



Watershed Protection Development Review

McKinney Falls State Park Contact Recreation Assessment.

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Abstract

The Austin/Travis County Health Department has collected approximately 5,000 samples for indicator bacteria at two sites within McKinney Falls State Park since 1993. Data were compared to current Texas Commission on Environmental Quality contact recreation standards, and to additional City of Austin Watershed Protection and Development Review Department bacteria data from other locations within the Onion Creek watershed. Both the upper and lower pools of McKinney Falls State Park are fully supporting contact recreation uses in every year from 1993 to 2007. There is an opportunity to reduce the frequency of monitoring at McKinney Falls State Park in favor of expanding contact recreation assessment to other popular swimming sites in the Austin area.

Introduction

The Austin/Travis County Health and Human Services Department (ATCHD) has collected approximately 5,000 samples of indicator bacteria from two locations on Onion Creek within McKinney Falls Texas State Park from 1993 through July 2007. The park is located in the lower mid-reach of the 135,000 acre Onion Creek watershed downstream of the Barton Springs Segment of the Edwards Aquifer recharge zone.

Water quality monitoring within the park was initiated by the ATCHD and the City of Austin Watershed Protection and Development Review Department (WPDRD) in response to contact recreation concerns (COA 2002). High levels of fecal coliform bacteria in Onion Creek resulted in a swimming ban within the park beginning in 1981. One source of the elevated indicator bacteria concentrations was determined to be the now discontinued Williamson Creek Wastewater Treatment Plant. The plant was decommissioned in 1986 (COA 2002).

Following the shutdown of the plant, monitoring was initiated to evaluate the re-opening of the park to swimming in 1993. Initial results after the first three years of monitoring found that bacteria levels were within contact recreation standards during non-storm influenced conditions (COA 2002). The city-maintained golf course just north of the park continues to be irrigated with treated wastewater effluent.

The currently preferred indicator for contact recreation assessment by the Texas Commission on Environmental Quality (TCEQ) is *Escherichia coli* bacteria (TCEQ 2006). Only *E. coli* data are assessed in freshwater streams if there are adequate data, even if fecal coliform data are available (TCEQ 2006). The recreational use of a water body is not supported if the long-term geometric average of the samples

collected over an assessment period (two to five years) exceeds the criterion or if the criteria for individual samples are exceeded greater than 25 percent of the time (Table 1).

Table 1. Contact recreation standards in colonies per 100 mL (TCEQ 2006).

Indicator	Geometric Mean	Individual Sample
Fecal coliform	200	400
<i>E. coli</i>	126	394

Methods

The ATCHD collects indicator bacteria samples two times per week at two pool locations within McKinney Falls State Park (Figure 1). Initially, fecal streptococci and fecal coliform bacteria were analyzed, although fecal streptococci monitoring was discontinued in 2003. *E. coli* monitoring began in 2003 and has been conducted concurrently with fecal coliform monitoring thru 2007. The lower pool location is downstream of the confluence of Williamson Creek. ATCHD bacteria data are analyzed at the City of Austin Walnut Creek Wastewater Treatment Plant lab facilities by membrane filtration standard method 9222 G and 9222 D for *E. coli* and fecal coliform, respectively (APHA 2005). The period of record for ATHCD data considered in this report is 20 April 1993 thru 2 July 2007.

The WPDRD has collected indicator bacteria data, biological data including periphytic algae and benthic macroinvertebrates, sediment quality and physiochemical water quality data at multiple sites throughout the Onion Creek watershed since 1993 at sampling frequencies up to four times per year. Both ATCHD and WPDRD data are stored in the WPDRD Field Sampling Oracle database.



Figure 1. Map of monitoring locations with McKinney Falls State Park.

ATCHD bacteria data were compared to current contact recreation standards using both the percentage of single sample exceedances and the annual geometric mean. Differences between the upper and lower pools were assessed by the non-parametric paired Wilcoxon signed-rank test (Sokal and Rohlf 1995).

The non-parametric Kruskal-Wallis test was used to compare recent (2004-2007) ATCHD *E. coli* data from within the park to WPDRD data from five other locations within the Onion Creek watershed on 10 similar dates (Table 2). Because WPDRD monitors on a reduced frequency from that of ATCHD, only these dates were used for ATCHD data to insure a comparable dataset.

Table 2. WPDRD sites from other locations within the Onion Creek watershed used for comparison to ATCHD data within the park.

WPDRD Site #	Site Name	Relation to Park
1366	Onion Creek @ South Austin Regional WWTP	10 miles downstream
241	Onion Creek @ Footbridge	8 miles upstream
236	Onion Creek @ Twin Creeks Road	12 miles upstream
612	Onion Creek near Driftwood (Hwy 150)	33 miles upstream
1365	Onion Creek at Pfulman Ranch	55 miles upstream

Temporal trends were assessed by linear regression using SAS PROC GLM. Correlation analyses were performed using Spearman’s non-parametric rank correlation coefficient (Sokal and Rohlf 1995). Statistical analyses were performed in SAS, version 9.1. Unless otherwise specified, statistical significance is defined by $\alpha \leq 0.05$, or a less than or equal to one type I error in 20 trials (Sokal and Rohlf 1995).

Mean daily discharge data for Onion Creek were obtained using the United States Geologic Survey (USGS) gage 08159000 located at the US183 bridge downstream of the park. WPDRD staff use antecedent rainfall to determine if creeks are storm-influenced prior to sampling (Table 3). Antecedent rainfall totals prior to sample collection from the Flood Early Warning System (FEWS) gage 4900 located near the park were compared to bacteria concentrations to determine if rainfall could be used to reliably predict unsafe contact recreation conditions.

Table 3. Rainfall totals within antecedent time periods used to determine storm-influenced flow conditions.

Average Rainfall in 24-Hour Period Prior to Sampling (Inches)	Time to Wait until Baseflow Conditions Return (Hours)
≥ 0.10	24
≥ 0.25	48
> 1.00	72

Results

Both the upper and lower pools of McKinney Falls State Park are fully supporting contact recreation uses in every year from 1993 to 2007. Both *E. coli* and fecal coliform bacteria data assessed by both the percentage of single sample exceedances and annual geometric means yield acceptable contact recreation concentrations by TCEQ standards. In no year since 1993 has either location been “of concern” for contact recreation according to TCEQ standards as applied to the ATCHD bacteria data (Figure 2, Figure 3).

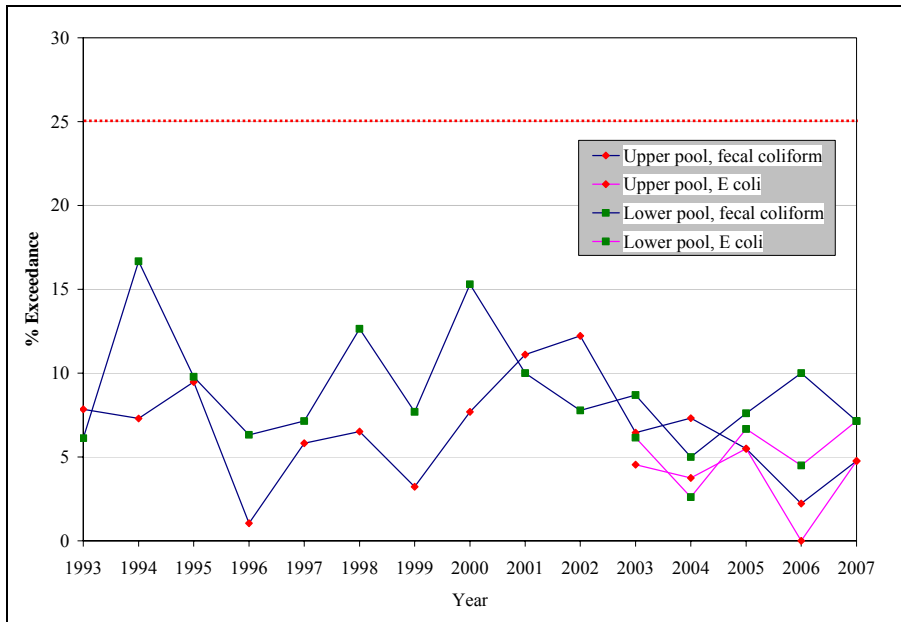


Figure 2. Percentage of samples by year exceeding the single sample contact recreation standards compared to 25% concern level (red dashed line).

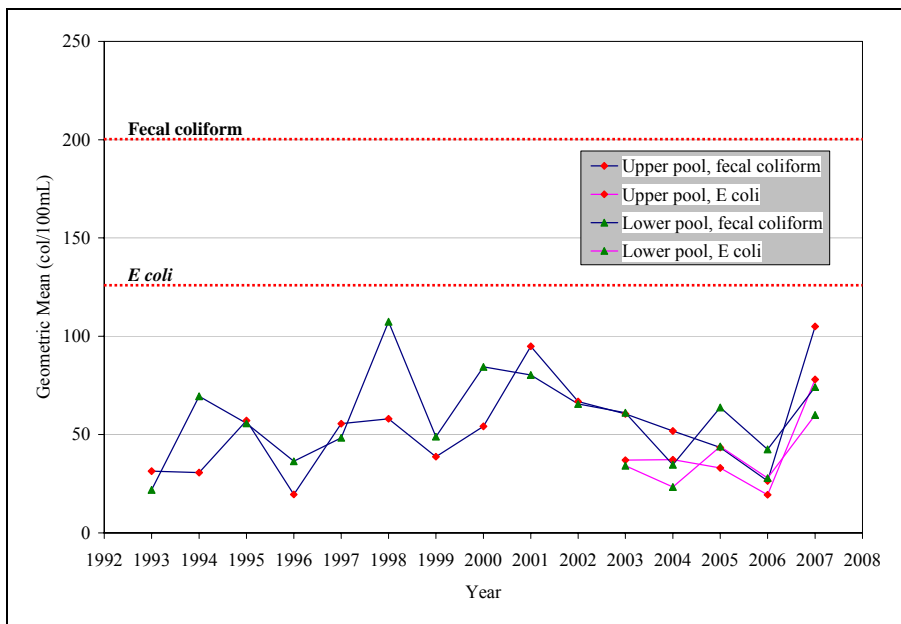


Figure 3. Annual geometric mean (col/100 mL) relative to TCEQ contact recreation standards for *E. coli* (126 col/100 mL) and fecal coliform bacteria (200 col/100 mL).

The maximum annual percentage of single sample exceedances (1993-2007) is below the 25% concern level at both locations for both *E. coli* and fecal coliform (Table 4). The maximum annual geometric mean (1993-2007) is below the contact recreation limits at both locations for both *E. coli* and fecal coliform bacteria (Table 5).

Table 4. Average and maximum annual percentage of samples exceeding the single sample contact recreation standard.

Parameter	Location	Avg. annual % single exceedance	Max. annual % single exceedance
<i>E. coli</i>	Upper Pool	3.7	5.5
<i>E. coli</i>	Lower Pool	5.4	7.1
Fecal coliform	Upper Pool	6.6	12.2
Fecal coliform	Lower Pool	9.2	16.7

Table 5. Average and maximum annual geometric mean of samples (colonies/100 mL).

Parameter	Location	Avg. annual geometric mean	Max. annual geometric mean
<i>E. coli</i>	Upper Pool	40.92	78.0
<i>E. coli</i>	Lower Pool	37.82	59.9
Fecal coliform	Upper Pool	52.94	105.0
Fecal coliform	Lower Pool	59.63	107.4

There is no statistically significant trend in annual geometric mean at either upper or lower pool locations for *E. coli* or fecal coliform bacteria.

The Wilcoxon signed-rank test shows the two sites to be significantly different ($Pr > |S| = 0.0001$) when all fecal coliform data are considered (1993-2007), with the lower pool site yielding higher mean fecal coliform counts over the period of record (mean difference between sites = 54 col/100 mL). The source of the difference is most likely due to the confluence of Williamson Creek entering Onion Creek between the two monitoring locations.

When analyzed annually, fecal coliform counts are significantly different between sites in 8 of 15 years (1993-2007) with higher counts at the lower pool in 7 of those 8 years. *E. coli* counts are significantly different between sites in 4 of 5 years with higher counts at the lower pool in 2 of those 4 years.

For the 10 unique dates from 2004-2007, there is no significant difference in *E. coli* between the upper or lower pool sites within the park and the other WPDRD monitoring sites throughout the Onion Creek watershed (Kruskal-Wallis $pr > \chi^2 = 0.3988$). There is no clear longitudinal pattern or substantial difference between sites based on the 10 unique dates from 2004-2007 (figure 4), consistent with previous analyses (COA 2002).

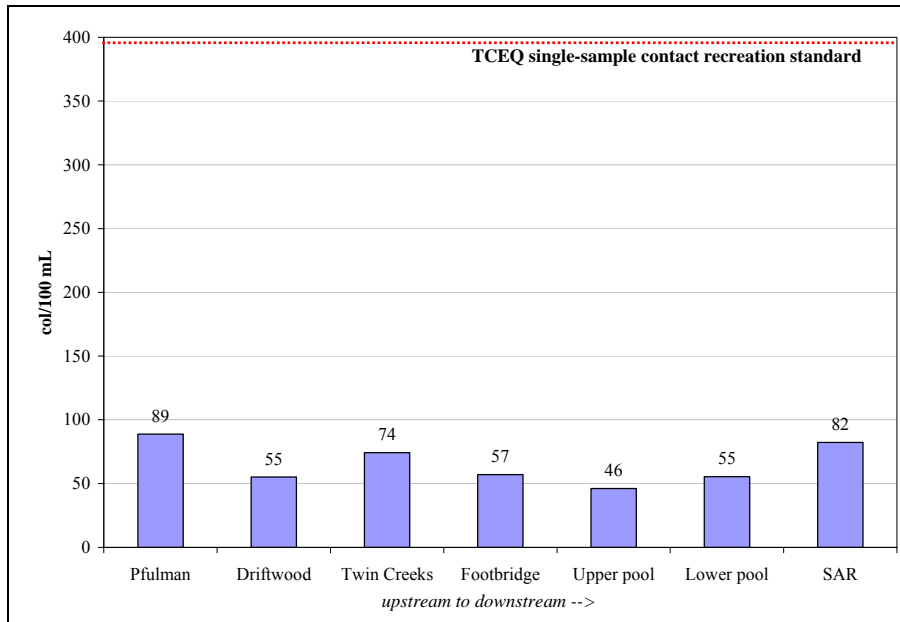


Figure 4. Mean *E. coli* concentrations from 10 unique dates during non-storm conditions in the Onion Creek watershed in relation to TCEQ single-sample 394 col/100 mL contact recreation standard.

Although the pools within McKinney Falls State Park are fully supporting contact recreation uses by TCEQ assessment methodologies, there are obviously certain times when the creek is less safe for contact recreation. Bacteria levels during storm-influenced conditions are higher than non-storm flow bacteria levels (COA 2002).

Bacteria levels are significantly and positively correlated to Onion Creek mean daily discharge as measured at the USGS gage at the US183 bridge (Table 6). The positive correlation of bacteria levels with increasing discharge and the typically higher probability of exceedance at the lower pool are evident in the probability of single sample exceedance when plotted against the associated percentiles of mean daily discharge (Figure 5).

Table 6. Spearman correlation coefficients (ρ) and associated significance for bacteria counts with mean daily flow at the Onion Creek at US183 gage.

Indicator	# obs.	Upper Pool		Lower Pool	
		ρ	Prob> r	ρ	Prob> r
<i>E. coli</i>	362	0.58	<0.0001	0.23	<0.0001
Fecal coliform	1219	0.62	<0.0001	0.28	<0.0001

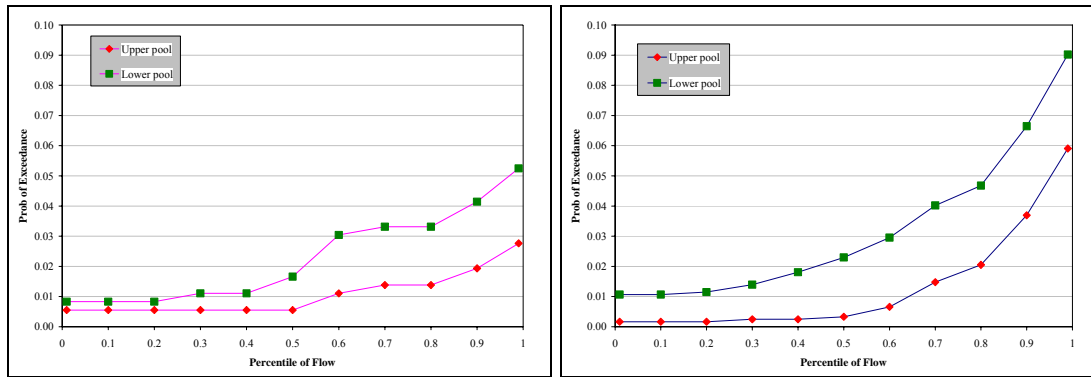


Figure 5. Probability of exceeding the single-sample contact recreation standard versus the percentile of mean daily discharge of Onion Creek at US183 for *E. coli* (left) and fecal coliform bacteria.

However, exceedances of the applicable single-sample criteria for both *E. coli* and fecal coliform have been measured (as recently as 2007) when zero mean daily discharge was recorded at the USGS gage and when discharge is less than the median daily value (3.9 ft³/s). Even at the 99th percentile of discharge (1,043 ft³/s), the probability of exceeding the single sample standard for either indicator bacteria is less than 10%. Although recreation is no longer safe in Onion Creek during high flow events due to increased turbidity and water velocity, Onion Creek discharge as measured at the USGS gage does not appear to be a reliably precise indicator of bacteria concentrations.

Bacteria counts are inversely related to days since rainfall events. Application of the WPDRD storm flow determination criteria to data from the FEWS gage near the park (FEWS4900) can be used to predict safe contact recreation limits (Table 7). On average, only 2% of days when *E. coli* concentrations were in excess of the single sample standard would have been missed using the WPDRD storm determination criteria (false negatives). In other words, *E. coli* counts were greater than 394 col/100 mL on 2% of days after the appropriate waiting period predicted by the WPDRD criteria based on antecedent rainfall totals. However, on average there is an 80% false positive prediction rate when the pools would have been closed based on WPDRD criteria although indicator bacteria levels were within acceptable limits.

Table 7. Contact recreation safety prediction success by antecedent rainfall totals from FEWS4900 based on *E. coli* counts.

Site	Prior rainfall (inch)	# days to close swimming	% false negatives	% false positives predicted
Lower pool	≤0.10	1	2.3	83.9
Lower pool	≤0.25	2	2.1	81.8
Lower pool	≤1.00	3	3.8	71.4
Upper pool	≤0.10	1	1.0	85.2
Upper pool	≤0.25	2	0.3	83.1
Upper pool	≤1.00	3	2.1	73.3

Conclusion

Both the upper and lower pools of McKinney Falls State Park are fully supporting contact recreation uses in every year from 1993 to 2007.

There is no significant temporal trend in annual geometric means at either location. For recent data, there is no significant difference under non-storm flow conditions between sites within McKinney Falls State Park and other sites throughout the Onion Creek watershed.

Indicator bacteria counts are different between the upper and lower pool locations and typically higher at the lower pool, downstream of the confluence of Williamson Creek. Exceedances of the single sample contact recreation standard are related to increasing Onion Creek discharge as expected, although Onion Creek discharge is not a reliable predictor of indicator bacteria concentrations. Antecedent rainfall can be used with WPDRD storm definition criteria to determine safe contact recreation conditions, although there would be a large number of unnecessary closures.

Discussion

Relative to most WPDRD monitoring programs, the ATCHD monitors indicator bacteria levels within the park at an exceptionally high frequency (two times per week). As the lower pool typically yields higher bacteria levels than the upper pool, the lower pool could be considered as the “worst-case” and monitoring only at the lower pool would provide for a conservative estimate of the safety of contact recreation within the park. Since both locations within the park are fully supporting contact recreation during non-storm conditions and there is no clear increasing temporal trend, the sample frequency and/or number of park sites could be reduced in favor of increasing contact recreation monitoring at other popular swimming locations in the Austin area within the Barton Creek (Gus Fruh, Campbell’s Hole) or Bull Creek (near Loop 360) greenbelts or in Lake Austin (Emma Long/City Park beach area).

E. coli bacteria are now the preferred indicator for contact recreation assessment, and TCEQ will not assess fecal coliform data if *E. coli* are available. Both fecal coliform and *E. coli* data have been collected concurrently by ATCHD since 2003. This overlapping dataset provides a sufficient number of data points (368 per site) for assessing the correlation between the indicators. Thus, fecal coliform monitoring could be discontinued. Again, a decrease in analysis costs could be used to increase contact recreation monitoring at other locations.

The clear disadvantage to the use of indicator bacteria for real-time contact recreation safety assessment is the 18-24 hour delay in determining test results due to the required incubation time for the microorganisms. This can result in both delayed closure and re-opening of swimming areas. The use of readily available real-time surrogates could provide a mechanism for faster closer and re-opening.

Although bacteria counts are positively related to Onion Creek discharge as expected, the use of discharge as a surrogate for indicator bacteria levels is not precise. Unless an acceptable probability of exceeding the single sample standard could be selected based on acceptable risk to the swimmer, a discharge threshold is not useful in determining whether contact recreation is safe relative to indicator bacteria concentrations. Obviously, there is some discharge threshold when increased velocity or turbidity alone would make contact recreation unsafe regardless of indicator bacteria concentrations.

Antecedent rainfall can be used to predict unsafe contact recreation conditions with a false negative prediction in (on average) approximately 2% of cases. However, an average false positive rate of approximately 80% would result in a large number of unnecessary closure days. Variability in the relationship of bacteria counts to rainfall could be reduced by inclusion of additional explanatory variables like Onion Creek discharge (high baseflow could dilute storm runoff) and number of days

between storms (isolated large storms may have higher non-point source pollutant loads than smaller multi-day series of storms which have already removed the “first-flush” of contaminants).

One additional alternative not evaluated quantitatively in this analysis is the use of water turbidity or Secchi disk depth as a surrogate for contact recreation safety. Both are easy to measure instantaneously in the field with a limited amount of inexpensive equipment. In-situ field assessment of turbidity or Secchi disk depth concurrently with indicator bacteria samples for a short period of time, potentially targeting isolated storm events, may provide data for establishing this type of rule-based closure.

References

American Public Health Association (APHA). 2005. Standard Methods for the Examination of Water and Wastewater, 21st edition. Prepared and published jointly by the American Public Health Association, American Water Works Association, Water Environment Federation.

City of Austin (COA). 2002. The Onion Creek Report Update. City of Austin Watershed Protection and Development Review Department, Environmental Resources Management Division. May 2002.

Sokal, R.R., and F.J. Rohlf. 1995. Biometry: the principles and practice of statistics in biological research, 3rd edition. W.H. Freeman and Company, New York.

Texas Commission on Environmental Quality (TCEQ). 2006. Draft 2006 Guidance for Assessing and Reporting Surface Water Quality in Texas: in compliance with Sections 305(b) and 303(d) of the Federal Clean Water Act. Prepared by Monitoring Operations, Surface Water Quality Monitoring Program. June 27, 2007.

http://www.tceq.state.tx.us/assets/public/compliance/monops/water/06twqi/2006_guidance.pdf