Phase II Final Report

Cooks Run Watershed Assessment

June 30, 2008

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Phase II Final Report

Cooks Run Watershed Assessment

Funded by the PA DEP
Growing Greener Grant Program

PA DEP Document No. 4100028837

This project was financed and administered by the Pennsylvania Department of Environmental Protection (DEP) through its Growing Greener Grant Project. For this project, the Bucks County Conservation District served as the Project Sponsor. In turn, the District selected Aqua Link, Inc. as its consultant to perform this assessment. The views expressed herein are those of the author(s) and do not necessarily reflect those of PA DEP nor any of their sub-agencies.

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Cooks Run during the Spring 2007. Photograph taken by Edward W. Molesky of Aqua Link, Inc.

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Acknowledgements

The second phase (Phase II) of the Cooks Run Watershed Assessment would not be possible without the financial support of the Pennsylvania Department of Environmental Protection through its Growing Greener Grant Program.

Aqua Link, Inc. and the District would like to thank the County Commissioners and the District Board of Directors for their support of the Cooks Run Watershed Assessment Projects (Phase I and Phase II), thereby allowing the District to serve as the Project Sponsor. Aqua Link commends their strong commitment for protecting and restoring the water resources of Bucks County.

Aqua Link would also like to thank Gilmore and Associates, Inc. for their assistance in assessing major stormwater management facilities for this project. Lastly, Aqua Link would like to thank Ms. Gretchen Schatschneider, District Manager of the Bucks County Conservation District, for all her hard work and assistance through the entire project.

Edward W. Molesky, CLM

President
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Executive Summary

The Cooks Run watershed, which is approximately 3.3 square miles in size, is located in central Bucks County. Cooks Run flows in a southwesterly direction and discharges into the Neshaminy Creek, which in turn flows into the Delaware River. Currently, Cooks Run is classified as Warmwater Fishery (WWF), MF (Migratory Fishery) under PA DEP's Chapter 93 Water Quality Standards. Both the Neshaminy Creek and Cooks Run are listed on the State's 303(d) List of Impaired Waters.

This report describes the findings of the second phase, Phase II, of the Cooks Run watershed assessment. Aqua Link prepared this report for the Bucks County Conservation District and the Pennsylvania Department of Environmental Protection (PA DEP). The District served as the project sponsor for this assessment and PA DEP provided funding through its Growing Greener Grant Program.

As part of this assessment, a comprehensive watershed management plan was developed for the lower Cooks Run subwatershed. Therefore, when combined, the Phase I and II reports provide recommendations to improve and further protect the water quality and aquatic habitats for all of Cooks Run. The Phase II management plan is based upon the field data collected during the stream and riparian visual assessment, the nonpoint source pollution (NPS) assessment and the stormwater management assessment in the lower Cooks Run subwatershed.

Overall, the primary goal of the Phase II Cooks Run watershed assessment was to develop a comprehensive management plan for the lower subwatershed in order to reduce nonpoint source pollutants to Cooks Run. Key recommendations offered in this management plan are to restore forested riparian buffers along streams, repair major nonpoint source (NPS) problem areas and retrofit major stormwater management facilities in the lower Cooks Run subwatershed. In this project, all of the identified nonpoint source problems are associated with streambank erosion.

1. Introduction

Cooks Run and its watershed (3.3 square miles) are located in central Bucks County. This stream flows in a southwesterly direction and eventually flows into the Neshaminy Creek, which subsequently flows into the Delaware River. Currently, Cooks Run is classified as Warmwater Fishery (WWF), MF (Migratory Fishery) under PA DEP's Chapter 93 Water Quality Standards. The headwaters of Cooks Run are located within the Borough of Doylestown and then flow through Doylestown Township and the Borough of New Britain. Both the Neshaminy Creek and its tributary, Cooks Run, are listed on the State's 303(d) List of Impaired Waters.

Scenic Section of Cooks Run in the Lower Subwatershed Area

As noted in the Cooks Run Watershed Assessment Phase I Final Report (Aqua Link, Inc. March 2004), the potential threat for water quality degradation continues to remain high within the Cooks Run watershed. This is largely due to the high degree of urbanization occurring within the upper portion of the watershed. In addition to urban land uses, other potential sources of nonpoint pollution to Cooks Run include more residential and commercial land development, stream bank erosion and others.

The Cooks Run Phase I Watershed Assessment revealed that Cooks Run is considered enriched with nutrients (phosphorus and nitrogen) during both baseflow (normal flow) and stormflow (high flow) conditions. Higher phosphorus and suspend solids (sediment) concentrations during storm events may be attributed to increased rates of streambank erosion and additional inputs from stormwater runoff. During baseflow conditions, elevated nutrient concentrations downstream of Limekiln Road are largely due to the discharge of treated effluent from the Harvey Avenue wastewater treatment plant (Aqua Link, March 2004).

During the Phase I assessment, dissolved oxygen concentrations in the stream were generally considered good and the pH values were near neutral during baseflow and stormflow conditions. Fecal coliform bacteria concentrations during baseflow and stormflow conditions were considered high and very high, respectively. The dramatic concentration increases during storms is likely due to the transportation of animal feces to the stream via stormwater runoff. Sources of animal feces within the watershed are pets and wildlife. Overall, the high bacteria concentrations make the stream unsuitable for primary contact recreation such as swimming (Aqua Link, March 2004).

Cooks Run Watershed Assessment

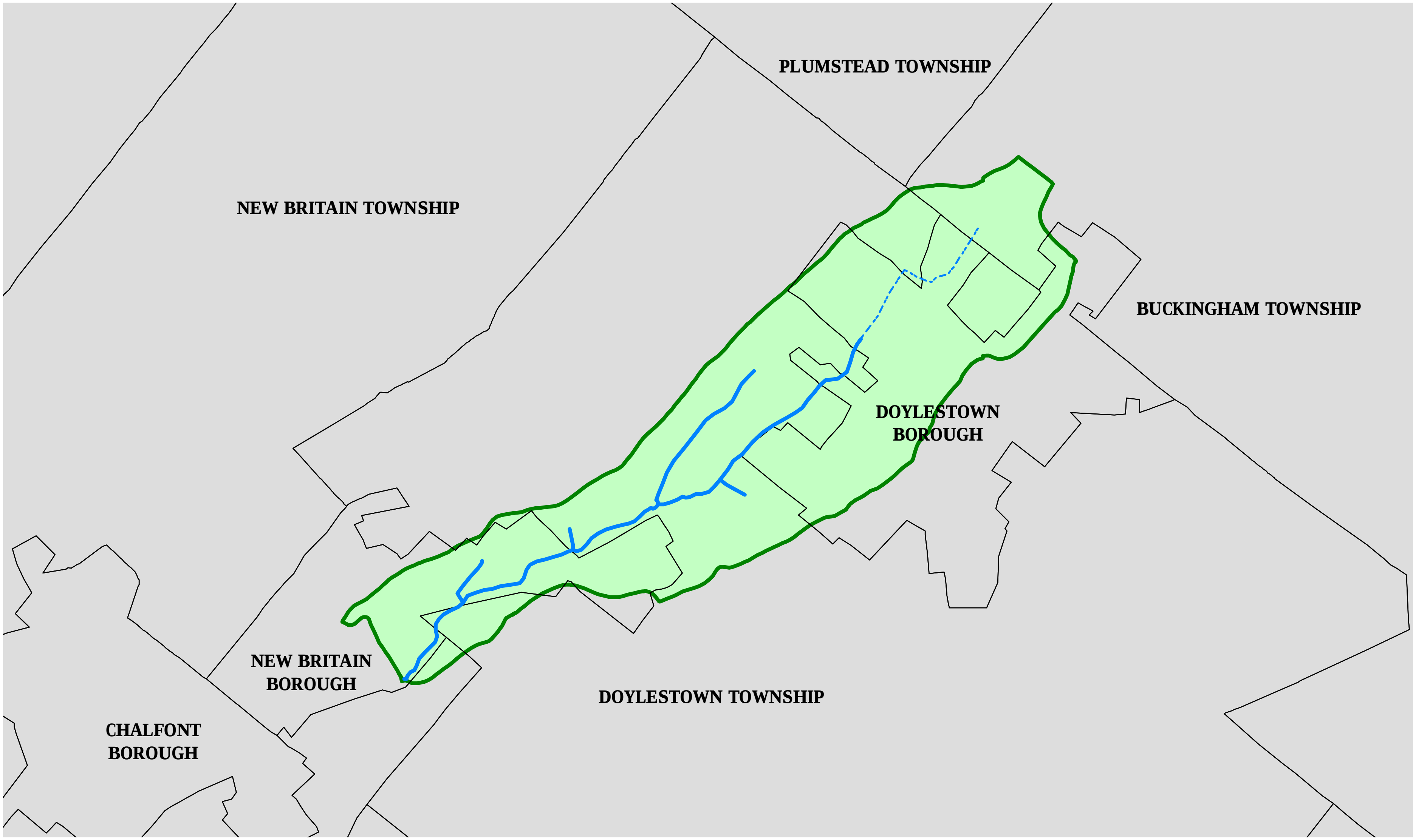

Figure 1.1 Political Boundary Map

- Cooks Run Watershed
- Municipal Boundary
- Cooks Run (USGS)
- Cooks Run (Determined by Aqua-Link, Inc. 2004)

4000 0 4000 Feet

Data Source:
PA Dep, USGS

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HERITAGE CONSERVANCY

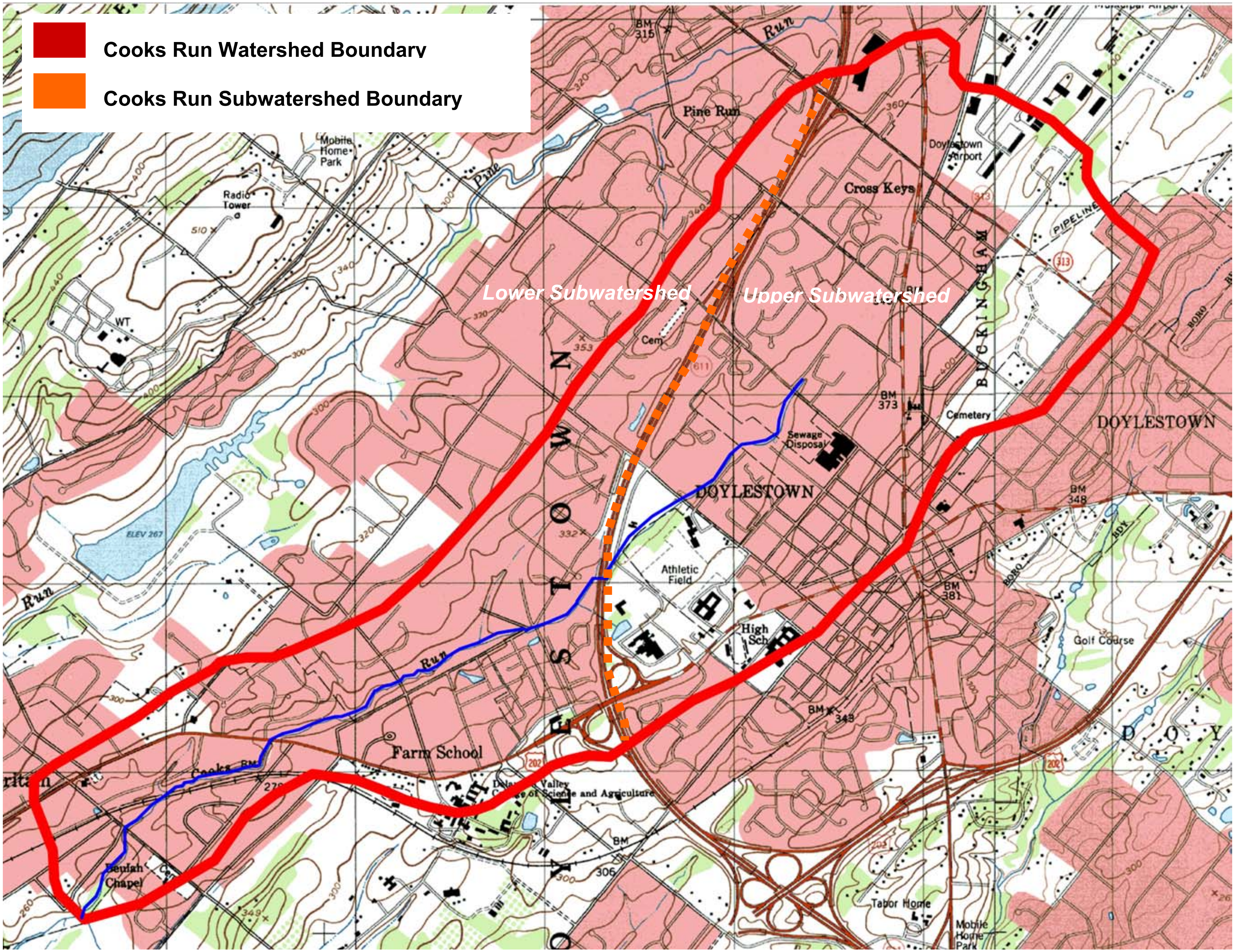

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Figure 1.2

Cooks Run Watershed Topographic Map

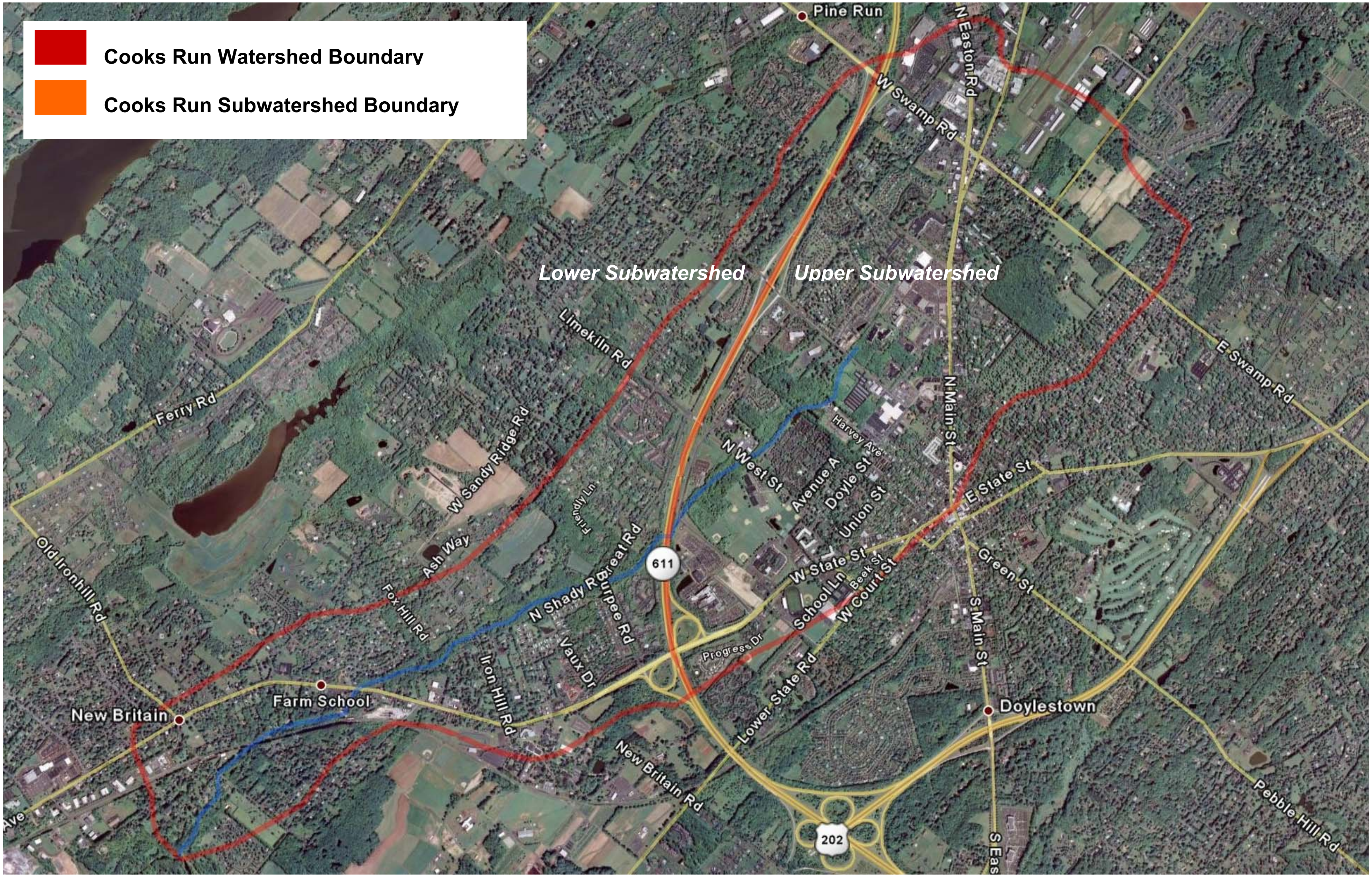

Figure 1.3

Cooks Run Watershed Aerial Photography Map

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The most prevalent heavy metals in Cooks Run during the study period were chromium, copper, lead and zinc. These metals are often associated with streams in urbanized watersheds. Overall, metal concentrations increased during stormflow conditions and these concentrations were the highest in the lower section of the watershed (lower subwatershed). The upper and lower subwatersheds are defined as those portions of the Cooks Run watershed above and below the Route 611 Bypass, respectively (Aqua Link, March 2004).

Macroinvertebrate (aquatic organism) data for Cooks Run reflects impairment from organic pollution and/or habitat degradation. Overall, these data indicate that the highest levels of impairment occur in the upper portion of the watershed (above the Route 611 Bypass). Somewhat lower levels of impairment were observed in the lower portion of the watershed (below the Route 611 Bypass). Based upon field observations and water quality data, higher levels of impairment in the upper subwatershed are apparently due to loss of aquatic habitats, especially as a result of stream channel modifications and excessive sedimentation (Aqua Link, March 2004).

For this Phase II assessment project, the Bucks County Conservation District received state funding by the Pennsylvania Department of Environmental Protection (PA DEP) through its Growing Greener Program to complete the second phase (Phase II) of the Cooks Run Watershed Assessment Project. The second phase is dedicated solely to the assessment of the lower section of the watershed (Figures 1.1 and 1.2). This section of the watershed is designated roughly as south of Route 611 down to the confluence of the Neshaminy Creek. The lower section of the watershed lies within Doylestown Township and New Britain Borough. The work that was performed during Phase II of Cooks Run Watershed Assessment Project is as follows:

- Evaluate major stormwater management facilities within the lower section of the watershed.
- Perform a stream and riparian corridor assessment of the lower section of the watershed.
- Provide recommendations to retrofit existing stormwater management facilities with respect to water quality, to stabilize severely eroding streambanks and to establish adequate riparian vegetation to protect streambanks and stream water quality in the lower section of the watershed.
- Provide additional mapping to support the above tasks.

This report represents the final phase (Phase II) of the Cooks Run watershed assessment project. At this time, the District and its partners will apply for additional funds to implement key elements of the developed Phase I and Phase II watershed management plans.

The Cooks Run Phase I Watershed Assessment began in February 2003 and was completed on March 31, 2004. The National Oceanic and Atmospheric Administration (NOAA) funded the first phase (Phase I) of the watershed assessment through its Coastal Zone Management Program. The following is a list of tasks that were completed under the first phase of this project:

- Mapping of the entire watershed (upper and lower sections)
- Detailed narrative of the entire watershed
- Stream water quality monitoring at four stations throughout the watershed during baseflow (normal flow) and stormflow (high flow) conditions.
- Macroinvertebrate (aquatic insect) monitoring at four stations throughout the watershed.
- Evaluate major stormwater management facilities within the upper section of the watershed. The upper subwatershed is defined as that portion of the watershed that begins north of Route 313 (headwaters) and extends down to Route 202.
- Perform a stream and riparian corridor assessment of the upper section of the watershed.
- Evaluate municipal ordinances for the entire watershed.

Information about the tasks and the first phase of this assessment can be found in the Phase I Final Report Cooks Run Watershed Assessment (Aqua Link, Inc. March 2004).

2. Overview of the Watershed Assessment

2.1. Primer on Stream and Watershed Dynamics

This section of the report is intended to serve as a primer on stream and watershed dynamics as it pertains to the urbanization process. Much of the information below was obtained directly from the document entitled *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs* (Schueler 1987). First, an overview of the impacts that urbanization has on streams and other receiving waters is discussed. Next, the specific impacts of various pollutants contained in urban runoff are presented.

Changes in Watershed Hydrology

Urbanization has a profound influence on stream quality. These are readily seen when a stream in an older urban area is compared to one in a more natural setting. The following narrative describes the changes associated with the development of hypothetical small watershed.

The hydrology of a stream changes in response to initial site clearing and grading. Trees that had intercepted rainfall are felled (Figure 3.1a). Natural depressions, which temporarily ponded water, are graded to a uniform slope. The thick humus layer of the forest floor that had absorbed rainfall is scraped off or erodes away. Having lost much of its natural storage capacity, the cleared and graded site can no longer prevent rainfall from being rapidly converted to runoff.

The situation worsens after construction is completed (Figure 3.l a). Rooftops, roads, parking lots, sidewalks and driveways make much of the site impervious to rainfall. Unable to percolate into the soil, rainfall is almost completely converted into runoff. The excess runoff becomes too great for the existing drainage system to handle. As a result, the drainage network must be "improved" to direct and convey the runoff away from the site (i.e., by installing culverts, curbs, gutters, storm sewers, or lined channels).

In a typical, moderately developed watershed, the net effect of development is a series of changes to stream hydrology (Figure 3.l b) including:

- Increased peak discharges about two to five times higher than pre-development levels.
- Increased volume of storm runoff produced by each storm, in comparison to pre-development conditions. A moderately developed watershed may produce 50% more runoff volume than a forested watershed during the same storm.

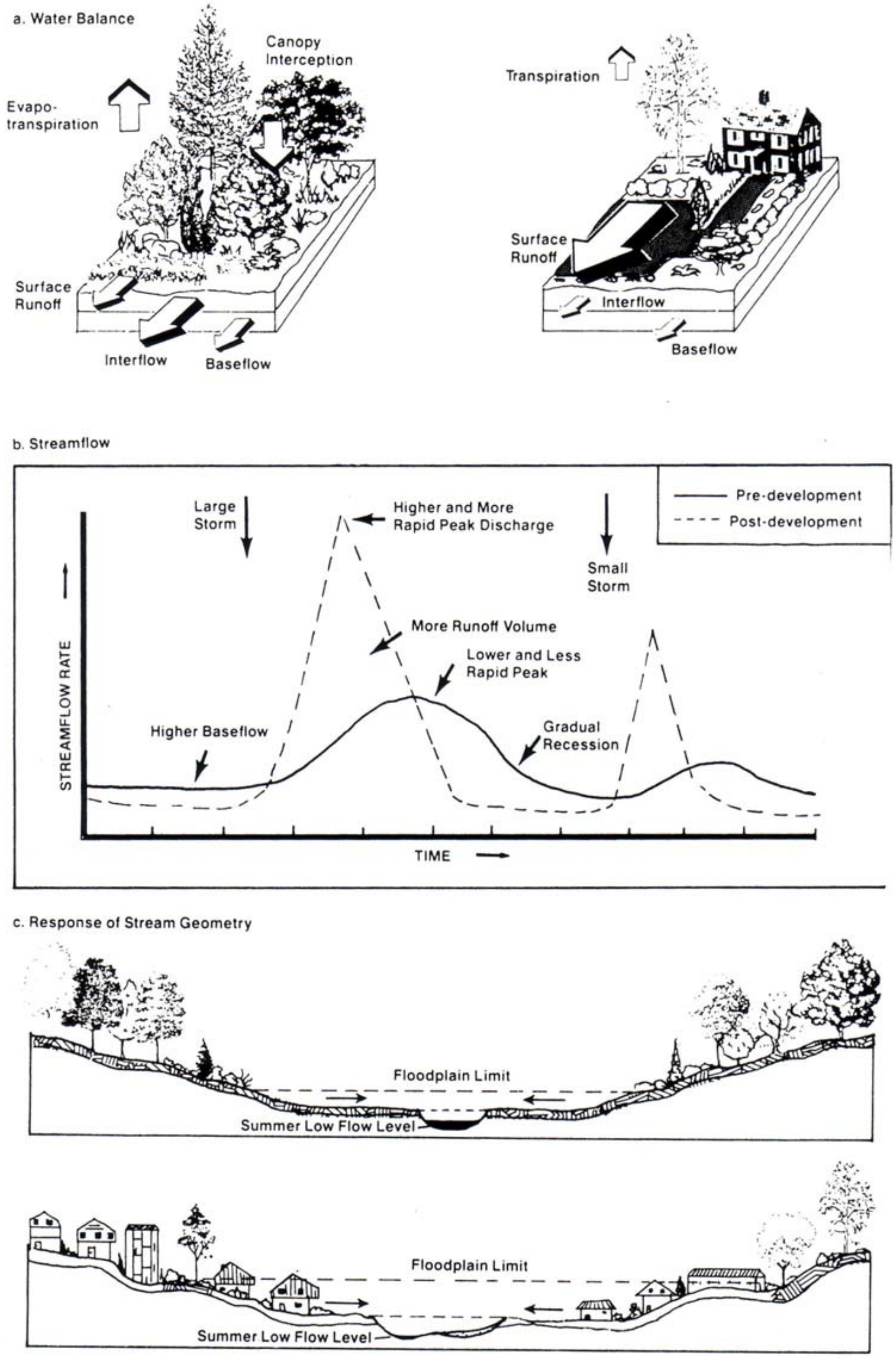

Figure 2.1 Changes in Watershed Hydrology as a Result of Urbanization

- Decreased time needed for runoff to reach the stream (termed the time concentration) by as much as 50%, particularly if extensive drainage improvements are made.

- Increased frequency and severity of flooding. A short, intense summer thunderstorm that had only slightly raised water levels in the past now turns the stream into a torrent. In a natural state, a stream experiences bankfull discharges (i.e., runoff entirely fills the stream channel) only about once every two years. In moderately developed watersheds, bankfull discharges may occur as often as three or four times a year.

- Reduced streamflow during prolonged periods of dry weather due to the reduced level of infiltration in the watershed. In smaller, headwater streams, the reduction may be enough to cause a perennial stream to become seasonally dry.

- Greater runoff velocity during storms that is due to the combined effect of higher peak discharges, rapid time of concentration, and smoother hydraulic surfaces that resulted from development.

Changes in Stream Geometry

The channel of an urbanizing stream must adjust to the new hydrological conditions, and this results in the following responses:

- The primary adjustment to the increased storm flows is through channel widening (Figure 3.l c). Numerous surveys have shown that most streams widen two to four times their original size if post-development runoff is not effectively controlled. The resulting streambank erosion is severe because most floodplain soils are unconsolidated and highly erodible.

- The elevation of the stream's floodplain must increase to accommodate the higher post-development peak discharge rate (Figure 3.l c). Property and structures, which had not previously been subject to flooding, are now may be at risk.

- Streambanks are gradually undercut and slump into the channel. Trees that had protected the banks are exposed at the roots, and are more likely to be windthrown, triggering a second phase of bank erosion.

- The unusually high quantities of the sediment eroded from streambanks and upland areas are seldom completely exported from the watershed. Much of it remains as temporary channel storage in the form of sandbars and other sediment deposits. Gradually, the extra sediment moves through the stream network as bedload. However, for many years, the channel substrate is covered by shifting deposits of mud and coarse sand.

Degradation of Aquatic Ecosystems

The aquatic ecosystems in urban headwater streams are particularly susceptible to the impacts of urbanization. The massive shift from the natural flow and channel conditions reduce the habitat value of the stream. Studies have shown that fish communities become less diverse and are composed of more tolerant species after the surrounding watershed is developed. Sensitive fish species either disappear or occur very rarely. In most cases, the total number of fish in urbanizing streams may also decline.

Similar trends have been noted among aquatic insects, which are the major food resource for fish. These species cling to rocks and rely on the passing flow of leaf litter and organic matter for sustenance. Higher post-development sediment and trace metals can interfere in their efforts to gather food. Changes in water temperature, oxygen levels, and substrate composition can further reduce the species diversity and abundance of the aquatic insect community. No single factor is responsible for the progressive degradation of urban stream ecosystems. Rather, it is probably the cumulative impacts of many individual factors such as sedimentation, scouring, increased flooding, lower summer flows, higher water temperatures, and pollution.

Pollutant Export During the Construction Phase

Pollutant export increases dramatically both during and after development. Initial clearing and grading operations during construction expose much of the surface soils. Unless adequate erosion controls are installed and maintained at the site, enormous quantities of sediment are delivered to the stream channel along with attached soil nutrients and organic matter.

Pollutant Export After Site Stabilization

Once the site is stabilized, pollutants accumulate rapidly on impervious surfaces and are easily washed off. The primary source of most pollutants is from the atmosphere in the form of wetfall and dryfall. Once deposited, up to 90% of the atmospheric pollutants deposited on impervious surfaces are delivered to receiving waters.

The various surfaces of the urban landscape are also an important source of many pollutants. Trace metals, for example, are a common component of many urban surfaces, such as flashing and other roofing materials, downspouts, galvanized pipes, metal plating, paints, wood preservatives, catalytic converters, brake linings and tires. Over time, these surfaces corrode, flake, decay, dissolve or leach out, thereby enabling these metals to wash away in urban runoff. This process is often exacerbated by the acidity of the rainfall.

Other sources of pollutants that accumulate and subsequently wash off impervious surfaces include pet droppings, vegetative matter, litter and debris. Several studies suggest that as neighborhoods become mature, some of these sources can become very important. Litter generation and pet dropping rates increase and the general level of "urban housekeeping" often declines, as neighborhoods grow older. Poor housekeeping is easier to define than to control. For example, heavy use areas often result in bare spots that erode, dumpsters are overloaded, out of sight alleyways and service areas are not kept up, used motor oil is dumped into storm sewers and homeowners fertilizers apply excessive quantities of fertilizers and pesticides, and so on.

Impacts of Urban Pollutants on Receiving Waters

The net effect of urbanization is to increase pollutant export by at least an order of magnitude over pre-development levels. The impact of the higher export is felt not only on adjacent streams, but also on downstream receiving waters such as lakes, rivers and estuaries. The nature of the impacts associated with specific urban pollutants is reviewed below.

Sediment

High concentrations of suspended sediment in streams cause many adverse consequences including increased turbidity, reduced light penetration, reduced prey capture for sight feeding predators, clogging of gills/filters of fish and aquatic invertebrates, reduced spawning and juvenile fish survival, and reduced angling success. Additional impacts result after sediment is deposited in slower moving receiving waters, such as smothering of the benthic community, changes in the composition of the bottom substrate, more rapid filling of small impoundments which create the need for costly dredging, and reduction in aesthetic values. Sediment is also an efficient carrier of toxicants and trace metals. Once deposited, pollutants in these enriched sediments can be remobilized under suitable environmental conditions posing a risk to benthic life.

The greatest sediment loads are exported during the construction phase of any development site. On stabilized development sites, the greatest sediment loads are exported from larger, intensively developed watersheds that are not served by BMPs that effectively control streambank erosion.

Nutrients

Excess levels of phosphorus and nitrogen in urban runoff can lead to undesirable algal blooms in downstream receiving waters (also known as eutrophication). Generally, phosphorus is the controlling nutrient in freshwater systems. The greatest risk of eutrophication is in urban lakes and impoundments that have long retention times (2 weeks or greater). Under optimal environmental growing conditions, these lake systems can experience chronic and severe eutrophic symptoms such as surface algal scums, water discoloration, strong odors, depressed oxygen levels (as the bloom decomposes), release of toxins and reduced palatability to aquatic consumers. High nutrient levels also promote the growth of dense mats of green algae that attach to rocks and cobbles in shallow, unshaded headwater streams. Finally, nutrient loads from urban runoff, in combination with other sources, can contribute to eutrophication in both fresh and tidal waters. As a general rule of thumb, nutrient export is greatest from development sites with the most impervious area. Exceptions include land uses that receive unusually high fertilizer inputs, such as golf courses, cemeteries, and other intensively landscaped areas.

Bacteria

Bacterial levels in undiluted urban runoff exceed public health standards for water contact recreation. Because bacteria multiply faster during warm weather, it is not uncommon to find a twenty-fold difference in bacterial levels between summer and winter.

Although nearly every urban and suburban land use exports enough bacteria to violate health standards, older and more intensively developed urban areas produce the greatest export. The problem is especially significant in urban areas that experience combined or sanitary sewer overflows that export bacteria derived from human wastes.

Oxygen Demand

Decomposition of organic matter by microorganisms depletes dissolved oxygen (DO) levels in slower moving receiving waters such as lakes and estuaries. The degree of potential DO depletion is measured by the biochemical oxygen demand (BOD) test that expresses the amount of easily oxidized organic matter present in water. Unfortunately, the BOD test is somewhat unreliable for measuring the oxygen demand of urban runoff since trace metals may inhibit bacterial growth and thus interfere with the test. The simpler chemical oxygen demand (COD) test, which measures all the oxidizable matter present in urban runoff, is not much better, since it includes some organic matter that does not ordinarily contribute to oxygen demand, and is only weakly correlated with BOD levels.

Despite the problems in measuring oxygen demand, it is clear that urban runoff can severely depress DO levels after large storms. BOD levels can exceed 10 to 20 mg/1 during storm "pulses" which can lead to anoxic conditions (zero oxygen) in shallow, slow-moving or poorly-flushed receiving waters. The problem is particularly acute in some older urban areas, where pulses of storm runoff BOD mix with overflows from combined or sanitary sewers.

The greatest export of BOD occurs from older, highly impervious residential areas with outdated combined storm sewers and large populations of pets. In contrast, only moderate BOD export has been reported from newer, low-density suburban residential development.

Oil and Grease

Oil and grease contain a wide array of hydrocarbon compounds, some of which are known to be toxic to aquatic life at low concentrations. The major source of hydrocarbons in urban runoff is through leakage of crankcase oil and other lubricating agents from the automobile. As might be expected, hydrocarbon levels are highest in the runoff from parking lots, roads and service stations. Residential land uses generate less hydrocarbon export, although illegal disposal of waste oil into storm sewers can be a local problem.

Hydrocarbons are lighter than water and are initially found in the form of a rainbow colored film on the water's surface. However, hydrocarbons have a strong affinity for sediment, and much of the hydrocarbon load eventually adsorbs to particles and settles out. If not trapped by BMPs, hydrocarbons tend to rapidly accumulate in the bottom sediments of lakes and estuaries, where they may persist for long periods of time and exert adverse impacts on benthic organisms.

Trace Metals

Trace metals are primarily a concern because of their toxic effects on aquatic life and their potential to contaminate drinking water supplies. As noted before, most of the metals found in urban runoff are derived from "leakage" of the urban landscape. A wide variety of trace metals were found in urban runoff samples taken during the special trace metals sampling program conducted as part of the Washington, D.C. area and national Nationwide Urban Runoff Program (NURP) studies. Specifically, the following metals were measured in detectable concentrations: arsenic, beryllium, cadmium, chromium, copper, cyanide, mercury, nickel, lead, selenium, thallium and zinc.

A wide variety of trace metals were found in urban runoff samples taken during the special trace metals sampling program conducted as part of the Washington, D.C. area and national Nationwide Urban Runoff Program (NURP) studies. Specifically, the following metals were measured in detectable concentrations: arsenic, beryllium, cadmium, chromium, copper, cyanide, mercury, nickel, lead, selenium, thallium, and zinc. With the significant exceptions of lead, cadmium, copper and zinc, most of the trace metals were found in only a few samples and then only in minute amounts that were well below human health or aquatic life criteria. Lead, copper and zinc were generally found in most samples and were occasionally recorded at levels an order of magnitude higher than recommended aquatic life criteria.

Toxic Chemicals

Most urban runoff rarely contains toxic chemicals in amounts that exceeded current safety criteria. Possible sources of toxic chemicals to streams are illegal disposal of household hazardous wastes, such as waste oil, paint thinners, preservatives and pesticides. In the Washington D.C area, ten different pesticides have been detected in urban runoff, but the concentrations were near the limits of detection (less than 1 ppb).

Chlorides

Chlorides or salts are often introduced into streams after they are applied to remove ice and snow from roads, parking lots and sidewalks. Salt levels in snowmelt runoff have been reported to exceed several thousand milligrams per liter. Due to its extreme solubility, almost all the chloride applied for snow removal purposes ends up in surface or ground waters. At high levels, chlorides are toxic to many freshwater aquatic organisms since most are only adapted to withstand a relatively narrow range of salinity.

Thermal Impacts

Elevated water temperatures can have dire consequences for stream biota, which are adapted to a coldwater environment. A rise in water temperature of just a few degrees Celsius over ambient conditions can reduce sensitive stream insects and fish species, such as stoneflies and trout. In general, sustained summertime water temperatures in degrees Celsius (70 degrees Fahrenheit) are considered to be stressful, if not lethal, to many coldwater organisms.

A number of factors can increase summertime water temperatures in urban headwater streams. Of these, three factors often act synergistically to increase water temperatures. First, as the urban landscape heats up on warm summer days, it tends to impart a great deal of heat to any runoff passing over it. Second, fewer trees are present on the streambanks to shade the stream channel, adding to the warming effect. Third, runoff stored in shallow wet ponds and other impoundments is heated in between storms and then may be released in a rapid pulse during a storm event.

2.2. Study Design and Data Acquisition

The Cooks Run watershed assessment was designed as a two-phased project. This multi-phased approach for this assessment was strongly encouraged and endorsed by representatives of the Pennsylvania Department of Environmental Protection (PA DEP). This report represents the second and final phase (Phase II) of the Cooks Run watershed assessment.

The Phase II watershed assessment solely focused on lower section of the Cooks Run watershed. The upper section of the watershed (upper subwatershed) is defined as that portion of the watershed north of the Route 611 Bypass. The lower section of the watershed (lower subwatershed) is defined as that portion of the watershed south of the Route 611 Bypass down to the confluence of Cooks Run and the Neshaminy Creek. The Phase II assessment largely involved intensive field reconnaissance by performing a stream and riparian visual assessment, a nonpoint source assessment and the stormwater management assessment in the lower section of the watershed.

2.2.1. Stream & Riparian Visual Assessment

Aqua Link with the assistance of the District performed a comprehensive stream and riparian visual assessment for the lower subwatershed. The stream and riparian visual assessment was performed during the early Spring 2006. As part of this assessment, field staff walked the entire main stem of Cooks Run within the lower subwatershed. Similar stream and riparian segments were delineated using a hand held GPS (Global Positioning System) unit (Garmin GPSmap 76S). In addition, digital photographs of each stream segment were taken.

In the field, stream segments were thoroughly evaluated using a *modified* version of the *Riparian Assessment Form* developed by Melissa Schnier of The Pennsylvania State University. The original riparian assessment form is part of the document entitled *Riparain Assessment Guide* (Schnier 2003). Aqua Link's modified version of this form is entitled the *Stream and Riparian Visual Assessment Form*. A copy of the modified assessment form as revised by Aqua Link is provided in Appendix B.

Using Aqua Link's modified form, stream segments were assigned a numerical score from 1 through 10 (ranging from poor to excellent) for each of the following ten attributes: riparian buffer width, riparian vegetation type, riparian vegetation density, bank vegetation type, bank vegetation density, bank stability, channel modification, in-stream cover, embeddedness and shading (canopy cover). The individual scores of all parameters were then tallied; and, based upon the total score, a stream segment was assigned an overall rating of of poor, marginal, good or excellent.

During the stream and riparian assessment, Aqua Link and the District acquired additional information about the need for riparian buffers and all pipes that directly discharge to the main stem of Cooks Run. For each segment, the amount of riparian buffers needed for each stream segment was estimated using a laser range finder. Also, all pipes that discharge directly into Cooks Run were identified. The shape and diameter of all discharge pipes were recorded. The locations of all discharge pipes were determined using a GPS unit and photographed with a digital camera. Information for all of the discharge pipes is presented in Appendix A.

2.2.2. Nonpoint Source Problem Assessment

Aqua Link identified significant nonpoint source problems while performing the stream and riparian visual assessment for Cooks Run in the lower subwatershed (refer to Section 3.2.3). In addition, Aqua Link walked several small, unnamed tributaries to Cooks Run and toured the remaining portion of the lower subwatershed via truck in order to identify any other significant nonpoint source (NPS) problem areas. The locations of all significant NPS watershed problems were recorded using a GPS receiver. Digital photographs were taken and written descriptions of the problem areas were prepared using field survey data sheets (Appendix C).

2.2.3. Stormwater Management Assessment

Gilmore & Associates (G&A) of New Britain, Pennsylvania were subcontracted by Aqua Link to perform the stormwater management assessment of the lower subwatershed. The purpose of this assessment was to determine if any of the facilities are good candidates for stormwater retrofitting. Initially, major stormwater management (SWM) facilities were identified using an aerial photograph of the watershed. Additional sites were identified during the inspection and assessment of previously identified facilities and through discussions with municipal engineers.

The locations of all major SWM facilities were recorded using a GPS unit. In addition, digital photographs of the facilities were taken during the on-site assessments. Lastly, G&A contacted the municipalities in order to obtain any available design information for the identified SWM facilities. G&A used this additional design information to evaluate whether the SWM facilities were constructed according to their intended design.

Design information for the SWM facilities was obtained from the local municipality where available to evaluate the stormwater management facility with regard to its design intent and construction. In some cases, information regard the proposed design/construction of such facilities was available prior to completion of the project so that the facility could be included in the watershed mapping. Both the design information, where available, and the existing condition of each facility was considered in the assessment.

3. Stream & Riparian Visual Assessment

3.1. Methodology

Aqua Link with field assistance provided by the Bucks County Conservation District performed a stream and riparian visual assessment of the lower subwatershed. The stream and riparian visual assessment was performed during the early Spring 2007. The lower section of the watershed (upper subwatershed) is defined as that portion of the watershed south of the Route 611 Bypass (Figure 1.1). For more information, refer to Section 2.2 for a detailed summary of how the stream and riparian visual assessment was performed and data were analyzed.

In addition, all stream and riparian data along with a copy of the *Stream and Riparian Visual Assessment Form* is located in Appendix B.

3.2. Results & Discussion

The results of the stream and riparian visual assessment are presented in Table 3.1 and graphically shown in Figures 3.1 and 3.2. Photographs of all stream segments are presented in Figure 3.3. Stream riparian ratings in this table were based upon the following scores: poor (0 to 35 percent), marginal (36 to 65 percent), good (66 to 85 percent) and excellent (86 to 100 percent).

Table 3.1 Stream and Riparian Data for the Lower Subwatershed

Stream Segment	Stream & Riparian Score	Stream & Riparian Rating	Length of Riparian Buffer Needed	
			Left Bank (ft)	Right Bank (ft)
16-17	86	Very Good	----	----
17-18	86	Very Good	----	----
18-19	69	Good	----	----
19-20	82	Good	----	----
20-21	80	Good	----	----
21-22	56	Marginal	----	----
22-23	84	Good	----	----
23-24	62	Marginal	----	----

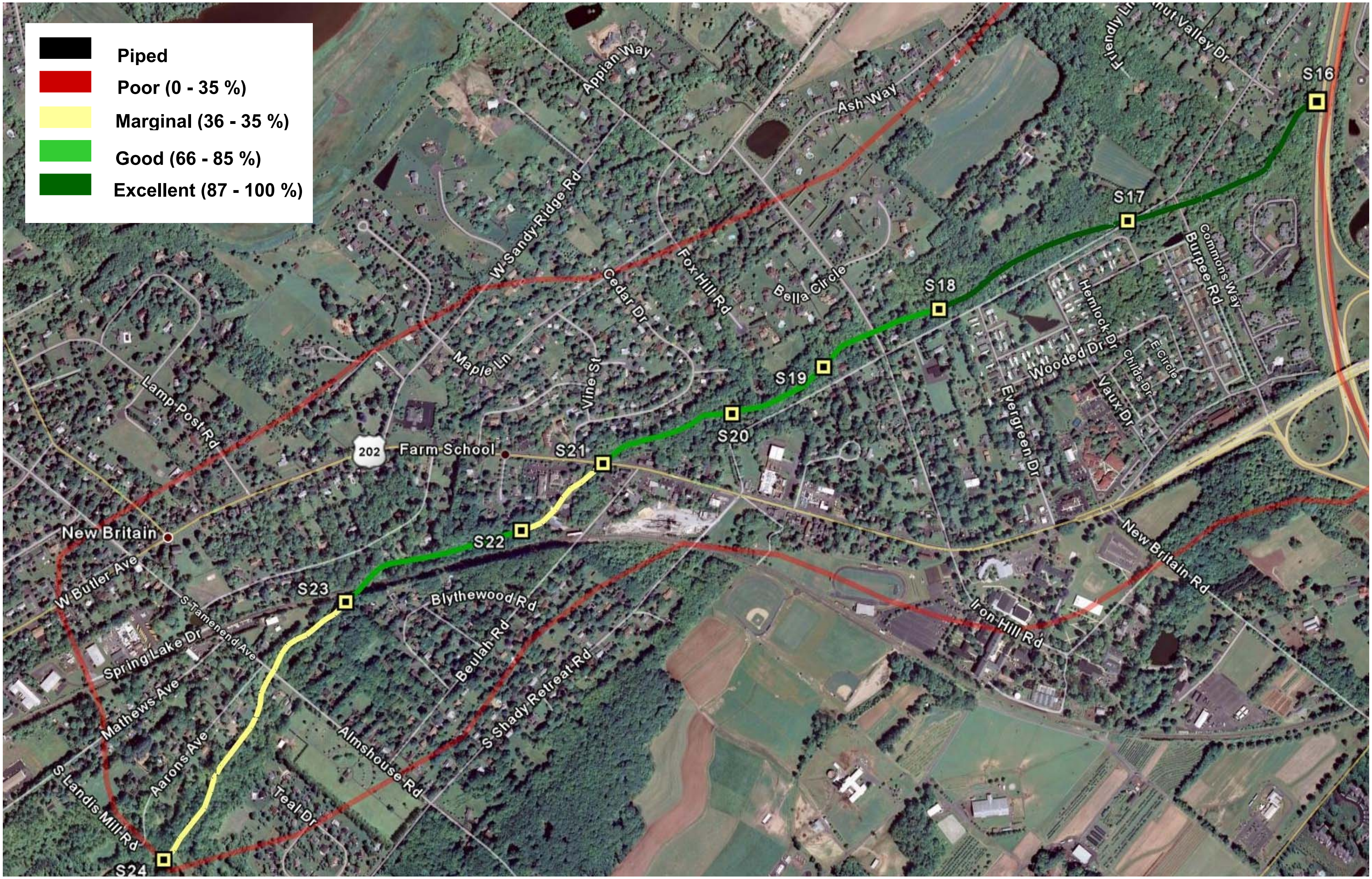

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Figure 3.1

Condition of Stream Segments in the Lower Cooks Run Subwatershed


Segment 16-17


Segment 17-18


Segment 18-19


Segment 19-20


Segment 20-21


Segment 21-22


Segment 22-23


Segment 23-24

Based upon the stream and riparian visual assessment, the scores of the eight stream segments ranged from 56 to 86 percent (marginal to very good) as shown in Table 3.1. The highest scores were recorded for Segments 16-17 and 17-18 as shown in Figures 3.1 and 3.2. It should be noted that the scores for these two segments were the highest for all segments throughout the entire Cooks Run watershed (upper and lower subwatersheds). Conversely, the lowest scores were noted for Segments 21-22 and 23-24, which lie in the southern end of the Cooks Run lower subwatershed. The major problems in these two segments are localized areas of stream bank erosion.

Unlike the upper subwatershed, our field investigation revealed that no extensive, large-scale riparian buffer restoration is needed for any of the stream segments in the lower subwatershed (Table 3.1). Areas requiring localized riparian restoration are discussed in conjunction with stream bank rehabilitation strategies in Section 4.

4. Nonpoint Source Watershed Problems

4.1. Methodology

Aqua Link identified major nonpoint source problems while performing the stream and riparian visual assessment for lower Cooks Run subwatershed (refer to Section 2.2). In addition, Aqua Link toured the remaining portion of the lower subwatershed via truck in order to identify any other significant nonpoint source (NPS) problem areas. Refer to Section 2.2 for more information about the methods employed to identify and gather field data about significant nonpoint source problems in the lower subwatershed.

4.2. Discussion of Major NPS Problems

Aqua Link identified a total of 6 major nonpoint source (NPS) problems within the lower Cooks Run subwatershed. These NPS problems are discussed below in detail. In addition, the locations and photographs of these NPS problems are shown in Figures 4.1 and 4.2, respectively. All NPS problems were assigned a score ranging from 1 to 5 (low to high) based upon its overall level of impairment.

A total of 13 major NPS problems were previously identified in the upper Cooks Run subwatershed. For more information about these NPS problems, refer to the Cooks Run Phase I Final Report prepared by Aqua Link, Inc. in March 2004.

NPS Problem No. 14

Problem description: minor streambank erosion due to the lack of a good riparian buffer containing woody vegetation. The adjacent lawn is maintained (mowed) right up to the streambank.

Stream Name:	Cooks Run
Stream Segment:	16-17
Level of Impairment:	2
Dimensions of NPS Problem:	200 feet occurring along right bank
Location of NPS Problem:	Between North Shady Retreat Road & Route 611 Bypass

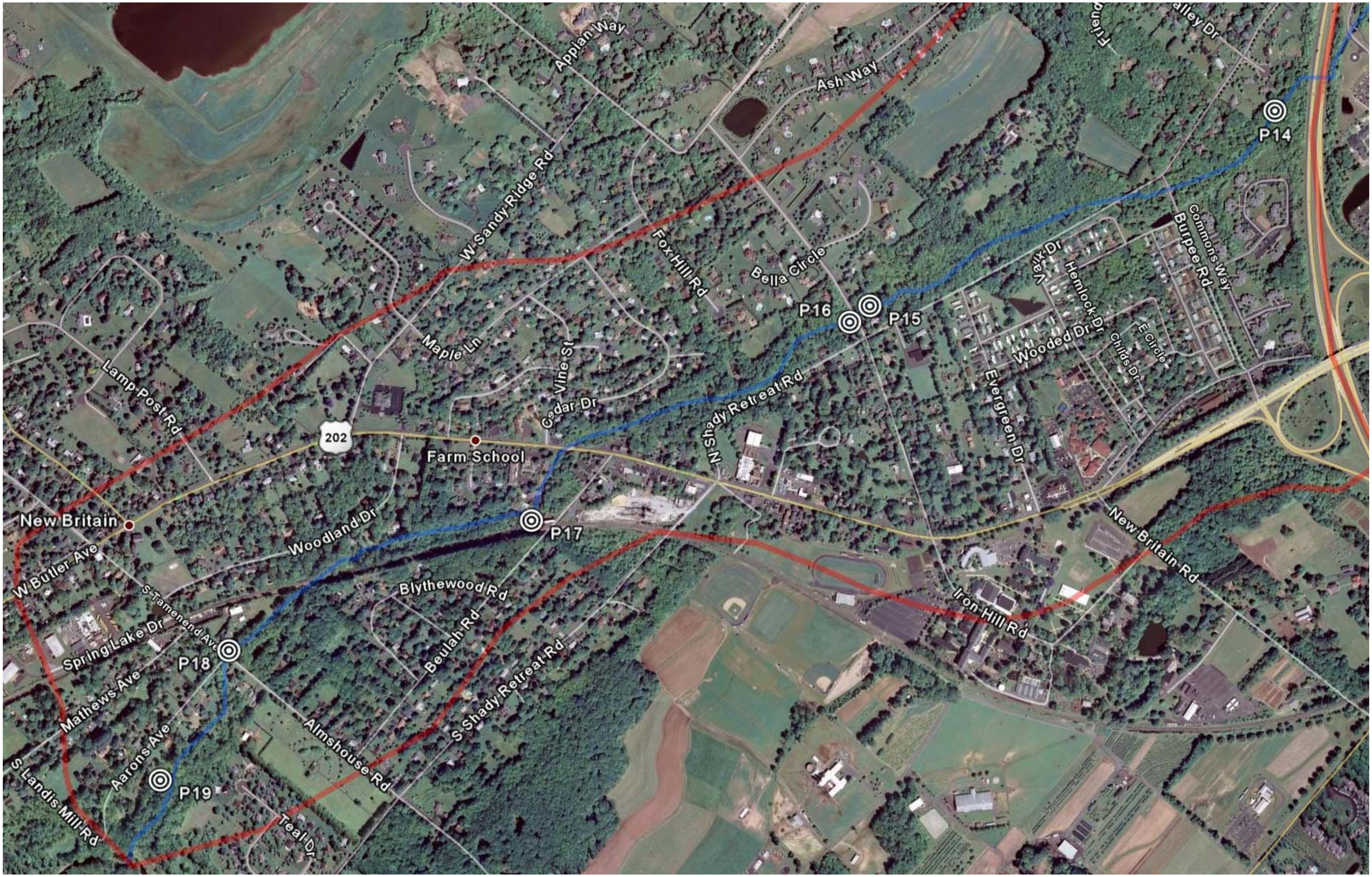

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Figure 4.1

Location of Major NPS Problems in the Lower Cooks Run Subwatershed

NPS Problem 14

NPS Problem 15 (First View)

NPS Problem 15 (Second View)

NPS Problem 16 (Upstream)


NPS Problem 16 (Downstream)

NPS Problem 17


NPS Problem 18


NPS Problem 19

NPS Problem No. 15

Problem description: severe streambank erosion due to the lack of a good riparian buffer containing woody vegetation. The adjacent lawn is maintained (mowed) right up to the streambank.

Stream Name:	Cooks Run
Stream Segment:	18-19
Level of Impairment:	5
Dimensions of NPS problem:	250 feet occurring along left bank.
Location of NPS Problem:	Upstream of Iron Hill bridge crossing

NPS Problem No. 16

Problem description: heavy sedimentation above and below bridge crossing. Large amount of accumulated sediments are likely exacerbating street flooding and adversely impacting aquatic organisms especially macroinvertebrate organisms such as aquatic insects, crayfish and mollusks.

Stream Name:	Cooks Run
Stream Segment:	18-19
Level of Impairment:	2
Dimensions of NPS problem:	n/a
Location of NPS Problem:	Upstream & downstream of Iron Hill bridge crossing

NPS Problem No. 17

Problem description: moderate streambank erosion and flooding at Gristmill Industrial Complex. Streambank erosion is apparently due to high waters, which frequently overflow an undersized culvert at the property. The culvert (approximately 6 feet in diameter) is used as a road crossing at the property. In an attempt to stabilize this section of stream, the property owner has attempted to armor the eroding streambanks with large chunks of concrete, black top, rock and other miscellaneous building materials. Prior to this stabilization, streambank erosion was likely considered severe. Most of the right streambank is completely devoid of a riparian buffer due to stream encroachment by the landowner.

Stream Name:	Cooks Run
Stream Segment:	21-22
Level of Impairment:	3
Dimensions of NPS problem:	125 feet occurring along both banks
Location of NPS Problem:	Gristmill Industrial Complex off of Beulah Road

NPS Problem No. 18

Problem description: severe streambank erosion due to the lack of a good riparian buffer containing woody vegetation. The adjacent lawn is maintained (mowed) right up to the streambank.

Stream Name:	Cooks Run
Stream Segment:	23-24
Level of Impairment:	4
Dimensions of NPS problem:	75 feet occurring along right bank.
Location of NPS Problem:	Private land along Almshouse Road

NPS Problem No. 19

Problem description: highly meandering, braided stream with moderate levels of streambank erosion. Moderate levels of streambank erosion have occurred and this erosion is largely due to the lack of a good riparian buffer with woody vegetation. The adjacent lawn areas are maintained (mowed) right up to the streambank.

Stream Name:	Cooks Run
Stream Segment:	23-24
Level of Impairment:	3
Dimensions of NPS problem:	n/a
Location of NPS Problem:	Near Aarons Avenue

4.3. Overview of Streambank Stabilization Practices

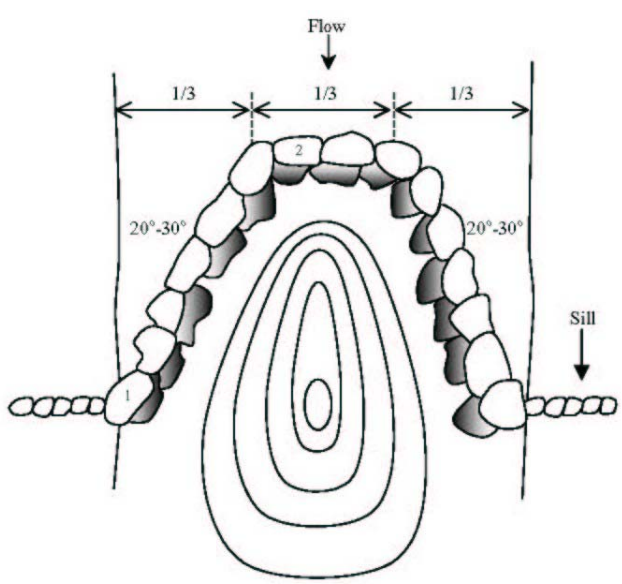
Streambank protective measures generally can be grouped into three categories: vegetative plantings, soil bioengineered practices and structural techniques. Soil bioengineering is a system of living plant materials that are used as structural components for bank stabilization. Common soil bioengineered techniques for streams are brush mattresses, live stakes, joint plantings, vegetated geo-grids, branch packing and live fascines (USDA 1996). Structural techniques include placed rock or boulders, riprap, gabions and retaining walls. In many instances, these three categories are used in combination with one another when stabilizing eroding streambanks.

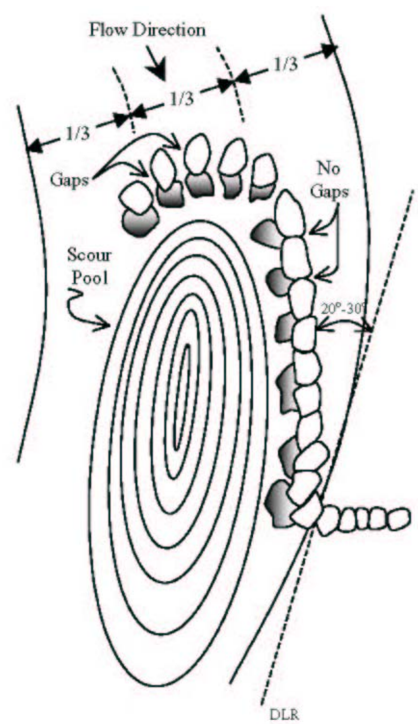
Marginal levels of streambank erosion are often stabilized using vegetative plantings, such as live stakes from willow (e.g., black willow, basket willow or purple osier willow) and dogwood trees. Live stakes should be about 24 inches long with a 3/8-inch minimum diameter at the butt end. Live stakes frequently are planted three-foot on center. Soil bioengineered techniques, such as live fascines, in conjunction with coir fiber logs and live stakes, can be used to stabilize moderately eroding streambanks. Live fascines (bundles of live branch cuttings generally from willow trees) may be installed along the lower third of the bank and at mid-bank, while coir fiber logs are often installed at the toe of the bank (edge of water) for additional support and stabilization. Typical costs for purchasing and installing live stakes and live fascines are $1 and $18 per stake and linear foot, respectively (King et al 1994). Costs for purchasing and installing coir fiber logs may range from $8 to $15 per linear foot.

Severely eroding streambanks are often stabilized using a combination of vegetative plantings, soil bioengineered techniques and structural practices. First, the streambanks are typically cut back and regarded to a 2:1 to 3:1 slope if possible. Rock with a geo-textile fabric is generally placed at the toe of the bank. The re-graded bank is seeded with desirable, erosion resistant grasses. Woody plant materials (as live stakes, seedlings or containerized plants), which are approved for soil bioengineering in riparian areas, are installed adjacent to the placed rock up to the top of the bank. Live stakes from willow (e.g., black willow, basket willow or purple osier willow) and dogwood trees are installed in between the placed rocks for additional stability and enhancing the overall appearance of the project site. The installation of live stakes within placed rock is commonly referred to as “joint planting”. Also depending upon the length of the slope, live fascines may be installed along the lower third of the bank and at mid-bank for additional support and stabilization. Typical costs for purchasing and installing rock with live stakes is $80 per linear foot, respectively (King et. al. 1994).

In addition, natural stream channel design (NSCD) structures can be installed along the outer bend or across stream channels. Common NSCD structures used in Pennsylvania are J hook rock vanes (J hooks), log vanes, rock vanes or rock cross vanes. These NSCD structures are commonly to deflect flow away from eroding stream banks, concentrate the flow in the center of the channel or enhance pool and riffle habitats.

Plan Views of Rock Cross Vane and J Hook Rock Vane





Prior to implementation, it will be necessary to obtain the proper permits from the Pennsylvania Department of Environmental Protection (PA DEP) for these projects. Under normal circumstances, a general permit (GP-3) is commonly issued for projects that are less than 500 linear feet and an Individual Permit for Small Projects is issued for projects greater than 500 linear feet. The proposed installation of any NSCD structures will likely require an individual permit regardless of the size of the project area.

4.4. Recommendations

As part of this assessment, Aqua Link has provided its recommendations to stabilize those major nonpoint source (NPS) problems discussed in Section 4.2. Our recommendations are discussed below in detail. As previously stated, the locations and photographs of the NPS problems are presented in Figures 4.1 and 4.2, respectively. The NPS problems were placed in one of the following categories:

- Highest Priority
- Medium Priority
- Lowest Priority

All of the recommendations involve implementing streambank stabilization practices, riparian buffer restoration measures or a combination of both. An overview of streambank stabilization and riparian buffer restoration best management practices are discussed in Sections 5.3 and 6.3, respectively.

4.4.1. Highest Priority

NPS Problem No. 15

Solution to the Problem: The streambank should be stabilized using soil bioengineered practices such as live stakes, live willow posts and live fascines. Steep bank should be regraded and either rock or coir fiber logs may be placed at the toe of the bank for added protection and stability. In addition, appropriate woody plant materials should be installed to establish a forested riparian buffer.

Stream Name:	Cooks Run
Stream Segment:	18-19
Level of Impairment:	5
Dimensions of NPS problem:	250 feet occurring along left bank.
Location of NPS Problem:	Upstream of Iron Hill bridge crossing

NPS Problem No. 18

Solution to the Problem: The streambank should be stabilized using soil bioengineered practices such as live stakes, live willow posts and live fascines. Steep bank should be regraded and either rock or coir fiber logs may be placed at the toe of the bank for added protection and stability. In addition, appropriate woody plant materials should be installed to establish a forested riparian buffer.

Stream Name:	Cooks Run
Stream Segment:	23-24
Level of Impairment:	4
Dimensions of NPS problem:	75 feet occurring along right bank.
Location of NPS Problem:	Private land along Almshouse Road

4.4.2. Medium Priority

NPS Problem No. 17

Solution to the Problem: The bridge crossing should be reconstructed in order to adequately handle larger storm events. At a minimum, the bridge crossing should be able to handle at least a 100-year storm event. In addition, the streambanks upstream and downstream of the bridge crossing should be reconstructed using bioengineered and conventional (e.g., rip rap, gabions) stabilization practices.

Stream Name:	Cooks Run
Stream Segment:	21-22
Level of Impairment:	3
Dimensions of NPS problem:	125 feet occurring along both banks
Location of NPS Problem:	Gristmill Industrial Complex off of Beulah Road

NPS Problem No. 19

Solution to the Problem: The main channel of this section of stream needs to be realigned. In addition, natural stream design structures discussed in Section 4.3 should be installed in order to concentrate the flow in the center of the channel and enhance pool and riffle habitats. The streambanks should be stabilized using soil bioengineered practices such as live stakes, live willow posts and live fascines. Lastly, appropriate woody plant materials should be installed to establish a forested riparian buffer.

Stream Name: Cooks Run
Stream Segment: 23-24
Level of Impairment: 3
Dimensions of NPS problem: n/a
Location of NPS Problem: Near Aarons Avenue

4.4.3. Lowest Priority

NPS Problem No. 14

Solution to the Problem: The streambank should be stabilized using soil bioengineered practices such as live stakes and live fascines. Prior to installing any plant materials, a coir fiber log should be installed at the toe of the bank for added protection. Thereafter, additional appropriate woody plant materials should be installed to establish a forested riparian buffer along the repaired section of streambank.

Stream Name: Cooks Run
Stream Segment: 16-17
Level of Impairment: 2
Dimensions of NPS Problem: 200 feet occurring along right bank
Location of NPS Problem: Between North Shady Retreat Road & Route 611 Bypass

NPS Problem No. 16

Solution to the Problem: Accumulated sediments above and below the bridge crossing should be removed.

Stream Name: Cooks Run
Stream Segment: 18-19
Level of Impairment: 2
Dimensions of NPS problem: n/a
Location of NPS Problem: Upstream & downstream of Iron Hill bridge crossing

5. Stormwater Management Assessment

5.1. Methodology

Gilmore & Associates (G&A) were subcontracted by Aqua Link to perform the stormwater management assessment of the lower subwatershed. The purpose of this assessment was to determine if any of the facilities are good candidates for stormwater retrofitting. Refer to Section 2.2 for more information about the methods used to perform the stormwater management assessment.

5.2. Discussion of Major SWM Facilities

G&A identified a total of 7 major stormwater management (SWM) facilities in the lower subwatershed. A description of each facility is presented below. The locations and photographs of the facilities are presented in Figures 5.1 and 5.2, respectively.

As noted in Section 1, major SWM facilities were identified and evaluated during the Phase I Assessment. In the Phase I Assessment, a total of 17 SWM facilities were identified in the upper subwatershed of the Cooks Run watershed. For more information about these facilities, refer to the Cooks Run Phase I Final Report prepared by Aqua Link, Inc. in March 2004.

SWM 18 - Gilmore & Associates Inc.

The offices for Gilmore & Associates Inc. are located within the Cooks Run Watershed. Constructed in 1999, the parking area along Butler Avenue utilizes porous asphalt with infiltration bed for stormwater management. The parking area is vacuum swept twice yearly to minimize pore clogging—once in the fall after all the leaves have fallen and again in the spring to remove any sand or cinders that have been carried into the site from elsewhere. After six years, the system still functions as intended and shows no visible degradation.

SWM 19 - Stonington Farms Apartment Complex

The Stonington Farms detention basin is a dry basin that is 'maintained' in a meadow condition. As shown in the photograph, this means that there is little or no maintenance performed. Although this basin provides superior vegetative filtration, the presence of young trees within the basin could be cause for concern. The basin should be inspected to confirm that the vegetation has not compromised the outlet structure of this basin. Also, the location and size of the trees should be identified, and any trees on or in close proximity to the berm should be removed to protect its integrity.

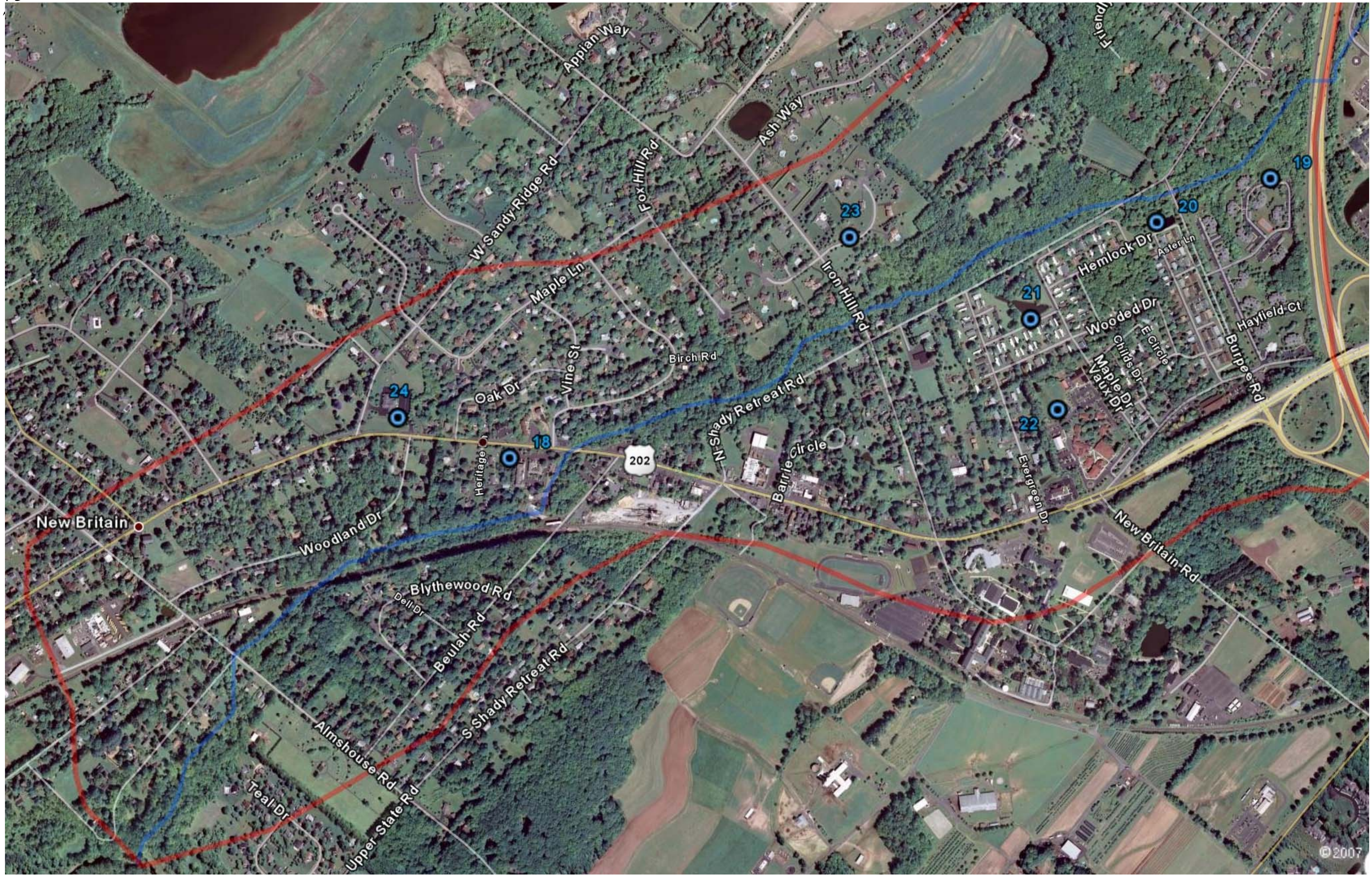


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Figure 5.1

Location of Major SWM Facilities in the Lower Cooks Run Subwatershed


SWM 18 – Gilmore & Associates, Inc.


SWM 19 – Stonington Farm


SWM 20 – Trailer Park – Pond No. 1


SWM 21 – Trailer Park – Pond No. 2


SWM 22 – Foundations Behavioral Health


SWM 23 – Fabia Court


SWM 24 – Fluehr Funeral Home

SWM 20 & 21 - Trailer Park

There are two retention basins within the trailer park. Pond No. 1 is located adjacent to Burpee Road and demonstrates significant degradation. This is readily apparent in the algae growth within the pond. The second pond, Pond No. 2, is located adjacent to Sandy Ridge Road. Although it does not have significant algae growth, this pond appears 'murky' which is indicative of sediment build up within the pond. Both ponds have a naturalized perimeter to provide vegetative filtration of overland flow into the ponds. These facilities would benefit from sediment forebays at basin inlets and water aeration.

SWM 22 - Foundations Behavioral Health

The stormwater management facility is designed as a dry detention facility and is being maintained in a meadow condition. The basin is well vegetated and apparently does not contain any invasive herbaceous plants or trees. There are no recommendations for this facility.

SWM 23 - Fabia Court

Fabia Court is a residential subdivision consisting of single-family homes. The stormwater management facility is designed as a wet pond. There are two ways in which this basin could be modified to improve water quality. First, although there is a vegetated perimeter, the vegetation is being overrun with cattails. These plants are known to be an invasive species, which will take over the pond in time. It is strongly recommended that they be removed and replaced with other aquatic or semi-aquatic vegetation. The second problem with this pond is the dense growth of filamentous algae. Overall, this pond should be treated to control the growth of nuisance algae and preventative measures taken to avoid future algal blooms. These measures would include aeration of the pond and reduction of nutrient pollution to the pond such as the excessive use of lawn fertilizers.

SWM 24 - Fluehr Funeral Home

The basin in front of the Fluehr Funeral home is a low profile, dry detention basin. The inflow pipes directly discharge to the low flow, stone channel, which minimize soil erosion and improves the conveyance of runoff during smaller rain events, without compromising potential infiltration. The owner maintains this basin as a well-manicured lawn. Although water quality may be improved by more naturalized vegetation, this would detract from the aesthetics of the site. Therefore, in light of the well-maintained appearance and function of the basin, there are no recommended improvements to this site.

5.3. Overview of Stormwater Retrofitting

Urbanization has a profound influence on stream and lake water quality. These impacts are more readily observed in older urban settings without any or inadequate stormwater controls as compared to newer urban areas (Schueler 1987). In general, stormwater management systems in older urban areas were designed to quickly capture surface runoff from impervious areas (roof tops, sidewalks, roadways, parking lots) and pipe it directly to receiving streams. In addition, increased imperviousness in a watershed subsequently results in less rainfall infiltration and percolation resulting in lower levels of groundwater recharge.

Urbanization allows for changes in watershed hydrology, changes in stream geometry, the degradation of aquatic ecosystems and pollutant export during construction and after site stabilization. Watershed hydrology is significantly altered after urbanization. Peak stream discharges are increased about 2 to 5 times higher than pre-development levels. The volume of stormwater runoff produced by individual storms is increased. For example, a moderately developed watershed many produce 50 percent more runoff than a forest watershed. The time required for runoff to reach a stream (time of concentration) is significantly decreased by as much as 50 percent. In addition, changes in watershed hydrology result in increased frequency and severity of flooding, reduced streamflow during prolonged periods of dry weather (due to decreased rates of soil infiltration) and greater runoff velocities during storm events (Schueler 1987).

Streams now must readjust (change in geometry) to the new hydrologic conditions in urban areas. The primary adjustment for increased stormwater volumes is channel widening. Stream channels may widen 2 to 4 times their original size if post-development runoff is not effectively controlled. The elevation of the stream's floodplain also will increase to accommodate higher post-development peak discharge rates, therefore, property and structures not previously at risk to flooding now may be at risk. Streambanks are gradually undercut and slump into the stream channel. Trees that previously protected the banks are now exposed at the roots and sometimes become windthrown, thereby triggering a second phase of bank erosion. Eroded soils from streambanks and upland areas are temporarily stored in the stream channel as sand bars and other sediment deposits. Gradually, these sediments migrate throughout the stream network as bedload, but unfortunately the stream channel will inevitably be covered by shifting deposited mud and coarse sands for many years to come (Schueler 1987).

In addition, urbanization adversely affects the overall composition of aquatic ecosystems. Increased levels of pollutants to receiving waters often result in lower levels of species diversity and the dominance of more tolerate, less desirable aquatic insects and fish. Pollutants are exported during construction and after site stabilization. There is a very high potential for large quantities of sediment with attached nutrients and organic matter to be transported to streams and lakes from active construction sites. This potential is greatly reduced when adequate erosion and sediment controls are properly installed and maintained. After construction, pollutants rapidly accumulate on impervious surface and are readily transported to receiving waters via stormwater runoff. These pollutants include sediments, nutrients, bacteria, oxygen consuming substances, oil and grease, metals, toxic chemicals and chlorides. In addition, increased temperatures of stormwater runoff (thermal pollution) will result in increased temperatures of receiving waters (Schueler 1987).

Land development (urbanization) prior to the 1970's had little to no stormwater management practices. Stormwater systems were primarily built only to transport runoff rapidly to receiving waters. In the 1970's, efforts began to address runoff induced flooding. Stormwater control structures including detention basins were generally designed to accommodate only peak rates of runoff. Therefore, these structures only held runoff for a few hours until it was deliberately discharged to receiving waters and did not address the loss of groundwater recharge, poorer runoff water quality or increased runoff volumes over pre-development conditions (Delaware Riverkeeper 2001).

The primary problem with the peak rate of runoff design for stormwater control structures (detention basins) is that receiving waters receive increased stormwater volumes for longer periods of time. Structures of this design throughout a watershed have a cumulative net effect of actually increasing the instream peak discharge rates and water volumes for extended periods. Therefore, the final result is that downstream flooding is exacerbated since flood flow is increased and extended (Delaware Riverkeeper 2001).

In addition, most detention basins are designed to control only 10 to 100-year frequency storms and fail to impact the 2 to 5-year storms. Many detention basins are designed to pass these smaller storm runoff volumes directly to streams. In general, the 2-year storm in a natural watershed produces bankfull discharge. Bankfull discharge is that amount of flow that fills the stream to the top of its banks. In urban areas, smaller, more frequent storms can result in bankfull conditions because of increased runoff volumes. Bankfull discharge is considered the effective discharge for stream channel formation (channel widening, channel downcutting and bank erosion).

Stormwater best management practices (BMP's) that are later incorporated into existing developments and urban areas is referred to as stormwater retrofitting. Retrofitting may only require minor modifications to existing control structures like detention basins or the construction of new control structures or devices. The underlying goal of retrofitting is to correct many of the problems that were described above. Below is a list of common retrofits that may be employed for existing stormwater detention basins (CH2MHill et. al. 1998):

- Modifying the outfall to create a two-stage release to better control smaller storms while not significantly compromising the major detention required for flood control

- Eliminating paved low-flow channels and replacing them with meandering vegetated swales

- Eliminating low-flow bypasses
- Incorporating low berms to lengthen the flow path and eliminate short-circuiting
- Incorporating stilling and settling basin at inlets
- Regrading the basin bottom to create a wetland area near the outlet or revegetating parts of the basin bottom with wetland vegetation to enhance pollutant removal, reduce mowing and improve aesthetics
- Creating a wetland shelf along the periphery of a wet basin to improve shoreline stabilization, enhance pollutant filtering and enhance esthetic habitat functions

5.4. Recommendations

As part of this assessment, G&A has provided its recommendations for retrofitting the stormwater management (SWM) facitilites that were discussed in Section 5.2. These recommendations are discussed below in detail. As previously noted, the locations and photographs of the facilities are presented in Figures 5.1 and 5.2, respectively. The SWM facilities were placed in one of the following categories:

- Strongly Recommended (Critical for Watershed Health)
- Recommended (Beneficial for Watershed Health)
- No Improvements Necessary

5.4.1. Strongly Recommended (Critical For Watershed Health)

SWM 20 & 21 – Trailer Park

Pond No. 1 along Burpee Road is significantly compromised from a water quality viewpoint with the excessive growth of algae. It is recommended that the pond be treated to remove the algae and an aeration system be installed to prevent future blooms. Both ponds appear to have significant sediment deposition, therefore it is recommended that sediment forebays be installed at the inflows to these basins. As an alternative, water quality devices may be installed in the storm inlets, which discharge directly to these basins.

SWM 23 - Fabia Court

There are two recommendations for this facility. First the invasive plants should be totally removed and then replaced with native wetland plant species. The second recommendation is to install some form of aeration device to prevent stagnation and reduce the frequency of algal blooms. Although more difficult to enforce, an additional recommendation is to reduce the nutrient loadings (i.e., lawn fertilizers) to the pond, which are contributing to the excessive growth of algae.

5.4.2. Recommended (Beneficial to Watershed Health)

SWM 19 - Stonington Farm Apartment Complex

The basin is maintained in a well-vegetated condition, however periodic inspections should be made to insure that outlet structure is clear of obstruction. Also, there are several young trees within the basin, which should be evaluated to determine whether they threaten the integrity of the detention facility and the berms.

5.4.3. No Improvements Necessary

SWM 18 - Gilmore & Associates Inc.

This structure was well conceived and the site owner is maintaining it as recommended in the newly issued draft BMP Handbook. Therefore there are no recommended improvements for this facility.

SWM 22 - Foundations Behavior Health

In general, this facility is well conceived and built. The plantings appear to be thriving and there are no recommended improvements offered at this time.

SWM 24 - Fluehr Funeral Home

This structure was well conceived and the site owner is maintaining it as a well-manicured lawn. Therefore, there are no recommended improvements for this facility.

6. Comprehensive Watershed Management Plan

Overall, the primary goal of the Cooks Run Phase II watershed assessment was to develop a comprehensive management plan to reduce nonpoint source pollutants to Cooks Run, which is a tributary to the Neshaminy Creek. Data and information, as presented in Sections 3 through 5, were used extensively in developing this watershed management plan for the lower subwatershed. Key recommendations of this plan are to restore forested riparian buffers along streams, repair major nonpoint source (NPS) problem areas and retrofit major stormwater management facilities in the lower Cooks Run subwatershed. These key recommendations are summarized in Table 6.1 and discussed in Sections 6.1 through 6.3.

Conversely, all recommendations to restore forested riparian buffers along streams, repair major nonpoint source (NPS) problem areas and retrofit major stormwater management facilities in the upper Cooks Run subwatershed are presented in detail in the Cooks Run Phase I Watershed Assessment Report (Aqua Link, Inc March 2004). The Phase I Report also includes watershed-wide recommendations, such as revising municipal ordinances and a thorough discussion of the water quality monitoring data collected for all segments of Cooks Run.

Table 6.1 Recommended Implementation Projects for the Lower Subwatershed

Category	Priority	Identification		Section
Riparian Buffer Restoration Projects	Highest	Segment No.	None	---
	Medium	Segment No.	None	---
	Lowest	Segment No.	None	---
Nonpoint Source Projects	Highest	NPS No.	15 & 18	4
	Medium	NPS No.	17 & 19	4
	Lowest	NPS No.	14 & 16	4
Stormwater Retrofitting Projects	Strongly Recommended	SWM No.	20, 21 & 23	5
	Recommended	SWM No.	19	5
	No Improvements Necessary	SWM No.	18, 22 & 24	5

The Bucks County Conservation District and other watershed stakeholders including Doylestown Township, Doylestown Borough and New Britain Borough should assume the responsibility of implementing the watershed best management projects listed in Table 6.1. Many of these recommendations will require a high level of technical expertise; therefore, watershed stakeholders will likely require the professional services of a qualified environmental consultant. Some of the recommendations, such as riparian buffer restoration projects, should attempt to maximize the use of local volunteers if applicable.

6.1. Riparian Buffer Restoration Projects

The stream and riparian assessment revealed that the stream segments in the best condition (ranked as excellent and good) within the lower Cooks Run subwatershed are located from the Route 611 Bypass downstream to Route 202 (East Butler Avenue). As shown in Figures 1.3 and 3.1, the lower subwatershed is defined as all lands lying west of the Route 611 Bypass downstream to the confluence of Cooks Run and the Neshaminy Creek. Of the remaining three stream segments, both marginal stream segments are located in between Route 202 to the confluence of the Neshaminy Creek. It should be noted that the lower Cooks Run subwatershed does not contain any stream segments that were categorized as either poor or piped.

Unlike the upper subwatershed, the lower subwatershed did not contain any significant areas requiring extensive riparian buffer restoration. Overall, the lower subwatershed is less urbanized with respect to commercial land uses. In this portion of the watershed, there is significantly less stream encroachment by land development, which translates into better riparian buffer protection than in the upper subwatershed.

Based upon the above, Table 6.1 does not list any major riparian restoration projects for the lower Cooks Run subwatershed. Therefore, any recommended minor riparian buffer restoration is discussed in Section 6.2 when addressing corrective measures for nonpoint source projects.

6.2. Nonpoint Source Projects

A total of 6 major nonpoint source (NPS) watershed problems were identified in the lower Cooks Run subwatershed during this assessment. This is opposed to 13 NPS problems identified during the Phase I assessment of the upper subwatershed. Many of the problem areas involve some degree of streambank soil erosion. Field reconnaissance revealed that the primary causes of streambank erosion are once again inadequate forested riparian buffers. Table 6.1 provides a list of priority ranked nonpoint source projects for future implementation.

6.3. Stormwater Retrofitting Projects

A total of 7 major stormwater management facilities were identified in the lower Cooks Run subwatershed. Conversely, a total of 17 SWM facilities were identified in the upper subwatershed as part of the Phase I assessment. Of these seven facilities, four are considered either critical or beneficial to the overall health of the Cooks Run watershed and therefore should be retrofitted. Table 6.1 provides a list of stormwater retrofitting projects that are ranked according to priority for future implementation.

6.4. Sources of Funding

Many of the recommendations offered in the comprehensive management plan are eligible for state or federal funding. State funding may be obtained through the Pennsylvania Department of Environmental Protection's Growing Greener Grant Program.

Federal funding may be obtained through U.S. Environmental Protection Agency's Section 319 (Nonpoint Source) Program and the National Oceanic and Atmospheric Administration's (NOAA) Coastal Zone Management Program.

If funding is not available, the watershed stakeholders are strongly encouraged to implement some of the recommendations using their own financial resources. This type of commitment is viewed highly by the above agencies and can greatly improve the success of receiving state and federal funding in the future.

7. Literature Cited

Alliance for the Chesapeake Bay. 1998. Stream Releaf Forest Buffer Toolkit. Funded by U.S. EPA and PA DEP. Section 319 NPS Program.

American Public Health Association. 1985. Standard Methods for the Examination of Water and Wastewater (16th Edition). American Public Health Association. Washington, DC.

Aqua Link, Inc. March 2004. Cooks Run Phase I Watershed Assessment Final Report. Prepared by PA DEP and the Bucks County Conservation District.

CH2MHill. 1998. Pennsylvania Handbook of Best Management Practices for Developing Areas.

Delaware Riverkeeper. 2001. Stormwater Runoff, Lost Resource or Community Assest? A Guide to Preventing, Capturing and Recovering Stormwater Runoff. Washington Crossing, PA.

Georgia Soil and Water Conservation Commission. Guidelines for Streambank Restoration. Prepared for the U.S. Environmental Protection Agency.

Hammer, M.J. 1986. Water and Wastewater Technology (2nd Edition). John Wiley & Sons, New York.

King, D.M., C.C. Bohlen and M.L. Kraus. April 1994. Stream Restoration: The Costs of Engineering and Bio-Engineered Alternatives. University of Maryland, Center for Environmental and Estuarine Studies. Chesapeake Biological Laboratory, Solomons Island, MD. EPA Agreement No. CR-818277-C1.

North Carolina University. River Course: Natural Stream Processes (Fact Sheet No. 1). North Carolina Stream Restoration Institute.

Pennsylvania Department of Environmental Protection (PA DEP). 1999. Application of the Rapid Bioassessment Protocol multimedia approach to Pennsylvania's Water Quality Network Sites (draft).

Schueler, T.R. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMP's*. Washington Metropolitan Council of Governments. Washington, DC.

Schnier, M. 2003. Riparian Assessment Guide. The Pennsylvania State University.

Shelton, T.B. 1996. Interpreting DrinkingWater Quality Analysis: What Do the Numbers Mean? 5th Edition. Publication No. E214. Rutgers University. New Brunswick, N.J.

United States Department of Agriculture, Natural Resources and Conservation Service. 2002. Soils Survey of Bucks County, PA.

United States Department of Agriculture, Natural Resources and Conservation Service. 1996. Engineering Field Handbook – Chapter 16: Streambank and Shoreline Protection.

Weber, Cornelius I. 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. EPA-600/4-73-001.

APPENDIX A

Summary of GPS Data

Cooks Run Phase II Assessment Project **Aqua Link, Inc.**
1005-08

GPS Coordinates for Stream Nodes, NPS Problems & Stormwater Discharge Pipes

Lat.	Long.	ID	Date/Time	Description	Stream Segment
40.3085513	-75.1496421	S16		stream node	
40.3059741	-75.1549468	S17	6/11/2007 14:04	stream node	
40.3039331	-75.1600833	S18	6/11/2007 13:35	stream node	
40.3030557	-75.1634941	S19	6/11/2007 13:01	stream node	
40.3019289	-75.1659127	S20	6/11/2007 12:35	stream node	
40.3009446	-75.1695559	S21	6/11/2007 12:10	stream node	
40.2995117	-75.1717846	S22	6/18/2007 13:00	stream node	
40.2979745	-75.176692	S23	6/18/2007 13:27	stream node	
40.2924696	-75.1817121	S24	6/18/2007 14:33	stream node	
40.3078576	-75.1506001	P14	6/11/2007 14:38	NPS Problem	16 17
40.3038196	-75.1615662	P15	6/11/2007 13:26	NPS Problem	18 19
40.3034825	-75.1621116	P16	6/11/2007 13:19	NPS Problem	18 19
40.2993723	-75.1707277	P17	6/18/2007 12:35	NPS Problem	21 22
40.2966793	-75.1789197	P18	6/18/2007 13:46	NPS Problem	23 24
40.293993	-75.180777	P19	6/18/2007 14:15	NPS Problem	23 24
40.3063543	-75.1536323	D48	6/11/2007 14:20	Storm Pipe	16 17
40.2994742	-75.1712378	D49	6/18/2007 12:43	Storm Pipe	21 22
40.2966908	-75.1789804	D50	6/18/2007 13:49	Storm Pipe	23 24
40.2965943	-75.1791127	D51	6/18/2007 13:54	Storm Pipe	23 24

GPS Coordinates for Stormwater Management (SWM) Facilities

Lat.	Long.	ID	Description
40, 18, 02.65"	75, 10, 17.341"	SWM 18	Gilmore & Associates, Inc.
40, 18, 23.588"	75, 9, 2.688	SWM 19	Stonington Farms Apt. Complex
40, 18, 20.325"	75, 9,13.853"	SWM 20	Trailer Park
40, 18, 13.059	75, 9, 26.205"	SWM 21	Trailer Park
40, 18, 6.279"	75, 9, 23.577"	SWM 22	Foundations Behavioral Health
40, 18, 19.181"	75, 9, 43.994	SWM 23	Fabia Court
40, 18, 5.679"	75, 10, 28.303"	SWM 24	Fluehr Funeral Home

APPENDIX B

Stream and Riparian
Visual Assessment Data

Cooks Run Watershed Assessment **Prepared by Aqua-Link, Inc.**
Project 1005-08

Stream & Riparian Visual Assessment - Forms

Riparian Rating:

Piped	Good (66-85%)
Poor (0-35%)	Excellent (86-100%)
Marginal (36-65%)	

No.	Parameter		Points	No. of Parameters	16-17 Points	17-18 Points	18-19 Points	19-20 Points	20-21 Points	21-22 Points	22-23 Points	23-24 Points
1	Riparian Buffer Width	Left	10	1	9	8	7	7	9	4	8	8
		Right	10	1	8	9	9	9	8	4	8	5
2	Riparian Vegetation Type	Left	10	1	9	9	2	9	10	5	9	8
		Right	10	1	8	9	9	9	10	5	9	2
3	Riparian Vegetation Density	Left	10	1	9	9	9	9	9	5	9	8
		Right	10	1	8	9	9	9	8	5	9	5
4	Bank Vegetation Type	Left	10	1	9	9	2	9	8	8	8	9
		Right	10	1	8	9	9	9	8	8	8	2
5	Bank Vegetation Density	Left	10	1	9	9	7	8	8	5	8	8
		Right	10	1	8	9	9	8	8	5	8	5
6	Bank Stability	Left	10	1	9	7	3	8	5	2	8	8
		Right	10	1	7	9	8	8	6	2	8	4
7	Channel Modification	Both	10	1	9	9	8	9	8	7	9	7
8	In-Stream Modification	Both	10	1	9	9	7	8	9	7	9	7
9	Embeddedness	Both	10	1	8	6	5	5	5	7	7	5
10	Shading (Canopy Cover)	Both	10	1	9	9	7	9	9	6	9	7
			100	10	86	86	69	82	80	56	84	62
			Riparian Rating:		86	86	69	82	80	56	84	62
					E	**E**	**G**	**G**	**G**	**M**	**G**	**M**
	Personal Rating of Stream	(Poor - Marginal - Good - Excellent)			Very Good	Very Good	Good	Good	Good	Marginal	Good	Marginal
	No. Stormwater Discharges				1					1		
	No. Watershed Problems											
	Mean Stream Width (ft)				15	15	15-20	15-20	15	15	20	15-20
	Segment Length - Desktop	(ft using digital maps)										
	Riparian Buffer Needed?	(yes or no for extensive buffers)			no	no	no	no	no	no	no	no
	Segment Length - Field	(ft)										
	Left Bank?	(distance in ft)										
	Right Bank?	(distance in ft)										

Stream & Riparian Visual Assessment - Forms

Riparian Rating:

Piped	Good (66-85%)
Poor (0-35%)	Excellent (86-100%)
Marginal (36-65%)	

Segment	Comments
16-17	Nice stream
17-18	Nice stream near Holiday Pet Resort. Some embeddness w/ sediment bars
18-19	Good stream. Left bank moweed resulting in some erosion
19-20	Good stream segment. Road on left bank.
20-21	Steeper banks w/ some vertical erosion. Deeper pools. Fil. Algae present in forest breaks. Septic odor mid-point of reach
21-22	Lots of refuse (concrete, pipes, metal) in channel. Steep banks attempted to be stablized with chunks of concrete. Flooding at commercial properties
22-23	Nice stream with a few vertical banks w/ erosion
23-24	Marginal stream w/ some rip rap by property owners

APPENDIX C

NPS Problems & Discharge Pipe Data

NPS Watershed Problems - Information

Site ID	Location	Stream Segment	Site Priority Ranking	Problem(s)	Banks	Distance (feet)	Corrective Measure(s)
P14	CR	16-17	2	SBE	right	200	BSP RBW
P15	CR	18-19	5	SBE	left	250	BSB BSP RBW
P16	CR	18-19	2	SB	n/a	n/a	SBR
P17	CR	21-22	3	SBE	both	125	BS
P18	CR	23-24	4	SBE	right	75	BSB BSP RBW
P19	CR	23-24	3	Braided stream	n/a	n/a	Stream reallignment

NPS Problems

SBE	Streambank erosion
LBE	Lake bank erosion
SCE	Stream channel erosion (incision)
SCW	Stream channel widening
RBN	Riparian buffer - none
RBP	Riparian buffer - poor
AGL	Agriculture - livestock
AGH	Agriculture - horses
AGP	Agriculture - pasture erosion
AGR	Agriculutre - row crops
AGM	Agriculutre - manure
BYR	Barnyard runoff
SS	Septic systems
SWR	Stormwater runoff
LOG	Logging
AMD	Acid mine drainage
RDE	Roadside ditch erosion
RSE	Road surface erosion
SB	Sediment bar

Corrective Measures

RBW	Riparian buffer (trees & shrubs)
RBH	Riparian buffer (grass & herb. plantings)
BSP	Bank stabilization (plantings only)
BSB	Bank stabilization (bioengineering)
BS	Bank stabilization (gabions, rip rap)
FDS	Flow deflecting structures
FHS	Fish habitat structures
SCR	Stream Channel Restoration
EF	Exclusionary fencing
PSC	Protected stream crossing
OSWS	Off-stream water source
SOI	Stormwater outlet improvements
DGRI	Dirt & gravel road improvements
NMP	Nutrient management plans
BYI	Barnyard improvements
SBR	Sediment bar removal

Cooks Run Watershed Assessment **Prepared by Aqua-Link, Inc.**
Project 1005-08

Stream Discharge Point Information

Discharge	Type	Stream Segment	Shape	Diameter (inches)	Drainage	Problem	Priority
D48	SW	16-17	round	19	Burpee & Shady Retreat Roads	none	1
D49	SW	21-22	round	24		none	1
D50	SW	23-24	round	16		none	1
D51	SW	23-24	round	26		none	1

Notes:

PFS	Partially filled with sediment
SCS	Stream channel scour
SBE-1	Stream bank erosion around pipe
SBE-2	Streambank erosion - opposite bank
Other	