LITTLE LEHIGH CREEK HYDRO-MODIFICATION, STREAMBANK RESTORATION, HABITAT IMPROVEMENT AND RIPARIAN PLANTING PROJECT

July 2000

Wildlands Conservancy

Funding Provided By:
PA Department of Environmental Protection
Watershed Restoration and Assistance Program

ACKNOWLEDGEMENTS

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

The authors are also grateful to the staff that represented the partners at numerous planning meetings, provided guidance and technical assistance and was otherwise available for consultation. Without the hard work and dedication of these individuals and organizations this project would not have been possible.

Environmental Fund for Pennsylvania
The Environmental Fund for Pennsylvania conducted an interview with Wildlands Conservancy staff and recorded a video to create an interactive web site on www.greenworkschannel.org.

Flyway Excavating, Inc.
Flyway Excavating, Inc. delivered stone from a local quarry to the project site and conducted excavation of the dam and concrete wall and final bank grading. Flyway Excavating also hauled the excavated concrete off of the project site.

Lance Leonhardt
Lance Leonhardt, with the assistance of Saucon Valley High School biology students, completed macro-invertebrate sampling, aquatic surveying and data analysis.

Lehigh County Conservation District
The Lehigh County Conservation District reviewed the Erosion and Sedimentation Control Plan that was developed for the project.

Little Lehigh Creek Chapter of Trout Unlimited
The Little Lehigh Creek Chapter of Trout Unlimited provided volunteers to assist in the construction and planting of the project.

Pennsylvania Department of Environmental Protection, Division of Dam Safety PA
DEP, Division of Dam Safety reviewed the removal plan and conducted an environmental assessment of the project site

Pennsylvania Department of Environmental Protection, Watershed Restoration and Assistance Program PA DEP, WRAP awarded Wildlands Conservancy a grant in the amount of $29,764.00 to fund the project. Project officer Patricia Pingel gave personal guidance and recommendations through the coarse of the project.

Pennsylvania Fish and Boat Commission, Division of Research
PA Fish and Boat Commission, Division of Research assisted Wildlands Conservancy in hosting its public meeting and presented an educational slide show entitled “The Negative Impact of Dams.”

Pennsylvania Fish and Boat Commission, Survey Section
PA Fish and Boat Commission, Survey Section surveyed the dam and its immediate surroundings. The Survey Section also developed a removal plan and prepared an Erosion and Sedimentation Control Plan for the project.

Rodale Press, Inc.
Rodale Press, Inc. donated copying services during the development of the project’s final report.

Additional Wildlands Staff
Interns Gregg Woodruff, Jared Bundra and Vanessa Diegel assisted in implementing the project and developing the project’s final report. Tom Gettings, Director of Special Projects, provided the pre- and post-project photographs used in this report. Sue Tantsits and Louise Schaefer developed a plant list for the riparian buffer establishment phase of the project and provided volunteer assistance. Other Wildlands Conservancy staff also assisted in the implementation of the project.

ABSTRACT

A low-head dam on the Little Lehigh Creek located on Wildlands Conservancy property was removed and a riparian vegetation zone was established. This project has reduced liability, restored migratory fish passage and created habitat and will also reduce sedimentation and thermal pollution and improve over-all water quality.

Figure 1. The run-of-the-river low-head dam located on the Little Lehigh Creek at Wildlands Conservancy's Pool Wildlife Sanctuary. The dam created negative environmental impacts and an unsafe situation for individuals utilizing the stream and adjacent property.

INTRODUCTION

In April 1999, Wildlands Conservancy received a grant through the Pennsylvania Department of Environmental Protection's Watershed Restoration and Assistance Program (WRAP) in the amount of $29,764 to implement the *Little Lehigh Creek Hydro-Modification, Stream Bank Restoration, Habitat Improvement and Riparian Planting Project*. The project site is 300 feet in length and is located on the property of Wildlands Conservancy in Lower Macungie Township, Lehigh County (Appendix A). The objectives of the project are to reduce non-point source pollution, reduce sedimentation, provide bank

stabilization, improve water quality, restore natural fish migration, and restore degraded fish and aquatic macro-invertebrate habitat. The removal of the dam will also reduce liability. By establishing a riparian buffer, removing the dam and applying bank stabilization techniques, aquatic habitat is being restored and water quality improvements are expected.

Low-head dams are defined as having a difference in elevation above and below the dam. Run-of-the-river dams are defined as those dams where the overflow from behind the dam extends from one side of the waterway to the other. On June 19, 1998 Governor Tom Ridge signed into law Act 1998-91 and House Bill 10, requiring owners of low-head, run-of-the-river dams to place and maintain warning signs and buoys above and below their dams and to assume all associated liability. The Pennsylvania Department of Environmental Protection (DEP) was required to notify all dam owners of this new legislation within the first 90 days of 1999. PA DEP has developed an existing process allowing dam owners interested in removing run-of-the-river dams to do so. To expedite this process, The Division of Dam Safety has adopted procedures to facilitate the breaching of dams in Pennsylvania.

Currents above dams and strong re-circulating currents and turbulent water existing below them create a very dangerous condition. The Department of Environmental Protection considers low-head dams to be one of the most dangerous hazards on Pennsylvania's waterways. The back currents and undertows existing below dams can trap boats and people. As water levels rise, even small low-head dams can become extremely hazardous.

Although it is not certain, it is speculated that the dam that was located on Wildlands Conservancy's property was constructed to provide an area for recreation and a source of water for irrigation. The exact age of the dam is unknown.

The Little Lehigh Creek, a major tributary of the Lehigh River, has a 108 square mile drainage basin. The limestone stream originates in Longswamp Township, Berks County and flows 24 miles through Lower Macungie Township into the City of Allentown, Lehigh County where it enters the Lehigh River. The Little Lehigh Creek is a municipal water source for the City of Allentown. Pennsylvania Department of Environmental Protection's Chapter 93, Water Quality Standards designate Little Lehigh Creek as a High-Quality Cold-Water Fishery and it is listed as a high-priority stream on the Section 303 (d) list of impaired streams. The Pennsylvania Fish and Boat Commission classifies the Little Lehigh Creek as a "Class-A Wild Trout Stream" containing a naturally reproducing population of brown trout. The predominant land uses in the watershed are agricultural and residential development, followed closely by commercial use and urban development. Siltation is the main cause of impairment induced by these land uses.

During the in-stream restoration phase of the project a 50-foot wide low-head run-of-the-river dam was removed. A 190-foot long concrete retaining wall was removed from the stream bank, and the bank was graded to a desirable slope.

During the riparian buffer phase of the project a 220 foot by 40 foot (8800 square-foot) no-mow zone was created. Within the zone 3654 square feet of jute matting, turf grass seed, wetland meadow mix with annual ryegrass and 1028 native trees, shrubs, and herbaceous plants were planted to stabilize eroded stream banks and provide immediate habitat benefits to wildlife. In addition to these plantings, an existing 110-foot-long riparian area was widened from approximately 20 feet to 40 feet.

This report explains each phase of the *Little Lehigh Creek Hydro-Modification, Stream Bank Restoration, Habitat Improvement and Riparian Planting Project* in chronological order. These phases consist of pre-project data collection and interpretation (macro-invertebrate survey, habitat assessment and aquatic survey), planning and permitting, in-stream restoration (dam removal, bank grading and stabilization) and riparian buffer establishment. Photographs documenting the various phases of the project are presented within the text of this report. A map illustrating the location of the work site and data sheets regarding the macro-invertebrate survey, habitat assessments, aquatic survey and a list of the riparian vegetation that was planted are included in the Appendix.

PRE-PROJECT DATA COLLECTION AND INTERPRETATION

Pre-project data consisting of a macro-invertebrate survey, a habitat assessment and an aquatic survey was collected to provide a reference in comparing pre and post project conditions. Pre-project and post-project photographs were also used as tools to evaluate the effectiveness of the project.

Macro-invertebrate Survey

On March 24, 2000 Lance Leonhardt, a licensed aquatic biologist and a biology teacher from Saucon Valley High School, with the assistance of his students and Wildlands Conservancy staff completed a macro-invertebrate survey of the project site. An aquatic kick net was used to sample square-meter sections of central and side channel riffles that were located approximately 30 feet downstream of the dam. The survey was conducted to measure the richness and diversity of the species present in the sample and was used to help determine the pre-project conditions of macro-invertebrate communities in the sampling area. A second survey will be taken to determine the downstream macro-invertebrate community's response to the project. A description of the macro-invertebrate communities found in the sample is located in Appendix B.

As a result of the macro-invertebrate survey analysis, reduced populations of shredding and scraping macro-invertebrates were identified. The reduced population of shredders may be due to the upstream retention of coarse particulate organic material by the dam. The low population of scrapers and filtering collectors may indicate a lack of stable substrates due to excessive scouring caused by the dam's overflow. Scouring and flow effects across the stream channel may be indicated by the difference in macro-invertebrate densities found within the central and side channel samples. Due to the removal of the dam and the planting of the riparian zone, the post-project samples are expected to show an improvement in habitat conditions.

Habitat Assessment

On April 20, 2000, Wildlands Conservancy staff conducted habitat assessments on two 300-foot stream reaches within the project site. The assessment method used was a version of US EPA's Rapid Bioassessment Protocols that was modified by the Pennsylvania Fish and Boat Commission's Habitat Management Section. In the assessments, a series of physical habitat-related parameters would be evaluated in the stream channel and riparian zone both upstream and downstream of the dam. Based upon the final numeric score, the stream reaches would be classified as poor, marginal, sub-optimal or optimal regarding the quality of available fish and aquatic macro-invertebrate habitat.

Both stream reaches were assessed using "riffle/run" type assessment forms. This assessment type was used to evaluate the stream reach downstream of the dam because it was dominated by high gradient and high velocity (greater than 1 meter/second) riffle areas. The "riffle/run" assessment was used to evaluate the stream reach upstream of the dam (even though riffles/runs did not exist) because this area would be considered an impacted "riffle/run" reach, due to the presence of the dam.

The habitat assessment conducted downstream of the dam yielded a final score of 146/200, placing this stream reach in the category of sub-optimal in regard to fish and macro-invertebrate habitat. The habitat assessment conducted upstream of the dam yielded a final score of 59/200, placing this reach in the category of marginal in regard to fish and macro-invertebrate habitat. Post project assessments will be conducted to detect any plural changes in fish and macro-invertebrate habitat within both of these reaches. For a detailed description of the habitat related parameters evaluated, please refer to the habitat assessment forms in Appendix C.

Aquatic Survey

On June 23, 2000 Wildlands Conservancy staff and Lance Leonhardt used a 100-1100 V DC backpack electro-fishing unit, block nets and dip nets to complete an aquatic survey from the dam continuing 300 feet downstream.

The sample collected during the aquatic survey was used to measure the richness (number of individuals within each species), diversity (number of different species) and total biomass (weight) of species present. These measurements were used to document pre-restoration conditions existing downstream of the dam. Brown Trout, Brook Trout and White Suckers were observed along with other high water quality dependant species. The survey revealed 222 individuals from 12 separate species and sizes ranged from 45 to 460 mm in length and 2 to 298 grams in weight. Using the baseline data collected in the sample, percent composition by individuals and by weight was calculated. Species collected in the sample were classified based upon their respective habitat tolerances, water quality tolerances and feeding guilds. The results of the aquatic survey are located in Appendix D.

A post-project aquatic survey will be conducted and used as a tool for determining the downstream fish community's response to the project.

PLANNING AND PERMITTING

Once funding was secured from the Pennsylvania Department of Environmental Protection's Watershed Restoration and Assistance Program, Wildlands Conservancy began the planning and permitting process.

In November 1999, Wildlands Conservancy hosted a public meeting to educate local citizens on the environmental impacts and liability associated with low-head run-of-the-river dams. At this meeting Scott Carney of the Pennsylvania Fish and Boat Commission's Division of Research presented a slide show entitled "The Negative Impacts of Dams". This meeting offered the public an opportunity to ask questions and receive information regarding the environmental impacts and liability created by dams.

In December 1999, Sarah Davis and Mark Mitchell of the Pennsylvania Fish and Boat Commission's Survey Section coordinated a survey of the dam and its immediate surroundings. PFBC used this survey to develop both a dam removal and an Erosion and Sedimentation Control Plan. Upon completion the removal plan was forwarded to the PA DEP's Division of Dam Safety to conduct an environmental assessment. The Erosion and Sedimentation Control Plan was reviewed by the Lehigh County Conservation District to assure that impacts would be minimized and soil conservation practices be adhered to during the project. After review, both agencies approved the plans.

Once the plans were approved Flyway Excavating, Inc. was contracted to execute the dam removal and adjacent bank grading. Implementation of the

Little Lehigh Creek Hydro-Modification, Stream Bank Restoration, Habitat Improvement and Riparian Planting Project would soon begin.

IN-STREAM RESTORATION

The in-stream restoration phase of this project was supervised by Wildlands Conservancy and implemented by Flyway Excavating, Inc., with the assistance of several volunteers.

Dam Removal

Once Flyway Excavating, Inc. was contracted to remove the low-head run-of-the-river dam, the project dates were set and implementation was ready to begin.

Flyway Excavating, Inc. arrived at Wildlands Conservancy to begin project implementation. Limestone riprap was purchased from a local quarry and hauled to the project site. The dam was accessed from the left stream bank and a staging area was prepared for equipment and machinery. Stone riprap was dumped along the left stream bank upstream of the dam (Figure 2), and a causeway was fashioned (Figure 3). This causeway was used to provide equipment access to the length of the concrete dam and a portion of the opposite stream bank.

Once access was established, a hydraulic jackhammer was attached to the track hoe. After positioning the track hoe on the causeway, the jackhammer was used to puncture the concrete dam breast (Figure 5). A bucket was attached to the track hoe to remove portions of concrete that had been broken (Figure 6). This removal of broken material would create a notch in the dam breast of approximately ten feet wide. Manipulating the notch size controlled the rate of water draw down (Figure 7).

Once the initial draw down had occurred, concrete was continually removed from the dam breast to enlarge the notch, allowing for continued draining of the water upstream of the dam (Figure 8). To assess the condition of the breach and allow a controlled draw down, excavation was paused periodically (Figure 9). This process would be repeated over the course of approximately two to three days until the entire dam breast was removed. Once the dam removal phase of this project was completed, the stone used in constructing the causeway was removed from the stream channel and used to stabilize the near stream bank (Figure 14).

Following the removal of the dam, a concrete retaining wall along the left stream bank was removed. The length of the retaining wall extended from the dam site

upstream for approximately 190 feet to an access bridge over the Little Lehigh Creek (Figure 15).

Bank Grading and Stabilization

Removing the concrete retaining wall allowed for the grading of this stream bank to an approximate 3:1 grade (Figure 16). After grading was completed, facultative wetland meadow mix and turf grass seed was applied to the soil. Biodegradable erosion control blanket was rolled out along the graded bank and secured using biodegradable stakes (Figure 17). Two stone paths were incorporated into this bank to provide education groups access to the stream (Figure 18).

RIPARIAN BUFFER ESTABLISHMENT

The riparian planting phase of the project was planned by the Wildlands Conservancy, who developed a list of native trees, shrubs and herbaceous material to be used in the re-vegetation of the project site. The implementation of this plan was completed with the cooperation of several other participants (refer to Acknowledgements).

In this phase of the project, non-point sources of pollution were addressed through the establishment of a no-mow zone approximately 220 feet in length and 40 feet in width and an existing stretch of riparian buffer 110 feet long and 20 feet wide was doubled in width. The dimensions of this riparian buffer are now 330 feet long and 40 feet wide. A total of 1028 native trees, shrubs, and herbaceous plants and fifty pounds of facultative wetland meadow mix and turf grass seed were planted within this zone (Figure 19). The entire seeded area was stabilized using 3654 square yards of biodegradable erosion control blanket, minimizing surface erosion and providing moisture retention for the newly planted seed. The addition of the native vegetation to the no-mow zone will stabilize the stream banks and provide shade and a food source to aquatic organisms. The newly established riparian buffer is expected to improve water quality and fish, aquatic macro-invertebrate and wildlife habitat. For a list of the riparian vegetation that was planted during this phase of the project, refer to Appendix E.

Figure 2. The stone that was used during the project was purchased and delivered from a local limestone quarry. Suitable access to the dam existed along the left streambank (looking downstream).

Figure 3. The equipment operator created a stone causeway to access the entire length of the concrete dam and a portion of the opposite streambank.

Figure 4. Once equipment access was established, a hydraulic jack-hammer was attached to the track-hoe and used to puncture the dam breast.

Figure 5. Portions of the concrete dam were broken into pieces that were manageable and easily manipulated.

Figure 6. Once the hydraulic jackhammer was used to puncture the dam, the concrete was removed to create a notch in the dam breast on the far bank.

Figure 7. An appropriate rate of water draw down was established by regulating the size of the notch.

Figure 8. Once the initial dam breach was completed, concrete was continually removed to increase the size of the notch.

Figure 9. The dam breast excavation was paused periodically to assess the condition of the breach and allow a controlled draw down.

Figure 10. Removing the dam created a slight disturbance of the stream substrate within the project area. The long-term environmental benefits achieved by removing the dam should, however, negate this temporary disturbance.

Figure 11. Breaching the dam caused a slow increase in the downstream water level by approximately three to four inches. The duration of this temporary rise in water level was approximately fifteen minutes and appeared to cause no negative downstream impact.

Figure 12. The opposite stream bank was stabilized with limestone riprap before the remainder of the dam was removed.

Figure 13. The stone that was used to stabilize the stream banks should vegetate and become camouflaged as sediment carried by the stream is deposited during storm events.

Figure 14. Once the opposite stream bank was stabilized, the remainder of the dam was removed. The stone causeway was then removed and used to provide stone to stabilize the near stream bank.

Figure 15. A concrete retaining wall approximately 190 feet in length was removed before creating a grade transition from the top of the bank to the streambed.

Figure 16. Once the concrete retaining wall was removed, the stream bank was graded to an approximate 3:1 grade. This grade will allow stream bank vegetation to become established. Impacts were minimized during bank grading by drawing soil *away* from the stream.

Figure 17. After stream bank grading was completed, stone riprap was placed along the toe of the stream bank to provide bank stability. Two access paths were excavated before applying biodegradable erosion control blanket along the length of stream bank.

Figure 18. The erosion control blanket was secured to the stream bank using biodegradable stakes. Access paths were installed to provide access for educational groups utilizing the stream corridor.

Figure 19. Several varieties of native trees, shrubs and herbaceous material were planted to establish a riparian buffer along this section of the Little Lehigh Creek. This vegetation will minimize soil erosion and provide shade to the stream, maintaining the cool stream temperature essential to fish and macro-invertebrate survival. Stream bank vegetation offers habitat for wildlife and serves as a buffer, protecting the stream from the negative impacts associated with land uses such as agriculture and urban development.

Figure 20. Once the vegetation was planted, exclusion fencing was erected to deter waterfowl access to the site and ensure growth. The fencing will be removed once the newly planted grass seed and vegetation becomes established.

CONCLUSION

In April 1999, Wildlands Conservancy received a grant through the Pennsylvania Department of Environmental Protection's Watershed Restoration and Assistance Program (WRAP) to implement the *Little Lehigh Creek Hydro-Modification, Stream Bank Restoration, Habitat Improvement and Riparian Planting Project*. The project was implemented on Wildlands Conservancy property in Lower Macungie Township, Lehigh County.

Wildlands Conservancy staff planned and coordinated the implementation of this project with the assistance of several other participants. The objectives of the project are to reduce non-point source pollution, reduce sedimentation, provide bank stabilization, improve water quality, restore natural fish migration, and restore degraded fish and aquatic macro-invertebrate habitat. The removal of the dam will also reduce liability. Dam removal has restored natural fish migration and in-stream habitat. Establishment of the riparian zone will reduce thermal pollution, reduce sedimentation, create wildlife habitat, provide an in-stream food source, improve water quality and stabilize stream banks.

The Little Lehigh Hydro-Modification, Stream Bank Restoration, Habitat Improvement, and Riparian Planting Project will serve as a demonstration site for similar stream restoration projects that will be implemented in the future. This project will serve as a success story, educating resource professionals, local and state governments and the general public of the negative environmental impacts and liability issues associated with dams and dam ownership. It will also serve as a reference to other organizations, agencies or landowners interested in pursuing similar projects, providing a detailed description of the planning, permitting and implementation process associated with such a project.

It is anticipated that the results of the post-project macro-invertebrate samplings, habitat assessments and aquatic surveys will show improvements in the quality of fish and aquatic macro-invertebrate habitat and an increase in species diversity and abundance. The realization of these improvements will indicate an improvement of water quality that will have positive impacts not only on the Little Lehigh Creek, but on the Lehigh River as well.

Appendix

I. **Site Map**

II. **Macro-invertebrate Survey**

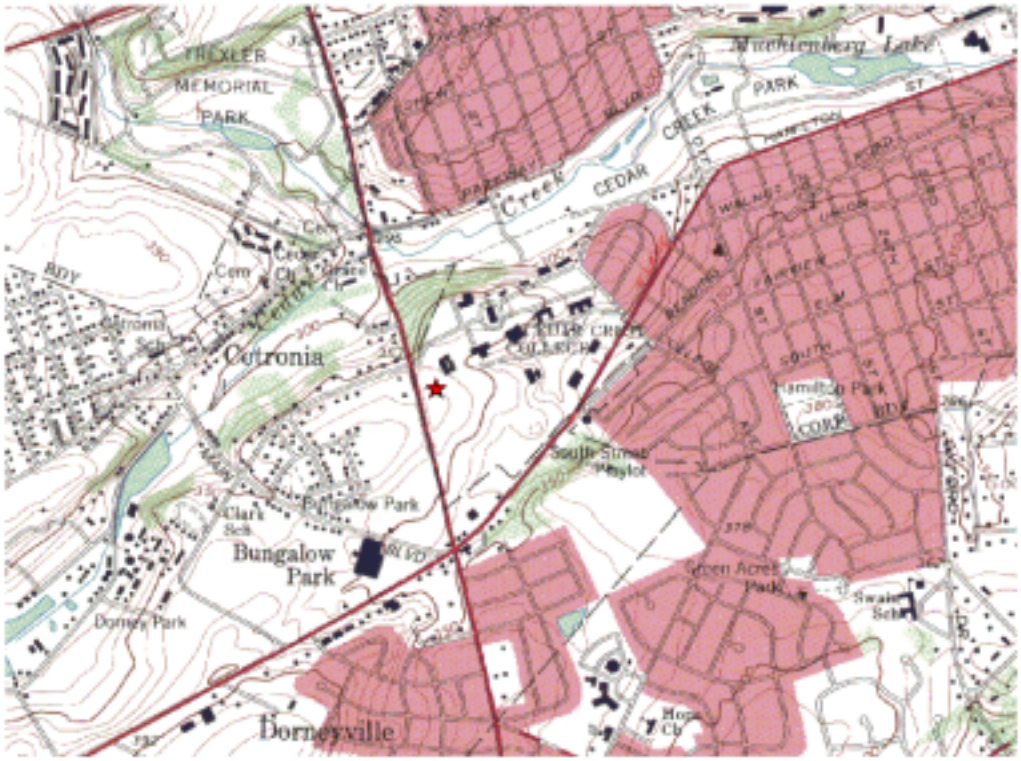
III. **Habitat Assessment**

IV. **Aquatic Survey**

V. **Riparian Species List**

Little Lehigh Creek Hydro-Modification, Streambank Restoration, Habitat Improvement and Riparian Planting Project

ALLENTOWN WEST QUADRANGLE



0.5 0 0.5 1 Miles

N
W E
S

Wildlands Conservancy

Macroinvertebrate Survey:Little Lehigh Creek/March 24, 2000/Wildlands Conservancy/Central and side channel riffles downstream of dam

Taxonomic Classification Class Order Family Genus	Number of Individuals in Sample	Functional Feeding Group	Family Level Pollution Tolerance Value (adapted from Hilsenhoff) for PA. DEP Unassessed Waters Field Form: Wadeable Streams	Tolerance Category (Based on FLPTV) I ≤ 4 T ≥ 5
INSECTS/ Plecoptera Capniidae *Allocapnia*	1	SH (shredder)	3	I
/Ephemeroptera Heptageniidae *Stenocron*	17	CG (collector gatherer)	3	I
Stenonema	20	SC (scraper)	3	I
Epeorus	2	CG	3	I
Ephemerellidae *Ephemerella*	598	CG	2	I
Eurylophella	1	CG	2	I
Baetidae *Baetis*	34	CG	6	T
Leptophlebiidae *Paraleptophlebia*	3	CG	4	I
Ephemeridae *Ephemera*	1	CG	4	I
/Tricoptera Hydropsychidae *Hydropsyche*	19	CF (collector filterer)	5	T
Cheumatopsyche	28	CF	5	T
Philopotamidae *Chimarra*	6	CF	3	I
Polycentropodidae *Polycentropus*	5	PR (predator)	6	T
Psychomyiidae *Psychomyia*	1	CG	2	I
Rhyacophilidae *Rhyacophila*	5	PR	1	I
/Diptera Chironomidae	194	CG / 10% PR	6	T
Tipulidae *Antocha*	12	CG	4	I
Simuliidae	12	CF	6	T
Emphididae *Chelifera*	3	PR	6	T
Hemerodromia	1	PR	6	T
Clinocera	1	PR	6	T
/Coleoptera Psepenidae *Psephenus*	7	SC	4	I
Elmidae *Optioservus*	20 (A+L)	SC	5	T
/Megaloptera Sialidae *Sialis*	2	PR	6	T
/ Lepidoptera	1	SH	5	T

CRUSTACEANS/Amphipoda/Gammaridae	***Gammarus***	**4**	**CG**	**4**	**I**
/Crangonyctidae	***Crangonyx***	**16**	**CG**	**4**	**I**
/ Isopoda /Asellidae	***Caecidotea***	**15**	**CG**	**8**	**T**
MOLLUSKS/Gastropoda/Anclidae	***Ferrissia***	**5**	**SC**	**7**	**T**
/Lymnaeidae		**1**	**SC**	**7**	**T**
TOTAL TAXA = 30					
TOTAL NUMBER of INDIVIDUALS IN SAMPLE		**1,035***			
SAMPLE TYPE		**m^2 kick-screen**			
SAMPLE AREA		**2 m^2**			
*** Combined sample: central channel (182 indiv) + side channel (853 indiv)**					

BIOASSESSMENT: LITTLE LEHIGH CREEK March 24, 2000 SAMPLE

CATEGORY	METRIC	EXPECTED RESPONSE TO INCREASING PERTERBATION	LITTLE LEHIGH 3/24/00 SAMPLE
Richness Measures:	**Total N. taxa**	**Descrease**	**30**
	No. EPT taxa	**Decrease**	**15**
Composition Measures:	**Ratio EPT/Chiron. Abundance (more robust when > 1)**	**Decrease**	**3.8**
	%EPT	**Decrease**	**71.0%**
	%Ephemeroptera	**Decrease**	**65.0%**
	%Plecoptera	**Decrease**	**0.1%**
	%Tricoptera	**Decrease**	**6.0%**
	% Chironomidae	**Increase**	**19.0%**
	% Dominant Taxa	**Increase**	**57.7%**
	FBI Index: Excellent 0.00-3.75 V.Good 3.76-4.25 Good 4.26-5.00 Fair 5.01-5.75 Fairly Poor 5.76-6.50 Poor 6.51-7.25 V.Poor. 7.26-10.00	**Increase**	**3.4 Excellent**
	# Intolerant Taxa (FLPTV $\leq$ 2)	**Decrease**	**4**
	% Individuals tolerant taxa (more robust when < 50%)	**Increase**	**32.9**
	Density (Individuals/ m^2)	**Variable**	**517.5/m^2**
Feeding Measures:	**Scrapers/Shredders + Total collectors**	**Autotrophic >0.75**	**0.056**
	Shredders/ Total Collectors	**Normal Shredder association linked to functioning riparian system >0.25**	**0.002**
	Filtering Collectors/Gathering Collectors	**FPOM Transport (in suspension) greater than normal particulate load in suspension >0.50**	**0.074**
	Scrapers + Filtering Collectors/Shredders + Gathering Collectors	**Stable Substate (e.g. bedrock, boulders, cobbles. Large woody debris) plentiful >0.50**	**0.13**
	Predators/ Total of all other groups	**Normal predator prey balance < 0.15**	**0.036**

EVALUATION:

Little Lehigh : Scores for **FBI, Total Taxa, No. EPT Taxa, % EPT** indicate fairly high water quality. Low score for **%P** (many stonefly taxa are shredders) coupled with a low **Shredders/ Total Collectors** ratio indicates a lack of shredders, possibly associated with retention of CPOM by dam. A low **Scrapers + Filtering Collectors/Shredders + Gathering Collectors** ratio may indicate a general lack of stable substrates and scouring at sample site associated with its proximity downstream to dam's overflow. The difference in **Density (Individuals/ m^2)** of central channel sample (182/ m^2) to side channel sample (853/ m^2) may indicate varying scouring and flow effects across stream channel.

BENTHIC INDEX OF BIOTIC INTEGRITY

(adapted by Leonhardt for use in 1-3 order streams of Lehigh Valley, PA, from Karr et. al.)

Biometric	**Predicted Response To Pollution**	**Score 1**	**Score 3**	**Score 5**	**Score:**
		Biometric Range	**Biometric Range**	**Biometric Range**	**Little Lehigh Creek @ Wildlands (3/24/00)**
Total # of Taxa	**decrease indicates degradation**	**<10**	**10-20**	**>20**	**5 (30 taxa)**
# of ephemeroptera taxa	**decrease indicates degradation**	**<3**	**3-5**	**>5**	**5 (8 taxa)**
# of plecoptera taxa	**decrease indicates degradation**	**<3**	**3-5**	**>5**	**1 (1 taxa)**
# of trichoptera taxa	**decrease indicates degradation**	**<3**	**3-5**	**>5**	**5 (6 taxa)**
# of Long-lived taxa (semi/merovoltine taxa)	**decrease indicates degradation**	**0-1**	**2-4**	**>4**	**3 (2 taxa)**
# Intolerant taxa (FLPTV ≤2)	**decrease indicates degradation**	**0-1**	**2-5**	**>5**	**3 (4 taxa)**
% of individuals in tolerant taxa	**increase indicates degradation**	**>50**	**20-50**	**<20**	**3 (32.9%)**
% of predator individuals	**decrease indicates degradation**	**<5**	**5-10**	**>10**	**1 (3.6)**
% dominant taxon	**decrease indicates degradation**	**>50**	**20-50**	**<20**	**1 (57.7)**
					Score = 27 FAIR

B-IBI Result Interpretation		
33-45	**Good**	Natural biological conditions indicated
21-33	**Fair**	Slight impairment of biological conditions indicated
0-21	**Poor**	Obvious impairment of biological conditions

STREAM HABITAT ASSESSMENT DATA SHEET **Total Score: 58**

Little Lehigh Creek / Pool Wildlife Sanctuary Dam Removal (Above Dam) 4/20/00
Stream/Site **Date**

1 EPIFAUNAL SUBSTRATE/AVAILABLE COVER

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/Available Cover (high and low gradient)	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.
SCORE _3__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

2 EMBEDDEDNESS

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
2.a Embeddedness (high gradient)	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.
SCORE _4__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

3a VELOCITY/DEPTH COMBINATIONS

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
3a. Velocity/Depth Regimes (high gradient)	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).
SCORE _1__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

4 SEDIMENT DEPOSITION

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
4. Sediment Deposition **(high and low gradient)**	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.
SCORE _1__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

5 CHANNEL FLOW STATUS

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
5. Channel Flow Status (high and low gradient)	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.
SCORE _19__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

6 CHANNEL ALTERATION

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration **(high and low gradient)**	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.
SCORE _10__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

7a FREQUENCY OF RIFFLES (OR BENDS)

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
7a.Frequency of Riffles (or bends) (high gradient)	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.
SCORE _1__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

8 BANK STABILITY (condition of banks)

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream	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 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.
SCORE _1__ (LB)	**Left Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**
SCORE _2__ (RB)	**Right Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**

9 BANK VEGETATIVE PROTECTION

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
9. Vegetative Protection (score each bank) **Note: Determine left** or right side by facing downstream (high and lowgradient)	More than 90% of the streambank surfaces and immediate riparian zones covered by native vegeation, 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.
SCORE _3__ (LB)	**Left Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**
SCORE _6__ (RB)	**Right Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**

10 RIPARIAN VEGETATIVE ZONE WIDTH

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
10. Riparian Vegetative Zone Width (score each bank riparian zone) (high and low gradient)	**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.
SCORE _6__ (LB)	**Left Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**
SCORE _1__ (RB)	**Right Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**

STREAM HABITAT ASSESSMENT DATA SHEET **Total Score: 137**

Little Lehigh Creek / Pool Wildlife Sanctuary Dam Removal (Below Dam) 4/20/00
Stream/Site **Date**

1 EPIFAUNAL SUBSTRATE/AVAILABLE COVER

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/Available Cover (high and low gradient)	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.
SCORE _9__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

2 EMBEDDEDNESS

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
2.a Embeddedness (high gradient)	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.
SCORE _18__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

3a VELOCITY/DEPTH COMBINATIONS

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
3a. Velocity/Depth Regimes (high gradient)	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).
SCORE _16__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

4 SEDIMENT DEPOSITION

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
4. Sediment Deposition **(high and low gradient)**	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.
SCORE _8__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

5 CHANNEL FLOW STATUS

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
5. Channel Flow Status (high and low gradient)	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.
SCORE _18__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

6 CHANNEL ALTERATION

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration **(high and low gradient)**	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.
SCORE _16__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

7a FREQUENCY OF RIFFLES (OR BENDS)

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
7a.Frequency of Riffles (or bends) (high gradient)	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.
SCORE _16__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

8 BANK STABILITY (condition of banks)

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream	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 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.
SCORE _8__ (LB)	**Left Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**
SCORE _8__ (RB)	**Right Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**

9 BANK VEGETATIVE PROTECTION

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
9. Vegetative Protection (score each bank) **Note: Determine left** or right side by facing downstream (high and lowgradient)	More than 90% of the streambank surfaces and immediate riparian zones covered by native vegeation, 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.
SCORE _6__ (LB)	**Left Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**
SCORE _8__ (RB)	**Right Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**

10 RIPARIAN VEGETATIVE ZONE WIDTH

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
10. Riparian Vegetative Zone Width (score each bank riparian zone) (high and low gradient)	**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.
SCORE _3__ (LB)	**Left Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**
SCORE _3__ (RB)	**Right Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**

Site: Little Lehigh Creek @ Wildlands Conservancy
Date: June 23, 2000
Investigator: Lance Leonhardt
Sampling Gear: Electrofishing backpack 100-1100 V DC/ Blocknets/Dip nets
Sampling length: 100m (downstream from dam) X 13m

Common Name	Scientific Name	# of Individuals in Sample	Range in Total Length (mm)	Tolerance Guild IBI#1 IBI#2		Feeding Guild IBI#1 IBI#2		Temperature Guild IBI#1 IBI#2	
Brown Trout	*Salmo trutta*	64	54-340	I	I	P	TC	SC	Ct
Brook Trout	*Salvelinus fontinalis*	3	260-370	I	I	P	TC	SC	C
White Sucker	*Catostomus commersoni*	49	80-395	T	T	O	GF	E	E
American Eel	*Anguilla rostratus*	2	345-460	T	T	I	TC	SC	E
Blacknose Dace	*Rhinichthys attratulus*	65	45-70	O	T	I	GF	E	E
Longnose Dace	*Rhinichthys cataractae*	9	60-85	I	M	I	BI	SC	Ct
Tessellated Darter	*Etheostoma olmstedi*	3	55-85	O	M	I	BI	SC	E
Pumpkinseed Sunfish	*Lepomis gibbosus*	4	65-130	I	M	I	GF	E	W
Rock Bass	*Ambloplites rupestris*	1	70	I	M	P	TC	E	E
Cutlips Minnow	*Exoglossum maxillingua*	5	60-110	I	I	I	BI	SC	E
Green Sunfish	*Lepomis cyanellus*	1	135	T*	T	O*	GF	E*	W
Slimy Sculpin	*Cottus cognatus*	16	65-75	I*	I	I*	BI	SC*	C
Total # Species in Sample = 12		Total # Individuals in Sample = 222							

- adapted for Ross

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

Tolerance Guild	Temperature Guild	Feeding Guilds
T = tolerant (able to tolerate environmental degradation)	SC = stenothermal cool/coldwater	I= Insectivore
I = Intolerant (sensitive to a wide range of environmental stresses)	E = eurythermal	O= Omnivore
O = Other (either intermediate in tolerance or conflicting tolerance designations in the literature)		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)	**Temperature Guild**	**Feeding Guilds**
T = Tolerant	C= Coldwater	GF = Generalist Feeder
M = Intermediate	Ct = Coldwater transitional	BI = Benthic Insectivore
I = Intolerant (sensitive to a wide range of environmental stresses)	E = Eurythermal (inhabits C-W waters)	TC = Top Carnivore
	W = Warmwater	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: Little Lehigh sample (6/23/00)
Species richness and community composition	**1. Number of stenothermal cool/coldwater species**	**2** **(3)** **4**	**>4** **>5** **>7**	**4** **5** **5-7**	**<4** **<5** **<5**	**5** **(6 species)**
	2. Number of eurythermal species	**2** **3** **4**	**<4** **<4** **<4**	**4** **4-7** **4-11**	**>4** **>7** **>11**	**3** **(6 species)**
	3. Presence of brook trout[1]		**Present**		**Absent**	**5**
	4. Percent of individuals as salmonids[2]		**>55%**	**20-55%**	**<20%**	**3 (30%)**
	5. Proportion of individuals as stenothermal cool/coldwater species[3]		**>80%**	**50-80%**	**<50%**	**1 (44.5%)**
	6.Number of intolerant species[4]	**2** **3** **4**	**>3** **>4** **>5**	**3** **4** **4-5**	**<3** **<4** **<4**	**5** **(7 species)**
	7. Percent individuals as white sucker[5]		**<10%**	**10-30%**	**>30%**	**3 (22%)**
Trophic composition	**8. Percent individuals as omnivores**		**<20%**	**20-45%**	**>45%**	**3 (22%)**
	9.Percent of individuals as insectivorous cyprinids[4]		**>45%**	**45-20%**	**<20%**	**3 (35.6%)**
Fish abundance and condition	**10. Individuals per square meter**	**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**	**5 (.185)**
	11. Percent of individuals with disease, tumors, fin damage, and skeletal anomalies[4]		**<2%**	**2-5%**	**>5%**	**5 (<2%)**

[1] Metric from Steedman (1988)
[2] Metric from Maret et al. (1997)
[3] Metric adapted from Lyons et al. (1996)
[4] Metric from Karr et al. (1986)
[5] Metric from New Jersey (Northern) IBI

Scoring: Excellent = 60-57 Good = 52-48 Fair = 44-39 Poor = 35-28 Very Poor = 23-12

Total score: 44.7
FAIR
(multiply initial total x 1.091 adjustment factor to get final total)

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: Little Lehigh Sample (6/23/00)
Species richness and community composition	1 .Number of coldwater/coldwater transition species [1]		>3	2-3	0-1	5 (4 species)
	1. Number of eurythermal/warmwater species[2]	2 3 4	<4 <4 <4	4 4-7 4-11	>4 >7 >11	1 (8 species)
	3. Presence of brook trout[3]		Present		Absent	5
	4. Percent of individuals as salmonids[4]		>55%	20-55%	<20%	3 (30.2%)
	5. Proportion of individuals as coldwater/coldwater transition species[5]		>88%	42-88%	<42%	1 (41.4%)
	6. % Intolerant individuals[1]		>43%	10-43%	<10%	3 (39.6%)
	7. Percent individuals as white sucker[6]		<10	10-30	>30	3 (22%)
Trophic composition	8. Percent individuals as generalist feeders[6]		<20%	20-45%	>45%	1 (53.6%)
	9.Percent of individuals as benthic insectivores[7]		> 45%	20-45%	<20%	1 (14.8%)
Fish abundance and condition	10. Individuals per square meter[2]	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	5 (.31)
	11. Percent of individuals with disease, tumors, fin damage, and skeletal anomalies[8]		<2%	2-5%	>5%	5
	12. Number of warmwater individuals per sample [1] (adjust proportionally for lesser/greater sampling lengths)[1]		<6 (50m) <12 (100m) <16 (150m)	6-20 (50m) <12-40 (100m) 16-60 (150m)	>20 (50m) >40 (100m) >60 (150m)	5 (5)
[1] Metric adapted from Mundahl and Simon (1999) [2] Metric adapted from Ross et al. (2000) [3] Metric from Steedman (1988) Scoring: Scoring: Excellent = 60-57 Good = 52-48 Fair = 44-39 Poor = 35-28			[4] Metric from Maret et al. (1997) [5] Metric adapted from Lyons et al. (1996) [6] Metric from New Jersey (Northern) IBI Very Poor = 23-12	[7] Metric adapted from Leonard and Orth (1986) [8] Metric from Karr et al. (1986)		Total score = 38 FAIR/POOR

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 of Riparian Plantings
Little Lehigh Creek Hydro-Modification, Stream Bank Restoration,
Habitat Improvement and Riparian Planting Project

	Scientific Name	Common Name	Quantity
Trees	*Acer pennsylvanica*	Striped Maple	3
	Acer rubrum	Red Maple	1
	Acer saccharinum	Silver Maple	12
	Betula alleghaniensis	Yellow Birch	5
	Betula lenta	Sweet Birch	10
	Betula nigra	River Birch	15
	Betula populifolia	Gray Birch	3
	Carpinus caroiniana	American Hornbeam	4
	Cercis canadensis	Redbud	1
	Diospyros virginiana	Persimmon	7
	Fagus grandifolia	American Beech	3
	Fraxinus americana	White Ash	1
	Fraxinus pennsylvanica	Green Ash	6
	Liriodendron tulipifera	Tulip Poplar	2
	Nyssa sylvatica	Black Gum	4
	Physocarpus opulifolius	Nine Bark	11
	Plantanus occidentalis	American Sycamore	2
	Quercus palustris	Pin Oak / Swamp Oak	5
	Quercus phellos	Willow Oak	2
	Salix nigra	Black Willow	67
	Sassafrass	Sassafrass	1
	Taxodium distichum	Bald Cypress	2
Shrubs	*Alnus rugosa*	Speckled Alder	4
	Aluns serrulata	Hazel Alder	4
	Amelanchier spp.	Serviceberry	8
	Aronia arbutifolia	Red Chokeberry	16
	Aronia melanocarpa	Black Chokeberry	8
	Cephalanthus occidentalis	Button Bush	26
	Cornus amomum	Silky Dogwood	12
	Cornus serciea	Red Osier Dogwood	15
	Ilex verticillata	Winterberry Holly	30
	Lindera benzion	Spicebush	14
	Rhododendron arborescens	Fragrant Azalea	3
	Rhododendron periclymenoides	Pinxter Bloom Azalea	4
	Rhododendron viscosum	Swamp Azalea	11
	Rhus aromatica	Fragrant Sumac	6
	Sambucus canadensis	Elderberry	3
	Thuja occidentalis	Eastern arborvitae	4
	Viburnum dentatum	Arrowwood	6
	Viburnum lentago	Nanaberry Viburnum	1

	Viburnum nudum	Smooth Witherod Viburnum	7
	Viburnum trilobum	High-bush Cranberry Viburnum	2
Herbaceous	*Ascelpias incarnata*	Swamp Milkweed	2
	Aster puniceus	Purple-stemmed Aster	37
	Chasmanthium latifolium	Northern Sea Oats	18
	Echinacea purpurea	Purple Coneflower	45
	Eupatorium fistulosum	Joe-Pye Weed	40
	Helenium autunale	Common Sneezeweed	19
	Hibiscus spp.	Swamp Rose Mallow	12
	Iris versicolor	Blue Flag Iris	33
	Juncus effusus	Soft Rush	49
	Lobelia cardinalis	Cardinal Flower	40
	Mimulus ringens	Monkey Flower	63
	Osmunda cinnamon	Cinnamon Fern	8
	Osmunda regalis	Royal Fern	9
	Peltandra virginica	Arrow Arum	10
	Pycnanthemum virgincum	Mountain Mint	19
	Schizachyrium scoparium	Little Bluestem	20
	Scirpus cyperinus	Wool Grass	79
	Scirpus validus	Woft-stem Bullrush	6
	Silphium perfoliatum	Cup Plant	13
	Sorghastrum nutans	Indian Grass	10
	Sparganium americanum	American Bur-reed	31
	Spiraea latifolia	Steeplebush	28
	Vernonia noveborensis	New York Ironweed	50
	Zizia aurea	Golden Alexander	72