

What we have really learned about sediment and nutrient dynamics from urban stormwater outfall monitoring ?



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4/22/14 STAC Research Workshop

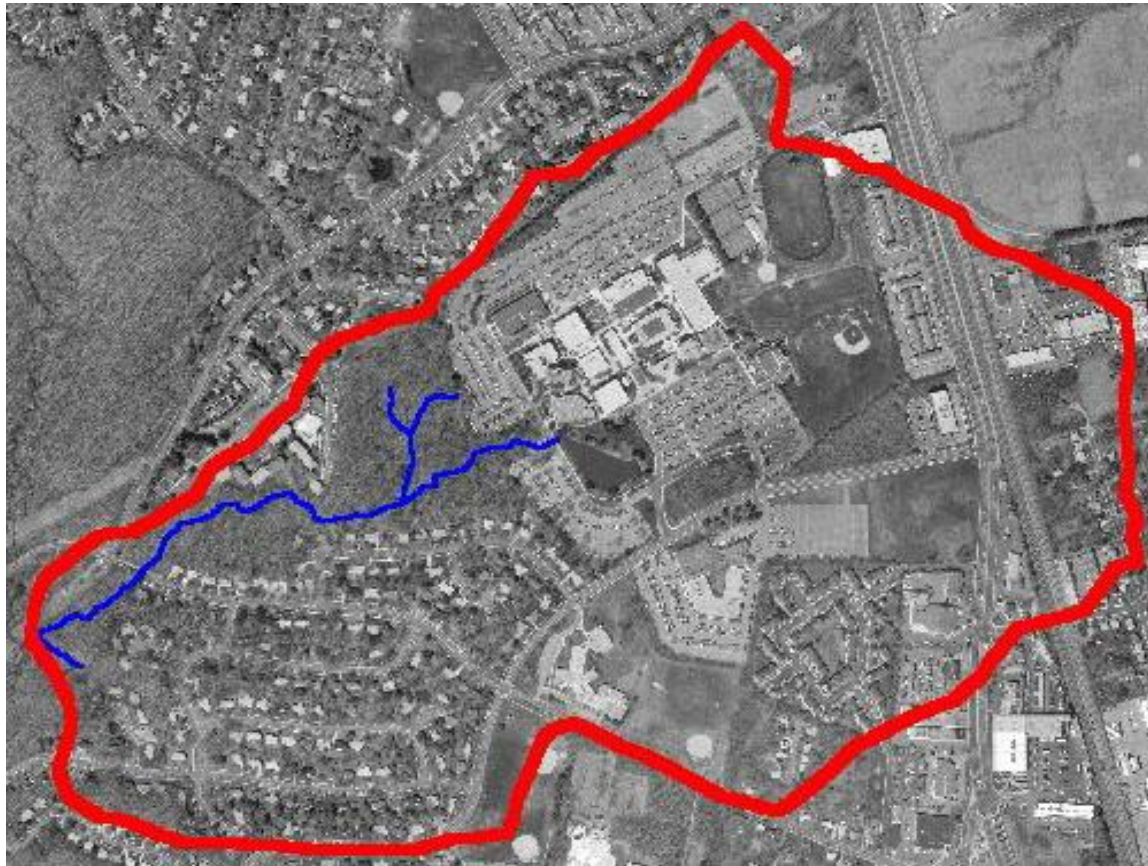
Key Themes

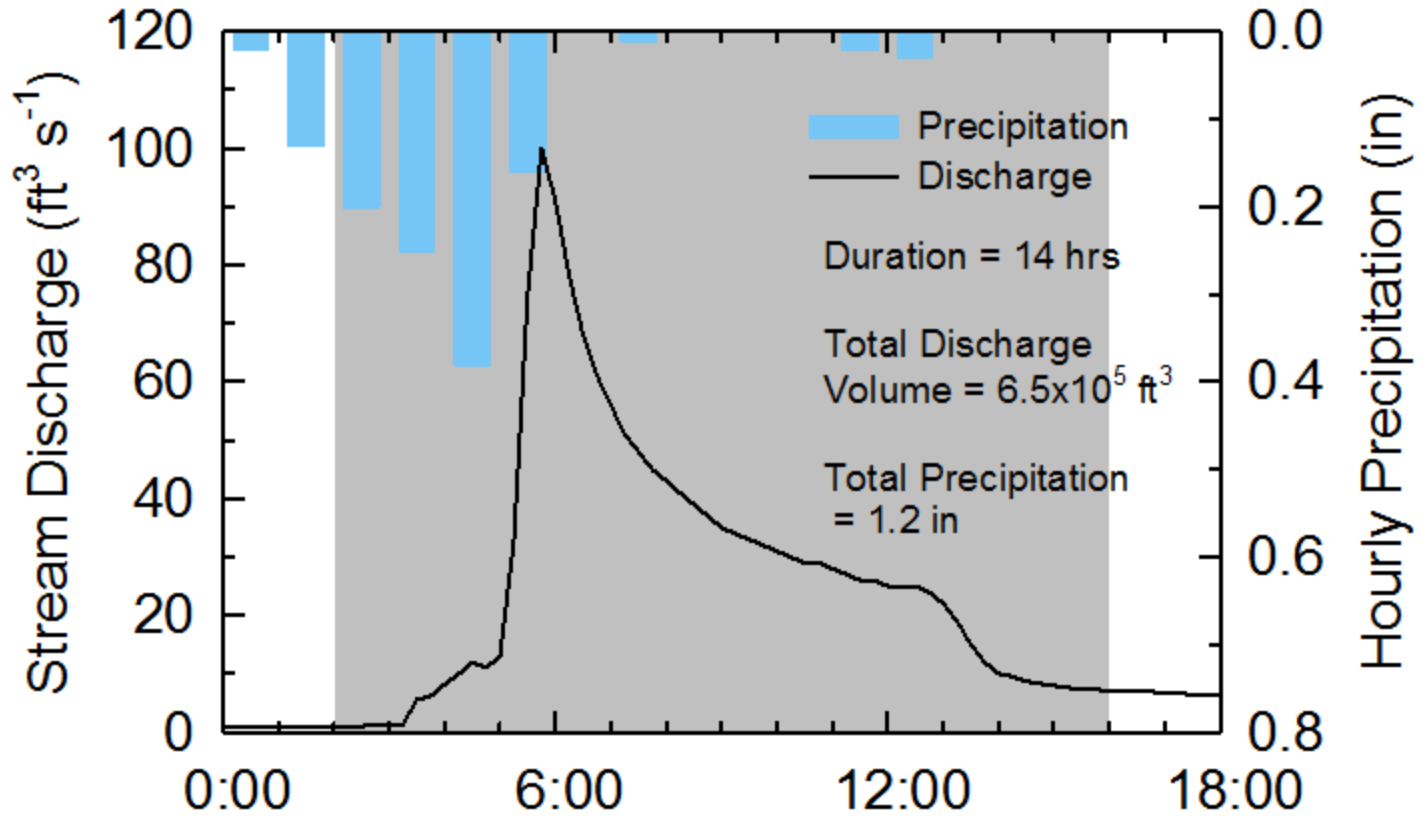
- Short history of outfall monitoring
- Establishing the Runoff Coefficient
- Sediment Dynamics
- Nutrient Dynamics
- What the monitoring does not tell us

A short history of outfall sampling

- Late 70's: 208 Monitoring, time-weighted composites
- Early 80's: NURP monitoring, flow-weighted composites (FWC)
- Mid 90's: MS4 Permit Monitoring -variable monitoring techniques from 3 grabs to FWC
- Mid 90's on: BMP inflow monitoring (FWC)
- 2004: National Stormwater Quality Database

Small urban catchments (25 to 75 Acres)
One Predominant urban land use
Multiple urban source areas
Prior to stream discharge





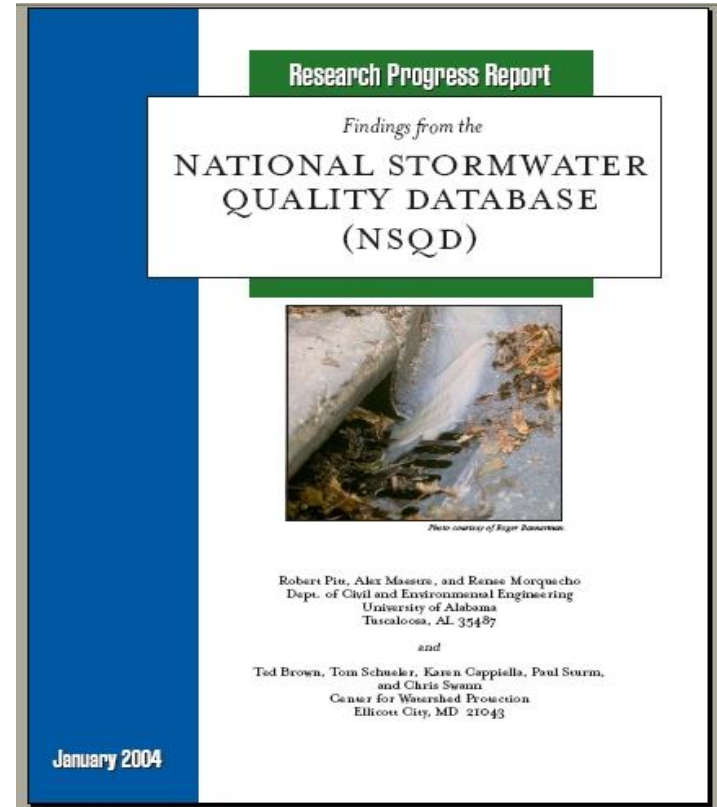
October 27, 2010

Flow Sampling,
 Event Mean Concentrations,
 Flow and Time Weighted Sample Composites
 Log Normal Distributions



National Stormwater Quality Database

Developed by
University of
Alabama and CWP
3800 storm events
30 parameters
About 35% of
events sampled in
Bay watershed



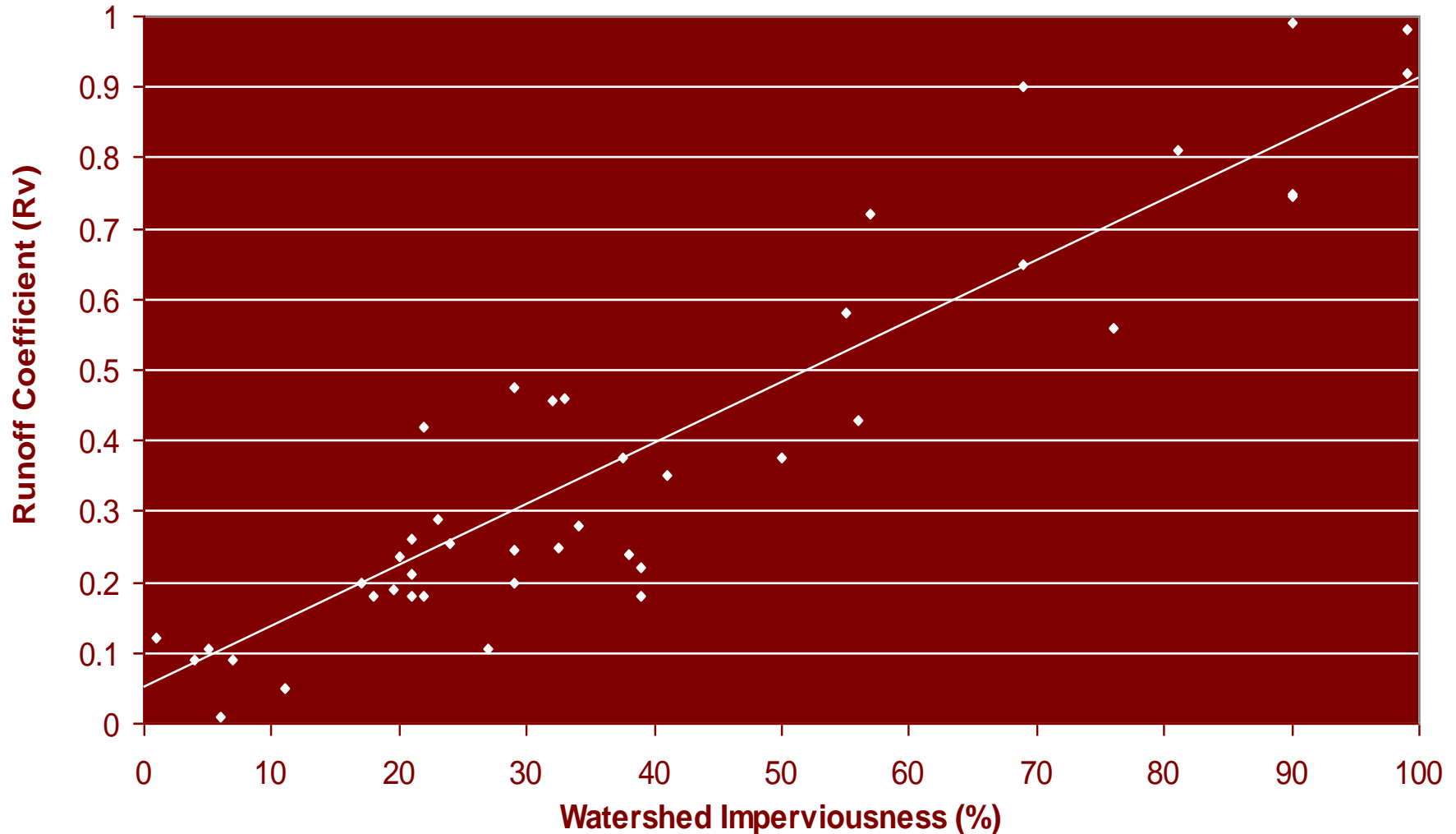
Note: More expanded NSQD EMC Database Analyzed by TetraTech (2014)

Establishing the Runoff Coefficient



Relationship Between Watershed Imperviousness (I) and the Storm Runoff Coefficient (Rv)

(Source: Schueler, 1987)



Additional Data from NSQD (2004) validate the slope and intercept

Site Runoff Coefficients (Rv)

Cover	HSG A	HSG B	HSG C	HSG D
Forest	0.02	0.03	0.04	0.05
Managed Turf / Disturbed Soil	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

Residential Impervious Cover

Zoning Category	Mean IC % + SE	% Car Habitat
2 acre Lots	10.6 +/- 1.3	75%
1 acre Lots	14.3 +/- 1.0	65%
$\frac{1}{2}$ acre lots	21.2 +/- 1.5	60%
$\frac{1}{4}$ acre lots	27.8 +/- 1.2	56%
1/8 acre lots	32.6 +/- 3.1	56%
Townhomes	40.9 +/- 2.7	55%
Multi-family	44.4 +/- 3.9	61%

Source: Capiella and Brown, 2000

Other Impervious Cover Relationships

Zoning category	Mean IC %	% Car Habitat
Agriculture	1.9 +/- 0.6	56%
Commercial	72.2 +/- 3.9	72%
Light Industrial	53.4 +/- 5.5	67%
Institutional	34.4 +/- 6.8	67%
Parks	12.5 +/- 0.7	na
Schools	30.3 +/- 4.8	na
Golf Courses	5.0 +/- 1.7	na

Outfall Sediment Dynamics

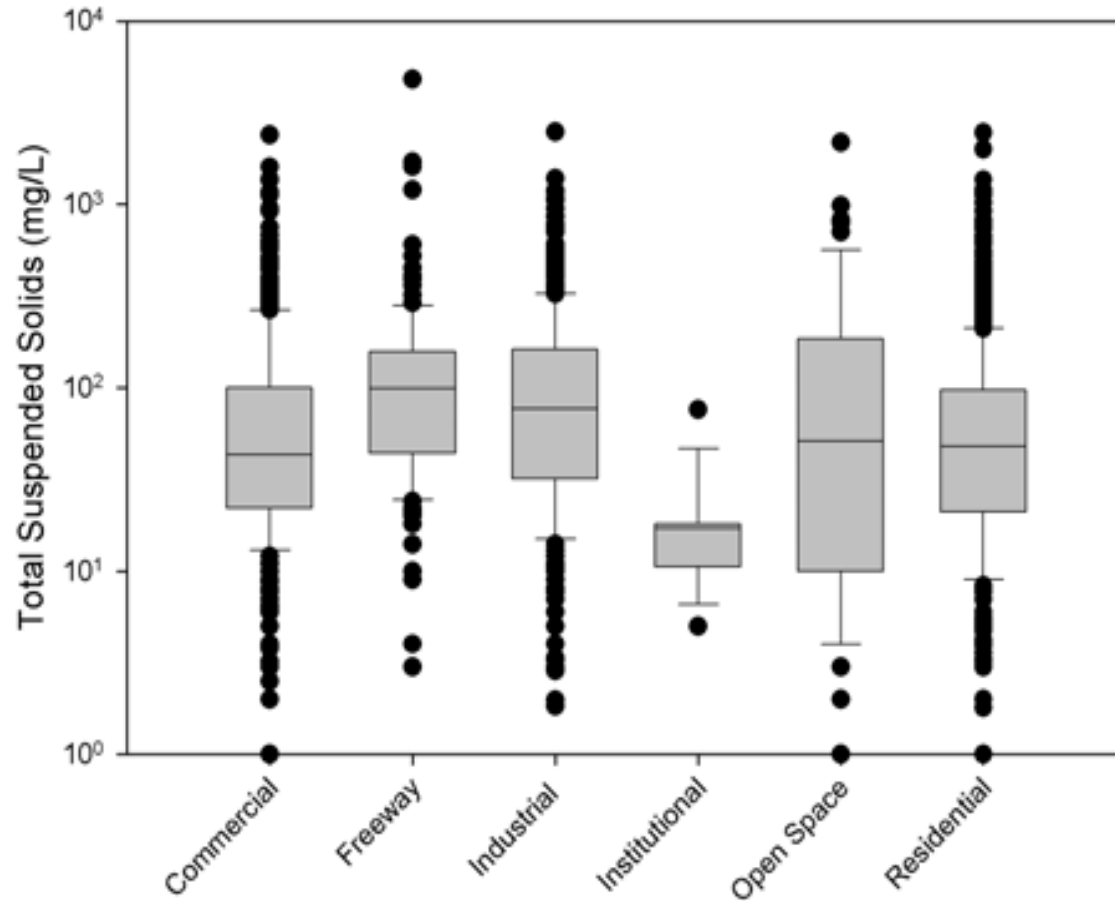


Median EMC for Suspended Solids (mg/l or ppm) NSQD, 2004

	ALL	RESID	COM	IND	HWY
Suspended Solids	63	50	48	90	99
Dissolved Solids	78	69	74	84	78
# samples	3757	983	464	471	185

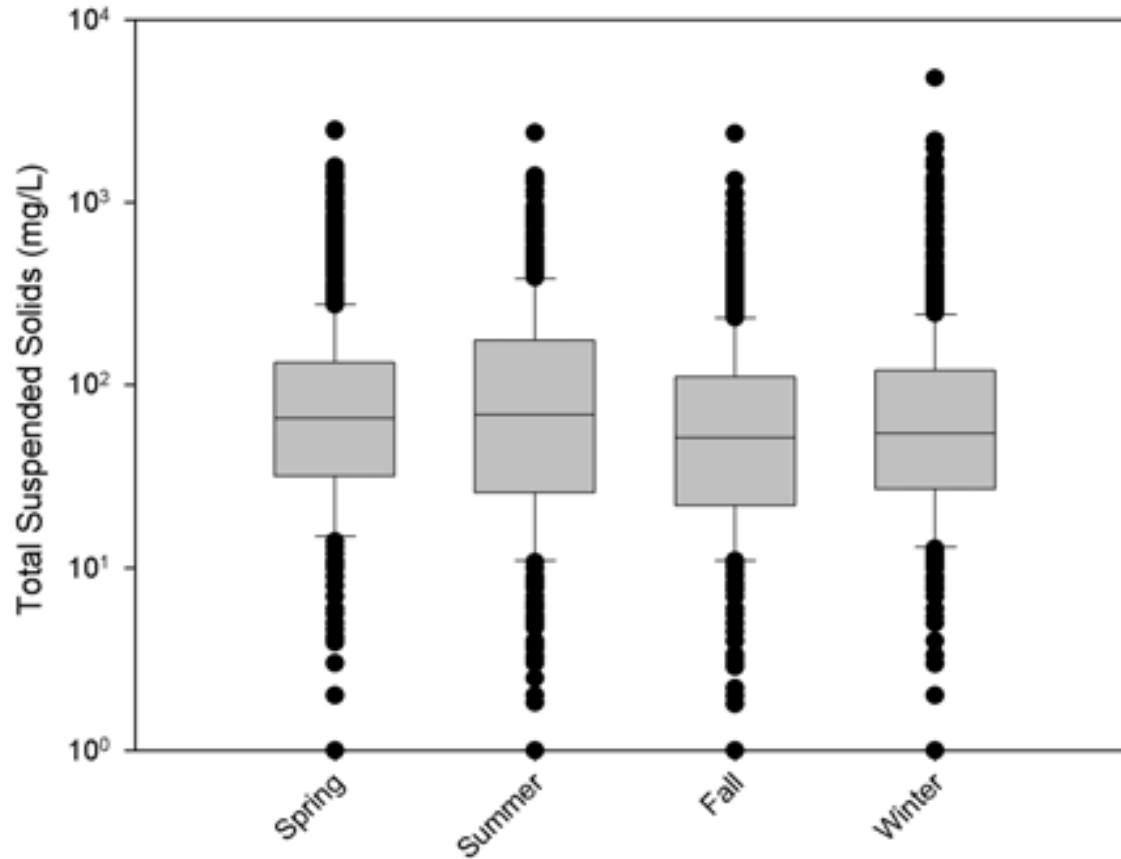
Urban Stream Storm TSS Concentrations Range from 250 to 1000 mg/l so the outfalls are NOT the primary source of sediment in urban watersheds

Effect of Land Use on TSS Event Mean Concentrations

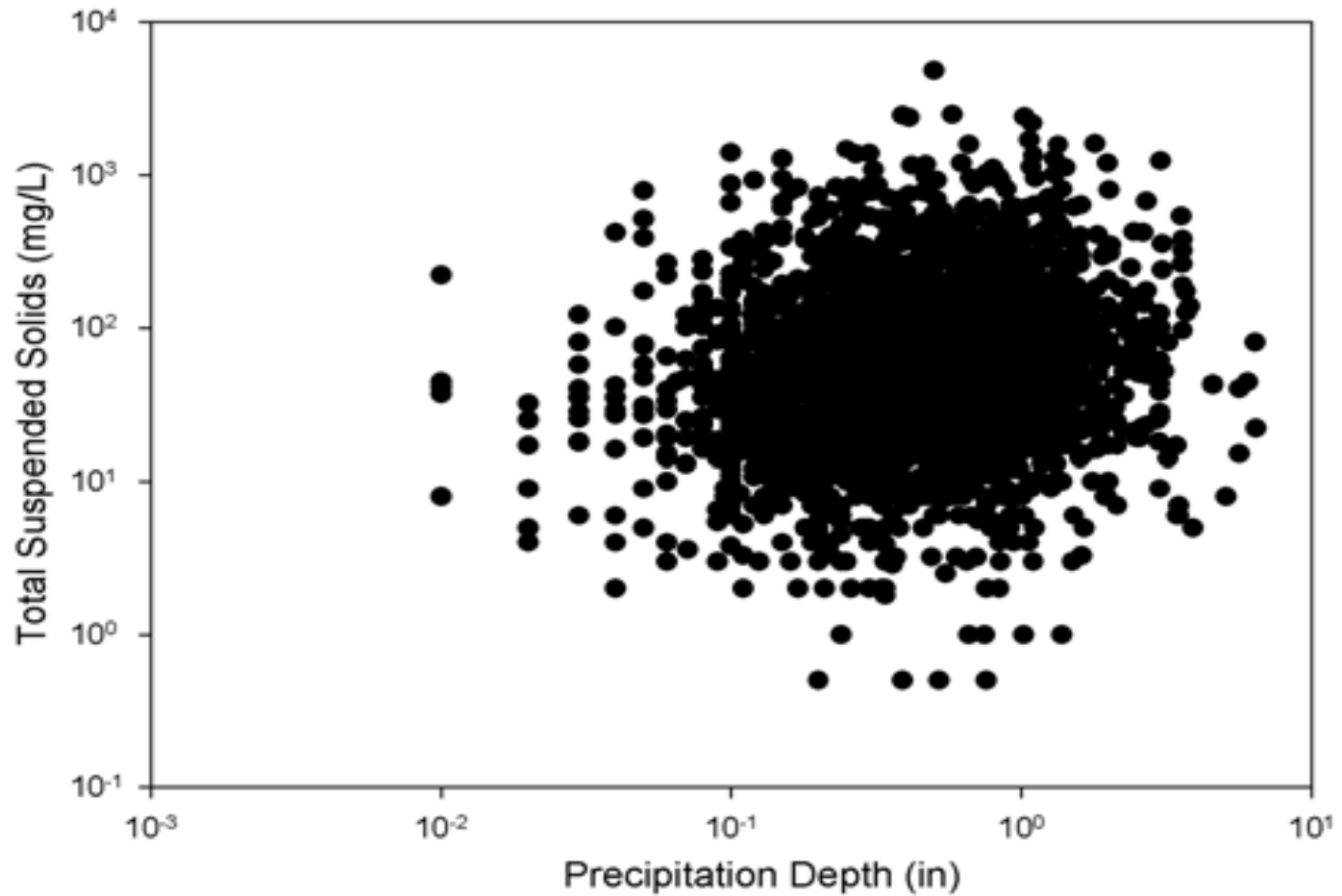


Log-normally distributed
Coefficient of Variation 1.6 to 2.0

No Real Seasonal Changes in TSS Concentrations



The Dubious Quest for the First Flush



Sediment Particle Size Distribution

- NURP Study: Db50: around 15 microns, but this reflects sampling intake bias
- Current research has Db50: around 30 to 100 microns
- Two sampling biases: saltation (+) and missing gross solids (---)



Photo Credit: Bill Selbig

Four Size Fractions In Urban Runoff, Two of which are Sampled

Fine Particulates



Coarse Particulates



Organic Detritus



Gross Trash/Debris



Tune in tomorrow for the
"great detritus debate"



Nutrient Dynamics in Outfall Monitoring



Median Phosphorus EMCs for different urban land uses

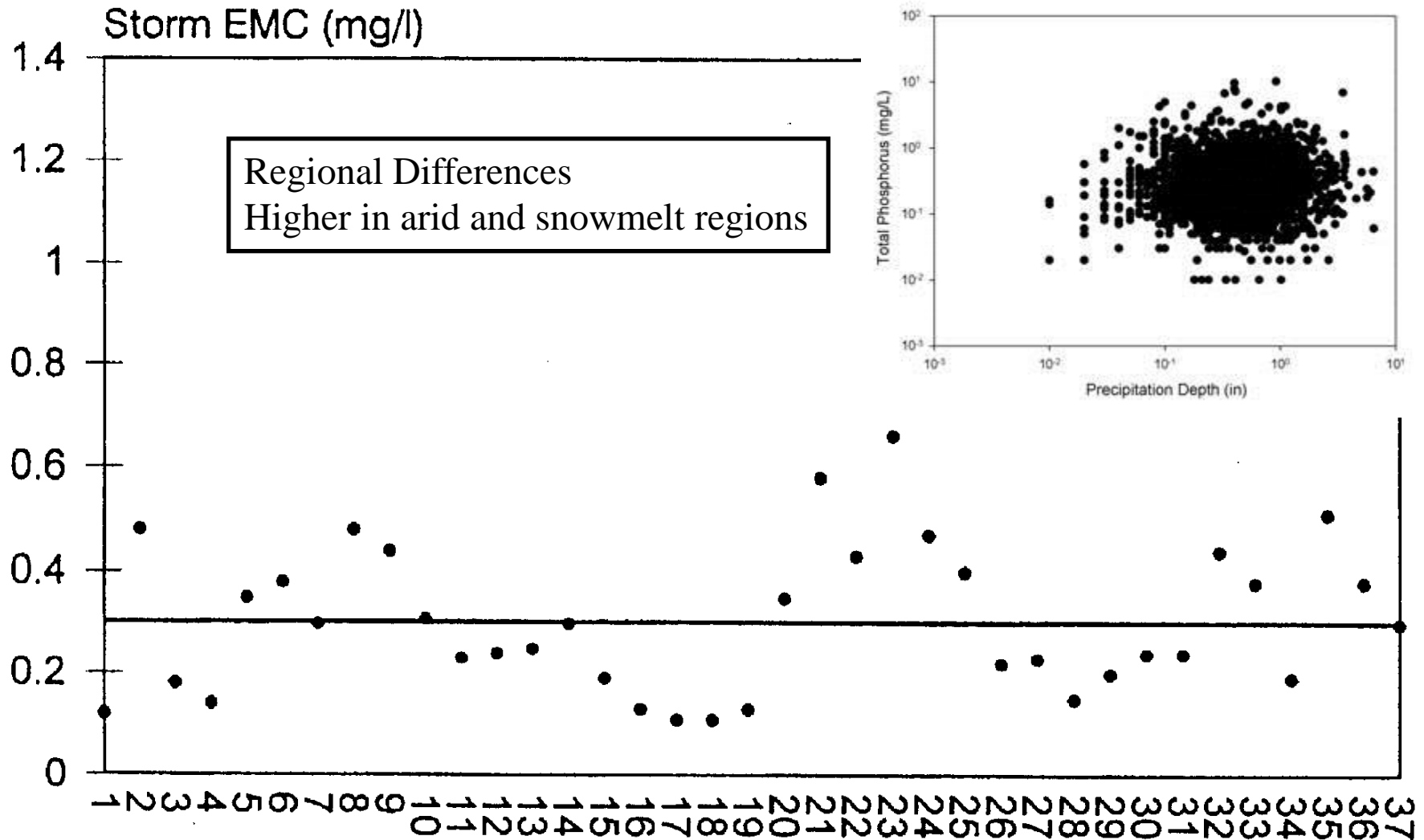
Urban Land Use	Total P (mg/l)
Residential	0.30
Commercial	0.22
Industrial	0.26
Freeway	0.25

Source: Pitt et al 2004, N = 3800 Storms

Soluble P about 40% of Total P
Coefficient of Variation: 1.1 to 1.5

Total Phosphorus Concentration in Stormwater Runoff

37 Residential Watersheds Across the United States



Source: CWP, 1996

Median Nitrogen EMCs for different urban land uses

Urban Land Use	Total N (mg/l)
Residential	2.0
Commercial	2.2
Industrial	2.2
Freeway	2.5
<i>Source: Pitt et al 2004, N= ~4000</i>	

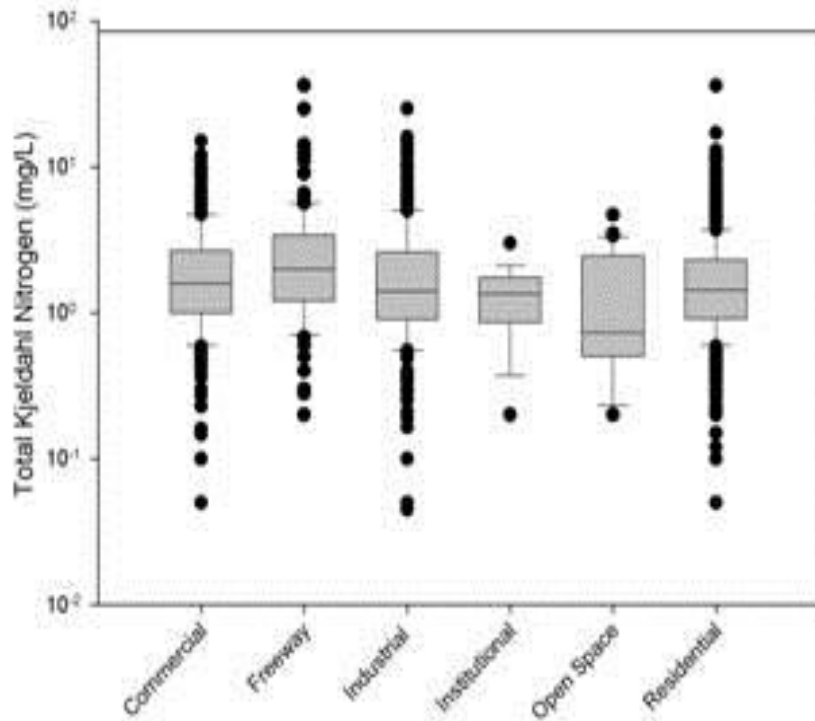
TKN: about 70% of TN

Coefficient of Variation: Ranges from 0.9 to 1.2

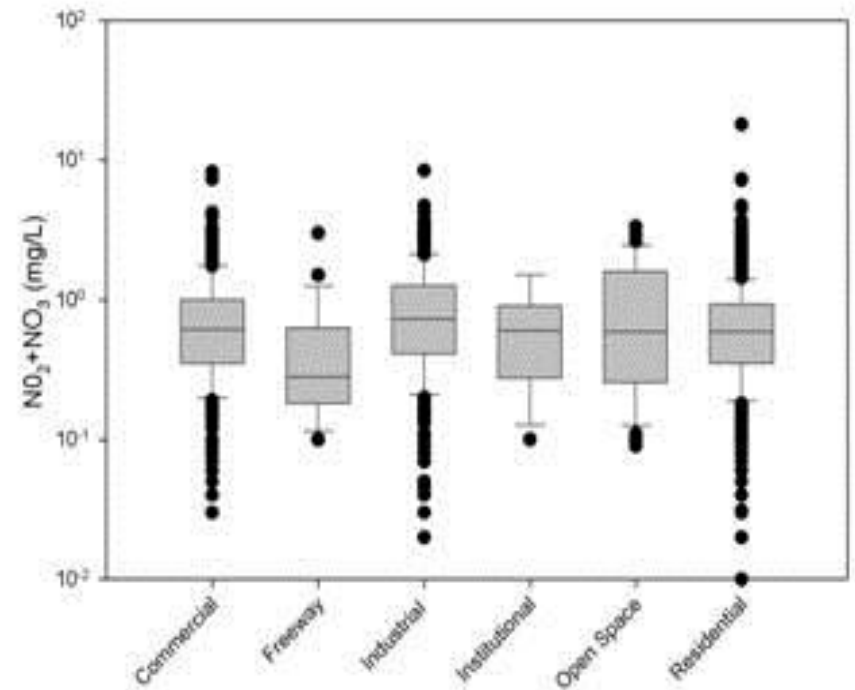
Log-Normally Distributed

Variability, but Not Related to Land Use

TKN



Nitrate



Coastal Plain Differences?

- From CWP, 2008

Table 1. Virginia Event Mean Concentrations	
Parameter	Median EMC (mg/L)
Total Nitrogen	
National	1.9
Virginia	1.86
<i>Residential</i>	2.67
<i>Non-Residential</i>	1.12
Virginia Coastal Plain	2.13
<i>Residential</i>	2.96
<i>Non-Residential</i>	1.08
Virginia Piedmont	1.70
<i>Residential</i>	1.87

What Outfall Monitoring Doesn't Tell Us

Dry Weather

Nutrient Loads from Pervious land !

- Fertilizer leaching
- Sewage exfiltration and overflows
- Groundwater migration
- Relict and existing septic systems
- Illicit discharges
- Drinking water transmission loss
- BMP return flows
- Others ?



Dry weather nitrogen loads 20 to 50% of Total Annual Nitrogen Load (Expert Panel)

Beyond Impervious and Pervious

1. Pie is still the same size
2. Allocate Slices to Nutrient Sources
3. Recognize Spatial Consequences



