Restoration Plan for
Shamona Creek and East Branch Brandywine Creek
Chester County, Pennsylvania
May 2010

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1.0 INTRODUCTION

"Red Streams Blue" is a program the Brandywine Valley Association has developed to focus on improving the water quality of impaired stream sections throughout the Brandywine Creek Watershed. The East Branch Brandywine Creek (a tributary to Brandywine Creek) within the study area is considered an impaired or "red" stream primarily due to excessive sediment and corresponding siltation in the watershed along with increased stormwater runoff. The PA Department of Environmental Protection includes the East Branch Brandywine Creek and two of its unnamed tributaries (UNTs) within the study area on its 303(d) list of impaired stream reaches (DEP 2008). Although Shamona Creek is not currently designated as "red", it is an important tributary to the East Branch Brandywine Creek and is included in this study since DEP has recently sampled the stream and determined that it is currently impaired.

The Shamona Creek and East Branch Brandywine Creek Watersheds include 12.4 square miles within the study area. These watersheds include a very diverse mix of land uses. Cover types are dominated by residential and commercial developments, preserved parkland, agricultural, and urban. Here, a restoration plan for Shamona Creek and the East Branch Brandywine Creek Watersheds is presented to address specific areas of impairment. With a clear plan for restoration, we may attain the greatest value from the recommended solutions and investments in the watershed.

In the environmental and biological fields of study, sources and causes of pollution in a watershed (leading to impairment) are typically categorized into two broadly defined categories known as Point Source Pollution and Non-point Source Pollution. The terms "point source pollution and non-point source pollution" refer not to a specific polluting substance or practice, but rather describe the means by which a pollutant is introduced.

Point source pollution is most often associated with industries or municipalities that discharge wastewater to natural waters through an outfall pipe or ditch. Point sources of pollution are relatively easy to measure and treat. Point source discharges of wastewater in the United States are regulated under the provisions of the Clean Water Act and must obtain discharge permits issued under the National Pollutant Discharge Elimination System (NPDES). An NPDES permit requires the discharger to meet certain technology-based effluent limits and perform effluent monitoring.

Unlike point sources, non-point sources of pollution occur over a wide area and are usually associated with large-scale land use activities such as agriculture, livestock grazing, mining, logging and development of impervious surfaces that result in increased amounts of stormwater runoff. Since there is not one specific point of discharge, non-point source pollution is more difficult to measure, regulate and treat because of the nature of the activities that cause it and the large-scale areas associated with generating the stormwater runoff. Non-point source pollution includes stormwater runoff that contains substances harmful to stream environments. Types of non-point source pollution common to agricultural areas include sedimentation from crop fields and nutrient runoff from fertilized fields, barnyards, and pastures. The lack or the removal of vital riparian habitat components (such as the destruction of forested riparian buffers) is also a major cause of streambank erosion, reduced filtration, and water quality impairment.

1.1. Land Development Concerns

The primary water quality problem resulting from increased land development is related to the increase in stormwater runoff from impervious surfaces such as roofs, parking lots, roadways and driveways. The increase in stormwater volumes and velocities contributes to accelerated erosion and sedimentation, while thermal and chemical pollution from roads and large parking lots further degrade water quality. The increased sedimentation can lead to other problems including alterations in the natural configuration of the channel, loss of stream meanders, decreased diversity of pool, riffle, and run patterns and corresponding destruction of the variety and abundance of aquatic habitat.

The increase of impervious surfaces within the watershed will also reduce infiltration and groundwater aquifer recharge. Groundwater that supports the base flows of Shamona Creek and East Branch Brandywine Creek and the hydrology to riparian wetlands can be further affected by an increase in impervious surfaces.

Future land development in the watershed will undergo regulatory review for stormwater discharge rate, volume, and water quality. Many of the existing developments within the watershed, including most of those in the Downingtown area and in the headwaters of Ludwig's Run, pre-date existing stormwater volume and rate control regulations. Moving forward, stormwater retrofits for existing urbanized areas should be encouraged through educational programs. Programs with a target audience of homeowners may be particularly effective, as potential projects will likely occur on individual parcels. Best management practices such as rain gardens, rain barrels, and maintenance of riparian buffers may be most appropriate.

At the municipal level, subdivision and zoning ordinances that are sensitive to the natural resources of Shamona Creek and East Branch Brandywine Creek should be reviewed periodically. Consistency with state regulations is necessary so that land development projects will protect the existing ground water recharge and surface water quality of the watershed.

1.2 Legacy Concerns

The central portion of Chester County mainly consists of industrial and suburban areas, yet some areas retain a relatively rural atmosphere. Most of the farms within the Shamona Creek and East Branch Brandywine Creek Watersheds are concentrated in the northwestern portion of the study area. Review of historical records of the region show that the entire watershed has a legacy of agrarian use. These historical land uses, including clearing and grubbing of forests without erosion and sedimentation controls and farming practices that did little to minimize erosion allowed for heavy sedimentation onto the valley floor after European colonization. The Downingtown area, which is along the East Branch Brandywine Creek, was once a significant industrial area with many mills. Dams that were constructed throughout the watershed allowed sediment to be deposited and cover the floodplain and riparian wetlands. As the dams failed or were breached, knick points formed and cut through the deposited sediment. The legacy of these activities resulted in a stream that is entrenched in the remaining sediment and largely disconnected from its floodplain (Walter and Merritts 2008). On a geologic scale, the function of

the stream will likely one day return. On a biotic scale, it is desirable to immediately restore the function of the ecosystem (as best possible) so that the biodiversity of the natural community may be restored and preserved with the greatest integrity.

2.0 METHODOLOGY

To determine the areas within Shamona Creek and East Branch Brandywine Creek Watersheds in need of the most attention, Kathy Bergmann and Jane Fava of Brandywine Valley Association and Aaron Clauser, Ph.D. of Clauser Environmental, LLC conducted stream walks on April 12th, 14th, 16th, and 29th, 2010. These walks included investigations of the mainstem and major tributaries in the Shamona Creek, Ludwigs Run, Park Run and East Branch Brandywine Creek Watersheds. Photographs, field notes, and GPS coordinates were collected at areas identified as potential concerns. Where access was not permitted, impacted areas were identified by conducting windshield surveys from roadways and reviewing aerial photography provided by the Chester County GIS Department. Sources of impairment were identified at the parcel level.

Clauser Environmental, LLC located the sample points and other features within the watershed using a Trimble GeoXT Global Positioning System (GPS) receiver during the site visits. The instrument settings used were: a) Elevation Mask of 15 degrees to limit lowest angle of satellite acceptance to 15 degrees, b) Signal Noise Ratio Mask 6 to minimize weak signal strength, and c) PDOP Mask 6 to control the geometry of satellite constellations. Logging interval was set at 1 second with typically a minimum of 60 readings collected at each point (Trimble Navigation 1994). Data collected in the field was downloaded to a personal computer for differential correction using GPS Pathfinder Office software (Version 4.2). Correction files were obtained from a dedicated base station located in Chester County, PA. Mission planning, parameter settings, and post processing typically allow an accuracy of less than (<) 1 meter. The precision of GPS collected data is subject to variation caused by canopy cover, atmospheric interference, time of day, and satellite geometry. GPS collected data should not be used in situations involving high property values, controversial projects, or in situations where legal questions may arise (Hook et al. 1995).

3.0 WATERSHED PROBLEMS AND SOLUTIONS

This section focuses on the sources and causes of impairment within the Shamona Creek and East Branch Brandywine Creek Watersheds and potential restoration practices that can be completed to address the noted impacts for high and medium priority areas. Low priority restoration projects are included in Appendix B. Each impacted segment identification number can be cross-referenced with its approximate location on the map in Appendix A.

3.1. High Priority Projects:

Impacted Stream Segment #22-27:

Kerr Park is a center for outdoor recreation within the Downingtown community. Several fish habitat enhancement structures have been installed within the park and are functioning well to provide habitat for both fish and macroinvertebrates within the stream. Within the park boundaries, a large section of the eastern streambank of the East Branch Brandywine Creek is mowed to within five feet of the stream. Within this area, trees to shade the stream are lacking and little buffer exists for waters leaving the mowed lawn areas.

One of the greatest assets within the park is a cooperative trout nursery. Waters flowing through the nursery discharge through a pipe that flows under a mowed lawn area and then discharges directly to the East Branch Brandywine Creek. The nursery contains a concentration of fish that are fed and managed intensively. Recently, such nurseries have been identified as potential sources of nutrient inputs to the stream system.

Solution:

Several opportunities to enhance water quality and the riparian zone exist within the area that would build on the important in-stream habitat work that has already been completed. In order to provide additional shading and aid in maintaining cool water within the stream and corresponding high dissolved oxygen conditions that benefit aquatic life, a forested riparian buffer could be implemented. The buffer area should extend along the East Branch as well as an unnamed tributary that flows through the park. To enhance the trout nursery area, a portion of the mowed lawn area above the discharge could be converted into a wetland treatment cell that would aid in uptake of nutrient discharges from the outfall.

Impacted Stream Segment #31, 35:

Within the headwaters of Ludwig's Run, the majority of development was completed during the time when stormwater control focused on rate controls rather than volume controls. Under modern regulations, volume control has become a priority to minimize the impacts of development on stream channel conditions. At the location of each sample point, existing volume control stormwater best management practices (retention ponds) have been installed, but lack maintenance of the outlet structures. Evidence of erosion around the outfall structures indicates that the actual rate of release from the basin may differ from the design.

Solution:

The existing stormwater basins at each of the sample points, as well as within this portion of the watershed, should be inspected by a qualified engineer to determine if the structure is currently functioning as designed. For those basins that have evidence of piping and erosion around the outfall structure pipe, antiseep collars should be considered for inclusion as part of the scope of any repairs. Opportunies for stormwater volume control should also be evaluated within this portion of the watershed. Best Management Practices such as stormwater basin retrofits, raingarden construction, and infiltration of rooftop drainage would likely benefit the hydrology and aquatic community of Ludwig's Run.

Impacted Stream Segment #37-38:

Within this forested stream segment, the stream has become severely eroded and entrenched. The streambanks are up to 10 feet high and are raw and actively eroding in a majority of this segment. The erosion appears to be closely linked to the impacts of stormwater discharges within the watershed.

Solution:

While improved stormwater management within the areas tributary to this stream segment would be the best long-term solution, a more symptomatic response is likely more realistic within this stream segment. Conservation of this area should include stabilization of the streambanks and installation of in-stream grade control structures. Since this area is heavily shaded by the surrounding forest, streambank stabilization would likely include riprap and pulling back of the streambanks to a more stable slope.

Impacted Stream Segment #73-74:

This portion of the headwaters of Shamona Creek includes streambanks that are actively raw and eroding that are about 3-4 feet high. The vegetation in this area includes a mix of meadow areas and early successional stage forest. A stormwater discharge channel that flows into the upstream portion of this stream segment from the highway to the east of the stream is actively eroding.

Solution:

Restoration of this area should include floodplain restoration with stabilization of the streambanks and the channel that discharges stormwater to this area. The existing vegetation and amount of available sunlight in this area should allow for primarily vegetative stabilization of the streambanks. Best Management Practices (BMPs) such as installation of live stakes, willow whips, and brush mattresses should be considered.

Impacted Stream Segment #76:
This on-line dam is a haven for populations of geese. While the geese are often aesthetically pleasing, they can provide excessive nutrient loading to aquatic ecosystems. When combined with nutrient inputs from over-fertilization of lawns and other sources, algal blooms may occur. With the eventual crash of the algal populations and resulting decomposition, dissolved oxygen levels within the stream may be depressed.

This on-line dam also includes a weir-type structure that allows for the water elevation within the dam to be manipulated. With boards installed, the weir-structure provides a barrier to fish and reptile migration within the watershed.

Solution:
Conservation practices that should be considered for this area include planting a vegetative buffer around the dam. By planting taller vegetation or leaving an un-mowed buffer strip around the pond, overpopulation of the area by geese would be discouraged. In order to promote fish and reptile migration to the upper reaches of the watershed, the weir should either be retrofitted as a passage structure or, more easily, all boards should be removed from the structure during times when migrations of fish and reptiles are most prevalent.

Impacted Stream Segment #79-84 and 80-84:

This stream segment includes severely eroded streambanks that are approximately 1-4 feet high along both the mainstem of Shamona Creek and an unnamed tributary that drains into Shamona Creek within this stream segment. The sediment that has been deposited within the floodplain was likely deposited during flooding events in which the Wharton Dam located at the downstream end of this segment was functioning to back up water and allow the sediment to settle out. The function of this flood control dam to properly regulate flows to Shamona Creek is an essential component to mantaining the downstream flow conditions.

Solution:

Conservation work in this area should include an investigation of the function of the Wharton Dam by a qualified engineer to determine if it is functioning as designed and if that design is optimum under current watershed conditions. If any alterations are required to improve the function of the dam, the dam should be retrofitted. In order to minimize sedimentation and corresponding nutrient inputs to the downstream areas, the areas where sediment has been deposited should be maintained to restore the original floodplain elevations within those areas. After restoring the original floodplain elevations, the streambanks should be stabilized and riparian buffers should be restored to shade the stream. The engineering evaluation of this structure is ongoing under a 2010 Growing Greener Grant award to Uwchlan Township.

Impacted Stream Segment #106:
During the streamwalk on April 29, 2010, extensive algal blooms were present upstream of this point within the Park Run tributary to the East Branch Brandywine Creek. The algal blooms were comprised of cyanobacteria (blue-green algae) that had formed extensive long strand shaped colonies that entirely covered the stream bottom in some areas.

Algal blooms typically correspond to high levels of nutrient inputs to the stream coupled with high levels of sunlight reaching the stream bottom. In the case of the observed bloom, leaf-out of trees within the riparian corridor over the following weeks would likely shade the stream and cause a population crash for the algal colonies. With a population crash of this nature, bacteria populations typically increase and utilize the available dissolved oxygen during the decay of the algae and can deplete the dissolved oxygen levels below the threshold of tolerance for other aquatic organisms.

Solution:
Restoration of this area should focus on nutrient reductions within the headwater areas of Park Run. The commerical, educational, residential, and recreational areas are all potential sources of nutrient enrichment through the use of lawn care products. A workshop should be considered for the late winter that is titled "Environmentally Sensitive Maintenance of Lawn Areas". The target audience should be local landscapers and groundskeepers (including those from the local golf course and school). Part of the discussion at the workshop should include naturalization of stormwater basins. Another opportunity would be to partner with local lawncare supply stores to prepare a handout on the importance of not overapplying lawn fertilizers within the watershed. Additionally, establishing a riparian buffer where it is lacking or minimal including the area of the upstream golf course would likely aid in reducing nutrient flows to the stream.

Impacted Stream Segment #116: Beaver Creek discharges to the East Branch Brandywine Creek near the downstream end of the study area. During the assessment stage of this project, sample point 4 was located on Beaver Creek. Sample point 4 was impaired for both biology and habitat. The location of sample point 4 includes a breached dam breast where the streambanks are eroded several feet high. The sediment appears to be legacy sediment that was deposited in the backwater of the dam.

Solution:

Restoration of this area should include legacy sediment removal to restore the floodplain of Beaver Creek. The restoration plan should include installation of a forested riparian buffer in the area that is currently mowed and stabilization of the streambanks.

3.2 Medium Priority Projects:

Impacted Stream Segment #11-14:

In this stream section, the western streambank has been cleared and mowed to the top of bank in the area of a campground. This area is within the backwater conditions created by the downstream dam and does not exhibit extensive streambank erosion although several smaller areas have approximately 2 foot high eroded streambanks. Geese are common in this area of relatively flat water and mowed lawn to the stream edge.

Solution:

Restoration of this stream segment should primarily focus on installation of a riparian forested buffer and stabilization of the small areas of erosion. By installing a riparian buffer comprised primarily of shrubs and trees with periodic access points to the stream, the stream will be better shaded and overpopulation of geese will be discouraged.

Impacted Stream Segment #16:

The approximately 4-foot high on-line dam in this area functions to deliver water through a diversion to the ponds in Kardon Park. The ponds are an important feature in the community and require water from the East Branch Brandywine Creek. The on-line dam provides a barrier to fish passage in all but the highest flooding conditions.

Solution:

Restoration of this area should focus on restoration of fish passage. Fish passage could be restored by either retrofitting the dam or dam removal. As the dam is utilized for recreation and diverting water to the Kardon Park ponds, it is currently functional so a fish passage retrofit is likely more feasible at this time.

Impacted Stream Segment #27-30:
This location near the downstream end of the study area includes a minimal riparian buffer on the western streambank. The western riparian zone includes mowed lawn areas, a parking area, and a walking trail. The in-stream fish habitat is minimal.

Solution:
This stream segment would benefit from riparian buffer plantings along the western streambank, extension of the fish habitat enhancement work that was completed upstream into a new phase in this area, and stormwater management retrofits to the parking area to the west of the stream. Stormwater management retrofits to be considered should include a demonstration rain garden and a bio-filtration swale.

Impacted Stream Segment #31-34:
The streambanks in this section of Ludwig's Run and an unnamed tributary to Ludwig's Run are eroded approximately 3 - 6 feet high. The eroded streambanks in this area appear to be related to stormwater impacts.

Solution:
Restoration of this stream segment should focus on decreasing the upstream stormwater impacts as well as streambank stabilization. The method of streambank stabilization for this area should be designed to have minimal impacts on the existing forest while providing long-term stability of the stream. One consideration would be to install cross vanes for grade control within the stream to ensure that additional downward cutting of the stream is minimized.

Impacted Stream Segment #42:
A small on-line dam in this location is utilized to provide water to an off-line pond. The on-line dam blocks fish passage within the stream.

Solution:
This dam should either be removed or retrofitted to allow for fish passage into the headwaters. If dam removal is selected, the restoration of the area should include installation of cross vanes for grade control to minimize the risk of this stream segment down-cutting.

Impacted Stream Segment #51:
The on-line dam in this area bocks fish passage within the stream. The dam is utilized to provide water to a small off-line pond. Just downstream of the dam area, Japanese knotweed (*Polygonum cuspidatum*) dominates the southern streambank.

Solution:
This dam should either be removed or retrofitted to allow for fish passage into the headwaters. The water intake for the pond could be designed into the dam removal project to allow for an in-stream intake. The invasive species within the area should be removed to minimize the risk of the plants spreading to other areas within the watershed. Native riparian zone plants should be planted in the area after the invasive removal.

Impacted Stream Segment #54-55:

A sewer line right-of-way within this area is being maintained as mowed lawn. The mowed lawn area extends to the edge of the streambanks where the stream is actively causing erosion around a sewer line manhole. The southern streambank is eroded approximately 2-3 feet high.

Solution:

Restoration of this area should include a minor streambank stabilization project and planting of native species within the riparian zone. The area of erosion around the sewer line manhole should be maintained.

Impacted Stream Segment #87-88:

A dam breast in this area is no longer functional with an unnamed tributary cutting around the sediment filled dam structure. Downstream of the structure, the stream channel is eroded with approximately 4 feet high streambanks. In the location of a pipeline crossing at the downstream end of the segment, riprap has been placed within the eroding channels in an effort to stabilize the channels.

Solution:

The eroding streambanks within this area should be stabilized. In the location of the dumped riprap, a stabilized channel should be implemented in place of the riprap. The dam structure could be removed if desired, as it is no longer functional.

Impacted Stream Segment #100:
About 250 feet of the southern streambank at this location is eroded approximately 12 to 15 feet high. Just downstream of the eroded area, a major streambank stabilization project utilizing riprap and gabion baskets has been installed.

Solution:
The area of erosion should be targeted for streambank stabilization. As the amount of material that would be required for removal to develop a more stable slope would be substantial, it is likely that stabilization of this area would best be accomplished by implementing riprap in combination with live stake plantings on the slope.

Impacted Stream Segment #112-113:
In this location, a Growing Greener Grant funded stream restoration project was implemented years ago. The existing streambanks and floodplain are being maintained in mowed grass to the edge of the stream.

Solution:
The riparian buffer in this area would benefit from plantings of a riparian zone forest and buffer to filter water discharging to Park Run from the lawn areas.

4.0 RESTORATION SOLUTION DETAILS

As was discussed in the previous section of this report, there are many opportunities for improvement. This section discusses specific concerns and conditions related to those improvement activities and best management practices (BMPs).

4.1 Habitat Restoration and Improvement

Streambank Stabilization & Restoration: Streambank stabilization is the most basic step in restoring a degraded stream. Eroded vertical walls or undercut banks are often present where erosion has gone unchecked over time in urbanized and agricultural areas. Traditional streambank stabilization involves: (1) re-grading localized laterally eroded banks by grading to a more stable slope (3:1 horizontal: vertical); (2) stabilizing the slopes with erosion control matting and vegetation; and, (3) incorporating in-stream structures and/or bioengineering techniques. Traditional in-stream structures may include toe-riprap, rock cribbing, root wads, and log or rock deflectors. Bioengineering methods that may be incorporated in bank stabilization commonly include fascines, branch packing, brush mattresses, live cribwalls, tree revetments, and live staking.

Established streambank stabilization project with root wads.

In-stream structures such as this J-hook can be installed to minimize erosion of the newly restored streambank until vegetation becomes established.

If a stream has been channelized or lacks stream bend meanders and adequate space and funds are available, a natural stream channel design (based on fluvial geomorphology) may be appropriate. Natural stream design uses a stable natural channel ("reference reach") as a blueprint for designing the restoration of the impacted reach. The reference reach provides a suitable pattern, dimension and profile for the design of the restored reach. With a design based on bank-full flow, energy should be managed through the reach to minimize erosion while still transporting sediment from upstream areas through the restored area.

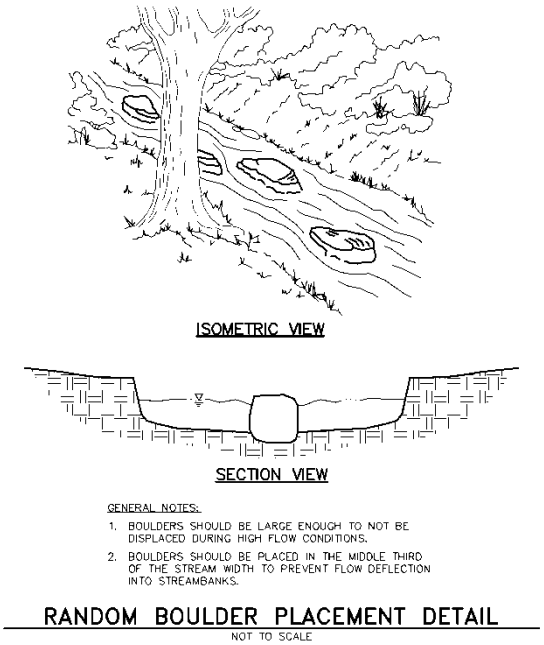
Floodplain Restoration:

Shamona Creek and East Branch Brandywine Creek have been greatly altered during the period following European colonization. The pre-colonial floodplain has been impacted by a combination of accelerated erosion in the uplands discharging excessive sediment onto the valley floor and constructed dams functioning as sediment traps. As the stream entered each dam, the loss of velocity allowed the stream to drop any sediment it was transporting and cover the pre-dam floodplain. As the dams were breached, the stream quickly cut through the "legacy sediment" and became entrenched. The resultant stream section has a very channelized appearance with steep, eroding banks. Over time, the excess soil in the valley floor was distributed to other areas that were not dammed, as the stream is not yet at a stable state to deal with the excessive sediments that are being flushed through the system.

However, just as sediment, fill, buildings, and other encroachments were placed into the floodplain, they can also be removed and floodplains re-established. This has been done successfully in many stream restoration projects throughout the Commonwealth. Sometimes restoring a floodplain will also allow for the re-establishment of forested riparian buffers and wetlands.

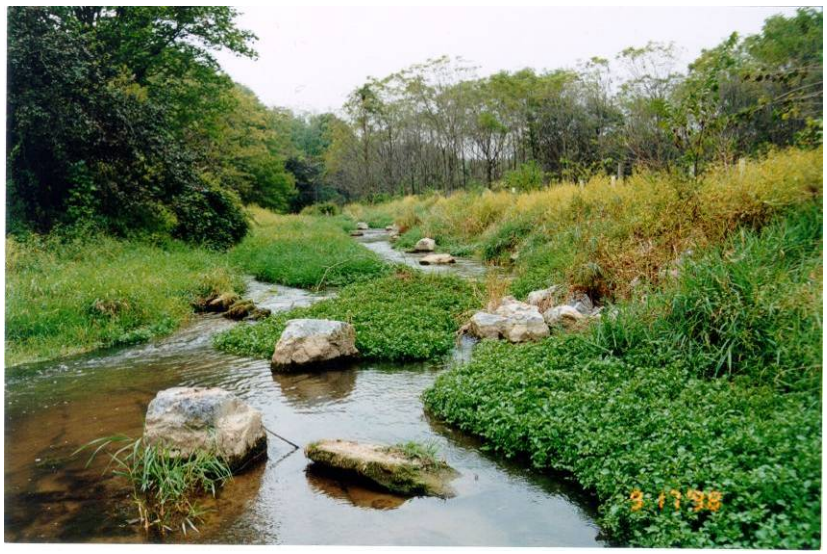
Sample photograph of floodplain restoration – removing previously placed fill and legacy sediments

4.2 In-stream Habitat Improvements for Fishery

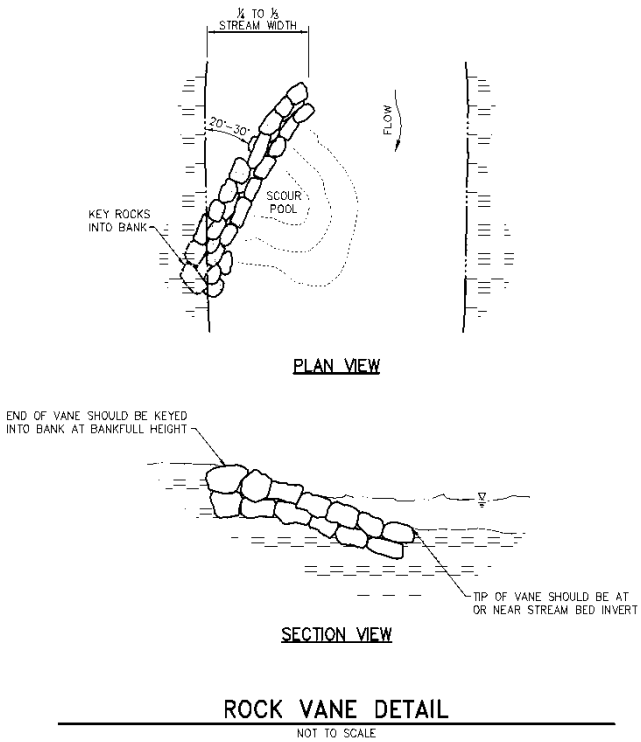


Boulder placements:

This type of fish habitat structure is very inexpensive and easy to install. It involves placing larger boulders (3-foot average diameter) with a track hoe or large backhoe. The large rocks provide instant cover for fish.



Sample photograph of boulder placements

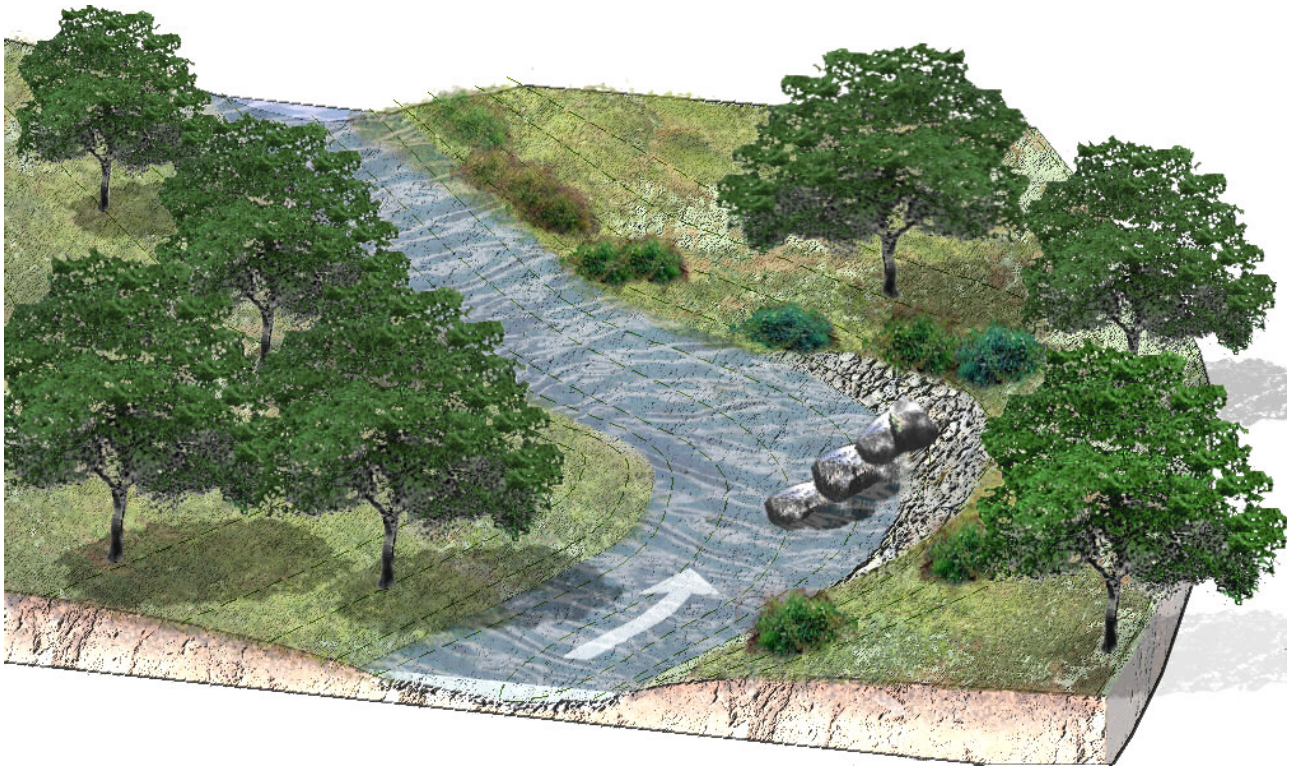


Rock vanes:

Rock vanes are a means of re-directing and centralizing stream flow during high water events in order to minimize bank erosion. However, they do need to be properly designed and installed. Rock vanes should be constructed of large rock or in combination with large, straight logs. Rocks that are preferably rectangular in shape measuring roughly 3-feet wide by 5-feet long by 1.5-feet thick should be utilized for proper construction of the rock vanes.

A large track-hoe will be necessary to install this style of rock vanes.

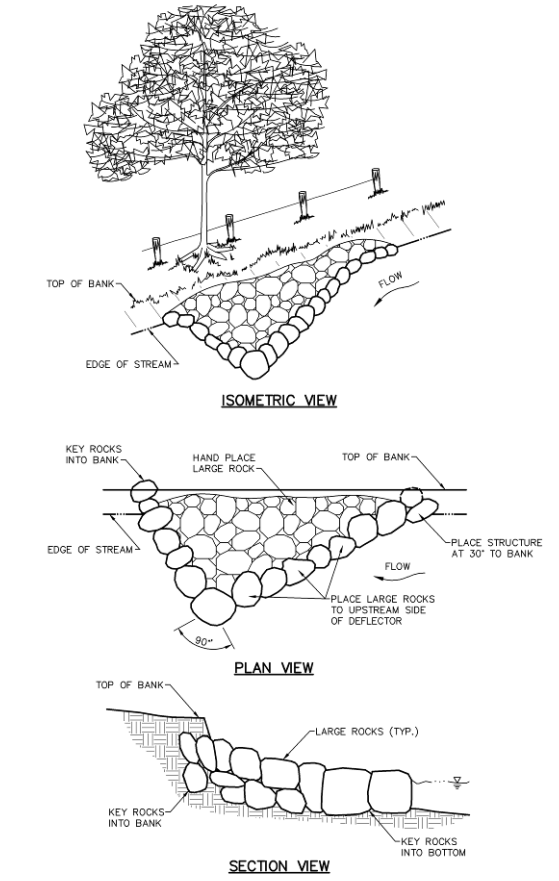
Costs will vary due to the availability of such rock in the general area, and ease of access into the work location.

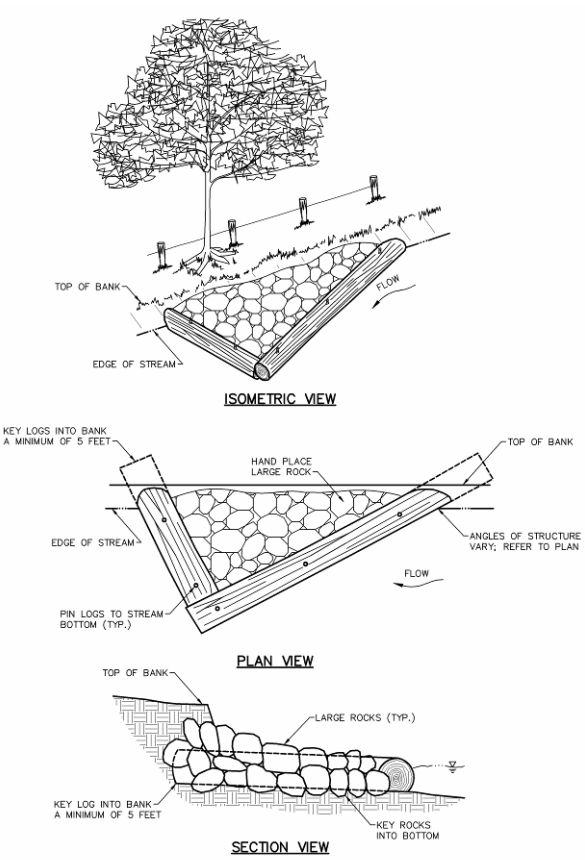


Sample rendering of rock vane

Rock deflectors and log frame deflectors:

Rock and log frame deflectors are used to stabilize eroding streambanks and provide in-stream habitat. Rock deflectors are a bit easier to install because the frame of the structure consists of larger rock, whereas the log frame consists of logs that have to be drilled and anchored to the substrate. A backhoe typically is needed for construction.

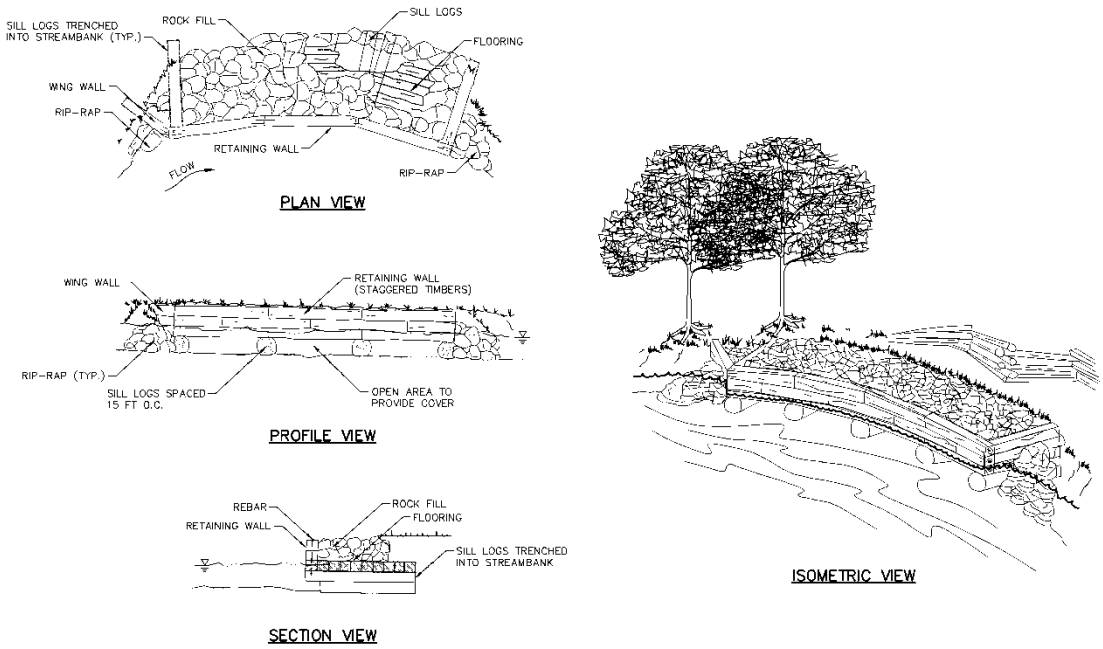




Sample photograph of a newly installed log frame deflector

Mudsills:

Mudsills are bank stabilization devices that are suited for use on the outside bends of eroding banks and are also fish habitat structures. A backhoe or trackhoe is usually necessary for installation.



MUD SILL DETAIL
NOT TO SCALE

Sample photograph of a mudsill indicated by the yellow arrow

4.3 Riparian Buffers and Landscaping

Forested riparian buffers long have been recognized as a vital component of stream health in ecoregions where they should be naturally occurring such as within the Shamona Creek and East Branch Brandywine Creek Watersheds. Forested buffers provide shade, helping moderate diurnal stream temperatures during both winter and summer months. Water temperature can increase during summer and decrease in winter by removal of shade trees in riparian areas.

Forest buffers also act as filters of stormwater runoff during storm events. For this reason, forest buffers are especially valuable in urban watersheds when stormwater can be discharged into a buffer, rather than discharged directly into a stream. A wide variety of pollutants such as suspended solids (sediment), nutrients (nitrogen and phosphorus), heavy metals, toxic organic pollutants, and petroleum compounds can be successfully filtered and trapped by the physical structure of the vegetation. In the case of nitrogen and phosphorus as well as some heavy metals and toxic organics, the pollutants can be taken up through the root systems and stored in the tree and shrub's biomass (wood).

Sample photograph of a three-year-old forest buffer planting

Forested riparian buffers serve to stabilize streambanks via the root systems of trees and shrubs that provide deep penetrating structural integrity to the soil. Buffers also reduce the erosive force of stormwater runoff and flood events because the aboveground, physical structure of trees and shrubs slow water velocity via friction. Long-term loss of riparian vegetation can result in accelerated streambank erosion and channel widening, increasing the width/depth ratio.

Riparian trees and shrubs provide terrestrial wildlife habitat. Riparian buffer strips often act as travel corridors for wildlife traveling from one area to another. Additionally, riparian forests serve to provide food, shelter, and nesting areas.

Riparian forests provide a vital function in aquatic ecosystems. Leaf detritus is the main food source supporting many lotic (flowing water) aquatic food webs. Large woody debris plays an important role, providing fish and insect cover and spawning locations.

Establishing a successful forested riparian buffer takes careful planning, planting, and maintenance.

The following tree and shrub species are recommended for forested riparian buffer plantings. All species are native and readily available through local tree nurseries.

TREE SPECIES	HEIGHT (Feet)	WILDLIFE VALUE	SHADE TOLERANCE	SPACING (Feet)
Red maple (*Acer rubrum*)	75-100	Food source–fruit and young shoots	Tolerant	12-15
Silver maple (*Acer saccharinum*)	75-100	Food source–seeds and young twigs. Good cavity tree.	Intermediate	12-15
Shagbark hickory (*Carya ovata*)	75-100	Food source–twigs and nuts	Intermediate	12-15
Persimmon (*Diospyros virginiana*)	50-75	Food source–fruit	Intolerant	10-13
Hackberry (*Celtis occidentalis*)	75-100	Food source–fruit and twigs	Intermediate	12-15
White ash (*Fraxinus americana*)	75-100	Food source–fruit	Tolerant	12-15
Red ash (*Fraxinus pennsylvanica*)	50-75	Food source–fruit	Intolerant	10-13
Eastern white pine (*Pinus strobus*)	75-100	High value food source–needles and seeds. Good cover and nesting tree.	Intermediate	12-15
Sycamore (*Platanus occidentalis*)	75-100	Moderate value for cover and food source–fruit	Intermediate	12-15
White oak (*Quercus alba*)	75-100	Food source–acorns and twigs	Intermediate	12-15
Red oak (*Quercus rubra*)	75-100	Medium value for nesting–food source	Intermediate	12-15
Pin oak (*Quercus palustris*)	75-100	Food source–acorns and twigs	Intolerant	12-15
Black willow (*Salix nigra*)	35-50	Food source–buds, fruit and twigs	Very intolerant	10-13
Sassafras (*Sassafras albidum*)	35-50	Food source–twigs and fruit	Intolerant	10-13
Slippery elm (*Ulmus rubra*)	50-80	Food source–seeds and twigs	Tolerant	10-13
White flowering dogwood (*Cornus florida*)	35-50	Food source–fruit	Intermediate	10-13
Redbud (*Cercis Canadensis*)	20-35	Minimal food source–seeds	Tolerant	10-13

SHRUB SPECIES	HEIGHT (Feet)	WILDLIFE VALUE	SHADE TOLERANCE	SPACING (Feet)
Sandbar willow (*Salix exigua*)	15-20	Food source–fruit and twigs	Very tolerant	8-10
Smooth alder (*Alnus serrulata*)	12-20	Food source–fruit	Very intolerant	8-10
Serviceberry (*Amelanchier Canadensis*)	5-25	Food source–fruit, twigs and leaves	Very tolerant	8-10
Buttonbush (*Cephalanthus occidentalis*)	6-12	Food source–fruit	Very intolerant	8-10
Silky dogwood (*Cornus amomum*)	6-12	Food source–fruit	Intolerant	6-8
Grey dogwood (*Cornus racemosa*)	6-12	Food source–fruit	Tolerant	6-8
Red-osier dogwood (*Cornus sericea*)	6-12	Food source–fruit, buds and twigs	Very intolerant	6-8
Winterberry (*Ilex verticillata*)	6-12	Intermediate wildlife value	Intermediate	6-8
Staghorn sumac (*Rhus typhina*)	35-50	Food source–fruit	Very tolerant	8-10
Highbush blueberry (*Vaccinium corymbosum*)	6-12	Food source–fruit	Tolerant	6-8
Northern arrowwood (*Viburnum regonitum*)	6-12	Food source–fruit	Tolerant	6-8

Unfortunately, multiflora rose (*Rosa multiflora)* and Japanese Knotweed (*Polygonum cuspidatum)* are very common invasive species within Shamona Creek/ East Branch Brandywine Creek Watershed. Species such as these have aggressively invaded riparian corridors throughout sections of Pennsylvania. In many situations, these plants are pioneer species, meaning they are some of the first plants to establish themselves in areas allowed to fallow.

If left unmanaged, these invasive species out-compete desired native species for space and nutrients. The correct natural progression and succession of the desired native plant community can be stalled for years, and in turn negatively impact the rest of the food web. Invasive species should be eradicated as the first step in planting a riparian buffer.

It is very important to maintain newly planted forest buffers by removing unwanted, invasive species. Mowing, string trimming, and physically pulling out invasive species can be effective ways of dealing with these unwanted "weeds", but many times enough root mass remains and the plant returns. In addition, mowing and such other physical removal means are labor intensive and many times not cost effective. Selective use of herbicide may be the best alternative for large areas where invasive species may not otherwise be controlled.

4.4 Stormwater Water Volume and Quality Improvement

Potential water volume and quality improvement projects associated with the Shamona Creek/ East Branch Brandywine Creek study area should include a combination of existing facility retrofits and innovative applications during new construction. The PADEP BMP manual and the Chester County Conservation District should be consulted for design ideas and requirements. Stormwater volume may be controlled by either infiltrating the stormwater into the ground, capturing the stormwater for use, or evapo-transpirating the water back into the atmosphere.

Infiltration trenches and drywells function to return stormwater directly into the ground and ultimately the underground water table. By collecting rooftop water that should contain minimal pollutants, it may be infiltrated with minimal risk of groundwater contamination. During construction of infiltration devices, the main consideration is minimizing compaction of the soil surface that underlies the stone bed. By utilizing an excavator and scooping the soil back and then placing the stone from above, compaction may be minimized. If built in combination with underground detention facilities, the bulk of the water from a new development can sometimes be infiltrated with minimal impact to the buildable area of a site. Infiltration in karst areas poses a concern through the potential formation of sinkholes.

Stormwater capture for use in Shamona Creek/ East Branch Brandywine Creek should be encouraged through educational programs. With the environmentally conscious populace of today, the use of rain barrels and cisterns could become commonplace with proper promotion.

Evapo-transpiration is another option for stormwater volume management. The use of rain garden bio-retention areas to allow wetland type plants to filter pollutants and minimize runoff should not be overlooked.

One of the larger concerns within the basin is that many of the stormwater basins are potentially malfunctioning. A good first step would be holding a stormwater basin workshop that all of the property owners and municipal representatives affiliated with basins would be invited to attend. The workshop could include speakers on maintaining outlet structures, legal issues regarding stormwater basins, and ideas for naturalization of stormwater basins. The financial aspect of not mowing and fertilizing vs. maintenance of a naturalized basin should be included.

Sample photograph of an underground detention facility installation

5.0 COST ESTIMATES

Costs associated with stream restoration work and the installation of best management practices will vary from site to site within the watershed. This is due to a variety of reasons including but not limited to: ease of access to the construction site, weather and soil conditions, availability of rock and other building materials, any available volunteer hours, and permitting and design costs.

It is always good practice to get a minimum of three bids for construction work. Time should be taken to prepare a thorough "request for bid" which specifically outlines work to be performed to the detail currently known. Contractors should be given many opportunities to see the proposed construction site so proper evaluation can be made. Keep in mind, an experienced contractor may have suggestions to the "scope of work" outlined within the "request for bid" which may save time and money.

Some requested services might need to be bid on a "time and materials" fashion. Plan design and permitting can fall into this category because aspects of the project will not be known until the design advances to a certain point.

Preliminary probable construction cost opinions are provided as a general guideline of costs associated with each high and low priority project in Appendix D. As the presented range of costs is preliminary, costs should be re-evaluated for the specific project before seeking project funding. It is important to consider in-kind materials and services such as volunteer effort, stream access, and current regulatory guidelines during the re-evaluation. To get a general idea of construction costs to be expected, the following listing is provided based on PRedICT 2007 and the experience of Clauser Environmental, LLC and RETTEW:

<u>Equipment with Operator</u>	
Back-hoe	$ 85.00/hour
Track-hoe	$ 135.00/hour
Bulldozer	$ 120.00/hour
Front end loader	$ 100.00/hour
Tri-axle dump truck	$ 95.00/hour
Mobilization/Demobilization	2.5% of construction cost
Bonds and Insurances	2.5% of construction cost
<u>Materials</u>	
Rock (riprap)	$ 17.00/ton delivered
	$ 30.00/ton installed
	$ 90.00/linear foot installed
Erosion control matting	$ 5.00–10.00/square yard installed
Silt fencing	$ 2.35/foot installed
Super silt fence	$ 10.00/foot installed
Gabion baskets	$ 35.00/square yard installed
Geotextile fabric	$ 2.25/square yard installed
Orange construction fence	$ 2.10/linear foot installed

Excavation

Earthen swales	$ 3.00/linear foot
Basin grading	$ 3.10/cubic yard
Trench work	$ 5.60/cubic yard
Place or strip topsoil	$ 2.35/cubic yard
Backfilling on-site soils	$ 3.00/cubic yard
Clearing and grubbing	$ 600.00/acre
Large tree removal	$ 265.00/tree

Streambank Stabilization Measures–In-stream Habitat Improvements

Streambank Stabilization	$ 55.00/foot
Live stakes	$ 2.00–$5.00/stake installed
Fascines	$ 6.50–$23.00/linear foot installed
Natural fiber rolls	$ 68.00/linear foot installed
Live crib walls	$ 13.00–$30.00/square foot of the front face
Root wads	$ 275.00–$1,200.00/root wad installed
Boulder placement	$ 650.00/ten boulders installed
Log vanes	$ 450.00/single wing installed
Rock vanes	$ 450.00/single wing installed
"J" Hook vanes	$ 550.00/vane installed
Rock deflectors	$ 450.00/deflector installed
Log deflectors	$ 500.00/deflector installed
Rock weirs (cross-vanes)	$ 1,450.00/vane installed

Streamside Buffers–Forest Buffers

Bare root seedling stock	$ 0.50–$1.75/seedling–not installed
Semi-transplanted bare root stock	$ 0.75–$2.20/seedling–not installed
Containerized stock (1–2 gallon)	$ 3.50–$7.50/container–not installed
Balled and burlapped stock	$ 30.00–$75.00/tree–not installed
Tree tube protectors	$ 0.75–$1.75/each–not installed
Buffer planted in seedlings	$ 1,050.00/acre
Reinforcement planting after 2 years	$ 70.00/acre
Mowing and general maintenance	$ 30.00/acre
Herbicide application	$ 100.00/acre
Riparian grass buffer seeding	$ 1,050.00/acre

Agricultural Best Management Practices

Conservation Tillage	$ 35.00/acre
Cropland Protection	$ 30.00/acre
Grazing Land Management	$ 400.00/acre
Vegetated Buffer Strip	$11,100.00/mile
Terraces and Diversions	$ 560.00/acre
Nutrient Management	$ 560.00/acre
Ag to Wetland Conversion	$14,500.00/acre

Ag to Forest Conversion	$ 6,750.00/acre
Streambank Fencing (high tensile, 2 wire)	$ 1.75–$2.25/linear foot installed
Stone ford cattle crossing	$ 600.00–$800.00/crossing installed
Stoned watering ramp	$ 350.00/ramp installed

Urban Best Management Practices	
Constructed Wetlands	$47,000.00/acre
Bio-retention Areas	$ 9,000.00/acre
Detention Basins	$12,000.00/acre

6.0 OBTAINING SUPPORT AND MONITORING PROGRESS

Education and cooperation of landowners within the watershed to implement best management practices and stream restoration solutions is the key to improving and preserving the natural resources and water quality of the Shamona Creek and East Branch Brandywine Creek Watersheds. Educating landowners as to why proposed improvements and changes should occur on their property is extremely important and takes tact, courtesy, respect and sometimes, persistence. Often times if they are clearly shown what is in it for them and helped to visualize the project's goals through actual examples (photographs) of completed projects, they are more likely to want to be a partner in a project. Furthermore, if you are able to communicate what the benefits of sound land management practices could mean to help improve the bottom line of partner farms and businesses, then they will be even more interested. Increases in crop production through preservation of topsoil and a decrease in veterinary bills for treating water borne and transmitted diseases such as mastitis (a painful udder infection that occurs in dairy cows) have a positive monetary effect.

The Brandywine Valley Association's presence in the community should facilitate landowner partnerships. Additional partnering will bring additional professional natural resources specialists into BVA projects and helps to further leverage available grant and funding resources. Some of the important teaming opportunities that are available to the Brandywine Valley Association include:

- Upper Uwchlan, Uwchlan, East Caln, East Bradford, East Brandywine, and Caln Townships, Downingtown Borough and Chester County Planning Commission (Adoption of protective municipal ordinance language to protect critical watershed resources)
- Brandywine Trout & Conservation Club
- Downingtown Borough's Shade Tree Commission (Make recommendations to Borough Council regarding rules and regulations governing the planting, maintenance, fertilization, pruning, bracing, removal and ordering of trees)
- Chester County Agricultural Preserve Board (Farmland Preservation)
- Chester County Conservation District (Agricultural BMP design, soil conservation and nutrient management, watershed consultation)
- Natural Resources Conservation Service (Conservation plans for individual farms and agricultural best management practices)

- Pennsylvania Department of Environmental Protection (Water quality studies and grant opportunities)
- Pennsylvania Department of Conservation & Natural Resources (Land preservation, resource management and grant opportunities)
- Pennsylvania Fish & Boat Commission (Fisheries protection, resource management and aquatic habitat improvement)
- Pennsylvania Game Commission (Wildlife protection and habitat improvement)
- Local Scout and Civic Groups (Riparian buffer volunteer planting)

7.0 LITERATURE CITED

Hook, D.D., B. Davis, J. Scott, and J. Strubble. 1995. *Locating Delineated Wetland Boundaries in Coastal South Carolina Using Global Positioning Systems*. Wetlands 15(1):31-36.

Pollution Reduction Impact Comparison Tool Version 2.0.8 (PRedICT). 2007. Penn State Institutes of the Environment.

Pennsylvania Department of Environmental Protection (DEP). 2008. *2008 Pennsylvania Integrated Water Quality Monitoring and Assessment Report.*

Trimble Navigation Limited. 1994. *GPS Pathfinder Professional System Operation Manuals.* Surveying and Mapping Division, PO Box 3642, Sunnyvale, California.

Walter, R. C. and D. J. Merritts. 2008. Natural Streams and the Legacy of Water-Powered Mills. Science 319(18 January 2008): 299.

APPENDIX A
FIELD INVESTIGATION MAP

APPENDIX B
GPS POINT DESCRIPTIONS AND ACTION ITEMS

APPENDIX C
POINT LOCATION DATA

APPENDIX D
PRELIMINARY PROBABLE CONSTRUCTION COST OPINION

APPENDIX E
PROFESSIONAL QUALIFICATIONS

Aaron S. Clauser, Ph.D., CPESC
At Clauser Environmental, LLC, he serves as Vice President and the technical/production lead on scientific projects. Dr. Clauser has his bachelor's degree in Biology and Environmental Studies from East Stroudsburg University of Pennsylvania and a doctorate in Environmental Science from Lehigh University. Dr. Clauser is a Certified Professional in Erosion and Sediment Control. He has experience as an environmental regulator with the Berks and Schuylkill Conservation Districts where he has served at both the technician and managerial levels. Dr. Clauser began consulting as a Senior Environmental Scientist and Project Manager for RETTEW Associates, Inc. He has given oral presentations at conferences held by the Ecological Society of America, American Society of Limnology and Oceanography, Coldwater Heritage Partnership, Partnership for the Delaware Estuary, Delaware Riverkeeper, Pocono Comparative Lakes Program and Schuylkill and Berks Conservation Districts and has collaborated on an article published about Pacific Northwest amphibians in a peer-reviewed journal. Dr. Clauser has completed numerous training courses including DEP sponsored NPDES, Chapter 102 and 105 technical seminars, Applied Fluvial Geomorphology for Engineers (FGE) by Wildland Hydrology, Inc., and Environmentally Sensitive Maintenance of Dirt and Gravel Roads Training. Dr. Clauser served in the PA Air National Guard where he attained the rank of Staff Sergeant. His doctoral dissertation entitled "Zooplankton to Amphibians: Sensitivity to UVR in Temporary Pools" includes quantitative optical and organismal level models that are extended to landscape level variations in pool optical properties and population level sensitivity to Ultraviolet Radiation.

Mark A. Metzler
At RETTEW, Mr. Metzler serves as the Watershed Specialist. Mr. Metzler has an associate's degree in Wildlife Technology from the Pennsylvania State University and is certified by the National Institute for Certification in Engineering Technologies in Land Management and Water Control / Erosion and Sediment Control. Mr. Metzler has ten years experience working in the environmental regulatory community (Lancaster County Conservation District) and three years of private consulting experience. He received training in both the 1987 Corps of Engineers Wetland Delineation Manual and the 1989 Federal Manual from both the PA Dept. of Environmental Protection and the US Corps of Engineers. In addition, he received soil mechanics training from the US Dept. of Agriculture – Natural Resources Conservation Service. As an environmental regulator, Mr. Metzler reviewed, permitted, and inspected over 2,000 various plans and project sites many of which involved impacts to Waters of the Commonwealth (wetlands, rivers, lakes). Mr. Metzler has designed several passive wetland treatment systems in conjunction with stream restoration projects in Lancaster County, PA and has performed wetland delineations in central and eastern Pennsylvania.

Joel M. Esh
Mr. Esh has an Associate in Specialized Technology Degree in Computer Aided Drafting and Design from York Technical Institute and 6 years of experience at RETTEW. He is responsible for the technical workload of the Natural Sciences department, including computer-aided drafting and design (CADD), global positioning systems (GPS), and geographic information systems (GIS). He has created and been involved with the design of stream restoration plans, dam removal plans, pond restoration plans, wetland mitigation plans, and wetland delineation plans. Additional training has included Introduction to Stream Processes and Ecology by Canaan

Valley Institute and West Virginia University. When working in the field, he has assisted with data collection and surveying for stream design and wetland delineations in PA, NY, and DE using the 1987 *Corps of Engineers Wetland Delineation Manual*. Utilizing GIS information, he has obtained and analyzed information for watershed assessments and created maps for grant applications and other uses. He has also been involved with cultural resources by performing site visits for documentation of buildings and bridges and creating plans for historic survey forms. In his first four years at RETTEW, he worked in the Transportation Engineering department, where he has directed data collection, prepared traffic engineering analysis, and completed PENNDOT plans involving right-of-way, traffic signals and highway occupancy permits utilizing PENNDOT resources.

Krista S. Clauser

As the President of Clauser Environmental, LLC, she is responsible for overall client satisfaction, quality assurance, educational outreach programs, and project management. Ms. Clauser has her bachelor's degree in Special Education and Elementary Education from Kutztown University of Pennsylvania and graduate level coursework in Education from Kutztown University of Pennsylvania and Indiana Wesleyan University. She has experience as a Special Education Teacher at Schuylkill Intermediate Unit and a homeschool educator at the elementary level. Ms. Clauser has expertise in integrating environmental/outdoor curricula into a diversity of subjects and educational settings.