



Lower Bull Creek District Park Contact Recreation Use Assessment Update, January 2011

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City of Austin Watershed Protection Department
Austin/Travis County Health and Human Services Department

Abstract

Previous studies (COA 2008) found fecal indicator bacteria concentrations were elevated above human contact recreation standards in Bull Creek District Park, a popular swimming and dog off-leash area in northwest Austin, and noted that park usage and most probably the dog off-leash use was the likely source of the fecal contamination. A public education campaign was initiated to improve collection of dog waste, but was unsuccessful at reducing bacteria levels below human health standards. A riparian restoration project was conducted in the park and dogs are currently allowed on-leash only. Bacteria levels have improved at the former off-leash area during the on-leash only period, particularly following a large flood event, and now are below the recreation standard.

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used in water testing may not directly cause illness, *E. coli* bacteria originate in the intestinal track of warm-blooded organisms including humans, dogs and birds and the presence of *E. coli* in natural waters is considered an indicator of the potential presence of pathogenic microorganisms. The Texas Commission on Environmental Quality (TCEQ) assesses contact recreation safety for humans using *E. coli* (TCEQ 2008). The contact recreation criteria for *E. coli* currently used by TCEQ is a long-term geometric mean of 126 colonies/100 mL (30 TAC 307), roughly equivalent to an increased risk of illness from water contact for 8 swimmers out of 1,000. The single sample limit of 394 mpn/dL is no longer used by TCEQ following recent standards revisions in 2010.

Methods

E. coli bacteria samples were collected at 4 monitoring locations (Figure 1, Table 1) by the Austin/Travis County Health and Human Services Department (ATCHHSD) and the Watershed Protection Department (WPD). ATCHHSD collected samples at the Lakewood Drive and Loop 360 locations generally on Monday and Wednesday mornings. WPD collected samples at all four monitoring locations on Sunday afternoons. The Lakewood site represents the direct effects of the dog off-leash area and high-intensity recreational use. The Loop 360 is not within the designated boundaries of the off-leash area, but does experience high-intensity recreational use. The Spicewood Springs monitoring location captures any impacts from the upstream portion of the mainstem of Bull Creek including several horse farms, while the Tributary 2 captures the more high-density residential and commercial land uses along the eastern boundary of the Bull Creek watershed.

Samples were collected every other week in sterile 125 mL sample containers, preserved on ice during processing, and *E. coli* counts were measured by Standard Method 9223b at either the Walnut Creek Wastewater Treatment Plant laboratory or at the WPD in-house lab. Additionally, WPD staff counted the number of people and dogs present during weekend site visits.

Table 1. Primary monitoring locations with short names used in this report, listed in downstream to upstream order.

Site #	Site Name	Short Name	Latitude	Longitude
4189	Bull Creek 375ft Upstream of Lakewood Drive	Lakewood	30.36626	-97.78572
350	Bull Creek @ Loop 360 First Crossing	Loop 360	30.37167	-97.78493
3456	Bull Creek Tributary 2 @ Bull Creek	Trib 2	30.38244	-97.77014
4472	Bull Creek @ Spicewood Springs Crossing 1	Spicewood	30.39034	-97.77500

Results

Site Means Versus TCEQ Standard

Site geometric means were calculated by time period for each site with sufficient data (at least 7 measurement dates) and compared to the TCEQ contact recreation standard (Figure 2). The time periods are defined by relevant management actions (Table 2). The historic geometric mean *E. coli* at the Loop 360 site based on 17 measurements from 2003 to 2007 is 70 mpn/dL.

Monitoring at Trib 2 and Spicewood was not initiated until late in the post-education period, and the Trib 2 site was frequently dry.

Table 2. Time periods based on relevant management actions

Name	Start	End	Basis
Historic	2003	Jul 2007	All historic routine <i>E. coli</i> monitoring data collected prior to the sewage spill
PostSpill	Aug 2007	Feb 2008	Data collected after the Bull sewage spill but before any management action in the park
PostEducation	Mar 2008	Aug 2009	Data collected after the start of the public education campaign
PreClosure	Sep 2009	Nov 2009	Data collected after the return of flow to Bull Creek in the summer of 2009 and prior to the closure of the park
Closure	Dec 2009	May 2010	Data collected when the former off-leash area was closed for physical restoration
OnLeash	June 2010	Dec 2010	Data collected after restoration when the park was opened with dogs allowed on-leash only

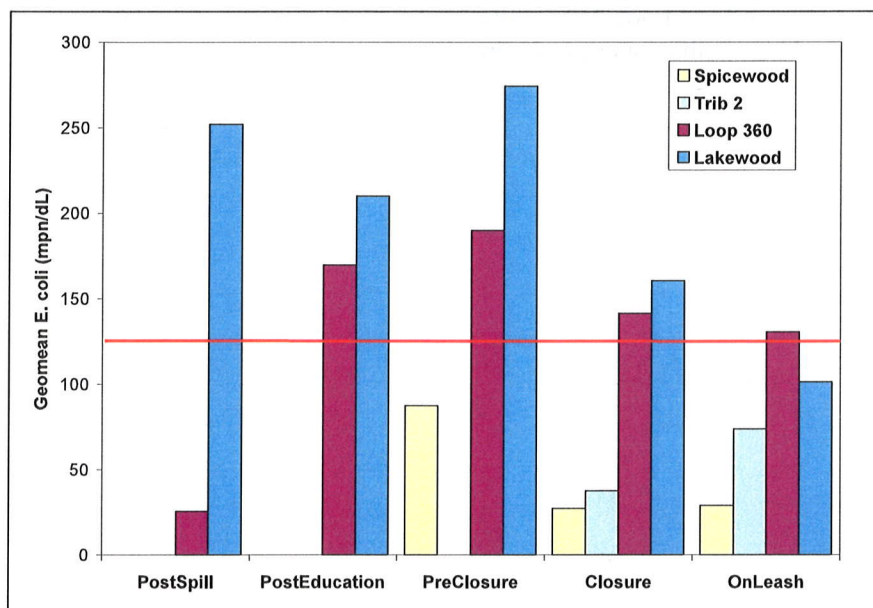


Figure 2. Site geometric mean *E. coli* by time period for sites and periods with at least 7 measurement dates. Sites in upstream to downstream order, left to right. Monitoring at Trib 2

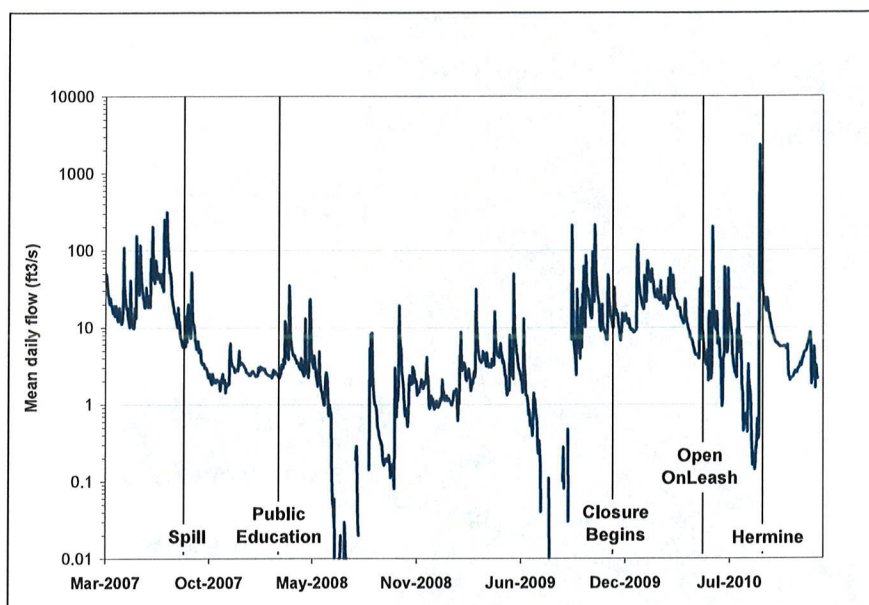


Figure 4. Mean daily flow in Bull Creek from the USGS gauge at Loop 360 (08154700).

Public Education Campaign

A public education campaign was initiated in March 2008 in an attempt to inform the public of the potential for fecal contamination of Bull Creek from uncollected dog waste. A press conference was held in the park that was well covered by local media, signage was posted in the park (Figure 5), and outreach was directed to individual park users. *E. coli* monitoring results were regularly posted in a kiosk at the park along with contact recreation warning signs. Public opinion surveys were conducted before and after the education campaign. There was a 31% increase in the number of respondents who believed that uncollected dog waste was a potential water quality problem, and 60% of respondents claimed to pick up dog waste more frequently than before the education campaign.

diversity of vegetative cover and reducing runoff to the creek. On the slopes, coir logs and cedar log terracing were used to slow down stormwater runoff and allow it to infiltrate. Between the log terraces, WPD broke up the extremely compacted soil, installed soil retention blanket, and planted seed, sod and rooted plants. Large limestone boulders were placed near the bend in the creek to retain soil and provide a seat wall for park visitors. Together, the boulders, log terraces, vegetative barriers and onsite signage encourage park visitors to stay on the trails and help maintain the long-term success of the restored landscape. While most of these efforts were focused on improving vegetative coverage on the surface they are also providing considerably better growing conditions for the existing grove of majestic Live Oak trees onsite. PARD installed a permanent underground irrigation system which helped to establish the recently planted vegetation and will allow it thrive in the future. The project had an estimated cost of \$137,500 and was successfully completed on-time and under budget. Monitoring of the restoration project indicated that the goals of the restoration project were achieved, although re-opening of the park to recreational use did produce limited damage to some of the restored vegetation near the “horseshoe” waterfall area.

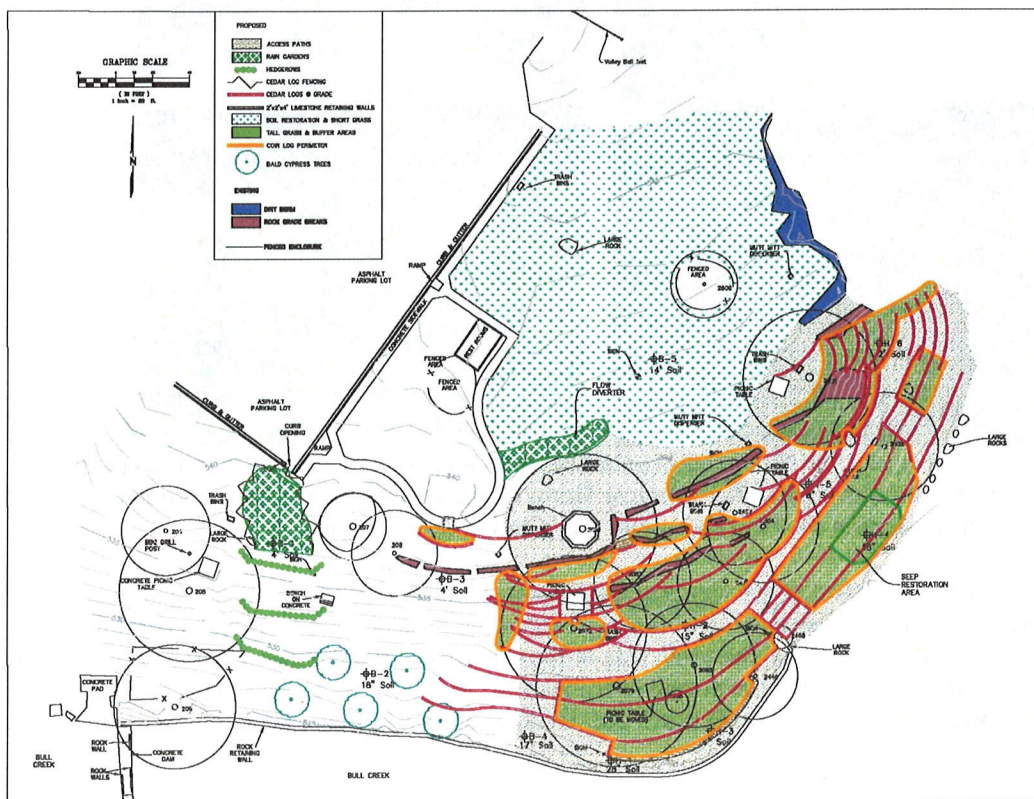


Figure 6. Schematic diagram of the riparian restoration project.

Tropical Storm Hermine

Several months after the completion of the restoration project Tropical Storm Hermine brought 12” of rain to the area on September 7 and 8, 2010. Although this rainfall total is over a 100-year event the overall distribution was such that the flows near the park can be characterized between a 10-year event and a 50-year event. Hermine caused extensive flooding in Bull Creek and deposited several inches of sand and gravel in some areas of the restoration project. Since the

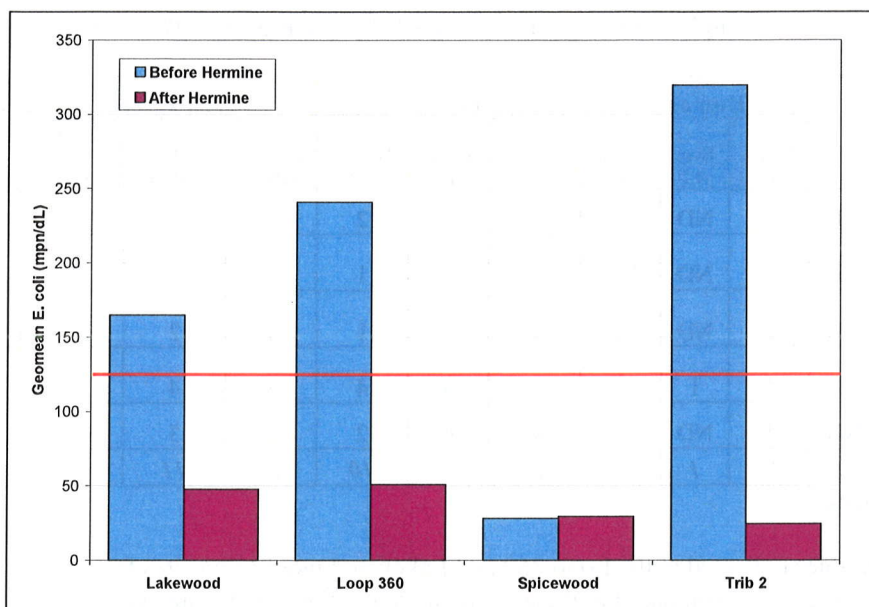


Figure 8. *E. coli* geometric means before (left, blue bar) and after Hermine (right, red bar), during the on-leash only period June 2010 to December 2010.

Genetic Microbial Source Tracking

Exploratory analysis using genetic library-independent microbial source tracking was attempted by the University of Texas at Austin for dog fecal samples and ambient water samples collected in late August 2010. Full validation of the qPCR assays is still underway as part of other COA source water investigations to characterize the source of local waters by chemical and biological profiles. The qPCR assays employed seven human-associated and four host-specific assays including dogs for *Bacteroidales* bacteria (Bae and Kirsits 2010). The BacCow-UCD marker is associated with cows, the BacCan-UCD is associated with dogs, the BacUni-UCD is the universal total *Bacteroidales* marker and the BacHum-UCD is associated with humans. The amplified *Bacteroidales* DNA from dog fecal samples showed weak cross-reactivity with the HF183 and BuniF2 human-associated markers, indicated by the lack of positive detection (ND) in all dog fecal samples except for one Buni-F2 detection. However, only 10 of the 19 dog fecal samples showed a positive signal with the dog-associated BacCan-UCD marker (Table 3). Thus, there appears to be a low false positive detection rate of dog fecal samples using the human markers although there is low confidence in the ability of the dog-associated markers to detect dog fecal contamination.

(*Petrochelidon pyrrhonota*) nesting underneath Loop 360 at Spicewood Springs Road. Fecal loading from cliff swallows is likely to peak in April from the time eggs are laid until fledging when the young birds are capable of leaving the nest. The UT study concluded that while birds are contributing fecal bacteria to Bull Creek especially during the 20-day period between hatching and fledging, the birds did not increase fecal bacteria above the current contact recreation standard (126 mpn/dL).

Correlations with Flow and Rainfall

In general there is little significant correlation between *E. coli* and mean daily stream flow measured by the USGS gauge at Loop 360 (08154700) as assessed by Kendall's tau-B correlation analysis (Table 5, Figure 9). *E. coli* at Lakewood was positively correlated with flow during the post-spill, post-education and on-leash monitoring periods. *E. coli* values at the Loop 360 site were inversely related to flow during the post-education period.

Table 5. Results of Kendall's tau-B correlation of *E. coli* with mean daily stream flow. Green shaded cells show significant correlation ($\alpha < 0.05$).

Period	Site	N	Tau-b	Pr>tau
Historic	Loop 360	17	-0.14	0.43
PostSpill	Lakewood Dr	158	0.17	0.01
PostSpill	Loop 360	20	0.32	0.06
PostEducation	Lakewood Dr	110	0.37	0.01
PostEducation	Loop 360	96	-0.21	0.01
PostEducation	Spicewood	10	0.12	0.66
PostEducation	Trib 2	4	-0.33	0.47
PreClosure	Lakewood Dr	33	-0.01	0.92
PreClosure	Loop 360	27	0.13	0.36
PreClosure	Spicewood	7	0.14	0.65
PreClosure	Trib 2	2	.	.
Closure	Lakewood Dr	33	-0.09	0.43
Closure	Loop 360	35	-0.21	0.09
Closure	Spicewood	12	-0.21	0.33
Closure	Trib 2	12	0.19	0.37
OnLeash	Lakewood Dr	35	0.27	0.03
OnLeash	Loop 360	36	0.13	0.27
OnLeash	Spicewood	17	0.31	0.08
OnLeash	Trib 2	16	0.11	0.56

Table 6. Results of Kendall's tau-B correlation of *E. coli* with number of days since rainfall and total rainfall in the 72 hours prior to sampling. Green shaded cells show significant correlation ($\alpha < 0.05$).

Period	Site	N	Days Since Rain		Rain in Last 72h	
			Tau-b	Pr>= Tau	Tau-b	Pr>= Tau
Historic	Loop 360	17	-0.36	0.05	0.42	0.03
PostSpill	Lakewood	158	-0.19	0.01	0.26	0.01
PostSpill	Loop 360	20	-0.12	0.46	0.21	0.25
PostEducation	Lakewood	110	-0.15	0.03	0.15	0.04
PostEducation	Loop 360	96	-0.15	0.04	0.17	0.03
PostEducation	Spicewood	10	0.11	0.65	-0.18	0.50
PostEducation	Trib 2	4
PreClosure	Lakewood	33	-0.05	0.72	0.26	0.05
PreClosure	Loop 360	27	-0.29	0.04	0.43	0.01
PreClosure	Spicewood	7	-0.1	0.75	0.07	0.85
PreClosure	Trib 2	2
Closure	Lakewood	33	0.05	0.71	0.14	0.27
Closure	Loop 360	35	-0.13	0.29	0.16	0.19
Closure	Spicewood	12	0.05	0.83	-0.17	0.48
Closure	Trib 2	12	0.03	0.88	-0.24	0.31
OnLeash	Lakewood	35	-0.32	0.01	0.23	0.09
OnLeash	Loop 360	36	-0.38	0.01	0.33	0.01
OnLeash	Spicewood	17	-0.24	0.18	-0.19	0.35
OnLeash	Trib 2	16	-0.08	0.68	-0.03	0.89

Correlations with Air Temperature and Month

Water temperature is not measured continuously, but air temperature is a good surrogate for water temperature and may be related to the likelihood of park use. National Weather Service Austin average air temperature measurements were compared to *E. coli* measurements on the same day by Kendall's tau-b correlation analysis. In general, *E. coli* measures are directly related to air temperature values (Table 7), although there was a significant inverse relationship to temperature at the Lakewood site during the post-education period.

There is no clear pattern in average monthly *E. coli* geometric means at the Lakewood or Loop 360 sites (Figure 10). January yielded the lowest overall monthly geometric means at both sites. The Lakewood site may yield higher geometric mean *E. coli* during the spring and summer months although the Loop 360 site may yield higher summer geometric mean *E. coli* values.

Load Duration Curves

Load duration curves are recognized tools for non-point or point-source determination in Total Maximum Daily Load assessments (EPA 2007). Load duration curves characterize water quality under different flow regimes to visualize the frequency and magnitude of standard exceedances. Impairments observed under low flow regimes typically indicate point source impacts while impairments observed under high flow regimes typically indicate non-point source impacts. Load duration curves were calculated for the Lakewood (Figure 11) and Loop 360 (Figure 12) sites by following EPA methodology using the mean daily flows from the USGS flow gauge at Loop 360 (08154700) without including a margin of safety in the contact recreation standard as the curves are not being used for actual TMDL apportionment.

Exceedances of the standard occurred across the range of flow regimes at the Lakewood site, suggesting a combination of point and non-point source impacts. There are clear differences in the post-spill periods before education began between the Loop 360 and Lakewood sites, with few exceedances at Loop 360 but consistent exceedances at Lakewood. The post-spill, pre-education time period was consistent with historical monitoring at Loop 360. The reduction in bacteria levels during the on-leash period occurred primarily after the flooding of Tropical Storm Hermine (Figure 13).

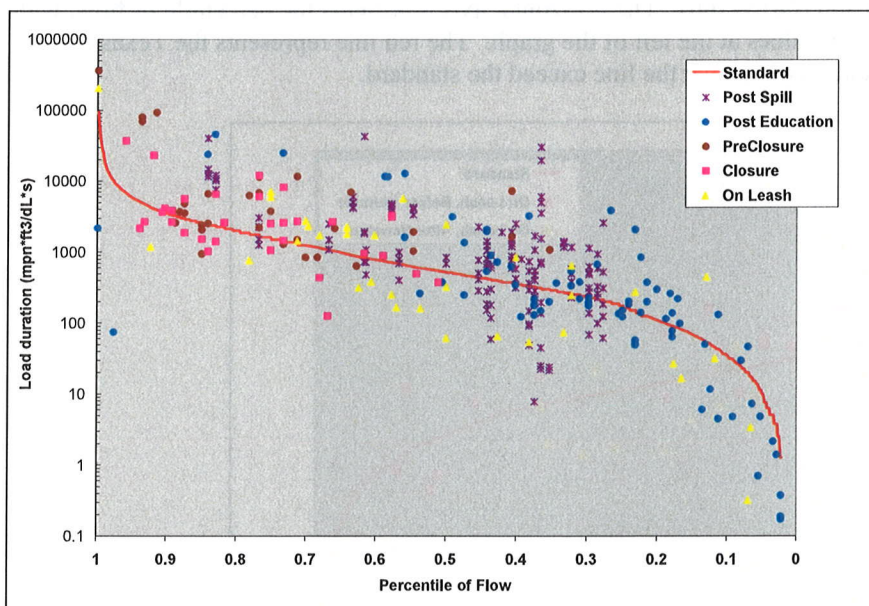


Figure 11. Load duration curve for the Lakewood site by time period calculated using mean daily flows from the USGS gauge at Loop 360 (08154700). The horizontal axis represents the percentile of flow, with the largest recorded flow values at the left of the graph. The red line represents the Texas contact recreation standard, and values above the line exceed the standard.

correlation with time by Kendall's tau-B analysis for the number of people or number of dogs present at the Loop 360 site for the period of record. There is a negative correlation of the number of dogs present ($\text{tau-B} = -0.32$, $n=48$, $\text{Pr}>\text{tau}=0.0019$) at the Lakewood site over time for the period of record, but no significant correlation with time in number of people present at the Lakewood site.

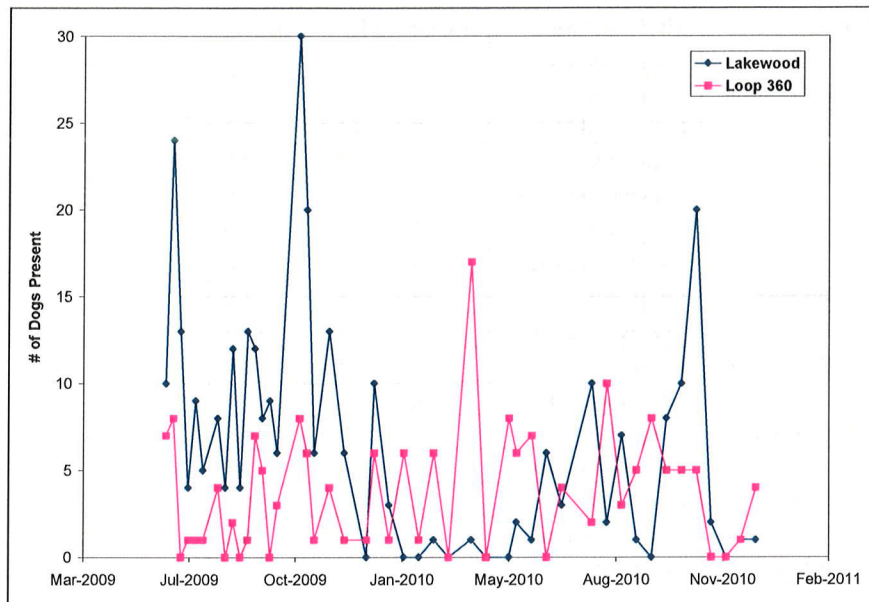


Figure 14. Number of dogs present at weekend sampling events.

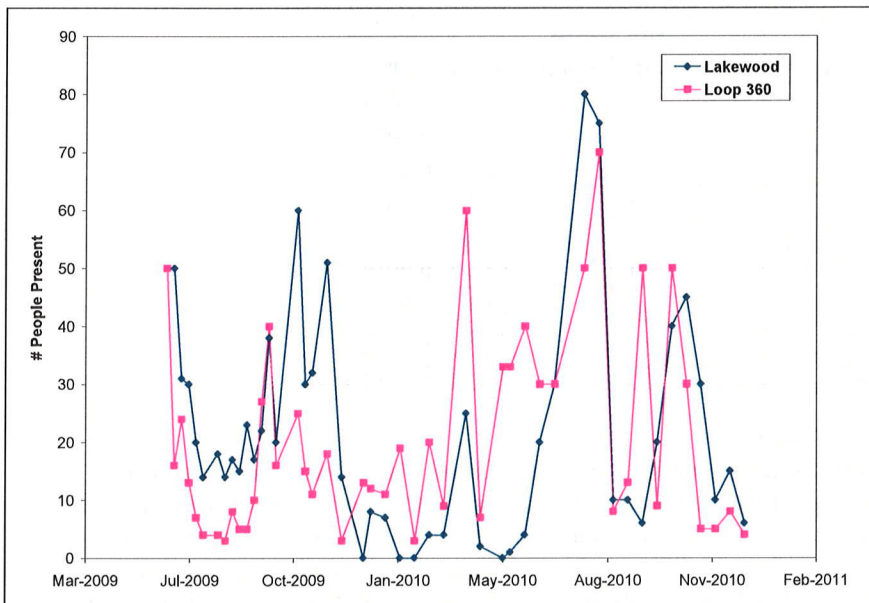


Figure 15. Number of people present at weekend sampling events.

The Lakewood site maintained significantly higher number of people and dogs than the Loop 360 site on average (Table 8) for the post-education and pre-closure period by Wilcoxon signed-rank test (Table 9). The Loop 360 site maintained significantly higher numbers of dogs than the Lakewood site during the closure period, and there is no significant difference in number of dogs

Weekend/Weekday

Previous analyses (COA 2008) noted a strong increase in *E. coli* concentrations on weekend days relative to weekdays, suggesting that park usage which is generally higher on weekends is correlated to indicator bacteria. The increased *E. coli* geometric mean on weekend pattern was maintained at the Lakewood site until the park was closed in December 2009 for restoration (Figure 16), although the difference in mean *E. coli* on weekends was only significant by the non-parametric Wilcoxon rank-sum test in the post-spill and post-education periods. A similar pattern of higher *E. coli* on weekends was never observed at the Loop 360 site (Figure 17). There is no significant difference by Wilcoxon rank-sum test between weekend and weekday *E. coli* at Loop 360 in any time period.

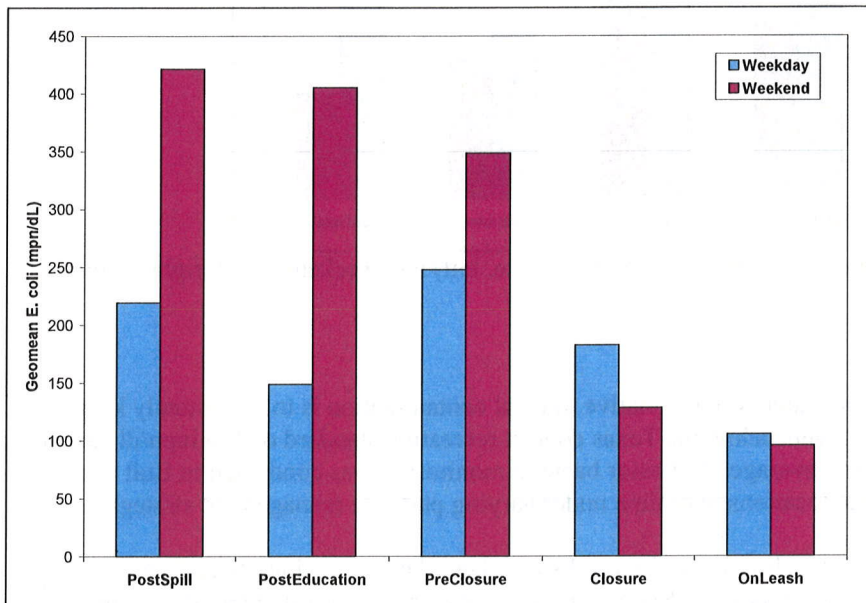


Figure 16. Geometric mean *E. coli* on weekdays (blue, left) and weekends (red, right) at the Lakewood site.

Based on load duration curves, there appears to be a mix of point and non-point sources of fecal contamination to Bull Creek. Usage by people may be increasing over time at the Loop 360 site while number of dogs present may be decreasing over time at the Lakewood site. Weekend *E. coli* concentrations remain significantly higher than weekdays at the Lakewood site thru the post-education period, suggesting a continued relationship between water column *E. coli* and park use. There was no difference in weekend and weekday bacteria levels at Loop 360.

Discussion and Recommendations

Until more specific and validated analytical methods become reasonably available, there will not be a determination that the fecal contamination is exclusively or primarily from dogs with a high degree of confidence. All indications suggest that the contamination is not from on-going leaking wastewater infrastructure, and genetic bacteria source testing conducted to date suggest the fecal contamination is of non-human origin. Most likely, there is a mix of fecal sources operating within Bull Creek District including non-point source fecal contributions from upstream areas, dog waste in the park and human usage that are interacting with instream sediments. Sediments may be acting as a reservoir for fecal bacteria that are re-suspended in the water column during recreation activities.

Genetic bacteria testing methods and applications are still in development, even on a national scale. Although genetic methods are appealing in similar situations where conflicting uses are in question, it is likely that the full application of these methods to the fecal source identification within Bull Creek could be several years away.

The increase observed at the Loop 360 site following the public education campaign may have been the result of overall increased usage of the park or creating a pattern of avoidance of the Lakewood area by some park users because of the increased signage there resulting in a transfer of use to Loop 360. The lack of an observed weekend/weekday pattern at the Loop 360 site may be a function of the geomorphology of that location, as that reach is more of a bedrock run with generally less sediment accumulation than the Lakewood site.

Remediation of fecal contamination where contact recreation is not supported is extremely challenging, as there are frequently uncontrollable sources like wildlife and a high degree of variability in bacteria measurements. Remediation efforts must control all known or probable fecal contamination sources to the maximum extent practical. Control of known fecal sources is the reasoning behind EPA policy recommendations (EPA 2001) and Texas Parks and Wildlife Department regulations (TPWD Code 59.134e) that restrict dogs from areas near human swimming locations.

It is likely that the combination of public education, volunteer activity, reduction in usage during the closure period, and physical restoration of the riparian areas reduced the fecal load to sediments in Bull Creek. Previously contaminated sediments were likely scoured away or buried by flooding from Tropical Storm Hermine. It is critical to maintain the reduction in fecal loadings to prevent sediments from becoming re-contaminated. If sediments become sufficiently re-contaminated by re-introduction of a fecal source, it is likely that contact recreation will not be supported even if that source is removed until another rare, large flooding event like Hermine occurs.

There is a range of signage posted within Bull Creek District Park currently, including both regularly updated postings of bacteria counts, swimming advisories, and educational signage on

park remains on-leash only for dogs to fully evaluate the potential impacts of this management strategy for a longer period of time after Tropical Storm Hermine. Additional monitoring should be continued at Bull Creek District Park, regardless of the selected management strategy, although a lower frequency may be appropriate, to insure contact recreation use remains supported.

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