E. coli Investigation

Summer, 2017

Cache County, UT

By

Yellowstone to Uintas Connection

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Introduction

The Little Bear River Watershed encompasses 182,000 acres in Northern Utah and Southern Idaho. The area includes much of Cache Valley as well as a large portion of the Bear River Range to the East and the Wellsville Range to the West. The land within this watershed is comprised of state, federal, and private property with uses such as recreation, agriculture, and urban development. 88% of the land is privately owned within the watershed[1].

Grazing cattle in the Little Bear River Watershed is common on Forest Service, BLM land, and private land. This study examines *Escherichia coli* (E. coli) concentrations at eight points within the Little Bear River Watershed. E. coli can be used as a water quality indicator of fecal contamination from warm bodied animals. Contact with these bacteria can cause sickness in humans including fever, nausea, and even death[2]. States have taken precautions to avoid E. coli outbreaks by defining recreation water bodies and setting standards for E. coli concentrations. The sampling locations for this study include Millville Canyon, Providence Canyon, Left Hand Fork, Friendship Campground, Rock Creek, Curtis Creek, Saddle Creek, and North Rich. All eight of these points within the watershed are classified as 2B (secondary) Contact Recreation under Utah Administrative Code R317-2[3].

Secondary contact recreation refers to activities in which arms and legs may come in contact with water, but the human body is not entirely submerged. Activities such as fishing and canoeing are considered secondary contact recreation. These activities are deemed to have reduced exposure to water and the bacteria within them.

Water Quality Standards

In Utah, the 2B Contact Recreation criteria for E. coli includes maximum geometric mean sample criteria of two hundred and six (206) E. coli organisms per one hundred (100) ml. This is based on a minimum of five (5) samples taken every three (3) to seven (7) days over a thirty (30) day period. The single sample maximum is six hundred and sixty-eight (668) E. coli organisms per one hundred (100) ml[4].

For water quality assessment purposes, up to 10% of representative samples may exceed the 668 per 100 ml criterion (for 1C and 2B waters) and 409 per 100 ml (for 2A [primary] *waters). For small datasets, where exceedances of these criteria are observed, follow-up ambient monitoring should be conducted to better characterize water quality.*

These numbers can be compared to Idaho's water quality standards which limit the geometric mean of both primary and secondary contact recreation waters to one hundred twenty-six (126) and the single sample for secondary contact recreation to five hundred seventy-six (576)[5]. While

[1]Utah Department of Environmental Quality. 2006. Little Bear River Watershed TMDL. https://deq.utah.gov/ProgramsServices/programs/water/watersheds/docs/2006/09Sep/Little_Bear_River_TMDL.pdf

[2] Center for Disease Control and Prevention. 2015. E. coli. https://www.cdc.gov/ecoli/general/index.html

[3] Utah Administrative Code. 2017. Standards of Quality of Waters for the State, Classification of Waters of The State. R317-2-13. https://rules.utah.gov/publicat/code/r317/r317-002.htm

[4] Utah Administrative Code. 2017. Standards of Quality of Waters for the State, Numeric Criteria. R317-2-14. https://rules.utah.gov/publicat/code/r317/r317-002.htm

[5] Idaho Administrative Code. 2000. Rules of the Department of Environmental Quality, IDAPA 58.01.02, "Water Quality Standards." https://adminrules.idaho.gov/rules/current/58/0102.pdf

Utah's water quality standards have improved since the revision of rule R317-2 (the previous maximum E. coli criteria was nine hundred forty (940) for 2B water),[6] they are still higher than Idaho standards.

Though the EPA does not give a recommendation for E. coli levels in secondary contact recreation waterbodies, they do give two recommendations for primary contact recreation areas (Table1). These recommendations are based on illness rates derived from the National Epidemiological and Environmental Assessment of Recreational Water (NEEAR) definition of gastrointestinal illness[7]. Both recommendations by the EPA are within one unit of Utah's primary recreation standards (Table 2). However, both standards still leave >3% chance of sickness for primary recreation users. This means that Utah standards still leave primary contact users at risk, especially if they are participating in primary contact recreation on a designated secondary contact recreation stream.

Table 1: EPA recommendations for primary contact recreation E. coli standards based on estimated illness rate. Standards are provided as geometric mean (GM) and statistical threshold value (STV) for estimated illness rates of 3.6% and 3.2%. Statistics are per 100 ml samples of water and refer to the colony forming units (cfu) of E. coli.

Estimated Illness Rate (NGI): 36 per 1,000 primary contact recreators		Estimated Illness Rate (NGI): 32 per 1,000 primary contact recreators	
GM (cfu/100 ml)	STV (cfu/100 ml)	GM (cfu/100 ml)	STV (cfu/100 ml)
126	410	100	320

Table 2: Utah's E. coli water quality standards for primary and secondary contact recreation water bodies. Standards are provided as geometric mean (GM) and statistical threshold value (STV).

Primary Contact Recreation (2A)		Secondary Contact Recreation (2B)	
GM (#/100 ml)	STV (#/100 ml)	GM (#/100 ml)	STV (#/100 ml)
126	409	206	668

E.coli Impacts From Cattle, Recreation and Wildlife

E. coli are typical of fecal bacteria found in the digestive tracts of animals and humans and are used as indicators of fecal contamination. Their presence may also be indicative of contamination by other bacteria or protozoans that can cause illness resulting in: diarrhea; nausea; vomiting; eye, ear, nose and throat infections; even death such as that experienced in the Milwaukee cryptosporidium outbreak in 1993.

Cattle have been shown to produce 5.4 billion fecal coliform and 31 billion fecal streptococcus bacteria in their feces per day. Since cattle spend a significant portion of their time in or near streams, lakes and wetland areas and average 12 defecations per day, they can contribute significant numbers of these organisms to surface waters.

[6] https://deq.utah.gov/ProgramsServices/programs/water/standards/docs/2008/07Jul/20080715_Triennial_Review_2008_June_20_2008_WQB.pdf

[7] EPA. 2012. 2012 Recreational Water Quality Criteria. https://www.epa.gov/sites/production/files/2015-10/documents/rec-factsheet-2012.pdf

Recent research in areas used by cattle, recreationists, pack animals or wildlife is pertinent to this effort. Research conducted in wilderness areas in the Sierra Nevada mountains included areas of high use by backpackers, high use by pack animals and cattle grazed watersheds. Fifteen areas used by backpackers yielded only one site containing E.coli and this site was significantly lower than those used by cattle or pack animals. Five years of data collection from these sites found similar results, concluding, "*Surface water from watersheds below cattle areas and those used by pack animals is at high risk for containing coliform organisms. Water from Wild, Day Hike, or Backpack sites poses far less risk for contamination by coliforms"*.

The costs of nutrients and bacteria from cattle grazing in the Sierra Nevada were characterized as, "*summer cattle grazing on federal lands affects the overall water quality yield from this essential watershed as cattle manure is washed into the lakes and streams or directly deposited into these bodies of water. This organic pollution introduces harmful microorganisms and also provides nutrients such as nitrogen and phosphorus which increase algae growth causing eutrophication of otherwise naturally oligotrophic mountain lakes and streams. Disinfection and filtration of this water by municipal water districts after it flows downstream will become increasingly costly. This will be compounded by increasing surface water temperatures and the potential for toxins release by cyanobacteria blooms*."

Another study in the Sierra Nevada mountains sampled for coliform bacteria in one ungrazed site and four sites grazed by cattle. Before cattle entered the area, all sites were below criteria for coliforms and E.coli. After cattle entered the area, the ungrazed site remained low, while the grazed sites rapidly increased above criteria and remained there until after cattle left the area, then quickly declined.

In a study of the effect of high precipitation years on benthic algae and coliform bacteria in areas grazed by cattle, areas used predominantly by pack animals, recreation areas used only by humans and remote wildlife areas in the Sierra Nevada mountains, mean benthic algae coverage was 29.5% in cattle grazed areas compared to 8.5% in pack animal areas, 3.7% in human use areas and 1.8% in wildlife only areas. E.coli attached to the benthic algae was 90% at cattle grazed sites, 23% at pack animal sites, 0% at human and wildlife sites. E. coli was detected suspended in water at concentrations greater than 100 colony forming units/100 ml at 70% of cattle grazed sites and none at pack animal, human or wildlife sites.

While this study focused on E. coli impacts, it is worth noting that livestock have many additional negative effects on stream systems. They impair water quality and quantity by increasing nutrients and sediment. They alter channel morphology through hoof shear causing channel widening and reducing depth. They alter hydrology by destroying bank stabilizing vegetation, increase water temperature by loss of stream shading vegetation and cause loss of fish and wildlife populations as a result of these habitat changes[8].

Sample Location Background Information

The North Rich sample point lies within the North Rich Cattle Allotment in the Wasatch Cache National Forest. Its northern boundary is highway 89 and its southern boundary is the Saddle Creek

[8] This section "E.coli Impacts From Cattle, Recreation and Wildlife" was taken directly from: Western Watersheds Project and Yellowstone to Uintas Connection. 2017. E. coli Investigation, Summer, 2016, Paris Creek, Bear Lake County, Idaho.

Allotment. Most streams within the North Rich Allotment, including the North Rich sample location, flow into Saddle Creek and eventually into the Blacksmith Fork River. The 2017 North Rich Cattle Allotment Annual Operating Instructions (AOI) authorizes 1260 cow/calf pairs for 80 days between June 16th and Sept 11th or 830 cow/calf pairs for 87 days between June 16th and Sept 30th[9]. In the 2004 assessment, only 7.3% of the capable rangeland within the North Rich allotment was determined to be "satisfactory" while 41.2% was "unsatisfactory"[10].

Both Rock Creek and Curtis Creek run through Hardware Ranch Wildlife Management Area (WMA) before flowing into the Blacksmith Fork River. Hardware Ranch is run by the Utah Division of Wildlife Resources. While this area is within a WMA, the UDWR accepts bids for cattle and sheep grazing. Sheep were sighted near Curtis Creek during the study.

Saddle Creek lies within the Saddle Creek Cattle Allotment in the Wasatch Cache National Forest. This creek runs through Left Hand Fork Canyon and into the Blacksmith Fork River. The 2017 Saddle Creek AOI authorizes 635 calf/cow pairs in the Saddle Creek Cattle Allotment between June 11th and September 14th[11].

The Friendship Campground sample location is within the South Cache Cattle Allotment and within the Left Hand unit. The allotment includes Forest Service land as well as leased private property. The 2017 South Cache allotment authorizes a total of 772 cow/calf units to graze from June 26th to September 20th[12]. The Left Hand unit dates are from September 17th to September 20th. This area is popular for recreation such as camping, fishing and hunting.

The Left Hand Fork sample site is located just below the South Cache allotment boundary at the mouth of Left Hand Fork. It is just upstream from the confluence of the Blacksmith Fork River and is adjacent to both Blacksmith Fork Canyon Road and private property. There is additional private property located between the South Cache Cattle Allotment and the sampling location.

The Millville Canyon sample location is within the Millville Cattle Allotment. The 2017 Millville Canyon AOI authorizes 88 cow/calf pairs to graze from July 1st to October 4th[13]. The canyon is only accessible by ATV or non-motorized transportation.

The Providence Canyon sample location is within the Providence Cattle allotment. The 2017 Providence AOI authorizes 149 cow/calf pairs to graze from June 18th to September 17th[14]. Providence Canyon provides a popular destination for hiking, biking, camping, and other forms of recreation.

Methods

Because these bacteria do not normally reproduce in water, E. coli/fecal coliform can be used as an indicator of pollution from warm-blooded animal wastes, and to evaluate associated beneficial use impairments, primarily recreational use impairments. Samples are taken from a well-mixed portion of the stream using sterile 100ml Whirl-Pak® bags to collect the sample and contain the sample from the site and during transport in coolers kept to ≤ 4°C until the sample is processed through the

[9] Logan Ranger District. 2017. Annual Operating Instructions, North Rich Cattle Allotment.
[10] USDA Forest Service. 2004. North Rich Allotment Final Environmental Impact Statement. Range 3-22. Table 3.3.
[11] Logan Ranger District. 2017. Annual Operating Instructions. Saddle Creek and Strawberry Cattle Allotments.
[12] Logan Ranger District. 2017. Annual Operating Instructions. South Cache Cattle Allotment.
[13] Logan Ranger District. 2017. Annual Operating Instructions. Millville Cattle Allotment.
[14] Logan Ranger District. 2017. Annual Operating Instructions. Providence Cattle Allotment.

Colilert® system. Sterile protective gloves were used for collecting each sample to prevent the samplers from contaminating the samples. Samples then must be sealed and placed in an incubator within six hours. Samples were transported to the Yellowstone to Uintas Field Office for processing. Once at the office, an ampoule of Colilert® reagent was added to each sample and mixed well, then the sample was poured into a 97 cell Quanti-Tray® and sealed using an Idexx Quanti-Tray® Sealer Model 2X[15]*. Once sealed, the sample tray was placed in an incubator held at 37 C for 24 hours. After 24 hours, each tray was inspected for the yellow color that indicates fecal coliform presence, then read under a Spectroline EA-160 ultraviolet lamp for E. coli delineation. The resulting counts for the two sets of cells are read against a chart of E. coli most probable numbers/100 ml for comparison to criteria. The method is EPA SM 9223B. During each sample trip, one blank and one duplicate sample were collected for quality control purposes. Initial samples (prior to August 23, 2016) were taken to the Bear River Health Laboratory in Logan, Utah for analysis*[16].

Table 3 Sample Locations

Location	Description	Latitude	Longitude
1	Left Hand Fork	41.631128	-111.707755
2	Friendship campground	41.661275	-111.665387
3	Rock Creek	41.605635	-111.587226
4	Curtis Creek	41.601313	-111.567406
5	Saddle Creek	41.686278	-111.523718
6	North Rich Creek	41.763813	-111.474835
7	Millville Canyon	41.6652139	-111.802222
8	Providence Canyon	41.6923611	-111.793056

[15] http://www.idexx.com/view/xhtml/en_us/water/products/quanti-tray.jsf

[16] This section, "Methods," was taken directly from: Western Watersheds Project and Yellowstone to Uintas Connection. 2017. E. coli Investigation, Summer, 2016, Paris Creek, Bear Lake County, Idaho.

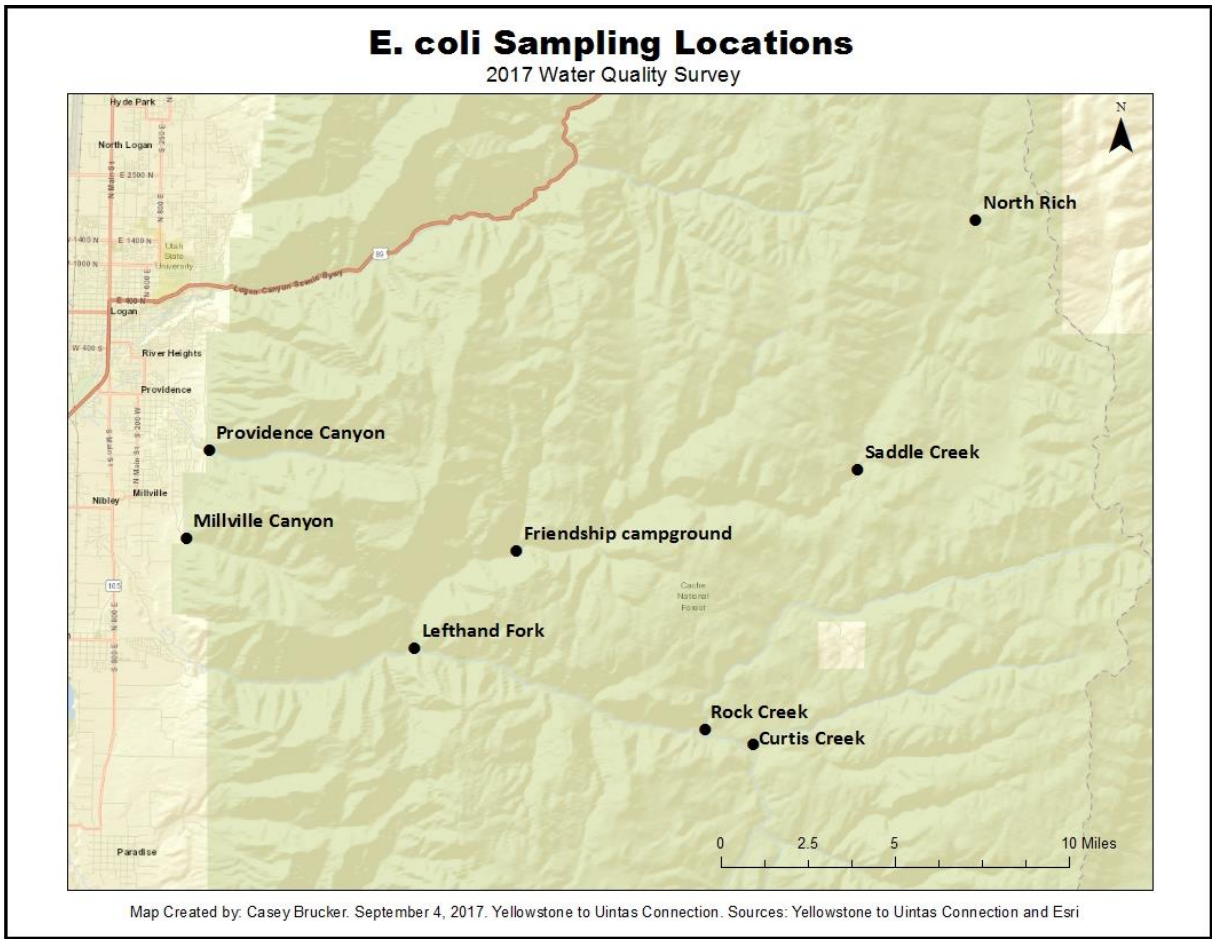


Figure 1 Map of Sample Locations

Results

Cattle were observed at Saddle Creek and North Rich before or during the study. Sheep were observed at Curtis Creek after the study. The study was extended for Friendship Campground and the mouth of Lefthand Fork when cattle were observed near the sample locations. The following (Fig. 2-10 and Table 4 & 5) describe the sample results. Sample site photographs are at the end of this report.

Lefthand Fork was sampled six times at the mouth of Lefthand Fork, above the confluence with Blacksmith Fork. Five samples were taken in August with total coliform ranging between 435.2/100 ml and 613/100 ml with the E. coli ranging between 24.3/100 ml and 41/100 ml. The sixth sample was taken in September after cattle were sighted upstream of the sample site (near Friendship Campground); the total coliform was 185.0/100 ml and the E. coli was 31.3/100 ml. Neither the geometric mean (Fig. 10) nor the single sample criteria for E. coli (Fig. 2) were exceeded during the sample period.

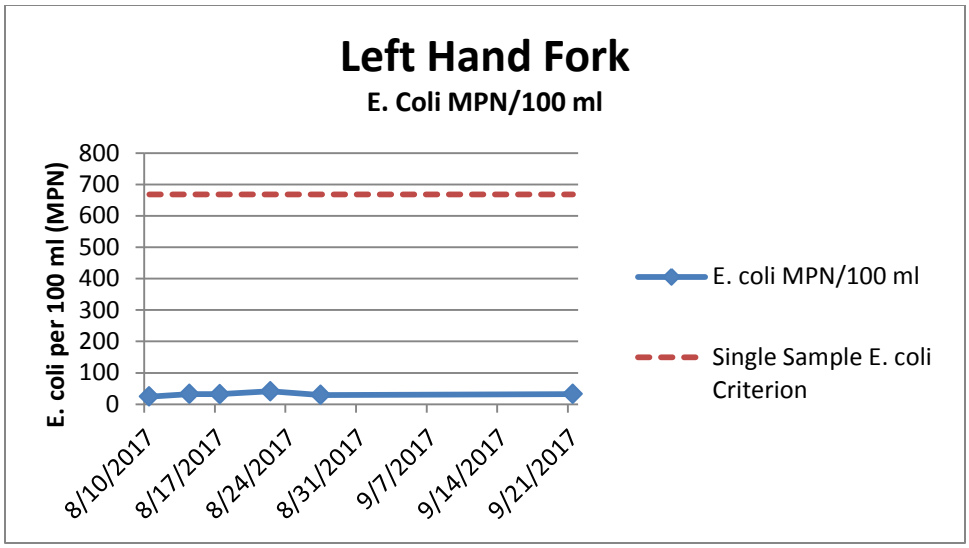


Figure 2: Left Hand Fork E. coli sampling results.

Friendship Campground was sampled six times upstream of the bridge that connects Forest Service Road 245 to Friendship Campground. Five samples were taken in August with total coliform ranging between 344.8/100 ml and 547.5/100 ml with the E. coli ranging between 29.9/100 ml and 40.8/100 ml. The sixth sample was taken in September after cattle were sighted near the sample site; the total coliform was 686.7/100 ml and the E. coli was 161.6/100 ml. Neither the geometric mean (Fig. 10) nor the single sample criteria for E. coli (Fig 3) were exceeded during the sample period. However, the E. coli sample taken when cattle were sighted was nearly four times greater than the largest number of E. coli sampled in August. While this doesn't prove causation, it gives evidence to suggest that cattle presence influenced the increase in E. coli concentrations at this sample location.

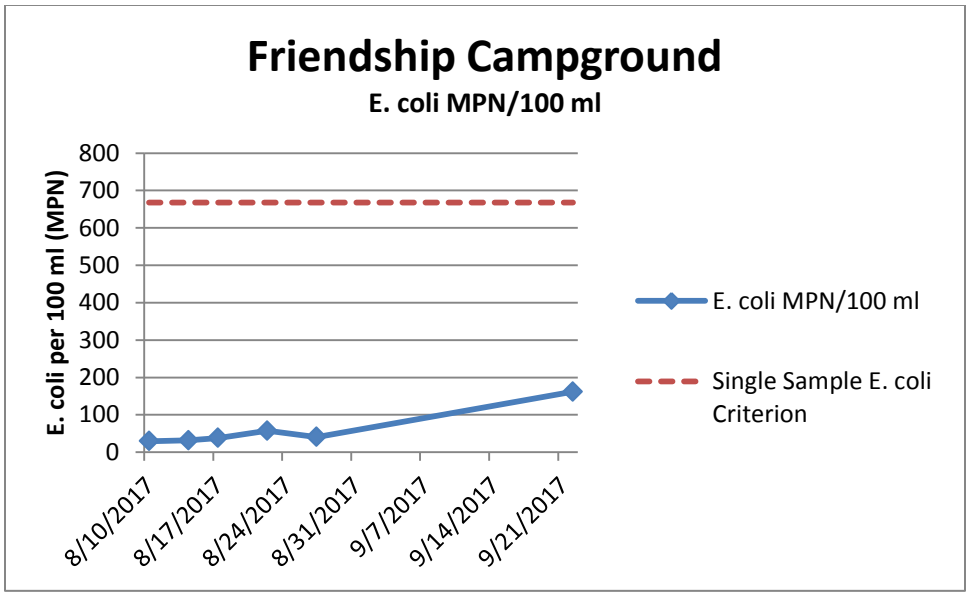


Figure 3: Friendship Campground E. coli sampling results.

Rock Creek was sampled five times in August. The E. coli samples ranged from 25.5 – 44.8/100 ml with a geometric mean of 30.6/100 ml (Fig. 10). Neither the geometric mean nor the single sample criteria for E. coli (Fig. 4) were exceeded during the sample period.

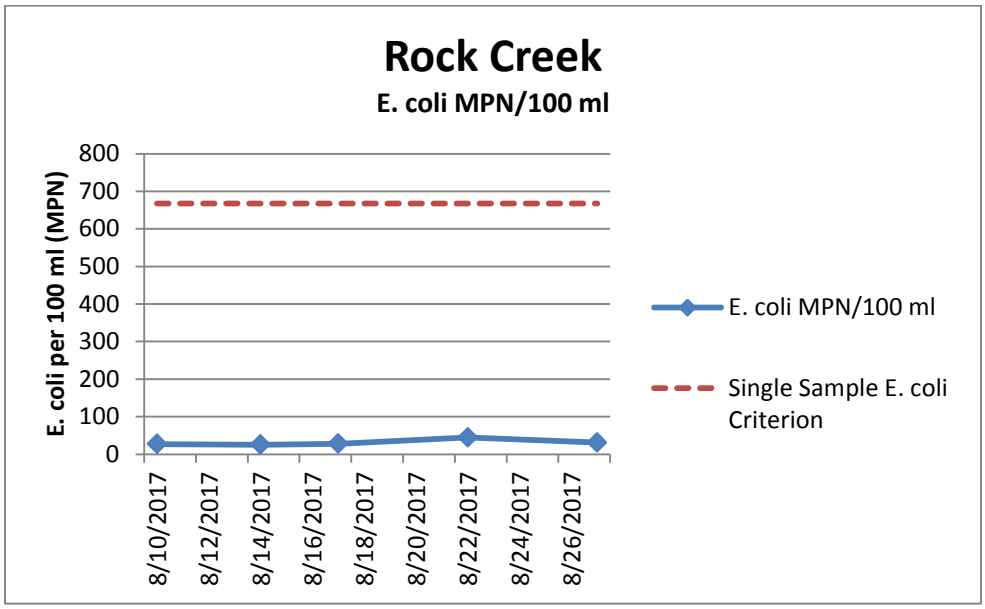


Figure 4: Rock Creek E. coli sampling results.

Curtis Creek was sampled five times in August. The E. coli samples range from 16.1/100 ml – 34.5/100 ml with a geometric mean of 20.8/100 ml. Neither the geometric mean (Fig. 10) nor the single sample criteria for E. coli (Fig. 5) were exceeded during the sample period.

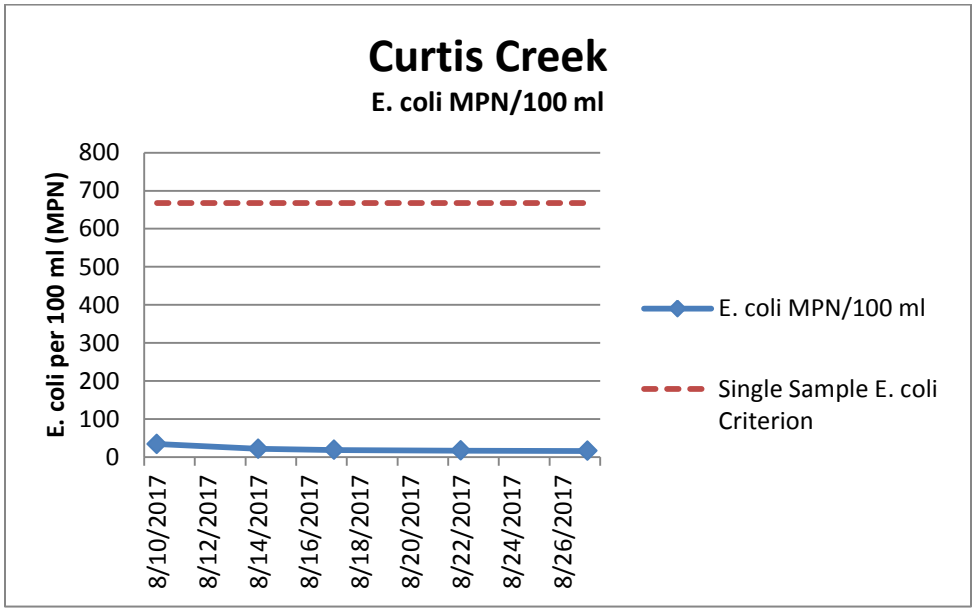


Figure 5: Curtis Creek E. coli sampling results.

North Rich was sampled six times. Both single sample and geometric mean criteria were exceeded during this sample period. The E. coli samples ranged from 387.3/100 ml to greater than 24,161.6/100 ml. The geometric mean for all six samples was 944.51/100 ml (Fig. 10). The single sample value was exceeded on August 7th and August 10th with E. coli values of >2,419.6[17] and 920.8, respectively (Fig.6).

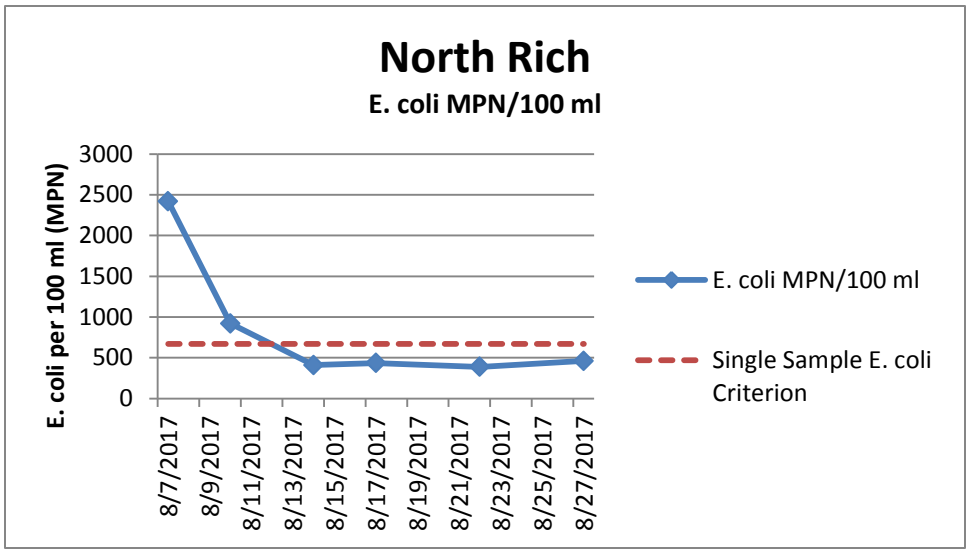


Figure 6: North Rich E. coli sampling results..

Saddle Creek was sampled six times between August 7th and August 27th. The E. coli ranged from 12.0/100 ml and 32.8/100 ml. The E. coli geometric mean was 17.5/100 ml (Fig. 10). Neither the geometric mean nor the single sample criteria for E. coli (Fig. 7) were exceeded during the sample period.

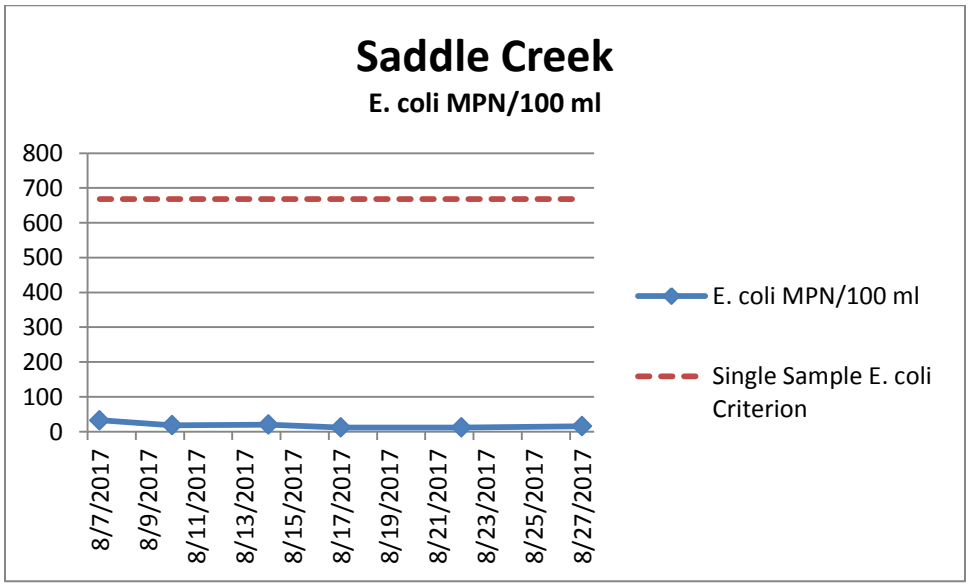


Figure 7: Saddle Creek E. coli sample results.

[17] This number reflects the maximum count possible using the IDEXX Quanti-Tray®/2000 MPN Table. All cells tested positive for E. coli.

Millville Canyon was sampled five times between July 14th and August 1st. The single sample criterion was exceeded on July 21st, 2017 with an E. coli sample of 920.8/100 ml (Fig. 8). The E. coli geometric mean criterion was also exceeded for this sample period with a geometric mean of 308.1/100 ml (Fig. 10).

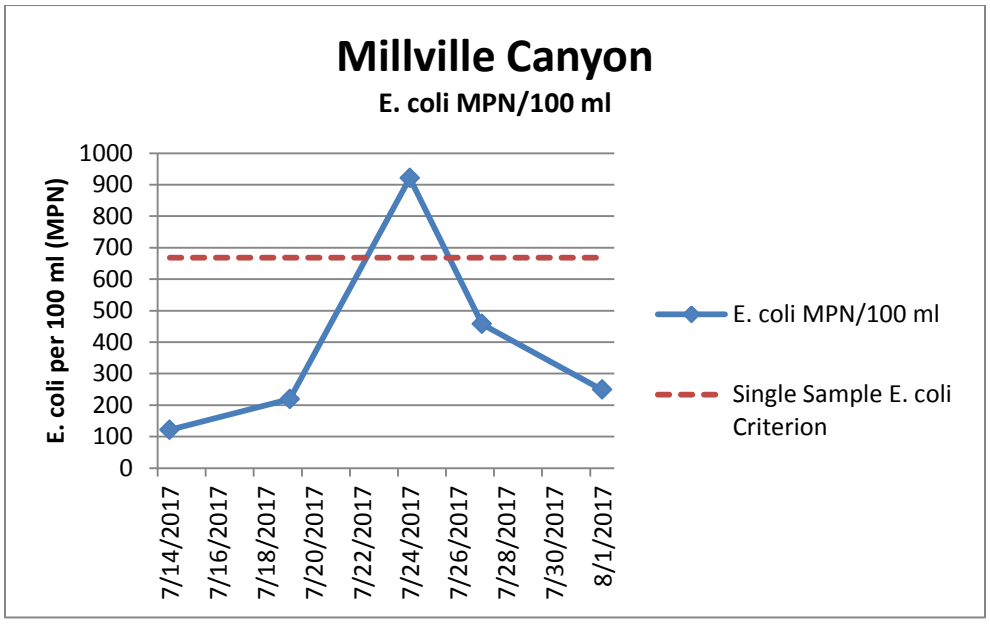


Figure 8: Millville Canyon E. coli sample results.

Providence Canyon was sampled five times between July 14th and August 1st. E. coli samples results ranged from 1.0/100 ml to 18.9/100 ml. Neither the geometric mean (Fig. 10) nor the single sample criteria for E. coli (Fig 9) were exceeded during the sample period.

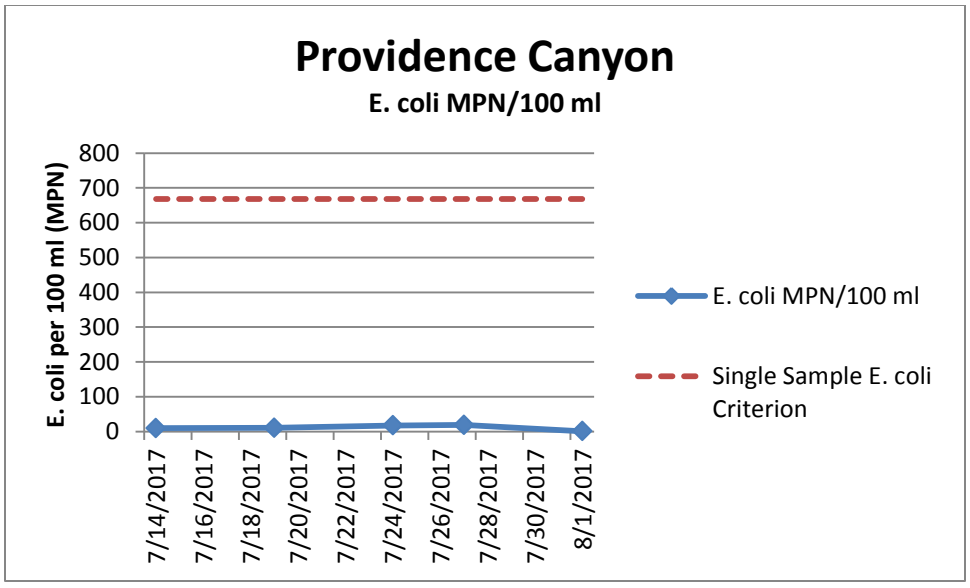


Figure 9: Providence Canyon E. coli sample results.

Table 4: E. coli sample results.

Location	Date Sampled	Total Coliform MPN/100 ml	E. coli MPN/100 ml
Curtis Creek	8/10/2017	131.7	34.5
Curtis Creek	8/14/2017	152.2	21.6
Curtis Creek	8/17/2017	240	18.9
Curtis Creek	8/22/2017	62.6	17.3
Curtis Creek	8/27/2017	72.7	16.1
Friendship Campground	8/10/2017	416	29.5
Friendship Campground	8/14/2017	547.5	31.8
Friendship Campground	8/17/2017	436	37.9
Friendship Campground	8/22/2017	344.8	57.3
Friendship Campground	9/22/2017	686.7	161.6
Friendship Campground	8/27/2017	410.6	40.8
Left Hand Fork	8/10/2017	436.6	24.3
Left Hand Fork	8/14/2017	524.7	32.7
Left Hand Fork	8/17/2017	613.1	31.8
Left Hand Fork	8/22/2017	435.2	41
Left Hand Fork	8/27/2017	435.2	29.5
Left Hand Fork	9/21/2017	185	32.7
Millville Canyon	7/14/2017	436	121.2
Millville Canyon	7/19/2017	601.5	218.7
Millville Canyon	7/24/2017	1986.3	920.8
Millville Canyon	7/27/2017	1986.3	456.9
Millville Canyon	8/1/2017	549.3	248.9
North Rich	8/7/2017	>2419.6	>2419.6
North Rich	8/10/2017	>2419.6	920.8
North Rich	8/14/2017	866.4	410.6
North Rich	8/17/2017	1119.9	435.2
North Rich	8/22/2017	648.8	387.3
North Rich	8/27/2017	1299.7	461.1
Providence	7/14/2017	98.8	9.6
Providence	7/19/2017	115.3	10.8
Providence	7/24/2017	139.6	17.5
Providence	7/27/2017	214.3	18.9

Providence	8/1/2017	82.3	1
Rock Creek	8/10/2017	2419.6	27.2
Rock Creek	8/14/2017	2419.6	25.5
Rock Creek	8/17/2017	1413.6	27.8
Rock Creek	8/22/2017	>2419.6	44.8
Rock Creek	8/27/2017	2419.6	30.9
Saddle Creek	8/7/2017	207.5	32.8
Saddle Creek	8/10/2017	178.9	18.7
Saddle Creek	8/14/2017	461.1	20.3
Saddle Creek	8/17/2017	1553.1	12
Saddle Creek	8/22/2017	209.8	12.2
Saddle Creek	8/27/2017	126.7	15.8

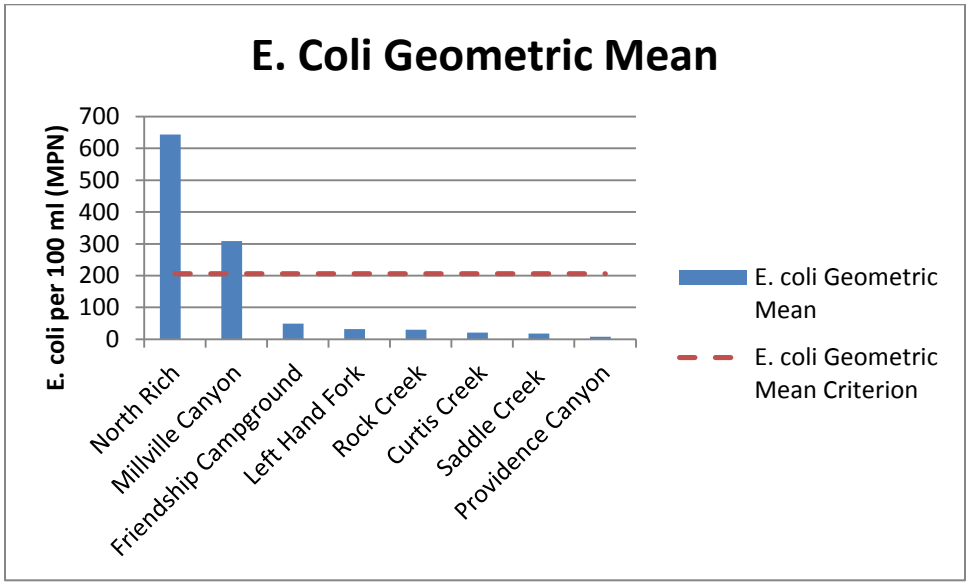


Figure 10: Geometric mean of each sample site in comparison to the E. coli geometric mean standards (206/100 ml).

Table 5: Geometric Mean of E. coli Sample Results

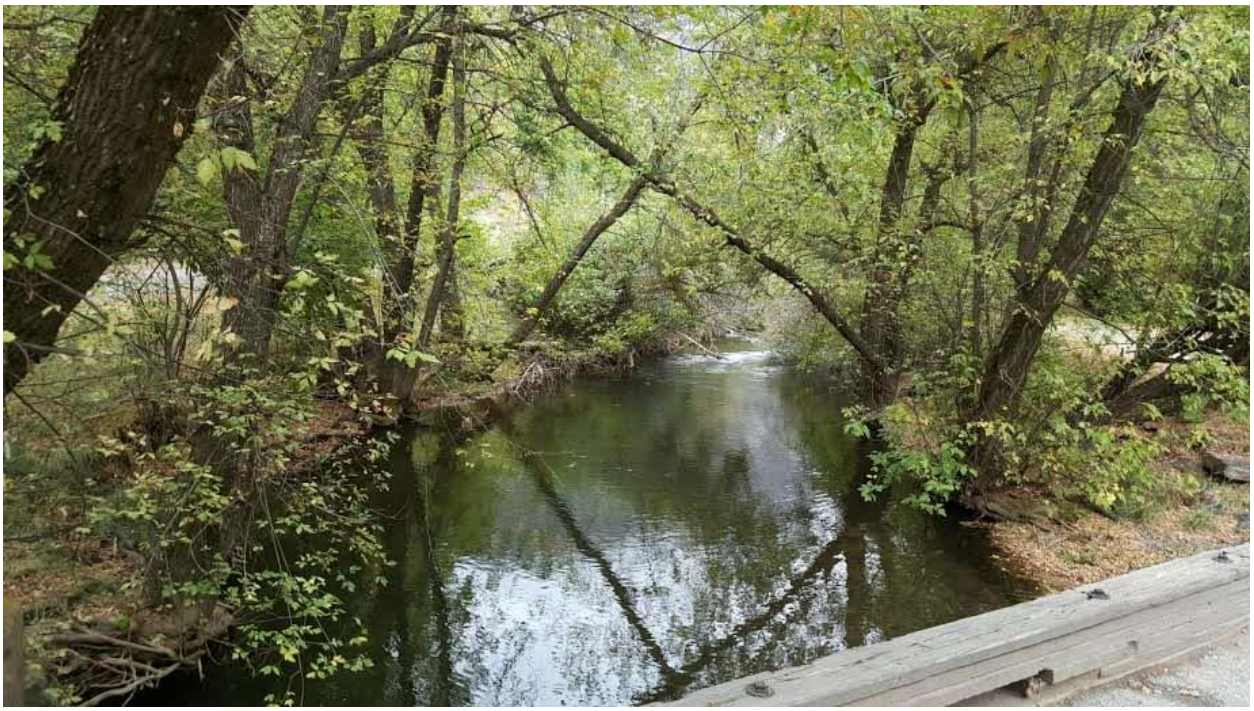
Location	Geometric Mean E. coli
Millville Canyon	308.0864
North Rich	643.6403
Left Hand Fork	31.61956
Providence Canyon	8.073075
Rock Creek	30.56878
Curtis Creek	20.83154
Saddle Creek	17.50794
Friendship Campground	48.75555

Conclusions

Monitoring conducted in the summer of 2017 within the Bear River Watershed has demonstrated that cattle grazing on Forest Service cattle allotments may be causing an exceedance of State E. coli criteria for Contact Recreation (class 2B). Each of the sample locations were taken on a creek listed as a class 2B Contact Recreation stream in the Utah Administrative Code (Rule R317-2. Standards of Quality for Waters of the State). In accordance with this classification, the criteria were violated at both Millville Canyon and North Rich during the 2017 sample period.

Left Hand Fork - 9/21/207

Friendship Campground - 9/21/207



Rock Creek - 9/21/207

Curtis Creek - 9/21/207

Saddle Creek - 9/21/207

North Rich - 9/21/207

Millcreek Canyon – 10/4/2017

Providence Canyon – 10/4/2017