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We answer to you.

# Restoration Plan
# for
# Trib. 414 Watershed
# Chester County, Pennsylvania
# August 2008

Prepared for:

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Red Streams BLUE
RAISING OUR STREAMS' I.Q.
A program of Red Clay Valley Association

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## 1.0 INTRODUCTION

“Red Streams Blue” is a program the Red Clay Valley Association has adopted to focus on improving the water quality of impaired stream sections throughout the Red Clay Watershed. While various sources of impairment affect Trib. 414, the impairment is primarily due to excessive agricultural siltation (including legacy sediment aspects) in the watershed (RETTEW 2008). The Pennsylvania Department of Environmental Protection (PADEP) includes the entire Trib. 414 watershed on its 303d list of impaired stream reaches (PADEP 2006).

The Trib. 414 Watershed includes a diverse mixture of land uses and cover types, ranging from rural farmland and forests to residential subdivisions and commercial areas. In general, the sections of the stream that include more forested cover along the riparian stream corridor and less impervious cover have better water quality.

This restoration plan for Trib. 414 Watershed presents strategies 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) typically are 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 at their origins. 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 commonly contains substances harmful to aquatic 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 a major cause of stream impairment.

### *1.1 Land Development Concerns*

The primary problem resulting from increased land development is 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 flow of Trib. 414 and the hydrology to riparian wetlands in the watershed can also be affected further by an increase in impervious surfaces.

Future land developments in the watershed will undergo regulatory review for stormwater discharge rates, volumes and water quality. Many of the existing developments within the watershed, including most of Parkesburg Borough pre-dates 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 Trib. 414 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*

This section of Chester County retains a relatively rural atmosphere in the face of rapidly expanding suburban sprawl. 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. 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). This is especially a concern in the lower portion of the watershed, where the lower stream gradient especially exacerbates this problem. On a geologic scale, the function of the stream will likely one day return. On a biotic scale, it is desirable to restore immediately 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 Trib. 414 Watershed in need of most attention, Red Clay Valley Association representatives and RETTEW scientists conducted stream walks on March 13 and 14, 2008. The walks included investigations of the mainstem and major tributaries in the Trib. 414 Watershed. 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.

RETTEW located the sample points and other features within the watershed using Trimble Pro XH Global Positioning System (GPS) receivers 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, c) PDOP Mask 6 to control the geometry of satellite constellations, and d) Mode Setting Overdetermined 3D which requires a minimum of five satellites for acceptable readings. 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 3.1). Correction files were obtained from a dedicated base station located in West Chester, 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 Trib. 414 Watershed and potential restoration practices that can be completed to address the noted impacts for high and medium priority areas. Each impacted segment identification number can be cross-referenced with its approximate location on the map in Appendix A. Low priority restoration projects are included in Appendix B and are mapped in Appendix A.

### *3.1 High Priority Projects:*

**Impacted Stream Segment #1-4:**

At the confluence of Trib. 414 and the East Branch of Red Clay Creek looking upstream on Trib. 414, a riparian forested buffer is lacking on the east side of the stream. The lawn area adjacent to the stream is mowed to the top of a 3-5' high eroded bank from points 1 through 4. Approximately 50 feet upstream of point #1, a 50 foot section of streambank was lined with broken concrete rip-rap. The stream has eroded behind the rip-rap area. The west side of the stream has a wide stream buffer. The plant community contains some invasive multi-flora rose.

**Solution:**

This section of stream requires streambank stabilization from a fluvial geomorphology (natural stream design) approach. The invasive multi-flora rose should be eradicated before a forested riparian buffer is planted with native tree and shrub species.

**Impacted Stream Segment #15:**

This section of Trib. 414 has evidence of the stream being relocated to its present location. It appears that Trib. 414 was diverted around the large off-line dam. At this location, the stream is attempting to reach a stable state and has eroded its streambank and is close to cutting through and spilling into the large off-line pond east of the stream. If the stream is able to cut through the bank at this location, approximately 600 feet of stream will go dry. Upstream of this location, the landowner is clearing the bank of vegetation.

**Solution:**

While the long-term stability of this section of the stream would include a major restoration effort to return the stream to its historic location, a much more practical approach is to stabilize the bank in the areas of erosion. Stabilization of this area should be coupled with landowner education, native riparian buffer plantings in the cleared area, and the inclusion of in-stream structures for fish habitat enhancement.

**Impacted Stream Segments #39-Headwaters and #73-Headwaters:**

The stormwater from the extensive impervious areas upstream of this location are likely the cause of much of the downslope degradation. While the stream is not incised and indicative of an impacted stream from a habitat standpoint, the shallow bedrock is likely playing a role in stabilizing this area. While points 39 and 73 indicate the areas of the watershed where stormwater management retrofits become most necessary, this high priority project is a watershed wide initiative. The field investigation map indicates where good sites for initial stormwater best management practice retrofit projects are located (Appendix A).

**Solution:**

Urban stormwater management retrofits that consider volume, rate, and water quality should be included with any work that drains into Trib. 414. While landowner education targeting homeowners will be helpful, an outreach program that targets the commercial areas of the watershed may have the greatest potential for success. Consideration should be given to development of a recognition program where businesses that install stormwater retrofits receive a "Friends of the Red Clay Watershed" sign to help identify them as a watershed steward to their patrons and employees. Educational programs in this community should focus on reducing the discharge of stormwater to Trib. 414. Stormwater retrofits including extended detention ponds, wet ponds, constructed wetlands, bioretention areas, filtering practices, infiltration practices (including drywells, infiltration trenches, permeable pavers, etc.), vegetated swales, green roofs, stormwater planters, rain gardens, rain barrels and stormwater cisterns should be encouraged (Shueler *et al* 2007).

**Impacted Stream Segment #57-58:**
This section of the stream includes a large well maintained ranch where livestock graze in several large pastures. An unnamed tributary to Trib. 414 flows through the center of the pastures and is freely accessible to livestock in the pastures. The streambanks in the upper section of this area are eroded up to three feet deep on the outside of meander bends.

**Solution:**
While a limited amount of streambank stabilization would be beneficial, the primary focus of restoration of this tributary should be on streambank fencing and establishing a riparian buffer. Fencing livestock out of the riparian corridor would allow for a forested riparian buffer to be installed. In areas where livestock need to cross the stream routinely, livestock crossings should be installed.

### *3.2 Medium Priority Projects:*

**Impacted Stream Segment #4-5:**

Upstream of this point, the eastern side of the stream is comprised of mature forest with 2-3 feet high eroded banks. The west side of the stream has 4-5 feet high eroded banks along this entire section. Multiflora rose is common in the open meadow/emergent wetland floodplain plant community located east of the stream.

**Solution:**

Streambank stabilization in this area that incorporates traditional streambank stabilization and natural stream design should be considered for this area. The wetlands and mature forest that surround this stream segment will add to the challenge of designing and permitting an effective natural stream design. The invasive multiflora rose should be eradicated from the project area.

**Impacted Stream Segment #17:**

The streambank in this area is freshly cleared and grubbed to the stream edge without erosion control best management practices.

**Solution:**

Install erosion and sedimentation controls according to Chester County Conservation District recommendations. A riparian buffer enhancement project that includes vegetating the streambank with native trees and shrubs should be considered.

**Impacted Stream Segment #19-23:**
From points 19 through 23, the riparian zone is mowed to the top of both streambanks.

**Solution:**
Riparian buffer enhancements in this area including native tree and shrub plantings to shade the stream would be a great benefit.

**Impacted Stream Segment #25-28:**
The streambanks throughout the majority of the stream segment from points 25 through 28 are incised approximately 3-4 feet deep. The upper end of this stream segment flows through a fallow field that is mowed to the top of the streambanks. While the lower section of the stream segment flows through a riparian buffer, invasive multiflora rose is dominant.

**Solution:**
Streambank stabilization utilizing traditional and natural stream design techniques. Invasive species removal should be completed throughout the entire stream segment area so that a native forested riparian stream buffer may be established.

**Impacted Stream Segment #34-36:**

The stream segment from points 34 through 36 includes a small (approximately 5 feet wide) stream buffer that is bordered by mowed lawn. The lawn area is relatively flat and just slightly above the grade of the stream. A depression east of the stream may be the remnants of a historic off-line ice dam. A small area of erosion around tile drains is present with approximately 2 feet high eroded streambanks in the downstream end of the stream segment. Further downstream is an area that recently has been planted with trees to create a forested riparian buffer.

**Solution:**

This section of stream may be an excellent location for the installation of a large floodplain bench wetland area that would help attenuate the effects of upstream stormwater discharges. Another less costly option to improve this stream section would be to install a forested riparian buffer throughout this section. Streambank stabilization in this area would be limited to traditional bank stabilization in the downstream section of the stream segment.

**Impacted Stream Segment #75:**

A stormwater outfall at this location is severely eroded from scour under the endwall.

**Solution:**

Maintain outfall by installing an energy dissipating device (likely rip-rap) and designing a stable channel (likely a step pool design). This area should be assessed for the installation of stormwater management retrofits.

## 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) regrading localized laterally eroded banks by grading to a more stable slope (3:1 horizontal to 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:***

Trib. 414 Watershed has 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 is 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.

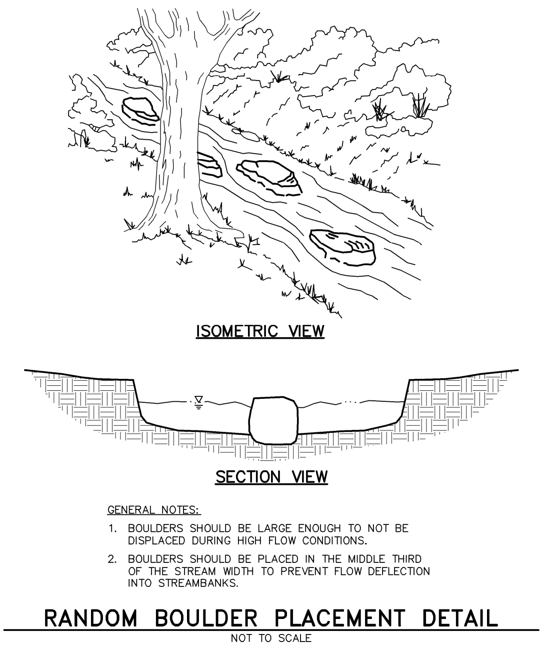
But just as sediment, fill, buildings and other encroachments were placed into the floodplain, they can also be removed and floodplains re-established. This has been done successfully in many stream restoration projects throughout the Commonwealth. Sometimes restoring a floodplain will also allow for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

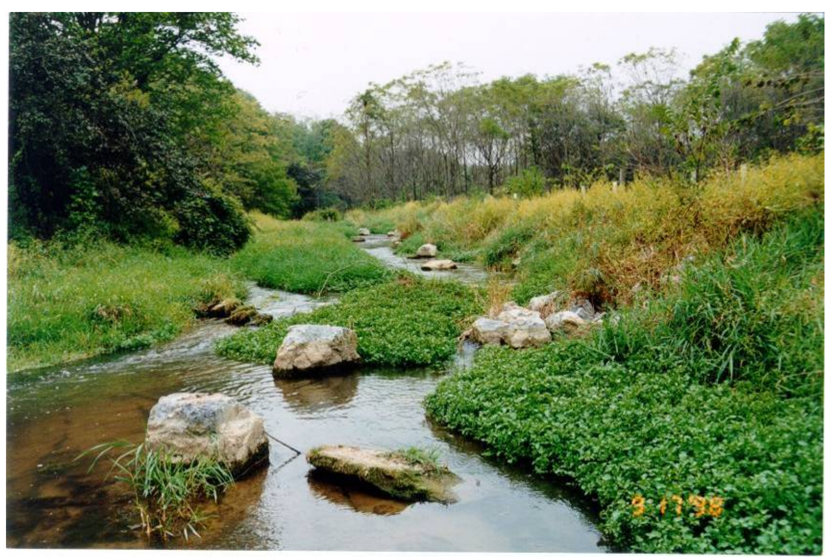
**Photograph of floodplain restoration – removing previously placed fill and legacy sediments.**

## 4.2 In-stream Habitat Improvements for Fishery

***Boulder placements:***

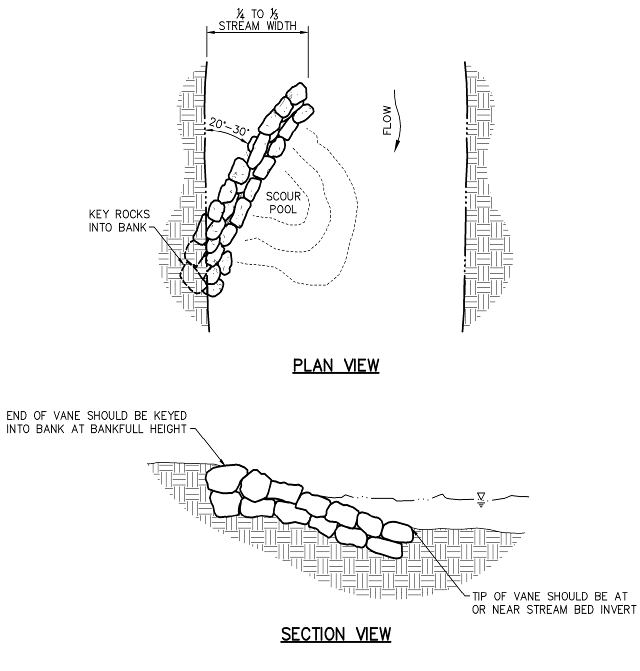
This type of fish habitat structure is very inexpensive and easy to install. It involves placing larger boulders (3-foot average diameter) with a track hoe or large backhoe. The large rocks provide instant cover for fish.



**Sample photograph of boulder placements**

## *Rock vanes:*

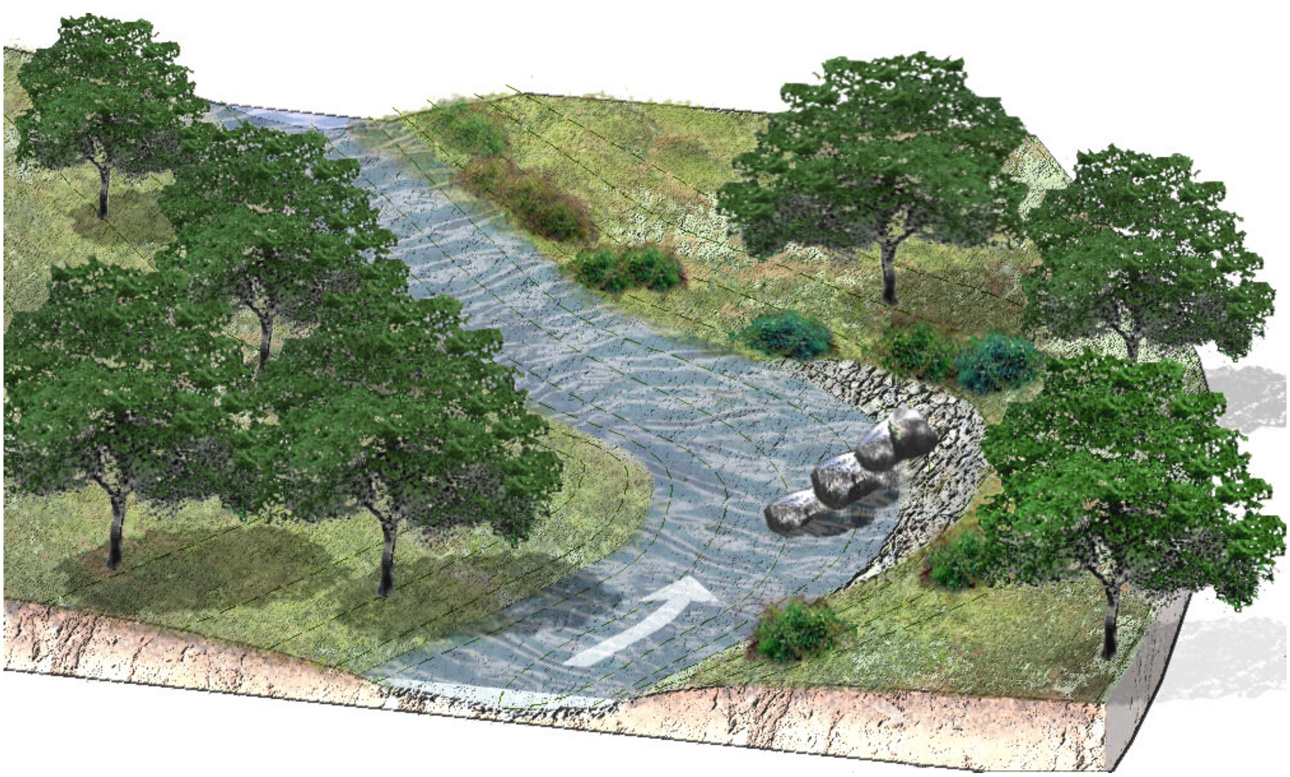



ROCK VANE DETAIL
NOT TO SCALE

Rock vanes are a means of redirecting 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.

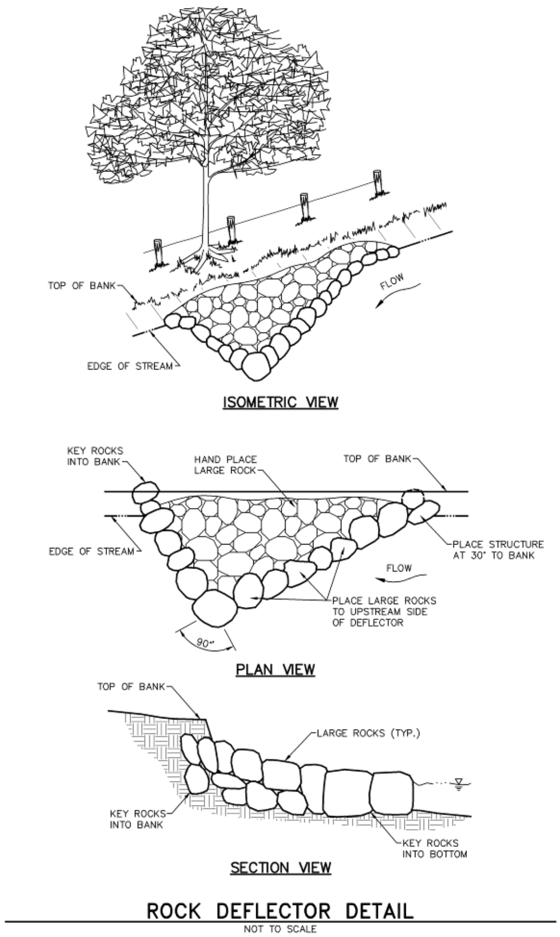
Costs will vary due to the availability of such rock in the general area, and ease of access into the work location.

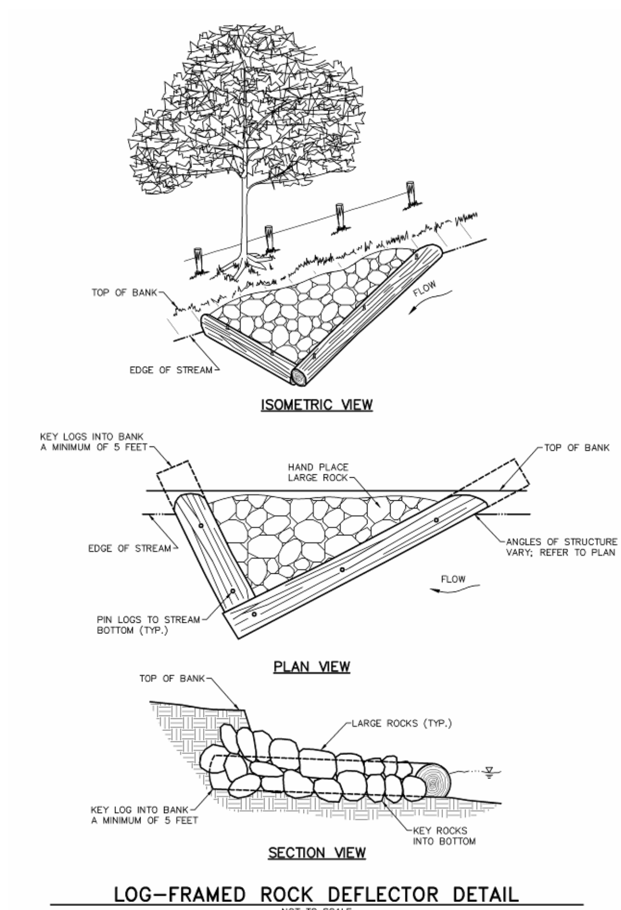


**Sample rendering of rock vane.**

***Rock deflectors and log frame deflectors:***

Rock and log frame deflectors are used to stabilize eroding streambanks and provide instream 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.

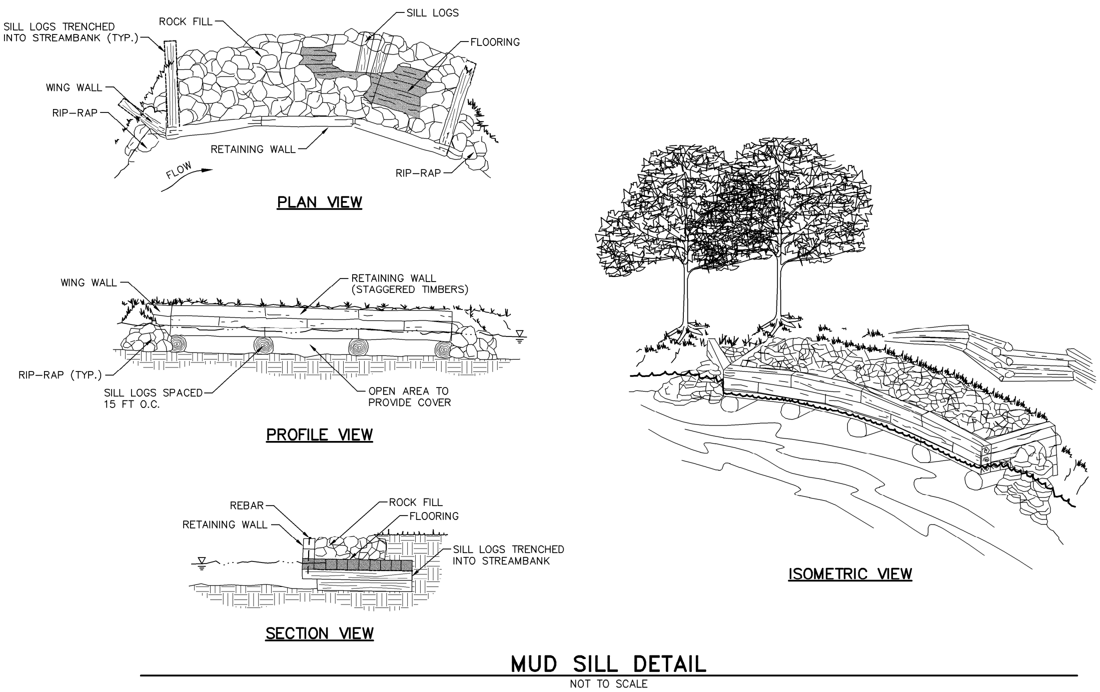



**Photograph of a newly installed log frame deflector.**

***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.




**Photograph of a mudsill indicated by the yellow arrow.**

### 4.3 Riparian Buffers and Landscaping

Forested riparian buffers have long been recognized as a vital component of stream health in ecoregions where they should be naturally occurring; Trib. 414 being no exception. 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 itself and/or in the case of nitrogen and phosphorus, as well as some heavy metals and toxic organics, be taken up through the root systems and stored in the tree and shrub's biomass (wood).

**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 force 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 native 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 recognitum*) | 6-12 | Food source–fruit | Tolerant | 6-8 |

Unfortunately, multiflora rose (*Rosa multiflora)* and mile-a-minute weed (*Persicaria perfoliata)* are very common invasive species within Trib. 414 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.

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. Also, mowing and such other physical removal means are labor intensive and many times not cost effective. Herbicide, when properly applied, can be a safe, efficient means of dealing with invasives.

## 4.4 Agricultural Improvements

***Streambank Fencing:*** Streambank fencing protects streambanks, promotes re-vegetation, enables forest buffer plantings, protects in-stream habitat and eliminates cattle from entering and loafing in the stream channel. The installation of a two-wire, high-tensile electric fence (powered by AC chargers or solar/battery chargers) is preferred. For construction, eight-foot long locust or pressure treated wooden fence posts should be pounded into the ground on 50-foot centers. Corners should be braced and constructed of 8-foot posts. Temporary poly wire electric fencing can be erected around planted riparian buffers until permanent fencing can be installed.

***Cattle Crossing:*** To direct cattle from barn to pasture or from one pasture to another, cattle crossings can be incorporated as needed into the streambank fence design to allow cattle to cross the stream at selected locations without damaging the integrity of the stream. Cattle crossings should be installed perpendicular across the stream and equipped with electric fence and droppers to deter cattle from wandering upstream or downstream of the crossing. Crossings can be constructed of rock (R-4 rock base covered with 2B stone) or through the use of concrete hog slats set at an 8:1 horizontal/vertical slope cut into streambanks. The center of the crossing should be set at the stream’s invert elevation.

***Nutrient Management:*** Nutrient management is a plan for managing the amount, source, placement, form and timing of the application of animal manure, chemical fertilizer, biosolids (sewage sludge) or other plant nutrients used in the production of agricultural products to prevent pollution, maintain soil productivity and achieve realistic yield goals. Nutrient management minimizes agricultural non-point source pollution of surface and ground water resources. Manure management facilities provide the opportunity to apply manure when soil conditions are suitable and crop nutrient needs are high. Manure storage facilities eliminate the need to haul and apply manure daily. Properly designed storage facilities are based on herd size, the area draining to the storage, wastewater and the nutrient management plan for the farm.

### 4.5 Stormwater Water Volume and Quality Improvement

Potential water volume and quality improvement projects associated with Trib. 414 should include a combination of existing facility retrofits and innovative applications during new construction. The PADEP BMP stormwater 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.

Stormwater capture for use in Trib. 414 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 bioretention areas to allow for wetland type plants to filter pollutants and minimize runoff should not be overlooked. 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 contain a healthy dose of ideas for naturalization of stormwater basins. The financial aspect of not mowing and fertilizing vs. maintenance of a naturalized basin should be included.

Additional ideas for stormwater management retrofits including the installation of large bioretention areas and constructed wetlands should be considered for this watershed due to the large amount of development that has already occurred in the headwaters.

**Photograph of a showcase naturalized stormwater basin in the Trib. 414 Watershed.**

## 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 both design and construction work. Time should be taken to prepare a thorough "request for bid" which specifically outlines work to be performed to the greatest detail currently known. Contractors should be given ample opportunity 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 may 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 and in 2008 dollars, 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 RETTEW:

| | |
|---|---|
| Equipment with Operator | |
| 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 |
| | |
| Materials | |
| Rock (rip-rap) | $ 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 | $ 5,600.00/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–$2.2/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 |

<u>Urban Best Management Practices</u>

| | |
|---|---|
| Constructed Wetlands | $47,000.00/acre |
| Bioretention 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 Trib. 414 Watershed. 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 shown clearly 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 Red Clay 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 Red Clay Valley Association include:

- East Marlborough and Kennett Townships and Chester County Planning Commission (Adoption of protective municipal ordinance language to protect critical watershed resources)
- Kennett Township Land Trust
- 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 management and protection, aquatic habitat improvement)
- Pennsylvania Game Commission (Wildlife protection, habitat improvement and policing)
- Local Scout and Civic Groups (Riparian buffer volunteer planting)

## 7.0 LITERATURE CITED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# APPENDIX A
# FIELD INVESTIGATION MAP

# APPENDIX B
# GPS POINT DESCRIPTIONS AND ACTION ITEMS

# GPS Point Descriptions and Action Items

| Point # | Description | Action Item | Key Partners | Red-Blue Priority | Comments |
|---|---|---|---|---|---|
| 1 | Confluence Trib. 414 and the East Branch of Red Clay Creek. Looking upstream on Trib. 414, no buffer on the east side of the stream, mowed to top of a 3-5' high eroded bank from points 1-4. Approx. 50 ft. upstream of the point is a 50 ft. section of broken concrete that was dumped as rip-rap. The west side of the stream has a wide stream buffer, and the plant community contains some invasive multi-flora rose. | Streambank stabilization, invasive species removal, riparian buffer enhancement. | Landowner, Agencies | High | The lack of wetlands on the east side of stream will simplify the permitting of restoration of this area. |
| 2 | 4" PVC outfall on the east bank. About 30 ft. upstream of the point, some construction debris has been dumped for streambank stabilization. | N/A | N/A | N/A | |
| 3 | Small online dam | N/A | N/A | N/A | |
| 4 | Intake structure from the small online dam. End of mowed to top of east bank. Upstream of this point, mature forest with 2-3 ft. eroded banks on east side. The west bank has 4-5 ft. eroded banks along this entire section. Some invasive species including multiflora rose in an open meadow/emergent wetland floodplain plant community. | Streambank stabilization, invasive species removal | Landowner, Agencies | Medium | |
| 5 | Top of open meadow floodplain area on the west bank. Upstream of this point is forested buffer on both sides of the stream. Upstream of this section, the banks are eroded 2-3 feet on the outside of meander bends, but are more stable than the downstream areas. | N/A | N/A | N/A | |
| 6 | An unnamed tributary discharges to the stream from the east side of the stream. Trib. 414 has stable banks in this section. | N/A | N/A | N/A | |
| 7 | Mowed within 10 feet of stream on the west bank for a 40 ft. section. Upstream of this point, 2-3 feet high streambanks are eroded. | Streambank stabilization, extend riparian buffer | Landowner, Agencies | Low | |
| 8 | Confluence of an unnamed tributary from the east. | N/A | N/A | N/A | |
| 9 | An unnamed tributary drains a small seep from the east. | N/A | N/A | N/A | |
| 10 | A palustrine emergent seep drains from the west at this point. From points 10-11, the streambanks are eroded approximately three feet primarily on the outside of meander bends. The in-stream cover in this area including woody debris provides good fish habitat. Oriental bittersweet and multiflora rose are dominant in the plant community upstream of this point. | Streambank stabilization, invasive species removal | Landowner, Agencies | Low | |
| 11 | Downstream edge of Hillendale Rd. bridge. A grass-lined roadside swale enters on the upstream side of the bridge. The stream is slightly over widened likely from past maintenance of the bridge. | N/A | N/A | N/A | |
| 12 | Confluence of outfall from a large off-line dam. | N/A | N/A | N/A | |

# GPS Point Descriptions and Action Items

| Point # | Description | Action Item | Key Partners | Red-Blue Priority | Comments |
|---|---|---|---|---|---|
| 13 | Seep enters from the west side of stream. From points 13-14, active agricultural fields are within 10-20 feet of the stream. The streambanks are eroded approximately 3 feet. Multiflora rose is dominant in the plant community. | Streambank stabilization, extend riparian buffer, invasive species removal | Landowner, Agencies | Low | |
| 14 | Confluence of an unnamed tributary from the west side of the stream. Upstream of this point, the stream is over widened and appears to have been excavated. The stable banks are 6-12' high. Fish habitat is lacking. | Fish habitat enhancement | Landowner, Agencies | Low | |
| 15 | Stream is eroding its bank and is very close to spilling into the large off-line pond east of the stream. The landowner is clearing the bank upstream of this point. | Streambank stabilization | Landowner, Agencies | High | |
| 16 | A small on-line 1-2' high dam under a private bridge exists at this location. | N/A | N/A | N/A | |
| 17 | A small pump in this location appears to be used to draw water for irrigation. The streambank in this area is freshly cleared and grubbed to the stream edge. | Riparian buffer enhancement | Landowner, Agencies, TreeVitalize | Medium | |
| 18 | A 3-4' high on-line dam at this location feeds the off-line pond. Fish likely are able to pass this barrier in high flow conditions. | N/A | N/A | N/A | |
| 19 | From point 19-23, the riparian zone is mowed to the top of both streambanks. | Riparian buffer enhancement | Landowner, Agencies, TreeVitalize | Medium | |
| 20 | Outfall pipe from off-line pond located west of the stream. | N/A | N/A | N/A | |
| 21 | A small wetland swale enters from the east. | N/A | N/A | N/A | |
| 22 | A small unnamed tributary enters from the west. | N/A | N/A | N/A | |
| 23 | Center of railroad bridge. Upstream of this point, riparian buffer exists on both sides of the stream. | N/A | N/A | N/A | |
| 24 | Roadway drainage discharges to the stream from the northwest. A 10-15' wide stream buffer in this area includes native plantings. The streambanks are 3-4' high. | Streambank stabilization | Landowner, Agencies | Low | |
| 25 | A small unnamed tributary discharges to the stream from the northwest. The 20-25' wide stream buffer in this area is very thick with multiflora rose. The streambanks are 3-4' high and are eroding. Proposed project area extends from points 25-28. | Streambank stabilization, invasive species removal | Landowner, Agencies | Medium | |
| 26 | Upstream of this point, the stream buffer narrows to 5-10' wide on both side of the stream with approx 3' high banks. | Streambank stabilization, invasive species removal, riparian buffer enhancement. | Landowner, Agencies | Medium | |

# GPS Point Descriptions and Action Items

| Point # | Description | Action Item | Key Partners | Red-Blue Priority | Comments |
|---|---|---|---|---|---|
| 27 | Downstream edge of Bayard Rd. stream crossing. In this section of the proposed project area, the vegetation is mowed to the top of the streambanks. | Streambank stabilization, invasive species removal, riparian buffer enhancement. | Landowner, Agencies | Medium | |
| 28 | Hillendale Rd. Bridge upstream edge. A 24" CMP discharges to the stream from the west. A small seep discharges from a spring house on the east side of the stream. This forested area is owned by the Kennett Township Land Trust. This section of the stream was determined to be unimpaired during the stream assessment. | N/A | N/A | N/A | |
| 29 | 18" CMP outfall draining stormwater from the west. Upstream of this point, the streambank is mowed to within 5-10' on both sides of the stream for approx. a 100' section. The west streambank is eroded and is an approx. 4' high bank. | Streambank stabilization, riparian buffer enhancement | Landowner, Agencies | Low | |
| 30 | Storm drain enters from the west through vegetated swales. A small unnamed tributary enters from the east approx. 15 feet upstream of the point. The east side of the stream has a 50-75' long section of 4' high eroded stream on the outside of a meander bend. | Streambank stabilization | Landowner, Agencies | Low | |
| 31 | A small vegetated swale discharges roadside drainage to the stream from a culvert pipe at this location. | N/A | N/A | N/A | |
| 32 | A small unnamed tributary enters from the east at this location. Upstream of this point, the streambanks are stable with an intermittently mowed buffer between the stream and the roadway that is approximately 20' from the streambank. | N/A | N/A | N/A | |
| 33 | Center of driveway crossing. Downstream of the bridge is a 30' area that is mowed to the top of bank. Upstream of the bridge, a 14" CMP discharges from the west. Upstream of the point is an area of stream restoration that includes native tree plantings. | Monitor restoration area to minimize invasive species, extend restoration area downstream | Landowner | Low | |
| 34 | Upstream edge of stream restoration area. Upstream of this point, the west side of stream is mowed to the top of bank. | Riparian buffer enhancement | Landowner, TreeVitalize | Medium | |
| 35 | The stream section from points 34-36 would be an excellent candidate for riparian buffer enhancement in the mowed area to the west of the stream. A small area of erosion around some tile drains is present with approx 2' high eroded streambanks. This field west of this section of the stream should be considered for a stormwater managment construction wetland. | Streambank stabilization, riparian buffer enhancement, constructed wetland | Landowner, Agencies, TreeVitalize | Medium | Stormwater Management |

# GPS Point Descriptions and Action Items

| Point # | Description | Action Item | Key Partners | Red-Blue Priority | Comments |
|---|---|---|---|---|---|
| 36 | Centerline of Sills Mill Bridge. A small unnamed tributary enters the stream from the east just downstream of the bridge. Upstream of this point is an on-line dam. The dam is acting as a sediment trap and allows a good bit of sediment to deposit in its backwater area. Fish passage to the headwaters is blocked by the dam. | Fish passage retrofit, dam removal | Landowner, Agencies, American Rivers | Low | |
| 37 | A small seep enters the stream from the west. | N/A | N/A | N/A | |
| 38 | Legacy sediments from Sills Mill Dam. The sediments in this location are from the backwater of the dam and would need to be include with the design of a removal of the Sills Mill Dam. | Legacy sediment removal, stream restoration with fluvial geomorphology techniques | Landowner, Agencies, American Rivers | Low | |
| 39 | The stormwater from the extensive impervious areas upstream of this location in subwatesheds 4 and 5 are likely the cause of much of the downslope degradation. Discharge pipe to stream along the east bank. Just downstream of the pipe, the stream flows over exposed bedrock that likely is controlling the grade of the stream in this area. | Stormwater retrofits in headwaters | Landowners, Townships, Agencies | High | Stormwater Management |
| 40 | Pond outfall from an offline pond to the east of the stream and confluence of unnamed tributary from the west. The area of the confluence is mowed to the top of streambank. | Riparian buffer enhancement | Landowner, TreeVitalize | Low | |
| 41 | Abandoned culvert stream crossing. | Remove stream encroachment | Landowner, Agencies | Low | |
| 42 | A fallow field north of the stream in this area is becoming overgrown with multiflora rose and invasive species. | Invasive species removal, Native riparian buffer plantings | Landowner, TreeVitalize | Low | |
| 43 | Downstream end of flood control structure that has been constructed on-line. The on-line control structure was blocked to fish passage by logs, leaves, and debris during the streamwalk. Small seeps enter the stream from both sides in the area of the structure. | Maintain fish passage through structure by clearing debris | Landowner | Low | |
| 44 | Downspouts at the top of the east bank are discharged directly to the stream. The stream bottom has exposed bedrock that controls grade in this area. | Stormwater volume retrofit | Landowner | Low | Stormwater Management |
| 45 | Roadway stream crossing. Upstream of this point, an on-line dam is constructed and includes gabion baskets and other hard engineering. Invasive *Phragmites* are dominant in the area of the pond inlet. | Invasive species removal, native plantings | Landowner | Low | |
| 46 | Outfall pipe from north. | N/A | N/A | N/A | |

# GPS Point Descriptions and Action Items

| Point # | Description | Action Item | Key Partners | Red-Blue Priority | Comments |
|---|---|---|---|---|---|
| 47 | Confluence of small off-line pond from east. Upstream of this point, the stream buffer is approximately 5 feet wide on the east side of steam. | Riparian buffer enhancement | Landowner, TreeVitalize | Low | |
| 48 | A new townhouse development in this area includes new stormwater control ponds and structures. A small off-line pond on the east side of the stream is currently dry. | N/A | N/A | N/A | |
| 49 | E&S controls below the new development appear effective including a large rock filter at this location. | N/A | N/A | N/A | |
| 50 | Upstream of this point, a woodlot includes riparian buffer on both sides of the stream. | N/A | N/A | N/A | |
| 51 | Outfall from an off-line pond on the west side of the stream. Construction debris has blown into the riparian area. | Litter clean-up | Landowner | Low | |
| 52 | A remnant of an on-line dam breast exists at this location | Remove stream encroachment | Landowner | Low | |
| 53 | Upstream of this point, the vegetation is mowed to within 5 feet of the west side of the streambank. The tributary has 3-4' high eroded streambanks. | Riparian buffer enhancement | Landowner | Low | |
| 54 | 5 tile drains, 1 stormwater pipe and 1 culvert from an upslope seepy area combine to begin the headwaters of the tributary. Stormwater appears to begin degrading the stream even at the top-most section of the watershed. | Stormwater volume retrofit | Landowner, Townships | Low | Stormwater Management |
| 55 | A small unnamed tributary drains into the unnamed tributary to Trib. 414 in this location. The stream flows through a forested area, but has 2-3 foot high eroded banks and a dominance of multiflora rose and oriental bittersweet in the plant community. | Invasive species removal, streambank stabilization | Landowner, Agencies | Low | |
| 56 | An unnamed tributary discharges to the stream in this location. | N/A | N/A | N/A | |
| 57 | Upstream of this point, a ranch with pasture straddles the stream corridor. The pasture is grazed to the stream and no provisions for riparian buffer have been made. The pastures are lightly stocked. | Streambank fencing, riparian buffer enhancement | Landowner, Agencies, TreeVitalize | High | |
| 58 | Upstream edge of the pasture area, the streambanks in this area are approx. 3 feet high and eroded on the outside of the meander bends. | Streambank fencing, riparian buffer enhancement, streambank stabilization | Landowner, Agencies, TreeVitalize | High | |
| 59 | Small seeps and drainage from roadway culverts enter the stream in this area. | N/A | N/A | N/A | |
| 60 | A seep drains from a small springhouse located north of the stream. | N/A | N/A | N/A | |
| 61 | Upstream edge of Bayard Rd. culvert. Downstream of this point, the southern streambank is steep and eroded. The stream enters a fenced in forested area. Downstream of the steep, eroded bank the streambanks are eroded and approx. 2 feet high. The stream bottom is a mix of cobble. | Streambank stabilization | Landowner, Agencies | Low | |

# GPS Point Descriptions and Action Items

| Point # | Description | Action Item | Key Partners | Red-Blue Priority | Comments |
|---|---|---|---|---|---|
| 62 | A small unnamed tributary enters the unnamed tributary from the west. The area immediately upstream of the confluence with Trib. 414 has some erosion of legacy sediments that were deposited in the low gradient of that area. | Streambank stabilization | Landowner, Agencies | Low | |
| 63 | A 12' high eroded streambank exists on the outside of a meander bend. The areas upstream and downstream of this point are stable. | Streambank stabilization | Landowner, Agencies | Low | |
| 64 | An erosional stormwater swale enters the stream from the west in this location. Downstream of this point, the stream flows through mature forest with stable banks. | N/A | N/A | N/A | |
| 65 | Downstream edge of bridge over the tributary. Litter has been discarded in this area. | Litter clean-up, stream signage to identify the stream as a resource | Landowner, Agencies | Low | |
| 66 | Railroad bridge over the tributary. The vegetation is mowed to the top of bank for approx. 30' above the bridge. Litter has been discarded between points 65-66 | Litter clean-up | Landowner | Low | |
| 67 | Abandoned stream crossing from an old driveway. The stream is surrounded by forested and wetland buffer. Some invasive *Phragmites* and multi-flora rose is present in the plant community. | Invasive species removal | Landowner | Low | |
| 68 | A drainage channel enters the stream from the east. Upstream of this point, the riparian buffer narrows. The mowed field east of this point should be considered for stormwater management retrofits such as a constructed wetland. | Riparian buffer enhancement, constructed wetland | Landowner, TreeVitalize | Low | Stormwater Management |
| 69 | Downstream of this point, the forested buffer is approximately 20' wide on the east side of the stream. The west side of the stream is forested downstream of this point. Upstream of this point, the forested buffer is approximately 10-20' wide | Riparian buffer enhancement | Landowner, TreeVitalize | Low | |
| 70 | Driveway crossing over stream. For approx. 100' below this point, the stream is mowed to the top of both banks. The stream is incised 2-3'. | Riparian buffer enhancement, streambank stabilization | Landowner, Agencies, TreeVitalize | Low | |
| 71 | Upstream of this point, the stream channel is stable and flows through a forested area. | N/A | N/A | N/A | |
| 72 | A stormwater management basin is located on the west side of the stream. | Native plantings retrofit in stormwater basin | Landowner | Low | Stormwater Management |

# GPS Point Descriptions and Action Items

| Point # | Description | Action Item | Key Partners | Red-Blue Priority | Comments |
|---|---|---|---|---|---|
| 73 | The incising stream in this section appears to be responding the large volumes of water leaving the upstream impervious area. The 3-4' high streambanks are eroding. The upslope stormwater basins appear to lack volume controls. This point is taken at the confluence of two tributaries. | Stormwater volume retrofit | Landowner, Agencies | High | Stormwater Management |
| 74 | An unnamed tributary discharges to the stream from a seep below a large stormwater basin. | N/A | N/A | N/A | |
| 75 | A stormwater outfall at this location is severely eroded from scour under the endwall. | Maintain outfall and assess for stormwater management retrofits | Landowner | Medium | Stormwater Management |
| 76 | Stormwater from the small development at the headwaters of this unnamed tributary is managed for rate through a stormwater basin. | Native plantings retrofit in stormwater basin | Landowner | Low | Stormwater Management |
| 77 | An unnamed tributary enters from the west in this location. The headwaters of the unnamed tributary includes drainage from development that has stormwater basins for rate management. | Native plantings retrofit in stormwater basin | Landowner | Low | Stormwater Management |
| 78 | Upstream of this point, the stream flows through a forested area. | N/A | N/A | N/A | |
| 79 | Several stormwater basins discharge to the stream in this section. The stormwater basins appear primarily designed for peak rate control. | Stormwater management retrofits including native plantings in the existing stormwater basins and new volume control BMPs. | Landowner | Low | Stormwater Management |
| 80 | An unnamed tributary enters from the west. The tributary contains a number of stormwater management basins that include native plantings. The effectiveness of the basins on this tributary could be monitored and make a nice study site to assess BMP effectiveness. | Monitor BMPs for effectiveness. | Graduate students/ interns | Low | Stormwater Management |
| 81 | A stormwater swale enters the tributary from the west in this area. The stormwater from this development appears to enter the stream without management. | Stormwater management retrofits | Landowner, Municipality | Low | Stormwater Management |
| 82 | The stream in this area appears manicured with the streambanks consisting of rock retaining walls. Additional shading of the stream would enhance this area. | Riparian buffer enhancement, restore natural stream dimensions | Landowner | Low | |

# GPS Point Descriptions and Action Items

| Point # | Description | Action Item | Key Partners | Red-Blue Priority | Comments |
|---|---|---|---|---|---|
| 83 | Upstream of this point, the stream crosses under Longwood Rd. and enters a successional forest area. | N/A | N/A | N/A | |
| 84 | Unnamed tributary through a forested area. The streambanks are 3-4' high and eroded and appear to be responding from increased stormwater due to impervious increases in the watershed. | Stormwater management retrofits, streambank stabilization | Landowner, Agencies | Low | |

# APPENDIX C
# POINT LOCATION DATA

# Point Location Data

| Point # | Northing | Easting | Approx. Elev. |
|---|---|---|---|
| 1 | 187470.00 | 2547394.98 | 233 |
| 2 | 188065.04 | 2547330.56 | 237 |
| 3 | 188265.61 | 2547358.10 | 233 |
| 4 | 188289.29 | 2547375.14 | 236 |
| 5 | 188843.65 | 2547471.91 | 245 |
| 6 | 188943.33 | 2547580.89 | 247 |
| 7 | 189117.49 | 2547396.89 | 244 |
| 8 | 189439.50 | 2547536.27 | 247 |
| 9 | 189853.91 | 2547485.11 | 246 |
| 10 | 190155.92 | 2547537.67 | 240 |
| 11 | 190987.22 | 2547550.47 | 257 |
| 12 | 191216.13 | 2547865.21 | 258 |
| 13 | 191310.58 | 2547875.47 | 254 |
| 14 | 191454.42 | 2548162.14 | 256 |
| 15 | 191795.42 | 2548647.50 | 260 |
| 16 | 191898.44 | 2548711.26 | 264 |
| 17 | 192013.11 | 2548753.97 | 249 |
| 18 | 192396.86 | 2548952.09 | 270 |
| 19 | 192427.89 | 2549023.40 | 267 |
| 20 | 192463.35 | 2549147.85 | 264 |
| 21 | 192511.28 | 2549410.47 | 271 |
| 22 | 192801.51 | 2549496.66 | 272 |
| 23 | 193016.68 | 2549601.34 | 294 |
| 24 | 193187.64 | 2549586.45 | 277 |
| 25 | 193462.12 | 2550050.56 | 274 |
| 26 | 193686.61 | 2550213.13 | 281 |
| 27 | 193996.16 | 2550534.41 | 288 |
| 28 | 194169.23 | 2550705.48 | 286 |
| 29 | 194905.82 | 2550741.35 | 296 |
| 30 | 195119.70 | 2550812.07 | 291 |
| 31 | 195381.51 | 2550807.95 | 293 |
| 32 | 195434.83 | 2550800.93 | 292 |
| 33 | 195757.26 | 2550741.33 | 308 |
| 34 | 196105.11 | 2550879.84 | 293 |
| 35 | 196193.94 | 2550818.83 | 300 |
| 36 | 196493.36 | 2550777.72 | 315 |
| 37 | 197161.65 | 2550412.41 | 319 |
| 38 | 197564.40 | 2550390.80 | 340 |
| 39 | 198158.67 | 2550239.02 | 347 |
| 40 | 198291.23 | 2550145.33 | 331 |
| 41 | 198430.43 | 2550118.21 | 343 |
| 42 | 198755.48 | 2550290.90 | 359 |

| Point # | Northing | Easting | Approx. Elev. |
|---|---|---|---|
| 43 | 198959.68 | 2550409.18 | 366 |
| 44 | 199278.08 | 2550778.88 | 372 |
| 45 | 199465.45 | 2550903.39 | 372 |
| 46 | 199752.45 | 2551176.44 | 374 |
| 47 | 199973.29 | 2551453.42 | 383 |
| 48 | 200321.28 | 2551802.06 | 401 |
| 49 | 200409.98 | 2551907.52 | 409 |
| 50 | 200437.68 | 2551967.65 | 408 |
| 51 | 200540.02 | 2552140.42 | 408 |
| 52 | 200635.07 | 2552210.89 | 422 |
| 53 | 200745.27 | 2552317.48 | 428 |
| 54 | 200859.42 | 2552403.18 | 426 |
| 55 | 189659.73 | 2547732.85 | 244 |
| 56 | 190042.20 | 2548260.18 | 261 |
| 57 | 190202.51 | 2548551.58 | 249 |
| 58 | 190376.47 | 2550546.03 | 277 |
| 59 | 190317.00 | 2550908.94 | 285 |
| 60 | 190351.98 | 2551119.69 | 289 |
| 61 | 190422.71 | 2551738.66 | 275 |
| 62 | 192279.74 | 2548098.84 | 272 |
| 63 | 192308.85 | 2547886.55 | 284 |
| 64 | 192747.72 | 2547638.92 | 289 |
| 65 | 192984.32 | 2547536.36 | 307 |
| 66 | 193264.15 | 2547425.25 | 305 |
| 67 | 194075.07 | 2547483.78 | 302 |
| 68 | 194853.21 | 2547274.77 | 318 |
| 69 | 195245.63 | 2547085.87 | 329 |
| 70 | 195587.95 | 2546964.32 | 344 |
| 71 | 195787.46 | 2546934.17 | 344 |
| 72 | 196206.58 | 2546895.87 | 367 |
| 73 | 196477.14 | 2546772.48 | 369 |
| 74 | 196581.17 | 2546783.88 | 365 |
| 75 | 196788.54 | 2546953.66 | 394 |
| 76 | 195198.36 | 2549335.77 | 328 |
| 77 | 196747.57 | 2550274.99 | 326 |
| 78 | 198277.67 | 2549824.16 | 330 |
| 79 | 199103.43 | 2549348.94 | 341 |
| 80 | 199645.09 | 2549200.51 | 350 |
| 81 | 200619.05 | 2549022.56 | 366 |
| 82 | 201560.02 | 2549043.39 | 388 |
| 83 | 201817.84 | 2548918.39 | 395 |
| 84 | 194340.94 | 2551158.11 | 290 |

Data is based on State Plane Coordinate System PA South, NAD83 datum.

# APPENDIX D
# PRELIMINARY PROBABLE CONSTRUCTION COST OPINION

RETTEW
We answer to you.

# Trib. 414 Watershed Preliminary Probable Construction Cost Opinion

| Site | Min Cost | Max Cost | |
|---|---|---|---|
| **1-4** | $125,000 | $200,000 | |
| **4-5** | $95,000 | $135,000 | |
| **15** | $10,000 | $30,000 | |
| **17** | $750 | $2,500 | |
| **19-23** | $2,500 | $5,000 | |
| **25-28** | $135,000 | $210,000 | |
| **34-36** | $1,000 | $90,000 | * |
| **39-Headwaters** | $5,000 | $200,000 | ** |
| **57-58** | $25,000 | $50,000 | |
| **73-Headwaters** | $5,000 | $100,000 | ** |
| **75** | $2,000 | $3,500 | |
| | $406,250 | $1,026,000 | |

* Minimum costs for this item include only riparian buffer enhancement; maximum costs include constructing a wetland

** Minimum costs for this item include only a mini-grant for environmental education; maximum costs include BMP retrofits.

RETTEW Associates, Inc. is not a construction contractor and therefore probable construction cost opinions are made on the basis of RETTEW's experience and qualifications as an engineer and represent RETTEW's best judgment as an experienced and qualified design professional generally familiar with the industry. This requires RETTEW to make a number of assumptions as to actual conditions which will be encountered on the site; the specific decisions of other design professionals engaged; the means and methods of construction the contractor will employ; contractors' techniques in determining prices and market conditions at the time, and other factors over which RETTEW has no control. Given these assumptions which must be made, RETTEW states that the above probable construction cost opinion is a fair and reasonable estimate for construction costs but cannot and does not guarantee that actual construction cost will not vary from the Probable Construction Cost Opinion prepared by RETTEW.

APPENDIX E
PROFESSIONAL QUALIFICATIONS

**Aaron S. Clauser, Ph.D., CPESC** - 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 has given oral presentations at conferences held by the Ecological Society of America, American Society of Limnology and Oceanography, 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. He is familiar with the 1987 *Corps of Engineers Wetland Delineation Manual*. Dr. Clauser has both conducted and been accepted as an expert witness regarding wetland delineations. 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 UVR

**Joel M. Esh** – Mr. Esh has an Associate in Specialized Technology Degree in Computer Aided Drafting and Design from York Technical Institute and 7 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.

**Jonathan P. Kasitz** – Mr. Kasitz has a bachelor’s degree in Biology/Ecology from Millersville University. He has used the 1987 *Corps of Engineers Wetland Delineation Manual* for numerous field delineations in PA, MD and NY. He has completed the U.S. Army Corp of Engineers’ Wetland Delineation Course. He has also been trained in several different stream assessment protocols, both in the eastern U. S. as well as in the Rocky Mountain region. Mr. Kasitz participated in internships with the PA Department of Environmental Protection in their Water Quality division and with the PA Department of Military and Veteran Affairs as a Biology Tech at Fort Indiantown Gap. He has worked with various government agencies including the

National Park Service at Yellowstone NP and the US Forest Service in Colorado. He has performed biological surveys for many different threatened and endangered species across the country. He also completed honors research on the effects of ponds on stream nitrate levels in Lancaster County while at Millersville.

**Daniel P. Synoracki** - Mr. Synoracki has bachelor degrees in Biology and Environmental Planning from Bloomsburg University of Pennsylvania. Mr. Synoracki has 21 years experience in environmental sciences and consulting. Trained in use of both the 1987 *Corps of Engineers Wetland Delineation Manual* and the 1989 Federal Manual, Mr. Synoracki has delineated numerous wetlands and coordinated successful permit applications for various developers, industries, utilities and state agencies in Pennsylvania, New Jersey, Delaware, Ohio, and Michigan. Mr. Synoracki has completed several training courses, including wetland delineation courses by the U.S. Army Corps of Engineers and the Wetland Training Institute, Applied Fluvial Geomorphology (FGM) by Pilotview, Inc., Habitat Evaluation Procedures and Instream Flow Incremental Measurements by the U.S. Fish and Wildlife Service, and Chapter 105 regulations by the Pennsylvania Department of Environmental Resources. Mr. Synoracki also has designed several stream and wetland mitigation and restoration plans, has provided oversight for compensatory wetland construction and implemented various monitoring programs through the collection and analysis of vegetation success and hydrology parameters.