

A Practical Methodology to Model Hydromodification Performance of Conventional and Low Impact Stormwater Controls

By

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Municipalities and stormwater authorities commonly require stormwater controls for new developments that match the peak flow of runoff for pre-and post development conditions for a couple of extreme design storm events. In many jurisdictions, peak flow attenuation is the only criterion and the resulting stormwater management basin designs have no benefit on water quality or channel protection. Peak attenuation is not a suitable design criterion for meeting these two stream protection goals. Water quality typically involves treatment of a given volume of runoff. Channel protection must be evaluated in terms of the cumulative excess shear stress that the post-development flows apply on the streambanks. Stress duration curves can be used to measure this impact. Because this is a cumulative effect over time, continuous hydrologic simulation is often the preferred tool for this analysis. Continuous simulation is not commonly performed in land design due to cost and expertise limitations; instead most designers are proficient with single-event modeling. This paper proposes a methodology to apply single-event modeling to the development of approximate shear stress duration curves that can be used to evaluate the effect of stormwater controls on streambank erosion. A one-time statistical analysis of the long-term rainfall record is required. The methodology is applicable to both conventional and Low Impact Development controls. The procedure also yields flow duration curves that can be used to examine the ability of these stormwater controls to replicate the pre-development hydrology.

The methodology was derived for applications in the state of Missouri due to the availability of synthetic design storms of various durations. Design assumptions were made for a typical residential development and a typical stream in the City of Columbia, Missouri. A record of 59 years of hourly precipitation data for Columbia was analyzed to develop storm statistics of depth and duration. Different stormwater controls were designed for this site, including conventional detention in wet basins as well as LID technologies. Various detention options were explored including 100-year flow attenuation only, and combinations of water quality volume retention, and 1-year storm extended detention for channel protection. The flows and shear stresses from each design scenario were analyzed to determine the effectiveness of different levels of

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stormwater controls and, more importantly, to assess the adequacy of stormwater design requirements.

The results indicated that current design standards solely based on attenuation of peak flows for extreme events are inadequate to protect water quality and prevent streambank erosion. In addition, they result in excessively large stormwater controls that reduce the amount of developable land. The addition of water quality and channel protection criteria, or the application of LID controls proved to meet these goals. The methodology can be easily implemented in a spreadsheet and can be used to optimize designs to match flow and shear stress duration curves for pre- and post-development conditions.