Technical Memorandum:
Water Quality Monitoring in the San Lorenzo River Watershed, 2014

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INTRODUCTION

The Water Quality Working Group of the San Lorenzo River Alliance (SLRA) has met multiple times since fall, 2013, to address issues related to water quality in the lower San Lorenzo River and its tributaries (see Figure 1). The initial focus of the Working Group's activity has been to address impairment of river water quality by bacteria. The reasons for this focus are twofold:

1. The SLRA wishes to improve the general quality and beneficial uses in the lower reaches of the San Lorenzo River, and
2. The SLRA seeks to participate with other stakeholders in the response to the impairment of beneficial uses of the river, as described in the San Lorenzo River Watershed Pathogen Total Maximum Daily Load (TMDL) regulation (Central Coast Water Board Resolution R3-2009-0023).

The TMDL Problem Statement characterizes the impairment as follows:

> "The beneficial use of water contact recreation is not protected in the impaired reaches of the San Lorenzo River Estuary (also known as San Lorenzo River Lagoon), San Lorenzo River , Branciforte Creek, Camp Evers Creek, Carbonera Creek, and Lompico Creek because fecal coliform concentrations exceed existing Basin Plan numeric water quality objectives protecting this beneficial use. All reaches in these waterbodies are impaired with the exception of Carbonera Creek, where the impairment extends from the mouth of Carbonera Creek upstream to its intersection with Bethany Road."

Focusing on the water contact recreation beneficial use cited in the TMDL, the guiding questions developed by the Working Group in its initial efforts to address the bacteria contamination issues are:

- What is the level of human bacterial contamination in the surface waters of the lower San Lorenzo River watershed?
- What are the key sources of human and other anthropogenic bacterial contamination in the lower San Lorenzo River?

The Working Group to date has employed a dual focus:

- Water quality monitoring
- Bacteria source identification and prioritization

The approach to date involves using water quality monitoring data and other information to help inform efforts to identify and prioritize bacteria sources for further investigation. Where feasible, the intention is to use the source identification results to guide efforts at source reduction and control. To that end, the Working Group's emphasis is on identifying and characterizing *controllable* sources of human and other anthropogenic bacteria.

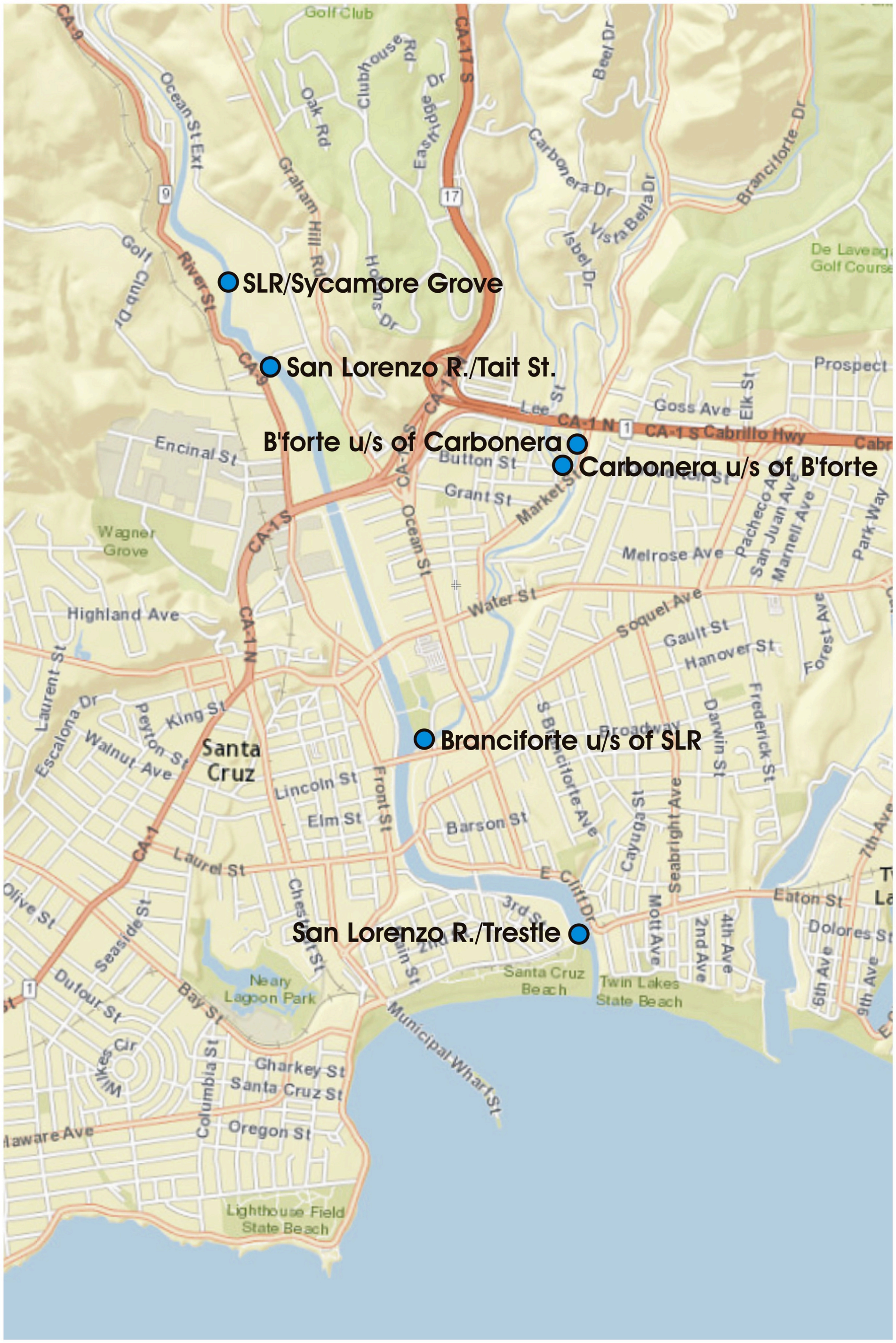

Figure 1. Lower San Lorenzo River Watershed, Showing 2014 Monitoring Sites[1]

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[1] Notes re: abbreviations used in figures/tables: "u/s" = upstream; "SLR" = San Lorenzo River; "B'forte" = Branciforte Creek. See List of Sites on p. 3 for site descriptions.

MONITORING METHODS

To provide the essential information needed to support the source identification efforts, the Working Group designed a water quality monitoring program for the peak 2014 recreational water contact period (May-October). Samples were collected monthly by Coastal Watershed Council (CWC) staff and volunteers during that period (see list of sample dates, below) from six sites at strategic points within the lower watershed (see Figure 1 and list of sites, below). Samples were collected using clean sample handling techniques, according to protocols specified in CWC's creek sampling Quality Assurance Project Plan (QAPP).

LIST OF 2014 MONITORING DATES:
Wednesday, May 21, 10 am start
Thursday, June 19, 10 am start
Thursday, July 17, 9 am start
Monday, August 18, 10 am start
Monday, September 15, 10 am start
Wednesday, October 15, 10 am start

LIST OF 2014 MONITORING SITES:
1) San Lorenzo River (downstream) at the lagoon, beneath trestle bridge
2) San Lorenzo River (upstream of main urban area inputs) at Tait Street
3) San Lorenzo River (upstream) at Sycamore Grove
4) Branciforte Creek upstream from confluence with San Lorenzo River, at start of concrete channel
5) Carbonera Creek just upstream from confluence with Branciforte Creek
6) Branciforte Creek just upstream from confluence with Carbonera Creek

A "multiple lines of evidence" analytical approach was implemented, in an effort to quantify the relative contributions of human sources to in-stream levels of fecal indicator bacteria. This involved analysis of samples for several specific groups of chemical and microbiological constituents. All analyses were performed at competent analytical laboratories with ELAP (Environmental Laboratory Accreditation Program) and/or NELAC (National Environmental Laboratory Accreditation) certification.

The multiple lines of evidence approach included analyses of collected water samples for the following constituents:

- Fecal sterols and stanols
- Caffeine
- Human Bacteroides
- Fecal indicator bacteria (FIB), including *E. coli*, Total coliform, and *Enterococcus*
- Standard field parameters (dissolved oxygen, temperature, conductivity, pH)

Fecal sterols, stanols and caffeine are considered to be chemical tracers that can be used to help identify potential contributions from human sources (c.f., Standley et al., 2000). The use of chemical source tracking methods represents an important additional line of evidence among the several lines of evidence previously applied in the investigation of bacteria sources in the San Lorenzo River watershed. The fecal sterol cholesterol is ubiquitous in the digestive tracts of animals and in the environment. Cholesterol is mostly metabolized in the human gut to the fecal stanol coprostanol. By contrast, in the environment cholesterol normally reduces to cholestanol. Coprostanol is therefore often used alone or in ratio to other fecal sterols/stanols to identify human fecal sources (c.f., Ahmed et al., 2011).

Sterols and stanols were analyzed via high resolution gas chromatography coupled with mass spectrometry (GC/MS). Axys Analytical Services used their own GC/MS method (Axys Method MLA-068 Rev 3; May-June samples); Physis Environmental Laboratories used a modified EPA 625 GC/MS method (July-October samples).

Caffeine is widely consumed in modern cultures, and while caffeine is readily metabolized by the human body, up to 10% of the consumed caffeine may be excreted, mostly via the urine (Ferreira, 2005). Caffeine has been shown to be a reliable indicator of human contamination in surface waters, and detection of caffeine can be interpreted as representative of the presence of human sewage (c.f., Ferreira, 2005). Caffeine analysis of the 2014 samples was done using the caffeine ELISA test at the City of Santa Cruz Wastewater Laboratory.

Bacteroides are anaerobic bacteria prevalent in the gastrointestinal tracts of mammals; species that are specific to the human gut may be used as indicators of human sewage contamination in environmental samples (Sauer et al., 2011). Samples were analyzed for human-specific bacteroides at the County of Santa Cruz Environmental Health Services laboratory, using the EPA HF183 method and an Applied BioSystem StepOne Real Time PCR Analyzer. Testing was accomplished by filtering 100 ml of stream water through a 0.4uM polycarbonate filter and processing using a GeneRite DNA-EZ ST2 Kit, S0205-50. The purified DNA extract was then run through the DNA Analyzer and compared to standards made up from a DNA sequence outlined in the HF183 procedure and purchased from Integrated DNA Technologies.

Fecal indicator bacteria are more generic indicators of bacteria levels; they are ubiquitous in the environment and derive from a variety of animal and other sources. Samples were analyzed at the County of Santa Cruz Environmental Health Services laboratory, using Idexx Chromogenic testing with Colilert-18 for total coliform and *E. coli* bacteria, and Enterolert for *Enterococcus* bacteria testing.

RESULTS AND DISCUSSION

As described below, the results of both the chemical and biological analyses indicate a likely preponderance of bird inputs, and provide little evidence of human inputs to the San Lorenzo River freshwater system. See Tables 1 and 2 for the specific chemical tracer data and FIB/Bacteroides data, respectively.

Chemical Tracer Results/Analysis

For five commonly-detected fecal sterols/stanols, including coprostanol, monthly average concentrations from the 2014 San Lorenzo River watershed samples were highest in the June samples (see “Monthly averages”, Table 1).

Coprostanol was detected by the analytical laboratory regularly in samples from all sites during May-August, but at relatively low concentrations compared to literature values for anthropogenically-impacted streams. Rates of analytical detection dropped after August: Coprostanol was only detected at the "Branciforte u/s of SLR" and "Carbonera u/s of Branciforte" sites in September, and only at the "Branciforte u/s of SLR" site in October (see Table 1 and Figure 2).

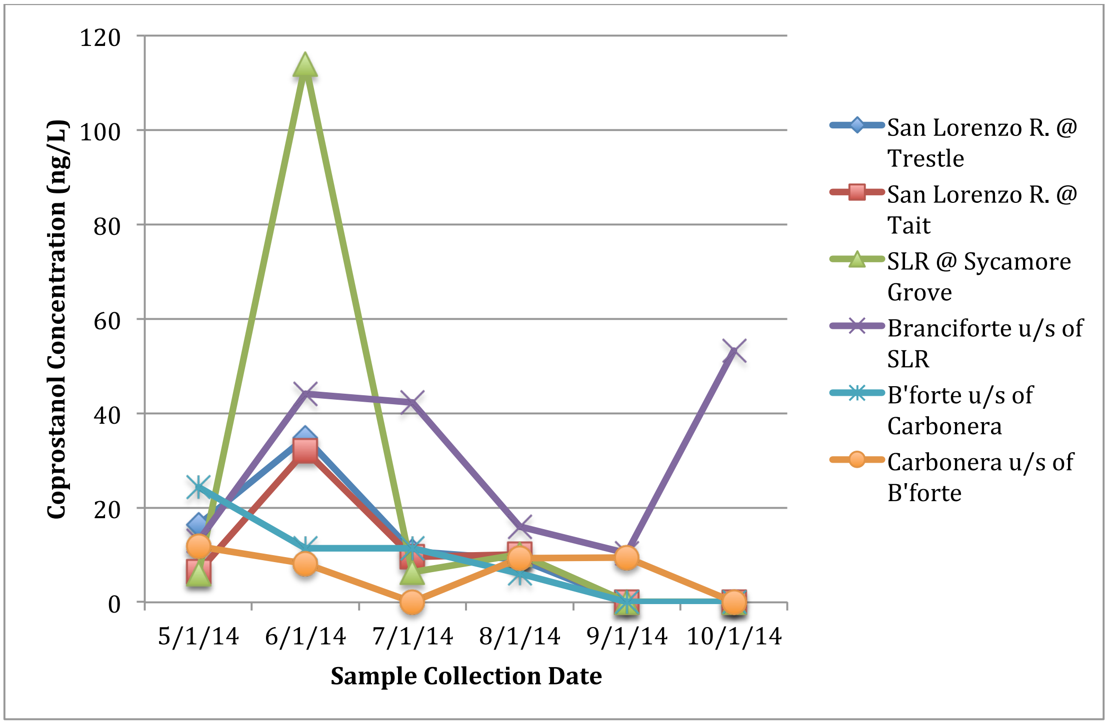

Figure 2. Monthly Coprostanol Concentrations at Six Sites, 2014 Monitoring

Three chemical tracer ratios were evaluated per Ahmed et al. (2011): two ratios designed to indicate the presence of human fecal contamination, and one designed to indicate the presence of avian fecal contamination. Using the 6-month average concentrations, as shown in Table 3, one of the ratios (Ratio #1 per Ahmed et al., 2011) weakly indicates the potential presence of human fecal contamination at the "SLR @ Sycamore Grove" station (calculated ratio=0.51, where human contamination is indicated by ratio >0.5); this result was principally due to the single elevated coprostanol measurement in June at that station.

The 6-month average avian indicator ratio (Ratio #10 per Ahmed et al., 2011), by contrast, strongly indicates potential avian fecal contamination at all sites except the "SLR @ Sycamore Grove" station (see Table 3). For this ratio, a level >67% indicates avian fecal contamination. The average ratio at the "SLR @ Sycamore Grove" station was 62%, while average ratios ranged from 76%-85% at the other five sites.

When each site and date is considered individually (as opposed to 6-month averages), only the "SLR @ Sycamore Grove" station on 6/19/14 (ratio=1.56) and the "Branciforte u/s of SLR" station on 10/15/14 (ratio=0.72) exceeded the Ratio #1 human fecal indicator (ratio>0.5; see Table 4), for a frequency of 2/36 (~5%). No sites exceeded the Ratio #4 human fecal indicator (see Table 5). Almost all sites and dates exceeded the Ratio #10 avian fecal indicator (see Table 6).

Using the ratios from Ahmed et al., 2011, the following results were obtained (where “hits” are those samples that exceeded the respective ratio):

- Ratio #1 (human fecal indicator): 2/36 hits
- Ratio #4 (human fecal indicator): 0/36 hits
- Ratio #10 (avian fecal indicator): 32/36 hits

Caffeine was not detected in any of the 36 samples, indicating low to non-existent human influence on water quality at the monitored sites, based on that single indicator compound alone. The City of Santa Cruz Environmental laboratory utilizes caffeine detection at levels ≥ 0.175 µg/L to qualify associated high levels of fecal indicator bacteria as sourced from domestic sewage. The City has frequently detected caffeine at those levels in samples from certain problem sites in the storm drain system, where there is presumed to be cross-contamination from sewer system sources (Akin Babatola, personal communication, 2015). (Human bacteroides and very high FIB levels are also typically detected at those sites.)

Fecal Indicator Bacteria and Bacteroides Results/Analysis

As shown in Table 2, FIB levels were highly variable from site to site and month to month. Highest monthly average[2] concentrations for total coliform occurred in September and October, while highest average concentrations for *E. coli* and *Enterococcus* occurred in October, as illustrated in Figure 3. The October averages were all significantly influenced by very high values at the Branciforte Creek site upstream of the confluence with the San Lorenzo River, so this apparent seasonal signal (a spike in October) may be an artifact of those high values at a single site.

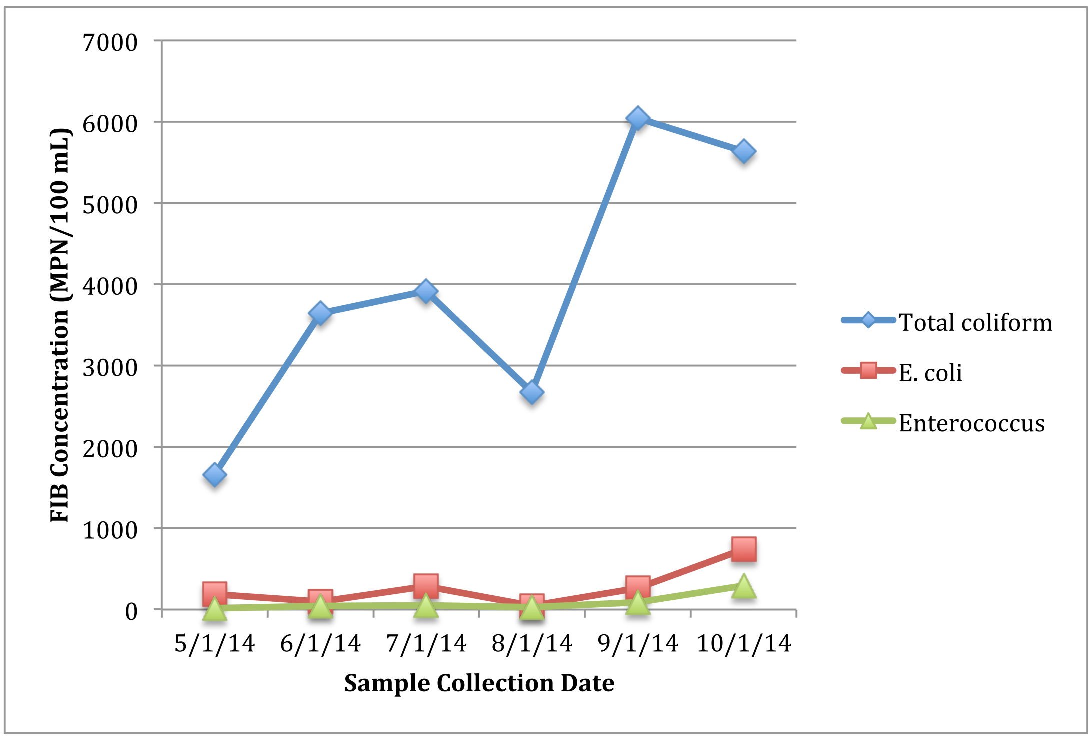

Figure 3. Monthly Geometric Mean Concentrations for FIB Constituents at Six Sites, 2014 Monitoring

[2] The average concentrations for the three FIB parameters are reported as geometric means, because of the high degree of variability in the FIB data, and because the regulatory compliance measure for these parameters is based on the geometric mean.

As shown in Table 2 and summarized in Table 7, the highest FIB results occurred most often at the Branciforte Creek site upstream of the confluence with the San Lorenzo River, and at the Carbonera Creek site (upstream of the confluence with Branciforte Creek.

Human Bacteroides were only detected at quantifiable levels in three of the 36 samples; two of those were at the Carbonera Creek site, and the other was at the Branciforte Creek site upstream of the confluence with Carbonera Creek. (See results in Table 2.) All three of those detected results were quantified at extremely low levels, and at those levels their reliability as indicators of actual environmental human contamination is uncertain.

Correlations: Chemical Tracers and FIB/Bacteroides Results

The chemical tracer results and ratios do not correlate well with the concurrent FIB results. See statistical correlation results, Table 8. Because there were no detected caffeine results, the caffeine data were not included in the correlation analyses.

There were also insufficient detected Bacteroides results to include the data in the correlation analyses. Higher FIB levels did not consistently co-occur with either the two “hits” on the Ahmed et al. Ratio 1 indicating human contamination, nor with the three low-level detected bacteroides results. (Note that these groups of indicators are not expected to correlate tightly because of differences in environmental degradation rates of bacteria and caffeine and/or stanols and sterols.)

SUMMARY/CONCLUSIONS

The following summarizes the essential results of the 2014 monitoring:

- For the fecal sterols and stanols analyses, very few samples indicate the presence of human contributions to the in-stream chemistry, while most samples exhibit indications of avian (bird) contributions.
- For caffeine, all 36 river and creek samples were reported as below the analytical detection level (commonly referred to as “non-detect”). By contrast, the City of Santa Cruz has detected caffeine in samples from certain problem sites in the storm drain system, where there is presumed to be cross-contamination from sewage sources.
- Human Bacteroides were only detected at quantifiable levels in three of the 36 samples; two of those were at the Carbonera Creek site (upstream of the confluence with Branciforte Creek).
- FIB levels were highly variable from site to site and month to month; highest results were most often obtained at the Branciforte Creek site upstream of the confluence with the San Lorenzo River, and at the Carbonera Creek site (upstream of the confluence with Branciforte Creek).
- The Bacteroides results don’t correlate well with either the concurrent FIB results or the chemical tracer results.

These results in combination clearly indicate a preponderance of bird inputs and limited human inputs to the lower San Lorenzo River freshwater system.

Preliminary conclusion: on an infrequent/episodic basis, chemical tracers indicate the potential occasional presence of human fecal contamination in lower San Lorenzo River watershed surface waters, while avian fecal contamination is commonly indicated.

NEXT STEPS

The Working Group would like to replicate the monitoring to confirm results under different (higher flow, non-drought) hydrological conditions; this will not happen in 2015 as the drought continues. Additional data analysis is proceeding, involving historical FIB monitoring data and related information from 2000-2013, including drought and non-drought years.

The group meanwhile will proceed with the source identification and prioritization process, focusing on the more significant/high probability potential sources from the conceptual model diagrams & potential source lists developed by the Working Group. Sources may be placed into one of the following three categories to prioritize bacteria sources in the San Lorenzo River watershed:

1. Know enough to go forward with source investigation
2. Know enough to not bother with additional steps
3. Don't know enough about source to decide; additional information needed

For follow-up in terms of source control and reduction, the emphasis will be placed on human and other anthropogenic sources that are deemed to be controllable.

The San Lorenzo River Bacteria TMDL contains effectively a "re-opener", which allows the Water Board to reconsider the numeric target and allocations. The results of the San Lorenzo River watershed monitoring and source ID investigation ultimately may be used to support such changes, to better focus the compliance efforts on reduction of human pathogen sources and other controllable anthropogenic sources.

REFERENCES

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Table 1. Chemical Tracer Analytical Results, 2014 Monitoring

	Measured Concentrations (ng/L) by Sample Collection Date						Descriptive Statistics [NDs est. as 1/2 RL]		
Constituent/Site ID	**5/21/14**	**6/19/14**	**7/17/14**	**8/18/14**	**9/15/14**	**10/15/14**			
Cholestanol							**Mean**	**Min.**	**Max.**
San Lorenzo R. @ Trestle	123	202	NA	NA	44.3	54.5	106	44.3	202
San Lorenzo R. @ Tait	73.6	79.3	NA	NA	19.5	17.7	47.5	17.7	79.3
SLR @ Sycamore Grove	63	73.1	NA	NA	33.8	21.1	47.8	21.1	73.1
Branciforte u/s of SLR	245	226	NA	NA	91.6	74.2	159	74.2	245
B'forte u/s of Carbonera	70.1	57.4	NA	NA	35.7	28.4	47.9	28.4	70.1
Carbonera u/s of B'forte	56.9	63.6	NA	NA	29.5	26.5	44.1	26.5	63.6
Monthly averages:	105	117			42	37			
Cholesterol									
San Lorenzo R. @ Trestle	1250	1640	375.7	916.2	1271.6	1562.9	1169	375.7	1640
San Lorenzo R. @ Tait	818	1120	241.7	290	241.9	536.2	541	241.7	1120
SLR @ Sycamore Grove	759	1150	244.4	276	435.8	271.7	523	244.4	1150
Branciforte u/s of SLR	1670	1630	455.7	549.3	1484.8	864.3	1109	455.7	1670
B'forte u/s of Carbonera	1280	1540	286.6	204.3	421.9	241	662	204.3	1540
Carbonera u/s of B'forte	761	1060	248.5	172.7	204	200.6	441	172.7	1060
Monthly averages:	1090	1357	309	401	677	613			
Coprostanol									
San Lorenzo R. @ Trestle	16.4	34.8	10.8	9.1	ND	ND	13.5	5.0	34.8
San Lorenzo R. @ Tait	6.41	32.1	9.6	10.2	ND	ND	11.4	5.0	32.1
SLR @ Sycamore Grove	6.07	114	6.4	10.2	ND	ND	24.4	5.0	114
Branciforte u/s of SLR	13	44.2	42.3	16	10.4	53.3	29.9	10.4	53.3
B'forte u/s of Carbonera	24.4	11.4	11.4	6.1	ND	ND	10.6	5.0	24.4
Carbonera u/s of B'forte	11.9	8.16	ND	9.3	9.5	ND	8.1	5.0	11.9
Monthly averages:	13.0	40.8	14.3	10.2	6.7	13.1			
Epicoprostanol									
San Lorenzo R. @ Trestle	3.21	7.07	ND	ND	ND	ND	5.05	3.21	7.1
San Lorenzo R. @ Tait	ND	3.62	ND	ND	ND	ND	4.03	0.53	5.0
SLR @ Sycamore Grove	ND	5.18	ND	ND	ND	ND	4.34	0.85	5.2
Branciforte u/s of SLR	3.72	5.79	5.2	ND	ND	ND	4.95	3.72	5.8
B'forte u/s of Carbonera	2.87	2.3	ND	ND	ND	ND	4.20	2.30	5.0
Carbonera u/s of B'forte	ND	1.7	ND	ND	ND	ND	3.71	0.55	5.0
Monthly averages:	1.95	4.28	5.03	ND	ND	ND			
Sitosterol									
San Lorenzo R. @ Trestle	238	1090	130.4	311.9	151.4	187.6	352	130.4	1090
San Lorenzo R. @ Tait	431	607	205.4	252.1	101.3	127.7	287	101.3	607
SLR @ Sycamore Grove	370	702	224.2	219.2	149.2	128.5	299	128.5	702
Branciforte u/s of SLR	835	1360	225	814.1	331.1	271.3	639	225.0	1360
B'forte u/s of Carbonera	627	1020	329.8	304.8	312.1	175	461	175.0	1020
Carbonera u/s of B'forte	585	1500	371.8	294.7	198.7	163.9	519	163.9	1500
Monthly averages:	514	1047	248	366	207	176			
Stigmasterol									
San Lorenzo R. @ Trestle	98	1940	67.9	466.3	132.9	58.0	461	58.0	1940
San Lorenzo R. @ Tait	115	251	82.8	110.4	28.8	47.1	106	28.8	251
SLR @ Sycamore Grove	93.6	295	82.1	83.8	43.7	34.3	105	34.3	295
Branciforte u/s of SLR	331	1860	198.8	562	195.3	98.2	541	98.2	1860
B'forte u/s of Carbonera	192	389	106.3	97.8	74.0	47.3	151	47.3	389
Carbonera u/s of B'forte	209	457	122.6	115.8	64.3	74.6	174	64.3	457
Monthly averages:	173	865	110	239	89.8	59.9			
Caffeine									
San Lorenzo R. @ Trestle	ND	ND	ND	ND	ND	ND	ND	ND	ND
San Lorenzo R. @ Tait	ND	ND	ND	ND	ND	ND	ND	ND	ND
SLR @ Sycamore Grove	ND	ND	ND	ND	ND	ND	ND	ND	ND
Branciforte u/s of SLR	ND	ND	ND	ND	ND	ND	ND	ND	ND
B'forte u/s of Carbonera	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbonera u/s of B'forte	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes: NA = not analyzed; ND = not detected
For results reported by lab as ND, values substituted with 1/2 RL for calculation of statistics

Table 2. Fecal Indicator Bacteria and Human Bacteroides Analytical Results, 2014 Monitoring

Constituent/Site ID	Sample Collection Date						Descriptive Statistics*		
Total Coliform (MPN/100 mL)	**5/21/14**	**6/19/14**	**7/17/14**	**8/18/14**	**9/15/14**	**10/15/14**	**GeoMean**	**Min.**	**Max.**
San Lorenzo R. @ Trestle	2046	6488	9804	1421	>24196	19863	6680	1421.0	24196
San Lorenzo R. @ Tait	689	1467	1376	1401	2247	882	1253	689.0	2247
SLR @ Sycamore Grove	933	1439	1860	1793	3255	7270	2175	933.0	7270
Branciforte u/s of SLR	6867	24196	>24196	12997	12997	>24196	15945	6867.0	24196
B'forte u/s of Carbonera	637	2046	1296	2046	4884	1515	1716	637.0	4884
Carbonera u/s of B'forte	3654	3448	4611	3873	4352	6867	4344	3448.0	6867
Monthly Geometric Means:	1661	3643	3920	2677	6047	5636			
***E.coli* (MPN/100 mL)**									
San Lorenzo R. @ Trestle	97	355	313	<5	295	495	141	5.0	495
San Lorenzo R. @ Tait	31	41	189	134	97	109	84	31.0	189
SLR @ Sycamore Grove	146	20	548	20	84	820	114	20.0	820
Branciforte u/s of SLR	2481	63	388	30	609	>24196	547	30.0	24196
B'forte u/s of Carbonera	203	75	52	30	73	121	77	30.0	203
Carbonera u/s of B'forte	195	624	784	763	2909	1291	806	195.0	2909
Monthly Geometric Means:	187	97	283	46	260	742			
***Enterococcus* (MPN/100 mL)**									
San Lorenzo R. @ Trestle	<5	31	10	<5	52	<5	11	5.0	52
San Lorenzo R. @ Tait	10	20	31	31	52	41	27	10.0	52
SLR @ Sycamore Grove	10	10	52	<5	98	3076	45	5.0	3076
Branciforte u/s of SLR	41	20	52	20	41	4106	72	20.0	4106
B'forte u/s of Carbonera	109	185	171	98	110	86	121	86.0	185
Carbonera u/s of B'forte	10	183	189	173	521	2909	212	10.0	2909
Monthly Geometric Means:	17	40	55	25	92	294			
***Bacteroides* (µg/µL)**									
San Lorenzo R. @ Trestle	ND	ND	ND	ND	ND	ND			
San Lorenzo R. @ Tait	ND	ND	ND	ND	ND	ND			
SLR @ Sycamore Grove	ND	ND	ND	ND	ND	ND			
Branciforte u/s of SLR	ND	ND	ND	ND	ND	ND			
B'forte u/s of Carbonera	ND	ND	ND	ND	4 X 10-8	ND			
Carbonera u/s of B'forte	4 x 10-9	ND	ND	4 X 10-8	ND	ND			

Notes: ND=result was reported as not detected, or as not quantified below a specified level of detection; GeoMean=geometric mean
* For constituent means/maxima and monthly averages, "<" and ">" values as shown are used directly in the computations

Table 3. Human and Avian Fecal Indicator Ratios from 6-Month Mean Concentrations, 2014 data

	Ratios per Ahmed et al. (2011) Based on 2014 Measured Means		
	Coprostanol/ Cholestanol	Coprostanol/ (Coprostanol+ Cholestanol)	Cholestanol/ (Coprostanol+ Cholestanol+ Epicoprostanol)
Site	(c/ch)	c/(c+ch)	ch/(c+ch+e)
San Lorenzo R. @ Trestle	0.13	0.11	85%
San Lorenzo R. @ Tait	0.24	0.19	76%
SLR @ Sycamore Grove	0.51	0.34	62%
Branciforte u/s of SLR	0.19	0.16	82%
B'forte u/s of Carbonera	0.22	0.18	76%
Carbonera u/s of B'forte	0.18	0.16	79%
Shading Indicates:			
Human Fecal Indicator:	>0.5 [Ahmed Ratio 1]	>0.7 [Ahmed Ratio 4]	
Avian Fecal Indicator:			>67% [Ahmed Ratio 10]

Table 4. Human Fecal Indicator Ratio #1 (Ahmed et al., 2011) Based on Individual Concentrations, 2014 data

	Coprostanol:Cholestanol Ratios by Sample Collection Date					
Site	**5/21/14**	**6/19/14**	**7/17/14**	**8/18/14**	**9/15/14**	**10/15/14**
			Est. from Cholestanol means			
San Lorenzo R. @ Trestle	0.13	0.17	*0.10*	*0.09*	0.11	0.09
San Lorenzo R. @ Tait	0.09	0.40	*0.20*	*0.21*	0.26	0.28
SLR @ Sycamore Grove	0.10	1.56	*0.13*	*0.21*	0.15	0.24
Branciforte u/s of SLR	0.05	0.20	*0.27*	*0.10*	0.11	0.72
B'forte u/s of Carbonera	0.35	0.20	*0.24*	*0.13*	0.14	0.18
Carbonera u/s of B'forte	0.21	0.13	*0.11*	*0.21*	0.32	0.19
Monthly averages:	0.15	0.44	*0.18*	*0.16*	0.18	0.28

Shading Indicates:

Human Fecal Indicator: ratio >0.5 [Ratio 1 from Ahmed et al. 2011, Table 21.2]

Table 5. Human Fecal Indicator Ratio #4 (Ahmed et al., 2011) Based on Individual Concentrations, 2014 data

	Coprostanol:(Cholestanol+Coprostanol) Ratios by Sample Collection Date					
Site	**5/21/14**	**6/19/14**	**7/17/14**	**8/18/14**	**9/15/14**	**10/15/14**
			Est. from Cholestanol means			
San Lorenzo R. @ Trestle	0.12	0.15	*0.09*	*0.08*	0.10	0.08
San Lorenzo R. @ Tait	0.08	0.29	*0.17*	*0.18*	0.20	0.22
SLR @ Sycamore Grove	0.09	0.61	*0.12*	*0.18*	0.13	0.19
Branciforte u/s of SLR	0.05	0.16	*0.21*	*0.09*	0.10	0.42
B'forte u/s of Carbonera	0.26	0.17	*0.19*	*0.11*	0.12	0.15
Carbonera u/s of B'forte	0.17	0.11	*0.10*	*0.17*	0.24	0.16
Monthly averages:	0.13	0.25	*0.15*	*0.14*	0.15	0.20

Shading Indicates:

Human Fecal Indicator: ratio >0.7 [Ratio 4 from Ahmed et al. 2011, Table 21.2]

Table 6. Avian Fecal Indicator Ratio #10 (Ahmed et al., 2011) Based on Individual Concentrations, 2014 data

	Cholestanol:(Cholestanol+Coprostanol+Epicoprostanol) Ratios by Sample					
Site	**5/21/14**	**6/19/14**	**7/17/14**	**8/18/14**	**9/15/14**	**10/15/14**
			Est. from Cholestanol means			
San Lorenzo R. @ Trestle	86%	83%	*87%*	*88%*	82%	84%
San Lorenzo R. @ Tait	91%	69%	*76%*	*76%*	66%	64%
SLR @ Sycamore Grove	90%	38%	*81%*	*76%*	77%	68%
Branciforte u/s of SLR	94%	82%	*77%*	*88%*	86%	56%
B'forte u/s of Carbonera	72%	81%	*74%*	*81%*	78%	74%
Carbonera u/s of B'forte	82%	87%	*82%*	*76%*	67%	73%
Monthly averages:	0.86	0.73	*0.80*	*0.81*	0.76	0.70

Shading Indicates:

Avian Fecal Indicator: ratio >67% [Ratio 10 from Ahmed et al. 2011, Table 21.2]

Table 7. Highest Monthly Levels and 6-Month Means, Fecal Indicator Bacteria and Human Bacteroides Results

	-- Highest Monthly FIB Levels --			***Bacteroides***
Sample Date	**Total coliform**	***E. coli***	***Enterococcus***	**Hits (Quantified)**
5/21/14	B'forte u/s of SLR	B'forte u/s of SLR	B'forte u/s of Carb.	Carbonera Cr.
6/19/14	B'forte u/s of SLR	Carbonera Cr.	B'forte u/s of Carb.	-
7/17/14	B'forte u/s of SLR	Carbonera Cr.	Carbonera Cr.	-
8/18/14	B'forte u/s of SLR	Carbonera Cr.	Carbonera Cr.	Carbonera Cr.
9/15/14	SLR @ Trestle Br.	Carbonera Cr.	Carbonera Cr.	B'forte u/s of Carb.
10/15/14	B'forte u/s of SLR	B'forte u/s of SLR	B'forte u/s of SLR	-
	-- Highest 6-Month FIB Levels --			
Highest 6 Mo. GeoMean:	B'forte u/s of SLR	Carbonera Cr.	Carbonera Cr.	
Highest 6 Mo. Max:	B'forte u/s of SLR	B'forte u/s of SLR	B'forte u/s of SLR	

Table 8. Correlation Coefficients (r and r^2) for Selected Parameters

	Coprostanol		**Coprostanol/ Cholestanol [Ahmed et al. Ratio #1]**		**Cholestanol/ (Cholestanol+ Coprostanol+ Epicoprostanol) [Ahmed et al. Ratio #10]**	
	r	**r-squared**	**r**	**r-squared**	**r**	**r-squared**
Total Coliform	0.23	0.052	-0.01	0.000	0.05	0.003
E.coli	0.28	0.078	0.31	0.093	-0.33	0.111
Enterococcus	0.10	0.011	0.22	0.047	-0.38	0.148