Katie Larsen
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Progress Report

The objective of my project is to develop a GIS tool/model that analyzes the impervious cover from transportation facilities on a developed urban watershed and identifies, using a variety of factors, the location and amount of impervious cover from those facilities to remove to improve stream quality and reduce flows to receiving waters. The Shoal Creek watershed in Austin, Texas will be used as the test case.

Steps Completed or In Progress

At this point, two major milestones have been reached:

1. An extensive literature review has been conducted on the following topics:

- Impacts of impervious cover, in general, on stream quality,
- Alternatives to structural approaches to handle development generated stormwater runoff, focused specifically on the benefits of removing impervious cover,
- GIS methods to identify impervious cover and effective impervious cover from aerial images,
- Differences in impacts of effective (EIA) vs. non-effective impervious (NEIA) cover on stream quality,
- Influence of location of impervious cover on stream quality, and
- Studies of the Shoal Creek watershed.

2. The following GIS datasets have been retrieved or requested from the City of Austin:

- Stormwater system (inlets, pipes, outfalls, culverts, ponds) (requested)
- DEM and watershed data for Shoal Creek watershed (requested)
- Planimetric data for transportation facilities, sidewalks and buildings (retrieved)
- HEC-HMS model for Shoal Creek watershed (requested)
- ROW data set (retrieved)
- Traffic count (not in GIS form yet, but data retrieved)

Expected Outcome

The expected outcome is a map showing impervious cover from transportation facilities in the Shoal Creek watershed to remove for improving stream quality, a quantitative determination of the resulting decrease in peak flow from the removal (using HEC-HMS) and a rough estimate of the cost savings compared to using structural approaches (from a review of studies done for Shoal Creek).

My main concern is being able to test with the GIS tool/model the hypothesis that by removing from transportation facilities a certain amount of impervious cover connected to the stormwater system (EIA) and in close proximity to the stream, there can be a significant reduction in cfs flow to the receiving waters, for less cost compared to managing stormwater using structural approaches (i.e., pipes and large detention facilities).

Proposed Process

The results of the literature review suggest that the following two characteristics of the impervious cover should be considered in the analysis:

- EIA and NEIA impervious cover (EIA is connected to the stormwater system; NEIA is not)
- Location of impervious cover

I have found two studies using methods with the most promise for this project:

- Roy & Shuster (2009) used impervious areas digitized into surface polygon features, and overlayed those in GIS with storm sewer vector features and topographic vector datasets. Their procedural method for determining effective impervious cover connected to the stormwater system using vector datasets is a little unclear to me though.
- Han & Burian (2009) used image processing software to classify pixels, using a classification technique (e.g., maximum likelihood) and filtering method (e.g., Lee filtering), into different impervious cover categories to form a total impervious area raster layer (TIA). To find the EIA, vector layers of the stormwater system were converted to raster data, and combined with the DEM. A search process was programmed into GIS to determine for each impervious cover raster cell whether it was connected or disconnected from the stormwater system (included use of the steepest gradient method to determine flow direction).

I'm leaning towards a raster-based method similar to Han & Burian (2009), however instead of classifying pixels using image processing software, I expect to use the planimetric data from the City of Austin that uses polygons to delineate impervious areas. I may convert those areas to rasters and combine with DEM to allow for steepest gradient flow analysis to determine which impervious cover raster cells are connected to the stormwater system (EIA).

Once the impervious cover areas are in raster form, the plan is to have the EIA raster cells further divided using algorithms, raster map algebra and/or GIS data overlays into categories based on the likelihood and appropriateness of their removal based on such factors as:

- Location within transportation facility (i.e., on the edge or in the middle of parking lots or roadways)
- Importance for transportation facility, determined by asking the following for each raster cell:
    - In an excees parking area? (requires polygon feature with parking space count and land use parking requirements based on square footage of building- this may be the least likely to be included due to lack of readily-available data, though site plan information on the City website may expedite organization of that data)
    - Part of an unnecessarily wide roadway based on traffic counts? (requires dataset with traffic count data for street and vector dataset with ROW and pavement width data)
- Influence on stream quality and amount of flow (considering factors such as distance from stream either physically and/or in hydraulic travel time and Manning's n of the impervious surface)

Removal priority will be given to EIA raster cells because the impacts on stream quality of effective impervious cover are more direct. Raster cells classified as NEIA will be considered for removal, however priority in those cases will be given to those NEIA cells closer to the stream (e.g., a 150 foot buffer).

Interestingly, few quantitative studies examine the importance of location of impervious cover to stream quality (Brabec, Schulte, & Richards, 2002). The literature offers limited insight into the location parameters to consider when assessing which impervious cover to remove, however Brabec, Schulte, & Richards (2002) stated the "distance between impervious cover and the stream channel appears to be one of the most important factors regarding placement, particularly for areas in which runoff is not piped directly to the stream," and cited the Hammer (1972) study on stream channel enlargement due to urbanization. Impervious cover within a stream buffer of 150 feet affected nutrient concentrations, but beyond that there was not much impact (Tufford, McKellar, Jr., & Hussey, 1998). Based on the Tufford study, a buffer area of 150 feet will be incorporated into the analysis to identify the impervious cover (EIA or NEIA) raster cells within 150 feet of a stream as potential candidates for removal, in addition to identification of EIA raster cells, since EIA is known to have more of an impact on stream quality than NEIA (Han & Burian, 2009). Additional research will be conducted to find relevant factors to consider in determining which impervious cover to remove.

Issues re: project:

The big issues I'm working through to implement this project are:

1. How to develop the most efficient method for finding EIA using the rasterized or vector-based stormwater systems dataset.
2. How to develop the most efficient way to process and program-in the criteria for selecting an impervious cover cell for removal.
3. How to use the results of the GIS model for HEC-HMS modeling to determine changes in cfs flow. It seems like Geo-HEC-HMS would assist with this? If Geo-HEC-HMS is not used, then GIS will be used to calculate the impervious cover before and after removal, and the results entered into HEC-HMS for modeling of hydrological response (using the City of Austin's HEC-HMS model for Shoal Creek).
4. How to have the spatial results of this project influence the HEC-HMS modeling (e.g., if removal of part of a transportation facility affects flows, then the HEC-HMS model would have to change to reflect different size of sub-basin).

Partial Bibliography

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