AEN-132

University of Kentucky
College of Agriculture, Food and Environment
Cooperative Extension Service

Modeling Best Management Practices

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As rainfall becomes runoff and flows over the land (i.e. overland flow) to the watershed outlet, it picks up pollutants such as sediment, nutrients, and pathogens (Figure 1). These pollutants enter waterbodies such as streams, rivers, and lakes, reducing the quality of the water. One way to protect the health of our waterbodies is through the use of best management practices.

What is a Best Management Practice?

A best management practice (BMP) is a process or structure that helps protect the health of waterbodies by reducing the transport of pollutants or the volume of runoff that reaches them. The focus of BMPs is on the reduction of nonpoint source (NPS) pollution. NPS pollution is diffuse meaning it comes from many locations in a watershed and not a single point such as a pipe (Figure 2). Some BMPs focus on the source of the pollutant such as with picking up trash and pet waste and implementing sediment and erosion control techniques. Other BMPs are physical structures that seek to increase infiltration, filtration and/or storage of runoff as a means of reducing pollutant loads.

The ability of a BMP to reduce NPS pollution is location and pollutant specific. Examples of BMPs include riparian or streamside buffers (Figure 3), vegetated filter strips, and rain gardens. Some BMPs work best on flatter land while others work well on steeper slopes. One BMP may work better at removing nitrogen from runoff while another is better at filtering out sediment. Understanding the effectiveness of BMPs based on their location in the watershed and in relation to different types of pollutants is an important part of protecting waterbodies. One way to do this is with the use of models.

Figure 1. As runoff flows over the land to waterways, it can pick up pollutants such as sediment, nutrients, and pathogens.

Source: Amanda Gumbert, Agricultural Programs

Figure 2. (a) Nonpoint source (NPS) pollution is diffuse, meaning it comes from many locations in a watershed, unlike (b) point source (PS) pollution, which comes from a single location.

Source: Carmen Agouridis, Biosystems and Agricultural Engineering

Figure 3. A riparian or streamside buffer is an example of a best management practice commonly used in both agricultural and urban watersheds.

Source: Amanda Gumbert, Agricultural Programs

What is a Model?

A model is anything that simplifies a complex real-world system allowing us to better understand processes or systems. Examples of models include mathematical equations, physical three-dimensional structures, and drawings. A watershed model is a tool that helps us understand how water is circulated through the hydrologic cycle and how contaminants are carried and transformed in the landscape. Watershed models use information about soils, land use, topography, climate, stream flow, nutrient and sediment concentrations and the like to help simulate rainfall-runoff responses.

Watershed models are helpful in evaluating the effectiveness of BMPs. Engineers and designers use such models to evaluate the ability of currently installed and proposed BMPs to improve water quality and reduce runoff volumes and peaks. Because the benefits gained through BMP implementation vary with local landscape characteristics and pollutant loads

and types, watershed models can help planners select an optimal combination of BMPs with regards to their cost and effectiveness.

Commonly Used Models

A number of watershed models are available for evaluating the effectiveness of BMPs. The type of model selected depends in part on the dominate land use, generally either agricultural or urban, the size of the watershed (i.e. drainage area), and the type of BMPs which the modeler wants to simulate (Table 1).

Agricultural Models

AGNPS (Agricultural Non-Point Source Pollution Model) and AnnAGNPS (Annualized Agricultural Non-Point Source Pollution Model)

Designed by the U.S. Department of Agriculture, Natural Resource Conservation Service, the AGNPS, and AnnAGNPS models are useful for studying the effects of watershed management decisions on hydrology, sediment and nutrient loading. The AnnAGNPS module allows the user to evaluate the risks and costs/benefits of various BMPs at reducing pollutant loads. Examples of BMPs evaluated in the models include riparian buffers, vegetated buffer strips, wetlands, fertilizer application rates, conservation tillage, controlled grazing, and grade stabilization. To learn more about AGNPS and AnnAGNPS and to download the models, visit http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/mt/home/?cid=stelprdb1042468.

SWAT: Soil and Water Assessment Tool

SWAT is a long-term continuous simulation model developed by the U.S. Department of Agriculture, Agri-

Table 1. Summary of Models Commonly Used to Evaluate BMP Effectiveness.

Model	Example BMPs Simulated	Source
Agriculture		
AGNPS and AnnAGNPS	Riparian buffers Vegetated buffer strips Wetlands Fertilizer application rates Conservation tillage Controlled grazing Grade stabilization	U.S. Department of Agriculture, Natural Resource Conservation Service
SWAT	Wetlands Vegetated filter strips Grassed waterways Controlled grazing Conservation tillage Grade stabilization Field terraces Modified fertilizer and pesticide application rates	U.S. Department of Agriculture, Agricultural Research Service
WEPP and Geo-WEPP	Conservation tillage Modified crop rotations Buffer strips	U.S. Department of Agriculture, Agricultural Research Service
Urban		
SUSTAIN	Rain barrels Rain gardens Constructed wetlands Wet and dry ponds Grassed swales Vegetated filter strips Sand filters Green roofs Permeable pavement	U.S. Environmental Protection Agency
SWMM	Rain barrels Rain gardens Green roofs Permeable pavement Street planters Infiltration trenches Vegetative swales	U.S. Environmental Protection Agency

cultural Research Service. The model operates on a daily time step and is designed to evaluate the impacts of BMPs on hydrology and water quality. SWAT has been used worldwide to model sediment, nitrogen and phosphorus load reductions associated with BMPs such as wetlands, vegetated filter strips, grassed waterways, controlled grazing, conservation tillage, grade stabilization, field terraces, and those related to fertilizer and pesticide application rates. To learn more about SWAT and to download the model, visit http://swat.tamu.edu/.

WEPP and Geo-WEPP

The WEPP and GeoWEPP models were developed by the U.S. Department of Agriculture, Agricultural Research Service. WEPP is a physically-based soil erosion simulation model that integrates hydrology, hydraulics, and plant and soil science. Geo-WEPP uses digital georeferenced information, such as a digital elevation model (DEM) to prepare model inputs. WEPP allow for the examination of BMPS in agricultural, rangeland and forested watersheds. Examples of BMPs evaluated in the models include conservation tillage, modified crop rotations, and buffer strips. To learn more about WEPP and Geo-WEPP and to download the models, visit http://www.ars.usda.gov/News/docs.htm?docid=10621.

Urban Models

SUSTAIN: System for Urban Stormwater Treatment and Analysis Integration

Developed by the U.S. Environmental Protection Agency, SUSTAIN is a model designed to aid stormwater professionals in the development of plans to better manage the quantity and quality of runoff from urban areas. SUSTAIN aids in the selection of an optimal combination of BMPs, based on cost and effectiveness, at the watershed scale. The model allows for the evaluation of multiple BMPs such as rain barrels, rain gardens, constructed wetlands, wet and dry ponds, grassed swales, vegetated filter strips, sand filters, green roofs, and permeable pavement. To learn more about SUSTAIN and to download the model, visit http://www2.epa.gov/water-research/system-urban-stormwater-treatment-and-analysis-integration-sustain.

SWMM (Storm Water Management Model)

SWMM was developed by the U.S. Environmental Protection Agency to aid in the management of stormwater in urban environments. The model primarily examines the hydrologic performance of urban BMPs though it can assess their ability to reduce wet weather pollutant loads. Examples of BMPs evaluated in the model include rain barrels, rain gardens, green roofs, permeable pavement, street planters, infiltration trenches, and vegetative swales. To learn more about SWMM and to download the model, visit http://www2.epa.gov/water-research/storm-water-management-model-swmm.

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Issued 10-2016