Gross Solids Characterization Study in the Tred Avon Watershed Talbot County, MD

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Introduction

The Tred Avon River is degraded by low oxygen, sediment, nutrients, fecal coliform and biological impairments. The upper reaches of the watershed are highly impacted by urban stormwater runoff from a water quality and aesthetic aspect. The shoreline areas contain large amounts of trash and debris impacting the aquatic habitat.

The Center for Watershed Protection (the Center) was contracted by Talbot County Department of Public Works (DPW) to develop and implement a monitoring study design to address the following objectives:

1. Estimate baseline gross solids patterns and loads in the Tred Avon watershed;
2. Estimate total weight and volume of gross solids and by type captured by bag filters; and
3. Provide estimates of cost effectiveness for the practice.

Results of a 15-month monitoring study are presented and the potential nutrient, sediment and oxygen demanding load reduction from the capture of gross solids, specifically leafy organic material, examined for cost-effectiveness as a source control practice or Best Management Practice (BMP).

Talbot County received funding from the 2010 Chesapeake Bay and Atlantic Coastal Bays Trust Fund to investigate several areas of nonpoint source management to address water quality in the Tred Avon watershed. The Munson Foundation provided additional funding to the Center in support of monitoring efforts.

Background

Gross solids, most notably trash, are a ubiquitous and a long-standing issue affecting the waters of the United States. Gross solids negatively affect community aesthetics and lead to impairment of waterways resulting in the issuance of Total Maximum Daily Loads (TMDLs). They are an emerging pollutant of concern that can also inhibit the health and enjoyment of urban waters, threatening wildlife and aquatic habitats, producing odors, and attracting vermin (CalTrans, 2003). Gross solids are defined by the American Society of Civil Engineers (ASCE) (2010) as: coarse sediment, organic debris (e.g., leaves, branches, seeds, twigs, and grass clippings), trash and litter (e.g., plastic, paper, Styrofoam, metal, and glass) (Table 1). Unlike other pollutants, gross solids have not been well characterized or quantified in terms of their source areas and associated pollutants that can contribute to impaired waters. For example, water quality sampling using automated samplers may limit the collection of particle sizes greater than 75 μm and

Table 1. Gross solids categories and their description (ASCE, 2010).	
Category	Description
Litter	Human derived trash, such as paper, plastic, Styrofoam, metal, and glass greater than 4.75 mm in size.
Organic Debris	Leaves, branches, seeds, twigs, and grass clippings greater than 4.75 mm in size.
Coarse Sediments	Inorganic breakdown products from soils, pavement, or building materials greater than 75 µm. Includes fragments of litter and organic debris not included in the other two categories.

therefore, may 'miss' an increasing proportion of solids in stormwater with increasing particle size (ASEC 2010).

Research studies suggest the potentially significant metal, nutrient and toxic pollutants associated with gross solids, particles larger than 75 μ m. For example, it is estimated that on average, 50% of the heavy metals and nutrients in stormwater are associated with larger-sized particles that are not typically collected using automated sampling devices (ASCE, 2010). Rushton (2006) found that 67% of gross solid samples had levels of polyaromatic hydrocarbons concentrations considered toxic to biota. Further, studies find that organic material is the largest component of gross solids collected (75 to 97%) with the remaining 3 to 25% as litter with measured average concentrations of 8,050 (mg/kg) total kjehdahl nitrogen (TKN) and 557 mg/kg total phosphorus (TP).

The loss of nutrients from decomposing leaves or leaf leachate suggests a potential impact on impacted urban streams. Nutrient loadings from this type of gross solids in urban impacted streams may be detrimental with their high pollutant loadings and reduced biological processing (i.e., urban stream syndrome, see Walsh et al 2005, Meyer et al. 2005, Wallace et al. 2008). Additional research is needed to better define the pollutant loads associated with gross solids, target source areas and identify programs and practices that can lead to their reduced impact on urban waters and clean-up communities. The results of this research may provide stormwater managers, with an expanded list of practices and programs to cost-effectively reduce targeted pollutants.

The Talbot County DPW and the Town of Easton took an innovative and proactive step to reduce gross solids from an urban watershed using Kristar Enterprises Nettech© gross pollutant trap technology. The Talbot County DPW contracted the Center to develop and implement a study design to monitor and evaluate the cost-effectiveness of this technology to reduce pollutant loadings entering local streams to help meet TMDL targets. Talbot County and the Town of Easton selected the Tred Avon as the study watershed, led the net selection and installation, and maintained the best management practices (BMPs) during the study. This collaboration was important for project success.

Study Sites

The Tred Avon watershed was selected by Talbot County DPW as the pilot study area due to its mixed land use characteristics and its bacteria, nutrients, low oxygen, and biological impairments. The Tred Avon watershed (Figure 1) is a major watershed of the Choptank River with an area of 31,242 acres that represents approximately 6% of the total watershed.

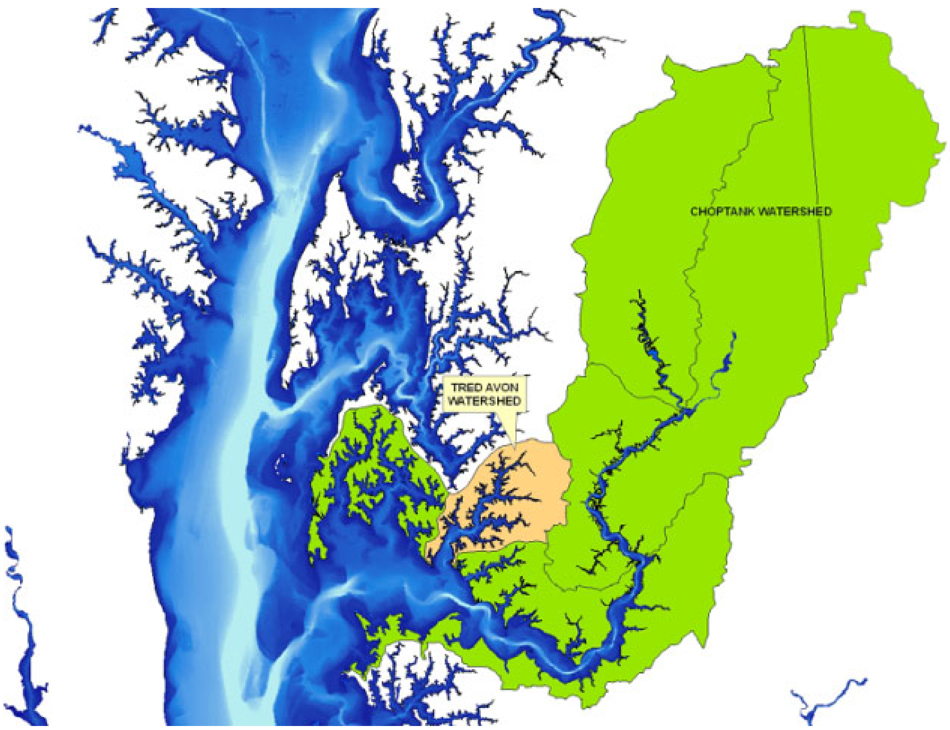


Figure 1. The Tred Avon watershed . Source: Talbot County Department of Public Works.

Talbot DPW selected the four stormwater outfalls in the Town of Easton for this study. The Town of Easton is also a coastal area that presents specific challenges to BMP selection as the area exhibits high groundwater tables, limited relief, and sandy soils. All of these typical coastal traits can limit the use of typical BMPs such as stormwater ponds. Four stormwater outfalls were fitted with the Kristar Enterprises Nettech© bag filters to capture and remove gross solids from stormwater. Talbot County DPW and theTown of Easton oversaw design, construction and installation, and the operation and maintenance of the bag filters. The bag filters are reusable heavy-duty polyethylene mesh nets with 19mm openings that capture gross solids and allow filtered stormwater to continue downstream. An important reason these nets were selected was due to the safety bypass system that releases the nets to prevent flooding. Once released, the nets are cinched and tethered so they can be retrieved after the storm without losing their content. Table 2 provides a summary of the land uses in the four outfall drainage areas that represented a range in impervious cover from 19% to 27% and canopy cover between 12% and 24%. A site map for the four outfalls is shown in Figure 2 with site specific images illustrated in Figure 3.

The Tred Avon watershed's existing BMPs, initiatives, and programs that aim to improve water quality include: 1) monitoring and assessment; 2) Tanyard Branch stormwater retrofit; 3) roadside ditch retrofits; 4) living shoreline installations; 5) Urban Bay Wise Program; 6) septic nitrogen retrofits; and 7) oyster recovery. Additional, non-structural BMPs in the Town of Easton include: street sweeping, catch-basin cleanout and leaf pick-up.

Methods

Gross solids sampling methods were developed based on guidance from the American Society of Civil Engineers (ASCE, 2010). The gross solids sampling methods were adapted to the unique study site and scope characteristics for Talbot County and Town of Easton staff. These methods were refined throughout the project to adapt to field conditions, maintenance needs and level of effort by staff. The field sampling methods and laboratory methods are outlined in this section with more detail provided in the *Monitoring Plan to Evaluate the Reduction of Gross Stormwater Pollutants in the Tred-Avon Watershed, Talbot County, MD (* Appendix A). Communication between partners was essential throughout method development and field sampling.

Gross solids sampling was divided into two types of sample: a) *basic samples* provided sample wet weight and *advanced* samples estimated sample wet and dry weights, gross solids characterization and chemical analysis. *Advanced* samples were taken from the Earle 48 site and paired with another site on a rotating basis. This sampling design allowed the Center to maximize resources available for the project to characterize gross solids on a seasonal basis while collecting data from all sites throughout the study period. Earle 48 was selected based on its mix of land use compared to the other three study sites (see Table 2)

Table 2.Percentage of land use and land cover for the four outfall drainage areas.

Site	Low density residential	Medium density residential	High density residential	Com-mercial	Insti-tutional	Forest	Total area (acres)	Impervious Cover[1]	Canopy Cover [2]
Earle 48	3.9	47.2	17.2	10.9	20.7	0	73.8	23.9	23.8
Earle 60	1.9	52.6	17.4	25.2	1.3	1.7	117.6	26.5	20.8
Glenwood Elliptical	1.0	25.9	37.2	20.6	15.4	0	45.6	25.7	11.9
Glenwood Circular	1.1	39.8	4.3	8.8	46.0	0	37.5	19.3	17.1

[1] Estimated from land use coefficients in Cappiella and Brown (2001)

[2] Provided by M. Cahoon, Talbot County Department of Public Works (June 2013)

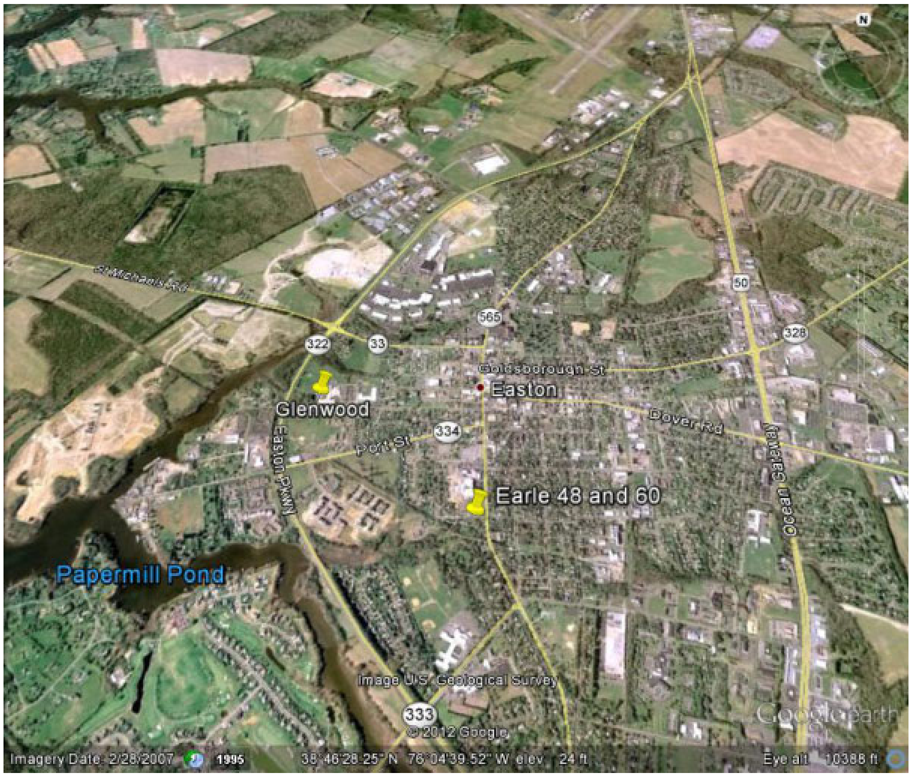


Figure 2. The Tred Avon watershed . Source: Talbot County Department of Public Works.

a) Glenwood Elliptical is a 54-inch outfall.

b) Glenwood Circular is a 36-inch outfall.

c) Earle 48 is a 48-inch outfall.

d) Earle 60 is a 60-inch outfall.

Figure 3. The four storm drain outfalls shown fitted with Kristar Enterprises Nettech© bag filters.

For *basic* sampling events, the Talbot County DPW and the Town of Easton followed the field sheet checklists that included these general steps: 1) remove the net containing gross solids; 2) allowed excess water to drain from net; 3) use crane scale to weigh the net and gross solids; 4) weigh the empty net; and 5) record site characteristics such as previous rain, net condition, and other observations. Once the fieldsheets were completed, for each outfall and net, the content was transported to a landfill and the fieldsheets were scanned and sent to the Center for data entry. A summary for this net removal sampling and transport to drying tables is provided in Figure 4. The field sheet checklists are provided in monitoring plan (Appendix A of this report).

Advanced sampling methods followed steps 1 through 5 above and then the gross solids for the selected outfall(s) were transferred to a truck lined with cleaned plastic tarp, transported to a covered area with drying tables, and regularly rotated until the net contents were dry. After the samples were dry, Center staff worked with at least one Talbot County DPW staff to sort, characterize, subsample, and record data. Table 3 lists the sample dates for the advanced samples.

The *advanced* sampling dates were distributed to provide seasonal representation of the gross solids collected and to compare gross solids between the four sites (Table 3). The *advanced* samples included the following general steps for each net: 1) sort gross solids into the main components which were: 1) litter, organic debris and coarse sediments; 2) remove large organic debris such as sticks and determine the volume and weight for each gross solids type using a graduated five gallon bucket and scale; 3) subsample content for laboratory analysis; 4) subsample each net for tree species analysis; 5) complete the chain of custody form(s); and 6) deliver the sample(s) to the laboratory on ice and deliver sample(s) to forester for species identification.

For all sample dates except 11/3/11, the whole sample consisted of the organic debris (excluding large branches) and coarse sediments. They were analyzed on-site for weight and volume, then sent to the laboratory of chemical analysis. Species identification of the leaf and seeds was also completed by Bryan Seipp, Watershed Manager and Forester at the Center. The litter and large organic debris (branches, twigs) were discarded after volume and weight determination. However, for the first *advanced* sample date on 11/3/11 the net contents were split into two equal parts. Half of the net contents) included the whole sample, while the other half of the organic debris was sieved using #4 and #200 sieves to separate out coarse sediments. Each subsample was sent to the lab for analysis. A summary of the advanced gross solids sample process is shown in Figure 4.

Table 3. A summary for the *advanced* gross solids sample dates.			
Sample Date[1]	Site Name(s)	Sample Type Delivered to Laboratory	Notes
11/3/11	Earle 48	Whole & Sieve	Net contents split into two equal parts. One part was sampled as whole sample and one part as coarse sediment sample.
12/15//12	Earle 48, Glenwood Circular	Whole	Unsuccessful bulk density measurement at the laboratory.
3/1/12	Earle 48, Glenwood Elliptical	Whole	Duplicate laboratory sample for Earle 48
4/27/12	Earle 48, Earle 60	Whole	
5/18/12	Earle 48	Whole	
9/21/12	Earle 48	Whole	Subsamples analyzed ‘as-is’ and after lab dried in oven
12/14/12	Earle 48	Whole	Subsamples analyzed ‘as-is’ and after lab dried in oven

[1] The analysis of samples followed 2-4 weeks after the sample was brought to the drying site

All gross solids samples delivered to the laboratory were analyzed for total nitrogen (TN), total phosphorus (TP), total solids dry, total volatile solids (TVS), and biological oxygen demand (BOD). Chesapeake Environmental Laboratory, Inc. (Stevensville, MD) conducted the sample analysis. The laboratory method used for each analyte is provided in Table 4.

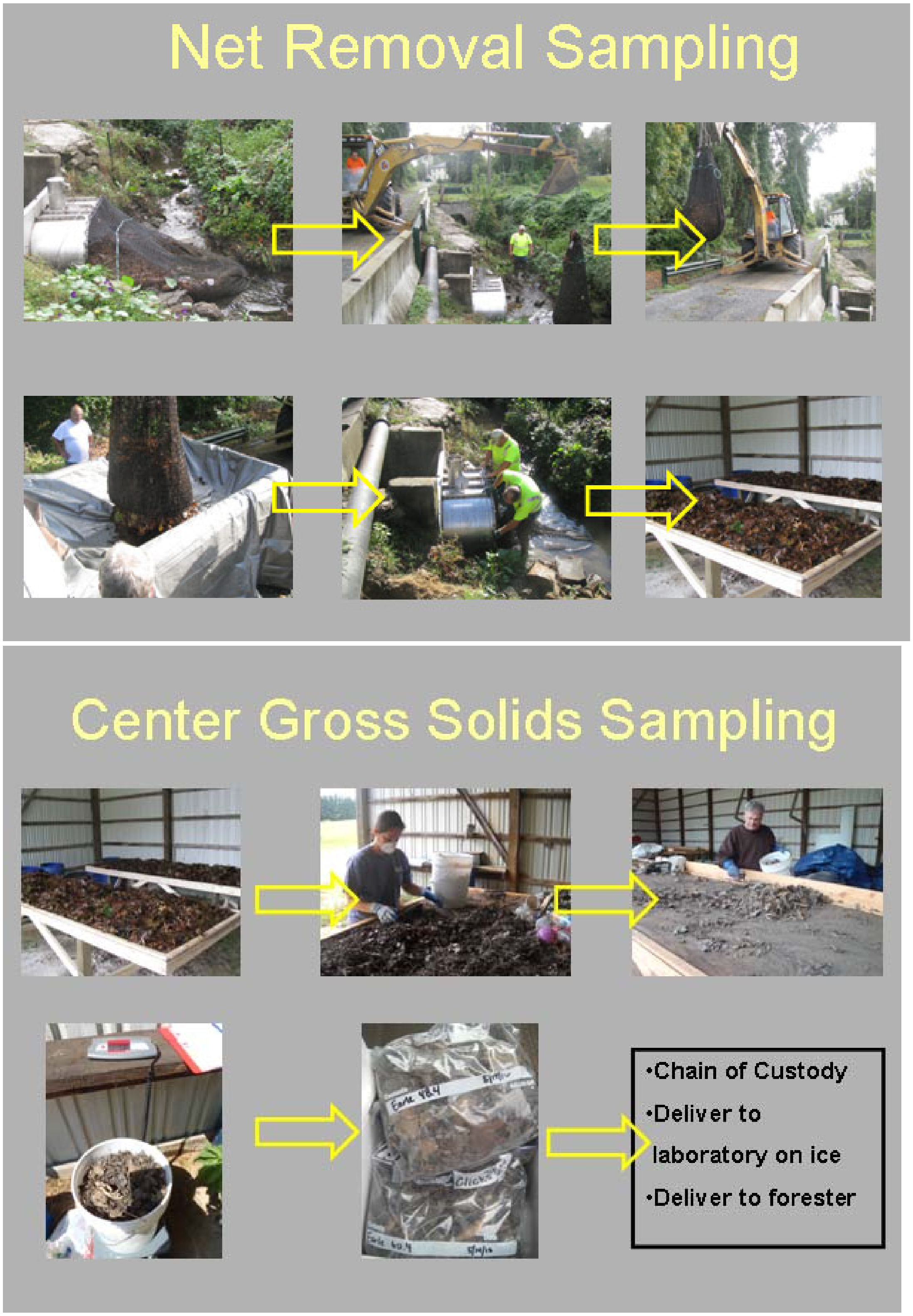


Figure 4. The four storm drain outfalls shown fitted with Kristar Enterprises Nettech© bag filters.

Table 4. Laboratory analytes and methods.				
Pollutant of Concern (analyte)	Sample Amount Needed	Sample Method	Units	Method Detection Limit (MDL)
Total Nitrogen	50 g	EPA 351.2/SM 4500 NorgC for TKN and EPA 300/SM 4500 NO3E/EPA 9056 WO/COMB for Nitrate/Nitrite	mg/kg	0.1
Total Phosphorus	50 g	EPA 365.4/SM4500 P B+E	mg/kg	0.1
Biological Oxygen Demand (BOD)	50 g	SM 5210B	mg/kg	1.0
Total Solids Dry	50 g	SM 2540 B	mg/kg	1.0
Total Volatile Solids (TVS)	50 g	SM 2540 E	mg/kg	1.0
Bulk Density	50 g	ASTM D1895B	mg/kg	NA

Non-structural Practice Survey

To evaluate the impact of street sweeping and storm drain cleanout programs on the effectiveness of the net filters, the Center prepared a survey for the Town Easton. The Town of Easton operates a street sweeping and inlet cleaning program that could have an impact on the amount of leaf material, and other gross solids being washed from the streets into the storm drains to the stream. Studies show that leaf material is commonly removed by street sweepers (Bill Stack, pers. comm, Breault et al. 2005, Sorenson 2012). Talbot County administered the survey and a copy of the survey is presented in Appendix B.

Results

A total of 60 *basic* gross solid samples were taken over the project period from November 2011 through December 2012 with subsequent sorting and chemical analysis for ten samples. One site Earle 48 (E48) was sampled for each of the advanced samples, while material from Earle 60

(E60), Glenwood Circular (GC) and Glenwood Elliptical (GE) were sampled in rotation, one time each. The maintenance period for the nets averaged 27 days with a range between 7 and 57 days when the nets were emptied (Figure 5). Overall, there was minimal maintenance required for the nets. The average collection period for the gross solids samples for this study is approximately monthly (or 33 days). The nets were typically one-third full or less, based on visual observations at the time of collection, and detached prior to their removal for sampling. The detachment of the nets was likely the result of high flows during a rain event that triggered the emergency release mechanism to prevent flooding. As a result, the nets were not actively collecting material for all days within the maintenance period. On three occasions, the net at Earle 60 required maintenance to repair a hole in the net. In October, the release mechanism was adjusted for Earle 48 to reduce the frequency of the nets detaching before they were filled with material. The frequency of maintenance was greatest in August when the nets were emptied three times (August 3, 17 and 28) but overall the days between maintenance were variable throughout the study period and there was no observable seasonal pattern.

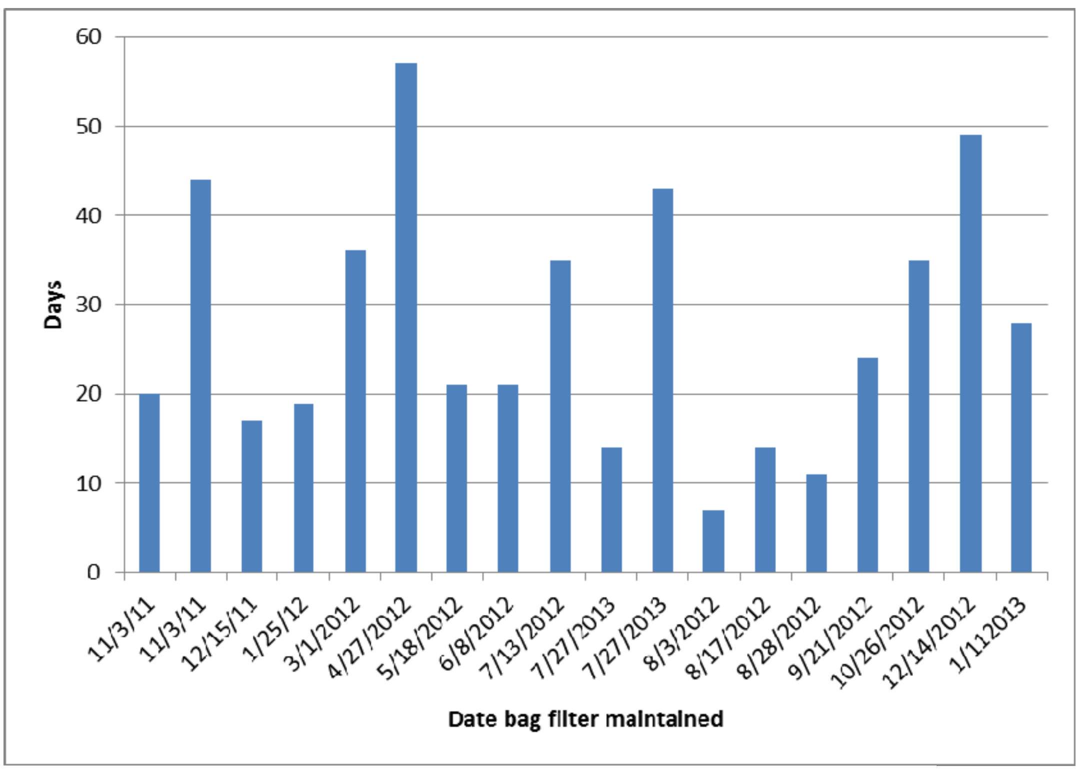
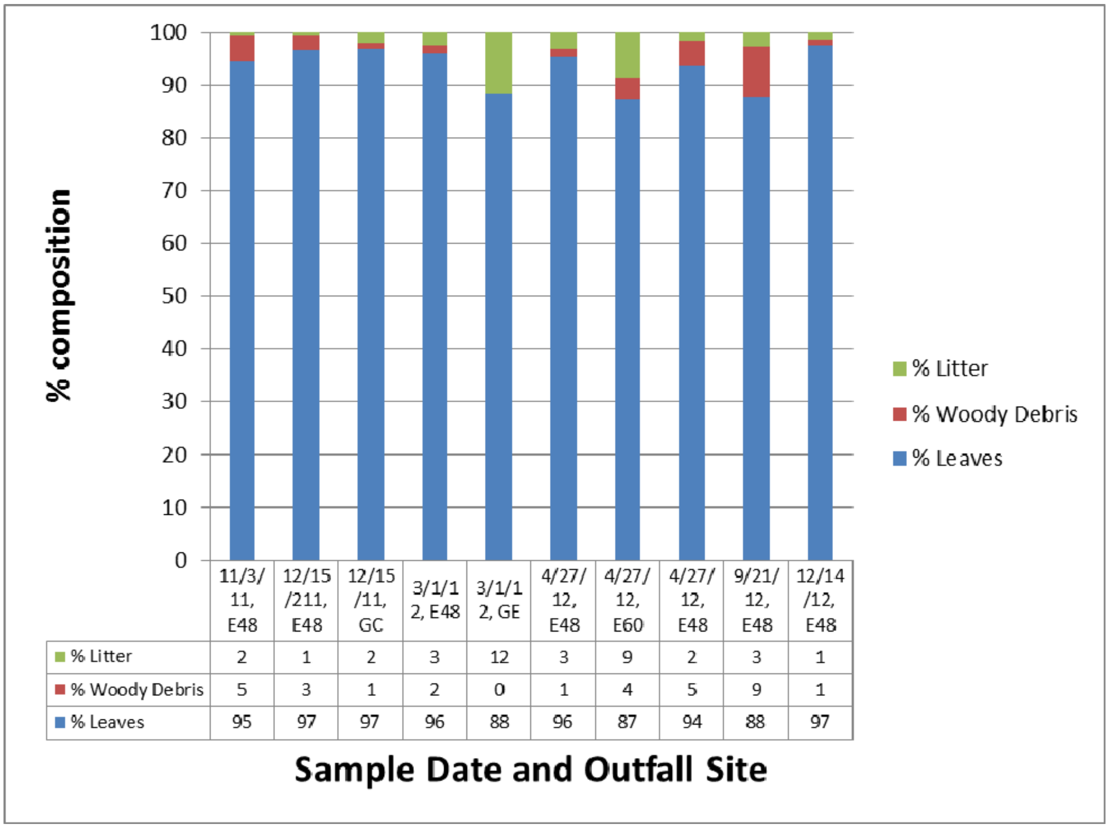


Figure 5. Days between maintenance of bag filters.



	11/3/11, E48	12/15/211, E48	12/15/11, GC	3/1/12, E48	3/1/12, GE	4/27/12, E48	4/27/12, E60	4/27/12, E48	9/21/12, E48	12/14/12, E48
% Litter	2	1	2	3	12	3	9	2	3	1
% Woody Debris	5	3	1	2	0	1	4	5	9	1
% Leaves	95	97	97	96	88	96	87	94	88	97

Figure 6. Composition of gross solids.

The majority of gross solids collected was leafy organic material (Figure 6) and is consistent with other studies. On average, the percent contribution by weight[1] was 93% leafy material (and sediment), 3% woody debris and 4% litter. An attempt was made to separate coarse solids and fine solids using #4 (particles >4.75mm) and #200 sieve (particles >4.75mm and < 75 microns) for the November 3, 2012 samples. This subsampling was problematic as the sediment adhered to the leafy material and dry leaves were breaking apart and filtering through the #4 sieve. The methods were not effective to separate the sediment from the leaves. As a result, the analysis of subsequent samples was based on whole gross solid samples that included both leaves and sediment. US EPA guidance does not recommend sieving for constituent concentrations (http://water.epa.gov/polwaste/sediments/cs/collection.cfm). There was a shift in the composition of the gross solids material throughout the 14-month sampling period to larger amounts of grass in the March samples and observed in the net *basic* samples in May and June. A spike in litter was found at one of the outfalls in March (Glenwood Elliptical) with an estimated 12% litter by weight.

[1] Field or 'as is' dry weight from the drying tables and not oven-dried from the lab.

The field dry weight and chemical composition of the gross solids is presented in Table 5 for the ten samples. A summary of the wet weights for all 60 gross solid *basic* samples is provided in Appendix C. The samples analyzed for chemical analysis were 87.2 % to 91.8% dry. The dry and wet weight of the 10 *advanced* gross solid samples are highly correlated and statistically significant (e.g. at 95% confidence level) as shown on Figure 7. The field dry weight is approximately 20% of the wet weight. The organic matter of the whole samples is based on the "% Total Volatile Solids" that represents the organic compounds of animal or plant origin. On average, the organic matter comprised 72% of the whole samples with a range between 47.8% and 81.4%. The remainder of the whole sample is likely inorganic sediment. The nutrient concentrations are high for the whole samples (Table 5) and are comparable to nutrient concentrations associated with sediment in agricultural streams (e.g. Walter et al. 2007) as well as other gross solids studies of leafy organic material (Table 6). Although the analysis of organic debris from other studies vary in the methods used to collect and analyze the samples, these results provide insight to the concentration levels associated with this material – all are high.

Table 5. Analysis of dry leaf matter from gross solid samples.

Sample Date	Outfall	Field Dry Weight (lb)	Total Solids Dry (%)	Total Nitrogen (mg/kg)	Total Phosphorus (mg/kg)	Total Volatile Solids (%)	Biological Oxygen Demand (mg/kg)
11/3/2011	E48	48.6	88.9	6,283	378	81.4	5,873
12/15/2011	E48	61.8	91.2	4,178	337	79.6	7,123
12/15/2011	GC	9.2	88.6	5,897	388	79.3	7,240
3/1/2012	E48[2]	37.7	91.775	6,162	423	47.8	2,991
3/1/2012	GE	4.6	86.3	12,422	815	79.12	2,865
4/27/2012	E48	47.2	90.7	20,181	1730	60.2	5,686
4/27/2012	E60	36.5	87.2	10,677	1660	70.1	7,040
5/18/2012	E48	24.8	90.6	10,748	892	64.8	6,333
9/21/2012	E48	29.7	87.4	7,250	942	76.8	5,507
12/14/2012	E48	42.1	87.4	12120	422	76.9	10837

[1] E48 = Earle 48; E60 = Earle 60; GC = Glenwood Circular; GE = Glenwood Elliptical

[2] Average with duplicate sample

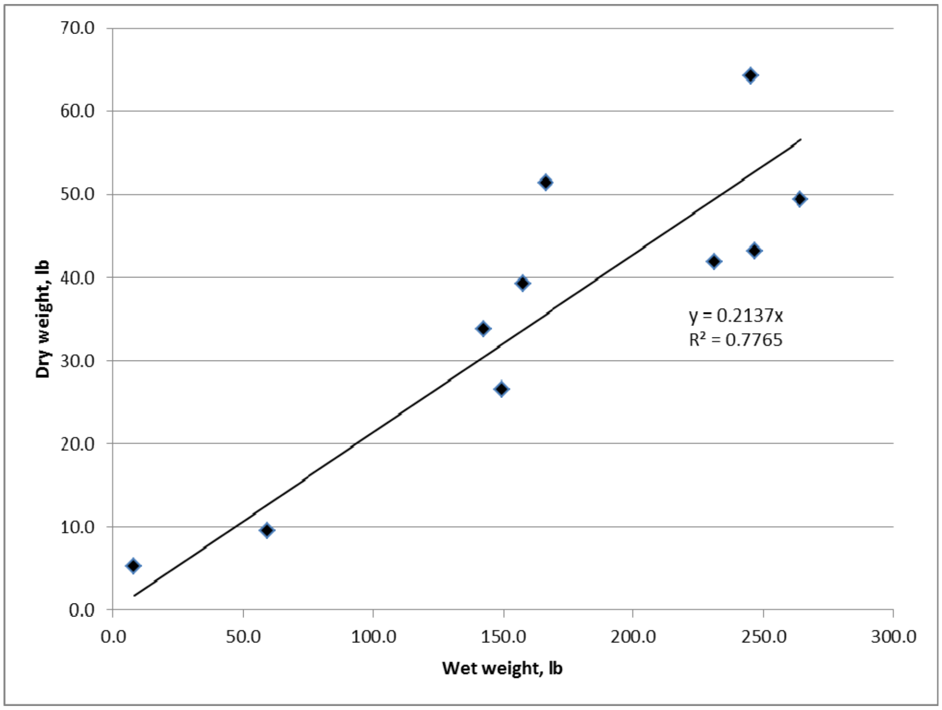


Figure 7. Dry vs wet weight of gross solids.

Table 6. Comparison on average nutrient concentration of organic debris gross solid samples.		
Study	TN (mg/kg)	TP (mg/kg)
Tred Avon net filters (current study)	9,592	799
Rushton et al., 2006[1]	8,050	556
City of Baltimore, 2004[2]	2,728	183
Berretta et al. 2010[3]	1,439	426

[1] Leaf material collected from CDS unit after 6 to 12 months. Samples sent to lab "as is" after air dried

[2] Organic debris collected from street sweeper. Material sent to lab without a drying period

[3] Represents 'biogenic material' from residential areas reported 27 samples from street sweepers in MS4 municipalities, median values for TP and TN were approximately 375 and 832 mg/kg

The nitrogen (TN) and phosphorus (TP) load contributed by the leaf material for individual samples was estimated by multiplying the average concentration of the leaf litter by the field dry weight of the material collected in the net. This load is assumed to be conservative as the majority of soluble reactive phosphorus and dissolved organic carbon leach from leaves within 48 hours following immersion (Wallace et al. 2008). The TN load per sample ranged from 0.05 lb to 0.95 lb and from no measurable TP up to 0.08 lb TP. The lowest nutrient load estimated is based on a very small amount of material collected at both Glenwood sites (i.e.,4.6 and 9.2 lbs of dry material), whereas the greatest mass of TN and TP are associated with the sample containing a majority of grass clippings, relative to leaves. Wallace et al. (2009) found that grass clippings released the greatest amount of phosphorus compared to the leaf species studied.

The potential annual nutrient load reduction from the Earle 48 site is estimated at 4.7 lb TN/year and 0.36 lb TP/year. This is estimated from the site's average TN and TP load is used (0.39 lb TN and 0.03 lb TP) and a monthly maintenance frequency.

Survey Results: Street Sweeping, Leaf Pick-up and Catch-basin Cleanouts

The Town operates two regenerative-air with mechanical brush sweepers and vacuum trucks for storm drain and inlet cleanouts. The street sweeping program covers approximately 75 lane miles and occurs on a monthly basis for the majority (95%) of streets, and daily for approximately 5% of the streets. Targeted street sweeping occurs in the fall to pick up leaves and debris, as well as winter debris (e.g. sand and de-icing material) in the early Spring. In addition, the Town provides a leaf pick-up program for residential areas in the fall. All street sweeping material is dumped at public works facility where it is air-dried and then, hauled to the landfill. The Town of Easton also has a leaf pick-up program that collects material from mid-October thru the end of January. The leaf material is collected by a leaf vacuum and hauled to a private farm. The Town of Easton has a regular storm drain and inlet cleaning program where approximately 450 inlets and storm drains are cleaned-out on an annual basis. The material collected from street sweeping, catch-basin cleanouts and leaf pickup are not weighed. Results of the survey are provided in Appendix B.

Cost Effectiveness of Bag Filters

The cost-effectiveness of the bag filters was estimated using the results from the Earle48 outfall, drainage area characteristics, and capital and maintenance costs for the Kristar Enterprises Nettech©. The bag filter for Earle48 cost $20,350 and $6,250 for installation. An annualized cost for the bag filters is estimated using the uniform annual cost formula. An interest rate of 5% is applied along with a 10-year life expectancy the bag filter (pers. comm here from Bill W). An annual maintenance cost of 10% of the initial capital costs was added to the total annual cost (i.e., $2,650).

$$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$

n = years
i = interest rate
A = periodic payment
P = total initial cost

The annual cost estimate for the bag filter for the Earle48 site is $6,105, or $347/ impervious acre treated. This metric was used to compare the cost-effectiveness of bag filters with other BMPs presented in King and Hagan (2011). This unit cost may be further reduced to $83/acre, if it is assumed that the gross solids collected by the nets treat the entire drainage area of impervious and pervious areas, as well (i.e., leaf fall from trees planted on pervious land contribute to bag filter gross solid load). The unit cost for each of bag filters at the other three sites may vary as the capital cost is unique to each outfall with varying drainage areas and impervious cover.

The unit cost for the bag filter is used along with the estimated annual nutrient load reduction to provide a cost-effectiveness value for this practice at the Earle 48 site. The estimated annual TN and TP loads for the Earle 48 site is 4.7 TN lb/year and 0.36 TP lb/year. The estimated annualized cost-effectiveness is $74/ lb TN/impervious acre and $988 /lb TP/impervious acre. This cost-effectiveness is further reduced if it is assumed that gross solids from the entire drainage area are collected by the nets to $18/ lb TN/ acre and $236 /lb TP/ acre. A comparison of other structural and non-structural stormwater controls is presented in Table 7.

The Significance of Gross Solids on Stream Nutrient Loadings

The material collected by the bag filters at each of the study sites demonstrate the large amount of gross solids stored in upland urban drainage areas and transported to streams through the storm drainage network. The majority of the gross solids collected is leafy organic material, despite the relatively low amount of canopy cover or forested land use in the study drainage areas. These results are consistent with other gross solids studies where the majority of material collected is leaves. The connectivity between upland areas and streams created by storm drains

Table 7. The cost-effectiveness of stormwater controls for nitrogen removal.		
Practice	Type of practice	Equivalent Annual cost ($/lb N/IC[1] ac)
Bag filter	Structural	$74[1]
Bioretention (new, suburban)	Structural	$335-$634[2,3]
Wet pond (new)	Structural	$733[4]
Street sweeping	Non-structural	$165[5]

[1] Based practice life expectancy of 10-years.
[2] Costs for other practices based on King and Hagen (2011) over a 20-year period and an urban loading rate of 14.1 lb TN/acre.
[3] Range represents a removal efficiency of 45% and 85% from Simpson and Weammert (2009).
[4] 20% removal efficiency for TN from Simpson and Weammert (2009).
[5] Berretta et al. 2011 expressed as lb N/year.

provides a highly efficient transport pathway of organic material, to the extent that Walsh et al (2005) describe these upland areas as “effectively riparian”.

The flashy hydrology and altered biological function exhibited by urban streams may limit, to some extent, the ecosystem processes of leaf litter in streams (e.g. Meyer et al 2005, Walsh et al. 2005). The hydro-geomorphic conditions and reduced abundance of microorganisms (e.g. macroinvertebrate shredders) likely affect decomposition processes. The high storm flows readily transport organic debris downstream while the timing and delivery of this food source is also altered. Although, leaf litter is a major energy or food source (DOC, phosphorus) to streams where microbial organisms decompose the organic matter and uptake, or/ release nutrients into the stream, its impact on urban stream nutrient loads may not be as beneficial. The nutrient loads provided by leaf litter may add to the elevated nutrients commonly found in urban streams and further impair stream and downstream conditions (e.g. outlets such as estuary).

The study design and bag filter technology provide conservative nutrient loading estimates. The early detachment of the bag filters from the outfalls, the ‘pass through’ of materials prior to debris dams forming within the bag filters and the release of soluble P and DOC soon after immersion all likely contributed to a reduced nutrient loading associated with the gross solids captured. Additional work is needed to find a solution to prevent the detachment of the bag filters to increase their capture efficiency. Once this is addressed, it may be necessary to increase the monthly maintenance frequency.

Maintenance

Field logs generated throughout the study period recorded the time to maintain the nets and the type of maintenance required. Overall, there are minimal maintenance requirements for the bag filters. The nets were emptied on an approximately monthly schedule and typically followed a large rain event that flush material from the storm drains to the outfall. On average, it took approximately 30 minutes to detach the net, drain the excess water, empty the content and re-attach the net to the outfall. A backhoe or other type of heavy equipment is needed to lift the filled bag filter from the storm drain to the road surface. The flushing efficiency of the storm drain network at the study sites is affected by the flat terrain as observations indicate material stored or floating in storm drain during site visits.

Findings & Recommendations for Bag Filter Source Control Practice

1. The bag filters are a cost-effective source control practice to remove nutrients associated with gross solids from streams.

2. An estimate of the field dry total gross solids and leaf litter material may be estimated by the wet weight collected by the bag filter. It is recommended to compile an average or median TN and TP concentration associated with the leaf litter based on this and other gross solids and leaf litter studies to determine the nutrient load associated with the dry leaf litter.

3. The selection of bag filter technology should include an automatic release mechanism to prevent backflow into the storm drain and create local flooding issues. This feature allows the material captured within the net to be stored until it can be maintained.

4. Further investigation is needed to determine the cause for the release of the bag filters prematurely; before the bag is filled.

5. The amount of gross solids collected should allow ease of removal. The bag filter was very challenging to remove using the backhoe when filled to 50 percent at Earle 60 – the largest bag filter used in the study (wet weight of 659 lbs, as per note on fieldsheet July 27, 2013).

6. Minimum monthly maintenance, or more frequently as needed following storm events.

7. Maintenance time is approximately 30 minutes per bag filter to detach, empty and re-attach.

8. Street sweeping and, or catch basin cleanouts programs in an urban drainage areas fitted with bag filters, such as Kristar EnterprisesNettech © may likely result in greater nutrient removal from leaf litter. The cost-effectiveness of the bag filters may change in drainage areas with greater tree canopies. Additional benefits of the bag filters may be gained in areas where trash is a concern, or is a known impairment.

9. Additional research is needed to statistically quantify the impact of leaf litter on urban stream nutrient loadings and if there is a seasonal effect on composition of gross solids collected by the bag filters and associated nutrient loadings. This would develop a more comprehensive urban nutrient mass balance for watersheds and identify the most cost-effective BMPs.

10. An U.S. EPA Chesapeake Bay Program expert panel should be convened to address this BMP and develop pollutant load reduction credits, as applicable to assist jurisdictions meet local and bay-wide TMDLs.

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APPENDIX A:

Monitoring Plan to Evaluate the Reduction of Gross Stormwater Pollutants in the Tred-Avon Watershed, Talbot County, MD

March 2013

Monitoring Plan to Evaluate the Reduction of Gross Stormwater Pollutants in the Tred-Avon Watershed, Talbot County, MD

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1. Purpose of Monitoring and Objectives

The Talbot County, Town of Easton and the Center for Watershed Protection, Inc. (the Center) worked in collaboration to evaluate the effectiveness of gross solids removal using bag filters to reduce trash in an urban watershed. Gross solids contribute to pollution entering receiving waters but are not well-characterized in terms of their annual pollutant loads due in part, to sampling equipment unable to capture these larger sized particles and debris (> 75 µm). The ASCE (2010) defines three types of gross solids that are presented in Table 1.the ASCE, 2010 is provided in Appendix A. The project will provide an initial characterization of gross solids pollutants using bag filter technology as a best management practice (BMP) in the Tred Avon River watershed. The data generated from the monitoring study will provide initial bounding estimates for gross solids removal from an urban watershed. In this urban watershed the local government and residents was observed trash to be an issue. The results will inform future, more comprehensive monitoring efforts to further evaluate this BMP practice type.

Objectives:

1. Estimate baseline gross solids patterns and loads in the Tred Avon watershed;
2. Estimate gross solids total weight and volume by gross solid type that was captured by bag filters; and
3. Provide cost effectiveness estimates for the practice.

Table 1. Gross solids categories and their description (American Society of Civil Engineers (ASCE), 2010).	
Category	Description
Litter	Human derived trash, such as paper, plastic, Styrofoam, metal, and glass greater than 4.75 mm in size.
Organic Debris	Leaves, branches, seeds, twigs, and grass clippings greater than 4.75 mm in size.
Coarse Sediments	Inorganic breakdown products from soils, pavement, or building materials greater than 75 µm (0.075 mm). Includes fragments of litter and organic debris not included in the other two categories.

1.1 Partners, Roles and Responsibilities

Project management was provided by the Center with the lead responsibility to coordinate project tasks, while Talbot County led implementation of the monitoring plan with support from the Town of Easton and the Center. A summary of key responsibilities for each project partner is provided in Table 2. The Center will lead a training day with all project partners. Regular communication between the Center and Talbot County is essential to the success of the project to ensure issues are readily addressed and the study design modified, as needed.

1.2 Study Site Description

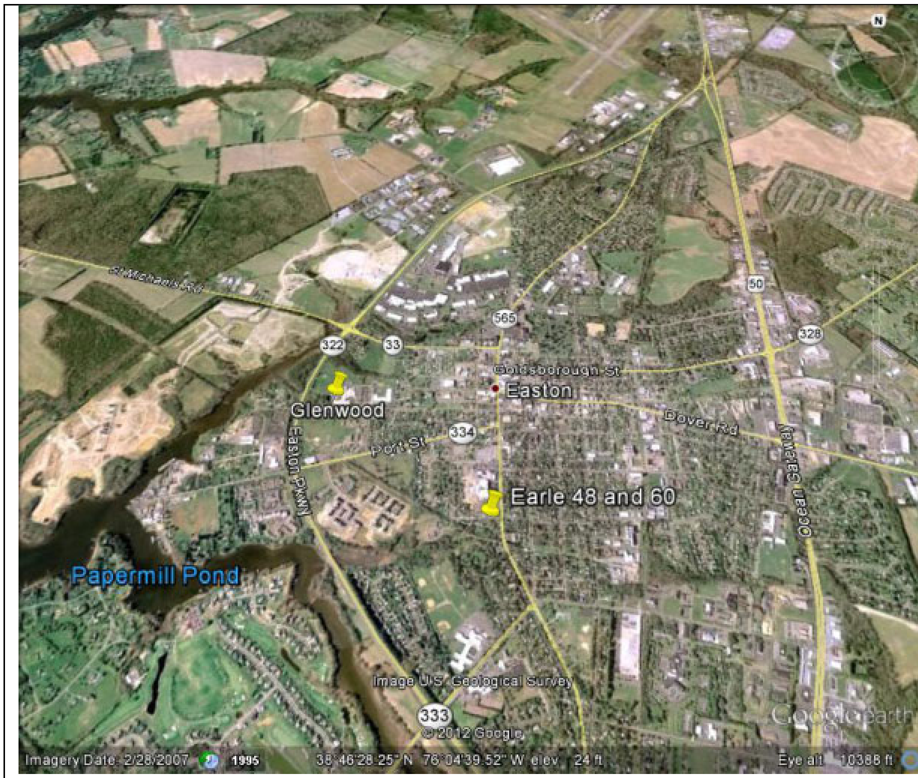
A total of four outfalls were custom-fitted with bag filters. The outfalls were selected by Talbot County Department of Public Works prior to the monitoring plan development. A summary of the outfall and drainage area characteristics is provided in Table 3. The outfall location and pictures of each outfall are provided in Figure 1.

Table 2. Project tasks and lead organization roles and responsibilities.

DATE	TASK	LEAD
	MONITORING PLAN	
May 13	Develop monitoring plan	Center
May 25	Review monitoring plan	Talbot
May 30	Revise and finalize plan	Center
June 10	Develop training materials	Center
	SAMPLING & DATA COLLECTION	
June to Sept	Install bag filters	County/Town
Sept	Test period for bag filters (2 weeks)	County/ Center
Oct	Training	Center lead, All attend
Oct 2011 to January 2013	Begin monitoring and data collection (7 sampling dates)	All attend
Following each monitoring event	Deliver samples to Chesapeake Environmental Laboratory, Inc. (Stevensville, MD)	Center
Ongoing	Bimonthly check-in with Talbot County/Town of Easton	Center
	COST EFFECTIVENESS & FINAL REPORT	
Oct 2011 to January 2013	Data compilation and analysis	Center P
March 2013	Project update and data review	Center
March 2013	Final report	Center

Table 3. Summary description of outfall pipe monitoring sites and associated drainage area.

Characteristic	Glenwood 1	Glenwood 2	Earle 1	Earle 2
Outfall pipe size	36 inch	60 inch	48 inch	54 inch
Outfall pipe shape	Circular	Elliptical	Circular	Circular
Drainage area (acres)	37.52	45.6	73.77	117.59
Type and inlet condition	Concrete, clean	Concrete, clean	Concrete, clean	Concrete, clean
Dominant land use	Residential	Residential	Residential	Residential
Impervious cover (%)	19.3	25.7	23.9	26.5
Street sweeping in drainage area?	Yes	Yes	Yes	Yes
Dry weather flow present?	Yes	No	No	no



a) Outfall site map. Image from Google.

b) Glenwood Elliptical outfall is 54 inch.

c) Glenwood Circular outfall is 36 inch.

d) Earle 48 outfall is 48 inch.

e) Earle 60 outfall is 60 inch.

Figure 1. The four storm drain outfalls shown (a) were fitted with Kristar Net Tech© bag filters (b, c, d, e) to capture and remove the gross solids from stormwater.

2. Monitoring Approach

Gross solids baseline monitoring is useful to understand the variation in urban watershed gross solids loads and their potential contribution to the total watershed-based annual pollutant loads. This study quantified the total weight and volume of gross solids as defined in Table 1 for all four outfalls. Samples will be analyzed for total nitrogen (TN), total phosphorus (TP), biological oxygen demand (BOD), total solids dry, and total volatile solids (TVS). Information gathered and data collected from the monitoring study were used to provide cost estimates for this stormwater practice. Checklists, standard operating procedures, and contact information were developed for each task outlined.

Seven sampling days occurred from October 2011 through January 2013. Sampling dates were identified in coordination with the Center and Talbot County when nets contained gross solids that were partially full (goal of 50% full) and the interim sampling period has no storm events greater than the 2 year storm event. The Center scheduled sampling days for the collected materials. The sampling protocol was based on the Level 1 protocol as defined by ASCE (2010). The County led Day 1 efforts, while Day 2 efforts were led by the Center. Day 1 tasks included the retrieval, transport, and drying of the gross solids, whereas Day 2 included the separation of gross solids into type and the weight and volume were recorded. For Day 2 sampling, subsamples of the gross solids will be prepared and delivered on ice along with the completed chain of custody form to Chesapeake Environmental Laboratory, Inc. (Stevensville, MD) for analysis. A description of the tasks for each day is provided. Interim sampling events are events where the bags were removed, Field Sheet Checklists #1 and #2 (i.e., maintenance checklists described later) were completed, but the samples were not dried or analyzed for nutrient load content. For these interim sampling events Talbot County staff recorded information in the Field Sheet Checklists provided by the Center to track cleanout intervals, estimate quantity of material collected by the bag filters, maintenance completed, weather conditions, and additional information. The Town of Easton, in coordination with Talbot County recorded weight measurements of total material captured by the nets (not separated into different gross solid types) for each net removal event to estimate accumulation rates of gross solids. The crane scale used is a Salter Brecknell CS2000 Electronic Crane that has a 2,000 lb capacity and an accuracy that is ±0.3% of the reading.

2.1 Description of Bag Filters

The bag filters used to capture gross solids is the Kristar Net Tech© (http://www.ecosol.com.au/solutions_nettech.asp). Corporate analysis of the Net Tech performance indicated that the net BMP removes and retains gross solids in stormwater flows. In addition, the net typically captures more than 91% of gross pollutants that are larger than 19 mm in diameter. The Net Tech was custom made for the Talbot County outfall pipes and were installed by the manufacturer. The nets can be removed, gross solids emptied to a container for transport, and the nets replaced at the outfall pipe. See Appendix B for an Net Tech informational brochure.

As the net fills, it is expected that gross solids less than 19 mm will be collected by the net once a 'debris dam' is formed by the gross solids. Verification of this assumption was made during the staff training and as measurements of the gross solids was taken. Modifications to the study design were made based on these findings, Talbot County information, and data gathered during the study.

2.2 Sampling Techniques and Level of Effort (e.g., number of samples)

Before Sampling Day Tasks

1. The Center coordinated with County staff to determine nets performance (i.e., are they working during storm events). For example, is the net detaching when full? Is the net not detaching or detaching when partially full? If the net is full and not detaching this may slow water upstream resulting is backwater which allows solids to settle out until the next storm.
2. The Center downloaded precipitation records from weather station at finest resolution possible (e.g., hourly). Note: May be limited to daily precipitation. This was determined based on location of nearest weather station. An option is to compare two rain gauges that are proximate to the study sites with varying temporal resolution to approximate desired information (e.g., 1 inch rainfall total for day may have occurred over 2 hrs, 4 hrs).
3. Center to schedule sampling date and coordinate outfall(s) sampled. County staff to prepare trucks, workers to assist with sampling (driving trucks, removing nets, weighing gross solids, etc.).
4. Truck bed/container to be lined with tarp that is *rinsed before and after each use*.
5. Center to contact Chesapeake Environmental Laboratory, Inc. and inform of anticipated sample date, number of samples, and type of analytes needed.
6. County will organize and provide field equipment on sampling days (see Section 4 for list of supplies).

Sampling Tasks

Gross solids sampling was divided into events that were not assessed by the Center (Day 1) and those that were assessed by the Center and analyzed by the laboratory (Day 2).

For sampling events that were not assessed by the Center, the Talbot County Department of Public Works (DPW) and the Town of Easton followed the field checklists that included these general steps: 1) removed the net containing gross solids; 2) allowed excess water to drain from net; 3) used crane scale to weigh the net and gross solids; 4) weighed the empty net; 5) recorded site characteristics such as previous rain, net condition, etc.; 7) completed the Field Sheet Checklists; 8) repeated this process for each net; 9) transported the net contents to the landfill; and 10) provided the Center with this data. The Day 1 net removal and transport to drying tables is graphically described in Figure 2. The Field Sheet Checklists are provided in Appendix C.

For sampling events that were assessed by the Center the above steps 1 through 7 were followed and then the gross solids for the selected outfall(s) were transferred to a truck lined with clean plastic, transported to a covered drying table, and regularly rotated until the net contents were dry. After the samples were dry Center staff worked with at least one Talbot County DPW staff to sort, characterize, subsample, and record data.

Seven gross solids sample dates that included 10 outfalls sampled were characterized by the Center. These Center characterized sample dates represent each season, include Earle 48 for each sample date, and include all other outfalls for one sample date each. For the Center characterized samples the gross solids sampling included the following general steps for each net: 1) sort gross solids into the main components which were: (1a) litter and (1b) organic debris and coarse sediments; 2) remove large debris such as sticks and determine the volume and weight for each gross solids type using a graduated five gallon bucket and scale; 3) subsample each net for laboratory analysis; 4) subsample each net for leaf and fruit type analysis by forester; 5) complete the chain of custody form(s); and 6) (6a) deliver the sample(s) to the laboratory on ice and (6b) deliver sample(s) to forester.

For all sample dates except 11/9/11 the whole sample consisted of the organic debris (excluding large branches) and coarse sediments and were analyzed for weight, volume, laboratory analysis, and leaf and fruit analysis. These samples are the “basic” samples. For these samples, the litter and large organic debris were discarded after volume and weight determination.

However, for the first sample date on 11/9/11, additional sampling was conducted to better assess the sample type and for sampling protocol feasibility in the study. The net contents were split into two equal parts.

- In one part (1/2 of the net contents) was the whole sample. In this basic sample, a whole, an organic debris, and a coarse sediment sample were each analyzed for weight, volume, laboratory analysis, and leaf and fruit analysis. Whole samples were sent to the lab that represented gross and coarse solids combined that were not separated by sieves.
- In one part (1/2 of the net contents) the “advanced” sample, organic debris was separated from the course sediments using sieves. The net contents were separated into four kinds

of gross solids: litter; gross solids greater than 4.75 mm (#4 sieve); coarse solids that are greater than 75 µm (#200 sieve) and smaller than the 4.75 mm and woody debris. Litter and large organic woody debris such as twigs were removed from the material and weighed separately. The gross and coarse solids comprised two samples that were sent to a lab for chemical analysis.

The Day 2 gross solids sample dates characterized by the Center are graphically described in Figure 3.

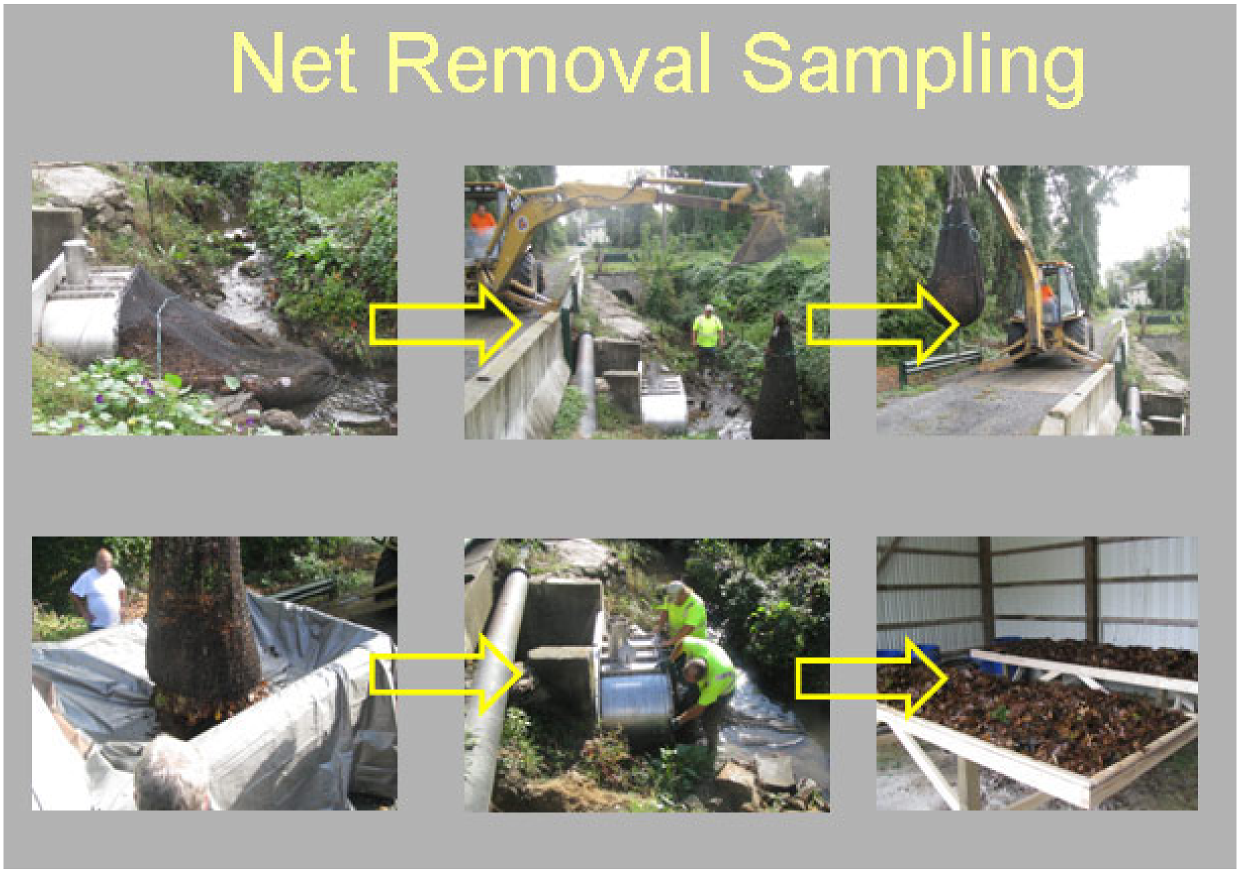


Figure 2. Net removal and transport to drying tables are graphically described. This is Day 1 sampling.

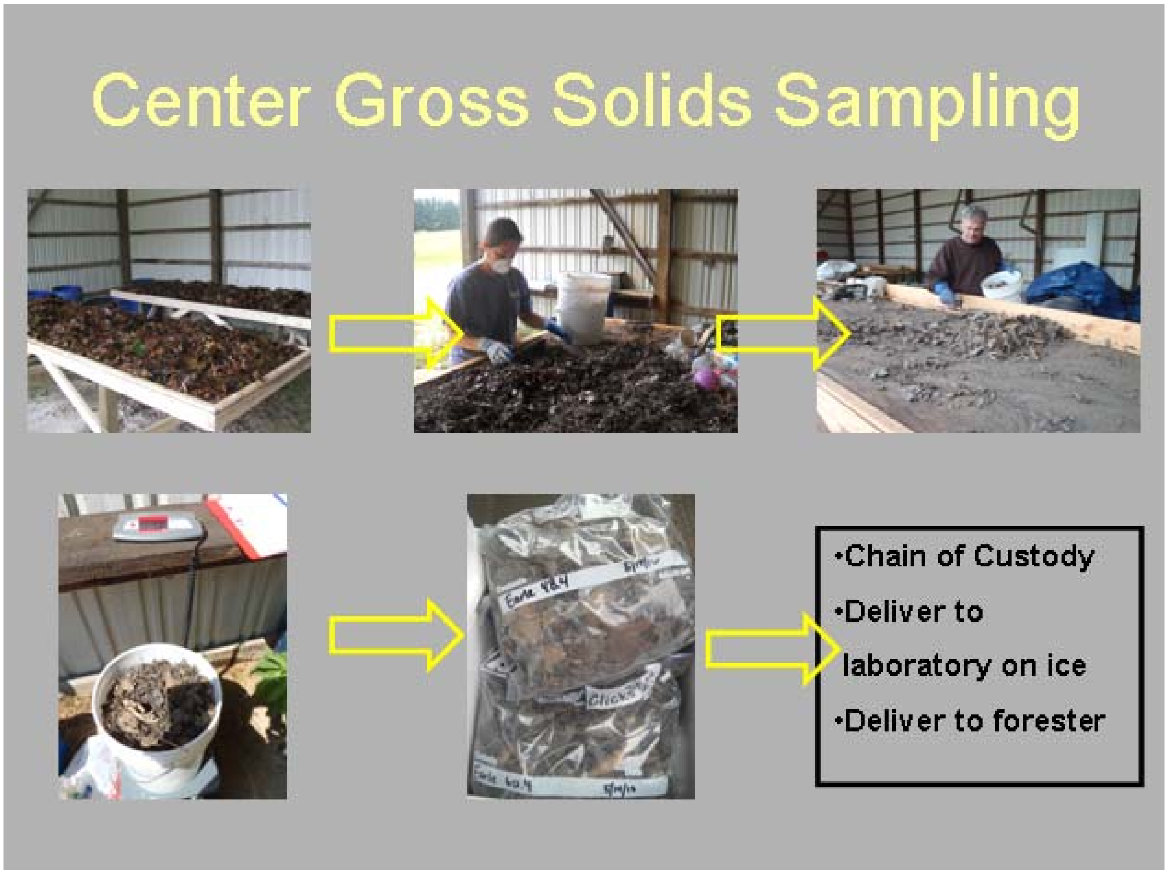


Figure 3. Gross solids sample dates that were characterized by the Center are graphically described. This is Day 2 sampling.

Day 1 Sampling

1. Record site characteristics in the field before the net containing gross solids is removed
2. Estimate percent of net filled with gross solids
3. Remove net containing gross solids and decant water as much as possible
4. Record crane scale weight on checklist
5. Transfer gross solids to a container lined with a stream water pre-rinsed tarp
6. Record empty net crane scale weight on checklist
7. Replace net on the outfall
8. Transport gross solids to a clear area where drying can occur under a cover
9. Place gross solids with a uniform thickness in the drying area. Separate out litter from organic debris and coarse sediment to the best extent practical.
10. Repeat 1 through5 for each sample outfall. Separate drying areas will be needed for each outfall collected.
11. Dry gross solids for 24 hours to 36 hours or until fully dry which will vary due to the humidity and temperature

NOTE: Wet weight was taken.

Day 2 Sampling

1. Field Preparation
    a. Compile Field Checklists completed by Talbot County
    b. Gather data sheets to collect Day 2 information and gather additional field materials needed (see also 4. Equipment and Supply Needs)
    c. Rinse 5 gallon bucket with outfall to be sampled with the bucket. Weight the empty container (i.e., tare). Record on field sheets.
2. Whole Sample
    a. Weight and Volume Measurements
        i. Separate the whole sample that consisted of the organic debris (excluding large branches) and course sediments.
        ii. Transfer whole sample to 5 gallon buckets
        iii. Weigh whole sample in a 5 gallon bucket
        iv. Record whole sample volume and weight measurements
    b. Laboratory Sample
        i. Place handfuls of sample into a labeled Ziploc bag with unique ID periodically during the weight and volume sampling. Ensure that the sample represents the whole gross solids for the outfall. Remove excess air, label, and complete chain-of-custody form.
        ii. Transport one sample per outfall on ice to the laboratory with chain of custody form. Transport one sample per outfall to the forester.
3. Litter Sample
    a. Separate the litter from the gross solid sample (i.e., litter is human derived material)
    b. Transfer litter to 5 gallon buckets
    c. Weigh litter in a 5 gallon bucket
    d. Record litter weight and volume measurements
    e. Dispose of litter once measurements are taken and recycle, if possible.
4. Organic Debris Sample
    a. Separate the organic debris from the gross solid sample (i.e., large sticks and branches)
    b. Transfer organic debris to 5 gallon buckets
    c. Weigh organic debris in a 5 gallon bucket
    d. Record organic debris weight and volume measurements
    e. Dispose of organic debris once measurements are taken

Volume measurements were estimated using known graduated volumes in 5 gallon buckets. Five gallon containers may leave significant ‘air space’ for litter and organic debris. Therefore, there may be volume measurement error for the litter and organic debris measurements. Samples were weighed on an OHAUS Digital Ship/Rec Scale, the capacity is 440 lb and minimum weight is 0.2 lb.

For the advanced sample date on 11/9/11, the coarse sediments were separated from the gross solids material with sieves. This was a two-step process. A #4 sieve was used to remove visible sediment from surfaces of herbaceous material. Coarse sediment will pass through the #4 sieve while the organic debris will be retained. Then the material that passed through the #4 filter was separated by passing through a #200 sieve. This separated the organic debris and coarse sediment gross solids material. Course Sediments (< #4 and > #200 sieves) and organic debris (>#4 sieve) were weighed and the volume was recorded.

The Center developed a centralized database to manage data generated from this project. For example, the database will include data generated from: field sheets recorded by Talbot County staff interim sampling days, maintenance logs, precipitation, gross solids volume and weight measurements, chemical analysis and estimate pollutant loads. Field Sheet Checklists are included in Appendix C.

2.3 Laboratory Analysis and Quality Control

Table 4 summarizes the chemical analyses completed and methods used for the gross solids samples. One field duplicate was gathered for Earle 48 on 3/16/12. Laboratory quality control, statistics, precision, outlier, and missing data will be reported to the Center and this information will be synthesized into the data analysis. The results will be reported in mg/kg and sent to the Center in electronic format within 14 days of sample submittal. The laboratory subcontracted total nitrogen and total phosphorus analysis, therefore the standard methods varied. The methods were standard methods (SM) or EPA methods that are comparable across all study samples. The reporting limits reported varied due to the sample size used for laboratory analysis, dilution factors used for sample concentration to fall w/in the calibration curve, and/or % solids present in the samples. However, the EPA method and SM detection limits did not vary. Close coordination with the laboratory staff before, during, and after sample drop off is imperative to plan and execute successful gross solids analyte results.

Pollutant of Concern (analyte)	Sample amount needed	Sample Method	Units	Method Detection Limit (MDL)
Total Nitrogen	50 g	EPA 351.2/SM 4500 NorgC for TKN and EPA 300/SM 4500 NO3E/EPA 9056 WO/COMB for Nitrate/Nitrite	mg/kg	0.1
Total Phosphorus	50 g	EPA 365.4/SM4500 P B+E	mg/kg	0.1
Biological Oxygen Demand (BOD)	50 g	SM 5210B	mg/kg	1.0
Total Solids Dry	50 g	SM 2540 B (dry at 104°C)	mg/kg	1.0
Total Volatile Solids (TVS)	50 g	SM 2540 E (loss on ignition at 550°C)	mg/kg	1.0
Bulk Density	50 g	ASTM D1895B	mg/kg	NA
Process	**Sample amount needed**	**Sample Method**	**Units**	**Method Detection Limit (MDL)**
Sieve Analysis (#4 & #200 sieve)	NA	USBR 514.2.6	mg/kg	NA

The Center developed centralized database to manage project data. The database included data generated from: field sheets recorded by County staff interim sampling days, maintenance logs, precipitation, gross solids sample Day 2 measurements, litter and leaf characterized gross solids information, laboratory results, and pollutant load calculations. Field Sheet Checklists are included in Appendix C.

2.4 Precipitation Data and Analysis

Precipitation data will be collected throughout the study period and the following information included in the central database managed by the Center.

- Daily precipitation (e.g., > 0.05in)
- Inter-event dry period: time period since previous rain event
- Duration of rainfall (e. g,. > 0.05in)
- Intensity (if available, from weather station)

3. Data Analysis

The data provided basic metrics on gross solids quantity and type collected in an urban watershed. The metrics included:

- Total weight and by category weight (lbs)
- Total volume and by category weight (ft^3)
- Percent litter, organic debris, and coarse sediment
- Analysis dry weight (mg/kg) for coarse sediment and organic debris for:
    - Total Volatile Solids, an estimate for percent organic matter
    - Total Nitrogen, Total Phosphorus, Biological Oxygen Demand
    - Total Solids Dry
    - Bulk Density (for one sample date was used)

Gross solids pollutant load estimates will be based on measurements of dry or field dry weight of the material and constituent concentrations. Daily loading estimates were derived and approximated based on the time interval between cleanout periods and drainage area to each outfall.

Cost effectiveness information were reported based on weight of gross solids collected and estimated nutrient loads (TN and TP) and the cost of Kristar Net Tech©. Maintenance costs were summarized based on the field logs completed by Talbot County and Town of Easton staff and expressed as an hours of staff time with additional capital costs as needed.

4. Equipment and Supply Needs

Equipment needed to conduct the field work included:

- Sieves that were 75 µm (#200 sieve) and 4.75 mm (#4 sieve)
- Tarp(s)
- Crane scale to measure wet gross solids in the net
    - Salter Brecknell CS2000 Electronic Crane used
- Trucks to transport gross solids material and equipment with crane to remove gross solid bags from stream
- Covered space to dry gross solids
- Work bench area to separate gross solids
- Protective gloves, dust mask, and other personal protective care
- Bucket, broom/dustpan, and garbage bags
- Field sheet checklists and datasheets to record weight, volume, and characteristics of the litter and leaf material
- Scale to weigh dried gross solids in bucket
    - OHAUS Digital Ship/Rec Scale used
- Ziploc bags or equivalent sample containers
- Camera
- Cooler with ice

5. Monitoring Study Timeline

The monitoring study timeline is provided in Table 5. This timeline was adapted to best meet the project goals and objectives.

Table 5. Project tasks, responsible parties, and timeline.									
Task and Responsible Party(ies)	2011 Jan - Mar	2011 Apr-Jun	2011 July-Sept	2011 Oct - Nov	2012 Jan-Mar	2012 Apr-Jun	2012 July-Sept	2012 Oct-Nov	2013 Jan-Jun
Install Kristar Net Tech ®(Town/County)			X						
Background Research (Center)	X								
Develop Monitoring Plan (Center)		X							
Net Visual Inspection/Monitoring (Town/County)		X							
Develop Training Materials (Center)		X							
Training (Center)		X		X					
1st Monitoring Day (Center)				X					
2nd and 3rd Monitoring Day (Center)					X				
4th and 5th Monitoring Day (Center)						X			
6th Monitoring Day (Center)								X	
7th Monitoring Day (Center)									X
Laboratory Sample Prep, Transport, and Data Handling (Center)				X	X	X	X	X	X
Project Coordination (Center)	X	X	X	X	X	X	X	X	X
Rainfall Data Collection (Center)				X	X	X	X	X	X
Outfall Net Maintenance, Observation, and Data Log Entry (Town/County)		X	X	X	X	X	X	X	X
Data Compilation (Center)				X	X	X	X	X	X
Data Analysis (Center)				X	X	X	X	X	X
Final Report Drafted (Center)									X
Final Report Review (Town/County)									X
Final Report to Town/County (Center)									June 2013

6. Data Quality Assurance and Quality Control (QA/QC)

Standard operating procedures, field sheet checklists, contact information, and methods were developed and followed for the sampling days. Training outlined these methods before Sampling Day 1. Net and outfall condition along with gross solids wet weight were gathered in field sheet checklists that were provided by the Talbot County and Town of Easton and maintained by the Center. These data sheets were compiled by the Center and transferred to a database for storage and interpretation (e.g., Microsoft Excel spreadsheet). Preliminary data results were reported to Talbot County. QA/QC was performed by the Center project's QC. In addition, chain of custody sheets were completed by Center staff per the laboratory protocols (see Appendix D for example chain of custody sheet).

7. Anticipated Problems

Gross solids is an emerging field and we anticipated that our methods needed to be adapted both on-the-fly in the field and during project. In addition, the Ecosol Net Tech© is a new technology used by the Talbot County and Town of Easton. Therefore, a learning period was expected to familiarize staff with operational use of the net and transferring materials effectively from the site to the transfer location. Coordination and open communication with the laboratory was needed to address issues in terms of proper sample preparation, processing, and/or reporting. In addition, the Center required the County to be the 'eyes on the project' since the Center staff are located at least 60 miles from the project location.

Additional anticipated problems included variable time needed for tasks, additional equipment, efficiency for data gathering and usefulness of data gathered to meet the objectives. Therefore, an adaptive management strategy was used for field work. The identified potential problems are detailed here.

- Project tasks involved variable time per sample date depending on the outfalls sampled and/or the amount of material collected: 1) net removal; 2) gross solids transfer to the land fill; 3) gross solids transport to the analysis area; 4) gross solids drying; 5) gross solids sorting; and 6) gross solids weighing
- Data analysis followed an adaptive management strategy, which included reviewing data gathered to determine trends and/or potential errors or gaps. All potential errors or gaps were addressed as early as possible.
- The net calibration to employ the float device that released the bag may not be correct for the outfall and watershed. This could lead to the net detaching early and a high amount of gross solids entering the stream.
-

Heavy rain events and the resulting high flows in the waterways could cause the nets to fail, clog, and/or fill more quickly than anticipated.

The recorded anticipated and observed potential problems can lead to additional gross solids research needs and/or lessons learned reported from this study.

8. Maintenance Checklist for Equipment and Study Sites

For the first two weeks after the nets were installed the Talbot County and/or Town of Easton checked each site often to determine how well the nets worked in the field. Then the training, sampling plan, data analysis, and additional tasks as outlined in Table 5 were conducted. The Maintenance Checklist consisted of the following items and are summarized in Field Sheet Checklist #1 “Post Storm Event Maintenance Check” and #2 “Net Removal for Total Wet Weight” (in Appendix C).

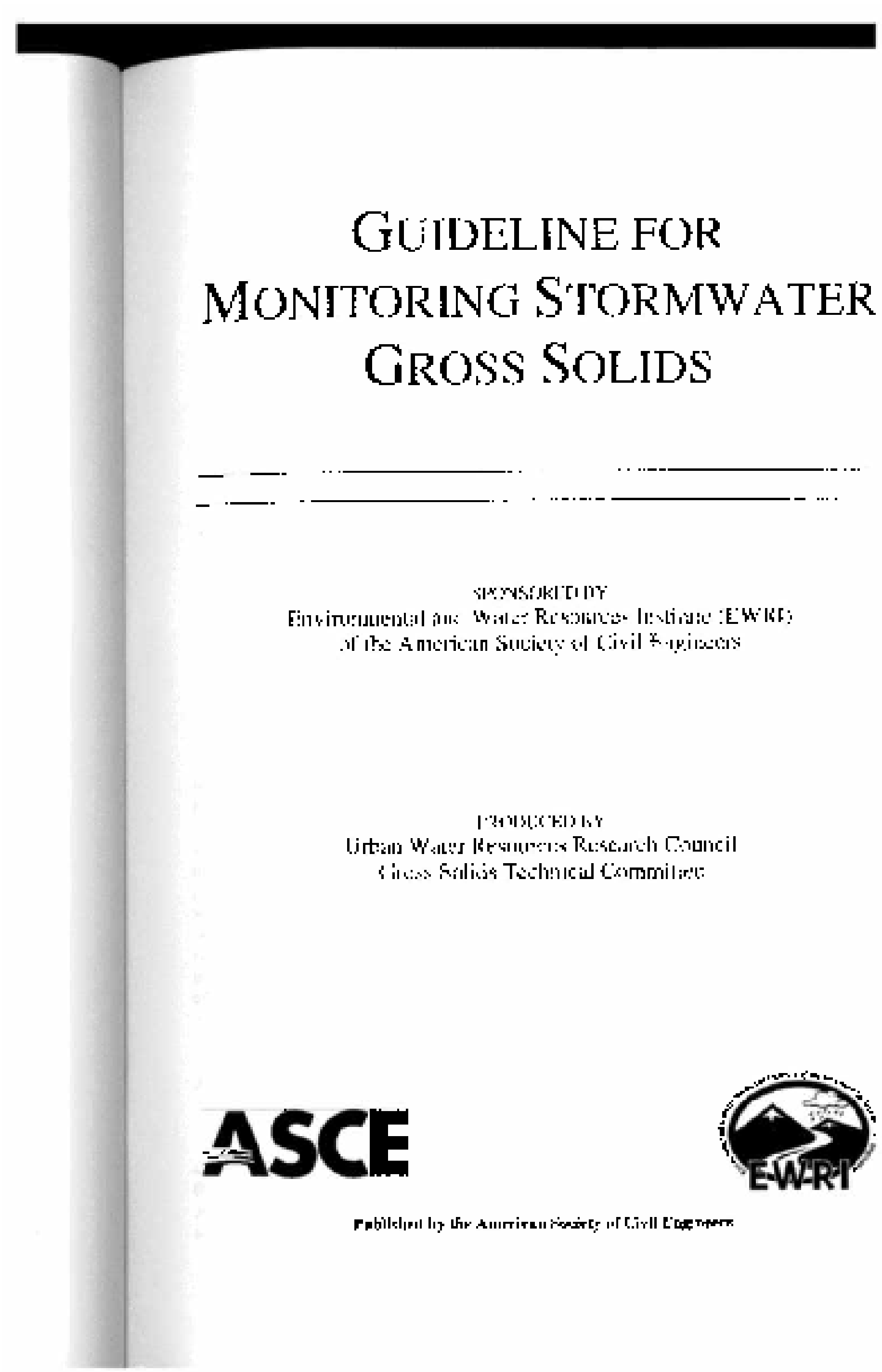
1. Date
2. Staff at the site
3. Rain in last 24 hours (Yes or No)
4. Date net last emptied
5. Amount of trash in the net (% net filled with material)
6. Is the stormdrain blocked, if yes then take picture
7. Did the site require maintenance, if yes then list
8. Was the bag filter emptied
9. Amount of time staff were at the site
10. Additional comments for the site
11. Outfall net content weight
12. Outfall net content and list the major type of net content
13. Outfall empty net weight
14. Additional comments

Record site data on the Maintenance Checklists and inform the Center about the site conditions. Then, transfer the Maintenance Checklists, photos, and additional information to the Center.

9. References

Environmental Water Resources Institute of the American Society of Civil Engineers (ASCE). 2010. Guideline for Monitoring Stormwater Gross Solids. Urban Water Resources Research Council Gross Solids Technical Committee. ASCE.

Appendix A: Guideline for Monitoring Stormwater Gross Solids (ASCE, 2010).



GUIDELINE FOR MONITORING STORMWATER GROSS SOLIDS

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Environmental and Water Resources Institute (EWRI)
of the American Society of Civil Engineers

PRODUCED BY
Urban Water Resources Research Council
Gross Solids Technical Committee

ASCE

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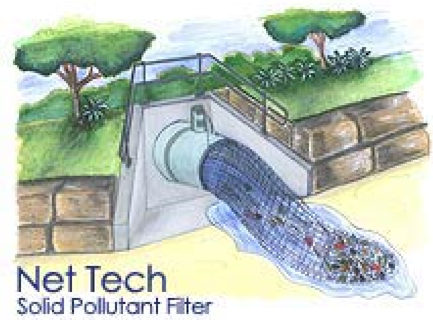
Published by the American Society of Civil Engineers

Appendix B: Kristar Net Solutions Information

Flexible, safe, and cost-efficient litter trap



Although in many cases treatment of pollutants as close as possible to the source is preferred (see here) there are many situations where in-line, or end-of-line, treatment is more appropriate and this is where Kristar's award-winning **Net Tech** Solid Pollutant Filter (refer below) and its **RSF 1000** and **RSF 4000** are often seen as more effective solutions.

It is here that our focus on solutions rather than products is evident. We always look to provide the best solution to your problem.

The Kristar **Net Tech** removes and retains gross pollutants in stormwater flows. Independent testing (see here) has confirmed that unit typically captures more than 91% of gross pollutants larger than 19mm in diameter.

The unit's simple design minimises any hydraulic impact, thereby enabling it to be installed in-line or end-of-line on most drainage networks. It can be fitted on a wide range of pipes, box culverts, multiple outlets, large junction pits, and open channels. It also works equally well in tidal and submerged environments.

The Kristar **Net Tech** unit's unique feature is a simple, yet highly-effective, release mechanism that eliminates the risk of flooding. Unlike other proprietary products the unit will treat 100% of all stormwater flows until the net becomes full or releases under critical flow conditions.

The Kristar **Net Tech** meets all accepted industry standards and guidelines, and has been independently tested at a NATA approved facility. You can see the results here.

The Kristar **Net Tech** is made from durable and reliable materials that ensure longevity and safe operating for its expected life. Only the highest-quality, corrosive-resistant materials are used in the manufacture of all Kristar units. For more information about materials used and their expected life, click here.

However, the flexibility of our approach means that if the Kristar **Net Tech** is not the most appropriate solution for your project you will most likely be able to use one of our other products, click here to learn more.

The product has been installed in many locations throughout Australia. To see a sample from our projects listing and read some case studies click here.

Read more below about the Kristar **Net Tech** and how it works or use the specifying form to provide us with details about your project so that we can provide you with a quote.

Net Tech drawings are available below for your information.

How it Works

The in-line/end-of-line Kristar **Net Tech** Solid Pollutant Filter removes, and retains, gross pollutants from stormwater flows. Unlike most other GPTs, it will continue to capture and retain gross pollutants during a rain event until the filtration net reaches capacity when it disengages from the end of the conduit. This helps eliminate any adverse impact or potential for flooding during peak flow storm events.

The Kristar **Net Tech** consists of a stainless-steel sleeve extension that is inserted and fixed into existing, or new, pipe outlets. This extension is fitted with a removable heavy-duty ultraviolet-stabilised polyethylene net for capturing, and retaining, gross pollutants.

Once installed, under any flow, the Kristar **Net Tech** will start capturing and retaining pollutants. The filtered stormwater passes through the net and downstream to the receiving waterway.

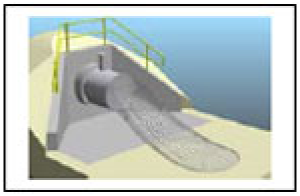
The unit has a fail-safe release mechanism that allows the filtration net to disengage when it has reached its maximum designed holding capacity.

When the filtration net disengages from the sleeve extension a pull cord connected to the main unit tightens around the net throat and prevents the remobilisation of captured pollutants.

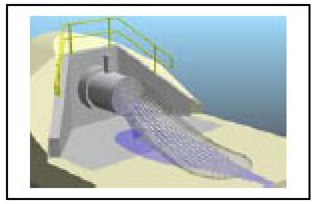
Once the net has released and at the end of the rain event it should be emptied and re-secured to the end of the sleeve extension ready for operation.

The Kristar **Net Tech** requires little, or no, structural change to the existing stormwater system, thereby reducing initial capital costs and minimising disruption to the general public during installation.

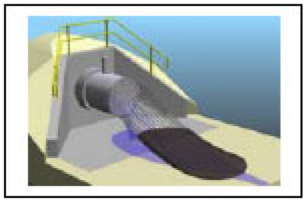
One key advantage with the design of the Kristar **Net Tech** unit is its ability to operate effectively in both submerged and tidal environments. Under these conditions the unit will continue to capture and retain pollutants without any remobilisation. This is a limiting factor with many other proprietary GPTs.



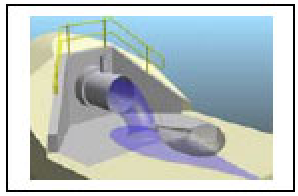
The Kristar **Net Tech** unit before a rain event - note the empty filtration net



The Kristar **Net Tech** unit in operation at the start of a rain event



The Kristar **Net Tech** unit in operation under full flow conditions



The Kristar **Net Tech** unit at the end of a rain event

Pollutant Removal Efficiency

The Kristar **Net Tech** Solid Pollutant Filter is designed to remove and retain gross pollutants and other attached pollutants present in stormwater flows. Independent testing (see here) has confirmed that unit typically collects and retains more than 91% of gross pollutants larger than 19mm in diameter at a range of flows.

Sieve Size (mm)	Capture Efficiency
> 19.00	91%
> 13.00	67%
> 6.70	47%
> 2.36	20%
> 1.78	17%
> 0.15	11%

Benefits

The defining advantages of the Kristar **Net Tech** are that it:

- Captures more than 90% of gross pollutants greater than 19mm;
- Does not re-mobilise captured pollutants;
- Eliminates the risk of flooding by use of a unique release mechanism;
- Has minimal head/hydraulic loss;
- Is easily installed, cleaned, and maintained;
- Can be retrofitted to most existing stormwater systems;
- Operates in dry, tidal, and submerged environments; and

- Is ideal for locations with limited access and as a low-cost alternative to large GPTs.

More information

For more information about the Kristar **Net Tech** please read/print our flyer.
Download flyer (223Kb, PDF)

For more detail please consult our technical specification manual.
Download manual (1.65Mb, PDF)

Appendix C: Field Sheet Checklists.

CHECKLIST #1: POST STORM EVENT MAINTENANCE CHECK

Date: ______________ Time Arrived at Site: ___________________

Circle Location Glenwood (elliptical) Glenwood (circular) Earle (60") Earle (48")

Staff at the Site: ____

<u>Purpose</u>: Visit **<u>all of the outfall</u>**<u>s</u> after a rain to see how full the net is and if there are any problems.

1. Has it rained in the last 24 hours? ---Yes or No
2. Date the net was last emptied ____
3. Circle the percent of the net that is filled (estimated)

   < 25% 50% >75% 100% (bag detached) Bag detached NOT full

4. Is the stormdrain catch basin blocked? ---Yes or No
   If Yes, take photo and list the photo number from the camera.

   ____

5. Did this site visit require any maintenance? ---Yes or No
   If Yes, what type and how many hours did it take?

   ____

6. Bag filter emptied? ---Yes or No
7. Time that you left the site
   ____

Additional Comments:

CHECKLIST #2: NET REMOVAL FOR TOTAL WET WEIGHT

Date: ______________ Time Arrived at Site: __________________

Staff at the Site: ____

Purpose: Empty the net for total gross solids measurements for each outfall.

1. Equipment checklist before going into the field:: **Camera, truck or other equipment to remove net, scale, clean tarps, gloves**
2. FILL OUT Checklist #1
3. REMOVE net and drain for approximately 5 minutes (no drips for 5 to 10 seconds)
4. WEIGH and RECORD wet contents of net:

OUTFALL #1: __________lbs
Circle Location Glenwood (elliptical) Glenwood (circular) Earle (60") Earle (48")
Circle Net Contents Leaves Trash Other Debris
Circle Major Content Leaves Trash Other Debris

OUTFALL #2: __________lbs
Circle Location Glenwood (elliptical) Glenwood (circular) Earle (60") Earle (48")
Circle Net Contents Leaves Trash Other Debris
Circle Major Content Leaves Trash Other Debris

OUTFALL #3: __________lbs
Circle Location Glenwood (elliptical) Glenwood (circular) Earle (60") Earle (48")
Circle Net Contents Leaves Trash Other Debris
Circle Major Content Leaves Trash Other Debris

OUTFALL #4: __________lbs
Circle Location Glenwood (elliptical) Glenwood (circular) Earle (60") Earle (48")
Circle Net Contents Leaves Trash Other Debris
Circle Major Content Leaves Trash Other Debris

5. TRANSFER content into truck for disposal
6. WEIGH and RECORD empty net:

OUTFALL #1: __________lbs OUTFALL #2: __________lbs

OUTFALL #3: __________lbs OUTFALL #4: __________lbs

7. Time that you left the site ________________________________
8. Dispose of gross solids

GENERAL COMMENTS & OBSERVATIONS

CHECKLIST #3: DAY 1 SAMPLING

Date: _______________ Time Arrived at Site: ____________________

Circle Location Glenwood (elliptical) Glenwood (circular) Earle (60”) Earle (48”)

Staff at the Site:

____

Purpose: Remove gross solids from net, wet weight and transfer to drying station.

1. Equipment checklist before going into the field:: **Camera, truck or other equipment to remove net, scale, clean tarps, gloves**

2. Has it rained in the last 24 hours? --- Yes or No

3. Date the net was last emptied ______________________________________

4. Circle the percent of the net that is filled (estimated)

< 25% 50% >75% 100% (bag detached) Bag detached NOT full

5. Is the stormdrain catch basin blocked? ---Yes or No

6. Take photos and list the photo numbers from the camera.

   ____

7. Did this site visit require any maintenance? ---Yes or No

If Yes, describe the type of maintenance and length of time (e.g. hours)

8. RINSE TARP by filling a gallon buck with water from the stream

9. REMOVE net and drain for approximately 5 minutes (no drips for 5 to 10 seconds)

10. WEIGH and RECORD wet contents of net:

OUTFALL #1: __________lbs
Circle Location Glenwood (elliptical) Glenwood (circular) Earle (60”) Earle (48”)

OUTFALL #2: __________lbs
Circle Location Glenwood (elliptical) Glenwood (circular) Earle (60”) Earle (48”)

OUTFALL #3: __________lbs
Circle Location Glenwood (elliptical) Glenwood (circular) Earle (60”) Earle (48”)

OUTFALL #4: __________lbs
Circle Location Glenwood (elliptical) Glenwood (circular) Earle (60”) Earle (48”)

11. TRANSFER Contents onto clean tarp on truck
****NOTE ONLY THE CONTENTS OF TWO NETS SHOULD BE TRANSFERRED TO THE DRYING STATION. THE OUTFALLS TO BE TRANSFERRED WILL BE GIVEN TO STAFF PRIOR TO EMPTYING NETS. THE CONTENTS OF THE OTHER 2 NETS MAY BE DISPOSED OF AFTER A WET WEIGHT IS TAKEN****

12. WEIGH empty net:

OUTFALL #1: __________lbs

OUTFALL #2: __________lbs

OUTFALL #3: __________lbs

OUTFALL #4: __________lbs

13. COVER material and TRANSPORT gross solids back to the sampling drying station. Separate trips will be needed for the two outfall net contents.

14. DRY gross solids on drying shelve. Items should not overlap and allow to drain.

15. RECORD Time the gross solids were placed out to dry:

____

16. Time that you left the sampling station:

____

17. Call Sadie Drescher at 410-461-8323 (work)

GENERAL COMMENTS & OBSERVATIONS

CHECKLIST #4: DAY 2 SAMPLING

Date: ______________ Time Arrived at Site: __________________ Site Name: _______________

Staff at the Site: ____

Pictures Taken (image number):____

Purpose: Sort gross solids and sample.

1. Before going into the field make sure you have supplies needed:
Camera, gloves, safety glasses, scale, sieve, sample bottles, chain of custody forms, cooler, and ice
2. Hours of drying: ____
3. See Section 2.2 from Monitoring Plan
4. MEASURE & RECORD Total dry weight of dry gross solids on field data sheets __________________(pounds)
5. COMPLETE chain of custody form and put in cooler
6. Recycle litter and dispose of organic debris, coarse sediment, and non-recyclable litter not sent to lab
7. Transport cooler to laboratory
8. Time that you left the sampling station: ____

GENERAL COMMENTS & OBSERVATIONS

Appendix D: Chain of Custody

CHAIN OF CUSTODY RECORD

PROJECT NAME Talbot County Gross Solids
COMPANY Center for Watershed Protection
ADDRESS 8390 Main Street, 2nd Floor Ellicott City, MD 21043
PHONE (410) 461-9323

Sadie Drescher / Richard Grimm
SAMPLED BY

Sadie Drescher [signature]
SIGNATURE

Sadie Drescher
PRINT NAME

Chesapeake Environmental Lab Inc
Water Analysis • Well & Septic Certification

St. #181
P.O. Box 946, Stevensville, MD 21666
1-800-300-TEST 410-643-0800 Fax 410-643-0801
celinc@atlanticbb.net
www.ChesapeakeEnvironmentalLab.com

SAMPLE NO.	DATE	TIME	SAMPLE LOCATION	CONTAINER SIZE	CONTAINER G/P	NO. OF CONTAINERS	SAMPLE MATRIX	PRESERVATIVE	ANALYSES: Total Solids (Dry)	Total Nitrogen	Total Phosphorus	BOD	Total Volatile Solids						COMMENTS
Earle 482	1/3/12	10am	Easton, MD Earle 48			1			✓	✓	✓	✓	✓						
Glen Circle	1/3/12	11am	Easton, MD Glenwood circle			1			✓	✓	✓	✓	✓						

Relinquished by:	Date / Time	Received by:	Relinquished by:	Date / Time	Received by:
Sadie Drescher [signature]	1/3/12, 13:37	[signature]			

Relinquished by:	Date / Time	Received by:	Relinquished by:	Date / Time	Received for Laboratory by:

Method of Shipment

Remarks: TVS & TSD results in % units, please

	YES	NO
Samples Iced yes	☒	☒
Samples Preserved no	☐	☒

APPENDIX B: Street Sweeping and Strom Drain Inlet Cleaning Survey

SURVEY ON MUNICIPAL STREET SWEEPING AND STORM DRAIN CLEANOUT PRACTICES

Town of Easton Public Works Department

A. STREET SWEEPING PROGRAM CHARACTERISTCS

1. Does your community have a current street sweeping program?

   X Yes
   ☐ No

If you answered NO, GO TO Section B.

2. Please select from the list what street sweeping equipment is most commonly used in your community. **Check only one.**

   ☐ Sweeper: mechanical brush
   ☐ Sweeper: mechanical brush with vacuum assist
   X Sweeper: regenerative-air with mechanical brush
   ☐ Sweeper: vacuum
   ☐ Other (please specify): ____
   ____

3. Please indicate the number of each type of street sweeper that is part of the fleet used in your community.

   ___ Sweeper: mechanical brush
   ___ Sweeper: mechanical brush with vacuum assist
   __2 Sweeper: regenerative-air with mechanical brush
   ___ Sweeper: vacuum
   ___ Other (please specify): _________________________________

4. Do you target any of the following specific pollutants as part of the street sweeping program?

   X Litter (paper products, glass, metal and other road hazards)
   X Leaves
   X Sediment/dirt
   ☐ Nutrients
   ☐ Not applicable (e.g., there are no targeted pollutants)

5. What is the total length of street swept? This estimate should be the curb-length of street where each side of the street is counted such that is one block is 1000ft and both sides of the street are swept the total length of street swept is 2000 ft.

   Estimate (circle feet or miles) Approximately 75 lane miles

6. Please complete the following list to estimate the proportion of streets that are swept more than once per year.

- ☐ 1x/year: Proportion of total miles swept __________%
- ☐ 2x/year: Proportion of total miles swept __________%
- X Monthly: Proportion of total miles swept Approx. 95%
- ☐ Bi-weekly: Proportion of total miles swept __________%
- ☐ Weekly: Proportion of total miles swept __________%
- X Daily: Proportion of total miles swept Approx. 5 %
- ☐ Other frequency (please list):

______________ Proportion of total miles swept __________%
______________ Proportion of total miles swept __________%
______________ Proportion of total miles swept __________%

7. Do you schedule street sweeping to pick up leaves and debris in the Fall?

- X Yes
- ☐ No

8. Do you schedule sweeping to pick-up sand, de-icing material and winter debris in the early Spring?

- X Yes
- ☐ No

9. Briefly describe how you dispose of material collected from the street sweeper.

____
____
____

10. Do you have an estimate of the weight or volume of sediments collected from street sweeping?

- X Yes**, please provide estimate and units**: _________________________
- ☐ No

11. Please rank from the list below the problems that most affect the performance of your street sweeping program, where 1 is the most comment and 5 is the least common problem. Use a "0" to indicate there is not a problem.

Rank	**Problem**
_X_	On-street parking
____	Inadequate budget
____	Untrained or poorly trained operators
____	Poor street conditions
____	Older or ineffective sweeping technology
	Others (please specify AND rank):
____	______________________
____	______________________
____	______________________

12. Do you have a training program for street sweeper operators?

☐ Yes
X No
☐ Don't know

B. STORM DRAIN CLEANOUT PROGRAM

13. Does your community clean out storm drains and/or inlets?

X Yes, cleanouts are regularly scheduled
☐ Yes, but only in response to complaints or clogging problems
☐ No

If you answered NO, GO TO Section C

14. Estimate how many storm drains and/or inlets are cleaned out annually in your community, OR select a range from the following list.

__________ storm drain ________ inlet _Approx. 450__ both

☐ 1 – 50
☐ 51 – 100
X 101 – 500
☐ 501 – 1,000
☐ more than 1,000

15. Estimate the total proportion of all storm drains and/or inlets that are cleaned out on an annual basis? __n/a_______% **storm drain inlet both**

16. Based on the storm drains and/or inlets that are cleaned out, what is the typical clean out frequency? **Storm drain inlet both**

- ☐ Seldom, if ever
- ☐ Once every 3 to 5 years
- ☐ Once every 2 years
- X Once a year
- ☐ Twice a year
- ☐ Other (please specify): ___________________

17. Please select from the list what equipment is most commonly used to clean out storm drains and/or inlets. Check all that apply. **Storm drain inlet both**

- ☐ Manual
- ☐ Hydraulic-suction cleaner
- X Vacuum
- ☐ Bucket Loaders
- ☐ Other (please specify) ________________________________

18. Please indicate the number of each type of equipment used to clean out storm drains and/or inlets in your community. **Storm drain inlet both**

___ Hydraulic-suction cleaner
__X Vacuum
___ Bucket Loaders
___ Other (please specify): ________________________________

19. What is the average volume of material removed per cleanout? (please specify units of measurement, cubic yards, ton, etc.)

Amount of material removed from storm drains: _______________
Amount of material removed from inlets: _______________
Amount of material removed from storm drains and inlets: ____________
X Don't know

Please provide any comments that may clarify your answer:

____

____

20. Briefly describe how you dispose of the material collected from storm drain and/or inlet cleanouts.

____Dumped at Public Works and then hauled to Landfill once material has dried____

C. LEAF PICK-UP PROGRAM

21. Does your community have a leaf-pick up program that is separate from street sweeping activities and storm drain cleanouts?

X Yes
☐ No

22. Is the leaf pick-up program throughout your community?

X Yes
☐ No

If you answered YES, GO TO 24

23. What areas or land uses are targeted for leaf-up pick?

X Residential
☐ Commercial
☐ Institutional
☐ Industrial
☐ Other, please specify: ____

____

24. When does the leaf pick up program begin and end?

Begin: __Mid October_________

End: ___End of January_____

25. Briefly describe how you dispose of the material collected from storm drain and/or inlet cleanouts.

___See # 9

__Leaves collected by leaf vac are hauled to a private farm.

Leaves collected by sweeper are dumped at Public Works and then hauled to landfill.

APPENDIX C: Sample Data

Analysis Date	Sample Date	Outfall	Days Since Bag Emptied	Wet weight (lb)	Total Interim Dry Weight (lb)	Field Dry Weight - LEAVES ONLY (lb)	Total Solids Dry (%)	Notes
11/9/2011	11/3/2011	Earle 48	20	166.5	51.4	48.6	88.9	
1/3/2012	12/15/2011	Earle 48	17	245.0	64.3	61.8	91.2	
1/3/2012	12/15/2011	Glenwood Circ	17	59.0	9.5	9.2	88.6	
3/16/2012	3/1/2012	Earle 48	36	157.5	39.3	37.7	91.1	
*3/16/2012**	3/1/2012	*Earle 48.2*					*92.5*	
3/16/2012	3/1/2012	Glenwood Ellip	36	8.0	5.2	4.6	86.3	
5/14/2012	4/27/2012	Earle 48	57	264.5	49.4	47.2	90.7	mostly grass clippings
5/14/2012	4/27/2012	Earle 60	57	231	41.9	36.5	87.2	mostly grass clippings
5/31/2012	5/18/2012	Earle 48	21	149.5	26.5	24.8	90.6	
10/4/2012	9/21/2012	Earle 48	24	142.5	33.8	29.7	87.4	
10/4/2012**	9/21/2012	Earle 48. dry	24				88.4	
1/9/2013	12/14/2012	Earle 48	49	246.5	43.2	42.1	87.4	
1/9/2013**	12/14/2012	Earle 48.dry	49				97.3	

* Duplicate sample sent to lab for chemical analysis; ** lab dry samples

Analysis Date	Sample Date	Outfall	Total N (mg/kg)	Total P (mg/kg)	Total Volatile Solids (%)	BOD (mg/kg)	TN (lb)	TP (lb)
11/9/2011	11/3/2011	Earle 48	6283	378	81.4	5873	0.31	0.02
1/3/2012	12/15/2011	Earle 48	4178	337	79.6	7123	0.26	0.02
1/3/2012	12/15/2011	Glenwood Circ	5897	388	79.3	7240	0.05	0.00
3/16/2012	3/1/2012	Earle 48	5379	321	50.9	2507	0.20	0.01
*3/16/2012**	3/1/2012	*Earle 48.2*	*6945*	*525*	*44.8*	*3475*	*0.26*	*0.02*
3/16/2012	3/1/2012	Glenwood Ellip	12422	815	79.1	2865	0.06	0.00
5/14/2012	4/27/2012	Earle 48	20181	1730	60.2	5686	0.95	0.08
5/14/2012	4/27/2012	Earle 60	10677	1660	70.1	7040	0.39	0.06
5/31/2012	5/18/2012	Earle 48	10748	892	64.8	6333	0.27	0.02
10/4/2012	9/21/2012	Earle 48	7250	942	76.8	5507	0.22	0.03
10/4/2012**	9/21/2012	Earle 48. dry	12600	871	71	6130	0.37	0.03
1/9/2013	12/14/2012	Earle 48	12120	422	76.9	10837	0.51	0.02
1/9/2013**	12/14/2012	Earle 48.dry	12390	438	80.1	8974	0.52	0.02

* Duplicate sample sent to lab for chemical analysis; ** lab dry samples