SCCWRP #1238

Sources and Impacts of Uncertainty in Uncalibrated Bioretention Models Using SWMM 5.1.012

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ABSTRACT

Using the USEPA's Storm Water Management Model version 5.1.012 (SWMM), a case study of a street right-of-way bioretention system (ROWB) configured as a storage node is compared against SWMM's Low Impact Development (LID) Controls for urban runoff retention, detention, and the timing of discharge. Through 12,000 one-year continuous simulations, single parameter perturbations and Monte-Carlo simulation of the uncalibrated models result in predicted annual runoff coefficients (representing stormwater retention) of 0.19–0.55 for an exfiltrating ROWB compared to 0.61 and 0.72 for a storage node with low and high assumed exfiltration capacity, respectively. Stormwater detention was represented by the frequency of event peak discharges exceeding an arbitrary low threshold value. The storage node simulations predicted peak discharges near or exceeding the upper values for the LID Control simulations. The dynamic representation of flow through porous media in the LID Control predicts greater retention and detention compared to the storage node over the range of uncalibrated models investigated. Sensitivity analysis of the LID Control parameterization indicates that the relative difference between the engineered media's porosity and field capacity have the most significant influence on predicted performance. Poor runoff retention results in scenarios where the engineered media exhibits a high field capacity relative to its porosity, whereas high field capacity is a desirable trait that should lead to superior performance. The model's calculation procedures and neglect of unsaturated flow or preferential pathways bias model output toward more frequent runoff bypass. The sensitivity analysis also demonstrates that the timing and duration of the discharge hydrograph are highly variable depending on parameterization. The wide range of potential performance generated from uncalibrated model parameterization leads to significant concerns for infrastructure planning and implementation, leading potentially to underperforming infrastructure, or excessive cost. Allocating resources to collect field performance data that enables robust model development, calibration, and verification at the green infrastructure (GI) stormwater control measure (SCM) scale offers the opportunity to reduce uncertainty in model predictions.