WALLER CREEK STATUS REPORT 2002

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ABSTRACT

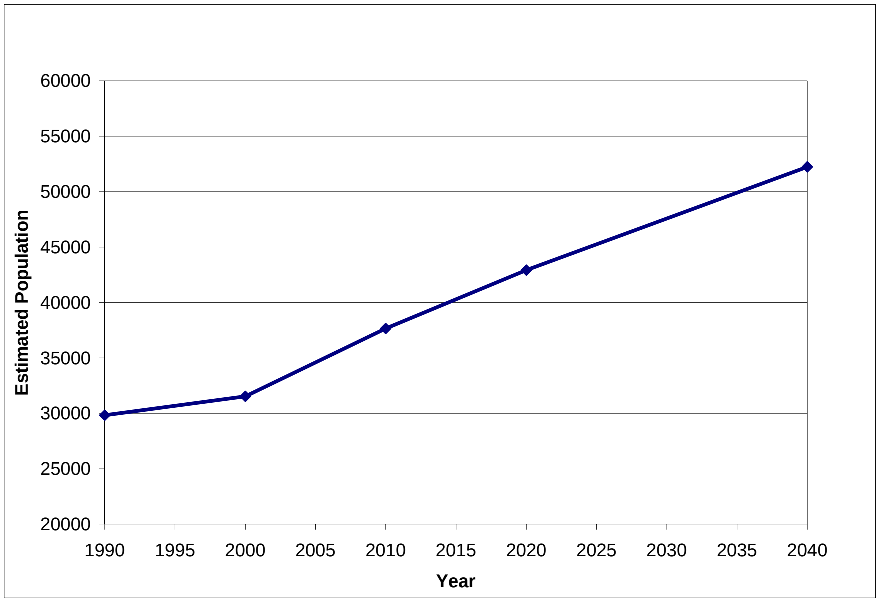
Water chemistry and biological data from Waller Creek were reviewed in order to evaluate temporal and spatial trends on this urban stream. The results of site analysis of variance indicated little discernable difference among sites and variability was high for conventional water chemistry constituents. Temporal trends were inconsistent with no notable degradation or improvements. Benthic macroinvertebrate surveys showed some significant site differences that appear to relate primarily to flow and possibly to nutrient enrichment. These surveys documented decreasing water quality over time; however, this result is apparently an artifact of the final survey, which took place after a long dry period. Overall, Waller Creek has low water quality and biological integrity when compared to other Austin area streams (worse than 75 percent of the watersheds for most measures).

INTRODUCTION

Waller Creek runs through the center of downtown Austin and is one of the most densely developed streams in the city at greater than 50 percent impervious cover. The University of Texas dominates the lower one-fifth of the watershed, with the remainder being roughly divided between commercial downtown development at the bottom (South) of the watershed and residential neighborhoods at the top (North). Most development was completed before the 1950's, and the public utility infrastructure throughout the watershed reflects outmoded designs and decaying construction materials. Wastewater lines are located down the middle of the channel in many places, and illicit dry weather discharges were observed throughout the storm sewer system. In addition to the effects of drainage infrastructure, the altered hydrogeology and imported soils from a multitude of developments in this watershed also contribute to the urban character of the stream (Ging et al.,1996). Flow starts and stops in several places along Waller's approximately 6.6-mile length, with some sections almost always dry and others with perennial flow (City of Austin, 1995). This non-contiguous flow regime may be attributed to groundwater seepage, leaking water and sewer lines or shallow recharge conduits and loose alluvial soils that can consume surface baseflow. Unfortunately, the sources and sinks of flow on Waller Creek are not well understood, although these dynamics are primarily what control baseflow water chemistry and ambient biological health of this stream. These inherently urban stream issues complicate both analysis strategies and solution development.

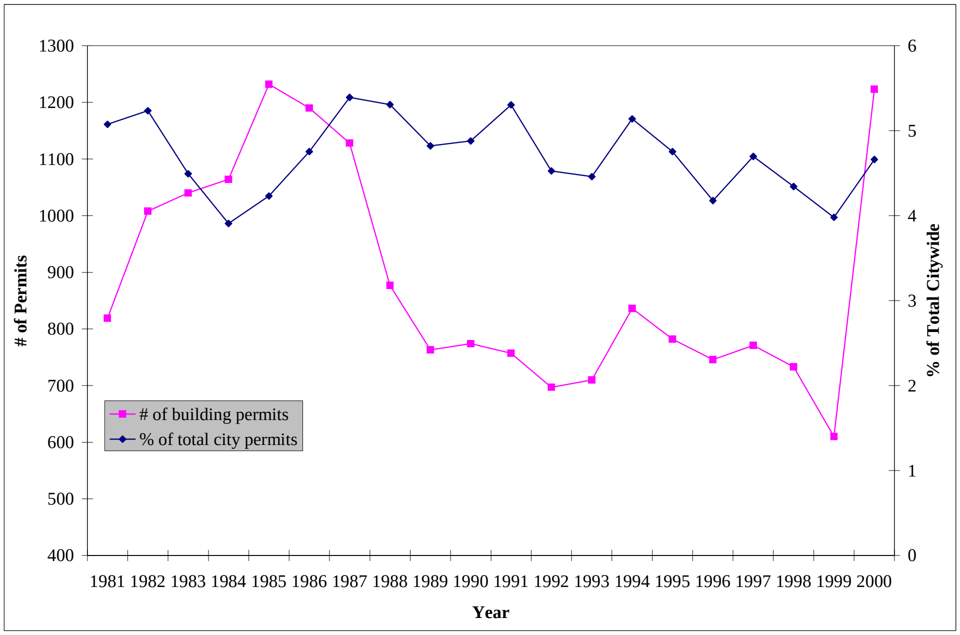
Combining U.S. Census Bureau data from 1990 and 2000 with estimates of future growth inside the confines of the Waller Creek watershed based on draft COA Smart Growth projections, the population of Waller Creek over time is presented in Figure 1. The projected increases in Waller Creek population may actually exceed the true carrying capacity of the watershed as current development has driven impervious cover to more than 50%. According to COA ordinances, Waller Creek is considered an urban watershed and thus falls into the desired development zone in which no water quality restrictions on impervious cover are applied.

Figure 1
Waller Creek Watershed Current Population and Estimated Future Growth Over Time



Although the estimated number of building permits issued for construction within the boundaries of the Waller Creek drainage area, taken from the COA Permitting, Inspection, and Environmental Review (PIER) database, spiked in the 1980s and again in 2000, the overall relative percentage of construction in Waller Creek compared to city-wide totals has remained fairly constant at approximately 5% over the last 20 years (Figure 2).

Figure 2
Waller Creek Estimated Number of Building Permits Issued and Percentage of City-Wide Construction in Drainage Area Boundaries Over Time

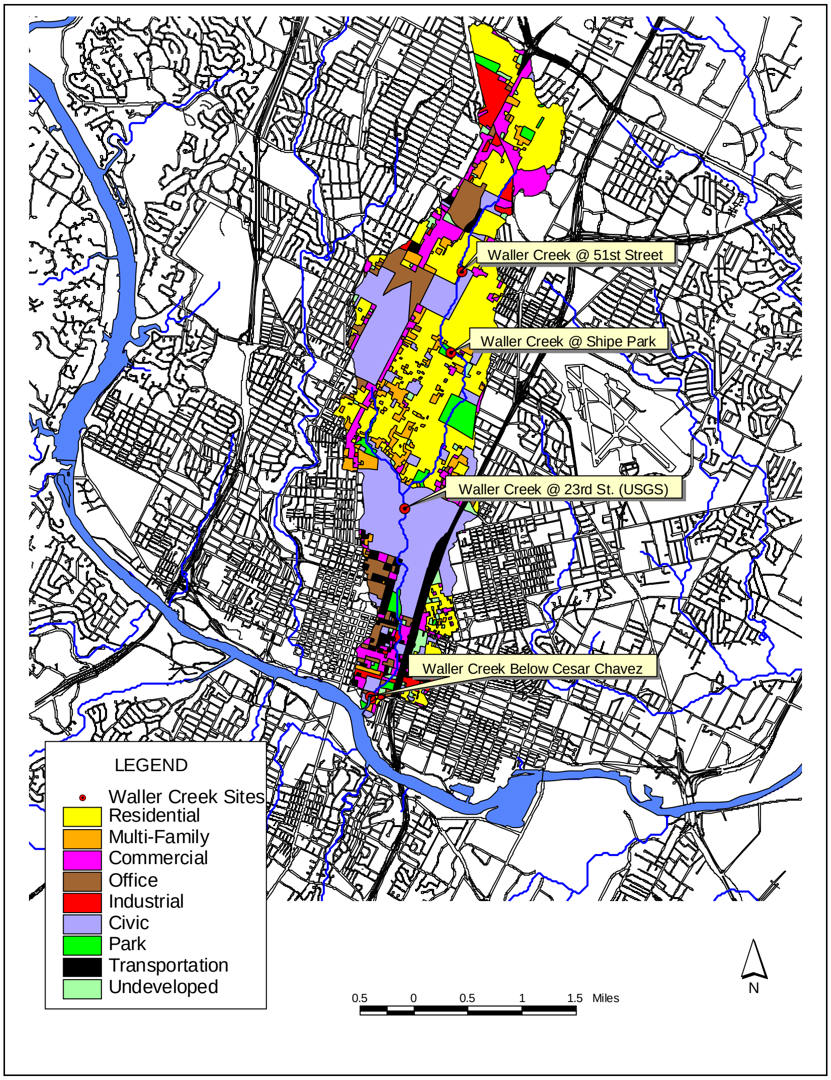


This report reviews a wide array of data on Waller Creek collected primarily by the City of Austin (1991-2001) but also by the USGS (1968-1995). Due to the diverse range of programs and data types presented here, the goal of this work is to review general status of the chemical and biological health of Waller Creek from both a spatial and temporal perspective and to provide background information to guide future monitoring efforts.

METHODS

Analysis in this report is concentrated on four sites along Waller Creek that have been sampled the most consistently and have the most data associated with them. They represent four general land use types; the mouth site at Cesar Chavez is influenced by downtown commercial development, the 23rd street site is in the middle of the University of Texas campus, the Shipe Park site is in the older residential and civic land uses of the Hyde Park area, and the 51st Street site is surrounded by newer residential and mixed commercial land uses at the top of the watershed (Figure 3).

Figure 3
Waller Creek Watershed Site Locations and Land Use Distribution.



Water Chemistry

All data were tested to determine spatial and temporal trends using the SAS Software System, version 8. Statistical significance for this report is defined by a type I, or false rejection of a true hypothesis, error ($\alpha \leq 0.05$) of 5% (Sokal and Rohlf, 1995).

Means and summary statistics for data sets that did not contain censored data points, or data below reporting levels also known as 'less-thans,' were computed using traditional methods described in the SAS PROC UNIVARIATE procedures (SAS, 1990a). Summary statistics for data sets with censored data points were calculated using non-parametric robust log-probability plotting methods (Helsel and Cohn, 1988; Helsel and Hirsch, 1992).

Comparisons to determine significant differences between grouping variables were performed on ranked data sets using analysis of variance tests in the SAS PROC GLM (SAS, 1989), similar to the procedures for a rank-sum test (Helsel and Hirsch, 1992), in combination with Duncan's multiple-range mean comparison test to explore other potential statistically significant groupings (Duncan, 1975).

Trend analyses were performed using ordinary least-squares (OLS) methods in the SAS PROC REG (SAS, 1989) on ranked data sets and with correlation analysis using Spearman's non-parametric ranked correlation test (Sokal and Rohlf, 1995). Trends observed from the OLS methods on ranked data sets containing censored observations were confirmed using Cox Proportional Hazards regression methods adapted from biological statistical methods and applied using the SAS PROC PHREG (Allison, 1995).

Benthic Macroinvertebrate Community

The benthic macroinvertebrate community was sampled and analyzed according to EPA Rapid Bioassessment Protocols (Plafkin et al., 1989,; Barbour et al. , 1999). Nine metrics (Table 2) are used individually as well as in an index score, which composites all metric scores into an overall site score that ranges from 1 to 100. This analysis will present results based primarily on the index score but also individual metrics. The Statistica software package (Statsoft, 1999) was used for the biological analysis. Analysis of variance was used to evaluate spatial differences among the four study sites, while simple linear regression analysis was used to evaluate temporal trends among and within study sites. The LSD post-hoc test (Statsoft, 1999) was used to evaluate analysis of variance results.

RESULTS

Water Chemistry

Although a general pattern of decreasing water quality is indicated from upstream to downstream, few significant differences exist between the four Waller Creek sites (Cesar Chavez, 23rd Street, Shipe Park and 51st Street). For example, mean nitrate/nitrite concentrations in baseflow for these four sites increase consistently from upstream to downstream (Fig. 4), but a significant difference is only found between the far upstream site (51st street) and the mouth site (Cesar Chavez). Non-storm fecal coliform levels follow a similar pattern except that the mid-reach 23rd Street site had significantly higher concentrations than all other sites (Fig. 5). Total phosphorus appears to show an increasing upstream to downstream trend, but none of these sites are significantly different from each other (Fig. 6). Although some apparent differences were found among sites, no relationship was determined between cumulative impervious cover levels at a given site and any of the water chemistry variables.

Figure 4
Waller Creek Mean Baseflow Nitrate/Nitrite as N By Site.

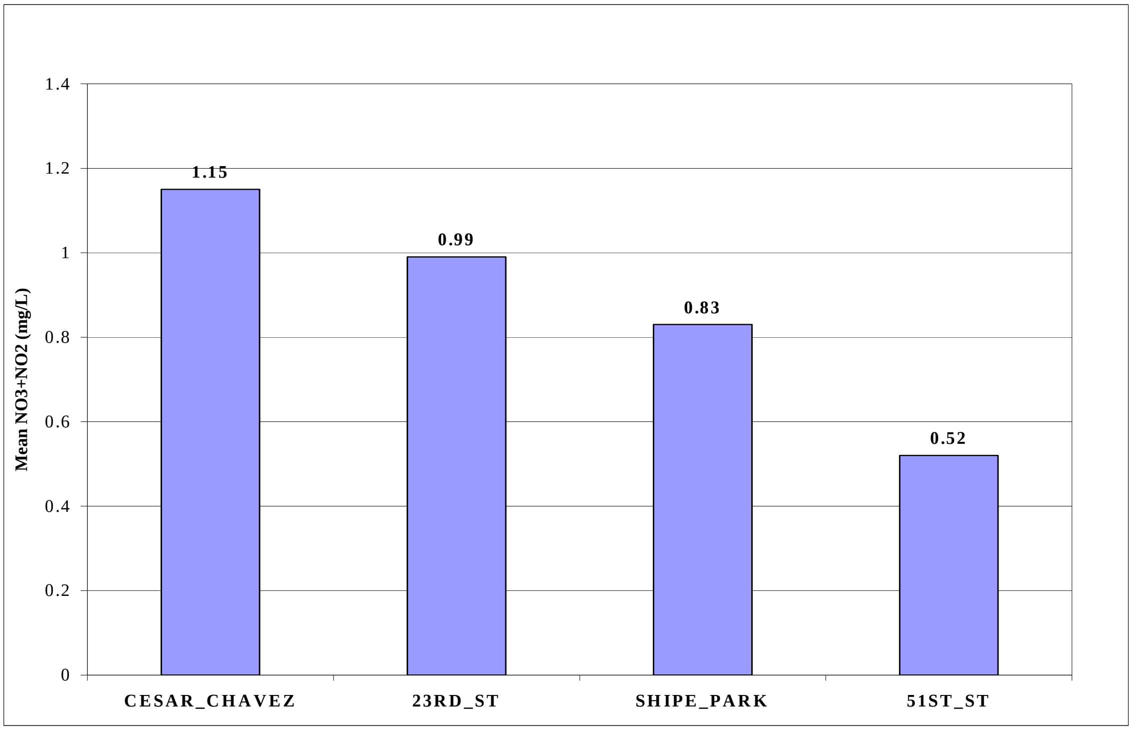


Figure 5
Waller Creek Baseflow Mean Fecal Coliform Levels By Site.

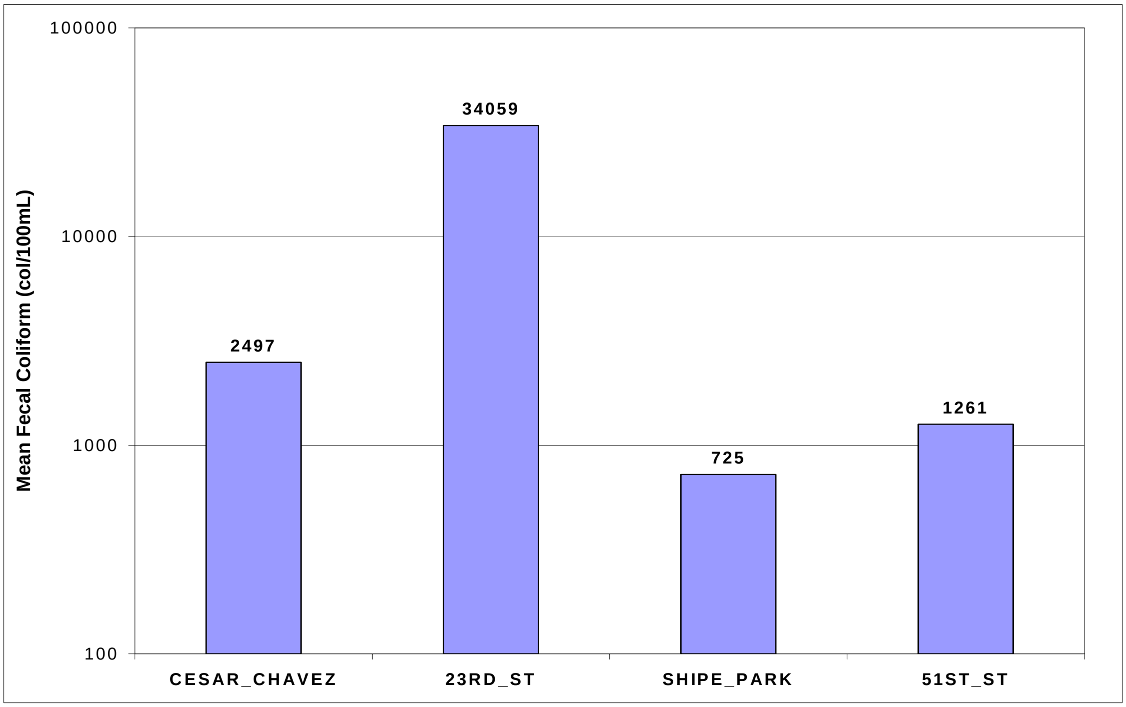
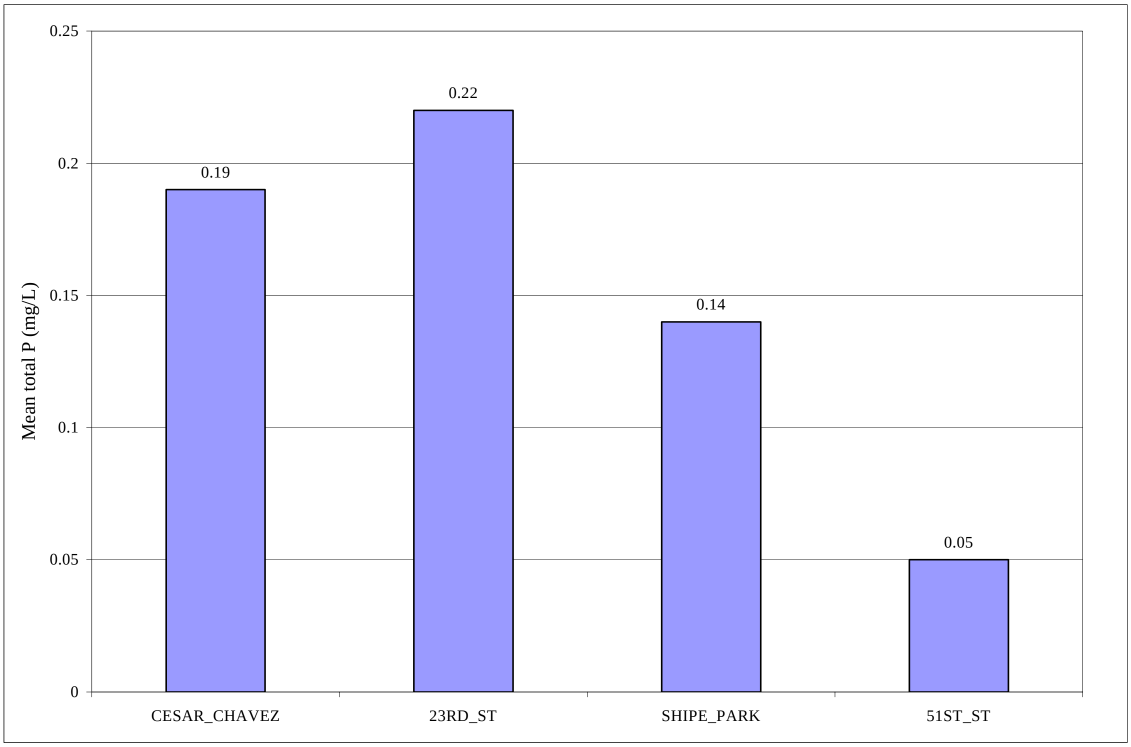


Figure 6
Waller Creek Baseflow Mean Total Phosphorus As P By Site



Temporal trends of water chemistry on Waller Creek were not consistent. Several parameters show significant decreases over time, some are increasing and others show no trend (Table 1). Decreasing ammonia values was the strongest trend, with an r-square of 0.37. All other significant trends were relatively weak, with r-squares less than 0.20. These weak relationships combined with several important water quality variables that showed no relationship whatsoever (dissolved oxygen, nitrate/nitrite, orthophosphorus) indicates that from a water chemistry standpoint, there have been no large changes, positive or negative, within the 10+ years of analyzed data.

Table 1
Water Chemistry Temporal Trends for the Waller Creek Watershed.

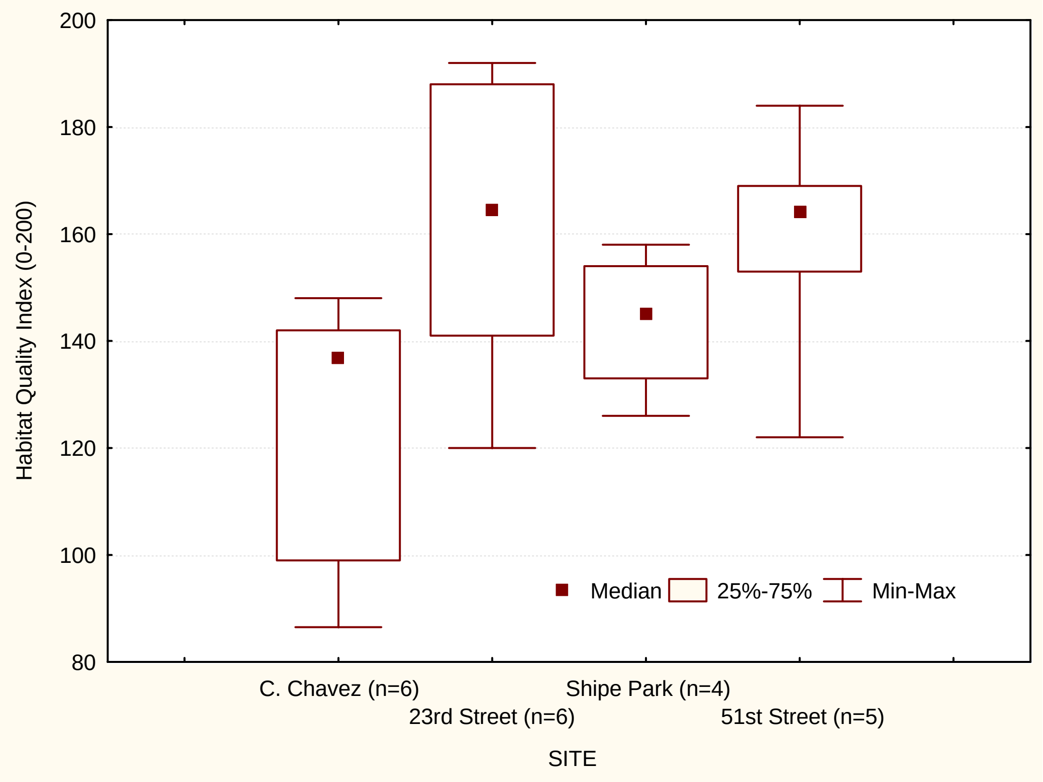
Parameter	**P-value**	**R-square**	**Trend**
NH3-N	<0.0001	0.37	Decreasing
Fecal Coliform	0.0125	0.1	Decreasing
pH	<0.0001	0.17	Decreasing
Conductivity	<0.0001	0.16	Increasing
Total Suspended Solids	0.0031	0.1	Increasing
Dissolved Oxygen	n/a	n/a	No Trend
NO2+NO3	n/a	n/a	No Trend
Orthophosphorus	n/a	n/a	No Trend
Turbidity	n/a	n/a	No Trend

Comparing Waller Creek to other Austin area streams, the Water Quality scores from the Environmental Integrity Index (EII) for Austin watersheds resulted in Waller Creek being rated worse than 77% of the 46 watersheds evaluated, with an EII water quality score of 50 out of 100.

Habitat

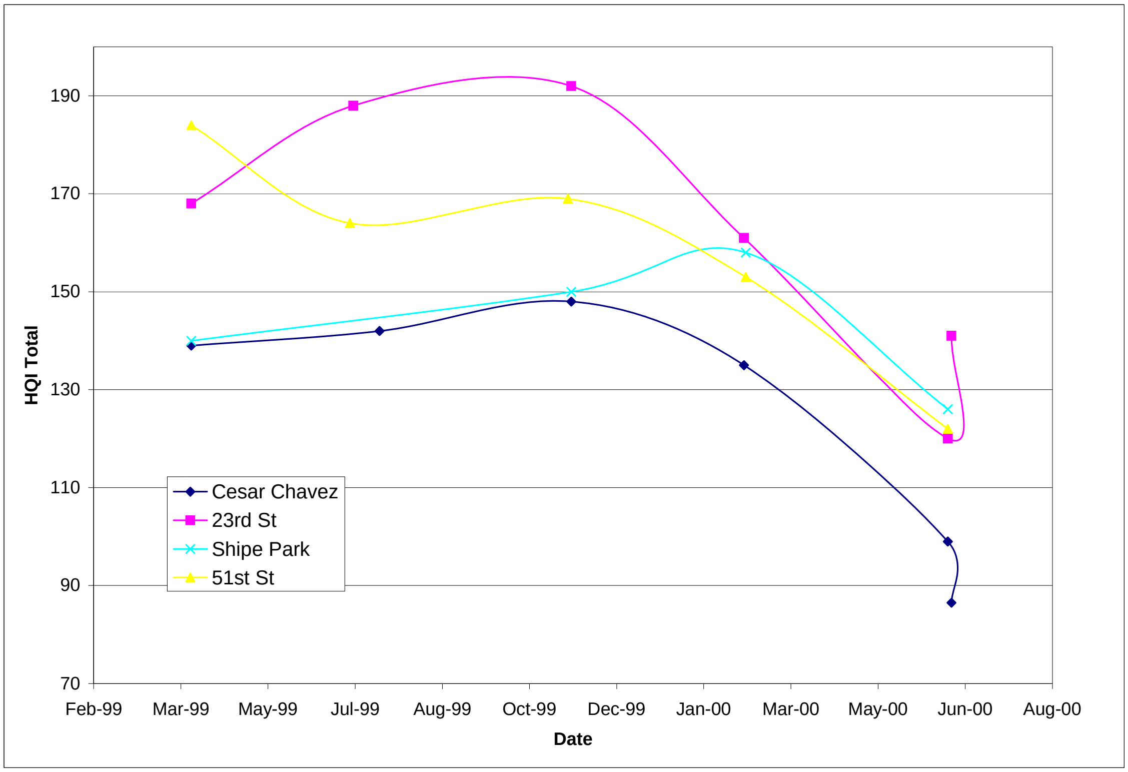
Habitat evaluation is based on results from the Habitat Quality Index (HQI) method developed by the EPA for use in the Rapid Bioassessment protocols (EPA 1998). Scores from 10 parameters are totaled (0-200) to give an overall site score, which can be compared spatially and temporally. HQI scores during biannual surveys (1999-2001) showed very little difference among the four main Waller Creek sites. There was no significant difference among sites (ANOVA), but it appears that habitat quality generally decreases as one travels from upstream to downstream (Fig. 7). The farthest downstream site (C. Chavez) had the lowest mean score among the four sites evaluated, and except for 23rd street, scores increased the higher upstream the site was situated. The 23rd street site had a slightly higher mean than the farthest upstream site (51st Street) even though it sits in the middle of the densely developed University of Texas campus, mainly due to a large, well-developed riffle.

Figure 7
Habitat Quality Index Score Distribution at Four Waller Creek Sites During 3 Years of Biannual Surveys. Sites are Listed (Left to Right) from Downstream to Upstream.



A significant negative relationship is indicated between time and site HQI scores. During five surveys from 1999 to 2000, scores at all sites dropped for the last two surveys, possibly due to erosion and sedimentation in the watershed (Fig. 8).

Figure 8
Mean Site HQI Scores at Four Waller Creek Sites During 5 Surveys in 1999/2000.

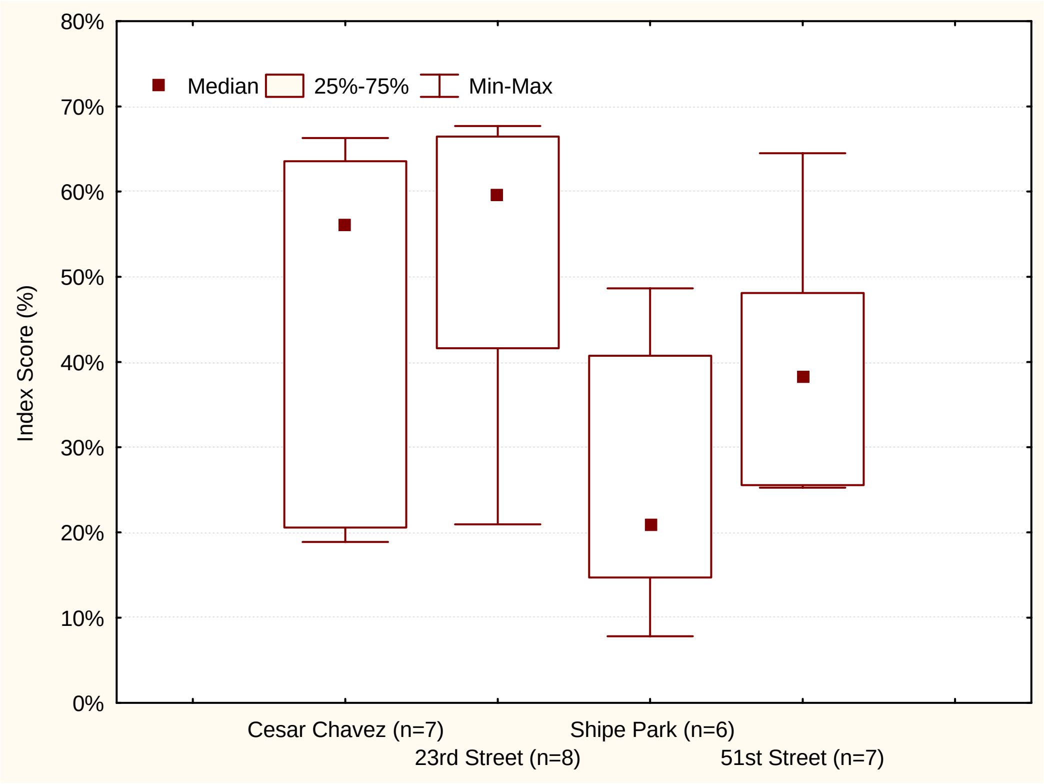


Overall, with an EII Habitat score of 59/100, Waller Creek habitat is worse than 52 percent of the 47 watersheds in the City of Austin.

Benthic Macroinvertebrate Community

Several consistent spatial patterns were noted among the benthic macroinvertebrate index scores. In an analysis of variance among the four Waller Creek sites, Shipe Park, with a mean index score of 26 was significantly worse than the two best scoring sites, Cesar Chavez and 23rd street (48 and 53, respectively, with a P-value of 0.04). However, Shipe Park was not significantly different from the 51st Street site, which had a mean index score of 40. Distribution of index scores at the four sites has been relatively variable during these surveys, with all four sites having scored below 25 and above 49 points during the period of record (Fig. 9).

Figure 9
Distribution of Total Index Scores from Four Waller Creek Sites (Downstream to Upstream) During Bi-Annual Surveys, 1996-2001.



Within individual metrics (as opposed to the summary score that combines all nine metrics) a similar pattern is shown, in which 23rd Street is the best scoring site and Shipe Park is the worst. In an ANOVA, four of the nine metrics used showed significant spatial differentiation between sites ($P<0.05$), generally with the 23rd Street site having higher scores than Shipe or 51st Street, Shipe being worse than all three other sites, and 23rd and Cesar Chavez not ever being different from each other (Table 2).

Table 2
Means and Analysis of Variance Post-Hoc Results Comparing Differences in Individual Metrics Scores Among Four Waller Creek Sites (From Downstream to Upstream: C. Chavez, 23rd Street, Shipe and 51st Street). N/S = Non-Significant ANOVA.

Metric	23rd St	51st St	Cesar Chavez	Shipe	Post-Hoc Result (LSD test)
Hilsenhoff Biotic Index	5.3	6.6	5.9	6.1	23rd >Shipe, 23rd >51st, 23rd = C. Chavez
# of Ephemeroptera Taxa	1.4	1.3	1.6	0.7	n/s
# of EPT taxa	2.4	1.3	2.6	0.7	23rd >Shipe, 23rd = 51st = C. Chavez
# of Tolerant Taxa	2.4	2.0	2.0	2.0	n/s
# of Taxa	11.0	12.7	11.7	9.7	n/s
% Dominance (3-Taxa)	64.2	56.1	59.2	69.4	n/s
% Chironomidae	17.1	20.9	22.6	66.5	Shipe < all other sites
% EPT	55.0	16.5	37.2	5.8	23rd >Shipe, 23rd >51st, 23rd = C. Chavez
% Predator	16.3	38.0	29.2	54.6	n/s

Temporal trend analysis of benthic community metrics from all four sites combined together showed a fairly consistent negative relationship with time during the 3 years of data analyzed. Comparable surveys were performed approximately twice per year for 1999, 2000, and 2001, and a correlation analysis with time showed that five out of nine metrics had a significant negative relationship and one metric (% predator) had a positive relationship (Table 3). The indexed score (combination of all nine metrics) also had a significant negative relationship with time (r = -0.48, Fig. 10). However, due to the relatively short time period (3 years) and small number of data points (n = 6) all these relationships appear to be strongly influenced by the last survey in 2001, which produced low scores at all four sites (less than 27/100).

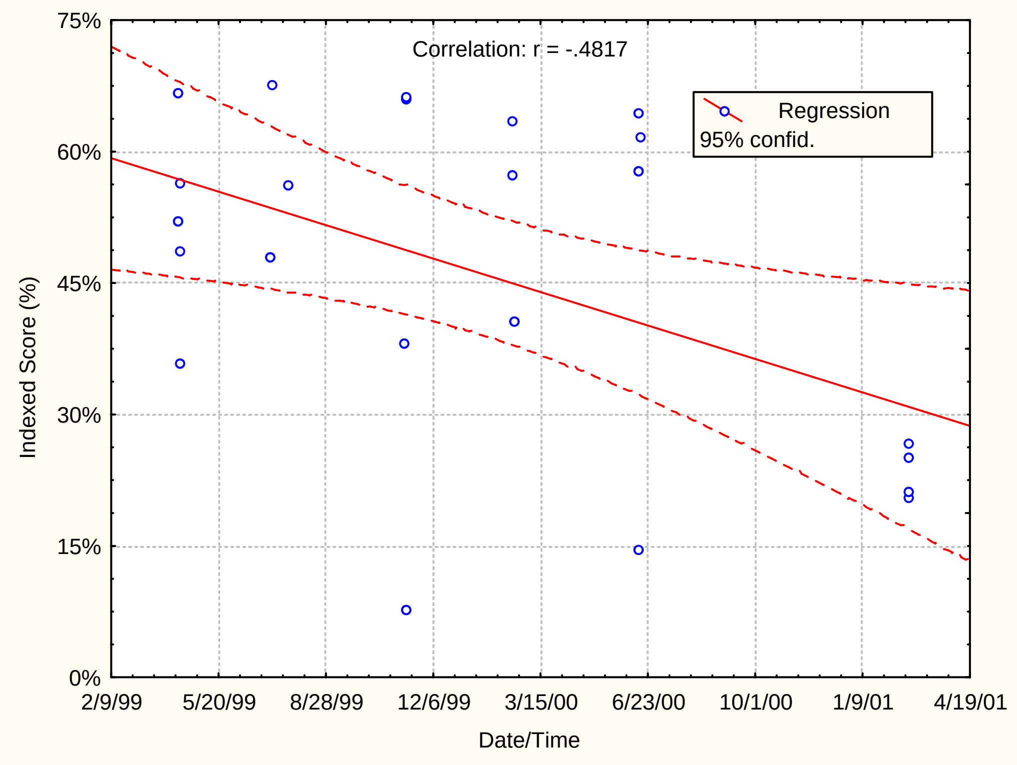
Table 3

Results of Correlation Analysis of Individual Metrics Scores and Combined Index Score vs. Time at Four Waller Creek Sites. N/S = Non-Significant Relationship.

Metric	r-Value	Relationship to Time/date.
Hilsenhoff Biotic Index	-0.56	Negative
# of Ephemeroptera Taxa	-0.61	Negative
# of EPT taxa	-0.56	Negative
# of Tolerant Taxa	-0.55	Negative
# of Taxa	n/s	No relationship
% Dominance (3-Taxa)	n/s	No relationship
% Chironomidae	n/s	No relationship
% EPT	-0.47	Negative
% Predator	0.43	Positive
Total Indexed Score	-0.48	Negative

Figure 10

Regression/Correlation Plot of Index Scores at Four Waller Creek Sites During Bi-Annual Surveys for 3 Years.



Using the EII benthic macroinvertebrate sub-indices to compare Waller to other Austin area streams resulted in Waller scoring worse than 82 percent of the 47 streams evaluated with a watershed score of 23 out of 100.

DISCUSSION

Water Chemistry

A high level of variation is present in the water chemistry variables in the Waller Creek data set. According to sample frequency analysis performed only ammonia, dissolved oxygen, pH, and temperature have been well characterized (Coefficient of Variation values ranging from 5% to 30%)). Many of the important water quality variables (nitrate/nitrite, total phosphorus, orthophosphorus, fecal coliform) are varying so much between sampling events that it could take many more years and many more replicates to show significant site differences. This high level of variation is indicative of water quality problems in the watershed, since only with high baseflow concentrations from point and non-point sources is such high variability seen in these constituents. Total load analysis performed for the City of Austin Masterplan (2001) showed that Waller Creek contributes more than 10% of the Town Lake (non-upstream) load of the common urban runoff constituents modeled although it only makes up 4% of the total Town Lake drainage area (COA, 2001).

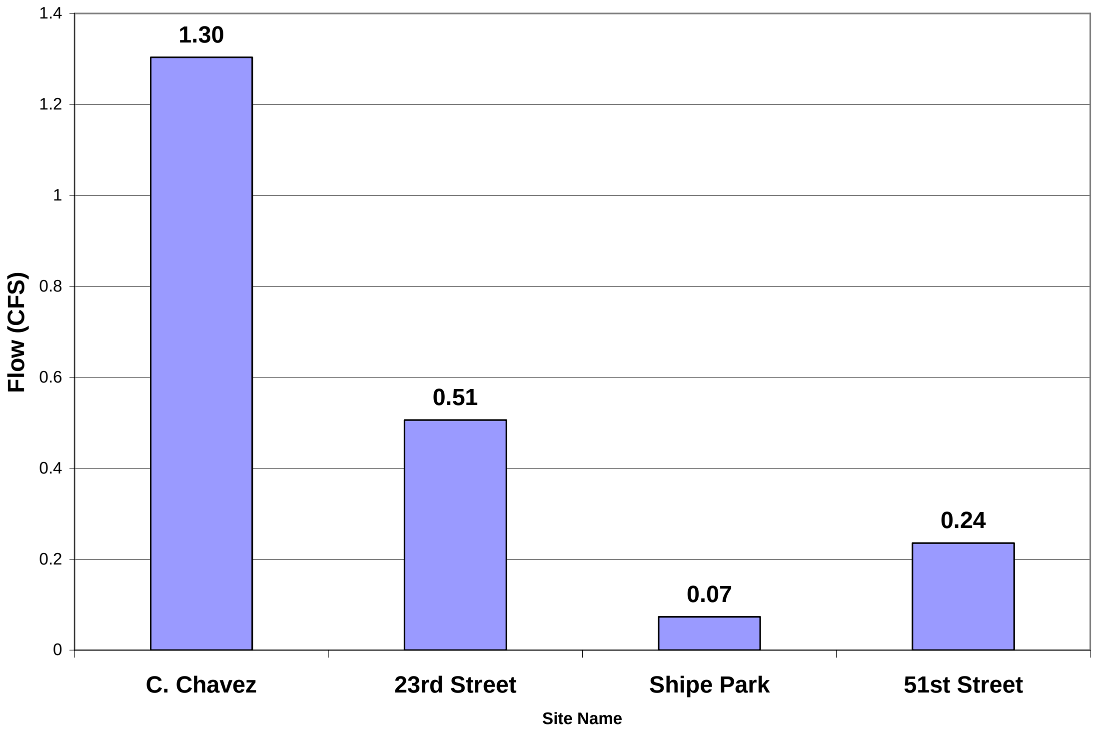
The degradation of baseflow water quality in Waller Creek is a watershed-wide problem that most likely stems from old infrastructure and lack of water quality best-management practices. Very little difference was indicated between development density and impervious cover among the Waller Creek sites (52% impervious cover at 51st Street upstream site and 50% at the Cesar Chavez downstream site). This was evident in the water chemistry analysis, which found little difference among all four sites. Local development level (drainage area within a 3000-foot radius buffer) similarly showed relatively little difference between sites, but could explain higher levels of some constituents at the downstream Cesar Chavez site (60 % impervious cover vs. 48 % impervious cover at the upstream 51st Street site).

In 1974, Waller Creek was assessed as being "the most seriously polluted of Austin's urban creeks" (COA, 1975), and this assessment is apparently still fairly accurate. The temporal trends observed in analysis of over 10 years of data showed little to no significant changes in water chemistry. This is not surprising since the watershed has been developed to its current level since the 1950's and apart from the Central Market wet pond, which drains a small tributary to Waller Creek (with a drainage are of 173 acres), no new best management practices have been constructed in the watershed that would be expected to improve water quality. To improve the rather poor standing of Waller Creek water chemistry (worse than 77% of Austin's watersheds based on current EII scores), extensive structural retrofits would be necessary to reduce non-point source pollution inputs from the dense older development, and comprehensive improvements must be made to the storm and sanitary sewer system to reduce point source inputs.

Habitat and Benthic Macroinvertebrate Community

If habitat is relatively similar between sites, as was the case with the four assessed Waller Creek sites, it can be assumed that differences between biological communities at these sites can be attributed to factors other than habitat. Unfortunately, physical factors outside of those measured in the Habitat Quality Index are probably driving the variation observed in Waller Creek benthic macroinvertebrate index scores. Observed flow differences at these sites were notable (Fig. 11) and generally correlated to drainage area, except that Shipe Park, the site with the second smallest drainage area, had the lowest flow. The upstream two sites had much less predictable baseflow than the downstream sites, and correspondingly lower index scores. Baseflow in this climate is more limiting to biological health than non-point source pollution or even habitat. In addition to baseflow constraints, the Shipe Park site was downstream of a chronic discharge from a municipal swimming pool, possibly limiting biological potential during summer months when the pool was open. This chlorinated water would probably sterilize all aquatic areas it came into contact with and require months of recovery time, potentially impacting biological communities year round. This discharge was/is not permitted, but was observed on several occasions by City staff and was a likely contributor to the lower index scores for this site.

Figure 11
Average Flow (cubic feet per second) at Four Waller Creek Sites during Biannual Surveys 1999-2001. Downstream to upstream corresponds to sites from left to right (n = 7, 8, 6, 7, respectively).



The significantly higher scores at the two downstream sites (23rd Street and C. Chavez) are most likely explained by the higher flow volumes and more predictable baseflow. However, higher general productivity at these sites, as evidenced by frequent algae blooms and persistence of heterotrophic bacteria communities, could also explain higher metric scores. Nutrient inputs from both non-point source pollution and point source discharges could be elevating the carrying capacity of the benthic macroinvertebrate community above background conditions (Reice, 1994; Lenat and Crawford, 1994; Ward and Stanford, 1983; Klein, 1979). Although water chemistry analysis at the Waller Creek sites did not show a difference in mean nutrient concentrations, it is possible that enough data have not been collected in this highly variable system. Dry-weather pulses from point source discharges in addition to stormwater inputs that would not be detected by the baseflow monitoring included in this study could be degrading the downstream sites more than the upstream sites due to the age and types of development in the lower part of the watershed. Biological monitoring should be able to detect these types of disturbances better than traditional water chemistry could, but the results of this study suggest that interpretation of these results is complex. It is likely that presence of baseflow, however polluted it may be, results in higher biological index scores than more ephemeral flow regimes and that nutrient inputs may be positively influencing these assessments.

Regarding the negative temporal trend of benthic macroinvertebrate index scores on Waller Creek, it is important to note that the final survey in the year 2001 is strongly influencing this relationship (Fig. 8). This survey was completed after a relatively dry winter in which flow at most sites was severely limited. Collection of more data over a longer period of time is necessary to support these preliminary findings. Apart from this final survey, the overall results are fairly stable, scoring between 40 and 75 out of 100 for the indexed site score.

RECOMMENDATIONS

Waller Creek is consistently in the bottom 30 percent of water quality among Austin-area streams. Although it is almost completely developed, methods are available to improve the integrity of this historic and high-profile urban stream. The following recommendations are provided to assist in solution development and to help clarify management priorities:

- Reduce/remove point source impacts from failing sanitary and storm water sewers. However, ensure that potential benefits outweigh potential damage caused by construction/destruction in the Waller Creek channel and riparian areas.
- Provide both physical and chemical benefits to Waller Creek by retrofitting the storm drainage system with small-storm detention and/or wet pond structures wherever possible. This is particularly true in all headwater areas and in any new development that may occur.
- Improve and/or restore riparian buffers (>100 feet from centerline of stream) along Waller Creek from headwaters (>5 acre drainage area) to mouth. Divert all storm sewer outlets across Low Impact Design swales or vegetated areas within riparian zone (See COA Waller Creek Erosion Assessment, 1997).
- Implement flow study to determine source and character of flows along mainstem and significant tributaries of Waller Creek.
- Continue biannual benthic macroinvertebrate surveys per NPDES permit requirements. This will document any long-term trends and should reflect any benefit provided by BMPs implemented in the watershed.
- Amend sampling plan with regards to water chemistry. Drop biannual surveys and utilize EII water quality data (4 replicates every 3 years) to document long-term trends.

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