city of austin
Watershed Protection

Bull Creek Water Quality, Benthic Macroinvertebrate and Stream Habitat Survey 2008

City of Austin Balcones Canyonlands Preserve – Permit 08-004

By Heather Perry

Introduction

The sampling plan for the Bull Creek Water Quality and Benthic Macroinvertebrate Survey (Project #18) began June 2005 (amended 02 June 2008) and replaces all previous Bull Creek sampling plans, except for EII efforts. This report contains all historic data that the City of Austin's WPDR Surface water section has collected through 2008. Future reports will update only on the year of collection.

The 11.4 mile long Bull Creek, located within Travis Co., encompasses a drainage area of 31.9 square miles, the majority of which lies atop the northern portion of the Edwards Aquifer recharge zone. Bull Creek abuts the Balcones Canyonlands Conservation Preserve (BCCP) and the "Hanks tract" as described in 1999 by City of Austin WPDR/ERM "has the highest level of aquatic fauna diversity of any study site in Travis County."

Bull Creek contains habitat for the endangered golden-cheeked warbler, *Dendroica chrysoparia*, and black-capped vireo, *Vireo atricapilla.* Along with these two species of birds, Bull Creek is home to the Jollyville Plateau salamander, *Eurycea tonkawae*, and to an endemic caddisfly, *Austrotinodes texensis*. *A. texensis* was described by David Bowles (1995) and is assumed endemic to karst springs/runs of the Edwards Plateau ecoregion.

The Jollyville Plateau salamander is found in tributary 5, 6 and 7 of Bull Creek. Populations are monitored on a quarterly basis at three locations where benthic macroinvertebrates, diatoms, water quality and habitat assessments are done. Of these three sites Tributary 6 (Hanks tract) and Tributary 5 (Hanks tract) have undergone urban development. Tributary 7 is still rural and is part of the BCP preserve and is referred to as the Franklin tract (Bendik, 2008).

Methods

Refer to the Bull Creek QAPP for specifics on sampling and frequency of sampling (Perry, 2008).

Table 1. City of Austin BCP Bull Creek sampling locations and sampling done at each location.

Site #	Site Name	TPDES Biological Site	EII Site	Salamander Site	Benthic and Habitat	Water Quality	Additional Parameters
349	Bull Creek Above Trib 7	Yes		yes	yes	yes	Cl/SO_4/Na
1164	Trib 5 Below Hank's Tract Property Line	Yes		yes	yes	yes	Cl/SO_4/Na
151	Trib 6 @ Bull Creek	Yes	Yes	yes	yes	yes	Cl/SO_4/Na

Results & Conclusions

Water Quality

Water quality samples were collected three times per year, with samples being sent to an independent lab (LCRA) for testing. The three locations within the preserve that are monitored by the CoA Surface water team are also Jollyville Plateau salamander sites and additional water quality parameters were collected (chloride, sodium and sulfate) along with other standard water quality measurements. *In situ* water chemistry readings were recorded at each visit (specific conductivity, temperature, pH and dissolved oxygen) along with a measurement of discharge (cfs). During the critical period (May/June and Aug/Sept) 24-hour diel water quality chemistry measurements were recorded using a submerged datasonde. For the purposes of this study site #349 is considered the reference site and background conditions for water quality. Water quality measurements are listed in Table 2 with minimum, maximum, median and means listed for each constituent measured.

Table 2. Water quality measurements from 1993-2008.

Site #	Parameter	Min	Max	Median	Mean	± SD
151	Ammonia as N (mg/L)	0.005	0.31	0.02	0.043	0.049
349	Ammonia as N (mg/L)	0.005	0.2	0.02	0.041	0.042
1164	Ammonia as N (mg/L)	0.005	0.28	0.03	0.053	0.052
151	Chloride (mg/L)	57.4	105	73.6	75.007	10.209
349	Chloride (mg/L)	11.8	22.8	15.2	15.666	2.463
1164	Chloride (mg/L)	12.7	46.4	20.7	23.441	8.250
151	Conductivity (µS/cm)	620	1068	936.9	937.931	63.400
349	Conductivity (µS/cm)	323.3	689.2	544.3	551.926	46.902
1164	Conductivity (µS/cm)	564.2	707	626	629.493	34.583
151	Dissolved Oxygen (mg/L)	5.71	13.78	9.51	9.517	1.684
349	Dissolved Oxygen (mg/L)	3.42	10.64	6.51	6.764	1.722
1164	Dissolved Oxygen (mg/L)	2.44	10.15	7.03	6.794	1.881
151	*E. coli* MPN/100mL	27	420	61.5	94.182	89.914
349	*E. coli* MPN/100mL	4	2400	26.5	139.542	483.628
1164	*E. coli* MPN/100mL	2	190	33.5	49.500	47.499
151	Nitrate/Nitrite as N (mg/L)	0.1	2	0.61	0.650	0.377
349	Nitrate/Nitrite as N (mg/L)	0.004	0.5	0.04	0.069	0.096
1164	Nitrate/Nitrite as N (mg/L)	0.153	0.731	0.4	0.412	0.127
151	Ortho P (mg/L)	0.002	1	0.02	0.043	0.118
349	Ortho P (mg/L)	0.002	1	0.02	0.043	0.138
1164	Ortho P (mg/L)	0.002	1	0.02	0.045	0.142
151	pH (s.u.)	6.58	8.34	7.66	7.596	0.321
349	pH (s.u.)	6.43	8.32	7.37	7.376	0.353
1164	pH (s.u.)	6.46	8.22	7.365	7.306	0.385
151	Sodium (mg/L)	2.19	59.5	45.2905	43.324	10.043
349	Sodium (mg/L)	3.96	12.5	8.1905	8.214	1.447
1164	Sodium (mg/L)	3.73	21.3	10.675	11.448	3.863
151	Sulfate (mg/L)	53.6	143	78.35	80.820	15.572
349	Sulfate (mg/L)	12.4	26.8	17.2	17.797	3.366
1164	Sulfate (mg/L)	10.7	26.4	20.4	20.097	3.346
151	TSS (mg/L)	0.4	94	1.2	3.089	10.748
349	TSS (mg/L)	0.2	22	1	2.188	3.887
1164	TSS (mg/L)	0.1	10	1	1.692	1.882
151	Temperature (°C)	10.89	26.47	21.325	20.245	3.639
349	Temperature (°C)	10.83	23.89	19.255	19.024	2.869
1164	Temperature (°C)	10.78	26	20.1	19.651	3.308

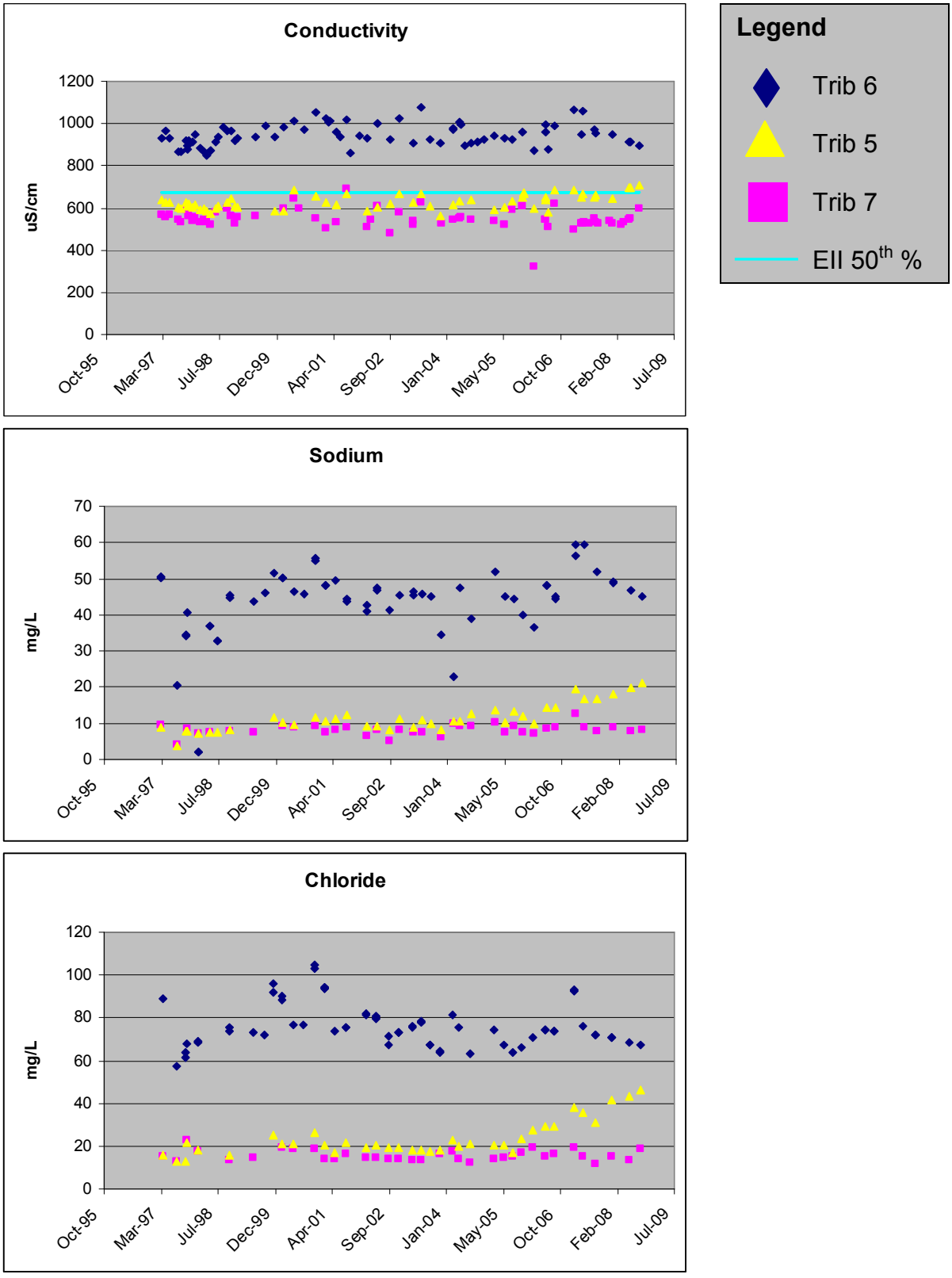

Figure 1. Conductivity, sodium and chloride measurements from 1997-2008 from Bull Creek Preserve sites on tributaries 5, 6 and 7; tributary 6 has historically high readings for all three measurements, while tributary 5 has increasing sodium and chloride concentrations starting around March 2004 sampling.

Site #349 and site #1164 generally follow the same pattern for conductivity, chloride, sodium and sulfate. Beginning around March 2004 tributary 5 (#1164) began an upward trend for both chloride and sodium. A temporal trend, OLS regression by date for both sodium ($p = 0.000$, $R^2 = 0.54$, $\alpha = 0.5$) and chloride ($p = 0.000$, $R^2 = 0.67$, $\alpha = 0.5$) (SAS 9.1) were both statistically significant. Sulfate showed no change over time at tributary 5 and it typically had similar measurements to reference site conditions. City of Austin project assessing groundwater changes from rural and urbanized conditions during subdivision construction showed that with increasing urbanization an increase in groundwater chemistry occurred, particularly the ion concentrations (COA *draft* 2008).

Table 3. Percent impervious cover for Bull Creek tributaries 5, 6 & 7 for 1997/1995, 2003 & 2006 calculated using planimetric measurements. The 1997 percents had to take into account data from 1995 for driveways and sidewalks that were not available for the 1997 impervious coverage data.

	%Impervious Cover (Planimetric)		
Site #	**1997/1995**	**2003**	**2006**
151	14	20	22
349	0	0	0
1164	5	14	18

Table 3 lists the percent impervious cover for each sampling location within the Bull Creek preserve. Percent impervious coverage for site #1164 increases by over 10% in less than a decade. While no statistical data is available at the present time comparing percent impervious coverage to changes in ion concentrations within tributary 5 over time; it is assumed that this could be one of the factors in the changes in water quality in this tributary.

Bull Creek drains into Lake Austin and the Texas Surface Water Quality Standards Chapter 307 lists maximum limits in Lake Austin as chloride 100mg/L and sodium 75mg/L; Barton Creek the limits are 50mg/L for both sodium and chloride (TCEQ 2008). While average conditions at the reference site are very low in comparison to background conditions on Lake Austin and Barton Creek there is concern that a recent trend in elevations of both sodium and chloride will continue to increase over time in tributary 5.

Average conductivity, sodium and chloride levels are given in Table 4 for water quality collection from 1997-2008. Background conditions (#349) are very low for chloride and sodium and conductivity is below the average levels seen in the City of Austin's EII sampling program which is on average reported as 674 µS/cm (Figure 1). When considering only sodium and chloride levels for 2004-2008 sampling for tributary 5 the average levels are 14.67 and 29.18 mg/L, respectively. Sodium and chloride levels are nearly twice the background level reported from site #349.

Table 4. Average conductivity (cond) (µS/cm), chloride (Cl) (mg/L) and sodium (Na) (mg/L) for Bull Creek preserve sites from 1997-2008. Site #349 is considered reference condition for this study.

	Avg Cond	Avg Cl	Avg Na	Year
151	946	76.5	43.3	1997-2008
349	**549**	**15.7**	**8.2**	1997-2008
1164	629	23.4	11.45	1997-2008
151	950	73.40	46.5	2004-2008
349	**537**	**15.58**	**8.9**	2004-2008
1164	649	29.18	14.67	2004-2008
151	944	78.08	41.7	1997-2003
349	**559**	**15.74**	**7.7**	1997-2003
1164	616	19.07	9.21	1997-2003

Habitat

Habitat assessments are conducted with each biological sampling event (May/June & August/September) and consist of either:

1. EPA habitat survey field sheet and Chanel Stability field sheet

   The EPA Physical Habitat Quality evaluation is a visual assessment of existing erosion-related in-stream and riparian conditions. The field assessment sheet is derived from Barbour and Striblings (1991), and describes four categories of conditions (optimal [20-16], sub-optimal [15-11], marginal [10-6] and poor [5-1]) for 10 parameters and are rated on a 20-point system.

   Chanel stability is a comprehensive evaluation of the stability and erosion occurring within stream reaches is conducted using the method developed for the U.S. Department of Agriculture by Pfankuch (1975) to answer three basic questions: (1) what are the magnitudes of the hydraulic forces at work, (2) how resistant are the various organic and inorganic bank and channel components to the recent stream flow exerted on them, and (3) what is the capacity to adjust and recover from potential changes in flow volume and increases in sediment production.

2. Intensive habitat survey

   Habitat data is then compiled and placed into a matrix to determine the Habitat Quality Index (HQI) for each site. The values are reported as (Figure 2):

Marginal	<113
Suboptimal	113-166
Optimal	>166

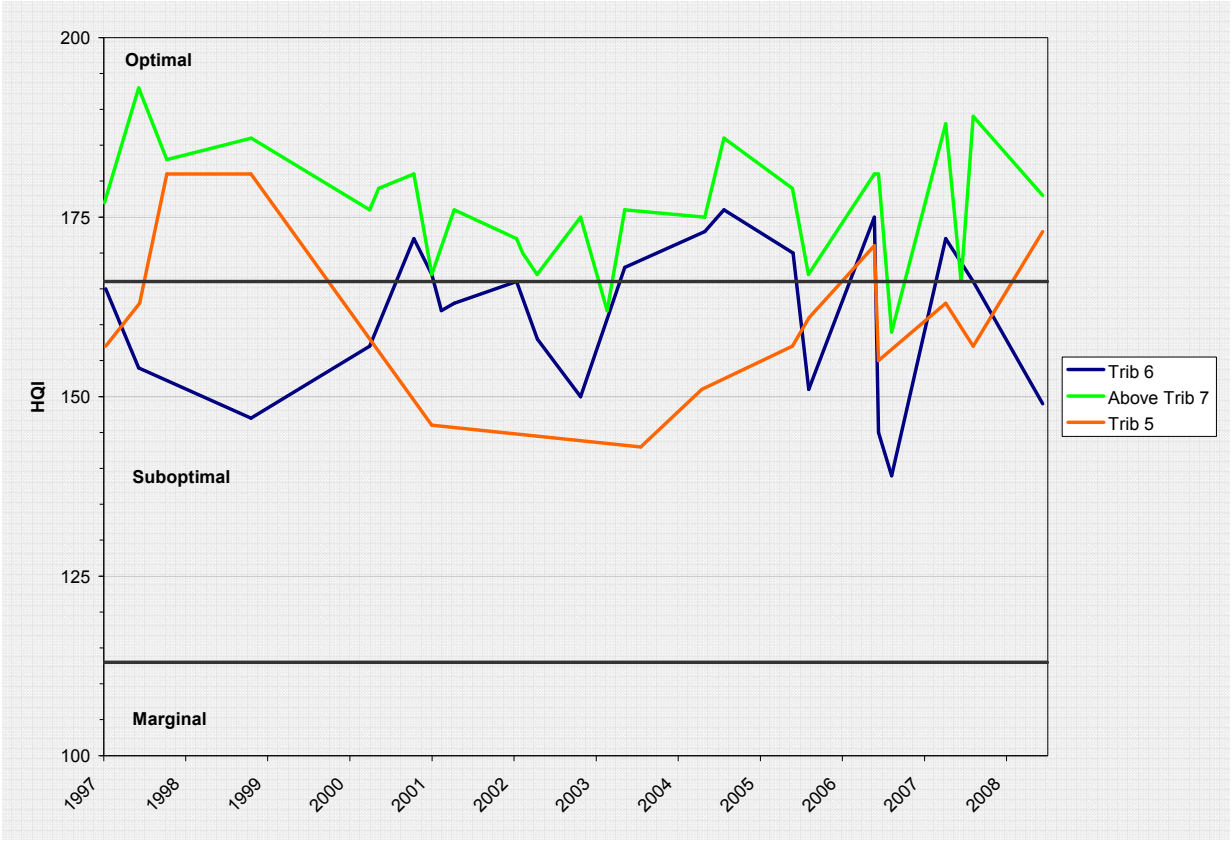

Figure 2. Habitat Quality Index scores for Bull Creek Preserve sites on tributaries 5, 6 and 7.

HQI values can change drastically depending upon drought conditions, excessive rain and season. None of the sites on the preserve have scored in the marginal category in the last decade.

Biological Sampling

Benthic Macroinvertebrates

Benthic macroinvertebrates are collected within riffles located within each study reach. Samples are collected with a surber sampler (600µm, 1ft^2) and are collected from the bottom, middle and top of each riffle. Identification is done to the lowest practical taxon. Samples are picked to represent 200± 20% organisms for each site. Sampling is done twice a year during the critical period (May/June & August/September).

Benthic macroinvertebrates are used in a variety of metrics calculations, and the most common metrics used in evaluation are # taxa, abundance and aquatic life use score (ALU). ALU scores are ranked as limited (<22), intermediate (22-29), high (29-36) and exceptional (>36). These scores can change due to season, temperature, flow and severe conditions such as flooding or drought. The three preserve sites typically score in the intermediate and high categories. Some years the ALU was limited and none of the sites have ever scored in the exceptional category (Figure 3).

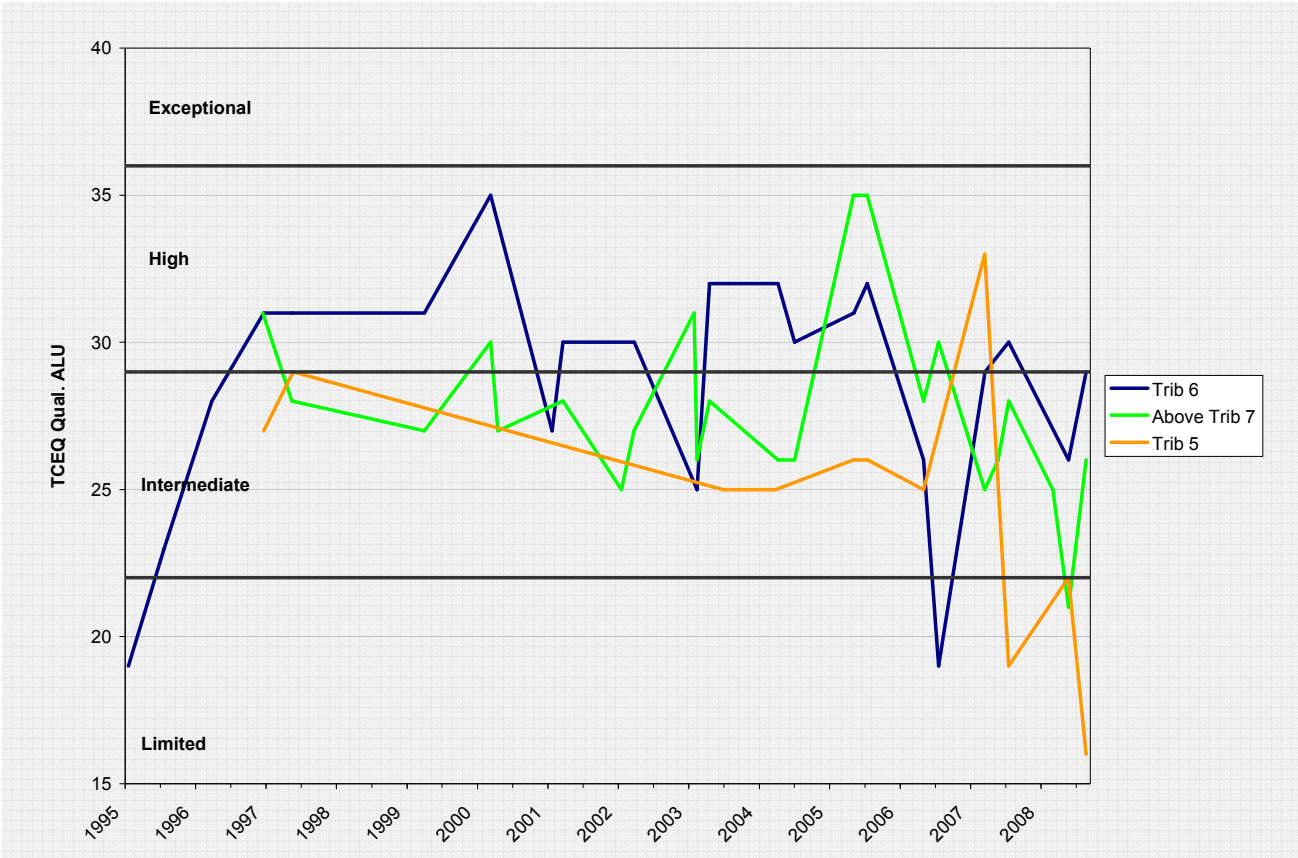

Figure 3. TCEQ qualitative Aquatic Life Use scores for tributaries of Bull Creek within the Bull Creek Preserve for 1995-2008; limited scores could be due to drought conditions (low flow) during those sampling periods.

Texas Commission on Environmental Quality (TCEQ) has listed the ALU scores for the Bull Creek tributaries in the Texas Water Quality Inventory Water Bodies Evaluated in March 2008. The scores for Bull Creek are based on data submitted to TCEQ by the City of Austin.

- **SegID 1403I** Bull Creek Tributary 5 (unclassified water body)
  Segment Size 1 Miles
  From the confluence of an unnamed tributary to Bull Creek west of the intersection of Pickfair Drive and Brightling Lane in Austin in Travis County to a point east of Hwy 620 in Travis County
  Segment Type Freshwater Stream
  Assessed in 2008: no
  Flow type: Intermittent
  ALU designation: minimal

- **SegID 1403H** Bull Creek Tributary 6 (unclassified water body)
  Segment Size 3 Miles
  From the confluence of Bull Creek Road west of Pickfair Drive in Austin in Travis County to a point east of Hwy 620 in Travis County
  Segment Type Freshwater Stream
  Assessed in 2008: no
  Flow type: Perennial
  ALU designation: High
  (TCEQ 2008).

Tributary 7 is not evaluated by TCEQ but the City of Austin has designated it with an ALU of high, and the flow is perennial with intermittent pools.

Table 5. Benthic macroinvertebrate taxa for Bull Creek Preserve sites for both historical data (1997-2007) and 2008 sampling.

CoA Historical - 2007 Benthic Macroinvertebrate Taxa				
	# Phyla	**# Orders**	**# Families**	**# Genera**
Trib 6 (151)	6	16	60	88
Trib 7 (349)	6	15	56	70
Trib 5 (1164)	5	14	43	47

CoA 2008 Benthic Macroinvertebrate Taxa				
	# Phyla	**# Orders**	**# Families**	**# Genera**
Trib 6 (151)	5	8	23	23
Trib 7 (349)	4	10	30	29
Trib 5 (1164)	3	8	20	20

Benthic macroinvertebrate taxa list is given in Appendix A. The list is broken into historical data and 2008 data. Of all the taxa listed only 13 taxa were collected at all sites for both historical-2007 and 2008 sampling. Another 12 taxa were collected at only five of the sites for historical-2007 and 2008 sampling. If these 25 taxa are considered the most commonly collected taxa for the Bull Creek Preserve sites and used as an average number of taxa expected the 2008 sampling is following this general trend (Table 5). Tributary 5 is lower in total number of genera but that may be due to low-no flows experienced this year (Table 5).

After biological sampling this year (2008) the City of Austin in conjunction with the BCP removed the first low water crossing on Tributary 5 which was located within the study reach on this tributary. On subsequent visits to this site the riffle is now dry and there is

concern that the riffle may have moved downstream due to changes in the reach. This will be taken into consideration during 2009 sampling if taxa numbers decline.

Diatoms

Diatoms are collected in conjunction with benthic macroinvertebrates. Three rocks are selected from the riffle and represent the bottom, middle and top portions of the sample area. Rocks are marked so a defined area is sampled from each rock. The sample is composited and is preserved in the ERM lab with 10% buffered formalin. Samples are sent out for identification by a 3rd party.

Four metrics are calculated for diatoms

- Number of Taxa / Taxa Richness
  - Number of unique taxa present in each sample
- PTI (Pollution Tolerance Index)
  - Average pollution tolerance level. This metric "rates diatom taxa by their sensitivity to pollution on a scale of increasing sensitivity, where 1 is least sensitive and 4 is the most sensitive" (Gilroy and Makosky 2008).
- *Cymbella* Richness
  - "Number of taxa in the *Cymbella*, *Encyonema*, *Encyonemopsis*, and *Reimeria* genera" (COA 2008). This metric looks at the number of cymbelloid taxa and is similar to PTI in that a decrease in this metric indicates a decrease in sensitive taxa (Gilroy and Makosky 2008).
- Percent Motile Taxa
  - "Number of organisms in *Navicula*, *Nitzschia*, *Surrirella*, *Craticula*, *Diadesmis*, *Luticola, Sellaphora*, *Hippodonta*, *Tryblionella*, *Geisselaria* genera as percentage of the total number of organisms" (COA 2008). This metric is based on the number of taxa and not on the number of individuals identified from the samples. This metric is used as a way to measure siltation because taxa that are able to move are more capable of surviving a siltation event. Therefore, increasing values correlates to an increase in siltation Gilroy and Makosky 2008).
- Percent Similarity to Reference Condition
  - "Community similarity index calculated using percentages of organisms in both reference and test samples. Reference conditions are generated from data collected at reference sites in biologically equivalent time periods" (COA 2008).

Diatoms from the years 2005-2007 were used in this analysis because for site #1164 there was only data available for these years, so data for the other sites were trimmed to accommodate this issue. The 2008 diatoms were just delivered to the City of Austin and as of this report metrics were not calculated for this data set. A diatom taxa list can be found in Appendix B.

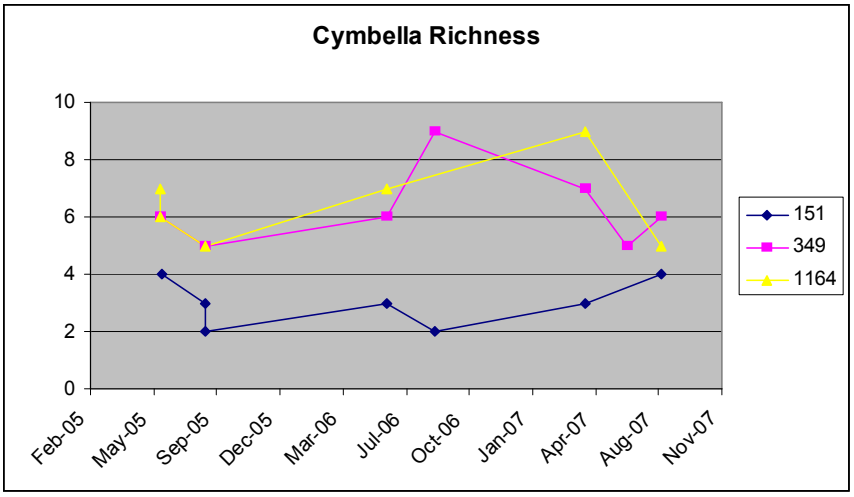

Figure 4. *Cymbella* Richness metric for Bull Creek diatoms (2005-2007); tributary 6 (#151) tends to have lower *Cymbella* richness which may be an artifact of the higher ion concentrations found within this tributary.

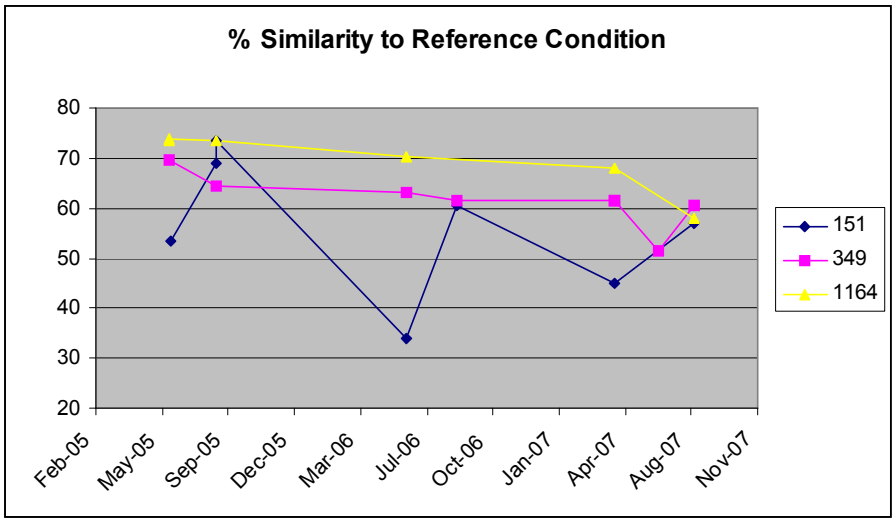

Figure 5. Percent similarity to reference condition metric for Bull Creek diatoms (2005-2007); sites 349 and 1164 show a similar trend, while site 151 has drastic drops between sampling events.

Table 6. Bull Creek diatoms metrics (averaged) for 2005-2007.

Site	*Cymbella* Richness	# of Taxa	% Motility	PTI	% Similarity
151	3	33	10	2.9	56
349	6.4	30	6.1	3.1	61.6
1164	6.5	40	10.1	3	69.5

The metrics graphed in Figures 4 and 5 showed trends over time for Bull Creek, while metrics for number of taxa, % motility and PTI had no detectable trend over time. When comparing these 5 metrics from these tributaries to metrics for Onion Creek tributaries there are noticeable differences between Bull Creek tributaries (Table 6) and Onion Creek tributary diatom metrics (Table 7).

Table 7. Diatom metrics calculated for tributaries of Onion Creek (COA 2002).

	Bear	Rinard	Slaughter	S. Boggy	Marble	Williamson	Cottonmouth
PTI	2.56	2.76	2.72	2.05	2.41	2.50	2.19
Cymbella Richness	2.50	3.25	2.70	1.67	2.00	2.38	1.00
Percent Motile	20.77	17.43	30.48	42.85	28.58	41.59	7.00
Percent Similarity	50.74	22.24	52.06	43.28	37.61	43.67	11.54
Number of Taxa	16.04	25.25	23.05	25.33	32.00	25.50	18.00

Cymbella richness for Bull Creek tributaries 7 (349) and 5 (1164) are twice as high as tributary 6. This metric in Onion Creek tributaries averages a value of 2.2 with the highest tributaries only having values of 2.7. This indicates that more sensitive taxa are present in higher numbers in tributaries 5 and 7. Tributary 5 (1164) is very close in *Cymbella* richness to tributary 7, which is the reference condition for this study.

Percent similarity is also much higher for the Bull Creek tributaries in comparison to the Onion Creek tributaries. Bull Creek tributaries ranged from 56-69.5% (Table 6) and averaged 62.4% similarity, while Onion Creek tributaries ranged from 11.54-52.06 (Table 7) and averaged 37.3% similarity to reference conditions.

Even though percent motility did not show a clear pattern in Bull Creek tributaries when compared to each other (Table 6) and therefore can be assumed, that if this is a measure of siltation, that there is little siltation occurring in this portion of Bull Creek. While there may be local occurrences of siltation due to construction or flooding this does not have a long term affect upon the system. In comparison the percent motile taxa present in Onion Creek tributaries ranges from 7-42.85 (Table 7) and averages 27. These values are nearly 3 times higher than the percent motile taxa in the Bull Creek tributaries.

Number of taxa for tributaries in Bull Creek are also much higher than Onion Creek tributaries. The highest number of taxa in Onion Creek comes from Marble Creek, with the average number of taxa found in Onion Creek tributaries being 23.5 (Table 7). The average number of taxa in the Bull Creek tributaries is 34 (Table 6). Both tributaries 5 6 have higher average number of taxa than the reference site tributary 7 (Table 6). This could be attributed to the higher levels of nutrients and algae in these tributaries or the high amount of leaf litter and riparian vegetation shading that occurs in tributary 7.

Literature Cited

Barbour, M.T. and J.B. Striblings. 1991. Use of habitat assessment in evaluating the biological integrity of stream communities. In Biological Criteria: Research and Regulation, 1991, pp 25-38. EPA-440/5-91-005. U.S. EPA, Office of Water, Washington, DC.

Bendik, N. 2008. Jollyville Plateau Salamander Monitoring QAPP. City of Austin.

Bowles, D. 1995. A New Species of *Austrotinodes* (Trichoptera: Ecnomidae) from Texas. Journal of the New York Entomological Society. 103(2)155-61.

City of Austin. 2002. The Onion Creek Update Report. Austin, Texas.

City of Austin. 2008 ***draft*****.** Differential changes in groundwater quality due to urbanization under varying environmental regulations in Austin, Texas. SR-07-OC.

City of Austin. 2008. Water Resource Evaluation Standard Operating Procedures Manual. Austin, TX.

Gilroy, M. and S. Makosky. 2008. Barton Springs Algae, City of Austin. SR-08-01.

Perry, H.A. 2008. Bull Creek Quality Assurance Project Plan. City of Austin.

Pfankuch, D.J. 1975. Stream reach inventory and channel stability evaluation. USDA Forest Service, R1-75-002. Government Printing Office #696-260/200.

SAS Institute. 2003. User's manual, version 9.1. SAS Institute, Cary, N.C.

Texas Commission on Environmental Quality (TCEQ). 2008. Texas Surface Water Quality Standards (Chapter 307- Appendix A) *In* Texas Administrative Code. http://info.sos.state.tx.us/pls/pub/readtac$ext.ViewTAC?tac_view=3&ti=30&pt=1

Texas Commission on Environmental Quality (TCEQ). 2008. 2008 Texas Water Quality Inventory Water Bodies Evaluated (March 19, 2008) *in* 2008 Texas Water Quality Inventory and 303(d) List. http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/08twqi/twqi08.html

Appendix A – Bull Creek Preserve Benthic Macroinvertebrate Taxa List *

							CoA Historical Data - 2007			*CoA 2008 Data*		
Phylum	**Sub-class**	**Class**	**Order**	**Family**	**Subfamily**	**Genus species**	**151**	**349**	**1164**	**151**	**349**	**1164**
Arthropoda			Isopoda				1		3			
Annelida	Hirudinea						4					
Annelida	Oligochaeta						53	101	71	3	8	3
Arachnida	Hydracarina (Acari)						662	187	54	2		
			Odonata	Aeshnidae		*Basiaeschna*		2	1			
			Odonata	Libellulidae		*Brechmorhoga mendax*	74	144	15	6	6	2
Mollusca			Basommatophora	Ancylidae		*Ferrissia*	1	1				
Mollusca			Basommatophora	Ancylidae		*Hebetancylus*	35	8	4			
			Diptera	Culicidae			1					
Arthropoda		Ostracoda					549	92	218			21
Arthropoda	Copepoda						10					
			Hemiptera	Belostomatidae		*Belostoma*			1			
Arthropoda			Isopoda	Asellidae		*Caecidotea*		16				
			Ephemeroptera	Caenidae		*Caenis*	310	30	47		2	
			Ephemeroptera	Baetidae		*Callibaetis*	12	3	5		1	5
			Ephemeroptera	Baetidae		*Camelobaetidius*	5	67	21			
			Ephemeroptera	Baetidae		*Fallceon*	4508	1095	1144	37	54	9
			Coleoptera	Lutrochidae		*Lutrochus luteus*	1	1				
			Trichoptera	Calamoceratidae		*Phylloicus ornatus*	11	99	52		7	
			Ephemeroptera	Baetidae		*Plauditus*		63				
			Diptera	Athericidae		*Suragina concinna*	96	92	136	1	60	2
Mollusca			Basommatophora	Ancylidae			1					
			Coleoptera	Dytiscidae	Cybistrinae		1					
			Collembola				2	1	1			
Nematoda							1	13				
Arthropoda			Amphipoda				26					
Mollusca			Basommatophora	Planorbidae		(unknown species possibly *Planorbella)*	13	6	14			
			Hemiptera	Saldidae		(unknown species possibly *Salda)*	2	2				
			Hemiptera	Notonectidae		*Ambrysus*	16					
			Diptera	Culicidae		*Anopheles*		1				3

							CoA Historical Data - 2007			CoA 2008 Data		
Phylum	**Sub-class**	**Class**	**Order**	**Family**	**Subfamily**	**Genus species**	**151**	**349**	**1164**	**151**	**349**	**1164**
			Hemiptera	Gerridae		*Aquarius*	1	1				
			Odonata	Coenagrionidae		*Argia*	902	619	205	23	64	19
			Diptera	Ceratopogonidae		*Atrichopogon*	4					
			Trichoptera	Ecnomidae		*Austrotinodes*			2			
			Coleoptera	Dytiscidae		*Berosus* (larvae)	10	3				
			Diptera	Ceratopogonidae		*Bezzia / Palpomyia*	14	21	7	4	9	
			Diptera	Stratomyidae		*Caloparyphus*	318	63	478	1	2	2
			Trichoptera	Hydropsychidae		*Cheumatopsyche*	749	808	48	18	23	26
			Trichoptera	Philopotamidae		*Chimarra*	43	167	7	1	9	
Mollusca			Neotaenioglossa	Hydrobiidae		*Cincinnatia cincinnatiensis*		2				
Mollusca			Veneroida	Corbucilidae		*Corbicula fluminea*	14					
			Megaloptera	Corydalidae		*Corydalus*	1	2				
			Hemiptera	Naucoridae		*Cryphocricos hungerfordi*	5					
			Diptera	Culicidae		*Culicoides*		1				
			Diptera	Ceratopogonidae		*Dasyhelea*	8	153	856			
			Odonata	Gomphidae		*Dromogomphus*	1					
Platyhelminthes			Tricladida	Planariidae		*Dugesia*	981	35	106	8	3	
			Coleoptera	Dytiscidae		*Dytiscus*		3				
			Odonata	Coenagrionidae		*Enallagma*	9	4				
			Odonata	Corduliidae		*Epitheca (Epicordulia) princeps*	1					
			Odonata	Gomphidae		*Erpetogomphus*	3	3		2		
			Odonata	Libellulidae		*Erythemis*	1					
			Diptera	Stratomyidae		*Euparyphus*	100	19	57			1
Mollusca			Basommatophora	Lymnaeidae		*Fossaria*		2	2			
			Hemiptera	Gerridae		*Gerris*	11					
Mollusca			Basommatophora	Planorbidae		*Gyraulus*		1				
			Diptera	Tabanidae		*Haematopota*	3					
			Trichoptera	Helicopsychidae		*Helicopsyche*	1582	102	20			
Mollusca			Basommatophora	Planorbidae		*Helisoma anceps*	1	7				2
			Coleoptera	Hydrophilidae		*Helochares*	1					
			Diptera	Empididae		*Hemerodromia*	6	4	2		12	1
			Odonata	Caloptrygidae		*Hetaerina*	45	19	6	2	3	4

							CoA Historical Data - 2007			CoA 2008 Data		
Phylum	**Sub-class**	**Class**	**Order**	**Family**	**Subfamily**	**Genus species**	**151**	**349**	**1164**	**151**	**349**	**1164**
			Coleoptera	Dytiscidae		*Heterosternuta*	1					
			Ephemeroptera	Ephemeridae		*Hexagenia*	4					
			Diptera	Tipulidae		*Holorusia*	2					
Arthropoda			Amphipoda	Gammaridae		*Hyalella*	761	1	1	114	27	45
			Coleoptera	Dytiscidae		*Hydaticus*	17	3				
			Coleoptera	Hydrophilidae		*Hydrochara*			1			
			Coleoptera	Hydrochidae		*Hydrochus*	1					
			Collembola	Entomobryidae		*Hydroisotoma*		1				
			Coleoptera	Hydrophilidae		*Hydrophilus* (Larvae)	1					
			Coleoptera	Dytiscidae		*Hydroporus*	3					
			Trichoptera	Hydroptilidae		*Hydroptila*	379	96	19	2		
			Coleoptera	Dytiscidae		*Laccophilus*	1					
			Ephemeroptera	Leptohyphidae		*Leptohyphes*	43					
			Trichoptera	Hydroptilidae		*Leucotrichia*	3					
			Odonata	Libellulidae		*Libellula*	18	1				
			Hemiptera	Macroveliidae		*Macrovelia*	2					
			Trichoptera	Odontoceridae		*Marilia*	109	38	115	29	4	1
			Trichoptera	Hydroptilidae		*Mayatrichia*		1	26			
			Hemiptera	Mesoveliidae		*Mesovelia*	1					
			Hemiptera	Gerridae		*Metrobates*	2		2			
			Coleoptera	Elmidae		*Microculloepus pusillus*	20	5		11	7	1
			Hemiptera	Veliidae		*Microvelia*	1	1				
			Diptera	Tipulidae		*Molophilus*	1					
			Trichoptera	Nectopsychidae		*Nectopsyche*	270	60	11	1		2
			Diptera	Stratomyidae		*Nemotelus*	1					
			Coleoptera	Dytiscidae		*Neoporus*	2					
			Trichoptera	Hydroptilidae		*Neotrichia*	1		1			
			Odonata	Cordulidae		*Neurocordulia*		5	2			
			Trichoptera	Hydroptilidae		*Ochrotrichia*	4	1	1			
			Trichoptera	Leptoceridae		*Oecetis*	20	8		1		
			Trichoptera	Hydroptilidae		*Orthotrichia*		1				
			Trichoptera	Hydroptilidae		*Oxyethria*	1					
			Lepidoptera	Crambidae		*Parapoynx*	1					

							CoA Historical Data - 2007			CoA 2008 Data		
Phylum	**Sub-class**	**Class**	**Order**	**Family**	**Subfamily**	**Genus species**	**151**	**349**	**1164**	**151**	**349**	**1164**
			Odonata	Libellulidae		*Perithemis*	13	42	5			
			Plecoptera	Perlidae		*Perlesta*	11	111			1	
			Lepidoptera	Crambidae		*Petrophila*	91	29	16			
Mollusca			Basommatophora	Physidae		*Physa (Physella)*	82	206	115		2	2
			Trichoptera	Polycentropidae		*Polycentropus / Cernotina*	92	22	12		1	
			Trichoptera	Polycentropidae		*Polyplectropus*			2			
			Diptera	Ceratopogonidae		*Probezzia*	18		16			
			Coleoptera	Psephnidae		*Psephenus*	809	592	1	34	141	
			Hemiptera	Veliidae		*Rhagovelia*	346	76	34	3	23	6
			Diptera	Simulidae		*Simulim*	1279	768	97	3	7	
			Trichoptera	Hydropsychidae		*Smicredia*	4	2				
Mollusca			Veneroida	Pisidiidae		*Sphaerium*	1					
			Coleoptera	Elmidae		*Stenelmis*	24	39		1	2	
			Ephemeroptera	Heptageniidae		*Stenonema / Maccaffertium*	42	42	66	2	1	7
			Diptera	Stratomyidae		*Stratiomys*	3					
Arthropoda			Amphipoda	Crangonyctidae		*Stygobromus*		2				
			Diptera	Tabanidae		*Tabanus*	5	4	2			
			Diptera	Tipulidae		*Tipula*	9	7			1	
			Hemiptera	Gerridae		*Trepobates*	19	4			1	2
			Ephemeroptera	Leptohyphidae		*Tricorythodes*	510	88	2	12	1	
			Diptera	Tipulidae		*Triogma*	5					
			Coleoptera	Hydrophilidae		*Tropisternus*	3	1				
			Trichoptera	Xiphocentronidae		*Xiphocentron*	1	1	11		1	
			Plecoptera	Leuctridae		*Zealeuctra*			4			
Arthropoda			Decapoda	Cambaridae			8	1	1			
			Diptera	Ceratopogonidae				14	12	1		
			Diptera	Chaoboridae				1				
			Diptera	Chironomidae	Tanypodinae		93	79	25	12	17	2
			Diptera	Chironomidae			2858	1635	1005	66	58	155
			Odonata	Coenagrionidae			9	19	1			
			Hemiptera	Corixidae			1					
			Diptera	Dixidae				1				

							CoA Historical Data - 2007			CoA 2008 Data		
Phylum	**Sub-class**	**Class**	**Order**	**Family**	**Subfamily**	**Genus species**	**151**	**349**	**1164**	**151**	**349**	**1164**
			Coleoptera	Elmidae			4					
			Collembola	Entomobryidae			3					
			Diptera	Ephydridae			8	2	2			
Annelida	Hirudinea			Glossiphoniidae			1					
			Odonata	Gomphidae			5	1	1			
			Trichoptera	Hydroptilidae			34	2	2	1		1
			Trichoptera	Leptoceridae			1				1	
			Odn	Libellulidae			10	7	6			
Mollusca			Basommatophora	Lymnaeidae			4	17				
Mollusca			Basommatophora	Physidae			1		4			
			Collembola	Poduridae					2			
			Trichoptera	Psychodidae				1			1	
			Diptera	Rhagionidae			20					
			Collembola	Sminthuridae			1	2				

* Counts used for this taxa list are total counts for all sampling dates and are not treated as separate events. Therefore, some sites may have been sampled on a more frequent basis for other projects prior to the Bull Creek Project that began sampling in 2005. Sampling for this project reflects only two samples a year and those are totaled for the 2008 data.

Appendix B – Bull Creek Preserve Diatom Taxa List *

	Historical - 2007		
	151	**349**	**1164**
Achnanthes Biasolettiana	144	941	290
Achnanthes Exigua	2		
Achnanthes Lanceolata	60		7
Achnanthes Thermalis	1	1	16
Achnanthidium Affinis		35	5
Achnanthidium Minutissimum	967	1455	1003
Achnanthidium Minutissimum V. Gracillima	2	68	17
Adlafia Bryophila		2	4
Amphipleura Pellucida		16	13
Amphora (Seminavis) Strigosa	3		
Amphora Cf. Normani	2		
Amphora Inariensis	55	4	6
Amphora Montana	14	1	1
Amphora Ovalis	86	4	2
Amphora Ovalis Var Libyca			2
Amphora Ovalis Var Ovalis	10		
Amphora Pediculus	447	25	28
Amphora Veneta	1		
Bacillaria Paradoxa	4		
Brachysira Brebissonii			7
Brachysira Neoexilis (Serians)	3	7	
Brachysira Vitrea	1	77	86
Caloneis Alpestris		2	
Caloneis Bacillum	4	6	2
Caloneis Schumanniana		1	
Caloneis Silicula	6		2
Campylodiscus Levanderi	8		
Cocconeis Pediculus	452	3	38
Cocconeis Placentula	877	2	22
Cocconeis Placentula V. Euglypta	61		14
Craticula Cuspidata	2		
Cyclotella Meneghiniana	15		3
Cyclotella Pseudostelligera			7
Cymatopleura Elliptica		2	
Cymbella Affinis	25	18	2
Cymbella Amphicephala			5
Cymbella Cistula		15	
Cymbella Cistula (Neocistula)		2	
Cymbella Cymbiformis		88	8
Cymbella Excisa		79	
Cymbella Exillis		18	
Cymbella Husdtedtii V Stigmata	6	20	
Cymbella Hustedtii	1		2
Cymbella Laevis	7	56	26
Cymbella Richness	25	62	39
Cymbella Turgidula		6	
Denticula Kuetzingii	71	169	103
Denticula Kuetzingii Var. Rumrichae		1	

	151	349	1164
Diadesmis Contenta		1	
Diploneis Elliptica	3	14	8
Diploneis Marginestriata			2
Diploneis Oblongella		13	45
Diploneis Puella	2	9	10
Encyonema Delicatula	4	375	153
Encyonema Elginense		2	
Encyonema Evergladianum	3	157	170
Encyonema Gaeumannii		4	23
Encyonema Gracile			4
Encyonema Hebridicum		127	0
Encyonema Minutum		2	2
Encyonema Norvegicum			2
Encyonema Perpusilla		3	
Encyonema Silesiacum	297	47	42
Encyonemopsis Silesiacum		9	
Encyonopsis Microcephala	7	140	175
Epithemia Turgida	2	11	4
Eucocconeis Flexella		68	5
Eunotia Arcus		38	
Eunotia Bilunaris	1	4	
Eunotia Flexuosa		64	
Eunotia Minor		4	7
Eunotia Pectinalis	8	94	41
Eunotia Praerupta		6	
Fragilaria Acus		11	2
Fragilaria Capucina	13	91	13
Fragilaria Construens V. Venter	1		
Fragilaria Tenera		67	3
Fragilaria Ulna	111	248	35
Fragilaria Vaucheriae	10		2
Geissleria Cummerowii			6
Gomophonema Sp 100			1
Gomphonema Acuminatum		8	
Gomphonema Affine	24	153	14
Gomphonema Angustatum	58	132	8
Gomphonema Angustum	6	81	10
Gomphonema Augur	1		
Gomphonema Clavatum			4
Gomphonema Insigne	2		
Gomphonema Intricatum	1		1
Gomphonema Intricatum Var. Vibrio		8	4
Gomphonema Mclaughlinii	2	8	6
Gomphonema Mexicanum	9		
Gomphonema Parvulum	116	11	2
Gomphonema Pumilum		4	
Gomphonema Rhombicum	244	191	23
Gomphonema Truncatum			1
Gomphosphenia Reicheltii (G. Groveii)		2	
Gyrosigma Nodiferum	11		
Gyrosigma Nodosa	4		1

	151	349	1164
Kobayasiella Subtilissima			45
Luticola Mutica			2
Mastogloia Elliptica	1	15	
Mastogloia Smithii		29	
Mastogloia Smithii Var. Lacustris		166	
Melosira Lineata	3		
Melosira Sp 100	2		
Melosira Varians	4		6
Meridion Circulare	14		
Navicula Atomus	5		
Navicula Cryptocephala	3	14	6
Navicula Cryptotenella	9	7	29
Navicula Erifuga		4	2
Navicula Ingenua	1	2	
Navicula Kotschyi	11	5	15
Navicula Lanceolata V Phyllepta	7		12
Navicula Leptostriata		4	
Navicula Menisculus	12		4
Navicula Minima	5	10	2
Navicula Oblonga		1	
Navicula Pseudoarvensis	1		
Navicula Pseudobryophila		1	
Navicula Radiosa	56	97	22
Navicula Recens	1	2	2
Navicula Schroeterii			4
Navicula Sp. 102	1		
Navicula Stroemii	19	21	48
Navicula Subminiscula	1	1	
Navicula Symmetrica	1		
Navicula Tenelloides	3		
Navicula Tripunctata	38	2	
Navicula Veneta	13	4	7
Navicula Viridula	4	1	
Navicula Viridula Var. Rostellata	2		
Nitschia Lanceolata V. Minutula	3		
Nitzschia Amphibia	60	104	71
Nitzschia Amphibioides		39	29
Nitzschia Clausii	4		
Nitzschia Dissipata	21	1	6
Nitzschia Fonticola	2		
Nitzschia Frustulum	59	1	8
Nitzschia Inconspicua	149	1	4
Nitzschia Linearis			1
Nitzschia Microcephala	25		9
Nitzschia Palea	7		8
Nitzschia Serpentiraphe		4	
Nitzschia Sp. 100			1
Nitzschia Tropica	3		1
Pinnularia Gibba		4	
Pinnularia Microstauron		4	
Pinnularia Viridis		2	1

	151	349	1164
Pleurosigma Salinarum	3		
Pleurosira Laevis	9		
Psammothidium Subatomoides	13	8	7
Reimeria Sinuata	55		
Rhoicosphenia Curvata	46		1
Rhopalodia Brebissonii	1		
Rhopalodia Gibba	2	21	2
Rhopalodia Parallela	2		
Sellaphora Pupula	2	3	2
Sellaphora Rectangularis			4
Staurosirella Pinnata	2		
Surirella Angusta	1		
Surirella Brebissonii	2		
Surirella Ovalis	1		
Synedra Nana		28	
Synedra Ulna	16	56	86
Terpsinoe Musica	12		
Thalassiosira Weissflogii			1
Tryblionella Apiculata	6	1	2

	CoA 2008 Data		
	151	349	1164
Achnanthes biasolettiana	8	160	38
Achnanthes (Eucocconeis) flexella			4
Achnanthidium minutissimum	3	37	77
Amphora inariensis	29		
Amphora libyca	4	2	11
Amphora montana			2
Amphora ovalis var. ovalis	42		2
Amphora pediculus	12		5
Brachysira vitrea			1
Caloneis bacillum			4
Campylodiscus hibernicus	1		
Capartogramma crucicula			
Cocconeis pediculus	85	2	5
Cocconeis placentula	237	11	14
Cocconeis placentula var. euglypta			
Cyclotella meneghiniana			1
Cymbella affinis		26	7
Encyonopsis (Cymbella) cesatii		2	4
Cymbella (formally cistula) neocistula)		8	
Cymbella kolbei			2
Cymbella laevis		5	17
Denticula kuetzingii	10	26	5
Diadesmis (Nav.) contenta	2		
Diploneis oblongella			6
Diploneis puella	1		5
Encyonema delicatula		137	19
Encyonema evergladianum	8	5	8
Encyonema minutum	1	15	24
Encyonema silesiacum		9	2
Encyonopsis microcephala	2	3	4
Eucocconeis flexella		7	
Eunotia bilunaris		2	
Eunotia pectinalis		62	19
Fragilaria capucina		18	
Fragilaria construens var. venter			6
Fragilaria tenera		14	
Frustulia weinholdii		4	4
Gomphonema affine		4	4
Gomphonema angustatum		2	
Gomphonema angustum		4	3
Gomphonema intricatum var. vibrio		114	8
Gomphonema mclaughlinii		13	
Gomphonema vibrioides		19	
Gyrosigma nodiferum			14
Mastogloia elliptica		6	
Mastogloia smithii		3	
Navicula cryptotenella	4		7
Navicula kotschyi (texana)	2		30
Navicula radiosa	16		16

	151	349	1164
Navicula recens			1
Navicula tripunctata	14		1
Nitzschia amphibia	3	3	6
Nitzschia amphibioides		10	8
Nitzschia dissipata			2
Nitzschia linearis			1
Pinnularia viridis			2
Reimeria sinuata	4		
Rhopalodia gibba		2	
Sellaphora laevissima			11
Sellaphora pupula			2
Sellaphora (Navicula) stroemii	2	2	9
Stauroneis smithii			2
Surirella bifrons			3
Synedra (Fragilaria) ulna	10	237	72
Thalassiosira weissflogii			1
Tryblionella apiculata			1
Tryblionella levidensis			

***** Counts used for this taxa list are total counts for all sampling dates and are not treated as separate events. Therefore, some sites may have been sampled on a more frequent basis for other projects prior to the Bull Creek Project that began sampling in 2005. Sampling for the diatoms for the 2008 data reflect the one sampling even (June 2008) collected during the sampling season as well as the duplicate since other taxa were reported in the duplicate.