Post-Construction Stormwater Technology Assessment Protocol for Metropolitan North Georgia

Metropolitan North Georgia Water Planning District
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POST-CONSTRUCTION STORMWATER TECHNOLOGY ASSESSMENT PROTOCOL

Objectives of the Protocol

The objectives of this protocol are to characterize a technology's effectiveness in removing pollutants from stormwater runoff for an intended application and to compare test results with vendors' claims.

Requesting a Technology Review

Vendors seeking a review of their technology or product by the Metro Water District (in order to receive an evaluation of their testing data, or to obtain a pilot use designation) should mail their submission to the following address:

Stormwater Treatment Technology Review Committee
Metropolitan North Georgia Water Planning District
229 Peachtree Street NE, Suite 100
Atlanta, GA 30303

Protocol Limitations, Release of Liability, and Disclosure

The Metropolitan North Georgia Water Planning District, and its Stormwater Treatment Technology Review Committee, ***make no representation, endorsements, or warranties, express or implied***, concerning the validity or suitability of this assessment method for any particular technology or product, or of the accuracy of the evaluation results produced using this protocol; and do not endorse, approve, make or permit to be made any claims based in whole or in part on these results to be asserted by the manufacturers of the systems or equipment assessed using this protocol. Purchasers and users of any technologies or products presented by a manufacturer or other entity using this protocol should make their own independent analyses and evaluations concerning the usefulness or value of any stormwater technologies or combinations of technologies in considering whether to use any particular technology or product for post-construction stormwater treatment. Use of the information generated under this protocol constitutes acceptance of this limitation of liability.

1.0 INTRODUCTION

In 2003, the Metropolitan North Georgia Water Planning District (Metro Water District) adopted its *Model Ordinance for Post-Development Stormwater Management for New Development and Redevelopment*. This model ordinance includes a stormwater quality treatment requirement that "all stormwater runoff generated for a site shall be adequately treated before discharge."

The Georgia Stormwater Management Manual (GSMM), referenced by the model ordinance, specifies an 80% reduction in the total suspended solids (TSS) loading on an average annual basis. The GSMM also provides guidance on meeting this performance goal as well as design criteria for various structural stormwater controls, such as stormwater ponds, sand filters and filter strips. Section 3.3.10 of Volume 2 of the Manual discusses proprietary (manufactured and/or commercial) structural controls and includes basic guidelines for considering a proprietary system.

These guidelines, however, were not intended to be testing protocols or procedures for evaluating the performance of a proprietary technology or product. Furthermore, the lack of consistent review and evaluation of monitoring and performance data has been a source of frustration for local governments, vendors and the development community.

As local governments are being asked to review and approve emerging stormwater treatment technologies, a consistent testing protocol and a process for evaluating and accepting proprietary stormwater treatment systems is necessary.

The objective of this protocol is to provide local governments and other entities with an assessment tool to use, if they so choose, as a starting point for evaluating a particular technology's effectiveness in removing pollutants from stormwater runoff for an intended application and to compare test results with vendor performance claims.

2.0 PURPOSE OF THIS DOCUMENT

This document's primary purpose is to establish a testing protocol and process for evaluating and reporting on the performance and appropriate uses of proprietary stormwater treatment technologies and systems for addressing post-construction stormwater runoff. It is not intended for use in evaluation of erosion and sedimentation control technologies or products for use during construction or land-disturbing activities.

Stormwater treatment technologies and products that have been tested according to this protocol can receive consideration to have their results evaluated and made available publicly on the Metro Water District website (www.northgeorgiawater.org). The review of vendor data and subsequent determinations and public dissemination is not intended to be an approval process or an endorsement of any product by the Metropolitan North Georgia Water Planning District. Purchasers and users of any technologies or products presented by a manufacturer or other entity using this protocol should make their own independent analyses and evaluations concerning the usefulness or value of any stormwater technologies or combinations of technologies in considering whether to use any particular technology or product for post-construction stormwater treatment. Local governments and other entities in the Metro Water District are free to use this information as part of their process to evaluate the suitability of these technologies or products.

3.0 STORMWATER TREATMENT TECHNOLOGY EVALUATION PROCESS

3.1 Overview

The technology performance evaluation process consists of the following elements (illustrated in the flowchart in Figure 1):

- Preparation of a technology engineering report by the vendor
- Implementation of performance testing of the technology
- Submission of technology engineering report and testing results to Metro Water District Stormwater Treatment Technology Review Committee (TRC)
- Review of technology engineering report and testing results by the TRC
- Posting of vendor information and additional determinations by the TRC on the Metro Water District website

Typically, the vendor will submit the technology engineering report and testing results at the same time, unless requesting a pilot use designation (see section 3.2).

The Metropolitan North Georgia Water Planning District will maintain a database on its website to assist local jurisdictions in identifying stormwater technologies and products that have verifiable performance information after review.

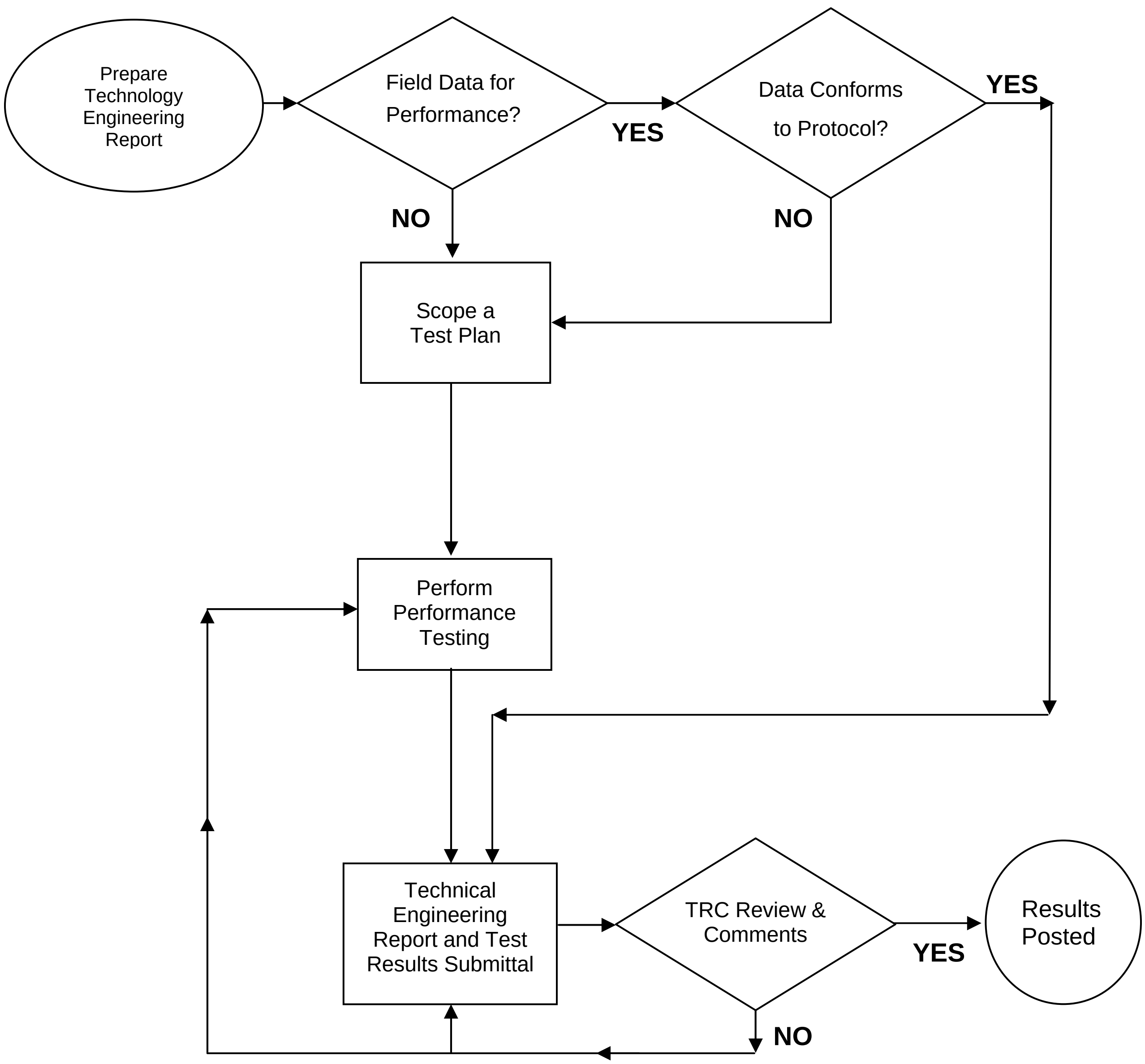
To be affirmatively evaluated by the Stormwater Treatment Technology Review Committee for posting on the Metro Water District website, a technology must meet both of the following criteria:

- A demonstrated ability to meet the stormwater performance claims outlined in the technology engineering report, verified by field testing performed in accordance with the Post-Construction Stormwater Technology Assessment Protocol ; and
- A demonstrated capability for sustainable performance with respect to factors other than treatment performance (e.g., maintenance requirements, potential for failure, durability, etc.)

Upon review of the information provided by the vendor, the Technology Review Committee will develop a summary to be included along with the vendor's reports and information.

Any Technology Review Committee comments are based solely upon the information presented in the engineering report and testing results provided to the Metro Water District. Technologies found not to have adequate product information and/or performance data may resubmit updated information at a later date. Each resubmission will be considered on its own merits as a new application with no consideration given to previous materials or reviews.

Figure 1. STORMWATER TREATMENT TECHNOLOGY EVALUATION PROCESS



3.2 Pilot Use Designation

An applicant may submit a technology engineering report to the Stormwater Treatment Technology Review Committee for consideration to obtain a pilot use designation for the purpose of collecting field performance data. These technologies will be listed on the Metro Water District website along with the technology engineering report. Local governments may allow pilot use designated technologies to be installed in new development or redevelopment situations provided that the vendor and/or developer agree(s) to conduct field testing based on the criteria in this protocol and agrees to retrofit installations that fail to meet performance claims.

3.3 Roles and Responsibilities

3.3.1 Metro Water District Stormwater Technology Technical Review Committee

The Stormwater Treatment Technology Review Committee (TRC) includes representatives from local governments in the Metropolitan North Georgia Water Planning District, Georgia EPD, and other stormwater and water resources professionals. The TRC's duties are:

- Reviewing technology engineering reports and testing results submitted by vendors for conformity to the Post-Construction Stormwater Technology Assessment Protocol;
- Making review information publicly available;
- Interacting with other state, regional and local government agencies to assess how well the process is meeting its objectives; and
- Revising the Protocol and website as needed.

3.3.2 Vendor/Manufacturer of the Technology

Technology Engineering Report

The vendor/manufacturer prepares a technology engineering report on their technology or product following the criteria in this protocol. The report must clearly identify the vendor's performance claims including:

- Reduction of pollutants from stormwater runoff
- Applications of the technology to be verified, including siting, location, land use, and land activity limitations or restrictions
- Full range of operating conditions for the technology
- Minimum maintenance requirements to sustain performance
- Capital and projected annual costs, including operations and maintenance costs

Performance claims must include quantitative data (e.g., load reductions and removal efficiencies for specific pollutants or categories of pollutants, application and design criteria, costs, etc.), but may include additional qualitative claims (e.g., advantages over other technologies, installation or maintenance considerations). See Section 5 (page 8) for the complete list of requirements for the technology engineering report.

Performance Testing and Reporting

The vendor/manufacturer completes performance field testing of the technology that meets the criteria in this protocol. This includes:

- Performance testing project plan
- Testing data including rainfall data, and influent & effluent concentrations
- Statistical analysis of data
- Data quality assurance summary
- Documentation of maintenance performed during the study period
- Evaluation of results

See Section 6.1 (page 10) for the complete list of requirements for performance testing reporting.

Performance testing should be performed or managed in person by a qualified independent engineering or testing firm (as consistent with state law on professional qualifications), or a recognized academic institution. If the performance testing was performed by the vendor/manufacturer, include a written certified review by such a firm or academic institution certifying that the methodology and evaluation of data was managed in person by such firm or academic institution and was performed in accordance with accepted standards.

Consideration of data and verifiable technology claims which will and/or have occurred outside of the state of Georgia may be accepted for performance claim verification by the Stormwater Treatment Technology Review Committee (see Section 6.2 on page 11).

4.0 TREATMENT PERFORMANCE GOALS

4.1 Stormwater Performance Objectives

The Georgia Stormwater Management Manual (GSMM) specifies a minimum standard for development projects requiring that "all stormwater runoff generated from a site should be adequately treated before discharge."

In technical terms, the GSMM defines this as treating stormwater runoff to provide an overall 80 percent reduction in the total suspended solids (TSS) loading on an <u>annual average basis</u> for post-construction stormwater runoff on all new development and redevelopment projects. This performance goal is referenced by the Metro Water District's Model Ordinance for Post-Development Stormwater Runoff for New Development and Redevelopment.

4.2 Treatment Train, Retrofits, and Pretreatment Applications

Vendors/manufacturers may also provide claims and evaluate their products for use in treatment trains, pretreatment (including gross solids removal), and retrofit applications where an 80% TSS removal may not be required. Some considerations might include:

- Provides mostly coarse solids removal (> 500 microns) including all litter and debris
- Improves the effectiveness, extends the useful life, or extends the maintenance cycle of a downstream treatment device or infiltration facility
- Results in a more cost-effective treatment system

In addition, a technology may also be evaluated for the removal of other stormwater pollutants in addition to TSS, such as nutrients, heavy metals, hydrocarbons and bacteria.

Please note that the Georgia Stormwater Management Manual and Metro Water District model ordinance provide no explicit performance standards for these applications or other stormwater pollutants.

5.0 TECHNOLOGY ENGINEERING REPORT REQUIREMENTS

At a minimum, the technology engineering report must contain the following information:

5.1 Technology / Product Specifications

The technology specifications must include: physical, chemical, and biological processes; operation and maintenance (O&M) requirements; process flow diagrams and algorithms; equipment drawing and specifications; existing test plans, performance data, certifications; and a description of process inputs and outputs. More specifically, the following information should be provided in the specifications:

1. General description of the technology, including all components and processes
2. Underlying scientific and engineering principles for the technology. Describe how the technology functions in treating stormwater runoff. Include information about physical, chemical, or biological treatment processes such as filtration, adsorption/absorption, settling, or inertial separation that may be involved in the treatment process
3. Minimum siting and design specifications to achieve stated performance, including but not limited to: pollutants that should and could be addressed; minimum and maximum influent concentrations; pollutants that will not be addressed or that may be increased; and siting, location, land use, and land activity limitations or restrictions
4. A discussion of the advantages of the technology when compared to conventional stormwater systems providing comparable stormwater control
5. Standard drawings, including a schematic of the technology and a process flow diagram
6. A discussion of technology hydraulics and system sizing to meet performance standards and goals (e.g., to handle the water quality volume, rate of runoff, type of storm, or recharge requirements)
7. Clear specification of the sizing process, including appropriate flow rates if applicable.
8. Full range of operating conditions for the technology, including minimal, maximal, and optimal conditions to achieve the performance goals and standards, and for reliability of the technology
9. Maintenance requirements to sustain performance and safe operation
10. Technology limitations, such as performance limits for control of certain water quality parameters, and predicted impacts from construction, operation, and maintenance of the technology
11. Identified secondary impacts
12. Discussion of the generation, handling, removal, and disposal of discharges, emissions, and waste byproducts in terms of mass balance, maintenance requirements, and cost
13. Discussion of pretreatment and preconditioning of stormwater, if appropriate to achieve stated performance of the technology or product
14. Identification of any special licensing or hauling requirements, safety issues, and access requirements associated with operation or maintenance of the technology
15. Capital and projected annual costs, including O&M costs
16. Executive summary

5.2 Specific Performance Claims

An applicant must make a performance claim that identifies the technology's intended use and predicts the technology's capabilities to remove contaminants and/or control the quantity of stormwater runoff. Performance claims should be objective, quantifiable, replicable, and defensible. Claims that are overstated should be avoided, as they may not be achievable.

A sample stormwater treatment performance claim might be structured as follows:

> *"The Model T system can capture and treat the WQ volume for up to a 1-acre runoff area that is up to 100% impervious. Under these conditions, a total suspended solid (TSS) removal rate of X% ± Y% (at a 95% confidence level) can be achieved with inflow TSS concentrations greater than 100 mg/l. for flow rates of Z cfs"*

Appendix A provides the permitted methods for calculating pollutant removal.

6.0 PERFORMANCE TESTING REPORTING

Performance testing includes the use of standardized test methods and procedures, a data quality assurance and control plan, data collection, and statistical tests of the data. The procedures for performance testing will be reviewed and validated by the Stormwater Treatment Technology Review Committee to ensure that the procedures for collecting, handling, and analyzing samples and data will be accurate, precise, representative, complete and comparable.

6.1 Reporting Requirements

All performance testing reporting must include the following:

1. Statement of performance testing objectives
2. Performance testing project plan (see below)
3. Standardized test methods and procedures used
4. QA/QC objectives and procedures
5. Date and time when samples were collected
6. Rainfall data (include antecedent dry period, total rainfall during sampling event, and rainfall intensity and duration)
7. Comparison of rainfall data to rainfall criteria
8. Comparison of collected aliquots to sampling criteria
9. Comparison of influent to effluent pollutant concentrations
10. Particle size distribution (PSD) analysis
11. Demonstration of scour prevention (if applicable)
12. An estimation of annual average total suspended solids (TSS) removal
13. Statistical data evaluation
14. Discussion of whether the QA/QC objectives were met
15. Discussion on deviations from any sampling procedures
16. Data quality assurance summary (field and laboratory QA/QC results)
17. Maintenance performed during the study period, including activities and frequency
18. Total amount (estimated dry weight) of sediment and floatables removed and sediment depth prior to each cleaning
19. Media replacement and/or cleaning, if applicable
20. Evaluation of results
21. Executive summary

The performance testing project plan should include the following:

- Describe and provide a scaled plan view of the demonstration site, indicating all buildings, land uses, storm drain inlets, and other control devices
- Include a description of the site drainage area, percent impervious area, percent area directly connected to the test facility, description of the path of storm water flow to the test facility, type of activities conducted, pollutant sources, soil type, geological and hydrological conditions, existing control structures, and a site drainage plan
- Estimate the impervious area within the drainage area and show sample inflow and outflow points
- Describe how the treatment technology was selected, designed and appropriately sized for the specific field test site
- Specify the location of flow devices and samplers in relationship to the inlets and outlets of the stormwater technology
- Demonstrate that flow devices and samplers are installed and positioned properly to ensure that samples are representative of influent runoff and effluent runoff

6.2 Use of Other Performance Testing Data

Field testing and the resulting data and verifiable technology claims which will and/or have occurred outside of the state of Georgia may be accepted for performance claim verification by the TRC with the following conditions:

1. Adherence to the protocol's performance testing reporting requirements under 6.1 (above)
2. Hydrological differences between the actual field test location(s) versus a representative location within Georgia must be accounted for with proper engineering design using rainfall data analyses and appropriate water quality volume treatment criteria. Only field test data from other regions within North America which have a Type II rainfall pattern will be considered
3. Appropriate particle size distribution that is applicable to the soil conditions for a representative location within Georgia (for consideration of potential applications where the site conditions are less than 90% impervious cover)

7.0 SAMPLING DESIGN CONSIDERATIONS

This section describes test procedures that can be used to evaluate a technology's performance.

7.1 Test Site Selection Considerations

Select field test sites that are consistent with the technology's intended applications (land uses) and geographical location in Georgia (e.g. Piedmont region, coastal areas, etc) that will provide influent concentrations typical of stormwater for those land use types. Testing at multiple sites is recommended. Additional test site considerations include:

- Field test site drainage area, tributary impervious cover and land uses (roadway, commercial, high-use site, residential, industrial, etc)
- Potential pollutant sources in the drainage area (e.g., parking lots, roofs, landscaped areas, sediment sources, exterior storage or process areas)
- Availability of baseline stormwater quality information to characterize conditions at the site. For sites that have already been developed, it is recommended that baseline data be collected to provide a sizing basis for the device, and to determine whether site conditions and runoff quality are conducive to performance testing
- Drainage area flow rates (i.e., water quality design flow, 2-year, 10-year, and 100-year peak flow rates) at 15-minute and 1-hour time steps as provided by an approved continuous runoff model
- Bypass requirements with flow rates and/or flow splitter designs necessary to accommodate the treatment technology
- Site adequacy for sampling, flow measurement access, and telephone/AC power, if needed
- Any potential adverse site conditions such as climate, tidal influence, high ground water, rainfall pattern, erosion, high spill potential, illicit connections to stormwater drainage areas, industrial runoff, etc.

7.1.1 Sampling Locations

To accurately measure system performance, samples must be collected from both the inlet and outlet from the treatment facility. The influent to the treatment technology should be sampled as close as possible to the treatment device inlet. Samples should represent the total runoff from the drainage area and should not include debris and large particles (see the TSS definition in the target pollutants section). To ensure that samples represent site conditions, design the test site so that influent samples can be collected from a pipe that conveys the total influent to the unit. To avoid skewing influent pollutant concentrations, the influent should be sampled at a location unaffected by accumulated or stored pollutants in, or adjacent to, the treatment device.

The effluent should be sampled at a location that best represents the treated effluent. If bypass occurs, bypass flows must be measured and bypass loadings calculated using the pollutant concentrations measured at the influent station. In addition, be aware that the settleable or floating solids, and their related bound pollutants, may become stratified across the flow column in the absence of adequate mixing. Samples should be collected at a location where the stormwater flow is well-mixed.

7.1.2 Stormwater Facility Design and Sizing

Sizing of the test facility must be based on meeting applicable performance goals by treating the water quality volume, or the design flow rate coinciding with treating the water quality volume.

7.2 Storm Event Criteria for Sampling

A minimum number of 15 storm or discrete flow rate sampling events is required per test site. The storms should be representative of the entire annual hydrologic range of storm events and constitute at least 20% of the total annual rainfall. It is recommended that sampling events be evenly distributed over the testing period to capture seasonal influences on storm conditions and system performance.

Each storm event for sampling must meet the following criteria:

- At least 0.15 inch of total rainfall
- A minimum inter-event period of 6 hours, where cessation of flow from the system begins the inter-event period
- A minimum storm duration of one hour
- Flow-weighted composite samples covering a minimum of 70% of the total storm flow, including as much of the first 20 % of the storm as possible. *Note: composite samples are not appropriate for all parameters (see below)*
- A minimum of 10 water quality samples (i.e., 10 influent and 10 effluent samples) should be collected per storm event. For composite samples, a minimum of 5 subsamples is acceptable (i.e., 2 composites with 5 subsamples = 10 water quality sample minimum or 1 composite sample with 10 subsamples = water quality sample minimum). If a storm is too small for 10 samples, an average of 10 samples per storm may be substituted. However, more than 10 samples per storm event should be collected wherever possible
- Flow measurements must be taken to predict or calculate pollutant loads. The mass of pollutants in the discharge should be based on flow rates and pollutant concentrations or another reasonable approach
- At least two storm events should be greater than 75% of the design storm used to size the test facility

7.3 Stormwater Sampling Methods

Programmable automatic flow samplers with continuous flow measurements should be used unless it is demonstrated that alternate methods are superior or that automatic sampling is infeasible. Grab samples should only be used for certain constituents, in accordance with accepted standard sampling protocols, unless it is demonstrated that alternate methods are superior. Constituents that typically require grab sampling include: pH, temperature, cyanide, total phenols, residual chlorine, oil and grease, total petroleum hydrocarbons (TPH), *Escherichia coli*, total coliform, fecal coliform, fecal streptococci, and enterococci.

Note: Time-weighted composite samples are not acceptable, unless flow is monitored and the event mean concentration can be calculated from the data.

7.4 Sampling for Total Suspended Solids (TSS)

7.4.1 Sampling Considerations

To determine percent TSS reduction, the samples must represent the vertical cross section (be a homogeneous or well-mixed sample) of the sampled water at the influent and the effluent of the device. The selection of the sampling location, its homogeneity, and placement of and sizing of the sampler tubing in the stormwater must be conducted with care to ensure accurate representativeness of the samples.

7.4.2 Particle Size Distribution (PSD)

Treatment technologies must be capable of removing TSS across the size fraction range typically found in urban runoff.

For field testing performance results, an analysis of the inflow particle size distribution (PSD) is required. The purpose of the requirement is to collect consistent information on particle size that will aid in evaluating system performance. PSD measurements will provide a frame of reference for comparing variability in performance between storms and between different sites. These measurements are an important tool with which to assess performance since performance is likely to be affected by particle size. For example, it is likely that performance will drop with a substantial increase in fine soil particles. Conversely, it is anticipated that performance will be high with sandy sediments. Therefore, all TSS analysis and particle size distribution should include only particles that are smaller than 500 microns.

Laser diffraction methods are effective for analyzing particles smaller than 250 microns. Therefore, particles greater than 250 microns must be removed with a sieve prior to PSD analysis. These large-sized particles will be analyzed separately to determine the total mass of particulates greater than 250 microns. This protocol functions as a supplement to the existing protocols provided by the manufacturers of laser diffraction instruments such that the larger-sized particles in the sample can also be measured.

For consideration of potential applications where the site conditions are less than 90% impervious cover, a treatment technology must show the capability of removing TSS for the Piedmont region of Georgia which has a general soil type that is Silty Clay Loam with an assumed PSD of 20-60-20. A readily available laboratory surrogate, Sil-Co-Sil 106, may be used to assess laboratory performance.

7.4.3 Accumulated Sediment Sampling Procedures

As appropriate to demonstrate facility performance, and to confirm the stormwater sampling-based percent removal data, the sediment accumulation rate can be measured. Practical measurement methods may be utilized, such as measuring sediment depth.

The following sediment constituents should be analyzed:

- Percent total solids;
- Total volatile solids; and
- Particle size distribution (PSD)

The sediment sample should be a composite from several grab samples (at least four) collected from various locations within the treatment system to ensure that the sample represents the total sediment volume in the treatment system. For QA/QC purposes, collect a field duplicate sample (see following section on field QA/QC). The sediment sample should be kept at 4°C during transport and storage prior to analysis. If possible, remove and weigh (or otherwise quantify) the sediment deposited in the system.

Analyze the grain size using the methods described for the PSD analysis above. Quantify or otherwise document gross solids (debris, litter, and other particles exceeding 500 microns in diameter). Volumetric sediment measurements and analyses should be useful in determining maintenance requirements, TSS mass balance, and whether the sediment quality and quantity are typical for the application.

8.0 DATA QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control (QA/QC) describe the measures that will be employed to ensure the representativeness, comparability, and quality of field samples for the performance testing of stormwater technologies. The following elements should be included in the QA/QC plan and procedures:

1. Equipment decontamination
2. Quality control (QC) samples
3. Preservation and handling
4. Quality Assurance (QA) on sampling equipment (e.g., calibration of automatic samplers and flow measurement devices)
5. Recordkeeping
6. Health and safety plan

See Appendix C for website resources for developing QA/QC plans.

8.1 Equipment Decontamination

Describe how sampling equipment (sampler head and suction tubing) will be decontaminated between sampling events to prevent sample cross-contamination. It is recommended that the suction tube be replaced at least once during the test period and more frequently if runoff is highly contaminated.

8.2 Quality Control Samples

1. <u>Equipment rinsate blanks</u>: Equipment rinsate blanks should be collected to verify that equipment is not a source of sample contamination. Equipment rinsate blanks are collected by passing reagent-grade water through clean equipment and collecting samples for chemical analyses. These samples are to be analyzed as regular samples with all appropriate quality control performed.

   It is recommended that equipment rinsate blanks be collected at the inlet monitoring station where stormwater is expected to contain the highest contaminant concentrations. However, if the inlet station is difficult to access (e.g., confined space entry required), the rinsate blank may be collected from the outlet station. Two separate rinsate blanks should be collected during the initial equipment startup and testing, and at least one additional blank should be collected midway through the sampling program. More frequent blank samples may need to be collected if site conditions warrant (e.g., following an event with unusually high contaminant concentrations).

   The equipment rinsate blank collection procedure should be described in the QA/QC plan. Include a description of the location and number of samples that will be collected, sample collection and processing procedures, and sample documentation (e.g., length of time that sampler was in place prior to collecting the blank, how much stormwater passes through the sample prior to collecting the rinsate blank). At a minimum, rinsate blanks should be collected after at least one storm event has been sampled (to “contaminate” the equipment) and after the equipment has been decontaminated according to the procedures specified in the QA/QC plan. The two initial blanks may be collected after a volume of stormwater similar to the volume that will be collected during a typical sampling event has been passed through the sampling equipment during the equipment testing process.

It is recommended that the equipment rinsate blank should be at a "not detected" level. If they are not, then they will have to be taken into account in determining whether the measurement quality objectives (MQO's) have been met. In the QA/QC plan, describe corrective actions that will be taken (e.g., modifying decontamination procedures, replacing suction tubing) if contamination is found in the blank.

2. Field duplicate samples: A field duplicate is a second independent sample collected at the same location. Field duplicates are primarily used to assess the variation attributable to sample collection procedure and sample matrix effects. The QA/QC plan must include a description of techniques used to collect duplicate samples and specify the collection frequency. At a minimum, collect 10 percent field duplicate samples.

8.3 Sample Preservation and Handling

Samples are to be preserved in accordance with US EPA-approved methods (EPA 1983), or Standard Methods (APHA, AWWA, WEF 1999). Preservation must be provided during sample collection, as well as during transport. Describe how cooling the automatic samplers will be conducted to maintain low temperatures throughout the sample collection period.

Provide a table in the QA/QC plan that lists sample container material, sample preservation, and holding time limits for the analyzed pollutants. EPA methods should be followed for sample container selection, preservation requirements, and target pollutant holding time limits. Pre-cleaned sample bottles should be obtained directly from the analytical laboratory. If the vendor proposes to obtain bottles from another source, provide a detailed bottle-cleaning procedure. Also, describe procedures that will be employed to label and track samples from collection through delivery to the analytical laboratory. Provide a sample chain of custody form in the QA/QC plan.

Samples collected as discrete flow composites may need to be manually composited following the sampling event. If samples will be manually composited, describe compositing procedures to prevent sample cross-contamination. Also, certain parameters may not be able to be composited, and must be collected as grab samples using an approved method. Describe how these samples will be collected and at what intervals they will be collected during the storm event.

8.4 Equipment Calibration

Describe the field equipment calibration schedule and methods, including automatic samplers, flow monitors, and rainfall monitors. The accuracy of the flow meters is very important so their calibration should be carefully conducted by the site professional in accordance with manufacturer's recommendations.

8.5 Recordkeeping

Maintain a field logbook to record any relevant information noted at the collection time or during site visits. Include notations about any activities or issues that could affect the sample quality (e.g. sample integrity, test site alterations, maintenance activities, and improperly functioning equipment). At a minimum, the field notebook should include the date and time, field staff names, weather conditions, number of samples collected, sample description and label information, field measurements, field QC sample identification, and sampling equipment condition, as well as any measurements tracking sediment accumulation. In particular, note any conditions in the tributary basin that could affect sample quality (e.g., construction activities, reported spills, other pollutant sources). Provide a sample field data form in the QA/QC plan.

8.6 Health and Safety Plan

A health and safety plan should be developed and included with the QA/QC plan covering installation, operation and maintenance of the technology. Specifically, the plan should address hazard identification and mitigation, engineered controls and procedures, personal protective equipment, and training. Where related to the stormwater technology, the health and safety plan should also cover the collection of stormwater samples in confined spaces (manholes, storm sewer lines, and utility vaults); collection of high flow stormwater samples from culverts, drainage channels, and sedimentation basins during storms; and chemical, biological or physical hazards associated with the technology.

9.0 STATISTICAL TESTING OF DATA AND DATA REDUCTION

Statistical testing should be performed on performance claim data to ensure that data are reliable, significant, and within confidence limits. When testing at specified ranges of flow and contaminant concentrations and when normal parametric statistical analysis is performed, coefficient of variation (CV) should be within $\pm$10% for efficiency data, wherever possible. A larger range of CV may be allowed where justified. The vendor must demonstrate that the data set is normally distributed prior to using normal parametric statistical analysis. Data sets that are not normally distributed will need to be evaluated using nonparametric statistical analysis and may require further analysis and review.

The *Data Quality Assessment Guidance Manual* (EPA QA-G9) includes an array of statistical methods, e.g., parametric analysis (mean, standard deviation, confidence intervals, and Z-statistic), comparison of populations (analysis of variance, box-whisker plots, and Tukey-tests), which can be used to compare and validate data sets. EPA QA-G9 can be downloaded from the following website: www.epa.gov/quality/qa_docs.html

APPENDIX A:

TREATMENT EFFICIENCY CALCULATION

- For technologies sized for long residence times (hours versus minutes), cumulative performance of several storms, wet season or annual time periods must be considered.
- For short residence times (several minutes), event mean comparisons are recommended. For discrete short-time step residence times (few minutes), lag times should be considered for influent/effluent comparisons.

Individual storm reduction in pollutant concentration.

Calculate the reduction in pollutant concentration during each individual storm as:

100 (flow-weighted influent concentration – flow-weighted effluent concentration) / flow-weighted influent concentration

Individual storm reduction in pollutant loading.

Calculate the reduction in pollutant loading during each individual storm as:

100(A-B)/A

where: A= (Storm 1 Influent concentration) * (Storm 1 volume)

B= (Storm 1 Effluent concentration) * (Storm 1 volume)

Aggregate pollutant loading reduction.

Calculate the aggregate pollutant loading removal for all storms sampled as:

100(A-B)/A

where: A= (Storm 1 Influent concentration) * (Storm 1 volume) + (Storm 2 Influent concentration) * (Storm 2 volume) +…(Storm n influent concentration) * (Storm n volume)

B = (Storm 1 Effluent concentration) * (Storm 1 volume) + (Storm 2 Effluent concentration) +…(Storm n Effluent concentration) * (Storm n volume)

Note: Concentrations are flow-weighted, and flow = average storm flow or total storm volume (vendor’s choice)

Annual average pollutant loading estimation

Estimate the annual average pollutant by developing a function of storm volume vs. pollutant loading reduction, and using either accumulated daily rainfall data or accumulated 15-minute intensity data for a typical year to calculate the total and annual average pollutant reduction.

APPENDIX B:

APPLICABLE TEST METHODS AND PROCEDURES

ASTM Methods

D3370, Practices for Sampling Water.

D4840, Guide for Sampling Chain of Custody Procedures.

D4841, Practice for Estimation of Holding Time for Water Samples Containing Organic and Inorganic Constituents.

D5612-94 (1998), Standard Guide for Quality Planning and Field Implementation of a Water Quality Measurement Program.

D5847-99a , Standard Practice for Writing Quality Control Specifications for Standard Test Methods for Water Analysis.

D5851-95, Standard Guide for Planning and Implementing a Water Monitoring Program.

D6145097, Standard Guide for Monitoring Sediments in Watersheds.

D3977-97, Standard Test Method for Determining Sediment Concentration in Water Samples.

D5907-96a, Standard Test Method for Filterable and Non-filterable Matter in Water.

D4841-88 (1998), Standard Practice for Estimation of Holding Time for Water Samples containing Organic and Inorganic Constituents.

PS74-98, Provisional Standard Test Method for Oil and Grease (Solvent Extractable Substances in Water by Gravimetric Determination.

D5790-95, Standard Test Method for Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectroscopy.

D6362-98, Standard Practice for Certificates of Reference Materials for Water Analysis.

D6104-97, Standard Practice for Determining the Performance of Oil/Water Separators Subjected to Surface Water Run-off.

F625-94, Standard Practice for Classifying Water Bodies for Spill Control Systems.

D5906-96, Standard Guide for Measuring Horizontal Positioning During Measurements of Surface Water Depths.

D5073-90 (1996), Standard Practice for Depth Measurement of Surface Water.

D5413-93 (1997), Standard Test Methods for Measurement of Water Levels in Open-Water Bodies.

D5243-92 (1996), Standard Test Method for Open-Channel Flow Measurement of Water Indirectly at Culverts.

D5130-95, Standard Test Method for Open-Channel Flow Measurement of Water Indirectly by Slope-Area Method.

D5129-95, Standard Test Method for Open Channel Flow Measurement of Water Indirectly by Using Width Constrictions.

D3858-95, Standard Test Method for Open-Channel Flow Measurement of Water by Velocity-Area Method.

D5614-94 (1998), Standard Test Method for Open Channel Flow Measurement of Water with Broad-Crested Weirs.

D5242-92 (1996), Standard Test Method for Open-Channel Flow Measurement of Water with Thin-Plate Weirs.

D5640-955, Standard Guide for Selection of Weirs and Flumes for Open-Channel Flow Measurement of Water.

D5089-95, Standard Test Method for Velocity Measurements of Water in Open Channels with Electromagnetic Current Meters.

D4409-95, Standard Test Method for Velocity Measurements of Water in Open Channels with Rotating Element Current Meters.

D5390-93 (1997), Standard Test Method for Open Channel Flow Measurement of Water with Palmer-Bowlus Flumes.

D1941-91 (1996), Standard Test Method for Open Channel Flow Measurement of Water with the Parshall Flume.

D4375-96, Standard Practice for Basic Statistics in Committee D-19 on Water.

E178, Practice for Dealing with Outlying Observations.

F1779-97, Standard Practice for Reporting Visual Observations of Oil on Water.

F1084-90 (1995), Standard Guide for Sampling Oil/Water Mixtures for Oil Spill Recovery Equipment.

APPENDIX C:

RESOURCES FOR DEVELOPING QA/QC PLANS

40 CFR SUBCHAPTER D (1995--1999) - WATER PROGRAMS - 40 CFR Part 122: National Pollutant Discharge Elimination System Select Subchapter D, Part 122.

http://www.epa.gov/epacfr40/chapt-I.info/

American Society of Civil Engineers (ASCE) - ASCE/EPA Stormwater Best Management Practices Nationwide Database.

http://bmpdatabase.org/

ASTM Store, Search for Standards - List, Title & Description for ASTM Methods (see ASTM appendix for specific methods applicable to Stormwater Technologies)

http://www.astm.org/.

CALTRANS Stormwater Management Program

http://www.dot.ca.gov/hq/env/stormwater/index.htm

EPA Web site: Water Quality Standards (Total Maximum Daily Limits)

http://www.epa.gov/OWOW/tmdl/index.html

EPA's Stormwater Program Website

http://cfpub.epa.gov/npdes/home.cfm?program_id=6

EPA Test Method Index (List of EPA Test Methods)

http://www.epa.gov/region1/info/testmethods/index.html