Powells Creek Watershed Management Plan

June 2008

Prepared for:
Prince William County Department of Public Works
Environmental Services Division
Watershed Management Branch
5 County Complex Court, Suite 170
Prince William, VA 22192

Prepared by:
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I. Executive Summary

1. Purpose

Prince William County, Virginia has a long history of progressive leadership in the area of watershed management. The County, which is the third most populous jurisdiction in Virginia, has experienced rapid and steady growth in recent years, which has placed additional pressures on the abundant natural resources. This report is a continuation of a large body of knowledge on the state of the Powells Creek Watershed that culminates in a series of strategic and focused conceptual project plans that can be used to budget capital improvement projects, provide mitigation for on-going County projects and measure the progress being made toward protecting the watershed.

2. Approach

This report builds on a number of previous efforts including, but not limited to, the 1989 Powells Creek Watershed Study: Hydraulic Analysis and the 2004 Prince William County Stream Protection Strategy. The Hydraulic Analysis is the only comprehensive and quantitative modeling effort of the watershed that exists. Despite the age of the study, the observations, recommendations and results presented appear to be highly relevant today. The Stream Protection Strategy provides a comprehensive and quantitative assessment of the conditions of the streams throughout the watershed.

With the benefit of these and other existing studies, Baker staff conducted focused, on the ground, reconnaissance of the receiving waters and watershed conditions to: a) ground truth the assessment data from the existing literature; b) determine the practical and required corrective action; and c) develop the basis for Project Concept Plans. This reconnaissance involved observations along all of the streams and tributaries and throughout most of the subwatersheds for seven of the eight subwatersheds that make up the Powells Creek Watershed.

3. Recommendations

General recommendations were made that should be considered in all aspects of future watershed development. These include:

1. Known locations of structural infrastructure flooding should be addressed through specific investigations and capital improvement projects.
2. Attenuation in Lake Montclair essentially disconnects the hydrology between the upper watershed and the lower watershed. Detention and Retention approaches should be focused in the headwaters of each section independently.
3. Post construction erosion and sediment control measures should be strictly enforced for all new development.
4. Opportunities to reduce sediment flow within the system should be considered.

Conceptual Projects were provided throughout the watershed. These projects target the observed imbalances within the watershed and offer specific opportunities to begin to address them. Many of the proposed concept projects are retrofits or re-designs to existing infrastructure, while others are offered as potential mitigation locations to offset impacts from ongoing municipal operations within the watershed. All projects, however, have a common goal of addressing the real and measurable impacts of development on the watershed. The following is a summary of the projects found in the Appendix.

			Cost	
Project Type	**No of Projects**	**Size of Projects**	**Design**	**Construction**
Stream Restoration	8	7250 LF	$810,000	$3,375,000
Stream Enhancement	4	7300 LF	$78,000	$537,000
Pond Retrofit	4	11 Acres	$160,000	$1,100,000
Culvert Retrofit	2	N/A	$85,000	$1,150,000
LID Retrofit	1	86 Acres	$65,000	$450,000

II. Introduction

1. Background

Prince William County is made up of ten watersheds, one of which is Powells Creek. Powells Creek drains to the Potomac River to the Southeast and is bounded by the Prince William Forest Park and the Town of Dumfries (Quantico Creek Watershed) to the south and Dale City (Neabsco Creek Watershed) to the north and Hoadly Road to the northwest.

The County has performed a number of studies and projects in recent years to better understand the nature of the watersheds throughout the County. Primary among these includes the *Prince William County Stream Protection Strategy* (2004), in which a County-wide assessment of stream conditions was performed. This study collected and documented:

- Habitat
- Physical Site Assessments (Buffers, Drainage Infrastructure, etc.)
- Geomorphic classification of stream types, and
- General stream characteristics.

The results of these stream assessments were compiled into a database, which along with GIS shapefiles, creates a tool with which the County can continually update the status of stream and watershed health.

Powells Creek Watershed has undergone steady development in recent years and, as such, has begun to see some degradation and encroachment into receiving waters. This project presents some alternatives for actionable recommendations that will provide beneficial improvement to receiving waters in Powells Creek and the Potomac River.

2. Purpose

While the County's Stream Assessment focused on the general health of the stream systems throughout the County, it did not propose specific corrective action for the root causes of observed impairments. The purpose of this project is to build upon the work that has previously been done to create conceptual restoration plans that the County may use to prioritize and plan for capital improvements in the Powells Creek Watershed. This project will use existing studies and information to the greatest extent practical so as to streamline the development of conceptual capital improvement projects.

Using previous studies in combination with field verification, Baker, in coordination with the County, has prepared concept plans, with implementation budgets, which have the potential to improve overall watershed function and health. The recommendations are presented at the end of this report and include: stream restoration and enhancement, stormwater management facility retrofits, LID retrofits, regional stormwater management facilities, drainage system infrastructure improvements and programmatic recommendations.

III. Watershed Condition

1. General Watershed Characteristics

The Powells Creek Watershed covers approximately 11,500 acres (18 mi^2) draining to the Potomac River along the southeast boundary of the County. The watershed is long and narrow, which affects the drainage characteristics, with a typical width of just 1.5 miles. The watershed has previously been broken into eight subwatersheds for the purpose of refining the drainage area influences.

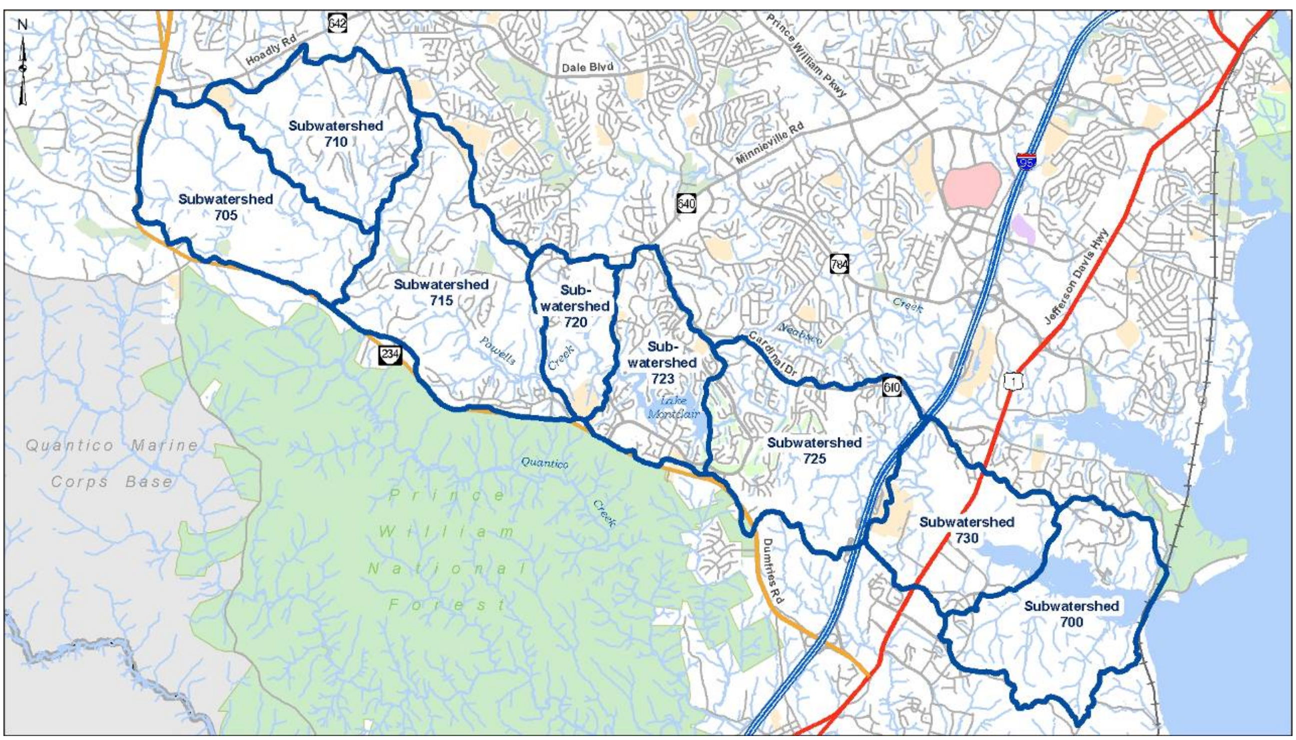


FIG 1: Powells Creek Watershed with Subwatersheds

The upper third of the watershed is somewhat rural in nature, with low density residential and agricultural land uses alongside the County's large acreage landfill operation and Resource Protection Area (RPA) buffers. The trend in recent years for this portion of the watershed appears to be one of sub-dividing the large agricultural tracts into higher density residential developments. Based on observations made during field visits, this trend appears to be one that will continue into the future.

The middle third of this watershed is, to a large degree, built out with medium density residential neighborhoods that have been in place for many years. The residential area around Lake Montclair and the associated recreational areas dominate this region of the watershed.

The lower third of the watershed has been a mix of large swaths of undeveloped, wooded land along with higher density development (i.e. apartments and townhouses). Existing construction observed during field visits indicates that larger lot developments such as schools and high density residential development will significantly change the landuse characteristics of this portion of the watershed in coming years.

a. Prince William County's Comprehensive Plan

The 2008 Prince William County Comprehensive Plan was officially adopted by the Board of County Supervisors on March 18, 2008. The Comprehensive Plan offers a clear strategy to meet such facets of the Community as: economic growth, livability, practical and fiscally sound residential development and cost effective transportation systems.

Currently, Prince William County is the third most populous jurisdiction in Virginia touting 34.8% growth between 2000 and 2006 and anticipating an additional 47% growth by 2030. By using the strategy set forth in the Comprehensive Plan, these population increases can be accommodated without compromising the standards that the residents have become used to.

The Powells Creek Watershed consists of Suburban Areas with some Urban Areas. Suburban areas accommodate the lower density residential, neighborhood-oriented retail and service uses and smaller scale employment uses found in the more traditional neighborhoods and along major intra-County transportation corridors such as Route 234. Suburban landuses that make up a significant percentage (i.e. greater than 10% of the subwatershed in which they are found) of the Powells Creek Watershed include:

Flexible Use Employment Center (FEC) – Areas of employment uses situated on individual sites or in campus-style "parks." Primary uses are light manufacturing, "start-up" businesses, small assembly businesses and office uses.

Suburban Residential High (SRH) – Areas of a variety of housing opportunities at the highest suburban density. The density range in these areas is 10-16 dwellings per developable acre.

Suburban Residential Medium (SRM) – Areas of a variety of housing opportunities a t a moderate suburban density. The density range in these areas is 4-6 dwellings per developable acre.

Suburban Residential Low (SRL) – Areas of housing opportunities at a low suburban density. The density range in these areas is 1-4 dwellings per developable acre.

Residential Planned Community (RPC) – This classification is intended for planned developments not less than 500 contiguous acres under one ownership or control in those areas of the County where provisions for sanitary sewers, sewage disposal facilities adequate highway access, and public water supply are assured.

Commonly found landuses in the Powells Creek Watershed that are not considered one of the Suburban Landuses include:

Environmental Resource (ER) – Areas made up of the FEMA regulated or natural 100-year floodplains and Resource Protection Areas (RPAs) as defined by the Chesapeake Bay Preservation Act.

Parks and Open Space (P&OS) – Designated areas for existing and projected parks and recreational areas of the County.

Regional Employment Center (REC) – Areas located close to and/or with good access from an interstate highway where intensive regional employment uses are to be located.

Public Land (PL) – Areas of existing and planned public facilities, institutions, or other government installations.

Semi-Rural Residential (SRR) – Areas where a wide range of larger-lot residential development can occur. These areas are made up of single family dwellings at a density of 1 dwelling per 1-5 acres.

For a more detailed description of these and other landuse categories, the latest version of the Prince William County Comprehensive Plan can be found on the web site of the Prince William County Planning Office.

b. Subwatersheds and Tributaries

Powells Creek Watershed is broken into the following eight sub-watersheds described in Table 1.

Table 1: Powells Creek Subwatersheds

Subwatershed Designation	Land Area [mi^2]	Predominant Landuse
700	2.53	This subwatershed is mostly wooded with increasing low and moderate density suburban residential landuses. Significant development for this subwatershed, in accordance with the Long Range Landuse Plan would be made up of: 34% Suburban Residential, Low Density; 21% Environmental Resource; 17% Parks and Open Space; and 12% Regional Employment Center.
705	2.45	The County's landfill operation and surrounding lands make up almost this entire subwatershed. The portions of this subwatershed that are not publicly owned are made up of low density development and semi-rural residential land uses. Significant development for this subwatershed, in accordance with the Long Range Landuse Plan would be made up of: 58% Public Lands; and 27% Flexible Employment Center.
710	2.09	Semi-rural residential land uses make up almost the entire subwatershed. This area of the County is almost fully built out, and the areas of open space that remain are currently undergoing residential development comparable to the subwatershed as a whole. Significant development for this subwatershed, in accordance with the Long Range Landuse Plan would be made up of: 68% Semi-Rural Residential; 16% Public Lands; and 16% Environmental Resource.
715	3.40	This subwatershed is made up of semi-rural residential and low density suburban residential. Much of the undeveloped acreage of this subwatershed is currently undergoing preliminary development. Significant development for this subwatershed, in accordance with the Long Range Landuse Plan would be made up of: 41% Semi-Rural Residential; 34% Suburban Residential, Low Density; and 19% Environmental Resource.
720	1.03	The zoning for this subwatershed is low density suburban residential, which is essentially the landuse for the entire subwatershed. Significant development for this subwatershed, in accordance with the Long Range Landuse Plan would be made up of: 59% Suburban Residential-Low Density; 23% Environmental Resource; and 14% Public Lands.
723	1.69	This subwatershed includes Lake Montclair and is primarily made up of the residential planned community of Montclair, which includes medium density residential and commercial landuses that have been in place for many years. Significant development for this subwatershed, in accordance with the Long Range Landuse Plan would be made up of: 49% Residential Planned Community; 31% Environmental Resource; and 13% Suburban Residential, Low Density.
725	2.78	This area has only limited areas of contiguous, wooded, undeveloped land and is split almost evenly between low to moderate suburban residential landuses and the Montclair residential planned community. Significant development for this subwatershed, in accordance with the Long Range Landuse Plan would be made up of: 28% Suburban Residential, Low Density; 26% Residential Planned Community; 18% Environmental Resource; and 16% Suburban Residential, Medium Density.
730	2.05	There are still large areas of wooded undeveloped land in this subwatershed, but zoning and recent development trends are moving toward predominantly high and medium density suburban residential landuses. Significant development for this subwatershed, in accordance with the Long Range Landuse Plan would be made up of: 26% Environmental Resource; 25% Suburban Residential, Low Density; 20% Suburban Residential, Medium Density; and 18% Suburban Residential, High Density.

Each of these subwatersheds is oriented along the main stem of Powells Creek, creating the linear and flashy nature of the watershed. The two subwatersheds at the very top of the watershed (705 and 710) represent the only examples of parallel subwatersheds in this watershed. These two subwatersheds combine the majority of the headwater drainage area in essentially a simultaneous confluence, which establishes the flow characteristics of the upper watershed.

Lake Montclair, located in Subwatershed 723, is a privately owned, recreational facility found in the center of the watershed on Powells Creek. This reservoir provides significant storage volume for runoff peaks and therefore regulates the flow characteristics of the lower watershed.

At the confluence of Powells Creek with the Potomac River, the Creek becomes brackish and is influenced by tides. At the direction of the County, field investigations were not performed in Subwatershed 700 for this report.

c. Watershed History and Development

The watershed has an interesting mix of historical development and new development that combine to create unique drainage issues. The headwater subwatersheds (705 and 710) along with the subwatershed containing Lake Montclair (723) have been substantially built out for many years.

FIG 2: Outfall structure at the Lake Montclair Dam

The Community of Montclair was established in 1968, and home building was mostly completed by the early 1990’s. Because of its position in the watershed, Lake Montclair serves as a sediment sink for the upper half of the watershed. According to the Montclair Property Owners Association’s web site, the association spent around $900,000 in 2007 to dredge the lake. The Association budgets $500,000 for the lake to be dredged every five years, but larger dredging operations were recently deemed necessary for maintenance. Dredging volumes for 2007 are estimated to be 34,000 yd^3 compared to 17,000 yd^3 removed in 2001 (prior dredging activities were done in 1991 and 1996).

The January 2008 Draft Forebay Assessment Study for Lake Montclair concluded that up to half of the sediment being dredged from Lake Montclair could be avoided through better controls of the local (i.e. within the community of Lake Montclair) outfalls and channels. While some of the sediment supply to the Lake is the result of natural processes and large scale watershed disturbances, these sources are much harder to control and would provide a less cost effective solution.

The other area containing historically built-out conditions was found in the two subwatersheds at the top of the watershed (705 and 710). Both have low density development with the southern of the two being dominated by the County's Landfill operations. The northernmost subwatershed is showing some signs of development in the few remaining areas of open space left, but these residential areas and the existing development are both at low density and the subwatershed has essentially minimal stormwater management due to the age and density of development found there.

The remaining five subwatersheds (715, 720, 725,730 and 700) have seen steady growth and development over recent years, with no less than nine multi-unit residential communities observed in various stages of development during field visits for this report.

d. Storm Drain Infrastructure and Stormwater Management

The storm drain infrastructure, including stormwater management facilities, for the Powells Creek Watershed is generally indicative of the age and density of the development found there. The upper subwatersheds (i.e. 705, 710 and 715) have little drainage infrastructure, and what is there is in discrete pieces as it was installed in most cases for small scale residential communities. There are a number of ponds in the upper watershed, but these too, do not provide watershed scale control of stormwater runoff due to the fact that many are farm ponds and those that were designed to offer stormwater management were either not designed regionally or control a very small drainage area.

FIG 3: The embankment and outlet structure for Lake Terrapin

Due to the presence of regional lakes such as Lake Montclair and Lake Terrapin, the center of the Powells Creek watershed holds the key to the overall hydrologic response of Powells Creek. Another significant factor is the percent of higher density residential development that exists, much of which has little or no distributed stormwater management in place. This includes subwatersheds 720, 723 and to a lesser degree 725. The *Powells Creek Watershed Study: Hydraulic Analysis* details the hydrologic impact that this facility has on the watershed as a whole. Lake Terrapin, in subwatershed 720, provides regional control of almost all of the developed (and developing) areas for half of the subwatershed.

The lower middle section of the watershed, represented by subwatershed 725, is directly below Lake Montclair. This subwatershed consists of three basic drainage conditions.

1. Development associated with the Lake Montclair community that has no appreciable stormwater management, but drains through an extensive storm drain network into Powells Creek.
2. Characterized by piped drainage systems within residential subdivisions, most of which lead to some form of stormwater management.
3. Rapidly disappearing wooded landcover.

The final section of the watershed is the lower subwatersheds, or those downstream of Interstate 95. This area contains some development that has been in place for a longer period of time (i.e. along US Route 1), which have limited or no stormwater management. The biggest trend in these areas, however, is the development of large, high density residential subdivisions, including schools. The newer subdivisions do appear to have adequate drainage and stormwater management, which combined with the attenuating effects of Lake Montclair should provide ample protection for Powells Creek. Drainage issues observed in this area that were potentially affecting Powells Creek included sanitary trunk lines crossing the creek and outfalls from developments that did not have adequate outlet protection/energy dissipation.

e. Geomorphology

Powells Creek Watershed is located within the Northern Piedmont and Northern Coastal Plain Physiographic Provinces of Virginia. The fall line between the provinces is in the vicinity where Powells Creek flows beneath Interstate 95. The watershed flows in a southeast fashion as a linear watershed, being substantially longer than it is wide.

The Northern Piedmont Province is located upstream of the Interstate 95 and is where the majority of sediment is collected and transported within the watershed. Most of Powells Creek and its tributaries are controlled with sporadic bedrock knick points and are single threaded channels, except in areas where there has been the influence of beaver activity; a frequent occurrence in this watershed. Nearly all the channels within this province are showing signs of erosion due to the flashy hydraulic response due to upstream urbanization.

The Northern Coastal Plain Province portion of Powells Creek is located east of Interstate 95 and flows to the Potomac River. In this area, Powells Creek is transitioning from a channel that transports sediment to a multi-thread and a depositional channel, due, in part, to tidal influence of the Potomac, beaver activity and channel slopes. The channel is also experiencing erosional problems due to upstream urbanization and watershed flashiness.

2. Summary of Existing Reports and Data

Powells Creek is considered by many to be a valuable natural resource that the County should prioritize in its watershed planning efforts. The following studies were found that comprehensively address, in part or in whole, the hydrologic functions of Powells Creek and the lands that drain to it and are summarized in this section:

Prince William County Stream Protection Strategy
Powells Creek Watershed Study: Hydraulic Analysis
Prince William County Water Quality Monitoring Program (Spriggs Road Station)
Virginia DEQ 303(d) List of Impaired Waters Needing TMDL Studies
Bioassessment of Nonpoint Source Impacts in Three Northern Virginia Watersheds

a. Prince William County Stream Protection Strategy

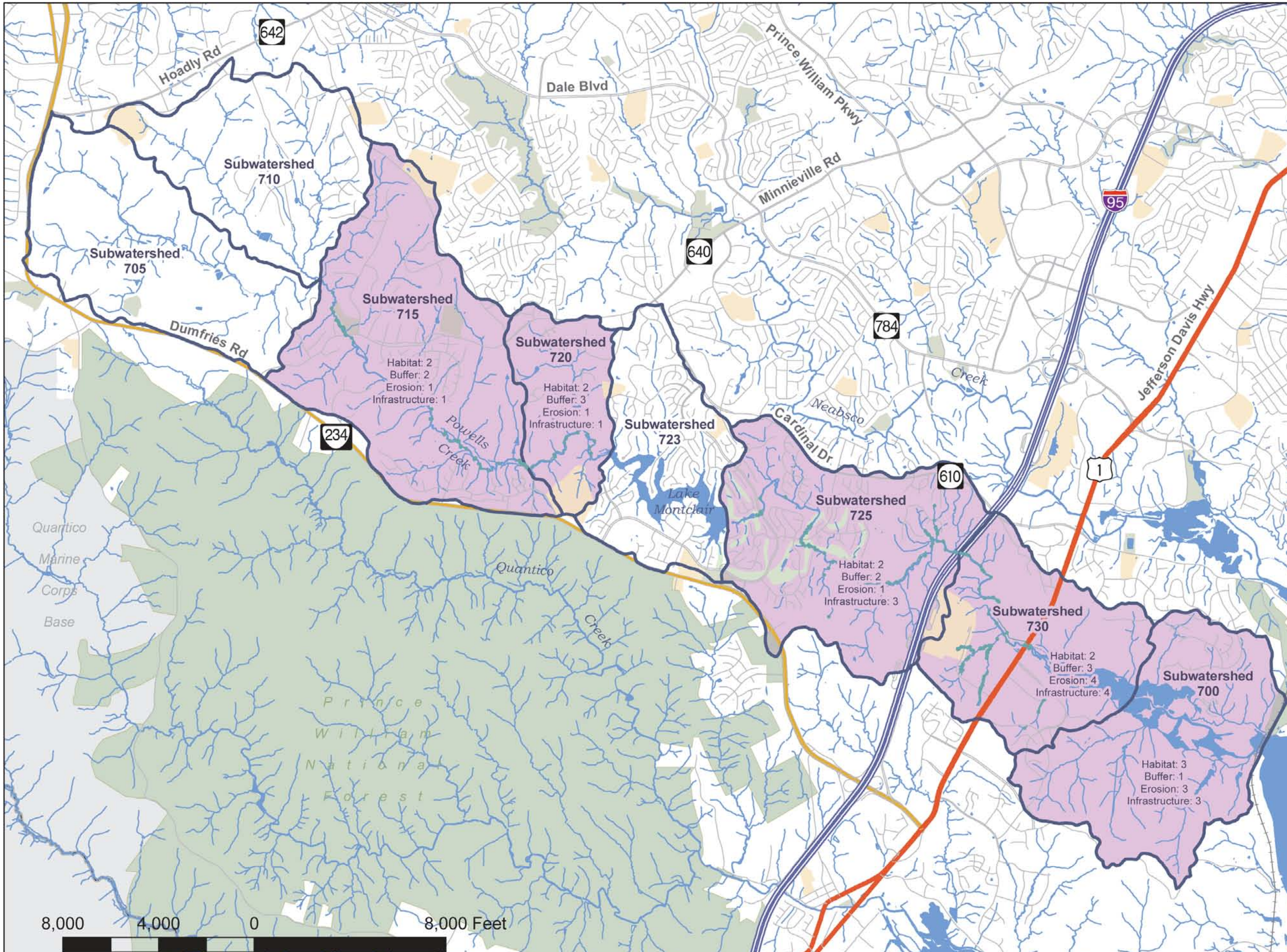
In 2004, a team consisting of CH2M Hill, Williamsburg Environmental Group and Michael Baker Jr., Inc. submitted the *Prince William County Stream Protection Strategy*. This study looked specifically at the streams themselves, rather than the watersheds draining to them, to determine what types of impacts the streams were reacting to. The purpose of this assessment was to collect information on and document:

- Habitat Conditions;
- Impacts on the stream from specific infrastructure and problem areas;
- General Stream Characteristics; and
- Biotic integrity.

Data collected were entered into a database and digitized into a GIS-based Stream Assessment Tool, which is now available online at www.pwcgov.com. Using a scoring system of 0 to 200, with 200 being the best and broken into categories of: Optimal (160-200), Suboptimal (107-159), Marginal (55-106) and Poor (0-54), Powells Creek scored 129, rating it as sub-optimal overall. Of the linear feet of stream assessed, 60,560 LF were rated as suboptimal and 7,130 LF were rated marginal. It should be noted that the overall score of 129 tied Powells Creek with Bull Run for the highest habitat score in the County, and the length weighted score for the County as a whole was 119. It should also be noted that the Stream Assessment study did not evaluate or consider streams in either of the headwater subwatersheds (705 and 710) or in subwatershed 723.

General conclusions and recommendations provided by this study suggest:

- Subwatersheds that have good habitat condition (optimal and suboptimal) should be protected to maintain and improve this condition. Subwatersheds where habitat is degraded (marginal), should be the object of restoration efforts to improve the streams.
- Deficient buffers ranged from poor to optimal. Subwatersheds rated as optimal in terms of the deficient buffers should be protected and enhanced either by increasing extent or improving their functionality (e.g. adding diversity of vegetation, removing invasive species and filling gaps). Buffers in suboptimal condition should be monitored to prevent further degradation. Buffers in marginal and poor condition should be improved either as part of new development activities or watershed restoration plans.



Powells Creek Watershed Management Plan

Figure 4:
2004 Stream Protection Assessment

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Legend

- Inventory Point
- Inventory Line

Other Features

- Subwatershed
- Waterbody
- Stream
- Inventoried Watersheds

Inventory Ratings
1=Optimal
2=Suboptimal
3=Marginal
4=Poor

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- Serious erosion problems (poor condition) should be stabilized to prevent additional damage. Plans for implementation of permanent mitigation measures should be given priority in these areas. Moderate erosion problems (marginal condition) should be considered candidates for stream restoration efforts, ideally as part of watershed restoration programs. Subwatersheds rated as optimal or suboptimal in terms of the severity of its erosion problems should be inspected periodically to verify that they continue in that state.
- Serious localized infrastructure problems (poor condition) should be corrected immediately. These actions provide both rapid and cost-effective remediation to evident environmental problems, as well as visibility to foster stakeholder support. Minor localized problems (marginal condition) should be monitored to prevent further degradation and identify the appropriate time to undertake mitigation measures. Subwatersheds rated as optimal or suboptimal should be inspected periodically to verify that they continue in that state.

The purpose of the Stream Physical Assessment and the expanded watershed management program was to address altering or replacing ineffective conventional stormwater management approaches and a focused, proactive approach to stream restoration. With this current effort, Baker has used the information provided in this previous study to focus our attention to areas previously deemed as needing attention. We have, therefore, not visited every degraded location in the watershed, and have tried to supplement the areas not observed first hand by conducting a desktop review of the latest aerial photography and GIS data that was made available by the County.

Figure 4 provides insight into the guidance provided by the Countywide Stream Assessment that Baker used to determine where to conduct field visits.

b. Powells Creek Watershed Study: Hydraulic Analysis

In August 1989, a hydrologic and hydraulic analysis of the Powells Creek Watershed was performed by Dewberry and Davis for the Trammel-Crow Communities under the supervision of Prince William County. The purpose of this study was to determine the impact that ultimate basin development will have on the drainage and flooding problems and to evaluate basin-wide stormwater and floodplain management methods to mitigate and manage the potential negative environmental impacts associated with full basin development.

It is interesting to note that with all of the development that has occurred in the Powells Creek Watershed over the last twenty years, the descriptions written in the hydraulic study describe, in large part, what is seen today as evidenced by the following passage and current photograph:

> "The topography of the watershed is characterized by steep slopes and ravines that drain to the Powells Creek channel. The Powells Creek channel is a defined channel eroded to bedrock in places and has an average longitudinal slope of 0.3 percent. Below U.S. Route 1, the Powells Creek channel is a flat marshy wetland area until it flows into the tidal Potomac River."

FIG 5: At left is a photo below US Route 1, where Powells Creek is a braided stream consisting of a wide floodplain and low gradient wetland. The photo on the right, taken below Lake Montclair shows the bedrock dominated stream above the fall line.

The 1989 Hydraulic report pointed out that Lake Montclair provides primary flood mitigation for the Powells Creek Watershed. There are no known plans for the construction of Lake Montclair, formerly known as Country Club Lake, which was built in 1963-1964 with a top elevation of 200 ft (NGVD). In 1970, the dam was raised by 6.5 feet, with improvements being made to the principal and emergency spillway (although no mention was made to changes in elevation for either). At the time of the Hydraulic study, the dam was being further modified per the recommendations of the 1978 US Army Corps of Engineers Phase I report to turn ownership over to the Montclair Homeowners Association, which is still the responsible party for the facility. The permanent pool elevation for Lake Montclair was reported to be 188 feet (NGVD) with the emergency spillway invert set at 193 feet (NGVD).

Hydrologic Analysis

The hydrologic analysis was conducted for design rainfall periods of 2-, 10-, 25-, 50-, 100-, and 500-year events using SCS methodology within the HEC-1 computer program. Rainfall depths associated with each of these return intervals were based on TP-40 and HYDRO-35, which was appropriate at the time of the study. However, these resources have been replaced by NOAA Atlas 14 and a quick comparison indicates that Atlas 14 rainfall depths for the 24 hour event are somewhat less than those reported from TP-40 and HYDRO-35 for events more frequent than the 50-year storm, but the 100-year event actually increased from 7.8 in to 8.14 in and the 500-year event increased from 9.5 in (extrapolated by hand) to 11.53 in. It is not prudent to reduce these rates for aerial corrections since Lake Montclair provides significantly more reduction through storage attenuation. Therefore, floodplains and floodprone areas that were based on smaller discharges associated with the older methodology should be considered suspect and a revision of these mapped areas considered.

Hydraulic Analysis

The Hydraulic Study evaluated water surface profiles and determined floodways using the effective FEMA models of the day and supplementing them with cross sections developed by manual methods on available five-foot contour maps to extend the studied area upstream to Minnieville Road. Current FEMA maps, effective January 1995, show the A zone floodplains extending well above Minnieville Road, with a Floodway delineation extending to the confluence of basins 705 and 710.

After looking at a number of scenarios for mitigating the impacts of development, it was concluded that very little, if any, activity foreseen in the Powells Creek Watershed would be expected to have a serious effect on the floodplain elevations associated with the 100-year flood event due to the flood reduction provided by Lake Montclair. Therefore, emphasis needs to be placed on issues associated with more frequent flooding events and the impact that these event have on the drainage infrastructure.

Stormwater Management Feasibility

In an effort to address adequate outfall issues and the implementation of water quality Best Management Practices (BMPs), as they were known to be at the time of the study, the 1989 Hydraulic Study evaluated the alternatives of strategic “overdetention” for site developments or regional facilities. A significant factor that exists now, but was not an obstacle in the late 1980’s is the permitting of on-line or regional facilities. Permitting associated with sections 401 and 404 of the Clean Water Act makes such facilities infeasible in most instances. A certain amount of creativity is required to accomplish the benefits of regional facilities while site based and distributed approaches become much easier to implement.

The drainage infrastructure was evaluated under 1989 existing conditions as well as projected ultimate landuse conditions, the culverts at Route 643 (Spriggs Road), Route 640 (Minnieville Road) and Route 1 were deemed inadequate or marginal for the design storms required for Primary and Secondary roadways. The culverts at Spriggs Road have been upgraded in recent years, but field visits found channel indicators at Minnieville Road that suggest roadway improvements might be needed to protect the riparian area downstream from hydraulic effects associated with the roadway.

FIG 6: Existing Spriggs Rd. Bridge – Built Since Hydraulic Study

Prince William County received proposals in March of 2008 for professional services to improve 10,600 linear feet of Minnieville Road between Spriggs Road and State Route 234, including the crossing of Powells Creek. This project will consist of widening Minnieville Road to a four lane divided roadway with a raised median and pedestrian features. A major roadway improvement such as this should offer sufficient opportunity to address all of the concerns regarding the existing crossing.

The assessment showed that Lake Montclair attenuates discharges in the lower portion of the watershed to rates comparable to Historic Landuse discharges that reflect the conditions of 1956, which is before the structure was built. The Existing and Ultimate Landuse conditions discharges both reflect the effects of the Lake's storage, however both neglect existing or future effects of stormwater management facilities within the lower half of the watershed.

For example, at Interstate 95 the existing conditions discharge for the 100-year return interval is 3509 cfs, and would be expected to increase to 4839 cfs under ultimate buildout conditions. However, this is within approximately 450 cfs (+/-10%) of the Historic landuse (i.e. prior to the construction of the impoundment).

Powells Creek Watershed Management Plan

Figure 7:
Flood Mapping
(Effective 1995)

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Flood Zones

Floodway

100 Year Floodplain

500 Year Floodplain

Other Features

Subwatershed

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Table 2: Discharge Comparison for Powells Creek Below Lake Montclair

	Existing Conditions			Ultimate Landuse			Historic Landuse		
	2-yr	10-yr	100-yr	2-yr	10-yr	100-yr	2-yr	10-yr	100-yr
Waterway Drive	372	983	2951	501	1733	4874	699	2045	4377
Northgate Drive	435	1047	2975	670	1789	4859	719	2079	4377
I-95	747	1828	3509	1298	2723	4839	750	2136	4393
Route 1	830	2017	3843	1431	2954	5111	768	2166	4393
Potomac River	914	2159	4120	1590	3171	5424	803	2233	4485

The hydrologic results in Table 2 show that Lake Montclair reduces the discharges for existing conditions to historic rates all the way to the Potomac. Ultimate Landuse discharge rates are reduced to historic rates essentially down to I-95 (within +/-10%) without consideration of additional attenuation provided by site and regional BMPs. Clearly the importance of Lake Montclair to the overall hydrologic response of the watershed can not be overstated and any program aimed to correct real or perceived issues within the watershed should be designed to work in concert with Lake Montclair.

Some interesting conclusions were provided to a sensitivity analysis performed by the 1989 Hydraulic Study that investigated multiple scenarios of landcover and stormwater management strategies. These are:

- Lake Montclair provides regulatorily adequate 10-year detention (below historic levels) for all existing development around and below the lake.
- Lake Montclair will continue to provide adequate 10-year detention (below historic levels) when all basins draining to the lake and those above Northgate Drive are fully developed. From Route 1 to the mouth of Powells Creek, the increase in discharge from 2000 cfs to 3500 cfs equates to an average depth increase of approximately 0.5 ft, neglecting tidal effects which would reduce the impact further.
- On-site detention in the lower half of the watershed provides minimal reductions in flood flows along Powells Creek. Stormwater Management is necessary, however, to protect tributaries to the Powells Creek channel from contributing to downstream impairments.

Watershed Management Plan

Based on the analyses performed in the Hydraulic Study, the following recommendations were made:

Upper Basin Recommendations (above Montclair)

1. Regional approach should be used to provide Stormwater Management. Regional approach should consist of cooperative operation and maintenance of Lake Montclair

and the construction of 3 major impoundments on the main stem of Powells Creek in the upper watershed.
2. Use regional facilities to address 10-year stormwater management requirement for the upper watershed, while strictly enforcing adequate outfall for the 2-year storm.
3. Provide BMPs (i.e. water quality treatment) on sites, to the degree possible, but encourage natural BMPs such as protection of undisturbed areas and leaving tributaries as natural as possible to provide natural storage, filtration of sediments and ensuring consistency of the time of concentration.
4. Redesign Route 640 (Minnieville Road) roadway and culverts to meet VDOT design conditions (is currently being pursued under County roadway project).
5. Implement channel bank stabilization projects for two 2000 LF reaches of Powells Creek: a) above Minnieville Road and b) immediately above Lake Montclair.

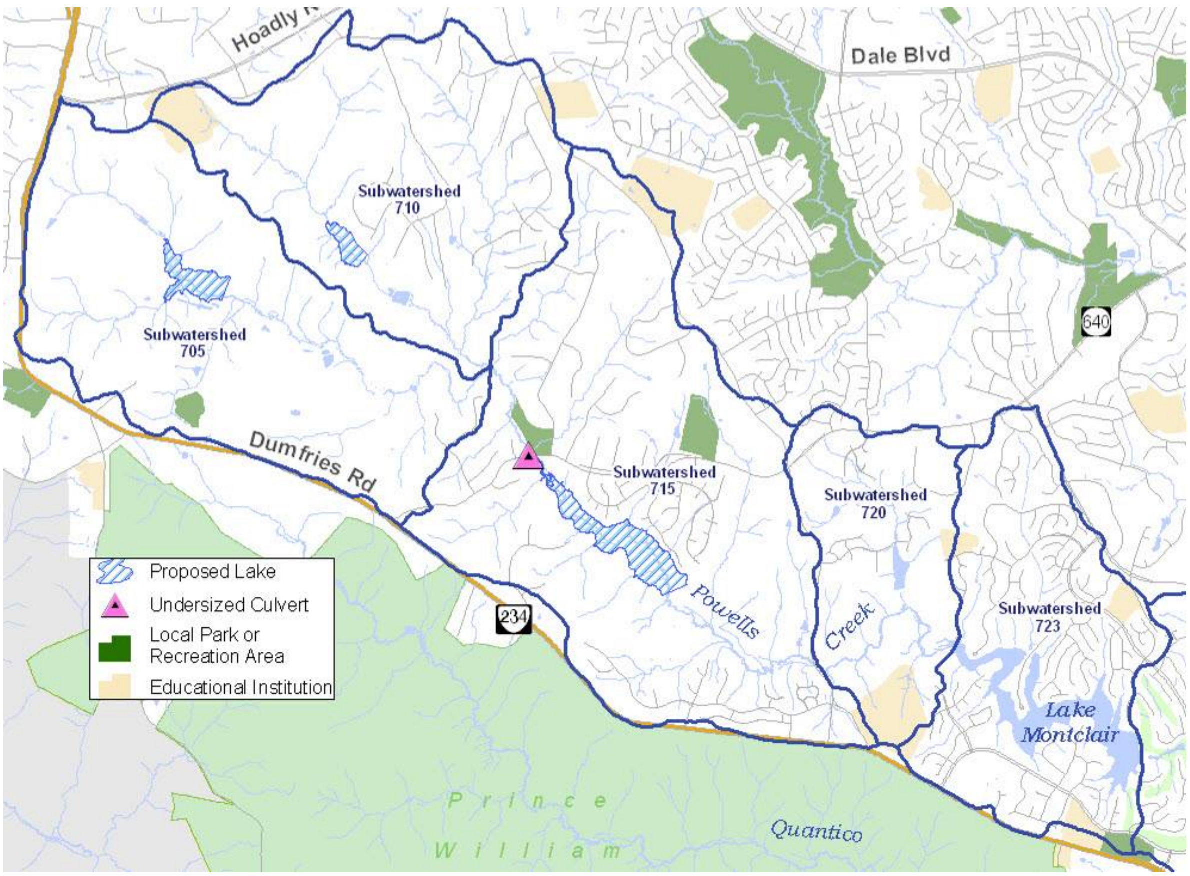

FIG 8: Upper Basin Recommendations from Hydraulic Study

<u>Northgate Drive Downstream to US Route 1</u>

6. Site-specific detention should be implemented above Route 1 with a minimum of 2-year detention being provided along Powells Creek.
7. A regional detention approach is required in the tributaries to Powells Creek to eliminate the need for US Route 1 improvements. Alternatively, the culverts under Route 1 could be enlarged if roadway improvements are proposed.
8. Encourage natural BMPs such as gravel trenches, flat ditches, level spreaders and undisturbed open space. Leave tributary channels as natural as possible, but protect

them from highly erodible banks and bends by the use of check dams. Allow flood flows to access the 100-year floodplain to create areas conducive to wetlands propagation and provide natural filtration.

US Route 1 to the Mouth

9. Discourage development in the 100-year floodplain of Powells Creek to protect tidal and non-tidal wetland areas
10. Provide adequate outfall for areas draining to Powells Creek.

The 1989 Hydraulic study, while dated, is still relevant today. Many of the conclusions and recommendations presented would add beneficial value to the function of the watershed as it continues to develop 20+ years after the study was done. However the one overwhelming obstacle to implementing these recommendations is that many of the suggestions that require wetland and stream impacts are no longer practical to consider in today's permitting climate. This all but eliminates the possibility for building on-line, regional stormwater management practices. Another issue is that we now have a better understanding of stream processes that help us maintain holistic stream function, not just from a capacity standpoint, but from a ecological, sediment transport and hydraulic standpoint.

c. Water Quality Station at Spriggs Road

There has been a water quality monitoring station at the Spriggs Road bridge over Powells Creek for several years, which is no longer in service. This station has monitored a variety of chemical constituents, the results of which have been provided by the County for consideration in this study. The constituents that have been evaluated are:

- Total Suspended Solids (TSS) – Organic and Inorganic matter found suspended in water column
- Total Kjeldahl Nitrogen (TKN) – The sum of Organic Nitrogen and Ammonia
- Oxides of Nitrogen (OX-N) – Nitrite and Nitrate forms of Nitrogen
- Total Nitrogen (TN) – Sum of TKN and OX-N
- Total Phosphorus (TP) – Sum of Organic and Inorganic forms of Phosphorus
- Ammonia-Nitrogen (NH3-N) – Nitrogen existing in the form of Ammonia

Table 3: Water Chemistry Reported for Powells Creek at Spriggs Road

Sample Date	TSS	TKN	OX-N	NH3-N	TP
1999	-	1.17	0.19	-	0.37
2000	-	0.95	0.23	-	0.20
2001	-	1.21	0.26	-	0.30
7FEB02	-	-	-	0.0	-
13MAR02	-	-	-	0.1	-
2MAY02	-	-	-	0.0	-
28AUG02	-	-	-	0.0	-
16OCT02	-	-	-	0.1	-
2002	-	0.83	0.26	-	0.26
20MAR03	349	1.79	0.25	-	0.47
21MAY03	86	1.15	0.13	-	0.24
17DEC03	105	0.25	0.13	-	0.09
2003	-	1.06	0.17	-	0.27
NURP AVG	125	1.88	0.86	0.46	0.31

Note: All samples are thought to be in mg/L and reports of 0.0 may indicate: no sample; undetectable sample or a sample of 0.0.

The data represented in Table 3 was provided by the County from readily available monitoring results on file. It is not clear whether additional data exists and conclusions that can be drawn from the sparse data available is limited. However, what we can see from the data is:

- TSS data is highly variable depending on when the sample is taken, and in these instances was either in the range of the NURP Average or well above.
- TKN fluctuates with every sample taken, although most are substantially below NURP Averages.
- Nitrites and Nitrates are relatively constant in all samples reported…all of which were well below the NURP Average.
- Total Phosphorus samples are consistently reported to be near the NURP Average.

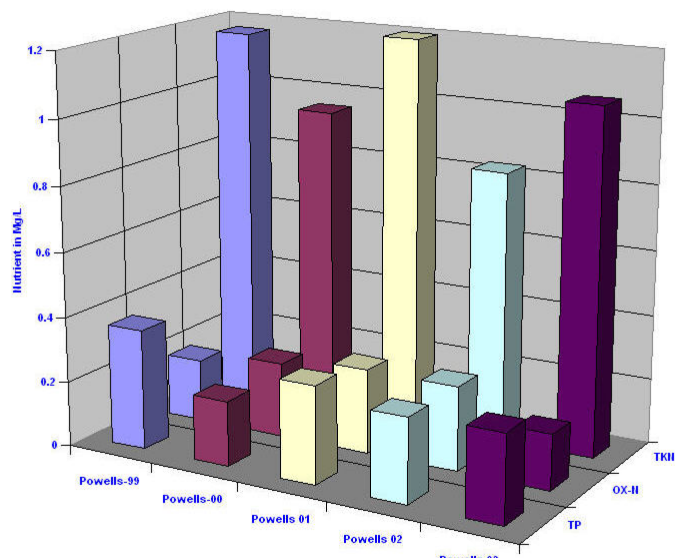

FIG 9: Nutrient Concentration Comparison by Year at the Spriggs Road Monitoring Station

While NURP Averages may not provide a meaningful comparison, these values were reported in the available records and do provide some context with which to assess the relative presence of Suspended Solids and reported Nutrients from this location.

Based on these results, Sediment and Phosphorus, which are often closely correlated, should be a major focus of restorative and preventative measures employed in this watershed.

d. 2006 303(d) List of Impaired Waters Needing TMDL Study

Total Maximum Daily Loads (TMDL) are watershed specific plans to determine through scientific analysis the amount of a pollutant that can be assimilated within the area in which it is generated. By quantifying the sources and loads of the pollutant, an implementation plan can be created to provide the roadmap for meeting the allowable loadings for a particular body of water. The TMDL program is mandated by the EPA and administered by the Virginia Department of Environmental Quality (DEQ), who tests Virginia's rivers, lakes and tidal waters for pollutants. TMDLs may be created for common pollutants such as sediment and nutrients or less common sources of impairments such as bacteria and even toxic industrial waste. Either way, it is the implementation plan that has the potential to impact the way we live and the development regulations that may be applied to the watershed.

The 2006 list of impaired waters included the entire section of Powells Creek below Lake Montclair. For regulatory purposes, this section is 5.02 miles and is scheduled to have a TMDL prepared in 2014. Impairments in this reach are Fecal Coliform, PCB and Benzo[k]flouranthene, based on ambient water quality monitoring and fish tissue/sediment monitoring at the Route 1 Bridge. While PCB and Benzo[k]flouranthene were initially listed in 2002, the fecal coliform listing is new for 2006.

It is generally thought that the PCB and Benzo[k]flouranthene reach into the Powells Creek watershed from the Potomac River where they are present. If this is the case, little can be done within this watershed, but caution and education on their presence is important to minimize potential human contamination. Fecal coliform bacteria impairments are becoming more widespread in urbanized communities throughout Virginia. The source of this bacteria is still widely speculated upon, but implementation plans may include expensive sewage system inspections and overhauls, pooper-scooper ordinances, leash laws or other means of reduction associated with the various sources of bacteria within our watersheds.

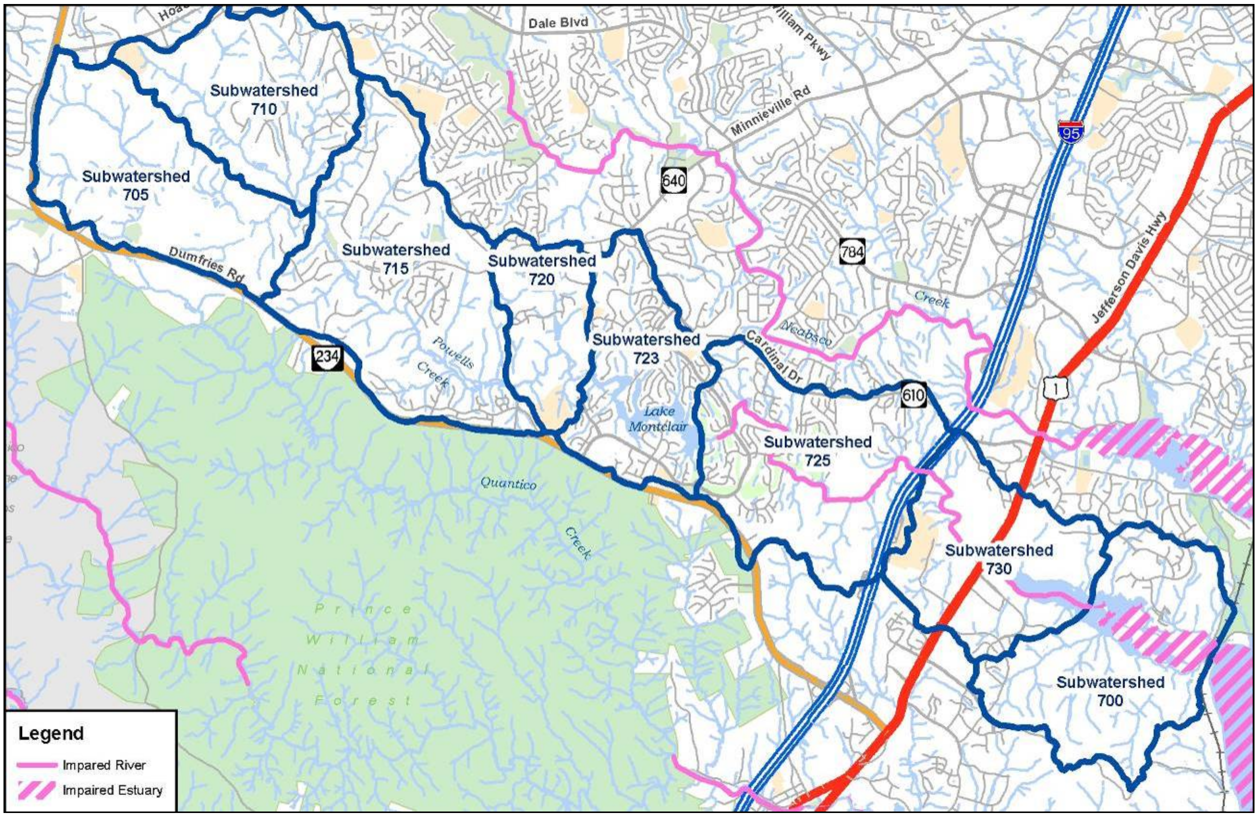

FIG 10: 2006 Impaired Water Bodies (Virginia DEQ)

e. Other Data

A July 1994 George Mason University benthic macroinvertebrate and fish sampling study in the Neabsco, Quantico and Powells Creek Watersheds was summarized in the previously referenced report on the *Prince William County Stream Protection Strategy*. If further investigation of this report is desired, the results were referenced to *Bioassessment of Nonpoint Source Impacts in Three Northern Virginia Watersheds* (Jones et al., 1994). The objective of this study was to evaluate the effect of suburbanization and Best Management Practices on the biological community. The sampling results indicated a correlation between benthic macroinvertebrate impairment and the degree to which the watershed was developed. The fisheries community showed a lesser degree of correlation to watershed development, and a higher correlation with watershed size. Samples downstream of BMPs showed degraded macroinvertebrate communities although the cause of the degradation could not be determined due to a lack of sites upstream.

For the purpose of the current study, the George Mason study held little value as it only looked at consequences rather than the process by which the consequences occurred. For example, it is widely accepted that development leads to degradation of benthic macroinvertebrate communities, but without understanding the process by which development affects the community, the knowledge, by itself, does not impact recommendations for remedial action.

IV. Watershed Action Plan

1. Initial Watershed Management Strategies

Based on early coordination with the County, the following list of watershed management strategies was developed with the intention of incorporating them into the final Project Concept Plans to the greatest extent practical, given the practical limitations, constraints and applicability found in the watershed.

1. Assessment and Recommendations to Improve Outfall Adequacy – The linear nature of the Powells Creek watershed ensures that the drainage area reaches the main stem very soon after runoff ensues. As such, outfall adequacy, as defined in MS-19, was not found to be a significant problem in the watershed. Therefore, no outfall improvement recommendations were made.
2. Stream and Riparian Zone Restoration Sites – There were locations along Powells Creek and its tributaries where instability was found to range from severe to moderate. In locations where instability might be addressed by providing additional vegetative stabilization techniques, full restoration was not recommended. However, in more severe locations or where conditions appeared to be worsening, restoration of the stream in accordance with natural channel design techniques was recommended.
3. Stream Stabilization Sites – Spot stabilization opportunities were not found to be a significant problem. Therefore, no recommendations were made to do so.
4. Stormwater Retrofit Sites – There are abundant opportunities to retrofit stormwater management facilities throughout the watershed. Several, but by no means all, alternatives are presented as Project Concept Plans in this report.
5. New Stormwater Management Practices – There exist a potential to develop new stormwater management practices within the Powells Creek watershed based on a holistic approach that takes into account the unique features of the watershed (e.g. length to width ratio, Lake Montclair, etc.). Several ideas are presented in the recommendations found in this section of the report, but additional quantitative analysis is required to determine a more concise approach.

6. Drainage System Infrastructure Improvements – Extensive drainage system infrastructure exists primarily within the area draining directly to Lake Montclair, which provides an extreme amount of quantity and quality control to meet applicable regulations. Therefore, large scale infrastructure recommendations were not found to be cost effective. Specific instances of drainage infrastructure improvement that were recommended included road crossings of the stream where indications existed to raise concern over the adequacy of the culvert capacity.
7. Programmatic and Regulatory Approaches – Minimal opportunities were found to offer suggestions of programmatic and regulatory approaches. Additional quantitative analysis could be performed that would provide a greater level of comfort for proposing a holistic watershed management approach to capitalize on unique features of the watershed. The primary focus of programmatic recommendations made consists of greater enforcement of existing regulations, particularly those pertaining to post-construction erosion and sediment control.
8. Strategies to Address Known Stream Dumping Areas – While instances of litter were found in various areas of the watershed (particularly in the lower fourth), large areas of dumping were not found, and as such, recommendations were not made.
9. Low Impact Development Practices (for new development and retrofits) – Due to the distributed nature of Low Impact Development (LID) and the need to keep project recommendations on County or HOA parcels, limited opportunities exist for LID recommendations. LID design approaches may prove to be a beneficial approach in future developing areas of the watershed and should be encouraged.
10. Regional Facilities – Large Best Management Practices (BMP) opportunities were evaluated both in this report and previous studies. While a regional approach may provide real and tangible benefits, these must be weighed against the permitting and other obstacles to implementation.

Using the strategies outlined above, extensive fieldwork was done to evaluate the potential for using these approaches to provide a means to improve the overall watershed function. The results of the fieldwork, along with analysis of the County's Geographic Information System (GIS) and the review of existing quantitative studies and reports resulted in the finding and recommendations put forth in the following sections.

2. Summary of Findings

Upon reviewing the previous efforts at assessing the condition of the Powells Creek Watershed, Baker conducted field reconnaissance of sub-watersheds to determine the sources of observed impairments and to develop strategies to provide corrective action. The field visits were limited to the subwatersheds that were determined to be suboptimal or worse by the studies previously discussed. However, the headwater subwatersheds (705 and 710), which were not evaluated in the Stream Assessment were observed in the field to investigate:

a) the potential for stream restoration opportunities to mitigate impacts forecasted by the proposed expansion to the Prince William County Landfill (limited to the channel below the landfill); and
b) the opportunity to effectively replicate the goals of the 1989 Hydraulic Study recommendations in a manner that could be permitted in the current regulatory environment.

Although subwatershed 723 does not have many stormwater management facilities, it is dominated by Lake Montclair, which provides tremendous peak flow reduction and captures much of the sediment and other contaminants that flow through the Watershed. As such, subwatershed 723 was not reported on in the Stream Assessment and was viewed as beneficial in the Hydraulic Study of the watershed and was therefore not field inspected, however, a desktop analysis was performed and recommendations made from that analysis are presented herein.

The Watershed Action Plan is, therefore, a combination of strategic recommendations to work with the existing infrastructure to improve the hydrologic functionality of the watershed and a set of specific capital improvement projects that address current, observed deficiencies. The goal of this action plan is to provide the County with the knowledge, tools and approaches that will aid in maintaining a watershed whose health is as good as it can be while development continues to occur.

a. Hydrology

The hydrology of Powells Creek Watershed, as previously discussed, is significantly influenced by Lake Montclair. This effectively divides the watershed into two separate watersheds that function, more or less, independently from one another. The 1989 Hydraulic Study concluded that Lake Montclair essentially addresses the detention needs for the watershed below the lake (i.e. the discharges below the lake are comparable to the pre-Lake Montclair discharges). Therefore, facilities may be provided, or upgraded, to ensure that discharges in the lower end of the watershed do not increase and thereby require enlarging the culverts under US Route 1. It is recommended that a more thorough investigation be performed to determine the adequacy of the Route 1 culverts, as they currently exist. Of particular interest is whether there has been an upgrade to these culverts since the 1989 Hydraulic Study and whether there have been historical episodes of roadway overtopping along Route 1. However, it is important to note that Route 1 and the associated culverts at the Powells Creek crossing are the responsibility of the Virginia Department of Transportation (VDOT), and there is little that the County could do to alleviate real or perceived issues without extensive coordination and cooperation from VDOT.

As observed during field visits, there are a number of subdivision scale ponds, both wet and dry that control runoff in the region below Lake Montclair. Several of these have been identified for potential pond retrofits in the Watershed Improvement Projects listed in Appendix A. It is recommended that existing and future stormwater management facilities located on tributaries, both above and below Lake Montclair, prioritize dry detention volume to the greatest degree possible, with a goal of providing extended detention (24-hour peak offset) for the 1-year storm to satisfy adequate channel requirements in accordance with Virginia's Erosion and Sediment Control laws. Incentives for providing extended detention for less frequent events should be considered in the context of where in the watershed these facilities exist and the anticipated benefits associated with such an incentive.

b. Hydraulics

The dominant feature affecting the overall hydraulic functionality of the watershed is Lake Montclair. As shown in the 1989 Hydraulic Study, the attenuation provided by this facility reduces the discharge in the lower portion of the watershed to a rate that is significantly less than if the lake were not there. The recommendations further state that regional detention facilities should be included in the upper portion of the watershed to reduce those peak rates of flow to rates that can be conveyed non-destructively through the channels, thereby reducing future erosion and scour.

The current permitting climate, however, makes such facilities infeasible, or at least impractical. Therefore, other opportunities to affect the peak rates of flow in the channels of the Powells Creek Watershed over a range of return intervals is presented in the recommendations that respects natural channel processes and has the potential to provide a permitable solution that accomplishes many of the goals outlined in the Hydraulic study.

Aside from the potential risk of channel erosion, bridge and culvert capacity has been identified as a concern at Minnieville Road, Spriggs Road and US Route 1. Of these, Spriggs Road has been upgraded to accommodate a larger discharge, and a roadway project for Minnieville road is included in the recommendations made by this report to address potential flooding and downstream headcutting associated with overtopping flows.

c. Flooding

Flood issues have not been identified as being a significant problem for the Powells Creek watershed due in large part to the high degree of attenuation provided by Lake Montclair. Throughout the watershed, the floodplains along major water courses are wide with very few residential or commercial structures built in floodprone areas. There is no reason to think that this trend is likely to change due to Resource Protection Area and floodplain regulations that are in effect in the watershed.

There is a FEMA regulated floodplain along the main stem of Powells Creek that extends from the Potomac River upstream to a point well inside Subwatersheds 705 and 710. This regulated floodplain includes detailed study information to a point above Minnieville Road and then extends as an approximate studied flood zone into the headwater subwatersheds (see Figure 7).

The 1989 Hydraulic Study did identify three locations where flooding may be an issue that should be addressed. These were: Powells Creek at US Route 1, Powells Creek at Spriggs Road and Powells Creek at Minnieville Road. In each of these cases the culverts were deemed inadequate to convey the anticipated peak discharges as the watershed developed.

FIG 11: Downstream face of culverts under Minnieville Road (Rt. 640)

Spriggs Road has been upgraded in recent years and is therefore assumed to be capable of passing the design discharge associated with the road classification. US Route 1 does not appear to have been upgraded in recent years, but the Hydraulic Study determined that it would be adequate for the 25- to 50-year discharge at ultimate basin development conditions without additional stormwater management. Field observations made during this study did not note evidence of roadway overtopping and the adequacy of this crossing was therefore not raised as a concern.

Minnieville Road, on the other hand, shows indications of recurring overtopping from higher flows in Powells Creek. These indications have been confirmed by County staff. Significant deposits of sediment exists at the outlet of the culverts, which impact the capacity of the culverts. The Hydraulic Study showed that the capacity of these culverts would be less than the two year discharge under ultimate development conditions without factoring in blockages due to sediment deposits. Other factors that affect the hydraulic conditions at Minnieville Road include the relatively low and long vertical sag at the location of the crossing of Powells Creek and the relatively wide floodplain above Minnieville Road. These factors contribute to the overtopping flows impacting a substantial length of Minnieville Road, and plunging into Powells Creek on the downstream side (as evidenced by erosion eating at the banks along the edge of pavement). Left unchecked, it would be expected that Powells Creek will continue to erode toward the Roadway until the shoulder no longer exists.

The County is currently working on an upgrade to Minnieville Road that would substantially address these concerns. It is recommended that this report be used to develop design criteria to provide a holistic approach to the future road crossing, rather than just a conveyance for the creek to flow under the road.

d. Water Quality

Mitigation to water quality impacts in the Powells Creek Watershed are provided, in most cases, throughout this watershed by on-site stormwater wet ponds. Wet ponds are viewed as providing improved water quality benefits over dry facilities by settling a greater amount of the sediment load entering and by biological and chemical processes that take place within the facility. Drawbacks to wet ponds, however, include maintenance and a reduced dry storage volume with which to attenuate runoff events.

The primary pollutants, associated with development within the watershed, are Total Suspended Solids and Phosphorus. Recent sampling by the Virginia Department of

Environmental Quality has also found bacteria to be a pollutant of concern, although the source of the bacteria is not known at this time.

e. Permitting

Due to the linear nature of the Powells Creek Watershed, the most efficient means of affecting the function of the watershed as a whole would be accomplished by on-line management measures. For watersheds such as this, off-line facilities tend to have a negligible impact to watershed scale metrics. However, the permitting issues associated with on-line facilities are often prohibitive in today's permitting climate for impacts to the waters of the US. An alternative to on-line facilities is to use a larger number of off-line facilities to manage the same drainage area and/or associated discharge.

A strategic permitting advantage that may exist in Powells Creek is to capitalize on historical impacts from existing in-stream stormwater management facilities or other impounding structures (e.g. roads). Existing facilities were often designed to achieve limited goals such as simple conveyance or on-site stormwater detention. By reconsidering their contribution to the watershed as a whole, potential project might include retrofits using different design criteria that would better serve the watersheds holistic needs while taking advantage of the previously permitted impacts to streams and wetlands.

3. Conclusions

Based on the review of previous studies, and in conjunction with field surveys and supplemented with a desktop analysis of available County records, the following conclusions have been drawn to aid in the development of approaches to benefit the functionality of the Powells Creek Watershed. It should be noted that there is more than one way to provide watershed improvements, but focusing on the conclusions identified in this report should enable the County to target approaches that create the most benefit for the investment.

- The watershed essentially functions as two discrete drainage areas due to the attenuation associated with Lake Montclair. Approaches should deal with the two halves of the watershed based on the issues found in each half, discretely, but we should not lose sight of potential influencing factors that cause one half to function dependently on one another.
- The watershed's high length-to-width ratio establishes a runoff response that promotes a flashy, hydrographic wave that propagates through the upper watershed. Extended

detention approaches would be most effective at offsetting the hydrographic nature of development in a watershed such as this.

- Tributaries are rather steep and narrow, which leads to highly incised channels, particularly in the lower half of the watershed. These result in smaller scale flashy hydrographs causing the incision. Development area scale extended detention would best address hydrographic issues in the tributaries.
- Both bedrock and sandy streams are present and necessitate appropriate strategies where applicable (i.e. streams will not respond well to a one size fits all approach across the entire watershed).
- Beaver activity in this watershed should be factored into any watershed project to account for the potential impact to hydrology, hydraulics and long term maintenance.
- Suspended sediment and phosphorus are the primary water quality pollutants. The lower half of the watershed has recently been listed as impaired by bacteria, but too little is known at this point to draw conclusions on the sources. Suspended sediment and phosphorus are often linked together and there is good reason to associate their presence with bank erosion throughout the watershed. Therefore, a primary focus of watershed management efforts should be on establishing a less flashy flow regime along with stream restoration and enhancement efforts, as appropriate.

4. Recommendations

The recommendations provided in this report are made through careful observation of the watershed and available indicators of its hydrologic functionality. While no modeling or measurements were made for this study, a great deal of relevant information was obtained through a review of historical data and analyses. The recommendations provided herein are broken into two categories. The first is a list of generalized recommendations for management approaches to the watershed based on the information compiled for this report. The second section is a list of specific capital improvements, prepared for the County's consideration for implementation to aid in accomplishing the goals and strategies laid out in this document.

a. General Recommendations

1. Three items were found that potentially affect the public health, safety and welfare. These issues should be prioritized in order to fulfill the County's responsibilities to the public.

    a. The first is the crossing of Minnieville Road over Powells Creek. Field indicators suggest that this roadway overtops frequently. These indications were validated by the Hydrologic and Hydraulic analysis provided in the 1989

Hydraulic Study and County staff. Roadway overtopping can create a significant hazard to the public, as cars can be swept away by as little as a foot of water. A secondary issue with overtopping at this location is that water plunging over the downstream roadside embankment is eroding the shoulder, which will begin to impact the stability of the road foundation. It is recommended that the culverts be evaluated and sized in accordance with roadway standards and that the vertical sag be evaluated to better manage overtopping flows and their impacts to the downstream shoulder and channel. A stream relocation and enhancement component would be expected as a part of this recommendation. (See Project Concept Plans 725-2 and 725-3)

b. The second identified potential hazard is the erosion taking place on the main stem of Powells Creek, below Deer Park Drive. Channel instability was observed to be threatening a steep slope upon which houses sit. A slope stability assessment and potential corrective action should be undertaken by qualified personnel. A secondary element of this bank instability is that Powells Creek should be restored to a more stable dimension, pattern and profile through this reach, thereby reducing stress on this embankment toe. (See Project Concept Plan 725-2)

c. A third potential public safety issue could not be evaluated, but it is recommended that further information be obtained to determine the adequacy of the culverts at the US Route 1 crossing of Powells Creek. If frequent historical flooding is shown to have occurred, the County may consider asking for an upgrade to this structure as well, however, VDOT is responsible for maintenance and improvements on Route 1.

2. Efforts should be made through capital improvements or development regulations to reduce the contribution of the headwater sub-watersheds (i.e. sub-watersheds 705 and 710) to the primary hydrographic wave in the upper watershed.

   The development in sub-watershed 705 has been very limited and the subwatershed is dominated by the County's landfill operation, which has not contributed to a decrease in the time of concentration. The existing Erosion and Sediment Control programs currently implemented at the County Landfill Facility should be continued. Stream restoration projects recommended for subwatershed 705 in this report would tend to increase the time of concentration, thereby improving the downstream contributions. However, the dominant motivation for restoring these streams would be to provide mitigation for projected impacts elsewhere in the subwatershed.

Sub-watershed 710, however, has undergone recent development. The effect of this development is to decrease the time of concentration, which increases the magnitude of the hydrographic wave below. Specific approaches to address this would include:

- Implementation of a large extended detention facility in sub-watershed 710 near the location recommended in the 1989 Hydraulic Study. Using extended detention will economize the greatest hydrographic benefit. An alternative location would be just below this location on private lands. The benefit of using this location is that there is an existing failed pond on this property that could be rehabilitated improving the property and potentially reducing the permitting impacts. The downside to this location would be that it would require coordination and work on private property.
- Retrofit existing ponds throughout subwatershed 710 to maximize dry storage volume, thereby attenuating peak discharges and offsetting the time of concentration as much as possible.
- Investigate the cumulative benefit of a widespread culvert retrofit approach to mitigate the flashy response of the watershed. This approach capitalizes on the existing roadway embankment for impounding runoff events, but can be designed in such a way as to facilitate sediment and macro-invertebrate movement and reduce downstream scour associated with culverts without causing permanent pools against the roadway embankment. Permitting coordination with VDOT and/or County DOT and environmental regulators should be performed early on before an unconventional approach such as this is implemented.

- There is an unnamed tributary in subwatershed 715 that confluences with subwatershed 710 and 705. It would make sense to modify the boundary of subwatershed 710 to incorporate this tributary, but from a hydrology standpoint, it should be considered part of subwatershed 710, as the time of concentration would be expected to have this tributary contributing simultaneously with the majority of subwatershed 710.

3. The flashy hydrologic response in the lower watershed is limited the tributaries of Powells Creek, as evidenced by field observations of scoured streams and discussed in the 1989 Hydraulic Study. Many of these tributaries run through developments that have stormwater management facilities (some of which are on-line). Emphasis in these areas should be placed on increasing the dry detention storage through extended detention and through the generous use of energy dissipation for discharges into receiving channels.

4. Post-construction erosion and sediment control standards should be strictly enforced on existing and future development projects. Of particular interest are outlet protection and energy dissipation measures, which were observed to be lacking throughout the lower watershed. Lack of appropriate outlet protection at concentrated outfalls leads to headcuts, scour and incised channels…a problem which contributes sediment to receiving waters and can not be fixed without intervention.

5. The Stream Assessment GIS and Database tool contains a great deal of information on the state of the streams, as a function of time. This product, however, is based on outdated GIS tools, which limit its functionality. The County should consider updating this database tool with a Geodatabase and continue to collect data on the state of the streams. Additional benefit could be obtained from using the core approach to broaden into the watershed, allowing the County to track watershed management projects (both upland and stream restoration).

6. There are several stream restoration projects presented in the following section of Project Concept Plans for Capital Improvement Projects. Stream restoration projects provide benefit through the natural attenuation of flooding and water

quality parameters and are often justified and perhaps financed by other conditions in the watershed. These conditions may include road projects, mitigation for impacts associated with planned expansion of the landfill and instability caused by utility and road crossings.

7. Lake Montclair is an integral part of the Powells Creek watershed functionality. Measures to control and/or reduce sediment loads originating upstream of Lake Montclair should be implemented wherever feasible.

b. Project Concept Plans

The Appendix contains more detailed summaries of the Project Concept Plans alternatives that are listed in Table 4. Based on the combination of fieldwork, GIS analysis and review of previous studies, the initial watershed management strategies were condensed to the following types of projects that should be considered for implementation within the Powells Creek Watershed.

Stream Restoration

Stream restoration projects were recommended at several locations throughout the watershed. These projects recommend a natural channel design approach to counteract an affected stream (incision was most often found) that no longer has a desirable hydrologic function between the channel and the floodplain/overbanks, which results in: excessive sediment export; loss of habitat; loss of ecological diversity and disconnection from the groundwater table. In these instances, a natural channel design was selected to reconnect flow to the floodprone areas, thereby reducing stress on the channel bed and banks.

Table 4 - Project Concept Plans Summary Table

Stream Reach ID:	Candidate Site:	Type:	Size or Length:	Location:	Drainage Area:	Problem Description:	Project Description:	Estimated Costs: Design:	Estimated Costs: Construction:
PCL003	730-1	Stream Restoration	550 LF	North of Powells Creek Boulevard	114 Acres	Unnatural channel without buffer	Enhance riparian buffer	$ 55,000	$ 275,000
PCL009	730-2	Stream Restoration	+/- 500 LF	Powells Creek, below Route 1	9,342 Acres	Unstable channel and undercutting of sewer main	Construct a riffle/cross vane sequence	$ 50,000	$ 300,000
PCL010	730-3	Stream Restoration	500 LF	Powells Creek, Upstream of Route 1	9,118 Acres	Channel instability and erosion	Shift migrating bend	$ 50,000	$ 200,000
PCL013	730-4	Stream Restoration	200 LF	Near Potomac High School	126 Acres	Two headcuts moving upstream	Realign channel and create step pool	$ 50,000	$ 200,000
PCL020	725-1	Stream Enhancement	900 LF	Powells Creek from PCL024 to I-95.	8,425 Acres	Stream bank erosion and overly wide channel transporting sediment	Enhance riparian buffer	$ 15,000	$ 72,000
PCL020	725-2	Stream Restoration	300 LF	Powells Creek below Northgate Road	7,470 Acres	Mid-channel bar that is causing erosion on banks	Divert flow away from eroding stream banks	$ 60,000	$ 150,000
PCL020	725-3	Stream Enhancement	900 LF	Powells Creek above Northgate Road	7,275 Acres	Golf course without functional buffer	Create buffer and stabilize banks	$ 18,000	$ 90,000
PCL021	725-4	Stream Restoration	900 LF	Labourn Drive, off of Beau Ridge Drive to Powells Creek	52 Acres	Severe stream bank erosion	Re-establish stable dimension, pattern and profile	$ 95,000	$ 450,000
PCL021	725-5	Pond Retrofit	1 Acre	End of Powells Crossing Court.	25 Acres	Severe stream bank erosion	Retrofit pond to reduce peak runoff	$ 25,000	$ 125,000
PCL024	725-6	Stream Restoration	800 LF	Between Lacrosse Court and Labourn Drive	55 Acres	Incised channels lacking vegetation for stability	Realign channel and raise bed elevation	$ 90,000	$ 400,000
PCL024	725-7	Pond Retrofit	0.25 to 0.50 acres	Between Lacrosse Court and Labourn Drive	53 Acres	Unstable channel suffering from scour and erosion	Retrofit wet pond to reduce peak flows	$ 25,000	$ 125,000
PCL031, PCL100, PCL101, PCL102, PCL103	715-1	Stream Enhancement	4000 LF	Powells Creek, upstream of Spriggs Road	4,331 Acres	Needs buffer protection	Plant RPA with native and resident vegetation	$ 35,000	$ 300,000
PCL106, PCL107	715-2	Culvert Replacement and Stream Enhancement	3500 LF	Powells Creek, downstream of Minnieville Road	3,582 Acres	Roadway overtopping as well as stream bank erosion	Culvert replacement and riparian buffer planting	$ 60,000	$ 900,000
PCL107, PCL108	715-3	Stream Enhancement	1500 LF	Powells Creek, upstream of Minnieville Road	3,227 Acres	Minor erosion along stream banks	Enhance riparian buffer	$ 10,000	$ 75,000
N/A	705-1	Stream Restoration	3500 LF	Powells Run, below landfill	1,111 Acres	Unstable and degrading channel	Re-establish stable dimension, pattern and profile and restore floodplain hydrologic function	$ 360,000	$ 1,400,000
N/A	720-1	LID Retrofit	86 Acres	Forest Park HS and adjacet property	+/-45 acres	Runoff is negatively affecting downstream channel	LID drainage retrofit	$ 65,000	$ 450,000
N/A	720-2	Culvert Retrofit	2 Acres	Lake Terrapin Drive	269 Acres	Sediment accumulation in Lake Terrapin	Culvert retrofit for SWM facility	$ 25,000	$ 250,000
N/A	710-1	Pond Retrofit	0.5 Acres	End of Cherry Ridge Court	35 Acres	Opportunity for pond retrofit	Retrofit pond and reconfigure outlet	$ 25,000	$ 250,000
N/A	710-2	Pond Retrofit	9 Acres	South of Lochmere Drive	615 Acres	Poorly maintained private pond	Rehabilitation and re-configuration of a large pond	$ 85,000	$ 600,000

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Two categories of natural channel design approaches were recommended, and in some cases the recommendations were interchangeable. The first category is a Priority Level 1 stream restoration, in which the channel invert is brought up to the appropriate elevation such that flow appropriately reaches the overbanks/flood prone area. The second category is a Priority Level 2 stream restoration, in which the floodplain is brought down to the appropriate elevation relative to the existing channel invert. The primary issue to consider when determining which approach to use is that a Priority Level 1 approach typically requires less earthwork (i.e. less costly), but often raises flood water to an unacceptable elevation. On the other hand, the Priority Level 2 approach can be used to reduce flood elevations and provide additional storage, but costs associated with hauling earth material can be prohibitive, unless there is a location close to the project site.

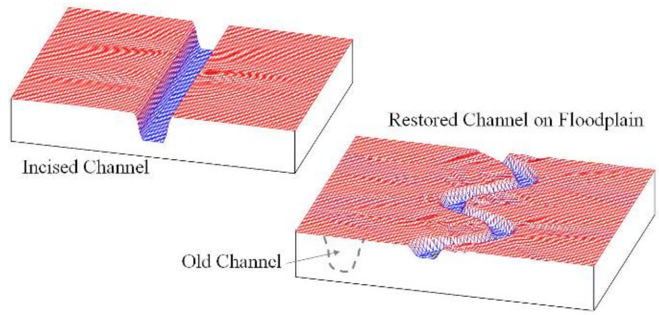

FIG 12: Before and After Representations of a Priority Level 1 Stream Restoration

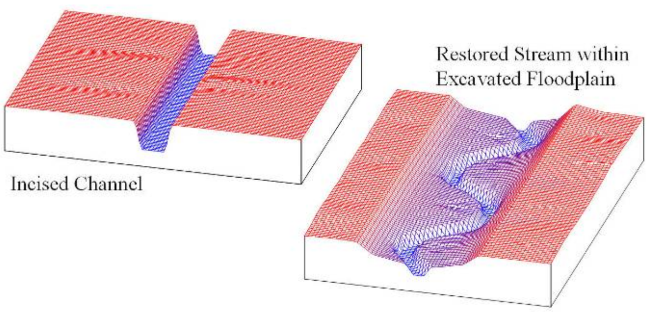

FIG 13: Before and After Representations of a Priority Level 2 Stream Restoration

A recent publication prepared for the Environmental Protection Agency (EPA) by the US Fish and Wildlife Service and Michael Baker Corporation laid out the elements that need to be present in a Natural Channel Design Project. While this list is not intended to replace experience and sound judgment, the items mentioned here do provide a good basis for which to judge the completeness of an evaluation and design project. These include:

1. **Watershed and Geomorphic Assessment**
   <u>Watershed Assessment</u>
      Was the watershed assessment methodology described?
      Was the current land use described along with future conditions?
   <u>Basemapping</u>
      Does the project include basemapping?
   <u>Geomorphic Assessment</u>
      Was the geomorphic assessment methodology described?
      Were vertical and lateral stability analyses completed?
      Was the cause and effect relationship of the instability identified?

Was the channel evolution predicted?
Were constraints identified that would inhibit restoration?

Hydraulic Assessment

Was stream velocity, shear stress, and stream power shown in relation to stage and discharge?

Bankfull Verification

Were USGS gages or regional curves used to validate bankfull discharge?
If a regional curve was used, were the curve data representative of the project reach data?
If gages or regional curves were not available, were other methods, such as hydrology and hydraulic models used?

2. **Preliminary Design**

Goals and Restoration Potential

Does the project have clear goals?
Was the restoration potential based on the assessment data provided?
Was a restoration strategy developed and explained based on the restoration potential?

Design Criteria

Were multiple methods used to prepare design criteria?

Conceptual Design

Were typical bankfull cross sections provided?
Were typical in-stream structures provided?
Was a draft planting plan provided?

3. **Final Design**

Natural Channel Design

Was a proposed channel alignment provided and developed within the design criteria?
Were proposed channel dimensions provided and developed within the design criteria?
Were specifications for materials and construction procedures provided and explained?

Sediment Transport

If required, was the type of sediment transport analysis explained?
Did sediment transport capacity analyses show that the stream bed would not aggrade or degrade over time?
Did sediment transport competency analysis show what particle sizes would be transported with a bankfull discharge?

In-Stream Structures

Based on the assessment and design, were in-stream structures required for lateral stability?
Based on the assessment and design, were in-stream structures required for vertical stability?
Were detail drawings provided for each in-stream structure?

Vegetation Design

Does the design address the use of permanent vegetation for long-term stability?

4. **Maintenance and Monitoring Plans**
Maintenance Plan
Is it clearly stated when maintenance will be required and if so, is it quantifiable?
Is it clearly stated how erosion will be addressed and by whom?
Monitoring Plan
Is it stated who is required to conduct the monitoring?
Does it have measurable performance standards?
Is monitoring required for at least three years?

5. **Overall Design Review**
Overall Design Review
Does the design address the project objectives?

Stream Enhancement

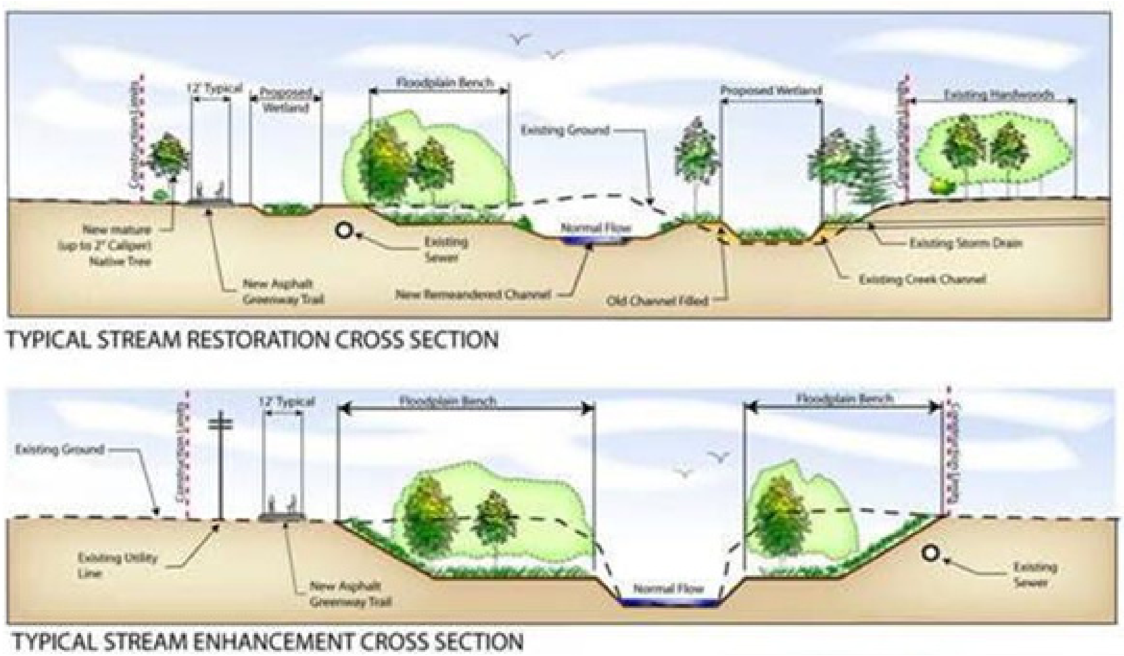

FIG 14: Stream Restoration and Enhancement Typical Cross Sections

Stream enhancement, in contrast to stream restoration, can typically be done without affecting the channel below the normal high water, which has a significant impact on the permitting requirements that might be attached to a project. As presented in the Project Concept Plans in the Appendix, stream enhancement primarily consists of measures to halt or slow down the lateral instability of streams through the use of matting and vegetation. Minimal earthwork is anticipated, but floodplains may be excavated to provide better access and/or storage for higher flows.

Pond Retrofit

Pond retrofit projects, as the name suggest, are projects where existing ponds are modified to alter and improve their net benefit to the receiving system. In most cases, ponds are built with consideration only for the area draining to them, and are designed to meet pre-determined, regional performance goals. By considering the watershed dynamics both above and below the pond and the needs of the watershed, as a whole, ponds may be retrofitted to provide a more holistic benefit within the watershed.

FIG 15: Northern Virginia Pond Retrofit Shortly after Construction

In the Powells Creek watershed, it was demonstrated that a primary concern should be that of flashy, and concentrated hydraulics, which promote shear stress on the channels that far exceed their ability to remain stable. Channel instability creates excessive sediment export, reduces the ability of riparian vegetation to remove contaminants from groundwater, increases direct export of nutrients and accelerates the flashy response of the watershed as a whole. For this reason, it is suggested that pond retrofits in this watershed be primarily focused on extending the residence time to the maxim extent practicable. This will primarily be accomplished by expanding the footprint and/or modifying the outfall structure. For regulatory reasons, water quality aspects of ponds must remain intact, at least from a functional standpoint. It may be possible to reconfigure a facility to maximize the detention provided without losing water quality functionality (e.g. installing a pre-treatment forebay).

In the context of the pond retrofits recommended in Appendix A, the following elements should be considered.

1. **Establish the Original Design Criteria or Existing Performance of the Facility**
   Are original design plans available?
   Does the facility function as designed?
   Can the facility be easily modeled (e.g. can surveyors access the outlet structure)?
   Does the existing facility lend itself to hydraulic modifications?
2. **Project Goals**
   For what recurrence interval and duration can extended detention be obtained?
   Is water quality management needed at this location?
   Is there a need for additional energy dissipation where concentrated flows outfall?

3. **Project Limits**
   Can the facility footprint be expanded to provide additional detention storage?
   Is there room to develop a treatment train approach to meet water quality requirements above the facility?
4. **Project Constraints**
   Are there any utilities that would need to be relocated?
   How does the ultimate outfall location affect options?
   How does the inflow point affect options?
   Would modification to the facility affect private properties or structures?

Roadway Culvert Replacement

The Minnieville Road crossing of Powells Creek physically showed signs of repetitive overtopping, which was consistent with the findings of the 1989 Hydraulic analysis of the structure. Roadway overtopping at this location is severely eroding the downstream shoulder of the road and will, without intervention, eventually cause a serious roadway failure to occur. Minnieville Road is a two lane road that carries heavy traffic loads during peak hours, and as such may need to be upgraded in the near future. The culverts under Minnieville Road are undersized and have significant blockages from sediment.

The culverts should be upsized to allow for the design flows to be conveyed under the roadway without overtopping during design runoff events. Additional concerns that should be addressed include the impact that this road crossing has on Powells Creek, which makes a couple of sharp bends downstream of the road crossing. Culverts should be designed with a low flow, countersunk barrel to alleviate sedimentation, which currently compromises the structure's ability to convey design flows.

Realignment of the culverts with respect to the upstream and downstream reaches should be considered with regards to how it may promote a more functional stream system. Field observations of downstream channel conditions showed relatively stable conditions and recommendations consisted only of additional vegetation to aid in the stability of the banks and floodplain.

Low Impact Development Retrofit

Low Impact Development (LID) is a site design philosophy whose goal is to eliminate the impact of the development on the hydrologic response of its subwatershed. This differs from conventional site design approaches that tend to orient their performance metrics toward one or two aspects of the hydrologic response. The means to accomplish these goals also differs in that LID promotes a distribution of smaller management "facilities" throughout the site to control the runoff at the source, whereas a conventional approach often conveys runoff rapidly away from the habitable areas and accomplishes it's goals with a larger treatment facility near the site's outfall location(s).

FIG 16: **Side by Side Comparison of Standard Concrete and Porous Concrete at Villanova University**

Due to the age of development in the Powells Creek watershed, there are numerous locations that present opportunities for LID retrofit projects, particularly within and throughout the Montclair community. However, for the purpose of this report, potential project locations were limited to areas that the County would have access to (e.g. County owned property, HOA common area, etc.). While the Montclair community does have common areas, where benefits could be realized through the use of LID approaches, the Lake removed the need to do so by exceeding the regulatory requirements for stormwater management, thereby making potential projects in this area a poor choice for limited County financial resources.

FIG 17: **Northern Virginia Retrofit Using Porous Pavers and Conversion of a Parking Island to a Bio-Infiltration Facility**

An LID retrofit opportunity was identified as a part of this study on the grounds of Forest Park High School. Forest Park High School offered an ideal project site based on: 1) It is a County owned parcel; 2) It is located along a major thoroughfare (Route 234), which gives it high visibility for public outreach purposes; 3) It spans from the top of the watershed boundary to within close proximity to Powells Creek, which means it is minimally influenced by other management practices that may flow through the site; and 4) It is a large enough parcel that there are opportunities to explore various aspects of LID and the impact of a drainage retrofit should be appreciable.

FIG 18: **GREENGRID® is a Modular Green Roof System for Retrofit Applications**

The LID retrofit should be holistic, in that the design should try to fully replicate the runoff hydrograph of the pre-developed site. To do this, the original site plans should be obtained to determine the existing conditions, if possible. A key to successful LID site designs for new development is simply to consider stormwater runoff early in the planning and design process. This allows the planner to locate the facilities on areas where they have the least impact on runoff conditions (e.g. on less pervious soils) is a key strategy, however, retrofit designs do not have the luxury of "fingerprinting" the site layout in this way. In like manner, preservation of hydrologically functional landcover (e.g. wooded and natural areas) is not an alternative for a retrofit design. The following outline is a list of strategies and design approaches that should be considered for LID retrofit projects in the Powells Creek watershed.

1. **Reduce Impervious Surfaces**
   Are there parking areas that could be considered overflow and converted to a less impervious material?
   Can necessary paved areas (e.g. driveways, parking, sidewalks, etc.) be converted to pervious surfaces?
   Are green roof retrofits a possibility?
2. **Disconnect Impervious Surfaces**
   Can walkways between buildings and parking be converted to pervious materials (e.g. pavers, concrete)?
   Can drainage from impervious surfaces be re-routed away from drainage networks into unused green spaces?
3. **Lengthen Flow Paths and Times of Concentration**
   Can existing drainage conveyance systems (e.g. curb, pipes, etc.) be removed in favor of vegetated swales?
   Can runoff be diverted to large areas of open space for increased time of concentration, vegetative uptake and infiltration?
4. **Locate Infiltration and Uptake Opportunities**
   Can existing medians and islands be converted to infiltration trenches?
   Can open areas be planted with species that efficiently transpirate water?
   Does the opportunity exist for a distributed stormwater management facility approach to be used?
5. **Manage Discharge Points to Avoid Concentrated Flows**
   Can the number of outflow points be increased to reduce discharge at each?
   Can level spreaders or other devices be used to reduce the energy associated with point source discharges?

It is important to note that public facilities, such as schools, have special needs to protect the health, safety and welfare of the population they serve. Special consideration needs to be given to sight lines, maintenance needs, hazards and other potential safety issues. These considerations may necessarily alter the design standards typically associated with LID approaches to include: limited use of tall and leafy vegetation (offering concealment to potential predators), limited use of landscape designs requiring intensive or continual maintenance and upkeep, deep or continual standing water.

FIG 19: **Henrico County has Shown Level Spreaders to be Very Effective at Eliminating Scour at Outfall Locations**

Culvert Retrofit

A culvert retrofit is a broad term to describe a number of hydraulic enhancements that can be fitted to a culvert to change the characteristics of how discharges are conveyed through the culvert. In most cases, the culvert under consideration was designed to convey drainage from one side of a road to the other. This means that, in many cases, VDOT or another transportation agency will have to approve any alteration to the infrastructure. If designed appropriately, the retrofit facility can significantly change the runoff characteristics without negatively affecting the culvert and/or roadway's functionality. Two primary concerns that transportation agencies raise regarding culvert retrofits is: 1) that the infrastructure must allow the design discharge to be conveyed without causing the roadway to overtop and 2) that water not be impounded against the structural prism of the roadway embankment for extended periods of time, which could lead to a premature failure of the roadway base.

FIG 20: **Construction of the Dale Blvd Retrofit project**

Large scale culvert retrofits have a history in Prince William County dating back to the early 1990's. A research project sponsored by the County and conducted by Virginia Tech built, modified and monitored a culvert retrofit for a 120" culvert under Dale Boulevard in the Neabsco watershed. Monitoring over and extended period of showed that this type of facility can have a positive impact on receiving waters. Perhaps more importantly, the County sponsored research highlighted some of the more important and unpredictable problems that can occur in real world applications. These included: trash and debris, beaver activity, maintenance and unanticipated off-site activities. While culvert retrofits are commonly found throughout Northern Virginia, they are often poorly conceived, lacking clear objectives and standardization in their application. Prince William County in is the fortunate position to use the data they have previously collected to determine how culvert retrofits may be designed to best serve the needs of the watershed.

There is mounting evidence to support the fact that road crossings, particularly culverts, play a more significant role in urban stream degradation, particularly incision, than other conventional metrics (Avolio, 2003), and that stream sediments are highly correlated to phosphorus, and therefore nutrient, impairments in downstream freshwater systems (Bledsoe, 2000). Culverts, therefore, are a logical place to address watershed scale urban impairments and have been shown to provide valuable reductions in priority pollutants and channel incision. The design of a culvert retrofit should evaluate the following five questions before a design approach is determined:

1. Is Dry Storage (Detention Capacity) Required?

In the Powells Creek watershed, we have already concluded that dry detention storage should be prioritized wherever possible. This has the added benefit of addressing the concerns regarding ponding water against roadway embankments in that ponded water is lower on the toe of the slope and is temporary.

FIG 21: This Dry Pond Structure was Built in Conjunction with the Roadway Culverts on a Small Drainageway

2. Is Wet Storage (including wetland creation) Beneficial?

A retrofit that is intended to maximize the wet storage volume has been shown to provide little benefit in the Powells Creek Watershed. An exception to this is if a culvert retrofit is to be used as a forebay to another facility (as is suggested for Lake Terrapin). A wet storage retrofit, similar to one iteration of the Virginia Tech research project would require a redundant embankment upstream of the roadway to ensure the safety of the roadway base material. This type of facility would be well suited in an area where there are particularly high loads of easily settled pollutants such as metals and/or suspended solids. However, with the primary goal being to reduce the incision producing flow characteristics of culvert discharges, wet storage volume is most often going to be counter-productive.

It should be noted, however, that enhancing the upstream floodplain's ability to uptake contaminants and cycle nutrients may be easily achieved by creating wetland pockets and vernal pools in the areas adjacent to the stream channel.

Since culverts, by definition, impact the channel, environmental permitting may be a significant obstacle to implementing a culvert retrofit strategy, but with each project, the value will become more apparent and the obstacles to permitting should become more manageable.

3. What are the Sediment Transport Needs of the Channel?

Sediment transport is a natural function of healthy streams. Creating obstacles to "healthy" sediment movement creates an imbalance in the stream system, resulting in a poorly functioning system. Assessing the sediment transport requirements of the stream in which the retrofit will be placed and making provisions for it to pass should be considered in the design of a retrofit. Barriers to the channel, and structural elements that are often associated with the creation of a wet storage area will block sediment and fish passage and may lead to excessive and costly maintenance needs.

FIG 22: Culvert Retrofit that Reduces Discharge Capacity, and does not accommodate sediment and animal passage.

4. Is Animal Passage a Perceived Need?

It is unlikely that animal passage will be a driving factor in the Powells Creek watershed due to the existing impacts to the system. In other locations in the County and on larger streams than those recommended by this report, fish or other animals may need to have access to move up and down the stream. This can be accomplished, where needed, by gradual slopes and persistently wet pathways.

5. How will the Facility Change the Riparian Ecological Make-up?

Backwater from any structure that provides detention (including roadway embankments) can alter the conditions that fostered existing vegetation and the associated ecosystem that they support. By raising or lowering the groundwater or exposing the system to prolonged inundation, the existing vegetation may suffer a sudden die off. This may be acceptable, as the existing vegetation may have established as a result of the lowered groundwater table that is a by-product of channel incision in urban watersheds. In these cases, it may be desirable to replace these species with a more suitable species for the anticipated conditions.

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