Runoff Ramblings: The Computation Conundrum: How to Account for (Small Storm) Runoff Reductions in (Larger Storm) Hydrology

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Introduction

All trends in stormwater management point towards using more runoff reduction, low-impact development, and green infrastructure approaches. Whatever name you wish to attach, a chief underlying principle is to reduce the overall volume of runoff, and therefore attendant pollutant loads, through site design techniques coupled with use of certain stormwater best management practices (BMPs) (e.g., rainwater harvesting, infiltration, bioretention).

It is becoming increasingly clear that runoff reduction approaches are very effective for the small storm events that generally define our water quality criteria. However, there is still a lot of uncertainty in the stormwater community about the benefits for larger storm events, such as those used to define criteria for channel protection and flood control. For instance, what actual benefits would be derived from disconnecting impervious cover, preserving green spaces, and using distributed practices for reducing the peak rates from the 2-year, 10-year, 25-year, or 100-year storm event? Further, once we estimate these benefits, are we confident enough in the science to reduce the sizing of the downstream big-storm drainage infrastructure?

This is perhaps a *Pandora's Box* of computational conundrums - a perfect venue for the *Runoff Rambler* to jump in!

The Traditional Approach: Quantity and Quality in Separate Silos

Stormwater management programs have traditionally been partitioned into programmatic goals for stormwater quantity and stormwater quality. Stormwater *quantity* goals focus on the significantly greater runoff volume and velocity associated with the decrease in water-retaining characteristics of the urbanized landscape. Stormwater *quality* goals seek to reduce the pollutant load (excess nutrients, metals, bacteria, sediment, etc.) that is delivered to the receiving stream.

Many state and local regulatory programs, ordinances, and design manuals have similarly partitioned computational methods for demonstrating compliance with stormwater quantity and quality criteria. Water quantity or peak rate computations are usually event-based and modeled using well-known and readily available hydrologic modeling tools such as those developed by the Natural Resources Conservation Service (NRCS). Water quality computations on the other hand, often consist of an average annual pollutant load and a pre-determined "water quality volume" to measure compliance with a defined pollutant load target.

As a result, while the regulatory goals and computational methods have been partitioned, the compliance strategies have evolved into a "one-facility-fits-all" approach of detention, retention, and extended detention ponds. With this design approach, the design elements for water quality tend to take a back seat compared to those for channel and flood protection (which account for most the required storage). Meanwhile, physical evidence from the past two decades has demonstrated that this strategy does not readily achieve the goal of protecting the physical, chemical, or biological integrity of receiving waters (EPA 2003).

Runoff Reduction: The Movement Towards Integrating Stormwater Quality and Quantity

Many states are now combining the quantity and quality programmatic goals into a comprehensive runoff volume strategy: retain a prescribed volume of stormwater runoff from the urbanized landscape in order to achieve all or partial compliance with the water quality and stream channel erosion requirements (see Runoff Ramblings - Is Runoff Volume the Real Pollutant?) This goal can be achieved through a combination of: (1) runoff minimization; and (2) runoff reduction.

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Runoff minimization is the cornerstone of Low Impact Development strategies that seek to influence the way land is developed: protect native vegetation, minimize impervious cover, maintain natural flow paths, preserve high infiltrative capacity soils (Hydrologic Soil Groups A & B), maintain sheet flow through vegetated areas, and other methods to reduce the amount of runoff that would otherwise be generated on the development site. Many of these minimization strategies are rewarded in the traditional NRCS hydrologic modeling methods with a lower runoff curve number and a longer time of concentration. Even disconnection of impervious cover is provided a credit (with certain limitations) in NRCS's Urban Hydrology for Small Watersheds (TR-55).

Runoff reduction calls for the implementation of BMPs that serve to reduce the volume of stormwater, such as soil amendments, engineered infiltration, extended filtration (e.g., bioretention with an underdrain), rainwater harvesting and reuse, and other practices that, individually or combined, serve to remove the captured volume of runoff from the discharge hydrograph. The performance credits or runoff reduction credit achieved by the various practices are assigned in terms of an annual runoff volume reduction based on documented field studies (Hirschman et al. 2008).

Crediting Volume Reduction Practices for Both Quality and Quantity Requirements

The runoff reduction achieved through minimization and reduction is applied to the annual runoff volume when computing the annual pollutant load using the Simple Method. The annual load is the product of the defined annual volume of runoff (i.e., runoff from the 90th percentile rain event) and the event mean concentration of the pollutant being measured. In principle, when runoff reduction practices are used to capture and retain or infiltrate runoff, downstream stormwater management practices should not have to detain, retain or otherwise treat the volume that has been removed. In other words, the volume of runoff reduction provided should be subtracted from the volume calculated by stormwater runoff peak flow computations. The challenge lies in how to accurately credit the annual volume reduction to the computation of the peak rate of runoff from larger single event storms for purposes of channel or flood protection.

The mechanics of peak flow reduction for the stormwater quantity goals of channel and flood protection include watershed storage and runoff attenuation. Many of the BMPs used to achieve runoff reduction do so by providing retention storage and runoff attenuation. While one could apply hydraulic routing to each runoff reduction practice, the modeling characteristics would likely not follow the traditional detention/retention routing parameters (given all the hydrologic and hydraulic variables such as evapotranspiration, storage within the soil media, infiltration, and extended filtration). Thus, the traditional computational approach would not only be complex, but also very cumbersome on a site scale due to the increased number of practices being applied within each drainage area.

There are likely numerous ways to approach this challenge. The advancement of hydrologic software and computer hardware has facilitated the use of continuous simulation models. On the other hand, there is also a need to keep the stormwater management compliance metrics simple for site designers and plan reviewers. Thus, sophisticated models can be used to analyze and synthesize land use patterns, soils, and other relatively simple parameters and develop relationships between retention storage provided on a development site and the corresponding credits for peak flow reduction for larger storms.

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A simplified version of such a relationship already exists in the NRCS runoff equations 2-1 through 2-4 provided in TR-55. These equations can be used to derive a *curve number adjustment* that reflects the reduced runoff volume associated with increasing the retention storage in a drainage area. In essence, a new (lower) curve number can be back-calculated by subtracting the retention storage provided in a BMP or a series of BMPs from the developed condition runoff depth (Koch 2005).

While it is not easy to predict the absolute runoff hydrograph modification provided by reducing stormwater runoff volumes, it is clear that reducing runoff volumes will have an impact on the runoff hydrograph of a development site. Simple routing exercises have indicated that the curve number adjustment approach using the NRCS runoff equations represents a conservative estimate of peak reduction for certain storms. In other words, if anything, the curve number approach may under-represent the actual peak-shaving benefits deduced from routing larger storms through a variety of runoff reduction practices.

The implications of using this or a similar approach are different, depending on where you sit. A site designer or developer will want to receive due credit for using distributed runoff reduction practices, and will certainly NOT want to have two separate and redundant systems for water quantity and quality control. The public works director, on the other hand, will want to make sure that this "due credit" translates to an actual peak flow reduction and will not result in street or basement flooding in the neighborhood. The importance of the chosen method is that these two camps can have a common language of quantity and quality control, and the overall site planning and review procedure can be more predictable.

Additional research to compare the results of hydraulic routing of management practices with the measured volume reduction in the field is needed to better predict the ability of these practices to modify the runoff hydrograph and reduce peak discharges. Documenting an accurate volume reduction for the larger storm events can provide a tremendous incentive to further maximize the use of site design techniques and runoff reduction practices as a way to address the comprehensive goals of a combined stormwater quality and quantity program.

What are your experiences and thoughts? Do you have the silver bullet for quantity and quality integration? Email us at rambler@cwp.org.

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