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Literature Review for Trash Amendment Compliance Strategy

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ACRONYMS AND ABBREVIATIONS

ABAG	Association of Bay Area Governments
ac	Acre
BASMAA	Bay Area Stormwater Management Agencies Association
Bay Area MRP	Municipal Regional Stormwater NPDES Permit for the San Francisco Bay Area
BMP	Best Management Practice
Caltrans	California Department of Transportation
CDS	Continuous Deflection System
COG	Metropolitan Washington Council of Governments
County	County of San Diego
gal/ac	Gallon per acre
GSRD	Gross Solids Removal Device
in	Inch
kg	Kilogram
lb	Pound
mm	Millimeter
MS4	Municipal Separate Storm Sewer System
NCHRP	National Cooperative Highway Research Program
NPDES	National Pollutant Discharge Elimination System
QAPP	Quality Assurance Project Plan
SFEP	San Francisco Estuary Partnership
State	State of California
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
US EPA	United States Environmental Protection Agency
WLA	Waste Load Allocation
yr	Year

EXECUTIVE SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

In preparation to respond to the State-wide Trash Amendments, the County has hired Michael Baker International to perform a literature review to serve as the foundation for monitoring work, as well as long term implementation and reporting. This literature review involves:

1. Documenting various studies within California and nationally that developed baseline trash loading rates as part of MS4 Permit compliance, or as a means to comply with Total Maximum Daily Load (TMDL) Waste Load Allocations. No known study presents long term data, and most field programs to measure trash were about one to two years, sometimes less. There is general agreement among the studies as to certain parameters shown to correlate well with generation of trash. Those are land use and population density. A study conducted by the Bay Area Stormwater Management Agencies Association (BASMAA) indicates a strong correlation also between the development of trash and income level of the local residents. BASMAA also discusses a high correlation between trash generation rates in commercial-retail land use area with proximity of fast food restaurants. There is disagreement as to the correlation, if any, between rainfall and development of trash, as well as with drainage area size. All studies were able to present average annual baseline trash load rates, either by weight or by volume, for typical land uses (i.e., residential, commercial, etc.). Although average rates are presented, most, if not all the studies, discussed high variation in trash measurement at a given location. Several anthropogenic factors believed to contribute to such variability include illegal dumping, inadequate storm drain maintenance practices, and/or inattentive street sweeping.

2. A description of a visual assessment method developed for use in the Bay Area. This visual assessment protocol is likely to have long term value to the County of San Diego for reporting because of its cost efficiency compared to quantitative measurement of trash. A visual assessment program will also allow the County to confirm or refine baseline trash loads.

3. A determination whether baseline rates developed elsewhere in California or nationally could be used (or adapted for use) within the County of San Diego's priority land use areas due to similarity in the variables known to correlate well with trash production. Based upon similarity of key parameters such as population density and median income, it is believed that baseline rates developed for use within Patapsco River Watershed (unincorporated areas of Baltimore County, Maryland) are the most appropriate for application within the County of San Diego. Other studies reviewed, though in some cases consisting of more robust data, were generally focused on communities with a large disparity in population density. If used "as is" (i.e., without further refinement), the Patapsco rates would dictate an annual baseline trash load of 22,062 gallons within the County's "high priority" land use areas. The annual baseline trash load is broken down by land use category in Table ES-1.

TABLE ES-1 COMPARISON OF AVERAGE TRASH GENERATION RATES

Land Use	Area (acres)	Trash Generation Rate (gallons per acre per year)	Total Annual Trash Load (gallons)
High Density Residential	981.0	1.6[1]	1.573
Transportation	235.1	0.8	188
Industrial	2798.2	3.2[2]	8,854
Commercial	3603.1	3.2	11,400
Total	*7617.4*		*22,015*

Notes: [1]Trash generation rate based on High Density Residential loading rate from Table 8.
[2]Industrial trash generation rate uses the commercial rate.

Based upon this load, the County would need enhanced street sweeping or other institutional controls deemed effective at reducing trash at a rate of 5 gallons per acre/year to be considered equivalent to "full capture" structures. Select sub sets of other data found in the BASMAA study could be used to modestly refine the Patapsco River Watershed rates due to similarity in population density and household income statistics of certain communities in the Bay Area with those of unincorporated San Diego County. However additional data would be required to perform this refinement.

4. Identify and document prior studies that quantify the reduction in trash achieved by street sweeping and other institutional, or non-structural controls such as manual pickup programs, code enforcement, and public education programs. Enhanced street sweeping and institutional controls, if defensibly quantified, can provide greater cost efficiency and flexibility towards compliance with the "Full capture equivalency" standard under the Statewide Trash Amendments. Prior studies by the California Department of Transportation (Caltrans) and others estimate that robust street sweeping and other non-structural practices are capable of reducing trash from 30% to 75%.

5. Documents the "state of the practice" procedures used to quantify trash generation rate in the environment. The method developed by BASMAA and described within this document appears to be the most practical and cost effective for use by the County of San Diego. Other monitoring programs that involve the testing of water chemistry and in stream measurement are, for a variety of reasons, unnecessary or impractical for local use.

6. Documents the performance and maintenance issues with popular full capture devices based upon manufacturer's literature as well as user feedback. Generally, speaking there are several cost effective proprietary full capture structures capable of meeting the specifications for trash collection within the Trash Amendments. A majority of proprietary devices used by public agencies within the Bay Area were perceived by staff as providing a satisfactory level of performance given the level of maintenance. Several non-proprietary design alternatives have also been developed by Caltrans, however, for a variety of reasons, were significantly greater in cost compared to proprietary options. The County will have a wide array of proprietary options to implement for full capture locations.

INTRODUCTION, SCOPE, AND REGULATORY FRAMEWORK

OBJECTIVES AND REQUIREMENTS OF STATEWIDE TRASH AMENDMENT

The State Water Resources Control Board (SWRCB) has recognized the wide-spread problem of impairments due to trash, as well as the administrative burden of developing and implementing TMDLs on a receiving water basis. In an effort to streamline and provide for consistency of the control of trash statewide, the SWRCB has developed amendments to the Water Quality Control Plan for Ocean Waters of California, and for the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays and Estuaries of California. The Amendments to these plans include six primary elements:

1. A water quality objective
2. Applicability
3. Prohibition of discharge
4. Implementation provisions
5. A time schedule
6. Monitoring and reporting requirements.

Trash has also been identified by the Regional Water Quality Control Boards as impairing beneficial uses, resulting in some receiving waters being placed on the 303(d) list (73 receiving waters to date in the State). The Los Angeles Regional Water Quality Control Board was one of the first Regions to develop a trash TMDL with the Los Angeles River Watershed Trash TMDL. The San Francisco Regional Water Quality Control Board also recognized trash as a problem in receiving waters and included special provisions in its Municipal Regional Permit for trash control requirements in an effort to forestall future trash TMDLs. Other Regions find trash to be a pollutant of concern in receiving waters. A variety of requirements and approaches to trash control are being implemented in urban areas throughout the State.

The Amendments apply to all waters of the State with the exception of those areas in the Los Angeles Region that are covered by trash TMDLs prior to the effective date of the Amendments. The Amendments are implemented through National Pollutant Discharge Elimination System (NPDES) Permits (Phase I, Phase II, Industrial General Permit and Construction General Permit and individual Permits), and are not enforceable until such time as incorporated into a Permit. The Amendments have been developed based on the assumption that certain land uses contribute the significant portion of the load to receiving waters. Accordingly, controlling trash from these identified land uses will ensure that receiving waters beneficial uses are not impaired (from trash).

The Amendments provide for two ‘tracks’ that a Permittee may select from to pursue compliance. Track 1 requires that Permittees install ‘full capture devices’ at MS4 outfalls or in MS4 systems that convey runoff from priority land uses. Such controls are required to be in place within 10 years from the date the Amendments are implemented via an NPDES Permit, or within 15 years of the effective date of the Amendments. Compliance with Track 1 is demonstrated when the Permittee can, “Demonstrate installation, operation, and maintenance of full capture systems and provide mapped location and drainage area served by of full capture systems.”

The second track, Track 2, allows the Permittee to, "Implement a plan with a combination of full capture systems, multi-benefit projects, institutional controls, and/or other treatment controls to achieve full capture system equivalency." This track has a schedule identical to that for Track 1. Demonstration of compliance with Track 2 requirements is achieved when the Permittee has, "Develop[ed] and implement[ed a] set of monitoring objectives that demonstrate mandated performance results, effectiveness of the selected combination of treatment and institutional controls, and compliance with full capture system equivalency."

Permittees that pursue the Track 2 compliance pathway must, "…submit implementation plans to their permitting authority... The implementation plans must: (a) describe the combination of controls selected by each MS4 permittee, and the rationale for the selection, (b) describe how the combination of selected controls is designed to achieve full capture system equivalency, and (c) how the full capture system equivalency will be demonstrated. The implementation plans are subject to the approval by the permitting authority."

Demonstration of 'full capture system equivalency' is a key part of successful implementation of the Track 2 pathway. The Amendments include two ways that a Permittee may demonstrate full capture system efficiency, using a 'Trash Capture Rate Approach,' and a 'Reference Approach.' The Trash Capture Rate Approach is based on quantifying the amount of trash capture in a particular land use or location. The Reference Approach assesses the condition of the receiving water by comparing the trash conditions of a reference receiving water with the receiving water from the Permittees jurisdiction. A literature review can be used to develop trash capture rates by land use under the Trash Capture Rate compliance approach.

SCOPE OF WORK AND FOCUS OF LITERATURE REVIEW

The County of San Diego has elected to comply with the Trash Amendments under Track 2. This Literature Review will form a portion of the basis for the Implementation Plan to be developed by the County. The Implementation Plan will describe, among other things, the combination of full capture systems, multi-benefit projects, other treatment controls, and institutional controls used to comply with the Amendment and demonstrate equivalency to the performance of Track 1.

One of the most important purposes of this literature review is to document the trash generation rates, where possible, from areas similar to the priority land uses in the County. This review seeks to identify any potential similarities in land use characteristics (i.e., zoning, population density, etc.) between the County's priority land use areas and other previous studies that would justify establishment of baseline trash load from literature values, as opposed to from a local pilot study (i.e., "implementation phase"). Documented generation rates will serve as the basis for demonstrating equivalency with Track 1 during the baseline trash study of the program, to be described in the monitoring and reporting portion of the Implementation Plan. Therefore it is important that baseline loads be realistic for local conditions within the San Diego County. The literature review is also intended to document the appropriate technical protocol for quantitative and visual monitoring of trash both to be used in future work efforts.

DETERMINATION OF TRASH GENERATION RATES

QUANTIFYING BASELINE TRASH LOAD

Numerous studies have been completed within California as well as other areas within the United States for the purpose of quantifying the accumulation rate of trash in urban, and sub-urban areas. Such studies have been conducted within the San Francisco Bay Area, the Los Angeles Region, Ventura County, and the Chesapeake Bay Region, among others. The studies were usually done in response to numeric standards for trash reduction imposed through an MS4 NPDES Permit, or a TMDL. The studies usually involved limited trash measurement data, compiled over a relatively short (i.e., one to two year, if not less) period. No two of the studies were completed in the exact similar manner. For example:

1. Some studies normalized data to account for street sweeping, or other non-structural Best Management Practices (BMPs). Others did not.

2. Some measured trash in units of volume, others by weight.

3. Some studies were conducted by measuring dry trash weighed and sorted from a structural BMP. Some studies were completed by simply counting the frequency of trash observed along a representative length of the watershed flowline.

4. Some studies considered a range of demographic factors such as income and population density. Most considered simply land use.

5. Some studies assumed trash generation area to be equivalent to drainage area. Others considered trash generation to be non-uniform within a given land use.

For these reasons, a direct comparison of trash generation data across the various studies is difficult. In many instances, computational adjustment is necessary to compare results on an “apples to apples” basis. Adjusted values across the various studies reviewed are shown in Table 1.

TABLE 1 COMPARISON OF AVERAGE TRASH GENERATION RATES

Land Use Designation	Trash Generation Rate (gallons per acre/year)					
	Bay Area MRP Study (BASMAA)[1]	Los Angeles River/Ballona Creek (Los Angeles Region)	Anacostia River (Prince George County & Montgomery County, MD)[2]	Patapsco River (City of Baltimore)[3]	Patapsco River (County of Baltimore)[4]	Revolon Slough/Malibu Creek (Ventura County, Los Angeles County)[5]
Commercial	6.2	14.77	0.21 (average)	3.15	3.16	N/A
Industrial	8.4	15.33	1.22 (average)	3.15	N/A	N/A
Residential	5.35 (average)	4.3 (average)	0.6 (average)	3.15	0.98 (average)	1.0
Retail	46.8	N/A	0.21 (average)	3.15	N/A	N/A
Schools/Institutional	6.2	N/A	N/A	N/A	0.80	N/A
Park	5.0	5.81	N/A	N/A	0.86	1.0
Transportation	N/A	N/A	N/A	N/A	0.82	N/A

A detailed discussion of how these rates were derived is presented in the sections that follow.

Bay Area

Beginning in 2010, the Bay Area Stormwater Management Agencies Association (BASMAA) installed "full capture" trash devices and monitored the generation of trash to help comply with numeric trash reduction requirements within the Municipal Regional Stormwater NPDES Permit for the San Francisco Bay Area (the Bay Area MRP). Interim results of the study were published in 2011 and 2012, with final recommendations published in 2014. In addition to pilot tests involving targeted installation of full capture devices and measurement of trash collected, the study also involved literature review and GIS analysis of land use and other statistics relative to the rate at which trash is generated, intercepted, and transported by stormwater into the MS4. The BASMAA analysis also included quantitative analysis of raw data previously collected by Los Angeles County to interpret for development of base-line trash rates for use in the Bay Area. The Bay Area MRP requires a 70% reduction of baseline trash load from the MS4 by 2017, and reduction ultimately to a point of "no adverse impacts" by 2022.

The report estimates that 3.5 million tons of trash are produced annually within the Bay Area, characterized typically be items such as food and beverage containers, packaging, cigarette butts, food

[1] All values are "Best". Where applicable values taken are for "moderate" income level

[2] Adjusted from 9 month monitoring period to annual basis. Values reported in lbs. converted at and assumed 2.5 lbs. per gallon based on an approximation of the lbs per gallon from the LA study as listed in Table 4. All values represent averages from various monitoring programs (i.e., outfall monitoring, parking lots, in stream, etc.)

[3] Taken from single "urban" land use value, and converted from values reported as weight at 2.5 lbs. per gallon based on an approximation of the lbs per gallon from the LA study as listed in Table 4.

[4] All values converted from weight at 2.5 lbs. per gallon based on an approximation of the lbs per gallon from the LA study as listed in Table 4.

[5] Land uses only correlated to those observed applicable in Las Virgenes Creek watershed.

waste, construction and landscaping materials, furniture, electronics, tires, and hazardous material, among others. The study also estimates that each person within the US generates more than 4 pounds of trash each day.

The BASMAA study sought to evaluate the significance of several variables that were deemed to potentially influence the amount of trash in stormwater. They were:

1. Type of Land Use and Businesses
2. Population Density
3. Income Level of the Community
4. Rainfall/Runoff Patterns
5. Street Sweeping Effectiveness
6. Level of Vehicular Traffic
7. Level of Environmental Concern in the Community

The significance of these variables was tested through the selection and completion of a monitoring program of 159 sites. A breakdown of the monitoring program, summarized by land use and household median income, is shown in Table 2. The sites were sampled four times between May of 2011 and April of 2012. A detailed discussion of the monitoring protocol and quality assurance methods is provided in Appendix F of this report. The land use information used in the analysis was taken from ABAG (Association of Bay Area Governments), and often times required grouping of land use sub-groups into broader categories to simplify the process of computing data and drawing conclusions.

- “Residential” in the BASMAA study included low, medium and high densities, as well as single and multi-family residences.
- “Retail and Wholesale” in some instances included post offices and hotels.
- “Commercial, Services, and Offices” was a broad mix of 30 land use categories from ABAG data including local government, education, research centers, offices, churches, and hospitals, among others.
- “Household Income” was taken from 2010 Census data. Median income for non-residential land uses was established by applying census data to a 5 or 15 acre buffer around the land use of interest.

Table 2 Summary of BASMAA Monitoring Sites (EOA, June 2014)

Land Use	Median Household Income		
	Low (< $50k)	Medium ($50 - $100k)	High (>$100k)
Residential	10	27	12
Commercial, Services and Offices	3	12	4
Retail and Wholesale	30	28	4
Industrial	13		
Urban Parks	3		
K-12 Schools	10		
Expressways	3		
Total # of Sites	**159**		

Trash generation rates were developed using the following equation, which accounts specifically for the effectiveness of street sweeping:

$$R = \frac{(V - D)/A}{1 - E}$$

R = annual site (land use) specific trash generation rate (gallons per acre)

V= total trash volume observed in the full capture structure from monitoring program (gallons)

D= total accumulation period of the study (days)

A= drainage area (acres)

E= estimated street sweeping effectiveness, adapted from Armitage, 2001 study

The quantitative significance of street sweeping and other non-structural best management practices is further discussed within the "Efficiency of Trash Mitigation Measures" section of this report. The resulting average annual trash generation rates for the San Francisco Bay Area are summarized below in Table 3. These rates were found not to differ significantly from those generated for the Los Angeles Region (discussed in the "*Los Angeles TMDL*" section of this report). Because trash generation rates were found to be highly variable and range over orders of magnitude for each land use, BASMAA developed trash generation maps using a color coded system to assist with visual monitoring and long term reporting. These maps characterize areas governed under the MRP as generating "low," "moderate," "high," or "very high" levels of trash, defined as follows:

- "Low" < 5 gallons/acre/year
- "Moderate" 5-10 gallons/acre/year
- "High" 10-50 gallons/acre/year
- "Very High" 50 – 150 gallons/acre/year

Using the rates from Table 3 as an initial estimate, 64% of lands governed under the Bay Area MRP are described as generating "low" level of trash followed by 28% "moderate," 7% "high," and 1% "very high." These characterizations can be refined over time through visual observation, review of municipal operations records, as well as through discussion with staff and members of the public. The visual assessment protocol intended to achieve this is discussed in detail within Visual Assessment of Trash Load section of this report.

TABLE 3 SUMMARY OF BASMAA ANNUAL TRASH GENERATION RATES (EOA, JUNE 2014)

Land Use	Low [b] (gallons per acre)	Best [b] (gallons per acre)	High [b] (gallons per acre)
Commercial & Services	0.7	**6.2**	17.3
Industrial	2.8	**8.4**	17.8
Residential [a]			
Less than $50,000/yr.	2.8-30.2	**8.2-87.1**	24.2-257
$50,000-$100,000/yr.	0.9-2.8	**2.5-8.2**	7.4-24.2
Greater than $100,000/yr.	0.3-0.9	**0.5-2.5**	1.0-7.4
Retail [a]			
Less than $50,000/yr.	10.4-110	**78.2-150**	202-389
$50,000-$100,000/yr.	2.1-10.4	**15.5-78.2**	40.0-202
Greater than $100,000/yr.	0.7-2.1	**1.8-15.5**	4.6-40.0
K-12 Schools	3	**6.2**	11.5
Urban Parks	0.5	**5.0**	11.4

a. For residential and retail land uses, trash generation rates are provided as a range, which takes into account the correlation between rates and household median income.

b. For residential and retail land uses: Low = 5% confidence interval; Best = best fit regression line between generation rates and household median income; and, High = 95% confidence interval. For all other land use categories: High = 90th percentile; Best = mean generation rate; and, Low = 10th percentile.

Computed trash generation rates were statistically analyzed to find correlation (if any) with hydrology, demographic information, income, population density, and other potentially influencing factors. The BASMAA study *did not* find a significant correlation between drainage area and the amount of trash observed/measured in the full capture structures. This somewhat counter-intuitive conclusion is attributed to the variation of sources and areas of accumulation and capture within the drainage area. However, drainage area is an extremely convenient, if not necessary, value to consider in the determination of trash generation rate and baseline load. Similarly, trash accumulation period (i.e., days between cleanouts) did not correlate well with trash generation rate. It is possible that the sources and level of trash interception may mask the significance of trash accumulation period in trash generation rate. The proximity of trash sources to inlets may also be a key contributing factor that masks the influence of accumulation period. The BASMAA study was not designed to directly assess the effects of rainfall on trash generation rate. However, it did apply historic rainfall records from the Los Angeles area to measured trash accumulation rates from the Los Angeles TMDL study. In doing so, little to no correlation was found between rainfall and trash generation rate. Unlike many other pollutants where the rainfall-runoff process heavily governs transport, it is possible that factors such as wind effects, illegal dumping, street sweeper error, and re-suspension during large events all preclude establishment of an accurate relationship between rainfall and trash generation rate (EOA, Inc., 2014).

Los Angeles TMDL

The Los Angeles Regional Water Quality Control Board identified the Los Angeles River, Ballona Creek and other water bodies as impaired by trash. These listings in the LA region spawned baseline trash generation monitoring in the Los Angeles River and Ballona Creek watersheds to determine the amount of trash discharged from stormwater conveyance systems to these water bodies and assist with development of subsequent TMDLs (EOA, Inc., June 20, 2014). The Los Angeles Trash TMDL was adopted by the Regional Board in September 2001, and was the first program of its kind to regulate trash as a pollutant. Specific waste load allocation was established for each year, with final compliance required by 2015. (Burns, September 16, 2014)

Trash monitoring was conducted by the County of Los Angeles between 2002 and 2004. In total, the County of Los Angeles selected and monitored trash generation in 175 sites that were controlled by a total of 590 full capture devices. Each site was also identified as draining one of five land use classes (commercial, industrial, high density single family residential, low density single family residential, and open space/urban parks). The resulting annual trash generation rates of the study for each land use are presented by volume and by weight in Table 4. There were several noteworthy limitations in the County of Los Angeles trash study (EOA, Inc., June 20, 2014).

1. Generation rates for the Los Angeles region did not explicitly consider the use or significance of institutional/non-structural control measures or other demographic factors such as income or population density. Although the level of street sweeping differed among the sites, differences in levels of trash intercepted as a result of this control measure were not accounted for in the trash generation rates established (EOA, Inc., June 20, 2014).
2. The effects of rainfall volumes and intensities for each storm and site combination were not evaluated (EOA, Inc., June 20, 2014).

TABLE 4 LOS ANGELES REGION TRASH GENERATION RATES (AS SUMMARIZED EOA, JUNE 2014)

Land Use	Annual Trash Generation Rate	
	Volume (gal/ac)	Weight (lbs./ac)
Commercial	14.77	22.12
High Density Single Family Residential	5.57	10.82
Industrial	15.33	21.58
Low Density Single Family Residential	3.03	9.47
Open Space/Parks	5.81	16.58

Anacostia Baseline Monitoring

From June 2008 through July 2009, the Metropolitan Washington Council of Governments (COG), Department of Environmental Programs collected baseline trash condition data for the Anacostia River for use in development of a trash TMDL. The study area included portions of the Anacostia River in

Montgomery County and Prince George's County, Maryland (Metropolitan Washington Council of Governments, Department of Environmental Programs, October 23, 2009).

Over the course of a one-year program, the COG completed the following:

1. Developed a quality assurance project plan (QAPP).

2. Conducted seasonal in-stream baseline monitoring at 30 randomly selected sites ("study reaches"). A total of 35,913 trash items were counted at these stations with little seasonal variability observed from the spring of 2008 through the spring of 2009. The six most commonly observed trash items accounted for 79% of counted items – those being plastic bags, food packaging, construction debris, Styrofoam, plastic bottles, and aluminum cans. Counted items along the stream study reaches ranged from as low as 0 to 10 items to greater than 50 per 100 feet sampled. No specific information is provided regarding the land uses draining to these study reaches. However, the contributing drainage area to each study reach varied from under one square mile to as high as 75 square miles – meaning the results lend themselves to scalability on a watershed level.

3. Conducted baseline road and parking lot monitoring to characterize six land use types. This aspect of the monitoring evaluated a "low density" (1 acre single family) site, a predominately "medium density" (1/8 acre single family) site, a "medium density" townhouse development, a "high density" apartment complex, a commercial shopping center anchored by a grocery store, as well as the Beltsville Industrial Park (57% Commercial/Industrial). The monitoring was performed by manual counting of trash items per 100 feet along the roadway or parking areas. The most commonly observed items in the parking lot and roadway areas were paper, food packaging, aluminum cans, and plastic bottles and cans. Results for the 9 month monitoring period from the October 2008 through July 2009 are summarized below in Table 5. Although the contributing drainage area for this element of the monitoring program is at a substantially smaller scale compared to the in-stream monitoring, the results provide relatively good isolation of the influence of land use type on trash generation rate.

4. Conducted trash outfall monitoring for the same six land use areas described above. The most commonly reported trash items identified in the outfall monitoring were plastic bags, food packaging, Styrofoam, and plastic bottles. Results for the 9-month monitoring period from the October 2008 through July 2009 are summarized below in Table 5.

5. Conducted trash monitoring for two Fresh Creek Netting Trashtrap sites in Prince George's County to characterize loading rates from upland land use areas. Results for the 9-month monitoring period from the October 2008 through July 2009 are summarized below in Table 6. The most frequently observed items were food packaging, plastic bags, plastic bottles, Styrofoam, paper, and aluminum cans. The Trashtrap Systems were observed to have experienced structural damage in one location due to high intensity rainfall events. Because of this, as well as budgetary constraints, both sites were periodically taken off-line during the monitoring period (Metropolitan Washington Council of Governments, Department of Environmental Programs, October 23, 2009).

TABLE 5 SUMMARY OF ANACOSTIA MONITORING PROGRAM ROAD AND PARKING LOTS, STORM DRAIN OUTFALLS (MW COG, 2009)

Land Use	Trash Generation Rate		
	Contributing Drainage Area (acres)	Road and Parking Lot Mean Weight (lbs./acre)	Storm Drain Outfall Weight (lbs./acre)
1 acre single family (Low Density).	6.9	0.1	0.3
1/8 acre single family (Medium Density)	65.2	0.5	0.8
1/8 acre townhouses (Medium Density)	2.3	0.4	5.2
Apartments (High Density)	3.1	0.2	1.3
Grocery Supermarket (Commercial)	4.2	0.4	0.4
Industrial Park (Commercial/Industrial)	226	4.2	0.4

TABLE 6 SUMMARY OF ANACOSTIA MONITORING PROGRAM FRESH CREEK NETTING TRASHTRAP SURVEY (MW COG, 2009)

Land Use	Trash Generation Rate	
	Contributing Drainage Area (acres)	In Stream Weight (lbs./acre)
“Small lot” single family (Medium Density)	659.2	0.2
“Small lot,” single family, and apartments (Medium and High Density)	40.8	1.6

Patapsco River

A 2014 study by Maryland Department of the Environment for the US EPA developed waste load allocations (WLAs) for trash and debris in portions of the Middle Branch and Northwest Branch of the Patapsco River Mesohaline Tidal Chesapeake Bay Segment. The spatial extent of the TMDL includes portions of Baltimore Harbor, the upstream areas of the Jones Falls watershed, and the Gwynns Falls watershed. The TMDL target was set equal to 100 percent removal or capture of the baseline trash load, making it a very similar approach used by EPA Region IX for trash TMDLs in California, as well as that developed for the Anacostia River. The baseline load for this TMDL is defined as the annual trash load calculated from monitoring data obtained from storm drain and in-stream sampling. Because of high seasonal and annual variability, average quantities are used from point and non-point sources. Compliance can be achieved by removing trash from anywhere within the spatial extent of the TMDL, so long as the total reported is equivalent to the baseline load. Since many trash removal processes were already occurring at the time of sampling for baseline loads, the TMDL values for compliance must be in addition to trash that was already being removed; the one exception being that Baltimore County was given credit for structural trash removal BMPs. For all watersheds within the TMDL, the MS4 is assigned the vast majority of both the daily and average annual waste load removal targets. For example, in Baltimore Harbor watershed, 42,869 of the total 44,655 lbs. of trash to be removed (96%) is assumed to come from the MS4. This is to be accomplished through adaptive management of enforcing illicit dumping laws, regulatory and voluntary trash removal and prevention programs, and storm drain capture devices.

To establish loading rates and baseline loads, monitoring data was collected at 6 storm drain outfalls within the City of Baltimore between March and October of 2011. The County of Baltimore conducted monitoring at twenty in stream sites and seventeen stormwater management facilities, selected randomly in the Jones Falls and Gwynn's Falls watersheds. Trash removed from these monitoring locations was developed into an annualized loading rate using the following equation:

$$Annualized\ Trash\ Loading\ Rate = \frac{W_s}{A * R} * \ R_A$$

s = Sample Event

W= trash weight (lbs.)

A= drainage area of sample site (acres)

R= rainfall during sample period (inches)

R_N= 30 year normal annual rainfall (inches)

The result of this equation produces a value that is normalized for precipitation, since the study assumes a "strong correlation between trash and rainfall" (Maryland Department of the Environment, December 2014). The results of the City of Baltimore and the County of Baltimore's baseline trash loads are summarized below in Table 7 and Table 8. All sites monitored by the City are considered "high density residential," with the exception of North Avenue. It is worth noting that the Maryland Department of the Environment elected to combine the data from the five stations within the City of Baltimore to develop a single all-purpose "urban" land use rate. Based on the limited amount of data, this approach was considered to produce a more robust average rate, capable of equalizing the effects of possible trash "hot spots." The values in Table 7 inherently capture any upstream practices already in place (i.e., street sweeping, volunteer clean ups, etc.). The values for the unincorporated areas of Baltimore County presented in Table 8 represent a much broader spectrum of land use.

TABLE 7 CALCULATION OF BALTIMORE CITY URBAN LAND USE LOADING RATE (MARYLAND DEPARTMENT OF THE ENVIRONMENT, 2014)

Site	Acre	Total (lbs.)	Total Rain	Annualized Unit Loading Rate (lbs./ac/yr.)
Desoto	20.48	55	42.07	5.96
Leon Day	19.38	221	42.07	15.39
Liberty	43.07	27.5	42.07	0.76
North Ave	23.39	151	23.9	16.83
Western Run	40.67	11.5	34.9	0.46
			Average	**7.88**

Table 8 Baltimore County Land Use Baseline Loading Rates (Maryland Department of the Environment, 2014)

Land Use	Annualized Unit Loading Rate (lbs./ac/yr.)	Number of Sites
Low Density Residential	0.90	4
Medium Density Residential	2.45	4
High Density Residential	4.01	2
Commercial	7.91	1
Institutional	1.99	2
Open Urban	2.15	1
Roadway	2.06	2
Forest	0.02	2

Revolon Slough/Beardsley Wash/Malibu Creek

In 2007, the California Regional Water Quality Control Board, Los Angeles Region created a TMDL to achieve water quality standards for trash in Revolon Slough and Beardsley Wash, within the Calleguas Creek Watershed. The TMDL staff report and Basin Plan Amendment incorporate numeric targets for trash, as well as baseline waste load allocations for point and non-point sources. Revolon Slough (referred to as “Beardsley Wash” above the Oxnard Plain) drains primarily agricultural areas, although some residential areas and a golf course contribute runoff. It outlets to Mugu Lagoon within Naval Base Ventura County. Regional Board staff have commonly observed Styrofoam cups and containers, glass and plastic bottles, paper cartons, packaging materials, and discarded mattresses, among other items. The Regional Board determined that current levels of trash exceed the existing Water Quality Objectives necessary to protect the beneficial uses of Revolon Slough, although staff had (as of 2007) not received any monitoring data that specifically quantifies the accumulation of trash. The numeric target for Revolon Slough/Beardsley Wash TMDL is *zero* trash (within the main reach, as well as its tributaries).

To establish trash generation rates for the TMDL, research from other watersheds was analyzed by Regional Board staff. This research included trash collection summaries from Long Beach as well as records of trash removed from a CDS unit installed in the City of Calabasas. Best estimates from cleanout material obtained from the Calabasas CDS unit put the trash generation rate at 64 gallons per year. Given the 0.1 acre contributing area, this equates to 640 gallons per square mile/year (1 gallon per acre/year). It is worth noting that the total drainage area to the CDS unit is 12.8 square miles. The assumption was made that the 0.10 square mile urbanized portion of the total is where the entirety of the trash as generated. Aerial photos of this urbanized area near Las Virgenes Creek obtained from Google Earth suggest a land use that is primarily moderate density single family residential, with some high density residential apartment complexes, and a sports complex. The 640 gallon per square mile/year value is used as the baseline waste load allocations for all MS4 sources (California Regional Water Quality Control Board Los Angeles Region, 2007).

A 2008 staff report was generated as part of the trash TMDL for the Malibu Creek Watershed. This staff report utilizes the same 640 gallon per square mile/year baseline waste load allocation for the MS4, citing the field data form the City of Calabasas CDS unit (California Regional Water Quality Control Board Los Angeles Region, 2008).

Caltrans Pilot Study Trash Loads

Annual air-dried litter loads during the two-year study period ranged from 3.1 kg/acre to 7.5 kg/acre. The data normalized by area assume a straight-line relationship between catchment size and litter load.

Data from the LMPS indicate that smoking and food related litter account for 20% to 30% of the litter by weight and volume. Seventy-nine percent of items by weight and 71% by volume were assigned to the "other" category. The LMPS data also indicate that approximately 80% of the litter collected at the outfall is floatable.

LAND USE CATEGORIZATION UNINCORPORATED SAN DIEGO COUNTY

One of the focus points of this literature review is to determine if, and to what extent, previously established baseline trash rates are appropriate to apply the County of San Diego's priority land use areas; with the assumption that those rates would only be applied in situations in which the key factors were similar. The studies reviewed as part of this work effort show that the following factors correlate well with observed trash generation rates:

1. Land use
2. Population Density
3. Household Income

Readily available data from the 2010 Census was reviewed to compare population density and median household income between the communities that make up the County of San Diego's priority land use areas versus the communities in the Los Angeles River, Ballona Creek, Anacostia River, and Patapsco River watersheds. Computations to determine median household income and population density on an area-weighted basis are provided in Appendix B, and summarized in Table 9 and Table 10. Table 9 shows that area weighted median income is generally consistent between the communities of unincorporated San Diego County versus Los Angeles, and near the Anacostia River and Patapsco River (suburban Baltimore and Washington D.C.) The fact that the County of San Diego resulted with the highest area-weighted value of all the study regions is likely due to the statistical influence of Rancho Santa Fe, Fairbanks Ranch, Mt. Helix, and others. Table 10 illustrates the large disparity in population density between San Diego County's unincorporated priority land use areas versus the other study areas.

Applying the rates in Table 3, Table 4, Table 5, and Table 8 to County of San Diego priority land use areas can provide a preliminary order of magnitude assessment of baseline trash rates. The results of that exercise are summarized in

Table 11 and graphically represented in maps provided within Appendix A. To account for high expected variability, the resulting annual loads can be grouped into the same four-tiered and color coded system developed by BASMAA (i.e., "low", "medium", "high", etc.). Evaluating the percentage make up of each category based upon area and volume can provide a preliminary indication of expected "hot spot" areas, since it illustrates what percentage of the study area is generating the majority of the trash. Justification for targeting certain areas with full capture structure can come from identifying where small areas are generating disproportionately high volumes. Summary results from that analysis are provided in Table 12 and Table 13.

In the BASMAA study, approximately 64% of the area was estimated as a "low" trash generation zone (i.e. less than 5 gallons per acre/year), (EOA, Inc., June 20, 2014). Given that percentage along with an awareness of the County's comparatively lower population density, the results suggested in Table 12 and Table 13 seem reasonably intuitive. Based purely on the relative similarity in population density (and assuming median income as equivalent), the Patapsco River Watershed rates would seem be the most appropriate to apply to the County of San Diego; meaning a baseline trash load of about 22,062 gallons annually (1,573 gallons for high density residential use areas, 235 gallons for transportation use areas, 8,854 gallons for industrial use areas, and 11,400 gallons for commercial use areas), with all sites presumed to be generating trash at a "low" (i.e. less than 5 gallon per acre/year) rate. The Patapsco River Watershed monitoring program involved measuring trash 5 times at 18 stormwater management facility locations within the unincorporated communities of Baltimore County. This created results for 90 event-locations, or data points (Maryland Department of the Environment, December 2014). To augment this data, select representative sub-sets from the BASMAA, (and to a much lesser extent Los Angeles, and Ventura County studies) could be used to refine the rates from the Patapsco River. For example, the BASMAA study conducted monitoring in locations such as Pleasanton and Brisbane, both similar in population density and median income to the County's priority land use areas. Doing this could increase the data points used to define the County's baseline rates by another 20% to 30%. Additional information that is not readily available through our literature review would need to be obtained from the parties that conducted those studies to perform such a refinement.

Table 9 Comparison of Median Household Income within Baseline Trash Study Areas

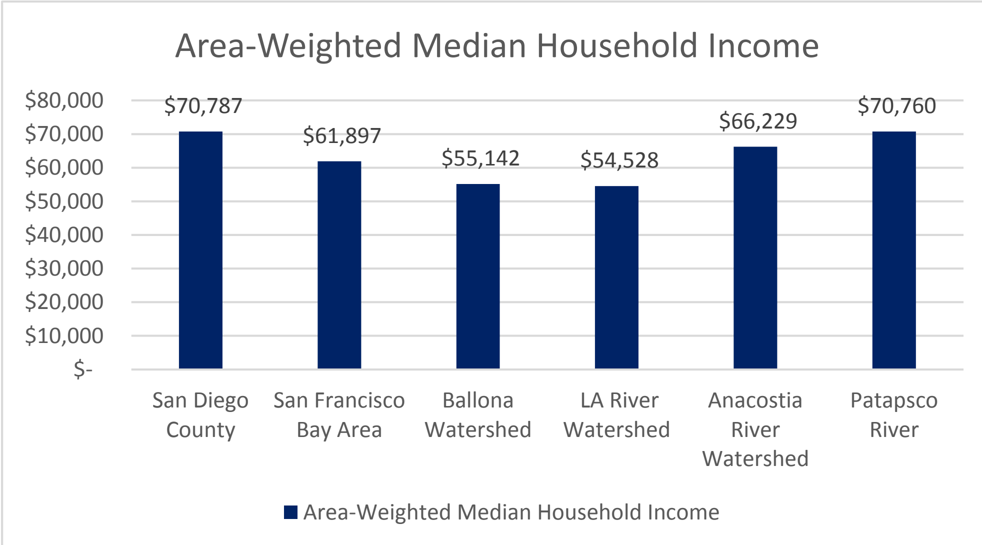

Table 10 Comparison of Average Population Density within Baseline Trash Study Areas

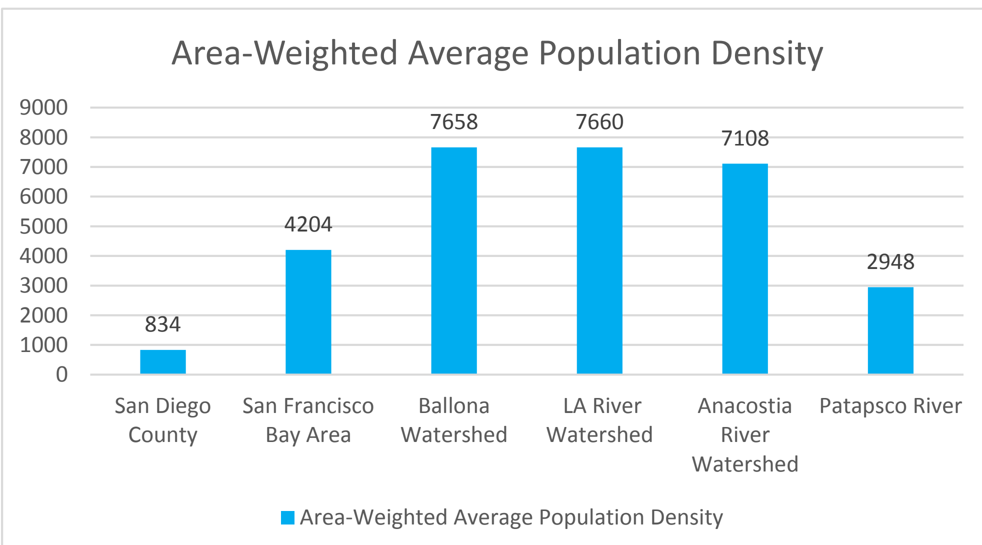

Table 11 Preliminary Annual Trash Load for San Diego County High Priority Land Uses

Annual Trash Load (Gallons)	Using BASMAA Rates	Using Los Angeles Region Rates	Using Rates from Anacostia River	Using Rates from Patapsco River (Baltimore County)
	97,083	101,813	14,132	22,062

The trash generation rates from four of the background studies were applied to the County's high priority land use areas and then classified into the BASMAA trash generating categories of low, medium, high and very high. Table 12 includes the percentage of the 11.9-square mile area that falls within each category. For example 67.8% of the high priority area in County of San Diego produces trash at a "high" rate (between 10 and 50 gallons per acre per year), based on rates from the LA region study.

TABLE 12 CONTRIBUTION OF BASELINE TRASH LOAD WITHIN SAN DIEGO COUNTY BY AREA

Percent by Area by Category	BASMAA Rates	LA Rates	Anacostia Rates	Patapsco Rates
Percent Area Low	3.1%	2.5%	100%	100%
Percent Area Medium	83.0%	29.7%	0.0%	0.0%
Percent Area High	13.9%	67.8%	0.0%	0.0%
Percent Area Very High	0.0%	0.0%	0.0%	0.0%

The total trash load was calculated using the rates from four of the background studies as applied to the 11.9 square miles of high priority areas within the County. Trash load computations are included in Appendix B. Table 13 breaks down the percentage of total volume of computed trash load by source. For example, based on rates from the LA region study, 94.4% of the baseline trash load by volume in San Diego County comes from land uses that are classified as "high", producing between 10 and 50 gallons per acre per year.

TABLE 13 CONTRIBUTION OF BASELINE TRASH LOAD WITHIN SAN DIEGO COUNTY BY VOLUME

Percent By Volume By Category	BASMAA Rates	LA Rates	Anacostia Rates	Patapsco Rates
Percent from Low	0.2%	0.2%	100.0%	100.0%
Percent from Medium	48.8%	5.4%	0.0%	0.0%
Percent from High	51.0%	94.4%	0.0%	0.0%
Percent from Very High	0.0%	0.0%	0.0%	0.0%

VISUAL ASSESSMENT OF TRASH LOAD

An "*On-Land Visual Trash Assessment Protocol"* (EOA, Inc., April 30, 2013) was prepared for the San Francisco Bay Area municipalities and outlines recommended procedures for visual assessment. The intent of these visual assessments is to provide qualitative estimates of the amount of trash generated on specific street segments, sidewalks, and adjacent land areas that may be transported to a municipal stormwater conveyance system. As outlined in the report, the protocol serves the following two purposes:

1. Confirmation of Trash Generation – to provide a line of evidence to conform or re-designate trash generation rate categories assigned to specific land areas via trash generation modeling, and;
2. Assessing Changes in On-Land Trash Conditions – to provide a qualitative tool to assist in evaluating changes in the level of on-land trash that could be transported to a stormwater conveyance system.

This approach requires a minimum of two people for both objectivity and safety. Additionally, an office point of contact should be designated and have readily available the cell phone numbers and inspection schedule/location of the field staff.

The following equipment is recommended, as defined in the protocol report:

- Clipboard;
- Pens/pencils;
- Digital camera (preferably with GPS capabilities);
- Draft trash generation maps that include the street segments to be assessed;
- One copy of the field form for each assessment area; and,
- Bright clothing and/or safety vests.

Timing of each visual assessment is critical to obtain accurate measurements of trash generation within a study area. Each assessment should be conducted when the amount of trash within the respective area is predicted to be the highest. For areas within the public right-of-way, where street sweeping occurs, visual assessments should be conducted immediately prior street sweeping. Performing the visual assessment immediately prior to street sweeping should reduce the number of vehicles parked along curb, which in turn will facilitate assessment of trash accumulation along the curb. For areas on private property, similar considerations should be given to the timing of each visual assessment to ensure other programs, such as organized manual trash pick-up events, do not skew results aimed at measuring trash generation within a specific area.

Trash condition categories were developed to give existing field conditions an initial grade, ranging from A to D. Figure 1, Figure 2, Figure 3, and Figure 4 provide a visual example of field conditions pertaining to each of the four trash condition categories. Appendix E provides an example of the form filled out during each visual assessment. The intent with this approach is to avoid intermediate grades, such as A/B;

however, field conditions or situations where team members cannot find agreement on their assessment of the trash condition may dictate the need for intermediate classification. A description of each category is provided below (EOA, Inc., April 30, 2013):

- **Trash Condition Category A:** Effectively no trash observed in the assessment area. There may be some small pieces in the area, but they are not obvious at first glance and one individual could easily clean up all the trash observed in a very short timeframe.
- **Trash Condition Category B:** Predominately free of trash except for a few pieces that area easily observed in the assessment area. The trash could be collected by one or two individuals in a short period of time.
- **Trash Condition Category C:** Trash is widely/evenly distributed and/or small accumulations area visible on the street, sidewalks, or inlets. It would take a more organized effort to remove all trash from the area.
- **Trash Condition Category D:** Trash is continuously seen throughout the assessment area, with large piles and a strong impression of lack of concern for litter in the area. There is often significant litter along gutters. It would take a large number of people during an organized effort to remove all trash from the area.

The visual assessment protocol is intended to assess the amount of trash observed in the field that can reasonably be transported to the storm drain system. As such, large items such as furniture, shopping carts, tires, and appliances should not be considered when assigning a trash condition category. Additionally, graffiti and landscaping should not influence the trash condition category.

The visual assessment protocol outlined below (EOA, Inc., April 30, 2013), is not intended to be labor intensive. Modifications to this protocol may be made when assessing changes in on-land trash conditions overtime; however, on average the protocol should take no more than 15 minutes per assessment areas. This includes performing the visual assessment, discussions among team members, and completion of the field data entry form. The protocol consists of the following steps that should be conducted in sequential order:

1. Review trash condition category definitions
2. Assemble equipment needed to conduct the assessment
3. Define the assessment area and delineate on assembled maps. Include both streets and adjacent parcels in assessment areas.
4. After arriving at the assessment area, team members should safely walk at a normal pace on the sidewalk or safe portion of the assessment area and carefully look for trash deposited. Team members should identify levels of trash in all portions of the public right of way, including but not limited to, the median, street, gutter, curb, sidewalk, back of sidewalk, vegetated areas. To the extent practical, team members should also identify the level of trash in land areas adjacent to the street that appear to be directly connected to the stormwater drainage system via a storm drain on the adjacent, or contribute trash to the storm drain in the public right of way.

5. Based on the observations made during the assessment it is plausible that the assessment area may need to be redefined once the assessment is complete. Team members may choose to expand or reduce the assessment area if they find that levels of trash in specific portions (i.e. parcels or street segments) of the assessment area are dissimilar from other portions. If this is the case, team members should define the assessment area on their maps, before completing the field assessment form or assigning a trash condition score.

6. Complete section I (Assessment Area) of the field inspection form.

7. Based on the observations in the assessment area, each team member should assign the area a primary condition category (A, B, C or D) based on the definitions provided. Team member should then discuss and collectively agree on the appropriate condition category to assign the area. If agreement cannot be reached among team members, they may choose the appropriate secondary category (A/B, B/C, or C/D) based on their assessment results.

8. If an assessment area receives an "A" grade by the team, safely look and/or around the storm drain inlet(s) draining the assessment areas to confirm that no or very little trash is in or around the storm drain inlet. If little to no litter is present in the storm drain inlet(s), then continue to assign an "A" grade to the assessment area. If the amount of trash in the storm drain inlet(s) is inconsistent with the "A" assignment, reassign the assessment area a condition category that is more consistent with a different condition category.

9. Complete the remaining sections of the field form for the assessment area.

10. Take at least one photo of each assessment area. The photos should represent the level of trash identified in the assessment area.

As mentioned above, the figures below provide a visual example of the four trash condition categories (EOA, Inc., April 30, 2013). The field data entry form is available in Appendix E.

CONDITION A – LOW TRASH LEVEL

Description of a Grade A: Effectively no trash can be observed on a city block or the equivalent. There may be some small pieces in the area, but they are not obvious at first glance and one individual could quickly pick them up.

FIGURE 1 CONDITION A - LOW TRASH LEVEL (EOA, INC. APRIL 2013)

CONDITION B – MODERATE TRASH LEVEL

Description of a Grade B: Predominately free of trash except for a few pieces that area easily observed in the assessment area. The trash could be collected by one or two individuals in a short period of time.

FIGURE 2 CONDITION B - MODERATE TRASH LEVEL (EOA, INC. APRIL 2013)

CONDITION C – HIGH TRASH LEVEL

Description of a Grade C: Trash is widely/evenly distributed and/or small accumulations area visible on the street, sidewalks, or inlets. It would take a more organized effort to remove all trash from the area.

FIGURE 3 CONDITION C - HIGH TRASH LEVEL (EOA, INC. APRIL 2013)

CONDITION D – VERY HIGH TRASH LEVEL

Description of a Grade D: Trash is continuously seen throughout the assessment area, with large piles and a strong impression of lack of concern for litter in the area.

FIGURE 4 CONDITION D – VERY HIGH TRASH LEVEL (EOA, INC. APRIL 2013)

Visual assessment of an area prior to the installation of full trash capture device is considered a vital element to developing a cost-effective compliance strategy. Through visual assessment, meticulous tracking and record keeping, and documentation of existing trash management services, it is feasible the County of San Diego can develop an overall compliance strategy without the need for full trash capture devices installed at every storm drain outfall.

EFFICIENCY OF TRASH MITIGATION MEASURES

The Track 2 compliance track allows for a plan with a combination of full capture systems, multi-benefit projects and institutional controls to achieve full capture efficiency. The proposed method of compliance is described in an implementation plan, which includes how full capture equivalency will be demonstrated. The efficiency of trash mitigation measures will be used as reductions to be applied to the 'full equivalency' trash capture rates developed in this literature review. The combination of these measures and full capture devices will be used to demonstrate equivalency.

GENERAL STREET SWEEPING EFFICIENCY

Street sweeping efficiency for trash reduction is reported in the literature based on direct measurement (what is picked up by the sweeper divided by the total trash load) and indirectly by assessing the trash load in a watershed at a control point with and without sweeping during the study period.

EOA's Technical Memorandum (EOA, Inc., February 2, 2012) reports on a study completed in South Africa to estimate the quantity of trash from a catchment that drained to a single outfall. In this study, the authors concluded that about 87 percent of the trash deposited (by any means) on the street was removed by sweeping. The authors developed a relationship to predict the total annual trash and vegetation load to a receiving water that included a factor for street sweeping.

EOA's Technical Memorandum (EOA, Inc., February 2, 2012) also reported on a study conducted in New York City to assess the effectiveness of street sweeping on trash reduction. The study excluded vegetation, and included an assessment to attempt to optimize the sweeping frequency on removal.

The study concluded that street sweeping removed 40% to 65% of trash, depending on the land use (amount of trash initially on the street), and that in high trash production areas, sweeping once per day provided significant increases in efficiency compared to sweeping once per week. Sweeping more frequently than this did not provide significant additional benefit.

The National Cooperative Highway Research Program (NCHRP) completed a literature review that examined the effectiveness of street sweeping. This study focused on sediment removal as well as other pollutants other than trash. Reported efficiencies varied from 20% to 70% (RBF Consulting, 2014).

CALTRANS LITTER MANAGEMENT PILOT STUDY

Caltrans (California Department of Transportation, June 26, 2000) has conducted significant research into the efficacy of sweeping for trash reduction. Caltrans routinely sweeps freeways and highways in addition to employing manual litter pickup programs as well as full capture devices. Optimizing the resources expended for each approach is of substantial interest to the Department.

The Caltrans study assessed the impact of 'increased' street sweeping as opposed to measuring the effectiveness of sweeping for litter removal from the roadway by measuring reductions at storm drain outfalls. Sweeping was conducted every week in the study area vs. once per month in the control area. Other studies of street sweeping efficiency have noted that a steady state of mass loading is approached within a matter of days for high loading land uses (Sartor & Boyd, 1972). Accordingly, the increase in efficiency measured by Caltrans under this study can be reasonably assumed to approximate the effectiveness of street sweeping for litter reduction to the receiving water. The results of the study for sites that showed a reduction indicated a street sweeping removal efficiency of about 33% by volume.

Caltrans litter data from samples collected at outfalls after storm events and compiled for the rainy season were qualitatively and quantitatively evaluated to identify whether or not each of the study BMPs was demonstrated to be effective. Data collected at each outfall were normalized by area and flow. The result is summarized as follows (California Department of Transportation, June 26, 2000) :

- Statistical tests indicate that increasing the frequency of litter pickup from monthly to weekly reduces the quantity of litter observed at the outfalls. This is the case for all measuring parameters (weight, volume, and count) regardless of whether the litter data are normalized by watershed area or flow. The average annual reduction between the treatment and control outfalls during the two-year study period were 30% by weight, 33% by count, and 41% by volume.

MANUAL PICKUP PROGRAMS

Manual litter pickup was also studied by Caltrans (California Department of Transportation, June 26, 2000) as a part of the study that assessed the effectiveness of sweeping. A similar study protocol was established, with a control and study catchment using a baseline litter pickup of once per month, and an enhanced pickup of four times per month. Assuming litter accumulation had reached a constant volume after one month, efficiency of litter pickup can be estimated by comparing to the weekly pickup data. Effectiveness (litter reduction) was measured at the outfall, making the results particularly useful in the present context.

The Caltrans study indicated an average volume reduction effectiveness for litter pickup at the outfall of about 37%. This reduction appears similar to that for street sweeping, and given the number of variables that could influence the result, the difference is likely not significant.

QUANTITATIVE EFFECTIVENESS OF EDUCATION, OUTREACH, AND ENFORCEMENT

Studies have been completed to estimate the effectiveness of public education on litter reduction. There are a variety of variables that can influence effectiveness relative to the type of media used and the message and how it is conveyed and whether there is litter in the environment. For example, (RBF Consulting, 2014) notes that posting litter-prevention messages in already littered environments is likely to exacerbate the problem. NCHRP estimates the effectiveness of public education and outreach at up to 35% compared to baseline.

Gershman et.al., (Gershman, January 2005) reports that the effectiveness of education and outreach can be in the range of 27% to 75% reduction compared to the null condition, with the higher end of the range associated with comprehensive programs that include public clean up days, litter hotlines, increased enforcement of litter laws and beautification projects.

FULL CAPTURE DEVICES

APPLICATION AND LIMITATIONS OF PROPRIETARY DEVICES

The "*San Francisco Bay Area Stormwater Trash Generation Rates*" (EOA, Inc., June 20, 2014) was prepared for the Bay Area Stormwater Management Agencies Association to establish stormwater trash generation rates. For this study, a full capture device was defined as "*a single device or series of devices that can trap all particles retained by a five millimeter mesh screen, and has a treatment capacity that exceeds the peak flow rate resulting from a one-year, one-hour storm in the sub-drainage area treated by the BMP*," (EOA, Inc., June 20, 2014). It is recognized that trash full capture devices likely do not capture all trash the enters the storm drain system; however, these devices do provide an acceptable level of stormwater trash management as indicated by the Water Board and in the Municipal Regional Stormwater NPDES Permit (MRP).

Trash full capture devices, both proprietary and non-proprietary, have been studied throughout California in response to revisions made to the Municipal Regional Stormwater NPDES Permit (MRP) throughout the state. The San Francisco Estuary Partnership (SFEP), a program of the Association of Bay Area Governments (ABAG), developed a "*Bay Area-wide Trash Capture Demonstration Final Project Report*" (San Francisco Estuary Partnership, May 8, 2014) using grant funding to evaluate proprietary trash full capture devices pursuant to the newly adopted Bay Area MRP.

The type and manufacturer of gross solids removal devices used in this study were selected by participating municipalities based on local conditions including available budget resources. In some cases, existing infrastructure precluded the installment and use of large devices. In other cases, fiscal resources prevented installation of larger devices.

Of the roughly 40 number of gross solids removal devices evaluated by the participating municipalities, only two were classified as "would not buy again," when reporting on the functionality and maintenance burden. Five of the 40 devices where classified as "unknown" by the participating municipalities when asked if they would use the device again. The remaining 33 devices would be purchased again, as reported by the municipalities involved in the study. Summary tables were developed by the municipalities to report on the performance, functionality and maintenance burden associated with specific device models, correlated with trash generation based on land use. Refer to Appendix D of this report for copies of those summary tables.

Feedback from the participating municipalities was part of the SFEP report. Notable comments and suggestions are provided below:

- "Would like another demonstration project to help cities buy additional devices after two years of evaluating maintenance, and time allowed for product improvement based on maintenance feedback."
- "While the Program provided a good resource as to what type of devices were available, unfunded cost for equipment and maintenance in the future is a real concern for the County."

- "[End-of-pipe] nets did capture trash; however there was a problem with the inner nets tearing during maintenance. Also, there was the problem with the nets not releasing when they were at capacity and a high flow situation existed in the storm system."
- "The cost of concrete vault for the device installation is too high. Also, it traps leaves which is not trash"
- "Do not capture trash at catch basins, capture at outflows."

NON-PROPRIETARY CALTRANS STRUCTURES

The "*Caltrans Phase I Gross Solids Removal Devices (GSRD) Pilot Study*" (California Department of Transportation, October 2003) was developed to evaluate the performance of non-proprietary devices that can capture gross solids and can be implemented into highway drainage systems.

Three different design concepts were developed for this pilot study, including (1) Linear Radial, (2) the Inclined Screen, and (3) the Baffle Box. Two configurations of the Linear Radial and Inclined Screen design concepts were incorporated into the study as follows:

1. The Liner Radial – Configuration #1 GSRD utilizes a modular well casing with louvers to serve as the screen.
2. The Liner Radial – Configuration #2 GSRD utilizes a rigid mesh screen housing with nylon mesh bags that capture gross solids.
3. The Inclined Screen – Configuration #1 GSRD utilizes parabolic wedge-wire screen to screen out gross solids.
4. The Inclined Screen – Configuration #2 GSRD utilizes parabolic bars to screen out solids.
5. The Baffle Box applies a two-chamber concept; the first chamber utilizes an underflow weir to trap floatable gross solids, and the second chamber uses a bar rack to capture materials that get past the underflow weir.

Installation costs for the devices, not including monitoring equipment, ranged from $13,054 per acre to $104,876 per acre. Variability in cost was due to site specific recommendations that included unidentified underground utilities, extensive site excavation, grading, and site vegetation.

Once a targeted storm event terminated, each GSRD was visually inspected and assessed for clogging, damage, proper drainage, and material accumulation. During each cleaning procedure, the weight and volume of gross solids removed from the device, bypass bag, and overflow basket (if applicable), were measured. The performance of each GSRD was assessed by evaluating how well the GSRD met the design objectives, which are outlined in Table 14 below. The objective criteria was set by a combination of the established TMDL for trash along with additional criteria and goals set by Caltrans.

Table 14 Design Objectives for Caltrans Pilot Study (Caltrans October 2003)

	Criteria (C) or Goal (G)		Description
TMDL Criteria	C1	Particle Capture	The device or system must capture all particles retained by a 5 mm (0.2 in nominal) mesh screen from all runoff generated from a one-year, one-hour storm (determined to be 0.6 in (15 mm) per hour for the Los Angeles River Watershed).
	C2	Clogging	The device or system must be designed to prevent plugging or blockage of the screening module.
Caltrans Criteria	C3	Hydraulic Capacity	The device or system must pass the Caltrans design flow. In District 7, this design flow is the 25-year peak flow.
	C4	Drainage	The device or system must drain within 72 hours to avoid vector breeding.
Caltrans Goal	G1	Gross Solids Storage Capacity	The device or system will hold the estimated annual load of gross solids, so that it requires only one cleaning per year.
	G2	Maintenance Requirements	The device or system will not require any maintenance other than inspections throughout the storm season.

Of the five gross solid remove device design concepts tested, the most promising devices, based on considerations of particle capture, clogging, passing design flow, drainage, stage capacity, and maintenance requirements, were the Linear Radial – Configuration #1 (louvered modular well casing), and the Inclined Screen – Configuration #1 (parabolic wedge-wire screen). A graphical schematic of each is provided as Figure 5 and Figure 6 below.

These two gross solids removal devices meet the definition of a full capture system – as defined by the Los Angeles River TMDL for trash. The TMDL defines a full capture treatment system as "any device or system that traps all particles retained by a five millimeter mesh screen and has a design treatment capacity of not less than the peak flow resulting from a one-year, one-hour storm (determined to by 0.6 inch per hour for the LA River watershed)," (California Department of Transportation, October 2003).

Design information for the two full capture devices included in the Caltrans study is provided below and on the following pages.

"The Linear Radial – Configuration #1"

This Gross Solid Removal Device (GSRD) utilizes a modular well casing with 5 mm x 64 mm (0.2 in x 2.5 in nominal) louvers to serve as the screen. Refer to Figure 5 for a graphical representation. Flows are routed through the louvers and into a vault. Key design and operation concepts are:

- Inflow is directed into the louvered screen contained within a concrete vault. The louvered screen and vault are linear and aligned parallel to the direction of flow.
- Flows pass radially through the louvered screen and into the vault.
- The louvered screen has a smooth, solid bottom section (extending 60 degrees) to facilitate the movement of settled gross solids toward the downstream end of the pipe.
- Sufficient screen area and volume are provided to accommodate the estimated annual volume of gross solids and to pass the require design storm.

- The vault can be configured with grates or covers, traffic or non-traffic rated, depending upon location within the highway right-of-way.
- The first section of pipe nearest the influent pipe has the same diameter as the louvered screen sections with an open top for emergency overflow. The overflow is designed to convey the Caltrans design flow and the opening has the same open cross sectional area as the pipe."

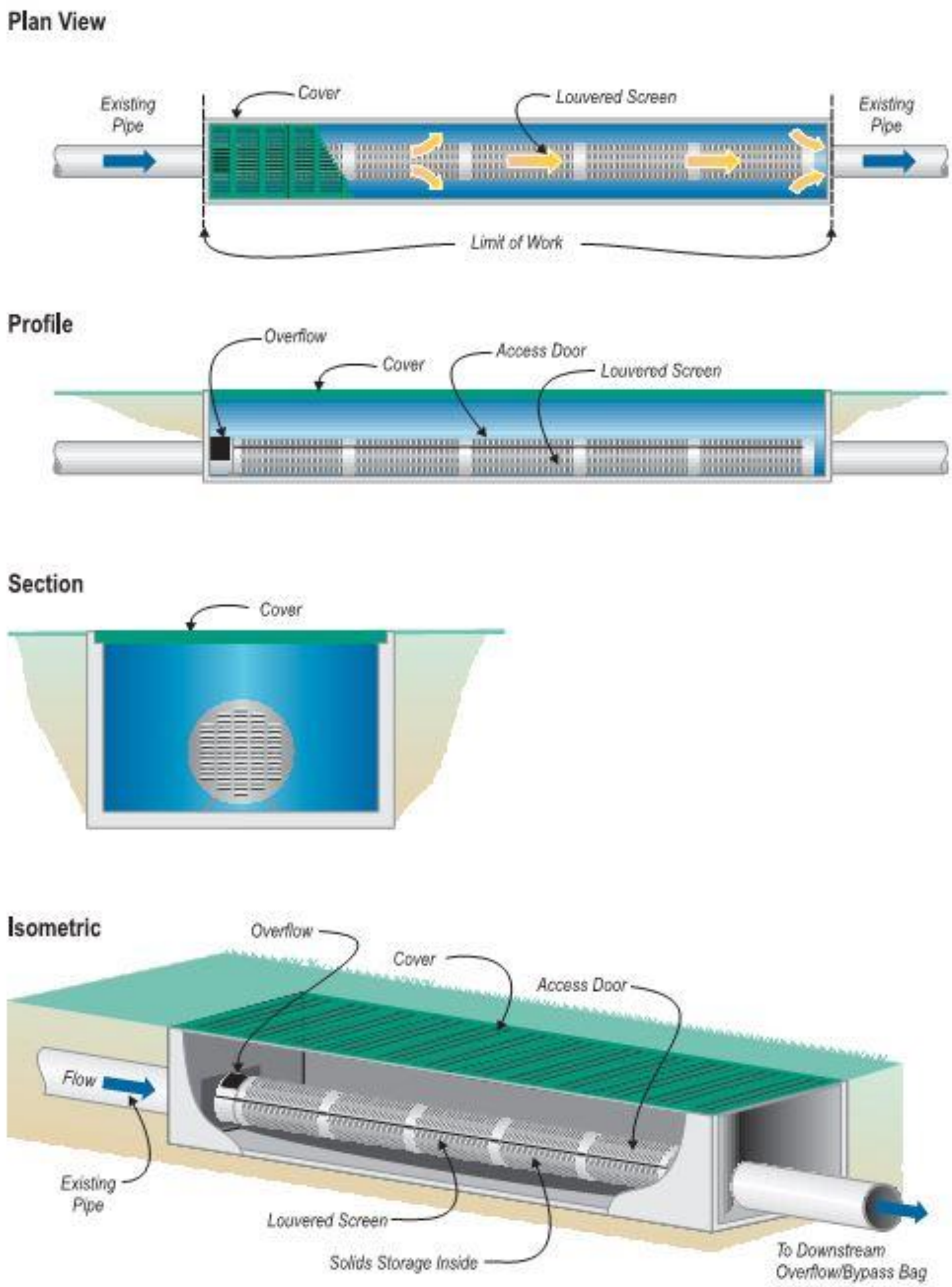

FIGURE 5 FULL CAPTURE DEVICE - CONCEPT LINEAR RADIAL CONFIGURATION 1 (CALTRANS OCTOBER 2003)

"The Inclined Screen – Configuration #1"

This GSRD uses a 3 mm (0.125 in nominal) spaced parabolic wedge-wire screen with the slotting perpendicular (horizontal orientation) to the direction of flow. The device is configured with an influent trough to allow some solids to settle. The flow then overtops a weir and falls through the inclined screen. After passing through the screen, the flow exits the GSRD. Gross solids are retained in a confined storage area that can be accessed by maintenance equipment. Key design and operational concepts include:

- Inflow enters a trough to distribute flows along the length of the screen. The trough also provides an area of reduced velocity where larger solids can settle.
- The trough is drained by a series of weep holes. Sufficient weep holes are provided to drain the trough within 72 hours to prevent vector propagation.
- Flowing storm water pushes the gross solids. The gross solids are moved by gravity down the face of the screen to the gross solids storage area.
- The gross solids storage area is sloped and configured with a drain pipe and inlet grate to allow it to drain between storm events.
- The vault can be configured with grates or covers, traffic or non-traffic rated, depending upon location within the highway right-of-way.
- In the case that the screens are completed plugged, storm water would overflow the entire device to the downstream receiving waters.

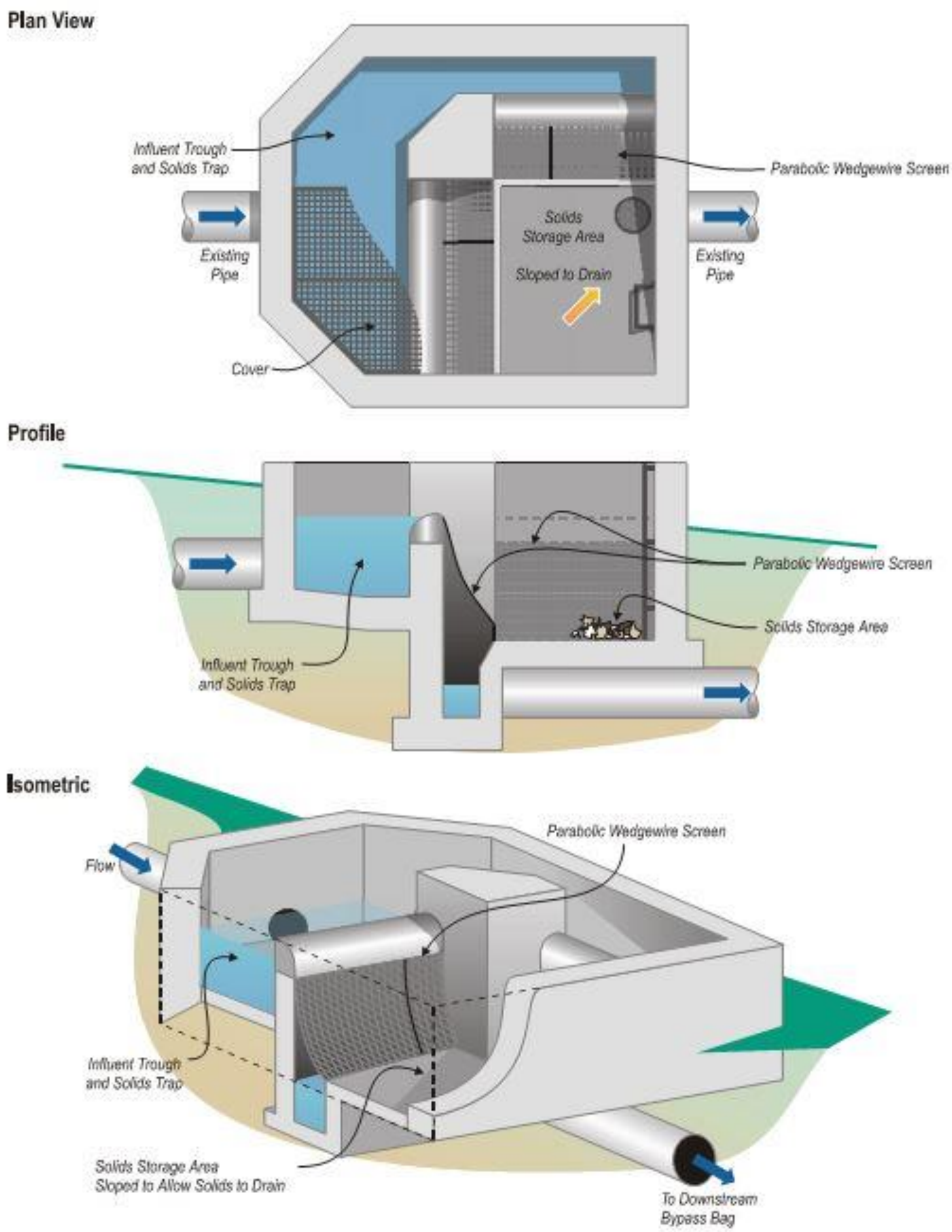

FIGURE 6 FULL CAPTURE DEVICE - CONCEPT INCLINED SCREEN CONFIGURATION 1 (CALTRANS OCTOBER 2003)

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Michael Baker
INTERNATIONAL

Appendix A
Preliminary Baseline Trash Load Maps San Diego County

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0 3 6 12 Miles

1 in = 3 miles

San Diego County High Priority Land Use Areas

BASMAA Study Trash Generation Rates

Exhibit 1

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San Diego County High Priority Land Use Areas

Los Angeles Region Study Trash Generation Rates

Exhibit 2

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San Diego County High Priority Land Use Areas

Anacostia Study Trash Generation Rates

Exhibit 3

Michael Baker INTERNATIONAL

0 3 6 12 Miles

1 in = 3 miles

San Diego County High Priority Land Use Areas

Baltimore Study Trash Generation Rates

Exhibit 4

Appendix B
Preliminary Trash Load Calculations

San Diego County
Trash Generation Calculations

San Diego County Unincorporated High Priority Land Uses					BASMAA Rates		LA Region Trash Generation Rates		Anacostia Rates		Patapsco Rates		Trash Load Rates for SD County High Priority Areas				
Land Use				Area	Land Use	TGR (gal/ac/yr)	Land Use	TGR (gal/ac/yr)	Land Use	TGR (gal/acre/yr)	Land Use	TGR (gal/ac/yr)	Land Use	BASMAA	LA	Anacostia	Patapsco
HDR Category	**% of total**	**#parcels**	**#units**	**Total Acreage**									**HDR**				
10-15 units/acre	7.24	2824	6652	551.41	Residential	8	HDR Single Family	6	HDR Apartments	1.7	HDR	1.6	10-15 units/acre	4,522	3,071	956	884
15-20 units/acre	2.74	718	3581	208.48	Residential	8	HDR Single Family	6	HDR Apartments	1.7	HDR	1.6	15-20 units/acre	1,710	1,161	361	334
20-40 units/acre	2.74	641	5121	208.89	Residential	8	HDR Single Family	6	HDR Apartments	1.7	HDR	1.6	20-40 units/acre	1,713	1,164	362	335
> 40 units/acre	0.16	28	551	12.20	Residential	8	HDR Single Family	6	HDR Apartments	1.7	HDR	1.6	> 40 units/acre	100	68	21	20
Total HDR	**12.88**	**4211**	**15905**	**980.97**									**Total**	**8,044**	**5,464**	**1,700**	**1,573**
Transportation				**Total Acreage**									Transportation				
Bus Stops	**3.086585181**		**326**	**235.12**		0.8		0.8		0.8		0.8		188	188	188	188
Industrial	**% of total**	**# of Ind. Sites**	**# of Comm. Sites**	**Total Acreage**									**Industrial**				
Industrial Park Total	2.87	22	-	218.36	Industrial	8	Industrial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Industrial Park Total	1,834	3,347	489	691
Light Industry - General	7.60	93	-	578.55	Industrial	8	Industrial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Light Industry - General	4,860	8,869	1,296	1,831
Warehousing	1.10	28	-	83.65	Industrial	8	Industrial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Warehousing	703	1,282	187	265
Extractive Industry	13.14	30	-	1000.66	Industrial	8	Industrial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Extractive Industry	8,406	15,340	2,241	3,166
Junkyard/Dump/Landfill	12.04	17	-	916.99	Industrial	8	Industrial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Junkyard/Dump/Landfill	7,703	14,057	2,054	2,901
Total Industrial	**36.73**	**190**		**2798.21**									**Total**	**23,505**	**42,897**	**6,268**	**8,854**
Commercial	**% of total**	**# of Ind. Sites**	**# of Comm. Sites**	**Total Acreage**									**Commercial/Retail**				
Hotel/Motel (Low-Rise)	0.54	-	21	40.87	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Hotel/Motel (Low-Rise)	253	604	92	129
Resort	4.02	-	27	306.48	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Resort	1,900	4,527	687	970
Public Storage	1.61	-	39	122.53	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Public Storage	760	1,810	274	388
General Aviation Airport	3.71	-	2	282.60	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	General Aviation Airport	1,752	4,174	633	894
Parking Lot - Surface	0.08	-	15	5.85	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Parking Lot - Surface	36	86	13	19
Wholesale Trade	0.44	-	3	33.60	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Wholesale Trade	208	496	75	106
Community Shopping Center	2.92	-	20	222.05	Retail*	47	Commercial	15	Grocery Supermarket	0.2	Commercial	3.2	Community Shopping Center	10,403	3,280	47	703
Neighborhood Shopping Center	2.96	-	48	225.33	Retail*	47	Commercial	15	Grocery Supermarket	0.2	Commercial	3.2	Neighborhood Shopping Center	10,557	3,328	48	713
Specialty Commercial	0.07	-	1	5.06	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Specialty Commercial	31	75	11	16
Automobile Dealership	0.00	-	1	0.19	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Automobile Dealership	1	3	0	1
Arterial Commercial	2.77	-	254	210.99	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Arterial Commercial	1,308	3,116	473	668
Service Station	0.72	-	52	54.56	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Service Station	338	806	122	173
Other Retail Trade and Strip Commerc	8.00	-	330	609.44	Retail*	47	Commercial	15	Grocery Supermarket	0.2	Commercial	3.2	Other Retail Trade and Strip Commercial	28,552	9,001	130	1,928
Office (Low-Rise)	2.20	-	105	167.61	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Office (Low-Rise)	1,039	2,476	375	530
Cemetery	4.16	-	17	316.51	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Cemetery	1,962	4,675	709	1,001
Religious Facility	9.07	-	185	690.77	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Institutional	3.2	Religious Facility	4,283	10,203	1,547	2,186
Hospital - General	0.08	-	2	6.36	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Institutional	3.2	Hospital - General	39	94	14	20
Other Health Care	0.87	-	27	66.23	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Institutional	3.2	Other Health Care	411	978	148	210
Racetrack	1.54	-	1	117.39	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Racetrack	728	1,734	263	371
Golf Course Clubhouse	1.49	-	28	113.41	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Golf Course Clubhouse	703	1,675	254	359
Marina	0.06	-	6	4.64	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Marina	29	69	10	15
Casino	0.01	-	2	0.60	Commercial	6	Commercial	15	Industrial Park (Commercial Industrial)	2.2	Commercial	3.2	Casino	4	9	1	2
Total Commercial	**47.30**		**1186**	**3603.05**									**Total**	**65,298**	**53,217**	**5,929**	**11,400**
Total Area				7617.35													
													Total (gal/yr)	**97,036**	**101,766**	**14,085**	**22,015**

Appendix C
Population and Median Income Statistics

Median Income and Population Density
Based on 2010 Census

San Diego County			
Community	**Zip codes**	**Median Household Income**	**Population Density (persons/mi^2)**
Alpine	91901, 91903	$ 76,663	531
Bonita	91902, 91908	$ 75,670	2,439
Bonsall	92003	$ 79,375	293
Borrego Springs	92004	$ 40,984	79
Bostonia	92021	$ 45,650	7,973
Camp Pendleton North	92055	$ 38,062	574
Camp Pendleton South	92055	$ 50,457	2,652
Campo	91906	$ 58,083	114
Casa de Oro-Mount Helix	92041, 92077	$ 86,109	2,738
Crest	92021	$ 84,246	397
Descanso	91916	$ 59,432	74
Eucalyptus Hills	92040	$ 72,639	1,113
Fairbanks Ranch	92067	$ 132,500	620
Fallbrook	92028, 92088	$ 58,279	1,739
Granite Hills	92021	$ 86,250	1,065
Harbison Canyon	92019	$ 78,313	382
Hidden Meadows	92026	$ 82,708	529
Jacumba	91934	$ 89,263	92
Jamul	91935	$ 112,923	366
Julian	92036	$ 70,625	192
La Presa	91977	$ 61,760	5,671
Lake San Marcos	92069	$ 67,045	2,455
Lakeside	92040	$ 63,852	2,836
Pine Valley	91962	$ 75,641	211
Potrero	91963, 91990	$ 35,536	208
Rainbow	92028	$ 51,154	166
Ramona	92065	$ 64,454	528
Rancho San Diego	91978, 92019, 91941	$ 89,604	2,437
Rancho Santa Fe	92067, 92091	$ 194,402	459
San Diego Country Estates	92065	$ 96,069	600
Spring Valley	91976-91979	$ 65,822	3,825
Valley Center	92082	$ 82,379	338
Winter Gardens	92040	$ 61,084	4,656

Median Income and Population Density
Based on 2010 Census

San Francisco Bay Area			
Community	**Zip Code**	**Median Household Income**	**Population Density (persons/mi^2)**
Berkeley	94701–94710, 94712, 94720	$ 27,775	6,362
Brentwood	94513	$ 74,767	3,477
Brisbane	94005	$ 58,600	213
Dublin	94568	$ 73,650	3,346
Fremont	94536–94539, 94555	$ 58,300	2,511
Livermore	94550, 94551	$ 97,750	3,382
Oakland	94601–94615, 94617–94624, 94649, 94659–94662, 94666	$ 26,400	5,009
Orinda	94563	$ 106,750	1,444
Pleasanton	94566, 94568, 94588	$ 85,200	2,896
Richmond	94801, 94802, 94804, 94805, 94807, 94808, 94850	$ 23,600	1,976
San Jose	95002, 95101, 95103, 95106, 95108–95113, 95115–95136, 95138–95141, 95148, 95150–95161, 95164, 95170, 94172, 95173, 95190–95194, 95196	$ 76,128	5,644
San Leandro	94577-94579	$ 42,500	5,546
San Mateo	94401–94404, 94497	$ 79,950	6,120
San Pablo	94806	$ 33,600	11,063
Sunnyvale	94085–94090	$ 85,760	6,174
Walnut Creek	94595–94598	$ 79,820	3,292

Ballona Creek Watershed			
Community	**Zip Code**	**Median Household Income**	**Population Density (persons/mi^2)**
City of LA	90001–90068, 90070–90084, 90086–90089, 90091, 90093–90097, 90099, 90101–90103, 90174, 90185, 90189, 90291–90293, 91040–91043, 91303–91308, 91342–91349, 91352–91353, 91356–91357, 91364–91367, 91401–91499, 91601–91609	$ 49,497	7,811
West Hollywood	90038, 90046, 90048, 90069	$ 52,855	18,229
Santa Monica	90401–90411	$ 69,013	10,663
Culver City	90038, 90046, 90048, 90069	$ 82,304	756
El Segundo	90245	$ 83,925	3,047
Redondo Beach	90277, 90278	$ 99,496	10,752
Hermosa Beach	90254	$ 101,655	13,669
Rancho Palos Verdes	90275	$ 118,893	3,093
Manhattan Beach	90266, 90267	$ 134,445	8,915
Beverly Hills	90209–90213	$ 136,210	5,974
Palos Verdes Estates	90274	$ 150,319	2,815

Median Income and Population Density
Based on 2010 Census

Los Angeles River Watershed			
Community	**Zip Code**	**Median Household Income**	**Population Density (persons/mi^2)**
Bell	90201–90202, 90270	$ 35,985	13,541
Huntington Park	90255	$ 36,397	19,269
Maywood	90270	$ 37,114	23,256
Bell Gardens	90201, 90202	$ 38,170	17,082
Cudahy	90201	$ 38,267	19,417
El Monte	91731-91735	$ 39,535	11,762
Lynwood	90262	$ 40,740	14,416
South Gate	90280	$ 42,776	12,838
Compton	90220–90224	$ 42,953	9,535
South El Monte	91733	$ 44,104	7,063
Paramount	90723	$ 44,934	11,177
Rosemead	91770-91772	$ 45,760	10,387
Montebello	90640	$ 47,488	7,464
Commerce	90022, 90023, 90040, 90091	$ 48,729	1,961
City of LA	90001–90068, 90070–90084, 90086–90089, 90091, 90093–90097, 90099, 90101–90103, 90174, 90185, 90189, 90291–90293, 91040–91043, 91303–91308, 91342–91349, 91352–91353, 91356–91357, 91364–91367, 91401–91499, 91601–91609	$ 49,497	7,811
Bellflower	90706, 90707	$ 49,637	12,418
Glendale	91201–91210, 91214, 91221, 91222, 91224–91226	$ 53,020	6,269
La Canada Flintridge	91011, 91012	$ 156,952	2,342
Alhambra	91801, 91802, 91803	$ 54,148	10,887
San Fernando	91340, 91341, 91342, 91344-91346	$ 55,192	9,960
San Gabriel	91775, 91776, 91778	$ 56,388	9,580
Downey	90239-90242	$ 60,939	8,893
Vernon	90058	$ 62,000	22
Temple City	91780	$ 66,075	8,876
Burbank	91501–91508, 91510, 91521–91523, 91526	$ 66,240	5,946
Pasadena	91101–91110, 91114–91118, 91121, 91123–91126, 91129, 91182, 91184, 91185, 91188, 91189, 91199	$ 69,302	5,929
Monrovia	91016, 91017	$ 71,768	2,668
Arcadia	91006–91007, 91066, 91077	$ 77,704	5,063
South Pasadena	91030/91031	$ 85,058	7,498
Calabasas	91301, 91302, 91372	$ 124,583	1,734
San Marino	91108, 91118	$ 131,758	3,484

Median Income and Population Density
Based on 2010 Census

Anacostia River Watershed			
Community	Zip Code	Median Household Income	Population Density (persons/mi^2)
Prince Georges County, Maryland			
Adelphi	20783, 20787	$ 63,560	5,587
Chillum	20782	$ 56,123	9,857
College Park	20740–20742	$ 56,957	5,354
East Riverdale	20737, 20738	$ 60,421	9,693
Hyattsville	20781-20788	$ 59,521	6,503
Montgomery County, Maryland			
Kemp Mill	20901	$ 98,973	4,946
Silver Spring	20902, 20903, 20905, 20906, 20910	$ 72,466	9,686
Takoma Park	20912, 20913	$ 71,962	7,998
White Oak	20904	$ 61,644	4,195

Baltimore Area (Patapsco River Medohaline Tidal Chesapeake Bay Segment)			
Community	Zip Code	Median Household Income	Population Density (persons/mi^2)
Jones Falls Watershed			
Reisterstown	21071, 21136	$ 60,201	4994
Owings Mills	21117	$ 70,548	3190
Cockeysville	21030, 21031, 21065	$ 65,697	1807
Lutherville	21030, 21031, 21065	$ 86,774	3097
Timonium	21093-21094	$ 80,000	1838
Gwynn's Falls Watershed			
Randallstown	21133	$ 76,398	3149
Woodlawn	20737, 20784, 21207, 21228, 21229, 21244	$ 64,974	3946
Pikesville	21208, 21282	$ 73,107	2,481

Appendix D
Performance, Functionality, and Maintenance Feedback for Full Capture Proprietary Structures

Table D-1 Device Type Performance by Land Use

Table 1: Device type performance by land use (From Trash Tracker. NR = not recorded)

Device type	Land use	Condition at maintenance	Maintenance time (range)	Equipment used for maintenance	Staff to maintain (range)	Comments
Small Devices						
Connector pipe screens	Commercial/271 devices	Intact – 269 devices Damaged - 2 (removable screen was bent)	15 min-1 hour	Vactor truck, manual tools, utility truck, "Green Machine", Vac-Con	1-3 persons	
	Residential/155 devices	Intact – 155 devices	15- 20 min	Vactor truck, manual tools, utility truck, "Green Machine"	1-3	
	Industrial/29 devices	Intact – 29 devices	NR	NR	1	
	School/15 devices	Intact – 14 Damaged - 1 (removable screen was bent)	15- 20 min	Vactor truck	1-3	
	Park/14 devices	Intact - 14	15 min	Vactor truck	1-3	
	Surrounding land use not indicated for 395 devices where other info was recorded	Intact– 392 devices Missing bolt -1 device Front grill support damaged – 1 device Grate malfunction -1 device	15 min	Vactor truck, manual tools	1-5	City is looking at other options that are easier and quicker to remove for cleaning, when necessary.
Drop inlet filter inserts	Commercial – 10 devices	Intact – 10 devices	6 min	Vactor truck, manual tools	2	
	School - 8	Intact - 8	6 min	Vactor truck, manual tools	2	
Curb inlet screens – manual retractable	Commercial – 17 devices	Intact - 17 devices	NR	manual tools	2	
Curb inlet screens –	Commercial - 14 devices	Intact - 14 devices	15 min	manual tools, utility truck	2-3	

TABLE D-1 (CONTINUED) DEVICE TYPE PERFORMANCE BY LAND USE

Device type	Land use	Condition at maintenance	Maintenance time (range)	Equipment used for maintenance	Staff to maintain (range)	Comments
automatic retractable	Park - 7 devices	Intact - 7 devices	NR	manual tools, utility truck	2	
	Land use NR – 68 devices	Intact – 68 devices	15 min	Vactor truck, manual tools	1-4	
Large Devices						
Hydrodynamic separators	Commercial - 9 devices	Intact – 7 devices NR -2 devices	45min-4 hours	Vactor truck	2-5	
	Residential – 3 devices	Intact – 3 devices	1 hour	Vactor truck	2-3	
	Industrial - 4	Intact – 4 devices	NR	Vactor truck	2	
	School – 1 device	Intact – 1 device	6 min	Vactor truck	2	
	Park – 1 device	Intact – 1 device	5 hours	Vactor truck	6	
Gross solids retention devices	Commercial – 1 device	Intact – 1 device	30 min	Vactor truck, manual tools	2	
	Residential – 1 device	Intact – 1 device	30 min	Vactor truck, manual tools	2	
	School – 1 device	Intact – 1 device	30 min	Vactor truck, manual tools	2	
End-of-pipe netting	Not indicated - 16 devices	Intact – 9 devices "Two of the four nets were torn" – 4 devices, "Nets are ripping" – 1 device Fixed hole – 1 device 2" hole repaired – 1 device Nets ripped – 1 device	30 min- 1 hour	NR	3-5	

TABLE D-2 DEVICE MODEL FUNCTIONALITY AND MAINTENANCE BURDEN

Table 4: Device model functionality and maintenance burden – individual responses (From device performance tables)

Device type	Vendor/ Model name	In general, how full were devices of this type at maintenance?	How many staff were needed to perform maintenance?	How long did it take to maintain one device?	What equipment did you use for maintenance?	Are maintenance requirements for this device reasonable, considering your staff and budget?	In general, what was the condition of devices at maintenance?	Would you purchase this device again?
Small devices								
Connector pipe screen	Advanced Solutions AS-2	Because these devices were only installed in March, maintenance will be done as part of annual Department drainage inlet maintenance conducted Sept-Oct before the rainy season.	3-4 people are anticipated.	TBD	Use of a Vac Truck, shovels is anticipated.	No. Unfunded cost for equipment and maintenance in the future is a real concern for the County.	Good	Yes
Connector pipe screen	United Stormwater - connector pipe screen	1/4 to ½ full	2	20 minutes	Vac truck	Yes, for the current number of devices	Good	yes
Connector pipe screen	United Stormwater - connector pipe screen	5%	3	15-30 minutes	Shovels & Buckets	Yes	Good	Yes
Connector pipe screen	United Stormwater - connector pipe screen	County has not yet maintained its connector pipe screens, which will commence in Sept. 2013.	Not yet determined.	Not yet determined.	Not yet determined.	Not yet determined.	Not yet determined.	Not yet determined.

TABLE D-2 (CONTINUED) DEVICE MODEL FUNCTIONALITY AND MAINTENANCE BURDEN

Device type	Vendor/ Model name	In general, how full were devices of this type at maintenance?	How many staff were needed to perform maintenance?	How long did it take to maintain one device?	What equipment did you use for maintenance?	Are maintenance requirements for this device reasonable, considering your staff and budget?	In general, what was the condition of devices at maintenance?	Would you purchase this device again?
Connector pipe screen	United Stormwater - Connector Pipe Screen	All devices were new in Oct. 2012. Checked during 1st rainstorm; not full, but were cleaned as needed to ensure effective operation	2	30-45 minutes each depending on amount of debris	Cleaned with manual equipment	No, it's difficult to remove devices for cleaning. Less maint. Required for the inlets w/curb screens (49 out of 52). City will start cleaning w/ vacuum truck in FY 13-14.	Good; no vandalism and no damage, but devices are relatively new.	Not exactly - City is looking at other options that are easier and quicker to remove for cleaning, when necessary.
Connector pipe screen	United Stormwater - connector pipe screen	75%	2	15-25 minutes	shovel, rake, trowel	Maintenance is under staffed and underfunded; maintaining the trash capture units stretches an already over committed staff even further	Good	Yes
Connector pipe screen	United Stormwater - connector pipe screen	half full	2	20 minutes	vactor jetter truck	yes	good	yes

TABLE D-2 (CONTINUED) DEVICE MODEL FUNCTIONALITY AND MAINTENANCE BURDEN

Device type	Vendor/ Model name	In general, how full were devices of this type at maintenance?	How many staff were needed to perform maintenance ?	How long did it take to maintain one device?	What equipment did you use for maintenance ?	Are maintenance requirements for this device reasonable, considering your staff and budget?	In general, what was the condition of devices at maintenance?	Would you purchase this device again?
Connector pipe screen	United Stormwater - connector pipe screen	20%	2	10-15 minutes	Shovel, Rake, &/or Vac truck	Yes, but only because we have only a small number. If we had a larger number of devices, the maintenance and time required would become a problem.	GOOD	YES
Connector pipe screen	United Stormwater - connector pipe screen	Varies with location. For MidCoast, units were generally 1/3 full, mostly leaf litter and debris.	4	15 minutes	Vac-Con	Yes	Good	Yes
Connector pipe screen	United Stormwater - connector pipe screen	1/4	2	35 minutes	Vactron, 2 pickups, and an arrow board	No but we will make it work.	Good	Yes
Connector pipe screen	West Coast Storm - connector pipe screen	half full	2	20 minutes	vactor jetter truck	yes	good	yes

TABLE D-2 (CONTINUED) DEVICE MODEL FUNCTIONALITY AND MAINTENANCE BURDEN

Device type	Vendor/ Model name	In general, how full were devices of this type at maintenance?	How many staff were needed to perform maintenance ?	How long did it take to maintain one device?	What equipment did you use for maintenance ?	Are maintenance requirements for this device reasonable, considering your staff and budget?	In general, what was the condition of devices at maintenance?	Would you purchase this device again?
Connector pipe screen	West Coast Storm - connector pipe screen	Varies with location. For Broadmoor & Daly City, units were general 1/4 full. For North Fair Oaks, units were generally less than 1/4 full.	2 to 3 staff	15 minutes	Vac-Con	Yes	Good	Yes
Connector pipe screen	West Coast Storm - connector pipe screen	1/4 to 1/2	2	20 minutes	Vac truck	Yes, for the current number of devices	Good	yes
Curb inlet screen -- auto retractable	G2 Construction - CamLock Debris Gate	County has not yet maintained its automatic retractable screens, which will commence in Sept., 2013.	Not yet determined.	Not yet determine d.	Not yet determined.	Not yet determined.	Not yet determined.	Not yet determined .
Curb inlet screen -- auto retractable	West Coast Storm - auto retractable screen	N/A	Sweeper truck (1 staff person); Hand sweeping as needed during rainy season in Broadmoor - 2 staff	10 minutes for hand sweeping	Sweeper truck and broom	Yes	Good. Curb inlet screens were effective in reducing maintenance of CPS units.	Yes

TABLE D-2 (CONTINUED) DEVICE MODEL FUNCTIONALITY AND MAINTENANCE BURDEN

Device type	Vendor/ Model name	In general, how full were devices of this type at maintenance?	How many staff were needed to perform maintenance ?	How long did it take to maintain one device?	What equipment did you use for maintenance ?	Are maintenance requirements for this device reasonable, considering your staff and budget?	In general, what was the condition of devices at maintenance?	Would you purchase this device again?
Curb inlet screen -- auto retractable	West Coast Storm - auto retractable screen	N/A, inlet screen	N/A	N/A	N/A	Yes	good	yes
Curb inlet screen -- manual retractable	United Stormwater - manual retractable curb inlet screen	Screens keep trash in street for the sweeper. Not full or clogged at first cleaning	In general 1 street sweeper driver	less than 3 minutes	high efficiency PM10 vacuum sweeper (picks up particles of 10 micrometer or less)	Yes	Good: all devices installed in Oct. 2012; 1st maintained in Nov-Dec	Yes, but as products improve, will use newer improved models
Curb inlet screen -- manual retractable	United Stormwater - manual retractable curb inlet screen	N/A (device deflects trash, does not house it)	2	5-10 minutes	Rake & Shovel	Yes, but only because we have only a small number. If we had a larger number of devices, the maintenance and time required would become a problem.	GOOD	YES
Curb inlet screen -- manual retractable	United Stormwater - manual retractable curb inlet screen	N/A, inlet screen	N/A	N/A	N/A	Yes	Good	yes

TABLE D-2 (CONTINUED) DEVICE MODEL FUNCTIONALITY AND MAINTENANCE BURDEN

Device type	Vendor/ Model name	In general, how full were devices of this type at maintenance?	How many staff were needed to perform maintenance ?	How long did it take to maintain one device?	What equipment did you use for maintenance ?	Are maintenance requirements for this device reasonable, considering your staff and budget?	In general, what was the condition of devices at maintenance?	Would you purchase this device again?
Curb inlet screen -- manual retractable	United Stormwater - manual retractable curb inlet screen	In conjunction with device installation, the County began a bi-monthly sweeping program for this area. During initial run of sweepers, curb screens were semi-full of leaves and garbage. In follow up sweepings, curb screens were much cleaner.	None. Street sweeping done by contract.		Street sweepers	No.	Good	Yes
Filter insert	Kristar - FloGard Plus Catch Basin Insert	5%	2	6 minutes	Vector Truck	Yes	Good	Yes
Filter insert	Kristar - FloGard Frame Mount Perimeter Insert	5%	2	6 minutes	Vector Truck	Yes	Good	Yes
Filter insert	Kristar - FloGard T-Series Catch Basin Insert	5%	2	6 minutes	Vector Truck	Yes	Good	Yes
Filter insert	REM - Triton Bioflex Drop Inlet Trash Guard	moderately	2	10 minutes	hydro	Yes	Good	yes

TABLE D-2 (CONTINUED) DEVICE MODEL FUNCTIONALITY AND MAINTENANCE BURDEN

Device type	Vendor/ Model name	In general, how full were devices of this type at maintenance?	How many staff were needed to perform maintenance ?	How long did it take to maintain one device?	What equipment did you use for maintenance ?	Are maintenance requirements for this device reasonable, considering your staff and budget?	In general, what was the condition of devices at maintenance?	Would you purchase this device again?
Filter insert	REM - Triton Bioflex Drop Inlet Trash Guard	Contra Costa County has not yet maintained its REM filter inserts, which will commence in Sept., 2013.	Not yet determined.	Not yet determine d.	Not yet determined.	Not yet determined.	Not yet determined.	Not yet determined .
Filter insert	REM - Triton Bioflex Drop Inlet Trash Guard	Majority of the items collected were organic materials	City contracts with outside vendor for maintenance	N/A	N/A	YES	Good	Yes
Filter insert	REM - Triton Bioflex Drop Inlet Trash Guard	75%	2	15-25 minutes	shovel, rake, trowel	El Cerrito Public Works Maintenance is under staffed and under-funded; maintaining the trash capture units stretches an already over committed staff even further	Good	Yes
Filter insert	REM Triton Bioflex Drop Inlet Trash Guard	Assumed half full	Assuming 2 (contracted)	Don't know (contracte d)	Don't know (contracted)	No	Good	Maybe

TABLE D-2 (CONTINUED) DEVICE MODEL FUNCTIONALITY AND MAINTENANCE BURDEN

Device type	Vendor/ Model name	In general, how full were devices of this type at maintenance?	How many staff were needed to perform maintenance?	How long did it take to maintain one device?	What equipment did you use for maintenance?	Are maintenance requirements for this device reasonable, considering your staff and budget?	In general, what was the condition of devices at maintenance?	Would you purchase this device again?
Filter insert	REM Triton Bioflex Drop Inlet Trash Guard	On average it appears they were all approximately 50%	2	20 - 25 minutes per unit	800 gallons industrial vacuum, broom & shovel	Yes	Good	Yes
Filter insert	REM Triton Bioflex Drop Inlet Trash Guard	The amount of trash removed ranges from 2 gallons during dry summer months, to 5 gallons during the rainy season.	1 to 2	15 minutes	Shovel and hand-pick	Yes	The condition of the devices have been very good at maintenance.	Yes
Large high-flow capacity devices								
End of pipe netting	Fresh Creek Technologies End of Pipe Netting Trash Trap[10]	Nets that were full needed to be replaced at maintenance. Recommend emptying them before they are full	3-5	1.5 hours	Crane truck		Many or most were torn, needed repair or replacement. Replacement delivery took over one month. Nets were replaced with heavier gauge material.	

TABLE D-2 (CONTINUED) DEVICE MODEL FUNCTIONALITY AND MAINTENANCE BURDEN

Device type	Vendor/ Model name	In general, how full were devices of this type at maintenance?	How many staff were needed to perform maintenance?	How long did it take to maintain one device?	What equipment did you use for maintenance?	Are maintenance requirements for this device reasonable, considering your staff and budget?	In general, what was the condition of devices at maintenance?	Would you purchase this device again?
End of pipe netting	Kristar - Nettech Gross Pollutant Trap	1/4 to 1/2	Hired an outside contractor. I think they had 3 guys on the job.	60 minutes	Backhoe to remove net.	Yes	We have had a couple cases of minor vandalism. Overall they have held up well.	Yes, and are planning on purchasing another one this year.
End of pipe netting	Kristar - Nettech Gross Pollutant Trap	One of the seven devices was completely full, two others were half full, during the first rain event after installation. After this the nets were less than a quarter full after each rain events.	3	45 to 60 minutes	Service truck, backhoe and a vacuum truck.	Yes	The materials are still in good condition after one season.	Yes
Gross solids retention device	Roscoe Moss Company - Storm Flo Screen	Maintenance not yet conducted as of 8/08/13. Trace material in screens.	estimated 3	unknown at this time	Vactor truck will be used.	no	excellent condition to date	unknown
Gross solids retention device	Roscoe Moss Company - Storm Flo Screen	full	2	90 minutes	Shovel and vactor truck	YES	GOOD	YES
Gross solids retention device	Roscoe Moss Company - Storm Flo Screen	full	2	90 minutes	Shovel and vactor truck	YES	GOOD	YES

TABLE D-2 (CONTINUED) DEVICE MODEL FUNCTIONALITY AND MAINTENANCE BURDEN

Device type	Vendor/ Model name	In general, how full were devices of this type at maintenance?	How many staff were needed to perform maintenance ?	How long did it take to maintain one device?	What equipment did you use for maintenance ?	Are maintenance requirements for this device reasonable, considering your staff and budget?	In general, what was the condition of devices at maintenance?	Would you purchase this device again?
Gross solids retention device	Roscoe Moss Storm Flo Screen SS4	70-80%	4	150 minutes	Vactor truck	no, the cost of maintenance is too high	good	no
Hydrodynamic separator	Contech - Continuous Deflective Separator	Has not been accepted by the City and developer will be required to clean prior to acceptance	City plans to contract with outside vendor for maintenance	N/A	N/A	YES	Good	Yes
Hydrodynamic separator	Contech - Continuous Deflective Separator	4.4 cu. yds.	5	5 hours	Vactor truck	Y	Good	Y
Hydrodynamic separator	Kristar - FloGard Dual-Vortex Hydrodynamic Separator	10.00%	2	45 minutes	Vactor Truck	Y	Good	Yes

Michael Baker INTERNATIONAL

Appendix E
On-land Visual Assessment Data Collection Form
(EOA, Inc., April 30, 2013)

On-land Visual Assessment Data Collection Form – Version 1.0

Agency: ______________________________ **Date:** ____________

Team Members: ______________________ **Contact E-mail:** ______________

Note: Fill out a separate Data Collection Form for each assessment area

I. Assessment Area

MAP ID	**Assessment Area:** Delineate the assessment area on the associated map, create a map ID, and mark the ID on the map and place in the box provided to the left. Below, describe the location and boundaries of the assessment area. Include the street segment name, length of the street based on cross streets, and land area description (if applicable).

II. Condition Category Assignment

Trash Condition Category

Conduct the assessment in accordance with the Visual On-land Assessment Protocol for Stormwater (Refer to Definitions on Back). Check one of the below categories based on the assessment.

❑ Low (A) ❑ Medium (B) ❑ High (C) ❑ Very High (D)

❑Low/Medium (A/B) ❑ Medium/High (B/C) ❑ High/Very High (C/D)

Photograph Documentation

Check the box below to indicate that photographs were taken and are maintained by your agency.

Photographs: ❑ Number of photographs taken: _______

Trash Condition Category	Definition
A	Effectively no trash is observed in the assessment area. There may be some small pieces in the area, but they are not obvious at first glance and one individual could easily clean up all trash observed in a very short timeframe.
B	Predominantly free of trash except for a few pieces that are easily observed in the assessment area. The trash could be collected by one or two individuals in a short period of time.
C	Trash is widely/evenly distributed and/or small accumulations are visible on the street, sidewalks, or inlets. It would take a more organized effort to remove all trash from the area.
D	Trash is continuously seen throughout the assessment area, with large piles and a strong impression of lack of concern for litter in the area. There is often significant litter along gutters. It would take a large number of people during an organized effort to remove all trash from the area.

III. Preliminary Source Identification (Optional)

Stormwater trash sources identified within the assessment area during assessments (CHECK ALL SOURCES THAT APPLY).

Vehicles

- ❑ Moving Vehicles
- ❑ Parked Cars
- ❑ Uncovered Loads
- ❑ Other ____________________

Inadequate Waste Container Management

- ❑ Overflowing or uncovered receptacles/dumpsters
- ❑ Dispersal of household trash and recyclables before, during and after collection
- ❑ Other ____________________

Pedestrian Litter

- ❑ Restaurants
- ❑ Convenience Stores
- ❑ Liquor Stores
- ❑ Bus Stops
- ❑ Special Events
- ❑ Other ____________________

Illegal Dumping

- ❑ Illegal dumping on-land
- ❑ Homeless encampments
- ❑ Other ____________________

IV. Comments and Additional Information about the Assessment Area and Sources

Appendix F
Field Protocols and Quality Assurance for Measurement of Trash Weight and Volume

Michael Baker
INTERNATIONAL

FIELD PROTOCOLS AND QUALITY ASSURANCE FOR MEASUREMENT OF TRASH WEIGHT AND VOLUME

COUNTY OF SAN DIEGO

Weston Solutions, Inc., in conjunction with Brown and Caldwell, developed a "*Final Monitoring Workplan for the Assessment of Trash in San Diego County Watersheds"* in August of 2007. This assessment program was designed to provide information on the spatial extent and relative amount of trash present, as well as the nature of the trash present.

Prior to a site visit, it is important to identify personnel who are familiar with the site and have some local knowledge of the general area. There should also be a general consensus among the monitoring team as to the extent of the area to be assessed. When possible, distinctive site characteristics, such as a large boulder or tree, should be used as starting/finishing length landmarks. The upper boundary of each bank should be used for the width of the monitoring site. This can be determined visibly by either a debris or water line. When determining site boundaries, it is important to remember that the intent of the trash assessment is to determine the trash which has been mobilized or has the potential to be mobilized by water at the defined locations.

Upon arrival at a designated site, a qualitative estimate of the presence of trash should be determined and documented in the top portion of the Trash Assessment Form (Attachment 1). This is a qualitative assessment which should reflect a first impression of the site. There are five categories to describe the amount and extent of trash at each site (Weston Solutions. Inc. and Brown and Caldwell, 2007):

- **Optimal**: On first glance, no trash is visible. Little or no trash (<10 pieces) is evident when the evaluated area is closely examined for litter and debris.
- **Suboptimal**: On first glance, little or no trash is visible. After close inspection, small levels of trash (~10-50 pieces) are evident in the evaluated area.
- **Marginal**: Trash is evident in low to medium levels (~51-100 pieces) on first glance. Evaluated area contains litter and debris. Evidence of site being used by people: scattered cans, bottles, food wrappers, blankets, or clothing are present.
- **Sub marginal**: Trash distracts the eye on first glance. Evaluated area contains substantial levels of litter and debris (>100-400 pieces). Evidence of site being used frequently by people: many cans, bottles, food wrappers, blankets, or clothing are present.
- **Poor**: Site is significantly impacted by trash. Evidence of trash accumulation behind a constriction point or evidence of excessive dumping. Evaluated area contains substantial levels of litter and debris (>400 pieces)."

BAY AREA

EOA, Inc. developed a *San Francisco Bay Area Stormwater Trash Generation Rates – Final Technical Report* for the Bay Area Stormwater Management Agencies Association (BASMAA) in June of 2014 (EOA, Inc., June 20, 2014). Excerpts from this report pertaining to (1) quality assurance, (2) sampling procedures, (3) trash measurement guidelines are provided below:

(1) Quality assurance procedures were implemented throughout the project to ensure that data of known quality were obtained. All field personnel used standardized field forms and monitoring procedures when removing trash and debris from monitoring sites. The procedures included a specified labeling protocol of bags of trash and debris and mandatory cleaning instructions. A training event was also conducted for field crews to ensure proper understanding of field monitoring and quality control procedures. As appropriate, the following errors were identified during the study and associated data were qualified appropriately:

- **Installation Errors** – devices that were installed incorrectly or in the wrong location;
- **Maintenance Errors** – trash and debris were removed from the incorrect site and as a result, a storm drain inlet without a device was cleaned;
- **Book-keeping Errors** – the location of the device that was monitored, or the cleanout date could not be confirmed;
- **Land Use Errors** – following delineation of the site drainage area and land use analysis, the site could not be defined as depicting a single land use category; and,
- **Jurisdictional Errors** – sites included streets swept by the California Department of Transportation and not a municipality.

Quality assurance procedures performed during trash characterization included oversight by two project managers, and reweighing/measurements of material to ensure consistency, accuracy and completeness. Trash and debris from 10% of samples were reweighed and measured. Relative percent differences (RPD) calculations were used to assess the accuracy of measurements.

(2) During each sampling event, all trash and debris were removed and placed in large plastic garbage bags and transported to the central site located at the City of San Jose's Mabury Corporation Yard. Participating municipalities were responsible for cleaning of inlets and transporting all material to the centralized location where the material was characterized. Standard operating procedures for removing material from each device, containing the material removed, and recording site/field information and chain-of-custody were developed by BASMAA as part of the study and utilized by municipal staff and contractors (EOA, Inc., April 21, 2011). Exact cleanout dates and any issues associated with the devices (i.e. damaged screens, observations of flows bypassing devices) were recorded by municipal staff or third party contractors responsible for cleaning of the devices. To ensure monitoring occurred during similar timeframes, the project manager scheduled cleanout events for all sites during the same week.

(3) Trash and debris removed from each storm drain inlet during the sampling event was sorted based on the project's trash classification systems and placed into containers between 32 ounces and 5 gallons in

size. For each type of category of trash and debris, material was weighed and volumes were recorded consistent with SOP's standardized field data sheets as part of the study (EOA, Inc., April 21, 2011). All items identified as recyclable beverage containers, single-use plastic grocery bags, or polystyrene foam food ware were also counted and recorded. Measurements procedures generally included the following steps:

- **Volume**: using the appropriate size containers, measure and record the total non-compacted volume of each of the seven trash categories and debris for each site. When a bucket of trash or debris is partially full, use a tap measure, ruler, or yardstick to estimate its total volume. The lowest reporting limit for total volume determination for trash or debris is 0.031 gallons for samples less than 4 ounces but greater than zero. Sites that do not contain one or more trash categories or debris are recorded as zero.

- **Weight**: weigh each full and partially full container and record total weight (bucket and trash/debris) for each. Weigh each empty bucket used to contain trash or debris for a specific site and subtract the bucket weight from the total weight. Weight should be reporting in increments of 0.01 pounds.

- **Item Count**: count the number of recyclable beverage containers, single-use plastic grocery bags, and polystyrene foam food ware items. Record all item counts.

- **Disposal**: after all measurements and records have been made for trash and debris, place all trash in disposal containers and/or bags unless instructed so save trash for future characterization. Recycle all recyclables and place all compostable debris in compost containers.

All data recorded on field data sheets were transferred into a project database. To ensure that all data were transferred correctly, quality assurance and control checks were performed during and following data entry.

Both weights and volumes of trash were measured during the study. Because samples contained varying level of moisture and were comprised of varying levels of low and high density items, the correlation between weight and volume is relatively moderate, but still significant. Based on the liner regression of the data, the average density of trash observed in storm drain inlets was 0.67 pounds to each gallon of material.

QUALITY ASSURANCE PLAN DISTRICT DEPARTMENT OF THE ENVIRONMENT

LimnoTech developed a "*Quality Assurance Project Plan Consolidated TMDL Implementation Plan and Monitoring Program"* for the District Department of the Environment in July of 2014 (LimnoTech, July 25, 2014). The purpose of this document is to prescribe the required procedures necessary for development and execution of the Consolidated TMDL Implementation Plan consistent with applicable guidance documents and generally accepted and approved quality assurance objectives.

This QAPP was designed to ensure the quality of predicting pollutant loads and load reduction in the Municipal Separate Storm Sewer System (MS4) area. For this program, per U.S. Environmental Protection Agency (EPA) guidance, the following QA procedures were adopted:

- Maintaining written records of data needs for modeling
- Keeping written rationale for model selection, model development, and linkages of models
- Keeping records of model assumptions
- Providing written documentation of code development and modifications
- Keeping records of all data used for model development and validation, including information on data quality and performance evaluation and acceptance criteria
- Documenting all model updates and revisions
- Maintaining a log book of model runs and listing all the model run conditions
- Providing a description of the limitations of the modeling framework"

Model input data was verified for quality from its sources. To determine whether the data sources met the acceptance criteria for the project, separate checks on each data source were conducted. Data was checked to determine whether to accept, reject, or qualify each individual data set based on requirements for the project. Validation and verification criteria were applied to determine if the available data met the project needs and if the data was sufficient to draw conclusions. Data was also tested for its usability to meet required spatial and temporal scales. Therefore, limitations in non-direct measurements identified through application of the acceptance criteria were resolved either by (1) using the data but identifying the implications of its limitations on the study results or, (2) for non-critical non-direct measurements that do not pass acceptance criteria, applying the models without the use of those non-direct measurements.

Any limitation on the use of data and subsequent interpretation of study results was reported in the final model report. Data quality objectives for representativeness, bias, completeness, and comparability to expected input data was evaluated for use of data in the model.

As previously described, data used for model inputs and corroboration was obtained from different sources. The QAPP includes checks on data from different sources to ensure achievement of the data compatibility requirements.

Data used during the project was maintained in either hard copy or electronic format, depending on its nature. Manipulation (e.g., transcription/copying, formatting) of the downloaded data was identified as one of the major preventable error sources in the project effort. Original copies of all data were kept in the project file and the original source of the data was documented in the database; thereby, allowing all data to be traced to its original source. Formatting of data to ensure usability and comparability (e.g., normalization of units, referencing or georeferencing of data points, etc.) was accomplished by the Modeling Team, who then documented their formatting to ensure all data manipulations could be tracked to ensure quality.

User-induced error can be identified and corrected under an appropriate level of QA/QC. Multiple steps were taken to ensure errors were minimized. Data formatting was reviewed, including the data element type, format, allowable values and ranges, and other parameters. Any manually entered parameter values from paper sources were evaluated by reviewing hard copy printouts. The review included a comparison of the original data sources and paper documentation. Any record identified as having issues was reviewed to determine whether corrected data can be acquired or the record omitted.

Data from various sources was combined in a database designed in MS Access. The Modeling Team coordinated data efforts including identifying data sources, collecting and compiling the data in one location, and maintaining the required data formats. The final model report and the final IP documents how data from various sources were utilized in the project. Project documentation included the sources of data, the procedure adopted to obtain the data in required format, the record-keeping procedure, and the process of compiling and combining the data to meet spatial and temporal scales of the model. Any pre- and/or post-processing required to meet the needs of the IP Modeling Tool were described in the final modeling report. The data will be checked for any inconsistencies in the records. Data in the forms of charts, plots and tables were included in the model memoranda or reports wherever appropriate.

The performance of data was evaluated by performing simple tests; e.g., a simple graphical representation in MS Excel program to show any inconsistency in the data. The QA procedure for data sets included (LimnoTech, July 25, 2014):

- Review data from different sources
- Summarize data handling procedure
- Maintain database with information of sources
- Check for data inconsistencies
- Check data for representativeness
- Perform and check data analysis
- Document the procedure for data analysis
- List the details on use of data
- Report any manipulations/transformations performed on data
- Document the appropriateness and completeness of data for required application
- Maintain information on QA/QC performed on data
- Archive original data and analyzed data

GENERAL TRASH MONITORING GUIDANCE

The Maryland Department of the Environment submitted a "*TMDL for Trash and Debris*" report to the U.S. Environmental Protection Agency (Region 3) in December of 2014. The study occurred between January and September 2011 and consisted of trash sampling at five stormwater outfalls. Sampling sites were selected based on a number of different contributing factors including accessibility, land use, and socioeconomics in order to capture a robust sample of the Baltimore City trash load. The most important factor was accessibility, in some cases, outfalls were not accessible due to a consistent submerged tailwater condition. The size and discharge amount of the outfall are also factors because of the sample device's ability to withstand excessive force of the water.

To determine the amount of trash accumulated during the year-long study, trash was removed at each site prior to the initial seasonal sampling. Baseline data was collected in October 2010 at each site. The project timeline was as follows:

- Baseline sampling in October 2010-November 2010
- Winter Sampling in December 2010-February 2011
- Spring Sampling in April 2011-May 2011
- Summer Sampling in July 2011-August 2011
- Fall Sampling in October 2011-November 2011

Collected trash was brought back to the laboratory and spread out on tarps to dewater. Items were emptied of contents (liquids, sediment, etc.) that would affect the normal weight of the object collected. Trash was sorted into five categories, (1) plastic bottles; (2) glass bottles, (3) aluminum cans; (4) other; and (5) dumping (items such as car parts, construction debris, shopping carts, and tires). Once sorted, the categories were weighed individually.

Results from the monitoring data were used to establish baseline point source and non-point source loads. The baseline load is defined as the annual trash load calculated from monitoring data collected through storm drain sampling. Smaller, common types of trash that convey through the storm drain system were considered part of the baseline point source load, while objects considered too large to convey through the storm drain system were considered part of the baseline non-point source load. In all cases, vegetation was not included as part of the baseline determination.

While storm drain outfall sampling is one of the more accurate trash monitoring programs, it is not the only effective application. Sampling requires installation of full trash capture devices, be it new construction or retrofitting existing pipes and/or inlets. Visual assessment is also key monitoring strategy that should be considered when developing a monitoring plan. At the very least, visual assessment will help identify areas where full trash capture devices are most effective. Below are some general guidelines to consider when developing a trash monitoring plan (Maryland Department of the Environment, 2014):

- Protocol Establishment
    - Develop a written monitoring protocol;
    - Include detailed descriptions of all monitoring activities that will occur, including: site selection, frequency of sampling, sampling methodology, data collection, and data management;
    - EPA Quality Assurance Project Plan (QAPP) procedures can be used for reference.
- Site Selection
    - Safety, private vs. public property, and accessibility should be considered when choosing monitoring sites;

  - The monitoring program should capture data from each land use within the monitoring area, as this is the basis for developing the trash generation rate;
  - Diversity in loading rates for each land use type should also be considered. For example, identification and sampling of outfalls corresponding to trash hot spots (i.e. a catchment area with excessively high trash loading) is recommended;
  - A variety of storm drain outfall sizes should also be sampled, including both major (>36") and minor outfalls.

- Sampling Frequency

  - Should effectively capture seasonality of trash loading rates;
  - Should be useful in determining both effectiveness of BMPs, as well as trash loading from baseline or control catchment areas;
  - Should include sampling in conjunction with large storm events (greater than one-year-storm, approx. 2.5" in 24 hours);
  - Monthly sampling is recommended.

- Sampling Methodology

  - Trash sampling devices should be sized appropriately to capture trash without becoming blocked too quickly;
  - In order to obtain an accurate weight of trash, sample should be drained of excess water and allowed to dry a nominal amount. All vegetation should be removed from the sample;
  - Weight data should be logged on data sheets and records should be kept for each monitoring site;
  - In addition to weight, characterization of trash types should be completed (i.e. sorting, counts, etc.) in order to target trash reduction strategies;
  - Photo-documentation of sample can also be used for additional evaluation of sample characterization.

- Data Submission

  - Data collected from monitoring can be submitted with annual MS4 report.

In addition to trash monitoring data (weights, counts, etc.), information regarding trash reduction efforts, and/or BMPs should be included in the database.

CALTRANS DISTRICT 7 LITTER MANAGEMENT PILOT STUDY

The California Department of Transportation conducted a "*Litter Management Pilot Study"* in June of 2000 to improve the quality of runoff from highway drainage facilities through field testing and evaluation of litter management practices. The objective of the study was to evaluate the effectiveness of structural and non-structural Best Management Practices (BMPs) that could result in a reduction of litter in the highway storm drain system. The structural BMP focus was on storm drain inlet inserts, while the non-structural BMP focus included increasing the frequency of street sweeping and manual liter pick-up programs from monthly to weekly.

Litter monitoring was conducted by attaching ¼-inch mesh collection bags to the 24 study outfalls and quantified by weight (24-hour air-dried), volume, and count. Refer to Figure F-1 below for an image depicting the end of pipe bags (California Department of Transportation, June 26, 2000). Eight of the 24 outfalls were also monitored for flow, rainfall, and chemical water quality parameters. When a litter collection bag was removed from an outfall for analysis, it was immediately replaced. All litter that came through the outfall during the study period was collected, characterized, and quantified. A litter lab was setup and protocols were developed to quantitatively measure and characterize the litter collected during the LMPS.

All litter samples collected from the outfall locations were returned to the litter lab for analysis. The litter bags contained all of the material retained by the ¼-inch mesh openings. This material is termed gross pollutants and consists of both vegetation and litter. The weight and volume of the litter bag contents were measured at the start of the characterization process. The contents of the litter bags were then emptied into a sorting tub, and the vegetation was sorted from the litter material. The weight and volume of vegetative material was recorded on the data sheet and then disposed. The protocol included identification of potentially toxic materials during the initial sorting phase so they could be handled appropriately. It should be noted that no such materials were found in debris analyzed during the LMPS.

The litter was placed on a drying screen and was allowed to dry for a minimum of 24 hours. The time that air-drying begins was recorded on the data sheet. The amount of time (in days) that had passed between the previous storm for which litter collection took place and the storm for which the litter analysis being conducted was recorded on the data sheet. The litter on the drying screen was photographed and identified by site/outfall number, storm number, and event number.

Once the litter material had air dried, it was sorted into 12 different categories to investigate the source of the material. These categories included:

- cardboard/chipboard
- cigarette butts
- cloth
- glass
- metal
- paper
- plastic film
- plastic moldables
- Styrofoam
- wood debris
- accident related
- other

Photo 2–5
Typical Litter Monitoring Bag at Outfall

Photo 2–6
Litter Monitoring Station with Fence Enclosure

FIGURE F-1 TRASH MANAGEMENT BMP SITE PHOTOS (CALTRANS JUNE 2000)

Quality assurance and quality control (QA/QC) of the litter data was performed at both the reporting and data entry stages. Before litter characterization data were entered into the database, data sheets were reviewed for completeness and consistency by the litter lab supervisor. QA/QC of data entry was performed by a double-data-entry process. All litter lab data was entered twice by separate data processors into separate data tables. A query was then performed to compare both data sets and identify records that did not match. These records were corrected to prepare a final data set.

The study also included QA/QC protocols for litter monitoring, which included a sample recovery protocol. The sample recovery protocol was established to track the transport of litter from inlet to outfall at the study sites. The method involves spiking the inlets prior to every trigger storm event with a known set of materials that are similar to litter collected during pilot monitoring. The spike items are marked with unique identifiers for each event so that recovery can be tracked during litter characterization.

GROSS SOLIDS REMOVAL DEVICE PILOT STUDY

The California Department of Transportation (Caltrans) developed a 2-year pilot study beginning in 2000 to evaluate the performance of non-proprietary devices aimed at capturing gross solids and the corresponding potential for implementation into existing and future highway drainage systems.

The following tasks outline the monitoring of gross solids conducted as part of this pilot study (California Department of Transportation, October 2003):

- Took photos of the device;
- Assessed device for clogging;
- Estimated the amount of gross solids accumulation within the device to assess if an interim cleaning would be required;
- Observed the accumulation and distribution of gross solids within the device;
- Checked the bypass bag and overflow basket for material accumulation; and
- Verified that the device was draining properly.

Each of the non-proprietary devices studied as part of the pilot study was designed to be cleaned once per storm season. However, when a device was determined, by visual inspection, to have reached approximately 85 percent capacity, or if extensive clogging or overflow was observed at a device, an additional cleaning was performed during the season. Each time a device was cleaned, the following four measurements were taken:

1. Wet weight of the gross solids removed from the device;
2. Wet volume of the gross solids removed from the device;
3. Wet weight of the gross solids removed from the bypass bag and overflow basket (if applicable); and;
4. Wet volume of the gross solids removed from the bypass bag and overflow basket (if applicable).

Weight and volume field measurements were taken only once during a cleaning. If multiple cleanings were required at a site, the data from each interim cleaning and the end-of-season cleaning were added together to obtain an annual gross solids loading for that site. Measurements were not taken on a per storm basis.

The weight of gross solids was estimated by placing an empty container on an electronic scale and taking the tare weight of the scale. The bags of gross solids (one at a time) were placed in the container and weighed on the scale. Field weight measurements from all bags for a single device were added together and the total weight calculated for that device.

The volume of gross solids was estimated by placing the bags of gross solids (one at a time) into a container of known volume. The bag was made as level as possible across the surface area of the container. The amount of freeboard was then measured and multiplied by the surface area of the container to obtain the remaining volume. This quantity was then subtracted from the total known volume of the container to yield the estimated volume of gross solids. Field volume measurements from all bags for a single device were added together and the total volume calculated for each device.

Additional weight and volume measurements were taken after shipping the gross solids to the Caltrans Litter Laboratory, where litter was separated from vegetated material. The additional measurements included weight and volume of litter and vegetation removed from the device, separate from each other; along with separate weight and volume measurements of litter and vegetation from the bypass bag and overflow basket (where applicable). The litter was then air-dried for 24 hours and additional weight and volume measures were taken.

Mobilization criteria varied between the two storm seasons (2000-01 and 2001-02). Initially, storm events with a predicted rainfall of at least 0.1 inches and a 75-percent or greater probability triggered the deployment of field teams. Mobilization for storm events with a predicted rainfall of 0.1 inches or greater and a 50 to 75-percent probability was determined on a storm-by-storm basis.

During the second season, water quality monitoring was removed from the scope and the mobilization threshold changed as a result. Post-storm field inspections were conducted after a rain event which produced at least 0.5 inches of rain. During-storm field inspections were conducted when at least 0.5 inches of rain was forecast with a minimum of 50-percent probability, and it had started raining."

The image on the following page, Figure F-2, was taken from the Phase 1 Pilot Study and outlines the gross solid measurement strategy:

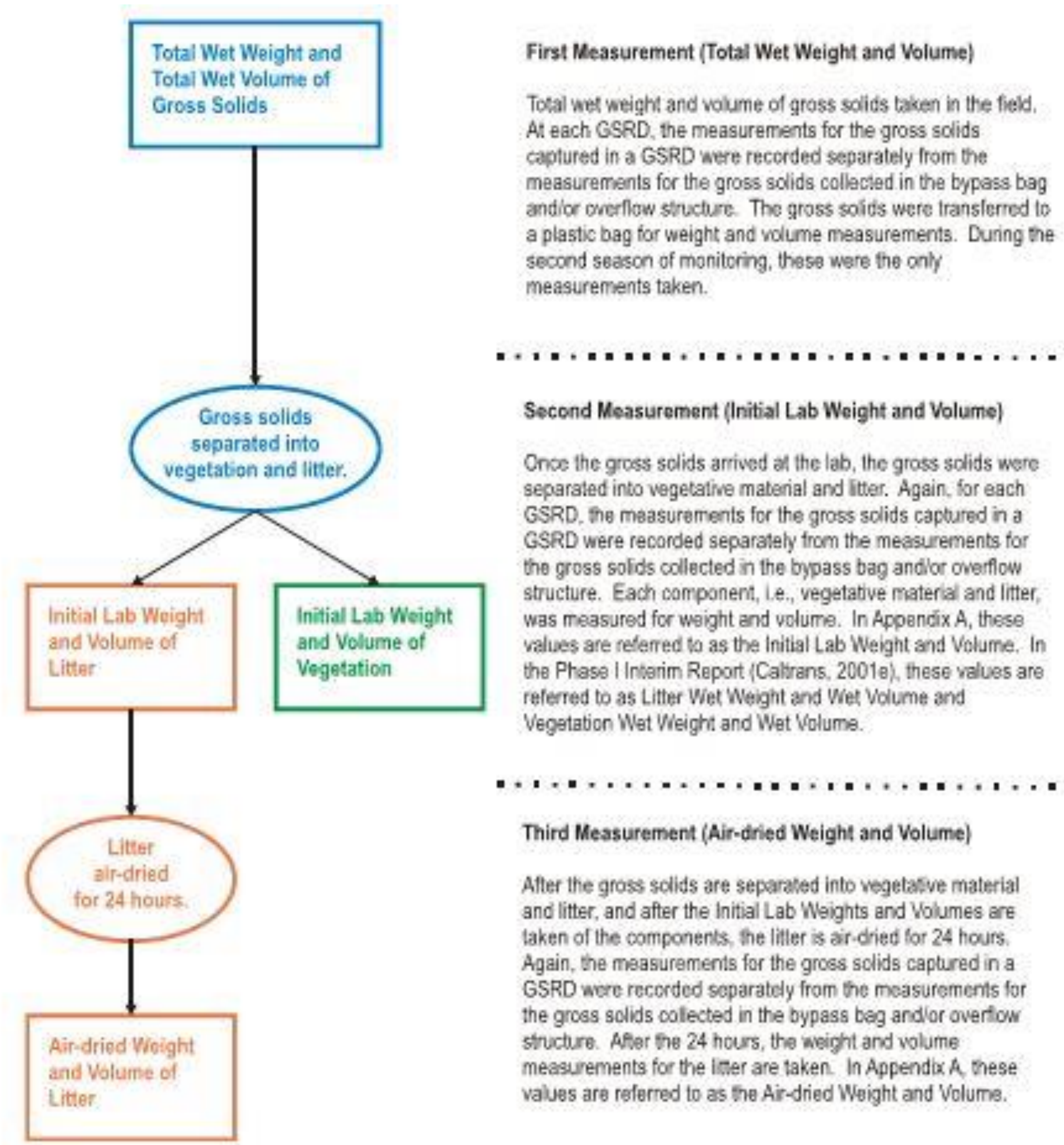

FIGURE F-2 FLOW CHART OF GROSS SOLIDS MEASUREMENTS (CALTRANS OCTOBER 2003)

The image below, taken directly from the Pilot study, summarizes the average time required and equipment used for the interim and post-season cleanings of each device. This data represents the efforts needed to clean the device, collect the captured and bypassed gross solids, and take field measurements of the weight and volume.

TABLE F-1 CLEANING REQUIREMENTS FOR CALTRANS PILOT STUDY (CALTRANS OCTOBER 2003)

Phase I GSRDs Pilot Study Cleaning Requirements

Site	Total Number of Cleanings		Average Person-hours per Storm Season	Average Person-hours per Cleaning	Equipment
	2000-01	2001-02			
LR1 I-10	1	1	24	24	A
LR2 I-210	1	2 X,Y	36	24	B
LR2 I-5	2 X	2 Y	16	8	C
IS1 SR-170	1	1	12	12	C
IS2 I-210	2 Y	1	12	8	C
IS2 US-101	2 Y	2 Y	24	12	C
BB I-405	2 Y	2 Y	24	12	C
BB I-210	2 Y	1	18	12	C

A. Shovels, Rakes, Brooms, Brushes, Boom Truck
B. Shovels, Rakes, Brooms, Brushes, Wheelbarrows, Dump Truck/Flatbed Truck
C. Shovels, Rakes, Brooms, Brushes, Pick-Up Truck
X. Device observed to be 85% full or more.
Y. Device cleaned due to observed clogging and overflow.

The cleaning efforts required for pilot studies and any related gross solid removal efficiency measurements and/or loading rate determination are inherently more time intensive, as compared to traditional cleaning methods. The use of a Vactor truck for maintaining these types of devices is not applicable when measuring the weight and volume of captured gross solids is required.

Gross solids collected and measured as part of the Caltrans Pilot Study were disposed of at dumpsters located at the yards of the companies performing the cleaning and monitoring. The gross solids were not tested before disposal, since most of the collected material consisted of vegetation, sediment, and litter such as cardboard and plastic. No special handing techniques (i.e. hazardous suits or breathing apparatuses) were required during the cleaning operations.

The recommend gross solid removal device inspection frequency, derived from the Caltrans Pilot study, is as follows:

- One inspection 30 days prior to the beginning of the rainy season (defined as October 1 through May 1).
- A few inspections during the rainy season. Preferably, these interim inspections should be conducted after a rain event of one inch or greater. In Southern California, the inspection frequency would average between two to three times per year.
- One inspection at the end of the rainy season in conjunction with the annual cleaning.

Inspections should consist of visual observations of the amount of gross solids collected in the device, noting any obvious obstructions to the hydraulic capability of the device, verifying that the device is properly draining following rain events, and observations related to site security (i.e. fences in place, gates locked, and no graffiti on the device).