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Urban Streams

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Editor
Allan E. Dittmer

Design/Layout
Nick Dawson
University of Louisville
Design & Printing Services

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Send electronic correspondence to r.barnett@louisville.edu

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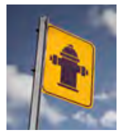

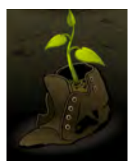

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Urban Streams

A solar powered filatration system installed for research on Beargrass Creek in Louisville, Kentucky.

The Most for the Least: Optimizing Water Pollution Reduction

Reid Christianson
Water Resources Engineer
Center for Watershed Protection, Inc.

Introduction

How much is a pound of nitrogen worth? The farmer might say it runs around $0.52 per pound. Somebody looking to use liquid nitrogen for cooling might say $5.50 per pound. When you ask somebody involved in reducing urban nitrogen runoff to the Chesapeake Bay, the answer will likely range from $100 to $10,000 per pound. Removing nitrogen once in our water is no small task, as can be inferred from the range in estimated costs, but this task, as well as restoring hydrologic function in our urban streams, is before us in many areas of the United States.

The cost per pound of pollutant reduction has become an important issue to local jurisdictions (towns, cities, counties, and states) since the initiation of stormwater management permits and the Total Maximum Daily Load (TMDL) process. Cost estimates for implementing stormwater management strategies are typically an order of magnitude higher than the cost to reduce pollution from other sources, because of the expense associated with modifying existing infrastructure, as is often required with stormwater retrofits.

The suite of urban stormwater retrofits available for use seems to grow each year. While providing additional options is never a bad thing, comparison between options and proper selection become increasingly important. Also, depending on the watershed being considered there could be other or additional water quality goals such as a reduction in phosphorus or sediment. Since each type of stormwater management practice has different removal capabilities for various water pollutants, not to mention varying costs, selecting appropriate measures becomes a difficult process.

Finally, having proper conditions in your watershed to implement the most cost effective stormwater management practice to meet all water quality goals is usually unrealistic. For example, there is likely not space to install ponds everywhere or the proper soil to install infiltration practices, meaning a suite of stormwater best management practices (BMPs) will be needed. Any actions taken to help select one BMP over another and reduce overall costs associated with these BMPs tend to be well worth the effort.

The Clean Water Optimization Tool

In an effort to help those tasked with improving water quality in their watershed, The Center for Watershed Protection Inc. (CWP) has recently developed the Clean Water Optimization Tool (CWOT). This tool focuses on using local knowledge as well as general cost trends to help select the most appropriate watershed-wide BMPs based on cost effectiveness for a given pollutant and watershed goals.

The initial development of the model was in response to the Chesapeake Bay TMDL, which has Watershed Implementation Plans (WIPs) as a component. A WIP is a plan set up by the states in the Bay Watershed to reduce a defined amount of nitrogen, phosphorus, and sediment being delivered to the Bay by the stormwater, agricultural, wastewater, septic, and forest sectors. Maryland opted to have each county in the state create a separate WIP, which was intended to use more local information for BMP selection and acceptance. This effort, particularly on the stormwater sector side, highlighted the need for proper BMP selection since the price tag associated with initially developed plans tended to be beyond what county budgets would accommodate.

Because the CWOT is a planning level tool, the intended use would be on a watershed or county scale. Detailed inputs required by site specific models are not needed due to generalized information about watershed/county characteristics, BMP functionality, and BMP cost being used. Though the tool is pre-

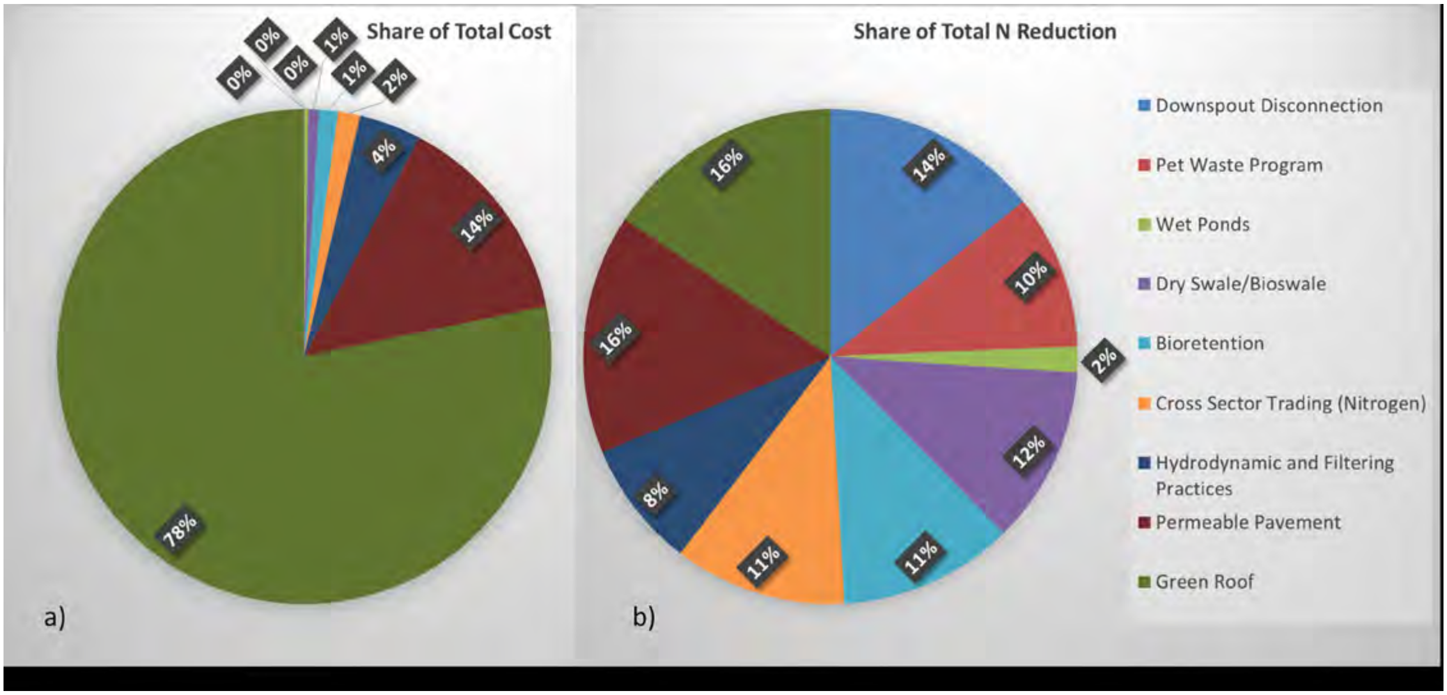

Figure 1. Graphic from the Center for Watershed Protection's Clean Water Optimization Tool showing a) the portion of cost associated with each BMP entered into the tool and b) the portion of total nitrogen reduction associated with each BMP. The level of implementation for a and b is the same.

populated with Maryland county land use and loading rates for nitrogen, phosphorus, and sediment, these are all modifiable, making local knowledge about BMP implementation potential a powerful component in realistically reducing costs.

Information included in the CWOT about BMP functionality largely came from the various expert panel reports put out by the Urban Stormwater Workgroup (A Chesapeake Bay Program entity tasked with coming up with urban stormwater recommendations). For those BMPs yet to have recommendations, CWP developed functionality based on in-house research or literature.

Cost information primarily came from King and Hagan, (2011), which were adjusted for inflation to 2014 dollars. Additional assumptions about cost came from CWP (2013). Though default costs have been incorporated into the CWOT, user overrides are available, and encouraged, to provide scenarios as realistic and locally applicable as possible.

Since not all stormwater management practices are the same in terms of pollutant reduction and cost, opportunities exist to optimize implementation. Optimization in the CWOT is based on user supplied and/or default information to select the most cost effective BMP first. This BMP is fully implemented to the maximum practical treatment entered by the user. If pollutant reduction goals are met, no other BMPs are added, as they are not needed to meet water quality goals. Accurate input, specifically on the maximum practical units treated, is critical when considering optimization, as this will determine future pollutant reduction as well as budgetary requirements.

Maximum practical units treated, though sounding complex, is a relatively simple concept where for each BMP the user enterers the amount of acres (or linear feet, or number of pet waste stations) potentially treated by that BMP in the watershed. If fully developed, the maximum practical units treated is, by far, the hardest component to develop for each BMP. That being said, partial development of practical units treated can be done. The following examples show partial and full development of maximum practical units treated, and how results can be used to inform watershed decisions.

As much as possible – given perceived watershed constraints

To illustrate the use of the CWOT, a BMP scenario was developed for a hypothetical watershed – Golden Oats. Goals for this rural dominated watershed, as defined by a local nutrient TMDL, include reductions in urban runoff total nitrogen (TN) of 40,000 pounds per year and total phosphorus (TP) by 750 pounds per year.

Rather than fully developing the maximum practical units treated, the Watershed Planning Department decided to start with general knowledge of the watershed they had as a collective and only consider BMPs they had experience with. They decided to call this scenario "perceived watershed constraints" as inputs were primarily subjective. Results indicated goals were NOT met, with only 6,200 lbs of annual TN reduction and 490 lbs of annual TP reduction at an annual cost of $17.8 million annually; however, though little effort went into this initial scenario, the

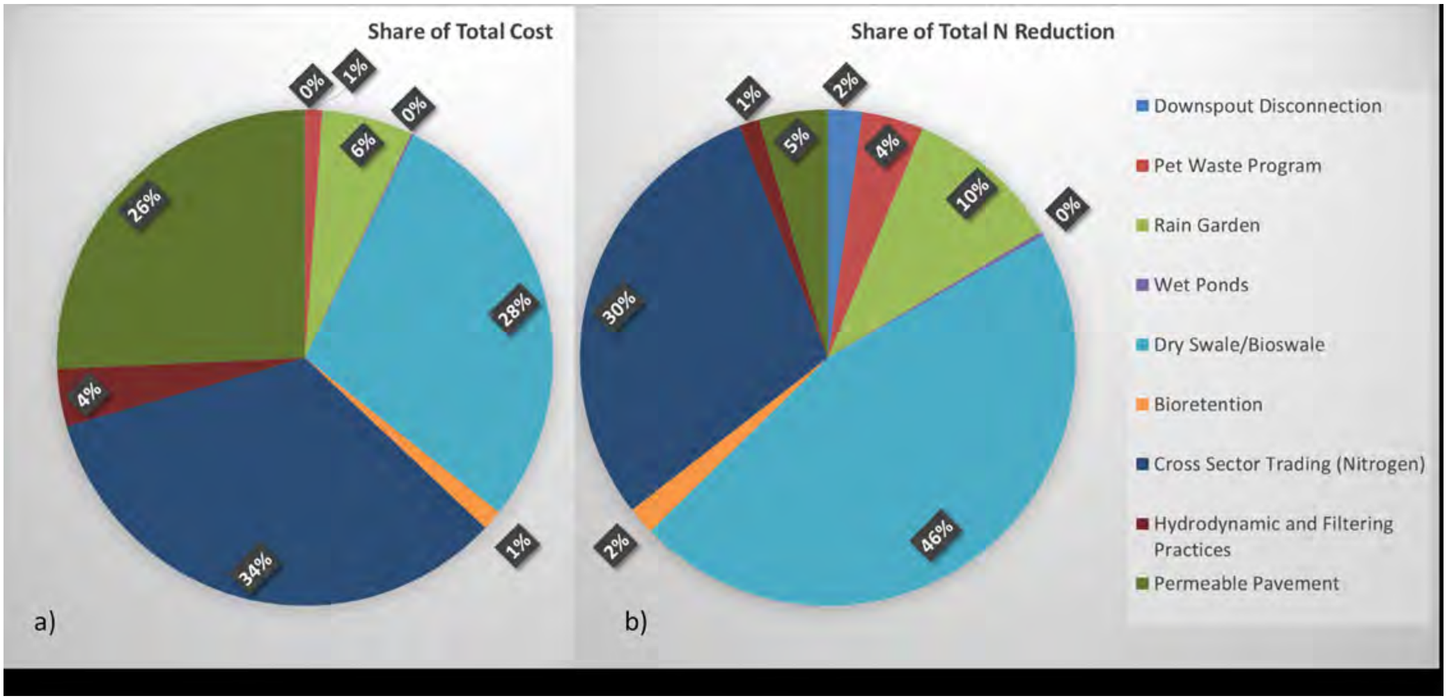

Figure 2. Graphical output from the Center for Watershed Protection's Clean Water Optimization Tool showing a) the cost percentage of each BMP entered into a revised example scenario (compare to Figure 1a) and b) the portion of total nitrogen reduction associated with each BMP.

group also noted results were helpful in reconsidering initially selected BMPs. For example, Figure 1a shows implementation of green roofs constitutes 78% of the total cost of this initial scenario. When, subsequently, looking at Figure 1b, which shows the relative amount of nitrogen reduction, it is apparent green roofs, in this example, provide relatively little nitrogen reduction when considering the costs. With this information, it is possible to reevaluate the heavy use of green roofs in this watershed.

Though overwhelmed by the price and disappointed by the reductions associated with the initial scenario, the group decided to reallocate the money spent on green roofs in the initial scenario towards more permeable pavement, a residential rain garden program, an expansion of a pet waste program, a dry swale initiative, and developing a cross sector trading program (essentially buying reductions from the agricultural community). Portions of this second scenario were based on results from a homeowner survey showing acceptance of rain gardens as well as responses indicating pet waste stations would be heavily used, if placed in the proper locations. Dry swales were suggested due to adequate topographic relief in the watershed, cross sector trading was considered due to the relatively large amount of agricultural land, and permeable pavement was increased as several parking lots were slated for repaving in the relatively near future. Now, total cost is similar to the initial scenario at $17.5 million annually, but reductions for TN and TP are 39,400 lbs/year and 1,650 lbs/year, respectively. Costs and removals are more balanced in this scenario, which implies better cost efficiency (Figure 2a and b).

More than enough – now let's get the cost down

The previous example was showing how a comparison tool could be used in the simplest sense – to basically compare BMPs. In this example, the same Golden Oats Watershed Planning Department decided to fully develop the maximum practical implementation of a large suite of BMPs using in-depth GIS analysis, watershed-wide survey data, green infrastructure connectivity goals (determined by the Natural Resources Development Committee), and priority areas for the local land conservation group to determine maximum practical units treated for the suite of BMPs. The idea was to provide more than enough pollutant reduction potential than was needed (not being concerned, at this point, with the budget).

Also taken into account was the standardization of retrofitting ditches (ditch enhancement) to provide stormwater filtering through the conversion to a dry swale. The standardization effort served to decrease the annual practice cost by 60% (to $1,500 from $3,840 per impervious acre pear year over 20 years). Standardization entailed a generic construction detail to allow rapid implementation of conversions of ditches to dry swales. Along with this effort the Soil Conservation District in the watershed agreed to streamline permitting for projects like this, as the disturbance was minimal and ditch hydraulics would be minimally impacted.

The list of BMPs after fully evaluating maximum practical units for each across the watershed consisted of 14 practices

Table 1. Maximum practical units available and units used for selected best management practices (BMPs) used to meet local water quality goals required by a Total Maximum Daily Load (TMDL) associated with the Golden Oats watershed.

Stormwater BMP	Maximum Practical Units Treated (acres)[1,2]	Optimized Units Treated (acres)[2] to meet Water Quality Goals
Permeable Pavement	58	0
Permeable Pavers	21	0
Rainwater Harvesting	250	0
Stormwater Planter	1	0
Green Roof	250	0
Downspout Disconnection	372	372
Bioretention	500	0
Rain Garden	625	11
Vegetated Filter Strip	120	0
Ditch Enhancement/Retrofit	3,000	3,000
Forest Buffer	500	500
Impervious Cover Removal	50	0
Outfall Netting System	600	0
Stream Restoration	12,000 lf	12,000 lf

[1]Each BMP in this example has an associated set of assumptions outlining where potential implementation would/could occur.

[2]Stream restoration is measured in linear feet (lf).

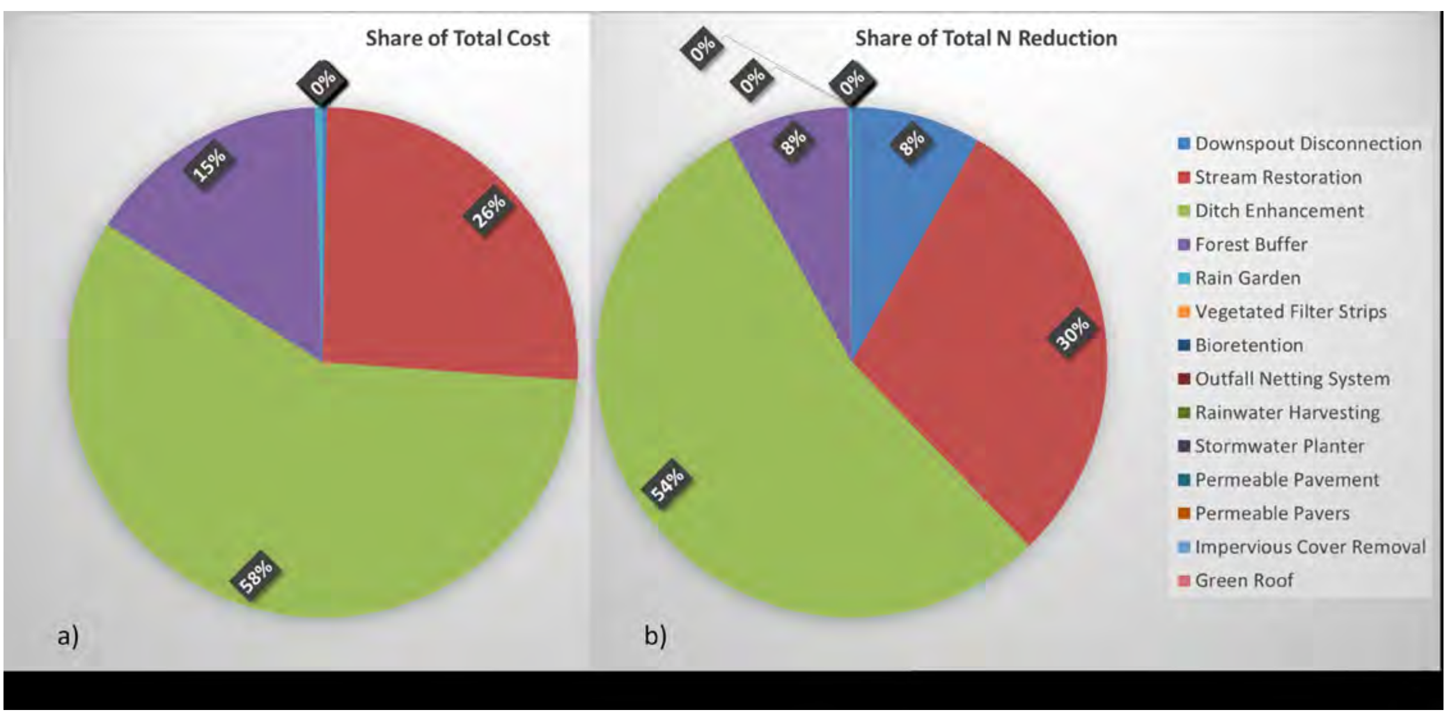

Figure 3. Graphical output of the Center for Watershed Protection's Clean Water Optimization Tool showing a) the portion of cost associated with each BMP and b) the portion of total nitrogen reduction associated with each BMP entered into the Golden Oats watershed example.

(Table 1), with an emphasis put on using the extensive ditch network in this watershed as prime locations for retrofitting. Also, when reviewing previous Natural Resources Development work, the group noticed 12,000 linear feet of severely degraded urban streams called out in their report, which seemed like a prime focus area and was included in the analysis.

Looking at the results from this effort in Table 1, it is apparent the TMDL goals could be met with an optimized subset of BMPs. Of course, this result may lead to further refinement of BMP selection criteria (and subsequent reallocation of funds). Evaluating the cost breakdown (Figure 3) and seeing a large portion of the cost (15%) coming from forest buffers, the team may suggest investigating a potential alternative BMP (i.e. this process could be refined further).

The annual price for the optimized scenario was $3.9 million annually, which suggests effort put into determining how many acres could practically be treated with a given BMP could, literally, save millions of dollars when compared to the initial example at more than $17 million annually.

Concluding Thoughts

Achieving water quality goals is no small task. When a plan is settled on, the associated price tag tends to leave folks scratching their heads and feeling a bit like the effort is hopeless. Being able to take a hard look at the developed plan and quickly evaluate potential alternatives using planning level estimates like those provided in the Clean Water Optimization Tool is a critical component to responsibly pursuing our water quality goals.

Reducing costs through continual advances in BMP technology (Law, Christianson, Fraley-McNeal, & Hoffmann, 2014) and development of "smart" BMPs to increase practice efficiency will continue and the number of tools in our toolbox will grow. Every advance will help; however, there is no real substitute for practices on the ground to mitigate the negative impacts associated with impervious cover.

Reid Christianson is a water resources engineer for the Center for Watershed Protection. Reid is a professional engineer in Iowa and Maryland, has been working in the water resources arena for over 10 years, and has a PhD in Biosystems Engineering from Oklahoma State University. He works on many types of projects from stormwater management design to watershed implementation plans.

References

CWP. (2013). Cost - Effectiveness Study of Urban Stormwater BMPs in the James River Basin: Center for Watershed Protection.

King, D., & Hagan, P. (2011). Costs of stormwater management practices in Maryland counties. *University of Maryland Center for Environmental Science*. Solomons, MD.

Law, N. L., Christianson, R. D., Fraley-McNeal, L., & Hoffmann, G. (2014). Building the Next Generation of Smart BMPs: Media Enhancements for Phosphorus Removal. *Watershed Science Bulletin*, 5(3).