RETTEW

We answer to you.

Restoration Plan
for
Little Buck Run Watershed
Chester County, Pennsylvania
August 2008

Prepared for:

Brandywine Valley Association
Robert G. Struble, Jr., Executive Director
1760 Unionville-Wawaset Road
West Chester, PA 19382
(610) 793-1090
(610) 793-2813 fax

A BVA PROGRAM

Prepared by:

RETTEW Associates, Inc.
Natural Sciences Group
950 East Main Street, Suite 220
Schuylkill Haven, PA 17972
(570) 385-2270
(570) 385-2217 fax
RETTEW Project No. 07-07568-003

Prepared by: Aaron S. Clauser
Aaron S. Clauser, PhD, CPESC
Senior Environmental Scientist

Reviewed by: Daniel P. Synoracki
Daniel P. Synoracki
Senior Environmental Scientist

TABLE OF CONTENTS

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. Little Buck Run (a tributary to Buck Run, tributary to Brandywine Creek) is an impaired or "red" stream due primarily to excessive sediment and corresponding siltation in the watershed. The PA Department of Environmental Protection includes the entire Little Buck Run watershed on its 303d list of impaired stream reaches (DEP 2006).

The 3.8 square mile Little Buck Run Watershed includes a very diverse mix of land uses. Cover types range from rural Amish farmland and forests to new single-family subdivisions and urban areas in Parkesburg Borough. In general, the sub-watersheds that support more forested cover along the riparian stream corridor and less impervious cover have better water quality.

Here, a restoration plan for Little Buck Run Watershed 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 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 Little Buck Run and the hydrology to riparian wetlands in the watershed also 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 Parkesburg Borough, 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 Little Buck Run 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 western part of Chester County retains a relatively rural atmosphere in the face of growing suburban sprawl. Most of the farms within the Little Buck Run Watershed are concentrated in the headwaters, especially on the northwest end of the watershed. However, 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. Dams that were constructed throughout the watershed allowed for 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 Little Buck Run Watershed in need of most attention, Brandywine Valley Association representatives and RETTEW scientists conducted stream walks on June 5th and 26th, 2008. These walks included investigations of the mainstem and major tributaries in the Little Buck Run 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 Little Buck Run Watershed 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 #9-13:

From points 9 through 13, approximately 40 percent of the streambank is eroded and is incised approximately 3-4 feet deep. The south side of the stream is in hay within 5-15 feet of the stream. The north side of the stream has an emergent wetland/meadow buffer that extends approximately 50 feet from the stream. The buffer is bordered by active agricultural fields. The irregular meander bends and unstable stream banks are indicative of a stream that is transitioning in form. Upstream of point 13, the streambanks are stable, but the stream appears unnaturally straightened, downstream of point 14, the streambanks are unstable and the meander wavelength appears very short and irregular.

Solution:

This unstable stream reach is an excellent candidate for stream restoration with an applied fluvial geomorphology (natural stream design) approach. The restoration project will likely include creating a new stable stream channel. The stable channel should be re-connected to a floodplain that is planted with native trees and shrubs. When implemented, this project will likely have defined, measurable water quality benefits including decreased sediment and nutrient loading and temperature reduction as well as habitat benefits for fish and other aquatic organisms.

Impacted Stream Segment #15-17:

The streambanks from points 15 through 17 are highly unstable and are 3-6 feet high and severely eroded. The stream bottom is comprised of fine sediment. This area is the most impaired in the watershed (RETTEW 2008). The project area is in a pasture that was not being grazed. An unnamed tributary enters this reach from the southwest and suffers similar degradation as the mainstem from where it crosses under SR-10 to its confluence with Little Buck Run.

Solution:

The restoration of this section of stream will include applying fluvial geomorphological concepts to design a stable stream reach. The design will likely include the use of instream structures for interim stabilization and then a combination of trees, shrubs, and herbaceous vegetation to provide long-term stability. While some existing wetlands will potentially increase the rigor of the permitting process, most of the area immediately adjacent to the existing stream is upland. One strategy that should be considered is incorporating floodplain wetlands into the design to help mitigate the effects of stormwater and other pollutants discharged from the borough. If this area is to remain in pasture, streambank fencing, forested riparian buffer, and stone cattle crossings should be incorporated into the design.

Impacted Stream Segment #19:

Parkesburg Borough has a very nice small-town atmosphere that experienced little change over the last fifty plus years. With that, the stormwater management infrastructure lacks many of the volume and rate controls that are now standard with land development. Little Buck Run receives most of the stormwater runoff and corresponding pollutants that discharge from the borough.

Solution:

Urban stormwater management retrofits that consider volume, rate, and water quality should be included with any work that drains into Little Buck Run (including areas that drain via the storm sewer system). Educational programs in this community should focus on reducing the discharge of stormwater to Little Buck Run. A park reforestation project that includes community volunteers to expand the riparian corridor through the borough park and rewards each participating volunteer with a rainbarrel would be a good first step. The event could include an informative table presentation where information on construction of small raingardens and use of rainbarrels and stormwater cisterns is provided. Other stormwater retrofit best management practices that have been shown to be effective include extended detention ponds, wet ponds, constructed wetlands, bioretention areas, filtering practices, infiltration practices (including drywells, infiltration trenches, permeable pavers, etc.), vegetated swales, green roofs, and stormwater planters.

Impacted Stream Segment #35:

The dam at this location is the largest on-line dam in the Little Buck Run Watershed. The dam currently is full of sediment and appears less than 2' deep at the deepest point. The shallow depth and lack of shading likely allow the water in the dam pool to increase in temperature. The upstream nutrient discharges likely contribute to excessive algal growth (in a process called eutrophication) in the dam pool. Anoxic conditions (reduced dissolved oxygen) typically result from algal population crashes and sometimes result in severe impacts to fish populations. The dam also blocks upstream fish migration.

Solution:

The best solution for this dam and improvement of water quality in the Little Buck Run Watershed would be its removal to allow for fish passage and reduce the potential for increasing the stream water temperature. A removal design that includes a floodplain with wetlands connected to the stream could help to mitigate the effects of upstream nutrient additions. The use of native trees and shrubs in the design to shade the stream should also be included. As per Parkesburg Borough representatives, the dam is currently being considered for removal.

Impacted Stream Segment #39-Headwaters:

The headwaters of Little Buck Run consists of several unnamed tributaries that drain through several dairy/beef farms that have pasture around the stream. Cattle have unrestricted access to the stream and likely contribute to nutrient pollution throughout the watershed.

Solution:

While some efforts have been made at a headwaters farm to install agricultural best management practices such as agricultural stream crossings (rather than fords) and a manure storage tank, more remains to be done. Of critical importance to restoring the stream is the installation of streambank fencing and cattle crossings in pasturelands. The fenced-in area should include riparian tree and shrub plantings to help shade the stream. While work immediately adjacent to the stream is often viewed as most critical, the upland areas that drain to the stream should not be overlooked. The NRCS and county conservation district should be contacted to ensure that up-to-date conservation plans are being implemented by farmers in the headwaters (and throughout the watershed).

3.2 Medium Priority Projects:

Impacted Stream Segment #14-15:
The southern streambank in this section is eroding and includes a 2 to 3 feet high eroded bank. Some areas of the bank have been undermined and have fallen into the stream via mass wasting. The vegetation is mowed to within five feet of the streambank.

Solution:
Stream restoration using traditional bank re-grading, fluvial geomorphology techniques, and riparian buffer enhancement.

Impacted Stream Segment #36-38:
The stream channel through this section appears to have been straightened and altered through agricultural operations. The stream is incised approximately 3 feet deep and is disconnected from its floodplain, but most of the streambank is stable with thick vegetation. The fields on both sides of this stream segment are in hay and are mowed within several feet of the stream.

Solution:
The primary focus of restoration in this area should be on riparian buffer enhancement. The NRCS and conservation district should be contacted to ensure up-to-date conservation plans are being implemented. The fields immediately adjacent to the stream should be considered for a project similar to those of the CREP program. While floodplain reconnection would be ideal, the minimal impervious area of the headwaters, typically low flows of the channel and stable streambanks make floodplain reconnection in this area less of a priority than in other areas of the watershed.

Impacted Stream Segment #42-46:

The majority of this stream segment has minimial to no buffer from surrounding encroachments. The upper section of the segment includes mowed lawn to the streambank. The lower section includes an area where sheep and horses have direct access to the stream. Fill in the floodway for roadways and several bridges over the stream has resulted in several areas with eroded streambanks. However, the areas of erosion are not severe and are infrequent.

Solution:
The installation of streambank fencing to keep the sheep and horses out of the stream would be a benefit. This section would be a great candidate for installation of a riparian buffer that incorporates native tree and shrub plantings. Landowner education will be key in developing the buffer and ensuring it is appropriately managed to minimize the colonization of the area by invasive species.

Impacted Stream Segment #48-50:

A lack of riparian buffer in this area exposes the stream to warming by the sun. A buffer could also filter runoff with potential pollutants from the lawn areas that the stream flows through. A small area of erosion exists near point 48, the remainder of the reach has mowed lawn to the ordinary high water mark. A small on-line dam also blocks fish passage into the headwaters area.

Solution:
Riparian buffer enhancements including native tree and shrub plantings to shade the stream and create a more diverse terrestrial wildlife habitat would be a great benefit. A removal of the small dam would open the tributary up to fish passage and should encourage small fish to move into the headwaters of the unnamed tributary.

Impacted Stream Segment #56:

This stream reach flows through mature forest. The forest includes SR-10. Some impacts from the highway drainage are possible. This area includes several All-Terrain Vehicle (ATV) trails and stream crossings. The trails leading to the stream cut across the sloping hill above the stream and collect runoff. The runoff is eroding the trails and is contributing to sediment discharging to the tributary.

Solution:

Install waterbars/trail improvements to dissipate water that collects in the trails leading to the point of the crossing. Upgrade crossings so that they are perpendicular to the stream and have level, natural rock approaches.

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.

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.

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

Floodplain Restoration:

Little Buck Run 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 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.

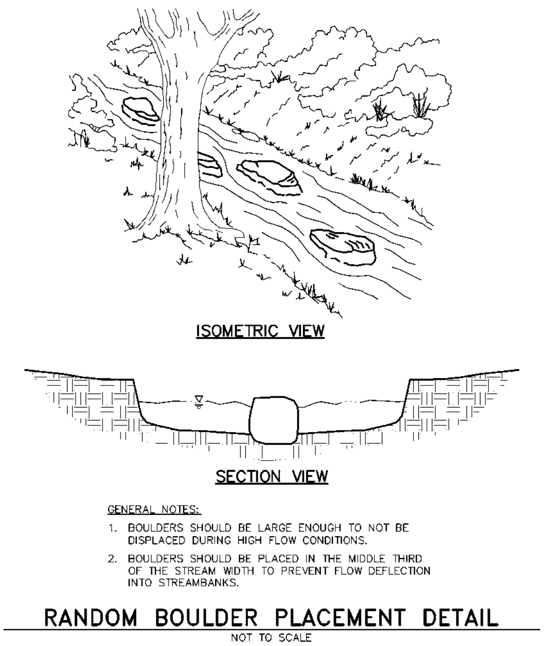
But just as sediment, fill, buildings and other encroachments were placed into the floodplain, they can also be removed and floodplains re-established. This has been done successfully in many stream restoration projects throughout the Commonwealth. Sometimes restoring a floodplain will also allow for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

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

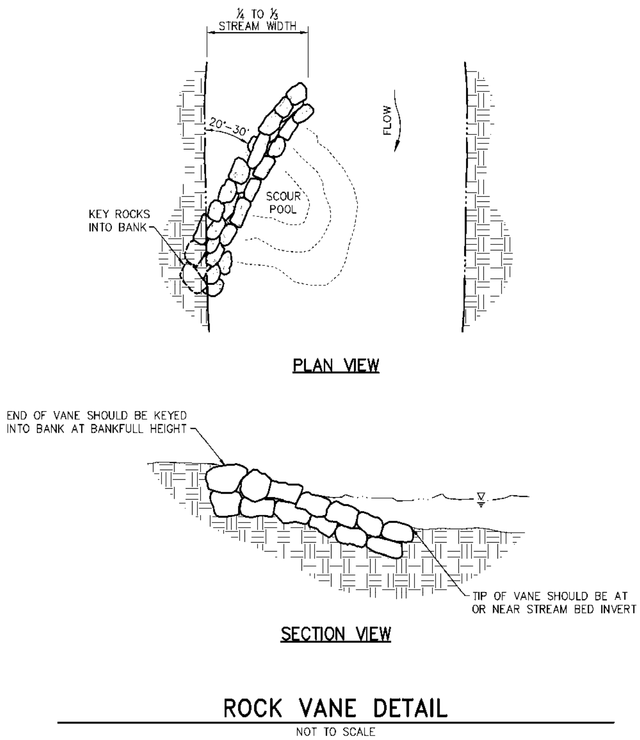
4.2 In-stream Habitat Improvements for Fishery

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

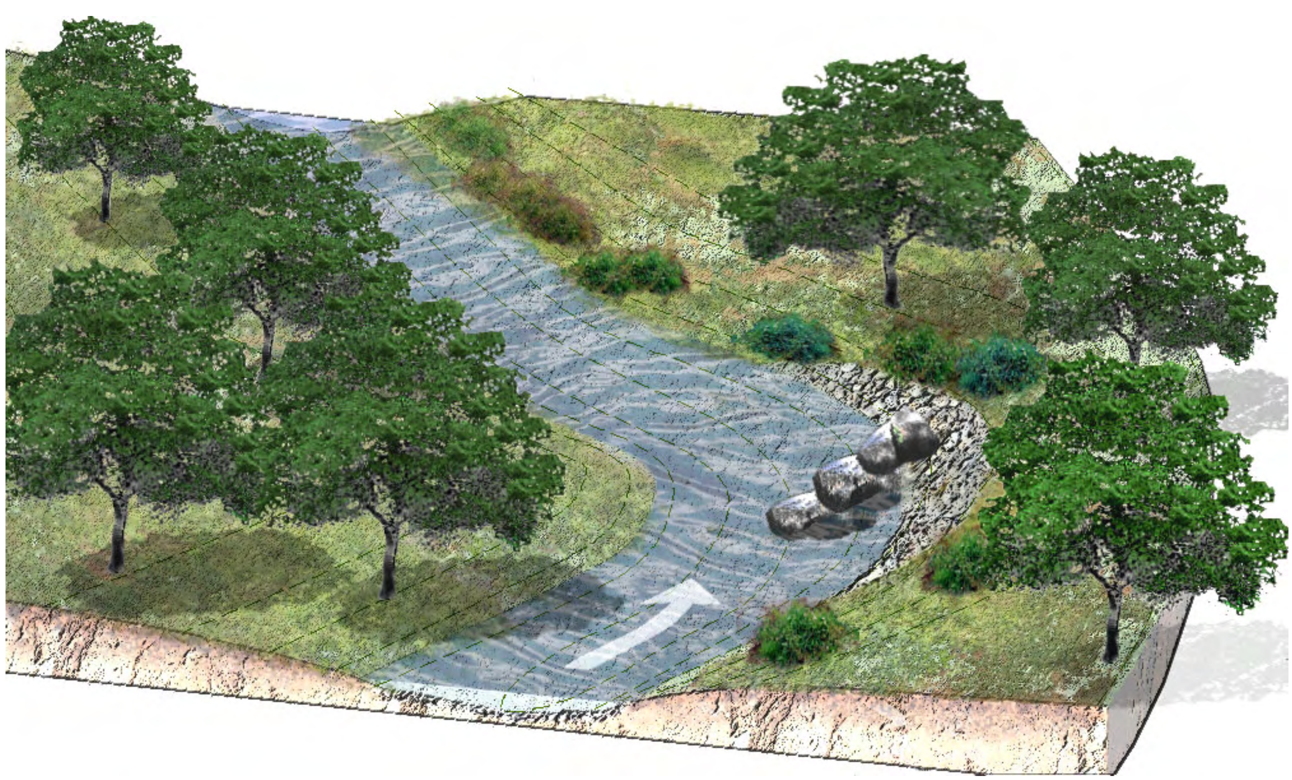


Rock vanes:

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.

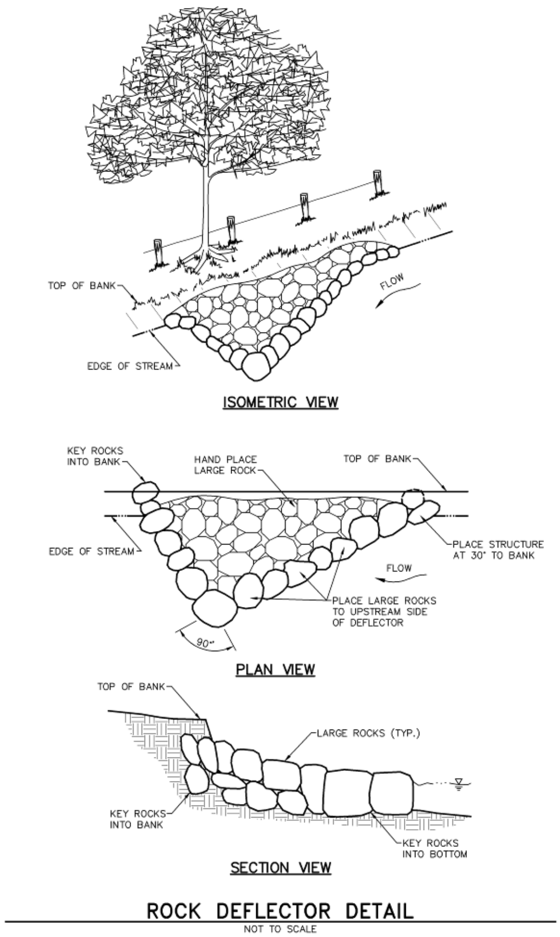
Costs will vary due to the availability of such rock in the general area, and ease of access into the work location.

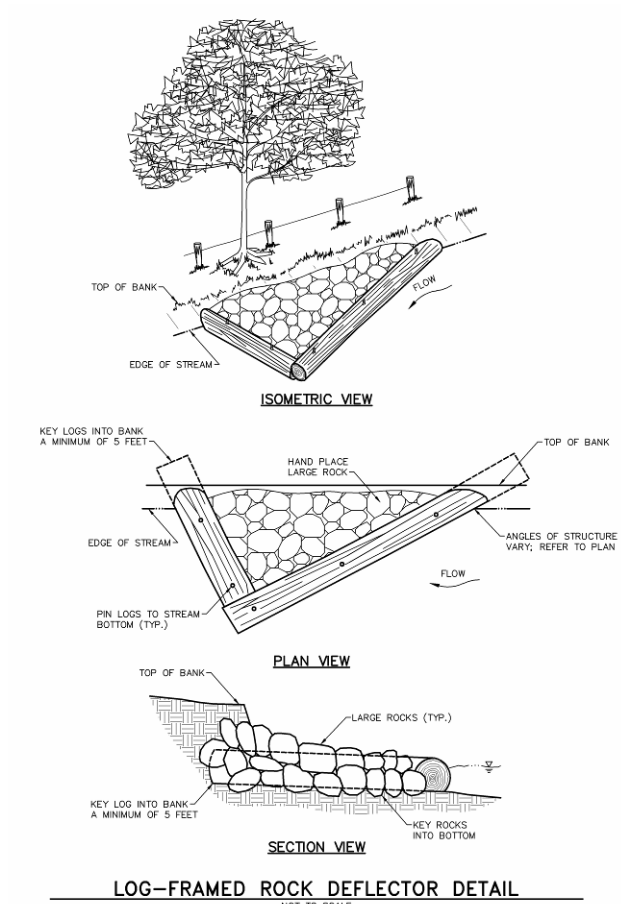


Sample rendering of rock vane

Rock deflectors and log frame deflectors:

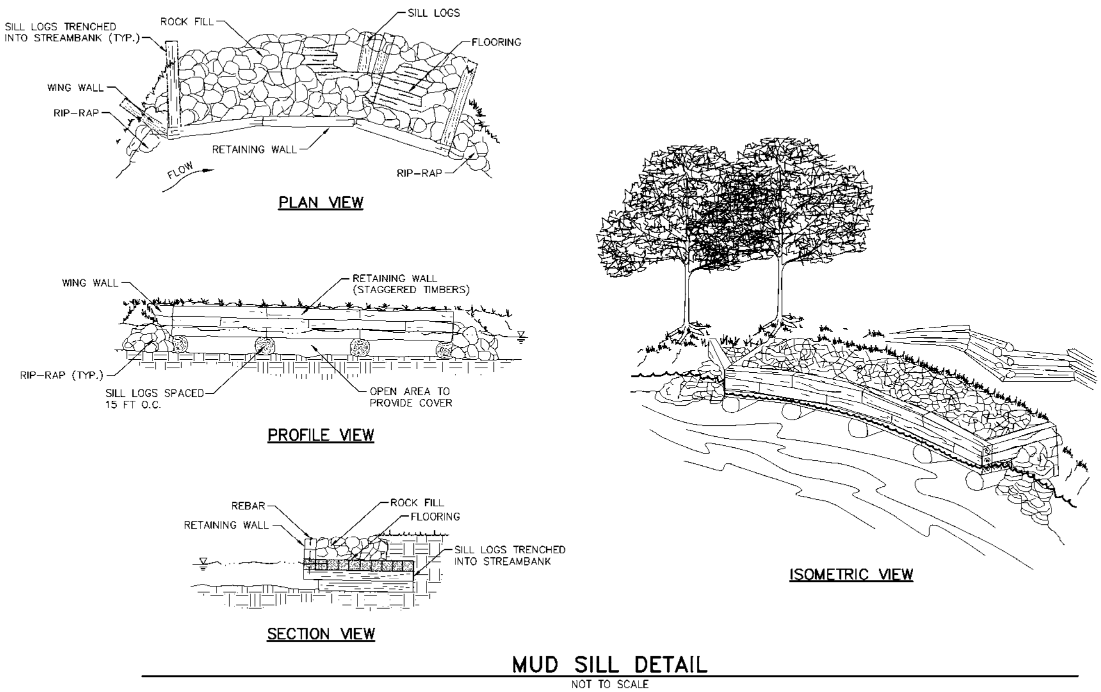
Rock and log frame deflectors are used to stabilize eroding streambanks and provide in-stream habitat. Rock deflectors are a bit easier to install because the frame of the structure consists of larger rock whereas the log frame consists of logs that have to be drilled and anchored to the substrate. A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




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; Little Buck Run 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).

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 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 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 mile-a-minute weed (*Persicaria perfoliata)* are very common invasive species within Little Buck Run 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. 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 Little Buck Run 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 Little Buck Run 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.

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 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, 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:

<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 (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–$2.20/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

<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 Little Buck Run 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 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:

- West Sadsbury, Sadsbury, and Highland Townships, Parkesburg Borough and Chester County Planning Commission (Adoption of protective municipal ordinance language to protect critical watershed resources)
- 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

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.

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

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
1	Confluence of unnamed tributary just upstream of the confluence of Little Buck Run with Buck Run. The small unnamed tributary enters from the north and is connected to a small pond that is home to a number of geese. A forested riparian buffer exists downstream of this point. The stream bottom is covered with sediment due to upstream sediment inputs and the low gradient from this point to the confluence with Buck Run.	Reduce potential nutrient input from goose population by discouraging geese inhabiting the area	Landowner	Low Priority	
2	Looking upstream, mowed to within 5-15' of the southern streambank, bamboo is growing on the north bank.	Expand riparian buffer, invasive species removal	Landowner, TreeVitalize	Low Priority	
3	The vegetation is mowed to within 5-10' of the streambank on both sides of the stream upstream of this point. The bottom has some cobble mixed in. The stream is incised 2-3 feet.	Riparian buffer enhancement	Landowner, TreeVitalize	Low Priority	
4	Old Stottsville Rd. Bridge over Little Buck Run. Some underdrains discharge into the stream at this location. Looking upstream, a nice riparian buffer consisting of abandoned pasture reverting to successional forest with some sizable trees.	N/A	N/A	N/A	
5	Confluence of unnamed tributary from the south	N/A	N/A	N/A	
6	Lightly grazed overgrown pasture containing two horses. The downstream end of the pasture contains stable banks, the stream bed is covered with sediment. The upstream end of the pasture nearing point 7 includes one 20' and one 30' section of 2-3 foot high eroded stream bank on the outside of meander bends.	Streambank stabilization	Landowner, Agencies	Low Priority	
7	Upstream end of pasture area. Looking upstream, a well established successional riparian buffer exists.	N/A	N/A	N/A	
8	A private deck is built over the stream at this point. An outfall from a 4" pipe enters from the north. Just downstream of the point, a three foot high eroded bank exists on the outside of a meander bend. Poison hemlock and multiflora rose are dominant plants in this area.	Invasive species removal, streambank stabilization	Landowner, Agencies	Low Priority	
9	A property line crosses the stream at this point. Moving upstream from points 9-13, approximately 40 percent of the streambank is eroded 3-4' banks. The south side of the stream is in hay within 5-15 feet of the stream.	Legacy sediment removal, stream restoration with fluvial geomorphology techniques, riparian buffer enhancement	Landowner, Agencies, TreeVitalize	High Priority	This section of the reach does not appear to include fringe wetlands that would be a permitting challenge.

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
10	Upstream of this point, approximately a 25' buffer exists on both sides of the stream. Eroded banks exist upstream and downstream.	Legacy sediment removal, stream restoration with fluvial geomorphology techniques, riparian buffer enhancement	Landowner, Agencies, TreeVitalize	High Priority	
11	Banks are eroded approximately 4' just upstream of this point.	Legacy sediment removal, stream restoration with fluvial geomorphology techniques, riparian buffer enhancement	Landowner, Agencies, TreeVitalize	High Priority	
12	Gravel ford over stream, banks are 3-5 feet high and eroded, a mix of cobble, gravel, and fines exists on the stream bottom.	Legacy sediment removal, stream restoration with fluvial geomorphology techniques, riparian buffer enhancement	Landowner, Agencies, TreeVitalize	High Priority	The potential presence of wetlands at the top of bank needs to be addressed in the restoration planning and permitting of this area.
13	Top of area with substantial instability. The section of stream from point 13-14 appears straightened, but has stable banks and a cobble/gravel bottom	Legacy sediment removal, stream restoration with fluvial geomorphology techniques, riparian buffer enhancement	Landowner, Agencies, TreeVitalize	High Priority	
14	The eroded southern streambank from points 14-15 is 2-3 feet high. The vegetation is mowed to within five feet of the streambank. The bottom is a mix of cobble and gravel.	Streambank restoration with fluvial geomorphology techniques, riparian buffer enhancement	Landowner, Agencies, TreeVitalize	Medium Priority	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
15	The streambanks from points 15-17 are highly unstable and are 3-6 feet high and severely eroded. The stream bottom is covered in fine sediment. This area appears to be the most impaired in the watershed and will likely require a large restoration effort. The project area is in a pasture that is currently not being grazed.	Legacy sediment removal, stream restoration with fluvial geomorphology techniques, riparian buffer enhancement	Landowner, Agencies, TreeVitalize	High Priority	Highest priority project in the watershed. Some existing wetlands in the project area will need to be included in the restoration planning stages.
16	An unnamed tributary enters from the south, the unnamed tributary has 3-4 foot high eroded streambanks and should be included with any restoration projects in this area.	Legacy sediment removal, stream restoration with fluvial geomorphology techniques, riparian buffer enhancement	Landowner, Agencies, TreeVitalize	High Priority	
17	Upstream end of proposed restoration area and downstream end of SR-10 crossing over Little Buck Run.	Legacy sediment removal, stream restoration with fluvial geomorphology techniques, riparian buffer enhancement	Landowner, Agencies, TreeVitalize	High Priority	
18	Downstream end of a 30-40' area where the vegetation is mowed to the eastern streambank. From point 18-20, an invasive colony of reed canary grass exists.	Invasive species removal, riparian buffer enhancement	Borough, Tree Vitalize	Low Priority	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
19	An unnamed tributary enters from the west. The headwaters of the tributary are contained within the stormsewer system of Parkesburg Borough. The park area that the steam flows through would potentially be a good candidate for riparian forest restoration. The construction of many of the buildings and much of the infrastructure in Parkesburg pre-dates volume and rate requirements for stormwater management.	Stormwater retrofits/rainbarrels for rate and volume control, homeowner stormwater management education, ensure local stormwater ordinances are up-to-date and enforced, riparian forest restoration in park	Borough, Tree Vitalize	High Priority	Stormwater retrofits and rainbarrel installation throughout the borough are high priority activities. Community volunteers could be involved in a Forest our Park kickoff activity where they help plant trees and are educated on stormwater management. A Rainbarrel Parkesburg campaign that includes installing rainbarrels at homes with gardens throughout the community and educating homeowners on their use should also be considered.
20	Mowed to top of bank for approximately 50'.	Riparian buffer enhancement	Borough, Tree Vitalize	Low Priority	
21	Downstream end of an approx. 30' long area of 3-4' highly eroded streambanks on the outside of a meander bend.	Streambank stabilization	Landowner, Agencies	Low Priority	
22	Outfall from a conventional stormwater basin. This basin may be a good candidate for naturalization/retrofit.	Stormwater basin retrofit	Landowner, Agencies	Low Priority	
23	Stream is heavily encroached upon. A building is within 2 feet of the stream on the east bank, the stream appears to have been straightened, but has a cobble bottom. The west side of the stream is encroached upon by a roadway. The stream corridor contains litter in this area.	Litter cleanup, ideal long-term would be floodplain restoration	Landowner, Community Volunteers	Low Priority	Floodplain restoration is not practical at this time for this location.
24	Beginning of box culvert that encloses stream under SR-10 and a portion of the Borough. A stormwater outfall discharges to the stream in this location. Downstream of the point is a section of gabion baskets to protect the area of the outlet of the culvert from scour. Several stormwater outfalls discharge into the box culvert	N/A	N/A	N/A	The stormwater discharges in this area are included in the high priority activities described for point 19

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
25	Upstream end of box culvert. Upstream of the culvert is an area where the stream is flowing over bedrock and has good grade control.	N/A	N/A	N/A	
26	Top of bedrock area. The west bank of the stream includes a 20-30' area of geotextile that was under an area of rip-rap. The rip-rap has been washed downstream.	Monitor to determine if the area of the geotextile begins to erode and should be maintained.	Landowner	Low Priority	
27	A private driveway crosses the stream at this point. Just above the crossing, a small unnamed tributary enters the stream from the west. Downstream of the crossing, a railroad trestle and an electric utility sub-station encroach on the floodway.	N/A	N/A	N/A	
28	The western side of the stream is mowed to within 10' of the stream. Fill from the commercial development encroaches in the floodway. East of the stream is a mature forest. The cobble bottom of the stream in this area appears to be excellent substrate for macroinvertebrate communities.	Raingarden installation in the floodway to handle stormwater from the small commercial building in this area. Floodplain restoration would be ideal.	Landowner	Low Priority	
29	Several 4" drain tiles enter from the west in this location. The stream buffer on the west bank is approx. 10' wide and is dominated by invasive species. Two patches of reed canary grass exist in this area and should be considered for control before they become dominant along the streambank. Multiflora rose is dominant upstream of the point.	Invasive species removal, riparian buffer enhancement	Landowner	Low Priority	
30	Several 4" drain tiles enter from the west in this location. The stream buffer on the west bank is approx. 10' wide. The west bank includes fill in the floodway.	Riparian buffer enhancement	Landowner	Low Priority	
31	48" CMP discharges from the west bank. Several sheds are placed on old fill that encroaches on the west bank. A good buffer exists along the east bank downstream of this point. Upstream of this point, a quarry operation encroaches on the east bank.	N/A	N/A	N/A	
32	36" CMP discharges from the quarry operation on the east bank.	N/A	N/A	N/A	
33	Remains of a breached dam breast. Legacy sediment issues are not a large problem for this location. Some sediment exists, but is stabilized with thick vegetation.	N/A	N/A	N/A	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
34	Discharge pipe from SR-10 enters the stream from the east via a short swale. The substrate in this area is a good mix of cobble and gravel.	N/A	N/A	N/A	
35	Dam breast of large on-line dam. The dam is full of sediment and appears less than 2' deep at the deepest. The dam blocks upstream fish migration and likely contributes to the adverse effects of the upstream nutrients that are discharged to the stream on stream organisms.	Dam removal/restoration	Landowner, American Rivers, and Agencies	High Priority	
36	A swale discharges to this point from a stormwater basin that is located south of the stream. Downstream of this point, a nice forested buffer exists and several seeps enter the steam from the southwest. The substrate ranges from sediment in the pools to gravel/cobble in the riffles. The channel is incised from 0-3 feet throughout this reach.	Stormwater basin retrofit	Landowner	Low Priority	
37	Ag crossing, the stream channel is incised approx. 3-4 feet, riparian buffer is lacking from points 36-38.	Streambank restoration, riparian buffer enhancement, ensure up-to-date conservation plans are being implemented	Landowner, Agencies, TreeVitalize	Medium Priority	
38	Downstream edge of culvert under N. Limestone Road. Downstream of this point, the stream channel is incised approx. 3 feet, riparian buffer is lacking.	Streambank restoration, riparian buffer enhancement, ensure up-to-date conservation plans are being implemented	Landowner, Agencies, TreeVitalize	Medium Priority	
39	Confluence of unnamed tributary from the west. Upstream of this point, the two unnamed tributaries are intermittent as per landowner. The headwater streams drain through several dairy/beef farms that have pasture around the stream. Cattle have unrestricted access to the stream. Several dams in the area likely were constructed to aid in irrigation.	Streambank fencing, riparian buffer enhancement, ensure up-to-date conservation plans are being implemented	Landowner Conservation District, NCRS	High Priority	Streambank fencing is very important in this area to address the high level of nutrients throughout Little Buck Run.
40	Small agricultural stream crossing	N/A	N/A	N/A	
41	Stream crossing for a private driveway. The tributary originates just above Leike Rd. from two 4" underdrains that drain a small area planted in bamboo.	N/A	N/A	N/A	
42	Downstream end of the horse pasture near the confluence of an unnamed tributary near the mouth of Little Buck Run.	N/A	N/A	N/A	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
43	Borough Line Rd. stream crossing, some erosion behind the upstream wing wall. Downstream end of stream crossing has a 4" drop into a scour hole. Downstream from this point, horses have access to the stream. Upstream of this point, sheep have access to the stream.	Monitor the downstream end of crossing to ensure it doesn't block fish passage with additional scour over the coming years. Streambank fencing for horses downstream of point and sheep upstream of point	Landowner, Conservation District	Medium Priority	The sheep could be easily fenced out of the stream by moving the existing fence to the other side of the stream.
44	Stream crossing looking upstream, mowed to both sides of the stream. Some erosion is occurring near the toe of slope of the road.	Riparian Buffer Plantings, Small Area of Streambank Stabilization	Landowner	Low Priority	
45	Stream crossing with some scour under the downstream end, fresh fill along the upstream bank	Bridge scour protection	Landowner	Low Priority	
46	Mowed to the top of both banks with some landscape plantings between points 45 and 46	Riparian buffer plantings	Landowner, TreeVitalize	Medium Priority	
47	The tributary upstream from this point is flowing in the roadside swale. A forested upland area exists to the east of the trib.	Investigate de-icing options to minimize pollutant input to the stream	Highland Township	Low Priority	
48	Mature forested buffer on both sides of the stream from points 46-48	N/A	N/A	N/A	
49	Small on-line dam that is well sedimented and is becoming vegetated with emergent wetland plants. The dam blocks fish passage into the headwaters area.	Dam removal/restoration	Landowner, American Rivers	Medium Priority	
50	Mowed to the top of bank from points 48-50. One small area of erosion exists near point 48, the remainder of the reach has vegetation on the banks.	Riparian buffer planting	Landowner, TreeVitalize	Medium Priority	
51	Old farm crossing at this point, the crossing area is mowed, seeps along the west side of the stream just below crossing, the stream bottom has cobble for substrate in this area.	N/A	N/A	N/A	
52	Confluence of two unnamed tributaries. The substrate of the southeastern tributary is sediment-laden and is likely receiving sediment from the upstream farming areas. Cobble in the tributary is approximately 50 percent embedded.	N/A	N/A	N/A	
53	Forested buffer extends from points 52-53.	N/A	N/A	N/A	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
54	Spring house that begins the southeastern unnamed tributary. Upslope of this point is agricultural uplands, downslope is a 10-15' wide riparian buffer next to hay fields. Intermittent stormwater discharges from the agricultural fields likely contribute to the sediment in the downstream tributary. The farm was primarily in hay during the time of the streamwalk	Maintain hay fields as buffer strips closest to the unnamed tributary, Ensure the farm is implementing a current conservation plan	Landowner, Conservation District, NRCS	Low Priority	
55	On-line pond at the headwaters of an unnamed tributary. The pond appears to have been treated with an algaecide such as copper sulfate. The input of nutrients from the upslope farms may potentially be contributing to excessive algal growth in the pond. Downstream of this point, the tributary has stable approximately 3' high banks. The forest has an understory of hay-scented fern and invasive multiflora rose.	Invasive species removal, Ensure upslope farms are implementing current conservation plans and contour farming	Landowner, Conservation District, NRCS	Low Priority	
56	ATV crossing of tributary with evidence of driving in stream channel on an unnamed tributary to Little Buck Run.	Install waterbars/ trail improvements to dissipate water that collects in the trails leading to the point of the crossing. Upgrade crossing to minimize disturbance.	Landowner, Agencies	Medium Priority	
57	36" SLCPP enters from the east. The stream is in close proximity to SR-10 in this area	N/A	N/A	N/A	
58	A 24" outfall enters from the east. Looking upstream, the channel appears to have been straightened some years ago. Looking downstream, evidence of ATV's driving along the western stream bank	N/A	N/A	N/A	
59	Some evidence of legacy human disturbance exists in the floodway in this area	N/A	N/A	N/A	
60	From points 59-60, a nice forested buffer exists, the stream bed has cobble present, but is mixed with sediment that is likely coming from the agricultural headwaters. Multiflora rose is present in the plant community.	Invasive species removal	Landowner	Low Priority	
61	Outfall from off-line pond. The streambank between points 61-62 has some evidence of erosion.	Bank stabilization	Landowner, Agencies	Low Priority	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
62	A breached on-line dam exists at this point. The dam was likely for diverting water into the existing off-line pond. A small area of streambank erosion exists in this area.	Remove structure and crush for use in bank stabilization	PENNDOT, DEP	Low Priority	This project could potentially be completed as part of bridge maintenance activities.
63	SR-10 Bridge crossing over the tributary with a culvert discharging to the stream in the southeast wing wall.	N/A	N/A	N/A	
64	Driveway crossing: downstream end of crossing has a 12" drop that likely blocks fish passage. The stream is located within a forested corridor that is surrounded by agricultural land.	Ensure upslope farms are implementing current conservation plans, Restore fish passage	Landowner, Conservation District, NRCS	Low Priority	
65	Development currently under construction. One sediment basin in the development has an emergency spillway that appears lower than the crest of the temporary riser.	Inspect Erosion and Sediment Control and Post Construction Stormwater Management BMP's for compliance.	Conservation District	Low Priority	

APPENDIX C
POINT LOCATION DATA

Point Location Data

Point #	Northing	Easting	Approx. Elev.
1	233079.31	2489429.98	450
2	232964.62	2489417.33	449
3	233018.05	2489323.45	453
4	233104.60	2488919.42	464
5	233088.37	2488418.23	451
6	233036.66	2488187.35	456
7	232973.96	2487510.44	451
8	233028.87	2487342.92	462
9	232958.37	2487026.36	462
10	232906.22	2486800.73	462
11	232893.29	2486695.02	460
12	232504.21	2486304.16	465
13	232907.41	2486645.44	465
14	231945.76	2485299.58	471
15	231720.82	2484657.29	479
16	231872.24	2484583.92	480
17	232245.51	2483725.26	488
18	232359.02	2483596.70	493
19	232476.31	2483260.93	490
20	232822.91	2483204.68	498
21	232943.12	2483227.82	503
22	233069.99	2483251.27	502
23	233279.00	2483217.08	520
24	233374.31	2483186.92	506
25	233752.96	2483408.20	512
26	233913.44	2483603.13	524
27	234361.19	2483485.52	541
28	234460.36	2483379.28	542
29	234697.63	2483156.68	541
30	234860.09	2483110.39	549
31	234944.54	2483108.30	550
32	235154.47	2483096.41	553
33	235445.91	2483030.44	578

Point #	Northing	Easting	Approx. Elev.
34	235847.93	2483067.24	579
35	236069.46	2482935.33	589
36	236757.78	2480892.97	617
37	236600.56	2479422.85	630
38	236584.99	2478601.47	641
39	236558.74	2478469.46	639
40	236616.19	2478442.90	639
41	236848.12	2478314.80	643
42	232839.09	2488450.83	463
43	232231.44	2488613.66	467
44	231861.40	2488635.45	475
45	231551.37	2488486.69	484
46	231273.55	2488235.48	492
47	231043.75	2488425.40	512
48	230469.80	2486848.04	541
49	229914.40	2486672.84	551
50	229762.25	2486729.87	540
51	229478.66	2486677.91	577
52	228984.60	2486677.75	577
53	228688.46	2486996.39	589
54	228449.79	2487009.21	598
55	228619.37	2486314.07	585
56	230428.85	2483694.58	516
57	230197.36	2483698.13	524
58	229723.83	2483422.61	567
59	229251.29	2483138.61	552
60	228641.30	2482938.11	558
61	228349.63	2483044.46	583
62	228119.28	2483018.61	580
63	228032.26	2482987.91	582
64	227604.10	2482963.90	601
65	230896.80	2481848.89	523

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

APPENDIX D
PRELIMINARY PROBABLE CONSTRUCTION COST OPINION

RETTEW
We answer to you.

Little Buck Run Watershed Preliminary Probable Construction Cost Opinion

Site	Min Cost	Max Cost	
9-13	$225,000	$300,000	
15-17	$325,000	$425,000	
19	$5,000	$100,000	*
35	$85,000	$135,000	
39-HW	$70,000	$90,000	
14-15	$85,000	$135,000	
36-38	$5,000	$15,000	
42-46	$20,000	$30,000	
48-50	$9,000	$15,000	
56	$5,000	$10,000	
	$834,000	$1,255,000	

*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 18 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.