PRELIMINARY SCOPE OF WORK
Mechanistic Studies on Pollutant Removal by Stormwater BMPs
(SMC Research Agenda Project 3.1)

Problem Statement
Most structural BMPs are treated as a "black box". Untreated stormwater enters the BMP, treatment occurs, and then stormwater exits the BMP. This influent-effluent concept is the cornerstone of BMP performance monitoring. Managers hope that stormwater volumes and/or pollutant concentrations decrease from influent to effluent.

What treatment processes occur as stormwater flows through the structural BMP is not well studied and frequently unknown. Likewise, BMP design often follows rules of thumb, rather than deliberately creating conditions to systematically induce treatment. The lack of process based design and implementation contributes to widely variable and frequently unpredictable BMP performance.

Structural BMPs can facilitate a large variety of physicochemical and biological processes to capture stormwater and remove contaminants, with proper attention given to design specifications. These processes include, but are not limited to, infiltration, sedimentation, filtration, sorption, ion-exchange, oxidation/reduction, biodegradation, and phytoremediation. The degree to which any of these elements are successful depends on characteristics within the BMP itself, including characteristics of materials used (such as engineered media) and flow conditions (e.g., residence time, mixing or contact time with treatment materials).

The aim of this proposal is to identify and quantify the treatment processes for removing different pollutants from stormwater within a structural BMP. The quantitative information on pollutant treatment and removal can then be utilized for optimizing structural BMP performance, setting design standards for structural BMP construction, and assessing when structural BMPs are not performing optimally and may require maintenance or retrofit.

Developing a process-based, mechanistic understanding of treatment directly leads to BMP design procedures that can guide engineers to match a pollutant to the appropriate treatment procedure (i.e., filtration, sorption, degradation, etc.) Ultimately, this will enable watershed managers – either regulators or regulated members of the SMC – to choose the structural BMP design characteristics that best satisfies the water quality objective(s) with confidence that pollutant-specific treatment processes will support consistent performance.

General Approach
This project will require 5 tasks.
1. Identify the BMP type and pollutants to evaluate
2. Literature review to identify existing knowledge on water quality treatment processes and mechanisms for this engineered BMP
3. Conduct detailed experiments in controlled environments to quantify treatment processes and identify operating conditions required to support the processes
4. Conduct field validation of predicted treatment effectiveness from controlled studies
5. Mechanistic treatment process documentation, design engineer training, and assimilation into design guidance manuals

Detailed Tasks

1. Identify the BMP type(s) and pollutant(s) to evaluate

There are a large variety of structural BMPs used across the landscape of southern California and an equally large variety of pollutants of concern to watershed managers. Direct quantification of the pollutant treatment processes in of any BMP-pollutant combinations would be beneficial, , but would require an enormously large effort.

Biofiltration is selected as the focus of this project since it is the most common structural BMP in southern California. These structural BMPs have an almost endless number of designs, but have four features in common: a) stormwater inlet, b) ponding zone (for sedimentation and UV exposure); c) engineered media (for filtration, sorption, ion exchange, degradation, etc.), and c) overflow and outlet.

Bacteria, nutrients (nitrogen compounds), and trace metals are the focus of this project since they are the most common pollutants of concern in southern California.

Data from the SMC's Regional BMP Monitoring Program will be used to identify which BMP design and which pollutants to focus on first. Design attributes (i.e., media characteristics) from the best performing structural BMP(s) in the Regional Monitoring Program will be selected for quantification of treatment mechanisms and processes. It is anticipated that media characteristics and outlet configurations including internal water storage zones or other hydraulic controls will be design attributes of importance.

2. Literature review to identify existing knowledge on water quality treatment processes and mechanisms.

Conducting a literature review for state of the knowledge on treatment mechanisms and processes for the selected structural BMP and pollutant combination is essential before starting any quantification or testing. The literature review will help focus testing efforts on the specific processes that will be most important to evaluate. The literature review will prevent duplication of effort, decrease testing time, and save money.

3. Conduct detailed experiments in controlled environments to quantify treatment processes

Quantifying treatment processes represents looking inside the "black box" of a BMP to identify why and how treatment occurs (or not). This taskis perhaps the most challenging and complex of the project tasks. Quantifying treatment mechanisms and processes requires controlled testing of BMP design parameters. Different factors such as media types, mixes of media types, influent concentrations, flow and pollutant loading rates, residence time, age, and others can influence treatment mechanisms and processes. To quantify treatment mechanisms and processes, controlled experiments will vary these factors one at a time across a range of local conditions. By examining physicochemical attributes of the media (grain size, pore size, surface to volume ratio, electrical conductivity, density, cation and anion exchange capacity, pH, hydrophobicity, oxic/anoxic/hypoxic conditions, etc.) combined with analysis of influent, effluent and in-media pollutant concentrations, engineers can discern the optimal treatment conditions for each pollutant type. Ultimately, a mechanistic model of treatment processes will be developed.

4. Conduct field validation of predicted treatment effectiveness from controlled studies

Mechanistic models of the treatment processes will enable engineers to predict treatment effectiveness for BMPs of varying designs. This task will utilize an SMC member-constructed

BMP to field validate the mechanistic treatment model developed during the controlled studies. New BMPs are being designed and constructed continually in southern California. These BMPs make an excellent target for this task. Ideally, the project team will work with the SMC member agency to design a BMP with the optimal performance design attributes predicted by the controlled lab experiments in the previous task.

Sampling will occur during wet weather or during simulated rainfall with spiked pollutant concentrations (or both). A minimum of three to six storms will be required for sampling of influent, effluent and in-media pollutant concentrations, as well as hydrological flow at the inlet, outlet, and through the structural BMP. In this way, the project can quantify mechanisms and processes in the field, and update any structural BMP models, if necessary.

5. Mechanistic treatment process documentation, design engineer training, and assimilation into design guidance manuals

Critical to the success of this project is to make sure SMC member agencies have access to the information and can use it for application within their jurisdictions. This will require proper documentation of the mechanism and treatment quantification through reports and publication. It will also require training of design engineers throughout the region to ensure the ideal structural BMP design parameters are well-understood by the experts and tradespersons to utilize the information accurately and appropriately. The project team will identify opportunities at CASQA and at each SMC member agency to conduct this face-to-face, hands-on training to accompany the documentation. Finally, once there is a well-trained group of practitioners, the application of the design guidelines for optimal mechanisms and processes should be assimilated into guidance manuals and design standard manuals. For example, the recommended design parameters from this study should be incorporated into the SMC's and CASQA's Low Impact Development (LID) Guidance Manuals. Individual SMC members may choose to put them in their individual design guidance manuals for land developers within their jurisdictions.

Products and Schedule

This project will require 36 months to complete based on the need to sample multiple wet seasons. Time may be extended for additional pollutants or BMPs

Task	Product	Schedule
Identify the BMP type and pollutants to evaluate.	SMC presentation recommending the list of BMP(s) and pollutant type(s)	6 months from project start
Literature review to identify existing knowledge on water quality treatment processes and mechanisms for this engineered BMP	SMC presentation summarizing state of the knowledge and a workplan for controlled testing	9 months
Conduct detailed experiments in controlled environments to quantify treatment processes	Technical memo documenting controlled experiment results	24 months
Conduct field validation of predicted treatment effectiveness from controlled studies	Technical memo documenting validation results	30 months

Mechanistic treatment process documentation, design engineer training, and assimilation into design guidance manuals	Draft and final Report, model design standard text for manuals, at least three training workshops	36 months

Resources / Budget

This project is estimated to require at least $700,000. The budget does not include construction of the BMP, and will leverage SMC member agency BMP Regional Monitoring and installations. Up to $500,000 may be available through leveraged grant funding.

Task	Cost
1. Identify the BMP type and pollutants to evaluate.	$50,000
2. Literature review to identify existing knowledge on water quality treatment processes and mechanisms for this engineered BMP	$75,000
3. Conduct detailed experiments in controlled environments to quantify treatment processes	$350,000
4. Conduct field validation of predicted treatment effectiveness from controlled studies	$150,000
5. Mechanistic treatment process documentation, design engineer training, and assimilation into design guidance manuals	$75,000
TOTAL	$700,000