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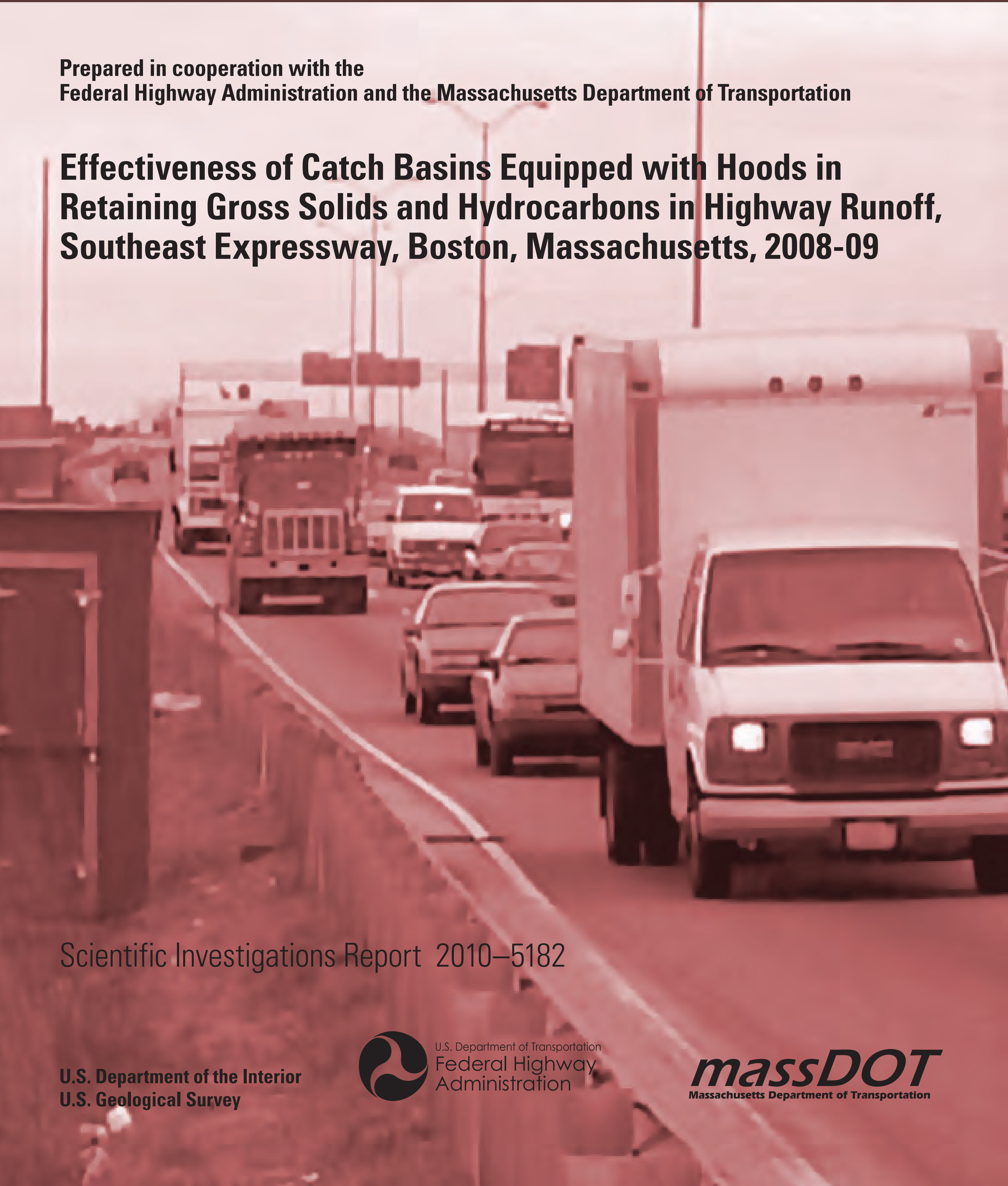
Effectiveness of Catch Basins Equipped with Hoods in Retaining Gross Solids and Hydrocarbons in Highway Runoff, Southeast Expressway, Boston, Massachusetts, 2008-09



Scientific Investigations Report 2010–5182

U.S. Department of the Interior
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Cover. Photograph of the Southeast Expressway near Tenean Beach in Boston, Massachusetts.

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By Kirk P. Smith

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U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

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Massachusetts Department of Transportation Disclaimer

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Contents

Abstract ... 1
Introduction ... 2
  Purpose and Scope ... 2
  Study area ... 2
Site Selection ... 2
Methods ... 4
  Site Preparation and Equipment Installation ... 4
  Collection and Analysis of Continuous Water-Level and Rainfall Data ... 9
  Collection and Analysis of Samples of Gross Solids ... 11
  Collection and Analysis of Samples of Oil and Grease and Total Petroleum Hydrocarbons ... 13
Effectiveness of Catch-Basin Hoods ... 18
  Retaining Gross Solids ... 18
  Retaining Oil and Grease and Total Petroleum Hydrocarbons ... 21
Summary ... 23
References Cited ... 24

Figures

1. Map showing study area with hooded catch basins, Southeast Expressway in Boston, Massachusetts ... 3
2. Schematic diagram of a deep-sump off-line hooded catch basin and location of the weir and debris collection structure ... 4
3. Photograph of a grate installed on a catch basin along the Southeast Expressway in Boston, Massachusetts, at start of the study ... 5
4. Photograph of a grate installed on a catch basin along the Southeast Expressway in Boston, Massachusetts, during resurfacing of the highway ... 5
5. Photograph showing A, standard cast-iron hood typically used along the Southeast Expressway, B, an Eliminator hood, and C, a Snout hood, which were tested along the Southeast Expressway in Boston, Massachusetts, 2008 ... 6
6. Photograph showing a typical debris collection structure attached to the catch-basin outlet pipe along the Southeast Expressway in Boston, Massachusetts, 2008 ... 8
7. Photograph showing seed materials added to the sump of catch basin 130 along the Southeast Expressway in Boston, Massachusetts, 2008 ... 9
8. Photograph showing floatable materials collected in a net from catch basin 739 on the Southeast Expressway in Boston, Massachusetts, 2008 ... 14
9. Photograph showing a vacuum truck emptying the entire contents of a single catch basin on a tarp prior to sample processing ... 15
10. Photograph showing a vertical water-column sample being collected with a Teflon dip-stick sampler from catch basin 739 on the Southeast Expressway in Boston, Massachusetts, 2009 ... 17
11. Pie chart showing the distribution of highway solids collected from the outfalls of six deep-sump off-line hooded catch basins along the Southeast Expressway in Boston, Massachusetts, May through November 2008 ... 19

12. Box plot showing the distribution of concentrations of oil and grease, and total petroleum hydrocarbons, measured in composite samples, collected in a prior U.S. Geological Survey study (Smith 2002), of highway runoff discharged from deep-sump off-line catch basins containing cast-iron hoods and those measured in composite samples of highway runoff discharged from a deep-sump off-line catch basin equipped with an Eliminator hood collected in this study (2009) along the same section of road on the Southeast Expressway in Boston, Massachusetts 22

Tables

1. Descriptions of six deep-sump off-line hooded catch basins monitored along the Southeast Expressway in Boston, Massachusetts...6
2. Rainfall and runoff statistics for discrete sampling periods for sites 131, 136, and 739 along the Southeast Expressway, in Boston, Massachusetts, 2008...........................10
3. Mass of gross highway solids greater than 0.25 inches in diameter collected from the outlets of six deep-sump off-line hooded catch basins fitted with hoods along Southeast Expressway, in Boston, Massachusetts, 2008..11
4. Mass and distribution of gross highway solids collected from the outlets of six deep-sump off-line hooded catch basins along the Southeast Expressway in Boston, Massachusetts, 2008...12
5. Total mass of highway solids collected from various points in the highway drainage system and the effectiveness for the six deep-sump off-line hooded catch basins in retaining gross solids along Southeast Expressway, in Boston, Massachusetts. 16
6. Recovery of seed materials from the debris-collection structures at the outlets of the six deep-sump off-line hooded catch basins and storm statistics for each period between sample collections along Southeast Expressway, in Boston, Massachusetts, 2008...20
7. Concentrations of oil and grease, and total petroleum hydrocarbons collected from the water surface in sumps of five deep-sump off-line hooded catch basins along the Southeast Expressway, in Boston, Massachusetts, 2008–09.......................................21
8. Concentrations of oil and grease, and total petroleum hydrocarbons, in flow-weighted samples of highway runoff collected from the outlet of catch basin 739 and in a vertical-profile sample collected in the sump of catch basin 739 along the Southeast Expressway, in Boston, Massachusetts, 2008–09.......................................22

Conversion Factors, Data, and Abbreviations

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
Acre	4,047	square meter (m^2)
square foot (ft^2)	0.09290	square meter (m^2)
square inch (in^2)	6.452	square centimeter (cm^2)
	Volume	
cubic foot (ft^3)	0.02832	cubic meter (m^3)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
inch per hour (in/h)	0 .0254	meter per hour (m/h)
	Mass	
ounce, avoirdupois (oz)	28.35	gram (g)

Horizontal coordinate information is referenced to North American Datum of 1983 (NAD 83).

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Effectiveness of Catch Basins Equipped with Hoods in Retaining Gross Solids and Hydrocarbons in Highway Runoff, Southeast Expressway, Boston, Massachusetts, 2008–09

By Kirk P. Smith

Abstract

Stormwater mobilizes litter and other debris along the roadway where it is transported to the highway drainage systems. Initial treatment for stormwater runoff typically is provided by catch basins in highway settings. Modification of catch basins to include hoods that cover the catch-basin outlet is intended to enhance catch-basin performance by retaining floatable debris and various hydrophobic organic compounds that tend to float on the water surface within the sump of the catch basin.

The effectiveness of six deep-sump off-line catch basins equipped with hoods in reducing the mass of gross solids greater than 0.25 inches in diameter and concentrations of oil and grease (OG) and total petroleum hydrocarbons (TPH) was examined along the Southeast Expressway, in Boston, Massachusetts. Two deep-sump catch basins were equipped with cast-iron hoods. Three were equipped with molded plastic hoods, known as an Eliminator, and a single catch basin was equipped with a fiberglass anti-siphoning hood, known as a Snout. Samples of gross solids greater than 0.25 inches in diameter, excluding gravel and metallic materials, were routinely collected for a 6-month period from a collection structure mounted at the end of each catch-basin outlet pipe. After about 6 months, all floatable, saturated low-density and high-density solids were removed from each catch basin. In addition to the collection of samples of gross solids, samples of sump water from five catch basins and flow-weighted composite samples of stormwater from the outlet of one catch basin were collected and analyzed for concentrations of OG and TPH.

A mass balance approach was used to assess the effectiveness of each catch basin equipped with a hood in retaining gross solids. The effectiveness of the deep-sump catch basins fitted with one of three types of hoods in retaining gross solids ranged from 27 to 52 percent. From 45 to 90 percent of the gross solids collected from the catch-basin sumps were composed of materials made of high-density plastics that did not float in water, and as a result, the effect that the catch-basin hoods had on these materials likely was marginal. The effectiveness for the deep-sump hooded catch basins, excluding the mass of high-density materials identified in the solids collected from the outlet pipe and the sump of the catch basins, ranged from 13 to 38 percent. The effectiveness for each catch basin, based solely on the material that remained floating at the end of the monitoring period, was less than 11 percent; however, these values likely underestimate the effectiveness of the hooded catch basins because much of the low-density material collected from the sumps may have been retained as floatable material before it was saturated and settled during non-storm conditions. The effectiveness of the catch basins equipped with hoods in reducing gross solids was not greatly different among the three types of hoods tested in this study.

Concentrations of OG and TPH collected from the water surface of the catch-basins varied from catch basin to catch basin and were similar to concentrations of flow-weighted composite samples collected during storms. Comparisons indicate concentrations of OG and TPH in flow-weighted composite samples collected at the outlet of a catch basin equipped with an Eliminator hood were not substantially different from concentrations of the respective constituents in flow-weighted composite samples collected during a previous study from catch basins containing cast-iron hoods in the same study area. The similarity between these flow-weighted concentrations and the concentrations of the respective constituents in a vertical profile sample collected from the catch-basin sump indicates that OG and TPH are emulsified in the sump of each catch basin during storms and circumvent the hoods.

Introduction

Natural and anthropogenic debris commonly accumulate along the edges of highways. These materials are mobilized during rain storms and wash into highway-drainage systems where they are ultimately discharged onto the toe of the highway embankments or to receiving water bodies. Debris, including litter and various fragments from damaged or deteriorating automobiles, can adversely affect receiving water quality and may result in the failure of a water body to comply with Massachusetts surface-water-quality standards (Massachusetts Department of Environmental Protection, 2007).

Deep-sump catch basins provide primary treatment for highway runoff along the Southeast Expressway in Boston, Massachusetts. Catch-basin hoods are intended to enhance catch-basin performance by retaining floatable debris, including floatable oil, grease, and petroleum hydrocarbons, at the water surface within the sump of the catch basin. Catch basins that do not contain hoods have no physical means of retaining floatable solids in the catch basin sump. Little or no floatable debris were observed in a survey of more than 40 catch basins that were not equipped with hoods on parts of Route 119, Route 2, Route 8, Interstate 95, Interstate 190, Interstate 195, and Interstate 495 in Massachusetts. In one study (U.S. Environmental Protection Agency, 1999a), catch basins equipped with hoods were reported to retain approximately 85 percent of the litter delivered to a New York City sewer system, whereas unhooded catch basins retained 30 percent of the litter. Recent evidence from a best management practice study (Smith, 2002) along the Southeast Expressway (Interstate 93), however, indicates that the actual benefit of hoods in deep-sump catch basins is limited for highway settings. At the conclusion of the 14-month study targeting a deep-sump catch basin containing a cast-iron hood, the structure was virtually free of litter and other debris, although large amounts of these materials were noted not only in the downstream water-quality inlet of the catch basin under study but in four other water-quality inlets located along the Southeast Expressway that also received discharge from deep-sump catch basins with hoods. Though catch-basin hoods may work well for large floatable debris (intact bottles and Styrofoam cups for example), submerged debris may pass under the hoods. Catch-basin hoods also can obstruct catch-basin maintenance activities (ASCG Incorporated, 2005), affecting the removal of sump materials and potentially damaging the hood itself. The U.S. Geological Survey (USGS), in cooperation with the Federal Highway Administration and the Massachusetts Department of Transportation (Massachusetts DOT), investigated the effectiveness of catch basins equipped with three types of hoods to retain gross solids, oil and grease (OG), and total petroleum hydrocarbons (TPH).

Purpose and Scope

This report describes the effectiveness for deep-sump offline catch basins equipped with three types of hoods along the Southeast Expressway for the purpose of retaining gross highway solids (excluding gravel and metal materials), OG, and TPH. The methods used for collection of data also are described. The effectiveness of these structural best management practices is based on highway-runoff data collected from May 2008 through April 2009.

Study area

The study area is composed of two northbound sections of the Southeast Expressway near the Neponset River and Tenean Beach in Boston, Massachusetts (fig. 1). Within the study area, deep-sump catch basins provide primary treatment for highway runoff. Highway runoff collected by the catch basins either is discharged to the embayment near Tenean Beach or infiltrates in the ground at the toe of the highway embankment. The two segments of highway that contain the hooded catch basins monitored in this study are about a mile apart.

Catch basins are circular concrete containers below the highway with steel grates at the pavement surface (fig. 2). The catch basins monitored along the Southeast Expressway have sumps (that is, storage area below the outlet pipe) that are 4 ft deep and are termed deep-sump catch basins. The catch basins do not contain curb inlets, and the grates cover the entire inlet. The initial catch-basin grates (fig. 3) contained 2 rows of 10 open parallel slits (1.2 in. by 9.4 in.); however, the highway was resurfaced about halfway through the study period (August), and the grates were replaced. The new grates (fig. 4) contain 36, 2.4 in. by 2.4 in. square openings. Prior to this study, each catch basin was equipped with a hinged cast-iron hood which fit over the catch-basin sump outlet. The hood loosely encapsulates the outlet opening and extends about 0.5 ft below the bottom of the outlet. As part of this study, cast-iron hoods were removed from four catch basins, and hoods of more recent designs were installed according to the manufacturers' specifications.

Site Selection

Six catch basins along the Southeast Expressway between Tenean Beach and the Neponset River in Boston, Massachusetts, were selected for monitoring and for collection of gross solids. In this study, gross solids refers to natural organic matter (leaves, sticks, and bark), litter, plastic and fiberglass automobile components, and other non-descriptive debris greater than 0.25 in. in diameter (excluding gravel, and metallic and asphalt particles). The selection of catch basins was made on the basis of the ability to define the drainage area for each catch basin, to mount a debris-collection structure

Orthophoto source MassGIS, EOEA, 1995

Figure 1. Study area with hooded catch basins, Southeast Expressway in Boston, Massachusetts.

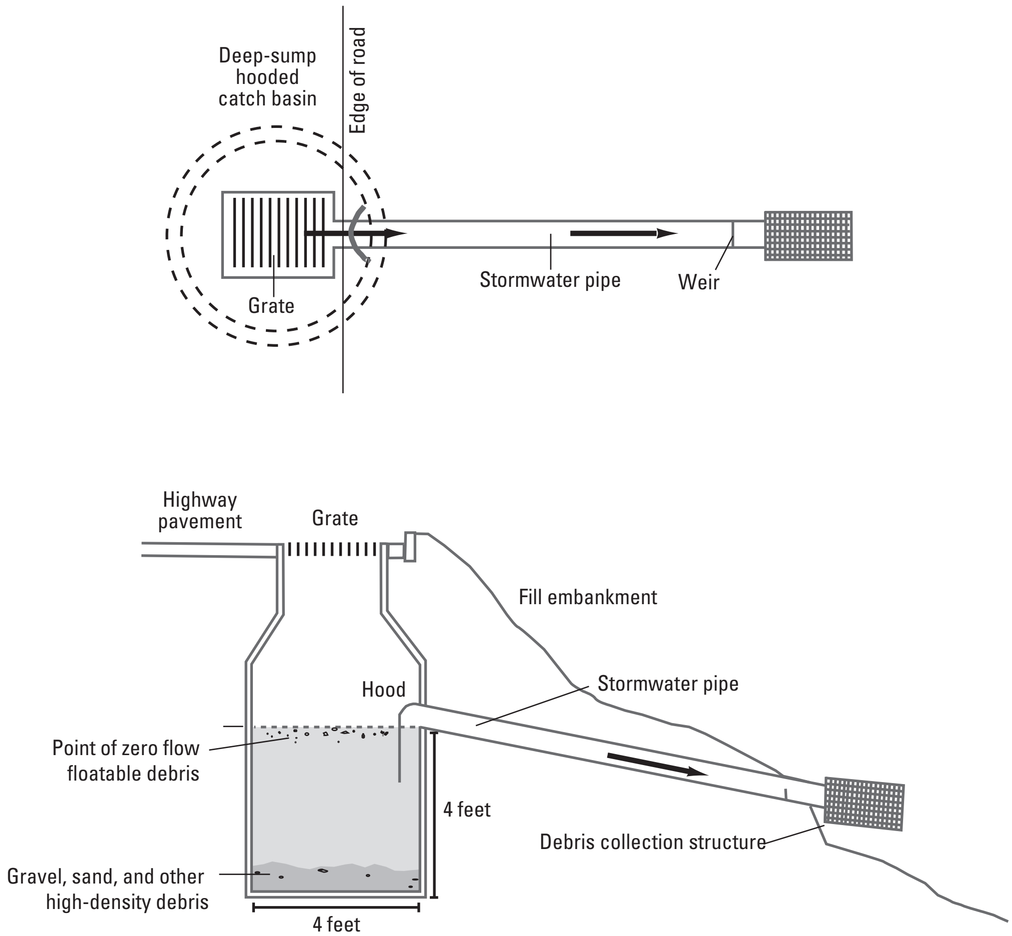

Figure 2. Schematic diagram of a deep-sump off-line hooded catch basin and location of the weir and debris collection structure.

to the catch-basin discharge pipe, and to collect samples of highway runoff for analysis of concentrations of OG and TPH. Only off-line catch basins were selected because they do not receive additional flow from other catch basins. The selection of sites was subject to the availability of locations away from roadway traffic and near the drainage outfalls. Highway construction plans detailing the drainage systems provided by the Massachusetts DOT were utilized for initial screening of potential catch basins.

On the basis of the previously defined criteria, six deep-sump, off-line catch basins were selected for monitoring gross highway solids (table 1). The cast-iron hoods (fig. 5A) were left installed in two catch basins (sites 131 and 742). Three molded plastic hoods, known as Eliminator hoods (fig. 5B), were installed at monitoring sites 136, 137, and 739, and a single fiberglass anti-siphoning hood, known as a Snout (fig. 5C), was installed at monitoring site 130. The design of the Snout hood requires the device to be mounted flush with the catch-basin wall. Unfortunately, the interior walls of many of the catch basins were deteriorated, and sub-drain pipes often protruded near the catch basin outlets, preventing the device from sealing properly. These common circumstances prevented the mounting of the Snout hood in all but one of the catch basins.

Methods

The methodology includes site preparation, installation of monitoring devices, and collection and analysis of continuous-monitor data, and collection of samples of gross solids and water from the catch basins.

Site Preparation and Equipment Installation

The six catch basins were cleaned with a vacuum truck by the Massachusetts DOT on May 1 and 14, 2008, prior to the installation of the new hoods and the collection of gross solids. A weir was installed in the outlet pipe of the catch

Figure 3. Grate installed on a catch basin along the Southeast Expressway in Boston, Massachusetts, at start of the study.

Figure 4. Grate installed on a catch basin along the Southeast Expressway in Boston, Massachusetts, during resurfacing of the highway.

Table 1. Descriptions of six deep-sump off-line hooded catch basins monitored along the Southeast Expressway in Boston, Massachusetts.

[USGS, U.S. Geological Survey; °, degree; ′, minute; ″, seconds]

USGS Streamgage number	Site designation	Latitude	Longitude	Drainage area (acres)	Curb mile	Catch-basin hood type
421751071024801	130	42°17′51″	71°02′48″	0.25	0.08	Snout
421749071024701	131	42°17′49″	71°02′47″	0.10	0.03	Cast-iron
421745071024506	136	42°17′45″	71°02′45″	0.19	0.07	Eliminator
421743071024401	137	42°17′43″	71°02′43″	0.18	0.06	Eliminator
421647071024705	739	42°16′47″	71°02′47″	0.08	0.03	Eliminator
421649071024801	742	42°16′49″	71°02′48″	0.10	0.03	Castiron

A

Figure 5. *A,* standard cast-iron hood typically used along the Southeast Expressway, *B,* an Eliminator hood, and *C,* a Snout hood, which were tested along the Southeast Expressway in Boston, Massachusetts, 2008.

B

C

Figure 5. *A,* standard cast-iron hood typically used along the Southeast Expressway, *B,* an Eliminator hood, and *C,* a Snout hood, which were tested along the Southeast Expressway in Boston, Massachusetts, 2008.

basins (fig. 2) located on the right-most northbound lane on the Southeast Expressway at sites 131, 136, and 739. The monitoring site at catch basin 739 was configured to measure and record rainfall, as well as the water level in the outlet of the catch basin. This monitoring site also was configured to collect water samples at the outlet of the catch basin for the analysis of concentrations of OG and TPH. Programmable water-level sensors also were installed in the catch basin outlet at sites 131 and 136. The Eliminator hoods (fig. 5B) and the single Snout hood (fig. 5C) were installed after the catch basins were cleaned. Cast-iron hoods were left in place at the remaining two catch basins. Debris collection structures were installed at each of the six monitoring sites after the catch basins were cleaned (fig. 2). These cylindrical devices (fig. 6) were constructed from 0.25-in. galvanized mesh screen. The screen was sandwiched between two plywood rings at the open end of the device. These rings were secured to the end of each pipe with bolts and wing nuts.

Following the installation of the new hoods and the occurrence of one or more storms, two types of floatable seed material were added to each of the catch basins (fig. 7) once the water in each catch basin resumed a normal static level. These materials included small sealed zip-lock bags (4 x 6 inches) with a label inside and small plastic tubes that were slightly larger in diameter than a cigarette or pen. These seed materials were quantified after each sample collection and again at the end of the field study to help determine the effectiveness of each hood in retaining standardized floatable materials.

Figure 6. A typical debris collection structure attached to the catch-basin outlet pipe along the Southeast Expressway in Boston, Massachusetts, 2008.

Figure 7. Seed materials added to the sump of catch basin 130 along the Southeast Expressway in Boston, Massachusetts, 2008.

Collection and Analysis of Continuous Water-Level and Rainfall Data

Water-level sensors were installed behind a weir mounted in the outlet pipe of the catch basins at sites 131, 136, and 739. The monitoring system at site 739 was programmed to measure water level and rainfall every minute. Baseline data (that is, data that are recorded regardless of the state of runoff) for water level and rainfall were recorded every 2 hours. Water level and rainfall were recorded on a 1-minute basis whenever the water level behind the weir in the catch basin outlet pipe was greater than the point of zero flow or when rain was measured. These data were collected from May 2008 through April 2009. The submersible monitoring device at site 136 also measured the water level every minute; however, the device recorded values on a 1-minute basis whenever a change in water level in the catch basin outlet pipe exceeded a water-level threshold of 0.02 ft. Baseline measurements at site 136 were recorded every 15 minutes. Data for site 136 were collected though August 2008. Similar data also were collected at site 131 for one week in June 2008.

Instantaneous flow was estimated on the basis of the water-level measurements and a level-discharge relation for each weir for all storms with available data. Storm statistics, such as total runoff, flow duration, and peak flow, were calculated from these instantaneous values for sites 131, 136, and 739 (table 2). Total runoff and flow duration for these catch basins for each sampling period was calculated by summing the discrete storm values for each statistic. The highest peak flow was selected where the sampling period included more than one storm. Total rainfall and maximum 1-hour rainfall intensity also were computed on the basis of

Table 2. Rainfall and runoff statistics for discrete sampling periods for sites 131, 136, and 739 along the Southeast Expressway, in Boston, Massachusetts, 2008.

[mm/dd, month/day; --, data type was not collected or is not available at this site; ft³, cubic feet; s, second]

Sampling period end date (mm/dd)	Site designation	Rainfall statistics		Runoff statistics		
		Total rainfall (inches)	Maximum hourly rainfall (inches/hour)	Peak Flow, ft^3/s	Total runoff duration, in hours	Total runoff volume, ft^3
05/14	739	0.24	0.07	0.03	6.9	737
05/17	739	0.78	0.16	0.08	14.0	448
05/28	739	0.20	0.12	0.04	2.6	73
06/05	739	0.56	0.14	0.04	3.0	187
06/17	739	1.03	0.25	0.10	5.3	618
06/24	739	0.12	0.08	0.03	0.4	10
07/02	739	0.89	0.66	1.21	2.4	1,770
07/11	739	0.72	0.45	0.57	3.3	1,650
07/21	739	0.87	0.39	1.21	4.8	3,990
07/30	739	4.38	1.33	1.21	27.5	12,700
08/04	739	1.06	0.73	1.21	5.6	1,750
08/13	739	1.63	0.37	0.62	11.3	1,170
08/28	739	0.46	0.13	0.29	58.7	2,510
09/09	739	2.10	0.54	0.10	17.9	3,690
09/24	739	0.83	0.3	0.69	7.3	684
09/30	739	3.85	0.48	0.50	46.6	11,600
11/03	739	1.44	0.29	0.95	15.5	5,820
06/24	131	--	--	0.31	0.9	222
05/14	136	--	--	0.00	2.5	2
05/17	136	--	--	0.03	13.3	177
05/28	136	--	--	0.13	2.8	119
06/05	136	--	--	0.01	2.4	41
06/17	136	--	--	0.12	5.0	566
06/24	136	--	--	0.18	0.6	139
07/02	136	--	--	1.20	3.1	5,310
07/11	136	--	--	1.20	7.1	16,200
07/21	136	--	--	1.19	5.1	14,900
07/30	136	--	--	1.20	35.9	12,200
08/13	136	--	--	0.33	7.7	1,310
08/28	136	--	--	0.89	9.1	661

data collected at site 739. Total rainfall includes all measured rain during each sampling period. The highest maximum 1-hour rainfall intensity was selected where the sampling period included more than one storm. These statistics are later evaluated in regard to the mass of gross solids collected at the outlet pipe of each catch basin to assess the circumstances that affect the performance of each catch-basin hood.

For the previous sites, runoff volumes estimated on the basis of drainage area and rainfall volume correlate poorly with measured volumes of runoff. Measured volumes of runoff often were substantially larger than volumes of runoff estimated. In part, this is explained by the spatial location of the sites and potential differences in the distribution of rainfall over the study area. It is also likely that construction activities on the roadway affected drainage patterns where water bypassed upgradient catch basins and entered the catch basins at sites 136, 137, and 739 that were centered on low points along the roadway. As a result, the effective drainage area for these sites for some storms may actually be larger than those listed in table 1.

Collection and Analysis of Samples of Gross Solids

Gross solids were retrieved about every week from each collection structure (fig. 6) at the end of a storm or series of storms. Solids removed from each device were placed in bags and transported to the USGS Massachusetts Water Science Center. Seed materials were removed from the mass of solids and tabulated. The mass of captured material from each catch-basin outlet was determined by drying the contents (less any seed material) at 105 degrees Celsius (°C) to a constant weight in a laboratory oven over a period of several days (table 3). The contents of each sample of dried solids were identified by visual inspection. Identifiable materials were placed in general categories, such as cigarette butts, plastics (wrappers, Styrofoam, and other plastics), and natural vegetation matter. The net weight for each category of each sample was measured and recorded to the nearest 0.01 milligram (table 4). Once all samples were processed, the individual samples of

Table 3. Mass of gross highway solids greater than 0.25 inches in diameter collected from the outlets of six deep-sump off-line hooded catch basins fitted with hoods along Southeast Expressway, in Boston, Massachusetts, 2008.

[Clean, indicates catch basin was cleaned on this date; mm/dd, month/day; --, no data available]

Sampling period end date (mm/dd)	Mass of solids collected from catch basin outlets, in grams					
	Site designation and hood type					
	130 (Snout)	131 (Cast iron)	136 (Eliminator)	137 (Eliminator)	739 (Eliminator)	742 (Cast iron)
05/01	--	--	Clean	Clean	Clean	Clean
05/14	Clean	Clean	0	0	0	0
05/17	1.80	2.47	0.00	2.08	0.00	10.54
05/28	0.00	4.76	0.00	0.24	0.00	0.00
06/05	0.00	0.21	0.55	0.00	0.00	0.00
06/17	3.71	7.21	0.45	2.58	0.24	5.79
06/24	0.00	37.90	1.10	13.75	0.00	0.00
07/02	4.79	91.20	817.58	307.93	542.63	242.72
07/11	1.14	13.76	327.37	5.44	101.23	90.16
07/21	303.95	311.25	617.26	23.47	264.28	54.30
07/30	86.85	0.00	194.24	0.00	403.81	108.69
08/04	44.29	182.90	--	197.97	424.54	115.00
08/13	7.17	39.69	25.41	6.13	47.05	25.67
08/28	0.28	1.49	0.00	0.00	14.73	1.36
09/09	6.23	43.94	14.29	3.32	177.61	49.80
09/24	4.59	33.03	7.73	3.24	179.91	131.88
09/30	13.87	40.20	28.43	1.91	85.72	82.13
11/03	19.46	45.22	36.68	36.68	171.34	175.47
Total	**498**	**855**	**2,071**	**605**	**2,413**	**1,094**

Table 4. Mass and distribution of gross highway solids collected from the outlets of six deep-sump off-line hooded catch basins along the Southeast Expressway in Boston, Massachusetts, 2008.

[--, no data available; mm/dd, month/day; Cig., cigarette butts; Plastic, both high- and low-density plastic materials; Veg., natural vegetation including grass, leaves, bark, and sticks]

Sampling period end date (mm/dd)	Mass of solids, in grams								
	Site designation and type of catch-basin hood								
	130 (Snout)			131 (Cast iron)			136 (Eliminator)		
	Cig.	Plastic	Veg.	Cig.	Plastic	Veg.	Cig.	Plastic	Veg.
05/14	--	--	--	--	--	--	0.00	0.00	0.00
05/17	0.19	1.56	0.05	0.40	0.02	2.05	0.00	0.00	0.00
05/28	0.00	0.00	0.00	2.22	2.04	0.51	0.00	0.00	0.00
06/05	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.55
06/17	0.00	3.49	0.22	0.02	3.05	4.13	0.00	0.00	0.45
06/24	0.00	0.00	0.00	5.48	9.23	23.19	0.00	0.34	0.76
07/02	0.83	1.63	2.33	5.82	11.49	73.89	27.15	54.29	736.14
07/11	0.00	0.26	0.88	2.03	1.62	10.11	14.66	6.98	305.72
07/21	8.85	53.29	241.81	3.51	14.08	293.65	35.35	134.10	447.81
07/30	18.37	5.56	62.92	0.00	0.00	0.00	10.58	14.76	168.90
08/04	3.33	17.50	23.46	19.08	37.90	125.93	--	--	--
08/13	2.05	2.22	2.90	6.31	4.83	28.55	2.74	12.61	10.06
08/28	0.07	0.07	0.14	0.04	0.05	1.41	0.00	0.00	0.00
09/09	0.39	0.27	5.57	3.08	8.56	32.30	0.63	2.61	11.05
09/24	1.26	1.13	2.21	4.02	14.40	14.61	1.04	4.02	2.67
09/30	0.14	4.02	9.70	6.99	21.44	11.77	1.22	0.99	26.22
11/03	2.47	7.90	9.09	6.02	2.23	36.97	1.75	11.25	23.68
Total	**37.96**	**98.90**	**361.3**	**65.22**	**130.9**	**659.1**	**95.13**	**241.9**	**1734**

plastic materials were combined for each catch basin and placed in a bucket of tap water at room temperature for a period of about 15 minutes to separate low-density plastic materials from high-density plastic materials. High-density plastics materials were retrieved from the bottom of each bucket, and the mass of these plastics was determined as described previously.

At the end of the solid-monitoring phase of the study, all floatable debris were removed with a net (fig. 8) from each catch basin, except for the catch basin at site 131, which did not have standing water in the sump. The remaining sump contents were removed one catch basin at a time with a vacuum truck. The sump deposits beneath the hoods were removed manually because there was insufficient room in the catch basin to angle the intake for the vacuum pipe under the hoods. The tank on the vacuum truck was cleaned prior to each use. After removing the sump contents of each catch basin, the solids were emptied from the vehicle on a large clean tarp at a nearby service depot (fig. 9). This step was repeated for each catch basin. All solid materials greater than about 0.25 in. in diameter were separated from the smaller gravel and asphalt materials by wet sieving. Solids, excluding large rock, asphalt, and metallic materials, were placed in plastic bags and transported to the USGS Massachusetts Water Science Center. Metallic items consisted of studs, nuts, and other heavy, dense items that were too dense to float and thus were treated like gravel and omitted from analysis. The mass of the floatable material collected with the net and the mass of the gross solids recovered from the sump material were determined by drying the contents at 105°C to a constant weight in a laboratory oven over a period of several days (table 5). Since many of the identifiable objects collected in the net were similar to

Table 4. Mass and distribution of gross highway solids collected from the outlets of six deep-sump off-line hooded catch basins along the Southeast Expressway in Boston, Massachusetts, 2008.

[--, no data available; mm/dd, month/day; Cig., cigarette butts; Plastic, both high- and low-density plastic materials; Veg., natural vegetation including grass, leaves, bark, and sticks]

Sampling period end date (mm/dd)	Mass of solids, in grams								
	Site designation and type of catch-basin hood								
	137 (Eliminator)			739 (Eliminator)			742 (Cast iron)		
	Cig.	Plastic	Veg.	Cig.	Plastic	Veg.	Cig.	Plastic	Veg.
05/14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
05/17	0.37	0.05	1.66	0.00	0.00	0.00	0.96	2.70	6.88
05/28	0.20	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
06/05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
06/17	2.21	0.26	0.11	0.24	0.00	0.00	0.15	0.56	5.08
06/24	0.66	8.45	4.64	0.00	0.00	0.00	0.00	0.00	0.00
07/02	1.64	7.92	298.37	13.25	44.87	484.51	11.40	12.87	218.46
07/11	0.54	0.00	4.90	5.23	6.91	89.09	6.53	10.48	73.14
07/21	1.15	4.13	18.20	14.42	22.74	227.12	11.24	23.59	19.47
07/30	0.00	0.00	0.00	36.75	71.03	296.03	16.68	12.67	79.34
08/04	9.02	130.46	58.49	28.86	90.08	305.60	13.91	18.09	83.00
08/13	0.94	2.39	2.80	5.17	6.04	35.84	3.70	3.35	18.62
08/28	0.00	0.00	0.00	0.94	0.74	13.05	0.76	0.00	0.61
09/09	0.00	1.25	2.07	3.04	50.24	124.33	5.53	3.74	40.53
09/24	0.31	1.29	1.65	3.17	63.19	113.55	7.96	17.01	106.91
09/30	0.01	0.61	1.29	2.83	4.38	78.52	3.61	2.60	75.92
11/03	2.01	0.97	33.71	4.94	32.21	134.19	20.38	39.00	116.09
Total	**19.04**	**157.8**	**427.9**	**118.8**	**392.4**	**1902**	**102.8**	**146.7**	**844.0**

what was observed in the sump material, the dried contents of the sump material were placed in a large bucket of water at room temperature for a period of about 15 minutes to separate potential floatable objects from high-density objects that were not buoyant under such conditions.

Collection and Analysis of Samples of Oil and Grease and Total Petroleum Hydrocarbons

Water samples were collected at the surface of the water column in the sump of each catch basin (except for site 131 which had no standing water in the sump at the time of sample collection) in the fall of 2008 at the end of the solid-monitoring phase of the study and again in the spring of 2009. These samples were collected by partially submersing the opening of a precleaned bottle beneath the surface of the sump water at each catch basin. A sample of the water column also was collected from the catch basin at site 739 in April 2009 using a Teflon dip-stick sampler (fig. 10). The dip-stick sampler consisted of a 7-ft Teflon pipe with a valve containing four 0.25-in. holes set 90 degrees from each other at the bottom and a closure at the top. The sample of water was collected by slowly lowering the device from the water surface to the sump floor at which point the top of the device was sealed, the sampler was removed, and the contents were dispensed directly into a precleaned bottle. This process was continued until sufficient water was collected for analysis. Finally, five flow-weighted composite samples of highway runoff were collected from the outlet of catch basin 739 from December 2008 to April 2009.

Flow-weighted composite samples were collected with an automatic sampler under datalogger control. The sampler intake line was mounted in a sloping manner to allow for

Figure 8. Floatable materials collected in a net from catch basin 739 on the Southeast Expressway in Boston, Massachusetts, 2008.

the complete purging and draining of sample water between samples. The sampler intake was fixed to a static mixer to provide a secure mount for the sampler intake, reduce transport velocity, and to provide agitation to produce a sample that represented the average quality of the runoff (Smith, 2002). Sampler intakes were oriented in a horizontal and downstream direction. Each automatic sampler was configured to hold one 20-liter Teflon-lined plastic bottle. The Teflon lining consisted of a double-wall Teflon pouch constructed in a clean room without the use of glue or adhesives. The sampler's intake lines consisted of 0.5-in. Teflon tubing attached to silicon pump-head tubing with a custom made Teflon discharge tube. The sampler tubing was cleaned, and the sample collection bottle was replaced prior to each storm.

All samples were shipped on ice overnight to TestAmerica Laboratories in Denver, Colorado, where they were analyzed for concentrations of OG and TPH. All samples were received by the laboratory in satisfactory condition. Concentrations of OG and TPH were determined using USEPA methods 1664A SGT and 1664A HEM (OG) (USEPA, 1999b).

The reliability of the chemical data was ensured by the preparation and analysis of quality-control samples. These quality-control samples include a field blank and five replicate samples. A field blank is used to test for positive bias that can result from contamination at any stage of the sample-collection, -processing, or -analysis process. One field blank was collected with the automatic sampler in preparation for storm sampling. This sample was collected by pumping organic-free blank water through the automatic sampler tubing and into the collection bottle and processing it in a manner consistent with the collection of environmental samples of stormwater. The laboratory did not detect TPH in this sample; however, they did estimate a concentration for OG (3.8 mg/L) less than the laboratory reporting limit (5 mg/L) but greater

Figure 9. A vacuum truck emptying the entire contents of a single catch basin on a tarp prior to sample processing.

than the method detection limit (1.4 mg/L). Concentrations of OG in flow-weighted composite samples of highway runoff ranged from 7.2 to 34 mg/L. On the basis of these values, the results for the field blank indicate that the cleaning procedure for the sampling equipment was adequate to prevent contamination due to prior use at greater than the reporting limit for each constituent. Analysis of laboratory method blanks indicates that all samples for TPH were affected by low-level laboratory contamination. A method blank is a sample used by the laboratory to monitor the level of contamination introduced during the sample preparation steps. Concentrations of TPH measured in method blanks were less than the laboratory reporting limit (5 mg/L) and greater than the detection limit (0.8 mg/L) for all samples.

Replicate samples are samples that are thought to be identical in composition to the environmental samples. Replicate samples provide a measure of bias and variability for the methods of sample collection, sample processing, and laboratory analysis, and for effects such as analyte degradation that can occur prior to laboratory analysis. A total of five replicate samples were collected. Two sequential replicate samples of sump water and three replicate-split samples of stormwater were collected to measure the variability of sample concentrations resulting from collection and processing of the water samples. Analysis of replicate highway runoff and sump water-column samples indicate that measurements for OG and TPH can be highly variable. The relative percent difference (RPD) between concentrations of OG in the primary samples and replicate samples ranged from 9 to 123 percent; the RPD between concentrations of TPH in primary samples and replicate samples ranged from 4 to 110 percent. The largest RPDs were observed for the two replicate samples collected from the catch basin sumps. The large difference between the primary sample and the replicate sample representing the surface film of the water column in catch basin 739 is likely the result of the bulk of

Table 5. Total mass of highway solids collected from various points in the highway drainage system and the effectiveness for the six deep-sump off-line hooded catch basins in retaining gross solids along Southeast Expressway, in Boston, Massachusetts.

[--, no data available]

Sample description	Mass of solids, in grams					
	Site designation and type of catch-basin hood					
	130 (Snout)	131 (Cast iron)	136 (Eliminator)	137 (Eliminator)	739 (Eliminator)	742 (Cast iron)
Catch basin outlet (total)	498.1	855.2	2,071	604.73	2,413	1,094
Catch basin outlet high-density plastics	61.07	19.11	128.0	129.3	223.8	8.39
Catch basin outlet anthropogenic low-density solids	78.41	177.6	224.1	46.12	283.0	232.2
Catch basin floatables	31.62	--	184.8	22.36	262.7	132.3
Catch basin sump (total)	392.3	939.2	1,811	203.2	663.8	833.9
Catch basin sump high-density plastics	310.3	419.9	1,090	112.44	595.2	375.8
Catch basin sump anthropogenic low-density solids	82.00	519.2	720.5	90.74	68.69	458.0
Effectiveness criteria	Effectiveness for each deep-sump hooded catch basin, in percent					
Gross solids (excluding mineral and metallic materials)	46	52	49	27	28	47
Low-density gross solids	21	38	32	19	13	35
Floatable solids (measured at conclusion of study)	6	--	6	4	10	8
Anthropogenic low-density solids	59	75	80	71	54	72

Figure 10. A vertical water-column sample being collected with a Teflon dip-stick sampler from catch basin 739 on the Southeast Expressway in Boston, Massachusetts, 2009.

the floating compounds being collected in the primary sample with less remaining for collection in the replicate sample. The difference between primary and replicate samples collected by the dip-stick sampler could have resulted from the agitation of bottom sediments during sample collection. The average RPDs for concentrations of OG and TPH in three flow-weighted composite samples were more precise at 17 and 10 percent, respectively.

Effectiveness of Catch-Basin Hoods

Samples of gross solids collected at the outlet of the six catch basins were summed and compared to the materials collected from the respective catch-basin sumps to compute the effectiveness of each catch basin to retain various solids during the study period. In this section, rainfall and runoff characteristics for each sampling period are compared to the mass of solids collected at the outlets of selected catch basins. Concentrations of OG and TPH in sump water and in flow-weighted composite samples of highway runoff are compared among five catch basins and to recent data from a prior study (Smith, 2002).

Retaining Gross Solids

A mass balance approach was used to assess the effectiveness of each catch basin equipped with a hood in retaining gross solids. At the conclusion of the monitoring period, the effectiveness of each deep-sump hooded catch basin (table 5) was calculated by dividing the sum of the catch-basin floatables and total gross solids from the catch-basin sump by the sum of the total gross solids (catch-basin floatables, catch-basin sump (total), and catch-basin outlet (total) from table 5).

The effectiveness of the catch basins equipped with the cast-iron, Eliminator, and Snout hoods in retaining gross solids ranged from 27 to 52 percent. The average effectiveness for the three catch basins fitted with the Eliminator hoods was about 35 percent, the average effectiveness for the two catch basins fitted with cast-iron hoods was about 49 percent, and the effectiveness for the catch basin fitted with the Snout hood was 46 percent.

High-density plastics such as lenses for automobile tail and parking lights, for example, were identified in both the sump and catch-basin outlet samples. From 45 to 90 percent of the gross solids in the catch-basin sumps were composed of materials made of high-density plastics, and about 1 to 21 percent of the total gross solids in samples collected at the outlet of each catch basin were composed of like materials (table 5). The effect that the catch-basin hoods have on these materials is likely marginal because these materials readily sink in water. When high-density plastic materials are eliminated from the sump and outlet values, the effectiveness for the deep-sump hooded catch basins is substantially lower (table 5, effectiveness for low-density gross solids). These results more likely reflect the ability of the device to retain true floatable debris because the remaining sump materials (largely cigarette butts) are buoyant when dry. The effectiveness of the catch basins in retaining gross low-density solids ranged from 13 to 38 percent; the average effectiveness of retaining gross floatable solids for the three catch basins fitted with the Eliminator hoods was about 21 percent. The effectiveness for each catch basin, based solely on the material that remained floating in the catch basin at the end of the monitoring period, was less than 11 percent for all types of hoods (table 5, effectiveness for floatable solids). However, these values underestimate the catch basin effectiveness because it is likely that the hoods initially retain much of the saturated solids that settle within the catch-basin sumps during non-storm conditions. In the absence of the hoods, such materials potentially could flush from the catch basins during storms before they reach a saturated condition. Thus, the actual effectiveness for the catch basins equipped with hoods for retaining gross floatable solids is likely in the range of 13 to 38 percent for highway settings.

The distribution of identifiable materials collected from the outlets of the six catch basins was similar (fig. 11). From 71 to 83 percent of all solids collected at the outlets of the six catch basins was natural vegetation matter. These distributions are similar to results for highway locations listed in other studies (Kim and others, 2006; ASCG, Incorporated, 2005; Kim and others, 2004). If the calculation for the effectiveness of the catch basins equipped with hoods is restricted to low-density anthropogenic materials (that is, floatable litter and automobile refuse) that are not readily biodegradable, the effectiveness for most hooded catch basins increases (table 5, anthropogenic low-density solids). Although such omissions seemingly improve the perceived effectiveness of the catch basins, natural organic matter will decompose and release nutrients and other constituents into the receiving water body, and therefore, natural organic matter should be included as objects of concern. Previous research indicates that the effectiveness for deep-sump hooded catch basins may be improved with more frequent catch-basin maintenance (USEPA,1999a); however, this may be impractical given the small amount of gross solids measured weekly (< 100 grams) in the catch basin outlets during this study.

The recovery of seed materials from the outlets of the catch basins after storms was largely limited to catch basins equipped with cast-iron hoods (table 6). In the case of the catch basin at site 131, the sump water tended to leak during dry periods. As a result, the seed material potentially could circumvent the hood as the water level in the sump increases and traps the materials between the hood and the catch-basin outlet. Seed materials also potentially could circumvent the cast-iron hoods through gaps between the edge of the hood and the walls of the catch basin at both sites equipped with these hoods.

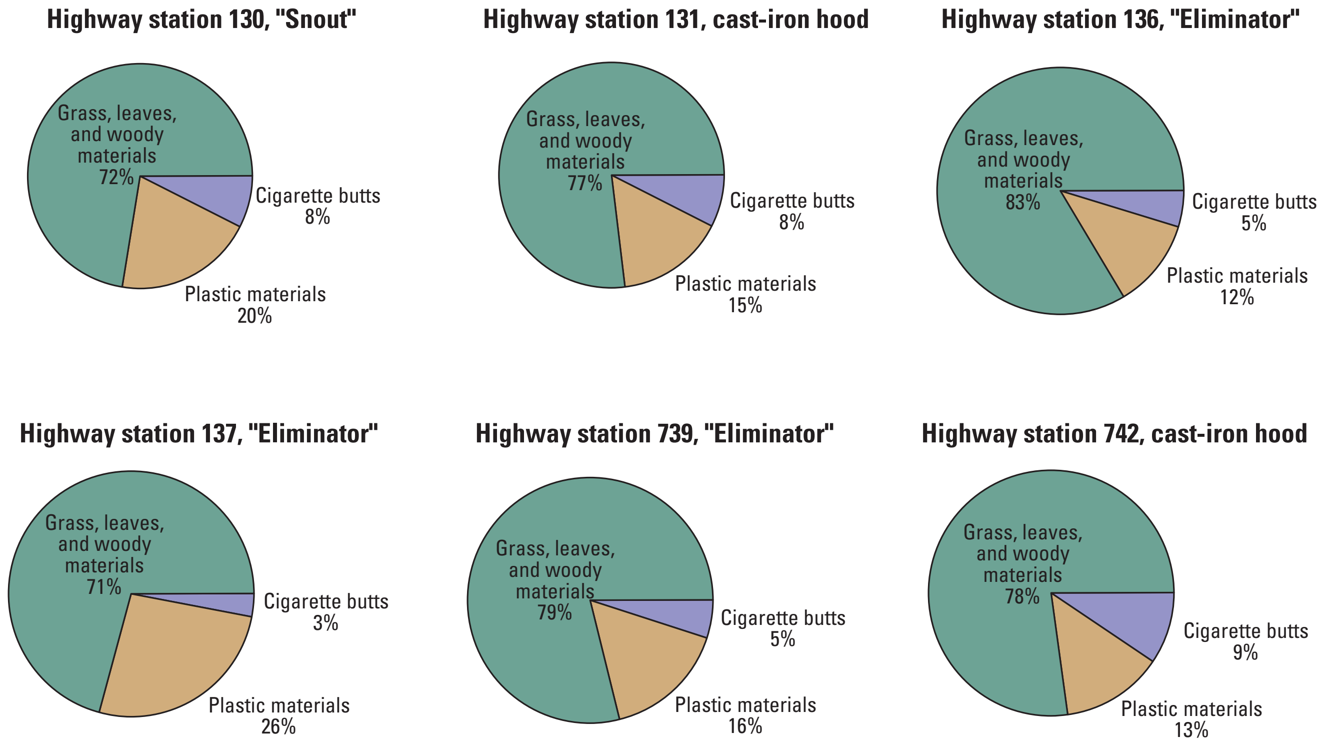

Figure 11. Pie chart showing the distribution of highway solids collected from the outfalls of six deep-sump off-line hooded catch basins along the Southeast Expressway in Boston, Massachusetts, May through November 2008.

Stormwater mobilizes litter and other highway solids along the roadway where it is transported to the highway drainage systems. As a result, the magnitude of the physical attributes for storms can affect the loading rates for litter and other gross solid loads (Kim and others, 2006; Kayhanian and others, 2002). In this study, the effectiveness of catch basins equipped with hoods decreased with an increase in rain intensity and peak flow. The Pearson product moment correlation coefficient was used to evaluate the degree of linear relationship between two variables (Helsel and Hirsch, 2002). The correlation coefficient ranges from -1 to +1. A negative coefficient indicates that one variable tends to increase as the other decreases, and a positive coefficient indicates that the two variables tend to increase together. The size of the coefficient from 0 to 1 and 0 to -1 indicates the extent of the relation. The Pearson correlation coefficients for gross solids (normalized by drainage area) collected from the outlet pipes for catch basins 136 and 739 to maximum 1-hour rainfall intensity and peak flow are 0.66 and 0.79, respectively. The Pearson correlation coefficients for total rainfall, total duration, and total volume of flow for each sampling period to gross solids are 0.31, -0.01, and 0.40, respectively. The division point that marks where there is or is not a linear relation between the two variables is determined from the size of the sample population (Johnson, 1984). For this study, the coefficients are computed from 30 sets of paired values (table 2; rain statistics are assumed to represent all sites for respective sampling periods), and the division point is 0.361 (Johnson, 1984). Thus, there is sufficient evidence to conclude that there are linear relations between 1-hour rainfall intensity, peak flow, and total volume of flow for each sampling period to gross solids because the respective Pearson correlation coefficients are greater than the division point. The loss of seed materials from the sump of the catch basins did not coincide with the high rainfall intensity and peak flow events. In general, the seed materials were larger and probably more buoyant than the bulk of the floatable solids measured in this study and did not respond to high intensity rainfall or peak rates of flow as did the small pieces of liter and natural organic materials. As a result, the effectiveness of the hoods in retaining large floatable items, which were limited in size by the catch basin grates in this study, may be greater.

Although there are many areas along highways where the amount of visible litter affects the surrounding aesthetics, catch-basins equipped with hoods may provide only limited benefit on Massachusetts highways because the small openings in the catch-basin grates restrict the potential capture of many of these larger items (beverage cups, cans, and bottles). The data presented in this report are not necessarily transferable to catch basins with different grate designs or catch basins that contain curb inlets which may allow larger material to pass to the catch basin sump.

Table 6. Recovery of seed materials from the debris-collection structures at the outlets of the six deep-sump off-line hooded catch basins and storm statistics for each period between sample collections along Southeast Expressway, in Boston, Massachusetts, 2008.

[mm/dd, month/day]

Sample collection date (mm/dd)	Rainfall Statistics			Number and type of seed material collected from catch basin outlet — Site designation and hood type											
	Total rainfall (inches)	Maximum rainfall intensity (inches per hour)	Number of storms between sample collections	130 (Snout)		131 (Cast iron)		136 (Eliminator)		137 (Eliminator)		739 (Eliminator)		742 (Cast iron)	
				Tube	Bag	Tube	Bag	Tube	Bag	Tube	Bag	Tube	Bag	Tube	Bag
05/14	0.24	0.07	2	0	0	0	0	0	0	0	0	0	0	0	0
05/17	0.78	0.16	1	0	0	0	0	0	0	0	0	0	0	0	0
05/28	0.20	0.12	1	0	0	2	1	0	0	0	2	0	0	0	0
06/05	0.56	0.14	3	0	0	0	0	0	0	0	0	0	0	0	0
06/17	1.03	0.25	4	0	0	0	1	0	0	0	0	0	0	0	0
06/24	0.12	0.08	1	0	0	7	3	0	0	0	0	0	0	0	0
07/02	0.89	0.66	3	0	0	0	2	0	0	0	0	0	2	0	0
07/11	0.72	0.45	3	0	0	0	0	0	0	0	0	0	0	5	0
07/21	0.87	0.39	4	0	1	0	0	0	0	0	0	0	0	3	0
07/30	4.38	1.33	6	0	0	0	0	0	0	0	0	0	0	2	0
08/04	1.06	0.73	4	0	0	0	0	0	0	0	0	0	0	0	0
08/13	1.63	0.37	8	0	0	0	0	0	0	0	0	0	0	0	0
08/28	0.46	0.13	3	0	0	0	0	0	0	0	0	0	0	0	0
09/09	2.10	0.54	2	0	0	0	0	0	0	0	0	0	0	0	0
09/24	0.83	0.30	3	0	0	0	0	0	0	0	0	0	0	0	0
09/30	3.85	0.48	3	0	0	0	0	0	0	0	0	0	0	0	0
11/03	1.44	0.29	6	0	0	0	0	0	0	0	0	0	0	0	0
				Seed materials recovered during storms, in percent											
				0	10	90	70	0	0	0	20	0	20	100	0

Retaining Oil and Grease and Total Petroleum Hydrocarbons

Water samples were collected from the catch-basin sumps and a catch-basin outlet during storms to assess the general effectiveness of the hoods in retaining OG and TPH within the catch basins. OG materials analyzed for include relatively non-volatile hydrocarbons, vegetable oils, animal fats, waxes, soaps, greases, and related materials (USEPA, 1999b). TPH materials are more restrictive, consisting of numerous relatively non-volatile hydrocarbon compounds that originate from crude oil. Hydrocarbons in petroleum fuels ranging from gasoline through number-2 fuel oil, which volatilize below 85^{o}C, may be only partially represented in such analyses because these hydrocarbons can be lost in the analytical process (USEPA, 1999b). Although methods for both types of hydrocarbons provide measurements for a group of rather non-specific compounds, test results from sample to sample may not necessarily represent the same source.

Water samples collected from the water surface of the catch-basin sumps represent the floating film of OG and TPH and, possibly, the maximum concentrations in the water in each catch basin. These 1-liter samples represent a water depth of less than 0.1 in., given the surface area of the catch basins. Concentrations of OG measured in samples of water collected from the upper water surfaces of the catch-basin sumps ranged from 6.5 to 46 mg/L (table 7). Concentrations of TPH in the same samples ranged from 3.2 to 26 mg/L (table 7). The lowest concentrations of both constituents were measured in samples collected in the catch basin at site 130 where the Snout hood was installed. The highest concentrations of OG were measured in samples collected in the catch basin at site 739 where the Eliminator hood was installed. Concentrations of OG also were high in samples collected in the catch basin at site 742 containing a cast-iron hood. Samples from this site also had the highest concentrations of TPH. The variability among these measurements is more likely a function of a non-uniform source of the constituents from site to site rather than an indication of the actual performance for each hood. The cast-iron hood installed in the catch basin at site 742 loosely fit over the outlet of the sump; as a result, this hood could not physically prevent floatable compounds from escaping the sump. This particular catch basin was located in an emergency pull-off area; thus the high concentrations of both constituents measured in samples collected from this catch basin likely are explained by the greater probability that runoff might be affected by emissions from disabled automobiles.

The distributions of concentrations of OG and TPH measured in flow-weighted composite samples of highway runoff collected at the outlet of the catch basin at site 739 (fitted with an Eliminator hood; table 8) are shown in figure 12 alongside concentrations of the respective constituents collected previously from deep-sump catch basins containing cast-iron hoods in the same study area (Smith, 2002). Unlike

Table 7. Concentrations of oil and grease, and total petroleum hydrocarbons collected from the water surface in sumps of five deep-sump off-line hooded catch basins along the Southeast Expressway, in Boston, Massachusetts, 2008–09.

[mm/dd/yyyy, month/day/year; mg/L, milligrams per liter; j, analyte was detected in method blank at a concentration less than the reporting limit (5 mg/L) and greater than the detection limit (0.8 mg/L); values in parentheses are concentrations for replicate samples; e, result is less than the reporting limit]

Site designation	Sample date (mm/dd/yyyy)	Oil and grease (mg/L)	Total petroleum hydrocarbons (mg/L)
130	11/3/2009	6.5	5.1 j
	4/29/2009	6.5	3.2 e, j
136	11/3/2009	19	12 j
	4/29/2009	19	6.7 j
137	11/3/2009	7.4	3.5 j, e
	4/29/2009	34	12
739	9/30/2008	46 (11)	26 j (7.6 j)
	10/29/2009	7.8	5.7 j
	4/29/2009	15	7.7 j
742	10/29/2009	23	15 j
	4/29/2009	34	13 j

Table 8. Concentrations of oil and grease, and total petroleum hydrocarbons, in flow-weighted samples of highway runoff collected from the outlet of catch basin 739 and in a vertical-profile sample collected in the sump of catch basin 739 along the Southeast Expressway, in Boston, Massachusetts, 2008–09.

[mm/dd/yyyy, month/day/year; mg/L, milligrams per liter; j, analyte was detected in method blank at a concentration less than the reporting limit (5 mg/L) and greater than the detection limit (0.8 mg/L); values in parentheses are concentrations for replicate samples; e, result is less than the reporting limit]

Sample date (mm/dd/yyyy)	Storm runoff volume (cubic feet)	Oil and grease (mg/L)	Total petroleum hydrocarbons (mg/L)
12/10/2008	1,610	7.2 (9.2)	4.4 e (4.6 e)
3/9/2009	617	34 (31)	10 j (9.5 j)
4/3/2009	235	15 (18)	7.8 j (9.6 j)
4/6/2009	590	13	4.1 e, j
4/11/2009	76.6	7.6 j	3.3 e, j
	Total static sump volume (cubic feet)		
4/29/2009	50	11 (19)	4.2 e, j (6.5 e, j)

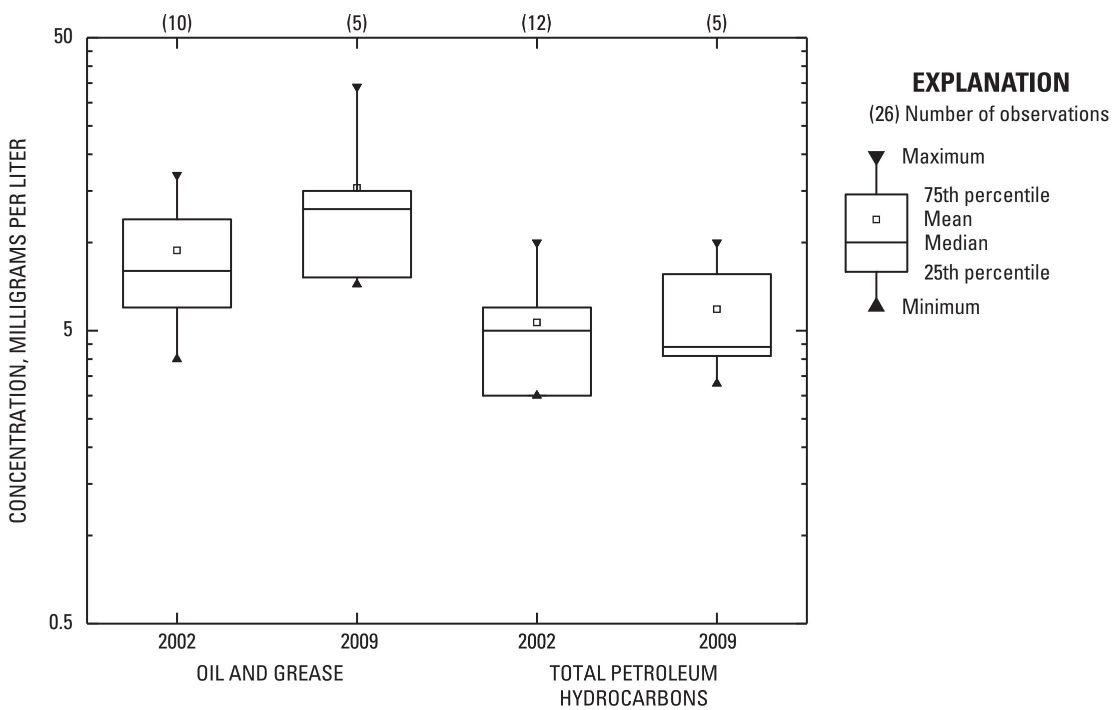

Figure 12. Box plot of the distribution of concentrations of oil and grease, and total petroleum hydrocarbons, measured in composite samples, collected in a prior U.S. Geological Survey study (Smith 2002), of highway runoff discharged from deep-sump off-line catch basins containing cast-iron hoods and those measured in composite samples of highway runoff discharged from a deep-sump off-line catch basin equipped with an Eliminator hood collected in this study (2009) along the same section of road on the Southeast Expressway in Boston, Massachusetts.

the loose fit of the cast-iron hood, the Eliminator hood fit tightly in the outlet pipe of the catch basin, and as a result, this device could retain floating oil and grease in the catch-basin sump under static conditions. However, the concentrations of OG and TPH in samples of highway runoff were not substantially different from those concentrations measured in samples of highway runoff collected from catch basins containing cast-iron hoods, which have no ability to retain floatable oils and grease. Furthermore, the similarity between the concentrations of the respective constituents in the vertical profile sample collected from the sump at the conclusion of storm sampling and the concentrations measured in samples of highway runoff indicates that the load for each constituent discharged from the catch basin dwarfs what was remaining in the sump of the catch basin. For example, the load of OG and TPH measured at the outlet of catch basin 739 for just the five storms sampled in this study was more than 80 times greater than the load remaining in the sump of the catch basin in April 2009, about 5 months after the catch basin was cleaned. These data indicate that OG and TPH become emulsified in the sump of each catch basin during storms and circumvent the hoods. However, during static conditions, the Eliminator hood, and presumably the Snout hood as well, potentially could retain more than 6 ft^3 of floatable oils (assuming a catch basin 4 ft in diameter and a hood depth of about 0.5 ft below the catch-basin outlet) that result from breached fuel tanks or other lubricant reservoirs as the sump water is displaced by a floating layer of product less than or equivalent to the depth of the hood below the catch-basin outlet. If the depth of the floating product exceeds the bottom of the hood, the product will begin to discharge from the catch basin.

Summary

The USGS, in cooperation with the Federal Highway Administration and the Massachusetts Department of Transportation began a study in 2008 to determine the effectiveness of catch-basin hoods in reducing the mass of gross solids and concentrations of OG and TPH along the Southeast Expressway, Boston, Massachusetts. Six deep-sump off-line catch basins were selected for monitoring and for the collection of gross solids (potentially floatable materials greater than 0.25 in. in diameter). These catch basins are located near, if not adjacent to, each other on two north-bound sections of highway about a mile apart. Existing cast-iron hoods were left installed in two catch basins. Molded plastic hoods, known as an Eliminator, were installed in three catch basins, and a single fiberglass anti-siphoning hood, known as a Snout, was installed in one catch basin.

A debris collection structure was installed at the outlet of each catch basin after the sump of the catch basin was cleaned. Floatable seed materials were subsequently added to each catch basin once the water in the sump recovered to a normal level and submersed the bottom of the hoods. Instantaneous flows were calculated from water-level measurements made behind weirs installed in the outlets of three catch basins. Instantaneous measurements of rainfall also were recorded near one catch basin. Samples of sump water for five catch basins were collected in November 2008 and again in April 2009 and analyzed for concentrations of OG and TPH. Flow-weighted composite samples of highway runoff also were collected from the outlet of one catch basin during five storms from December 2008 to April 2009. These samples also were analyzed for concentrations of OG and TPH. Samples of gross solids were routinely collected from the collection structures at the outlet pipe of the six catch basins and dried to a constant weight. Seed materials were removed from the mass of solids and tabulated. Identifiable materials from the samples of gross solids were placed in three general categories (cigarette butts, plastics, and natural vegetation matter), and the mass for each category was determined. After about 6 months, all floatable debris were removed with a net from each catch basin, and the remaining sump contents were removed from one catch basin at a time with a vacuum truck. The entire contents for each catch basin was wet sieved, and the mass of gross solids was determined after the samples were dried to a constant weight. The total mass of high-density plastics in samples collected from the debris collection structures at the outlet pipes and the sumps was determined for each catch basin.

A mass-balance approach was used to assess the effectiveness of each catch basin equipped with a hood in retaining gross solids. The overall effectiveness of the deep-sump catch basins equipped with cast-iron, Eliminator, and Snout hoods in retaining gross solids ranged from 27 to 52 percent. The average effectiveness for the three catch basins fitted with the Eliminator hoods was 35 percent, the average effectiveness for the two catch basins fitted with cast-iron hoods was about 49 percent, and the effectiveness for the catch basin fitted with the Snout hood was 46 percent. From 45 to 90 percent of the gross solids collected from the catch-basin sumps were composed of materials made of high-density plastics that did not float in water; therefore, the effect that the catch-basin hoods had on these materials was likely marginal. The effectiveness for the deep-sump hooded catch basins estimated on the basis of low-density solids are substantially less (13 to 38 percent). The effectiveness for each catch basin, based solely on the material that remained floating at the end of the monitoring period, was less than 11 percent; however, these values likely underestimate the effectiveness of the catch basin since much of the low-density material collected from the sumps may have been retained as floatable materials before they were saturated and settled in the catch-basin sumps during non-storm conditions.

The effectiveness of the catch basins equipped with hoods did not differ greatly among the three types of hoods tested in this study. The recovery of seed materials in the outlets of the catch basins after storms was largely limited to catch basins equipped with cast-iron hoods where seed material likely circumvented the hoods as a result of gaps between the edge of the hood and the walls of the catch basin.

The distribution of identifiable materials collected from the outlets of the six catch basins was similar; 71 to 83 percent of all solids consisted of natural vegetation matter, 3 to 9 percent consisted of cigarette butts, and 12 to 26 percent consisted of various plastic materials. Correlations between the mass of gross highway solids collected from the outlet of the catch basins normalized by drainage area and storm characteristics indicate that the effectiveness of catch basins for retaining gross solids decreased with an increase in rain intensity, peak flow, and total volume of flow.

Concentrations of OG and TPH collected from the water surface of the catch-basins varied from catch basin to catch basin irrespective of hood type. These results indicate that concentrations of OG and TPH were more likely from non-uniform sources than evidence of differences in effectiveness of each structural best management practice. Comparisons revealed that concentrations of OG and TPH in flow-weighted composite samples of highway runoff collected at the outlet of a catch basin equipped with an Eliminator hood were not substantially different from those concentrations in flow-weighted composite samples of highway runoff for the respective constituents collected from catch basins containing cast-iron hoods in the same study area for a previous study. The similarity between these flow-weighted concentrations from this study and the concentrations of the respective constituents in a vertical profile sample collected from the catch-basin sump indicates that OG and TPH become emulsified in the sump of each catch basin during storms and circumvent the hoods. However, during static conditions, the Eliminator hood, and presumably the Snout hood as well, potentially could provide spill control for floatable fuel and lubrication fluids.

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