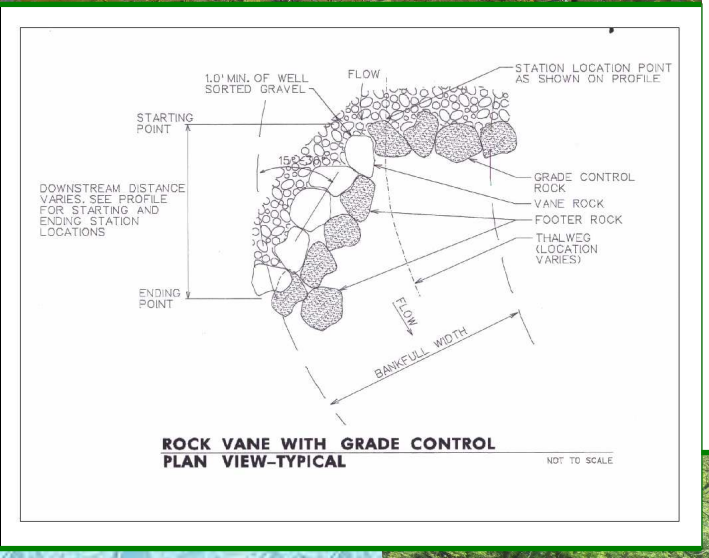
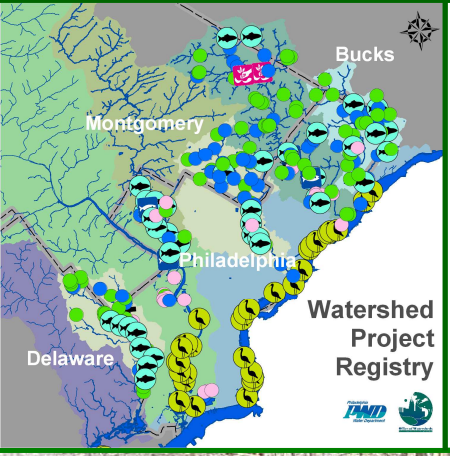
Stream Restoration



Overview

In an ideal world, flowing streams and rivers would remain in harmony with the surrounding environment. Banks would remain stable with lush, vegetative protection. Fish and macroinvertebrates would thrive within their in-stream habitat. The floodplains surrounding the streams would be accessible with an even mix of wetland and mature forest.

Unfortunately, in the world we live in, our streams and rivers have been abused by the effects of urbanization. As populations and development have increased within the city, stormwater discharge and stormwater runoff entering into our streams have increased as well. The increase in stormwater runoff from all of the impervious areas within the city has created a flashy regime for the majority of our in-city streams. Both maximum discharge and total runoff volume are increased compared to undeveloped watersheds. As a result, banks are no longer gentle slopes but rather steep, almost vertical banks, making the floodplain practically inaccessible. These steep banks have been created from the stream channel downcutting and overwidening into the underlying geology. As stream channels become physically larger and further disconnected from their historic floodplains, more stormwater forces are restricted to the stream channel, where compromised, heavily eroded banks are least suited to dissipate them.



A holistic approach to stream restoration is necessary to ensure the successful restoration and stabilization of impaired streams. This approach recognizes that a stable stream channel is not just a function of the balance of in-stream morphological features but also recognizes interconnections with the surrounding riparian ecosystem. Consequently, the restoration of impaired streams will encompass the replication of natural hydrologic and ecological cycles, sustainability, enhancement to riparian and in-stream aquatic habitat, and improved aesthetics.

In most cases, exaggerated stormflow has caused banks to erode and the channel to incise at an accelerated rate. Stream bank stabilization will make use of standard rock vanes, “J” vanes, cross vanes, wing deflectors, root wads, grade control measures and live branch layers. These types of modifications will stabilize banks as well as increase habitat heterogeneity and provide additional refuge to various fish and benthic macroinvertebrate species. This approach to stream bank stabilization combines the disciplines of fluvial geomorphology, hydraulics, hydrology, and applied ecology. It is dependant on accurate identification of stream classification type, an understanding of hydrologic actions within the watershed and their effects on the stream channel, and clearly defined restoration goals. Sound fluvial geomorphologic principles and an understanding of the natural stream system are integral to creating a stable stream channel that facilitates the restoration of the riparian ecosystem.

BEFORE

The stream channel should be designed to accommodate a range of flows by constructing a low flow channel within a larger high flow channel. The low flow channel will provide aquatic communities with habitat that effectively manages baseflow. The high flow channel will provide a lower velocity refuge for organisms during storm events. Once restoration is complete, a stable, sustainable environment will allow a reintroduced macroinvertebrate community to thrive. Improvements to the number, health, and diversity of the benthic invertebrate and fish species are ideal goals for stream restoration.

AFTER

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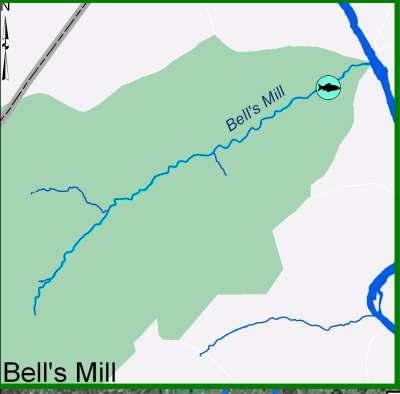
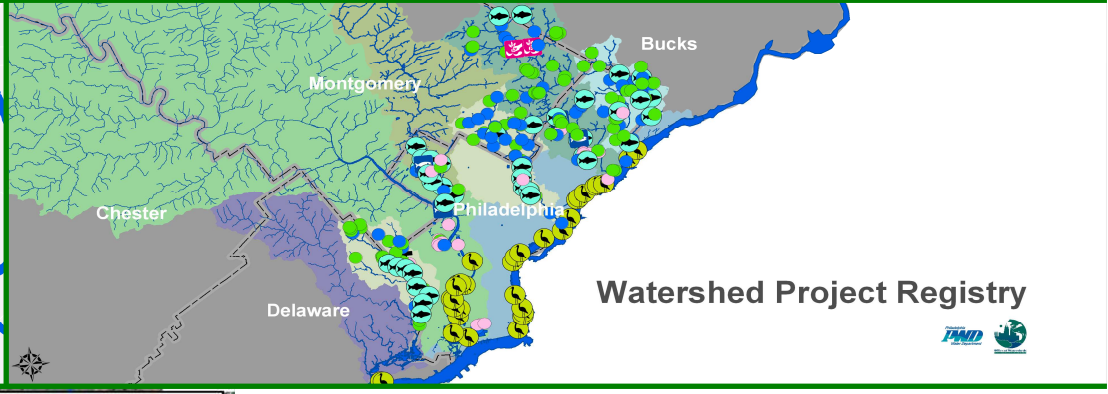
Bells Mill Stream Restoration

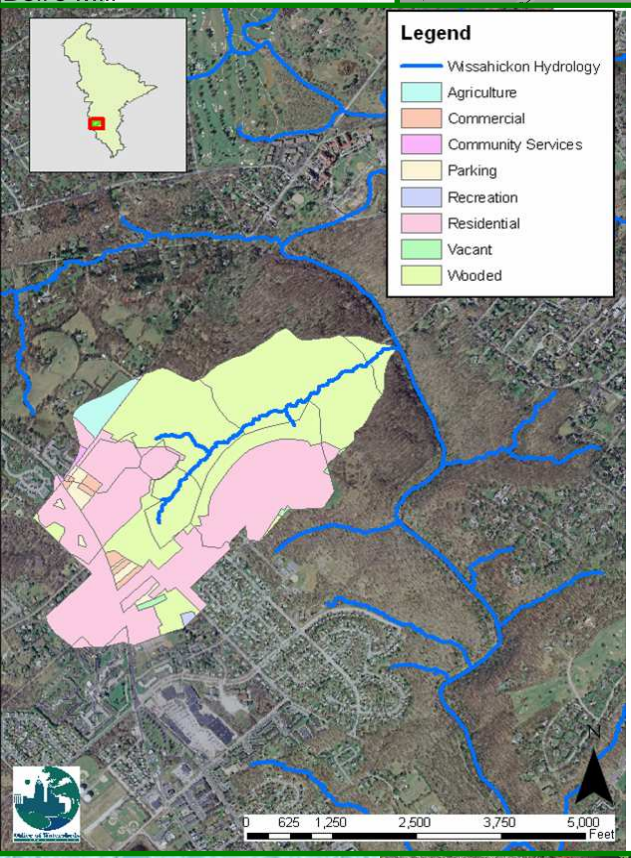
Bells Mill is a second order tributary to the Wissahickon Creek. The tributary arises from an outfall near the intersection of Lykens and Bells Mill roads. It then travels parallel to Bells Mill road for approximately 5,100 ft before the Wissahickon confluence. The tributary runs through a wooded area of Wissahickon Park; however, there are instances when the streambanks abut Bells Mill road. A small un-named tributary enters Bells Mill approximately 1,300 ft from the headwaters.

Bells Mill can be characterized as a type B stream for 400 ft until stormwater outfall W-084-02 discharges into it. At this point the tributary becomes entrenched and overwidened. Substrate is composed mainly of course gravel, cobble, and bedrock. The watershed is a total of 328 acres. The majority of the watershed is comprised of wooded (50%), and residential area (44%). Minor components include parking (2%), agriculture (2%), and commercial area (1%).

There are two major PWD stormwater outfalls discharging into Bells Mill, W-084-01 and W-084-02. A scour pool exists where outfall 0-084-02 discharges into the tributary creating stagnant water and water quality degradation at low flows. The entire length of the tributary downstream of the outfall is actively eroding due to high flows during wet weather events.







Due to the volume and velocity of water being discharged to Bells Mill during wet weather events, the tributary is deeply entrenched and overwidened. The restoration of Bells Mill would include eliminating the scour pool below outfall W-084-02 by utilizing stone for energy dissipation. Additionally, the streambanks and bed downstream of the outfall would need to be stabilized using principles of natural stream channel design. High grades and the presence of Bells Mill Road adjacent to the creek inhibit the creation of meanders. Instead, appropriate energy dissipating structures such as rock vanes and channel-spanning, step structures are proposed for installation.

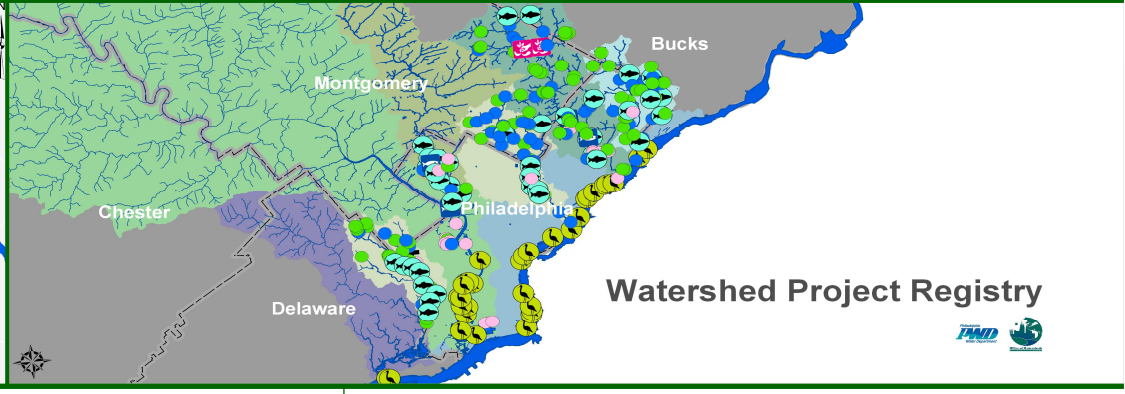
PWD is designing a restoration/stabilization design for Bells Mill Run. In order to create this restoration design, PWD has conducted a background investigation of Bells Mill Run. This investigation included data collection, historic data and mapping, a field survey, a wetland identification and delineation report, and a cultural resources survey. A natural channel design and stream bank stabilization evaluation was also conducted and included geomorphic inventory and assessment, hydrologic and hydraulic analysis, stream restoration/stabilization alternatives analysis, and a floodplain analysis. The design proposes to focus on specific restoration areas rather than restoring the whole tributary. Streambank stabilization will make use of standard rock vanes, “J” vanes, cross vanes, wing deflectors, root wads, grade control measures and live branch layers.

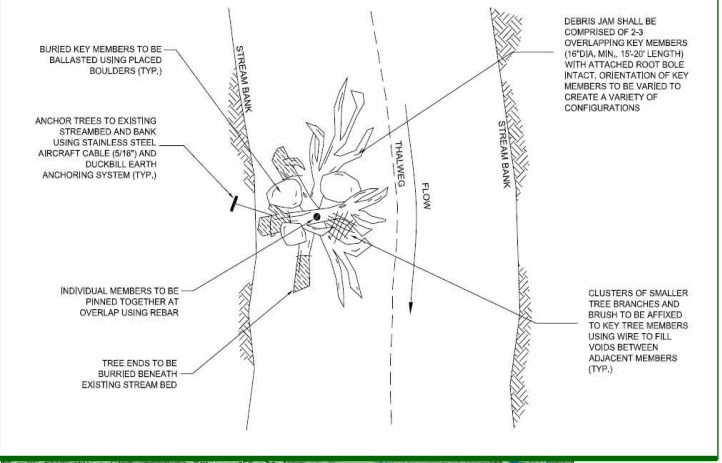
Wises Mill Stream Restoration

Wises Mill Run is a steep first-order tributary to the mainstem of the Wissahickon Creek. The tributary consists of a northern branch, which is 3,500 feet in length, and a southern branch, which is 1,300 feet in length. The two branches merge just north of Wises Mill Road and continue for another 1,900 feet before meeting the Wissahickon Creek. The stream channel is classified as a step-pool, or a Rosgen B1-3 stream. The dominate substrate varies from bedrock to cobble-sized material. Both the valley floor and channel have been substantially impacted by past and current land use.

The influences of urbanization have had significant impacts on the Wises Mill watershed. Since the late 1950's, the contributing watershed has been fully developed. The residential neighborhood's storm sewers collect stormwater from the 261 acre area that eventually discharge into Wises Mill Run. Over the last 50 years, the accelerated stormwater flows have severely impacted the receiving creek bed. These effects have been significantly exacerbated over the last ten years during which the stream has been exposed to several rather large storm events.

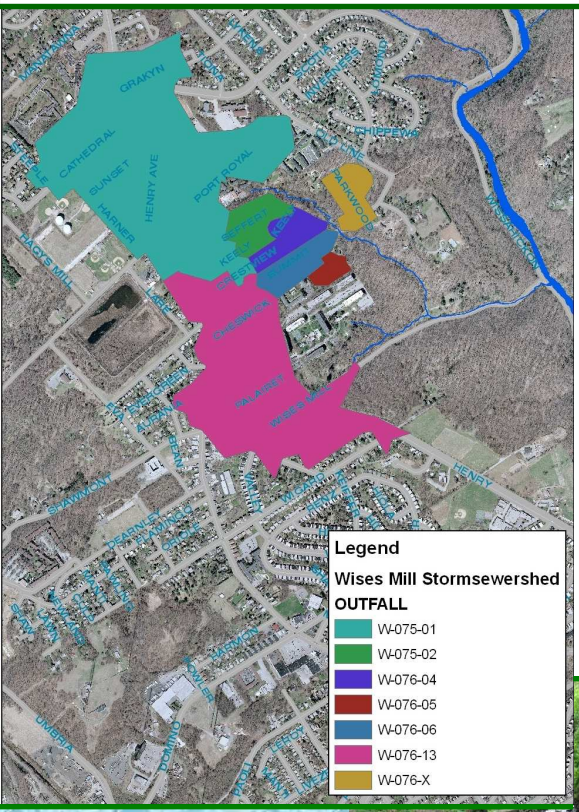
Some influences that have affected the Wises Mill project area include:





- Local channelization
- Historical deforestation and removal of in-stream large woody debris and associated alluvium
- Lateral encroachment and channel constriction by roads and other infrastructure
- Historical imposition of artificial channel knickpoints and grade controls, including three masonry dams, two small private bridges, three large box culverts, and one smaller culvert
- An urban flow regime aggravated by recent high-magnitude storm events

Their combined influence has resulted in the severe entrenchment of both the northern and southern branches of Wises Mill Run. In the near future, it is predicted that the stream will continue to downcut and eventually widen. These impacts will continue to contribute excessive amounts of sediment to the Wissahickon Creek. In addition, the widening of Wises Mill Run will continue to compromise Wises Mill Road, which runs parallel to the stream.



PWD is identifying restoration strategies to reduce sediment loading, improve geomorphic stability, and enhance in-stream flows and habitat quality (AKRF, 2008). While existing conditions do not warrant large-scale channel realignment or restoration, a modest program of limited in-stream intervention is recommended to reduce streambank erosion at severe sites, improve in-stream habitats, and address critical infrastructure issues. PWD is designing six in-stream rehabilitation projects that will reduce stream bank erosion at two severe sites, replace a falling concrete/masonry structure with a series of step-pool structures and enhance in-stream and riparian habitat quality in four channel segments. In some of these rehabilitation projects, floodplain areas will be lowered by two to three feet and replanted with native trees and shrubs. Root wads and placed woody debris piles will be installed to enhance in-stream habitat. Woody debris piles will be anchored to the stream bed and bank using Duckbill earth anchoring systems.

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Stream Restoration

Marshall Road Stream Restoration

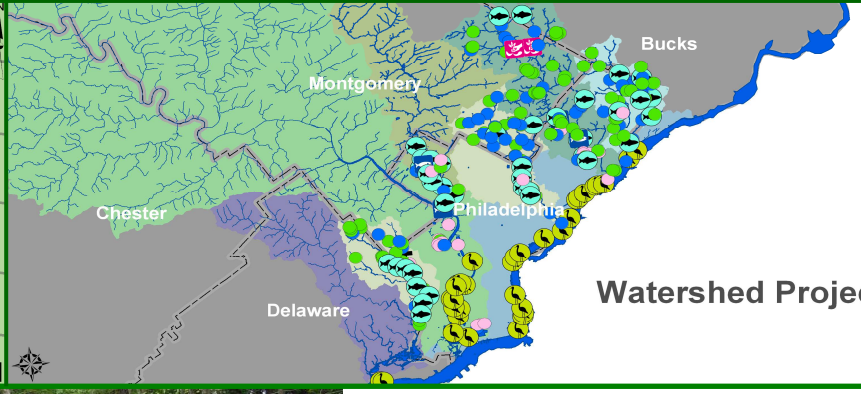
The Darby and Cobbs Creeks Watershed drain parts of Chester, Delaware, Montgomery and Philadelphia Counties to the Delaware River through the Tinicum Wildlife Refuge. The Watershed is bounded on its southern edge by Interstate 95. The waters in the drainage area receive point source discharges including municipal wastewater, CSO and other urban and suburban stormwater, sanitary sewer overflows, and industrial storm, process, and cooling waters. Non-point sources in the watershed include atmospheric deposition, areas of runoff sheet flow from urban and suburban areas, and individual on-lot domestic sewage systems discharging through shallow groundwater.

The concept behind this project was to implement a sustainable approach to stream habitat restoration that would mitigate the impacts of urban development and related hydrologic and hydraulic modifications. By enlisting the members of the Darby-Cobbs Watershed Partnership and national experts, this local watershed restoration effort restored 1000 linear feet of the Cobbs Creek stream corridor between Pine Street and Cedar Avenue using natural restoration techniques.

The primary source of impairment was identified as urban stormwater runoff and secondarily due to combined sewer overflows (Everett, 1998). The pollutants of concern for the Darby and Cobbs Creeks Watershed are dissolved oxygen, fecal coliform, and dissolved iron.

Abandoned bridge abutments upstream of the project area were constricting flow and directing it downstream into an outside meander bend. Additionally, high flows were being diverted around the outside of one of the abutments, accelerating erosion downstream and subsequently depositing sediment into the middle of the channel. As a result, a sanitary sewer line had become exposed and its structural integrity was jeopardized. The erosion and sedimentation was also causing the loss of riparian vegetation and increasing the embeddedness of downstream substrate. As a result, fine particles of soil were being deposited on the streambed, covering gravel and cobbles, and making the bed unsuitable for macro-invertebrate habitat and fish spawning. Excessive discharges continued to erode the stream channel, removing in-channel features like pools and riffles and altering the flow hydraulics. The loss of in-stream habitat structure, coupled with excess sedimentation is one reason for declines in aquatic diversity in the Cobbs Creek.

The proposed design included modification of the channel for the area adjacent to the bridge abutments at the upstream limit of the project area and continuing downstream for approximately 1000 linear feet, including realignment of the channel away from the sewer line along the downstream left.



The design included regrading of the stream channel to accommodate new planform geometry with increased sinuosity and decreased channel width-depth ratio. The ideal meander width ratios (belt width/bankfull width) ratios were limited by: 1) the adjacent sewer line on the downstream right side of the project area; 2) a desire to limit encroachment into the existing riparian area (including limiting tree loss and protecting endangered plant species); and 3) private property concerns along the downstream right side of the channel.

The project was constructed in 2004 and has been in place for almost five years now. Channel modifications included bank stabilization measures to ensure channel stability and limit channel migration. These bank stabilization measures included vegetation, root wads, and boulder bank stabilization. Vegetation and root wads provided bank protection and enhanced habitat diversity. Boulder bank stabilization was incorporated along the project area for several reasons: the natural occurrence of rock within the watershed area, a means to protect banks prior to full vegetation establishment, and a mechanism to reinforce the channel boundaries adjacent to the sewer line and the bridge abutments. PWD plans to conduct post-construction monitoring of this restoration project in the spring and summer of 2009. Post-construction monitoring will include the installation and monitoring of bank pins and scour chains. A longitudinal profile of new stream channel will also be surveyed.

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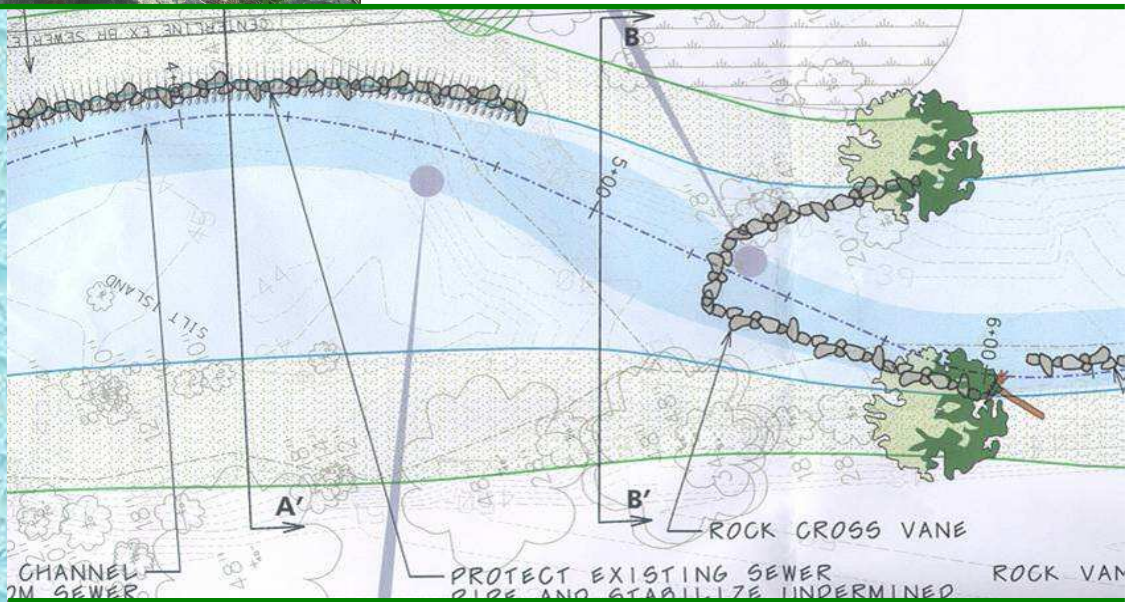


Stream Restoration

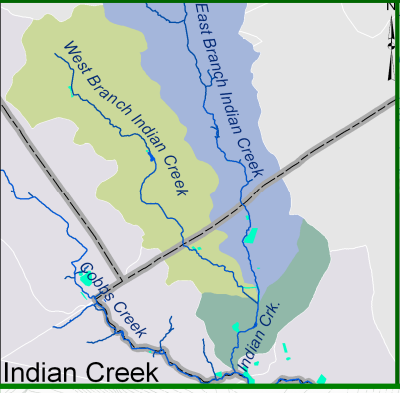
Indian Creek Stream Restoration

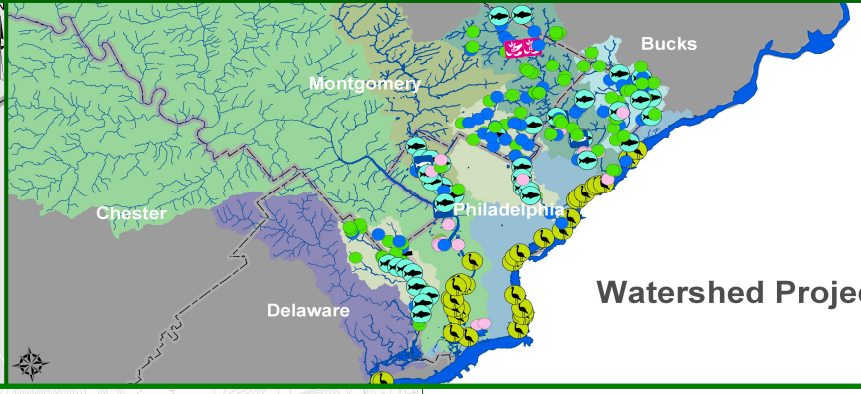
Indian Creek is a second order tributary to the mainstem of Cobbs Creek and can be further subdivided into eastern and western branches. The east branch of Indian Creek Watershed is a total of 1.96 square miles (1,254 acres) and is situated in the northeastern corner of the Cobbs Creek watershed. The west branch of Indian Creek Watershed is a total of 1.75 square miles (1,118 acres) and shares its eastern boundary with the western side of the east branch of Indian Creek Watershed.

Approximately 700 feet of the West Branch of Indian Creek has been encapsulated in a 6' x 6' culvert since 1928 before it outfalls into the eastern branch. During storm events, the combined sewer is overwhelmed resulting in overflows from the regulator (C-05) chamber that release diluted sewage into the culverted reach of the western branch prior to entering the east branch of Indian Creek and ultimately Cobbs Creek.

Urbanization of the watershed has increased the storm flows that inundate the sewer with sediment and debris leading to frequent flooding of the area during even minor storm events. Since 2002, the entrance of West Indian Creek has been almost completely blocked by aggregating sediment and debris. This has resulted in the formation of a braided stream system that has exacerbated erosion before making its way to East Indian Creek during major storm events.

The goal is to design and construct a new stream channel to the east branch of Indian Creek that completely bypasses the combined sewer system. This will remove the flow of the west branch of Indian Creek from the combined sewer thereby greatly reducing sewer overflow events and decreasing flooding of the park by providing a route for the water to be conveyed. The day-lighting of this reach of the West Indian Creek will result in approximately 600-800 ft of stream reclamation, including natural stream features such as constructed pools and riffles.





The major components of this project are summarized below:

Day-lighting and Natural Stream Channel Design of West Indian Creek

During storm events, West Indian Creek is forced to bypass the culvert and define its own path towards East Indian Creek, resulting in shallow braided channels. The stream will be daylighted upstream of the culvert headwall into a single channel with appropriate sinuosity, bankfull cross-sectional area, and riffle-pool sequences. The implementation of this plan will result in the creation/restoration of 600-800 feet of natural stream channel and associated riparian areas. If possible, wetland areas in the floodplain would be enhanced as an added feature to the day-lighted stream.

C-05 In-System Storage

During large storm events, the C-05 regulator would bypass flow from the combined sewer, merging with West Indian Creek.

This component of the project aims to daylight West Indian Creek and create a natural confluence with the east branch of Indian Creek. An added benefit to this component is the availability of additional combined sewer overflow (CSO) storage volume. By bypassing West Indian Creek through a new stream channel, the volume of the culvert is no longer required to accommodate its storm flow. By installing a dam just upstream of the outfall into the east branch of Indian Creek, this volume can be used to significantly lessen the amount of CSO flow discharging into the stream. The reduction was estimated to be from 24 CSOs per year to 3 CSOs per year.

Natural Stream Channel Design of East Indian Creek

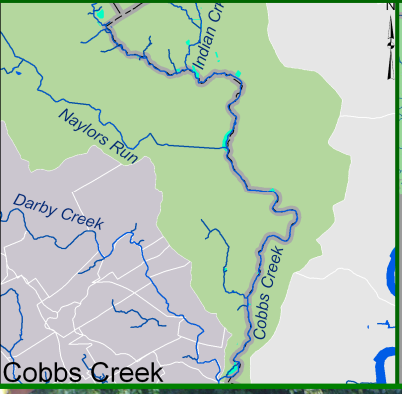
In addition to day-lighting and channel design of West Indian Creek, a substantial portion of East Indian Creek is also proposed for improvement. As a result of excessive stream flows and exacerbated sediment transport and scouring events, this portion of East Indian Creek has become severely entrenched. Based upon analysis of available orthophotography in the area, the stream has migrated approximately 20-40 feet towards a concrete access road. The situation has been degraded further by the unintentional diversion of storm flows from the west branch of Indian Creek. To properly accommodate the day-lighted portion of West Indian Creek, as well to repair the actively degrading East Indian Creek, approximately 700-1000 feet of East Indian Creek would need to be restored.

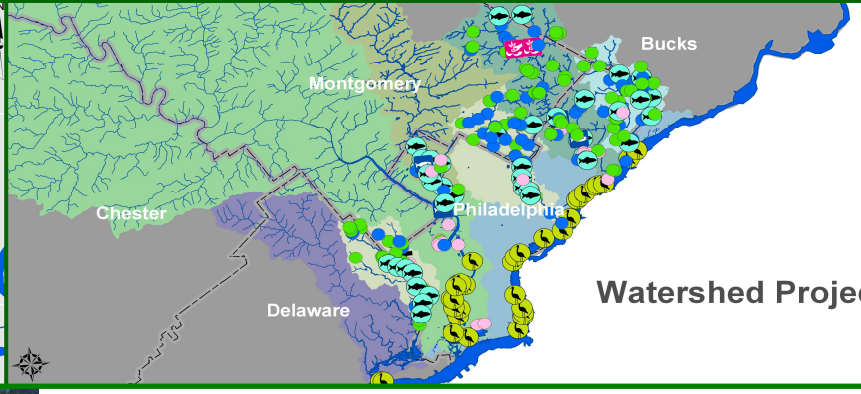
Cobbs Creek Stream Restoration

Cobbs Creek is a third-order tributary with a drainage area of 22.5 square miles. It originates in Montgomery County and flows approximately 8.3 miles in a southeasterly direction until its confluence with the Darby Creek. Its main stem roughly defines the western border of Philadelphia County. The Cobbs Creek watershed is also comprised of an additional 5.5 miles of tributaries, such as Indian Creek and Naylors Run, which emanate from Montgomery and Delaware counties.

The Darby-Cobbs Watershed is a well-developed area with 73% of land use classified as 'residential' and only 3% of the land within the watershed is classified as 'wooded' and/or 'recreational areas'. Although the watershed has a low percentage of 'open' land, its location adjacent to the Darby Creek, Cobbs Creek and tributaries provides the greatest benefit possible as a riparian buffer

The Cobbs Creek Watershed is densely developed with the majority of its landuse designated as high-density residential and commercial land. Although the surrounding Cobbs Creek Park acts as a buffer, the Creek experiences a "flashy" hydrologic regime reflective of its urban surroundings. The large percentage of impervious land (>30% in many subsheds) results in suppressed baseflow and exaggerated stormflow. According to baseflow separation analysis





based on 27 years of flow data at USGS gage 01475550, baseflow accounts for only 42% of mean total yearly flow. This flow regime, which is common to urban watersheds, has had significant impacts on the channel morphology of Cobbs Creek. Evidence of these impacts is clearly observed in the stream's inability to effectively transport sediment and its actively eroding banks.

Designated uses of the Cobbs Creek Watershed are for warm water fisheries (WWF) and migratory fishes (MF). The entire main stem is listed as impaired in the Pennsylvania Department of Environmental Protection (PADEP) 2006 Pennsylvania Integrated Water Quality Monitoring and Assessment Report. The creek is not meeting the designated aquatic life use and is listed for urban runoff/storm sewers and municipal point sources. A Total Maximum Daily Load (TMDL) allocation does not currently exist, but is designated to be finalized by 2015.

PWD is assessing the feasibility of accomplishing a natural stream channel design for 7.1 miles of Cobbs Creek. The evaluation of the existing data of the creek is the start of a long-term program of restoration design and construction activities on the main stem of Cobbs Creek and its adjoining riparian areas. These activities will be part of PWD's implementation of the Cobbs Creek Integrated Watershed Management Plan, the goals of which include protecting, enhancing and restoring the beneficial uses of the Cobbs Creek waterways and riparian areas.

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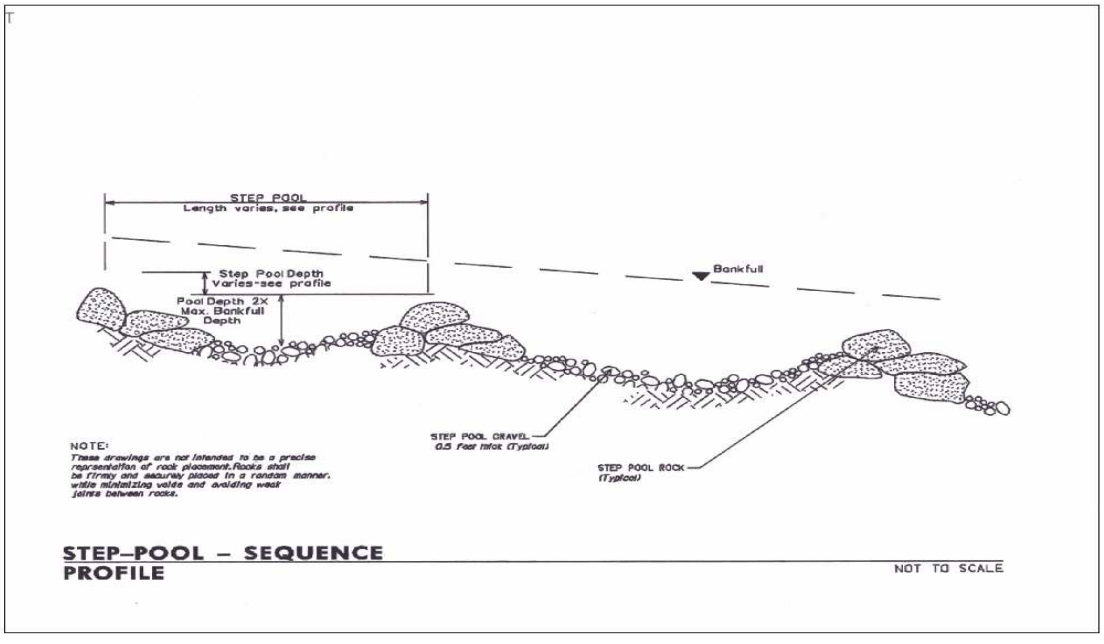
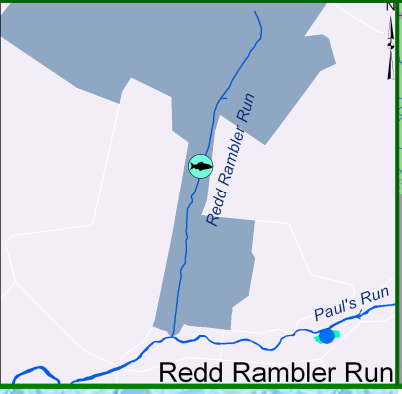
Stream Restoration

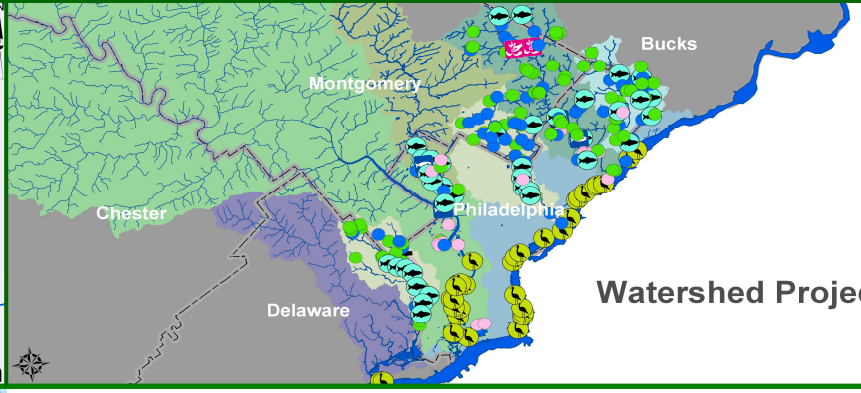
Redd Rambler Run Stream Restoration

Redd Rambler Run is a tributary to Pennypack Creek located in Northeast Philadelphia. Redd Rambler Run sits flows through approximately 70 backyards in a Philadelphia subdivision. Its problems are typical for an urban stream—channel incision, bank erosion, and blockages to the movement of fish and other aquatic life. The purpose of this project is to "recreate a stable, aesthetically pleasing stream with the potential to nurture habitat."

In recent years, PWD received calls from a number of concerned homeowners along Redd Rambler Run. Each had a specific complaint regarding conditions in their backyards – lost fencing, exposed tree roots, dwindling yard space, exposed pool foundation. Each complaint that was received from the homeowners was a direct result of the transformation of their normal flowing backyard stream into a raging torrent of water during storms. Upon inspection, PWD discovered widespread erosion that affected not only the callers' properties, but that of their subdivision at large. After further investigation, PWD began developing plans to launch a pilot project involving the restoration of approximately 2,700 feet of streambed and channel along Redd Rambler Run, where crumbling banks revealed the decade-long effects of urban development. The stream restoration methods are intended to mimic nature and help the stream maintain itself, while improving water quality and reducing damage caused by fast, heavy flows of stormwater runoff.







PWD has conducted a preliminary assessment and a field survey of the site in order to determine the channel width required to adequately convey both normal stream flow and expected storm flows within the revitalized channel Existing fences, sheds, walls and trees may need to be relocated or rebuilt to provide a stable, sustainable channel for the restored stream. Finally, design plans were prepared that holistically considered the engineering requirements for a stable stream with the current physical characteristics of the stream and its neighboring properties. Together, this information details the proposed stream alignment and channel treatments that will meet the residents' goals (a stable, aesthetically pleasing stream) and PWD's overall restoration design goals (a clean stream with the potential to nurture habitat). The design involves minor channel realignment at localized reaches, bank re-grading and stabilization using stone and planted materials, and channel bed stabilization through a combination of pools and shallow riffles (a shallow area of a stream in which water flows rapidly over a rocky or gravelly stream bed). The minor channel realignment away from existing structures and large trees will include the narrowing of the channel width for steeper side slopes, the steepening and roughening of the channel bed in localized areas, and the use of imbricated walls along steep embankments, especially around permanent structures.

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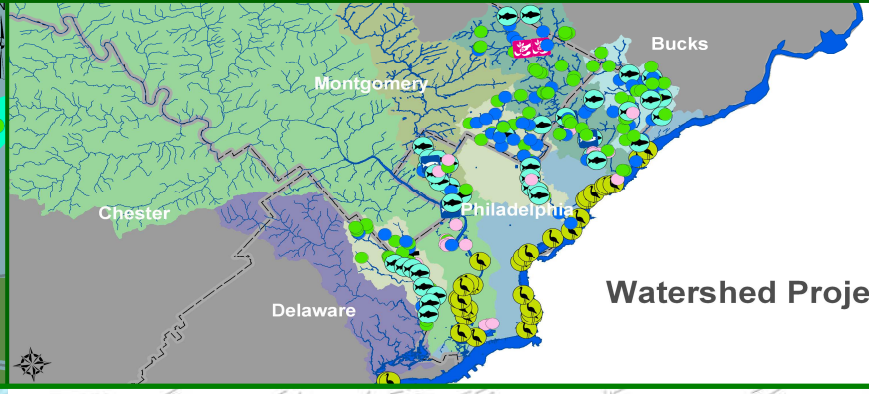
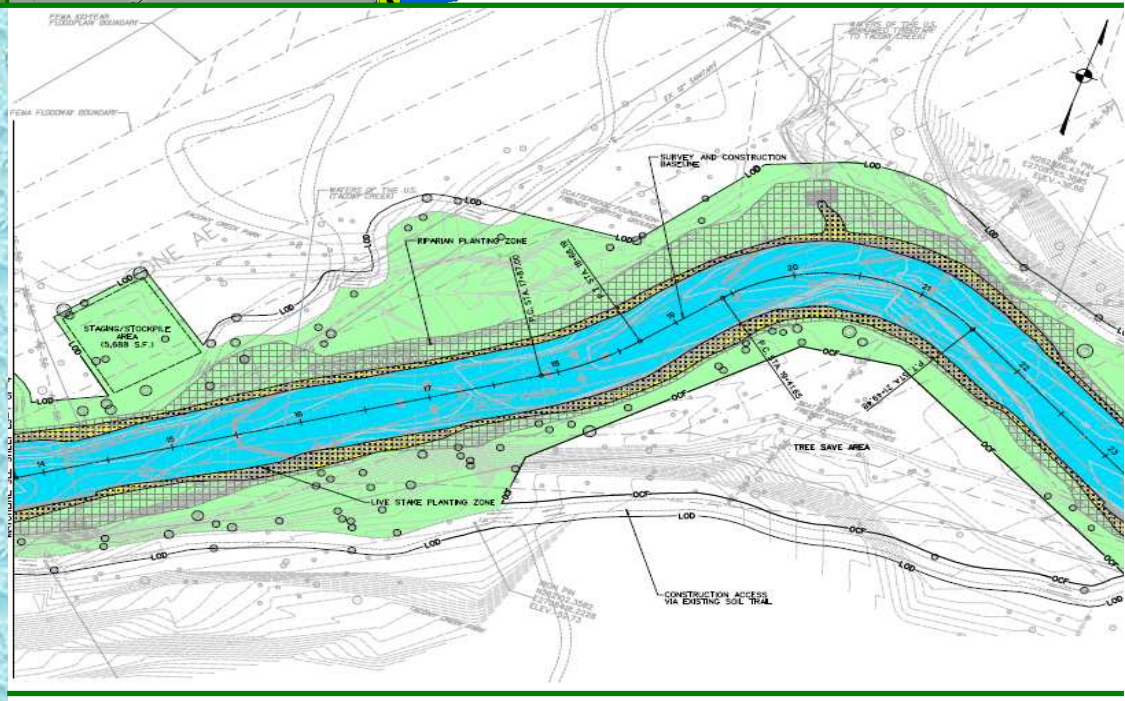
Whitaker Avenue – Tacony Creek Stream Restoration

The City of Philadelphia Water Department (PWD) is developing a natural stream channel design for the restoration of a section of Tacony Creek within the City of Philadelphia. The project area includes, approximately, a 2200-foot reach of Tacony Creek located south of Roosevelt Boulevard (US 1), downstream of the Whitaker Avenue Bridge and upstream of the Wyoming Avenue Bridge in northeastern Philadelphia. The project area exists within portions of Tacony Creek Park, owned by the Fairmount Park Commission (FPC), Friends Hospital Grounds, owned by the Scattergood Foundation, and Right-Of-Way bordering a former railroad crossing, owned by PECO. Project objectives/goals include providing a natural channel design that protects existing PWD infrastructure, stabilizes eroding stream banks, addresses the impacts of urban hydrology, enhances aquatic and riparian habitat; and provides cost savings over structural solutions.

The project reach is impacted by a flashy hydrologic regime common to many urban stream systems. Abandoned railroad abutments are constricting floodplain access in the upper portion of the site. Several outer meander bends are experiencing severe bank erosion and evidence of lateral channel migration. Erosive processes have exposed existing PWD infrastructure including a pair of sanitary manholes. Sedimentation and loss of aquatic habitat are evident throughout the project reach. Aesthetically, the channel is scattered with trash and debris including several abandoned automobiles.

The two existing, abandoned railroad abutments and adjacent segments of stone retaining wall will be removed to eliminate associated hydraulic impacts and reestablish a more stable channel dimension. Eroded meander bends will be realigned with a more stable radius of curvature and reestablished using stone tow protection in conjunction with bioengineered bank stabilization treatments. Rock vane structures will be installed in the





channel at meander bends within the project reach to redirect flows away from outside stream banks and adjacent sanitary infrastructure and to improve aquatic habitat. A portion of the existing stream, currently impacted by a cut-off channel, will be restored to a single channel to improve sediment transport. Boulder clusters will be placed in the channel to improve flow diversity and in-stream habitat. Recommendations have been developed for the removal of existing trash and debris from the channel in order to improve aesthetic site conditions. Enhancements to the existing riparian corridor have been proposed by incorporating native seeding and supplemental riparian plantings following construction. Riparian plantings will consist of native tree and shrub species common to the area.

BENEFITS:

- Minimization of impacts of non-point source pollution contributed by upstream runoff.
- An integrated restoration of 1,700 ft. of stream that improves the physical, chemical, and ecologic metrics of stream health.
- A stable channel in dynamic equilibrium with it's surrounding watershed.
- Stream bank stabilization measures featuring soil bioengineering and natural channel design measures that protect infrastructure and the environment in a highly sustainable manner.
- A healthy, vegetated riparian zone to add biological diversity to the stream system.
- Enhance, In-stream aquatic habitat.
- Opportunities for the community to learn about stream ecology and morphology.
- Increased habitat heterogeneity (i.e. pools, riffles, runs).

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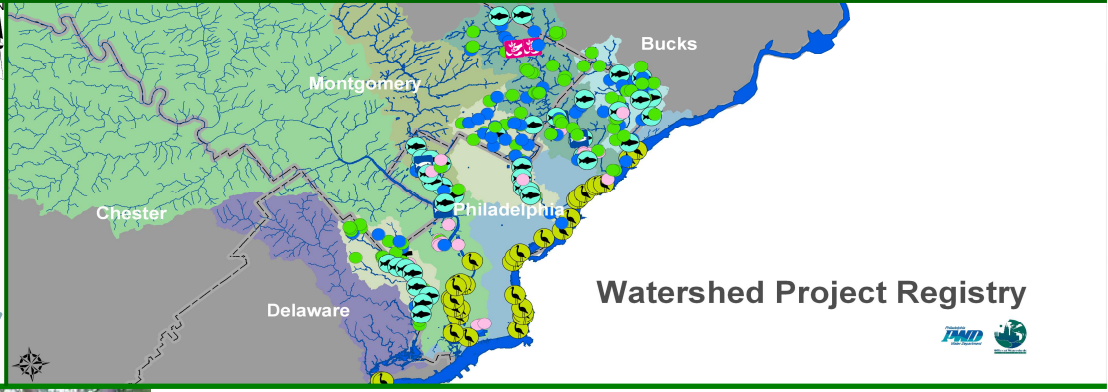
Philadelphia Water Department

Tacony Creek Stream Restoration

The Tookany/Tacony-Frankford Creek Watershed is located within both the City of Philadelphia and Montgomery County. The mainstem is approximately 14.5 miles in length – about 6.2 miles within the City (Tacony-Frankford Creek) and 8.3 miles in Montgomery County (Tookany Creek). Much of the Tacony Creek Watershed is served by a combined sewer system. Wet weather overflows at combined sewer outfall (CSO) structures periodically cause releases of combined sewage to streams.

Tookany/Tacony-Frankford is an urban stream system that has been adversely affected by development and land use practices over the past century. Impervious cover is estimated at 40.9% of the watershed in total and 53.6% within the city of Philadelphia. Tookany/Tacony-Frankford streams are extremely "flashy"- increases in streamflow and erosive forces occur almost immediately following the onset of storm events. Both maximum discharge and total runoff volume are increased compared to an undeveloped watershed.

Changes in hydrology have resulted in de-stabilization of much of the watershed. Urbanization promotes a cumulative, self-reinforcing pattern of streambank erosion. As stream channels become physically larger and further disconnected from their historic floodplains, more stormwater forces are restricted to the stream channel, where compromised, heavily eroded banks are least suited to dissipate them. These overwidened



stream segments deficient in baseflow make very poor habitats for all but the most tolerant generalist species. Streambank erosion, including erosion around PWD infrastructure, was observed along the Tacony Creek.

Designated use of the Tacony Creek is for warm water fishes (WWF). The entire mainstem, within Philadelphia County, is listed as impaired in the Pennsylvania Department of Environmental Protection (PADEP) 2006 Pennsylvania Integrated Water Quality Monitoring and Assessment Report Category 4c - Waterbodies, Pollution not Requiring a TMDL. The creek is not meeting the designated aquatic life use and is listed for urban runoff/storm sewers with the cause listed as flow alterations, other habitat alterations, and water/flow variability. An additional 1.59 miles of the Tacony Creek are listed in Category 5 – Waterbodies, Pollutants Requiring a TMDL as not meeting the designated fish consumption use.

PWD is developing a plan that prioritizes and identifies potential stream, wetland and riparian enhancement projects within the Tacony Creek Watershed. The primary goal is to develop a riparian based plan for stream, wetland, riparian corridor creation and water quality best management practices (BMPs). The goal of the design project is to include wetland creation, stream restoration, water quality BMPs and fish passage improvements.