Figure 1. Example of a Regional BMP: Ballona Freshwater Marsh

PHOTO: KEN SUSILO

Discussion: Low Impact Development

Urban Runoff and Stormwater: Strategies and the Need to Use All the Tools in Our BMP Toolbox

KEN SUSILO

In concept, the management of urban runoff impacts is a simple goal, and the means by which to achieve this goal are straightforward—avoid increasing runoff and pollutant generation (i.e., eliminate the sources), remove those pollutants that cannot be avoided, and restore hydrologic cycles. Understanding pollutant sources such as air deposition and reducing other sources through industry activities such as product replacement (e.g., through the California Stormwater Quality Association's Brake Pad Partnership efforts) are important parts of the solution.

The challenges involved with physically cleaning polluted urban runoff and stormwater lie in finding opportunities within our existing communities, and within these opportunities, selecting the most appropriate strategies and techniques. New construction (development and redevelopment) provides opportunities for protecting and improving water quality, but these new construction opportunities can be sparse in older urbanized areas.

The BMP Toolbox

The Best Management Practices (BMP) toolbox includes an array of proprietary and "public domain" flow control and water quality treatment BMPs; some utilize advanced treatment methods while others focus on natural treatment systems. Two fundamental distinctions can be made regarding BMP implementation. These are issues of scale and retention.

Scale

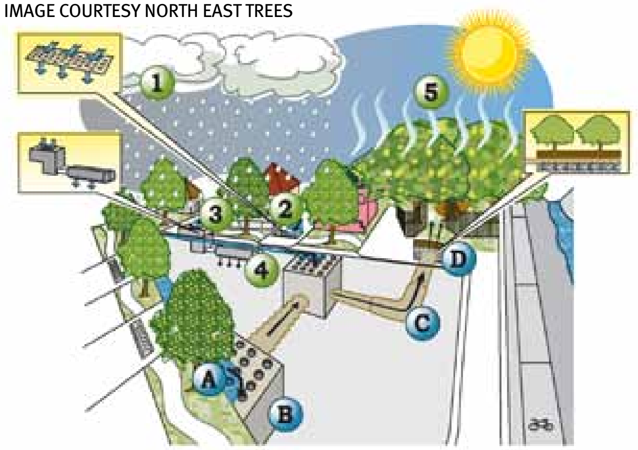
Issues of scale refer to the BMP in relation to its tributary drainage area. For purposes of discussion, three scales are proposed (Geosyntec 2008):

- Regional or sub-regional BMPs refer to BMPs that treat larger tributary drainage areas, typically on the order of 100 acres or more. These BMPs frequently require either incorporation at a master plan level or, in a retrofit condition, a diversion from an existing storm drain system. Examples include regional treatment wetlands or basins such as those planned or constructed in Malibu (Legacy Park Project), Playa Vista (Ballona Freshwater Marsh, Figure 1), and Central Orange County (San Diego Creek Natural Treatment System).

- Distributed BMPs treat smaller areas, typically on the order of tens of acres (e.g., one or more neighborhood

Figure 2. Example of a Distributed BMP: Oros Street Project

IMAGE COURTESY NORTH EAST TREES



blocks). Distributed BMPs are typically maintained by public entities or homeowners associations. Examples of distributed BMPs are the Oros Street and South Park Projects (Figures 2 and 3, respectively) in Los Angeles and Bicknell Avenue Green Street in Santa Monica.

- On-site BMPs refer to on-site Low Impact Development (LID) BMPs that are constructed at a parcel or lot level. These have also been referred to as institutional BMPs as their construction is typically the result of regulatory requirements imposed on private property owners for construction and maintenance, instead of on public works agencies (see the parking lot example in Figure 4).

Retention

The concept of "retention" is a critical term in the stormwater quality discussion. Retention, for the purposes of this paper, refers to those BMPs that have no surface water discharges (up to a water quality design event). These BMP types are sometimes called "zero discharge" BMPs, but this definition is not appropriate because they generally discharge to groundwater.

Retention BMPs rely on mechanisms such as infiltration (e.g., trenches, bioretention facilities, subsurface infiltration basins), evapotranspiration (e.g., green roofs), and harvesting (capture and use systems, such as cisterns). Infiltration BMPs may help restore some elements of the pre-urbanization hydrologic cycle through aggressive reintroduction of water into groundwater. Harvesting BMPs potentially offset some potable water demand. Both infiltration and harvesting approaches have the potential to provide water supply benefits.

For discussion of stormwater quality, however, each system is limited by different parameters. Infiltration BMPs are limited by the potential for the soil to safely and effectively accept large quantities of water without causing unintended consequences (Susilo, Matasovic, and Johnson 2009). Harvesting is limited by the ability to effectively use (e.g., for irrigation or indoor toilet use) captured stormwater, resulting in variable periods of transient storage, limiting the ability of the system to function effectively as a stormwater BMP (Strecker and Poresky 2010).

The corollary to retention BMPs are treatment BMPs with some surface discharges. The "natural treatment system" subset of treatment BMPs potentially reduces a fraction of the stormwater volume through evapotranspiration (e.g., bioretention with underdrains, bio-swales, green/brown roofs, amended soils, etc.), while the second subset of more engineered treatment BMPs, which includes filtration systems, gross solids removal devices, and proprietary settlement/deflection systems, do not reduce stormwater volumes.

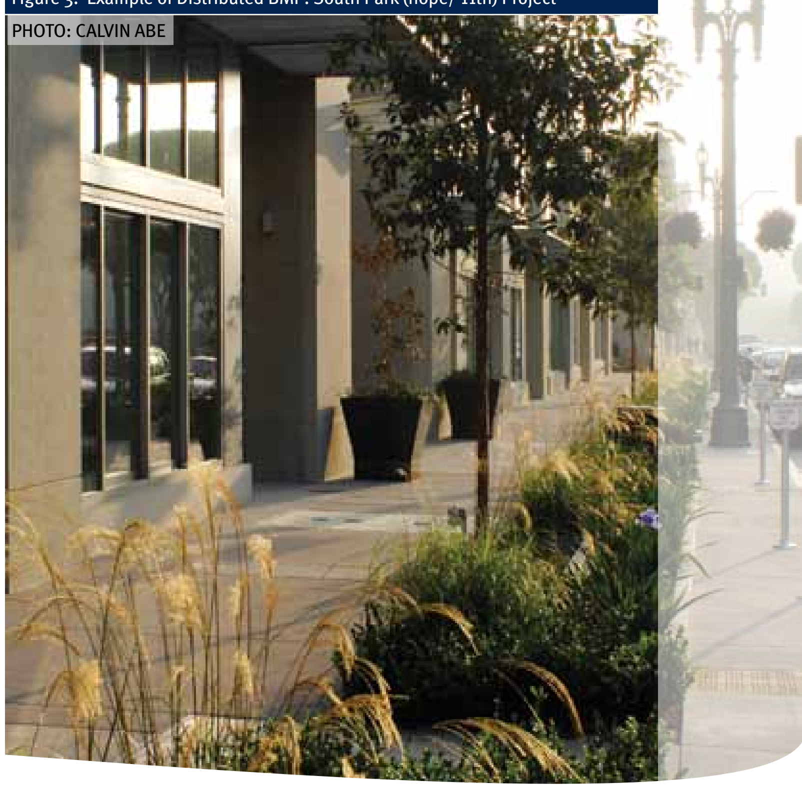
How Effective Are BMPs?

BMP performance is the subject of significant discussion and debate. From a surface water quality perspective, there are three critical elements to consider:

1. Hydrologic variability and design storm. Volume and flow-based design storms are often thought of as static criteria. Some BMPs, however, are highly sensitive to hydrologic conditions in relation to BMP operations. If, for example, captured stormwater takes a long time to infiltrate into the soil, or if diversion of the stormwater to a wastewater system depends on that system's capacity at a given time, then the system dynamics are highly sensitive to the transient storage conditions before and during the storm event. That is, if a system is already filled with stormwater, then a subsequent storm would result in a bypass of the BMP and potential exceedance of water quality targets (Susilo et al. 2009). Thus, particularly

Figure 3. Example of Distributed BMP: South Park (hope/ 11th) Project

PHOTO: CALVIN ABE



for large-scale systems, it is beneficial to evaluate real long-term precipitation data and drawdown rates to predict system effectiveness or to include real-time optimization methods and adapt the system over time (Quigley et al. 2008).

2. Treatment effectiveness. Two major sources of information are available to support the appropriate selection (and prediction of effectiveness) of BMPs. The International Stormwater BMP Database (Geosyntec and Wright Water Engineers 2008) is the most comprehensive database of BMP information and provides statistically based metrics on BMP effluent concentrations by pollutant type and BMP type (see Figure 5). The Water Environment Research Foundation's Critical Assessment of Stormwater Treatment and Control Selection Issues (Strecker et al. 2005) provides guidance based on fundamental unit processes, and emphasizes the importance of understanding pollutant types and forms as well as runoff hydrology before developing a treatment concept. The unit process approach is also incorporated in the Environmental Protection Agency (EPA) SUSTAIN model (U.S. EPA 2009). Both data types are critical to the understanding of BMP performance.

3. Operations and maintenance. If designed properly, BMPs will accumulate target pollutants and will require maintenance. Historically, there has been little effort to link operations and maintenance with BMP selection and required BMP performance. Recent efforts, such the BMP manuals developed for the County of Los Angeles Department of Public Works (2009) and the Los Angeles Unified School District (LAUSD 2009), place a heavy emphasis on maintenance practices.

The consequences of ignoring one or more of the above factors include increased risk of nonperformance of BMPs or worse, an exacerbation of the water quality problem we attempted to solve. There may also be false expectations of BMP performance, particularly when linked to specific pollutants of concern.

Strategies: What Do We Do and Where?

Not all BMP types and strategies are appropriate in all circumstances. For new development and redevelopment, where older regulatory requirements (Standard Urban Stormwater Mitigation Plans) were based primarily on design storm volumes and flow rates, new regulatory requirements appear to be much more prescriptive (e.g., limiting effective impervious areas), and much more focused on the on-site/LID scale of implementation, with a mandated emphasis on retention BMPs.

For agencies faced with Total Maximum Daily Load (TMDL) implementation requirements, opportunities are limited, and the needs are challenging, since the performance requirements include water quality standards-based metrics that differ among impairing pollutants. Regional BMPs have the potential to provide multi-benefit, cost-effective returns on investment and are potentially very valuable tools from the toolbox, but are often limited by land availability.

Figure 4. Example of On-site LID BMP in Parking Lot

PHOTO: GEOSYNTEC CONSULTANTS

Conclusions on Strategy

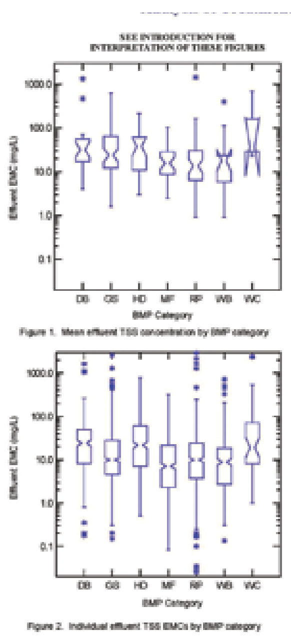
Strategically, examining the issue from a receiving water quality perspective, it is apparent that stormwater quality could benefit from a renewed focus on the use of the entire toolbox on a watershed basis. There are a number of potential arguments in favor of this position:

Design reliability: The state of the practice in stormwater BMPs is still developing. Implementation of a range of BMP strategies allows for adaptive incorporation of successful BMPs and phasing out of non-performing ones.

Long-term reliability: Operations and maintenance are keys to long-term success. Stormwater quality performance should consider variabilities with maintenance practices and the individuals or agencies responsible for maintenance.

System effectiveness and reliability: Regional BMPs are limited by land availability and hydraulics, but are often the last line of defense before discharge to a receiving water. In a developed urban area, covering all areas that contribute to stormwater pollution using only distributed and on-site BMPs is very difficult. It is also much more difficult to ensure that on-site BMPs are maintained over

Figure 5. Example of Effluent Statistics from the International BMP Database



the long-term. In combination, on-site BMPs can reduce flows so that capacity requirements for regional facilities can be reduced, allowing for smaller footprints and more opportunities for placement in a developed urban environment.

Opportunities: In urbanized environments, particularly those with aging infrastructure, the opportunities to improve stormwater quality are more constrained due to existing infrastructure issues, legacy contaminated soils, the cost of land, etc. Opportunities need to be created and then optimized. Encouraging creative solutions such as cross-agency and public-private partnerships can increase the potential to solve the larger water quality problem. Many of these opportunities can have additional public benefits as well (e.g., park or habitat development).

Water resources benefits: In Southern California, water is a valued resource, but water costs (relative to treated stormwater costs) benefit from an extensive water infrastructure. Focusing BMP types in areas with the highest water resources value (e.g., aggressive infiltration in areas that can benefit from supplemented groundwater) provides multiple benefits. Finally, implementing harvest and use strategies that are linked to potable water supply offsets (e.g., direct linkage of stormwater storage capacity to harvested indoor water use for toilet flushing) may not be consistently protective or cost-effective (as demand decreases, available storage decreases, increasing the potential for bypass events).

Perhaps the most pressing challenge to managers of stormwater quality is funding. While California and the Los Angeles Basin benefit from the availability of ballot-driven bond funds, these sources are not sustainable, and region-wide, there are very limited streams of continuous revenue (an exception is Santa Monica's Measure V Program). Integrated strategies have the potential to get access to funding by a) providing multiple mutual benefits and tapping into other funding sources (e.g., parks development, water supply, flood mitigation, street maintenance funds, urban forests, etc.); b) encouraging linkages to environmentally sensitive redevelopment, consistent with smart growth principles (Crabtree 2010) while creating new stormwater project opportunities; and c) demonstrating fiscal stewardship and promoting cost-effective strategic approaches in conjunction with sustainable funding strategies.

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