



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.

Introduction	2
Methods	3
Results	5
<i>Site Means Versus TCEQ Standard</i>	5
<i>Public Education Campaign</i>	7
<i>Bull Creek Dog Off-Leash Group</i>	8
<i>Riparian Restoration Project</i>	8
<i>Tropical Storm Hermine</i>	9
<i>Genetic Microbial Source Tracking</i>	11
<i>Bacteria in Sediment Study</i>	12
<i>Fecal Loading from Birds</i>	12
<i>Correlations with Flow and Rainfall</i>	13
<i>Correlations with Air Temperature and Month</i>	15
<i>Load Duration Curves</i>	17
<i>Park Usage</i>	18
<i>Nutrients from Bull Creek Study</i>	20
<i>Weekend/Weekday</i>	21
Conclusions	22
Discussion and Recommendations	23
References	25

Introduction

In August 2007, a sanitary sewage overflow occurred in the Bull Creek Watershed between West Rim Cove and Spicewood Springs Road, upstream of Lower Bull Creek District Park in Austin, Texas. The 48 acre park, including approximately 3 miles of hiking trails, is a popular location for swimming and wading and previously included a dog off-leash area near Lakewood Drive. The Austin/Travis County Health and Human Services Department (ATCHHSD) received complaints of gastrointestinal illness among people who swam at Bull Creek District Park. An epidemiologic investigation concluded that contact with water at Bull Creek was the common exposure between all persons that became ill. A multi-departmental task force investigated the elevated levels of *E. coli* indicator bacteria in Bull Creek from August 2007 to December 2007. These events and associated monitoring data thru December 2007 are documented in a previous report produced by the multi-departmental City of Austin task force (COA 2008). The primary conclusions and recommendations of the previous analysis (COA 2008) were:

- *E. coli* indicator bacteria at the Lakewood Drive monitoring site exceeded the State of Texas contact recreation standard.
- *E. coli* levels were higher at the Lakewood Drive monitoring site near the designated dog off-leash area than the Loop 360 monitoring site although both sites were downstream of the sewage spill.
- *E. coli* levels were higher on weekends than weekdays, suggesting that usage of the park was correlated to higher indicator bacteria.
- There was no corroborating evidence of on-going leaking wastewater infrastructure that would cause the elevated levels of *E. coli* bacteria
- The most likely cause of the fecal contamination at the Lakewood Drive monitoring site was the dog off-leash use.
- A public education campaign should be implemented in an attempt to reduce the bacteria levels in Bull Creek while maintaining all uses of the park.

This report chronicles the events and monitoring data since the previous analysis. As recommended in the previous City of Austin report (COA 2007), a public education campaign was initiated and indicator bacteria monitoring was extended thru December 2010. The public education campaign did not reduce the bacteria levels in the park, and a physical restoration project was conducted at the former off-leash area by the Watershed Protection Department. As part of the on-going scientific evaluation of the hypothesis that park use was correlated to elevated bacteria levels, *E. coli* was monitored while the park was closed for six months during the restoration construction. Following restoration work, a limited-use period with dogs allowed in the park on-leash only was instituted for 6 months with on-going bacteria monitoring. During the 6-month on-leash only period, a tropical storm caused significant flooding and geomorphic alteration of Bull Creek near the Lakewood Drive monitoring location. Significant temporal milestones since the previous analyses discussed in this report are:

- Mar 2008: A public “Scoop the Poop” education campaign was initiated
- Jun 2008: The citizen volunteer BCDOG group was formed
- Dec 2009: The park was closed to conduct a physical restoration project.
- Jun 2010: The park was opened for on-leash only use
- Sep 2010: Tropical Storm Hermine caused extensive flooding in the watershed

Indicator bacteria are selected on the basis of ease of measurement, persistence in the environment, and correlation to sources of pathogenic organisms (APHA 1995). Currently, *Escherichia coli* are the preferred indicator bacteria (TCEQ 2008). Although the type of *E. coli*

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

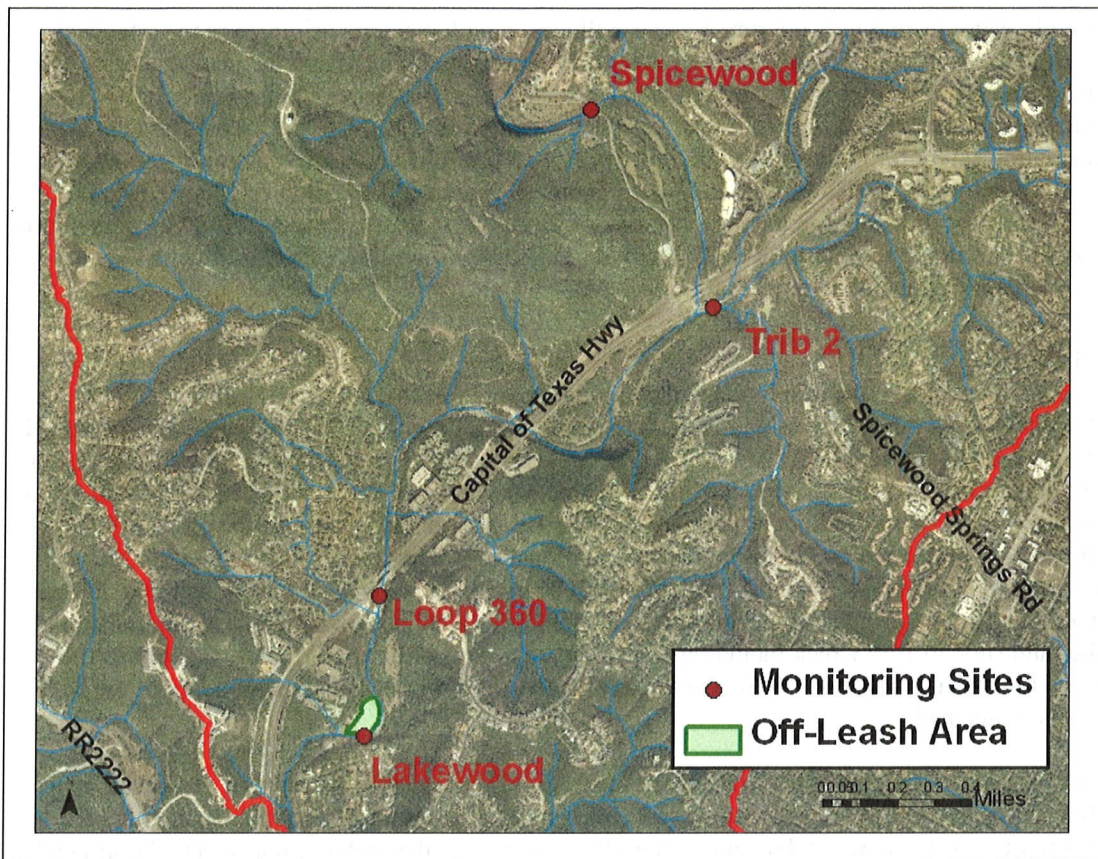


Figure 1. Primary monitoring locations.

Contact recreation fecal impairments are assessed generally following TCEQ guidance (TCEQ 2008) using a geometric mean of data collected when the creek is flowing above the 7Q2 compared to the standard of 126 mpn/dL. Data collected when Bull Creek flows as measured by the USGS Gauge 08154700 at Loop 360 were less than 0.1 ft³/s were excluded following TCEQ guidance. Geometric means above the standard indicate fecal contamination resulting in potentially unsafe human water contact conditions. Multiple samples collected on the same day were averaged before any other analysis. The deviation from standard TCEQ guidance is the time period of assessment. While TCEQ assesses contact recreation safety over a 5-year period, the time frame of this study required a shorter evaluation period.

Exploratory library-independent genetic microbial source tracking methods were evaluated by the University of Texas at Austin (Bae and Kirsits 2010) against dog fecal samples and for ambient water samples collected by WPD in late August 2010. DNA was directly extracted with the MP Biomedicals FastDNA Spin Kit for Soil. The 20 L ambient water samples were processed thru a hollow fiber ultrafilter on the same day they were collected. DNA was analyzed by quantitative polymerase chain reaction (qPCR) with seven human-associated and four host-specific *Bacteroidales* assays. Positive signals from testing of water samples using these markers may indicate the contribution of fecal bacteria from that source.

Bacteria concentrations in sediment were assessed independently and are documented in a separate report (Wagner and Scoggins 2010). Although the conclusions are repeated in this report, please refer to the full report for more detailed methodology.

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

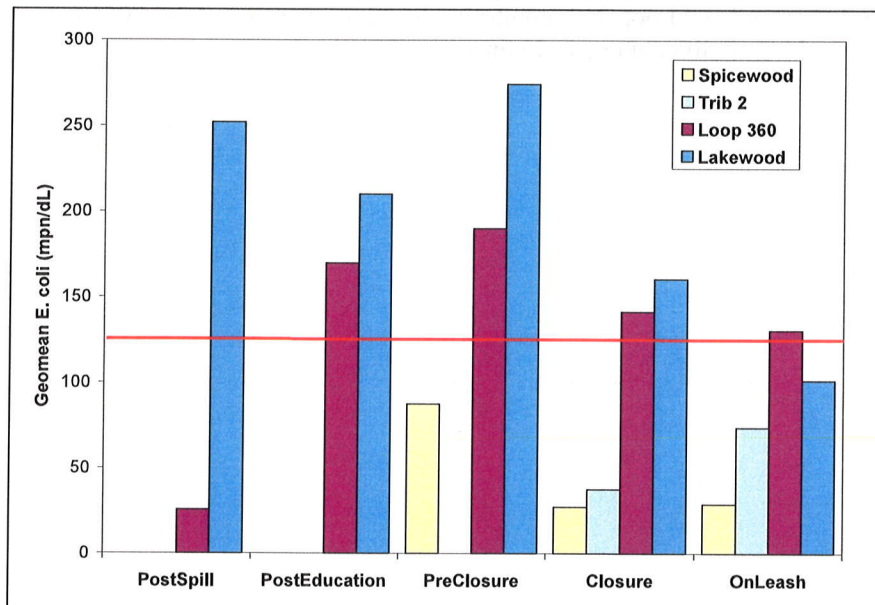


Figure 2. Site geometric mean *E. coli* by time period for sites and periods with at least 7 measurement dates. Sites in upstream to downstream order, left to right. Monitoring at Trib 2

and Spicewood began late in the post-education period and the Trib 2 site was frequently dry. The red line represents the Texas contact recreation standard (126 mpn/dL).

Bacteria levels increased at the Loop 360 site following the onset of public education and remained elevated throughout the remainder of the study until Tropical Storm Hermine in September 2010 (Figure 3). The historic *E. coli* geometric mean at Loop 360 is 70 mpn/dL (n=17, 2003-2007). Bacteria levels began to decrease at the Lakewood Drive monitoring site during the closure period, and fell below the standard during the on-leash period for the first time since sampling was initiated in August 2007. The Trib 2 site flows less frequently than mainstem Bull Creek, and the upstream sites maintain lower bacteria levels than sites in the park.

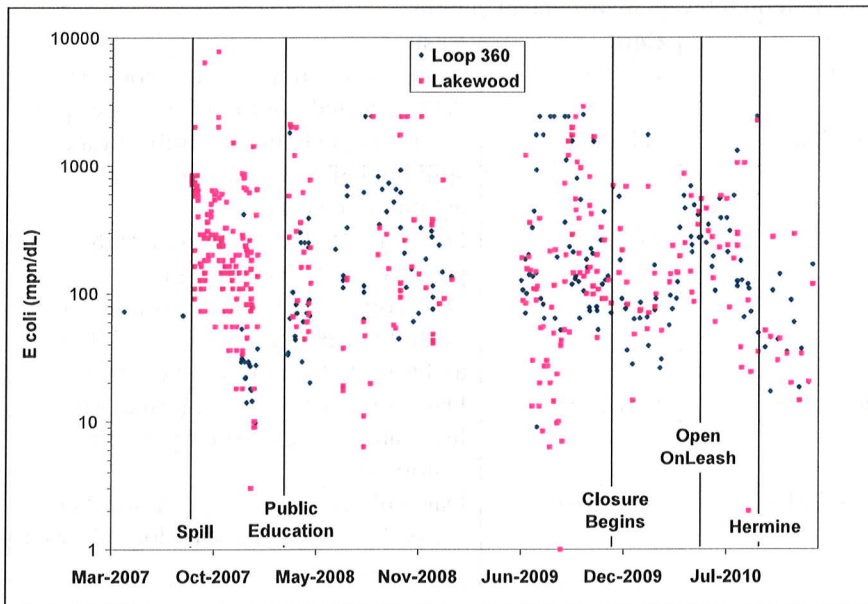


Figure 3. *E. coli* at the Lakewood and Loop 360 monitoring locations over time from 2007 to 2010 with vertical bars marking significant events in time.

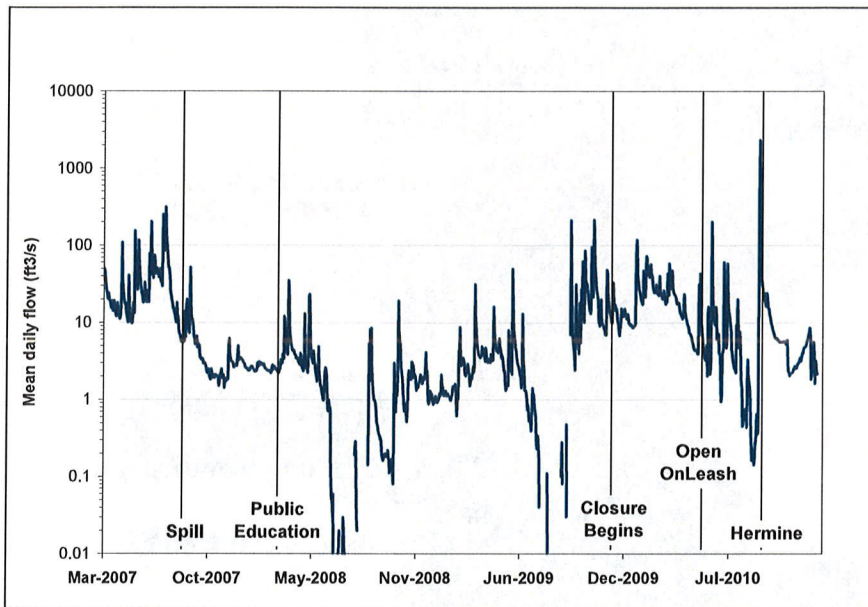


Figure 4. Mean daily flow in Bull Creek from the USGS gauge at Loop 360 (08154700).

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.



Figure 5. Example of educational signage posted in Bull Creek District Park.

Bull Creek Dog Off-Leash Group

The Bull Creek Dog Off-Leash Group (BCDOG) became active in June 2009 and began work doing outreach and additional maintenance within Bull Creek District Park. Following the unsuccessful results of the public education campaign to reduce bacteria levels in Bull Creek, COA staff decided to postpone additional actions including potentially prohibiting dogs in the park or removing the off-leash use to see if the volunteer group could affect a positive change. While the BCDOG volunteers made improvements to the appearance of the park and reduced the amount of visible dog waste on the ground, bacteria levels continued to remain above the contact recreation standard. For this reason, COA staff decided to temporarily close the park for 6 months to conduct a physical restoration project while continuing to monitor bacteria levels in an attempt to test the hypothesis that park use was correlated to elevated bacteria.

Riparian Restoration Project

The restoration project was a collaborative effort between the Watershed Protection Department (WPD), the Parks and Recreation Department (PARD), and the non-profit organization American YouthWorks (AYW). It was designed, managed and funded by the WPD Stormwater Treatment and Stream Restoration Section. The majority of the construction work was completed under contract by the American YouthWorks, with support by PARD and WPD field crews. The restoration project was initiated to enhance the pollution reduction efforts of the public education campaign and the volunteer activity to pick up dog waste. The primary goal of the restoration project was to create a functional riparian landscape that acts as a water quality filter for runoff, reduce continued erosion and reverse the effects of soil compaction in the Critical Water Quality Zone near the swimming areas. These functions were restored to the site by enhancing the soil and vegetation, installing terraces and rain gardens to capture and treat runoff, and by limiting pedestrian foot traffic to specific pathways (Figure 6). The soil in the upland grassy area was amended with compost and reseeded with native grasses thereby increasing the density and the

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.

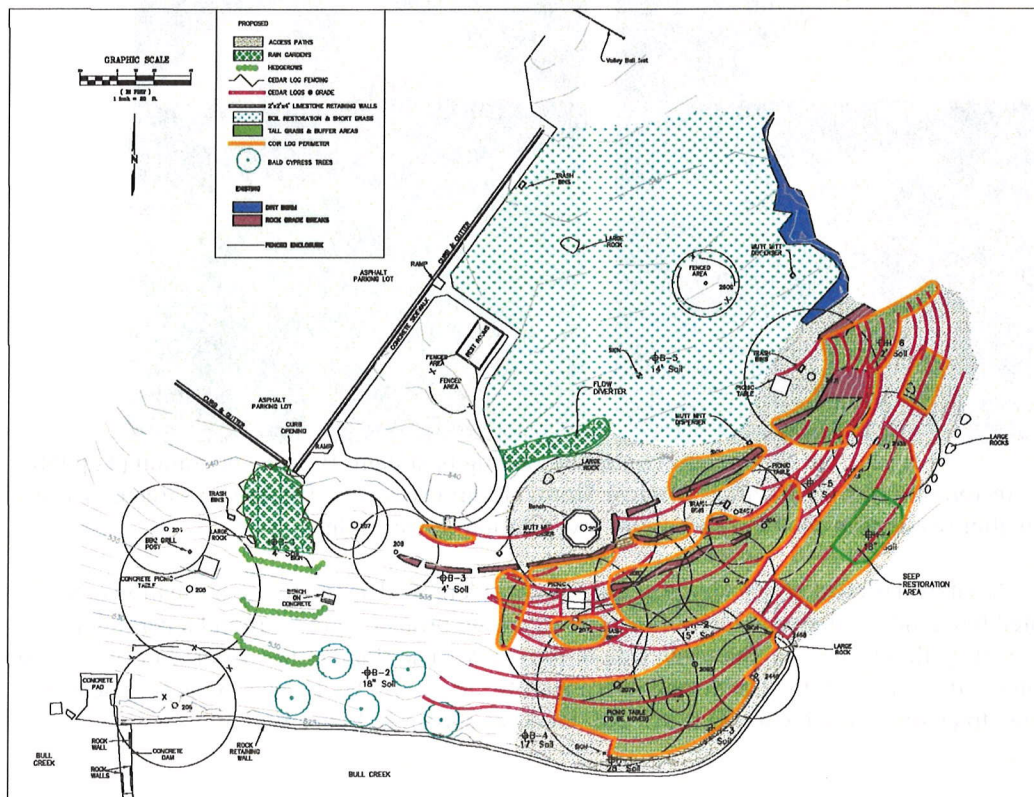


Figure 6. Schematic diagram of the riparian restoration project.

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

park is in a floodplain, the flooding and deposition is a natural occurrence and was not unexpected. In the long term this deposited material will be beneficial to the riparian landscape. However, in the short term WPD is proceeding to re-establish the limited areas of vegetation that were impacted which may extend the time required for full establishment of the new vegetation. Although the damage to the overall project was considered minimal, the landscape near the limestone block wall will require additional time to heal. As for the creek itself, the former “horseshoe” waterfall area was completely filled in by sediments (Figure 7).



Figure 7. Area near the “horseshoe” waterfall looking upstream: Before restoration (Top left), after restoration (top right), after Tropical Storm Hermine (lower left); Area upstream of waterfall soon after restoration showing successful revegetation (lower right)

Unfortunately Tropical Storm Hermine caused considerable damage to the mitigation areas related to the new Lakewood Drive low water crossing project, with trees and a parking lot removed by floodwaters on the south side of the creek. The flood either scoured or buried older sediment deposits near the Lakewood Drive monitoring site. This impact to the sediment was related to an overall reduction in the E. coli levels as shown in figure 8.

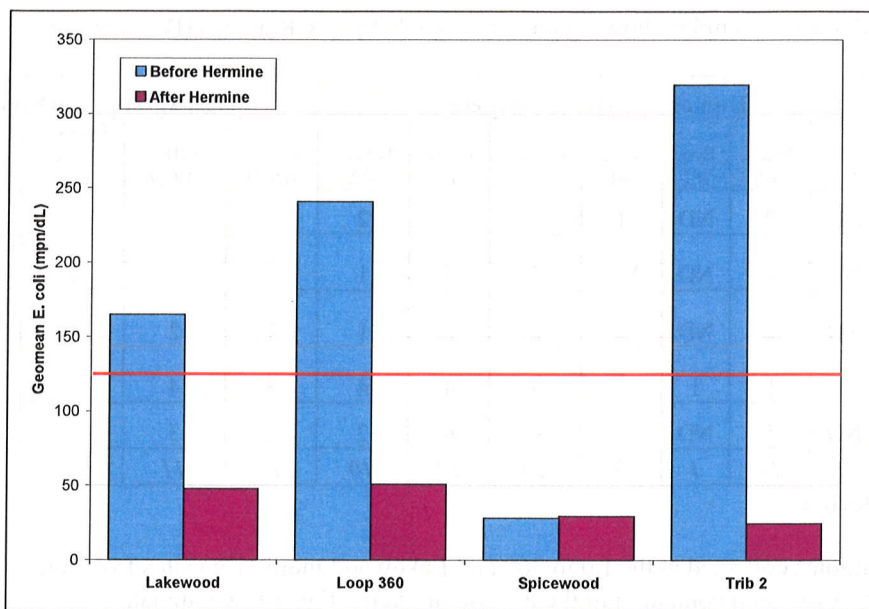


Figure 8. *E. coli* geometric means before (left, blue bar) and after Hermine (right, red bar), during the on-leash only period June 2010 to December 2010.

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.

Table 3. Number of dog fecal samples showing positive signals by qPCR assays (Bae and Kirsits 2010).

Sampling Area	#	Human-associated markers							Host-specific markers			
		HF-183	Bsteri-F1	Buni-F2	Bfragi-F1	Pcopri-F1	Bvulg-F1	Bthetal-F2	BacUni-UCD	BacHum-UCD	BacCow-UCD (cow)	BacCan-UCD (dog)
Pease Park	2	ND	2	ND	1	2	2	2	2	2	2	2
Auditorium Shores	5	ND	4	ND	ND	5	3	1	5	3	1	4
Bull District park	2	ND	2	ND	2	2	2	1	1	2	1	1
Red Bud Isle Park	4	ND	5	1	3	4	4	4	3	4	2	2
Norwood Dog Park	6	ND	5	ND	3	6	6	2	5	3	2	2
Sum	19	0	18	1	9	19	17	10	18	11	8	10

ND indicates non-detection

The ambient water samples collected at the Loop 360 and Lakewood monitoring sites from late August 2010 were processed and compared to the genetic markers. For the two human-associated markers that showed weak cross-reactivity with the dog fecal samples, HF183 and BuniF2, there was no detection of human-associated *Bacteroidales* genomic DNA at either site and a positive detection of dog-associated *Bacteroidales* genomic DNA at the Loop 360 site (Table 4). Analysis of ambient samples suggest that the fecal bacteria may be of non-human origin.

Table 4. Average Ct values measured by qPCR assays in the water samples

Sample Name	Human-associated markers							Host-specific markers			
	HF 183	Bsteri F1	Buni F2	BfragiF 1	Pcopri F1	Bvulg F1	Bthetal F2	BacUni-UCD	BacHum-UCD	BacCow-UCD	BacCan-UCD
Loop 360	ND	ND	ND	27.15	26.12	ND	ND	ND	ND	ND	34.15 ^b
Lakewood	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

^a ND indicates non-detection

^b one positive out of duplicates in undiluted and 1:10 dilution

Bacteria in Sediment Study

WPD conducted a study on the bacteria levels associated with instream sediments from Bull Creek from April to December 2008 (Wagner and Scoggins 2010). *E. coli* bacteria were effectively isolated from instream sediments and compared to the ambient samples from the overlying water column. The study concluded that sediments may be a source of *E. coli* through resuspension. Point or non-point loading sources could contaminate sediments with fecal bacteria that are released when humans or dogs agitate the stream sediments during recreation. However, there was a lack of spatial or temporal consistency in the sediment bacteria concentrations that would explain the results of the routine water column bacteria monitoring.

Fecal Loading from Birds

The University of Texas at Austin (UT) was commissioned by the Texas Department of Transportation (TXDOT) to study the impacts of birds nesting under bridges on fecal bacteria levels in underlying streams (Sejkora et al 2010). Bird and bat colonies inhabiting bridges over streams are known sources of fecal contamination. The UT study included monitoring on Bull Creek within the park from February 2009 to June 2010 relative to migratory cliff swallow

(*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