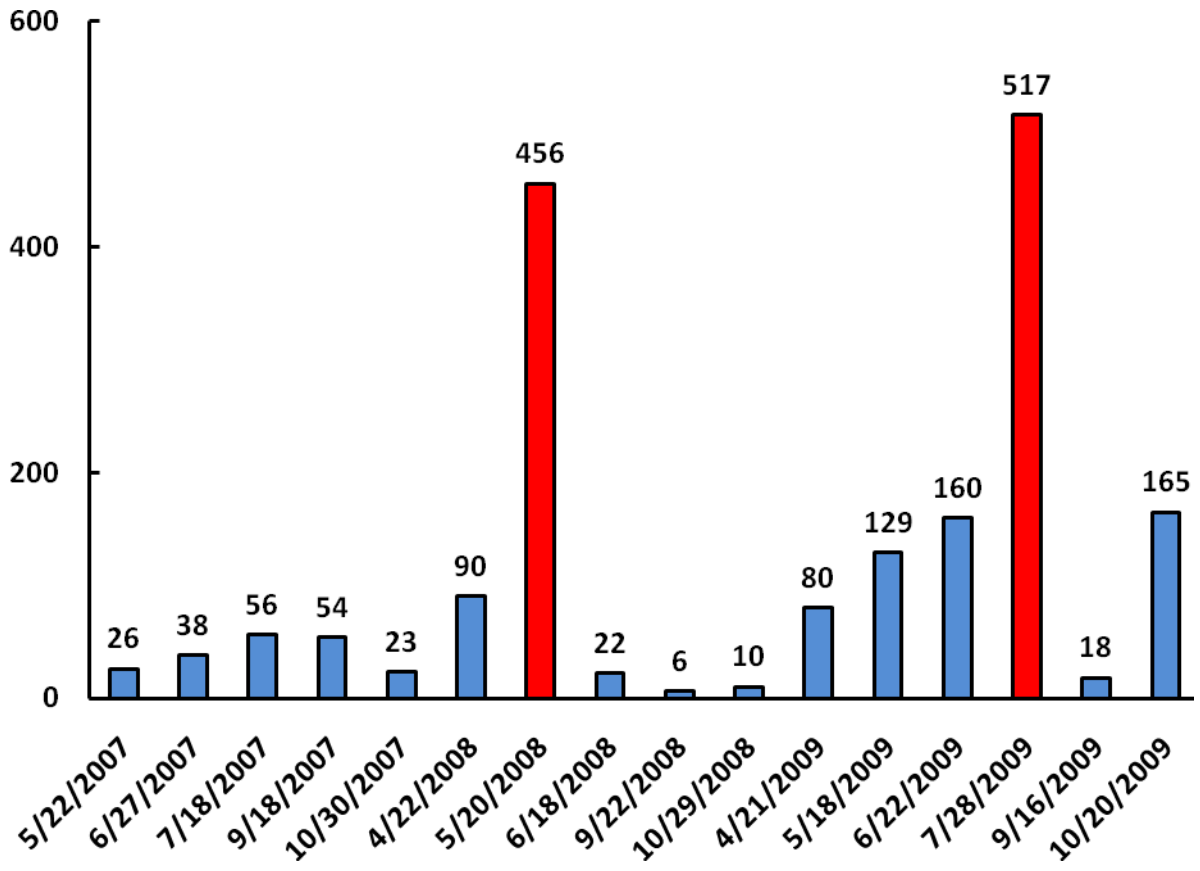

Figure 14. Fecal coliform bacteria density (FC/100ml) at Laurel Creek at Sandstone (N52) site during 2007-2009.

Lick Creek, site N05

One of the six (17%) samples collected in 2009 exceeded both 200 and 400 FC/100ml (Fig. 15).

Since 1990, 27 of 149 samples (18%) exceeded 200 FC/100 ml.

In 2009 fecal coliform bacteria density ranged from 14 to 457 FC/100 ml (mean 121, geometric mean 66, median 73).

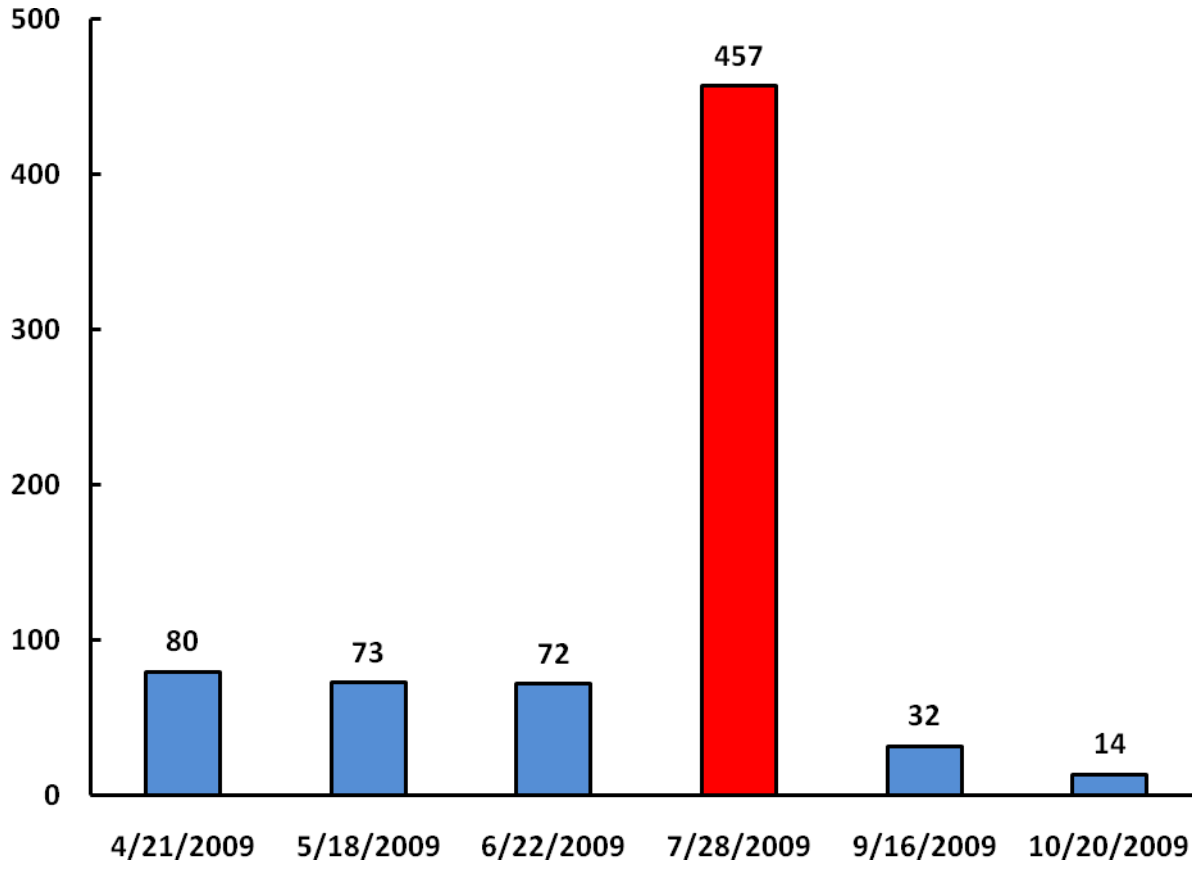

Figure 15. Fecal coliform bacteria density (FC/100ml) at Lick Creek (N05) site during 2009.

Meadow Creek, site N06

None of the six (0%) samples collected in 2000 exceeded 200 FC/100 ml (Fig. 16).

Since 1990, 28 of 149 (19%) samples exceeded 200 FC/100 ml.

In 2009 fecal coliform density ranged from 16 to 195 FC/100 ml (mean 72, geometric mean 53, median 51).

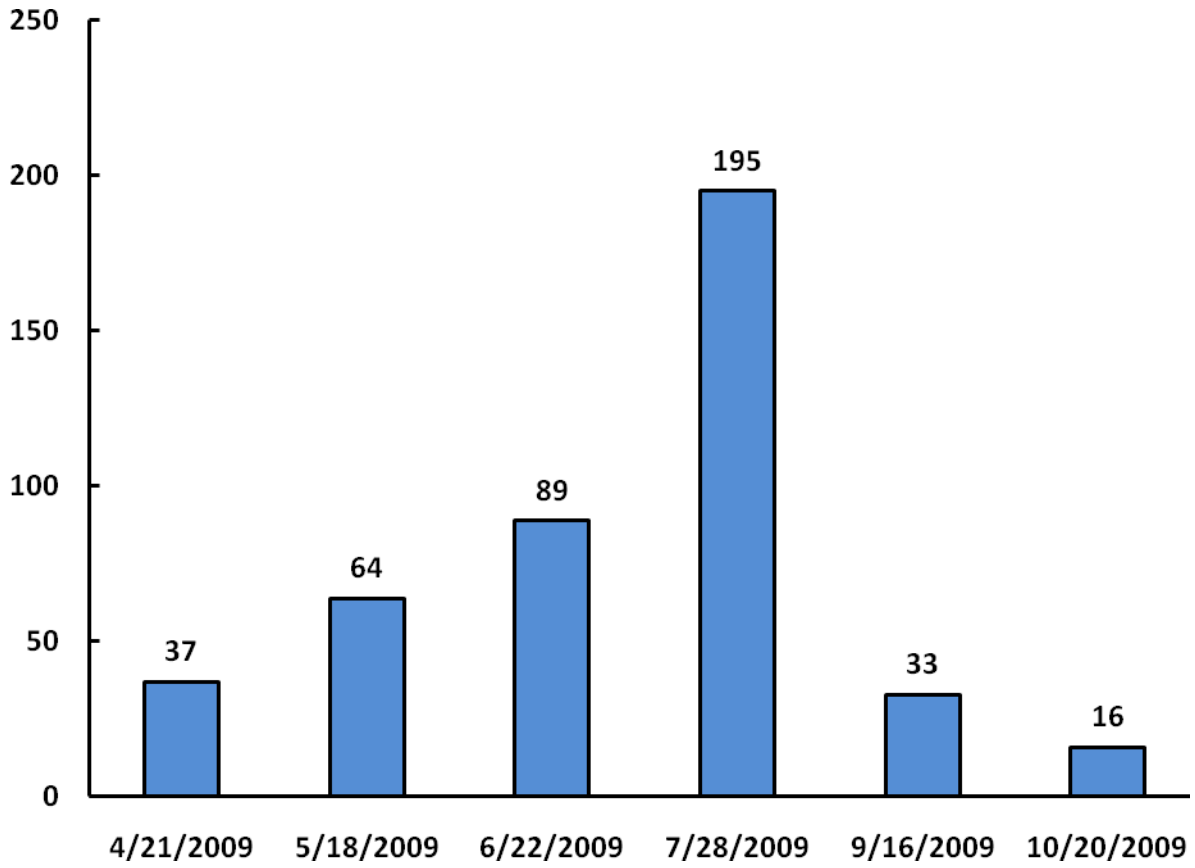

Figure 16. Fecal coliform bacteria density (FC/100ml) at Meadow Creek (N06) site during 2009.

Todd Creek, site N44

During 2009, none of the five samples (0%) exceeded 200 FC/100ml (Fig. 17)

Since 2007, only one of the 12 sample dates (8%) exceeded 200 FC/100 ml (Fig. 17).

In 2009 fecal coliform bacteria density ranged from 1 to 94 FC/100ml (mean 20, geometric mean 3, median 2). Note that because of the extreme value for September 11 2007, a logarithmic scale is used on the vertical axis of Fig. 17.

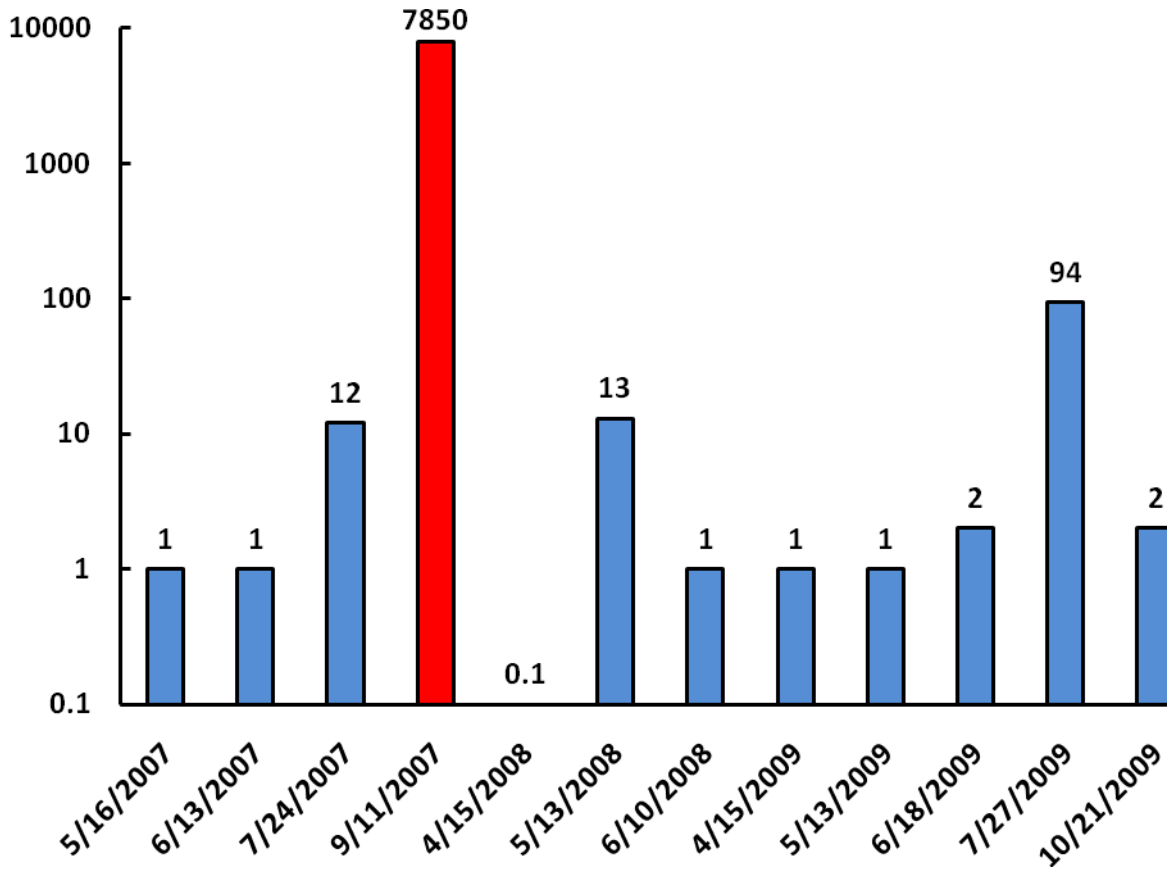

Figure 17. Fecal coliform bacteria density (FC/100ml) at Todd Creek (N44) site during 2007-2009.

Dunloup Creek, site N11

Two of six (33%) samples taken in 2009 exceeded both 200 and 400 FC/100ml (Fig. 18).

Water quality at this site is unsatisfactory for contact recreation. Since 1990, 71 of 158 (45%) samples exceeded 200 FC/100 ml.

In 2009 fecal coliform bacteria density ranged from 53 to 552 FC/100 ml (mean 233, geometric mean 169, median 142).

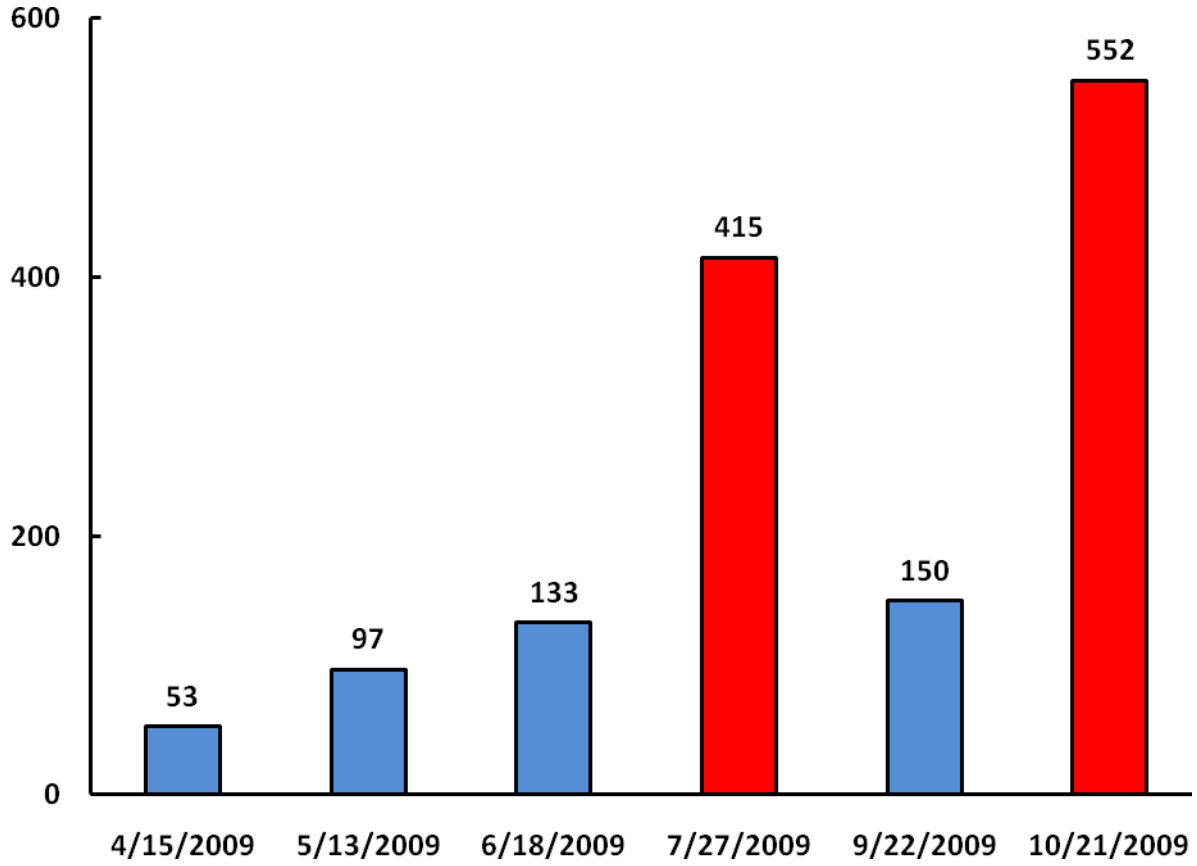

Figure 18. Fecal coliform bacteria density (FC/100ml) at Dunloup Creek (N11) site during 2009.

Arbuckle Creek at Minden, site N40

Five of the six (83%) samples collected in 2009 exceeded 200 FC/100 ml and three (50%) exceeded 400 FC/100ml (Fig. 19).

Since 2004, 19 of 28 samples (68%) have exceeded 200 FC/100ml.

Water quality at this site is wholly unsatisfactory for water contact recreation.

In 2009 fecal coliform bacteria density ranged from 187 to 3093 FC/100 ml (mean 924, geometric mean 556, median 415).

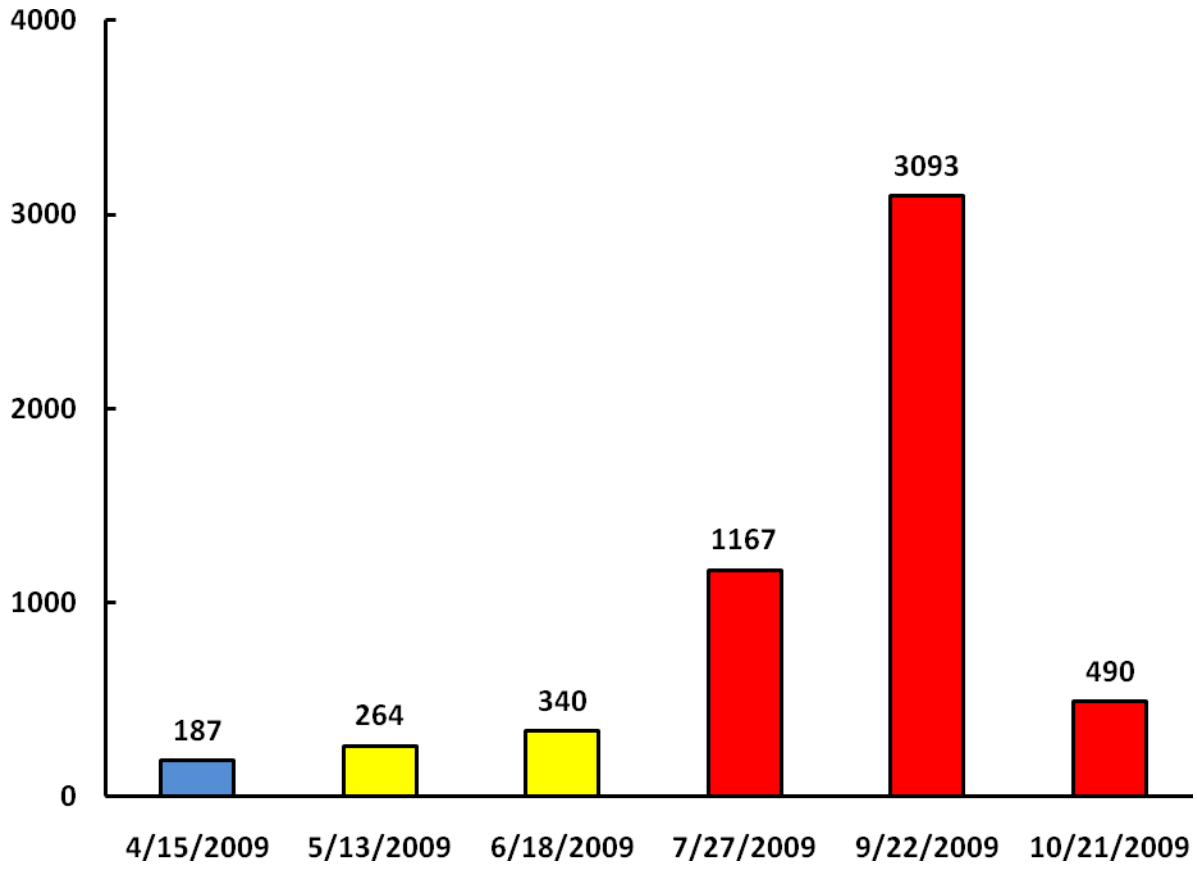

Figure 19. Fecal coliform bacteria density (FC/100ml) for Arbuckle Creek at Minden (N40) site during 2009.

Arbuckle Creek, site N13

Four of the six (67%) samples collected in 2000 exceeded 200 FC/100 ml and one (17%) exceeded 400 FC/100ml (Fig. 20).

Water quality at this site is unsatisfactory for contact recreation. Since 1990, 84 of 144 samples (58%) have exceeded 200 FC/100 ml.

Water quality at this site is wholly unsatisfactory for water contact recreation.

In 2009 fecal coliform bacteria density ranged from 80 to 980 FC/100 ml (mean 345, geometric mean 256, median 252).

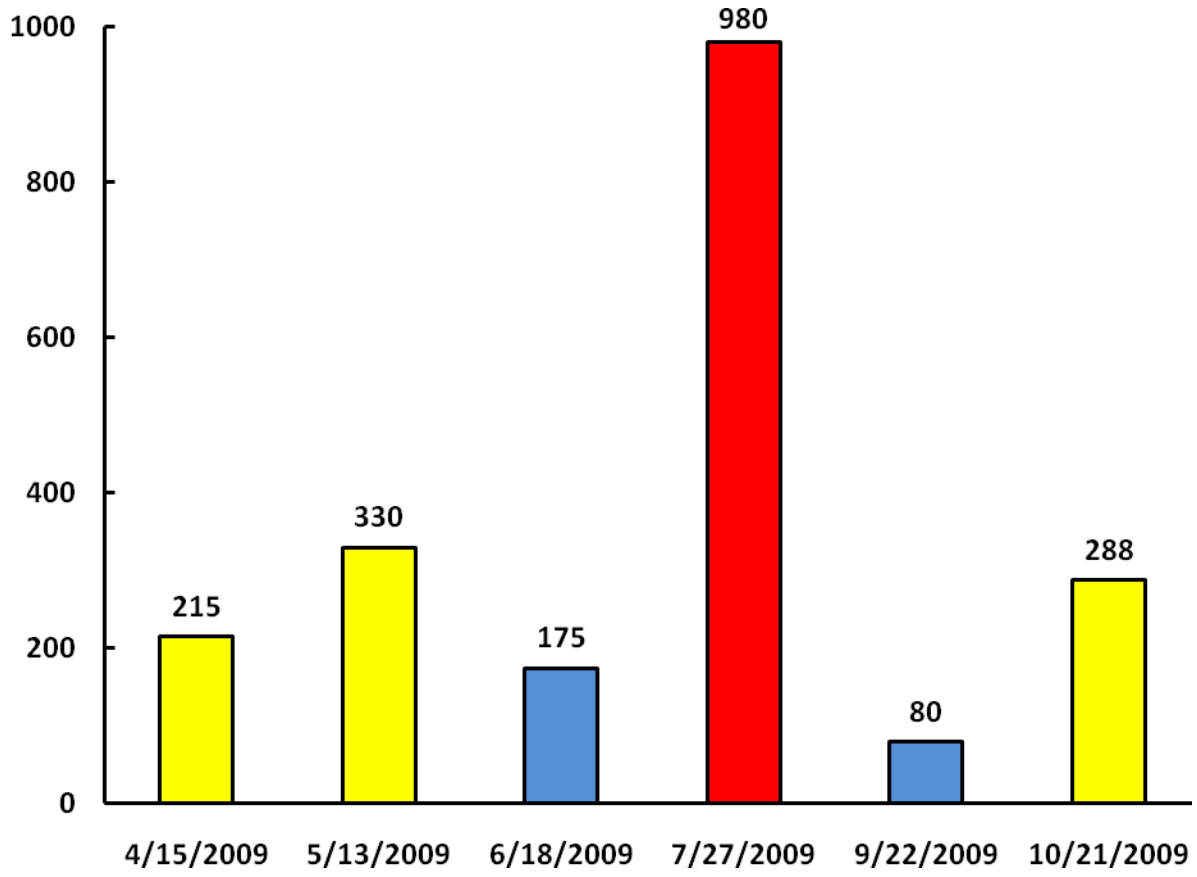

Figure 20. Fecal coliform bacteria density (FC/100ml) at Arbuckle Creek (N13) site during 2007-2008.

Rush Run, site N43

None of the six samples (0%) collected in 2009 exceeded 200 FC/100 ml (Fig. 21).

Since 2007, one of 16 samples (6%) of samples exceeded 200FC/100ml, and that sample also exceeded 400 FC/100ml.

In 2009 fecal coliform bacteria density ranged from 2 to 132 FC/100ml (mean 44, geometric mean 16, median 28). The value for May 15 2007 is slightly different than presented in the previous report due to a re-evaluation of the data. Note the use of a logarithmic vertical axis.

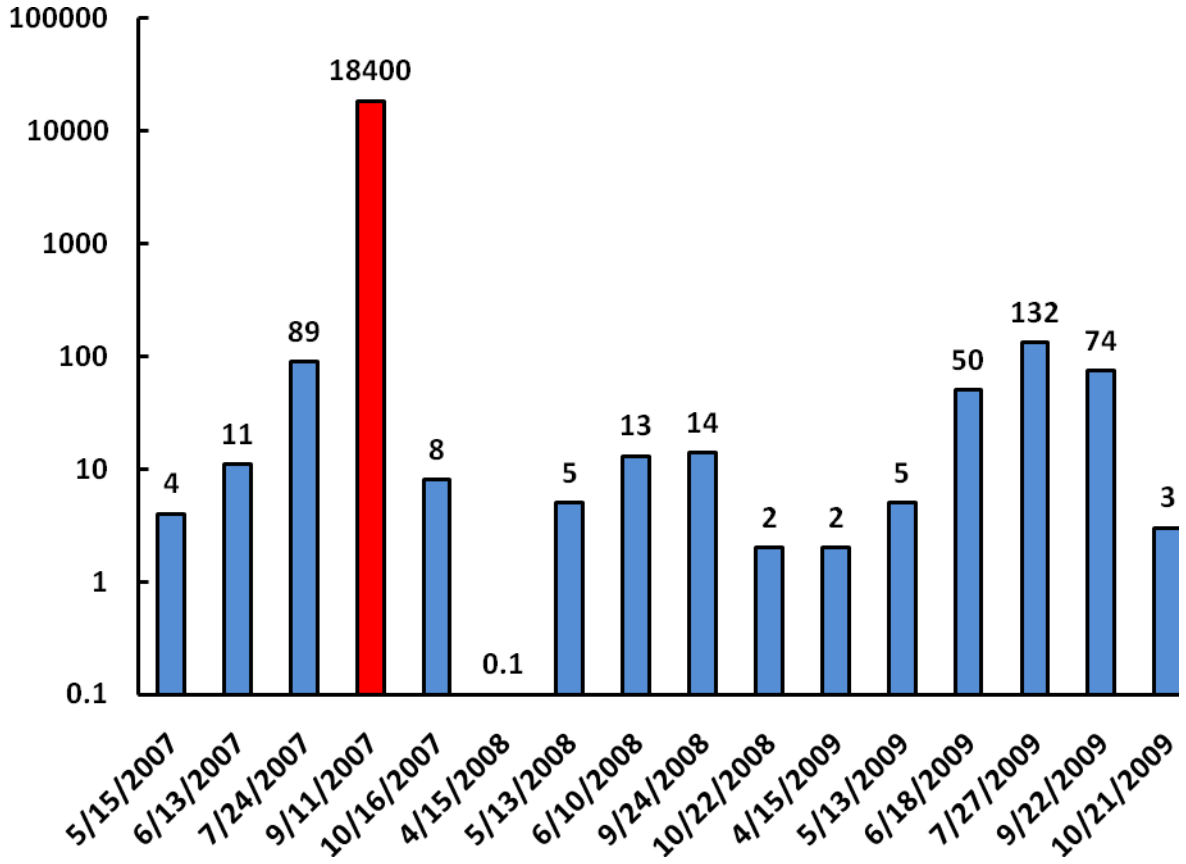

Figure 21. Fecal coliform bacteria density (FC/100ml) at Rush Run (N43) site during 2007-2008.

Keeney Creek below Winona, site N38

One of the six (17%) samples collected in 2009 exceeded both 200 FC/100ml and 400 FC/100ml (Figure 22).

Since monitoring began in 2003, 11 of the 36 (31%) samples exceeded 200 FC/100ml.

Water quality at this site is unsuitable for water contact recreation.

In 2009 fecal coliform bacteria density ranged from 18 to 727 FC/100 ml (mean 201, geometric mean 109, median 123).

The National Park Service discontinued monitoring Keeney Creek at Winona (site N16) after we established site N38. For N16, 124 of 130 samples (95%) collected between 1990 and 2007 exceeded 200 FC/100ml. Site N38 is about 1.1 miles below site N16.

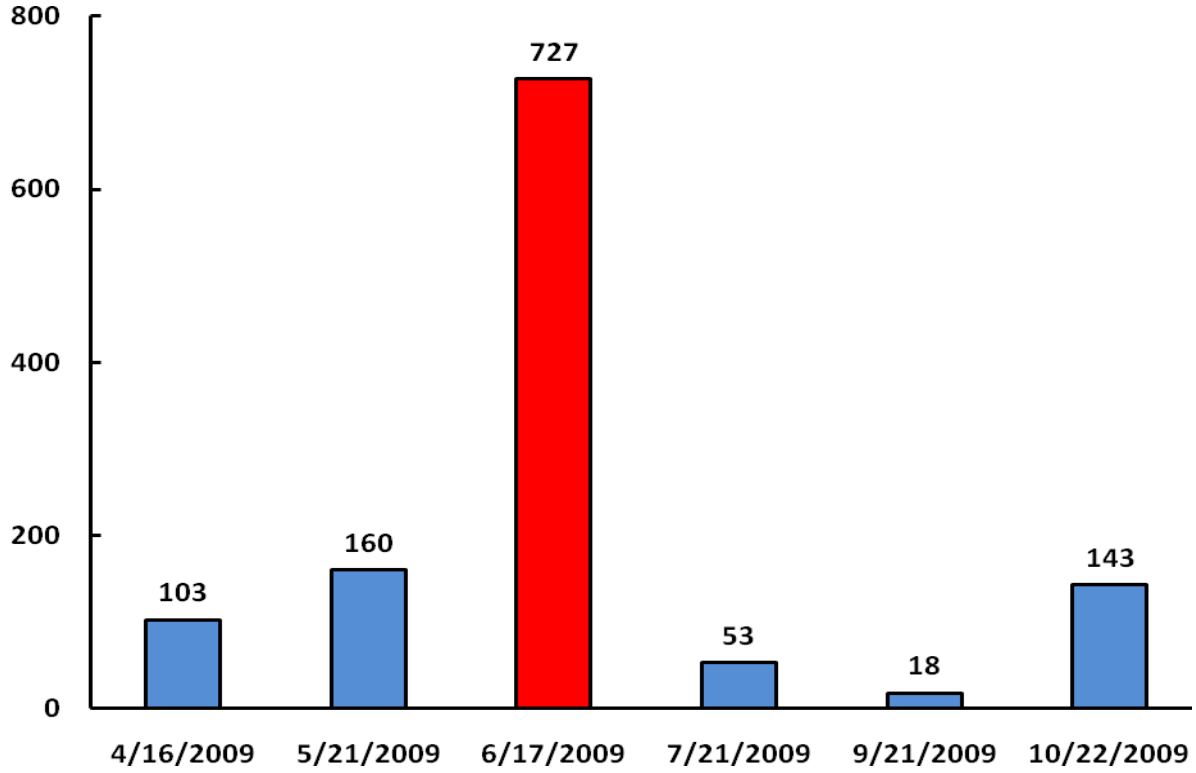

Figure 22. Fecal coliform bacteria density (FC/100ml) at Keeney Creek below Winona (N38) site during 2009.

Short Creek, site N41

One of the five samples (20%) collected in 2009 exceeded 200 FC/100 ml (Fig. 23).

Since monitoring began in 2007, four of 13 samples (31%) have exceeded 200FC/100ml, and two (15%) have exceeded 400 FC/100ml.

In 2009 fecal coliform bacteria density ranged from 5 to 470 FC/100ml (mean 107, geometric mean 24, median 10).

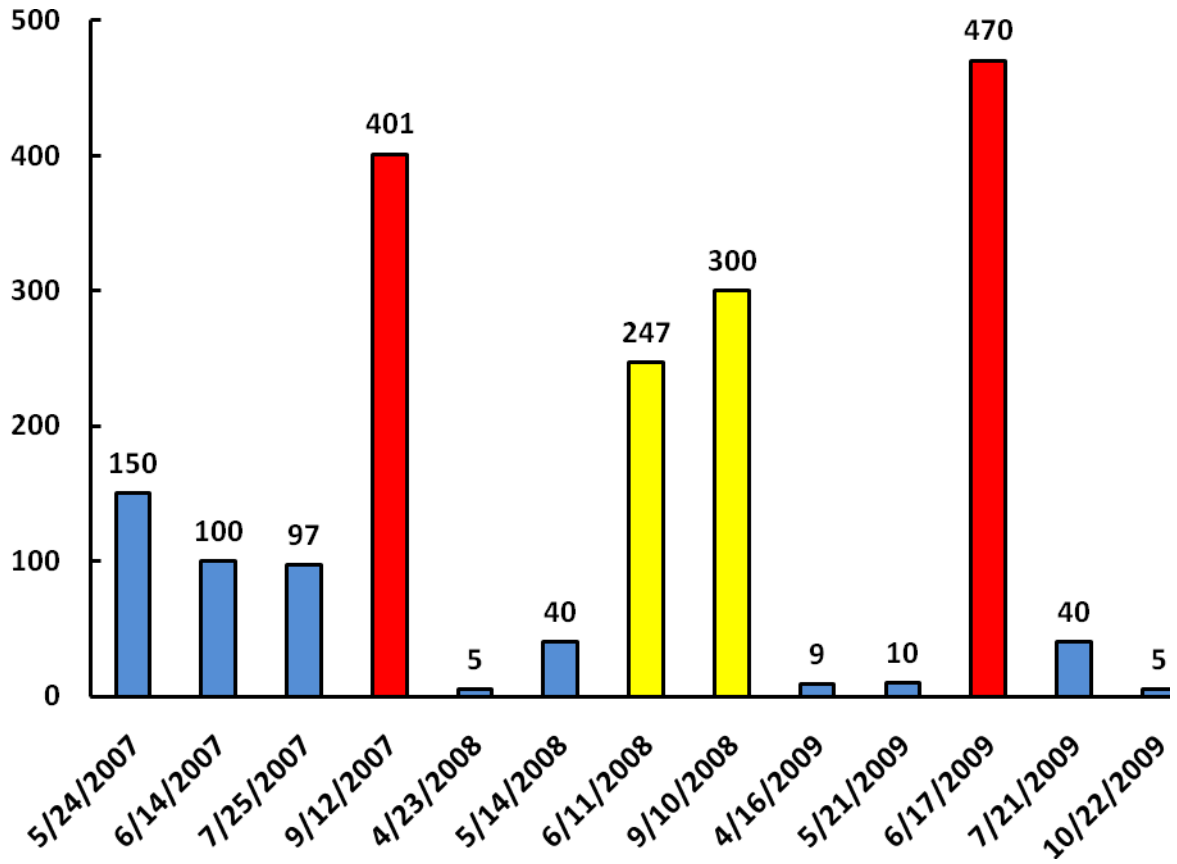

Figure 23. Fecal coliform bacteria density (FC/100ml) at Short Creek (N41) site during 2009.

Fern Creek, site N42

None of the six samples (0%) collected in 2009 exceeded 200 FC/100ml.

Since monitoring began in 2007, three of the 16 samples (19%) exceeded 200 FC/100ml and one (6%) exceeded 400FC/100ml (Fig. 24).

In 2009 fecal coliform bacteria density ranged from 1 to 92 FC/100ml (mean 40, geometric mean 16, median 33).

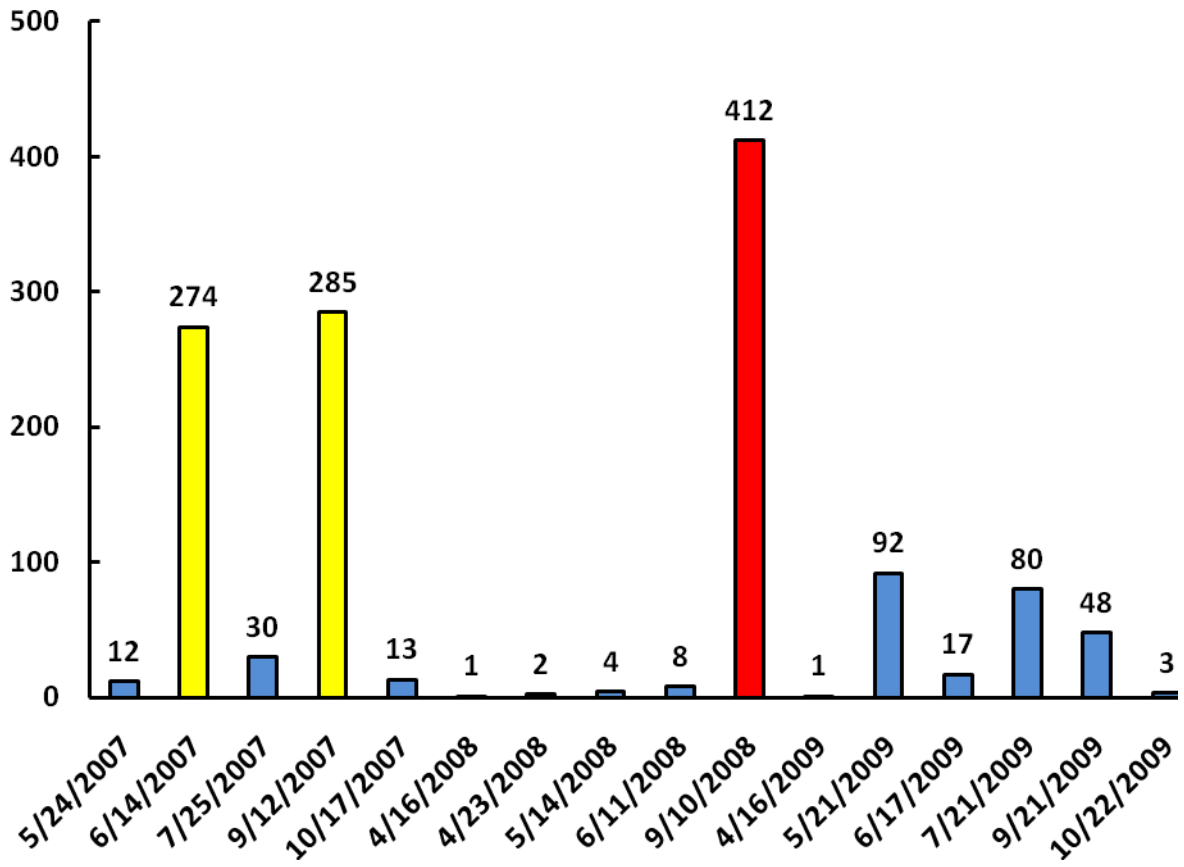

Figure 24. Fecal coliform bacteria density (FC/100ml) at Fern Creek (N42) site during 2009.

Wolf Creek, site N18

One of the six (17%) samples collected in 2009 exceeded both 200 and 400 FC/100 ml (Fig. 25).

Since 1990, 33 of 147 samples (22%) have exceeded 200 FC/100 ml.

In 2009 fecal coliform bacteria density ranged from 2 to 5733 FC/100 ml (mean 996, geometric mean 50, median 68). Note the use of a logarithmic axis in Fig. 25 due to the extreme value on July 21.

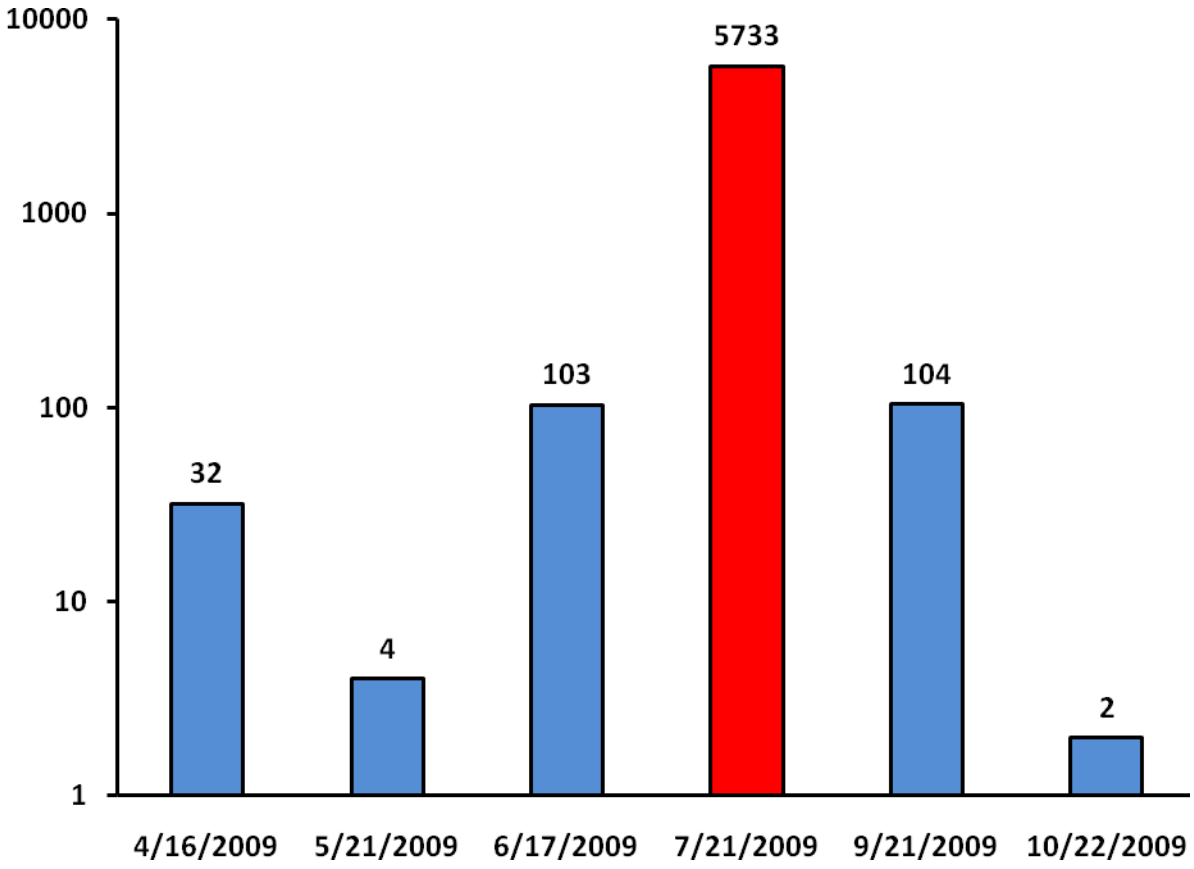

Figure 25. Fecal coliform bacteria density (FC/100ml) at Wolf Creek (N18) site during 2009.

Marr Branch, site N19

Three of the six (50%) sample dates in 2009 exceeded 200 FC/100 ml and two (33%) dates exceeded 400 FC/100 ml (Fig. 26).

Water quality at this site is unsatisfactory for contact recreation. Since 1990, 93 of 145 (64%) samples have exceeded 200 FC/100 ml.

In 2009 fecal coliform bacteria density ranged from 13 to 960 FC/100 ml (mean 394, geometric mean 136, median 207).

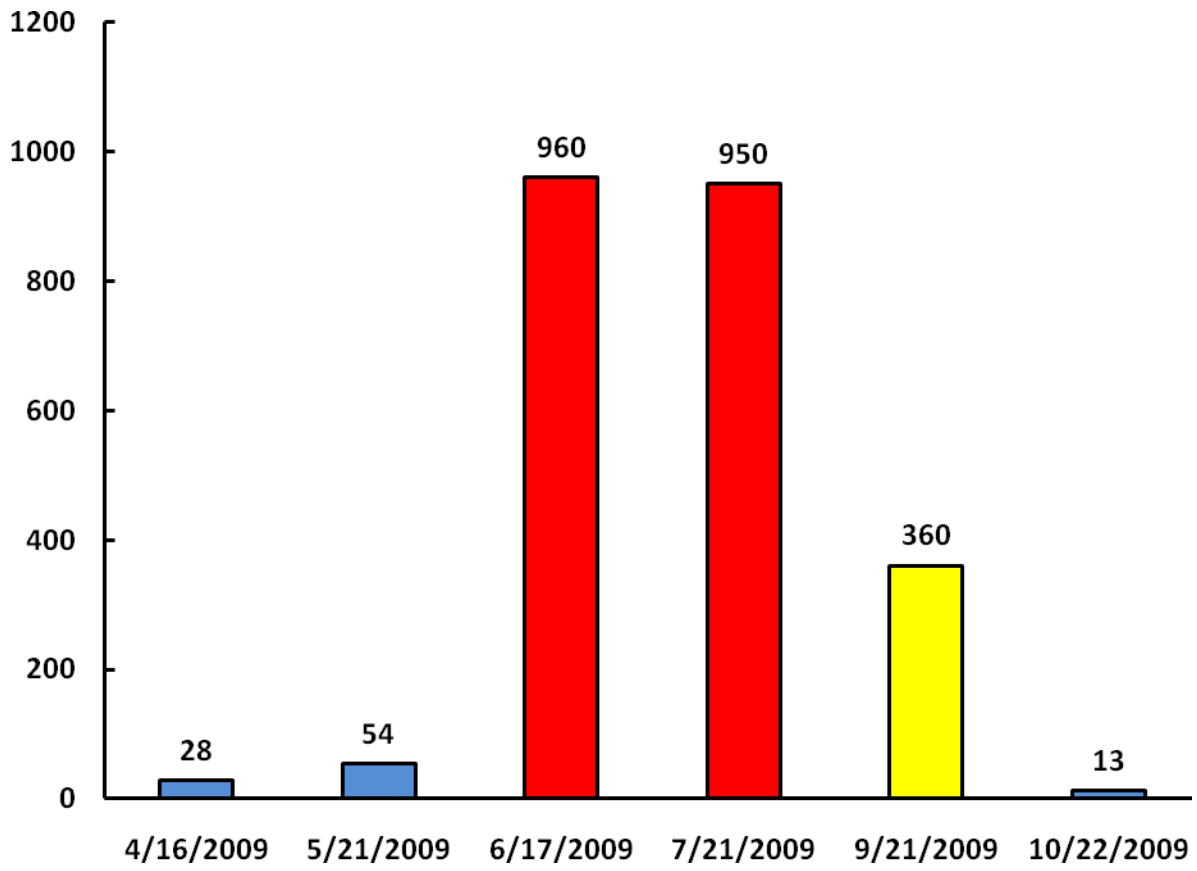

Figure 26. Fecal coliform bacteria density (FC/100ml) at Marr Branch (N19) site during 2009.

DISCUSSION

PROGRAM CHANGES IN 2007

Mapping of our existing data showed a number of streams that not been monitored. To get a better geographic understanding of local water quality, in 2007 we added 14 previously unmonitored sites in New River Gorge National River to our monitoring program. One was a mainstem site; New River at Stonecliff (N32). This site was sampled previously in evaluating impacts of the 2001 floods (see Resource Assessment Team 2001) and as part of storm-event monitoring program that will be reported on separately because different protocols were used. The other thirteen sites were tributaries, and include: Tug Creek (N49), Brooks Branch (N50), Big Branch (N48), Owens Branch (N51), Kates Branch (N47), Fall Branch (N46), Sandstone Falls Creek (N45), Laurel Creek near Sandstone (N52), Todd Creek (N44), Arbuckle Creek at Minden (N40), Rush Run (N43), Short Creek (N41) and Fern Creek (N42).

To accomplish this without increasing staff or costs, a number of sites judged to have sufficient long-term data, mostly with records of good water quality, were temporarily dropped from the monitoring program. As a sufficient knowledge base accumulates about water quality in these recently added streams, we will again reevaluate our monitoring program.

The first three years of monitoring these new sites shows some clear trends.

First, New River at Stonecliff is similar to other New River mainstem sites in having relatively low baseline fecal coliform densities. Values have ranged from 2-405 FC/100ml, with the highest values occurring in 2009. Slightly higher percentages of samples from this site exceeding the contact recreation standard may be due to use of this area as a swimming beach for families with small children.

For the tributary sites, some show a clear indication of being unsuitable for contact recreation. These sites are Tug Creek, Brooks Branch, Owens Branch, and Sandstone Falls Creek. For these streams, streamside residences without sewer service for functioning septic systems are the likely reason for the poor water quality.

Two sites show good water quality. These are Big Branch and Fall Branch. These streams have few human residences in their watersheds.

Some streams show marginal water quality. These sites include Kates Branch, Laurel Creek near Sandstone, Short Creek, and Fern Creek. Values exceeding the contact recreation standard are moderately frequent, but the magnitude is usually not very high.

Two sites , Todd Creek and Rush Run present an enigma. For all but one sampling date, fecal coliform bacteria densities were low, often well below the contact recreation standard. However, for one date (9/11/2007), both of these streams had extremely high densities (7,850 FC/100ml for Todd Creek and 18,400 FC/100ml for Rush Run). This sampling date coincided with a large rainfall event, and such events are known to increase fecal bacteria densities in streams. Continued monitoring will give us a clearer picture of whether these events are anomalous or more common.

MADAM CREEK

There has been a marked improvement in water quality at this site. Through 2004, 108 out of 115 samples (94%) exceeded 200 FC/100ml. Not only was the frequency high, but the magnitude of these samples was also high. For example, between 1995 and 2004, 73 of 79 samples (92%) exceeded 400 FC/100ml, with 58 of 73 samples (73%) exceeding 1000 FC/100ml. Eight of those 11 years had a bacteria density greater than 10,000 FC/100ml, ten years had densities greater than 9,000 FC/100 ml. Perhaps the only reason that 1998 did not have a value so great was that we only collected two samples that year. The maximum density we recorded over this time span was 37,600 FC/100ml.

From 2005 through 2008, only eight of 22 samples (36%) exceeded 200 FC/100ml, and only two samples (9% of 22) exceeded 400 FC/100ml, with a maximum bacteria density of 600 FC/100ml. In fact, 2007 and 2008 were the only two years in our monitoring history that has not seen a value greater than 400 FC/100ml in Madam Creek. The results for 2009 dropped a little bit from 2005-2008, with four of the six samples (67%) exceeding 200 FC/100ml and three (50%) exceeding 400 FC/100ml. Still, this is a much better result than was observed up until 2004.

The dramatic improvement in Madam Creek water quality is likely due to the extension of a sewer line across the New River to serve residences in this area. We welcome this effort by the City of Hinton that demonstrates the concern about water quality in a community that has the New River as its lifeblood. While Madam Creek water quality is still not suitable for contact recreation, these improvements provide hope for future efforts.

ARBUCKLE CREEK

Like Madam Creek, Arbuckle Creek has a long history of awful water quality. For the site near the mouth (N13), over half of the samples collected since 1990 exceeded the contact recreation standard. What is more appalling is the magnitude of these exceedances. Eleven of the samples have been 25,000 FC/100ml or greater, including a maximum value of 250,000 FC/100ml.

In 2004 we began sampling a new, upstream site, Arbuckle Creek at Minden (N40), on the same days we sampled the old, downstream site. Since 2004 we have analyzed 28 samples at each site.

The previous report (Purvis 2009) documented much higher fecal coliform densities at the upstream site (N40) than at the downstream site N13). That pattern generally held in 2009, except for the first two sample dates, which had a slightly higher density at the downstream site.

Beginning in 2004, 20 of the N13 samples (71%) exceeded 200 FC/100ml and nine (32%) exceeded 400 FC/100ml, three (11%) exceeded 1000 FC/100ml, one (4%) exceeded 10,000 FC/100ml, and none exceeded 100,000 FC/100ml.

For the upper site (N40), 22 of the samples (79%) exceeded 200 FC/100ml, 16 (57%) exceeded 400 FC/100ml, 13 (46%) exceeded 1000 FC/100ml, and two (7%) exceeded both 10,000 and 100,000 FC/100ml.

While the frequency of exceeding 200 FC/100ml is similar between the two sites, it is clear that the magnitude of exceedances is greater at the upper site (N40). The upper site is just at the park boundary, and therefore closer to residences, businesses, and sewage treatment plants in the Arbuckle Creek watershed, while the lower site (N13) is nearly two miles downstream.

Two sewage treatment plants, operated by separate management entities, discharge into Arbuckle Creek. High levels of fecal coliform bacteria in Arbuckle Creek are probably due to faulty sewer system

collection lines, plant facilities, and/or plant operations (including bypasses during storm events). Several plans to improve management at the more problematic plant have been discussed. That plant is currently using a consultant to improve efficiency. Hopefully this will result in improved sanitary conditions in Arbuckle Creek.

KEENEY CREEK

Keeney Creek is another stream with a long history of water quality problems. From 1990 through 2008, 124 out of 130 baseline samples (95%) analyzed for Keeney Creek at Winona (N16) exceeded 200 FC/100ml.

Completion of a road down Keeney Creek below Winona allowed us to sample inside the park beginning in 2003 (Keeney Creek below Winona – N38). At this downstream site, only 11 of 36 samples (31%) exceeded 200 FC/100ml and only three (8%) exceeded 400FC/100ml.

As noted earlier for Arbuckle Creek, there is a clear decrease in fecal coliform bacteria density as Keeney Creek flows downstream. First described in an earlier report (Wilson *et al*. 2006), continued monitoring supports this assertion. Although we have now stopped regular monitoring of N16, the National Park Service believes that this downstream dynamics of fecal coliform bacteria in high gradient streams like Arbuckle and Keeney Creeks warrants future research.

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