FINAL DRAFT

A long-term post-project evaluation of an urban stream restoration project

(Baxter Creek, El Cerrito, California)

By

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LA 227

December 10, 2004

Abstract

Post-project evaluation and monitoring of stream restoration projects are rarely conducted, and long-term evaluations are even less common but are needed in order to gage the success of a project and to determine the time scale of biological recovery in the system. This study is a 5-year comparison to an initial post-project assessment completed in 1999 that evaluated an urban stream restoration project in Poinsett Park (El Cerrito, California). The results of this study found that habitat quality differed spatially between reaches, but was temporally similar in 1999 and 2004 with slight improvements at the restored reach in 2004. The biological assessment in 2004 found no improvements in ecological condition of the biotic assemblage compared to 1999. This lack of improvement may be attributed to the detrimental and limiting effects of a highly urbanized watershed. It is also possible that the aquatic communities successfully colonized the restored reach within the 2 years following the completion of the restoration project in 1997. A survey of the neighborhood residents indicated that, overall, they were pleased with the restored creek site 7 years after the completion of the project. Approximately half of the residents that moved to the neighborhood after the restoration project was completed were unaware that this segment of creek was previously underground. Long-term evaluations of restoration projects can help managers and designers of future projects determine the timeline of the success of a project.

Introduction

Post-project evaluation and monitoring of stream restoration projects are rarely conducted (Kondolf & Micheli 1995). This lack of post-project monitoring impedes the field of restoration science because it is unclear if the restoration techniques used in a project were successful at meeting the project's goals. Future restoration projects cannot glean knowledge from the performance of past projects if they are not evaluated after their completion (Kondolf 1998).

Long-term post-project evaluations of stream restoration projects are even rarer, yet are needed in order to assess long-term changes in the aquatic biota, geomorphology, and flow variability over 5 to 10 years (to capture the $Q_5 – Q_{10}$). Long-term post- project evaluations can give insight to the overall success of the project and help estimate the time scale for a restoration project to "plateau" or reach the highest attainable biological condition (Barbour et al. 1999) following its completion.

The sociological aspects of stream restoration are not often included in post-project evaluations, but are important in urban settings to determine the perceived success of a restoration by the neighborhood residents. Surveys of residents near a restoration project can be used to determine social attitudes, values, and perceptions regarding the manner in which the restoration was conducted (FISCRWG 1998). Considerations of both scientific goals and social perceptions result in a comprehensive overview of the achievements and failures of a restoration project.

This study is a long-term post-project evaluation of an urban stream restoration project completed in 1997, for which I conducted initial biological, habitat, and sociological evaluations in 1999 (Purcell et al. 2002). The objectives of this 2004 study are to compare these same parameters (biological, habitat, and sociological) 5 years after the initial evaluation in 1999 at a restored, unrestored, and previously restored reach of stream. This 5-year comparison examines conditions at the restored reach 7 years after the completion of the restoration project.

Study Reaches

The three study reaches are located in the East Bay hills of the San Francisco Bay Area (northern California). These reaches are in a Mediterranean climate region which generally has dry, warm summers with little to no rain from May to October and cool, wet winters with an infrequency of freezing (Gasith & Resh 1999).

The Baxter Creek watershed, approximately 11.0 km^2, begins in the El Cerrito Hills (Contra Costa County, California) and flows through Richmond to its mouth at San Francisco Bay (Figure 1). The restoration project site is located on a 70-m reach of Baxter Creek at the east end of Poinsett Park in El Cerrito (37 56'N; 122 18'W) (Figure 2). In the 1940s, like many urban creeks in the San Francisco Bay Area, this segment of Baxter Creek was put underground in a cement culvert to address flooding and sanitation concerns (Dury 1995). The east end of Poinsett Park was previously a grassy lawn, but today the formerly culverted creek emerges at the tip of a triangular park and flows west before it goes back underground beneath a playground, maintenance building, and large cemented basketball court at the west end of the park (Figures 3 and 4). Streets border all sides of the park.

To evaluate the relative conditions in the restored reach of Poinsett Park, I selected two comparison reaches. The first is an unrestored reach of Baxter Creek approximately 300 m upstream from the restored reach (37 56'N; 122 18'W) near the stream’s source (Figure 1). Sampling at this reach provided an estimation of the stream's pre-culverted, unrestored condition. This reach, approximately 30 m below the source, has ivy-lined banks and is semi-channelized with limited riparian vegetation, consisting mostly of non-native species.

The second comparison reach is a segment of the south fork of Strawberry Creek located on the University of California, Berkeley, campus (37 52'N; 122 15'W). Strawberry Creek runs through the University of California, Berkeley campus, the city of Berkeley (Alameda County, California), and then empties into the San Francisco Bay (Figure 5). This reach underwent extensive ecological restoration between 1987-89 (Charbonneau & Resh 1992) and is considered a success story in stream restoration (Owens-Viani 1999). Due to its proximity (< 10 km distance) and geomorphic similarity, it is used in this study as baseline data for the "best attainable conditions" for an urban stream in this region. I selected biological sampling areas in Strawberry Creek that were comparable (i.e. slope, depth, substrate composition and density of riparian vegetation) to the two sampling areas on Baxter Creek.

The Restoration

In 1992, the El Cerrito City Council conducted a financial analysis of a broken culvert beneath Poinsett Park. The City Council determined that it was more cost effective to "daylight" or open a 70 m section of underground culvert at the east end of Poinsett Park than to repair it over time. The Waterways Restoration Institute (WRI) designed and managed the restoration project.

The original goal of the restoration project in Poinsett Park was to recreate pre-culvert conditions, but no reference conditions existed in the watershed for developing design criteria. Most of Baxter Creek was channelized, highly degraded, or in underground culverts. Therefore the WRI estimated design channel dimensions using regional hydraulic geometry relationships between channel sizes and drainage areas. The WRI selected a channel sinuosity and slope to match to a steep 10% valley slope. The designed channel had a width of 2 m and a depth of 30 cm.

Methods

To fulfill the study objectives, this long-term evaluation of Baxter Creek included (1) a visual-based habitat assessment, (2) a biological assessment of stream health and water quality using benthic macroinvertebrates, and (3) a sociological assessment of the Poinsett Park neighborhood. The 2004 evaluation is intended to be a 5-year comparison to the initial study I completed in 1999.

Habitat Assessment

The assessment of habitat quality is a critical part of stream monitoring because it evaluates the quality and quantity of habitat available to aquatic organisms at a given site (Barbour et al. 1996). I conducted a visual-based habitat assessment of the entire reach of each of the three study reaches using the U.S. Environmental Protection Agency's Rapid Bioassessment Protocol (Barbour et al. 1999). This protocol is based on a qualitative analysis of bank covering (riparian vegetation), bank stability, and instream habitat diversity and is the standard method for habitat assessments across the United States (Hannaford et al. 1997). The habitat parameters I evaluated were: epifaunal substrate, substrate embeddedness, velocity/depth, sediment deposition, channel flow status, channel alteration, frequency of riffles, bank stability, vegetative protection, and width of riparian vegetative zone. Each habitat parameter was rated on a scale of 0-20 (Poor to Optimal). The sum of the parameters gave an overall score for each reach out of a total possible score of 200.

Biological Assessment

Biological assessment (or bioassessment) has long been considered the most appropriate means to evaluate stream health rather than complete reliance on chemical and physical measurements (Rosenberg and Resh 1993). The organisms most frequently used in bioassessment are benthic macroinvertebrates because they are ubiquitous in most stream environments, have relatively long life histories, and a range of tolerance to perturbations in the stream (Rosenberg and Resh 1993).

For the biological assessment I selected three sampling areas approximately 10 m apart at each of the three reaches (nine sampling areas total). I used the following criteria to select each sampling area: (1) shady areas with substantial canopy cover; (2) riffle areas (to maximize macroinvertebrate taxa richness); (3) areas with riparian vegetation; and (4) areas of similar depth, width, and substrate size.

I conducted the biological sampling using a D-frame net placed downstream from the sampling area. I first scrubbed all large and medium-sized stones (> 10 cm diameter) within an area of approximately 1 m^2 to remove any organisms that might be attached to them, and put the scrubbed rocks aside to clear the area. With the D-frame net still in place I kicked vigorously for a timed one-minute interval to loosen the substrate and collect dislodged organisms in the net. I then drained the collected material in the net and placed the sample into a plastic bag filled with 70% ethanol to preserve the organisms.

In the laboratory, I separated each sample into two subsamples according to substrate size, using a 4-mm and a 0.4-mm sieve. I then identified all benthic macroinvertebrates in the sample to the taxonomic level of family (e.g. Merrit and Cummins 1996). I compared the reaches based on measures of Family Richness (number of families), Taxa Richness (number of species), the number of taxa of EPT (the largely pollution sensitive orders Ephemeroptera, Plecoptera, and Trichoptera), the proportion of the macroinvertebrate community that are EPT, and the calculation of a Family Biotic Index. These metrics are all widely used approaches in biological monitoring of streams (Resh & Jackson 1993). The Family Biotic Index is calculated by assigning a pollution tolerance value to each species of macroinvertebrate, multiplying this value by the number of individuals of that species collected, and dividing the sum of these products by the total number of individuals collected (Resh et al. 1996) (see Appendix A for sample calculations). A high value indicates an assemblage with mostly pollution tolerant species, while a low value indicates the presence of many pollution sensitive species.

Sociological Assessment

I conducted a resident survey of eight questions in the Poinsett Park neighborhood to obtain information on resident's opinions and perceptions of the Baxter Creek restoration project (Appendix B). I completed the survey in person at all households directly adjacent to the park and within one block of Poinsett Park. Of the 72 households attempted I completed 45 surveys. If residents were not at home, I left a written form in their mailbox and collected it later. 47% of the residents surveyed were located directly adjacent to the park, while the other 53% were within one block of the park.

Results

Habitat Assessment (1999 vs 2004)

The habitat assessment score in 2004 varied between reaches (Table 1). The unrestored Baxter Creek reach had the lowest score of the three reaches in 2004 (77). The restored reach on Baxter Creek scored higher then the unrestored reach (127), but was lower than the best attainable conditions reach, Strawberry Creek, which had a total score of 142.

While the physical habitat assessments scores differed between reaches, but did not differ between years at the unrestored and Strawberry Creek reaches (Table 1). The restored reach showed the most improvement when comparing 1999 to 2004 habitat assessment results. The total habitat score at the restored reach improved 8 points between 1999 and 2004, which is primarily due to an increase in the parameter "vegetative protection." The willows grew taller and became more established over the 5-year period, stabilizing the banks at the restored reach and creating a more complex habitat for benthic macroinvertebrates. In comparison, the unrestored and Strawberry Creek reaches both declined slightly by -2 points, which may be attributed to the lower amount of flow in the channel and the resulting lower score in the parameter "channel flow status."

Biological Assessment (1999 vs 2004)

Macroinvertebrate taxa richness at all sampling sites overlapped considerably in 2004 (Table 2), as did the faunal composition (Table 3 & 4). Overall, the restored reach had higher taxa and family richness then the unrestored reach and Strawberry Creek had higher richness then both the unrestored and restored reach (Figure 6). The mean number of taxa at the restored reach (11.0) was slightly higher than that of the unrestored reach (8.7). Family richness averaged 14.3 and 11.7 at the restored and unrestored reaches, respectively. Strawberry Creek samples averaged 12.3 taxa and 15.3 families.

The reaches differed in numbers of individuals collected (Table 2). The unrestored reach had the most total number of individuals (2,319) compared to less individuals at the restored reach and Strawberry Creek (1,418 and 1,468 respectively). Despite the high number of individuals at the unrestored reach, the majority of these individuals were pollution-tolerant taxa such as Oligochaeta (worms), Gastropods (snails) and Chironomidae (midges).

When I compared the mean values of a Family Biotic Index (FBI) calculated for each reach (Table 2), I found a lower value (which indicates a higher mean pollution sensitivity of the macroinvertebrate assemblage) at the Strawberry Creek reach (5.7) than at either the restored (6.8) or at the unrestored reach (6.4).

A widely used approach in biological assessments is to use the richness and proportion of the community that is in three largely pollution-sensitive orders of aquatic insects -- the mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera), which are commonly referred to as 'EPT' (Resh et al. 1996). EPT richness averaged 2.0 at the restored reach, 0.0 at the unrestored reach, and 4.0 at the best-attainable-conditions reach (Strawberry Creek). In terms of proportion of faunal composition, the percentage of EPT ranged from 0.0-0.7% at the restored reach, 0% at the unrestored reach, and 0.16-3.8% at Strawberry Creek.

Overall, the metrics from the 1999 results were slightly higher than in 2004 with the exception of Family Biotic Index and some of the EPT metrics (see shaded numbers in Table 2). In 1999, taxa and family richness and total number of individuals were higher at all three reaches compared to 2004. Family Biotic Index was of higher value (lower score) in 2004 compared to 1999 results at all three reaches. EPT richness was higher at Strawberry Creek then the restored reach in both 1999 and 2004 (Figure 7). EPT richness was also higher at the restored reach compared to the unrestored reach in 1999 and 2004. Percentage of EPT individuals was higher at the unrestored reach and the restored reach in 1999, but lower at Strawberry Creek compared to 2004.

Survey of Attitudes

The demographics of the 45 respondents to the survey in 2004 indicated that the majority of the respondents were female, between the ages of 25-40, and had moved there in the last 8 years (Figure 8). The results of the survey responses from both 1999 and 2004 are summarized in Table 5. It is interesting to note that 48% of the residents that moved to the neighborhood *after* the completion of the restoration project were unaware that the creek was formerly in an underground culvert. Most residents in 1999 and 2004 said that they enjoyed living near the newly uncovered creek (84% and 95% respectively) and the most common reasons for liking the creek were its aesthetic properties (pretty, natural-looking), the sounds, and the recreational value.

When asked what their general perceptions were about stream restoration, the responses varied widely in 2004. The most common responses were that the purpose of restoration was to rejuvenate native biology/ landscape (62%), improve aesthetics of the neighborhood (28%), and improve water quality (9%). The majority responded that the restored Baxter Creek would increase property value (59%).

Despite the overwhelming positive responses towards the restoration, there were also several negative views and concerns about the restoration. The main concerns among those surveyed were the size, density and safety issues associated with the riparian trees. The willows planted in the riparian zone have grown considerably since being planted in 1997. The trees reduced visibility in the neighborhood and led to power outages in a few homes along the park. While many respondents remarked that they loved the aesthetics of the trees and the increased privacy, others disliked the “overgrown” and “messy” appearance of the trees and believed that they created a place for burglars and homeless people to hide. The City of El Cerrito has done periodic maintenance of the vegetation in Poinsett Park, but not a substantial thinning of the willow trees since the project’s completion.

Discussion

Comparing habitat assessment results indicates that habitat quality did not change substantially in the five years since the initial assessment in 1999. The unrestored Baxter Creek and Strawberry Creek reaches had only a 2-point decrease in total habitat score between 1999 and

2004. Yet, at the restored reach there was an 8-point increase between 1999 and 2004 (Table 1). Again, this increase may be attributed to the growth of the riparian vegetation at the restored reach that led to a substantially higher score in the parameter of 'vegetative protection'. While these results show snapshots of the habitat condition in 1999 and 2004, the quality of habitat at the three reaches in the intervening years is unknown.

Despite the minimal temporal differences in habitat quality between 1999 and 2004, there were clear differences among reaches for each of the years. The best-attainable-conditions reach (Strawberry Creek) had better habitat quality than the restored reach, and the unrestored reach was still the poorest quality of the three reaches. The corresponding condition category to the mean score of each reach is shown in the bottom row of Table 2 (Barbour et al. 1999). The unrestored reach's mean score was in the 'marginal' category, while the restored reach and Strawberry creek scored in the 'suboptimal' category. These condition categories are of low quality compared to a natural stream reach, but show relative conditions among the three urban stream reaches.

Results from the 2004 biological assessment showed no marked improvement in the composition of the biotic assemblage compared to 1999 (Table 2). This lack of improvement in the biological condition may be attributed to several factors. Although I sampled the sites at the same time of year in both 1999 and 2004 (late June), flows were higher in 1999 due to late spring rains. The lower flow in 2004 may explain the lower taxa and family richness and overall abundance of organisms. Natural interannual variability of stream biotic assemblages may also account for the differences between 1999 and 2004 biological assessment results (Vogel et al. 1998).

The impacts of urbanization may also limit the potential of the biotic community at the restored reach. Habitat quality improved slightly (8 points), but the biological metrics did not improve, so there may be other limiting factors besides habitat that are preventing increased biological diversity at the restored reach. Walsh and Breen (1999) found that macroinvertebrate community development in urban areas was limited not only by habitat simplification but by the presence of organic pollution and increased run-off from the impervious areas. The high degree of impervious surface in the Baxter Creek watershed upstream of the restored reach and the myriad of pollutants entering the creek from surrounding storm drains may limit the improvement of the aquatic community. The 1999 biological assessment may represent the ecological 'plateau' of the community within the constraints of a highly disturbed and impacted system.

Macroinvertebrate colonization may be limited by the short length of the restored reach (70 m), the fact that it is culverted at both ends (as is the majority of Baxter Creek up- and downstream), and the large distance from the restored reach to sources of colonizers (Cairns 1990). Consequently, potential colonizers from other sites have relatively little area to select appropriate egg-laying sites, or have adequate habitat for larval survival and population establishment or have insufficient resources to support a more diverse insect assemblage (V. Resh, personal communication 2004).

In 1999, I observed numerous frogs along the restored reach and after daylighting residents mentioned the "deafening" sound of the frogs at Poinsett Park (Purcell et al. 2002). In contrast, in 2004 I did not observe frogs at the restored reach and survey respondents said they no longer heard frogs at Poinsett Park. One resident mentioned that repairs to a water line upstream by East Bay Municipal Utility District (EBMUD) may have rerouted municipal water through Baxter Creek. EBMUD uses chloromine (a combination of chlorine and ammonia) to treat its water and this chemical may have led to a decline in the frog population, but it is hard to say for sure. In urban watersheds it is very difficult to tease apart the many stressors in the system to determine what specifically causes these biological declines.

Lack of biological change from 1999 to 2004 suggests that the restored reach achieved its biotic assemblage potential in 2 years, and did not increase further after that. If Baxter Creek is typical of other such sites, it suggests that a 2-3 year post-project monitoring timeline will yield a useful picture of the biological success of a project.

The perceptions of the Poinsett Park residents indicate that the majority of the residents surveyed liked living near the newly uncovered creek with a few dissenting opinions. The improved resident reaction in the 2004 survey can be attributed to improved aesthetics and increased riparian vegetation. Yet the increased vegetation was also the source of many negative comments as well. The irony of the negative comments about the "overgrown" willows is that the creation or expansion of riparian zones is one of the major elements in urban stream restoration that consistently results in improved stream biological conditions.

In urban stream restoration projects the public's perception is a crucial element in the success or failure of a project. Several residents complained that the City of El Cerrito was not responsive to their complaints about the growth of the willows and this contributed to their negative feelings about the restoration. Increased educational materials and responsiveness by the City of El Cerrito could improve relations with the Poinsett Park neighborhood and thus the overall sociological success of the project.

Conclusions

Long-term evaluations are important to conduct in order to determine recovery time of biotic communities or changes in the watershed over time. These lessons can then be applied to future projects in the region. Long-term evaluations can detect if there have been major detrimental impacts in the watershed that have caused the biotic assemblages to decline.

Based on the biological and habitat assessment results, the restoration project at Baxter Creek improved habitat and biological conditions initially following the restoration project (1999) compared the unrestored reach. The long-term evaluation (2004) indicated that conditions have not improved since 1999 possibly due to limiting factors of urbanization in the surrounding watershed.

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Figure Captions

Figure 1. Map of Baxter Creek watershed. The black squares indicate the location of the restoration project in Poinsett Park and the unrestored reach upstream.

Figure 2. Photographs of the restoration reach looking upstream during construction in 1996 (top), one year after restoration in 1998 (middle), and seven years after restoration in 2004 (bottom).

Figure 3. Photo of Poinsett Park in 2004 looking downstream (creek outlets directly behind the sign). Park is surrounded by streets on all sides.

Figure 4. Photo of downstream inlet of Baxter Creek in Poinsett Park. Notice small retention basin constructed and grate over the inlet to prevent clogging from trash and debris.

Figure 5. Map of Strawberry Creek watershed. The black square indicates the location of the sampling reach for this study. Solid blue lines are above ground segments of the creek, while dotted red lines are segments that are in underground culverts.

Figure 6. Taxa richness at all three reaches in 1999 and 2004.

Figure 7. EPT richness at all three reaches in 1999 and 2004. EPT = Species within the order Ephemoroptera, Plecoptera or Trichoptera.

Table captions

Table 1. Comparison of Habitat Assessment scores in 1999 and 2004 for the three study reaches (a higher score indicates better habitat). Qualitative scores correspond to condition categories of: 0-5 (poor), 6-10 (marginal), 11-15 (suboptimal), and 16-20 (optimal) for each parameter. Total possible score is 200.

Table 2. Biological metrics evaluated at each of the three reaches in 1999 and 2004. Shaded values indicate a higher ecological value between the two years at each reach. EPT = Species within the order Ephemoroptera, Plecoptera or Trichoptera.

Table 3. Biological assessment mean and range (in parentheses) of insects collected at each of the three study reaches in 1999 and 2004. A dash indicates that no individuals were found in that sample.

Table 4. Biological assessment mean and ranges (in parentheses) for non-insect taxa of macroinvertebrates collected at each of the three study reaches. A dash indicates no individuals were found in that sample.

Table 5. Summary of Poinsett Park resident survey in 1999 and 2004.

Figure 1. Map of Baxter Creek watershed. The black squares indicate the location of the restoration project in Poinsett Park and the unrestored reach upstream (scale: 2’’ = 1 mile).

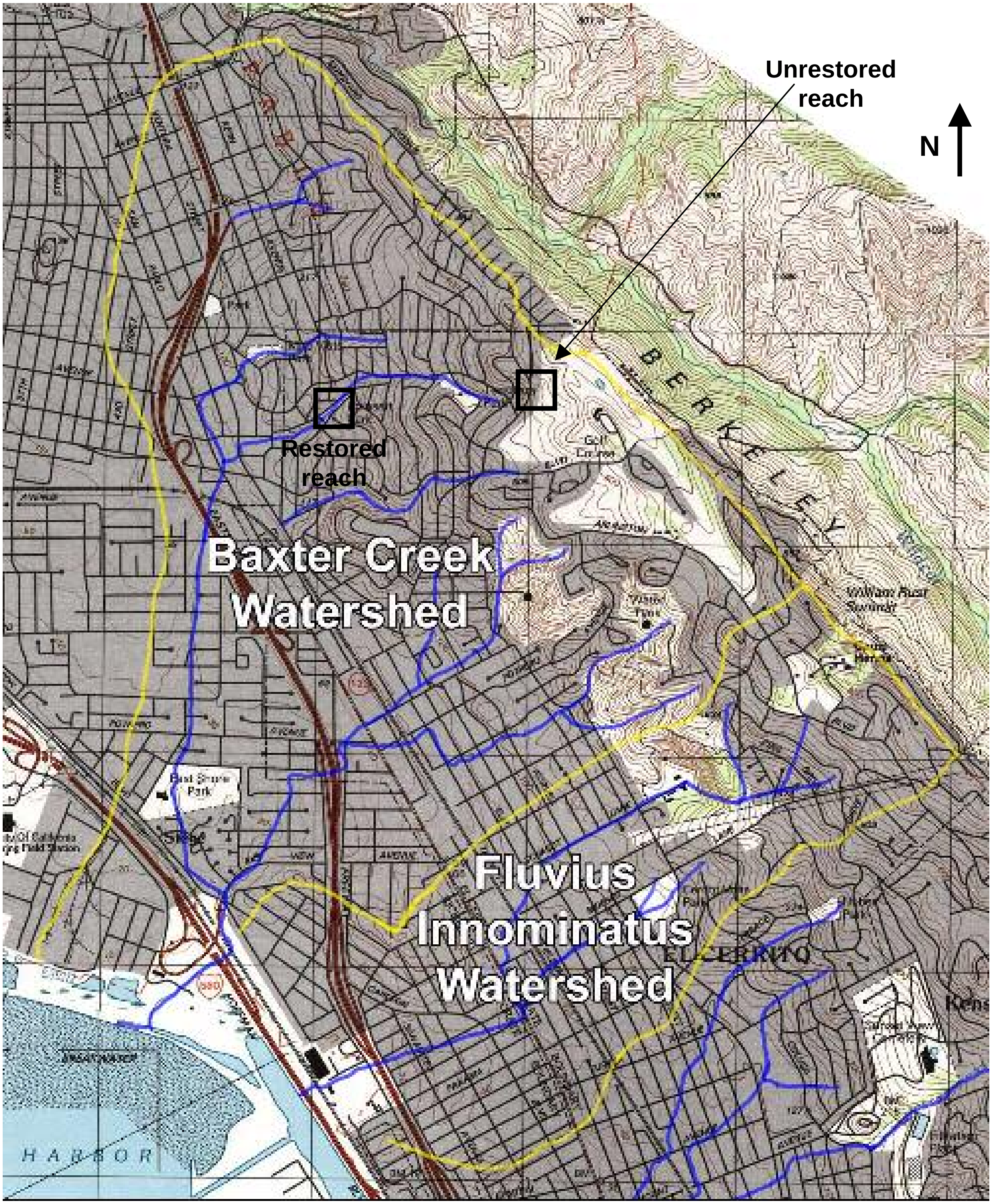

Figure 2. Photographs of the restoration reach looking upstream during construction in 1996 (top), one year after restoration in 1998 (middle), and seven years after restoration in 2004 (bottom).

(top two photos taken by Lisa Owens-Viani and bottom photo taken by Alison Purcell)

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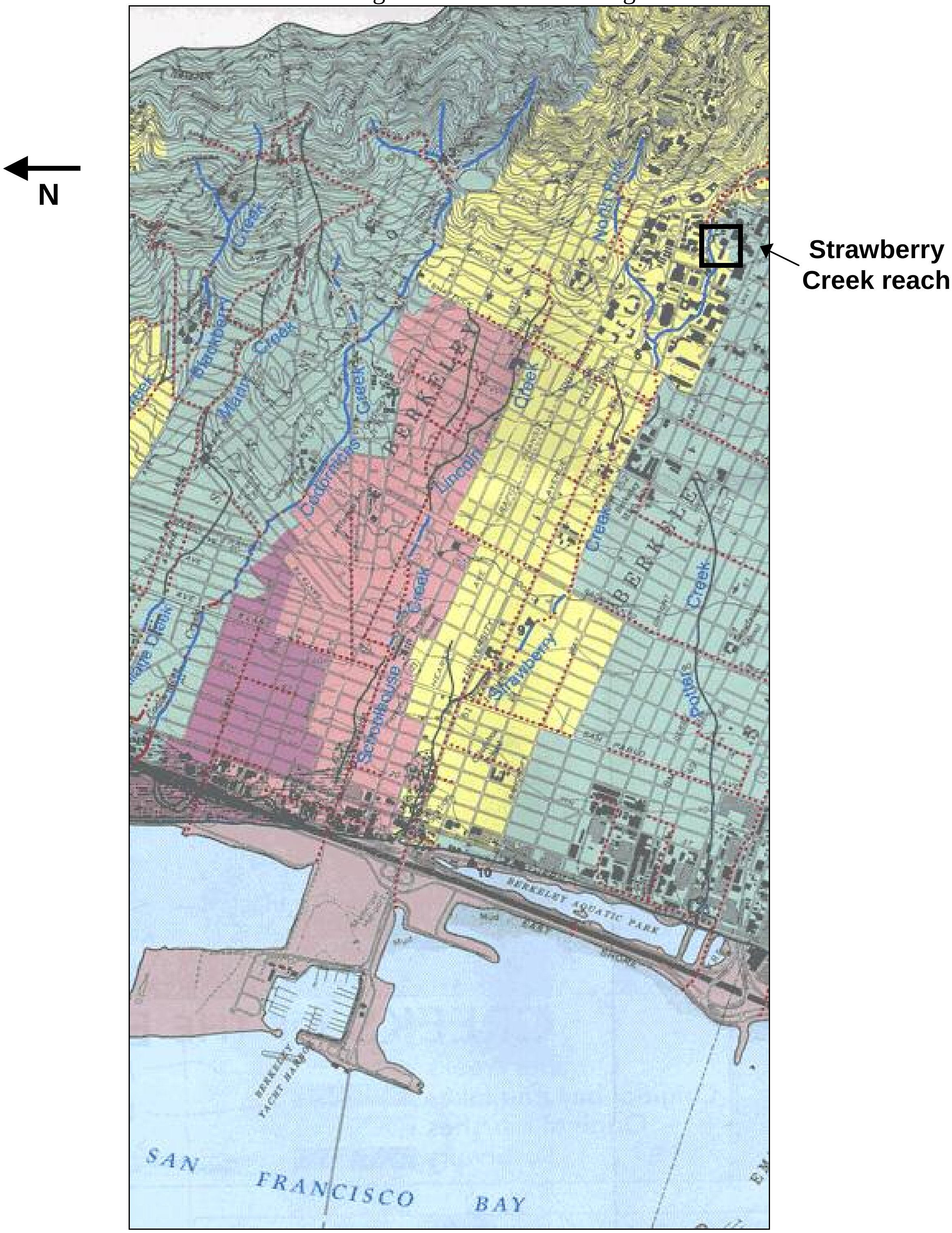

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	Unrestored *Baxter Creek*		**Restored** *Baxter Creek*		**Best Attainable Conditions** *Strawberry Creek*	
Habitat Parameter	**1999**	**2004**	**1999**	**2004**	**1999**	**2004**
Epifaunal Substrate/ Available Cover	8	7	13	12	14	13
Embeddedness	12	11	13	14	15	14
Velocity/Depth Regime	9	8	16	15	15	15
Sediment Deposition	7	7	9	11	14	16
Channel Flow Status	7	5	12	10	16	14
Channel Alteration	10	10	10	13	14	14
Frequency of Riffles (or bends)	14	13	18	18	15	15
Bank Stability	6	6	11	12	17	17
Vegetative Protection	4	8	11	16	17	17
Width of Riparian Vegetative Zone	2	2	6	6	7	7
Total Score:	**79**	**77**	**119**	**127**	**144**	**142**
Change in total score between 1999 and 2004:	-2		+8		-2	
Mean: (corresponding condition category)	7.9 (Marginal)	7.7 (Marginal)	11.9 (Suboptimal)	12.8 (Suboptimal)	14.4 (Suboptimal)	14.6 (Suboptimal)

Table 2. Biological metrics evaluated at each of the three reaches in 1999 and 2004.
Shaded values indicate a higher ecological value between the two years at each reach.
EPT = Species within the order Ephemoroptera, Plecoptera or Trichoptera.

	Unrestored *Baxter Creek*		**Restored** *Baxter Creek*		**Best Attainable Conditions** *Strawberry Creek*	
	Mean ± standard dev (Range)		**Mean ± standard dev (Range)**		**Mean ± standard dev (Range)**	
Metric	**1999**	**2004**	**1999**	**2004**	**1999**	**2004**
Taxa Richness	22 (16-28)	8.7 ± 5.3 (7-10)	23 (18-31)	11 ± 3.0 (8-14)	22 (18-27)	12.3 ± 2.31 (11-15)
Family Richness	17 (12-22)	11.7 ± 1.53 (10-13)	19 (15-26)	14.3 ± 3.06 (11-17)	19 (15-24)	15.3 ± 2.31 (14-18)
Total Number of Individuals	1,610 (781-2,799)	773 ± 640.72 (373-1512)	713 (606-1,187)	472.7 ± 176.79 (287-639)	910 (319-1,681)	489.3 ± 264.58 (184-651)
Family Biotic Index	7.6 (7.3-7.8)	6.4 ± 0.33 (6.2-6.9)	6.9 (6.4-7.3)	6.8 ± 0.55 (6.4-7.4)	6.6 (5.8-7.4)	5.7± 0.32 (5.5-6.1)
EPT Richness	0.7 (0-2)	0 ± 0	1 (1)	2 ± 2.0 (2-4)	3.3 (3-4)	4 ± 3.0 (1-7)
Percentage of EPT Individuals	0.1 (0-0.3)	0	2.0 (0.1-0.3)	0.44 ± 0.004 (0-0.7)	0.5 (0.2-0.9)	1.53 ± 0.02 (0.16-3.8)

Table 3. Biological assessment mean and range (in parentheses) of insects collected at each of the three study reaches in 1999 and 2004. A dash indicates that no individuals were found in that sample.

		Unrestored *Baxter Creek*		**Restored** *Baxter Creek*		**Best Attainable Conditions** *Strawberry Creek*	
Insect Order	**Family (# of taxa)**	**1999**	**2004**	**1999**	**2004**	**1999**	**2004**
Odonata (Zygpotera)	Coenagrionidae - *Argia vivida* (1)	59.3 (40-73)	11 (7-18)	106 (85-130)	129 (75-203)	24 (18-28)	11.5 (7-16)
Odonata (Anisoptera)	Aeshnidae (1)	-	-	-	-	-	0.3 (0-1)
Collembola (springtails)	Hypogastruridae (1)	-	-	-	-	1.3 (0-3)	-
	Entomobryidae (2)	1 (0-3)		0.7 (0-1)	0.7 (0-2)	0.3 (0-1)	-
Ephemeroptera (mayflies)	Baetidae (1)	0.3 (0-1)	-	-	2.5 (2-3)	-	-
Plecoptera (stoneflies)	Nemouridae (1)	-	-	-	-	5.3 (1-12)	0.67 (0-2)
Trichoptera (caddisflies)	Hydropsychidae (1)	-	-	-	-	0.7 (0-1)	-
	Hydroptilidae (1)	0.3 (0-1)	-	4.3 (1-11)	-	-	-
	Lepidostomatidae (1)	-	-	-	-	18.3 (1-32)	3.3 (1-7)
	Limnephilidae (1)	-	-	-	0.3 (0-1)	0.3 (0-1)	-
	Rhyacophilidae (1)	-	-	-	-	0.7 (0-1)	-
Hemiptera	Saldidae(1)	-	-	-	-	-	2 (1-3)
Megaloptera	Sialidae (1)	-	-	-	-	2 (1-3)	-
Diptera (true flies)	Chironomidae (4)	73 (19-114)	242.3 (49-504)	290.7 (137-537)	66.3 (34-127)	1,532 (95-512)	317 (61-452)
	Simuliidae (1)	5.7 (3-8)	-	14 (1-36)	59.7 (33-136)	91.7 (12-213)	9 (2-23)
	Tipulidae (1)	6.7 (4-9)	2 (1-3)	4.7 (2-8)	6.5 (5-8)	1 (0-3)	-
	Empididae (1)	2 (0-5)	-	9 (0-26)	-	40 (7-91)	7.3 (0-22)
	Tabanidae (1)	-	-	-	0.3 (0-1)	-	-
	Psychodidae (2)	3 (0-9)	-	-	-	-	-
	Stratiomyidae (1)	-	-	2 (0-5)	-	-	-
	Pelecorhynchidae (1)	0.7 (0-1)	-	-	-	1.3 (0-3)	-
Coleoptera (beetles)	Gyrinidae (1)	-	-	-	1 (0-3)	-	-
	Dytiscidae (1)	-	-	-	-	2 (0-5)	-
	Dryopidae (1)	-	-	0.3 (0-1)	-	0.3 (0-1)	-
	Hydrophilidae (1)	-	-	1 (0-2)	-	-	0.3 (0-1)
	Elmididae (1)	0.3 (0-1)	-	-	-	-	1 (0-3)

Table 4. Biological assessment mean and ranges (in parentheses) for non-insect taxa of macroinvertebrates collected at each of the three study reaches. A dash indicates no individuals were found in that sample.

		Unrestored *Baxter Creek*		**Restored** *Baxter Creek*		**Best Attainable Conditions** *Strawberry Creek*	
Insect Order	**Family (# of taxa found in study)**	**1999**	**2004**	**1999**	**2004**	**1999**	**2004**
Amphipoda (scuds)	Gammaridae (1)	1.3 (0-2)	5.7 (0-17)	0.3 (0-1)	-	10.3 (1-24)	46.3 (7-86)
Ostracoda (1) (seed shrimp)		11 (0-33)	79 (22-136)	13 (2-26)	-	50.7 (29-79)	2.5 (2-3)
Isopoda (1) (pill bugs)		0.3 (0-1)	2.5 (2-3)	0.3 (0-1)	1.3 (0-4)	0.7 (0-1)	-
Gastropoda	Physidae (1)	18.7 (2-38)	51 (7-113)	29 (13-43)	12.5 (8-17)	32.3 (9-48)	23 (13-40)
	Viviparidae (1)	521 (300-892)	-	33.3 (6-60)	-	11 (9-13)	-
	Lymnaeidae Fossaria (1)	75.3 (0-120)	135 (8-237)	89.7 (28-182)	159.3 (68-326)	40 (12-26)	17 (10-24)
	Planorbidae (1)	-	-	1.3 (0-3)	-	-	-
Bivalvia (1) (clams)	Schaeridae	327 (129-511)	36 (11-67)	1.7 (1-3)	2 (0-6)	5.3 (1-13)	-
Oligochaeta (1) (worms)		473.7 (167-1,027)	229.7 (43-561)	72.7 (36-108)	2 (1-3)	22.7 (16-31)	11.7 (2-26)
Turbellaria (flatworms)	Platyhelminthidae (1)	20 (9-36)	6.7 (0-20)	22 (3-60)	35 (19-53)	29 (0-63)	39.7 (19-78)
Acarina (7) (water mites)	sp. 1	2.3 (0-7)	-	4.7 (0-8)	1.5 (1-2)	0.3 (0-1)	3 (1-5)
	sp. 2	0.7 (0-1)	-	1 (0-1)	0.3 (0-1)	1.7 (0-5)	-
Hirudinea (leeches)	Bdellidae (1)	1 (0-2)	-	0.7 (0-1)	-	-	-

Figure 6. Taxa richness at all three reaches in 1999 and 2004.

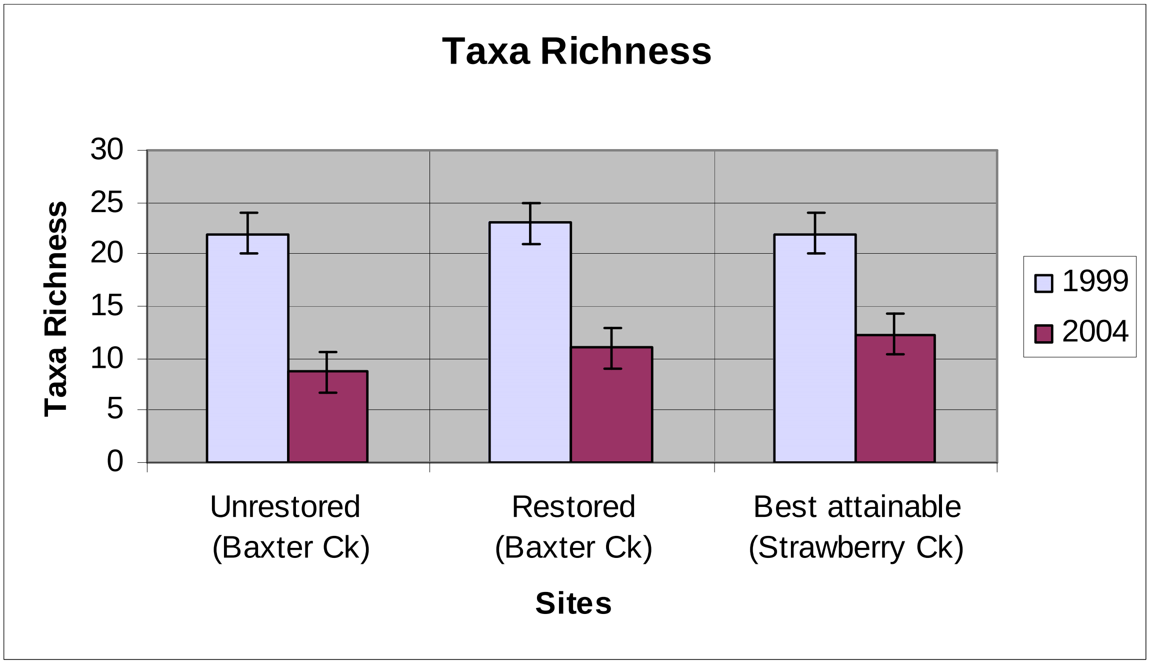

Figure 7. EPT richness at all three reaches in 1999 and 2004. EPT = Species within the order Ephemoroptera, Plecoptera or Trichoptera.

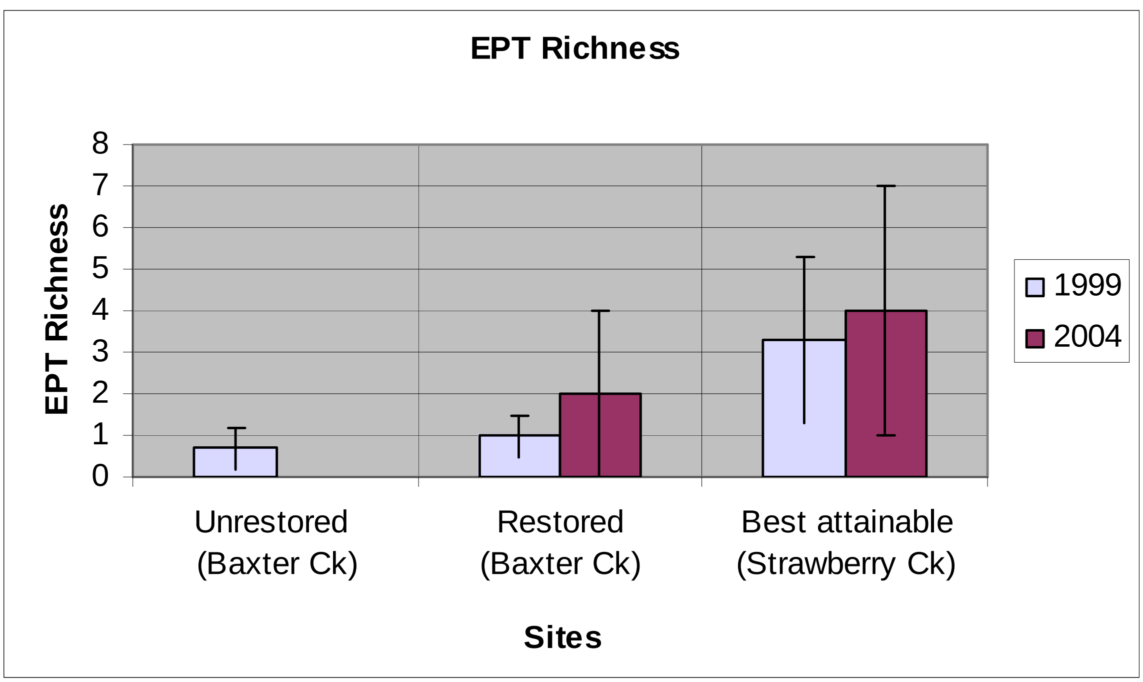

Figure 8. Characteristics of survey respondents in 2004

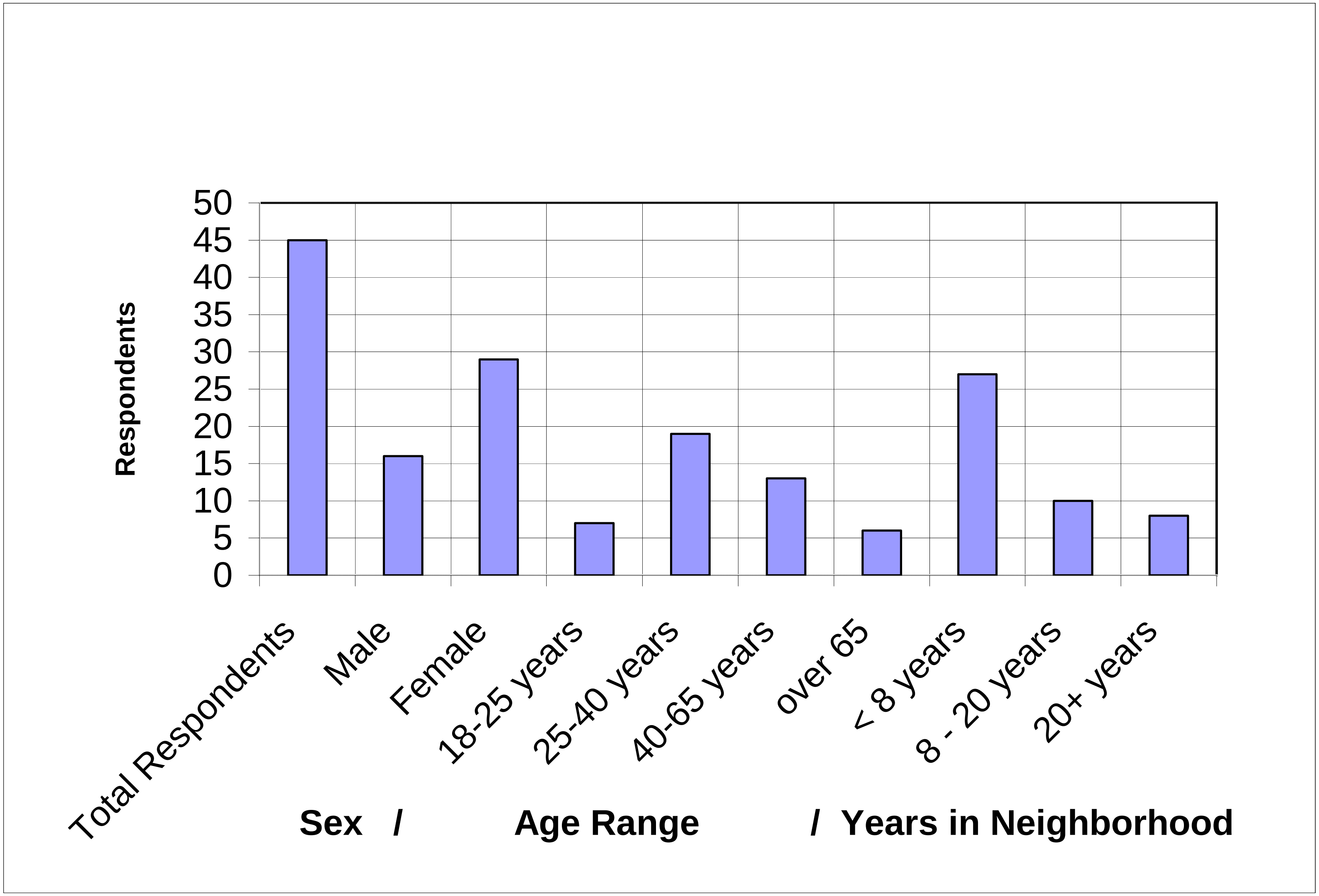

Table 5. Summary of Poinsett Park resident survey in 1999 and 2004.

Questions	Responses	
	1999	**2004**
1. How long have you lived in this neighborhood?	0-3 yrs: 24% (11/45) 3-20 yrs: 58% (26/45) 20+ yrs: 18% (8/45)	0-3 yrs: 19% (7/37) 3-20 yrs: 62% (23/37) 20+ yrs: 19% (7/37)
If less than 5 years: Were you aware that prior to 1997 the creek in Poinsett Park was in an underground culvert?	N/A	YES: 52% (11/21) NO: 48% (9/21)
2. Do you **enjoy** living near a creek?	YES: 84% (38/45) NO: 16% (7/45)	YES: 95% (42/44) NO: 5% (2/44)
Why? (top three answers)	Aesthetics: 42% (18/38) Natural setting: 35% (15/38) Recreational use: 9.5% (4/38)	Sounds: 28% (12/43) Aesthetics: 21% (9/43) Kids/dogs: 16% (7/43)
Why **not**?	Preferred grass: 9.5% (4/6) Flood concern: 2% (1/6) Didn't notice a difference: 2% (1/6)	Overgrown: 3% (1/39)
3. How **often do you visit the park**?	A few times per week: 56% (25/45) Once a month: 4% (2/45) Less than once a month: 40% (18/45)	A few times per week: 40% (18/45) Once a month: 38% (17/45) Less than once a month: 7% (3/45) Never: 16% (7/45)
4. Were/are you **involved** in the restoration area?	YES: 42% (19/45) NO: 56% (25/45)	YES: 34% (14/41) NO: 66% (27/41)
5. In general, what do you think is the **primary goal of any creek restoration** (not just the one in Poinsett Park)?	Native biology/landscape: 42% (17/40) Improve aesthetics: 20% (8/40) Improve water quality: 15% (6/40) Spend taxpayer's money: 8% (3/40) No goals: 5% (2/40)	Native biology/landscape: 64% (24/44) Improve aesthetics: 28% (11/44) Improve water quality: 9% (4/44) Recreation: 5% (2/44) Education: 3% (1/44) No idea: 5% (2/44)
6. How do you think the recently uncovered creek will **affect your property value?**	Increase: 58% (26/45) Decrease: 2% (1/45) Remain the same: 20% (9/45) Don't know: 20% (9/45)	Increase: 59% (24/41) Decrease: 0% (0/41) Remain the same: 12% (5/41) Don't know: 29% (12/41)
7. Did this restoration **live up to your expectations**?	YES: 82% (32/39) NO: 18% (7/39)	YES: 72% (13/18) NO: 28% (5/18)
8. How do your perceptions/feelings about the restoration **compare** with when it was first completed (seven years ago)?	N/A	IMPROVED: 69% (11/16) WORSENED: 31% (5/16)

Appendix A

Sample calculations of Family Biotic Index (site at the unrestored reach). Family Biotic Index is on a scale of 0-10 (a high value indicates an assemblage with mostly pollution tolerant species, while a low value indicates the presence of many pollution sensitive species).

Order/Family	**Number of individuals**		**Tolerance value**		**Total**
Coenagrionidae	18	x	7	=	126
Chironomidae	49	x	6	=	294
Tipulidae	3	x	3	=	9
Gammaridae	17	x	4	=	68
Isopoda	3	x	8	=	24
Physidae	7	x	8	=	56
Lymnaeidae	160	x	8	=	1280
Oligochaeta	85	x	5	=	425
Platyhelminthidae	20	x	4	=	80
Total:	**373**				**2450**

Family Biotic Index = Total tolerance value / total number of individuals
= 2450 / 373
= **6.57***

*A Family Biotic Index score of 6.57 is in the ‘poor’ category for water quality condition (from water quality table in Resh et al. 1996)

APPENDIX B

2004 SURVEY OF POINSETT PARK RESIDENTS

Location of interview/Address: ____

Home adjacent to creek? Y / N   Were they home? Y / N → left survey at home? Y / N

Name of interviewee (if given) ____

Description of person:

Age estimate: ___   Ethnicity: _________________   Sex: M___ F ____

Other descriptive features: __________________________

ORAL QUESTIONNAIRE

1. How long have you lived in this neighborhood? _______________

If less than 5 years:

Were you aware that prior to 1997 the creek in Poinsett Park was in an underground culvert? A restoration project in 1997 dug up (or 'daylighted') the creek and planted vegetation on its banks.

YES / NO

2. Do you enjoy living near a creek?   YES / NO

   Why or why not?

3. How often do you go to Poinsett Park?

A few times a week ___   About once/month ___   Less than once/month ___   Never ___

4. Are you involved, in any way, with the restoration area? (doing gardening in the park etc..)

   YES / NO

IF YES:

In what ways are you involved?

Why did you get involved?

APPENDIX B (pg.2) – 2004 SURVEY continued..

5. In general, what do you think is the **primary goal** of any creek restoration?

(not just the one in Poinsett Park – CHOOSE ONE)
__ Improvement of **water quality** and/or **storm drain c**ontrol
__Improvement of **Aesthetics / Beauty** of the neighborhood
__ Rejuvenation of **native biology/la**ndscape
__**Recreational** uses
__**Educational** tool for learning about nature/environment

Other:

6. How do you think creek restoration has affected property values?

INCREASE / DECREASE / STAY THE SAME / DON'T KNOW

ONLY FOR PEOPLE WHO'VE LIVED HERE LONGER THAN 7 YEARS (i.e. you lived here when the restoration was completed):

7. Did this restoration live up to your expectations? YES / NO /

8. How do your perceptions/feelings about the restoration **compare** wtih when it was first completed (seven years ago)? IMPROVED / WORSENED

Any additional comments?

Would you like a copy of the results of this study? YES / NO

If yes, please include following information:

Name ____________________

Address: ____________________

____