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Quittie Creek Nature Park Stream Restoration Project
In-Stream Physical Habitat and Fish Cover Monitoring Report

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Background

As in-kind match toward the Quittapahilla Creek Watershed Association's Pennsylvania Department of Environmental Protection, Growing Greener Program Grant, the Pennsylvania Fish and Boat Commission (PFBC) committed to providing pre- and post-implementation monitoring of physical habitat and fish cover conditions at the proposed Quittie Creek Nature Park Stream Restoration Project Site. As of May 2012, the project is in the design and permitting phase, PFBC staff conducted pre-implementation monitoring at the proposed project site and an upstream control site on Quittapahilla Creek, and no date has been set for project construction. After construction of the proposed project, PFBC will conduct another round of monitoring at the upstream control and project sites.

In addition to conducting pre- and post-implementation monitoring, PFBC agreed to develop in-stream habitat criteria and physical habitat/fish cover objectives that will be used to evaluate project success. Existing data collected by PFBC staff in May 2010 at Saucon Creek, near Hellertown, Northampton County, were used to develop in-stream habitat criteria and the monitoring objectives for the proposed project. The Saucon Creek site was selected as the "reference" site since it has similar physiographic and basin characteristics to those of the proposed project treatment site, but Saucon Creek differs from the proposed project site, in that it supports a Class-A wild brown trout fishery and its watershed is more forested, less urbanized, and consists of less impervious area. Basin characteristics of the Saucon Creek "reference" site and the upstream control and proposed project sites on Quittapahilla Creek are summarized in Table 1.

Table 1. Basin Characteristics of Saucon Creek Reference Site and Quittapahilla Creek Control and Proposed Project Sites.

Basin Characteristic	Saucon Creek Reference Site	Quittapahilla Creek Control Site	Quittapahilla Creek Treatment Site
Latitude / Longitude	40.6012 / -75.3453	40.3277 / -76.5005	40.3288 / -76.5093
Physiographic Province	Ridge & Valley		
Physiographic Section	Great Valley Section		
EPA Level IV Ecoregion	Northern Limestone/Dolomite Valleys (67a)		
Drainage Area (mi^2)	46.4	43.7	44.8
Mean Basin Elevation (ft)	544	547	545
Adjusted Basin Slope, in Degrees	5.85	2.60	2.59
Percent of Area Covered by Carbonate Bedrock	56.6	77.6	78.0
Mean Annual Precipitation (in)	45.0	43.0	43.0
Maximum Daily Temperature (F)	60	60	60
Percent of Area Covered by Forest	47.0	16.2	16.1
Percent of Impervious Area Determined from NLCD 2001	4.4	12.4	12.3
Percent of Area Covered by Urban Land from Enhanced NLCD 1992	17.1	21.7	21.6
Percent of Area Covered by Urban Land from NLCD 2001	19.2	35.6	35.4
Change in Percent of Area Covered by Urban Land 1992 to 2001	2.1	13.9	13.8

The goal of the proposed project is to restore riparian and in-stream habitat conditions at the project site by stabilizing the actively eroding stream channel. Based on the conditions observed at the Saucon Creek reference site, and to a lesser extent, the existing conditions observed at the Quittapahilla Creek control and treatment sites, the monitoring objectives of the project are listed below. These objectives should be attained approximately one year after project construction is completed.

1. Increasing the percentage of the project site consisting of stable streambanks to a minimum of 83.8% (+/- 4.2%)
2. Reducing the wetted width:mean depth ratio value to 31.1 (+/- 1.6)
3. Increasing sediment transport capacity by increasing the velocity index value to 1.24 ft/sec (+/- 0.06 ft/sec)
4. Decreasing the percentage of the substrate consisting of sand or finer materials to a maximum of 23.8%
5. Increasing the median substrate particle size category to coarse gravel
6. Reducing glide habitat to approximately 14%, and increasing pool and riffle habitat to approximately 33% and 14% of the project area, respectively
7. Increasing mean thalweg depth to 2.68 ft (+/- 0.13 ft)
8. Increasing the standard deviation of thalweg depth measurements to 0.88 ft (+/- 0.04 ft)
9. Increasing mean residual pool depth to 1.31 ft (+/- 0.06 ft)
10. Increasing the standard deviation of residual pool depth measurements to 0.89 (+/- 0.04 ft)
11. Increasing the area of residual pools > or = 1.00 ft depth per 100 ft of stream channel to 110 ft^2 (+/- 5.5 ft^2)
12. Increasing the amount of large fish cover to 13.0% (+/- 0.6%)
13. Reducing the mean distance to closest adult fish cover to 10.0 ft (+/- 0.5 ft)

Methods

PFBC staff conducted a survey of the existing physical habitat and fish cover conditions at the upstream control and proposed project sites on Quittapahilla Creek between May 1 and May 3, 2012. . At the Quittapahilla Creek sites, data were collected from a 600 foot-long reach of stream channel at each site (Figure 1). Physical habitat and fish cover data were collected from a 1,600 foot-long reach of stream channel at the Saucon Creek reference site on 11 May, 2010 (Figure 2).

Within each monitoring reach, systematic measurements were taken along 21 evenly spaced transects across the wetted channel. At each of the 21 transects, the wetted width of the channel was recorded, and water depth and predominant substrate particle-type was measured/noted at 0%, 20%, 40%, 60%, 80%, and 100% of the measured wetted width, and at the deepest point along the transect. Thus, within each monitoring reach, a total of 147 depth measurements and predominant substrate particle-type characterizations were recorded using the substrate particle-type categories shown in Table 2. In addition, the predominant channel unit type (riffle, run, glide, or pool) was noted at each of the 21 transects.

An overall wetted width:mean depth ratio was calculated for each monitoring reach using the following equation:

$$\text{Wetted Width:Mean Depth Ratio} = \frac{\text{Mean of 21 transect wetted width measurements}}{\text{Mean of 147 transect depth measurements}}$$

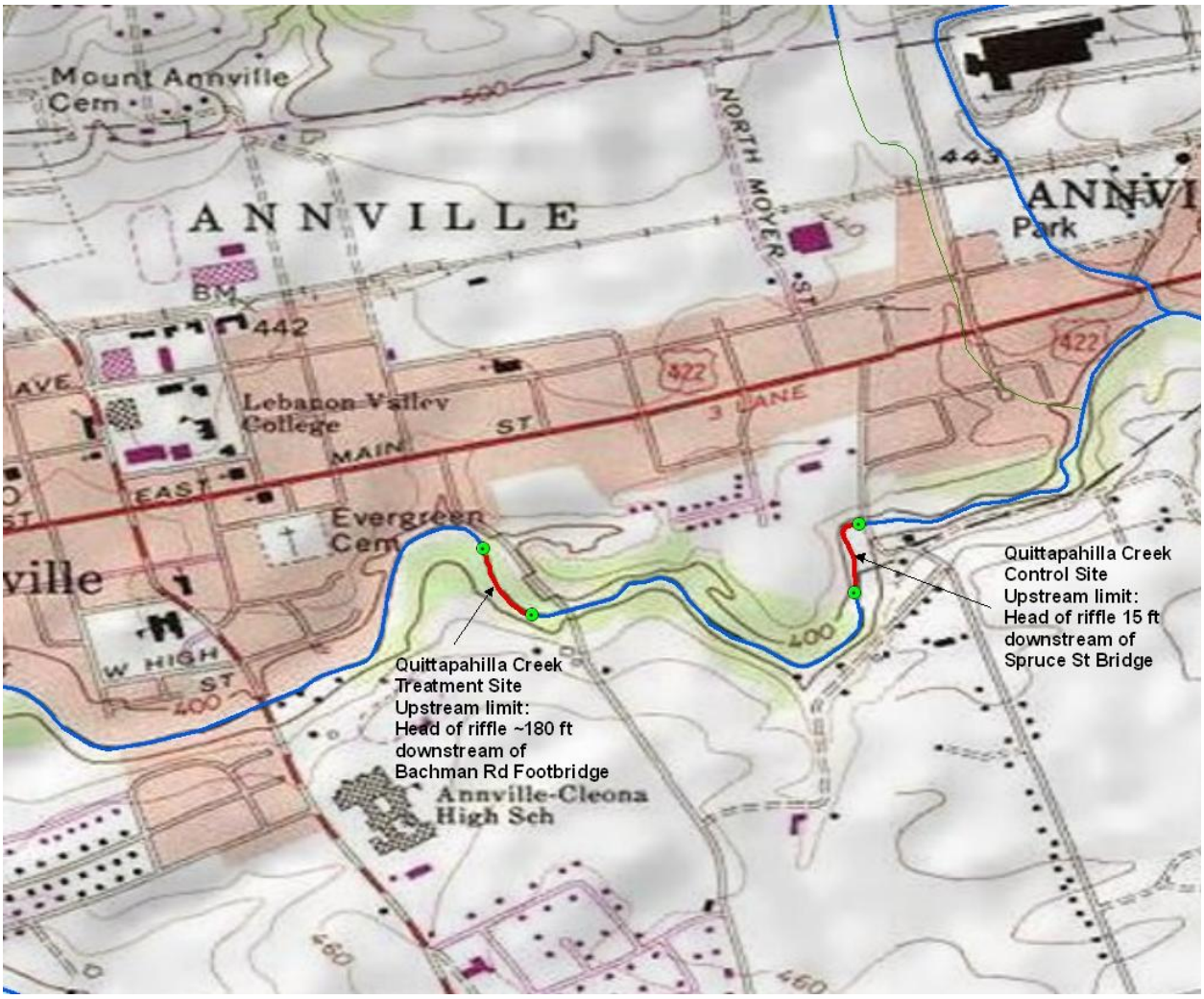

Figure 1. Quittapahilla Creek Control and Treatment Site Location Map.

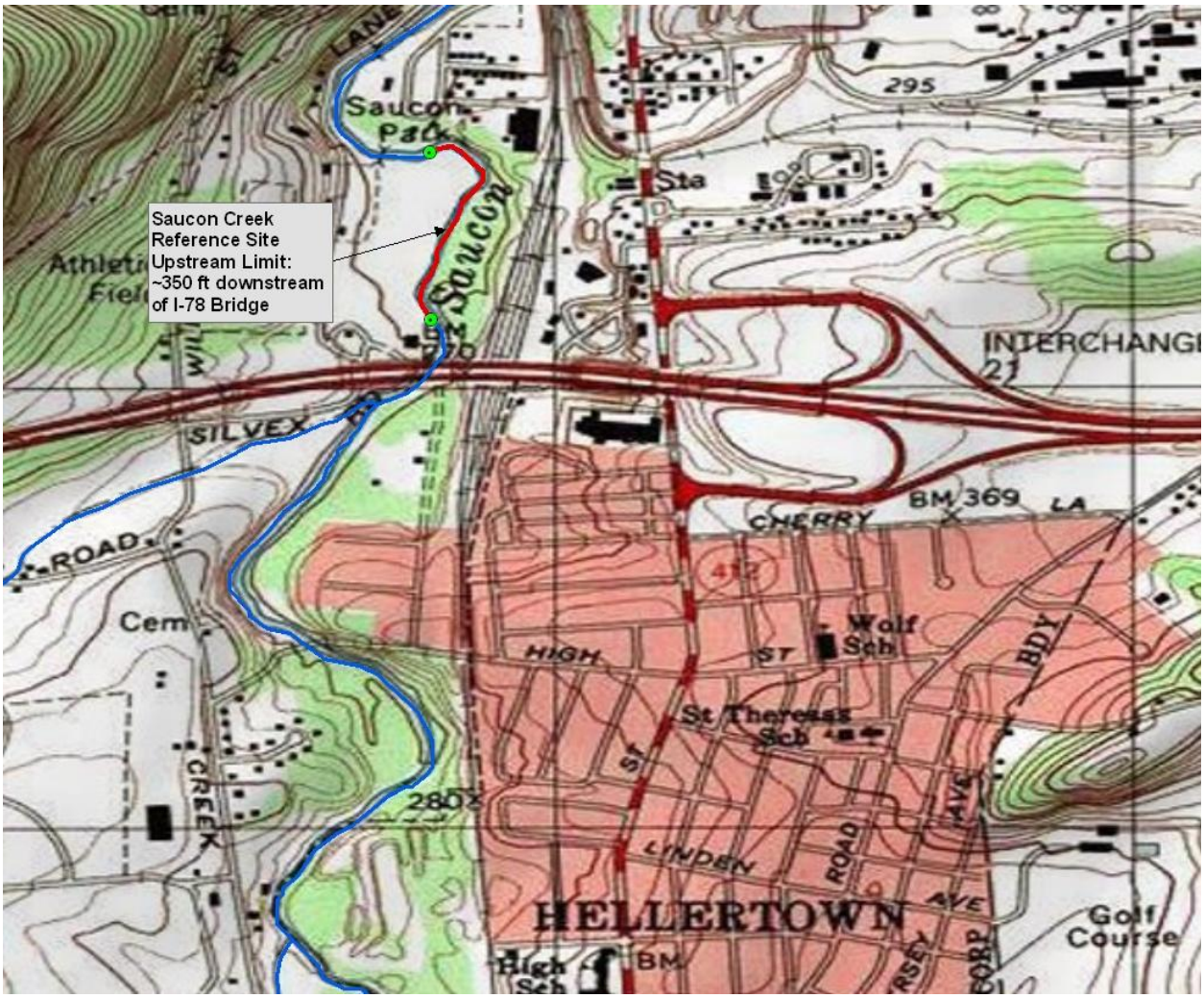

Figure 2. Saucon Creek Reference Site Location Map.

Table 2. Substrate Particle Size Categories.

Substrate Size Classes	Intermediate Axis Size Descriptor
Silt / Clay / Muck	Not gritty (<0.06 mm)
Sand	Gritty (>0.06 mm – 2 mm)
Gravel (Fine)	Up to marble size (>2 mm – 16 mm)
Gravel (Coarse)	Marble to tennis ball (>16 mm – 64 mm)
Cobble	Tennis ball to basketball (>64 mm – 250 mm)
Boulder (Small)	Basketball to meter stick (>250 mm – 1,000 mm)
Boulder (Large)	Meter stick to car (>1,000 mm – 4,000 mm)
Concrete / Asphalt	Any size
Bedrock (Rough)	Larger than a car (>4,000 mm) with rough surface
Bedrock (Smooth)	Larger than a car (>4,000 mm) with smooth surface
Other	

Velocity index values were calculated for each monitoring reach using the following equation:

$$\text{Velocity Index} = \frac{\text{Stream discharge (cfs)}}{\text{(Mean of 21 transect wetted width measurements (ft))} * \text{(Mean of 147 transect depth measurements (ft))}}$$

Substrate particle size class data collected at each monitoring reach were summarized in cumulative frequency tables and these tables were used to identify the percent sand or finer material and the median substrate particle size category of each monitoring reach.

The % riffle, %run, % glide, and % pool channel unit composition of each monitoring reach was calculated as the number of transects categorized as riffle, run, glide, or pool, divided by the total number of transects surveyed, expressed in percent. For example, if a total of seven transects were classified as riffle habitat, the % riffle value was calculated as follows:

$$\%\ \text{Riffle} = \frac{\text{7 riffle transects}}{\text{21 total transects surveyed}} \times 100 = 33.3\%\ \text{Riffle}$$

At each monitoring reach, a thalweg profile survey was conducted and water surface slope was measured using a laser level. The thalweg profile is a longitudinal survey of depth in the flow path of the deepest water in the stream channel. 101 equally spaced thalweg depth measurements were recorded between the upstream and downstream limits of the monitoring reach. Thalweg profile and surface water slope data were used to calculate the mean and standard deviation of thalweg depth measurements and to summarize the residual pool characteristics of the monitoring reach. Residual pools are depressions along the streambed that would contain water even if the stream was not actively flowing. Residual pools are formed by downstream controls (typically riffles) that act as dams causing back-watering. The residual pool characteristics of each monitoring reach were summarized using an excel spreadsheet developed by U.S. Environmental Protection Agency, Region III staff.

The entire length of both streambanks within each monitoring reach were assessed using the bank stability guidelines provided in Barbour et al. (1999) and in Overton et al. (1997). The total length of unstable streambank in each reach was measured and recorded. In general, steep banks that were not covered by vegetation in vigorous condition or by cobble or larger material, and appeared to be likely to collapse and/or suffer from erosion, were considered to be actively eroding and unstable. More specifically, unstable streambanks showed evidence of one or more of the following: (1) breakdown (clumps of bank broken away and banks are exposed), (2) slumping (banks have slipped down), or (3) tension cracking or fracture (a crack is visible on the bank), and/or (4) vertical and actively eroding (bank angle steeper than 80 degrees from the horizontal, and less than 50 percent covered by perennial vegetation, roots, rocks of cobble size or larger, or logs of 0.1 m in diameter or larger). Streambank stability data from each monitoring reach was summarized as percent stable streambanks as follows:

$$\%\ \text{Stable Streambanks} = \frac{\text{Total length of streambank assessed - Total length of unstable streambank}}{\text{Total length of streambank assessed}} \times 100$$

At each of the 21 transects, the length and type of fish cover located within 1 ft. of the transect line was measured parallel to the transect line. The percent fish cover values for each monitoring reach were determined by the sum of the lengths of cover from all transects combined, divided by the sum of the lengths of transects (wetted widths), and expressed as a percentage. In addition to percent fish cover, the distance to the nearest fish cover was measured from the wetted width mid-point of the transect line, and the type of cover was recorded. For each monitoring reach, the mean distance to closest fish cover was calculated by averaging the 21 distances recorded throughout the monitoring reach.

On 02 May, 2012 stream discharge was measured at the proposed project site using the midsection, current-meter method, commonly used by the United States Geological Survey at gaging stations, described in detail in Buchanan and Somers (1969) and Rantz et al. (1982). In general, this measurement is the summation of the products of the partial areas of the stream cross-section and their respective average velocities. Velocity and depth were measured at a minimum of 20 verticals across the cross-section. At each vertical, velocity was measured at 0.6 of the depth below the surface. Stream discharge was not measured at the upstream control site because rain in the early morning hours of 03 May substantially increased stream discharge above the conditions under which the majority of the data were collected at this site on 02 May. Therefore, the water yield value (cfs per square mile of drainage area) recorded at the treatment site on 02 May was used to estimate the discharge at the Quittapahilla Creek Control site by multiplying the drainage area of the control site by the water yield value of 1.07 recorded at the treatment site on 02 May.

Monitoring Results

Stream discharge, wetted channel width and depth, and velocity index data from the Saucon Creek reference site and the Quittapahilla Creek control and treatment sites are summarized in Table 3. In general, the stream channel at the Quittapahilla Creek treatment site is characterized as having a higher wetted width:mean depth ratio and a lower velocity index value, relative to the values recorded for these parameters at the Saucon Creek reference and Quittapahilla Creek control sites.

The median substrate particle size category recorded at the Quittapahilla Creek treatment site was sand with nearly 60% of the substrate consisting of sand or finer particles. The median substrate particle size category recorded at both the Saucon Creek reference site and the Quittapahilla Creek control site was coarse gravel, with less than 30% of the substrate consisting of sand or finer particles. Substrate particle size class data collected at the Saucon Creek reference site and the Quittapahilla Creek control and treatment sites are summarized in Table 4, with percent sand or finer material values in bold font and the median substrate particle size category of each monitoring reach highlighted.

Table 3. Stream Discharge, Wetted Channel Width and Depth, and Velocity Index Data.

Parameter	Units	Saucon Creek Reference Site	Quittapahilla Creek Control Site	Quittapahilla Creek Treatment Site
Discharge (Q)	cfs	90.92	46.58*	47.75
Water yield	cfs/mi^2	1.94	1.07*	1.07
Mean wetted width (WW)	ft	47.7	33.6	50.1
Mean depth (Mean D)	ft	1.53	1.14	1.21
Channel Area (A) (WW*Mean D)	ft^2	73.1	38.3	60.6
WW : Mean D ratio		31.1	29.4	41.4
Velocity Index (Q/A)	ft/sec	1.24	1.22	0.79

(*) Estimated values as explained in the Methods Section above.

Table 4. Substrate Particle Size Class Data.

Substrate Particle Size Class	Saucon Creek Reference Site		Quittapahilla Creek Control Site		Quittapahilla Creek Treatment Site	
	Percent	Cumulative Percent	Percent	Cumulative Percent	Percent	Cumulative Percent
Fines (Silt, Clay, Muck)	8.2	8.2	21.1	21.1	26.9	26.9
Sand	15.6	**23.8**	7.5	**28.6**	31.0	**57.9**
Fine Gravel	9.5	33.3	11.6	40.1	13.1	71.0
Coarse Gravel	42.9	76.2	25.2	65.3	6.9	77.9
Cobble	17.7	93.9	26.5	91.8	15.9	93.8
Small Boulder	6.1	100.0	6.8	98.6	6.2	100.0
Large Boulder	0.0	100.0	1.4	100.0	0.0	100.0
Concrete/Asphalt	0.0	100.0	0.0	100.0	0.0	100.0
Bedrock (Rough)	0.0	100.0	0.0	100.0	0.0	100.0
Bedrock (Smooth)	0.0	100.0	0.0	100.0	0.0	100.0

Channel unit composition at the Quittapahilla Creek treatment site consists primarily of run (42.9%) and glide (38.1%) habitat, with some pool (14.3%) and riffle (4.8%) habitat present. The Quittapahilla Creek control site consists primarily of run habitat (76.2%), with some riffle (19.0%) and pool (4.8%) habitat also present, but no glide habitat. The Saucon Creek reference site consists of a relatively even mix of run (38.1%) and pool (33.3%) habitat, with lesser but equal amounts (14.3%) of riffle and glide habitat. Channel unit composition data collected at the Saucon Creek reference site and the Quittapahilla Creek control and treatment sites are summarized in Table 5.

Table 5. Channel Unit Composition Data.

Channel Unit Type	Saucon Creek Reference Site	Quittapahilla Creek Control Site	Quittapahilla Creek Treatment Site
Percent Riffle	14.3	19.0	4.8
Percent Run	38.1	76.2	42.9
Percent Glide	14.3	0.0	38.1
Percent Pool	33.3	4.8	14.3

Water surface slope values recorded at the Saucon Creek reference site and the Quittapahilla Creek control and treatment sites were nearly identical and ranged from 0.152% at the Saucon Creek reference site to 0.158% at the Quittapahilla Creek treatment site. Mean thalweg and residual pool depth values at both of the Quittapahilla sites were lower than those recorded at the Saucon Creek reference site, and the thalweg and residual pool depth values recorded at Quittapahilla Creek sites were noticeably less variable than those observed at the Saucon Creek reference site. The amount of residual pool area greater than or equal to 1.00 ft depth per 100 ft of stream channel at the Quittapahilla Creek sites was also much lower than the amount recorded at the Saucon Creek reference site. Water surface slope, thalweg depth, and residual pool data collected at the Saucon Creek reference site and the Quittapahilla Creek control and treatment sites are summarized in Table 6.

Table 6. Water Surface Slope, Thalweg Depth, and Residual Pool Data.

Parameter	Units	Saucon Creek Reference Site	Quittapahilla Creek Control Site	Quittapahilla Creek Treatment Site
Water surface slope	%	0.152	0.157	0.158
Mean thalweg depth	ft	2.68	1.98	2.24
Std. dev. thalweg depth	ft	0.88	0.44	0.46
Mean residual pool depth	ft	1.31	0.56	0.66
Std. dev. residual pool depth	ft	0.89	0.50	0.44
Residual pool area >or= 1 ft deep	ft^2/100 ft of stream channel	110.3	27.5	24.9

The percent stable streambank values recorded at both Quittapahilla Creek sites were substantially lower than the value recorded at the Saucon Creek reference site. More than 83% of the streambank surface at the Saucon Creek reference site was stable, while approximately 58% of the streambank surface at the Quittapahilla Creek control site was stable. Streambank stability conditions were dramatically reduced at the Quittapahilla Creek treatment site, with only 29.4% of the streambank surface identified as stable. Streambank stability data collected at the Saucon Creek reference site and the Quittapahilla Creek control and treatment sites are summarized in Table 7.

Table 7. Streambank Stability Data.

Parameter	Saucon Creek Reference Site	Quittapahilla Creek Control Site	Quittapahilla Creek Treatment Site
Left Descending Streambank			
Length of streambank assessed	1600	600	600
Total length of unstable streambank	217.1	240.4	344.5
Percent of streambank stable	86.4	59.9	42.6
Right Descending Streambank			
Length of streambank assessed	1600	600	600
Total length of unstable streambank	302.2	265.1	502.2
Percent of streambank stable	81.1	55.8	16.3
Left and Right Streambanks Combined			
Length of streambank assessed	3200	1200	1200
Total length of unstable streambank	519.3	505.5	846.7
Percent of streambank stable	**83.8**	**57.9**	**29.4**

The amount and composition of fish cover at the Saucon Creek reference site was substantially different from that recorded at the Quittapahilla Creek treatment site and control sites. A percent fish cover value of 13.0% was recorded at the Saucon Creek site, and cover consisted primarily of deep pools (> 3.0 ft) with additional cover provided by woody debris and boulders. The amount of fish cover at the Quittapahilla Creek sites was substantially lower than that observed at the Saucon Creek reference site. A percent fish cover value of 8.6% was recorded at the Quittapahilla Creek control site, and cover

consisted primarily of woody debris and boulders. The percent fish cover value recorded at the Quittapahilla Creek treatment site was 6.2%, and cover consisted primarily of submerged macrophytes, woody debris and boulders. Percent fish cover data from the Saucon Creek reference site and the Quittapahilla Creek control and treatment sites are summarized in Table 8.

Table 8. Percent Fish Cover Data.

Cover Type	Saucon Creek Reference Site		Quittapahilla Creek Control Site		Quittapahilla Creek Treatment Site	
	% Cover	Frequency	% Cover	Frequency	% Cover	Frequency
Pool	10.6	8	0.0	0	0.6	1
Woody debris	2.1	8	3.9	8	1.1	7
Boulder	0.3	2	3.6	10	0.9	3
Submerged Macrophytes	0.0	0	0.0	0	2.0	3
Other Debris	0.0	0	0.2	1	0.5	2
Rootwad	0.0	0	0.2	1	0.5	2
Overhanging vegetation with 1 ft of the water surface	0.0	0	0.2	1	0.4	2
Undercut bank	0.0	0	0.3	1	0.1	1
Overhanging vegetation with 3 ft of the water surface	0.0	0	0.0	0	0.1	1
Emergent macrophytes	0.0	0	0.1	1	0.0	0
Total Fish Cover	**13.0**	**18**	**8.6**	**23**	**6.2**	**22**

Although fish cover was more abundant at the Saucon Creek reference site, cover was more-evenly distributed throughout the channel at both of the Quittapahilla Creek sites than it was at the Saucon Creek reference site. Mean distance to closest fish cover values recorded at the Quittapahilla Creek control and treatment sites were 9.7 ft and 14.0 ft, respectively. The mean distance to closest fish cover value recorded at the Saucon Creek reference site was 16.8 ft. Mean distance to closest fish cover data from the Saucon Creek reference site and the Quittapahilla Creek control and treatment sites are summarized in Table 9.

Discussion

The overall goal of the proposed Quittie Creek Nature Park Stream Restoration Project is to restore riparian and in-stream habitat conditions at the project site by stabilizing the actively eroding stream channel. In order to accomplish this goal, a wide range of modifications to the existing channel will need to be implemented at the project site to stabilize the actively eroding streambanks, improve sediment transport through the project area, and improve instream and riparian habitat conditions at the site. In order to evaluate the effectiveness of the project and the attainment of the overall project goal and the specific objectives outlined above, PFBC staff will conduct post-construction monitoring activities approximately one year after the construction of the project. Post-construction monitoring activities will mirror the pre-construction monitoring work conducted in May 2012 described above. The following discussion summarizes PFBC's recommendations of instream habitat and fish cover conditions that should exist at the proposed project site approximately one year after the project is constructed.

These recommendations are based primarily on the conditions observed at the Saucon Creek reference site, which supports a Class A wild brown trout fishery, and to a lesser extent, the existing conditions observed at the Quittapahilla Creek control and treatment sites.

Table 9. Mean Distance to Closest Fish Cover Data.

Parameter	Units	Saucon Creek Reference Site	Quittapahilla Creek Control Site	Quittapahilla Creek Treatment Site
Mean distance to closest cover	ft	16.8	9.7	14.0
Std. Dev. of distance to closest cover measurements	ft	12.5	7.1	8.5
Mean relative distance to closest fish cover	Relative to the mean wetted width of the channel	0.36	0.30	0.29
Std. Dev. of relative distance to closest fish cover measurements		0.29	0.21	0.18
Cover Type	**Distribution Pattern**	**Percent of Measurements**	**Percent of Measurements**	**Percent of Measurements**
Boulder	Typically evenly distributed	4.8	52.4	42.9
Pool	Related to channel unit configuration	38.1	0.0	4.8
Submerged macrophytes		0.0	0.0	9.5
Other debris		0.0	0.0	4.8
Woody debris	Typically associated with edge habitat	38.1	23.8	28.6
Overhanging vegetation within 1 ft of the water surface		9.5	9.5	4.8
Rootwad		9.5	4.8	4.8
Undercut bank		0.0	9.5	0.0

The activities proposed in the project area should stabilize the actively eroding streambanks in the project area so that a minimum of approximately 84% of the streambanks are stable. In addition, the proposed project should reduce the wetted width:mean depth ratio of the project area to a value of approximately 31.1. This wetted width:mean depth ratio should result in a velocity index value of approximately 1.24 ft/sec, increase the sediment transport capacity of the channel, and reduce sediment deposition within the project area. The median particle size category observed in the project area should be improved from its current condition of sand to coarse gravel, and the substrate should consist of no more than approximately 24% sand or finer material.

The proposed activities should diversify the channel unit composition of the project area, which currently consists primarily of run and glide habitat. Channel unit composition changes should focus on reducing glide habitat to approximately 14%, and increasing pool and riffle habitat within the project area to approximately 33% and 14%, respectively. Changes in channel unit composition should be implemented in a manner that results in increases in thalweg and residual pool depth and diversity (standard deviation) values similar to those recorded at the Saucon Creek reference site and outlined in Table 6. In addition, the newly-created pool habitat should attempt to increase the amount of high-

quality residual pools (> or = 1 ft depth) in the project area to approximately 110 ft^2 per 100 ft of stream channel.
The project should result in an increase in fish cover to a minimum of approximately 13%. Efforts should be made to increase cover provided by pools and woody debris. Efforts should also be taken to assure that cover is evenly distributed throughout the project site, with a mean distance to closest cover value of approximately 10 ft or less.

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