The Green Build-out Model: Quantifying the Stormwater Management Benefits of Trees and Green Roofs in Washington, DC

Project Summary

The Green Build-out Model is a planning tool that quantifies the cumulative stormwater management benefits of trees and green roofs for different coverage scenarios across the District of Columbia. It calculates potential reductions in stormwater runoff within the municipal separate storm sewer system (MS4) and the combined sewer system (CSS) that contribute to water quality impairment in the Nation's capital.

The Green Build-out Model adds the "green component" to the existing hydrologic and hydraulic model of the District (Mike Urban). This was the same model used by the DC Water and Sewer Authority to support development of the Long Term Control Plan (LTCP) for the CSS. The MS4 areas were added to the model so that all of the municipal sewer systems were included in one planning tool.

The Green Build-out Model integrates GIS land cover data and hydrologic processes using rainfall storage and coverage areas for trees and green roofs. Interception storage for trees was based on USDA Forest Service research and modeling. The storage amount for green roofs was based on literature values.

Two planning scenarios were evaluated with the Green Build-out Model and compared to existing or baseline conditions. An "intensive greening" or "Green Build-out" scenario considered adding trees and green roofs wherever it was physically possible. A "moderate greening" scenario looked at adding trees and green roofs where it was more practical and reasonable to do so. A separate tree box scenario estimated the stormwater management benefits associated with increasing the existing tree box dimensions in the downtown area where most sidewalks are at least 20 feet in width.

Scenarios were evaluated with a continuous simulation hydrologic and hydraulic model under average annual rainfall conditions (1990 hourly data) and for a 6 hour (1 inch) design storm. Reductions in runoff volume, discharge volume, and discharge frequency were determined by sewershed for both the CSS and MS4 areas and for the Anacostia, Potomac, and Rock Creek watersheds within the District.

An estimate of pollutant load reductions achieved with green roofs was developed by considering the difference in pollutant loading from a conventional roof and that of a green roof. Annual operational savings for DC WASA from reduced pumping and treatment costs as a result of stormwater flow reductions were estimated using $.01 per gallon.

Key findings show:

- For an average year, the intensive greening scenario prevents over 1.2 billion gallons of stormwater from entering the sewer systems, resulting in a reduction of 10% or over 1 billion gallons in discharges to the District's rivers, and a 6.7% reduction in cumulative CSO frequencies (74 individual CSO discharges).
- For an average year, the moderate greening scenario prevents over 311 million gallons of stormwater from entering the sewer systems, resulting in a reduction of 3% or 282 million gallons in discharges to the District's rivers, and a 1.5% reduction in cumulative CSO frequencies (16 individual CSO discharges).
- Reductions in stormwater runoff volume are up to 7% across the city, with up to 27% reductions in individual sewersheds under the intensive greening scenario.

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- Reductions in discharge to the District's rivers from the CSS area are 6% for the moderate greening scenario and over 22% for the intensive greening scenario.
- With the intensive greening scenario, installing 55 million square feet of green roofs in the CSS area would reduce CSO discharges by 435 million gallons or 19% each year.
- Stormwater management benefits from incremental tree cover were approximately 5 times greater for trees over impervious surfaces, such as streetscapes and parking lots, than for trees over pervious surfaces.
- Larger tree boxes in the downtown area could reduce stormwater runoff by 23 million gallons each year.
- Replacing conventional roofs with green roofs has the potential to keep thousands of pounds of nutrients, metals, and other pollutants out of area waterways.
- WASA could potentially realize between $1.4 and $5.1 million per year in annual operational savings in the CSS area due to reduced pumping and treatment costs.
- Acre equivalencies for trees and green roofs to achieve 1 million gallons of stormwater runoff reductions in an average year.

The Green Build-out model provides an innovative and powerful planning tool for stormwater management in the District of Columbia. The grant findings provide information by sewershed and watershed to target investments in trees, green roofs, and larger tree boxes to yield the greatest return of stormwater benefits city-wide. The research also provides general hydrological relationships and modeling methodologies that are transferable to other municipalities.

These findings show that trees, green roofs, and larger tree boxes provide substantial overall reductions in stormwater runoff and discharge volumes in sewer systems District-wide. The greatest opportunity is at the sewershed level in the CSS area where the total reduction in discharge volume for all sewersheds was greater than 22%.

Trees, green roofs, and larger tree boxes provide limited reduction in CSO frequencies. However, reductions in stormwater runoff volumes could have implications for the detailed design of the LTCP. As this research only models interception storage, other LID solutions should be considered when evaluating the capacity to manage large storm events.

Trees, green roofs, and larger tree boxes provide stormwater controls in urban areas where options and space are limited and show particular promise in the MS4 area where subsequent reductions in pollutant loadings could provide the District an option to make progress toward meeting TMDL requirements for its impaired waters.

In addition to stormwater management benefits and for the same investment, an increase in tree cover, more green roofs, and larger tree boxes would also provide improvements in air quality, public health, social capital, and economic development, and reductions in carbon dioxide, energy costs, UV radiation, and the urban heat island effect.

Grant resources in addition to the full report include:

- Advisory Team Policy Recommendations
- Model Results Display Tool to easily access model findings for stormwater runoff reductions including data at the sewershed-level
- Green Build-out Mini-Model to test different coverage assumptions and calculate resulting reductions in stormwater runoff

The full report, Green Build-out Model Results Display Tool, and the Green Build-out Mini-Model are available online as of May 2007 at: www.caseytrees.org

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