Mill Creek Restoration in Lower Merion Township

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Abstract

Bryn Mawr College and the Lower Merion Conservancy were awarded a Growing Greener Grant to restore approximately 1400 linear feet of stream, including relocating 400 linear feet, in the headwaters of Mill Creek in Lower Merion Township, Montgomery County, Pennsylvania. Mill Creek is a tributary to the Schuylkill River and is the primary drainage network for Lower Merion Township.

Through Lower Merion Township’s Ashbridge Park and Bryn Mawr College’s School of Social Work Campus, much of Mill Creek suffers from channelization and bank erosion. Previous attempts at stabilizing the stream simply reinforced the streambanks and did not take into account the natural stream process. The restoration design removes all of the improper bank stabilization techniques and returns the stream reaches to a natural state utilizing new channel geometry based on the current dominant discharge. The new channel will not only reduce storm velocities, but will restore the natural riffle/pool sequences destroyed by the channelization. Natural materials such as rootwads, log vanes, and bioengineering will provide bank stabilization and instream cover. Native trees, shrubs, and forbs will provide a natural buffer along the restored stream and in time will provide canopy coverage and bank stabilization that the existing channel was lacking.

Background

In the spring of 2001, Bryn Mawr College and the Lower Merion Conservancy applied for a Pennsylvania Department of Environmental Protection Growing Greener Grant. From their experience with a regional basin retrofit, Bryn Mawr College saw three key components to a successful grant application: (1) identify a sustainable environmental project, (2) communicate with local agencies, environmental groups and non-profits and (3) provide matching funding. Soon after Bryn Mawr College completed the basin retrofit, the Lower Merion Conservancy expressed an interest in completing a study of the Ashbridge Tributary within Lower Merion Township’s Ashbridge Park. Coincidentally, Bryn Mawr began plans to replace several bridges on their School of Social Work Campus, adjacent to the park property. This appeared to be a perfect match. The College was able to improve their plan by incorporating stream restoration, the conservancy would receive matching funds and construction management expertise, Villanova University would add an additional BMP to their BMP Demonstration Park.
and Lower Merion Township would receive an improved stream channel. Over the course of the following year, the partners developed their plans and received a Growing Greener Grant.

The resulting project rehabilitated more than 1,400 linear feet of stream located in the headwaters of Mill Creek in Lower Merion Township, Montgomery County, Pennsylvania. Mill Creek, part of the Schuylkill River Basin, is the primary drainage source for Lower Merion Township, draining more than 30% of the entire Township. The project restored approximately 1000 linear feet of an unnamed tributary to Mill Creek (referred to as Ashbridge Tributary because about 700 feet of the stream flows through township property known as Ashbridge Park) and relocated approximately 400 linear feet of Mill Creek on property owned by Bryn Mawr College. The Ashbridge tributary joins the Mill Creek as it leaves the Bryn Mawr property. This confluence is the downstream end of the project.

The upstream end of the Ashbridge tributary begins at the outfall of a stormdrain pipe under Airdale Road. It is a first order stream only because the entire upstream drainage network has been piped to this point. The drainage area to the Ashbridge tributary is 194 acres of developed land with an impervious percentage estimated at greater than 50%. Because of the large percentage of impervious area, the base flow in the channel is minimal (perhaps 0.5 cfs) while storm flows are flashy and powerful. The increased storm flows have created severe erosion as the channel has tried to adjust to the increased flows. Previous “solutions” to the stream’s erosion problems in past decades, included retaining walls and cured-in-place concrete bags. Of the 700 feet of channel in Ashbridge Park, over 500 feet of bank was hardened. These structural stabilization techniques only exacerbated erosion on unprotected banks. The severe erosion created sedimentation in the channel that smothered the gravels and cobbles that naturally occur in the channel bed.

The 300 feet of the Ashbridge tributary on the Bryn Mawr property was completely encased between stone retaining walls. The retaining walls created a channel that was too small for the dominant or bankfull discharge. The small, confined channel created high velocities and shear stresses during storm flows which have caused bed scour. The scour undermined the retaining walls in a number of locations. The retaining walls also did not allow the stream to interact with a flood prone area except during very infrequent, large storm events. The stream also had to pass through three culverts on the campus before reaching Mill Creek.
There was no riparian buffer along the Ashbridge tributary because mown turf grass was maintained to the edge of water on both the park and campus. Some large trees did provide shading; however, about 75% of the stream had no canopy coverage. The lack of canopy coverage allows for increased water temperatures in the stream. The small amount of woody vegetation did not provide sufficient leaf and stem litter for appropriate food chain production. Biological census data collected by the Lower Merion Conservancy demonstrates a substantial decline in Mill Creek's macroinvertebrate biodiversity in recent decades, with very few organisms inhabiting the Ashbridge tributary, most of which are classified as pollution-tolerant by the Pennsylvania Fish and Boat Commission.

The upstream end of the 400 feet stream relocation project on Mill Creek is located where the stream enters the college property. The drainage area to this reach of Mill Creek is 364 acres; however, the percent impervious in this watershed (estimated at about 30%) is less than the watershed of the Ashbridge tributary. Therefore the baseflow (about 1 cfs) is higher than in the Ashbridge tributary and the peak storm flows are less than those in the Ashbridge tributary even though the drainage area is larger. Nearly all 400 feet of channel was “protected” by gabion walls and stone retaining walls. Just as on the Ashbridge tributary, the Mill Creek was confined by these structures and was actively scouring the channel bed. The stone retaining walls were undermined and failing in many locations. The active scouring of the channel bed removed nearly all bed features.
that would create aquatic habitat. The Mill Creek also had to pass through two culverts before the Ashbridge tributary joins it at the end of the project area. Except for the first 100 feet of channel, there are no trees around this reach of the Mill Creek allowing increased water temperatures.

**Project Description**

The severely eroding, tight meanders in Ashbridge Park made it apparent that the Ashbridge Tributary was adjusting to an increased dominant (bankfull) discharge. The first step in the design process was to determine the current bankfull discharge. This is important because a natural channel is shaped by its bankfull discharge and thus many of the design parameters such as width/depth ratio, entrenchment ratio, radius of curvature, etc. are based on the bankfull width. Because nearly all of Mill Creek and Ashbridge Tributary are encased in retaining walls or are severely degraded it was not possible to identify bankfull indicators on these two streams. Therefore we were not confident with any of our field determined bankfull discharges. We were also not confident in regional curve determined bankfull discharges because the smallest watershed utilized on these curves was around two square miles while the Mill Creek and Ashbridge Tributary drainage areas are well under one square mile. The TR-20 watershed model was utilized to determine bankfull discharge. It has been our experience in designing stream restorations for developed watersheds in Maryland that the 2-year, 24-hour peak discharge computed from TR-20 is very close to a bankfull discharge. The design discharge for the Ashbridge Tributary is 184 cfs and 154 cfs for Mill Creek.

The next step in the design process was to find a reference reach to help guide the restoration design. A reference reach should be a stable channel of the same classification and valley type with similar bed material and similar hydrologic regime. An extensive search was performed throughout Montgomery and Delaware Counties for a stable “C” channel with coarse (mainly cobble and gravel) bed material. Due to numerous anthropogenic impacts such as roads, utilities, and channelization as well as channel degradation from urbanized hydrology, a suitable reference reach was not found. This made it necessary to expand the search to less developed watersheds. A reference reach was located in the Maryland piedmont with a mostly agricultural land use. Although the drainage area to the reference reach is 4.6 square miles the bankfull discharge was estimated from field cross sections and regional curve data at about 200 cfs. Cross sections of pools and riffles were surveyed to obtain measurements of bankfull width, floodprone width, point bar slope, bankfull depth, average slope, riffle slope, run slope, glide slope, and others. Measurements were also taken of belt width, radius of curvature, and meander wavelength. From these field measurements bankfull ratios such as width/depth, entrenchment, width/radius of curvature, riffle slope/average slope were calculated along with cross sectional area and mean velocity. All of this data was then used to design the proposed channel for both the Ashbridge Tributary and Mill Creek. Site constraints such as avoiding large trees, utilities and property lines made it necessary to adjust some of the channel parameters. Also, the lack of upstream bedload supply in the Ashbridge Tributary was also taken into consideration when designing the channel cross section to keep the shear stress below critical shear stress for the D_{84}. 

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In Ashbridge Park, all of the improper bank stabilization features were removed. The channel was reconstructed to adjust the width and meander pattern to conform to the current bankfull discharge. An appropriate floodprone area was also created. These changes in channel geometry will allow the restored channel to remain stable during storm flows. In-stream bank stabilization and stream restoration techniques consist of rock cross vanes, root wad revetments, live branch layering, boulder toe protection and boulder bank stabilization. Cobble and gravel was harvested from the existing channel and placed in the riffles of the restored channel. Native riparian vegetation is established along each stream bank to provide shade, detritus, and to intercept and filter storm water runoff from surrounding upland areas. Lower Merion Township has pledged a large portion of the park around the channel to riparian stream buffer establishment.

The remaining 300 feet of Ashbridge tributary on the college property was restored in much the same way as the channel in Ashbridge Park. The stone retaining walls were removed and the channel cross section and meander pattern was adjusted to the current dominant discharge. Natural channel stabilization practices were utilized. A native riparian buffer is also established around this reach of the Ashbridge tributary.

In a similar fashion the Mill Creek portion of the project was also resized and realigned to properly handle its dominant discharge. The existing parking area split by the Mill Creek was consolidated to allow for a more naturally designed channel. The new, naturally-designed channel meanders around the new parking area and joins back to its original alignment before it exits the college property. Natural channel stabilization techniques were also utilized in the new Mill Creek channel and a native riparian buffer is established on both sides of the channel.

The relocation of Mill Creek around the new parking area not only restores the channel to a more natural state but it also increases the length of stream from 400 feet to almost 700 feet. The previous channel also lacked a natural riffle and pool sequence with most of the channel in a riffle condition. This condition does not provide the proper aquatic habitat for a natural channel. The new channel has a natural riffle and pool sequence with pools occurring in the meanders and riffles in the cross-over reaches.

The project will also eliminate three of the five culverts on the site so that only the Ashbridge tributary will have to pass through two culverts.
Conclusion

Natural channel design techniques were used to design a new, stable channel for over 1400 linear feet of degraded and channelized stream in Lower Merion Township. Natural channel design relies on determining the current bankfull discharge and utilizing reference reach data to design stable channel parameters such as width, depth, radius of curvature, cross sectional area, and many others. The new channel is stabilized with techniques such as log vanes, rock j-vanes, root wads and live branch layering. The new channel also improves aquatic habitat by reducing fine sediment load and creates better riffle/pool sequences. In addition, rootwads provide cover for fish. Lastly, a native riparian buffer is established to provide stabilization, shade, and leaf litter.

By combining the efforts of Bryn Mawr College, Lower Merion Conservancy, Villanova University and Lower Merion Township, this project will not only improve the stream environment, but also provide a demonstration area for others to emulate and an educational tool to be studied.