Chapter Three: Discussion and Conclusion

3.1 Introduction/Overview

The objective of this study was to develop a stream prioritization tool that evaluates stream reaches in terms of the potential water quality improvements that could be achieved through restoration versus practical constraints to project implementation. This study is inextricably linked to the countywide stream assessment and Reynolds study conducted prior to this project. The first two sections of the discussion below critically examine these efforts. Next, the criteria and prioritization tool developed and applied in this study are discussed. A theoretical framework is then presented that suggests an organizational structure for the future development of municipal watershed programs.

3.2 Countywide Stream Assessment

In the Henrico County Stream Assessment and Watershed Management Program phase I documentation, field investigators were instructed to identify reaches in the field during the countywide field assessment. Reaches were separated based on major differences in how they would score using the habitat assessment. Paper maps were used to identify where the reaches were located geographically along the stream network. No geospatial references or measured values were used to identify the exact location and spatial extents of the stream reaches.

During the field investigation of the nine reaches assessed in this study, the reported stream reach lengths in the Phase II: GIS and Database Tools documentation (CH2MHill 2001) did not reasonably correlate with the measured stream distances using a hip chain device. Some of this can be attributed to differences in map lengths versus actual in-stream thalweg length due to infield stream sinuosity. However, in several cases the actual stream length was double or half of what was reported in the GIS as the stream length. Only in one case did the reported and measured stream reach length show a greater than 90% correlation.

Lack of actual field measurement and geographic location of the stream reaches during the countywide stream assessment severely compromises the integrity and value of the reach identification. Hand held GPS units and hip chains can be used in stream assessment to give spatial locations and extents for reaches assessed in the field. The countywide stream assessment could have been greatly improved by actually locating and measuring the reaches. This was recently accomplished using a hip chain in the Upper Pocoshock Creek Watershed in Chesterfield County, Virginia (KCI 2003). Mapped stream lengths and hip chain measured thalweg lengths expressed a greater than 90% correlation in most instances.

Reaches were differentiated based on observations of a significant change in the habitat parameters. However, the reaches are being evaluated in this study for their potential as restoration projects. As previously stated, the geomorphic processes form the foundation for restoration design. Under this paradigm the goal is designing a system that is in a state of dynamic equilibrium and balances its sediment load and flow regime. Road crossings effect stream hydrology and hydraulics and are typically in a backwater condition and trap sediment upstream of the crossing. A stream reach located on either side of a road crossing actually represents two design projects instead of a single effort due to the differences in in-stream hydraulics, hydrology, and sediment transport. In many instances stream reaches were delineated in the stream assessment that extend above or below a road crossing (Figure 7). The value of the reach identification as it related directly to stream restoration design would have been greatly improved if reaches did not extend up or downstream of road crossings.

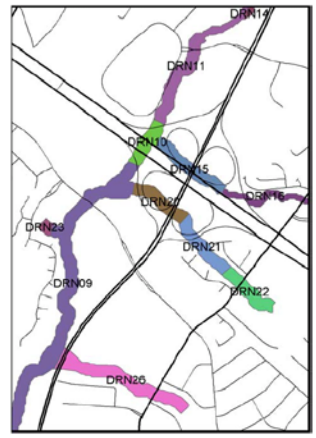

Figure 7: Reaches shown extending beyond road crossings

A larger question is concerns the use of habitat scores to differentiate stream conditions to provide useful information for selecting and prioritizing stream restoration sites. If one accepts that the goal is the design of a stable channel, this author believes that they do not provide significant value to restoration efforts. This is because habitat scoring methods, which are largely based on the EPA's Rapid Bioassessment Protocol II (Barbour et al 1999), focus on biological and not geomorphic assessment. This is a matter of some debate amongst the stream restoration community. An interagency team in the Eastern Kentucky Coalfield Region has developed a stream assessment protocol and stream mitigation calculator tool based largely on habitat methods because this "was the assessment procedure singled out by the interagency team as having the greatest utility for the program's needs" (USACE Louisville District et al 2002). In this study, habitat scores successfully distinguished reference sites from test sites (USACE Louisville District et al 2002).

A study in progress conducted by Virginia Commonwealth University is assessing a number of Coastal Plain streams in Virginia to examine how well habitat scores and measured geomorphic parameters correlate to collected benthic macroinvertebrate and fish community data. This study hopes to determine what assessment parameters best correlate to the health and integrity of in-stream biological communities (Walls 2003). The results of the study are pending but may provide useful insight in this matter.

Hnerico County chose to use a habitat assessment because it represented a cost effective method that field personnel with limited stream assessment training and experience could complete, and it identified that most of the county streams were in fair to poor condition. This provided the county with a justification to develop the Environmental Program (White 2001). While this provided immediate value to the development of the program it may provide little value in actually making restoration decisions.

The reach identification conducted in the countywide stream assessment could have increased value in terms of actual restoration projects if it was based on a rapid geomorphic assessment tailored to the range of conditions present in Henrico County's streams. This would provide information about the current and predicted future state of the stream in terms of stability and would result in reaches that could be viewed as restorable units. If a geomorphic assessment is viewed as too time and cost intensive, at a minimum, headcuts should be inventoried. Including headcuts as an inventory category in the stream assessment would provide useful information on vertical instability with almost no additional time and expense. More current County based stream assessment have included headcuts as an inventory item (Gould 2001).

The component of the countywide stream assessment that does have the most potential value to actual stream restoration is the inventory data collected. Data was collected on pipes and ditches, buffers, bank erosion, utility infrastructure, and road crossings. All of these represent sources or expressions of impairment at the reach level and could be addressed in restoration design. Again, this data is somewhat limited by the lack of measured extents and exact geospatial location, information on type and condition was collected and can be utilized in design.

In summary, while the countywide stream assessment was successful using habitat based methods to fulfill the immediate goal of documenting the overall level of stream impairment in Henrico County, the use of these scores did not produce reaches that are logical “restorable units”. Further studies are needed to determine what assessment protocols are most useful for indicating overall aquatic integrity and useful in making design decision. Lack of recognition of the hydraulic separation effect of road crossings also led to reach segmentation that does not support design. Stream reaches at any level of investigation must be field measured and geographically located if this information is to have true value in planning and design decisions.

3.3 Reynolds Study

Sub-objective 3 of The Copperas Creek Restoration Plan: Prioritizing and Implementing Stream Restoration Projects in Henrico County, VA, states that the study will develop a method to score each stream restoration project and rank them by score (Reynolds 2001). The Reynolds study did not meet this goal. Instead it successfully “selected” a group of high priority stream reaches as potential restoration projects using a GIS filter based approach, but did not rank and score them. This is an important distinction because sub-objective 3 of the Reynolds study was actually accomplished in the current study.

However, this does not undermine the value of the Reynolds study. A total of 440 miles of stream were assessed. Prioritizing all of these streams would be a major undertaking. When a large stream reach data set exists, an intermediate selection step makes logical sense. This eliminates streams that do not need to be restored at all and allows more refined analysis to be reserved for those streams that would benefit the most from restoration. An examination of the four filters is presented below.

The first filter was the ratio of existing to future impervious cover. Eliminating stream reaches in areas prone to future watershed changes through development is a strong point of the study and is supported in the literature and in practice. However, this filter could have been significantly improved.
The Reynolds study eliminates stream reaches at a subwatershed level. Impervious surface is not distributed evenly throughout a stream’s watershed and some reaches may be more or less impaired than the overall watershed percentage of impervious cover might indicate. This is recognized as one of the limitations of the Center for Watershed Protection’s Impervious Cover Model (1998). In addition, development does not occur evenly across a subwatershed. The future impervious percentage is also based on average conditions.

It is probable that some stream reaches were eliminated that have high restoration potential due to the uneven distribution of existing and future impervious cover. Delineating catchment-level watersheds for each stream reach could refine the study. The catchment scale is also the level at which site development occurs and is the most significantly influenced by impervious cover. This means that any given stream reach would be evaluated in terms of its current and future impervious surface and not that of the overall subwatershed. This would reduce the scale effect limitation imposed by using subwatersheds (CWP 1998)

In addition, adding insight from the Impervious Cover Model (ICM) could refine the filter. The model predicts that streams in watersheds that have less than 11% impervious cover are sensitive but not impaired. Six of the watershed assessed had less than 11% future impervious cover values. Four of these passed the filter. The ICM would predict that streams in these watersheds should not be impaired in their present and future state. Eliminating watersheds with less than 11% future impervious cover would improve the use of this filter.

The habitat score was used to eliminate streams as restoration candidates in Filter Two. The Reynolds study faces the same issues with the habitat score as the countywide assessment. It is possible that reaches that were good restoration candidates based on geomorphology and channel stability but scored well in the habitat assessment were eliminated. In addition, it is possible that stable channels scored poorly in terms of habitat and were passed but are poor potential candidates.

Figure 8 is a photograph of an approximately 4500 linear foot stream reach in Chesterfield County that was historically straightened. While this channelization effort is responsible, at least in part, for severe plan form and vertical stability upstream it is highly stable in its current configuration and is a poor candidate for restoration. However, because it is essentially one long riffle embedded with sands, it has poor habitat features. It would have passed based on habitat score.

Figure 8: Straightened reach in Chesterfield County

Filter Three in the Reynolds study uses the habitat score of the upstream reach. Again the same issued with habitat scores are repeated. However, the filter indirectly selected 1st order headwater streams. Headwater streams are extremely vulnerable to development and impervious cover and dominate the landscape through their shear number and cumulative length. They are also the same scale as development (CWP 1998). Restoring the headwaters as a first round of stream restoration projects make intuitive sense and represents a sound planning decision. This filter could be refined by simply passing1st order headwater streams and eliminating the other reaches. It does not need to be based on the habitat score to achieve this objective

3.4 Stream Restoration Decision Support Tool

The prioritization tool was based on the assessment of criteria. The restoration opportunities criteria are based on the potential restoration state and channel stability and bank erosion were largely included to make up for the lack of geomorphic and stability data in work preceding this study. The feasibility criteria are based on the limitation the urban environment places on stream restoration implementation.

The Channel Stability criterion did not significantly differentiate the stream reaches assessed with six of the nine reaches scoring between two and three. This can be attributed to two factors. First, many of the streams appeared to have historically downcut and widened and were approaching equilibrium. It may be the case that many of the streams were actually in a similar state. However, the scoring tool created may need refinement to better distinguish streams.

Geomorphic and stability assessment are relatively young and have not been rigorously tested over a broad range of conditions. Further research focusing on the correlation of assessment parameters to actual in-stream aquatic integrity is needed to provide validation to this type of assessment.

The Stream Bank Erosion Rate criterion did appear to distinguish between streams. Four reaches had rates between 0.26 and 0.32 and 4 reaches had rates between 0.71 and 0.90. Bank erosion potential seems to be a good indicator in this study of potential restoration improvement value. The use of the BEHI method in this study could be greatly improved by the development of actual measured stream bank erosion data and the creation of a Henrico curve to use in place of the Colorado curve presented in the Rosgen paper (1999). Using the Colorado curve means that the calculated reach rates may not accurately represent actual erosion rates but are more useful for comparative purposes. In addition, developing average shear stress values based on measured data from Henrico streams could also improve the integrity of the rate value calculated.

The Stormwater Discharge and Riparian Forested Buffer Criteria do seem to differentiate the streams with a range of values shown in each category. The major limitation of these criteria is that no additional level of analysis was added and the assessment simply tallied up the existing inventory data. Existing methodologies exist for designing riparian forested buffers for non point source pollution removal efficiency (Fischer and Martin 1999, Herson-Jones et al 1995). Because the County has advocated a fixed buffer width into its program, the efficiency of riparian buffer projects within that fixed width could be compared to prioritize the most efficient projects. Chemical sampling of stormwater discharges could be used to prioritize which outfalls seemed to have the most water quality impacts.

The Ownership criteria showed a wide range of values from one to 56. It does seem to significantly differentiate the stream reaches based on contraints. However, it is important to note that this criterion is based on assumptions of project acceptability by ownership type. Human behavior is unpredictable and does not always fall into distinct categories. The number of owners may be more significant than type. Access and Permitting did not differentiate the streams primarily because of the limited range of possible values. Streams either had between zero and two improved access points. Permitting only had two scoring categories and without published regulatory guidance, decisions on stream restoration projects will be made case-by-case using discretionary authority from a technically limited regulatory community. The differentiation expressed in the overall feasibility constraints score presented in the prioritization tool results can be most attributed to ownership. Refining the other two criteria could greatly improve the ability of the feasibility constraints to meaningfully distinguish between stream reaches.

The overall results of the prioritization tool show the streams falling into two general groupings based on the total score. Three reaches have total scores between 14 and 17 and six reaches have scores between 20 and 23. The lower scoring set represents higher priority projects than the higher scoring set. The improvement to constraint ratios did not further distinguish between the lower set with all having values around two. However, in the six higher scoring streams, the ratio did differentiate the streams with values ranging from 1.51 to 0.72. The individual and overall scores and ratios all provide useful pieces of information about the stream reaches as potential restoration projects and will provide the County with a decision support tool for implementing project work. Although this method was only applied to one subwatershed, it was developed to accommodate more data efficiently. At the County's discretion more stream reaches could be assessed and added to the tool. This would greatly improve the ability to interpret the results, as the current data set is limited in size.

3.5 Municipal Stream Restoration Planning Framework

In conclusion, the study did seem to achieve the overall goal with some room for refinement and improvement. In addition, work preceding this study could be significantly refined and improved. An important point is that Henrico County was one of the pioneers in the development and establishment of a municipal watershed program. To date, their program is the most detailed and comprehensive program in the Commonwealth of Virginia. As leaders, County staff did not have a significant body of work to draw from and inevitably did not conduct the study in a way that maximized the efficiency of the end goal of implementing water quality in all stages of the process. It is the hope of this author that this study and the two Henrico studies that came before it will provide a much needed example of how a municipal watershed management program can be developed.

To this end a framework is presented in Figure 9. It is the hope of this author that the framework will aid municipalities that are interested in starting a watershed program. The framework presents watershed program development as having two major stages. The stages are planning and implementation. Planning is comprised of three chronological stages: assessment, selection, and prioritization. These three stages are the subject of this study and are represented by the countywide stream assessment, the Reynolds study, and the development and application of the prioritization tool. The second stage consists of design,

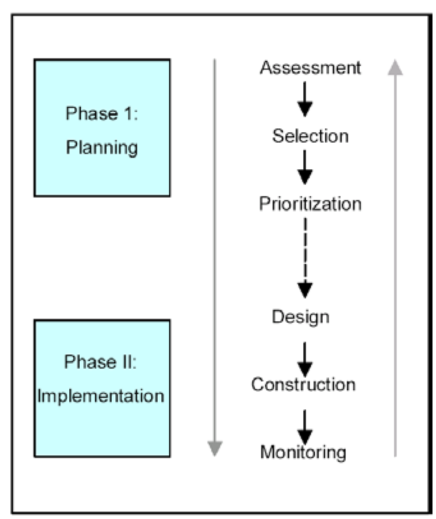

Figure 9: Framework for municipal watershed programs

construction, and monitoring and is not the subject of this paper.

Successful use of the framework requires a thorough understanding of how each component informs the next. The hope is that this lead to more integrated decision-making early in the process that may avoid, minimize, or eliminate some of the issues and problems identified in this study. If stream restoration projects are the end goal in the implementation stage, the planning stage must use geomorphology and channel stability as the dominant assessment, selection, and prioritization tool.

This is because these principles guide stream restoration design and translate into reasonable and attainable selection, prioritization and project success criteria. The character and quality of the biological stream community cannot be addressed through stream restoration design in and of itself because watershed conditions play such a determining role in chemical water quality requirements for macroinvertabrates. Every downstream road crossing would have to be modified to ensure that fish could access a particular stream restoration site.

Another key issue for municipalities developing watershed programs is whether to conduct a countywide assessment or to target a pilot watershed. There are advantages and disadvantages to both. A countywide assessment allows for the entire stream corridor network to be assessed and considered through the selection and prioritization process. The result is that the highest priority streams in the entire county are identified for the first projects. This ensures that the areas of greatest need are met in a chronological manner.

However, this takes time. The Henrico County Department of Public Works initiated their program in 2000 and just recently awarded contract for the first two stream restoration jobs. In addition, they have learned some valuable lessons about how they could refine their assessment to better support decisions about individual projects. If they had started with a pilot watershed they could have incorporated these lessons into the assessment of the next pilot watershed.

Recent discussions with other stream restoration practitioners and municipal staff have reiterated how constraining property ownership can be. One landowner can effectively kill the possibility of ever restoring even the highest priority stream. Some members of the stream restoration community feel that this is a serious issue for a watershed based prioritization approach to identifying a first round of potential stream restoration projects. As an alternative, municipalities could limit their initial assessment, selection, and prioritization to streams on county owned or controlled land. This eliminates the identification of potential projects that die on the vine when landowners are approached.

The reality is that only a few stream restoration projects are actually in the ground in the Commonwealth of Virginia. Municipal watershed programs are largely the realm of trial and error. The stream restoration community must develop a larger body of work and cultivate networks and forums to openly discuss approaches, successes, and failures before we can more fully evaluate different approaches. It is the hope of this author that the study presented in these pages contribute to that discussion.