Day 3: Stormwater Sampling Methods and Automatic Sampler Setups

Mostly excerpted from:
Burton, G.A. Jr., and R. Pitt. *Stormwater Effects Handbook: A Tool Box for Watershed Managers, Scientists, and Engineers*. CRC Press, Inc., Boca Raton, FL . 2002. 911 pages
Freely available at:
http://unix.eng.ua.edu/~rpitt/Publications/BooksandReports/Stormwater%20Effects%20Handbook%20by%20%20Burton%20and%20Pitt%20book/MainEDFS_Book.html

Plus excerpts from various research projects

Robert Pitt, Ph.D., P.E., BCEE
Emeritus Cudworth Professor of Urban Water Systems
Department of Civil, Construction, and Environmental Engineering
University of Alabama, Tuscaloosa, AL USA

1

1

Types of Stormwater Sampling for Different Objectives

- Source area sampling to identify and quantify sources of stormwater pollutants
- Performance testing of stormwater controls
- Outfall sampling to quantify land use discharges and benefits of distributed controls
- Receiving water sampling to supplement study on beneficial use impairments

2

2

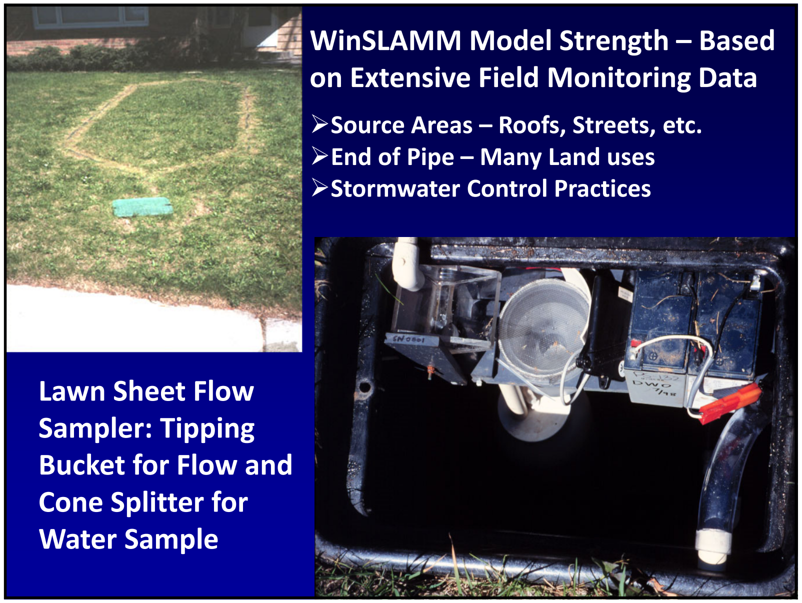
Source Area Sampling

3

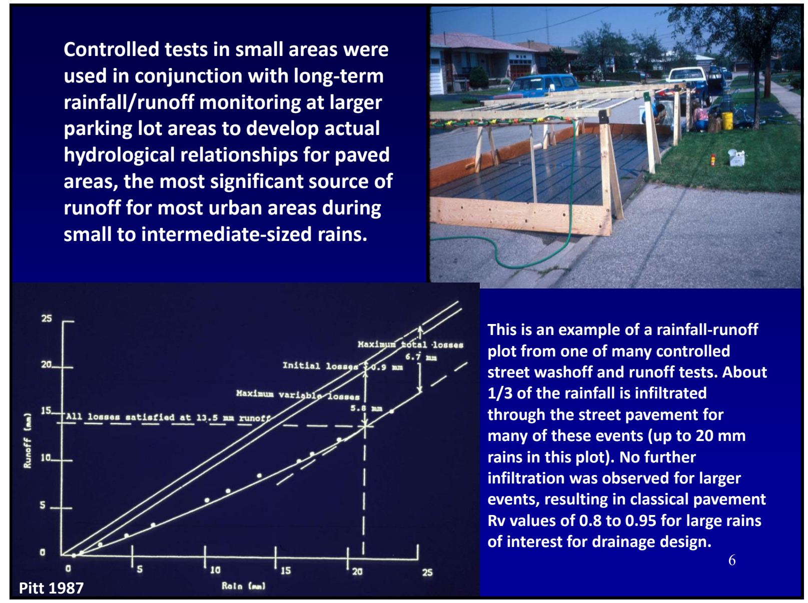
3

Many types of runoff monitoring have been used to understand transport and fate, from small source areas to outfalls.

4


WinSLAMM Model Strength – Based on Extensive Field Monitoring Data
➢Source Areas – Roofs, Streets, etc.
➢End of Pipe – Many Land uses
➢Stormwater Control Practices
Lawn Sheet Flow Sampler: Tipping Bucket for Flow and Cone Splitter for Water Sample

5


Controlled tests in small areas were used in conjunction with long-term rainfall/runoff monitoring at larger parking lot areas to develop actual hydrological relationships for paved areas, the most significant source of runoff for most urban areas during small to intermediate-sized rains.
Maximum total losses 6.7 mm
Initial losses 0.9 mm
Maximum variable losses 5.8 mm
All losses satisfied at 13.5 mm runoff
Runoff (mm)
Rain (mm)
Pitt 1987
This is an example of a rainfall-runoff plot from one of many controlled street washoff and runoff tests. About 1/3 of the rainfall is infiltrated through the street pavement for many of these events (up to 20 mm rains in this plot). No further infiltration was observed for larger events, resulting in classical pavement Rv values of 0.8 to 0.95 for large rains of interest for drainage design.
6

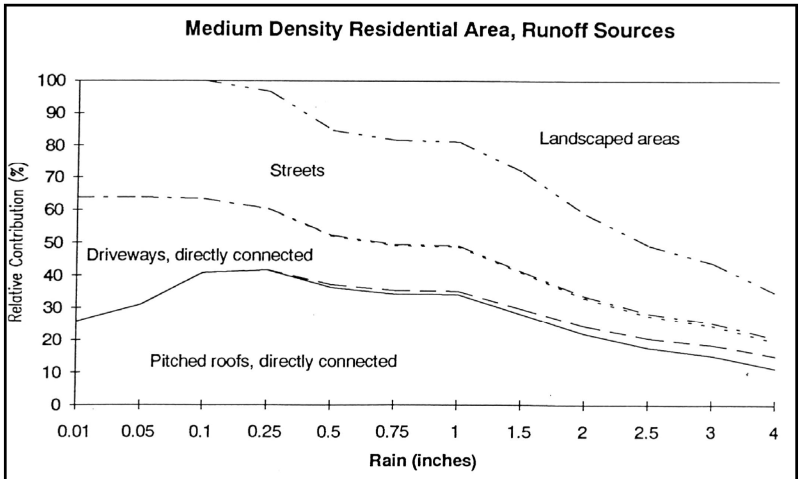
6


Source Area Sampling in Drainage Area with Stormwater Control Testing
6/11/2003

7

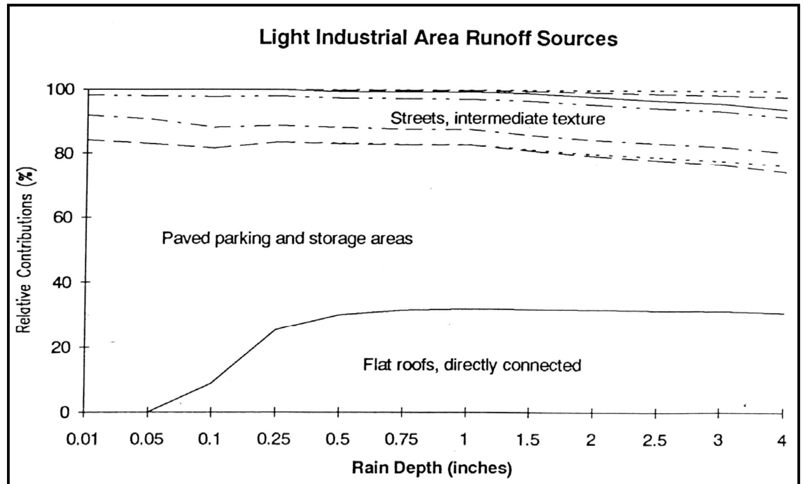

Other Source Area Sampling Methods

8



Paved areas become less important flow sources when landscaped areas start to contribute flows during later periods of the event (in this case, after about 0.5 in or 10 mm of rain)

9



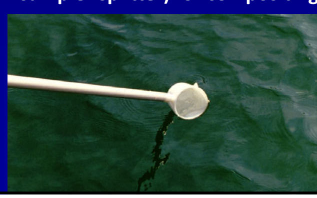
Flow source changes are less dramatic for areas that are mostly paved and have large roof areas. Travel time to the outfall is the predominant factor affecting source contributions for this case.

10

Manual Sampling Procedures

Dipper Samplers

- The simplest manual sampler is a dipper sampler
- These samplers can only obtain samples from the surface of the water. If subsurface samples are needed, then samplers having closure mechanisms need to be used.
- A dipper allows sampling of surface waters away from the immediate shoreline and from outfalls or sewerage pipes more conveniently than by using other types of samplers.
- Dippers are commonly used to sample small discharges from outfalls, where the flow is allowed to directly pour into the sampler.
- The sample is poured directly into sample bottles, or into a larger container (preferably a churn sampler splitter) for compositing several dipped samples.



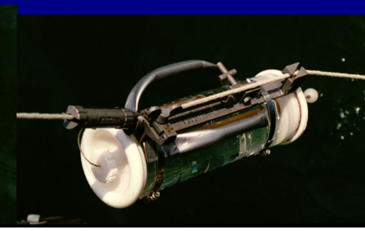
11

11

Manual Sampling Procedures

Submerged Water Samplers with Remotely Operated Closures

- This design allows unhindered flow through the sample container before closure, enabling faster equilibrium with surrounding waters.
- Several of the vertical units can be used on a single line to obtain water samples from various depths simultaneously.
- A weighted messenger slides down the line that the samplers are attached to, striking a trigger mechanism that closes the end seals, releasing the next messenger for the next sampler on the line.



12

12

Manual Sampling Procedures

Depth-Integrated Samplers for Suspended Sediment

- Suspended sediment is usually poorly distributed in both flowing and quiescent water bodies. The sediment is usually in greater concentrations near the bottom. Larger and denser particles are also predominantly located in lower depths.
- Depth-integrating sampling is commonly done in small upland streams. Sampling in smaller and more turbulent flows (such as in some sewerage or at outfalls during moderate to large storms) is not as severely affected by sediment stratification.

When collecting a depth-integrated sample, the sampler needs to stand to the side and downstream of the sampling area to minimize disturbance. The rod is lowered vertically through the water column at a constant rate at about 0.4 times the stream velocity. The sampler is lowered at this constant rate from the surface of the stream to the stream bottom, and then reversed and brought back to the surface at the same rate.

13

13

Manual Sampling Procedures

Manual Pump Samplers

Pump water sampling systems commonly used for well sampling can be used to deliver a water sample to a convenient location, especially useful when sampling wide and swift streams from a bridge, if weighted.

14

14

Manual Sampling Procedures

Source Area Sheetflow Samplers

- Manual sheetflow samplers are usually used when collecting grab samples from many different sampling locations.
- A small team can visit many sampling sites during a single rain to obtain multiple grab samples for statistical comparisons.
- The main drawback is that the samples are not composited during the rain and only represent the conditions during the short sampling period.

15

15

Monitoring to Evaluate Performance of Stormwater Controls

16

16

Basic Monitoring Strategy to Verify Stormwater Controls

- Scale-up of monitoring from field, to pilot, to full-scale stormwater control devices
- Need flexibility of small units with flow control and convenient sampling ports to test many variables under large variety of conditions
- Need to verify with full-scale units to check performance under real-world conditions

17

Different Pilot-Scale Stormwater Treatment Setups

18

Milwaukee, WI, Ruby Garage Public Works Maintenance Yard MCTT Tests (0.25 acre site)

19

Minocqua, WI, MCTT Tests (2.5 acre site)

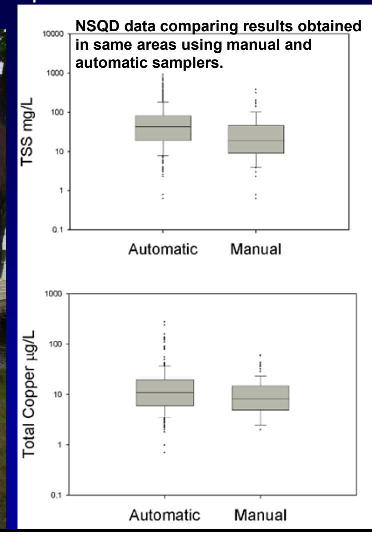
20

Field Pilot Scale Tests – Controlled Sediment Tests

Sample triplicates made using a churn splitter; analytical duplicates made using cone splitter

21

May have small biases with automatic vs. manual sampling, but automatic sampling allows unattended operation under a variety of conditions and captures complete event. Manual sampling can better represent complete range of particulate matter in sample.



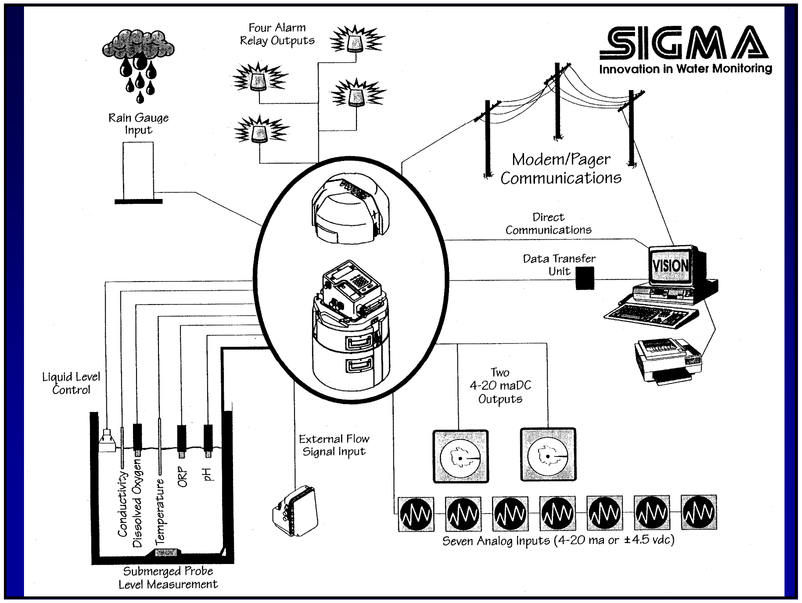
22

Monitored Full-Scale Up-Flow Filter in Tuscaloosa, AL

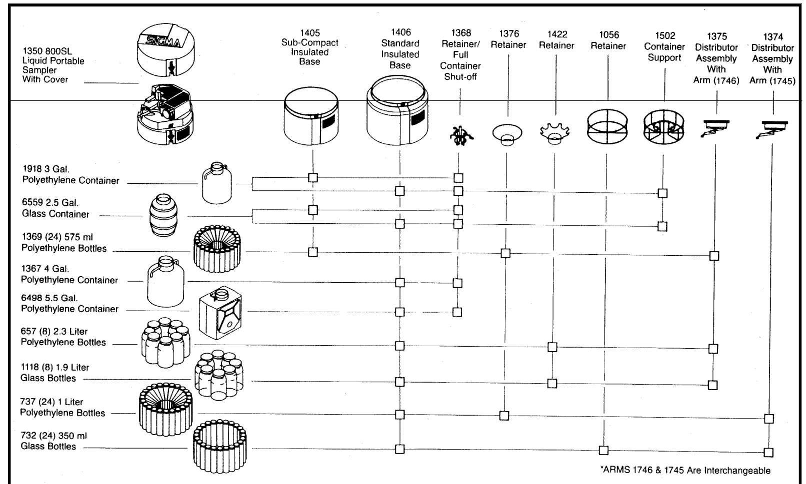
23

Outfall Monitoring to Characterize Land Use Discharges and to Measure Benefits of Distributed Stormwater Controls

24



25



26

26

Advantages and Disadvantages of Manual and Automatic Sampling

Type	Advantages	Disadvantages
Manual	Low capital cost	Probability of increased variability due to sample handling
	Point-in-time characterization	Not a composite unless long duration visit
	Compensate for various situations	Inconsistency in collection
	Note unusual conditions	High cost of labor
	No maintenance	Repetitious and monotonous task for personnel
	Can collect extra samples in short time when necessary	
Automatic	Consistent samples	Considerable maintenance for batteries and cleaning; susceptible to plugging by solids
	Probability of decreased variability caused by sample handling	Restricted in size to the general specifications
	Minimal labor requirement for sampling	Inflexibility
	Has capability to collect multiple bottle samples for visual estimate of variability and analysis of individual bottles	Sample contamination potential
		Subject to damage by vandals

27

27

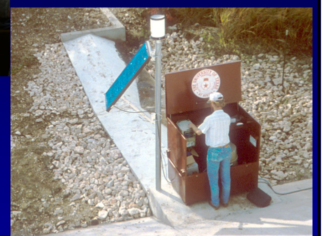
Monitoring Equipment Descriptions

- Automated Precipitation Measurement (Recording rain gauge)
- Manual Precipitation Measurement (Non-recording rain gauge) as a standard
- Automated Flow Measurement (primary devices including pipes, gutter, flumes and weirs, and secondary devices including bubbler level sensor and area-velocity sensors).
- Manual Flow Measurement (direct velocity reading using velocity meter or similar device combined with level measurement using field rulers) to calibrate automatic flow measurement equipment.
- Automated Water Quality Sample Collection (composite sampling equipment).
- Field Water Quality Measurement (pH, temperature, ORP, dissolved oxygen, turbidity, and conductivity meters).

28

Automatic ISCO sampler used to monitor snowmelt in Toronto, Ontario, manhole

ISCO sampler used in instrument shelter with flow monitoring and telemetry equipment in Madison, WI



Intermittent stream monitoring in Austin, TX

29

29

Refrigerated automatic sampler located at detention pond outfall in Madison, WI

Discrete sample bottle base for ISCO automatic sampler.

Composite sample bottle from Toronto snowmelt sampler.

30

30

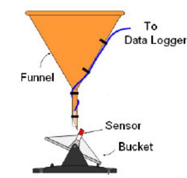
Losses of Particles in Automatic Sampler Intake Lines

	30 cm/sec flow rate		100 cm/sec flow rate	
	Critical settling rate (cm/sec)	Size range (µm, for ρ = 1.5 to 2.65 g/cm^3)	Critical settling rate (cm/sec)	Size range (µm, for ρ = 1.5 to 2.65 g/cm^3)
100% loss	30	2,000 - 5,000	100	8,000 - 25,000
50% loss	15	800 - 1,500	50	3,000 - 10,000
25% loss	7.5	300 - 800	25	1,500 - 3,000
10% loss	3.7	200 - 300	10	350 - 900
1% loss	0.37	50 - 150	1	100 - 200

Typical 3/8 inch sample line is about 9,500 µm in diameter (about the same for holes in inlet strainer) which restricts the absolute maximum size particle. Goal of 10% maximum loss associated with about 350 µm particles, or less, for super-speed sampler.

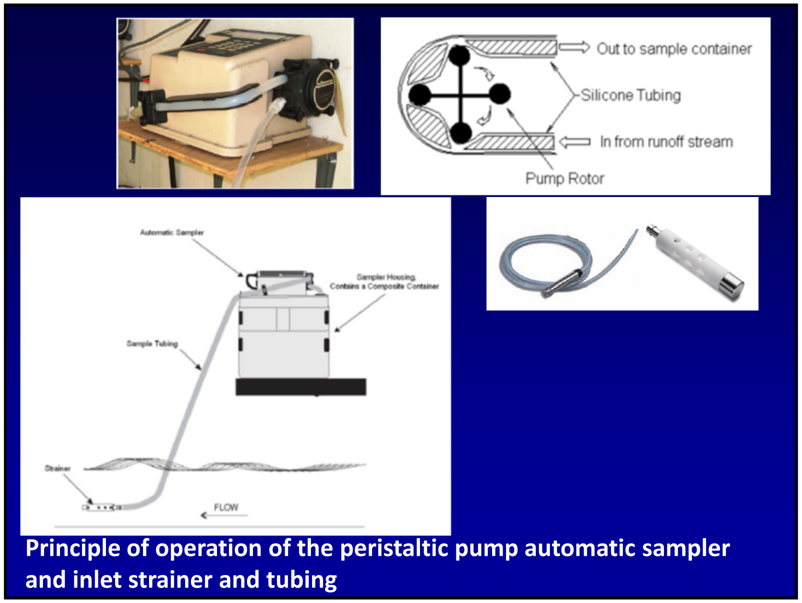
31

31



Non-Recording Rain Gauge and Tipping Bucket Rain Gauge

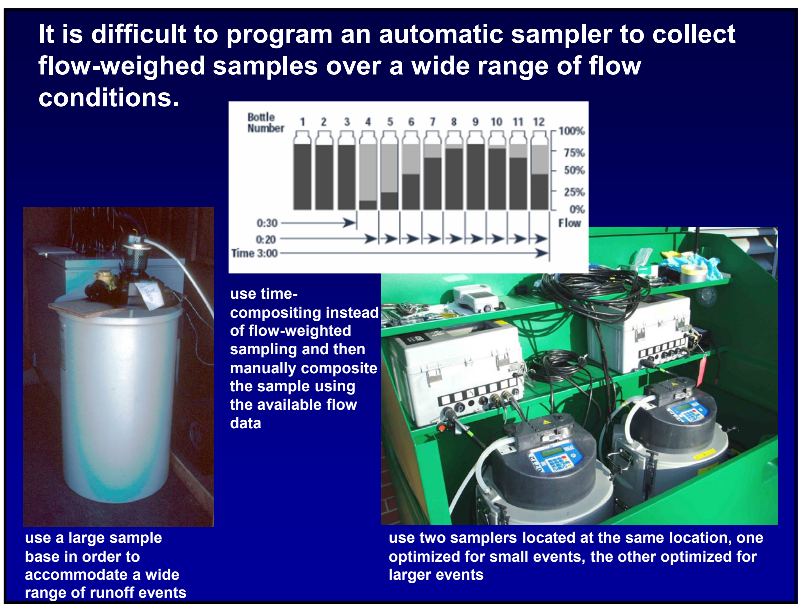
32


Out to sample container
Silicone Tubing
In from runoff stream
Pump Rotor
Automatic Sampler
Sampler Housing, Contains a Composite Container
Sample Tubing
Strainer
FLOW
Principle of operation of the peristaltic pump automatic sampler and inlet strainer and tubing

33


Many stormwater monitoring configurations used over the years

34


It is difficult to program an automatic sampler to collect flow-weighed samples over a wide range of flow conditions.
Bottle Number
1 2 3 4 5 6 7 8 9 10 11 12
100%
75%
50%
25%
0%
Flow
0:30
0:20
Time 3:00
use time-compositing instead of flow-weighted sampling and then manually composite the sample using the available flow data
use a large sample base in order to accommodate a wide range of runoff events
use two samplers located at the same location, one optimized for small events, the other optimized for larger events

35


USGS and WI DNR Monitoring Facility for Hydrodynamic Separator Tests, Madison, WI

36

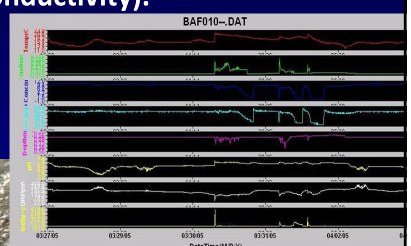
Simple methods to obtain representative sample: create cascading and well-mixed flow at sampling location (well-mixed flow with bedload and no stratification). Examples shown for gutter and pipe flow installations.

37

End of pipe monitoring to check mass balance using source area flow and pollutant contribution calculations/modeling

38

The use of continuous water quality sondes can supplement other sampling programs by providing high resolution data for a variety of constituents (turbidity, temperature, DO, ORP, and conductivity).



Effluent cascading onto water quality sonde

Sonde data analysis screen showing ten days of high-resolution (every 15 minute) water quality measurements

39

Issues Concerning Stormwater that May Need to be Addressed

- Rainfall patterns must be considered for area being studied, and accurate flow measurements are necessary as performance is commonly related to hydraulic conditions. Most flow instruments must be calibrated at the site.
- The variability of stormwater quality must be considered when designing a sampling program.
- Incorrectly reported data can have a very large effect on many statistical analyses
- Variability of stormwater quality does not always vary as anticipated ("first-flush" relatively rare, unless mostly paved areas and small drainage areas; little relationship with rain depth of event, but stronger relationship with peak rain intensity energy)
- Sources of flows and pollutants vary with land use and development characteristics

40

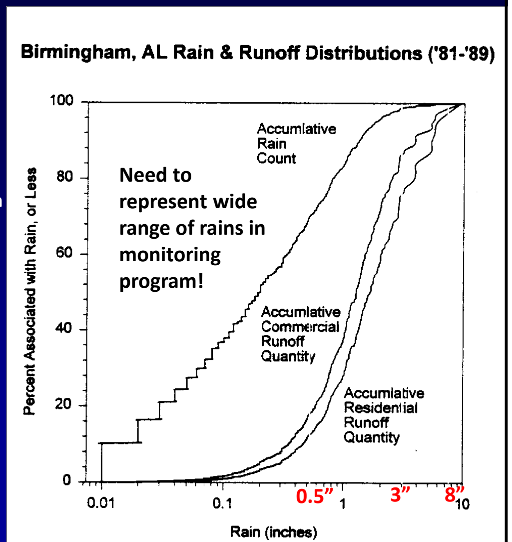
Probability distribution of rains (by count) and runoff (by depth). Central Alabama Rain Condition:

<0.5" (<10 mm): 65% of rains (10% of runoff). Need to focus on these rains!

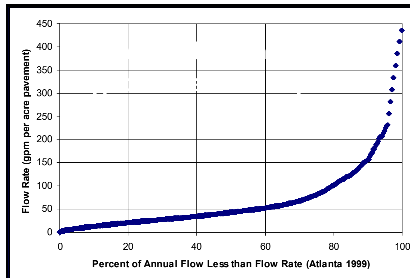
0.5 to 3" (10 to 75 mm): 30% of rains (75% of runoff). We therefore need to focus on these rains!

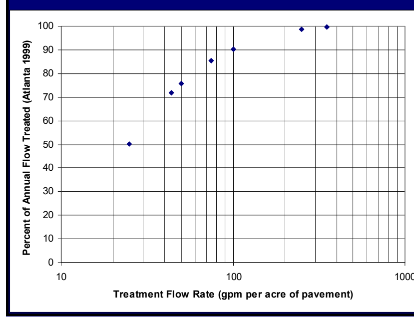
3 to 8" (75 to 400 mm): 4% of rains (13% of runoff). Channel stability issues. Need to focus on these rains!

>8" (>400 mm): <0.1% of rains (2% of runoff). Safety issues; need to focus on these rains!



41





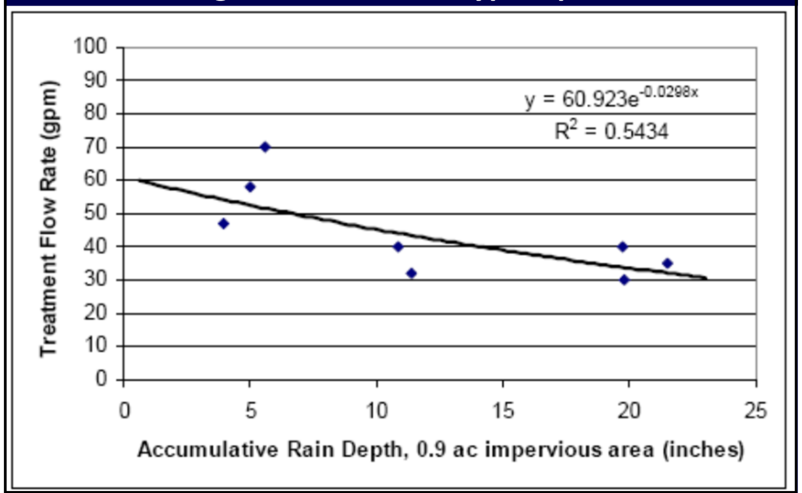
Continuous Simulation can be used to Determine Needed Treatment Flow Rates:

- 90% of the annual flow for SE US conditions is about 170 gpm/acre pavement (max about 450).

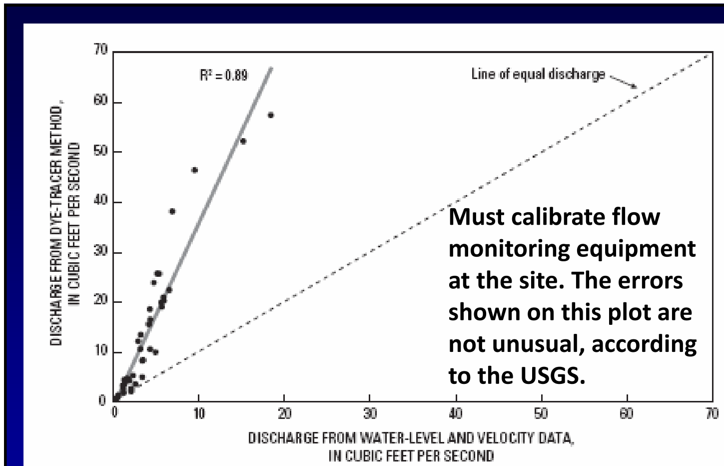
- treatment of 90% of annual runoff volume would require treatment rate of about 100 gpm/acre of pavement. More than three times the treatment flow rate needed for NW US.

42

Treatment Flow Rate Changes during 10 Month Monitoring Period of Prototype UpFlo™ Filter



43

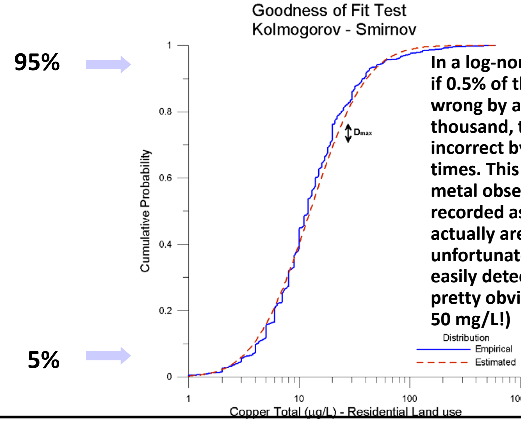


Relation between actual discharges determined using a rhodamine dye tracer and measured discharges, computed by water-level and velocity data, during free-flow conditions and actual runoff events (Selbig and Bannerman 2008)

44

Typical Stormwater Constituent Probability Distribution

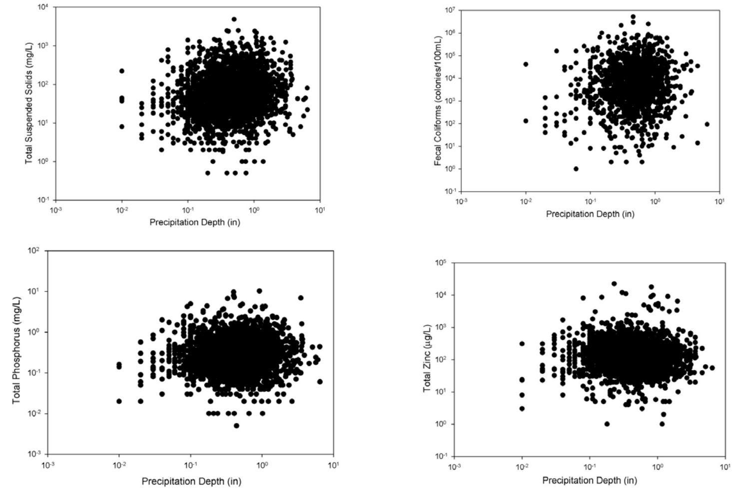
Many stormwater constituent concentrations are log-normally distributed between about the 5th and 95th percentiles of the observations (this example is for several thousand residential stormwater copper observations from the National Stormwater Quality Database, NSQD)



In a log-normal distribution, if 0.5% of the samples are wrong by a factor of a thousand, the COV will be incorrect by more than 10 times. This can occur when metal observations are recorded as mg/L when they actually are µg/L, an unfortunately common, but easily detected error (it's pretty obvious that Cu is not 50 mg/L!)

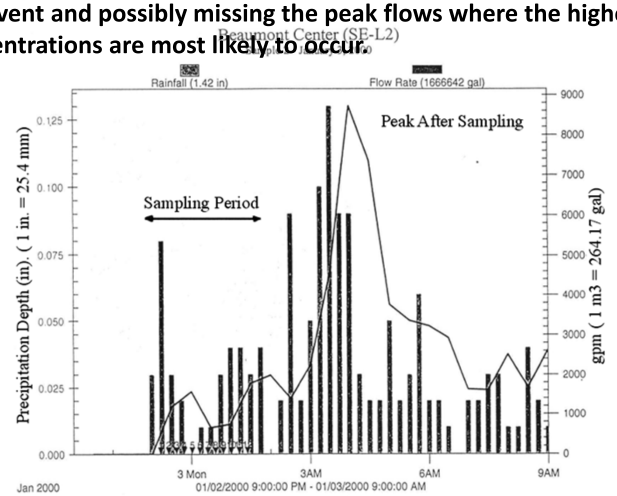
45

Plots of concentrations vs. rain depth typically show random patterns (several thousand residential stormwater quality data observations from the NSQD).

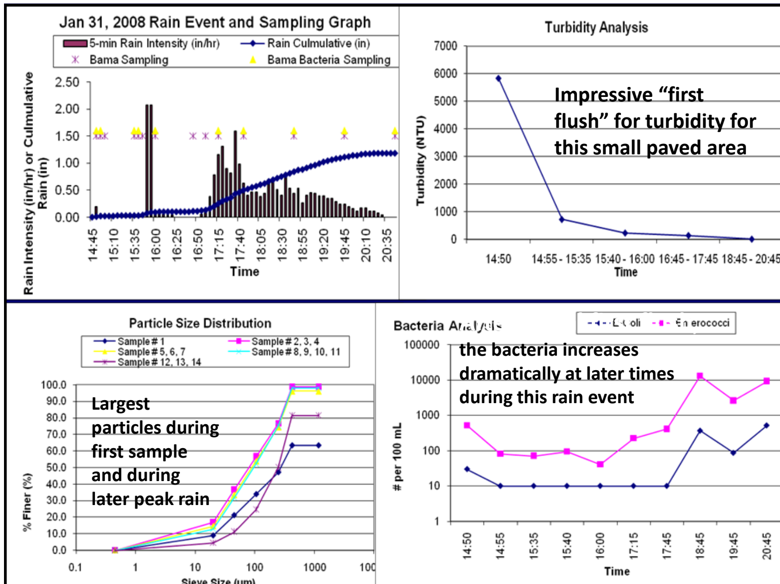


46

Many US NPDES stormwater monitoring programs only monitor the first three hours of the runoff event, possibly missing much of the event and possibly missing the peak flows where the highest concentrations are most likely to occur.



47



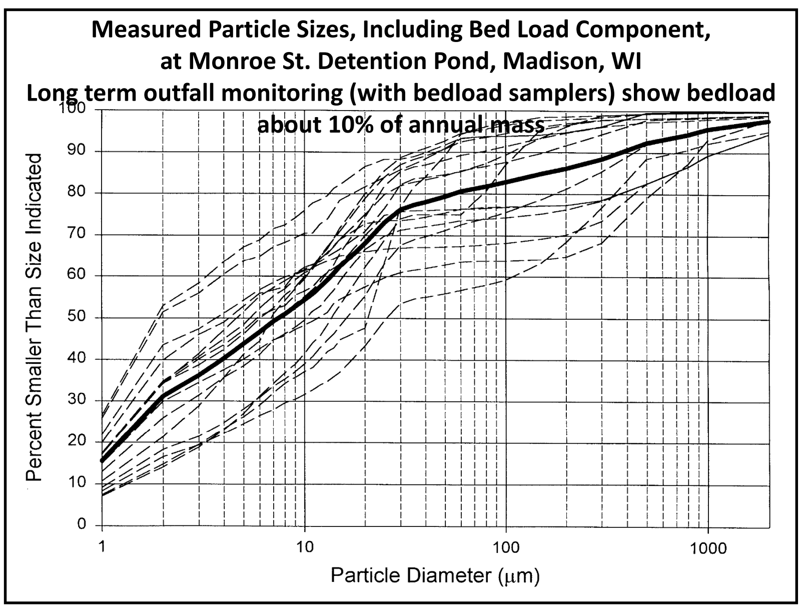
48


Stormwater Quality Variability Can be High, Even for One Location During a Single Storm Event – Can Reflect Different Sources Contributing Flows at Different Times of Runoff

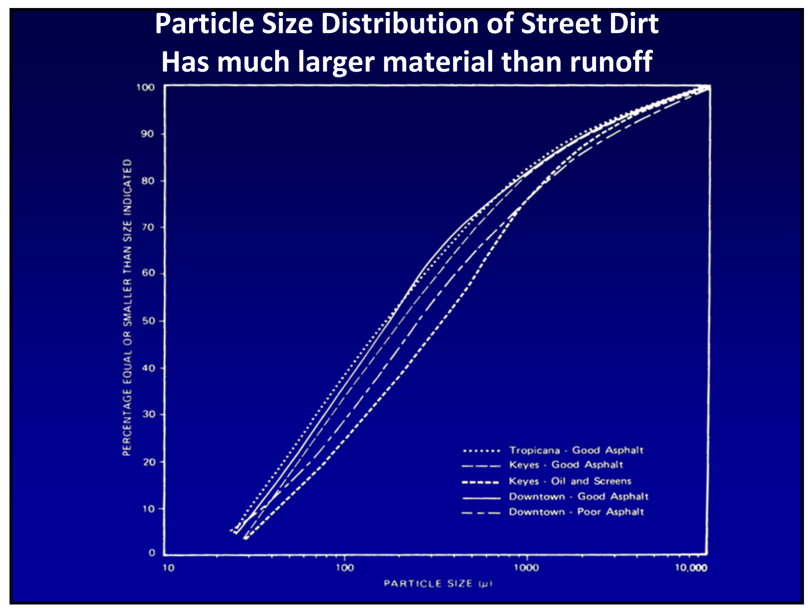
49


Evidence of relatively large stormwater particulates seen in areas of sediment accumulation. This is an inlet to a wet pond in Colorado where large amounts of sand were used for traction control. This accumulation is from several winters time.

50


Measured Particle Sizes, Including Bed Load Component, at Monroe St. Detention Pond, Madison, WI
Long term outfall monitoring (with bedload samplers) show bedload about 10% of annual mass
Percent Smaller Than Size Indicated
0
10
20
30
40
50
60
70
80
90
100
1
10
100
1000
Particle Diameter (µm)

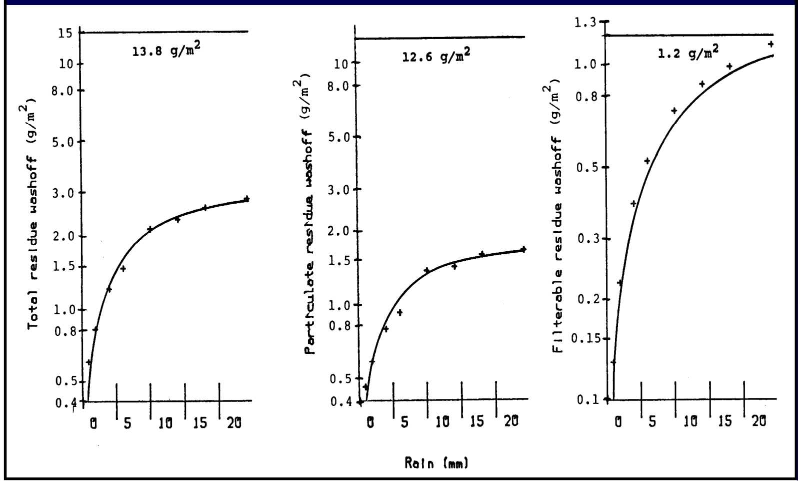
51


Particle Size Distribution of Street Dirt
Has much larger material than runoff
PERCENTAGE EQUAL OR SMALLER THAN SIZE INDICATED
0
10
20
30
40
50
60
70
80
90
100
10
100
1000
10,000
PARTICLE SIZE (µ)
Tropicana - Good Asphalt
Keyes - Good Asphalt
Keyes - Oil and Screens
Downtown - Good Asphalt
Downtown - Poor Asphalt

52

Washoff Plots for Heavy Rain Intensities, Dirty Streets, and Rough Pavement Textures

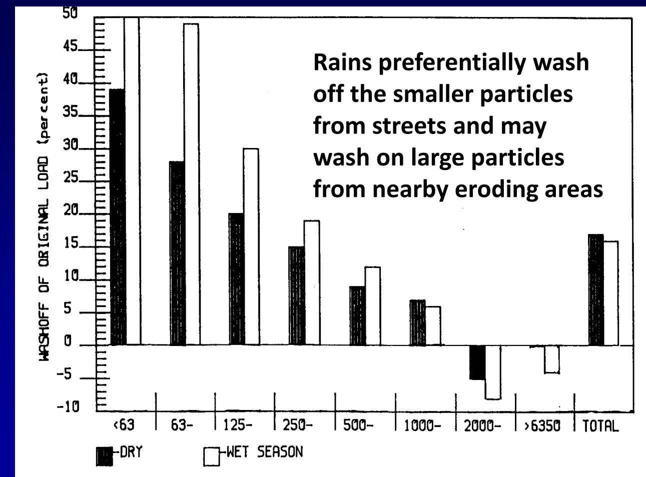
Only about 10 to 25% of street dirt washes off streets during rains



53

Washoff of Street Dirt, Bellevue, WA

Monitored results during actual rains over 2 year period



Pitt 1985

54

Receiving Water Monitoring

55

55

Fate of stormwater pollutants and actual receiving water effects need to be directly monitored

56

Programming Stormwater Samplers

- Need to program automatic samplers to collect samples under a wide-range of flow conditions.

Programming an Automatic Sampler

Automatic samplers go through three phases to collect a sample. First, the sample line is back-flushed to minimize sample cross-over and to clear debris from the sample intake. Next, the sample is collected. Finally, the sample is back-flushed again before going into a sleep mode to await the next sampling instruction. It can require several minutes to cycle through this process. A volume of 1850 mL of water fills a 10 mm (3/8 inch) diameter sample line that is 7.5 meters (25 feet) long. If a sample volume of 350 mL is to be collected for each sample interval, the following total volume of water is pumped by the sampler for each sample instruction:

back-flush line:	1850 mL
fill tube:	1850 mL
collect sample:	350 mL
back-flush line:	1850 mL

This totals about 6 L of water to be pumped. Typical automatic samplers have a pumping rate of about 3.5 L per minute for low head conditions (about 1 meter). It would therefore require about 1.7 minutes to pump this quantity of water. With pump reversing and slower pumping speeds at typical pumping heads, this could easily extend to 2 minutes, or more. If the sampler collects 3 liters of sample instead of 350 mL, then another minute can be added to this sampling time for one cycle.

58

Automatic samplers can generally operate in two sampling modes, based on either time or flow increments. The sample bases can generally hold up to 24 bottles, each 1 L in volume. A single sample bottle of up to about 20 L is generally available for compositing the sample into one container. These bottle choices and the cycle time requirements of automatic samplers restrict the range of rain conditions that can be represented in a single sampler program for flow-weighted sampling.

It is important to include samples from small rains (from about 0.01 to 0.2 inch) in a stormwater sampling program because they are very frequent and commonly exceed numeric water quality criteria. Moderate sized rains (from about 0.2 to 3 inches) are very important because they represent the majority of flow (and pollutant mass) discharges. The largest rains (greater than about 3 inches) are important from a drainage design perspective to minimize flooding and safety problems.

It is very difficult to collect a wide range of rain depths in an automatic sampler using flow-weighted sampling. Conflicts occur between needing to have enough sub-samples during the smallest event desired (including obtaining enough sample volume for the chemical analyses) and the resulting sampling frequency during peak flows for the largest sampling event desired.

59

Problem: desired minimum rain to be sampled: 0.15 inch in depth, 4 hour runoff duration, having a 0.20 Rv (volumetric runoff coefficient); largest rain desired to be sampled: 2.5 inch in depth, 12 hour runoff duration, having a 0.50 Rv; the watershed is 250 acres in size and 3 samples, at least, are needed during the smallest rain.

The calculated total runoff for these conditions is therefore:

minimum rain: 0.10 (0.15 in) (250 ac) (ft/12 in) (43,560 ft^2/ac) = 13,600 ft^3.

maximum rain: 0.50 (2.5 in) (250 ac) (ft/12 in) (43,560 ft^2/ac) = 1,130,000 ft^3.

The average runoff flow rates expected are roughly estimated to be:

minimum rain: (13,600 ft^3/4 hr) (hr/3600 sec) = 0.95 ft^3/sec.

maximum rain: (1,130,000 ft^3/12 hr) (hr/3600 sec) = 26 ft^3/sec.

Based on monitoring of many runoff events, the peak flows are estimated to be about 3.8 times these average flow rates:

minimum rain: 3.6 ft^3/sec.

maximum rain: 100 ft^3/sec.

60

As the smallest storm is to be sampled three times during the runoff period, the volume of flow per sub-sample is simply:

13,600 ft^3/3 @ 4,500 ft^3.

Therefore, the total number of samples collected during the maximum rain would be:

1,130,000 ft^3/4,500 ft^3 @ 250 samples.

If the minimum sample volume required was 1 L, then each sub-sample could be as small as 350 mL. This would result in about 1 L of sample during the minimum storm, but would result in about 90 L during the maximum storm (obviously much larger than the typical 10 to 20 L container). During the estimated high flow conditions of the largest storm, a sub-sample would be collected every:

4,500 ft^3 per sample/100 ft^3/sec @ 45 seconds

61

61

If the sampler required 2 minutes to collect 350 mL, the sampler would not complete its cycle before it was signaled to collect another subsample. This would result in the sampler pump running continuously during this peak time. Since the peak flow period is not expected to have a long duration, this continuous pumping may not be a serious problem, especially considering that about 250 samples are being collected. The biggest problem with this setup is the large volume of sample collected during the large event.

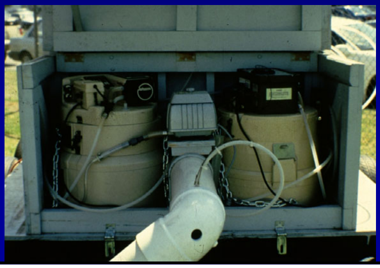
Automatic sampler with large base for monitoring wide range of flows, with large chest freezer USGS discrete sampler in background, at Bellevue, WA

Alternatives to using a large sample base in order to accommodate a wide range of flows include:

- use time-compositing instead of flow-weighted sampling (if discrete sampling, the individual time-initiated samples can be manually composited after the event, but this requires substantial labor time),
- use two samplers located at the same location, one optimized for small flows, the other optimized for larger, or
- visit the sampling station during the storm and re-program the sampler, switch out the bottles, or manual sample.

62

62

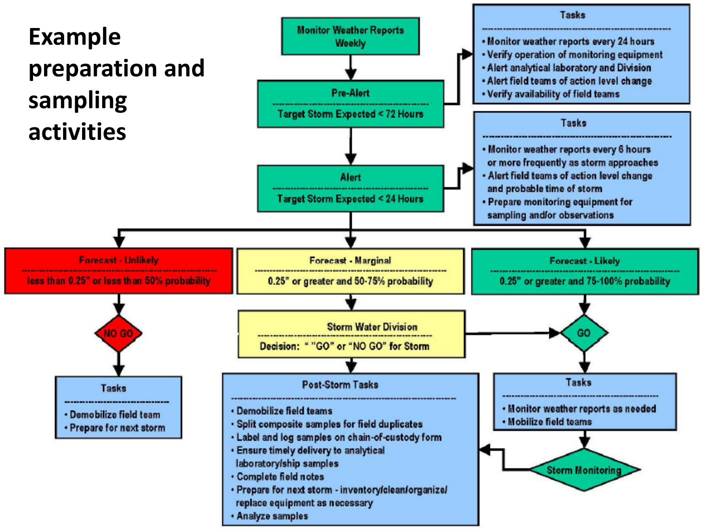


Double monitor setups for sampling over a wide range of flow conditions

63

63

Example preparation and sampling activities



64

Programming of Automatic Samplers

- System counters (e.g., precipitation, runoff volume, sample count, etc.) are reset to zero.
- The mode is switched from non-storm monitoring mode to storm monitoring mode, which typically will increase data collection frequency (to 1-minute logging intervals) and allow the system to begin sample collection once thresholds are met.
- Thresholds are set for sampling locations to allow stations to enter sample collection mode. Thresholds can include the minimum precipitation amount, flow depth, or flow volume required to initiate the sample collection routine.
- For flow-paced sampling, the flow volume per sample (i.e., the flow volume that passes between each composite aliquot collected) is set based on the expected amount of runoff generated from the rainfall event.
- The system must have "start sampling" and "stop sampling" options that can be selected when appropriate (e.g., at the beginning of a storm, during bottle changes, at the end of a storm).
- When samples have been collected, the sampling event is terminated and software is switched back to the non-storm monitoring mode.
- Data are downloaded from the datalogger to a personal computer immediately following the storm event.

65

Sample Number Requirements

Coefficient of Variation, *CV*, of Percent Removal	Statistical Confidence Level, 1-α	Power of Detecting Specified Percent Removal, 1-β	Sample Size to Detect Specified Percent Removal	
			25%	50%
0.4	90%	80%	9	3
0.6	90%	80%	18	4
0.8	90%	80%	28	6

66

Example Stormwater Monitoring (San Diego evaluation of biofilter)

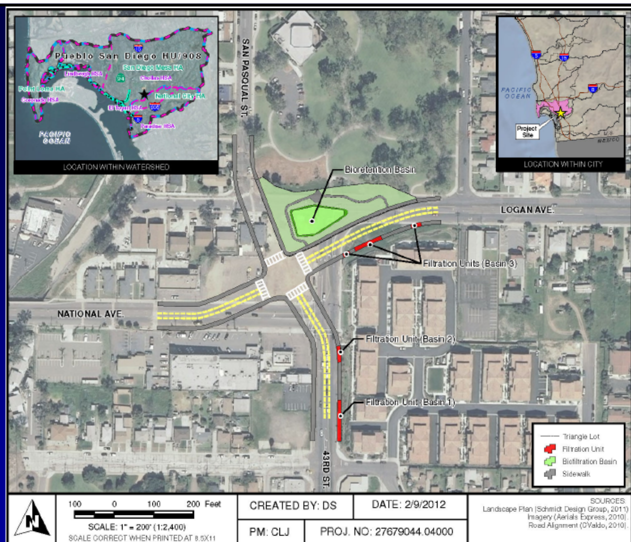
67

67

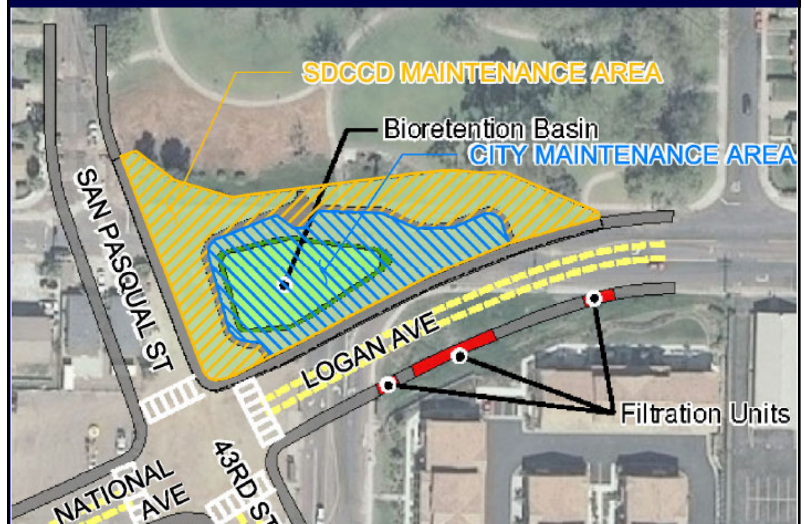
Sampling Information Needs

- Model sites for expected runoff conditions (runoff volume vs. rain depth; concentrations expected; expected performance)
- Bottles and preservatives
- Sampler programming (volume per sample pulse as a function of sample volume needs)
- Maintenance issues (clogging, bypassing, chemical capacity)
- Design suggestions (sizes of treatment units, etc.)

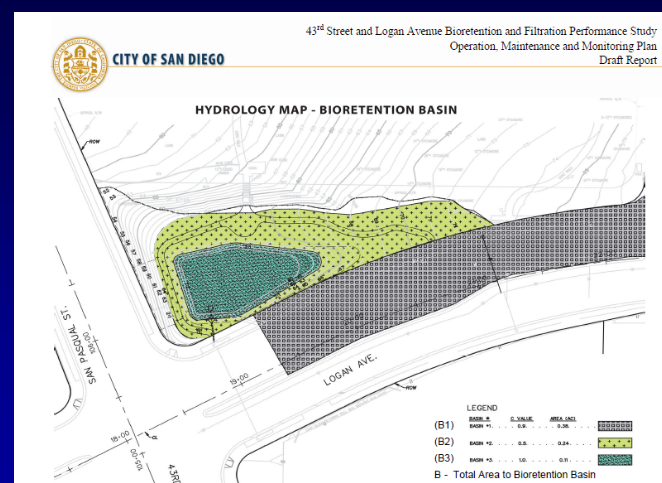
68



43rd and Logan Bioretention and Filtration Performance Study Site Map



Site Name	Location	Type of BMP	Monitoring Sample Location Description	Type of Samples
Bior-I	N. of Intersection of 43rd Street and Logan Avenue	Bioretention Basin	Modified Reverse Curb Outlet	Stormwater
Bior-E	N. of Intersection of 43rd Street and Logan Avenue	Bioretention Basin	Perforated Drain Pipe Entering Type F Catch Basin	Stormwater
Bior-B	N. of Intersection of 43rd Street and Logan Avenue	Bioretention Basin	Outlet Pipe from Type F Catch Basin	N/A – Flowrate only
Filt-I	NW Corner of 43rd Street and Newton Ave. – gutter flow line	Filtration Unit	Gutter Upstream of 1st Filtration Unit Curb Inlet Opening	Stormwater
Filt-E	E. 43rd Street just S. of Intersection with Logan Ave. Catch Basin drain from Filtration Units	Filtration Unit	Perforated Drain Pipe Entering Catch Basin Downstream of Filtration Unit	Stormwater
Filt-B	E. 43rd Street just S. of Intersection with Logan Ave. Catch Basin Flow (Bypass from Filtration Units)	Filtration Unit	Catch Basin Downstream of Filtration Unit at Curb Inlet Opening	N/A – Flowrate only

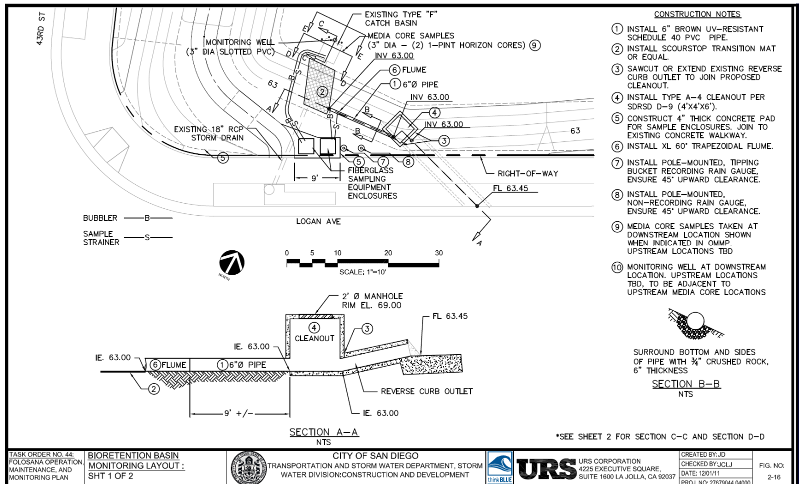


Drainage Map – Bioretention Basin "Triangle Lot"

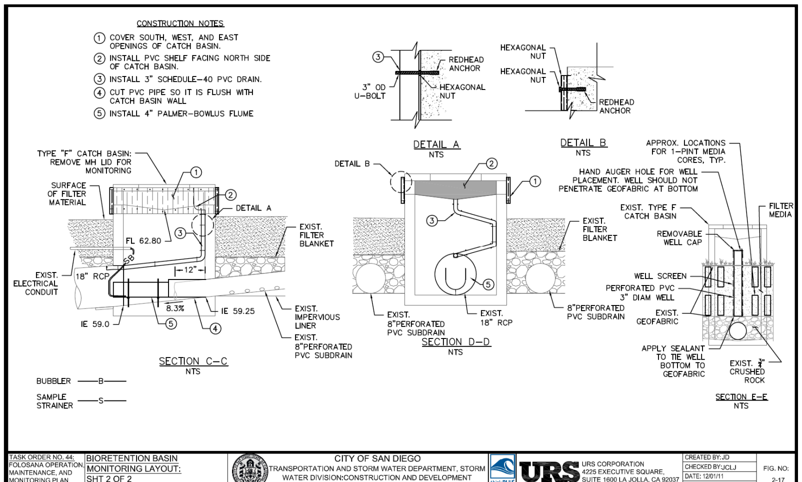
Comparison of Watershed Areas and Land Uses

Watershed	HSA No.	Land Use										
		Ag	Auto	Comm.	Ind.	Inst.	Parks	LDR	HDR	Roads	Trans.	Water
City of San Diego (all watersheds)	-	4,618 2.4%	341 0.2%	6164 3.2%	10,952 5.8%	15,027 7.9%	83,935 44.1%	38,558 20.3%	13,384 7.0%	7,405 7.0%	4,091 2.1%	5,829 3.1%
Chollas (within City boundary)	908.22	14.43 0.1%	30.97 0.2%	695.39 5.1%	518.93 3.8%	1,177.08 8.6%	2,397.83 17.5%	4,967.80 36.3%	2,643.57 19.3%	967.62 7.1%	234.93 1.7%	32.42 0.3%
Triangle Lot	908.22	-	-	-	-	-	0.33 46.47%	-	-	0.38 53.53%	-	-
Monitored Filtration Unit (Basin F1)	908.22	-	-	-	-	-	-	0.99 46.70%	0.21 9.90%	.092 43.40%	-	-
Unmonitored Filtration Unit (Basin F2)	908.22	-	-	-	-	-	-	-	-	0.25 100%	-	-
Unmonitored Filtration Unit (Basin F3)	908.22	-	-	0.44 12.98%	-	-	-	0.42 12.40%	0.27 7.96%	2.26 66.66%	-	-

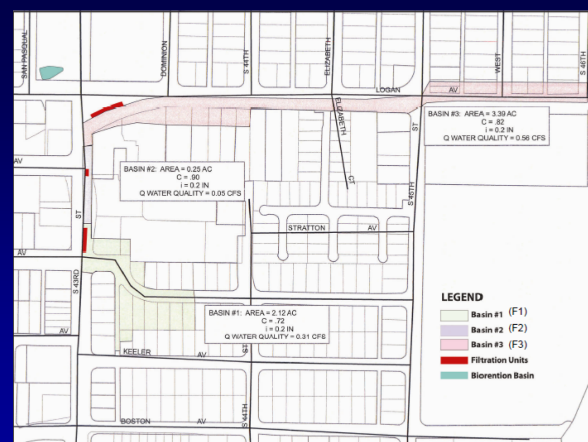
73



74



75



Drainage Map – Filtration Unit Stormwater Controls – 43rd Street and Logan Avenue

76

Basin Land Use and Composite Runoff Coefficient for Filtration Units and Bioretention Basin

Basin	Land Use	Area (acres)	C	Composite C	Rainfall Intensity (in)	Water Quality Event Runoff (cfs)
F1	Single Family Residential	0.99	0.55			
	Multi-Family	0.21	0.70			
	Street	0.92	0.90			
	Total	*2.12*		*0.72*	*0.20*	*0.56*
F2	Street	0.25	0.90			
	Total	*0.25*		*0.90*	*0.20*	*0.05*
F3	Single Family Residential	0.42	0.55			
	Multi-Family	0.27	0.70			
	Commercial	0.27	0.85			
	Street	2.26	0.90			
	Vacant	0.17	.050			
	Total	*3.39*		*0.82*	*0.20*	*0.56*
B	Street (B1)	0.38	0.38			
	Park, vegetated (B2)	0.24	0.24			
	Park, bioretention basin (B3)	0.11	0.11			
	Total	*0.73*		*0.78*	*0.20*	*0.11*

Notes:
F designates Filtration Unit drainage area.
B designates the bioretention basin's drainage area.

77

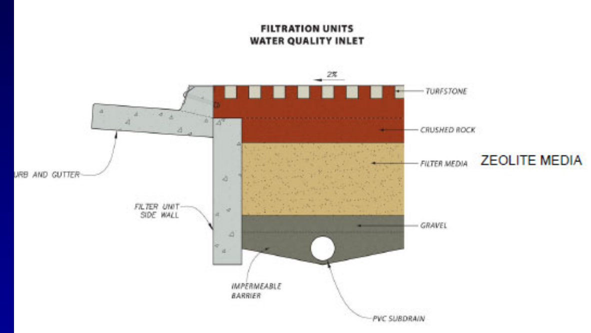
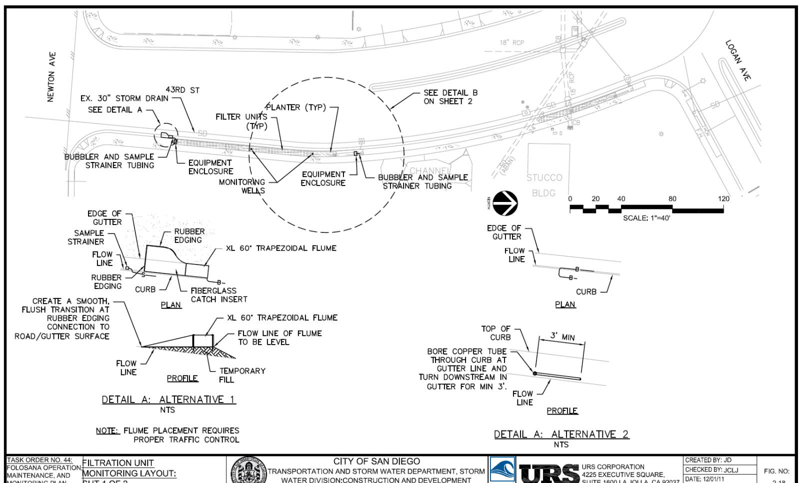
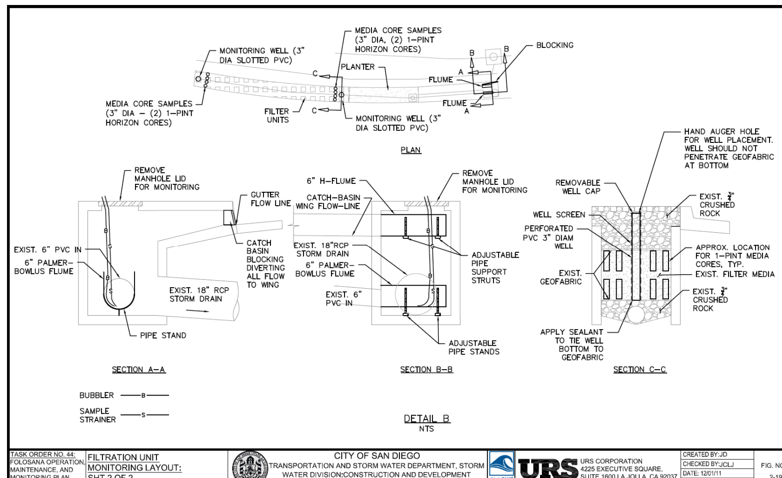


Figure 2-6. Schematic of Filtration Unit BMP

78



79



80

Site Inspections

- Photo documentation of site conditions and accumulation of gross solids.
- Recording visual estimates of the total volume of gross solids and percent composition by volume of trash, sediment, and organic debris (i.e., leaf litter and other vegetative material) in the stormwater control, curb and gutter both upstream and downstream of the stormwater controls, and in the catch basin immediately downstream of the stormwater control.
- Visual assessment of stormwater control for clogging.
- Visual inspection for proper drainage of the stormwater control (no standing water) in the monitoring wells.
- Inspection for presence of vectors.
- Noting condition of treatment media.
- Documenting observations related to stormwater control integrity/structural deterioration.
- Notifying Division Project Manager of any maintenance issues that require immediate attention.

81

Chain-of-Custody Form

Laboratory: Lab #
Date Rec'd

From:
Consultant Name
Address
Telephone Number
Fax Number

Project Name:
P.O.#:

Project #:
Required Completion Date:

Sample ID #	Site ID #	Lab ID #	Matrix/Analysis	Containers	Pres.	Sample Date/Time	Condition Upon Receipt

Data Reports **MUST** include the following: Sample/Site ID, Analytical Method, Detection Limit, Date of Extraction if applicable, Date of Analysis, Analytical Results and Signature of QA Reviewer.

Special Instructions/Comments:

Relinquished By: Date/Time	Transporter	Received By: Date/Time
Relinquished By: Date/Time	Transporter	Received By: Date/Time
Relinquished By: Date/Time	Transporter	Received By: Date/Time

82

Analyte	Target Detection		Analytical Technique	Method Number
	Limit	Units		
Conventionals				
Hardness as $CaCO_3$	2.0	mg/L	titrimetric/colorimetric; ICP, calculation	EPA 130.2; 130.1, 200.7; SM 2340B, 2340C
Turbidity	0.05	NTU	Nephelometric	EPA 180.0; SM 130B, 2130B
Total Suspended Solids (TSS)	1.0	mg/L	dried filter weight	EPA 160.2, SM 2540D
Total Dissolved Solids (TDS)	1	mg/L	Gravimetric	EPA 160.1/ SM 2540C
Suspended Sediment Concentration (SSC)	1	mg/L	Gravimetric	ASTM D3977; SM 2450 F
Particle Size Distribution	varies	mg/kg	Beckman-Coulter Counter, Laser Particle Counter	ASTM 4464; Bob Pitt's Method
Conductivity	0.1	µmhos/cm	conductivity meter	EPA 120.1; SM 2510B
pH	0.1	std. units	Electrometric	EPA 150.1; SM 4500H+B
Redox Potential	1	mV	Electrode	ASTM D-1498; SM 2580
Biochemical Oxygen Demand (BOD)	1	mg/L	Electrode	SM 5210B
Chemical Oxygen Demand (COD)	5	mg/L	Colorimetric	SM 5220C, 5220D
Total Organic Carbon (TOC)	0.5	mg/L	Combustion	SM 5310D
Dissolved Organic Carbon (DOC)	0.5	mg/L	Combustion	SM 4500-O G, 5310B
Nutrients				
Nitrate as Nitrogen (NO3-N)	0.1	mg/L	IC	EPA 300.0
Nitrite as Nitrogen (NO2-N)	0.1	mg/L	IC	EPA 300.0; SM 4500NO2B
Ammonia Nitrogen (NH3-N)	0.1	mg/L	Electrode; Titrimetric	SM 4500-NH3 B
Total Kjeldahl Nitrogen (TKN)	0.1	mg/L	Colorimetric; Titrimetric; Potentiometric	EPA 351.2, 315.3
Total Nitrogen (TN)	0.1	mg/L	Calculation	SM4500-NORG B
Total Phosphorus	0.03	mg/L	Colorimetric	EPA 365.2; SM 4500PB
Dissolved Ortho-Phosphorus	0.1	mg/L	IC	EPA 300, 365.2

83

Analyte	Target Detection		Analytical Technique	Method Number
	Limit	Units		
Major Ions				
Sulfide, Total	0.5	mg/L	Colorimetric	SM 4500 S2-D
Chloride	1.0	mg/L	IC	EPA 300.0
Sulfate	0.5	mg/L	IC	EPA 300.0
Sodium	0.5	mg/L	ICP	EPA 200.7
Calcium	1.0	mg/L	ICP	EPA 200.7
Magnesium	0.1	mg/L	ICP	EPA 200.7
Potassium	0.5	mg/L	ICP	EPA 200.7
Silicon	0.05	mg/L	ICP	EPA 200.7
Boron	0.02	mg/L	ICP	EPA 200.7
Fluoride	0.1	mg/L	Titrimetric	SM 4500 F C
Metals (Total Recoverable and Dissolved)				
Aluminum	0.05	mg/L	ICP-MS; ICP	EPA 200.7, 200.8
Antimony	0.001	mg/L	ICP-MS	EPA 200.8
Arsenic	1.0	µg/L	GF-AA; ICP-MS	EPA 206.3; 1632a; 200.8
Barium	0.001	mg/L	ICP-MS	EPA 200.8
Beryllium	0.001	mg/L	ICP-MS	EPA 200.8
Cadmium	0.2	µg/L	GF-AA; ICP-MS	EPA 213.2; 200.8b
Chromium	1.0	µg/L	GF-AA; ICP-MS	218.2; 200.8b
Cobalt	0.001	mg/L	ICP-MS	EPA 200.8
Copper	1.0	µg/L	GF-AA; ICP-MS	220.2; 200.8b
Iron	0.05	mg/L	ICP-MS	EPA 200.8
Lead	1.0	µg/L	GF-AA; ICP-MS	239.2; 200.8b
Mercury	0.002	mg/L	CV-AA	EPA 245.1
Molybdenum	0.001	mg/L	ICP-MS	EPA 200.8
Nickel	2.0	µg/L	GF-AA; ICP-MS	249.2; 200.8b
Selenium	0.001	mg/L	ICP-MS	EPA 200.8
Silver	0.001	mg/L	ICP-MS	EPA 200.8
Thallium	0.001	mg/L	ICP-MS	EPA 200.8

84

Analyte	Target Detection Limit	Target Detection Units	Analytical Technique	Method Number
Zinc	5.0	µg/L	GF-AA; ICP-MS	289.2; 200.8b
Biologicals				
Total Coliform	1	MPN/100mL	Incubation	SM 9221B
Fecal Coliform	1	MPN/100mL	Incubation	SM 9221E
Enterococcus	1	MPN/100mL	Incubation	SM 9230B
Organics				
Oil and Grease	1	mg/L	Gravimetric	EPA 1664
TPH (Diesel)	13.6	µg/L	GC-MS	EPA 8015DRO
TPH (Gasoline)	12.4	µg/L	GC-MS	EPA 8015GRO
TPH (Motor oil)	39.4	µg/L	GC-MS	EPA 8015DRO
Chlordane	0.5	µg/L	GC-ECD	EPA 608
DDT	0.05	µg/L	GC-ECD	EPA 608
Diazinon	0.005	µg/L	GC-NPD	EPA 8141
PAHs	10, 25, 50	µg/L	GC-NPD; GC-MS	EPA 610/8100, 8270
Organochlorine Pesticides and PCBs	0.2	µg/L	GC-ECD	EPA 8081/8082/608
Arochlor and PCB Congeners	0.5 / 0.2	µg/L	GC-MS	EPA 8270 SIM
Organophosphorus Pesticides	0.01, 0.02, 0.04, 0.005	mg/L	GC-NPD	EPA 614/ 8141
Synthetic Pyrethroid Pesticides	0.002	µg/L	GC-MS SIM	EPA 8270

Notes:

a EPA Method 1632 is an additional available "clean technique" GH-AA method that can be used for this constituent. EPA method approval is in progress.

b EPA Method 1638 is an additional available "clean technique" GH-AA method that can be used for this constituent. EPA method approval is in progress.

85

Recommended Quality Control Sample Frequency

QA/QC Sample Type	Minimum Sampling Frequency	Constituent Class
Field Duplicate	Once every ten samples collected at a given sampling station.	All
Laboratory Duplicate	Once every ten samples collected at a given sampling station.	All
Equipment Blank	Equipment blanks should be collected prior to each sampling season for each piece of equipment to be used for sample collection (tubing, strainers).	Metals and other common contaminants.[1]
Bottle Blank	Composite and sample bottles should be blanked every batch[2] at a 2% frequency; or manufacturer or laboratory-certified to concentrations below the reporting limits used for the sampling program.	Metals and other common contaminants. [1]
Field Blank	Once every ten samples collected at a given sampling station.	Metals and other common contaminants. [1]
Matrix Spike/Matrix Spike Duplicate	Once every ten samples collected at a given sampling station.	Metals and other common contaminants. [1]

86

Analyte	Holding Time	Minimum Sample Volume[a]	Container Type	Preservation
Conventionals				
Hardness as $CaCO_3$	6 months	100 mL	Glass or Plastic	4°C , $HN0_3$ or H_2SO_4 to pH < 2
Turbidity	48 hr	100 mL	Glass or Plastic	4°C
Total Suspended Solids (TSS)	7 days	100 mL	Glass or Plastic	4°C
Total Dissolved Solids (TDS)	7 days	500mL	Glass or Plastic	4°C
Suspended Sediment Concentration (SSC)	7 days	500mL	Glass or Plastic	4°C
Particle Size Distribution	24 hrs	1L	Glass	4°C
Conductivity	28 days	50 mL	Glass or Plastic	4°C; filter if hold time > 24 hrs
pH	Immediately	50 mL	Glass or Plastic	4°C
Redox potential	24 hrs	50 mL	Plastic	4°C
Biochemical Oxygen Demand (BOD)	48 hrs	300 mL	Plastic	4°C
Chemical Oxygen Demand (COD)	28 days	50 mL	Glass	4°C and H_2SO_4
Total Organic Carbon (TOC)	28 days	150 mL	Glass	4°C and H_2SO_4
Dissolved Organic Carbon (DOC)	28 days	150 mL	Glass	Field filter, 4°C and H_2SO_4
Nutrients				
Nitrate as Nitrogen (NO3-N)	48 hr	200 mL	Glass or Plastic	4°C
Nitrite as Nitrogen (NO2-N)	48 hr	200 mL	Glass or Plastic	4°C
Ammonia Nitrogen (NH3-N)	28 days	500 mL	Amber Glass	4°C and H_2SO_4
Total Kjeldahl Nitrogen (TKN)	28 days	500 mL	Glass or Plastic	4°C and H_2SO_4 to pH<2
Total Nitrogen (TN)	28 days	500 mL	Amber Glass	4°C and H_2SO_4
Total Phosphorus	28 days	100 mL	Glass or Plastic	4°C and H_2SO_4 to pH<2

87

Analyte	Holding Time	Minimum Sample Volume[a]	Container Type	Preservation
Dissolved Ortho-Phosphorus	48 hrs	50 mL	Plastic	4°C
Major Ions				
Sulfide, Total	7 days	50 mL	Plastic	$ZnAc_2$ and NaOH and 4°C
Chloride	28 days	50 mL	Plastic	4°C
Sulfate	28 days	50 mL	Plastic	4°C
Sodium	6 months	100 mL	Plastic	HNO_3
Calcium	6 months	100 mL	Plastic	HNO_3
Magnesium	6 months	100 mL	Plastic	HNO_3
Potassium	6 months	100 mL	Plastic	HNO_3
Silicon	6 months	100 mL	Plastic	HNO_3
Boron	6 months	100 mL	Plastic	HNO_3
Fluoride	28 days	100 mL	Plastic	4°C
Metals[b,c] (Total Recoverable and Dissolved) Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Molybdenum, Nickel, Selenium, Silver, Thallium, Zinc	6 months (filter for dissolved fraction and preserve within 48 hrs; 6 months to analysis)	100 mL	Teflon, Plastic or Borosilicate Glass -	4°C and HNO_3 to pH < 2[c]
Mercury	28 days	500 mL	Plastic or Glass	4°C and HNO_3
Biologicals				
Total Coliform	8 hrs	100 mL	Sterile Plastic or Glass	<10°C
Fecal Coliform	8 hrs	100 mL	Sterile Plastic or Glass	<10°C

88

Analyte	Holding Time	Minimum Sample Volume[a]	Container Type	Preservation
Enterococcus	8 hrs	100 mL	Sterile Plastic or Glass	<10°C
Organics				
Oil and Grease	7 days	1 L	Amber Glass	4°C and H_2SO_4
TPH (Diesel)	7 days / 40 days post extraction	500 mL	Amber Glass	4°C
TPH (Gasoline)	7 days	2 x 40 ml	Glass VOA vials	4°C and HCl
TPH (Motor oil)	7 days / 40 days post extraction	500 ml	Amber Glass	4°C
Chlordane	7 days / 40 days post extraction	1 L	Amber Glass	4°C
DDT	7 days / 40 days post extraction	1 L	Amber Glass	4°C
Diazinon	7 days / 40 days post extraction	1 L	Amber Glass	4°C
PAHs	7 days / 40 days post extraction	1 L	Amber Glass	4°C
Organochorine Pesticides and PCBs	7 days / 40 days post extraction	1 L	Amber Glass	4°C
Arochlor and PCB Cogeners	7 days / 40 days post extraction	1 L	Amber Glass	4°C
Organophosphorus Pesticides	7 days / 40 days post extraction	1 L	Amber Glass	4°C
Synthetic Pyrethroid Pesticides	7 days / 40 days post extraction	1 L	Amber Glass	4°C

Notes:
a Parameters with like preservatives can be combined into a single container if the same laboratory is performing the analyses.
For example, TDS, TSS, turbidity, conductivity, and pH can be put in a single 1 L plastic container.
b Metals are collected in a single container.
c Filter dissolved samples before preservation.

Conclusions

- Many options for collecting stormwater samples for analyses
- Automatic flow-weighted composite sampling considered the "gold standard"
- However, manual sampling may be best for some conditions
- Many steps are necessary to ensure problem-free sampling