PRIORITIZING THE LOCATION OF GREEN INFRASTRUCTURE TO MAXIMIZE EFFECTIVENESS OF STORMWATER MITIGATION, FOR THE CITY OF SANDY SPRINGS

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Abstract. Cities across the Metro-Atlanta region are experiencing a renaissance as market demand for urban live, work, and play, is driving infill development. As these cities transform from lower density suburban architecture to denser walkable communities, their stormwater infrastructure becomes challenged to support increases in runoff due to impervious surfaces and changes in intensity of rainfall events. Green infrastructure and low impact development approaches which include better planning and site design practices can reduce the potential for flooding and further degradation of stream water quality.

Our objective was to identify and prioritize the locations for stormwater interventions that can be used to minimize stormwater impacts to already TMDL-listed streams within the boundaries of the City of Sandy Springs. A high resolution model of impervious surface, topography and land use was derived from LIDAR and integrated with the existing stormwater infrastructure to identify areas which receive high surface flows.

These areas were then ranked and prioritized to provide a new roadmap for stormwater management within the boundaries of the City. We will report the results of our modeling effort and discuss how these results can be used to identify restoration opportunities in flood prone areas and describe how these alternatives provide cost effective solutions to stormwater management on public and private owned properties.

INTRODUCTION

Environmental sustainability, quality of life, and economic prosperity are related features of the most successful communities around the country. The success of these communities comes from a strong commitment from elected officials and the community in implementing their vision. Cities like New York, Seattle and Philadelphia are recognizing that they can utilize green technologies to support infill development in ways that reduce infrastructure costs and increases resilience to floods and other natural hazards.

Urbanization, through the increase in impervious surfaces, brings with it impacts on hydrology of streams including changes to the timing of delivery, quantity, and energy of water flow, as well as water quality impacts. These translate to increased risks of flooding, floodplain expansion, streambank erosion, habitat loss, reductions in baseflow volume, and reduced water quality. When it rains, water can be absorbed through pervious surfaces such as vegetated areas, uncompacted soils or gravel, which allow the passage of water into the surface.

In contrast, impervious surfaces such as rooftops, roads, parking lots, sidewalks and driveways, prevent rain from being absorbed and increase the amount of water runoff from these areas. This stormwater collects contaminants as it moves across impervious surfaces that carry the increased volume of polluted water into a city's stormwater system. The more impervious surfaces, the more polluted water entering the stormwater system.

Land development across the City of Sandy Springs is happening at a pace that outstrips the existing stormwater systems resulting in increased discharges of polluted water into local rivers and streams and exceeding the capacity of floodplains and other natural landscape features to capture, store and clean the excess stormwater.

Traditional stormwater infrastructure was designed to move stormwater quickly off the landscape using streams as conduits. Urbanization causes stormwater volumes to rapidly exceed the stormwater system capacity and cause backups that result in street and basement flooding; waterways, floodplains and wetlands are degraded and natural habitats are destroyed and biodiversity suffers.

These impaired waterbodies no longer support healthy aquatic communities and do not meet designated uses set by the State. In addition, there is an increase in property damage from erosion and flooding, and a further reduction in land and property values caused by loss of amenities, such as recreation, that are provided by streams, rivers, floodplains and wetlands.

Expanding capacity through new gray (traditional) stormwater infrastructure is often cost prohibitive and does not provide sufficient water retention needed to mitigate flooding, maintain water quality and maintain the integrity of stream systems. Furthermore, these highly engineered systems reduce resiliency responses to natural hazards such as extreme rainfall and droughts.

Green Infrastructure (GI) includes a range of soil-water-plant systems that intercepts stormwater, infiltrates a portion into the ground, evaporates a portion into the air, and releases a portion of it slowly into the stormwater system.

Low Impact Development (LID) with GI is an approach that uses land use planning and site design practices to maintain stormwater on site by increasing infiltration and storage, thus minimizing adverse impacts of development to the hydrologic cycle. It requires two key components; understanding the quantity of water moving through the landscape, and where to most effectively place interventions in the watershed to reduce the environmental impacts of changing flows. Often, the best locations for intervening in stormwater management might be in public easements along roads or within sewer and water easements, which are typically found in low lying areas.

In addition, smaller more strategically identified sites may do a better job of enhancing infiltration and have a greater aesthetic than larger engineered detention facilities. Smaller strategically located sites on private lands may also reduce local flood conditions by reducing the impacts from impervious surfaces from newer developments. In many of these cases the cost of stormwater management will be significantly lower than larger engineered options.

Therefore, the objective of this project was to identify and prioritize the location of areas that can be used to minimize stormwater impacts to TMDL listed streams within the City of Sandy Springs. We can refit the models to support urban stormwater management planning by identifying the best locations for enhancing ecosystem services through wetland construction.

METHODS

The City of Sandy Springs provided the following dataset for modeling; Lidar point cloud, parcel level zoning data, parcel level land use data, building footprints, sewer and stormwater locations, and transportation. A 1-meter resolution digital elevation model was created from the Lidar data. Other data sources include soil data from USDA and hydrology from USGS. All data modeling was performed at a 1 meter pixel resolution. All models were developed for the entire city limits.

Land cover was derived from Lidar point cloud data using both intensity and height. A three-category land cover map included impervious surface, tree cover, water, and open (grass) areas. Each raster pixel was given a curve number using the land cover, soils and slope.

Two sub-models were created 1) Potential Runoff Index and 2) Distance to Nearest Stormwater Conveyance, to create the final site selection output. The models were run across the area of the City limits and then reclassified and prioritized for each of the individual watersheds found within the City limits. All pixels in the watershed were then mapped and ranked, low, medium and high priority for stormwater improvement.

Potential Runoff Index (PRI)

PRI is calculated as the proportion of saturated variable source runoff generated from the two-year 24-hour storm event that may enter an open waterbody. It is an inverse index between zero and one, with zero exhibiting the greatest potential amount of non-point source runoff. The indexed values have been reclassified to a scale 1-9, where 9 represents the greatest potential amount of runoff.

Distance to Nearest Stormwater Conveyance (DNSC)

DNSC represents a location's (Pixel's) contribution to nonpoint source pollution based on its hydrologic flow distance to all streams, open storm conduits and catch basins. The DNSC is a measure of a potential restoration/mitigation sites position in the landscape, and thus its potential effect on limiting nonpoint source pollution. The DNSC is calculated by determining the distance based upon flow length of all pixels. Reclassified 1-9, where 9 represents areas closest to stormwater conveyance.

Site selection model

The final site selection model was created by multiplying the values from the PRI and the DNSC models and rescaling these results from 1-9 within each of the individual watersheds in Sandy Springs (Nancy Creek, March Creek, Crooked Creek and Long Island Creek). These results weigh the runoff by distance to stormwater conveyance, so that higher areas of accumulated runoff which are closer to stormwater intakes will result in a higher priority for managing infiltration. The final data are reported as high, medium and low priority within each of the watersheds.

RESULTS AND DISCUSSION

The final model output assigns a ranking of each pixel for their contribution to the stormwater system for each of the watersheds within the Sandy Springs City Limits. Each grid cell is ranked and prioritized relative to the watershed supporting flows into the stormwater system. To use the data for planning purposes, we ranked each parcel by the amount of area that supports high amounts of stormwater flow. Figure 1 shows an area of Sandy Springs bisected by I-285 and bordering GA 400 on the right.

The area includes the top of Nancy Creek Watershed and part of the March Creek Watershed, both of which flow directly into the Chattahoochee River. Parcels with high values are seen in black. When connected, these parcels provide a first evaluation of the larger green infrastructure support. These areas indicate where substantial stormflows connect to the current stormwater system.

Figure 2 provides more detailed information to support site planning for the inclusion of biofiltration, floodplain, or wetland features for water storage and infiltration. The output represents the path of flow within each of the parcels. In this instance, black areas show both high connectivity and collection of runoff. The results are modeled at 1 meter resolution which can support site planning activities.

Optimizing the effectiveness of green infrastructure to support stormwater management will require, fine tuning the placement of each intervention and designing for flows that move through a parcel from neighboring parcels. Thus, the outputs from this model can allow for better site design and implementation of smaller more effective green infrastructure solutions for infiltration.

The model results can further be integrated with a hydrologic model such TR-55, L-Thia and other modeling approaches to estimate potential pollution loadings and runoff reduction, thereby allowing the user select and size the appropriate biofiltration system (Liu et al 2016). We are currently working with the Sandy Springs Environmental Project (SSEP) a nonprofit group, to incorporate these results into a decision support system to help evaluate development proposals for their environmental impacts.

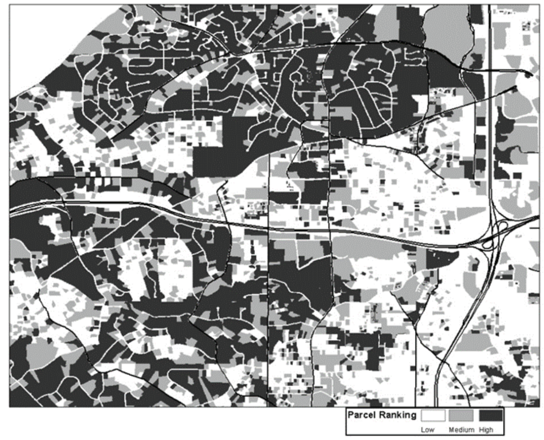

Figure 1. Parcels ranked for their stormwater contributions. Black is high and white is low.

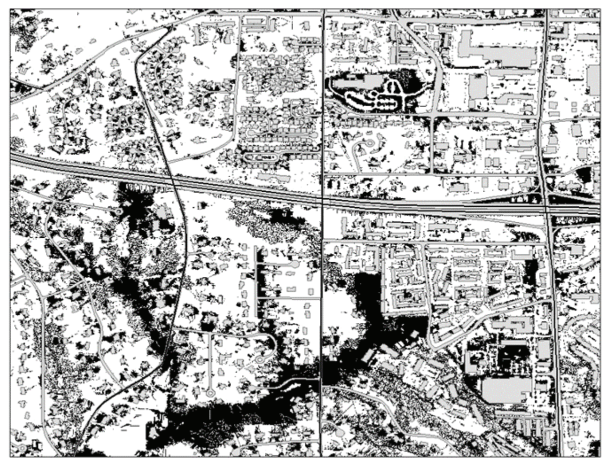

Figure 2. Model output of high-resolution data for establishing stormwater flow and storage.

LITERATURE CITED

Liu, Y., L O Theller, B C Pijanowski, B A Engel. 2016. Optimal selection and placement of green infrastructure to reduce impacts of land use change and climate change on hydrology and water quality: An application of the Trail Creek Watershed, Indiana.