Bacteria Contamination of Surface Waters Due to Livestock Grazing in the Stanislaus National Forest, California

(Sixth Year of Study)

Summary of 2014 Results

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Surface waters were tested for pathogenic bacteria indicators (i.e., *E. coli*, fecal coliform bacteria, and total coliform bacteria) for the sixth consecutive years within commercial cattle grazing allotments in the Stanislaus National Forest. The sample sites from the first three years of sampling, 2009 through 2011, focused on comparative sampling done at a specific site before cattle presence and then at the same site after the arrival of cattle. The results showed that individual and average concentrations of fecal coliform bacteria in surface waters were consistently below regulatory thresholds at all sites before cattle presence or where no livestock grazed during the season. Shortly after cattle were released into the national forest to graze in allotments, fecal coliform concentrations were much higher, and in places exceeded state standards. *E. coli* and total coliform concentrations followed the same pattern. Reports at the end of study field seasons in 2009 and again in 2010 focused on documenting the violations of state standards for fecal coliform concentrations in recreational contact waters. The 2011 report highlighted the difference in *E. coli* and fecal coliform concentrations detected in waters when cattle were not present compared to the *E. coli* and fecal coliform concentrations detected when cattle were present in the Stanislaus National Forest. The report for 2012 and 2013 discusses results from sampling that specifically focused on water quality in streams within grazed areas in national forest roadless areas and wilderness areas. The potential is high in those areas for recreational users to drink the contaminated stream water.

Water samples were collected from six sites in four grazing allotments in 2014. The winter of 2013/2014 was by far the driest winter since this study commenced in the summer of 2009. The results from 2014 were more variable than other years of this study. The results from 2009-2013 consistently showed that there were low levels of fecal coliform found in creeks before cattle arrived. After cattle presence, the concentration of fecal coliform would rise and remain elevated until cattle left the area. This year, some sample sites had extremely high levels of fecal coliform while cattle were present, while the fecal coliform levels at other sites remained relatively low throughout the summer. The trend from the last six years is that the overall highest levels of fecal contamination have been found during the wetter years and lower levels of fecal contamination are found during the drier years.

Field Site Selection for 2014

Six sites that were exposed to commercial livestock grazing during the summer of 2014 were sampled within the Stanislaus NF. One of these sites has also been sampled in 2009, and two sites were also sampled in 2012. These sites are described below, and Table 1 provides location (i.e., latitude, longitude) coordinates for each site, using datum NAD 83.

Bloomfield (BF)
Sample site: 2,399 meters (7,871 feet) elevation
Samples were collected from an unnamed tributary stream of the North Fork Mokelumne River approximately 60 meters (200 feet) upstream from the confluence of the unnamed tributary stream and the river. The sample site is within the Highland Lakes Range Allotment. This site was selected because it is about a half mile upstream of the Bloomfield campground, which is immediately adjacent to the North Fork Mokelumne River. The proximity of the river to the campground makes it likely that campers, especially those unaware of possible pollution, use water from the river. Two "before livestock arrival" samples were collected on June 23, 2014. Seven "after livestock" samples were collected between July 11 and August 6, 2014.

North Fork Mokelumne (NFM)
Sample site: 2,392 meters (7,848 feet) elevation
Samples were collected from the North Fork Mokelumne River 100' downstream of the confluence with the unnamed stream that the BF sample is taken. Two "before livestock" samples were collected on June 23, 2014. Four "after livestock arrival" samples were collected between July 10, and August 6, 2014.

Bear Tree Meadow (BTM)
Sample site: 2,548 meters (8,361 feet) elevation
Samples were collected from an unnamed tributary of the North Fork Mokelumne River in the Carson-Iceberg Wilderness (within the Highland Lakes Range Allotment). This site was selected in order to have a site near the PCT and within the designated wilderness. Three "before livestock" samples were collected between June 23, and July 10, 2014. Eight "after livestock arrival" samples were collected between August 6 and September 12, 2014.

Bull Run (BR)– sample site: 2,022 meters (6,634 feet) elevation
Samples were collected below Bull Run Meadow from a major tributary of Cow Creek (which is within the Herring Creek Range Allotment). Cow Creek is entirely within the Stanislaus River watershed and flows into the Lower Middle Fork of the Stanislaus River. Two "before livestock" samples were collected June 10-17, 2014. Fourteen "after livestock arrival" samples were collected between June 25 and September 9, 2014.

Niagara Creek (NGC) - sample site: 2,179 meters (7,149 feet) elevation
Samples were collected from Niagara Creek (which is within the Long Valley/Eagle Meadow Range Allotment). Niagara Creek is entirely within the Stanislaus River watershed and flows into Donnell Lake on the Middle Fork of the Stanislaus River.

Four "before livestock" samples were collected between June 10 and July 11, 2014. Four "after livestock arrival" samples were collected between July 16 and August 5, 2014.

Bell Creek (BC) – sample site: 1,991 meters (6,532 feet) elevation
Samples were collected from Bell Creek, where it flows through Middle Bell Meadow (which is within the Bell Meadow/Bear Lake Range Allotment). Bell Creek is entirely within the Tuolumne River watershed and flows into the Tuolumne River via the Clavey River. Three "before livestock" samples were collected between June 19 and July 14, 2014. Ten "after livestock arrival" samples were collected between August 8 and September 9, 2014.

Table 1. List of water sample sites (lat/long datum NAD 83).

Site name	County	Latitude	Longitude
Bloomfield	Alpine	38.5331	-119.8199
North Fork Moke	Alpine	38.5344	-119.8216
Bear Tree	Alpine	38.5014	-119.7888
Bull Run	Tuolumne	38.2491	-119.9636
Niagara Creek	Tuolumne	38.3007	-119.8763
Bell Creek	Tuolumne	38.1656	-119.9413

Methods

Field Water Collection

A Quality Assurance Project Plan (QAPP) was prepared for this water-monitoring project and all procedures specified in the QAPP were followed.

Water samples that were collected for bacteriological testing were collected while wearing sterile gloves and collected in sample bottles sterilized and provided by AquaLab Water Analysis (which has ELAP certification). The bacteriological samples were collected before any other work was performed at the site. The sterilized Nalgene bottles hold 125mL of liquid. They were filled to 100 mL with sample water taken directly from flowing water approximately 0.1 m below the surface.

The sample containers were marked with a unique 3-digit identifying number with an indelible marker so that the markings would not "run" or otherwise become illegible when collecting the sample. The collection date, time and samplers' names were recorded on the field datasheets, which are retained at the CSERC office; they are also recorded on the Chain-of-Custody form that was transmitted to AquaLab along with each sample. No sampling bottles were contaminated during sampling or transit.

All water samples collected for bacteriological analyses were delivered to AquaLab within six hours from the time the samples were collected. The sample bottles were placed in Zip-loc plastic bags (to avoid any potential contamination from the ice water) on ice in a cooler until delivered into the custody of AquaLab.

While collecting the water samples, the relative flow of the stream being sampled was recorded on a field datasheet along with other observations about the sample area.

Laboratory Analyses

Water samples were delivered at Twain Harte, CA, to AquaLab, a State-certified analytical laboratory. All water samples were tested for *E. coli,* total coliform, and fecal coliform bacteria within the 6-hour holding time specified in the QAPP, using Multiple Tube Fermentation (Most Probable Number/100 mL). The detection limit using this method of analysis is two fecal coliform organisms/100 mL of water. The detection maximum using this method of analysis is 16,000 fecal coliform organism/100 mL of water.

A copy of AquaLab's Quality Assurance SOP for Multiple Tube Fermentation is on file at the CSERC office and included in appendix 5. The analytical methods utilized by this laboratory are specified in *Standard Methods For the Examination of Water and Wastewater* (19th Edition).

Data Analysis for Comparison to State Standards

The bacteria results were compared to the relevant water quality standards contained in the Central Valley Regional Water Quality Control Board's *Water Quality Control Plan for the Sacramento and San Joaquin River Basins* ("Basin Plan"). Water contact recreation is a designated beneficial use of the receiving waters included in this study. To protect that beneficial use, the Basin Plan specifies (in part) the following numeric objectives (i.e., standards):

> *In waters designated for contact recreation (REC-1), the fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed a geometric mean of 200/100 ml, nor shall more than ten percent of the total number of samples taken during any 30-day period exceed 400/100 ml. (Basin Plan at III-3)*

Data were compiled whenever five or more samples were collected within a 30-day period, and results were judged as a "Type 1 Violation" whenever the geometric mean of five samples collected over a 30-day period exceeded 200 fecal coliform colonies per 100 ml of water. Results were judged as a "Type 2 Violation" whenever more than ten percent of the samples collected over a 30-day period exceeded 400 fecal coliform colonies per 100 ml of water. In effect, a Type 2 Violation exists for this study any time there are at least five samples during a 30-day period for which any single sample exceeded 400 fecal coliform colonies per 100 ml of water.

For this study, reporting periods were tabulated only when five or more samples were collected within a 30-day period. This conservative method of data analysis documented 51 violations of the above state water quality standards for fecal coliform bacteria. A more comprehensive analysis (i.e., tabulating all possible 30-day periods by re-starting the 30-day calendar each day) would produce additional violations.

Results

Comparison of Data From Sites with "Before vs. After Livestock" Data

At Bloomfied Meadow, the average *E. coli* concentration before cattle presence was <2 (n=2) [mean FC= <2, n=2]. The average *E. coli* concentration after cattle presence was 389 (n=8), with one sample above 1,600 [mean FC=389, n=8].

At North Fork Mokelumne, the average *E. coli* concentration before cattle presence was <2 (n=2) [mean FC= <2, n=2]. The average *E. coli* concentration after cattle presence was 449 (n=4), with one sample above 1,600 [mean FC=449, n=4].

At Bear Tree, the average *E. coli* concentration before cattle presence was <2 (n=3) [mean FC= <2, n=3]. The average *E. coli* concentration with cattle presence was 23 (n=8), [mean FC=23, n=8].

At Bull Run, the average *E. coli* concentration before cattle presence was 11 (n=2) [mean FC= 11, n=2]. The average *E. coli* concentration with cattle presence was 40 (n=14), with two samples over 100 [mean FC=56, n=14].

At Niagara Creek, the average *E. coli* concentration before cattle presence was <2 (n=4) [mean FC= 18, n=3]. The average *E. coli* concentration after cattle presence was 170 (n=4), with all samples above 100 [mean FC=170, n=4].

At Bell Creek, the average *E. coli* concentration before cattle presence was 9 (n=3) [mean FC= 2, n=4]. The average *E. coli* concentration after cattle presence was 9,570 (n=10), with five samples of 16,000 or above [mean FC=9970, n=10].

Comparison to Previous Year Results at Bull Run (2009), Bloomfield (2012), and Bear Tree Meadow (2012) Sample Sites

At Bull Run, seven water samples were collected "before" grazing between June 9, 2009 and July 1, 2009. Seven "after livestock arrival" grazing water samples were collected between July 9, 2009 and August 13, 2009. At Bull Run in 2009, the average *E. coli* concentration before cattle presence was 10 (n=8) [mean FC= 12, n=8]. The average *E. coli* concentration after cattle presence was 127 (n=10), with two samples of 300 or higher [mean FC=140, n=10].

At Bloomfield, three "before livestock arrival" samples were collected on June 15 and July 12, 2012. Five "after livestock" samples were collected between July 18 and August 7, 2012. At Bloomfied Meadow, the average *E. coli* concentration before cattle presence was 11 (n=4) [mean FC= 12, n=3]. The average *E. coli* concentration after cattle presence was 578 (n=5), with two samples above 1,000 [mean FC=578, n=5].

A Bear Tree, no "before livestock" samples were collected in 2012. Seven "after livestock arrival" samples were collected between August 7, 2012 and August 28, 2012. The average *E. coli* concentration with cattle presence was 1200 (n=7), with three samples higher than 1000 [mean FC=1200, n=7].

2014 Results Compared to State Standards

Below are tables that provide results for each of the 33 documented violations of state water quality standards.

Violation #1 (Type 1 Violation) — Site: Bloomfield
Sampling dates: July 10, 2014 – July 23, 2014

Date	FC / 100ml
7/10/14	210
7/10/14	170
7/10/14	170
7/10/14	500
7/23/14	300
Geo Mean	**247**

Violation #2 (Type 2 Violation*) — Site: Bloomfield
Sampling dates: July 10, 2014

Date	FC / 100ml
7/10/14	210
7/10/14 (1)	170
7/10/14 (2)	170
7/10/14*	500
7/10/14	80

Violation #3 (Type 1 Violation) — Site: Bloomfield
Sampling dates: July 10, 2014 – July 23, 2014

Date	FC / 100ml
7/10/14	210
7/10/14 (1)	170
7/10/14	80
7/10/14	500
7/23/14	300
Geo Mean	**212**

Violation #4 (Type 1 Violation) — Site: Bloomfield
Sampling dates: July 10, 2014 – July 23, 2014

Date	FC / 100ml
7/10/14	210
7/10/14 (2)	170
7/10/14	80
7/10/14	500
7/23/14	300
Geo Mean	**212**

Violation #5 (Type 1 Violation) — Site: Bloomfield
Sampling dates: July 10, 2014 – August 6, 2014

Date	FC / 100ml
7/10/14	210
7/10/14 (1)	170
7/10/14	500
7/23/14	300
8/6/14	80
Geo Mean	**212**

Violation #6 (Type 1 Violation) — Site: Bloomfield
Sampling dates: July 10, 2014 – August 6, 2014

Date	FC / 100ml
7/10/14	210
7/10/14 (2)	170
7/10/14	500
7/23/14	300
8/6/14	80
Geo Mean	**212**

Violation #7 (Type 1 Violation) — Site: Bloomfield
Sampling dates: July 10, 2014 – August 6, 2014

Date	FC / 100ml
7/10/14	170
7/10/14	170
7/10/14	500
7/23/14	300
8/6/14	80
Geo Mean	**203**

Violation #8 (Type 2 Violation*) — Site: North Fork Moke
Sampling dates: June 23, 2014 – July 17, 2014

Date	FC / 100ml
6/23/14	2
6/23/14	2
7/10/14	11
7/10/14	14
7/17/14*	1600

Violation #9 (Type 1 Violation) — Site: Bell Creek
Sampling dates: August 28, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
Geo Mean	**16000**

Violation #10 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: August 28, 2014

Date	FC / 100ml
8/28/14*	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000

Violation #11 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: August 28, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14*	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000

Violation #12 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: August 28, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14*	16000
8/28/14	16000
8/28/14	16000

Violation #13 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: August 28, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14*	16000
8/28/14	16000

Violation #14 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: August 28, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14*	16000

Violation #15 (Type 1 Violation) — Site: Bell Creek
Sampling dates: August 28, 2014 – September 9, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
9/9/14	3000
Geo Mean	**11448**

Violation #16 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: August 28, 2014 – September 9, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
9/9/14*	3000

Violation #15 (Type 1 Violation) — Site: Bell Creek
Sampling dates: August 28, 2014 – September 9, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
9/9/14 (1)	5000
Geo Mean	**12679**

Violation #16 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: August 28, 2014 – September 9, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
9/9/14* (1)	5000

Violation #17 (Type 1 Violation) — Site: Bell Creek
Sampling dates: August 28, 2014 – September 9, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
9/9/14	1700
Geo Mean	**10218**

Violation #18 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: August 28, 2014 – September 9, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
9/9/14*	3000

Violation #19 (Type 1 Violation) — Site: Bell Creek
Sampling dates: August 28, 2014 – September 9, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
9/9/14 (2)	5000
Geo Mean	**12679**

Violation #20 (Type 1 Violation) — Site: Bell Creek
Sampling dates: August 28, 2014 – September 9, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
9/9/14 (3)	5000
Geo Mean	**12679**

Violation #21 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: August 28, 2014 – September 9, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
9/9/14* (2)	5000

Violation #22 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: August 28, 2014 – September 9, 2014

Date	FC / 100ml
8/28/14	16000
8/28/14	16000
8/28/14	16000
8/28/14	16000
9/9/14* (3)	5000

Violation #23 (Type 1 Violation) — Site: Bell Creek
Sampling dates: September 9, 2014

Date	FC / 100ml
9/9/14	3000
9/9/14	5000
9/9/14	1700
9/9/14	5000
9/9/14	5000
Geo Mean	**3638**

Violation #24 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: September 9, 2014

Date	FC / 100ml
9/9/14*	3000
9/9/14	5000
9/9/14	1700
9/9/14	5000
9/9/14	5000

Violation #25 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: September 9, 2014

Date	FC / 100ml
9/9/14	3000
9/9/14*	5000
9/9/14	1700
9/9/14	5000
9/9/14	5000

Violation #26 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: September 9, 2014

Date	FC / 100ml
9/9/14	3000
9/9/14	5000
9/9/14*	1700
9/9/14	5000
9/9/14	5000

Violation #27 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: September 9, 2014

Date	FC / 100ml
9/9/14	3000
9/9/14	5000
9/9/14	1700
9/9/14*	5000
9/9/14	5000

Violation #28 (Type 2 Violation*) — Site: Bell Creek
Sampling dates: September 9, 2014

Date	FC / 100ml
9/9/14	3000
9/9/14	5000
9/9/14	1700
9/9/14	5000
9/9/14*	5000

Violation #29 (Type 1 Violation) — Site: Bell Creek
Sampling dates: August 28, 2014 - September 9, 2014

Date	FC / 100ml
8/28/14	16000
9/9/14	5000
9/9/14	1700
9/9/14	5000
9/9/14	5000
Geo Mean	**5085**

Violation #30 (Type 1 Violation) — Site: Bell Creek
Sampling dates: August 28, 2014 - September 9, 2014

Date	FC / 100ml
9/9/14	3000
8/28/14	16000
9/9/14	1700
9/9/14	5000
9/9/14	5000
Geo Mean	**4591**

Violation #31 (Type 1 Violation) — Site: Bell Creek
Sampling dates: August 28, 2014 - September 9, 2014

Date	FC / 100ml
9/9/14	3000
9/9/14	5000
8/28/14	16000
9/9/14	5000
9/9/14	5000
Geo Mean	**5697**

Violation #32 (Type 1 Violation) — Site: Bell Creek
Sampling dates: August 28, 2014 - September 9, 2014

Date	FC / 100ml
9/9/14	3000
9/9/14	5000
9/9/14	1700
8/28/14	16000
9/9/14	5000
Geo Mean	**5591**

Violation #33 (Type 1 Violation) — Site: Bell Creek
Sampling dates: August 28, 2014 - September 9, 2014

Date	FC / 100ml
9/9/14	3000
9/9/14	5000
9/9/14	1700
9/9/14	5000
8/28/14	16000
Geo Mean	**4591**

Conclusion

Many of the results from 2014 continue to document significant pollution of surface waters that is resulting from cattle grazing as currently permitted and regulated on National Forest System lands. After six years of collecting water samples for bacteriological testing at sites scattered throughout the Stanislaus National Forest, the results remain consistent. The concentration of indicator bacteria detected in the forest waters is very low until cattle are released into summer grazing allotments. Shortly after cattle arrive within a stream sample area, the concentration of indicator bacteria rapidly rises and remains high as long as the cattle are present. While violations were not found at every site sample this year, there was still an increase in the amount of fecal coliform after cattle presence.

The results presented here document 33 individual violations of California's regulatory water quality standards for bacteria within range allotments where water sampling was performed during the 2014 summer season.

The 33 individual violations, combined with CSERC's previous studies done during the 2009, 2010, 2011, 2012, and 2013 grazing seasons, provide persistence evidence of the failure of Best Management Practices (BMPs) to comply with state water quality standards. This study documents that BMPs as currently applied by the Stanislaus NF are not achieving water quality in livestock-affected streams that meets state water quality standards. This study also documents that, even with implementation of BMPs, significant pollution of surface waters is still resulting from cattle grazing as currently regulated and permitted on National Forest System lands.

Further, the levels and methods of livestock grazing in the sampled areas are not unlike practices throughout the Stanislaus NF and other public lands where livestock grazing occurs in the Sierra Nevada. These findings confirm earlier studies indicating that widespread pollution of surface waters is occurring due to livestock presence on National Forest System lands in the Sierra Nevada, and demonstrate the need for consideration of: (1) appropriate changes in permitted livestock grazing activities in order to eliminate or reduce contamination of surface waters, (2) increased water quality monitoring of high use livestock sites where prolonged or concentrated presence of cattle increases the potential for violations of water quality standards, and (3) removal of livestock from known areas where current livestock management techniques (such as fencing and herding) have not resulted in compliance with water quality standards (Derlet et al, 2008 and 2010).

This is the sixth year where "before cows" and "cows present" water sampling has detected high levels of fecal coliform, total coliform, and *E. coli* in national forest areas used by varying numbers of recreational visitors. One obvious consideration for reducing the risk of exposing recreational visitors (swimmers, hikers, campers, backpackers) to pathogens or indicators of pathogens in national forest water is to evaluate where the areas with the highest levels of backcountry recreational use occur within each national forest. Keeping livestock out of those high-use recreational areas would appear to be one effective strategy to avoid, in those specific areas, recreational visitors exposure to water that fails to meet State standards for recreational contact and public health.

References:

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