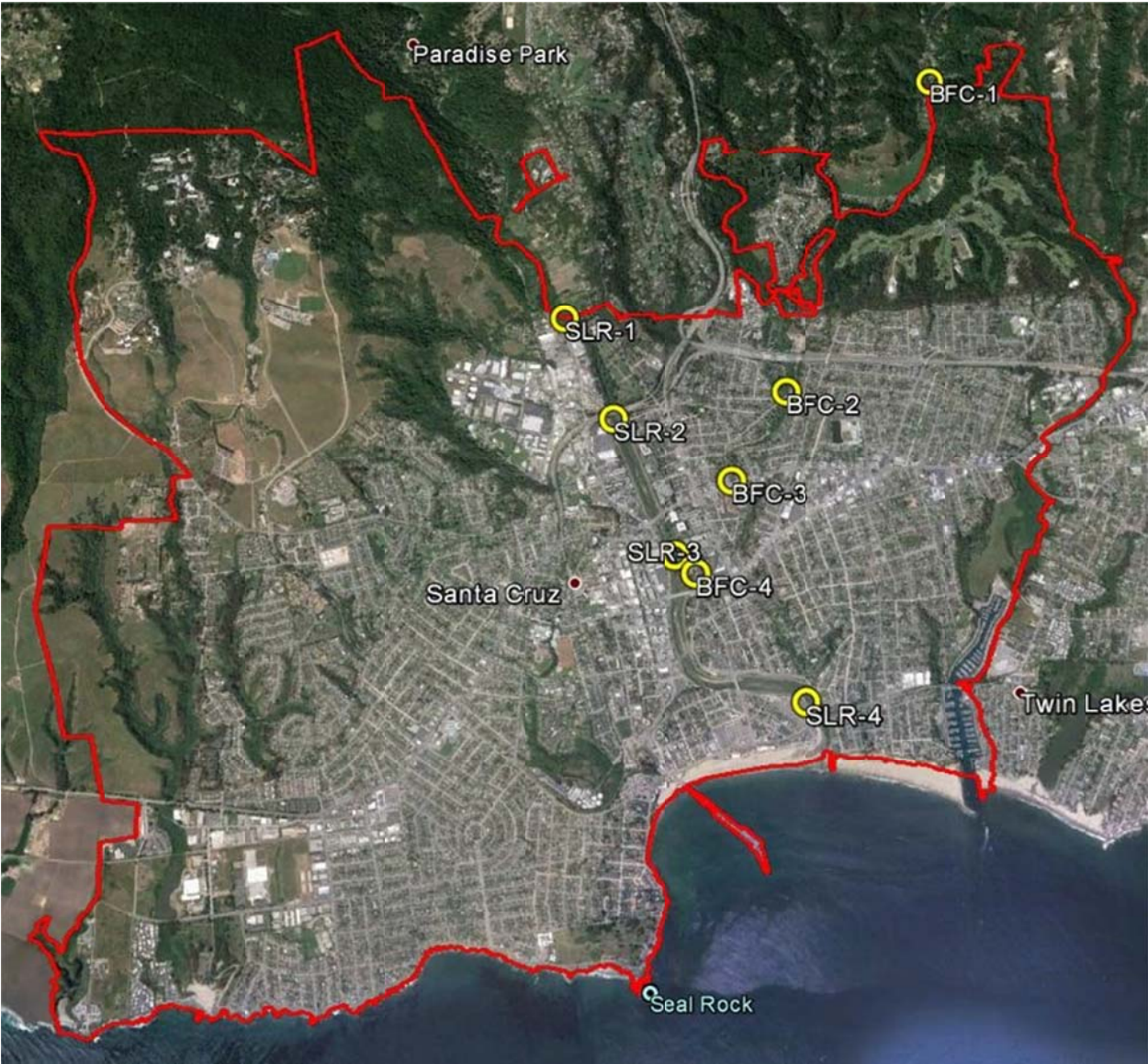


Monitoring of Waterborne Indicator Bacteria and Nutrients within San Lorenzo River and Branciforte Creek

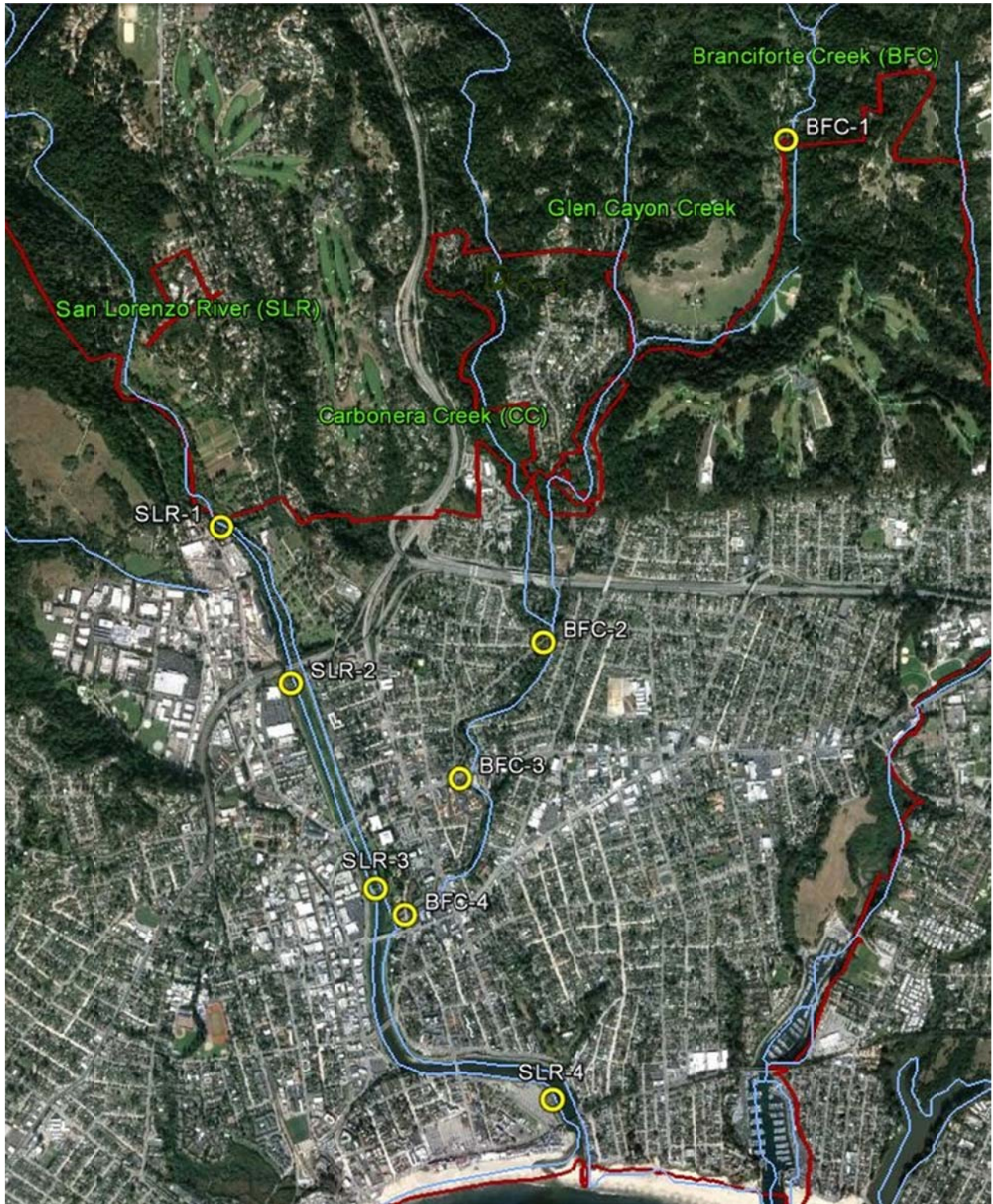
Performed by the Santa Cruz City Wastewater Treatment Facility

2015

Sample locations include four along the San Lorenzo River and four along Branciforte Creek.







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## Executive Summary

The City has implemented its monitoring program in San Lorenzo River (SLR) since the promulgation of the TMDL for pathogens in 2010, to both (a) develop information on the trends of bacteria levels order to assess the effectiveness of the interventions and management practices implemented; and (b) develop information for controlling anthropogenic sources of the bacteria so as to subsequently implement measures to affect those and other identifiable controllable sources of bacteria in the river.

The City samples and analyzes for indicator bacteria along the San Lorenzo River from Tate Street and from the Branciforte Creek junction through the SLR estuary into the ocean. The City also initiated testing for domestic sources of bacteria by directly monitoring for caffeine associated with high Fecal Indicator Bacteria (FIB) in the river, and by working within a regional framework to identify Fecal sterols associated with high FIB in the river. In 2015, the City added the analyses of sediments and nutrients to aid in the unraveling of the emerging bacteria profile in the lower San Lorenzo River.

The current study reports concentration of enterococcus, fecal coliform, and total coliform bacteria at locations within the San Lorenzo River and Branciforte Creek within city limits between July 2014 and July 2015. A log mean calculation, requiring five samples collected within a 30 day window, yields a total of 64 data points for each fecal coliform and enterococcus. This recent data comprise approximately 312 measurements from 8 different sites during this time frame and complement existing data from previous years in the included plots.

To explore the seasonal nature of local water quality, this study plots the log mean bacterial concentration versus the calendar year for each sampling site.

In the first quarter of 2015, the City of Santa Cruz studied fecal coliform and enterococcus concentrations within the San Lorenzo River and Branciforte Creek. Results show the water quality to be in keeping with results observed in previous years, e.g., pp. 6 & 18.

In the second quarter of 2015, the City of Santa Cruz added new parameters to the surface water monitoring protocol in order to investigate suspended sediment as well as nutrient loads within the San Lorenzo River and Branciforte Creek. Total suspended solids,

nitrate, ortho-phosphate, and ammonia are parameters which may indicate conditions favorable to bacterial transport and growth within surface waters. As a result of this investigation, we can see that suspended sediments, as well as nutrients, are detectable and similar within San Lorenzo River and Branciforte Creek. These may support some bacterial transport and growth within the water body upon fecal deposit.

Overall, the City monitoring program results indicate the following:

1. Bacteria levels generally increase as the river courses through the City to and through the estuary;
2. Bacteria concentrations from Branciforte Creek into the river are very high and would be expected to keep the river's bacteria levels high in spite of interventions taken within the lower stretches of the river within the city;
3. Bacteria levels in Branciforte Creek feeding into lower San Lorenzo River increase with rainfall events, and can be expected to correlate with sediment inflows from Branciforte into the river.
4. Initial 6-month studies of the fecal tracer chemicals in the river indicate the preponderance of non-human sources for the bacteria, and implicate avian sources.
5. The City's data as well as other regional data sources are now leading to the conclusion that the SLR bacterial sources are largely avian, and sediment influenced.

In summary, the trends and observations are as follows:

SLR bacteria levels remain high and increase in concentration as the river courses through the city, and especially as it receives input from Branciforte Creek;

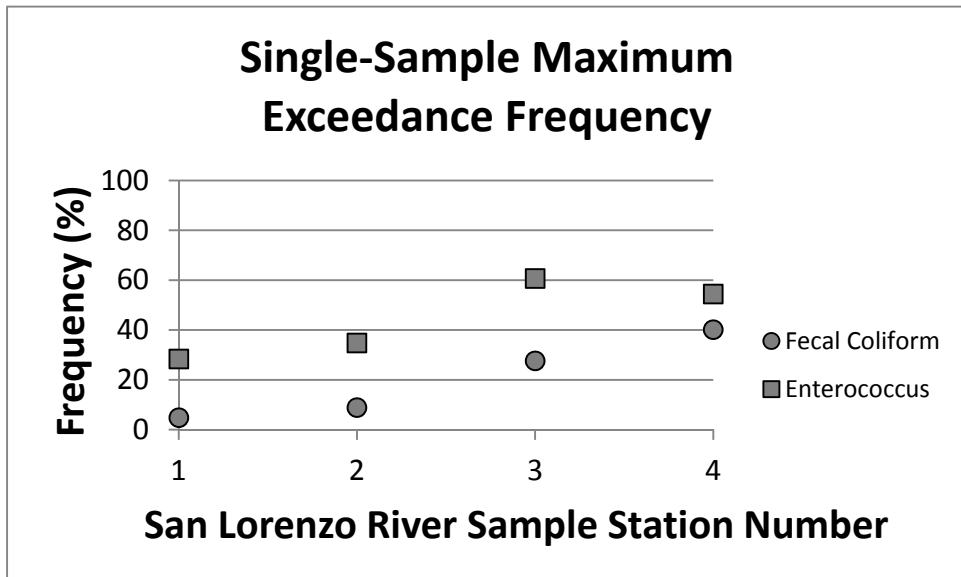
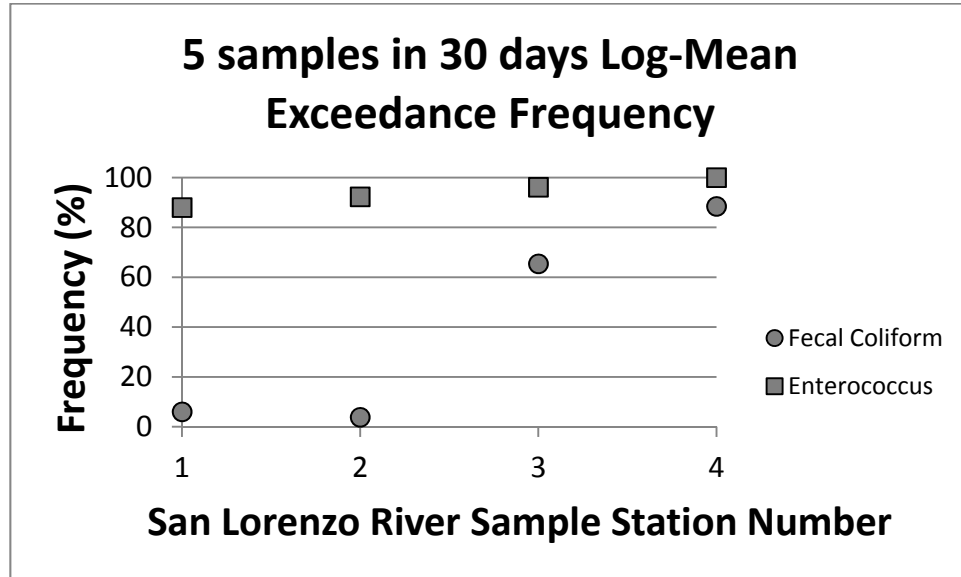
Bacteria input from Branciforte Creek is elevated post significant rainfall events, which are also likely associated with higher levels of sediment input from the creek into the river.

Highest levels of association of fecal sterols with high bacteria levels are related to avian sources, as per the finding of the San Lorenzo River Alliance funded partially by the City, with trace chemistries performed by the City and two contract laboratories.



## San Lorenzo River (SLR) Monitoring

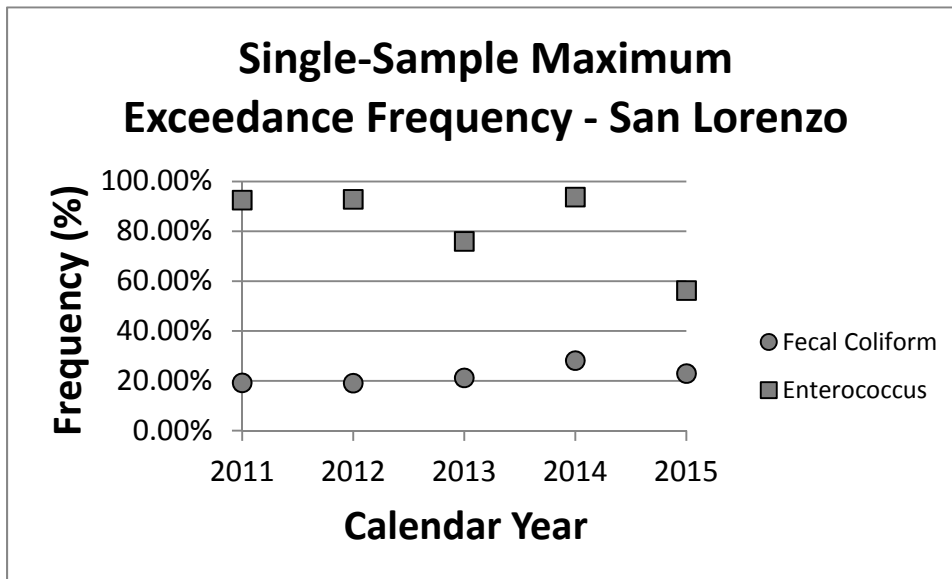
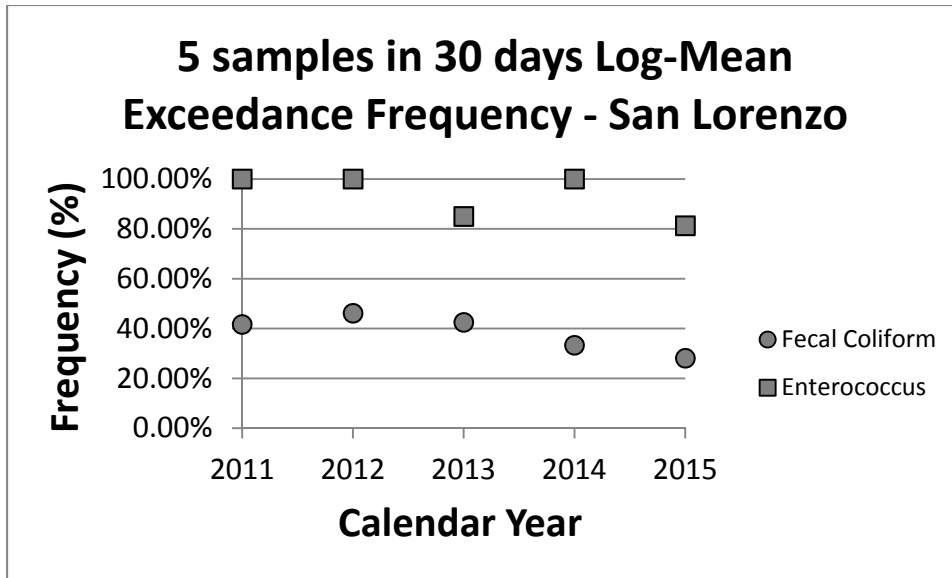
### San Lorenzo River (SLR) - Bacteria Monitoring Exceedance Frequency



The above plots show the exceedance frequency of the Log-Mean and Single-Sample Maximum limits for bacteria concentration observed at each of the four sample locations along the San Lorenzo River for all time.

Log-Mean limits: Fecal Coliform, 200 (CFU/100 mL); Enterococcus, 33 (CFU/100 mL)

Single-Sample Maximum limits: Fecal Coliform, 400 (CFU/100 mL); Enterococcus, (104 CFU/100 mL)

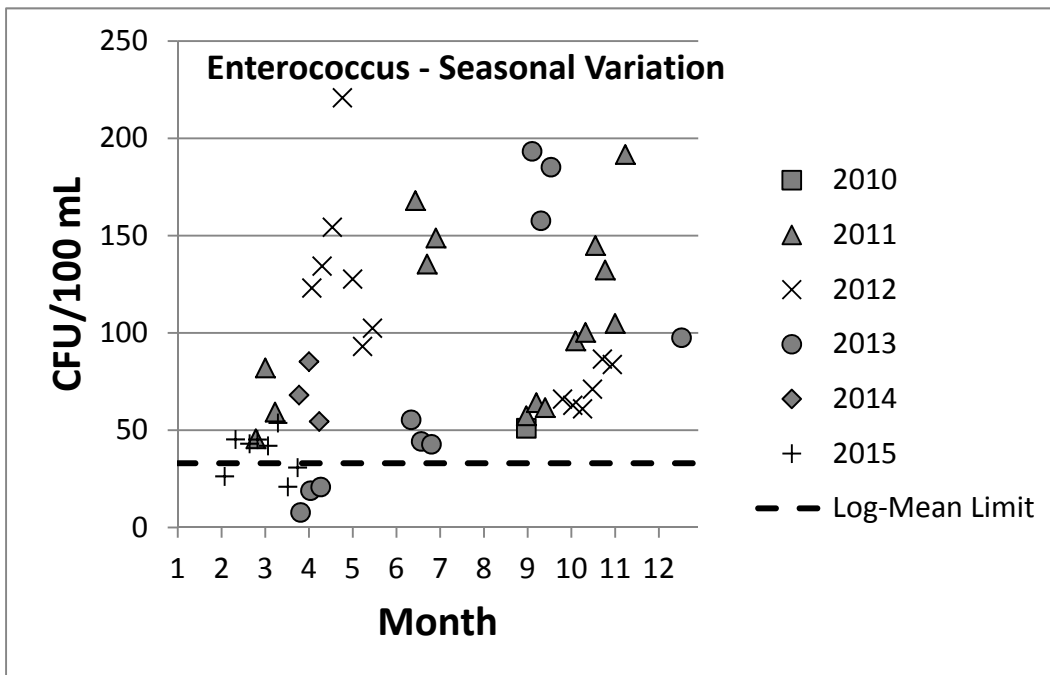
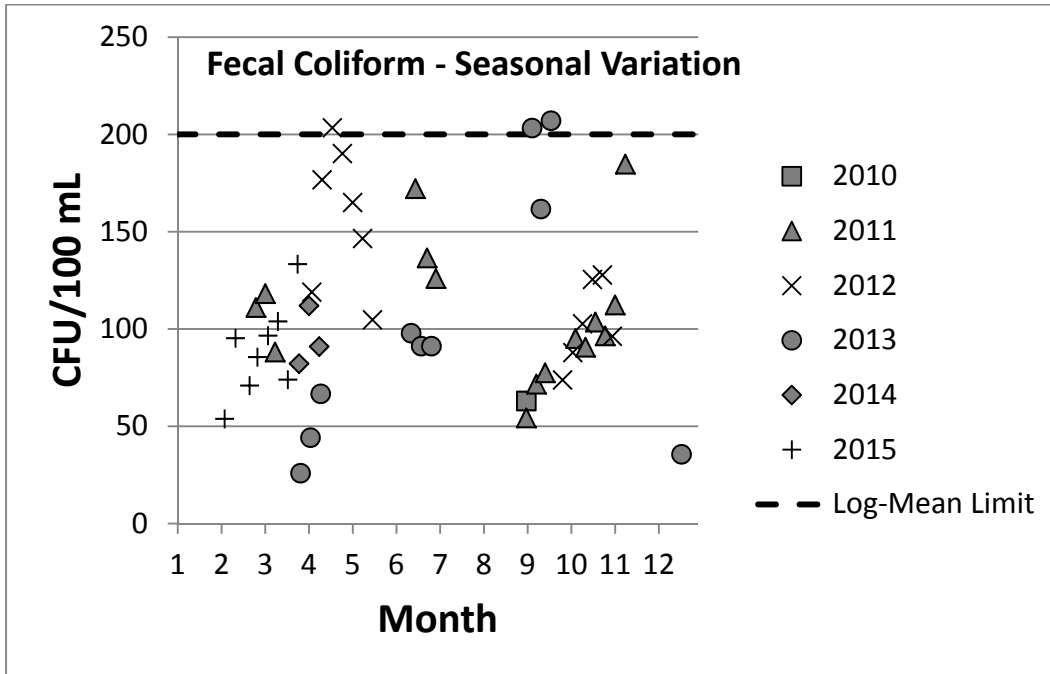


The above plots show the exceedance frequency of the Log-Mean and Single-Sample Maximum limits for bacteria concentration observed at each of the four sample locations, in sum, within the San Lorenzo River per calendar year.

Log-Mean limits: Fecal Coliform, 200 (CFU/100 mL); Enterococcus, 33 (CFU/100 mL)

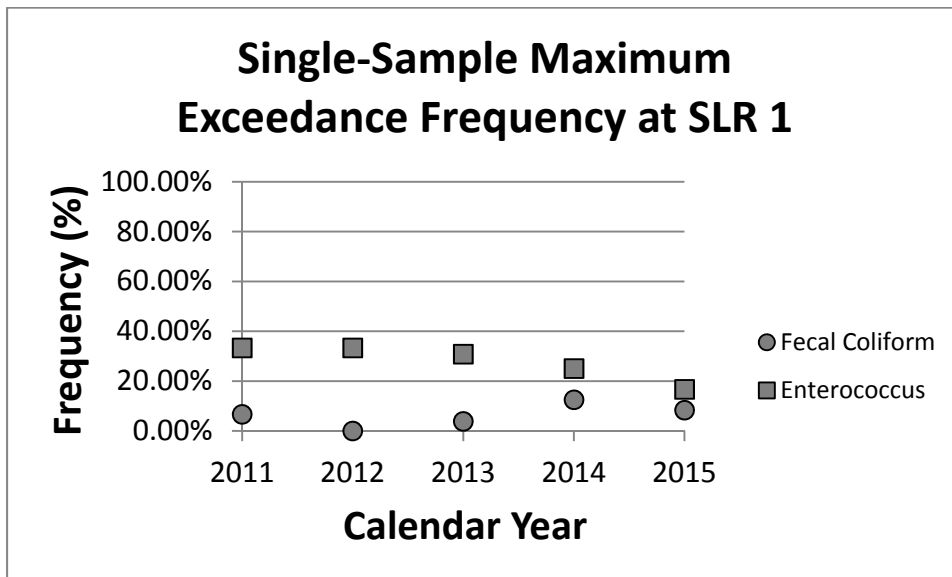
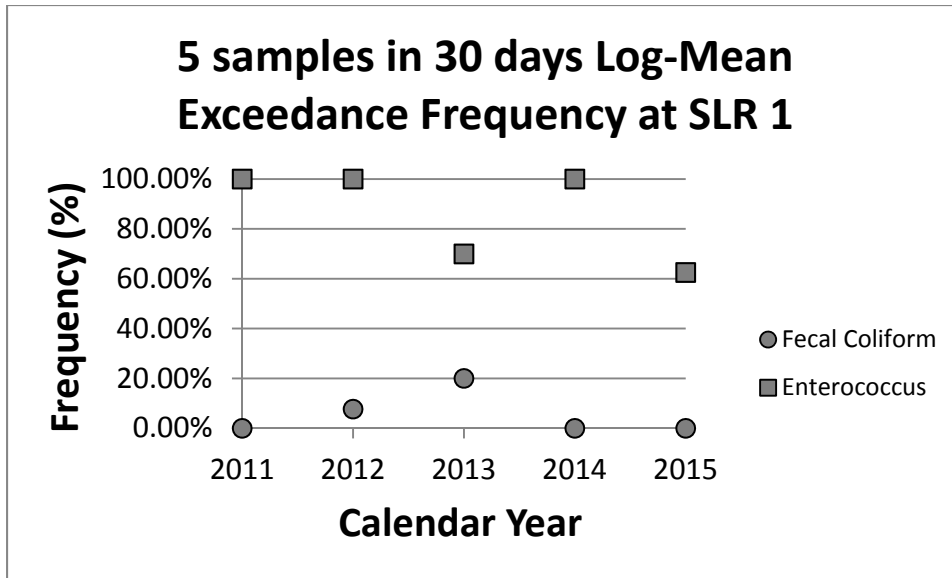
Single-Sample Maximum limits: Fecal Coliform, 400 (CFU/100 mL); Enterococcus, (104 CFU/100 mL)

San Lorenzo River Sample Station Number 1 (SLR 1)



The above plots show the 5 samples in 30 days Log-Mean bacteria concentration observed at the sample station versus the calendar month for each year since 2010.



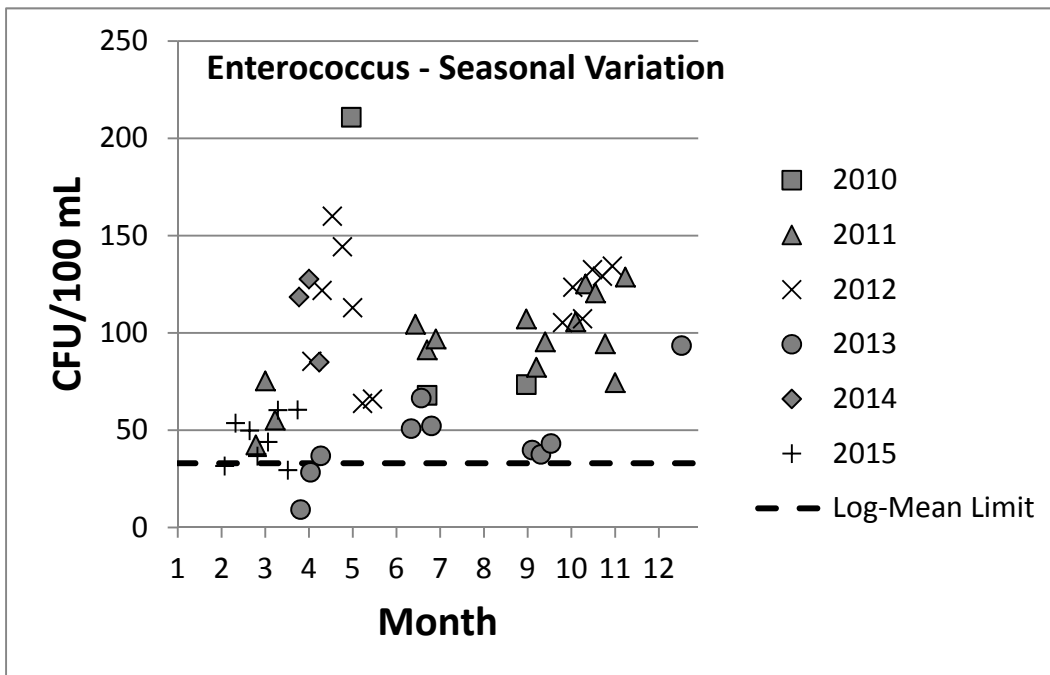
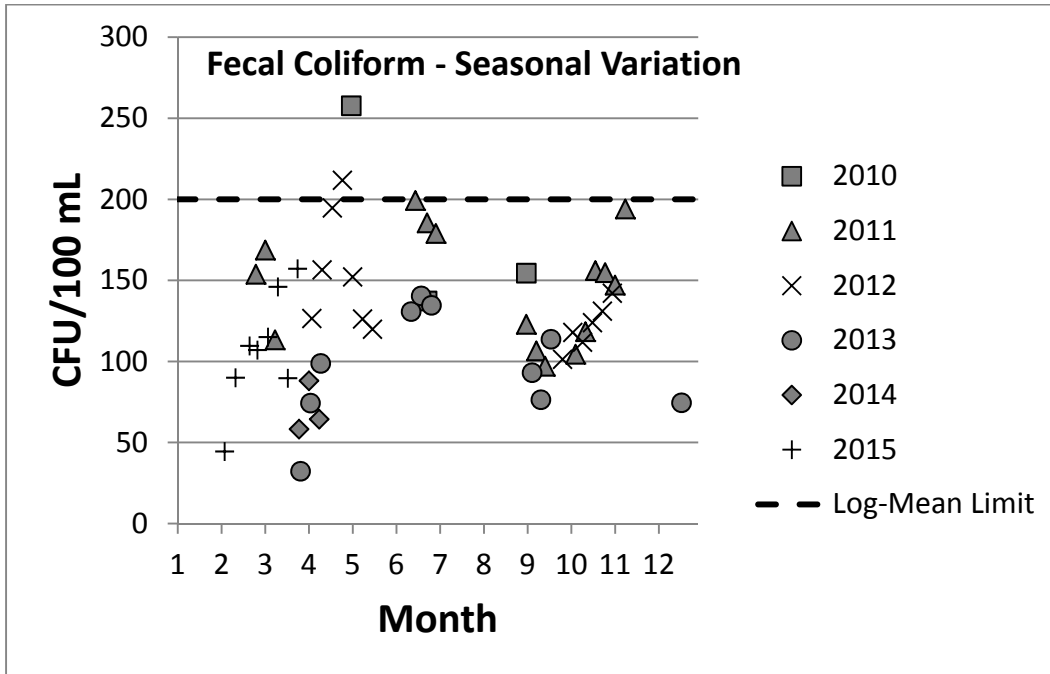


The above plots show the exceedance frequency of the Log-Mean and Single-Sample Maximum limits for bacteria concentration observed at this San Lorenzo River sample station per calendar year.

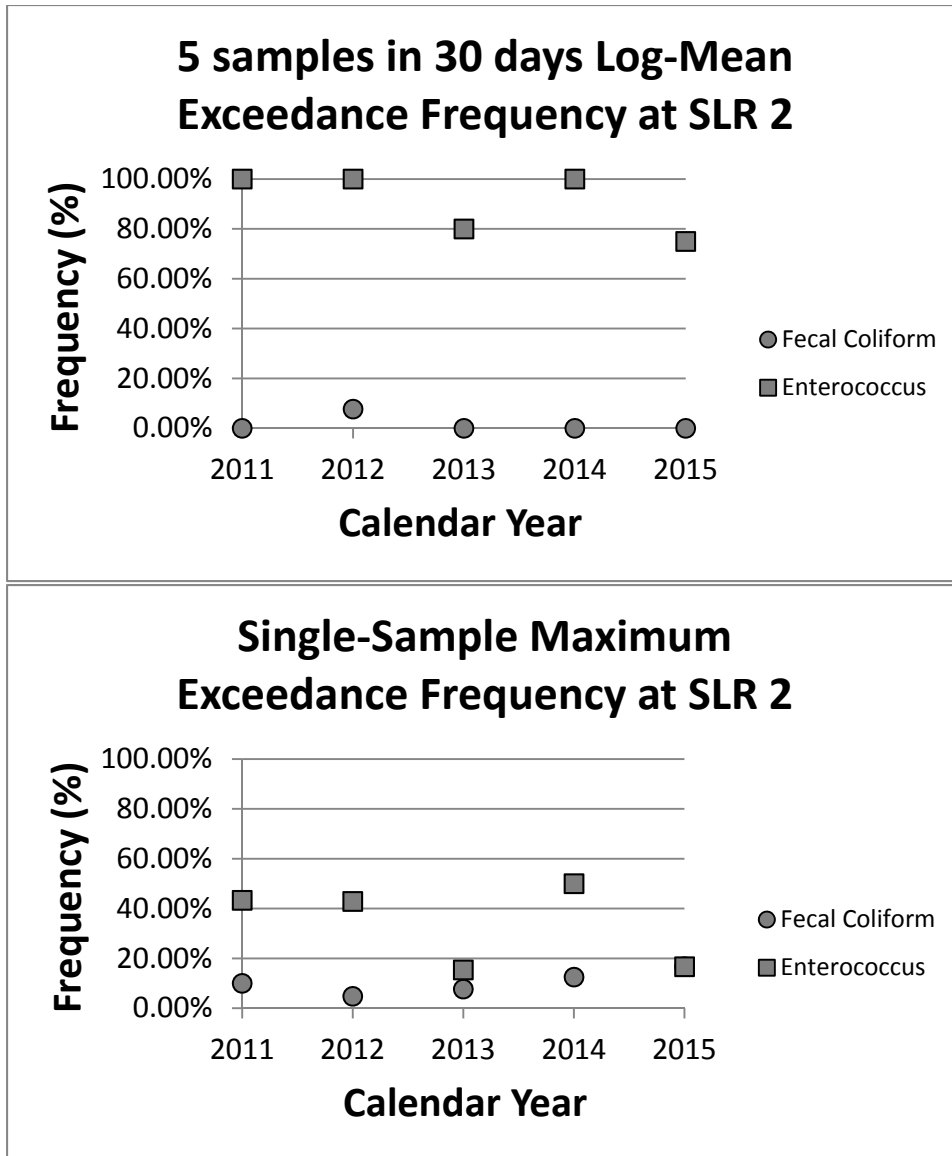
Log-Mean limits: Fecal Coliform, 200 (CFU/100 mL); Enterococcus, 33 (CFU/100 mL)

Single-Sample Maximum limits: Fecal Coliform, 400 (CFU/100 mL); Enterococcus, (104 CFU/100 mL)

San Lorenzo River Sample Station Number 2 (SLR 2)



The above plots show the 5 samples in 30 days Log-Mean bacteria concentration observed at the sample station versus the calendar month for each year since 2010.

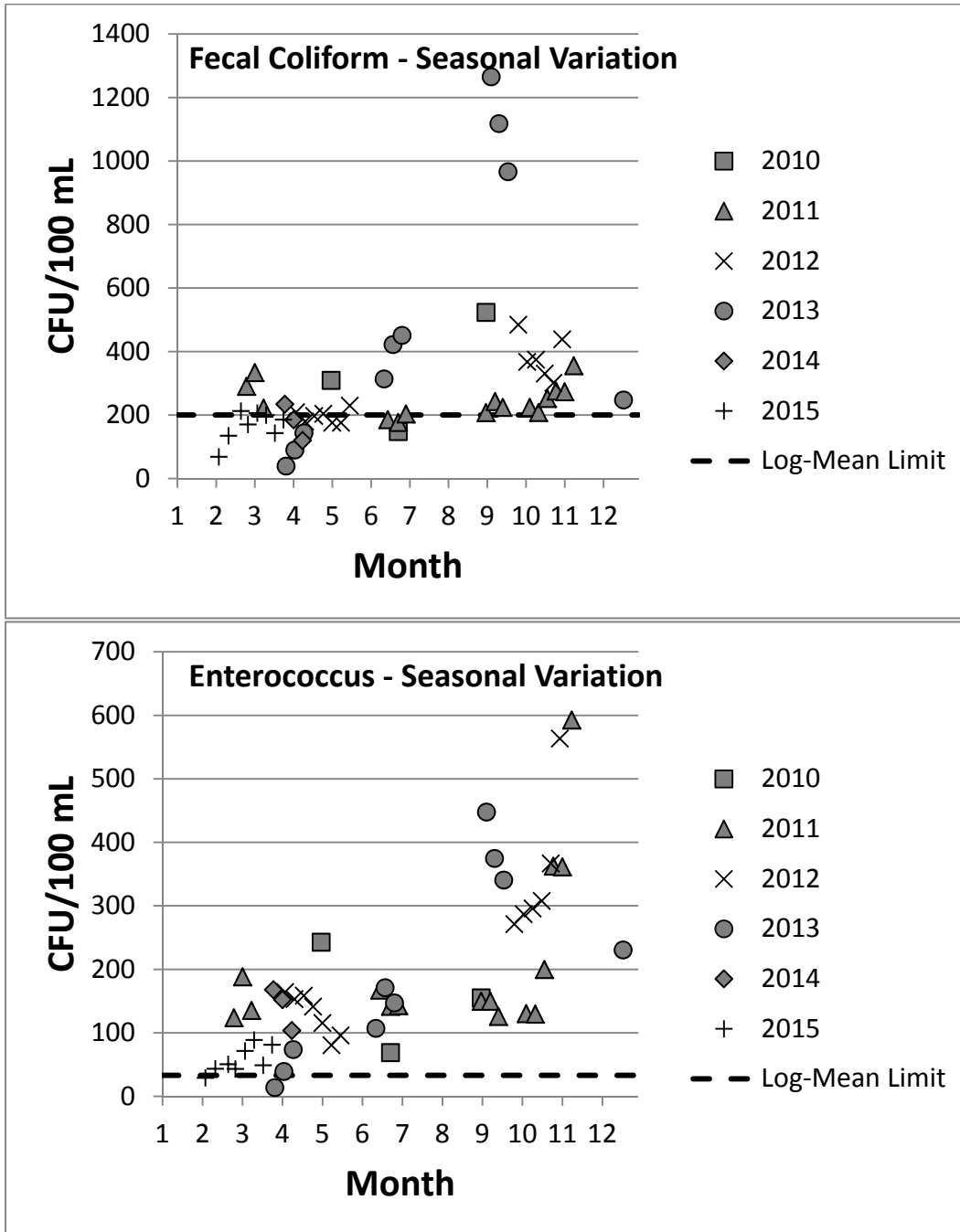


The above plots show the exceedance frequency of the Log-Mean and Single-Sample Maximum limits for bacteria concentration observed at this San Lorenzo River sample station per calendar year.

Log-Mean limits: Fecal Coliform, 200 (CFU/100 mL); Enterococcus, 33 (CFU/100 mL)

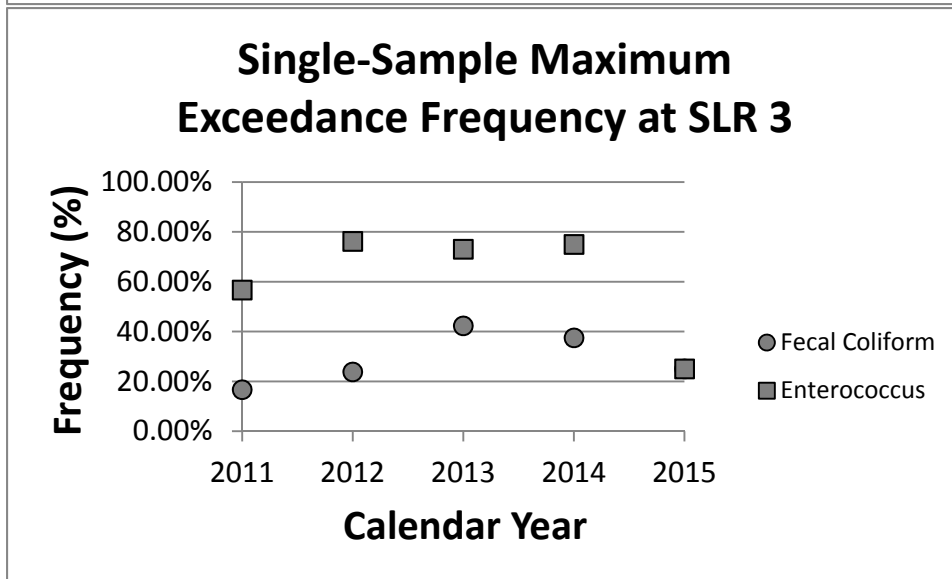
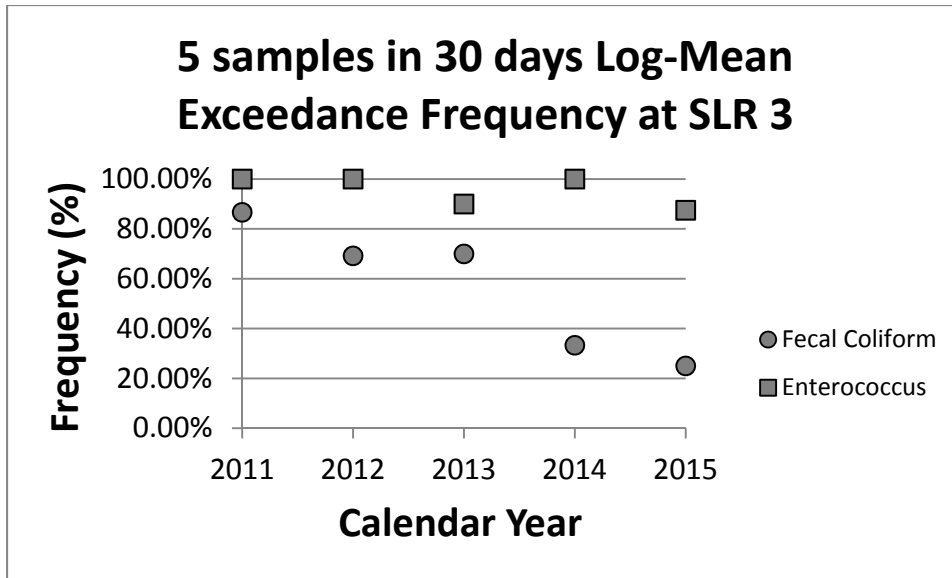
Single-Sample Maximum limits: Fecal Coliform, 400 (CFU/100 mL); Enterococcus, (104 CFU/100 mL)

### San Lorenzo River Sample Station Number 3 (SLR 3)



The above plots show the 5 samples in 30 days Log-Mean bacteria concentration observed at the sample station versus the calendar month for each year since 2010.



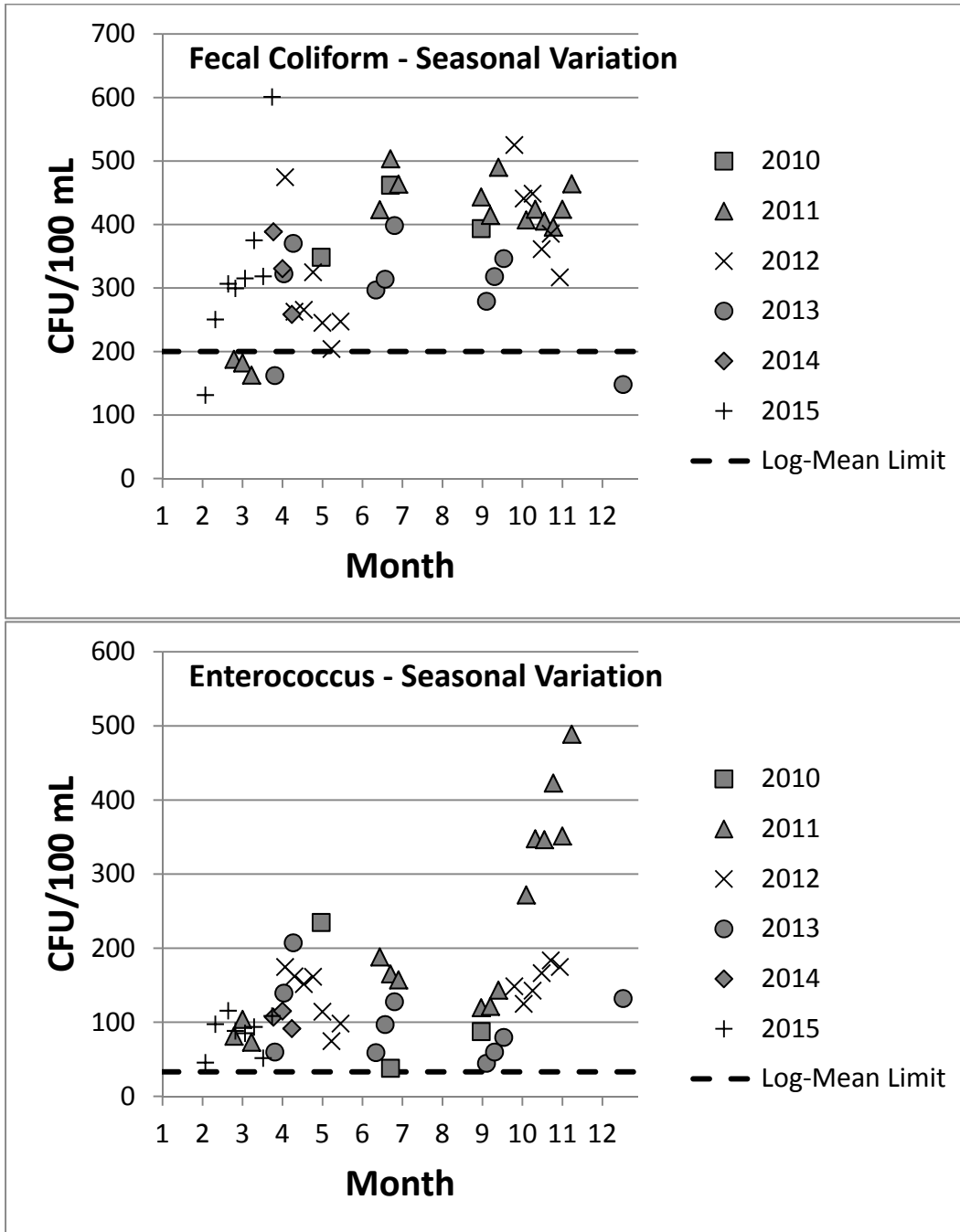


The above plots show the exceedance frequency of the Log-Mean and Single-Sample Maximum limits for bacteria concentration observed at this San Lorenzo River sample station per calendar year.

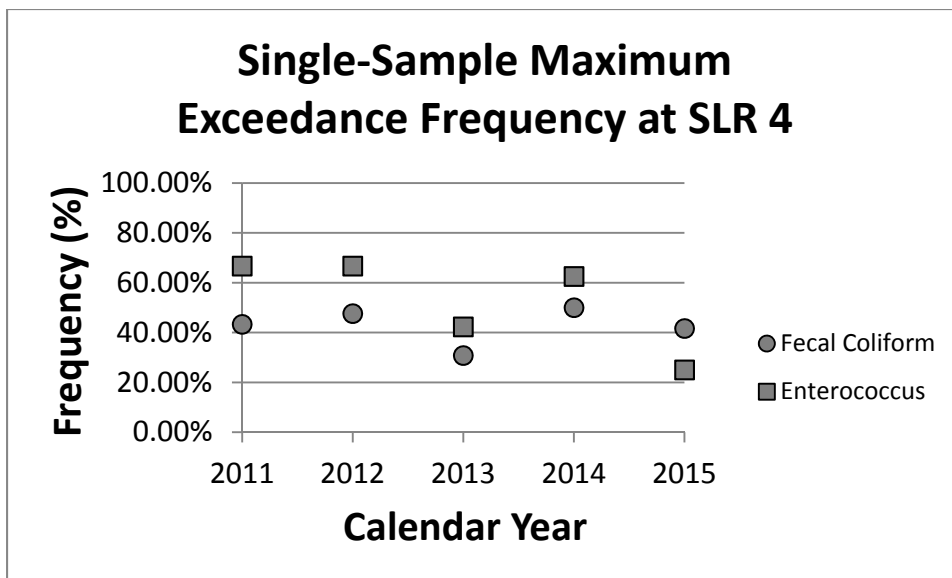
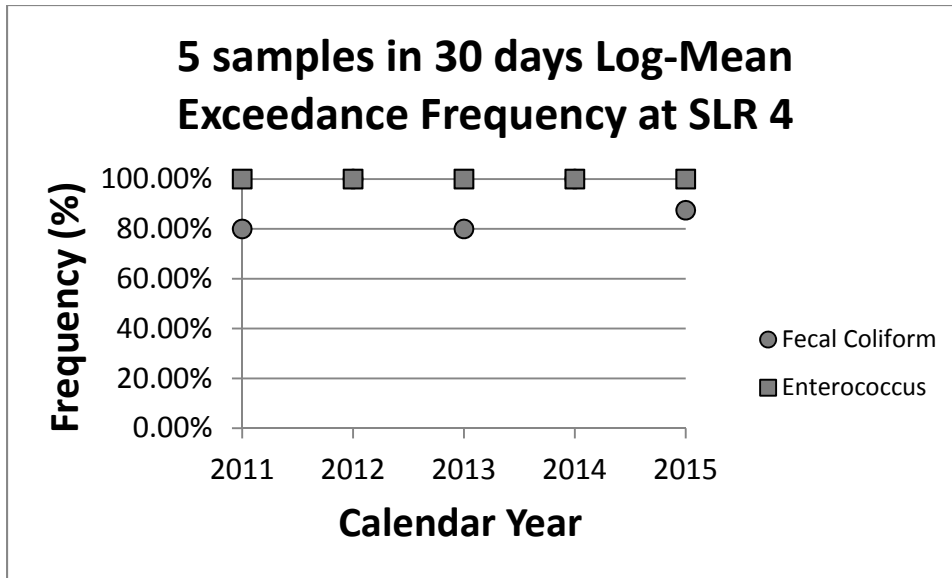
Log-Mean limits: Fecal Coliform, 200 (CFU/100 mL); Enterococcus, 33 (CFU/100 mL)

Single-Sample Maximum limits: Fecal Coliform, 400 (CFU/100 mL); Enterococcus, (104 CFU/100 mL)

San Lorenzo River Sample Station Number 4 (SLR 4)



The above plots show the 5 samples in 30 days Log-Mean bacteria concentration observed at the sample station versus the calendar month for each year since 2010.

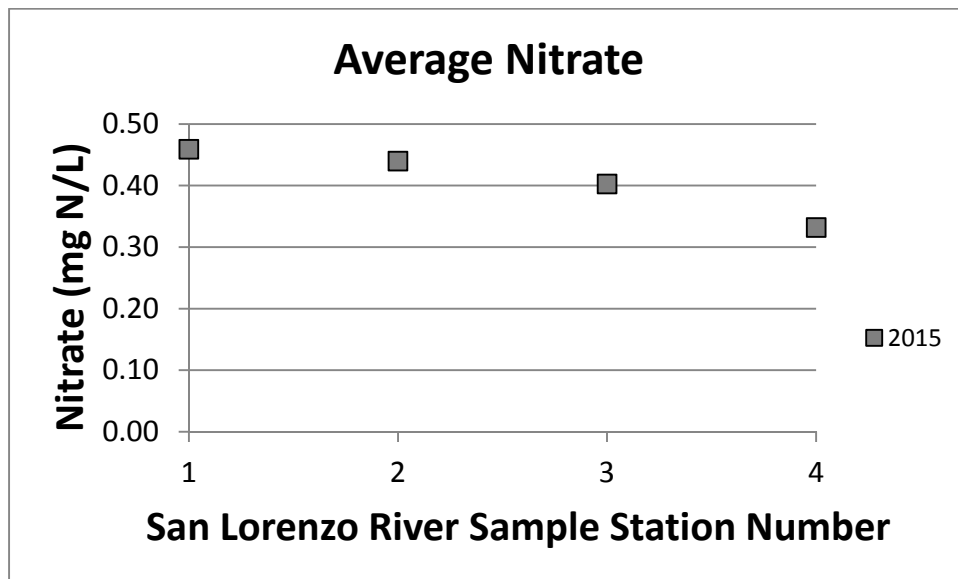
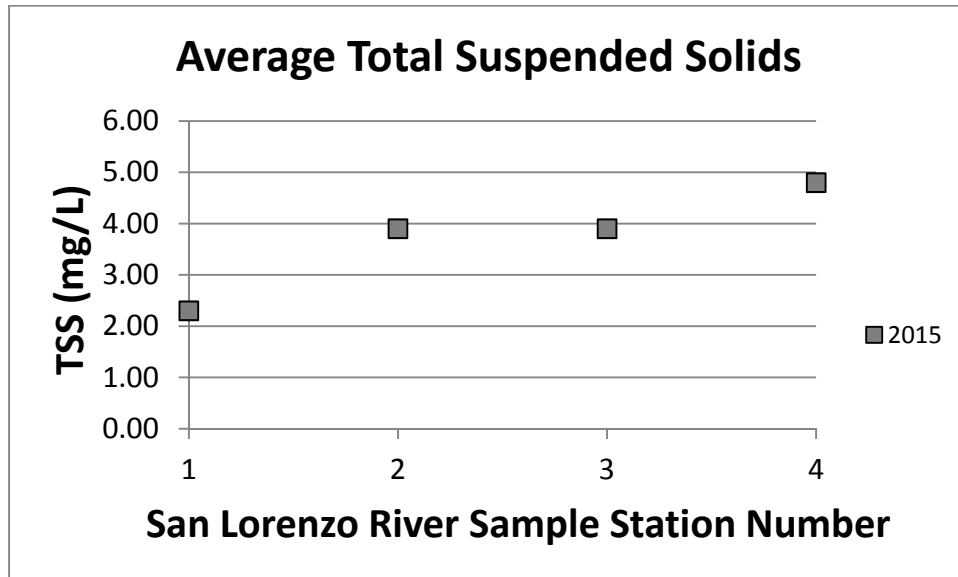


The above plots show the exceedance frequency of the Log-Mean and Single-Sample Maximum limits for bacteria concentration observed at this San Lorenzo River sample station per calendar year.

Log-Mean limits: Fecal Coliform, 200 (CFU/100 mL); Enterococcus, 33 (CFU/100 mL)

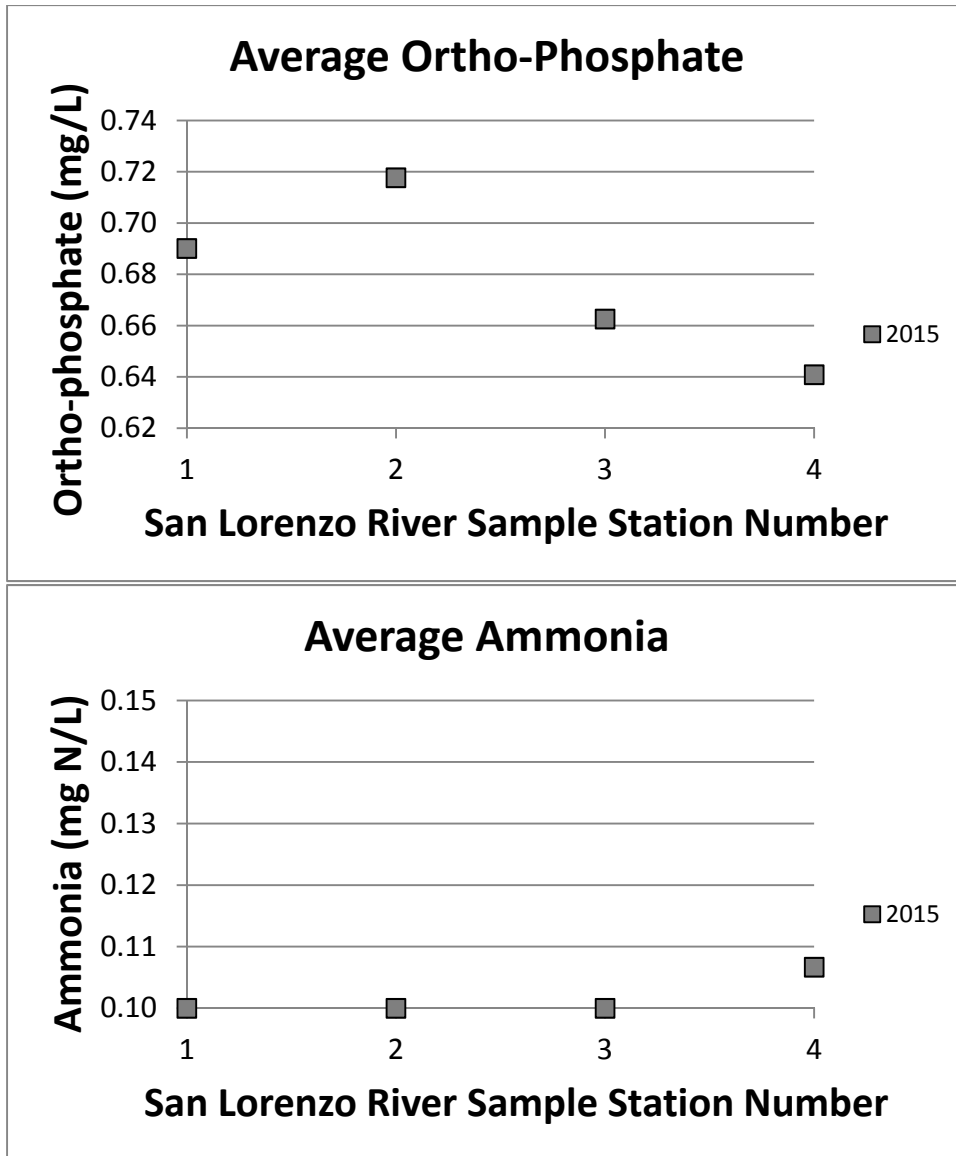
Single-Sample Maximum limits: Fecal Coliform, 400 (CFU/100 mL); Enterococcus, (104 CFU/100 mL)

## San Lorenzo River (SLR) – Sediment and Nutrient Monitoring



The above plots show the average total suspended solids (TSS) and nitrate concentration observed at each of the four sample locations along the San Lorenzo River.

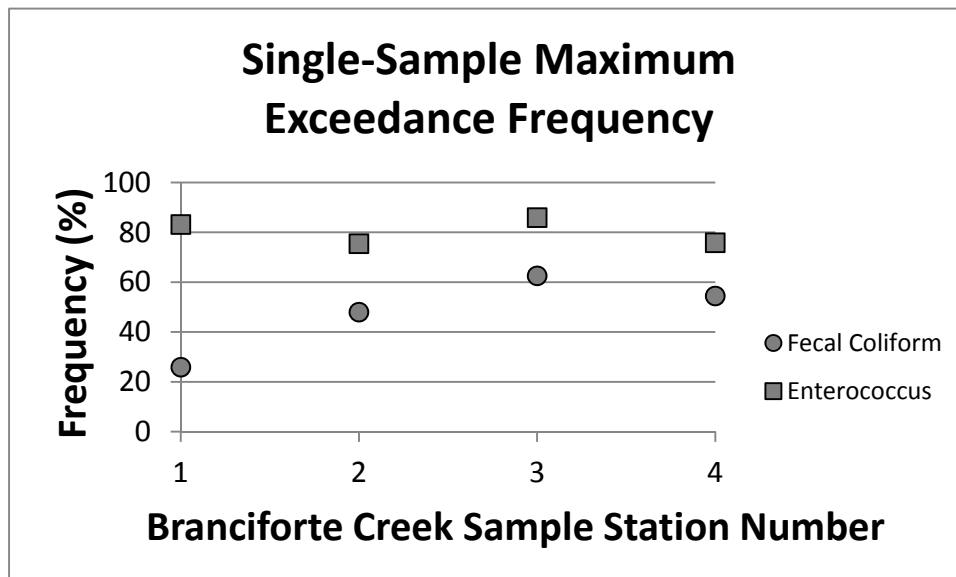
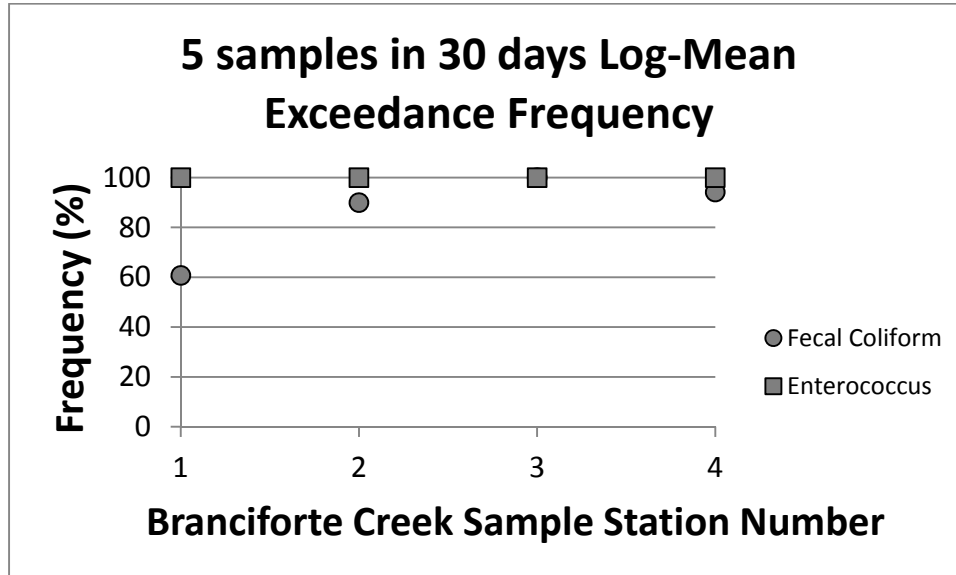




The above plots show the average ortho-phosphate and ammonia concentration observed at each of the four sample locations along the San Lorenzo River. Our chosen method to measure ammonia yields a detection limit of 0.10 (mg N/L)

## Branciforte Creek (BFC) Monitoring

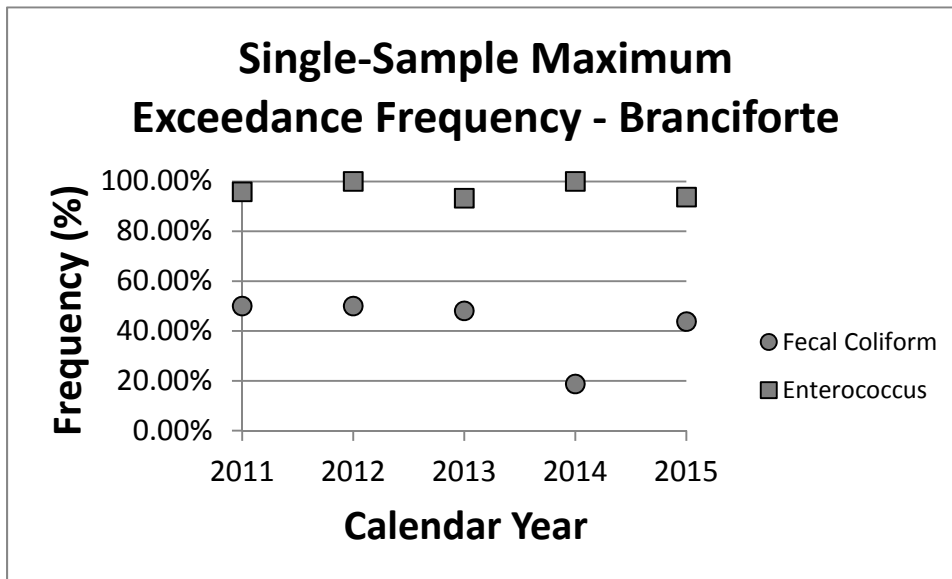
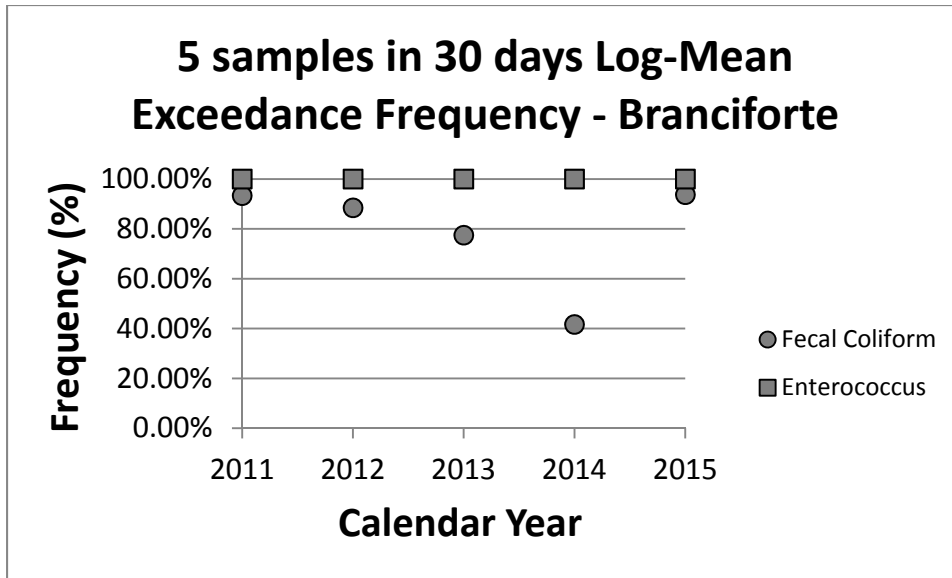
### Branciforte Creek (BFC) – Bacteria Monitoring Exceedance Frequency



The above plots show the exceedance frequency of the Log-Mean and Single-Sample Maximum limits for bacteria concentration observed at each of the four sample locations along Branciforte Creek for all time.

Log-Mean limits: Fecal Coliform, 200 (CFU/100 mL); Enterococcus, 33 (CFU/100 mL).

Single-Sample Maximum limits: Fecal Coliform, 400 (CFU/100 mL); Enterococcus, (104 CFU/100 mL)

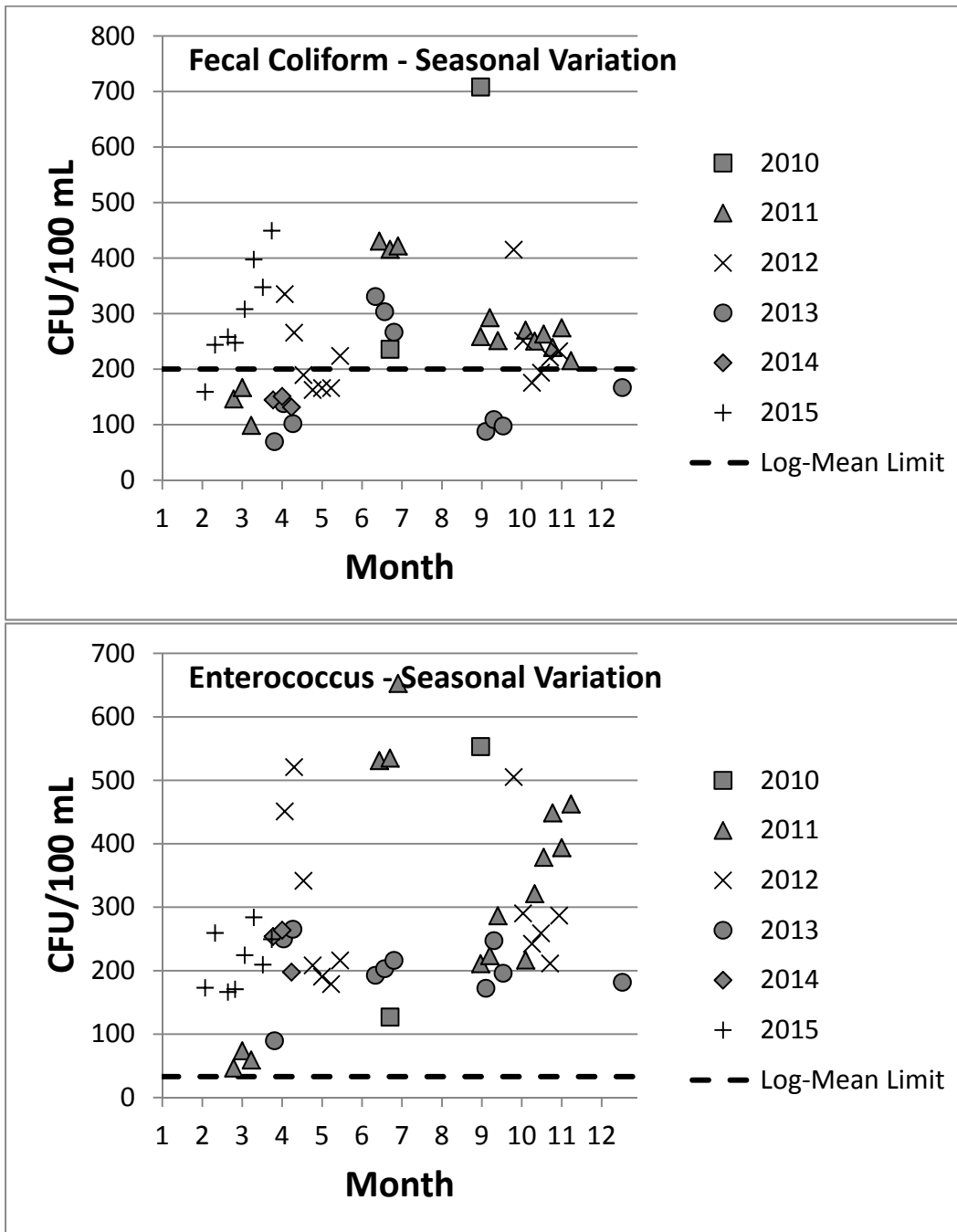


The above plots show the exceedance frequency of the Log-Mean and Single-Sample Maximum limits for bacteria concentration observed at each of the four sample locations, in sum, within Branciforte Creek per calendar year.

Log-Mean limits: Fecal Coliform, 200 (CFU/100 mL); Enterococcus, 33 (CFU/100 mL)

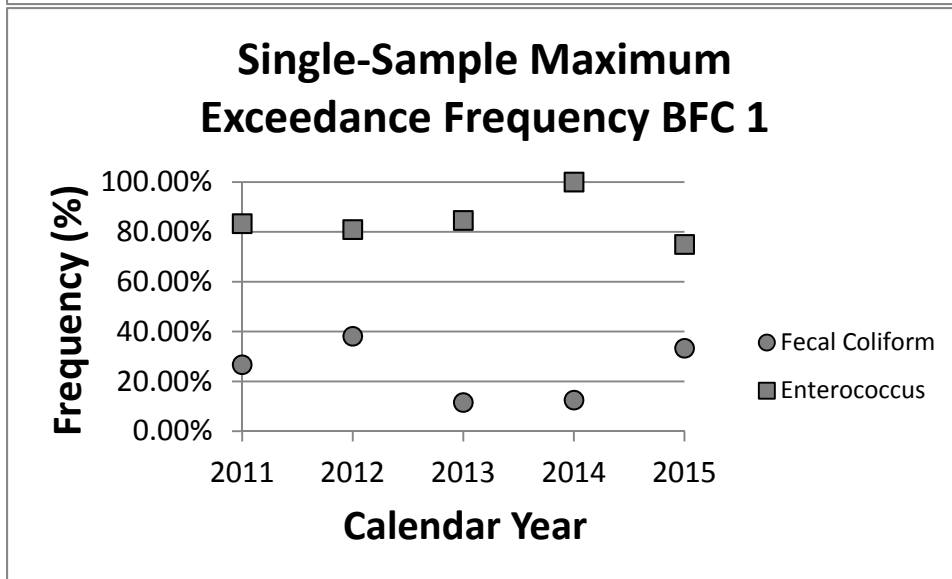
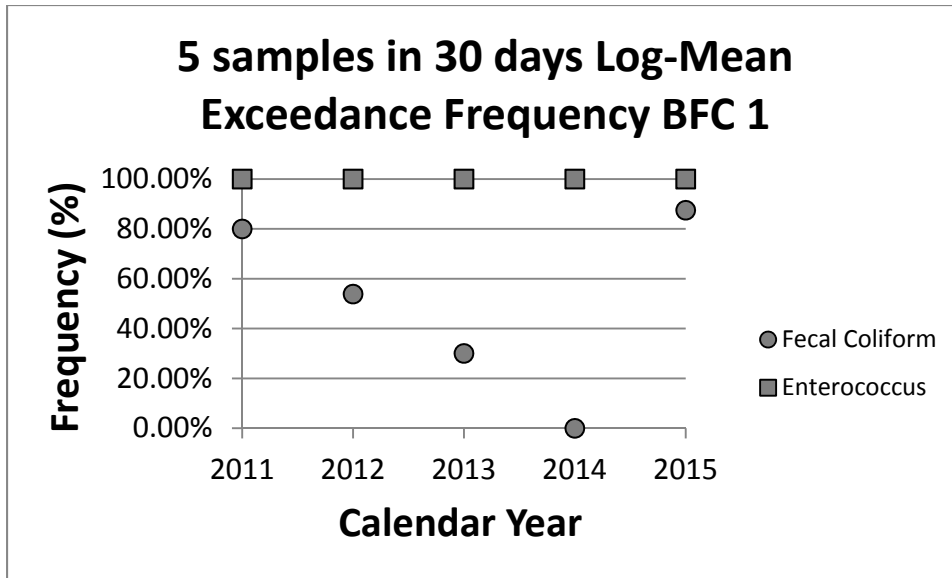
Single-Sample Maximum limits: Fecal Coliform, 400 (CFU/100 mL); Enterococcus, (104 CFU/100 mL)

Branciforte Creek Sample Station Number 1 (BFC 1)



The above plots show the 5 samples in 30 days Log-Mean bacteria concentration observed at the sample station versus the calendar month for each year since 2010.



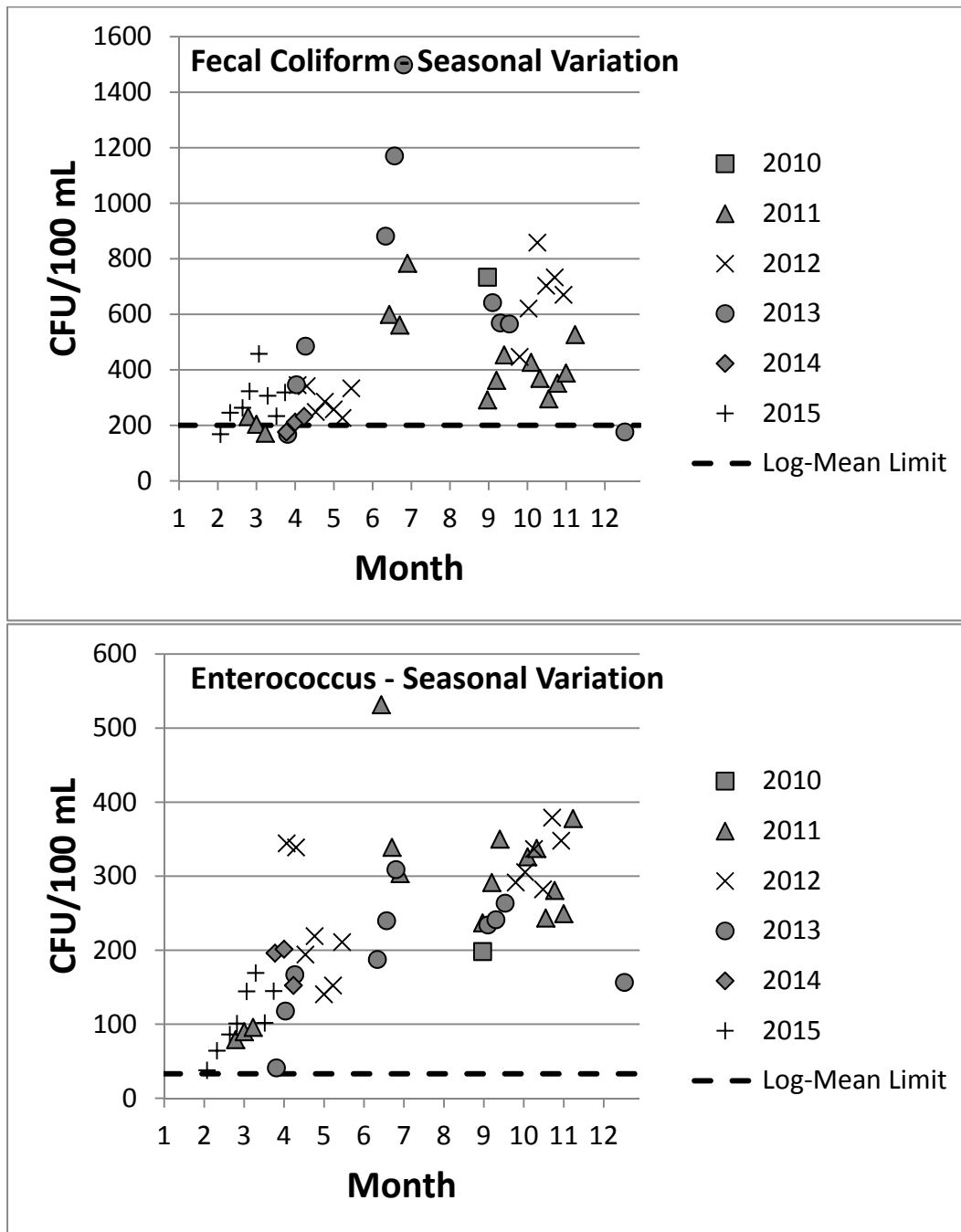


The above plots show the exceedance frequency of the Log-Mean and Single-Sample Maximum limits for bacteria concentration observed at this Branciforte Creek sample station per calendar year.

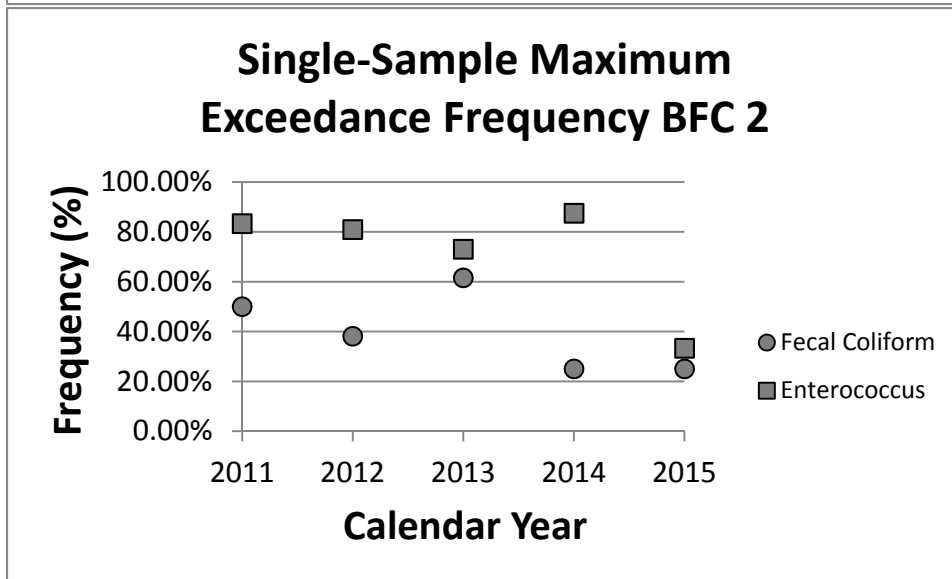
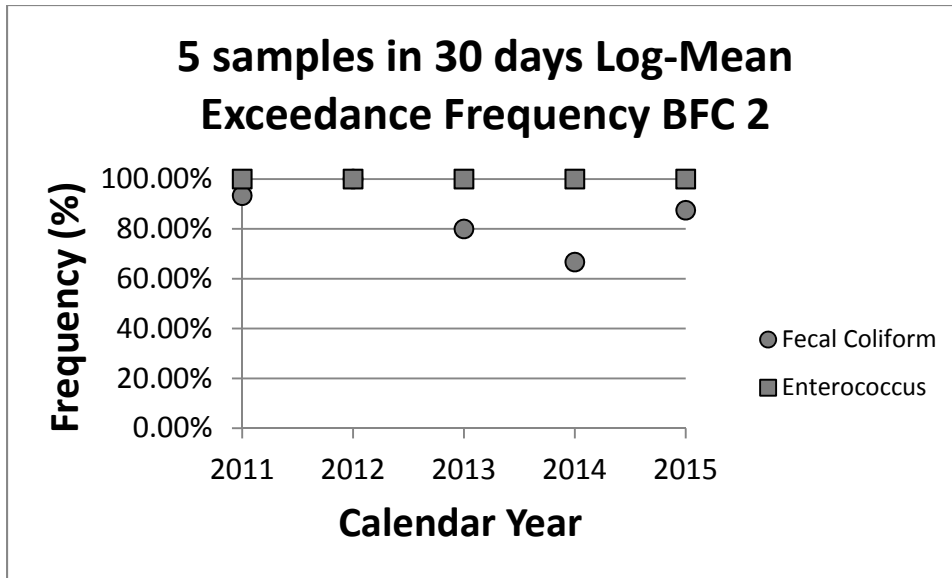
Log-Mean limits: Fecal Coliform, 200 (CFU/100 mL); Enterococcus, 33 (CFU/100 mL)

Single-Sample Maximum limits: Fecal Coliform, 400 (CFU/100 mL); Enterococcus, (104 CFU/100 mL)

**Branciforte Creek Sample Station Number 2 (BFC 2)**



The above plots show the 5 samples in 30 days Log-Mean bacteria concentration observed at the sample station versus the calendar month for each year since 2010.

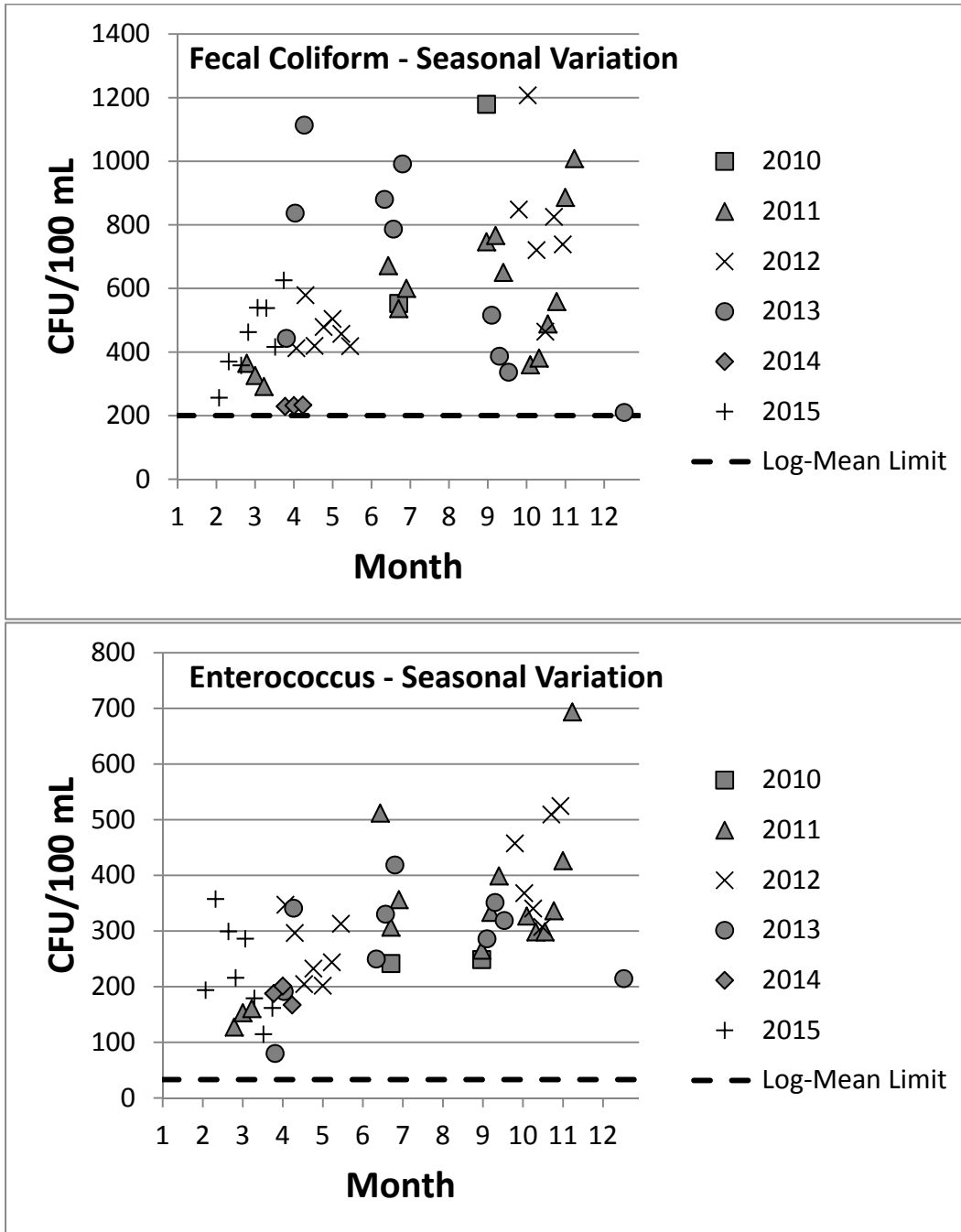


The above plots show the exceedance frequency of the Log-Mean and Single-Sample Maximum limits for bacteria concentration observed at this Branciforte Creek sample station per calendar year.

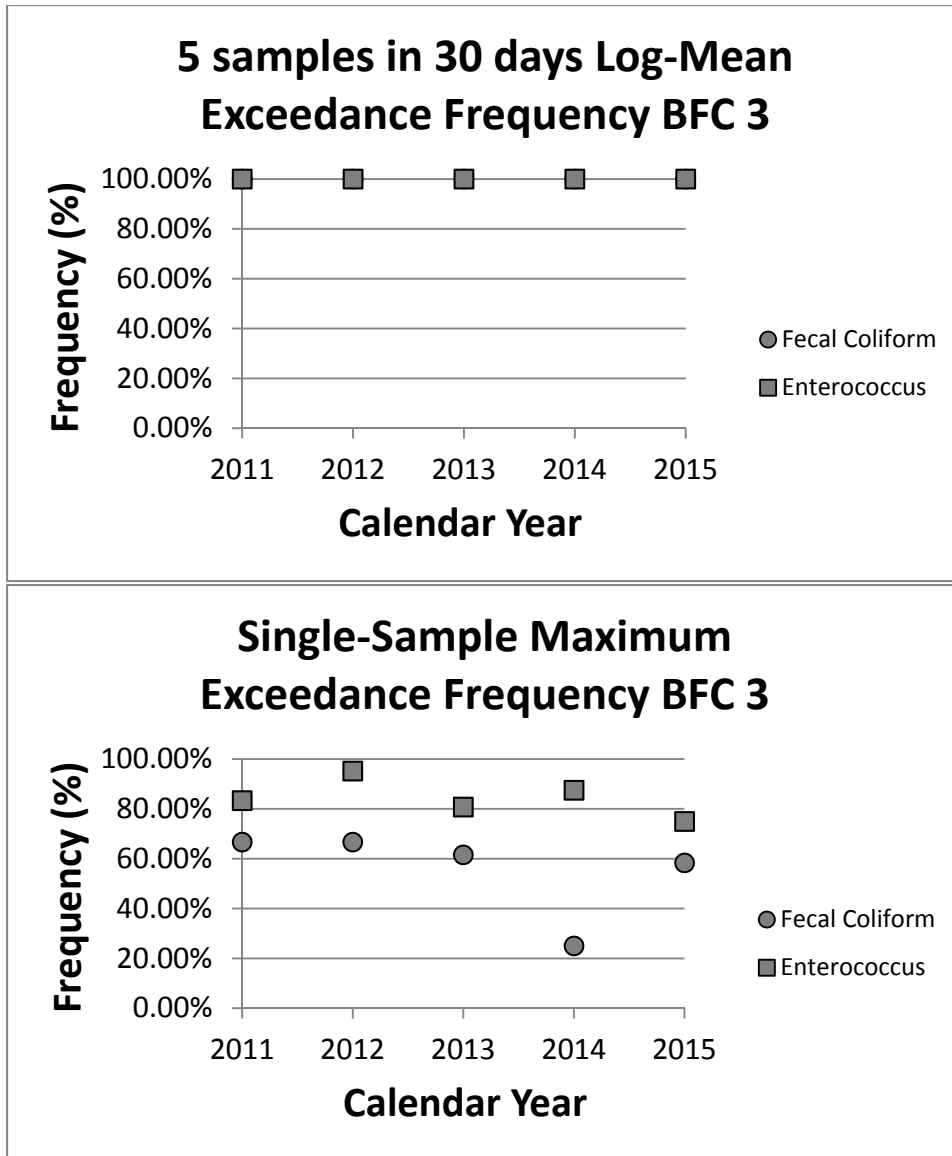
Log-Mean limits: Fecal Coliform, 200 (CFU/100 mL); Enterococcus, 33 (CFU/100 mL)

Single-Sample Maximum limits: Fecal Coliform, 400 (CFU/100 mL); Enterococcus, (104 CFU/100 mL)

Branciforte Creek Sample Station Number 3 (BFC 3)



The above plots show the 5 samples in 30 days Log-Mean bacteria concentration observed at the sample station versus the calendar month for each year since 2010.

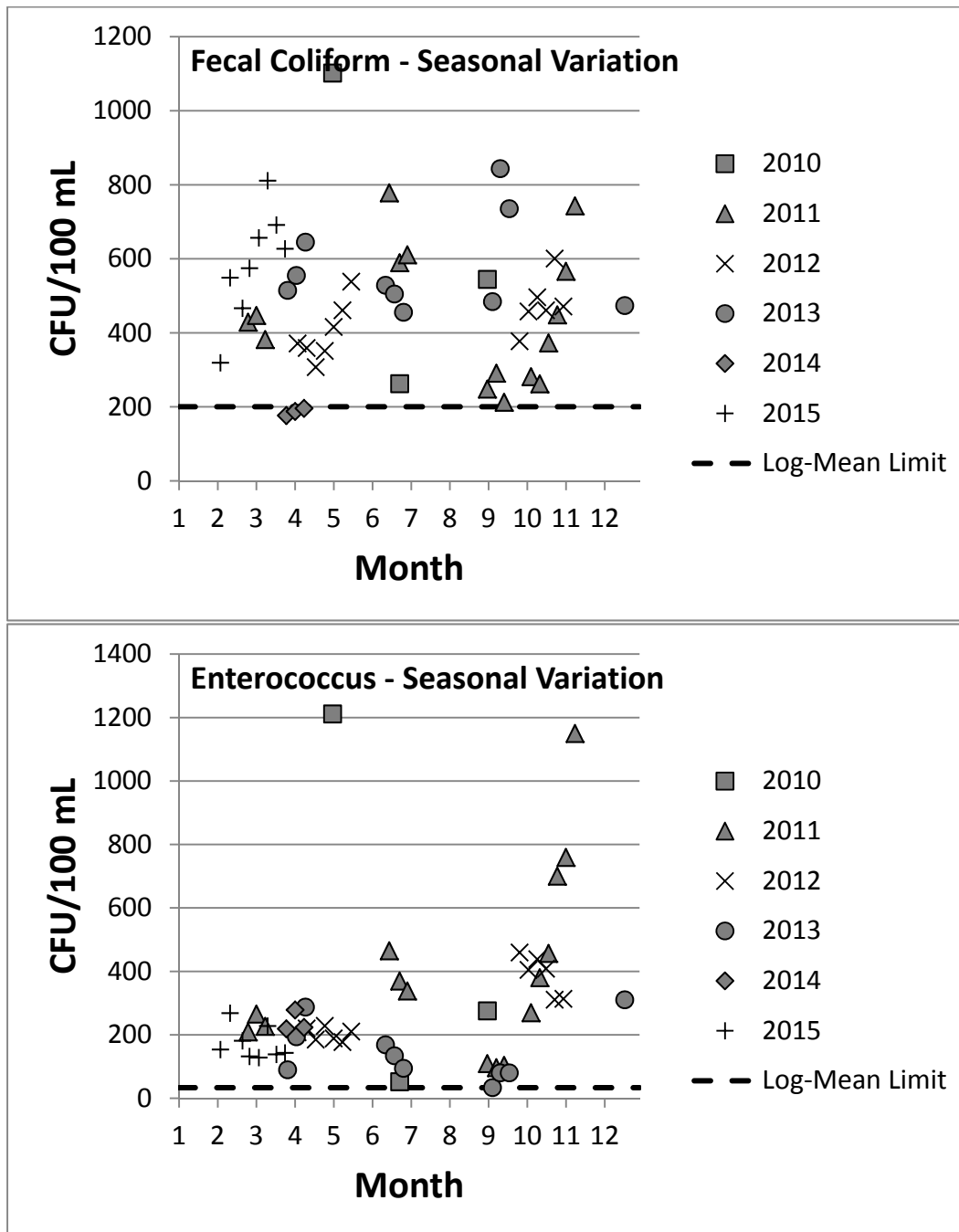


The above plots show the exceedance frequency of the Log-Mean and Single-Sample Maximum limits for bacteria concentration observed at this Branciforte Creek sample station per calendar year.

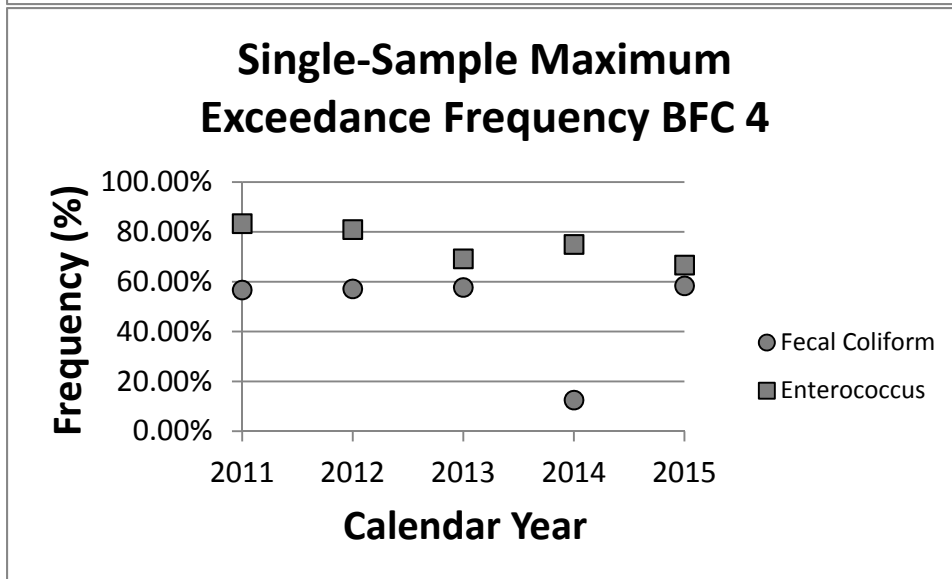
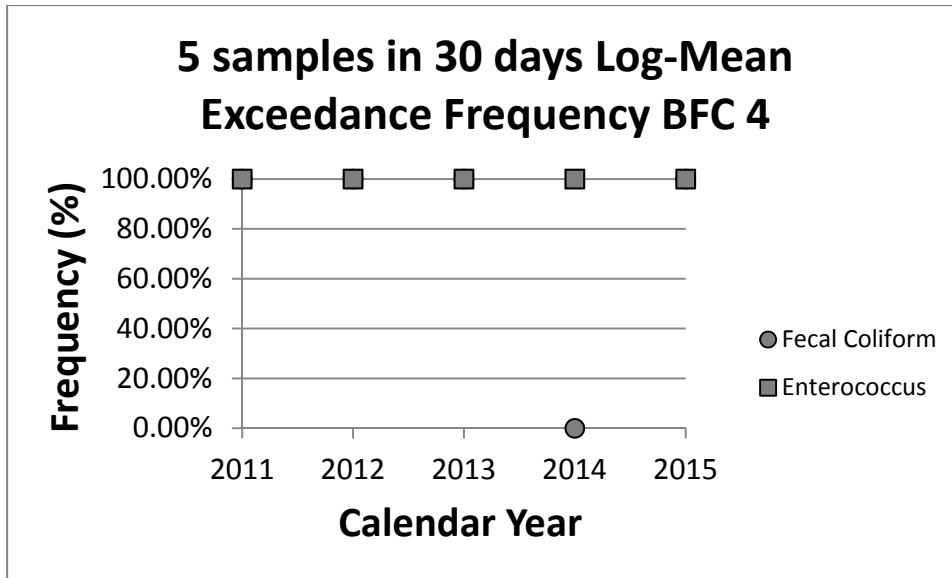
Log-Mean limits: Fecal Coliform, 200 (CFU/100 mL); Enterococcus, 33 (CFU/100 mL)

Single-Sample Maximum limits: Fecal Coliform, 400 (CFU/100 mL); Enterococcus, (104 CFU/100 mL)

**Branciforte Creek Sample Station Number 4 (BFC 4)**



The above plots show the 5 samples in 30 days Log-Mean bacteria concentration observed at the sample station versus the calendar month for each year since 2010.

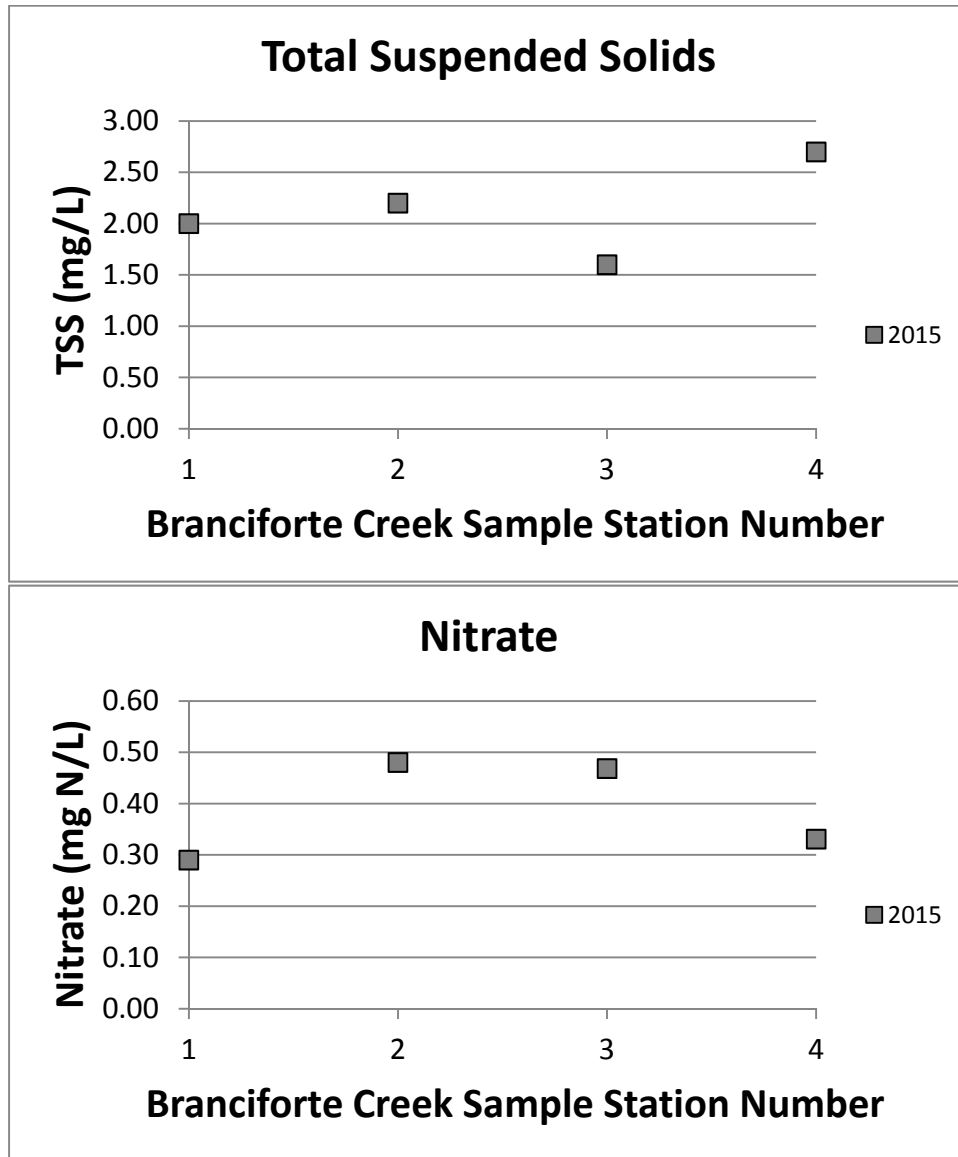


The above plots show the exceedance frequency of the Log-Mean and Single-Sample Maximum limits for bacteria concentration observed at this Branciforte Creek sample station per calendar year.

Log-Mean limits: Fecal Coliform, 200 (CFU/100 mL); Enterococcus, 33 (CFU/100 mL)

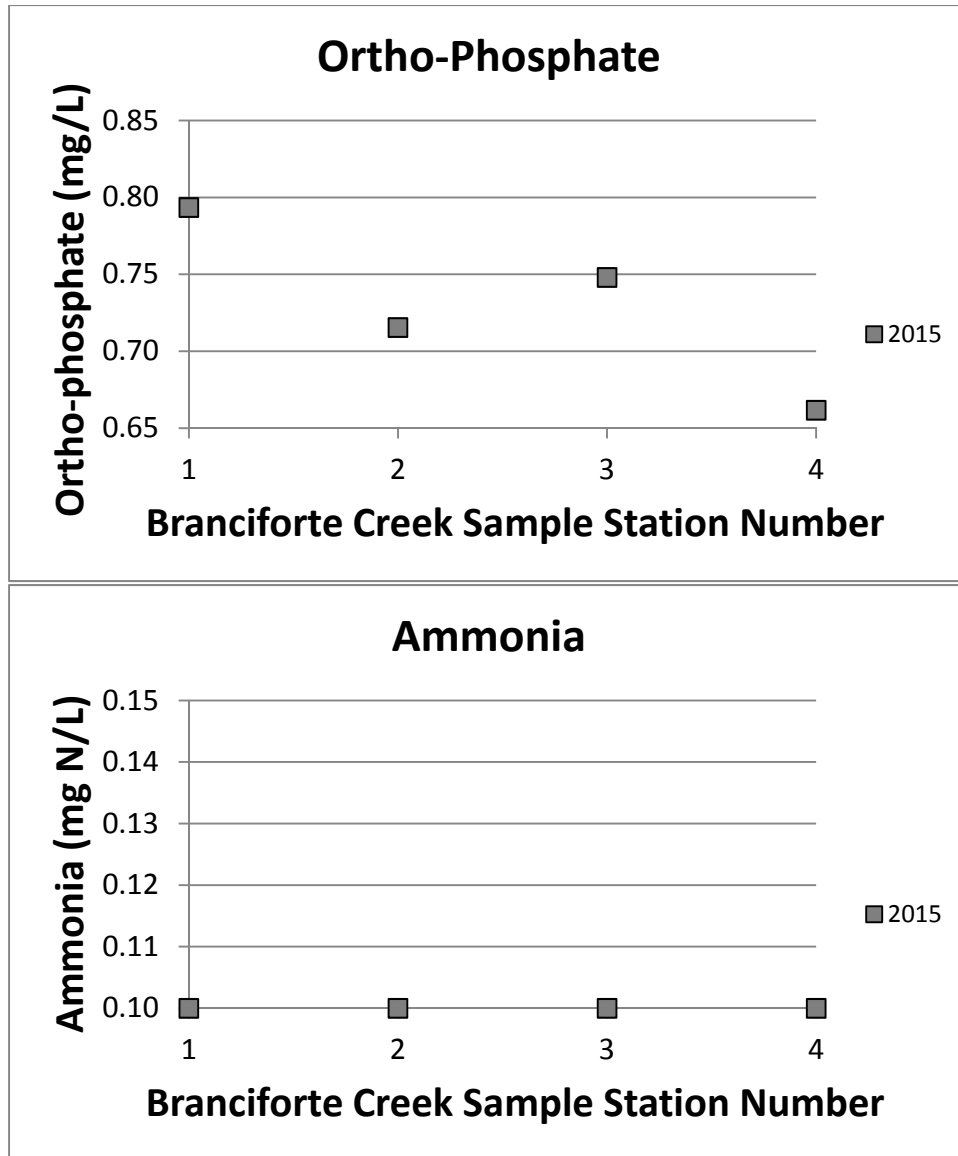
Single-Sample Maximum limits: Fecal Coliform, 400 (CFU/100 mL); Enterococcus, (104 CFU/100 mL)

## Branciforte Creek (BFC) – Sediment and Nutrient Monitoring



The above plots show the average total suspended solids (TSS) and nitrate concentration observed at each of the four sample locations along Branciforte Creek.





The above plots show the average ortho-phosphate and ammonia concentration observed at each of the four sample locations along Branciforte Creek. Our chosen method to measure ammonia yields a detection limit of 0.10 (mg N/L)