

# GUIDELINE FOR MONITORING STORMWATER GROSS SOLIDS



The Gross Solids  
Technical Committee

**ASCE**



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Betty Rushton, Chair	John Sansalone	Roger James
Gordon England	Ben Urbonas	Linda Pechacek
Daniel Smith	Robert Pitt	William Selbig
Tony Wong	John Gray	Qizhong Guo
Marcos Quigley		

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Listed below are the members of the Peer Review Committee:

1. Richard Fields, P.E., DEE, D.WRE, Leader, Urban Wet-Weather Flow Research Program, National Risk Management Research Lab, US EPA
2. Andrew Earles, Ph.D, P.E., Vice President, Wright Water Engineers, Denver Colorado
3. Elizabeth Fassman, Ph.D, Department of Civil and Environmental Engineering, University of Auckland, New Zealand

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## 1.0 INTRODUCTION

Gross solids are litter, trash, leaves, and coarse sediments that travel as floating debris or bedload in urban stormwater conveyance systems. Historically, most monitoring programs designed to determine the effectiveness of Best Management Practices (BMPs) for stormwater pollution have narrowly defined the size, concentration, and mass of *solids* in the runoff. This is attributed to the sample collection methods commonly used. These methods generally exclude *solid material* greater than 75 microns that is not effectively collected using automatic water quality samplers, or the coarse sediments that are transported as bedload. Though often unaccounted for in monitoring programs, these large size pollutants can degrade aquatic habitat, cause visual blight, smother productive sediments, leach harmful pollutants, and cause unpleasant odors.

Traditionally, evaluations of stormwater Best Management Practices have focused on dissolved and suspended pollutants in the water column because the sampling methods were adapted from experience with wastewater treatment plants. Therefore, pollutants were sampled in the influent and effluent water using grab samples from the water column or autosamplers, with flow measurements being made using velocity or weir measurements. Stormwater pollutants differ from wastewater, however, by being intermittent in nature and often having high volumes of gross solids in the storm runoff that are not measured using autosamplers or other standard techniques. This report recommends guidelines for measuring the gross pollutant fractions found in stormwater.

**Table 1**  
**Gross Solids Categories**

<b>Category</b>	<b>Description</b>
<b>Litter</b>	Human derived trash, such as paper, plastic, Styrofoam, metal, and glass greater than 4.75 mm in size (#4 sieve)
<b>Organic Debris</b>	Leaves, branches, seeds, twigs, and grass clippings greater than 4.75 mm in size (#4 sieve)
<b>Coarse Sediments</b>	Inorganic breakdown products from soils, pavement, or building materials greater than 75 microns. It also includes fragments of litter and organic debris not included in the other two categories. (#200 sieve).

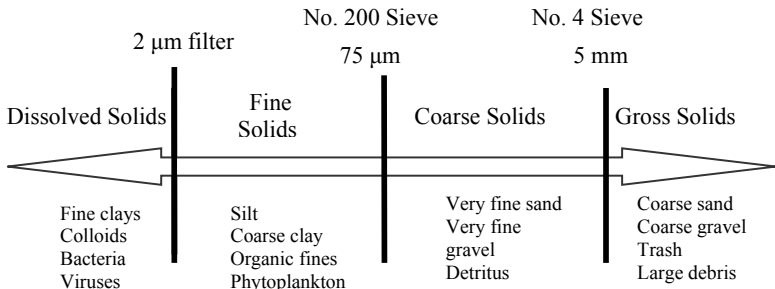
The selection of 75 microns as the lower size limit used to define gross solids was chosen because this is usually the largest size that can be seen by the naked eye or representatively collected and analyzed using auto-samplers. It was about the smallest size collected by proprietary BMPs designed to collect gross solids. A lower limit of 75 microns was also selected since this was the boundary between sand and silt used by soil scientists (AASHTO and USCS, Liu, T.K. 1970, Das 1997) and it was easily separated in the laboratory using a #200 U.S. sieve size (ASTM Standard D 2487-92). In addition, 75 microns was close to the 63 micron divide used by the



U.S. Geological Survey to distinguish between silt/clay and sand-sized suspended sediment in rivers (Horowitz 1995).

The lower size limits of litter have been defined in previous studies anywhere from 5 mm to 10 mm. These sizes have usually been selected to match the size of the mesh in the type of device used to collect the litter. In this guideline, the boundary of 4.75 mm (close to 5 mm) is selected as the lower limit for litter and organic debris since it is very difficult to separate smaller fragmented particles from the coarse sediment size fraction. In addition, this size can be conveniently separated in the laboratory using a #4 U.S. sieve size and includes the 5 to 10 mm size reported by other studies (Caltran 2000, Allison et al. 1996, Allison et al. 1998, Hydroqual 1995, Armitage and Rooseboom 2000, Lloyd et al. 2001, Butler et al. 2002).

For inorganic sediments, the #4 sieve corresponds to the separation between coarse sand and gravel (ASTM standard D 2487-92). A laboratory test can be used to quantify the organic fraction of the less than 4.75 mm solids and distinguish the organic fraction from the coarse sediment, if this is a goal of the monitoring project. Visual separation can be performed on solids larger than 5 mm if the monitoring program requires it. Other research designates these general size ranges for classifying solids as shown in Figure 1, adapted from a publication describing monitoring methods for solids (Roesner *et al.* 2007). Note that the Roesner study uses two categories for sediments greater than 75 microns, coarse solids, and Gross Solids, while this guideline uses only one category called Gross Solids for all sediments greater than 75 microns in size.



**Figure 1.** Solids Size Classification Diagram

Source: Roesner *et al.* 2007

These particle size boundaries are meant to be general guidelines and not hard and fast rules. For example, the AASHTO classification considers the material to be silt-clay if more than 35% passes the #200 sieve size. For ASTM D2487, the criteria for fine-grained soils (silts and clays) occur when 50% or more passes the #200 sieve. On the other end of the scale for coarse solids, automatic water quality samplers are able to collect particles larger than 75 µm (Owens 1996), but even when these

particles make it into the 4 to 5 gallon collection bottle it is difficult to keep them in suspension long enough to become a part of the laboratory sample (Selbig 2007, Rushton personal experience). In addition, proprietary BMPs often collect particles smaller than 75  $\mu\text{m}$ . For example, in a study of a CDS unit, 1 to 8 percent of the total solids sampled passed the #200 sieve in 10 samples analyzed for three cleanout periods (Rushton 2006). In an evaluation of drop box inserts between 2 to 11 percent of six samples collected for three sampling events passed the #200 sieve (Rushton et al. 2004). There are no distinct boundaries between particle sizes, but a majority of the particles sizes shown in Figure 1 are found within these ranges. These monitoring guidelines are designed for BMPs that primarily collect particles greater than 75 microns.

A gross solid monitoring guideline is needed for several reasons:

- The U.S. Environmental Protection Agency has identified sediment as a widespread impairment of the Nation's rivers and streams, affecting aquatic habitat, drinking water treatment processes, and recreational uses of rivers, lakes and estuaries as well as providing attachment sites for harmful pollutants such as mercury, pathogens and metals (US EPA 2000 and others).
- Physical, chemical, and biological damages attributable to fluvial sediment in North America alone are now estimated to be between \$20 billion and \$50 billion annually (Pimental and others, 1995, Osterkamp and others, 1998, 2004).
- The growing interest in mitigating the aesthetic and environmental impacts of trash and debris in the nation's waters and regulation of these pollutants through TMDLs has resulted in the development of a number of proprietary products designed to trap and separate large particles from the runoff flow path before discharge. The performance of BMPs and the material collected by these BMPs has not been fully tested with standardized methods and cannot be evaluated using historical or wastewater techniques.
- An accurate quantification and characterization of all particle sizes, including gross pollutants, is needed for testing and evaluating BMPs in order to facilitate proper BMP design, and development of maintenance requirements and schedules.
- Most Gross Solids cannot be sampled by traditional automatic samplers and have been ignored in studies evaluating the impact of storm water runoff on receiving waters.
- Some research of source area runoff in the eastern United States has reported that a significant portion of the mass of heavy metals, PAHs, and nutrients such as total phosphorous are associated with particles  $>150 \mu\text{m}$  that have not been effectively sampled in the past (Sansalone et al. 1998, Rushton 2006).
- In an intensive sampling program of fluvial sediment in rivers, the U.S. Geological Survey reported that the  $> 63 \mu\text{m}$  fraction can make a substantial contribution to suspended sediment associated trace element concentrations and should not be ignored (Horowitz 1995).

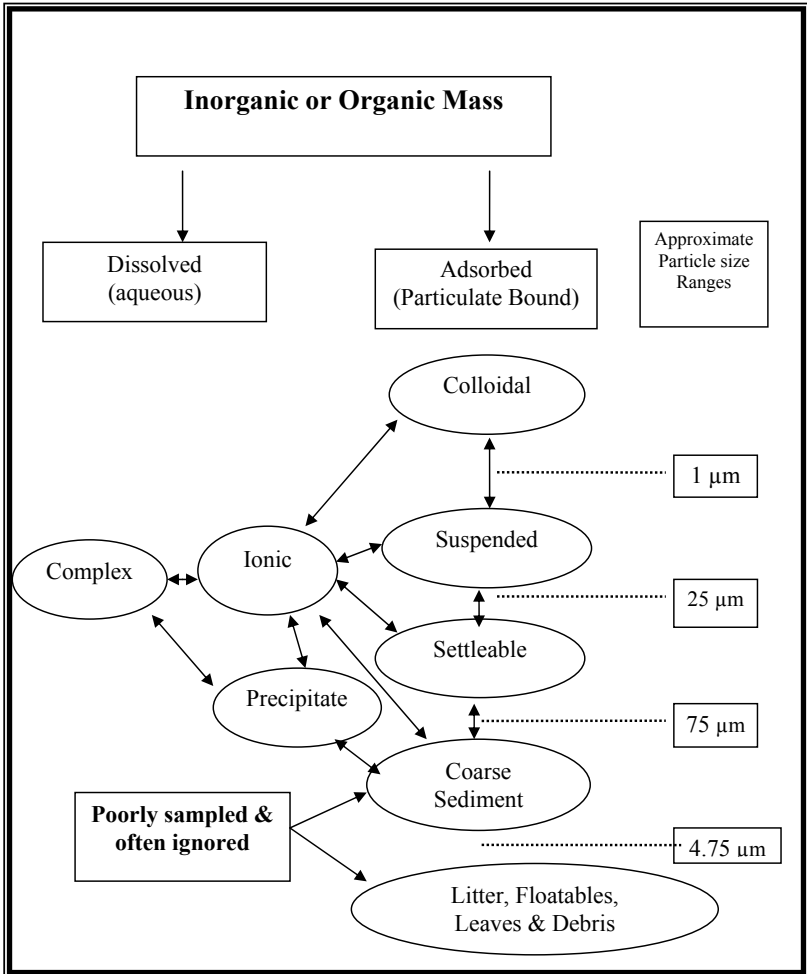
The purpose of this guideline is to standardize data collection procedures used in evaluating the removal of Gross Solids by BMPs, allowing for direct comparison of field data from separate studies by using the same collection methodologies. Since the protocols for collecting and analyzing pollutants in the water column is well represented elsewhere, (i.e. TARP 2003, ASCE/EPA 2002, EPA 2002, USGS variable dates), these practices will only be mentioned in passing. The guidelines presented in this report will emphasize methods for evaluating Gross Solids. This document is only a guideline and should be revised and refined once it has been tested in the field.

## 2.0 BACKGROUND

The total pollutant load entering a BMP is a combination of pollutants suspended and dissolved in the water column, as well as pollutants associated with the Gross Solids, which may be floating litter and debris, large organic and inorganic material suspended in the water column, or material moving as bedload by sliding, rolling, or bouncing along on or near the bottom of the conveyance system. The size of solids in stormwater consists of dissolved molecules, colloids, and suspended particles, as well as larger-sized floating or suspended matter (Figure 2). This conceptual framework of particle size distribution and partitioning in stormwater consists of dissolved molecules, colloids, and suspended particles, as well as larger sized floating or suspended matter. The figure is based on work reported by Ying and Sansalone 2008, Kim and Sansalone 2008, and others.

The smallest particles, colloids, are present in large concentrations in natural water and their relatively large surface area per mass provide numerous adsorption sites for pollutants (Minton 2005), but larger heterogeneous particles also provide numerous adsorption sites. Scanning electron microscopy reveals that large particles are rarely smooth or spherical in shape. The surfaces of these highly irregular shapes have greater surface areas than spherical shapes, giving them a higher capacity for adsorbing pollutants. In a detailed study of highway runoff, particles in the 420 to 850  $\mu\text{m}$  range had the highest total surface area per mass for all storm events measured (Sansalone *et al.* 1998). These folds, pores, notches, pits, and roughness result in additional surface areas that increase the opportunity for attachment sites and chemical reactions.

In addition, it is important for the stormwater manager to understand the granulometric characteristics of particles in stormwater in order to apply appropriate treatment techniques to control pollution. Different BMP systems are more efficient for removing certain particle sizes. Also understanding the relative location in the watershed of the treatment system can make the best use of limited resources. For example, coarse sediments and debris are discharged and deposited near source areas, while smaller particles are more readily transported in the flow stream. An understanding of particles also takes into consideration that larger ( $>75 \mu\text{m}$ ) particles and organic debris tend to cause progressive clogging of filter systems that are more efficient for removing small suspended solids, colloidal and dissolved constituents.



**Figure 2.** Particle Size Distribution and Partitioning of Solids in Stormwater Runoff

The division between suspended and settleable particle sizes in Figure 2 uses the 1-hr Imhoff settling test. The division between settleable and sediment is the fraction that passes through a #200 U.S. size sieve. The #4 U.S. sieve separates the litter, floatables, leaves, and debris.

Chemical reactions are constantly taking place between constituents in all particle size classes. These reactions are controlled by conditions in the water column, such as temperature, pH, dissolved oxygen, and alkalinity. In addition, physical conditions including parameters such as position in the watershed, flow

characteristics, storm intensity, turbulence, hydraulic efficiency, first-flush phenomenon, and friction also affect the size of particles and constituent fractionations shown in Figure 2. Colloids, dissolved and suspended solids have been well studied in stormwater research projects since they are routinely collected using automated water quality samplers. Automatic water column samplers do not collect floating litter and debris and have limited ability to collect representative samples of settleable and coarse sediments that travel as bedload or saltation. In contrast, some studies that capture the entire volume of runoff have shown that the majority of the mass of particles in storm water runoff are actually in the settleable and coarse sediment range (>25- $\mu$ m) (Sansalone *et al.* 1998, Sansalone *et al.* 2005). Proprietary BMPs, such as hydrodynamic separators and baffle boxes, primarily capture only this large size fraction. However, including these coarse sediments, organic debris, and trash in this larger size fraction increases the complexity in calculating a removal efficiency of solids and other pollutants.

There are at least three ways to evaluate the performance of BMPs. One way is to compare the influent and effluent Event Mean Concentrations (EMCs) for judging removal effectiveness. The second way is to convert the EMCs to loads and calculate the mass of constituent removed by the BMP. These first two methods can give a direct estimate of the loads of various constituents reaching the receiving waters. The third way is to calculate BMP removal efficiencies in term of percent removals, whether based on average annual EMCs or annual loads removed.

Calculating percent removal for Gross Solids is not straight forward. At best, we can measure the volume or mass of the material actually removed by the BMP device, but this data does not lend itself to clear estimates of “efficiencies” or percent removals. The nature of Gross Solids is such that, at this point in time, there are no proven methods for comparing upstream and downstream loadings since Gross Solids are measured as a total mass rather than a concentration and there is no appropriate “conversion factor” for combining TSS or other stormwater pollutants in the water column with the gross sediment mass in order to calculate overall removal efficiencies.

Heavy particles in a sample skew efficiency results when all size particles are added together. On a mass basis the coarse fraction dominates the gravimetric load and total surface area for particle size distribution, and therefore contributes the most weight to pollutant mass (Sansalone *et al.* 1998, Sansalone and Cristina 2004). This large size fraction (> 75  $\mu$ m) is effectively removed by pre-treatment stormwater BMPs (typically higher than 80%), but the “fine” fraction (particles smaller than 75  $\mu$ m) is far more difficult to remove. Devices such as baffle boxes, hydrodynamic separators and wet ponds are highly effective at capturing the coarse fraction, but have varying efficiencies on the fraction below 75  $\mu$ m depending on properties such as flow rate, residence time, system design parameters and maintenance practices.

Several recent studies have attempted to develop methods to convert mg/l and mg/kg measurements to a comparable mass so that Gross Solids can be added to the

pollutant data in the water column and a total efficiency calculated, but none of these methods have been validated (Smith and England 2008, Rushton 2006, James 2006, Kim and Sansalone 2008 and others).

For example, some pollutants in stormwater are attached to particles or are dissolved in the water column as shown in Figure 2. These particles can have vastly different weights, surface areas, settling velocities, and specific gravities. Organics have specific gravities around 1.0, inorganic solids like sand have specific gravities of 2.45 to 2.65, and clay has a specific gravity as low as 1.5. Particulate matter from rainfall runoff studies that captured the entire pollutant load have characterized these particles as largely inorganic with specific gravity in the range of 2.3 to 2.7, with a volatile fraction generally less than 30% (Sansalone *et al.* 1998). The transport of particulate-bound pollutants is greatly influenced by their associated particle size and specific gravity. Each of these pollutant masses may not have the same environmental impact, or may not be removed by the same treatment mechanism. Other researchers suggest that since the transport of particulate-bound pollutants is greatly influenced by the associated particle size (and specific gravity), data for particulate-bound pollutants should be separated into several parts and reported according to their characteristics (aqueous, sediment, organic debris and litter).

Another challenge in measuring Gross Solids is that some gross pollutant traps are designed to retain the collected material in a wet sump until the unit is cleaned out (wet systems) while other BMPs are designed to collect the material above any standing water in the trap (dry systems). Quantification of the amount of gross pollutants collected in wet units is not a simple task since (1) it is difficult to obtain an accurate dry weight of collected material, (2) the decanted water may dissolve or mask gross pollutants, and (3) some of the pollutants (i.e. nutrients, metals, organics, and inorganics) leach from the Gross Solids into the standing water in relatively short time periods (Strynchuk *et al.* 2000, Dodge 2005). In addition, even when pollutants, such as heavy metals associated with Gross Solids are not immediately bio-available, they can accumulate in the sediments and under anoxic conditions can, in part, mobilize into the water column and introduce toxicity to benthic organisms (Burton and Pitt 2002).

In contrast, dry systems, such as inlet traps, make characterization and testing of gross pollutants a somewhat simpler task than wet traps. In dry systems, it may be possible to collect nearly 100% of the pollutants in the screens or filters. Where appropriate in this guideline, a distinction is made for methods that are necessary for wet versus dry systems. Appendix A provides a list, brief summary, and some web addresses for various types of Gross Solid collection devices.

### **3.0 MONITORING PLAN DEVELOPMENT**

There are large variations in pollutants accumulated in structural BMPs among rainfall runoff events. These variations are due to many variables, such as size of contributing watershed, rainfall intensity and duration, antecedent dry period, land use, soil type, seasonality, deicing practices, landscaping practices, etc. In order to normalize these variations when studying Gross Solid removal effectiveness of various BMP facilities, yearly data accumulation measurements of such solids can provide more useful results than shorter time frequency comparisons. It therefore becomes important to keep accurate records of cleanout intervals, cleanout volume, and cleanout mass. In addition, tributary catchment and weather characteristics should be collected, such as rainfall amount, intensity and duration, number of rainfall events, area of the catchment, land use, types of curbing, other BMPs in the catchment, street sweeping activities, unusual weather events, urban landscaping practices and proximity to major pollution sources such as picnic and outdoor dining areas, beaches and industries. The basic information collected should be as a minimum, consistent with the International Stormwater BMP Database Requirements (See Appendix B) and other future efforts. Weather and flow requirements are discussed in a later section.

Each site and structural BMP is unique, so a monitoring program should be customized to meet individual circumstances. For example, excess dry weather flows or submerged pipes can result in sampling and disposal problems in wet systems. When cleaning a wet BMP, the inflow to the BMP should be closed off to eliminate dry weather flows. If the outflow is submerged, it should also be plugged. This becomes important because the volume of water in the conveyance system will flow into the BMP as it is cleaned, can dilute or flush out pollutants trapped in the BMP, and can be many times greater than the capacity of the cleanout truck.

In order for a monitoring program to deliver a reasonable level of accuracy, the program must be well planned. Unless a study is designed to compare characteristics of a specific rainfall event to gross pollutant accumulation, the Gross Solids analysis should be performed at the time of clean out. Since BMPs have a designed storage capacity, units should be cleaned out before this capacity is reached to prevent re-suspension or bypass in future storm events. A running record of cleanouts will assist in estimating required maintenance cleanout frequency and should become a standard procedure for all BMPs that remove Gross Solids. The BMP capacity should be noted in the cleanout report, along with the volume and characterization of material cleaned as discussed below. A detailed manual for developing a maintenance program has been published by the University of Minnesota (Gulliver and Anderson, 2007).



### 3.1 PROGRAM LEVEL DETERMINATION

The first step in any monitoring plan for determining the effectiveness of Gross Solids removals is to determine the purpose and budget available for such testing and monitoring. A monitoring program can range from basic and relatively inexpensive, to extremely complex and expensive. **Recognizing that not all BMP monitoring programs have the same goals or available funds, three Levels of monitoring are defined to balance goals, funding constraints, and levels of accuracy.** The Levels are first defined based upon broad goals in this section, followed by specific Level sampling requirements in Section 5.0 tailored to the program Level. Each succeeding higher program Level should include all of the elements of the preceding lower Level.

*Level 1* - A Level 1 monitoring program is intended to demonstrate basic effectiveness of a facility to remove Gross Solids. It requires only a simple data gathering effort to provide minimal performance data to quantify the mass or volume of the Gross Solids removed from a BMP and to analyze a limited number of pollutants in the solids. It is not necessary to include water column monitoring, although this would provide other useful information. Examples of Level 1 programs are the requirements associated with State or Federal grants to communities for stormwater retrofitting projects. Grant conditions often require that a small number of parameters be tested, which will provide performance data to estimate the effectiveness of a structural BMP installed with grant funding. The objective is to demonstrate pollution removal for the BMP based upon the pollutants collected. In order to control costs, minimal laboratory analysis is performed and statistical validity of results using a large number of storms is not typically required. At least two gross solid samples should suffice for analysis of each cleanout period.

*Level 2* - Level 2 programs are of a higher level of complexity and cost than Level 1 programs. In addition to Level 1 parameters, Level 2 programs include water quality sampling, collection of flow data, and a more detailed analysis of Gross Solids. More extensive laboratory tests are used to quantify individual pollutants of concern. These programs could be used by BMP developers or agencies for screening performances of BMPs, or for studies to set TMDL regulations.

An example of the water column sampling and analysis component for Level 2 testing program is published in the Technology Acceptance Reciprocity Partnership Protocol for Stormwater Best Management Practice Demonstrations (TARP 2003 or later), endorsed by California, Massachusetts, Maryland, New Jersey, Pennsylvania, and Virginia. For the TARP (Tier 2) protocol, a minimum of 15 qualifying storm events greater than 0.1 inch of rainfall are tested using flow weighted composite samples from auto-samplers. Accurate flow measurements are required to determine flow rates and volumes for each storm. Long term sampling of at least one year is recommended to account for

seasonality of pollutant loadings and rainfalls. The TARP program and others of this type only measure water column pollutants in dissolved and suspended forms. The sampling scheme proposed in this Guideline for Monitoring Gross Solids should be added to the TARP-type program to produce a Level 2 monitoring effort. Other current sources for water quality sampling methods are the Environmental Technology Verification Protocol (US EPA 2002 or later) and the United States Geological Survey Field Manual for Water Quality Testing (USGS variable dates).

**Level 3** - Level 3 programs are highly complex, and often expensive studies of BMPs that could be used to develop data for research programs, for development of new or improved BMPs, to perform multi-year analysis of annual mass loadings and long term impacts on ecosystems, or TMDL development. These programs are customized to study many parameters, or specific parameter(s), such as toxic organics. They are typically performed by technology testing and development firms or universities, with a research scientist or engineer determining the parameters to be measured.

### **3.2 QUALITY ASSURANCE PLAN**

The next step of the monitoring program is to develop and obtain approval of the appropriate Quality Assurance Project Plan (QAPP) required by local or state authorities. A QAPP establishes the test methods, equipment, and procedures that should be used to collect stormwater BMP data. Test results will often not be recognized by authorities without an approved QAPP. Examples of QAPP plans can be accessed from web sites (US EPA 2008a, US EPA 2008b, or Caltran 2003 Sections 1.3 and 2.3).

## 4.0 GROSS SOLIDS SAMPLING TECHNIQUES

Implementing the monitoring plan is the next step. The techniques that are used to collect samples are critical to the success of a monitoring or research program. If proper techniques are not employed, the samples may be compromised during collection and no subsequent analyses will provide accurate data. For all Levels of effort, the litter and trash should be separated from the sediment. For Level two and three programs, the debris and sediment also should be separated from each other and analyzed independently. The subjects discussed in Sections 4.1, 4.2, and 4.3 apply to all sampling activities.

### 4.1 SAMPLE COLLECTION

See Table 1 for more precise definitions of Litter, Debris, and Sediment as used in this document.

**4.1.1. Litter (Trash)** - Some types of BMPs designed to collect Gross Solids, such as inlet traps, are not designed to collect litter and this sample collection discussion will not be applicable. Floating trash is collected by being skimmed off the top of the water on a regular basis as necessary and air dried under cover. In some BMPs, trash will be captured on screens and will be mixed with large organic debris and associated sediments. This material is stored within the trapping device until the device is cleaned out, and the entire mass, or sub-samples of the litter/debris/sediments, are collected upon cleanout. Once the material is taken to the disposal site, a final sorting through the sample will be performed to separate the litter from the rest of the material. The volume of all of the litter should then be air dried and measured. For more detailed studies, the litter should be sorted into categories and each category measured and weighed. Examples of studies designed to quantify litter are described in Appendix C.

**4.1.2. Sediment/Debris** – Some types of collection devices are easy to access and can be sampled by hand using an appropriate tool such as a shovel. In other devices, representative samples of the sediment/debris portion can be more difficult to collect, meaning sediment sampling techniques may have to be used. Choosing the most appropriate sediment sampler for site conditions is important. Burton (1991), US EPA (2006a) and Edwards and Glysson (1999) provide some insight into the pros and cons of various samplers. The two types of samplers recommended for our purposes are grab samplers and core samplers.

Grab Samplers – Grab samplers are effective for surface samples. They consist of a set of jaws that shut or a bucket that rotates into the sediments. They are relatively easy to operate, but are prone to washout, especially when leaves, litter, or rocks are present that keep the jaws from completely closing.

They also tend to fall on their sides due to inadequate or incomplete penetration of the material.

Core Samplers – Core samplers give better results if the researcher is interested in stratification, or if a single core can be taken from the top to the bottom of the material. Core samplers usually collect less material than a grab sampler and several cores may be necessary to collect adequate volumes of sample material for lab testing. A core sampler may not be able to penetrate a mass that contains mostly leaves.

Other Possible Methods Include:

- Use of a pre-washed vacuum truck and segregation and dewatering of materials at the dump site.
- Collection by hand via confined-space entry
- Freezing core samplers

## **4.2 CONTAMINATION PREVENTION**

*Type of material* - Care must be taken to keep from contaminating the sample while it is being collected. For collecting and storing samples, for example, stainless steel or glass is recommended for metals. Some plastics cannot be used for Polycyclic Aromatic Hydrocarbons (PAHs), while Teflon is necessary for other samples. Consideration for contamination prevention should also be given for the sampling devices, such as a scoop, spatula, mixing containers, or any other utensils that come in contact with the sample. Depending on the type of analysis, only equipment and containers made of certain materials can be used.

*Equipment Decontamination* – For most sampling applications, site water rinse of equipment in between sampling sites is sufficient, but if cross contamination is possible, an approach recommended by ASTM (2000) includes: 1) soap and water wash, 2) distilled water rinse, 3) acetone or ethanol rinse, and 4) site water rinse. It is also recommended that equipment be washed in the lab by the ASTM procedure before sampling is initiated to make certain that the equipment has not been contaminated by a previous application.

*Constituents of Special Concern* – If metals or other inorganic compounds are specifically targeted, sampling and handling equipment should be suspended over a tub and rinsed from the top down with 10 percent nitric acid using a pump or squirt bottle (ASTM 2000). If organic compounds are targeted, sampling equipment can be decontaminated using acetone, followed by a site water rinse (US EPA 2006a). Also organic compounds can be contaminated from rubber or plastic materials. According to ASTM (2000) and APHA (1995), contact of the sample with the following substances should be avoided: PVC, natural or neoprene rubber, nylon, talcum powder, polystyrene, galvanized metal, brass, copper, lead and other metal materials, soda glass, paper tissues, and painted surfaces.

*Sample Containers* – Most containers for samples are sent directly from the laboratory where the samples are to be analyzed. The sample containers are often specifically prepared for the targeted constituents and are suitable for most applications. Commercially pre-cleaned containers are also available from many vendors. For samples stored at the laboratory, the US EPA (2006a) recommends the following precautions: High density PTFE or Teflon containers are least likely to add chemical artifacts and are less likely to break than glass. Volatile compound containers should have a septum to minimize the escape of volatile gases. If samples contain photoreactive compounds, such as PAHs, then brown glass or shielding with an opaque material such as aluminum foil will reduce changes in concentrations and should be stored in the dark. Plastic or acid-rinsed glass containers are recommended for heavy metals.

### **4.3 SUB-SAMPLING AND COMPOSITING SAMPLES**

The contents of most BMPs designed to collect Gross Solids will have to be sub-sampled. For small dry systems such as inlet traps, this can usually be accomplished directly in the BMP. For large BMPs with deep enclosures, vertical stratification can result and sub-samples should be collected from each depth. Spacing will depend on the total depth of the material, but aliquots from at least four or five depths should be collected. Gross Solids are usually not homogeneous, and at least two samples collected separately should be analyzed for all testing Levels to help determine variability. Each composite sample consists of several grab samples of equal size taken from different locations in the device and thoroughly mixed together evenly. The following suggestions for compositing sediment samples are recommended (US EPA 2006a):

- Overlying water should be siphoned off, not decanted, from samples prior to sub-sampling<sup>1</sup>.
- All utensils used to process samples should be made of inert materials.
- Sub-samples should be collected away from the sides of the sampler to avoid potential contamination.
- For samples of parameters with holding times, samples should be processed prior to long-term storage, and within 72 hours (preferably within 24 hours) of collection. See Appendix E for examples of holding times recommended for various constituents.
- Prior to placing samples in containers, sufficient sample homogenization is critical for accurate quality measurements.
- Similar depths for each duplicate sample aliquot should be maintained.

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<sup>1</sup> Siphoning water off the top of the sample uses the same principle as siphoning gas out of your automobile gas tank. Take a piece of laboratory flexible tubing, fill with water, crimp both ends and place down the side of the container, let go of the ends of the tubing and siphon into a glass cylinder placed at a lower level. If some sediment is transferred to the cylinder, this last amount of water can be decanted and the sediment placed back into the sample container.

- Samples should be kept at 4° C or frozen. Be aware that freezing and thawing appears to increase the release of soluble organic carbon (Burton 1991). If organic carbon is a constituent of concern, do not freeze.
- If samples are to be refrigerated, the container should be filled to the brim to reduce oxygen exposure. This is particularly critical for volatile compounds. If a sample is to be frozen, the container should be filled to approximately 90% of its volume to allow for expansion.
- Mechanical sieve analysis shall be conducted on the entire mass of air-dried solids (40°C and low humidity). A dry mass is determined before and after sieving and a mass recovery error of < 2% is generally required.
- **Results are to be reported as mg/kg or µg/kg dry weight.**

If a complete analysis of all solids collected in a stormwater monitoring program is desired a procedure such as described by Roesner et al. (2007) or Sansalone and Kim (2008) should be used.

*Gross Solids are solid materials, and as such, many testing methods used for water borne pollutants are not appropriate for laboratory analysis. Many laboratories that analyze water quality samples do not have the equipment or ability to test the soils, solids, and biological tissue that comprise Gross Solids. Appendix F shows examples of laboratory methods that can be used for Gross Solids analysis.*

## 5.0 PROCEDURES FOR PROGRAM LEVEL MONITORING

Table 2 summarizes the specific measurements and analyses that are recommended for each of the three Levels of Gross Solids monitoring. Each Level should include the steps from each preceding Level. Level 3 includes suggestions of tests that might be performed, but are not required. Definitions of litter, debris, and sediment are listed in Table 1. Note that the chemical analysis for the Gross Pollutants may cover different parameters than the aqueous testing regime since some parameters, such as PAHs, are often detected in sediment/debris, but not in the water column. *Also note that dry sediment cannot be tested for TSS.* Certain BMPs have a combination of wet and dry treatment methods. Monitoring of gross pollutants for these devices will require customized approaches. The plan for testing BMPs should be designed using the appropriate combinations of the procedures described below.

**Table 2**  
**Program Level Summary**

<b>Level 1</b> <b>Minimal Monitoring</b> <b>(Screening Evaluation)</b>	<b>Level 2</b> <b>Detailed Monitoring</b> <b>(Performance Evaluation)</b>	<b>Level 3</b> <b>Advanced Monitoring</b> <b>(Research and Design)</b>
<ol style="list-style-type: none"> <li>1. Rainfall amount</li> <li>2. Time interval since last cleaning</li> <li>3. Volume and weight of material captured in each chamber</li> <li>4. Separation of large litter from coarse sediment and organic debris</li> <li>5. At least two samples for chemical analysis of sediment/debris mixture</li> <li>6. Percent organic matter of sediment/debris sample</li> <li>7. Percent solids</li> </ol>	<ol style="list-style-type: none"> <li>1. Rainfall characteristics</li> <li>2. Separation of organic debris from coarse sediment</li> <li>3. Mass and weight of debris</li> <li>4. Mass and weight of sediment</li> <li>5. Sediment particle size distribution using sieve analysis</li> <li>6. Chemical analysis for two debris sample per chamber</li> <li>7. Chemical analysis for two sediment sample per chamber</li> <li>8. Percent organic matter of sediment sample in each chamber</li> <li>9. Water quality sampling using standard methods.</li> <li>10. Flow measurement for storm duration including bypassed &amp; base flow</li> </ol>	<ol style="list-style-type: none"> <li>1. Sediment chemical analysis for each sieve size and whole sample.</li> <li>2. Additional chemical analysis for special parameters</li> <li>3. Subdivide litter and debris into special categories</li> <li>4. Baseflow measurement and chemical analysis.</li> <li>5. Leachate analysis</li> <li>6. Mass balance</li> <li>7. Other analysis as needed</li> </ol>

**Level 1** – This basic Level of evaluation is planned so that the amount and type of material collected by gross solid collectors can be compared to each other. It includes basic information such as: rainfall, cleanout intervals, volume and type of material collected by the BMP, as well as watershed information and BMP cost (see Appendix B).

1. *Rainfall* should be measured at the site, if possible, or at a nearby weather station. Data recorded daily is desirable.
2. *Time interval since the last cleanout* - Document the time interval between cleanouts and the depth and volume of accumulated material, percent of maximum volume accumulation for the BMP under study, and other pertinent data. One approach is to measure the accumulated depth of Gross Solids in the BMP each month and plot it on a graph with the monthly rainfall data. See Appendix D for an example.
3. *Volume of material captured in each chamber* will depend on the type of BMP under study. The volume and mass of material collected by the BMP should be estimated at the time of cleanout. For Level 1, the entire volume including litter, debris, and sediments can be estimated either while in the BMP (if possible), in the vacuum truck, or at the disposal site. The dimensions of the BMP are known so the volume can be estimated by measuring the depth of the accumulated mass at one or more locations in the containment chamber. Wet and/or dry density determinations can be made to estimate wet and/or dry mass from volume. Record the method used to measure the volume of material.
4. *Separation of litter from sediment and debris* – This is usually done by hand. Some BMPs such as inlet traps are not designed to capture large litter. In BMPs such as those, discard any stray litter in the sub-samples targeted for laboratory analyses. For analysis of litter capture devices, the litter is separated, air dried under cover, and a volume calculated for each cleanout period. At the time of cleaning, large, heavy litter such as bottles should be separated from the litter and debris. Air-dried weight can vary depending on humidity, temperature, and drying time. If weights are recorded, it is recommended that drying methods be recorded.
5. *Chemical analyses of sediment/debris mixture for pollutants of concern* – After the litter is separated from the sediment/debris, the remaining material should be prepared for the chemical analysis and at least two separate representative samples of the mixture taken from each chamber and analyzed for pollutants of concern using standard soil analysis techniques. At a minimum, analyze for total nitrogen, total phosphorus, recoverable metals, percent moisture, and total solids. Since PAHs are often found in measurable amounts in Gross Solids, this would be a desirable parameter to measure. **Report the results as  $\mu\text{g}/\text{kg}$  or  $\text{mg}/\text{kg}$  dry weight.**



6. *Percent organic matter* - One example method is the Walkley-Black Method. See the discussion for organic matter in Level 2 for more information.

**Level 2.** This monitoring Level includes all of the Level 1 tests and adds more intensive techniques to separate litter, debris, and sediment. It also includes storm flow data and additional laboratory analyses.

1. *Rainfall* should be measured at the site, if possible, or at a nearby weather station and rainfall characteristics should be calculated using the following parameters. See Appendix D for an example.
- Rainfall amount (mm, in) = amount measured for each event > 12.7 mm (0.05 in).
  - Inter-event dry period (hr) = time period since previous rain event (Use definition developed by regulatory agencies for your region or > 25.4 mm (0.1 in) and > 6 hour inter-event dry period between storms as suggested by EPA.).
  - Duration (hr) = period of active rainfall. (Once the storm has essentially passed or less than 12.7 mm (0.05 in) falls)
  - Intensity (mm/hr, in/hr) = total event rainfall/duration
2. *Separation of organic debris from sediment* – Separate the sediments from the herbaceous materials (leaves, twigs etc.) and other larger Gross Solids by using screens or sieves. To do this, take representative aliquots from throughout the collected material and combine by mixing well. Spread this mixture to approximately ½ inch thickness on plastic sheeting, and air dry for 4 days at room temperature. The dried material is then sieved through a 4.75 mm nylon screen or stainless steel sieve (No. 4 U.S. Mesh). Material is then shaken or vibrated to remove visible sediment from surfaces of herbaceous material. For contaminants of interest that preferentially volatilize, a dry analysis should be coupled with a wet analysis (with an accurate determination of moisture content). Gross Solids that contain a significant amount of attached fine solids should include a separation process so that the Gross Solids and attached fine solids are separated and quantified. For example, burning may have advantages over washing methods.
3. *Mass and weight of debris* - The next step is to determine the volume and mass of the organic debris sampled. For dry BMPs, 100% of the volume of Gross Solids can generally be collected and measured inside or outside of the BMP. Representative sub-samples should be taken for analysis and the organic debris separated from the sediment as described above. Litter should have already been separated from the total mass and measured as described in Level 1(4). Organic debris from decomposing leaves and grass sometimes breaks down to become small particles that are difficult to discern from coarse sediment. Some pollutants attach to the organic debris with concentrations that vary depending on particle size.

4. *Mass and weight of sediment* – Representative samples of mixed debris/sediment in each chamber should be taken. Separate the debris from the sediments as described above and report sediment as a dry weight.
5. *Sediment particle size using sieve analysis* – A laboratory sieve analysis should be made using standard methods with four or five different sieve sizes between and including #4 and #200. This would be used to characterize the gradation of the sediment (see discussion below). Use the gradation to calculate masses of fine solids less than 75 microns and coarse sediments greater than 75 microns.
6. *Chemical analysis for sediment samples* – It is important to analyze samples before sieving because sieving methods may distort the chemical composition of soils or organic material and bias the results since many pollutants of interest adsorb on the surface area of the particle. It would be more appropriate to run a test similar to that used for water analyses.
7. *Chemical analysis for debris samples* – In addition to the analyses recommended for Level 1, Level 2 analysis should include: nitrate + nitrite, ammonia, PAHs, total organic carbon and bulk density. Other constituents could include any pollutants of special concern for the region. **Report as mg/kg or µg/kg dry weight.** A complete list of possible constituents and suggested laboratory methods can be found in Appendix F.
8. *Percent organic matter of sediment* - A common analysis for measuring percent organic matter of soils is the loss-on-ignition (LOI) method carried out at high temperatures. It gives quantitative oxidation of organic matter, but inorganic constituents of the soil, chiefly the hydrated aluminosilicates, lose structural water and carbonate minerals and some hydrated salts are decomposed upon heating (Nelson and Sommers 1996). The Walkley-Black Method is preferred since the weight loss caused by heating in the LOI method is considerably in excess of the actual organic matter content. If this error is acceptable then use ASTM D 2974-87 Method C, which is an ash burning at 440 degrees Celsius. The Walkley-Black Method ASTM F1647-02a Method B is a more accurate method to quantify organic matter by providing a more precise characterization of organic matter with acid-dichromate and heat oxidation (modified Walkley-Black). The procedure is based on a method published in “Methods of Soil Analysis, Part 2: Nelson and Sommers (1996) provide descriptions for a necessary conversion factor. A good discussion for analyzing total organic matter, including Walkley-Black, is available on the United States Environmental Protection web site (Schumacher 2002).
9. *Water quality sampling using standard methods.* Water quality monitoring is not a part of this guideline since it is well defined elsewhere. Suggested methods for water-quality sampling can be found in reports by the Technology Acceptance Reciprocity Partnership (TARP 2003 or later update), the ETV Verification

Protocol (US EPA 2002 or later update), or the U.S. Geological Survey (Bent et al. 2003).

*10. Flow measurement.* Depending on the location, flow measurements can be taken by installing weirs, flumes, velocity meters, or other types of flow measuring devices that do not have an affinity for clogging. Each device should be installed in the appropriate hydraulic setting using manufacturer's recommendations. A comprehensive discussion of various flow measurement devices can be found in Burton and Pitt (2002 pp 373-377), EPA (2002 p 83), and Brater and King (many editions). Techniques for site selection, installation, and maintenance of various flow measurement devices are discussed in Church and others (1999). The amount of bypass and base flow should also be measured where appropriate.

**Level 3.** This Level of testing consists of customized studies and data collection: (1) to facilitate in-depth data interpretation for development of new BMP processes, (2) to better understand BMP functioning, or (3) to answer specific questions posed by the study. The program design and procedures are to be developed by research scientists and engineers. Some characterization methods are listed in Table 2, but these are not mandatory. For example, chemical analysis on each sediment particle size might be one of the goals for this level.

## 6.0 SUMMARY

Gross pollutants consist of litter, organic debris, and coarse sediments, which are significant components of stormwater pollution. Gross Solids have not typically been measured in monitoring studies that have quantified pollutant removal efficiency. While these pollutants are not normally monitored in testing programs, many pollutants are bound to Gross Solids. In response to growing concerns about Gross Solids in urban areas, manufacturers have developed a number of proprietary products designed to trap and separate Gross Solids from stormwater runoff.

TSS measurements have historically been used for sediment characterization in stormwater runoff. Studies have shown that autosamplers are not effective in sampling large sediment particles, giving erroneous results for TSS measurements. *It is recommended that stormwater TSS be defined as solid particles less than 75 microns in size. Sediment sizes greater than 75 microns should be called coarse sediments and measured as a separate Gross Solids component, rather than an aqueous pollutant.*

The ASCE's Urban Water Resources Research Council (UWRRC) has developed this guideline for sampling and measuring Gross Solids in end of pipe BMPs, inlet traps, or other devices that collect Gross Solids. This guideline does not suggest methods for collecting water quality data, since those methods have been developed by other researchers, nor does it make recommendations for calculating pollutant removal effectiveness for BMPs. Methodologies for calculating BMP efficiency are still being developed.

There are many variables to consider when monitoring gross pollutants. Principal factors to investigate in developing a monitoring program are the purpose of the monitoring project, fiscal constraints, desired accuracy, parameters to be monitored, whether the BMPs traps Gross Solids in a wet, dry, or combined condition, and time constraints for completion of the program. These factors should be used to determine a program Level for monitoring. Three program Levels have been defined. Level 1 is a basic collection of samples with a minimal amount of laboratory analysis. Level 2 starts with Level 1 methods, adds intensive techniques to separate litter, organic debris, and sediment, then uses laboratory analysis to quantify basic individual parameters of concern. Level 3 programs are research programs customized for specific goals. Suggestions are made for Level 3 analysis, but these programs can be customized for any type of research needs. Program Levels increase in cost and intensity of effort required as greater levels of detail and accuracy are pursued. Note that the guidelines in this report for each level are minimum criteria, and additional techniques or parameters may be added as needed.

To determine the total pollutant load removed in a BMP, it must be recognized that there are two components to be measured in different ways: a) the aqueous pollutants measured as concentrations and converted to masses through the

use of total flow data, and b) the Gross Solids pollutants measured as masses. The dissolved and suspended solid concentrations should be calculated using traditional auto-sampling techniques, flow volume measurement, flow composite sampling, and mass conversion analyses. Gross Solids trapped in a BMP should be collected and measured using the methods described in this guideline. Pollutants associated with each category of Gross Solids, as described in Table 1, should then be summarized as a mass for each category. Summarizing the masses of pollutants for each Gross Pollutant category, along with the aqueous masses calculated in a) above, gives a total mass of pollutants trapped in a BMP.

Calculating removal efficiencies for dissolved and suspended solids is straight forward, but methods for calculating removal efficiencies under field conditions for Gross Solids are currently not developed. It is suggested that for Level 2 and Level 3 programs, the entire spectrum of pollutants be analyzed using additional guidelines or protocols. These include, but are not limited to the following:

For Water Quality:

- The Technology Acceptance Reciprocity Partnership (TARP 2003 or later).
- The ETV Verification Protocol: Stormwater Source Area Treatment Technologies (US EPA 2002 or later).
- U.S. Geological Survey Techniques of Water-Resources Investigations, book 9 USGS (2006 or later).

For Solids:

- Guidance for Improving Monitoring Methods and Analysis for Stormwater-Borne Solids (Roesner et al. 2006).
- Event-Based Size Distributions of Particulate Matter Transported During Urban Rainfall-Runoff Events (Kim and Sansalone 2008 or Sansalone and Kim 2008).

Monitoring methods for Gross Solids are still in the developmental stage. These guidelines for monitoring storm water Gross Solids have been developed to establish uniform guidance in characterization of the wide range of solids in storm water runoff. ASCE found it necessary to develop the guidance because of the lack of commonly accepted methods. We expect that the guidance will be periodically updated, refined, and improved based on actual field testing under various conditions.

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# APPENDIX A

## A SAMPLING OF GROSS SOLIDS REMOVAL TECHNOLOGIES

Hydrodynamic Separators, inlet devices and oil-water separators are a group of pre-constructed BMPs that are engineered for stormwater pollutant removal in ultra-urban areas (i.e. areas where parking lots, roads, and sidewalks can cover nearly 100 percent of the land). A variety of companies make these BMPs. The list below, with brief descriptions, is provided as a sample of the types of technology available to remove Gross Solids. A virtual trade show of available products can be accessed on the internet (US EPA 2006b).

**Sedimentation Basins** are sumps that allow surface water runoff to retain coarse material by velocity reduction and gravity settling. Their purpose is to prevent solids from clogging the storm sewer or being washed downstream. These must be cleaned on a regular schedule to maintain their function of trapping sediments.

[www.epa.gov/OW-OWM.html/mtb/catchbas.pdf](http://www.epa.gov/OW-OWM.html/mtb/catchbas.pdf)  
[www.stormwatercenter.net](http://www.stormwatercenter.net)

More sophisticated devices have been developed to improve on performance.

**Baffle Boxes** are concrete or fiberglass structures which contain a series of sediment settling chambers separated by baffles. Stormwater flows through sections of the box causing pollutants to settle out of the water. Screens above normal water levels remove organic debris, providing nutrient removals.

[http://www.epa.gov/OW-OWM.html/mtb/baffle\\_boxes.pdf/](http://www.epa.gov/OW-OWM.html/mtb/baffle_boxes.pdf/)  
<http://www.stormwater.ucf.edu/toolkit/vol2/Contents/pdfs/>

**Hydrodynamic Separators** are flow-through structures with a settling or separation treatment mechanism to remove sediments and other pollutants. Depending on the type of BMP, this separation may be accomplished by means of swirl action or other methods.

<http://www.epa.gov/OW-OWM.html/mtb/hydro.pdf/>  
[http://www.stormwaterauthority.org/assets/Hydrodynamic\\_separators.pdf/](http://www.stormwaterauthority.org/assets/Hydrodynamic_separators.pdf/)

**Oil Grit/Separators** are similar to baffle boxes but have the added advantage of also collecting the free oil from storm water. They also may contain screens to help retain larger or floating debris and a coalescing unit to help promote oil/water separation.

<http://www.epa.gov/OW-OWM.html/mtb/wtrqlty.pdf/>

**Modular Treatment Systems** consists of a series of sedimentation chambers and constructed wetlands within a modular tank.

<http://www.epa.gov/OW-OWM.html/mtb/modtreat.pdf/>

**Inlet Traps** are designed to hang in grated or curbed inlets and capture Gross Solids. Some of the models are also designed with an inner component that contains an oil-absorbent material.

<http://www.fhwa.dot.gov/environment/ultraurb/3fs13.htm/>

[http://www.stormwaterauthority.org/assets/Catch\\_basins.pdf/](http://www.stormwaterauthority.org/assets/Catch_basins.pdf/)

<http://www.mackblackwell.org/OLD/research/finals/arc2018/>

[http://www.lowimpactdevelopment.org/ffxcty/2-1\\_catchbasin\\_draft.pdf](http://www.lowimpactdevelopment.org/ffxcty/2-1_catchbasin_draft.pdf)

## APPENDIX B

### STANDARD FORMAT EXAMPLES

The information in this section has been adapted from the International Stormwater BMP Database. The entire manual is available at <http://www.bmpdatabase.org/doc>. Read especially manual pages 156-160 for watershed and site information requirements and pages 192 and 193 for specific information about hydrodynamic separators. These pages will provide specific instructions that will help fill out the information in this Appendix. Check the web page regularly for updates.

### GENERAL TEST SITE INFORMATION

Test Site Name including: City, County, State, Zip Code, Country, and Time Zone

Geo-referencing including: Township, Range, and Principal Meridian  
USGS Quadrangle Map with Altitude, Section, and Quarter Sections

Latitude: Degrees, Minute, Seconds

Longitude: Degrees, Minute, Seconds

Sponsoring Agency including: Name, Agency Description, and Address.

The address should include: Street, City, State, County, and Zip Code. Also include Phone, Fax and E-Mail

Monitoring Agency includes: Agency Name, Description, Address, and Phone as above.

Provide any other comments that apply

### WATERSHED INFORMATION

Watershed Name, Hydrologic Unit Code (8-digit), EPA Reach Code (RF1 or RF3)  
Unit System (S.I. or U.S. Standard)

Physical Characteristics such as Total Watershed Area, Total Length of Watershed, Total Length of Grass-Lined Channels, total Disturbed Area, % Irrigated Lawn and/or Agriculture, % Total Impervious Area, % of Total Impervious Area that is Hydraulically Connected, % of Watershed served by Storm Sewers, Storm Sewer Design Return Period, Average Watershed Slope, Average Runoff Coefficient, Hydrologic Soil Group, Soil Type and Type of Vegetation, Visual Observations of Gross Solids.

Description of Roads including: Total Paved Roadway Area, Total Unpaved, Total Length of Curb and Gutter on Paved, Total on Unpaved, % Paved Roads Draining to

Grass Swales/Ditches, % Unpaved Roads Draining, Type of Pavement on Roadways, Traffic Counts (such as AADT or VDS).

Parking Lots: Total Paved Parking Lot Area, Unpaved, Total Length of Curb and Gutter on Paved and Unpaved, % Paved Parking Lot Draining to Grass Swales/Ditches, Unpaved, and Type of Pavement in Parking Lots with % porous.

Land Uses: Land Use Types, % of each Land Use in Watershed.

### GROSS SOLID COLLECTOR DESIGN DATA

The ASCE International Database does not have protocols for Gross Solids. Additional data used for Gross Solids analysis includes:

- Test Site Name, Watershed Name and BMP Type and Name. Design Information:
- Include a drawing of the device with dimensions of each element.
- List other BMPs in watershed such as ponds, forebays, ditches, swales, and street sweeping.
- Enumerate Gross Solids storage capacity, site visit, maintenance, and clean-out schedule
- Provide maximum flow capacity and by-pass information
- Provide maintenance practices in the watershed such as Street Sweeping
- Give Proximity to pollution sources such as beaches, picnic and outdoor dining areas, drive through restaurants, incinerators, industries, etc.
- Provide description of the tributary catchment and activities that affect delivery of Gross Solids
- List installation cost estimates - Cost of unit, construction costs, land costs and value, engineering and overhead.
- Provide clean-out information: Type and cost of clean-out and disposal of Gross Solids
- Document dates of cleanouts
- Provide volume of mass in vault – by individual compartments
- Characterize the type of material in screens
- Calculate volume and mass of material in screens

Provide any other comments that apply.



**CALTRAN EXAMPLE:**

Litter characterization was conducted in a specially designed litter lab (Caltran 2003). All litter samples/bags collected from the outfall locations were returned to the litter lab for analysis. The litter bags contain all material retained by the 1/4<sup>th</sup> inch mesh openings. This material was termed gross pollutants and consists of both vegetation and litter. The weight and volume were measured at the start of the characterization process. The contents of the litter bag were emptied into a sorting tub and the vegetation was sorted from the litter. The weight and volume of vegetative material was recorded on the data sheet and then disposed.

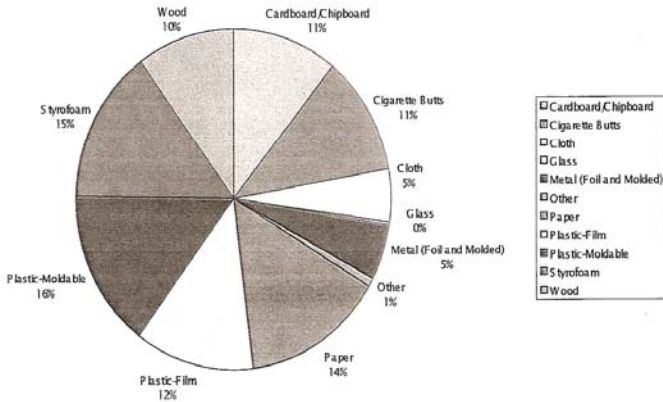
The litter material was then sifted through to recover any spike materials. The spike material was weighed as a composite and weight was recorded on the data sheet. The spike materials were then sorted into different material categories (i.e. cigarette butts, Styrofoam, fabric, etc.). Both the color and category of the recovered spike material were recorded on the data sheet.

The remaining litter material was placed on a drying screen and allowed to dry for a minimum of 24 hours and the time of air drying was recorded on the data sheet. Other data included antecedent dry period, a photographic record for each site with outfall number, storm number, and event number. Litter data were compiled at the end of the storm season and processed into charts and graphs. An example is shown in Figure 6-3.

In a later report, Caltrans recommended a specific procedure to analyze Gross Solids (Caltrans, 2003). The total wet weight and volume of Gross Solids should be measured in the field. Gross Solids can be weighed using an electronic scale, while volume measurements can be made by displacing a known volume of water. Once the Gross Solids arrive in the lab, they should be separated into debris (vegetative matter) and litter. Separation may require visual examination and separation of natural and manmade material. The weight and volumes of each component should be recorded. The litter is allowed to air dry for 24 hours, and again the weight and volume are measured.



**Figure 6-3**  
**LITTER CATEGORY DISTRIBUTION BY VOLUME FOR ALL**  
**EVENTS COMBINED**



Source: Caltrans 2003

### ALBUQUERQUE STUDY:

A leachate analysis was conducted on the Gross Solids collected in the AMAFCA/Albuquerque study (Dodge, 2005). Leachate from the solids was used to determine the amount of water quality constituents of concern that would leach or wash off of the gross pollutants. Based on this study, it appears that a significant amount of water borne pollutants easily washes off of debris. The following procedure was used.

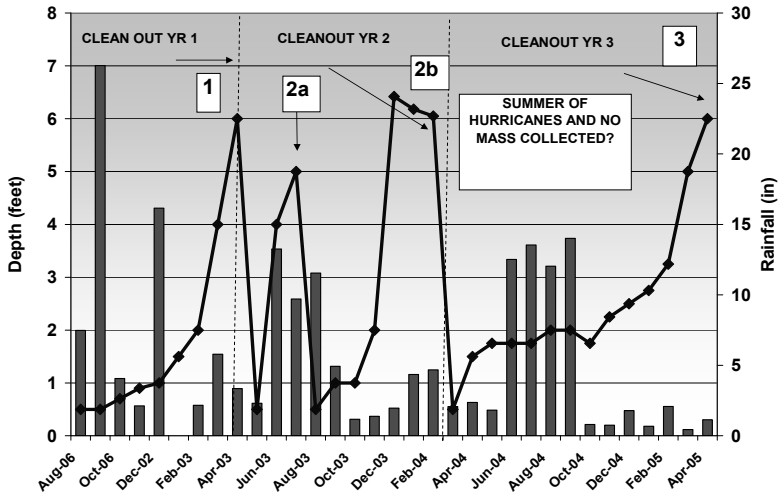
- One cubic yard of Gross Solids was collected from separate locations
- Each cubic yard was immersed in distilled water for 15 minutes
- The leachate was sampled and delivered to a laboratory for water quality analysis using standard procedures.

The results supported the conclusion that Gross Solids can markedly degrade the water quality by increasing metal concentrations. Specifically total copper, total lead, and total zinc of the leachate solutions showed increased concentrations when compared to the stormwater average. The leachate also showed presence of Petroleum Hydrocarbons and Solvents, (ethylbenzene, toluene, total xylenes, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, chrysene, fluoranthene, and pyrene).

## APPENDIX D

### EXAMPLE OF A RAINFALL, SOLIDS ACCUMULATION, AND CLEANOUT RECORDS

*Rainfall* should be measured at the site, if possible, or at a nearby weather station. The most common method is a tipping bucket rain gauge. Excellent descriptions of the proper placement, calibration, and other useful advice are available in many texts (Burton and Pitt 2002, p. 378, 387; EPA 2002, p. 61).



**Figure E-1.** Example of monthly rainfall, accumulated volume, and cleanout record presentation.

Source: Rushton 2006a.

The bars represent the monthly rainfall amount and the line represents the height of the mass collected in the chamber of the device. The cleanout intervals are represented by the numbered boxes, with the yearly records separated by the dotted lines. Six feet was the depth of the containment chamber. Street sweeping likely affected the results.

## APPENDIX E

### EXAMPLE INFORMATION FOR DEBRIS/SEDIMENT SAMPLE HANDLING PROCEDURES

Parameter	Container	Preservation	Holding Time
Sieve analysis	1 gal. Ziploc bag	N/A	N/A
Percent Organic Matter	1 gal. Ziploc bag	N/A	N/A
Density	1 gal. Ziploc bag	N/A	N/A
Total Nitrogen	8 oz Glass Wide Mouth	4°C	7 days
Chemical Oxygen Demand	8 oz Glass Wide Mouth	4°C	7 days
Total Phosphorus	8 oz Glass Wide Mouth	4°C	7 days
Mercury	8 oz Glass Wide Mouth	4°C	28 days
Aluminum	8 oz Glass Wide Mouth	4°C	6 months
Barium	8 oz Glass Wide Mouth	4°C	6 months
Chromium	8 oz Glass Wide Mouth	4°C	6 months
Cadmium	8 oz Glass Wide Mouth	4°C	6 months
Iron	8 oz Glass Wide Mouth	4°C	6 months
Nickel	8 oz Glass Wide Mouth	4°C	6 months
Zinc	8 oz Glass Wide Mouth	4°C	6 months
Copper	8 oz Glass Wide Mouth	4°C	6 months
Acenaphthylene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
Benzo(a)pyrene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
Benzo(g,h,i)perylene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
Fluoranthene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
Fluorene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
2-Methylnaphthalene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
Naphthalene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
Pyrene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after

## APPENDIX F

### EXAMPLE ANALYTICAL METHODOLOGY FOR ORGANIC DEBRIS AND COARSE SOLIDS

Parameters	Matrix	Units	Method	Precision (% RSD)	Accuracy (% Recovery)	MDL	PQL
Sample Preparation	Sediment/Debris/ Solid	N/A	USBR 514.2.6	N/A	N/A	N/A	N/A
Sieve Analysis (5 screens: #4 #20, #40, #80, #100, <#200)	Sediment/Debris/ Solid	N/A	ASTM D422	N/A	N/A	N/A	N/A
Percent Organic Matter	Sediment/Debris/ Solid	%	ASTM D2974	N/A	N/A	N/A	N/A
Density	Sediment/Debris/ Solid	g/cc	ASTM D2937	N/A	N/A	N/A	N/A
Total Nitrogen	Sediment/Debris/ Solid	mg/kg	EPA 351.2	12	64 - 136	2	8
Chemical Oxygen Demand	Sediment/Debris/ Solid	mg/kg	EPA 410.4	12	71 - 136	500	2000
Total Phosphorus	Sediment/Debris/ Solid	mg/kg	EPA 365.1	14	70 - 132	0.0094	0.0376
Mercury	Sediment/Debris/ Solid	mg/kg	EPA 7470	12	67-141	0.0035	0.014
Aluminum	Sediment/Debris/ Solid	mg/kg	EPA 6010	15	80 - 116	1.5	6
Barium	Sediment/Debris/ Solid	mg/kg	EPA 6010	9	88 - 111	0.09	0.36
Chromium	Sediment/Debris/ Solid	mg/kg	EPA 6010	7	88 - 112	0.09	0.36
Cadmium	Sediment/Debris/ Solid	mg/kg	EPA 6010	8	89 - 113	0.035	0.14
Iron	Sediment/Debris/ Solid	mg/kg	EPA 6010	18	79 - 138	1.25	5

Parameters	Matrix	Units	Method	Precision (% RSD)	Accuracy (% Recovery)	MDL	PQL
Nickel	Sediment/Debris/ Solid	mg/kg	EPA 6010	7	85 - 111	0.1	0.4
Zinc	Sediment/Debris/ Solid	mg/kg	EPA 6010	18	80 - 125	5	20
Copper	Sediment/Debris/ Solid	mg/kg	EPA 6010	17	84 - 120	0.07	0.28
Acenaphthylene	Sediment/Debris/ Solid	µg/kg	EPA 8270	22	36 - 122	69	276
Benzo(a)pyrene	Sediment/Debris/ Solid	µg/kg	EPA 8270	9	55 - 117	67	268
Benzo(g,h,i)perylene	Sediment/Debris/ Solid	µg/kg	EPA 8270	13	56 - 123	130	520
Fluoranthene	Sediment/Debris/ Solid	µg/kg	EPA 8270	20	50 - 126	72	288
Fluorene	Sediment/Debris/ Solid	µg/kg	EPA 8270	14	40 - 131	74	296
2-Methylnaphthalene	Sediment/Debris/ Solid	µg/kg	EPA 8270	18	25 - 113	79	316
Naphthalene	Sediment/Debris/ Solid	µg/kg	EPA 8270	21	27 - 112	82	328
Pyrene	Sediment/Debris/ Solid	µg/kg	EPA 8270	13	51 - 121	160	640

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