

**Stream Restoration of Monocacy Creek at Route 512**

**2001**

**Wildlands Conservancy**

Funding Provided By:  
Pennsylvania Department of Conservation and Natural Resources  
Keystone Acquisition and Development Grant Program

**Rivers Department**

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## **Acknowledgements**

Numerous individuals, groups, agencies and organizations cooperated in the completion of this project. Wildlands Conservancy would like to thank all of the individuals and organizations that made this project a reality. Without their hard work this project would not have been possible. Listed below are the members of the project partnership and their main contributions.

The authors would like to take this opportunity to also thank the staff persons who represented the partners at numerous planning meetings, provided technical guidance and assistance or who were otherwise available for consultation. Without the hard work and dedication of these individuals and organizations this project could not have been completed.

### **A-1 Construction, Inc.**

A-1 Construction, Inc. constructed the stone retaining wall and donated \$9,142.50 in materials and labor services to the project. Marty Lukachek, Vice President, provided technical assistance throughout the spring raceway restoration phase of the project.

### **Chrin Brothers, Inc.**

Chrin Brothers, Inc. donated \$6,594.35 in stone and hauling services toward the project. Approximately 600 tons of stone were donated. Greg Chrin, Vice President, and Tom McMonigle, Landfill Engineer, attended project meetings and assisted in coordinating the delivery of stone to the project site.

### **Mr. and Mrs. Dennis and Pam Collins**

Dennis and Pam purchased lunches for volunteers and Wildlands Conservancy staff during the project. Dennis and Pam are neighbors of the project site and Dennis Collins is also Wildlands Conservancy's Director of Land Preservation.

### **David A. Klein Real Estate**

David A. Klein Real Estate took ownership of the property on which the project site is located near the completion of the project and offered continued property owner support of the project. Wildlands Conservancy would like to thank David Klein, President, who made the transition between property owners smooth and aided in the completion of the project.

### **Greentree Nurseries, Inc.**

Jack Murphy, Estimator with Greentree Nurseries, Inc., attended project meetings and provided technical guidance with the riparian planting phase of the project. Greentree Nurseries delivered and planted seven red maple trees and completed the tilling and final grading of portions of the project site. Two of these trees, valued at \$2,200.00, were donated toward the project.

**Hilltop Excavating, Inc.**

Bill Jones, President, attended project meetings and provided technical guidance during the planning of the project. Hilltop Excavating, Inc. completed the construction and removal of a temporary stone access ramp, the construction of the stone and sawtooth deflectors, the delivery and grading of topsoil, and the clean-up of the project site. Hilltop Excavating, Inc. donated \$5,000.00 in equipment, labor, materials, and services toward the project. Wildlands Conservancy would like to extend special thanks to equipment operator Dave Kunkle and truck drivers John Uhnak and Jeff Jones.

**Northampton Area Senior High School**

Pam Hoffner, Biology Teacher, Gene Thrash, Social Studies Teacher and students from Northampton Area Senior High School provided volunteer assistance during the project, which included the placement of the biodegradable coconut rolls, the hand grading of topsoil, and the planting of trees, shrubs and grasses.

**Pennsylvania Department of Conservation and Natural Resources**

Through their “Keystone Acquisition and Development Program,” the Pennsylvania Department of Conservation and Natural Resources provided Wildlands Conservancy with a grant in the amount of \$39,000.00. The grant was used to acquire professional services and materials as well as to cover Wildlands Conservancy’s staff and travel costs in administering the project. Terry Hough, Environmental Planner, served as project officer and provided Wildlands Conservancy with technical assistance throughout the planning and implementation of the project.

**Pennsylvania Fish and Boat Commission, Habitat Management Section**

Karl Lutz, Area Habitat Manager, assisted with the design of the stream habitat improvements and the development of a “Fish Habitat Improvement Plan.” Through their cooperative “Adopt-a-Stream” Program, the Pennsylvania Fish and Boat Commission also provided permitting assistance, on-site technical guidance, and \$3,966.80 toward the purchase of the biodegradable coconut logs, erosion control blanket and wooden stakes used to construct the habitat improvements.

**QuestOne Decision Sciences Corporation**

QuestOne Decision Sciences Corporation provided a \$20,000.00 cash donation toward the project and donated the use of their offices for project meetings. QuestOne Decision Sciences Corporation also provided Wildlands Conservancy with a landowner agreement, allowing the project to take place. Holly Marston represented QuestOne Decision Sciences Corporation at project meetings and assisted in the planning and coordination of the project.

**Summit Management and Realty Company, Inc.**

Tiffany Sotal of Summit Management and Realty Company, Inc., assisted in project coordination and communication between Wildlands Conservancy and QuestOne Decision Sciences Corporation. Summit Management and Realty Company, Inc. also assisted with the placement of the “Do Not Feed the Geese” signs, project site preparation and management.

**Reidler Foundation**

The Reidler Foundation provided a \$4,000.00 grant toward the project. The grant was used to cover a portion of Wildlands Conservancy’s staff time and travel costs throughout the administration of the project.

**Rodale, Inc.**

Rodale, Inc. donated scanning services toward the project. Bob Gerhardt provided assistance with the scanning and digitizing of the photographs presented within this report.

**Wildlands Conservancy Staff**

The authors would like to extend their appreciation to the Wildlands Conservancy staff members and interns who assisted with the various aspects of this project. Wildlands Conservancy staff members and interns assisted in collecting pre- and post-project photographs and data, organizing press coverage, securing rental trucks, maintaining and transporting plant and project materials, planting trees, constructing habitat improvements, and organizing volunteer support and lunches.

## Introduction

In October 1999, Wildlands Conservancy received a grant from the Pennsylvania Department of Conservation and Natural Resources' "Keystone Acquisition and Development Program" in the amount of \$39,000.00 to implement a stream and riparian buffer restoration project on the Monocacy Creek in Hanover Township, Northampton County. The objectives of the project are to reduce non-point source pollution, improve water quality, and restore degraded wildlife, fish and aquatic macro-invertebrate habitat. Additional objectives of the project are to provide an educational experience for the general public, the project participants, to enhance recreational opportunities, and to improve aesthetics. The project scope included the construction of stream habitat improvement devices, the planting of a native riparian buffer, and the restoration of an existing spring raceway that contributes groundwater to the Monocacy Creek.

The project site is 450 feet in length and is located immediately upstream of the Pa. Route 512 bridge on the former property of QuestOne Decision Sciences Corporation. The site is situated within the 1.9-mile reach of the Monocacy Creek that is managed by the Pennsylvania Fish and Boat Commission as a "Trophy Trout" section. A site location map is located in Appendix A.

## Background

The Monocacy Creek is a 20.3-mile long limestone stream that encompasses a drainage area of approximately 48.8 square miles. The Monocacy Creek is classified by the Pennsylvania Department of Environmental Protection as a "High Quality Cold Water Fishery" and is listed on the Section 303(d) list of impaired streams. According to the 303(d) list siltation induced by agricultural land uses, surface mining and urban storm water is the main cause of water quality impairment to the Monocacy Creek.

The restoration of the Monocacy Creek at Route 512 was recommended within Wildlands Conservancy's *Monocacy Creek Rivers Conservation Management Plan*, which was completed in 1998. The plan identifies the natural, cultural and historic resources contained in the watershed and identifies specific areas (within the watershed) requiring protection and/or restoration.

A low-head, run-of-the-river dam located downstream from the Route 512 bridge is the primary cause of impairment to this section of the Monocacy Creek (Figure 1). This dam has reduced stream flow, accelerated erosion of the upstream banks, increased stream width and accelerated the deposition of fine sediment throughout the upstream channel. Mowing stream banks, feeding waterfowl by the public, and the excessive grazing of vegetation by waterfowl have also accelerated stream bank erosion throughout the project site.



Figure 1. The low-head dam that is located immediately downstream of the project site has impacted the water quality and aquatic habitat of the Monocacy Creek.

In 1999, Wildlands Conservancy organized a public meeting to discuss the condition of this section of Monocacy Creek and to encourage landowners to implement Best Management Practices (BMPs) to minimize non-point source pollution to the Monocacy Creek. The objectives of this meeting were to also gain public support and explore the possibility of removing the existing dam and restoring the stream channel. Although the multiple owners of the dam were not receptive to removing the dam, QuestOne Decision Sciences Corporation demonstrated an interest in improving their section of the Monocacy Creek. QuestOne pledged their support by providing financial assistance for the implementation of a stream restoration project. They also agreed to modify their management practices and allow riparian vegetation to become established along their property. Signs were erected to instruct the public that the property was under environmental reconstruction and to refrain from feeding waterfowl (Figure 2).



Figure 2. Promoting environmental awareness among the public, neighbors, and project participants was emphasized to ensure the long-term success of the project.

### **Pre-Project Data Collection and Interpretation**

Data consisting of a habitat assessment and an aquatic survey, and site photographs to document pre-project site conditions were collected prior to implementing the project. These were used to aid in the development of an overall management strategy and provide a reference for comparing the pre- and post-project physical and biological conditions of the site.

### **Habitat Assessment**

In August 2000, Wildlands Conservancy staff completed a habitat assessment on a 330-foot reach of the Monocacy Creek within the project site. The United States Environmental Protection Agency's "Rapid Bio-assessment Protocols," modified by the Pennsylvania Fish and Boat Commission's Habitat Management Section was used to complete the assessment. Although riffles and runs were not evident, a "riffle/run" type assessment was used since the survey reach was considered an impacted "riffle/run" reach due to the presence of the low-head dam located downstream. In the assessment, a series of physical parameters were evaluated and numerically scored to identify specific habitat-related limiting factors existing within the riparian zone and stream channel. The habitat assessment was also used to determine what physical parameters would be addressed during the stream restoration project. Based upon the final score, the reach can be classified as "poor", "marginal," "sub-optimal," or "optimal" with regard to the quality of available fish and aquatic macro-invertebrate habitat.

The habitat assessment yielded a score of 80 out of a possible total score of 200, placing the stream reach in the category of “marginal” with regard to fish and aquatic macro-invertebrate habitat. The primary limiting factors impacting the reach included the deposition of fine sediment, absence of stream bank and riparian vegetation, absence of epifaunal substrate/available cover, embeddedness of cobble and gravel substrates by fine sediment, absence of well developed riffles, and the absence of velocity/depth combinations. Post-project habitat assessments will be conducted to document the anticipated improvements in the physical habitat-related parameters. A detailed description of the habitat related parameters evaluated are located in Appendix B.

### **Aquatic Survey**

In August 2000 Wildlands Conservancy staff, in conjunction with Lance Leonhardt, Biology Teacher at Saucon Valley High School, used a 100-1100 V DC backpack electro-fishing unit and dip nets to complete an aquatic survey on a 330-foot stream reach of the Monocacy Creek within the project site. Individuals collected in the sample were classified based upon their respective habitat tolerance, water quality tolerance, feeding guild, and temperature guild. Three Indexes of Biotic Integrity (IBI's) were used to evaluate the sample based upon species richness and community composition, trophic composition, and fish abundance and composition. Each of these parameters was assigned a numeric score to determine the overall biotic integrity of the sample. “Poor” scores for each of the IBI's indicate the influence of water quality impacts on the biotic integrity of the stream section sampled. A detailed analysis of the fish sample collected during the aquatic survey is located in Appendix C.

### **Spring Raceway Restoration**

In September 2000, A-1 Construction, Inc. completed the restoration of the existing spring raceway (Figures 3-6). The scope of the raceway restoration consisted of the construction of a stone retaining wall, designed to narrow the existing raceway, thereby enhancing the flow and maintaining the temperature of the groundwater spring that discharges into the Monocacy Creek. The retaining wall was also constructed to provide bank stabilization while complementing the existing historic stone wall. Upon completion of the retaining wall, the area behind the wall was back-filled with stone and topsoil, seeded with a transitional native conservation seed mixture, stabilized with straw and planted with native shrubs.



Figure 3. In addition to establishing a riparian buffer and constructing stream improvements, the project included the restoration of a historical spring raceway that empties into the Monocacy Creek. Note the riparian vegetation present after a “no-mow” management style was implemented as a preliminary, short-term recommendation until implementation of the project.



Figure 4. The spring raceway improvements were designed to provide stream bank stabilization and an enhanced cold water flow into the Monocacy Creek. A hand furnished stone wall was constructed to maintain the historical appearance of the property, while accomplishing these objectives.



Figure 5. Mowing and waterfowl grazing of riparian vegetation has accelerated stream bank erosion adjacent to the spring raceway.



Figure 6. The area immediately behind the wall was back filled with stone and soil to provide a medium for the establishment of native trees, shrubs and grasses.

### **Fish Habitat Improvements and Riparian Buffer Establishment**

In May 2001 Wildlands Conservancy, Chrin Brothers, Inc., Hilltop Excavating, Inc. and students from Northampton Area Senior High School completed the in-stream restoration phase of the project. The scope of this phase of the project included the construction of a stone deflector with a biodegradable coconut fiber log face and three smaller saw-tooth deflectors (Figures 7 and 8). The deflectors were designed to reduce stream width, increase stream velocity, reduce thermal pollution (warming), reduce sediment deposition, provide stream bank stabilization and improve habitat for fish and aquatic macro-invertebrates (Figures 9-11). A layer of topsoil was also placed over the stone and sawtooth deflectors to provide a medium for the establishment of native trees, shrubs and herbaceous plants (Figures 12 and 13).

Upon completing the in-stream habitat improvement phase of the project, Wildlands Conservancy, Greentree Nurseries, Inc., Northampton Area Senior High School Students and other volunteers planted several varieties of native trees, shrubs and herbaceous plants to establish a riparian buffer throughout the project site (Figures 14 and 15). The objectives of establishing this buffer were to minimize stream bank erosion and non-point source pollution, provide shade and improve fish, macro-invertebrate and wildlife habitat.

Greentree Nurseries, Inc. used a tree spade system to deliver and plant seven red maple (*Acer rubrum*) trees within the floodplain area adjacent to the

deflectors. These red maples (15-20 feet in height, 4½-5 inches in caliper) were used to establish a transition in the height of plant material between the project site and the Gertrude Fox Conservation Area, a forested stream corridor located immediately adjacent to and upstream of the project site.

Greentree Nurseries, Inc. also completed the tilling of approximately .4 acre of floodplain area adjacent to the deflectors. The objectives of tilling this area were to reduce water, light and nutrient competition and provide a seed bed for the establishment of native conservation seed mixtures. The area was also tilled to remove the root structures of the existing invasive and non-native shrubs and other plants that had colonized a portion of the project site.

A total of 20 lbs. of facultative wetland meadow mixture, 11 lbs. of transitional seed mixture and 16 lbs. of an upland seed mixture were applied to the tilled area, stone deflector and sawtooth deflectors. The stone deflector was stabilized with biodegradable erosion control blanket. The remaining tilled and seeded areas were stabilized with straw. A list of herbaceous species included within the above native seed mixtures is found in Appendix D.

Upon seeding and stabilizing the site, Wildlands Conservancy staff used a two-person gasoline-powered auger to drill a series of holes placed in semi-random arrangement throughout the project site. Wildlands Conservancy, Northampton Area Senior High School students, and other volunteers planted a total of 280 trees, 330 shrubs and 3150 herbaceous plants to establish a native forested riparian buffer measuring approximately 145 feet in width and 425 feet in length (Figures 16 and 17). The riparian buffer was established to provide bank stabilization, reduce non-point source pollution entering into the stream and improve the water quality and habitat within the tributary and corridor for wildlife, fish and aquatic macro-invertebrates. Tree, shrub and herbaceous species were selected based upon current site conditions, their individual habitat requirements, and their wildlife food and cover value. For a list of the riparian vegetation that was planted during this phase of the project, refer to Appendix E.



Figure 7. Mowing, grazing and continual trampling of the stream banks by waterfowl contributed to the stream bank erosion that was occurring along the project site.



Figure 8. Saw-tooth deflectors were constructed to provide stream bank stabilization and improved aquatic habitat. A layer of topsoil was placed over the deflectors to provide a medium for the establishment of native vegetation.



Figure 9. A view looking upstream at the project site from Route 512, immediately prior to the construction of stream improvements and the establishment of a riparian buffer.



Figure 10. Approximately 600 tons on stone were used to construct the stream improvement devices, which consisted of one stone and three saw-tooth deflectors.



Figure 11. A backhoe was used to construct the stone and saw-tooth deflectors. The deflectors were constructed using mixed sizes of stone, and were dressed with layers of topsoil to provide a medium for the establishment of native trees, shrubs and grasses.



Figure 12. A view looking upstream at the project site from Route 512, after two days of excavation work on the stone deflector had been completed.



Figure 13. Silt fencing was erected around the perimeter of the deflector to prevent sediment from entering the stream during and prior to construction. Upon completion of the deflector, native wetland, transitional and upland seed mixtures were applied to the soil. Biodegradable coconut blanket and straw mulch was used to provide soil stabilization and to promote vegetative growth.



Figure 14. Seven 5" caliper red maple trees were planted to establish a transitional zone between the project site and the Gertrude Fox Conservation Area. This would allow for the "blending" of the project into the natural landscape.





Figure 17. An upstream view of the project site immediately following the construction of stream improvements and the establishment of a riparian buffer.



Figure 18. A granite and bronze monument was placed at the site to educate the public and to provide recognition for the various partners who supported and assisted with the project.

## **Conclusion**

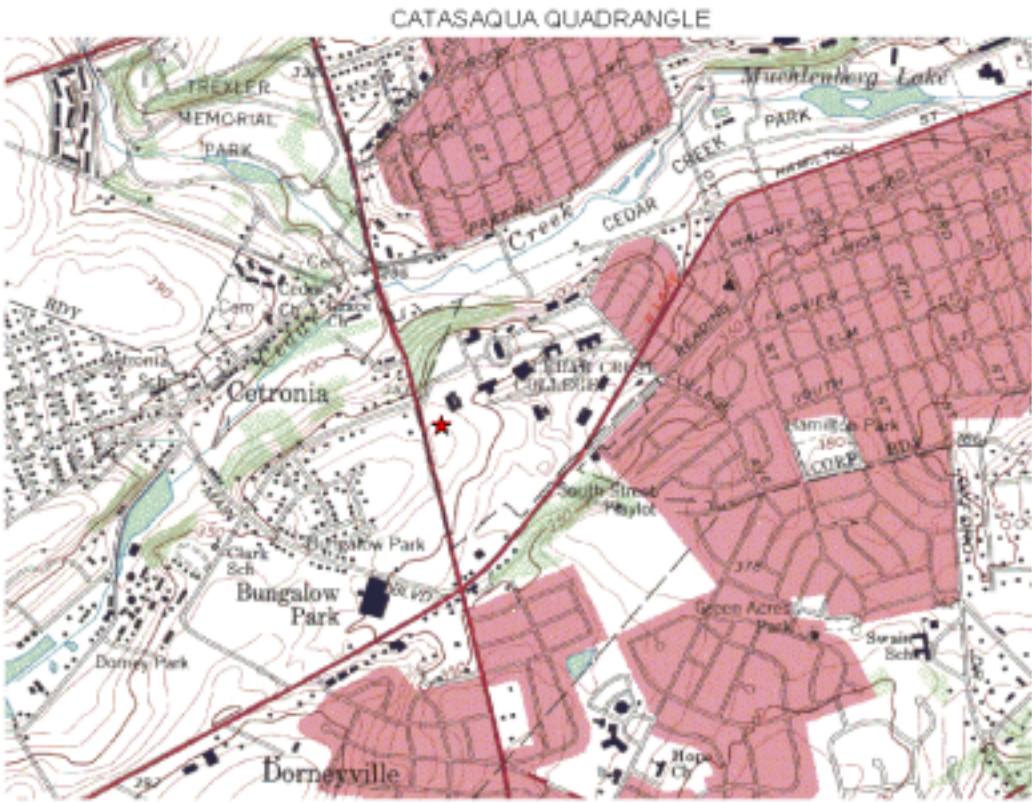
In October 1999 Wildlands Conservancy received a grant from the Pennsylvania Department of Conservation and Natural Resources' "Keystone Acquisition and Development Program" to implement a stream and riparian buffer restoration project on the Monocacy Creek in Hanover Township, Northampton County. During the project a spring raceway was restored, in-stream habitat improvement devices were constructed, and a native riparian buffer was established. The objectives of the project were to reduce non-point source pollution, improve water quality, and restore degraded wildlife, fish and aquatic macro-invertebrate habitat. The project provided a valuable educational experience for the many organizations and individuals who participated. It is also expected that recreational opportunities and aesthetics will be improved as a result of the project.

It is anticipated that the results of the post-project habitat assessments and aquatic surveys will show improvements in aquatic habitat and in species diversity and abundance. The realization of these improvements will indicate an improvement in the water quality of the Monocacy Creek.

## **Appendix**

- I. Site Location Map**
- II. Habitat Assessment**
- III. Aquatic Survey**
- IV. Native Seed Mixtures**
- V. Riparian Species List**

# Stream Restoration of Monocacy Creek at Route 512



**STREAM HABITAT ASSESSMENT DATA SHEET**

**Total Score: 73**

Monocacy Creek / Route 512  
Stream/Site

8/30/00  
Date

**1 EPIFAUNAL SUBSTRATE/AVAILABLE COVER**

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
<b>1. Epifaunal Substrate/Available Cover (high and low gradient)</b>	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potent potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% (10-30% for lo for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.
<b>SCORE _3_</b>	<b>20 19 18 17 16</b>	<b>15 14 13 12 11</b>	<b>10 9 8 7 6</b>	<b>5 4 3 2 1 0</b>

**2 EMBEDDEDNESS**

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
<b>2.a Embeddedness (high gradient)</b>	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-70% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
<b>SCORE _8_</b>	<b>20 19 18 17 16</b>	<b>15 14 13 12 11</b>	<b>10 9 8 7 6</b>	<b>5 4 3 2 1 0</b>

**3a VELOCITY/DEPTH COMBINATIONS**

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
<b>3a. Velocity/Depth Regimes (high gradient)</b>	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is <0.3 m/s, deep is > 0.5m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing , score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
<b>SCORE _4_</b>	<b>20 19 18 17 16</b>	<b>15 14 13 12 11</b>	<b>10 9 8 7 6</b>	<b>5 4 3 2 1 0</b>

**4 SEDIMENT DEPOSITION**

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
<b>4. Sediment Deposition (high and low gradient)</b>	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constructions and bends; moderate depositions of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
<b>SCORE _5_</b>	<b>20 19 18 17 16</b>	<b>15 14 13 12 11</b>	<b>10 9 8 7 6</b>	<b>5 4 3 2 1 0</b>

**5 CHANNEL FLOW STATUS**

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
<b>5. Channel Flow Status (high and low gradient)</b>	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
<b>SCORE _16_</b>	<b>20 19 18 17 16</b>	<b>15 14 13 12 11</b>	<b>10 9 8 7 6</b>	<b>5 4 3 2 1 0</b>

**6 CHANNEL ALTERATION**

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
<b>6. Channel Alteration (high and low gradient)</b>	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
<b>SCORE <u>15</u></b>	<b>20 19 18 17 16</b>	<b>15 14 13 12 11</b>	<b>10 9 8 7 6</b>	<b>5 4 3 2 1 0</b>

**7a FREQUENCY OF RIFFLES (OR BENDS)**

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
<b>7a. Frequency of Riffles (or bends) (high gradient)</b>	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffle infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
<b>SCORE <u>4</u></b>	<b>20 19 18 17 16</b>	<b>15 14 13 12 11</b>	<b>10 9 8 7 6</b>	<b>5 4 3 2 1 0</b>

**8 BANK STABILITY (condition of banks)**

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
<b>8. Bank Stability (score each bank)</b> <b>Note: determine left or right side by facing downstream</b>	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable, infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
<b>SCORE <u>6</u> (LB)</b>	<b>Left Bank 10 9</b>	<b>8 7 6</b>	<b>5 4 3</b>	<b>2 1 0</b>
<b>SCORE <u>7</u> (RB)</b>	<b>Right Bank 10 9</b>	<b>8 7 6</b>	<b>5 4 3</b>	<b>2 1 0</b>

**9 BANK VEGETATIVE PROTECTION**

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
<b>9. Vegetative Protection (score each bank)</b> <b>Note: Determine left or right side by facing downstream (high and low gradient)</b>	More than 90% of the streambank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 cm. or less in average stubble height.
<b>SCORE <u>2</u> (LB)</b>	<b>Left Bank 10 9</b>	<b>8 7 6</b>	<b>5 4 3</b>	<b>2 1 0</b>
<b>SCORE <u>1</u> (RB)</b>	<b>Right Bank 10 9</b>	<b>8 7 6</b>	<b>5 4 3</b>	<b>2 1 0</b>

**10 RIPARIAN VEGETATIVE ZONE WIDTH**

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
<b>10. Riparian Vegetative Zone Width (score each bank riparian zone) (high and low gradient)</b>	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.

<b>SCORE_1__(LB)</b>	Left Bank 10 9	8 7 6	5 4 3	2 1 0
<b>SCORE_1__(RB)</b>	Right Bank 10 9	8 7 6	5 4 3	2 1 0

**Site: Monocacy Creek @ Rt. 512 bridge**

**Date: August 25, 2000**

**Sampling Gear: Electrofishing backpack 100-1100 V DC/Dip Nets**

**Sampling Length and Width: 100m X 30m upstream from bridge**

Common Name	Scientific Name	# of Individuals in Sample	Range in Total Length (mm)	Tolerance Guild		Feeding Guild		Temperature Guild	
				IBI#1	IBI#2	IBI#1	IBI#2	IBI#1	IBI#2
Brown Trout	<i>Salmo trutta</i>	10	79-270	I	I	P	TC	SC	Ct
White Sucker	<i>Catostomus commersoni</i>	69	39-145	T	T	O	GF	E	E
American Eel	<i>Anguilla rostratus</i>	1	390	T	T	I	TC	SC	E
Tessellated Darter	<i>Etheostoma olmstedi</i>	89	39-82	O	M	I	BI	SC	E
Bluegill Sunfish	<i>Lepomis macrochirus</i>	12	48-86	T	T	I	GF	E	W
Pumpkinseed Sunfish	<i>Lepomis gibbosus</i>	1	99	I	M	I	GF	E	W
Largemouth Bass	<i>Micropterus salmoides</i>	10	49-71	O	M	P	TC	E	W
Slimy Sculpin	<i>Cottus cognatus</i>	93	42-99	I	I	I*	BI	SC*	C
Redfin Pickerel	<i>Esox americanus americanus</i>	10	67-195	O	M	P*	TC	E*	E
<b>Total # Species in Sample = 9</b>		<b>Total # Individuals in Sample = 295</b>							

- adapted for Ross

**(Attributes used for F-IBI #1)** Ross et. al. USGS Biological Resources Division, Research Development Laboratory, Wellsboro, PA

Tolerance Guild

T = tolerant (able to tolerate environmental degradation)  
 I = Intolerant (sensitive to a wide range of environmental stresses)  
 O = Other (either intermediate in tolerance or conflicting tolerance designations in the literature)

Temperature Guild

SC = stenothermal cool/coldwater  
 E = eurythermal

Feeding Guilds

I= Insectivore  
 O= Omnivore  
 P = Piscivore

**(Attributes used for F-IBI # 2)** Leonhardt (Adapted in-part from: Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities, ed Simon, Table12)

Tolerance (to environmental perturbations)

T = Tolerant  
 M = Intermediate  
 I = Intolerant (sensitive to a wide range of environmental stresses)

Temperature Guild

C= Coldwater  
 Ct = Coldwater transitional  
 E = Eurythermal (inhabits C-W waters)  
 W = Warmwater

Feeding Guilds

GF = Generalist Feeder  
 BI = Benthic Insectivore  
 TC = Top Carnivore  
 WC = Water column insectivore

**F-IBI # 1 ( adapted from Ross, van Snik Gray, Bennett: A Coldwater Index of Biotic Integrity for Tributaries of the Middle and Upper Delaware River, USGS Biological Resources Division, Research Development Laboratory, Wellsboro, PA) (under revision)**

Category	Metric	Stream Order	Scoring: 5 (best)	3	1 (worst)	Score: Monocacy Creek sample 8/25 /00
<b>Species richness and community composition</b>	<b>1. Number of stenothermal cool/coldwater species</b>	2	>4	4	<4	<b>1</b> <b>(4 species)</b>
		3	>5	5	<5	
		(4)	>7	5-7	<5	
	<b>2. Number of eurythermal species</b>	2	<4	4	>4	<b>3 (5 species)</b>
		3	<4	4-7	>7	
		4	<4	4-11	>11	
	<b>3. Presence of brook trout<sup>1</sup></b>		<b>Present</b>		<b>Absent</b>	<b>1</b>
	<b>4. Percent of individuals as salmonids<sup>2</sup></b>		>55%	20-55%	<20%	<b>1 (3.4%)</b>
	<b>5. Proportion of individuals as stenothermal cool/coldwater species<sup>3</sup></b>		>80%	50-80%	<50%	<b>3 (69%)</b>
	<b>6. Number of intolerant species<sup>4</sup></b>	2	>3	3	<3	<b>3 (4 species)</b>
		3	>4	4	<4	
		(4)	>5	4-5	<4	
	<b>7. Percent individuals as white sucker<sup>5</sup></b>		<10%	10-30%	>30%	<b>3 (23.4%)</b>
<b>Trophic composition</b>	<b>8. Percent individuals as omnivores</b>		<20%	20-45%	>45%	<b>3 (23.4%)</b>
	<b>9. Percent of individuals as insectivorous cyprinids<sup>4</sup></b>		>45%	45-20%	<20%	<b>1 (0%)</b>
<b>Fish abundance and condition</b>	<b>10. Individuals per square meter</b>	2	>0.08	0.05-0.08	<0.06	<b>1 (0.098)</b>
		3	>0.15	0.10-0.15	<0.10	
		(4)	>0.28	0.17-0.28	<0.17	
	<b>11. Percent of individuals with disease, tumors, fin damage, and skeletal anomalies<sup>4</sup></b>		<2%	2-5%	>5%	<b>5 (&lt;2%)</b>
<sup>1</sup> Metric from Steedman (1988) <sup>2</sup> Metric from Maret et al. (1997) <sup>3</sup> Metric adapted from Lyons et al. (1996) <sup>4</sup> Metric from Karr et al. (1986) <sup>5</sup> Metric from New Jersey (Northern) IBI						<b>Total score: 27.3</b> <b>POOR/VERY POOR</b>  <b>( multiply initial total x 1.091 adjustment factor to get final total)</b>
<b>Scoring: Excellent = 60-57    Good = 52-48    Fair = 44-39    Poor = 35-28    Very Poor = 23-12</b>						

**F-IBI # 2 ( Leonhardt: A F-IBI for 1-4 Order Coldwater Streams in southeastern, PA.)**

Category	Metric	Stream Order	Scoring: 5 (best)	3	1 (worst)	Score: Monocacy Sample (8/25/00)
<b>Species richness and community composition</b>	1 .Number of coldwater/coldwater transition species <sup>1</sup>		>3	2-3	0-1	3 ( 2 species)
	1. Number of eurythermal/warmwater species <sup>2</sup>	2 3 (4)	<4 <4 <4	4 4-7 4-11	>4 >7 >11	3 ( 7 species)
	3. Presence of brook trout <sup>3</sup>		Present		Absent	1
	4. Percent of individuals as salmonids <sup>4</sup>		>55%	20-55%	<20%	1 ( 3.4%)
	5. Proportion of individuals as coldwater/coldwater transition species <sup>5</sup>		>88%	42-88%	<42%	1 (34.9%)
	6. % Intolerant individuals <sup>1</sup>		>43%	10-43%	<10%	3 (34.9%)
	7. Percent individuals as white sucker <sup>6</sup>		<10	10-30	>30	3 (23.4%)
<b>Trophic composition</b>	8. Percent individuals as generalist feeders <sup>6</sup>		<20%	20-45%	>45%	3 (27.7%)
	9.Percent of individuals as benthic insectivores <sup>7</sup>		> 45%	20-45%	<20%	5 (61.7%)
<b>Fish abundance and condition</b>	10. Individuals per square meter <sup>2</sup>	2 3 (4)	>0.08 >0.15 >0.28	0.05-0.08 0.10-0.15 0.17-0.28	<0.06 <0.10 <0.17	1 (.098)
	11. Percent of individuals with disease, tumors, fin damage, and skeletal anomalies <sup>8</sup>		<2%	2-5%	>5%	5
	12. Number of warmwater individuals per sample <sup>1</sup> (adjust proportionally for lesser/greater sampling lengths) <sup>1</sup>		<6 (50m) <12 (100m) <16 (150m)	6-20 (50m) <12-40 (100m) 16-60 (150m)	>20 (50m) >40 (100m) >60 (150m)	3 (23)
<sup>1</sup> Metric adapted from Mundahl and Simon (1999) <sup>4</sup> Metric from Maret et al. (1997) <sup>7</sup> Metric adapted from Leonard and Orth (1986) <sup>2</sup> Metric adapted from Ross et al. (2000) <sup>5</sup> Metric adapted from Lyons et al. (1996) <sup>8</sup> Metric from Karr et al. (1986) <sup>3</sup> Metric from Steedman (1988) <sup>6</sup> Metric from New Jersey (Northern) IBI						<b>Total score = 32</b>
<b>Scoring: Scoring: Excellent = 60-57    Good = 52-48    Fair = 44-39    Poor = 35-28    Very Poor = 23-12</b>						<b>POOR</b>

**Excellent:** Comparable to best situations with the least human disturbance: intolerant native coldwater species common; brook trout are the primary top carnivores and are present in good numbers; exotic salmonids are absent or uncommon; tolerant species may be present in low to moderate numbers.

**Good:** Evidence for some environmental degradation and reduction in biotic integrity; brook trout uncommon or absent; exotic salmonids often dominate, keeping the abundance of top carnivores high; tolerant species may be common but do not dominate.

**Fair:** The stream reach has experienced moderate environmental degradation, and biotic integrity has been significantly reduced; total species richness is often relatively high, but intolerant and native stenothermal coldwater species are usually uncommon; exotic salmonids may be common to abundant, but tolerant eurythermal species or warmwater species or both are usually more abundant.

**Poor and Very Poor :** Major environmental degradation has occurred, and biotic integrity has been severely reduced: total species richness may be relatively high, but intolerant native species are usually absent, tolerant eurythermal species or warmwater species or both dominate. (Adapted in part from Lyons and Wang 1996)

List and Description of Native Seed Mixtures  
 Restoration of Monocacy Creek at Rt.512

<b>Mixture Type:</b>	<b>Scientific Name:</b>	<b>Common Name:</b>
<b>Wetland Meadow Mix:</b>	<i>Elymus virginicus</i>	Virginia Wild Rye
	<i>Poa palustris</i>	Fowl Bluegrass
	<i>Verbesina alternifolia</i>	Wingstem
	<i>Veronia noveboracensis</i>	New York Ironweed
	<i>Verbena hastata</i>	Blue Vervain
	<i>Scirpus polyphyllus</i>	Many-leaved Bulrush
	<i>Glyceria grandis</i>	American Mannagrass
	<i>Solidago rugosa</i>	Wrinkle-leaf Goldenrod
	<i>Heliopsis helianthoides</i>	Ox-eye Sunflower
	<i>Eupatorium perfoliatum</i>	Boneset
	<i>Eupatorium maculatum</i>	Spotted Joe-Pye-Weed
	<i>Juncus effusus</i>	Soft Rush
	<i>Aster prenanthoides</i>	Zig Zag Aster/Swamp
	<i>Aster novae-angliae</i>	New England Aster
	<i>Geum laciniatum</i>	Rough Avens
	<i>Carex lurida</i>	Lurid Sedge
	<i>Senecio aureus</i>	Golden Ragwort
	<i>Euthamia graminifolia</i>	Grass Leaf Goldenrod
<i>Carex stipata</i>	Awl Sedge	
<i>Zizia aurea</i>	Golden Alexanders	
<b>Upland Seed Mixture:</b>	<i>Andropogon scoparius</i>	Little Blue Stem
	<i>Elymus canadensis</i>	Canada Wild Rye
	<i>Achillea millefolium</i>	White Yarrow
	<i>Veronicastrum virginicum</i>	Culver's Root
	<i>Aster pilosus</i>	Health Aster
	<i>Silphium perfoliatum</i>	Cup Plant
<b>Transitional Seed Mixture:</b>	N/A	Cave-in-Rock Switchgrass
	<i>Elymus virginicus</i>	Virginia Wild Rye
	<i>Aster pilosus</i>	Heath Aster
	<i>Liatris spicata</i>	Spike Gayfeather
	<i>Daucus carota</i>	Queen-Anne's-Lace
	<i>Aster novae-angliae</i>	New England Aster
	<i>Eupatorium maculatum</i>	Spotted Joe Pye Weed
<i>Veronia noveboracensis</i>	New York Iron Weed	

**List of Native Trees, Shrubs and Herbaceous Material  
Planted in the Monocacy Creek Stream and Riparian Buffer Restoration Project**

	<b>Scientific Name</b>	<b>Common Name</b>	<b>Quantity</b>
<b>Trees:</b>	Betula nigra	River Birch	45
	Fraxinus pennsylvanica	Green Ash	45
	Liquidambar styraciflua	Sweet Gum	40
	Acer saccharinum	Silver Maple	45
	Liriodendron tulipifera	Tulip Poplar	55
	Platanus occidentalis	American Sycamore	40
	Quercus bicolor	White Oak	10
<b>Shrubs:</b>	Cornus amomum	Silky Dogwood	50
	Cephalanthus occidentalis	Buttonbush	50
	Itea virginica	Virginia Sweetspire	50
	Clethra alnifolia	Sweet Pepperbush	50
	Ilex verticillata	Winterberry Holly	20
	Ilex verticillata	Winterberry Holly	30
	Aronia arbutifolia	Red Chokeberry	20
	Aronia arbutifolia	Red Chokeberry	30
	Viburnum dentatum	Arrowwood	20
	Viburnum dentatum	Arrowwood	30
<b>Herbaceous:</b>	Iris versicolor	Northern Blue Flag	450
	Hibiscus moscheutos	Swamp Mallow	450
	Scirpus validus	Soft Stem Bulrush	450
	Aster puniceus	Purple Stemmed Aster	450
	Lobelia cardinalis	Cardinal Flower	450
	Asclepias incarnata	Swamp Milkweed	450
	Lobelia siphilitica	Blue Lobelia	450
		<b>Total</b>	<b>3780</b>