

# **Chapter 5**

## **Summary, Conclusions, and Recommendations**

### **5.1 Summary**

This thesis has focused on the hydrologic and resulting ecologic impacts that residential development of the Back Creek watershed, located just outside the City of Roanoke, Virginia, would have on its receiving channel, Back Creek. Extensive literature review revealed that many studies exist focusing on direct linkages between land cover and stream health, linkages of land cover with channel hydrology, and linkages of hydrology with stream health. However, evaluation of studies directly linking land cover and stream health revealed that hydrologic processes relating land cover changes and the resultant changes in stream health are ignored. Many of these studies assume that similar watersheds would have the same hydrologic reaction to land cover changes, thereby allowing researchers to transfer relationships and data between watersheds. Previous studies linking land cover change with hydrology have postulated an increase in runoff and decrease in groundwater recharge resulting in an increase in flow variability in the receiving channel. Finally, studies attempting to link hydrology with stream health have found that increased flow variability and disturbances can be detrimental to many stream species as the natural flow regime of the channel is replaced. The need for research linking watershed development to stream health using hydrologic processes was then identified.

### **Hydrologic Impacts**

The hydrologic effects of residential development scenarios for Back Creek were first evaluated using eight residential development scenarios using low density, medium density cluster, medium density conventional and high density development patterns. These scenarios represented a large range of development as the baseline scenario contained only 1% impervious area as the most developed scenario contained 34% impervious area. The HSPF program was used to simulate streamflows from 43 years of

hourly rainfall data. The scenarios were preprocessed using the macro driven Scenario Generator (Lohani et al., 2002) and evaluated using the HSPF hydrologic program. Output from HSPF for channel flows was then analyzed with the Visual Basic Post Processor program. Summarized output from the Post Processor program revealed a substantial increase in extreme events and a shift in the channel flow regime. Flood frequency curve analysis revealed an upward/leftward shift in curves with increased development indicating an increase in the frequency of large storm occurrence. Analysis of the modeled 43 year record showed an increase in the number of storms in each return period class, indicating a greater discharge response with increased development from the watershed to the same storm events. Probability density analysis of the output showed that the most frequently observed channel flowrate would decrease with increased development while the overall variability and frequency of extreme events increased. Finally, low flow analysis revealed a decrease in channel flowrate for increased development for 15 day or less flow values.

### **Stream Health Impacts**

The analysis of impacts on stream health was carried out in two parts: first, flow variability analysis using ecologically significant statistical variables; and second, habitat suitability analysis for fish species representing habitat guilds. Flow variability analysis focused on using the three pertinent statistical variability categories: low flow, high flow, and overall variability. These categories each contained two or three relevant variables for which relative ranges were developed using the baseline as the reference and the highest density development scenario as the worst case. Index values indicating the perceived impact to stream health were assigned to each statistical category and an average index was obtained for each scenario. The index value for each scenario followed the amount of development, measured by percent imperviousness closely, indicating the decrease in stream health with increasing development.

Habitat suitability analysis identified three habitat guild representative fish species found in Back Creek: the central stoneroller (representative of the run guild), the fantail darter (representative of the riffle guild), and the smallmouth bass (representative of the pool guild). The amount of time and area that acceptable and optimum velocity,

depth, and both depth and velocity habitat were available for each species for each development scenario was found. Results indicated that Back Creek at baseline (1% imperviousness) is a riffle habitat dominated stream with some run habitat and very little pool habitat. Scenario data output showed a substantial decrease in both the area and time that both habitat criteria were available for fantail darters, while little change was detected in the habitat available for the central stoneroller and smallmouth bass. These results indicate that Back Creek would remain a riffle species habitat dominated stream, with a decrease in the amount of riffle habitat and little to no change in the run and pool species habitat.

## **5.2 Contributions and Conclusions**

- A methodology was presented by which stream health impacts from residential development can be predicted using hydrologic processes and stream health indicators. Long term continuous hydrologic modeling formed the base of this method. To the knowledge of the author, no other study has used long term (43 years) hourly rainfall to model possible residential development and link these results to stream health indicators.
- Residential land development will increase the occurrence of both high flow and low flow extreme events while lowering the baseflow for Back Creek. This change in flow regime will increase with development (as measured by imperviousness) and result in greater streamflow variability.
- An increase in flow variability will decrease the overall stream health of Back Creek. The effect of flow variability can be measured by indexing hydrological statistics with ecological significance.
- The species composition of Back Creek will also be affected by an increase in flow variability as the amount of velocity and depth habitat for riffle species is greatly decreased while the habitat available for run and pool species is moderately decreased.

### **5.3 Limitations and Recommendations**

Although this study presents some groundwork for using hydrologic processes to link development and stream health, additional work could greatly improve the results. The addition of stormwater drainage analysis for the development scenarios, although work intensive, would increase the accuracy of the hydrologic scenario results. Adding water quality and the increased pollutant load typically associated with development would enhance the stream health analysis. And, finally, analyzing overland erosion and in channel sediment processes would enable the addition of sediment suitability to the habitat suitability analysis.