Method for Predicting the Efficiency of Proprietary Storm Water Sedimentation Devices (1006)

Wisconsin Department of Commerce
Wisconsin Department of Natural Resources

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Introduction and Organization

Both regulators and the regulated community must be able to predict how well proprietary sedimentation devices will perform in the field. These predictions will be used in storm water management planning and for evaluating compliance with regulatory and grant programs.

The purpose of this standard is to establish a uniform process for predicting the site-specific efficiency of proprietary sedimentation devices. There are two approaches that may be used in Wisconsin to meet state regulatory and grant requirements:

- One is to use an acceptable model that calculates efficiency based on Stokes' Law settling.

- The other is to use an acceptable model that contains device-specific efficiency data in lieu of Stokes' Law settling.

This technical standard is separated into three divisions. The first division is the core of the technical standard, and includes modeling and reporting requirements for predicting device efficiency using either Stokes' Law settling or device-specific efficiency data. The second division is Appendix A, which establishes criteria for acceptable models. The third division is Appendix B, which establishes laboratory testing criteria for defining device-specific efficiency curves when used in lieu of Stokes' Law setting.

Throughout the text of this standard and its appendices:

- The term "Section" refers to portions of the technical standard proper,
- The term "Part" refers to portions of the appendices,
- Criteria are requirements that must be met to comply with the standard,
- Considerations are informational only. Any suggestions made in the considerations section may be followed at the discretion of the user.

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I. Definition

This standard includes modeling, data and reporting requirements for predicting the efficiency of *proprietary flow-through storm water sedimentation devices* (*devices*) in reducing *total suspended solids* mass loads and concentrations. This standard also includes device installation and maintenance requirements necessary to assure devices are installed consistent with modeling assumptions. This standard does not constitute a *general product approval method*.

II. Purpose

This standard is used to predict the reduction in the *average annual* mass load of total suspended solids and to predict the concentration of total suspended solids discharged from a sedimentation device when installed to treat runoff from a specific drainage area of defined characteristics. Application of this standard provides information necessary for regulators and the regulated community to predict the effectiveness of these devices in meeting *regulatory*, grant-based and other storm water management requirements and goals.

III. Applicability

A. This standard applies to devices that have been, or will be, installed to control total suspended solids, through *sedimentation processes*, from urban areas including *development*, *new development, re-development* and *infill areas*.

B. These methods and procedures are acceptable as a basis for evaluating whether predicted device performance meets State of Wisconsin regulatory and grant requirements for urban storm water management.

Note: See Consideration VI.A and VI.B. for information about state requirements.

IV. Federal, State and Local Laws

Users of this standard shall be aware of applicable federal, state and local laws, rules, regulations or permit requirements governing the installation, maintenance and required treatment efficiency of proprietary devices. This standard does not contain the text of any federal, state or local laws.

V. Criteria

A. MODELING REQUIREMENTS

1. APPROVED MODEL REQUIRED. An approved model shall be used to predict the reduction in the average annual mass load of total suspended solids and to predict the concentration of total suspended solids discharged from a sedimentation device installed to treat runoff from a specific drainage area of defined characteristics.

   a. The Source Loading and Management Model (SLAMM) is approved for this use when applied in accordance with the modeling procedures specified in Appendix A, Part 1 & 2.

   b. The administering authority may approve other models using the approval process set forth in Appendix A, Part 3.

2. MODEL PROCESS SUB-ROUTINES. The model may predict pollution control efficiency based on either of the following:

   a. THEORETICAL SEDIMENTATION MODELING METHOD. This method predicts the total suspended solids reduction efficiency of a device based on principles of gravity settling (Stokes Law and Newton's Law).

      Note: See Consideration VI. C. for a discussion of Stokes' and Newton's law settling.

   b. LABORATORY DATA BASED SEDIMENTATION MODELING METHOD. This method predicts the total suspended solids reduction efficiency of a device based on device-specific efficiency data generated in a laboratory in lieu of generic gravity settling algorithms.

      i. The efficiency data for tested devices shall be generated in accordance with the laboratory testing protocol and reporting requirements presented in Appendix B.

      ii. Laboratory data collected and evaluated in accordance with Appendix B may be scaled for use with untested devices in the same device classification. Scaling shall meet the requirements of Appendix B, Part 3.2.A and the analysis and reporting requirements of Appendix B, Part 6.

Note: In this method, the device pollutant reduction efficiency reflects the sum total of gravimetric and enhanced settling processes provided by the device. Although scour is not modeled as a separate process, scour testing is required to identify the design treatment flow rate and by-pass requirements for modeling and installation.

B. REQUIREMENTS FOR REPORTING PERFORMANCE PREDICTIONS. The following information shall be reported to the *administering state agency* in support of performance predictions for a device installed to control total suspended solids in a drainage area of specified characteristics.

1. Device name, schematic diagram and model number
2. Device cross-sectional surface area and dimensions used in making the surface area calculation
3. *Design treatment flow rate*
4. Sump information including: depth of clean sump (in feet) as measured from the bottom of the sediment chamber to the outlet invert; maximum allowable sediment depth (in feet) as measured from the bottom of the sediment chamber to the top of the maximum allowable sediment depth.
5. By-pass information including: location (internal, external); flow-rated capacity; justification for selected by-pass capacity.
6. Tributary area size, land use type, acres of the paved and unpaved surfaces and the connectedness of these areas to the storm drain system
7. Identity of model input files
8. Efficiency determinations:

    a. Average annual % reduction of total suspended solids mass load

    b. Range and mean of the event-mean total suspended solids discharge concentrations

C. DEVICE INSTALLATION & MAINTENANCE REQUIREMENTS. Proprietary sedimentation devices shall be installed and maintained in a manner consistent with laboratory testing and modeling assumptions used to predict effectiveness. This includes the following requirements:

1. The device shall be installed in accordance with manufacturer recommendations.

2. The installed device shall be equipped with an internal or external bypass to divert flows in excess of the design treatment flow rate.

a. For the THEORETICAL SEDIMENTATION MODELING METHOD, the design treatment flow rate shall not exceed .008 cfs/ft^2, where f^2 is the cross sectional area of the primary sedimentation chamber.

Note: See Consideration VI.D. for the derivation of this factor.

b. For the LABORATORY DATA BASED SEDIMENTATION MODELING METHOD, the design treatment flow rate shall be determined through the scour verification testing conducted under Appendix B, Part 4.

3. Accumulated pollutants shall be removed from the device as recommended by the manufacturer. This includes periodic removal of sediment to maintain device efficiency and reduce scour. Sediment shall not be allowed to accumulate to a depth greater than the *maximum sediment storage depth*.

4. If the device is modeled using the theoretical sedimentation modeling method, the device shall be equipped with either a permanent pool having a depth at least three (3) feet above the maximum sediment storage depth to reduce scour, or shall be equipped with internal flow control structures to reduce scour velocities.

Note: See Consideration VI.E. for a discussion of scour.

VI. Considerations

A. Chapters Comm 20, Comm 60, NR 151, NR 216 and Trans 401 either contain or make reference to requirements for reducing the average annual mass load of total suspended solids discharged in storm water runoff to waters of the state. Chapter Comm 82 establishes requirements for the effluent concentrations of total suspended solids discharged from *storm water plumbing system*s to subsurface dispersal or irrigation areas.

B. Comm 82 also includes effluent limitations on the discharge of oil & grease, BOD_5 and fecal coliform from storm water plumbing systems to subsurface dispersal or irrigation systems. This standard does not address these pollutants.

C. The theoretical sedimentation model approach applies the upflow (surface overflow) equation to a defined particle size distribution. The predicted reductions apply to the influent load estimated for each runoff event. Load reductions are predicted by particle size class. Scour is not typically modeled as a separate process. The model also predicts the event mean total suspended solids discharge concentrations for each runoff event based on the combined effects of device treatment and by-passing.

The method predicts retention efficiency based on the upflow (surface overflow) equation:

$v = Q/A$, where:

v = critical particle settling velocity
Q = discharge rate from the sedimentation chamber
A = sedimentation chamber surface area

Stokes' law is for laminar flow conditions and is generally applicable to plain settling for particles up to about 100 µm in size. Newton's law is applicable for turbulent settling, generally for particles larger than 5,000 µm in diameter (assuming a specific gravity of about 2.65). Between these sizes, a smooth transition is used to predict settling. Stokes' Law covers the most critical range, where most of the storm water particles are likely present, and the large particles are "easily" captured by the proprietary devices.

D. For devices modeled using the Theoretical Sedimentation Modeling Method, the design treatment flow rate shall not exceed .008 cfs/ft^2, where f^2 is the cross sectional area of the primary sedimentation chamber. This limitation is intended to assure that scouring flows are bypassed. The factor of .008 is based on the settling rate of a 63 micron particle size with a specific gravity of 2.7 in water at a temperature of 68 degrees Fahrenheit. The factor of .008 also incorporates a safety factor of 1.5.

E. The THEORETICAL SEDIMENTATION METHOD assumes no re-suspension (scour) of previously trapped material, which is known to occur and which will decrease efficiency of the device. The requirement for by-pass or internal flow controls is meant to reduce scour so that modeled efficiency is closer to actual operating efficiency. The THEORETICAL SEDIMENTATION METHOD also does not account for any other processes, such as filtration, which can increase pollution control efficiency.

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VIII. Definitions

Administering state agency (V.B.): The state agency or its agents responsible for administering the storm water regulations applicable to the site. Responsible state agencies are the Department of Natural Resources for chs. NR 151 and NR 216 and the Department of Commerce for chs. Comm 20, Comm 60 and Comm 82.

Average Annual (II): A condition (such as rainfall or mass load) characterized by a calendar year of precipitation, excluding snow, which is considered typical. Typical average rainfall years for five regions in Wisconsin are available from the Department of Natural Resources.

Design Treatment flow rate (V.B.3.): The maximum hydraulic discharge capacity (volume/time) of the sedimentation treatment chamber allowable for installations in Wisconsin. It is the capacity at which scour losses are acceptable, as determined by the requirements of this standard.

Note: The design treatment flow rate has a safety factor built in. The safety factor is 1.5 for devices modeled with the Theoretical Sedimentation Modeling Method (See VI.D.). The safety factor is 1.2 for devices that have had a scour verification test under Appendix B, Part 4

Development (III.A.): As defined in s. NR 151.002, Wis. Adm. Code.

Devices (I): See definition of *Proprietary flow-through storm water sedimentation device.*

Device classification (Appendix B, Part 1.1): A group or “family” of devices that include similar geometry, flow pattern, sedimentation mechanism and high-flow bypass ability. Devices in the same classification are best thought of as a series of devices of different sizes offered under a similar name by the same manufacturer.

General product approval method (I): A method that gives blanket approval for use of a device.

In-fill area (III.A.): As defined in s. NR 151.002, Wis. Adm. Code.

Maximum sediment storage depth (V.C.3.) This is the maximum depth of sediment accumulation recommended by the manufacturer to maintain acceptable sediment removal efficiency and reduce scour losses.

For devices modeled using the Theoretical Sedimentation Modeling Method, this depth is specified by the device manufacturer.

For devices modeled using the Laboratory Data-Based Sedimentation Method, it is the sediment depth at which the device passes the scour verification test specified in Appendix B, Part 4.0.

New development (III.A.): As defined in s. NR 151.002, Wis. Adm. Code.

Proprietary flow-through storm water sedimentation device (I): A chamber or set of chambers (which may include internal baffles or other equipment and associated piping) that is provided as a defined product by a commercial vendor, and is warranted by that vendor to provide specific storm water pollutant removal performance under specified conditions. These devices can consist of prefabricated equipment supplied by a manufacturer, structures constructed on-site, or a combination thereof.

Redevelopment (III.A.): As defined in s. NR 151.002, Wis. Adm. Code.

Regulatory (II): Decisions made in administering state storm water management requirements. This includes sites regulated by the Department of Natural Resources under chs. NR 151 and NR 216, and the Department of Commerce under chs. Comm 20, Comm 60 and Comm 82.

Sedimentation processes (III.A.): Removal of sediment by a device through entrainment in the settling chamber(s). Includes basic gravity settling as well as settling enhanced through other physical processes such as centrifugation or tube settling. It does not include the effects of filtration.

Storm water plumbing system (VI.A.): Piping, appliances and devices that convey, hold or treat storm water from building runoff. This includes all piping connected to piping conveying runoff from buildings. The portion of the storm plumbing system under the authority of the Wisconsin Uniform Plumbing Code is that portion conveying storm water to the municipal system or discharging to grade.

Suspended sediment concentration (Appendix B, Part 3.1.): Operationally defined as the concentration or mass of sediment determined by testing under method ASTM D3977-97 (1989 Standard Methods).

Total suspended solids (I): Operationally defined as the concentration or mass of sediment determined by testing under method EPA 160.2 (EPA 1979)

Appendix A

CRITERIA FOR THE THEORETICAL SEDIMENTATION MODELING METHOD
and
LABORATORY DATA-BASED SEDIMENTATION MODELING METHOD

1.0 Introduction

This appendix contains modeling requirements for predicting the site-specific efficiency of proprietary flow through sedimentation devices. The pollution reduction algorithms used in the model may be based either on basic Stokes' Law settling or on device-specific efficiency data generated under the lab protocol set forth in Appendix B.

SLAMM is an approved model for both the theoretical sedimentation modeling method and the laboratory data based modeling method. Part 2.0 of this appendix covers requirements for using the Source Loading and Management Model (SLAMM).

An alternative model to SLAMM may be used, but it must be approved by the administering authority under Part 3 of this appendix.

2.0 SLAMM Modeling procedures

Note: Modeling results for site specific applications shall be reported to the administering state agency in accordance with the requirements of the technical standard, Section V.B.

2.1. GENERAL SLAMM MODELING REQUIREMENTS. The following requirements apply when using SLAMM in either the theoretical sedimentation modeling method or the laboratory data based sedimentation modeling method.

A. The NURP particle size distribution shall be assumed for the influent storm water.

B. The annual rainfall files shall meet those specified by the Department of Natural Resources.

C. The device shall be modeled to by-pass flows greater than the design treatment flow rate. The modeled design treatment flow rate of the device shall not exceed the flows allowed under Section V.C.2a or V.C.2.b of the standard.

D. Efficiency calculations shall include by-pass effects in final calculations of mass load reduction and concentration of total suspended solids discharged in the device effluent. Water bypassed around the sedimentation chamber shall be modeled as receiving zero treatment.

E. The device surface area shall represent the plan-view area of the settling chamber where the bulk of the sedimentation occurs.

F. Credit shall not be given for sedimentation that occurs, or is predicted to occur, in storm water conveyance pipes leading to or exiting the device.

2.2 ADDITIONAL SLAMM MODELING REQUIREMENTS FOR THE THEORETICAL MODELING METHOD

A. SLAMM version 9.0.1, or later, shall be used. The SLAMM model is available from PV & Associates, at http://www.winslamm.com.

B. For model versions 9.0.1 through 9.2.0, the catch-basin subroutine shall be used to model the device. For model version 9.2.1 or later, the hydrodynamic device subroutine shall be used.

C. Parameter files appropriate for use in Wisconsin are identified in Table A-1. File selection depends on the version of SLAMM being used. Parameter files shall be selected in accordance with the following table.

Table A-1. Parameter Files Required When Using SLAMM for the THEORETICAL SEDIMENTATION MODELING METHOD or the LABORATORY DATA-BASED SEDIMENTATION MODELING METHOD.

Parameter File	Model v. 9.0.1	Model v. 9.1.0 – 9.1.2	Model v. 9.2.0
Rainfall (*.ran)	Select files, start & end dates in accordance with s. NR 151.12(1)	Select files, start & end dates in accordance with s. NR 151.12(1)	Select files, start & end dates and winter season range in accordance with s. NR 151.12(1)
Particle Size Dist.	NURP.cpz	NURP.cpz	NURP.cpz
Pollutant File	WI_GEO01.ppd	WI_GEO01.ppd	WI_GEO01.ppd
Delivery File	WI_DLV01.prr	WI_DLV01.prr	WI_DLV01.prr
Particulate Solids Concentration File	WI_AVG01.psc	WI_AVG01.psc	WI_AVG01.psc
Runoff Coefficient File	WI_SL01.rsv	WI_SL01.rsv	WI_SL06 Dec06.rsv
Street Delivery Files	WI_Com Inst Indust May05.std WI_Res and Other Urban May05.std	WI_Com Inst Indust May05.std WI_Res and Other Urban May05.std Freeway.std	WI_Res and Other Urban Dec06.std WI_Com Inst Indust Dec06.std Freeway Dec06.std

2.3 ADDITIONAL SLAMM MODELING REQUIREMENTS FOR LABORATORY DATA BASED MODELING METHOD

A. SLAMM version 9.2.1, or later, shall be used.

B. The hydrodynamic device subroutine shall be used.

C. The parameter files shown in Table A-1 for model version 9.2.1, or later, shall be used.

D. Lab tested efficiency input data – The device performance shall be modeled using efficiency data developed from the data collected and analyzed in accordance with Appendix B.

Note: The Department of Natural Resources shall take the data reported for the laboratory testing under Appendix B, Part 6 and incorporate it into SLAMM as device-defined efficiency data. Manufacturer's reports on performance projections may be reviewed by a technical committee prior to incorporating the device efficiency data into SLAMM. The administering state agency may make revisions to the manufacturer's performance projections based on comments of the technical committee. The administering state agency will give the manufacturer an opportunity to challenge any such changes.

3.0 APPROVAL OF ALTERNATIVE MODELS

A. The administering authority may approve the use of a model other than SLAMM. In making its determination, the Department will use the following process.

1. The applicant shall submit a written request to the administering authority that identifies the proposed model.

2. The administering authority shall provide the applicant with a set of input data to test the applicant's model. The purpose of the test is to determine how well the applicant's model can duplicate percent efficiency that has been monitored in the field.

Note: Input data provided by the administering authority for the model test will typically include: a) dimensions and design flows of a test device; b) description of test device flow control structures; c) rainfall information such as rainfall durations and depths; d) drainage area characteristics such as tributary area, land use and % connected imperviousness; particle size distribution of influent storm water; % efficiency based on sum of loads.

3. Using the Department's input data, the applicant shall use its alternative model to predict and report the cumulated per cent load reduction over the modeling period.

4. The administering authority shall compare the applicant's modeling results with the monitored results for the test site and make a determination whether the alternative model is acceptable. To be acceptable, monitoring data shall have been collected and analyzed using the US EPA Environmental Testing Verification Protocol.

   Note: At this time, test data sets are available for Stormceptor, Vortechs, and Downstream Defender. The Stormceptor, Vortechs, and Downstream Defender were the subject of intensive monitoring efforts designed to verify the performance of each device and verify the load reductions estimated by WinSLAMM. All the monitoring was conducted by the U.S. Geological Survey (USGS) and the results of the monitoring are available in USGS reports. Verification of the Vortechs and Downstream Defender was part of the EPA's Environmental Technology Verification (ETV) program.

5. To be approved, the modeling method must be able to produce an estimate of device efficiency that is reasonably close to the monitored efficiency as expressed by the sum of the loads (SOL), where:

   % Load Reduction Efficiency = 100 x (1-(A/B)),

   and where

   A = Outlet SOL for the device
   B = Inlet SOL for the device

   Note: The SOL is the combined percent load reduction efficiencies for all the modeled events and provides a measure of the overall performance efficiency for the events sampled during the monitoring period. A modeled estimate will be considered reasonable if it is within 15 percentage points of the measured values.

6. The administering authority will send a written response to the applicant with a decision concerning the acceptability of the alternative model.

Appendix B

Wisconsin Laboratory Testing Method for Determining and Reporting the Performance of Proprietary Storm Water Sedimentation Devices

1.0 Introduction

1.1 Purpose and Overview of Testing Method

The purpose of this testing method is to determine the performance of a full-scale device in a lab setting. The data from this testing will be used to prepare pollutant reduction efficiency curves for incorporation into models that will in turn be used to predict the annual efficiency of the device when deployed in a specific location under specified annual rainfall sequence.

In this appendix, the word “testing” refers to a suite of tests. The suite of tests for each device includes a set of sedimentation tests and a scour verification test. The set of sedimentation tests includes a defined test repeated for each of four specified flow rates.

In the sedimentation tests, total suspended solids and suspended solids concentrations of the influent and effluent are measured to determine pollution control efficiency. A mass balance of sediment entering and retained in the device provides supplemental data. Performance data is evaluated by particle size class at four flow rates. Performance may also be reported for untested devices within a *device classification* based on scaling relationships determined from the test data. Data may be reported to the Department of Natural Resources for incorporation into the Source Loading and Management Model (SLAMM), or may be incorporated into an alternative model approved in accordance with Appendix A, Part 3.

The scour verification test is run once at a stepped, increasing flow rate to identify by-pass requirements for the device.

1.2 Testing Objectives

<u>Objective 1.</u> To quantify the mass, by particle size class, of sediment particles trapped by a device under different flow rates.

<u>Objective 2.</u> To present and analyze data to show device efficiency as a function of particle size and flow rate, and to show scaling relationships for predicting the efficiency of untested devices in the same device classification.

Objective 3. To verify that at flows up to 1.2 times the design treatment flow rate, significant scour of previously deposited sediment does not occur.

2.0 Laboratory and Data Analyst Qualifications

2.1. Laboratory Qualifications

A. Laboratory testing shall be conducted by an independent laboratory, or shall be overseen by an independent third party if conducted at the manufacturer's own laboratory.

B. The laboratory conducting the performance testing must be able to provide the range of flows, sediment characteristics, measurement and recording systems, and trained personnel necessary to generate reliable test results. A general statement of laboratory qualifications shall be submitted with the required report (Part 6.)

C. If the manufacturer is using its own lab and a third party observer, the third party observer shall meet the following requirements:

i) The observer shall have no financial or personal conflict of interest regarding the test results.

ii) The observer shall have experience in a hydraulics, sampling and sedimentation lab, be familiar with the test and lab methods specified in this standard and have a professional license in an appropriate discipline.

iii) The observer shall approve the experimental set-up and lab testing protocol and observe the test during its full duration.

D. Prior to initiating tests, the manufacturer shall contact the administering state agency to discuss selection of a laboratory to conduct the required testing. If the manufacturer is using its own lab, it shall contact the administering state agency to discuss selection of an independent observer.

i) For the Department of Natural Resources, contact:

Wisconsin Department of Natural Resources
Attn: State Storm Water Coordinator
Bureau of Watershed Management
101 South Webster Street
PO Box 7921
Madison, WI 53707-7921
General Bureau Phone: 608-267-7694

ii) For the Department of Commerce, contact:

Wisconsin Department of Commerce
Attn: Plumbing Product Review
Safety and Buildings Division
PO Box 7162
Madison, WI 53707-7162
Phone: 608-266-6742

2.2 Data Analysis

A. The analysis of lab data shall be performed by a qualified individual. A statement of qualification for the selected individual shall be submitted with the report required under Part 6.

B. Prior to initiating data analysis the manufacturer shall contact the administering state agency to discuss selection of an individual to perform this task.

3.0 Sediment Removal Performance Testing

3.1 Test Parameters

Note: The scour verification test described under Part 4.0 should be performed first as the results are needed to identify the design treatment flow rate (DTFR). The DTFR is needed to identify flow rates for the sedimentation testing.

A. Flow Rates. Each device shall be tested at a minimum of four discrete steady-state flow rates. These are 10%, 20%, 50% and 100% of the *design treatment flow rate.*

Note: See Consideration Part 7 AA for justification of the selected flow rates.

i) The design treatment flow rate shall not exceed 83% of the maximum flow rate for which the device passes the scour test requirements in Section 4.0.

Note: This provides a safety factor of 1.2.

B. Test Sediment Composition.

i) Test sediment shall be comprised of ground silica mixed in accordance with the proportions shown in Table B-1.

Table B-1. Test sediment mix.

Total mixed weight: 15.35 lbs.	
US Silica Product Gradation	**Weight**
F 65	0.90 lbs
OK 110	1.2 lbs
Sil-Co-Sil 250	0.25 lbs.
Sil-Co-Sil 106	4.0 lbs.
Sil-Co-Sil 52	1.0 lbs
Min-U-Sil 40	2.0 lbs
Min-U-Sil 30	1.0 lbs
Min-U-Sil 15	1.0 lbs
Min-U-Sil 10	4.0 lbs.

Note: See Consideration Part 7.A. for the derivation of this mix.

ii) A particle size distribution analysis of the dry sediment test mix shall be performed prior to running the lab test and the results shall be reported as part of the requirements set forth under Appendix B, Part 6.

C. Influent Concentration. The *suspended sediment concentration* in the influent pipe shall be maintained between 150 mg/l and 250 mg/l. The concentration of inorganic sediment in the influent water shall be 10 mg/l or less prior to mixing with the test sediment.

D. Water Temperature. Water temperature shall be maintained between 50^{o}F and 80°F.

3.2 Procedure and data collection

A. Number of Devices. When the purpose of the testing is to characterize the efficiency of a series of devices in the same device classification through scaling, testing shall be performed on at least two of the device models.

i) The definition of a device classification shall be the responsibility of the manufacturer. It must be based on technically defensible criteria including similarity between models in geometry, flow pattern, sedimentation mechanism and by-pass.

ii) The devices selected to represent the device classification must reasonably represent the range of device models for which the efficiency curves are being defined. The ratio between the primary sedimentation chamber surface areas of the devices tested shall be at least 2.5.

B. <u>Component tests</u>. For each device model, the required test procedure shall be completed for each of the four flow rates identified in Part 3.1.A.

C. <u>Chamber.</u> A "false floor" shall be constructed in the sediment chamber to simulate a device that is partially filled. The false floor shall be placed to simulate a sediment accumulation of 50% of the *rated sediment capacity* for the device. At the start of the test, the chamber shall be clean of sediment.

D. <u>Test length</u>. Each test will be run for the duration needed to accumulate a mass of trapped sediment adequate to perform the required analyses.

Note: Each sediment removal performance test should be run until approximately 5 pounds of material has been trapped. See Consideration Part 7.B for an example calculation of estimated test time to trap this mass of material.

E. <u>Sediment sampling frequency</u>. For each test, samples shall be collected and analyzed in accordance Table B-2. All samples shall be discrete samples unless otherwise noted. Numbers in parentheses are the minimum number of samples that must be collected and reported for each test.

Table B-2. Required Sampling for Each Sediment Removal Performance Test

Sampling Location	Particle Size Distribution	Total Sediment Mass	Total Suspended Solids Concentration	Suspended Sediment Concentration
Sediment supply hopper	(1)	Total mass weighed at beginning and end of test		
Influent pipe	(5)		(5)	(5)
Settling Chamber	(composite from 3 sub-samples of collected mass)	Total mass collected		
Effluent Pipe	(5)		(5)	(5)

F. <u>Flow sampling frequency</u>. Flow shall be monitored throughout the test.

G. <u>Temperature sampling frequency</u>. Water temperature shall be monitored periodically during the course of the test.

4.0 Scour Verification Testing

4.1 Purpose

The purpose of the scour verification test is to verify that the device will not lose a significant amount of pre-deposited sediment at a flow rate up to 1.2 times the design treatment flow rate. This verification test will be used to identify the design treatment flow rate to meet modeling and field installation requirements.

4.2 Pre-loading and Flow

A. The sediment chamber shall be pre-loaded to the maximum sediment storage depth. A false floor may be used to create an apparent sediment depth provided that the depth of sediment placed on the false floor averages at least six (6) inches. Sediment shall be well-mixed and distributed as evenly as practical.

B. The material used to pre-load the device shall be mixed according to the formula presented in Table B-3.

Table B-3. Sediment Specifications for the Scour Verification Test

Material	% by Weight
Concrete Sand (ASTM C33)	15
US Silica: Mauricetown Series – NJ 0 Sand	10
US Silica: Mauricetown Series – NJ 4 Sand	20
US Silica: Ottawa Flint Silica Series-Flint #12	15
US Silica: Ottawa Flint Silica Series-Flint #15	10
US Silica: Ottawa Foundary Sand –F60 Grade	15
US Silica: 20/40 OIL FRAC	10
US Silica: HI-50	5

Note: See Consideration Part 7.C. for derivation of this mix.

C. The device shall be filled with clean water to operating depth prior to initiating the scour test. Sediment suspended during the process of filling the chamber shall be given sufficient time to settle prior to initiating scour test flows.

D. The scour testing shall be performed using clean influent water. The concentration of inorganic sediment in the influent water shall be 10 mg/l or less prior to entering the sediment chamber.

4.3 Scour Test Sampling

A. Once the scour test sediment has been added to the sediment chamber and allowed to settle, the scour test shall be run starting at the lowest test flow and progressing to increasingly greater flows. Each test flow shall be constant for a period of 30 minutes or the time it takes to replace 5 volumes of water in the primary sedimentation chamber, whichever is greater. Do not add new test sediment to the device for each new test flow. In calculating the volume to be displaced by the test flow, the volume of the sedimentation chamber shall not include any volume below the maximum sediment storage depth.

B. Samples shall be collected and analyzed in accordance with Table B-4. All samples shall be discrete samples unless otherwise noted. Numbers in parentheses are the minimum number of samples that must be collected and reported.

Table B-4. Required Sampling for the Sediment Scour Test

Sampling Location	Total Suspended Solids Concentration	Suspended Sediment Concentration
Influent pipe	(5)	(5)
Effluent Pipe	(5)	(5)

C. Flow sampling frequency. Flow shall be monitored periodically throughout the course of the test.

D. Temperature sampling frequency. Water temperature shall be monitored periodically throughout the course of the test.

4.4 Analysis

A. 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.

B. The maximum design treatment flow rate for modeling under Appendix A, Part 2.1.C., shall not exceed 83% of the flow rate for which the device is determined to pass the scour verification test.

Note: This provides a safety factor of 1.2.

5.0 Quality Assurance & Control

Laboratory data submitted under this technical standard shall be collected under a quality assurance/quality control plan. The QA/QC plan shall include the following:

A. Project description
B. Project organization & responsibility
C. Data quality objectives
D. Project test methods

   i) Sample collection methods
   ii) Methods to adjust for expected background concentrations of material in inflow test water
   ii) Equipment cleaning & blanks
   iii) Duplicate samples
   iv) Sample preservation methods
   v) Chain of custody

E. Laboratory procedures

   i) Constituents for analysis
   ii) Laboratory performance standards
   iii) Analysis method references
   iv) Frequency and type of lab QA samples
   v) Data reporting requirements
   vi) Data validation procedures
   vii) Corrective actions

6.0 Reporting Test Results

6.1 Laboratory Report - A laboratory report shall be prepared and submitted to the administering state agency. The report shall follow the following format. The administering state agency may allow deviation from this format upon request of the manufacturer or the lab.

Chapter 1.0 Executive Summary

Chapter 2.0 Background

2.1 Name laboratory, principal investigator & subcontractors
2.2 Qualifications statements for laboratories and data analysts
2.3 Lab equipment list including: name, model and dimensions (depth & height) of the device tested;

pumps, compressors, mixers, valves, flow and water quality sampling equipment; storage tanks; standpipe and plunge pool; filtration equipment.

2.4. Settling chamber diameter (L_1) and depth (L_2) measurements

2.5 Inlet and outlet pipe dimensions

2.6 Results of scour verification test

2.7 Modifications made to the device to enhance transportation or test feasibility and explanation of why these modifications are not expected to affect the lab results.

2.8 Process flow diagram showing test device, piping, water source, pump, storage tanks, filters, sediment injection system, sampling locations & flow meter.

Chapter 3.0 Sedimentation Efficiency Testing and Results

The following shall be reported for each device tested.

3.1 Date, flow rate and elapsed time for the test

3.2 Tabular results of test parameters required under Table B-2 (Part 3.2.E). Where particle size data is required, it shall be reported for each of the following 8 particle size classes (in microns):

1) < 20	5) 80 - 125
2) 20 – 40	6) 125 - 250
3) 40 – 63	7) 250 - 300
4) 63 – 80	8) > 300

a. Test Sediment Introduced. Total mass of test sediment placed in the sediment hopper, total mass remaining in the hopper, and total mass (calculated by difference) of test sediment discharged from the hopper during the test. Component mass by particle size class of test sediment placed in the hopper

b. Influent and Effluent Sampling Results. For each discrete influent and effluent sample, the total suspended solids concentration, the suspended sediment concentration, the component mass and concentration by particle size class.

c. Test Sediment Retained. Total mass of test sediment removed from the settling chamber. Component mass by particle size class of sediment removed from the settling chamber.

3.3 Performance Efficiency: Concentration Data

Tabular data for each test flow showing the calculated per cent reduction in mass of test sediment based on inlet and outlet concentrations reported in Part 3.2. Calculations shall be by total mass and by particle size class.

a. Percent reduction shall be based on a comparison of inlet and outlet concentrations. Discrete sample results must be combined to perform this analysis.

% Reduction = (inlet – outlet)/inlet * 100

b. The report shall describe how the inlet and outlet concentrations determined from discrete sampling are combined in calculating the percent reduction for each test flow.

c. The tabular analysis shall be presented in the following format:

Flow Rate (cfs)	Total Mass Reduction (%)	% Reduction by Particle Size Class (Microns) Based in Inlet/Outlet Concentrations							
		<20	20-40	40-63	63-80	80-125	125-250	250-300	>300
.10*DTFR [1]									
.20*DTFR									
.50*DTFR									
1.00*DTFR									

1. DTFR = design treatment flow rate as determined by the scour verification test.

d. The tabular data set above shall also be presented in graphical form. A separate graph for each particle size class shall be presented that shows the percent reduction (y) as a function of flow rate (x) for the particle size class. A formula shall be developed for each graph.

Note: See Consideration Part 7.D. for an example of how these data may be graphically reported.

3.4 Performance Efficiency: Mass Retained. Tabular data for each test flow showing the calculated per cent reduction based on mass entering the device and mass retained. Calculations shall be by total mass and by particle size class. Particle size classes shall include those identified under Part 3.2.

a. Percent reduction shall be based on a comparison of mass of sediment introduced to the sediment chamber and mass of sediment retained in the sedimentation chamber, where:

% Reduction = (mass in – mass retained)/mass in * 100

b. The tabular analysis shall be presented in the following format:

Flow Rate (cfs)	Total Mass Reduction (%)	% Reduction by Particle Size Class (Microns) Based on Mass Introduced and Mass Retained in the Sediment Chamber							
		<20	20-40	40-63	63-80	80-125	125-250	250-300	>300
.10*DTFR [1.]									
.20*DTFR									
.50*DTFR									
1.00*DTFR									

1. DTFR = design treatment flow rate as determined by the scour verification test.

c. Graphical representation of this data is not required.

Chapter 4.0 Scaling Relationships

4.1 Method Documentation

a. Scaling formula

b. Theoretical basis & verification

Note: See Consideration Part 7.E. for one approach to scaling.

4.2 Application of formula to specific devices

a. Device characteristics including critical dimensions and design treatment flow rate

b. Tabular and graphic results for device (See 3.3.c and 3.3.d)

Chapter 5.0 Scour Test and Results

5.1 Test date and elapsed time for test
5.2 Test flow rate
5.3 Test material used to pre-load the device.
5.4 Influent and effluent concentration measurements
5.5 Data interpretation
5.6 Calculated design treatment flow rate for use in Wisconsin.

Note: The calculated design treatment flow rate will be 0.85 times the flow rate at which the device passes the scour test.

Chapter 6.0 Quality Assurance & Control Test Data

Chapter 7.0 Signatures for report submittal

The report shall be signed by the laboratory director or his designee, the person responsible for data analysis and reporting and, if applicable, the third party observer. The signers shall attest that the laboratory testing and data analysis has been conducted in accordance with the requirements of this technical standard.

7.0 Considerations

AA. The majority of the annual runoff volume to a properly sized device can be expected to occur during runoff events having peak flow discharges well below the design treatment flow rate. Sediment testing for each device will generate only 4 data points, one for each test flow rate. The flow rates for which data is collected should be reflective of the flow rates that the device will encounter most often when modeled.

Table B.4A shows modeling results for a theoretical device having a design treatment flow rate of 0.5 cfs and an impervious tributary area of 0.5 acres. The test file included 109 rainfall events. Of the runoff events that did not by-pass the device, most (81%) generated peak flow rates less than or equal to the DTFR and few events (8%) generated peak flow rates over 50% of the DTFR. This phenomenon has also been observed at actual field installations. Based on this information, test flow rates equal to 10%, 20%, 50%, and 100% of the design treatment flow rate are required. If a manufacturer desires to get additional definition of the efficiency curve, it can additional flows at its discretion.

Table B.4.A. Frequency distribution of runoff event peak flows modeled for a theoretical device installation having 109 rainfall events, a DTFR of 0.5 cfs and a tributary area of 0.5 impervious acres.

Peak Flow Class (% of the Design Treatment Flow Rate, or DTFR)	**Runoff Events in the Class (number)**	**Portion of Peak Runoff Events in Class**
0 – 25%	81	81%
25 – 50%	11	11%
A 50 – 75%	5	5%
75 – 100%	3	3%

Note: This modeling exercise includes 109 rainfall events. Nine (9) events exceeded the DTFR and would have by-passed the device. Statistics are based on 100 events.

A. The ground silica mixture required for sediment testing is a modification of a base mix prepared to meet the NURP particle size distribution. The base mix formula was calculated by Hydro, International using a selection of standard ground silica products and a computer program. A batch of the base mix was prepared by Hydro and sent to Wisconsin DNR for lab testing to validate that it closely matches the NURP particle size distribution. The base mix formula (shown in the table below) was shown by lab testing to be very close to the NURP particle size distribution. The results of the lab testing are shown in the second table.

Table B-5. Base mix formula for sediment testing

Total mixed weight: 14.3 lbs.	
US Silica Product Gradation	**Weight**
F 65	0.45 lbs
OK 110	0.6 lbs
Sil-Co-Sil 250	0.25 lbs.
Sil-Co-Sil 106	4.0 lbs.
Sil-Co-Sil 52	1.0 lbs
Min-U-Sil 40	2.0 lbs
Min-U-Sil 30	1.0 lbs
Min-U-Sil 15	1.0 lbs
Min-U-Sil 10	4.0 lbs.

Table B-6. Results of verification that compares base mix with the NURP particle size distribution.

Particle Size, Microns	NURP, % Finer Than	Test Material, % Finer Than
1	2	11
2	14	17
3	23	23
4	29	31
5	35	35
6	41	40
7	46	45
8	51	49
9	53	52
10	56	54
11	58	56
12	60	-
13	62	-
14	63	62
15	65	63
20	71	68
25	75	73
30	78	76
35	80	80
40	82	83
50	84	86
60	87	88
63	-	88
80	89	90
100	91	93
125	-	95
150	94	96
200	95	97
250	-	98
300	97	99
500	99	100

Although the base mix accurately matches the NURP particle size distribution, there are not enough sand sized particles to allow an evaluation of how the test device deals with these coarser particles. To correct this problem, the base mix was adjusted by doubling the amount of OK110 (from 0.6 to 1.2 pounds) and F65 (from .045 to 0.90 pounds). Almost all the particles in the OK 110 are between

90 and 125 microns, while the F65 contains particles that are primarily in the range of 106 to 250 microns.

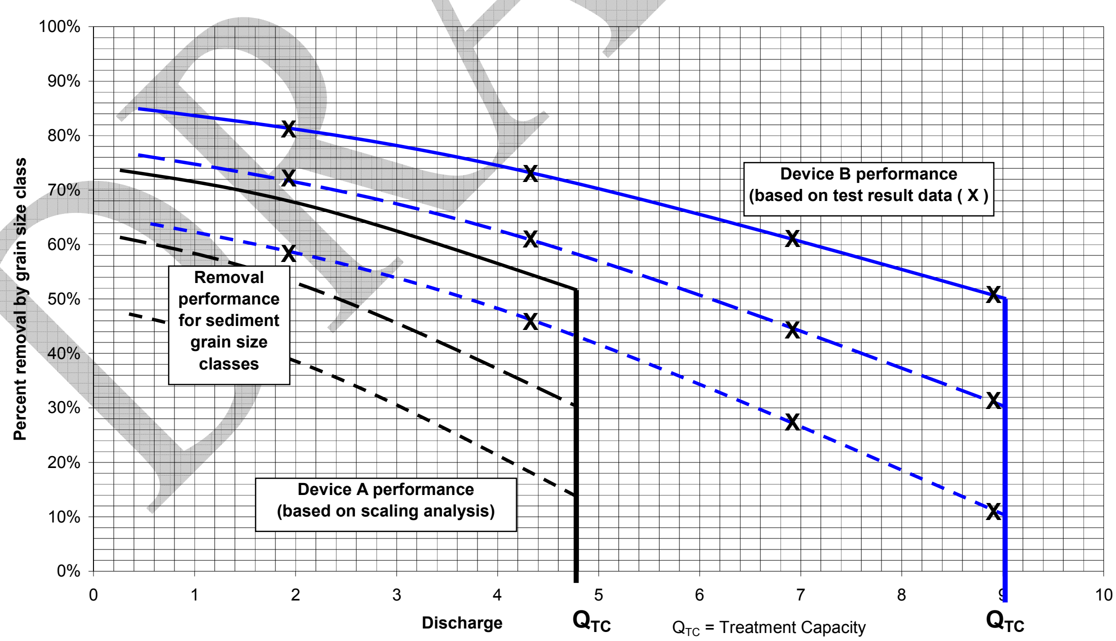
B. The sediment removal performance test under Section 3.0 should probably be run until at least 5 pounds of material has been trapped. Assuming an influent concentration of 250 mg/l suspended sediment concentration, a control efficiency of 10% (using the NURP particle size distribution) and a test flow rate of 0.5 cfs, it should take approximately 120 minutes to run this test once the flow has achieved equilibrium assuming there is no significant scour. The mass of test sediment placed in the supply hopper would have to be at least 50 pounds.

C. The Department of Natural Resources provided Hydro, International with a particle size distribution based on the material measured in the sedimentation chambers of three field installations (Vortechs, Downstream Defender, and StormCeptor). Hydro used a program to develop the specified mix.

D. Suggested graphical presentation of sedimentation test data showing data for multiple devices on the same graph.

Illustration of performance data required for Proprietary Storm Water Sedimentation Devices

Note: Only three grain size clsses shown



E. Manufacturers are encouraged to consider an approach to developing a predictive formula for scaling device performance using the following format:

Percent Reduction = Function $(L_1 * L_2 * Vs)/Q$

Where:

L1 = Device characteristic length 1
L2 = Device characteristic length 2
Vs = Particle size settling velocity
Q = discharge through the device

Manufacturers are also encouraged to provide the most accurate predictive methodology for their devices, including approaches other than that listed above.