Critical Assessment of Stormwater Treatment and Control Selection Issues

Historically the process of selecting stormwater treatment systems has centered on choosing from a menu of options with little to no consideration of the underlying processes. However, because no two sites have the exact same characteristics, this one-size-fits-all approach is not always the most effective. Practices are now shifting to an approach that allows designers to incorporate unit operations and processes (UOPs) in a way that is similar to the design process for wastewater treatment systems—where specific components are chosen based on what they can accomplish.

This report provides a framework for selecting and designing stormwater treatment systems based on the pollutants and parameters of concern and the application of various treatment processes. It will assist stormwater design engineers as they move from treating stormwater quality designs as a black box process to achieving pollutant and hydrologic/hydraulic specific goals by integrating unit processes and system components into treatment trains.

Conceptual Design Methodology

The conceptual design methodology presented in this report is driven by well-defined stormwater management goals and a solid understanding of site characteristics, constraints, and water quality conditions. As opposed to other design approaches that recommend the selection of typical BMPs based solely on documented performance factors, such as percent removal, effluent quality and/or percent capture, the approach presented here is to first select the UOPs that address the pollutants of concern and stormwater management goals, and then individually select the components of a treatment system based on those UOPs. The steps of the conceptual design process are illustrated in Figure 1.

Selection of Unit Operations and Processes

Many UOPs applicable to stormwater treatment have been previously developed in the fields of water and wastewater engineering. UOPs can be divided according to four fundamental process categories: 1) hydrologic operations, 2) physical operations, 3) biological processes, and 4) chemical processes. The selection of any one of these UOPs should be based on the characteristics of the target pollutants in relation to specific stormwater management goals.

Conceptualizing the Treatment System

Treatment system components (TSCs) are the fundamental elements of a stormwater system. Each TSC provides one or more UOP mechanisms. For instance, a dry detention basin is a TSC that provides both sedimentation and detention. Therefore, not until all applicable UOPs have been identified should individual TSCs be selected. TSCs include conventional design elements, such as swales, ponds, tanks, and also pretreatment devices (e.g., hydrodynamic devices, trash racks, catch basin screens, etc.), custom hydraulic controls (e.g., flow splitters, weirs, orifices, etc.), and tertiary enhancements (e.g., soil amendments, engineered media, selected vegetation, etc.). Many TSCs include multiple unit processes at varying levels of effectiveness. Therefore, the placement of these components in relation to one another in a treatment system must be carefully considered.

After complimentary and/or compatible TSCs are conceptualized into a candidate treatment system, the practicability

BENEFITS

- Demonstrates a unit operations and processes approach for evaluating and selecting stormwater treatment system components.
- Presents detailed information useful for characterizing watersheds and stormwater runoff.
- Supplies tools for evaluating the treatability of common stormwater constituents.

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of implementing the complete system should be evaluated. Practicability refers to both feasibility and treatability including an estimation of treatment performance and cost considerations. Also, every candidate treatment system will have various design constraints, operations and maintenance requirements, and safety and aesthetic issues that must be considered before the system is hydrologically sized and economically optimized.

Sizing the Conceptual Design

The design of a selected stormwater treatment system must address the project goals and objectives as well as the design requirements of the regulating authority. Several methods for hydrologic design exist including: flow attenuation design, volume reduction design, and flow-duration design. Flow attenuation, also referred to as "peak shaving", is typically achieved with storage and controlled release, but increasing the flow path may also be feasible. Volume reduction is possible through infiltration and evapotranspiration, both of which are highly dependent on site-specific conditions including soils, vegetation, and climate. Flow-duration seeks to reduce both magnitude and the time period of flow by incorporating the principles from both flow attenuation and volume reduction. The applicability of any of these design methods depends on whether the system is "volume-based" such as detention basins, or "flow-based" such as sand filters and swales. These facilities can be sized using a hierarchy of procedures including simple design storm approaches, rainfall frequency analyses, and continuous runoff simulation.

Continuous simulations can be performed using a number of models such as SWMM, HEC-HMS, HSPF, or even spreadsheet models. Continuous modeling permits optimization for design on the basis of minimum cost, minimum downstream discharge, minimum downstream pollutant load, and a variety of other possibilities.

Developing the Monitoring Program

Stormwater treatment system monitoring projects are initiated to address a broad range of programmatic, management, regulatory, and research goals. Monitoring goals are often focused on the achievement of water quality objectives (including hydrology/hydraulics and water quality) downstream of the facility. Multiple methods, all with different cost and time structures, can be used for sampling including manual and automated methods for collecting grab samples as well as time-weighted and flow-weighted composite samples.

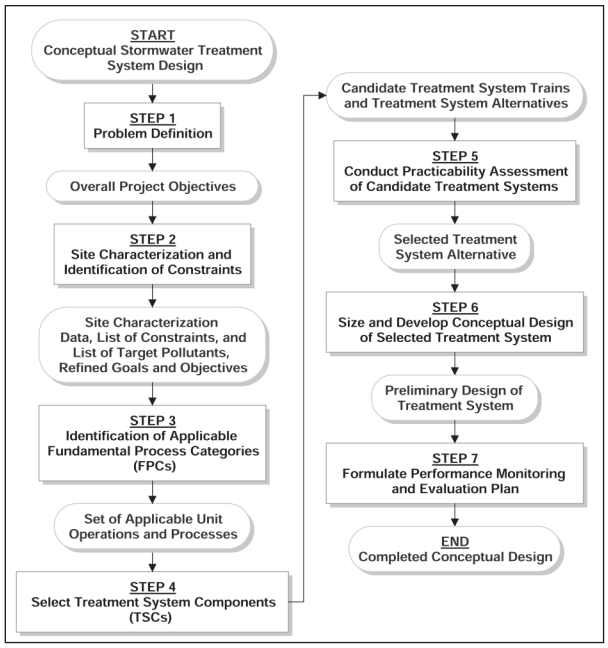

Figure 1: Stormwater Treatment Design Methodoloy.

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