Chapter One: Introduction and Background

1.1 Problem Statement

Several Virginia municipalities including the counties of Chesterfield, Fairfax, James City, Henrico, Albermarle, Roanoke and the cities of Fairfax, Arlington, and Lexington have initiated watershed studies or programs in the last several years for a variety of purposes. Goals of these programs include NPDES compliance, integrating water resource planning into neighborhood planning, and improving the overall quality of municipal aquatic resources. While the programmatic goals are divergent, a commonly held desire to incorporate stream restoration project work is held amongst the decision makers developing and implementing these programs. Such tools are needed for setting stream restoration priorities.

Municipal level watershed and stream corridor management requires the use of decision support tools to effectively identify and differentiate the quality of aquatic resources. These tools must integrate and analyze multiple data layers to aid in land use planning, watershed/stormwater management, and stream corridor preservation and restoration efforts. Decision support tools allow managers to utilize available technology and integrate and analyze data to make informed, scientifically sound choices.

A literature review revealed that there is a growing body of decision support tools for watershed management. Several focus on the use of existing analytical watershed models such as the EPA's BASINS, SWMM to enable evaluation of different stormwater control strategies and assist in the development of total managed daily loads strategies (TMDL's). The goal is to allow "a decision-maker to analyze the water quality impacts, the cost-benefits, the equity issues and the reliability of the…control strategies" (Parandekar 1999). The United States Geological Survey has developed and tested a decision support tool to couple watershed and river-reach models that simulate hydrology with routing and reservoir management models to assess water availability versus water needs (Mastin and Vaccaro 2002).

The B.C. Ministry of the Environment et al. presents a decision support tool that aids in identifying watersheds and fish populations that are most suitable candidates for fish sustainability planning (2001). Several other decision support tools have been published for flood planning, computing discharge, and integrating FORTRAN based watershed models into a GIS environment (Murray 2000, Zayars-Irizarry 1998, Kyu-Cheoul 1999). An extensive literature review revealed that only one decision support tool specifically address the stream channel. It details a method to incorporate geomorphic field data into a GIS environment. The study relates measured channel cross-sectional morphology to parameters such as stream order and watershed area. (Miller et al 1996).

While existing watershed management decision-support tools may be utilized by municipalities for land planning and stormwater management, the literature review revealed that there is no existing methodology to enable decision makers to make informed choices about stream restoration projects. Several municipalities have conducted stream and watershed assessments and baseline studies to characterize the existing condition of their stream corridor resources. All have recognized that restoring impacted streams is an important element in an overall water quality improvement strategy. However, stream restoration design and construction is complicated and highly technical and stream restoration sites display a wide range of variability.

Many decision makers are asking the same question. Which streams represent priority restoration projects based on the existing level of impairment and feasibility issues. The goal of this study is to answer that question through the investigation and development of planning methods that can be integrated into a decision support tool to aid municipalities in determining what streams are the highest priority sites for stream restoration activities.

1.2 County Watershed Programs

An initial review of municipal watershed programs and studies was conducted to identify a “client” for the study. The goal was to identify a municipality to create a stream restoration prioritization decision support tool for with a well-developed program. Henrico County was chosen for several reasons. First they were one of two municipalities in Virginia that had completed a county-wide stream assessment and inventory. Second they were the only county that had an existing study that identified “high priority” stream restoration projects. Third, they were willing to provide complete access to their stream assessment and inventory data. Fourth and finally they had expressed a specific interest in ranking/prioritizing the streams identified as “high priority” in a previous study. The following sections present some background information on Henrico’s program and the previous study mentioned above.

The Henrico County Stream and Watershed Program

Henrico County is an urban municipality to the north and east of Richmond, Virginia. In November 2001 the Henrico County Department of Public Works implemented the Henrico County Stream Assessment/Watershed Management Program. The program represents a progressive watershed management approach to addressing stormwater quality concerns at the municipal level (Perry and White 2002). The county implements stormwater quality measures through the application of the stormwater management requirements included in the plan of development and subdivision plan review process.
The stormwater management requirements include on-site practices and cash contributions to the county’s Environmental Fund. The fund provides the county with a mechanism to implement water quality improvements at a watershed level

and direct resources where they are most needed for the overall integrity of the county's stream corridor network. On-site practices include forested stream buffers, stormwater ponds, and outfall dissipation structures. Watershed improvement projects involve stream corridor restoration, preservation and enhancement, and regional stormwater controls and retrofits (County of Henrico 2001).

The requirements are determined by the proposed development's impervious area percentage and the watershed management area designation. Watershed management area designations are based on habitat assessments and stream corridor inventories of problem areas conducted on 440 miles of Henrico County streams. These results were compiled in a database and the stream reaches were given a habitat, an inventory, and a total score. Each watershed in the county was placed into one of four management categories based on the assessment and inventory results. These categories are "preservation", "enhancement", "restoration" and "urban management" (County of Henrico 2001).

A watershed level management approach presents challenges compared to projects initiated at the site level. Watershed level work must address public health and safety concerns and involves multiple stakeholders. Because the county is collecting cash contributions to fund projects, county residents and developers have a vested interest in where and how the money is spent.

The field of watershed level stream corridor management is relatively young and the regulatory community in Virginia currently has no published guidance documents concerning stream assessment and mitigation. As a result, individual regulators often lack stream restoration project experience or technical expertise. The lack of consistent procedural requirements and the youth of the field can lead to lengthy delays in permitting and missed restoration opportunities. Most stream restoration projects are considered on a case-by-case basis through the use of "discretionary authority."

Henrico County has recognized that the process of choosing, implementing, and gaining public and regulatory acceptance for water quality improvement projects can be aided by the development of a consistent and scientifically sound methodology. This can help prioritize which projects get done and in what order and therefore will result in the most environmental and public benefit for the money spent. The stream prioritization decision support tool developed and presented in this study is designed to help accomplish this.

The Reynolds Study

In 2001 Reynolds conducted a study in conjunction with the Henrico County Department of Public Works to identify streams that were the best candidates for a “first round” of stream restoration work. The stated objective was the development of a tool to prioritize stream restoration projects in Henrico County using to the maximum extent possible the results of the county-wide stream assessment and inventory. In the study, streams were run through four “filters” in ArcView 3.2. The filters used were: the ratio between existing and future impervious subwatershed surface area, the habitat score of the reach, the habitat score of the upstream reach, and the inventory score. Streams that passed all four filters were considered priority restoration reaches.

The first filter applied was ratio of existing to future impervious cover. Existing impervious cover was measured using the direct measurement method. The county’s existing ArcView shape files were used to measure the area of rooftops, sidewalks, roads, and parking areas. Future impervious cover was estimated based on the county’s 2010 land use plan (Reynolds 2001). While direct measurement uses land cover, future impervious cover was predicted using average impervious areas by land use. This is called the land use method (Center for Watershed Protection 1998).

The ratio of existing to future impervious cover was calculated. Ratios closest to 1 have the highest ranking meaning that they are least susceptible to land use change and increase in impervious cover in the near future. Watersheds with ratios greater than 0.89 passed the first filter. In addition, watersheds designated as 50-10 stormwater areas also passed the filter (Henrico County Department of Public Works, 2001). 50-10 refers to areas that will be required to provide stormwater retention/detention to release the 50-year design storm at a ten-year rate (Reynolds 2001).

The key concept behind the first filter is that impervious cover provides one of the best tools for evaluating the health of watersheds and streams (Center for Watershed Protection 1998). Therefore, it is assumed that streams contained within the passing watersheds “will have a greater chance of succeeding in the long term” because they are built out or “future land uses will not significantly change impervious cover or increase stormwater runoff in the next nine years” (Reynolds 2001). It is important to note that this filter was applied at the watershed level and not to the individual stream reaches assessed in the earlier stages of the county’s program development. All stream reaches in a non-passing watershed were eliminated as potential stream restoration projects.

Thirty-seven watersheds passed through the first filter reducing the number of candidate restoration streams to 354. Seventeen of these watersheds passed on the 50-10 criteria alone and had a ratio lower than 0.89. The first filter eliminated twenty-six watersheds.

The second filter applied to the remaining streams was the habitat score from the countywide stream assessment. Reaches that scored a habitat score of “fair” or “poor” passed the filter. Streams with “good” habitat scores were eliminated as restoration candidates. At this stage 187 reaches passed the filter and 167 were eliminated (Reynolds 2001). A key assumption is that scores based on habitat assessments conducted by scientists and engineers are an indicator of the restoration potential of a stream reach.

The third filter applied to the stream reaches was the habitat score of the upstream reach. While streams are broken into reaches for assessment, classification, and restoration purposes, the stream corridor functions as a contiguous and connected linear system. Upstream erosion and sediment transport can impact a stream reach. If a reach is restored and the upstream reach is eroding, this can have negative impacts and even cause project failure in the restored reach (USDA 1998).

The third filter attempts to incorporate this factor by passing only those stream reaches that have an upstream reach with a “good” habitat score. This was based on the assumption that upstream reaches with “good” habitat scores would not negatively impact the downstream reach. One must assume from the study that habitat scores of “fair” or “poor” effectively indicate that the reach has a potential to impact the downstream reach via erosion and sediment transport.

Only three of the 187 remaining reaches had an upstream reach with a “good” habitat score. There were 63 headwater streams that have no upstream reach. All of these reaches pass the filter. A total of 66 streams passed the third filter and 121 were eliminated (Reynolds 2001).

The fourth filter applied to the remaining streams was the inventory score. The inventory conducted during the countywide stream assessment scored the streams on each incidence of erosion, in-stream obstructions, deficient forested riparian buffers, and utility line encroachment. The department of public works has stated that the presence and condition of these items has the most overall impact on the health and integrity of the county’s streams (Reynolds 2001).

A total inventory score was tallied for each reach and placed into four categories. The categories are minor, moderate, moderate-severe, and severe. Streams with inventory scores in the moderate, moderate-severe, and severe categories passed the filter while streams with “minor” scores were eliminated. 48 streams passed filter four and were therefore identified as the group of stream reaches that were the best candidates for stream restoration.