EXECUTIVE SUMMARY

Stormwater Management Optimization Toolbox

ESTCP Project RC-201305

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ACRONYMS AND ABBREVIATIONS

APG	Aberdeen Proving Ground
BMP	Best Management Practice
DoD	Department of Defense
EISA	Energy Independence and Security Act
ERDC-CERL	Engineer Research and Development Center - Construction Engineering Research Laboratory
MST	Model Selection Tool
NAS	Naval Air Station
RAE	Relative Absolute Error
SMOT	Stormwater Management Optimization Toolbox
SUSTAIN	System for Urban Stormwater Treatment Analysis and Integration
SWMM	Stormwater Management Model

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1.0 INTRODUCTION

As stormwater regulations for hydrologic and water quality control become increasingly stringent, Department of Defense (DoD) facilities are faced with the complex and difficult task of simultaneously complying with multiple laws and regulations, such as the Energy Independence and Security Act (EISA) of 2007 and the Clean Water Act Total Maximum Daily Loads, as well as the need to secure Municipal Separate Storm Sewer Systems permits. This often requires facilities to plan, design, and implement structural best management practices (BMPs) to capture, filter, and/or infiltrate stormwater runoff. These requirements can be complicated, contradictory, and difficult to plan. As a result, many DoD facilities overbuild or oversize these BMPs to ensure compliance.

2.0 OBJECTIVES

This project demonstrated the Stormwater Management Optimization Toolbox (SMOT), a spreadsheet-based tool specifically designed to help DoD facilities achieve compliance with regulatory stormwater requirements at minimal cost. The demonstration took place in two phases: (1) a phase that demonstrated that the recommendations of the Model Selection Tool (MST) accurately result in the minimum BMP cost for 45 facilities located in regions with widely varying climatic and regional conditions, and (2) a demonstration of SMOT at two facilities to showcase the capabilities of the model platforms, illustrate the ease of implementation, and ultimately validate the model selection element.

3.0 TECHNOLOGY DESCRIPTION

SMOT is a spreadsheet-based tool comprised of the MST, Scaled Model Platforms, and BMP Sizing Tool/Master Plan. SMOT has the ability to effectively analyze and plan for BMP implementation, resulting in potential cost savings by reducing BMP sizes while simultaneously achieving compliance with multiple objectives. SMOT identifies the most cost-effective modeling method based on an installation's local conditions (soils, rainfall patterns, drainage network, and regulatory requirements).

SMOT uses national datasets to gather watershed characteristics information, and then processes the information through the MST, which makes recommendations of the modeling method to use. SMOT recommends one modeling method out of three possible alternatives: a simple design storm approach (e.g., the 95th percentile rainfall treatment), a simple continuous simulation approach, or a continuous simulation approach that is coupled with optimization.

After the MST identifies the general modeling method, specific watershed models identified in the Scaled Modeling Platforms are used to carry out the modeling analysis. Modeling results from the recommended platform are then fed into the BMP Sizing Tool to guide the implementation process. The BMP Sizing Tool within SMOT estimates the required new development BMP sizes for the subwatershed in which the new development occurs, the area of the new development, and the desirable type of BMP to be implemented.

On the basis of the modeling results, the BMP Sizing Tool interpolates the BMP volume and area required (expressed in the depth of runoff to be captured/infiltrated) as development occurs in the subwatershed of interest. If development is planned for a subwatershed with constraints identified, SMOT helps select a substitute location (subwatershed) within the larger watershed with higher potential infiltration than the proposed development subwatershed. The BMP Sizing Tool allows a design engineer to select the type of BMP, to size the BMP, and to customize layer depths of a BMP. Finally, SMOT provides a basic report of the selected BMP including typical cross-section of the BMP and major dimensions.

SMOT is able to assist with various stormwater management efforts, from analysis method selection (MST), to actual modeling analysis (Scaled Modeling Platforms), to final BMP implementation (BMP Sizing Tool or BMP Master Plan) across DoD facilities. The Toolbox is expected to help DoD facilities achieve substantial cost savings during the process of complying with stormwater regulations.

4.0 PERFORMANCE ASSESSMENT

In Phase 1, the project team effectively demonstrated the MST at 45 installations located in regions with varying climatic and regional conditions.

MST was able to match runoff predictions by the Stormwater Management Model (SWMM) with a strong correlation of R2>0.98 and a low relative absolute error for total runoff volume (relative absolute error [RAE]<10%). When MST was assessed against the System for Urban Stormwater Treatment Analysis and Integration (SUSTAIN) overflow, MST was able to mimic outputs with a high level of correlation (R2>0.99) and a close approximation in total run-off volume (RAE<10%). It was concluded that the MST could serve as a reasonable alternative to the SWMM for runoff volume, and to the SUSTAIN model for BMP simulations.

In Phase 2, the project team successfully demonstrated SMOT at two facilities, Aberdeen Proving Grounds (APG) and Naval Air Station (NAS) Key West. The team conducted full-scale demonstrations using detailed modeling approaches for continuous simulation coupled with or without optimization (SWMM or SUSTAIN). These modeling approaches were applied at a single subwatershed at each installation and then at the subcatchment basin for NAS Key West. The selected subwatersheds within each installation had development potential, so modeling was conducted for 30%, 60%, and 90% impervious surfaces. BMP size results from the full-scale modeling efforts were compared against each of the modeling approaches, and finally against the original MST recommendations and SMOT outputs. For APG, the BMP size results from the full-scale modeling efforts resulted in outputs within 10% of each other and greater than the continuous approach by 10% for the Design Storm approach. These results confirm that optimization does not yield significant savings for APG and that the recommendations from MST and detailed modeling efforts are consistent at APG.

Full-scale modeling at NAS Key West identified that continuous simulation done both with and without optimization resulted in BMP sizes that were 10% smaller in size than the continuous simulation. When models were applied at the subcatchment scale, the resulting BMP sizes again confirmed that the continuous simulation with optimization was the correct modeling approach for NAS Key West. These results validated the MST outputs and confirmed that the MST is appropriate and applicable at all scales.

5.0 COST ASSESSMENT

The cost model for SMOT validation mainly consisted of labor and resources associated with modeling analyses, as well as the construction costs for the proposed BMPs. BMP costs were determined from completing a comprehensive regional analysis to determine planning-level region specific construction costs. Regional labor rates were used to determine costs for generation of design plans and modeling analysis for corresponding BMPs, stormwater systems, and modeling approaches. For each of the demonstration sites, MST identified the most cost-effective modeling approach, resulting in projected savings of approximately 21-77%.

6.0 IMPLEMENTATION ISSUES

MST, a major component of SMOT, recommends the most cost-effective modeling approach based on installation specific information input by the user. As SMOT is applied at an installation, the user first prepares baseline watershed characteristics data that will be input into the toolbox. Although MST was developed to use readily available input characteristic data, the need for user input to inform baseline data about the installation being considered (such as long-term precipitation records) presents the most significant implementation issue for SMOT and its components.

There are two primary implementation issues with SMOT – both data related. Limited long-term precipitation records for installations with either no or limited long-term rain gauges will require user knowledge to "fill-in" the 10-year plus requirement for rainfall timeseries. And installations with limited geospatial data for infrastructure of the area of interest will require additional data collection or will have over- or underestimated results. The use of SMOT has the potential to help DoD identify appropriate modeling approaches and significantly reduce BMP implementation costs.

SMOT helps eliminate the guesswork of selecting a model method; it can reduce modeling costs by predicting when sophisticated modeling can be avoided; it can help reduce BMP sizes and costs through optimization when it is cost-effective; and finally, it can streamline the compliance and design processes by providing simplified guidance in the form of a BMP Sizing Tool or Master Plan.