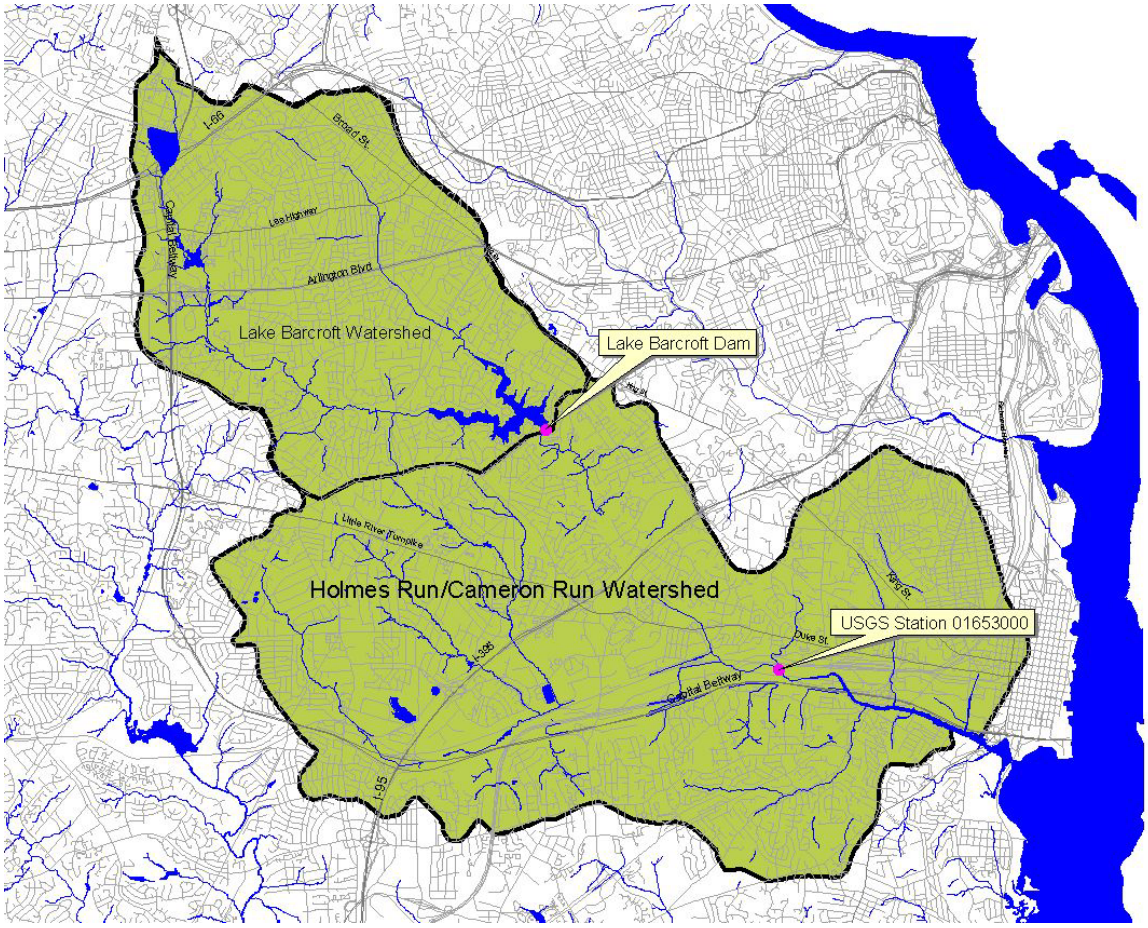
Stream Flow in the Holmes Run/Cameron Run Watershed



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Introduction

UrBIN

This report was solicited by VaTech to support the Urban Biodiversity Information Node (UrBIN) pilot biodiversity study in the Holmes Run/Cameron Run watershed. UrBIN, part of the National Biological Information Infrastructure (NBII), aims to provide communities with the information and tools needed to proactively manage urban natural resources. As citizens, elected officials, and researchers seek to address the issues and impacts associated with rapid landscape change in our nation's metropolitan areas, it is increasingly clear that the knowledge base for making wise land use decisions is lacking in many respects. UrBIN is being developed as a response to this need. The goal is for UrBIN to serve a coordinating role in the delivery of standards, tools, and techniques necessary to find and make use of biological resources information. Stakeholders in UrBIN include resource managers, scientists, educators, and the general public.

As communities establish urban natural resources programs, there is concern over the degree to which existing scientific knowledge can support sound decision making. UrBIN seeks to provide a framework that provides access to existing studies and data, but also makes clear where gaps in the knowledge base exist. UrBIN also seeks to develop and refine a coordinated process for communities to follow in assembling the information necessary to make land use and natural resources decisions. The pilot UrBIN study of the Holmes Run/Cameron Run watershed is the first step in establishing this framework and developing applicable decision support tools.

Holmes Run/Cameron Run Pilot Study

The Holmes Run/Cameron Run watershed is part of the Potomac River basin in the Washington, D.C. metropolitan area. At the point where the stream's mainstem enters the Potomac, it is called Hunting Creek. Major tributaries include Backlick Run, Indian Run, Turkeycock Run, and Tripps Run. Lake Barcroft is the major waterbody in the watershed. The watershed includes portions of Fairfax County and the cities of Alexandria and Falls Church.

Holmes Run/Cameron Run provides an interesting test case for urban biodiversity analyses because the entire watershed is highly urbanized. This pilot study will demonstrate one scenario that is common throughout the metropolitan D.C. area. Future studies to further develop the UrBIN framework will likely explore other common scenarios, such as partially built-out watersheds and those just beginning to feel development pressures. Consideration of a range of development conditions is an important part of understanding urban ecology issues and developing the means to apply that understanding. Certainly biodiversity and threats to it vary greatly across an urbanized region, particularly in relation to development density. The Holmes Run/Cameron Run pilot study focuses on one case of that variability – the highly urbanized state.

Stream Flow Characteristics in the Holmes Run/Cameron Run Watershed

One component of the Holmes Run/Cameron Run Watershed Study is landscape characterization and spatial analysis. The goal is to understand what urban biodiversity means in this watershed, achieved by examining the study area from several perspectives. One perspective that this report attempts to address relates to the run-off and stream flow characteristics in the watershed.

Run-off in urban watersheds is unique for several reasons. There is often an increase in run-off from urban watersheds compared to less developed watersheds of comparable size because there is a greater amount of impervious surface and a smaller amount of open space where stormwater can infiltrate into soil. Urban areas often utilize more channelized streams and concrete or metal storm sewer systems for flood control. These systems reduce the Manning's n values (friction factors) of the runoff surface, causing flow velocities to increase and creating possible erosion and sedimentation problems in unlined downstream channels. An increase in flow and erosion can have a significant impact on the biological habitat and biodiversity of a stream, and thus is a concern to UrBIN.

Historical flow data is available at a USGS gage station on Cameron Run and at the Lake Barcroft dam, so these subwatersheds were both analyzed. The drainage area to the Cameron Run gage is approximately 80 percent of the Holmes Run/Cameron Run watershed and the drainage area to the Lake Barcroft dam is approximately 36 percent of the entire watershed.

The Holmes Run/Cameron Run Watershed

The Holmes Run/Cameron Run watershed lies in the Middle Potomac-Anacostia-Occaquan basin (Figure 1). It is a multi-jurisdictional watershed with 31.5 square miles of its total estimated area (42 square miles) lying in the eastern portion of Fairfax County. The remaining area lies in the cities of Alexandria and Fall Church (Figure 2). The principal tributaries of Holmes Run/Cameron Run are Tripps Run, Backlick Run, Turkeycock Run, Indian Run, and Pike Branch. Lake Barcroft (135 acres), Fairview Lake (15 acres) and four regional ponds are also apart of the watershed (Figure 3).

The headwaters of Holmes Run lie near the junction of the Capital Beltway (I-495) and I-66, approximately 1.5 miles east of the City of Falls Church. Flowing south and east, Holmes Run drains a portion of the area between Tysons Corner and the cities of Vienna and Falls Church. The stream crosses beneath four major highways before flowing into Lake Barcroft. The other stream flowing into Lake Barcroft is Tripps Run. It drains the southwestern half of the City of Falls Church. The Lake Barcroft dam is positioned at the confluence of Holmes Run and Tripps Run. Approximately 4 miles southeast of the dam, Holmes Run meets Backlick Run, and the name of the main stem changes to Cameron Run.

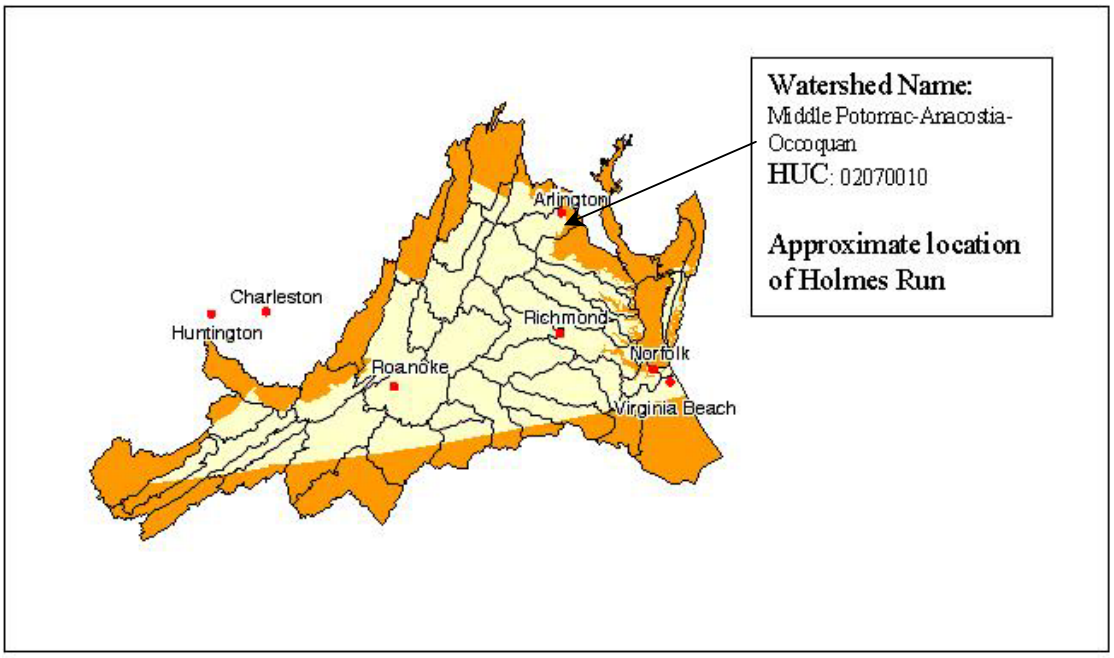

Figure 1. Location and HUC of Holmes Run/Cameron Run Watershed

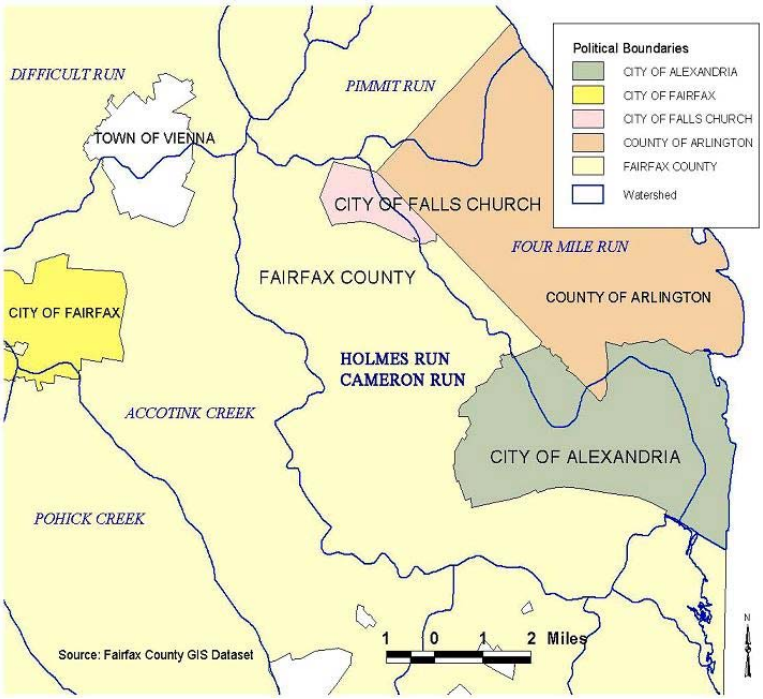

Figure 2. Political and Watershed Boundaries

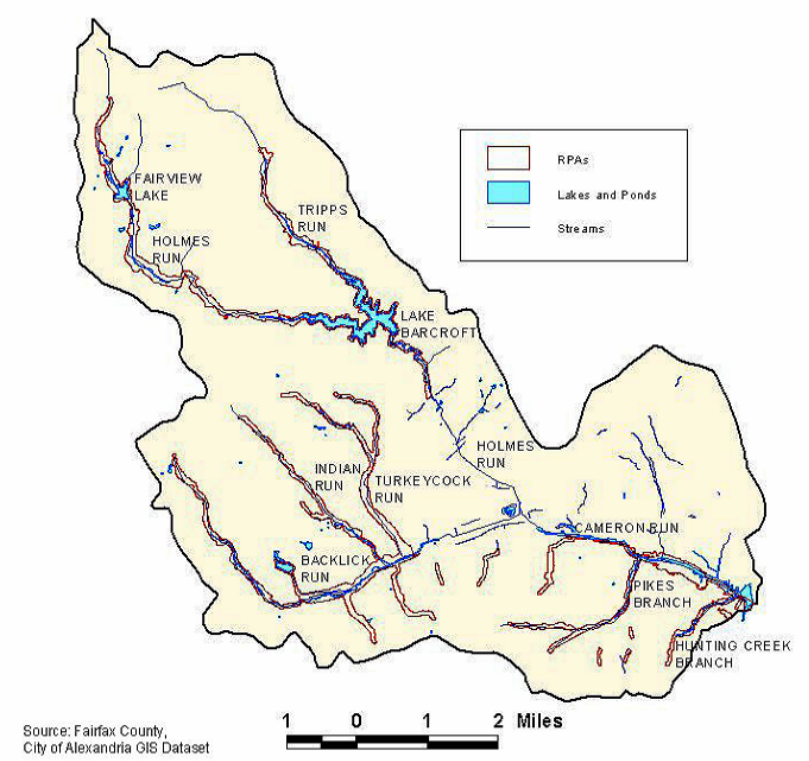

Figure 3. Streams, Lakes, Ponds, and Resource Preservation Areas* in the Holmes Run/Cameron Run Watershed (*RPAs under Virginia Cheapeake Bay Preservation Act)

The Holmes Run/Cameron Run watershed has experienced substantial growth and development since 1950, and the entire watershed is now considered highly urbanized, or ultra-urban. The population of Fairfax County has more than doubled since 1970 and the number of housing units has more than tripled (Fairfax County, 2002). With increased growth comes increased impervious surface and increased runoff. The watershed is now comprised of over 40% impervious area (Figure 4).

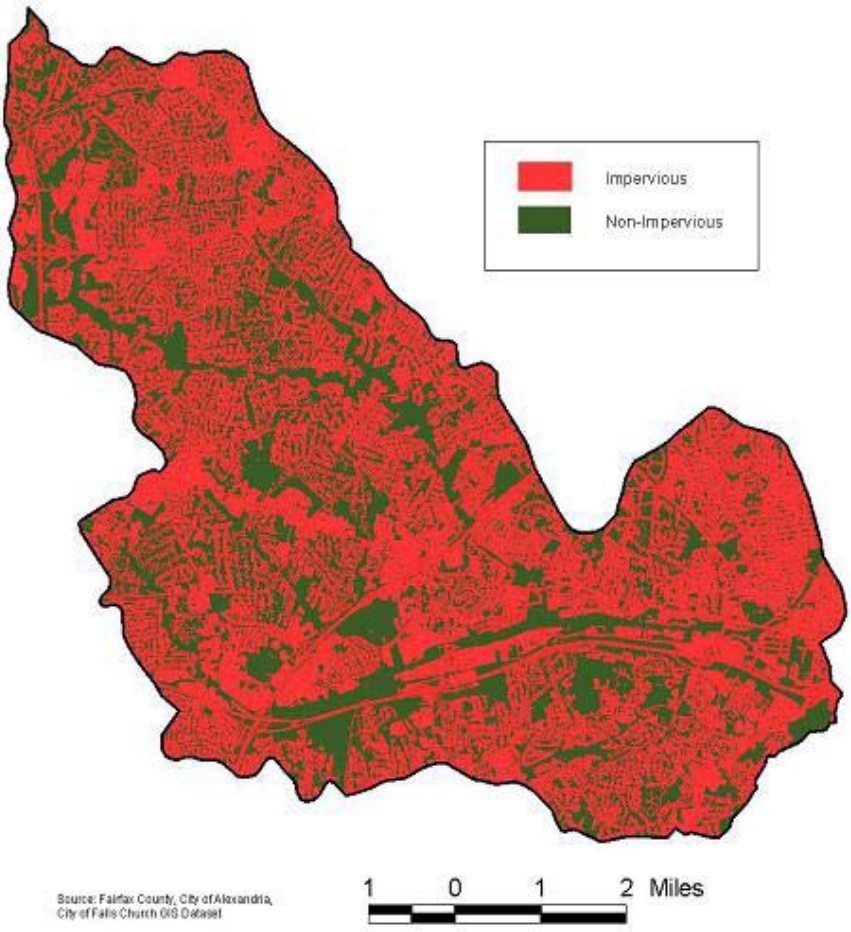

Figure 4. Impervious Area in Holmes Run/Cameron Run Watershed

Lake Barcroft

Lake Barcroft is one of the most recognized features in the Holmes Run/Cameron Run watershed. The lake's Watershed Improvement District (WID) actively manages the resource and provides a useful example of water quality protection for the rest of the watershed. The lake was created in 1915 when the need for water in Alexandria led to the construction of a reservoir to store water from the branches of Holmes Run. The North Branch of Holmes Run is now called Tripps Run. When the reservoir became too small to serve Alexandria in the late 1940s, the 135-acre lake and the surrounding 566 acres of woodlands came under private ownership (Finley, 2001).

The Lake Barcroft watershed is approximately 15 square miles, 36 percent of the total 42 square mile Holmes Run/Cameron Run watershed. It is located in the northwest portion of the watershed (Figure 5). This area is not as highly urbanized as the southern areas of the watershed, and consists of approximately 23% impervious surface (ArcView analysis with Fairfax and Falls Church GIS data).

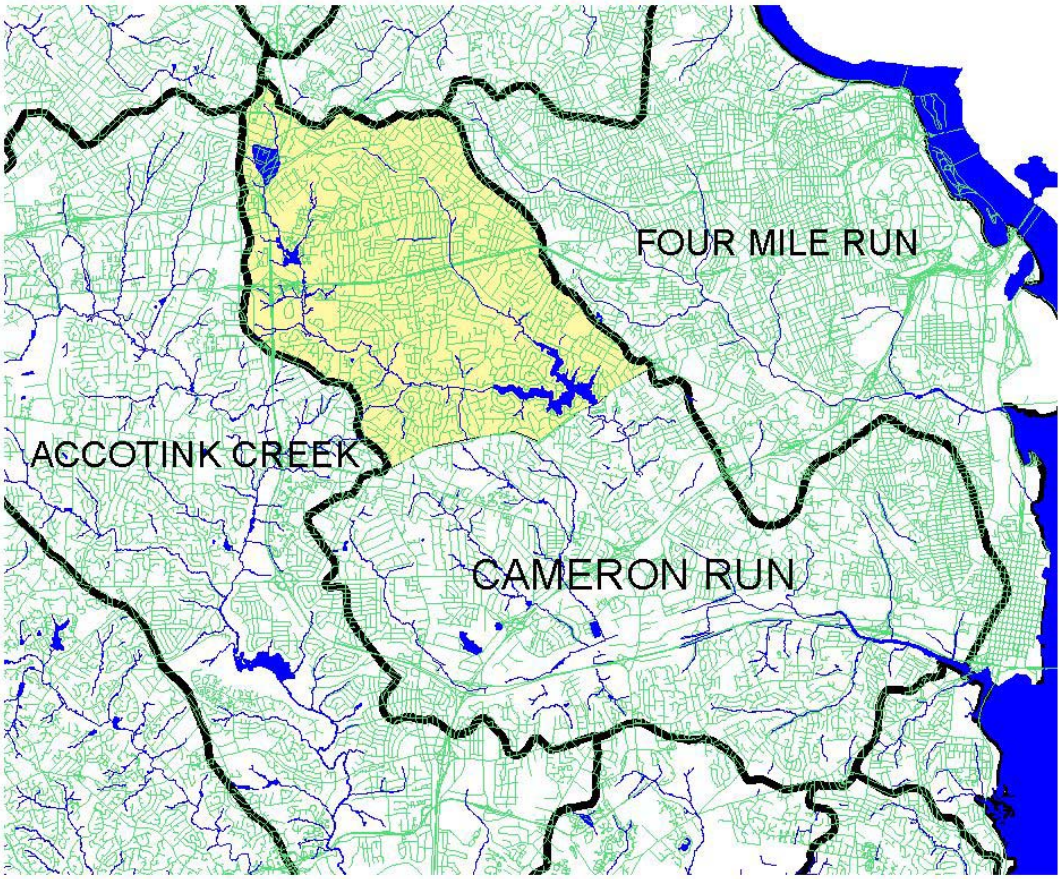

Figure 5. Lake Barcroft Watershed Within the Cameron Run Watershed

Obtaining Flow Data

Flow data within the watershed is available at both a USGS gage station and at the Lake Barcroft dam (Figure 6).

USGS Gage on Cameron Run

Historical flow data for Cameron Run has been recorded at USGS gage station 01653000, Cameron Run at Alexandria, VA. The gage is located off of Eisenhower Avenue in Alexandria (Figure 7). The drainage area to the gage is 33.7 miles, 80 percent of the total Holmes Run/Cameron Run watershed. The period of record for flow data at this gage is June 1, 1955 to current, with occasional dates missing. Daily flow for this time period was obtained from the USGS Water Resources website for Virginia: http://waterdata.usgs.gov/va/nwis/discharge.

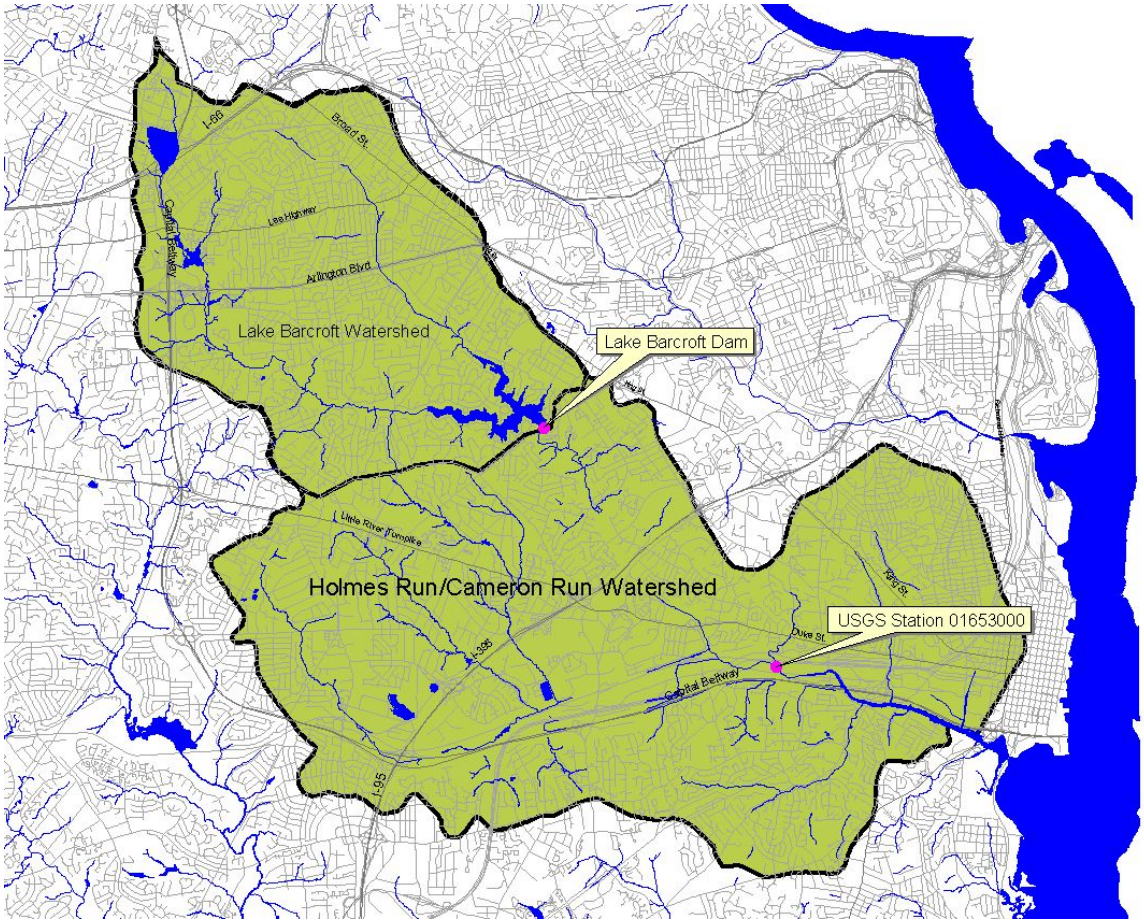

Figure 6. Stream Flow Stations Within the Holmes Run/Cameron Run watershed.

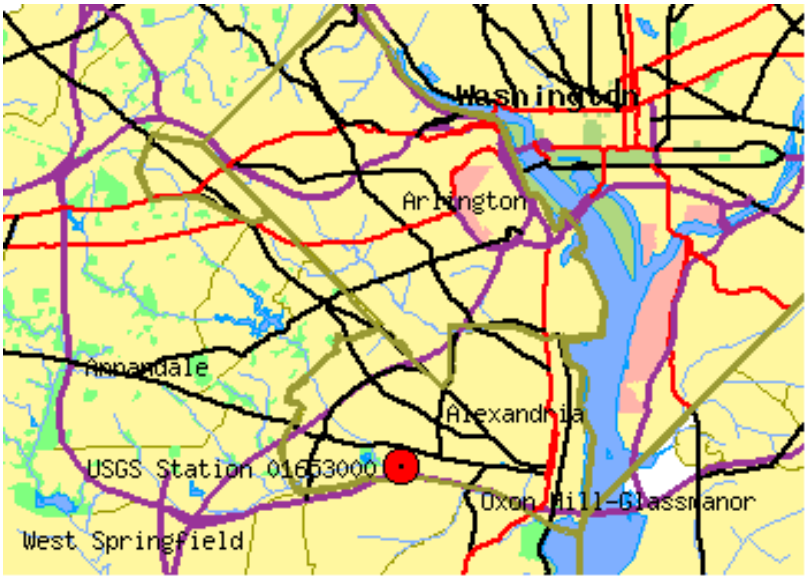

Figure 7. USGS 01653000 Cameron Run at Alexandria, VA

Dam at Lake Barcroft

The Lake Barcroft dam creates approximately 2,000 ac-ft of lake volume. The dam is controlled by a bascule gate, a hinged device used to control lake water level, counterbalanced so that when one end is lowered the other is raised (Figure 8). The gate, due to Riparian Law, is meant only to impound the existing lake water and not to accumulate more. The gate is set to maintain a level elevation of 208.5 feet. If the lake level increases, the gate will lower until the pre-determined level is reached (Foley, 2002).

Figure 8. Lake Barcroft Dam

The control system consists of a digital controller that receives signals from a lake level instrument and a gate position detector. This instrument also records the lake level and gate position at constant time increments, thus providing data to determine the dam discharge. GKY and Associates created a Fortran *DAMFLOW Program* to convert the raw data from the data collector at the dam into usable discharge data.

The period of record for the raw data recorded by the dam's data collecter is October 1, 1991 to current. Unfortunately, the Lake Barcroft maintenance staff did not have current data readily available to include in the report, so the dam discharge data was only evaluated until January 24, 2001.

Evaluation of Cameron Run Flow Data

The flow data at USGS station 01653000 was evaluated from June 1, 1955 to December 9, 2002, excluding the period from November 30, 1984 to September 30, 1986 when data was missing (Figure 9). The lowest flow on record is 1 cfs, recorded in August of 2002. The highest flow on record is 3,680 cfs recorded in June 1972.

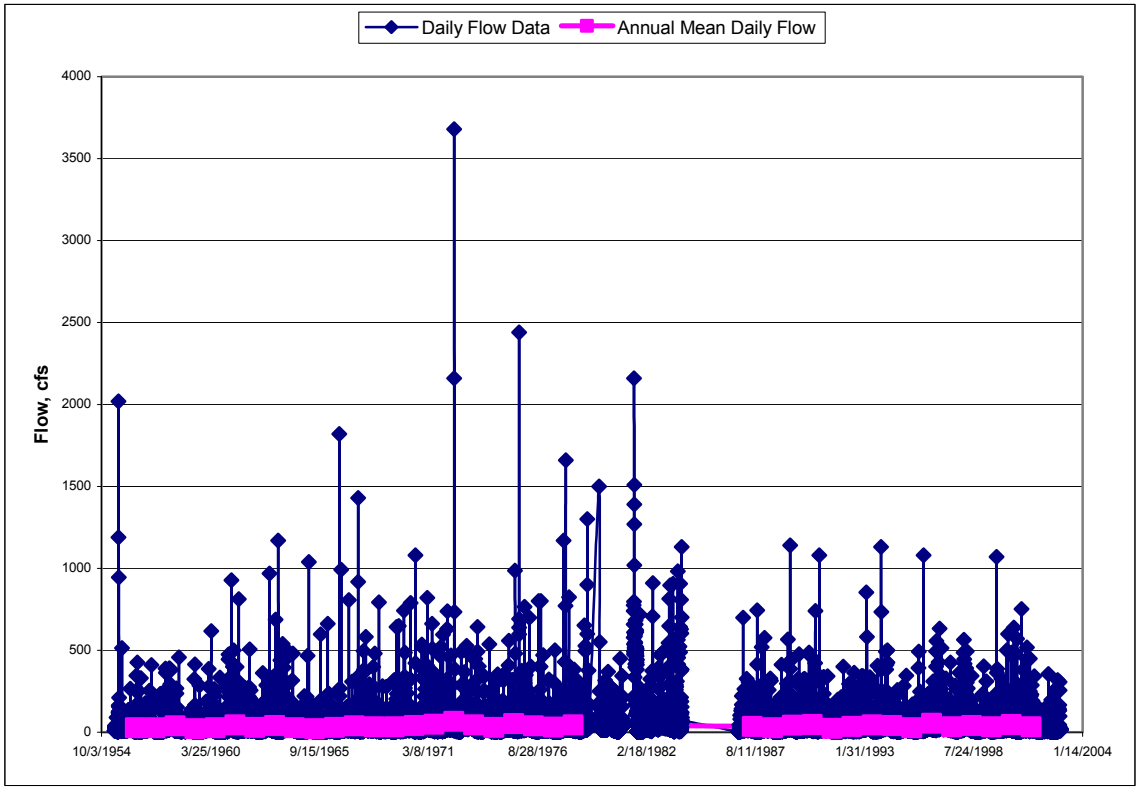

Figure 9. Cameron Run Flow Record at USGS 01653000

Flow During 2002

Flow data reported during the project year, 2002, is of particular interest. The flow reported in 2002 is one of the lowest on record. The baseflow in the stream dropped from a normal 25 cfs to approximately 6 cfs (Figure 10). The mean monthly flow was well below normal flow from January through September (Figure 11). Precipitation data from the closest National Climatic Data Center (NCDC) weather station to the watershed, Washington Reagan National Airport, was evaluated to compare trends with the flow data (NCDC, 2002). The total monthly precipitation was well below normal for six of the eleven evaluated months. The area suffered from a severe drought during 2002, noticeable in the extremely low flows reported at the Cameron Run gage. Precipitation at Washington Reagan National Airport was 32% lower than normal from January through September 2002. The mean daily flow at the gage was 58% lower than normal for that period.

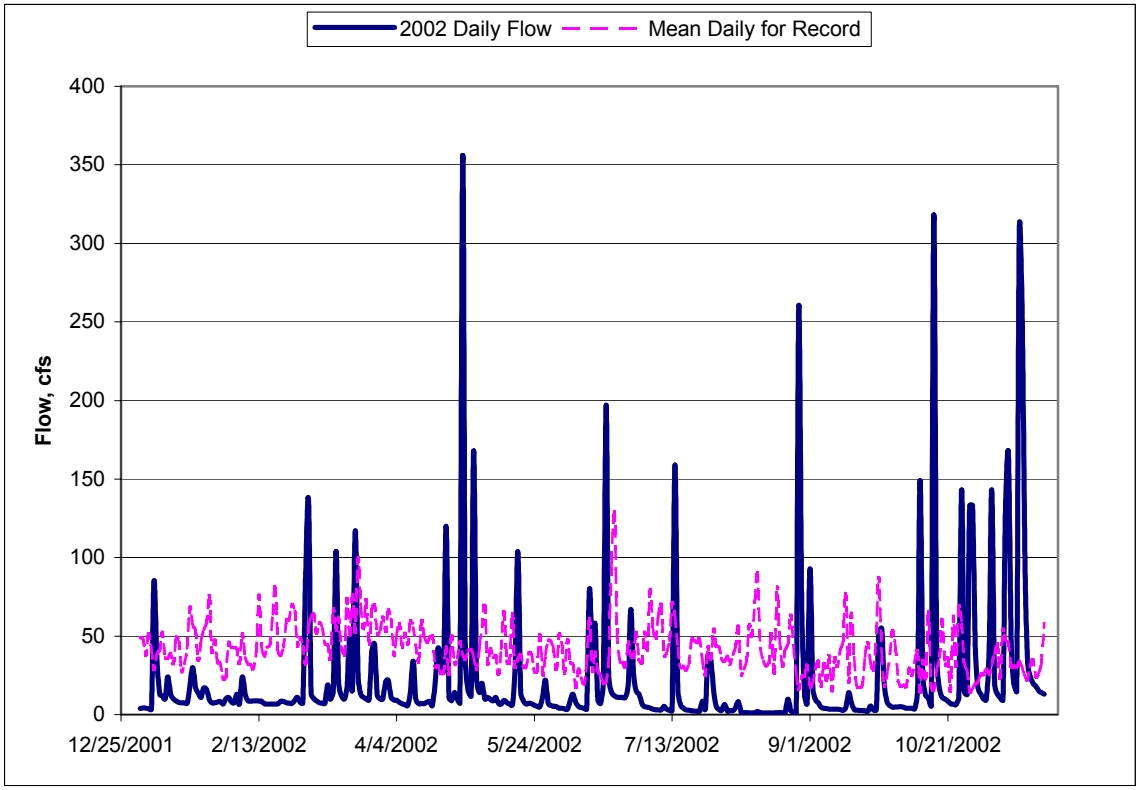

Figure 10. Daily Flow at Cameron Run Gage During 2002

Low flow conditions, as experienced in 2002, greatly impact the in-stream water quality. Point source pollution regularly entering the stream will have a more critical impact than nonpoint source pollution that requires stormwater for transport. When storms occur infrequently, there is also a greater chance of toxic shock to aquatic environments when pollutants that have accumulated for a long period on the ground surface, are suddenly washed off to the stream. Flow, and therefore water quality, conditions in Cameron Run during 2002 should be considered abnormal.

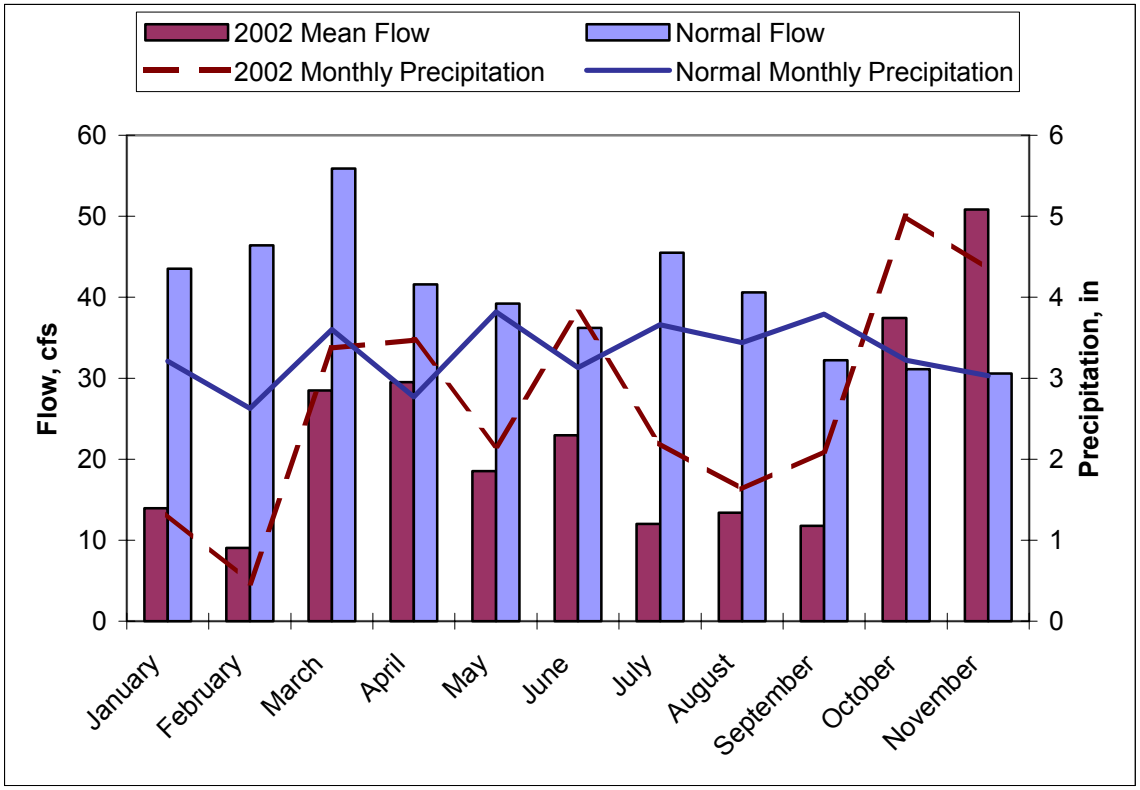

Figure 11. Cameron Run Flow During 2002 Compared to Average Flow

Development Impacts on Flow

Several factors my impact the channel flow at a particular location, including, the precipitation, watershed characteristics, channel slope, and channel area. If precipitation is held constant, other factors may still increase the flow. If the impervious area in the watershed increases due to development, the flow is expected to increase under the same rainfall conditions.

Historical trends of the Cameron Run data were evaluated to determine if flow has increased over time, independent of precipitation increases. There is obviously a strong correlation between the precipitation and the stream flow (Figure 12 and 13), but other factors such as watershed characteristics influence the flow as well. The ratio of the mean annual flow to the total annual precipitation for each year on record was calculated and a trend was reported (Figures 14 and 15). An increase in flow over time, independent of precipitation, is apparent. This increase is likely the result of increased development in the watershed over time.

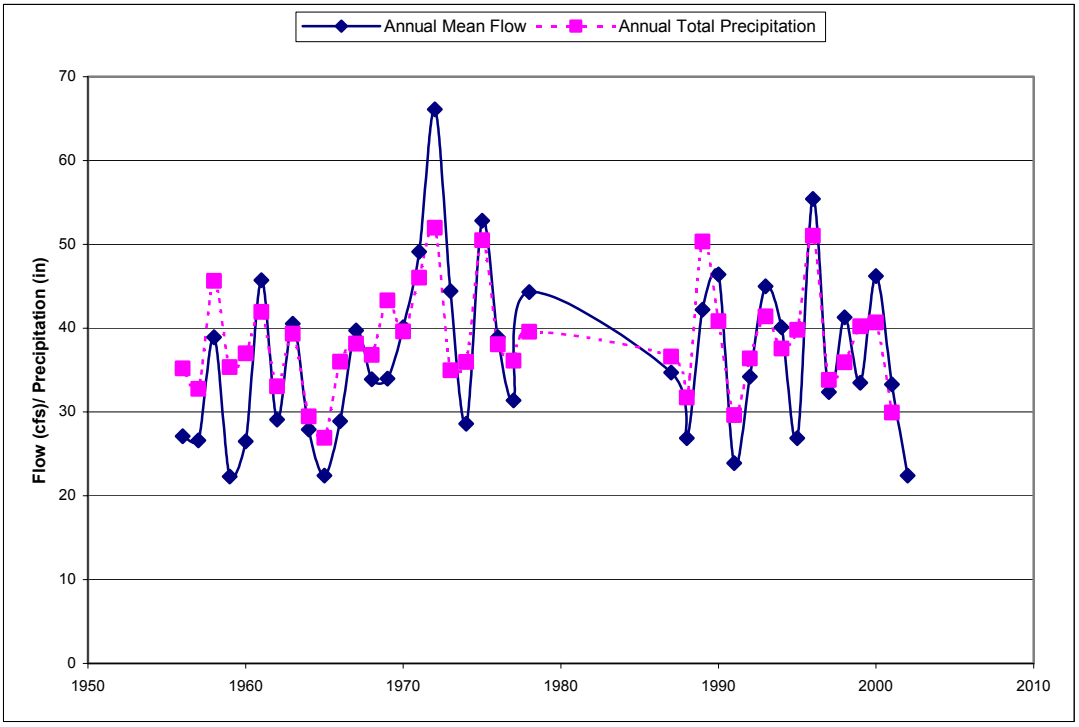

Figure 12. Relationship of Cameron Run Stream Flow to Precipitation

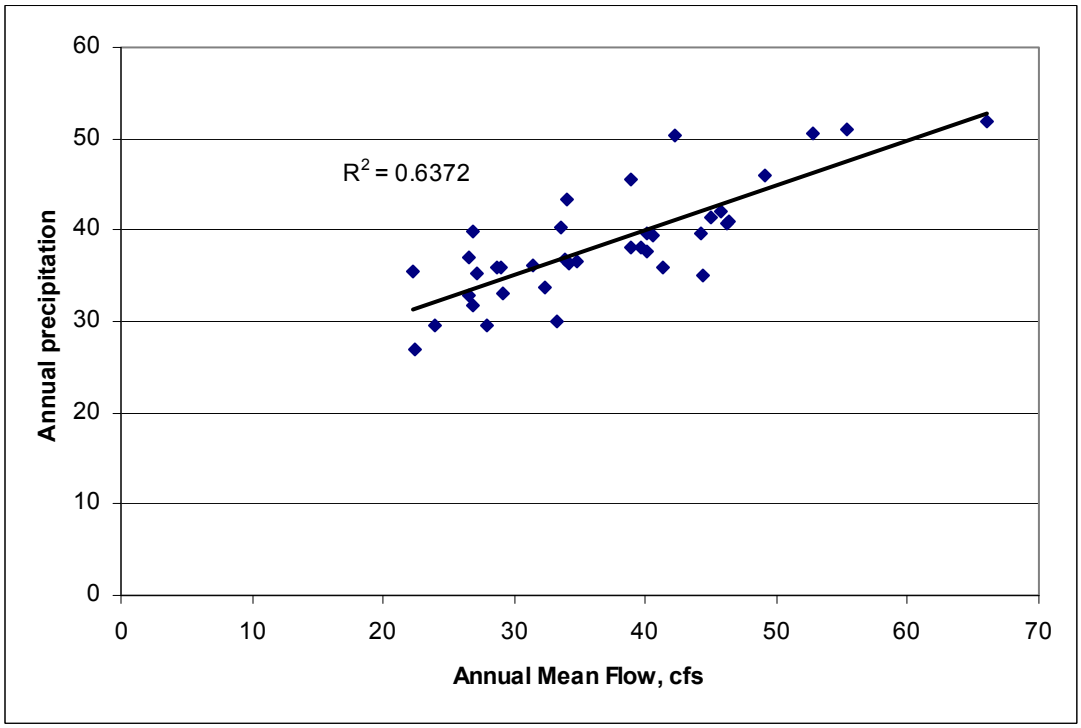

Figure 13. Correlation Between Precipitation and Flow

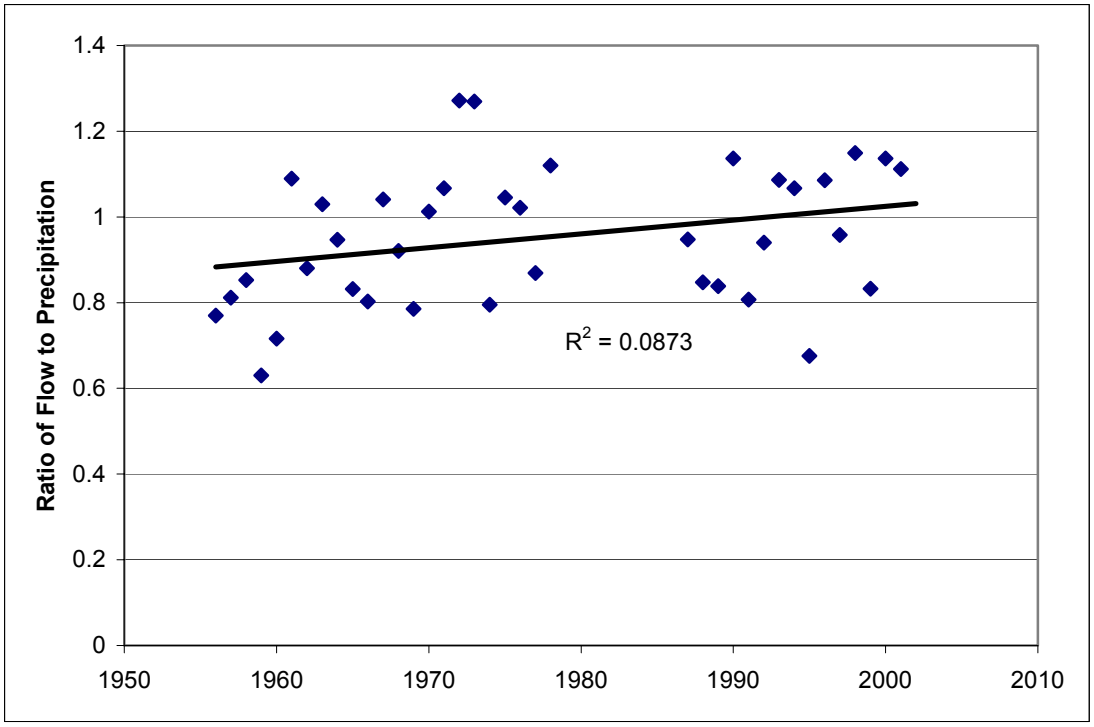

Figure 14. Historical Trend of Cameron Run Flow

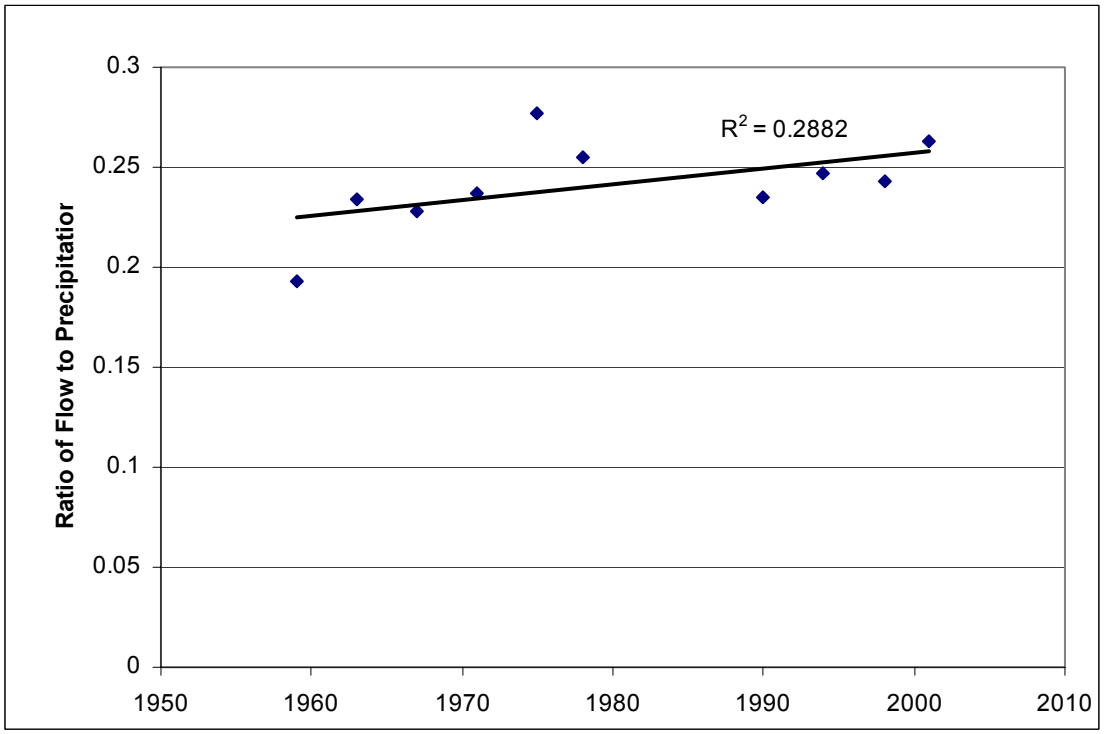

Figure 15. Historical Trend of Cameron Run Flow Based on Four-Year Average Flow

Comparison of Lake Barcroft Dam Discharge Data to Cameron Run Flow Data

The Lake Barcroft dam is designed to retain a relatively constant water surface elevation, so generally, the inflow to the lake will equal the outflow. Since there is no excess storage, the dam discharge at Lake Barcroft should approximately equal the flow to the dam drainage point. Since the Lake Barcroft watershed and the entire Holmes Run/Cameron Run watershed receive approximately the same storm events, the dam flow was expected to have a high correlation to the downstream flow recorded at the Cameron Run gage.

The correlation between available daily data is not as high as expected (Figure 16). The Lake Barcroft watershed is not as developed as the entire Cameron Run watershed as a whole, which can explain some lack of correlation. Also, while the dam gate is designed to keep the lake at a constant level, the discharge may still be more or less than the inflow to the lake. It is possible that excess or minimized discharge may occur during extreme wet or dry weather conditions. For example, if conditions have been very dry and the lake level drops below the normal level, the dam will start impounding future inflow until the lake level is once again normal. Flow at the Cameron Run gage would not properly correspond to the dam discharge at these times. While the gage location receives the discharge from the dam, the gage is also reporting flow from runoff below the Lake Barcroft watershed.

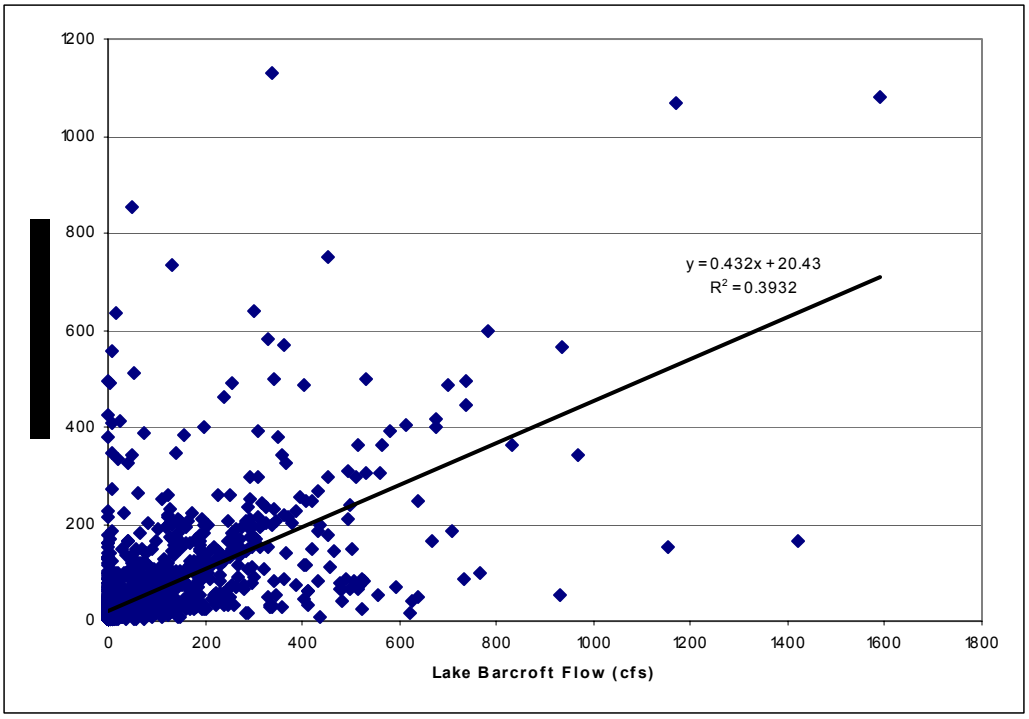

Figure 16. Correlation Between Cameron Run Flow and Lake Barcroft Flow (1991-2001)

There is a higher correlation between the flow data from 1994 to 2001 (Figure 16), rather than the entire dataset, 1991 to 2001 (Figure 17). This may be the result of minimizing the occurrences of excess storage or discharge from the dam.

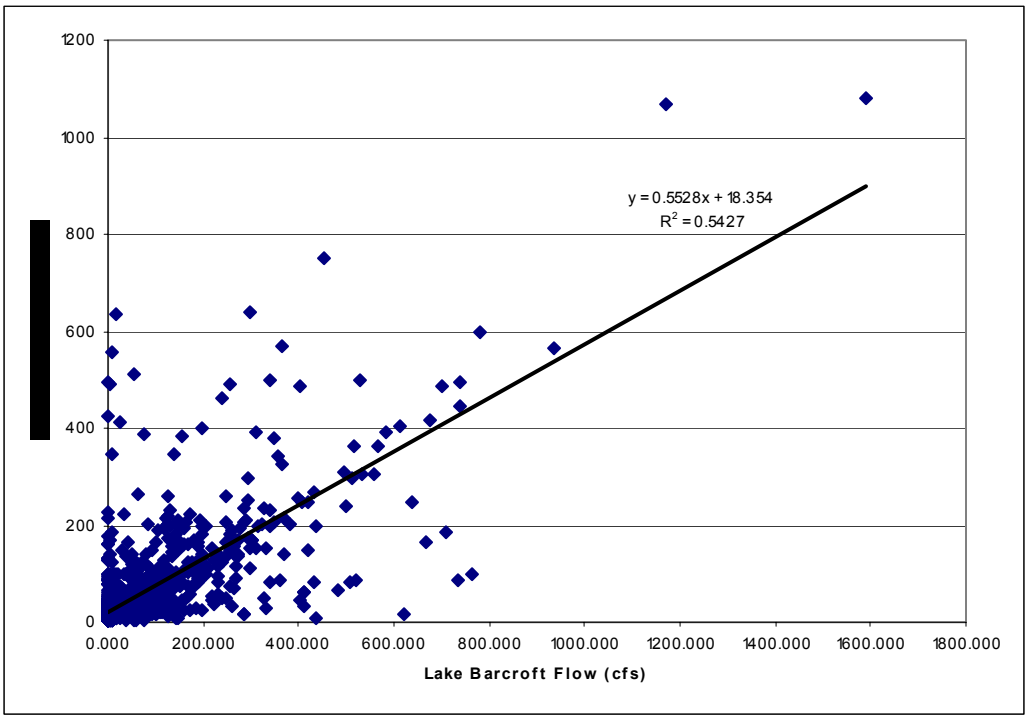

Figure 17. Correlation Between Cameron Run Flow and Lake Barcroft Flow (1994-2001)

Conclusions

Evaluating the stream flow characteristics in Cameron Run and its tributaries is of interest to the UrBIN Holmes Run/Cameron Run watershed biodiversity pilot study because a change in flow patterns can have a significant impact on aquatic health and thus the biodiversity within a watershed. The available flow data within the Holmes Run/Cameron Run watershed indicates that there has been an increase in flow since 1970, independent of precipitation. This increase in flow is likely due to major development increases within the watershed since 1970. The increases in impervious area in the urban watershed has resulted in increased runoff and increased stream flow.

The correlation between recorded flow at the Lake Barcroft Dam and the USGS gage on Cameron Run is not as high as expected, but the relationship can still be used to obtain a reasonable prediction of flow at either location.

Stream flow is one of several factors which can impact the biodiversity of the urban watershed. The Holmes Run/Cameron Run pilot study attempts to evaluate many other factors, and this study should be reviewed to gain an understanding of all possible impacts on the biodiversity within an urban watershed.

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