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EVALUATION of HYDRODYNAMIC SEPARATORS

INTRODUCTION

This document provides technical information to assist the stormwater community with decision making processes pertaining to the proper implementation of manufactured treatment devices (MTDs). It is recognized that a wide variety of stormwater regulatory programs exist. This report provides an overview of performance parameters that should be considered in association with fundamental technical principles and regulatory guidelines that commonly apply to stormwater programs. While the focus of this report is directed toward the use of hydrodynamic separators; much of the information provided herein can be applicable to other proprietary MTDs as well (e.g., filters).

Many MTDs have undergone laboratory performance testing with the analytical results of those testing programs providing the basis for performance claims. Unlike field testing programs, laboratory tests allow for side-by-side performance claim comparisons when the same protocols and test processes are followed. It is generally acknowledged in the stormwater community that the laboratory testing programs associated with widely recognized MTD products do not readily allow for a simple, universally-accepted performance comparison procedure. Toward that end, SWEMA offers resource information to assist stakeholders with an MTD evaluation process. A discussion of important technical factors in need of consideration for the evaluation of flow through gravity separators (also vortex or hydrodynamic separators) is provided below.

TOTAL SUSPENDED SOLIDS (TSS) vs. SUSPENDED SEDIMENT CONCENTRATION (SSC)

Stormwater programs often establish a water quality treatment goal of 80 percent TSS removal, either for individual storm events or on a net annual basis. TSS refers to Total Suspended Solids, and is defined by the test method of the same name (formerly EPA Method 160.2, now Method SM2540D), which involves measuring the dry weight of solids trapped by a pre-weighed filter. This test method was originally developed for wastewater analysis and was later applied to stormwater analysis.

There are two methods by which TSS can be measured. The first involves extraction of a subsample (Method SM2540D), while the second method Suspended Sediment Concentration (SSC) involves analysis of the entire sample (ASTM D 3977-97). The subsample method is totally dependent on sample homogeneity achieved by mixing during the subsample extraction. While it is generally quite intuitive that analysis of the complete sample will produce more accurate results by eliminating error associated with subsample extraction, this has been repeatedly demonstrated in laboratory testing. The use of SSC as the more accurate method of determining the suspended solids load in stormwater is well accepted throughout the scientific community.

Additional information is available that addresses this matter. Two articles that discuss the relationships between TSS and SSC analytical methodologies offer perspectives on this important topic. *TSS vs. SCC: Storm Water's Dirt Debate*[1], by Austin Meyermann, and *TSS vs. SCC*[2], by James Lenhart, P.E., In addition, recent independent laboratory test data has been assembled in an article entitled *SSC vs. TSS: A Data Discussion*[3], by James T. Mailloux, to demonstrate differences between TSS and SSC analysis (Alden Research Laboratory, 2010). These articles are available for download or via links on the www.stormwaterassociation.com website under Publications.

Based upon the previous discussion and supporting materials in Appendices A and B, it is recommended that stakeholders rely on suspended solids evaluations based on SSC (ASTM D3977) data for any comparative analysis of MTDs.

PARTICLE SIZE DISTRIBUTION

Every stormwater management practice (proprietary or otherwise) functions differently depending on the particle size distribution of the solids it is designed to remove. Therefore, it is important for a regulatory agency to establish a target particle size distribution (PSD). If jurisdictions do not possess specific PSD data for their stormwater runoff, consideration should

[1] Austin Meyermann, "TSS vs. SSC: Storm Water's Dirt Debate," Storm Water Solutions, Vol. 3, No. 1 (February 2006).
[2] James Lenhart, P.E. "TSS vs. SSC" Storm Water Solutions Vol. 4 No. 1 (February 2007).
[3] James T. Mailloux "SSC vs. TSS: A Data Discussion" Paper prepared for Stormwater Equipment Manufacturers Association, July 2010.

be given to areas of similar hydrologic and geologic conditions and the PSDs that are consistent with that region. Particle size distribution is related to many factors including native soils, urban wear, brake dust, sanding, airborne fallout, rainfall intensity, condition of impervious surfaces, and antecedent conditions. It is important to note that on highly impervious parcels, the native soils will have less influence on the stormwater PSD than factors such as urban wear and rainfall intensity.

For hydrodynamic separators, PSD is quite important given the significant difference in settling velocities associated with different size particles. Clay-sized particles are those less than 2 microns (μm) in diameter and settle at a rate of less than 1 ft/day, silt particles range from 2 to 62 μm with a settling rate of over 100 ft/day, and sand-sized particles extend up to 2,000 μm and have settling rates well in excess of 1,000 ft/day. With these physical limitations, flow through gravity settling devices generally have limited ability to settle and retain clay and silt particles, relegating the removal of the finer particles to advanced treatment mechanisms, such as filtration technologies.

A logical approach to specifying a PSD is to adopt a target particle distribution that balances the desired performance objectives and the costs of targeting ever finer particles and higher water quality treatment. It should be recognized that smaller particulates generally contain a larger adsorbed pollutant load (by mass) due to the higher surface area to weight ratio.

To properly compare and size MTD systems, the following criteria should be considered:

- Target PSD,
- Target removal efficiency (percentage or weighted average) of the targeted PSD, and
- Define how to calculate the water quality flow rate or process to which the above apply.

Manufacturers should be able to provide test data which demonstrates under which configurations their systems can meet these criteria. It is also important to consider scaling when comparing different flow-through separators. Since it is not practical to test every model size for a given device, it is necessary to scale the results of testing one model to the other model sizes in a particular line. One approach to scaling is to maintain a constant relationship between inflow rate and the surface area of the device (hydraulic loading rate). Other approaches consider the entire volume of the device (surface area and depth) and result in higher operating rates for larger models than a strict surface area approach would yield. It is recommended that stakeholders develop an understanding of the scaling methodology being utilized when comparing various flow-through devices.

RE-SUSPENSION / SCOUR

MTDs are typically utilized as flow-through devices designed to provide stormwater quality treatment as a component within or adjoining the stormwater conveyance network. The stormwater conveyance network is commonly engineered to safely convey the 10-year or 25-year storm event downstream. Achieving stormwater quality treatment during all (large and small) storm events can be addressed by: (1) increasing the ability of the MTD to achieve sediment removal by targeting an increasing majority of the runoff events (example 90^{th} percentile of runoff), understanding that excess runoff greater than a prescribed water quality storm may by-pass the MTD and, (2) preventing re-suspension and pollutant washout from the MTD during large flow events. Large or intense storms can have significant potential to generate large peak flows that can lead to flush-out (re-suspend/scour) of previously captured pollutants from within the MTD, negatively influencing the ability of the MTD to achieve the water quality goals.

To ensure the stormwater conveyance network is functioning as designed, it must maintain the ability to safely convey stormwater as designed. Many flow-through MTDs utilize an internal bypass to allow the conveyance of large flow events. Prior to considering the use of an MTD with an internal bypass, the MTD should be understood hydraulically as well as evaluated from a water quality re-suspension/scour prevention performance perspective.

The two methodologies to prevent re-suspension/scouring of previously captured pollutants are:

- Apply an MTD in an "off-line" design configuration to ensure the conveyance of large flow events while preventing large, intense flow events from inducing re-suspension/scouring of previously captured pollutants. An off-line application would typically include an external bypass (upstream water quality diversion structure placed within the conveyance system), sending the water quality flow to the MTD placed off the conveyance system, and return flow from the MTD back to a return junction structure placed within the conveyance system.
- Some MTDs can be applied in an "in-line" design configuration allowing water conveyance while successfully preventing re-suspension/scouring of previously captured pollutants. It should be noted that not all MTDs function the same hydraulically, even with an internal-bypass. It is recommended that prior to an MTD being applied as an in-line MTD, that the MTD be evaluated for performance under conditions that could result in re-suspension/scour. In-line applications typically offer more flexibility in design, and generally require less total infrastructure, making the application more amenable when used in the urban core based on available space and pre-existing underground infrastructure and utilities.

MAINTENANCE

Maintenance of MTDs, as well as public domain (land based) best management practices, (BMPs) is an integral component of stormwater management in order to ensure that a system performs properly. For information purposes an ASCE/EWRI task committee was formed in 2008 to develop a document to provide inspection and maintenance guidance for MTDs. That document is entitled *Inspection and Maintenance Guidance for Manufactured BMPs*[4] and includes recommendations for MTD maintenance in seven areas as follows:

1. Designing for maintenance,
2. Defining standard maintenance triggers,
3. Defining maintenance fundamentals (maintainability) for all MTDs,
4. Defining maintenance tasks by design (hydrodynamic separators or filtration),
5. Identifying entities capable of maintaining MTDs,
6. Identifying entities to train maintenance providers, and
7. Reviewing recommended disposal techniques for captured materials.

Implementation of stormwater BMP inspection and maintenance programs can often be inadequate or even ignored. An appropriate maintenance enforcement plan is considered an essential element of an effective stormwater management program. It is readily acknowledged that the lack of effective enforcement can lead to a diminished level of maintenance frequency. As a result, adverse consequences to water quality treatment flow can be realized. We suggest implementation of sustainable and achievable BMP maintenance enforcement programs that include a stormwater BMP database.

Maintenance cost is an important consideration for all BMPs, including MTDs. Cost of maintenance can be a function of several factors including (but not necessarily limited to) device type, maintenance cycle (frequency), equipment needed, personnel training, site conditions and disposal requirements. It is acknowledged that cost prohibitive maintenance activities typically result in decreased maintenance frequency. We recommend that device maintenance schedules be submitted to the end user, and tracked as a component of the maintenance enforcement program and BMP database.

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[4] William F. Hunt, Gordon England, Hans DeBruijin, Richard Gee, Qizhong (George) Guo, William Lord, Mark Miller, Omid Mosheni, and Scott Perry, "Inspection and Maintenance Guidance for Manufactured BMPs" Proceedings of World Environmental and Water Resources Congress 2008 Ahupua's, 2008

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