Development of Certification Guidelines for Manufactured Stormwater BMPs

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Abstract

Manufactured stormwater Best Management Practices (BMPs) are becoming an integral part of stormwater infrastructure, as well as a component of wet-weather flow technology. They are commonly used but there are few guidelines regarding the use of these manufactured devices. An ASCE/EWRI task committee was formed in May 2007 to develop guidelines for the certification of manufactured stormwater BMPs. The committee kickoff meeting was held at the EWRI 2007 Congress in Tampa, Florida. At this meeting, the scope of work was discussed, with the consensus being to focus on physical separation of particles for the full spectrum of stormwater-borne non-dissolved solids. Complex issues regarding testing and certification BMPs were identified, and six subcommittees were formed to address these issues simultaneously. These six subcommittees are: (1) Laboratory Testing, (2) Field Monitoring, (3) Scaling, (4) Data Evaluation, (5) Data Reporting, and (6) Maintenance. This paper provides the results of the Task Committee work to date (January 2008), including review of the existing test, verification, and certification procedures and protocols and identification of additional standards development.

Introduction

The use of manufactured stormwater Best Management Practices (BMPs) (or manufactured treatment devices) is rapidly increasing in order to meet escalating water quality regulatory requirements in re-development and new development situations where land space is not readily available to accommodate other types of BMPs. However, there are few guidelines regarding the use of manufactured BMPs, especially regarding the verification and certification of their performance.

Objectives of the task committee are to review existing verification/certification programs for various types of manufactured stormwater BMPs and to seek input on verification/certification methods from a variety of stakeholders. Stakeholders will include, but are not limited to, engineers, scientists, regulators, manufacturers, vendors, and owners. This review and input will be used to develop new guidelines for verification/certification. The issues to be considered will include laboratory testing methods, field monitoring requirements, performance criteria, design flows or volumes, scaling laws, maintenance procedures and schedules, and other topics of relevance and importance.

This work is the collaboration of the Stormwater Infrastructure Committee of EWRI's Water, Wastewater, and Stormwater Council (WWSC) and the Wet Weather Flow Technology Committee of the Urban Water Resources Research Council (UWRRC). In addition, parallel efforts are being undertaken by ASTM and WERF. To avoid inconsistencies between the organizations, liaisons from the task committee were established for these other groups.

Deliverables from the task committee will be a document of developed guidelines (a technical guidance manual) published by EWRI, intermediate and final papers presented at the ASCE/EWRI Congress and other professional meetings, and articles in peer reviewed ASCE journals.

Development of the Scope and Formation of Subcommittees

The kickoff meeting for the task committee was held on May 16, 2007 during the EWRI Congress 2007 in Tampa, Florida. The Committee developed a scope of work and formed six subcommittees to tackle sub-components of the work.

BMPs are capable of treating a host of pollutant parameters. Based on the present scientific limitations, time constraints, and existing regulatory requirements, a consensus was reached to initially develop guidelines to test BMPs for sediment (solids) removal through the processes of hydrodynamic separation and filtration. Development of guidelines for the treatment of other parameters and processes may be developed in the future.

An objective of this task committee is the development of certification guidelines that regulatory agencies can use in their own programs to certify BMPs. The intent is to develop the guidelines in a way that allows a wide, yet reasonable, range of data collection and verification, so the verified data can be used by different regulatory agencies to certify performance under specific site conditions and regulatory mandates.

To address a variety of certification issues simultaneously, the following six subcommittees were formed: (1) Laboratory Testing, (2) Scaling, (3) Field Testing, (4) Data Evaluation, (5) Data Reporting, and (6) Maintenance.

To facilitate communications among members and provide an organized information repository, a committee web site was planned and, subsequently, established at http://watertech.rutgers.edu.

Review of Existing Laboratory Testing Protocols and New Development Needs

A literature search revealed two primary BMP laboratory testing protocols being used at this time. The first is a laboratory testing protocol for hydrodynamic separators developed in 2003 by the New Jersey Department of Environmental Protection (NJDEP, 2003) for the purposes of issuing a Conditional Interim Certification (CIC) to stormwater manufactured treatment devices (MTDs) that were tested under laboratory conditions. The CIC is confirmed through a subsequent field monitoring program. The testing and data verification function of the laboratory work is carried out by the New Jersey Corporation for Advanced Technology (NJCAT). Regulatory performance certification is carried out by NJDEP.

In the New Jersey (NJ) lab testing protocol, a particle size distribution (PSD), representing the United States Department of Agriculture (U.S.D.A.) definition of a sandy loam material, was specified. The mean particle diameter was approximately 67 microns, which was larger than the U.S.D.A soil texture classification boundary between silt and sand of 50 microns but smaller than the silt-sand classification boundary of 75 microns in the Unified Soil Classification System and the American Association of State Highway and Transportation Officials (AASHTO) Soil Classification system. The maximum particle size was 1,000 microns (coarse sand), and the minimum particle size was one (1) micron (clay). The particle density recommended was equal to or less than 2,650 kg/m^3.

Test conditions of the NJDEP laboratory protocol include:

1. At a minimum, completion of 15 test runs, 3 tests each at a constant flow rate of 25, 50, 75, 100, and 125 percent of the treatment flow rate (the water quality design flow rate). These tests should be undertaken with an initial (bottom) sediment loading of 50% of the unit’s capture capacity.

2. The three tests for each treatment flow rate should be conducted for influent concentrations of 100, 200 and 300 mg/L.

3. To check the potential for sediment re-suspension and washout in online systems (with internal high flow bypass-in contrast with an offline system, with external high flow bypass), completion of two tests at the maximum hydraulic operating rate (the flood control design flow rate), utilizing clean water, with initial

(bottom) sediment loading at 50% and 100% of the unit's capture capacity. The temperature of the water should be between 73 to 79 degrees Fahrenheit or colder.

To compute the theoretical annual suspended solids removal efficiency, first calculate individual removal efficiency for the 15 test runs. Then average the three test runs for each of the five operating rates and multiply the average percent removal by a specified weight factor for that particular operating rate, summing up the five weighted removal efficiencies. The weight factors (0.25, 0.30, 0.20, 0.15, and 0.10, respectively for the five operating rates) are based upon the average annual distribution of runoff volumes in New Jersey and assumed similarities with the distribution of runoff peaks.

The second significant BMP protocol identified was written by the Wisconsin Department of Commerce and the Wisconsin Department of Natural Resources. This protocol was recently developed for lab testing of hydrodynamic separators (WDC & WDNR 2007). The observed primary differences between the Wisconsin and the NJ protocols (NJDEP 2003) are:

1. As discussed above, the NJ sediment protocol is for one specific PSD, which is similar to soil types in the New Jersey area. The Wisconsin protocol requires analysis of PSDs of influent and effluent water samples, as well as sediment samples from the bottom of the device. Therefore, removal efficiencies for different particle size ranges (< 20 microns, 20-40 microns, 40-63 microns, 63-80 microns, 80-125 microns, 125-250 microns, 250-300 microns, and > 300 microns) can be evaluated from influent sample PSD vs. effluent PSD and/or from inlet sediment load PSD vs. bottom sediment PSD. As a result, the measured particle removal efficiencies can be applied to a wide variety of soil conditions by certification agencies in many regions, rather than only to a single tested PSD condition by a single certification agency. In the Wisconsin protocol, the NURP (USEPA 1983) particle size distribution shall be assumed for the influent storm water in calculating the overall removal performance.

2. To address resuspension in online BMPs, the Wisconsin protocol specifies a pass/fail criteria as follows: "A device passes the scour test if the suspended sediment concentration in the effluent pipe does not exceed the suspended sediment concentration of the influent by more than 10 mg/l." The scour potential is required to be tested at the maximum sediment storage capacity and at the maximum hydraulic capacity, defined as the flow beyond which the flow would bypass the treatment compartment. One issue, which should be further studied, is the necessity of additionally testing the scour potential at the maximum rate of total inflow. The total inflow includes the treatment flow as well as the internally bypassed flow. No numerical pass/fail criterion is specified in the NJ protocol.

3. The Wisconsin protocol requires testing of at least two different model sizes to confirm any proposed scaling relationship including those that utilize the Peclet number by Wilson et al. (2007). The NJ protocol allows the use of one full size model with laboratory testing, but the use of scaling factors is not defined.

Nevertheless, in most cases of conditional interim certification, NJDEP used the surface area to scale up the treatment flow rate.

4. The Wisconsin protocol recommends application of laboratory developed "removal efficiency vs. particle size & flow rate" curves to a series of modeled runoff events in a year to determine the annual solids removal efficiency of the treatment unit. The SLAMM watershed model (Pitt and Voorhees 2002) is recommended for inflow and sediment load modeling, but other models would be accepted as well upon approval. The NJ protocol specifies a weighting factor for each of the five tested flow rates and uses the weighted average of the measured removal efficiencies as the annual removal efficiency.

For filtration devices, NJDEP has recommended the use of fine particles (Sil-Co-Sil 106) in the influent, with the mean particle size of 22 microns. There is a need for developing a separate laboratory-testing protocol for filtration devices. Filter flow rate performance and filter sediment load capacity should be tested in addition to the solids removal efficiency. It is important to recognize that filter systems are often two unit processes, with a sedimentation compartment upstream of the filter. The issue of measuring the performance of more than one unit process in a treatment train is complex. A method to test a module as a part of the large filtration unit and/or as a part of the treatment chain needs to be further explored.

Review of Existing Field Monitoring Protocols and New Development Needs

For field monitoring, NJDEP has recommended the Technology Acceptance Reciprocity Partnership (TARP) protocol for stormwater BMP demonstrations (TARP 2003) and its amendments (NJDEP 2006).

For monitoring site selection, the NJ-amended TARP protocol specifies the following:

1. The mean influent concentration of the sediments must be in the range of 100-300 mg/L.

2. The mean particle size must not exceed 100 microns.

Although not explicitly stated in the protocol, the unit to be monitored should have been sized, installed, and maintained properly. A proper characterization of the site prior to monitoring is critical to success of any monitoring program.

The stormwater data collection requirements of the NJ-amended TARP protocol are:

1. A qualifying storm event must exceed 0.1 inch of total rainfall.

2. The minimum inter-event period must be 6 hours.

3. Sampling one hundred percent (100%) of the storm flow should be the goal. However, flow-weighted composite samples covering a minimum of 60% of the total storm flow will be accepted.

4. The goal is an average of 10 samples per storm event, with a minimum of 6 samples (i.e., six (6) influent and six (6) effluent samples) collected for each storm event.

5. The number of water quality sampling events must be representative of the storm events in the respective climatic regions, with the following criteria:

   - The total sampled rainfall must be a minimum of 15 inches of precipitation.
   - At least 15 storms, but preferably 20 storms, must be sampled.

6. The TARP Tier II Stormwater Protocol sampling requirement during adverse weather conditions is not applicable.

7. At least two storms must exceed 75% of the design treatment capacity.

8. Scouring tests must be completed (either in the laboratory or field) for the manufactured treatment devices at 125% of the treatment flow rate. These tests should be operated with initial sediment loading of 50% and 100% of the unit's capture capacity.

9. Both Total Suspended Solids (TSS) (EPA Method 160.2 or APHA et al. Standard Method 2540 D) and Suspended-Sediment Concentration (SSC) (ASTM Method D3977) test methods must be used to establish the TSS removal efficiency of the manufactured treatment devices.

In the laboratory analysis of the same water sample, the whole sample is utilized for SSC analysis while a sub-sample is utilized for TSS analysis. The sub-sampling procedures (shaking and pouring or stirring and pippeting) are typically biased toward the small or lighter particles (Gray et al. 2000). NJDEP commissioned a study to establish a relationship between the SSC-TSS difference and the (equivalent) particle size (Guo 2006). In the most recent NJDEP conditional interim certifications based on the laboratory data, this relationship was used to project the level of SSC removal necessary to achieve the desired level of TSS removal. Application of this relationship to the field data would require measurements of the particle size as well as the particle density (or measurement of the particle settling velocity alone) in order to define the equivalent particle diameter.

Other existing field monitoring protocols include but are not limited to: ETV (2002), TAPE (WADOE 2002), and ASCE & USEPA (2002).

The Committee may find that these protocols can be reconciled. They may also be improved based on recently developed WERF stormwater-borne classification and analysis protocol (Rosener et al. 2007) and ASCE stormwater gross solids monitoring guidance (Rushton and England 2007). A significant recommendation from these protocols is to classify stormwater-borne solids into fine (less than 75 microns but larger than 2 microns), coarse (from 75 microns to 5 mm), and gross solids (larger than 5 mm). This proposed classification leads to three different sets of field sampling procedures, laboratory analysis methods, and BMP functionalities.

Data Evaluation, Data Reporting, Scaling, and Maintenance

Progress on maintenance, scaling, data evaluation, and data reporting and additional information on developing field monitoring and laboratory testing guidelines are reported elsewhere at this EWRI Congress by the subcommittees and individual committee members.

Some of the remaining key issues are:

1. Determination of the overall solids removal performance from the collected field data under different flow rates, different particle sizes, and unsteady/transient conditions.

2. Scaling of lab-tested and field-monitored data from one model size to other model sizes, and scaling of lab-tested and field-monitored data from one influent PSD to other influent PSDs.

3. Verification/certification of maintainability and maintenance intervals of stormwater BMPs.

Conclusions and Recommendations

The committee and its subcommittees actively reviewed the existing protocols and recent research results. New research activities and new collaborations/partnerships have been stimulated. Review and identification of new development needs will continue in preparation for development of the new guidelines as the committee enters its next phase.

Acknowledgments

Input from the committee members is appreciated. However, this paper, as an interim summary report, was not reviewed and endorsed by the entire committee.

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