Evaluating Performance of Stormwater Controls

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

Basic Monitoring Strategy to Verify Stormwater Control Performance

- 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

Scour of Captured Sediment in Storm Drain Catchbasin Inlets

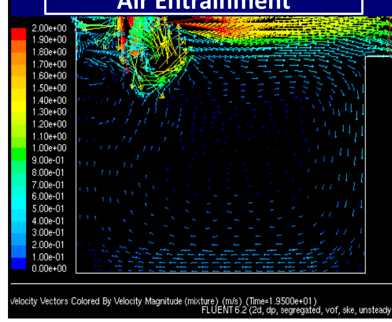
- Three flow rates: 10, 5, and 2.5 LPS (160, 80, and 40 GPM)
- Velocity measurements (Vx, Vy, and Vz)
- Five overlying water depths above the sediment: 16, 36, 56, 76, and 96 cm

- 155 total points per test
- 30 velocity measurements at each point

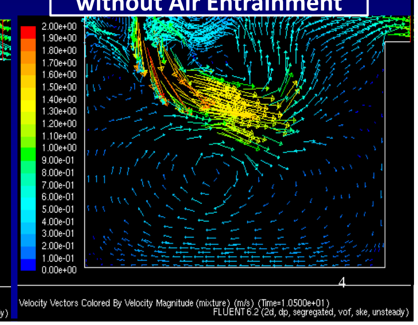
CFD Modeling to Calculate Scour/Design Variations

- Used CFD (Fluent 6.2 and Flow 3D) to determine scour from stormwater controls; results being used to expand WinSLAMM analyses after verification with full-scale physical model
- This is an example of the effects of the way that water enters a sump on the depth of the water jet and resulting scour

Calibrated CFD Model with Air Entrainment

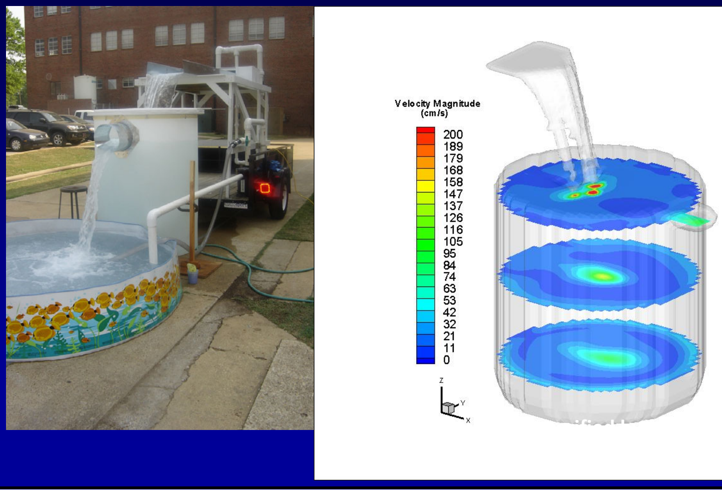


Uncalibrated CFD Model without Air Entrainment



Physical and 3D-CFD Modeling

Scour tests of previously deposited sediment in sumps



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Experimental Description: *Scour Tests*

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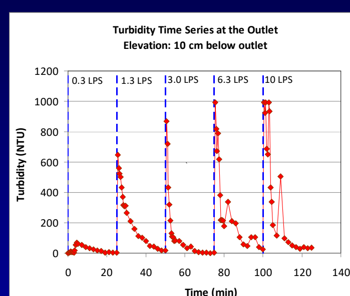
Scour Tests Results: *Turbidity Time Series – Sequential Flow rate*

- A decreasing exponential pattern was found in the turbidity time series for each flow rate at steady conditions.
- The initial impact of the plunging water jet disturbs the sediment bed exposing all the particle sizes.
- The impacting zone is stabilized by dispersion, and buoyancy (air entrainment). Steady state is reached.
- Small particles are suspended and washed out creating a hole and leaving the large particles on the sediment bed surface.
- The large particles create an armoring on the sediment surface bed which protects the small particles below from being scoured.



- This turbidity time series shows that the armoring is created exponentially over time.

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Different Pilot-Scale Stormwater Treatment Setups

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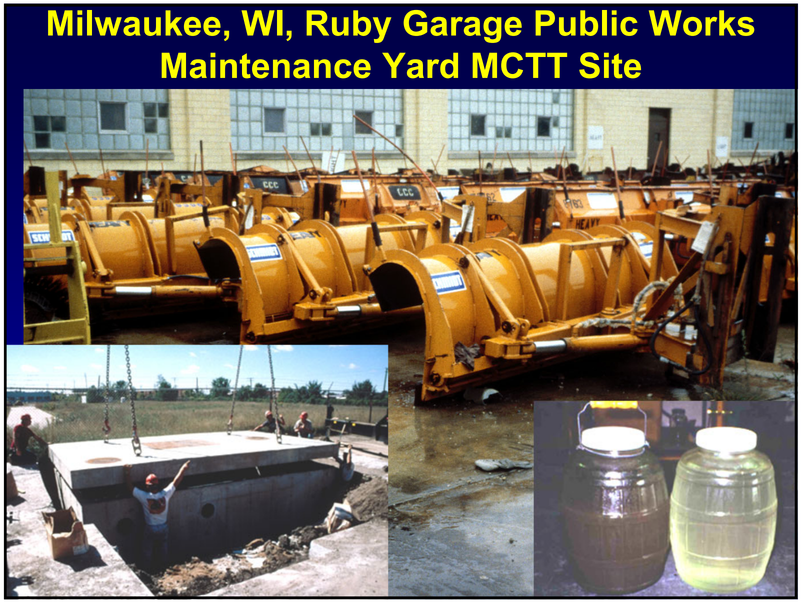
Milwaukee, WI, Ruby Garage Public Works
Maintenance Yard MCTT Site

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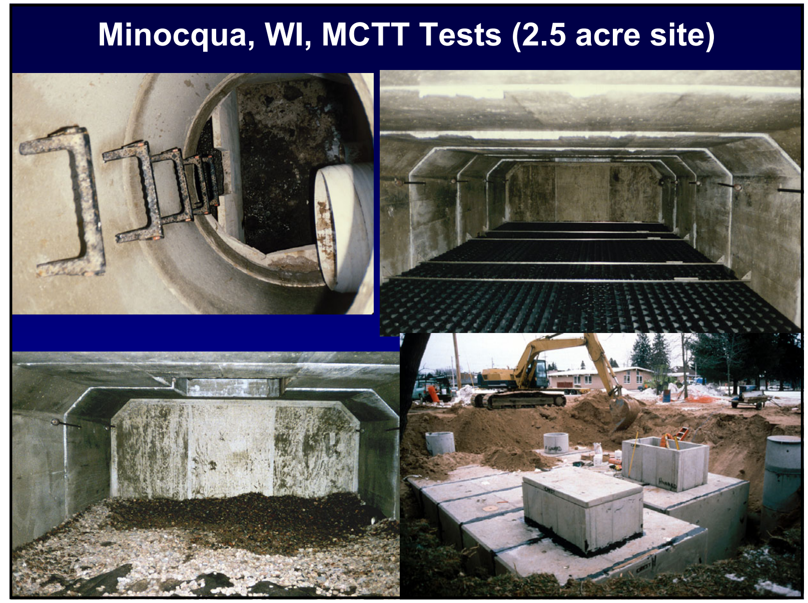
Minocqua, WI, MCTT Tests (2.5 acre site)

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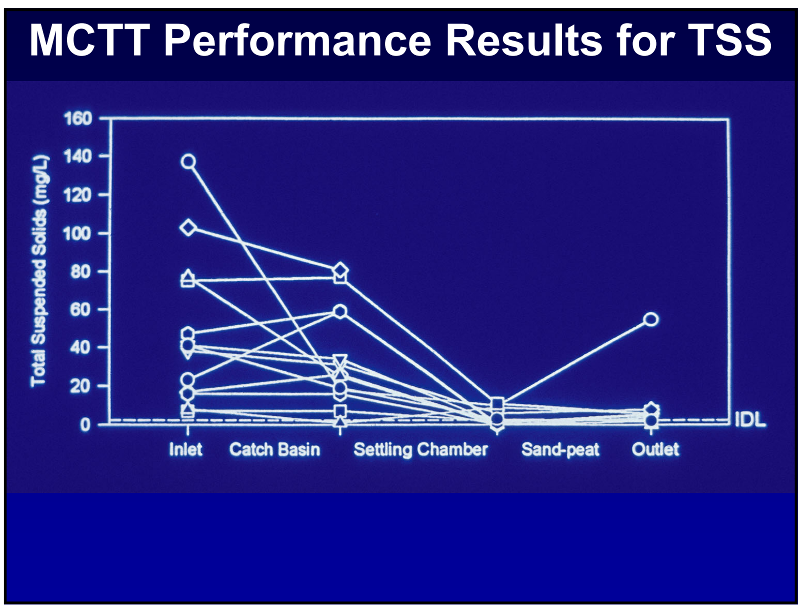
MCTT Performance Results for TSS
Total Suspended Solids (mg/L)
160
140
120
100
80
60
40
20
0
IDL
Inlet
Catch Basin
Settling Chamber
Sand-peat
Outlet

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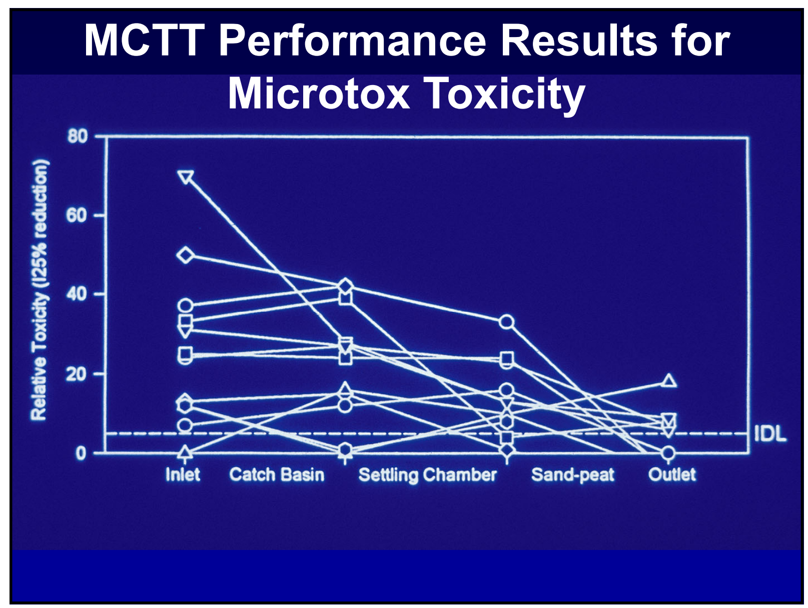
MCTT Performance Results for Microtox Toxicity
Relative Toxicity (I25% reduction)
80
60
40
20
0
IDL
Inlet
Catch Basin
Settling Chamber
Sand-peat
Outlet

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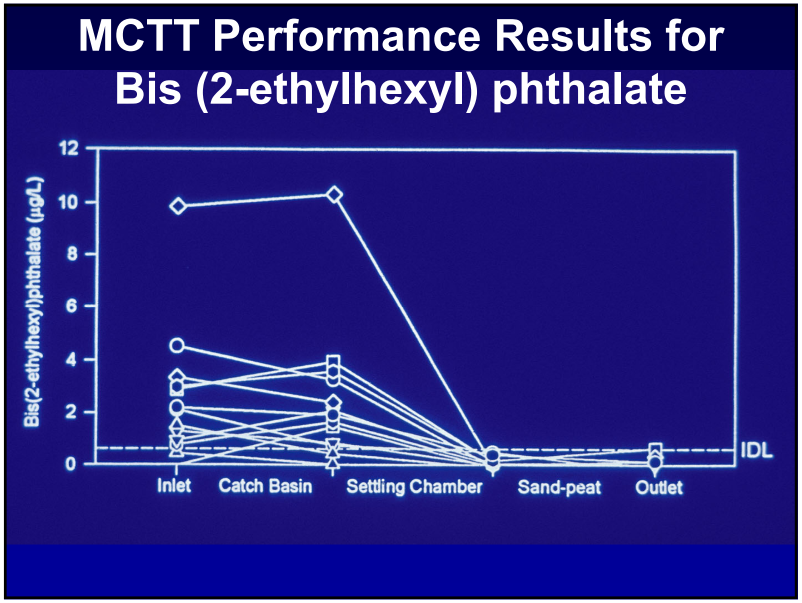
MCTT Performance Results for Bis (2-ethylhexyl) phthalate
Bis(2-ethylhexyl)phthalate (µg/L)
12
10
8
6
4
2
0
IDL
Inlet
Catch Basin
Settling Chamber
Sand-peat
Outlet

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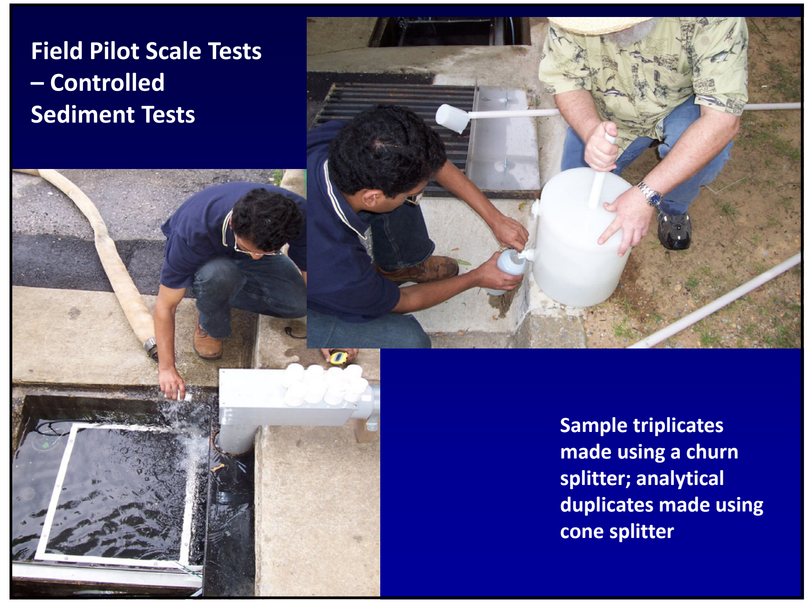
Field Pilot Scale Tests – Controlled Sediment Tests
Sample triplicates made using a churn splitter; analytical duplicates made using cone splitter

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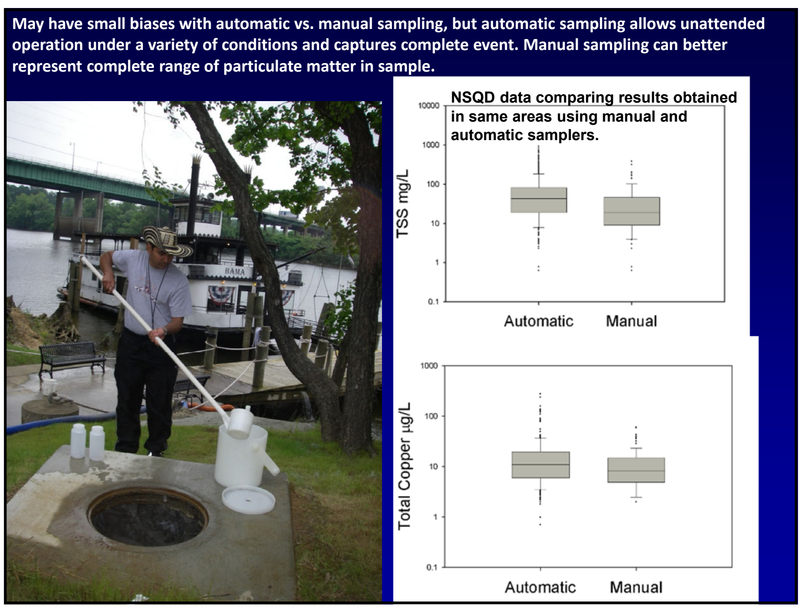
May have small biases with automatic vs. manual sampling, but automatic sampling allows unattended operation under a variety of conditions and captures complete event. Manual sampling can better represent complete range of particulate matter in sample.
NSQD data comparing results obtained in same areas using manual and automatic samplers.
TSS mg/L
10000
1000
100
10
1
0.1
Automatic
Manual
Total Copper µg/L
1000
100
10
1
0.1
Automatic
Manual

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

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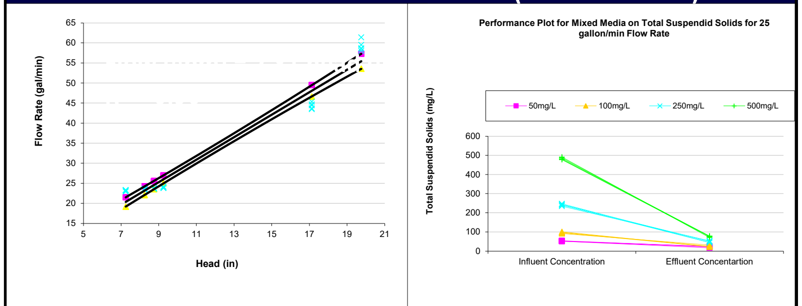
Results of Full-Scale Field Installation (controlled tests)



25 gallon/min Flow Rate and 100 mg/L Conc.

Particle Size (µm)	Influent Conc. (mg/L)	Effluent Conc. (mg/L)	Reduction (%)
< 0.45	220	160	27
0.45 to 3	5.2	1.1	78
3 to 12	19	11	38
12 to 30	26	8.3	68
30 to 120	16	1.3	92
120 to 1180	28	0.18	99
> 1180	5.7	0	100
sum >0.45 µm	99	21.9	78

25 gallon/min Flow Rate and 500 mg/L Conc.

Particle Size (µm)	Influent Conc. (mg/L)	Effluent Conc. (mg/L)	Reduction (%)
< 0.45	240	120	49
0.45 to 3	26	3.2	88
3 to 12	92	32	65
12 to 30	130	28	79
30 to 120	81	3.9	95
120 to 1180	142	0.55	100
> 1180	30	0	100
sum >0.45 µm	500	67.7	86

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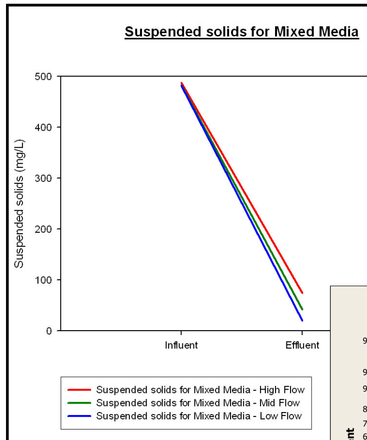

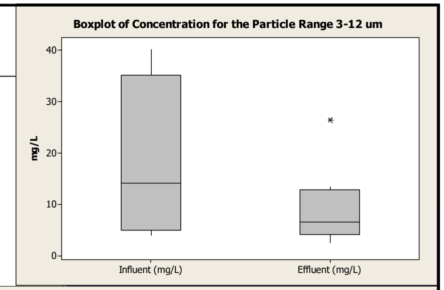

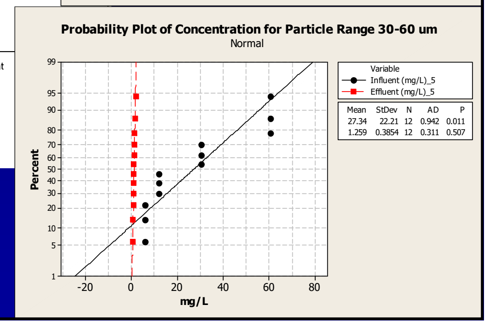

Very high levels of control, even for very small particles.

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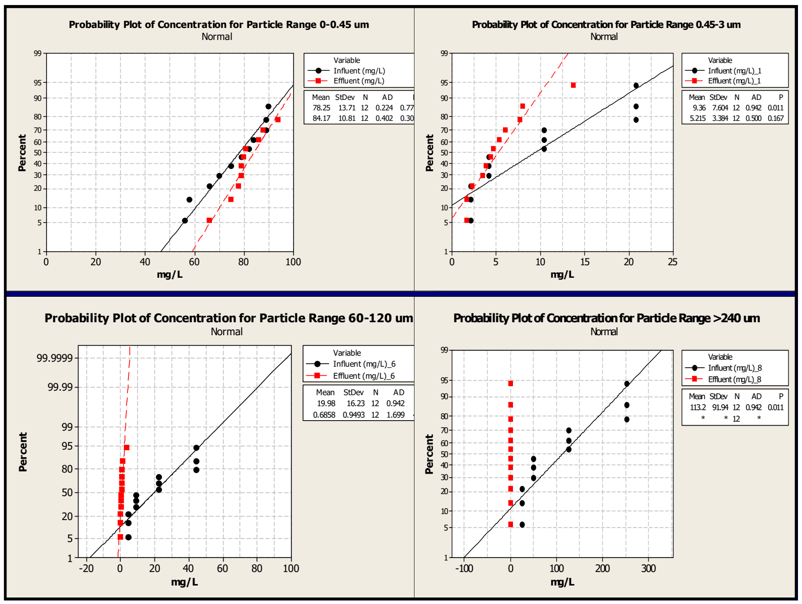

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The Monroe St. detention pond in Madison has been monitored by the WI DNR and USGS for many years. The data have been used to verify the wet detention pond routines in WinSLAMM and Detpond (amongst other ponds). Retrofitted to result in 90% SS control, the long-term monitored results were 87%.

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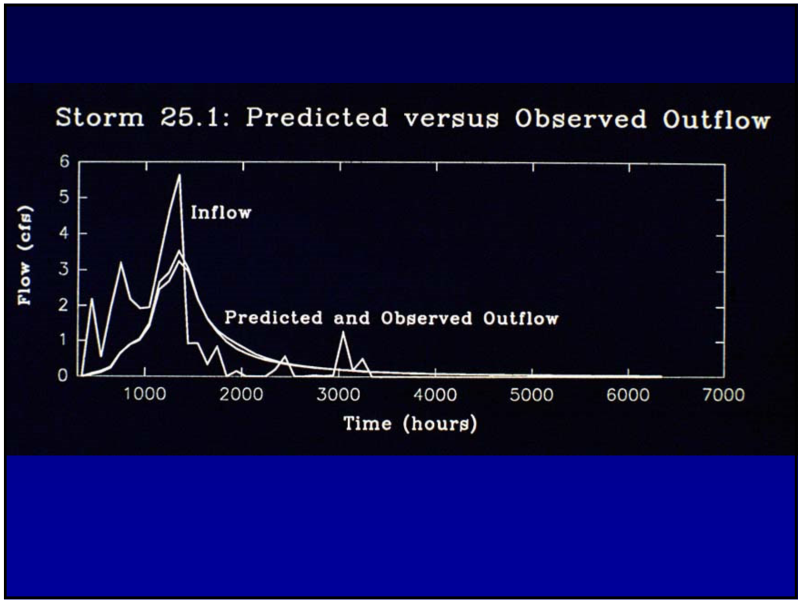

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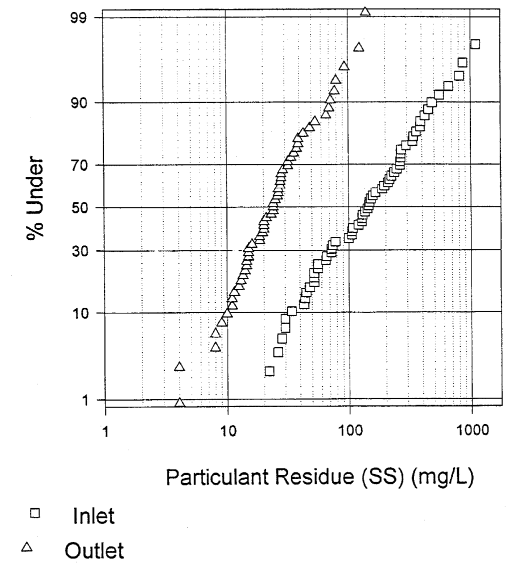

TSS influent vs. effluent concentrations Monroe St. wet pond, Madison, WI (USGS data) showing large differences with treatment.

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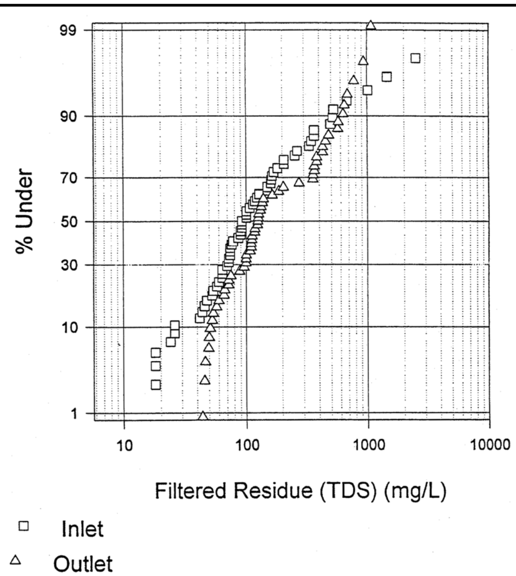

little treatment benefit for TDS, and

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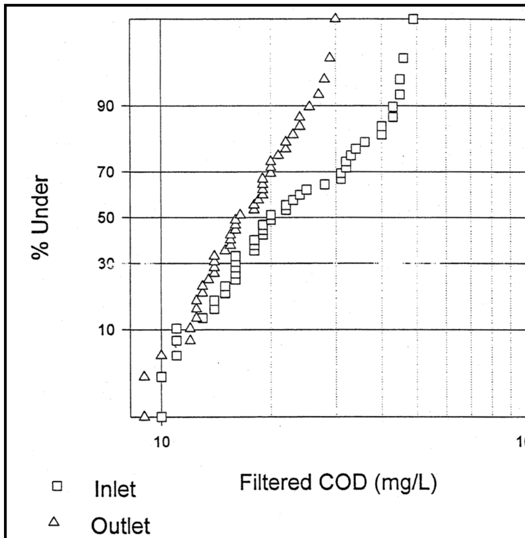

odd relationship for filtered COD (large removal at high concentrations; low to no treatment at low concentrations)

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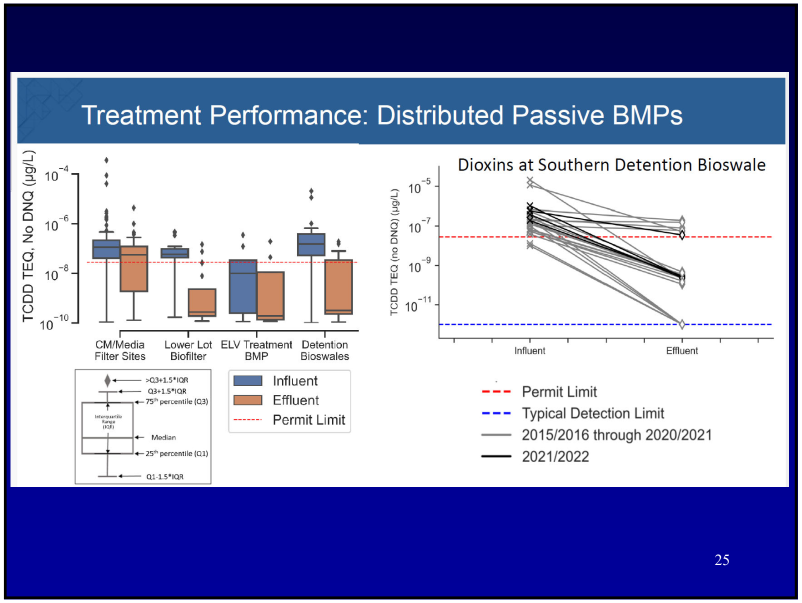

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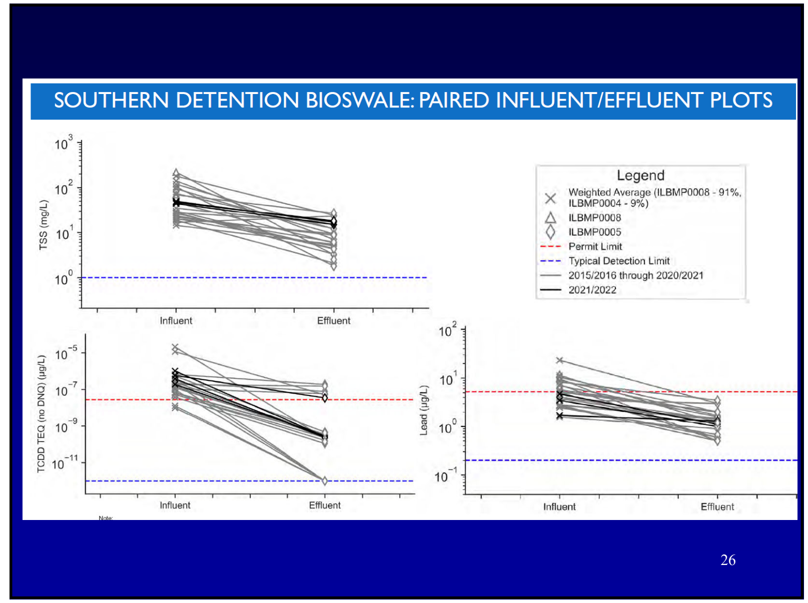

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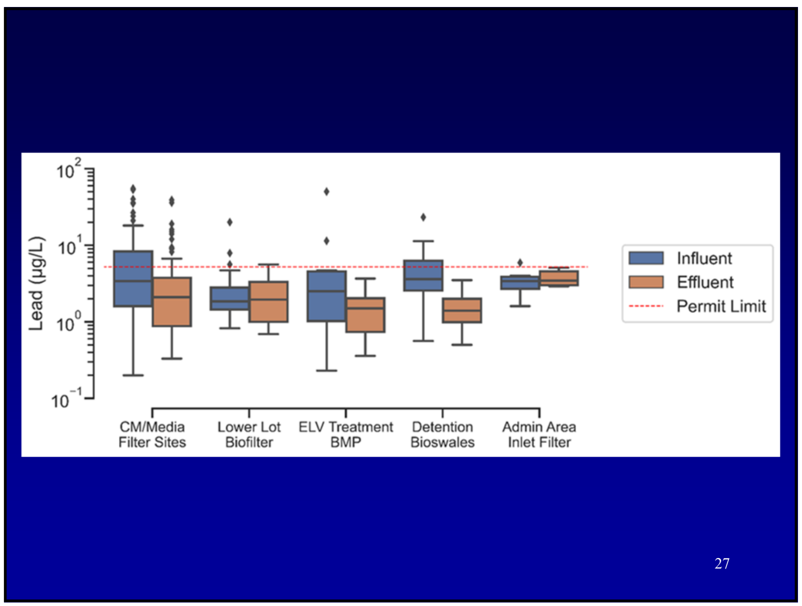

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Observed concentration trends in influent samples combined (except for background CMs)

Constituent	Significance of Regression Trend	Slope Factor, if Significant (all decreases)	Average Overall Concentration Change over 9 Years, if significant slope
TSS	0.033	9.6 mg/year	85 mg/L decrease
TCDD	0.93		
Total Cu	0.78		
Filtered Cu	0.35		
Total Pb	0.025	0.72 µg/year	6.5 µg/L decrease
Filtered Pb	0.42		
Total Cd	0.35		
Conductivity	<0.001	0.025 mS/year	0.23 mS decrease
Median particle size	0.41		
pH	<0.001	0.13 pH units/year	1.2 pH units decrease
Temperature	0.054 (marginal)	0.18 °C/year	1.6°C decrease
Turbidity	0.070 (marginal)	5.9 NTU/year	53 NTU decrease

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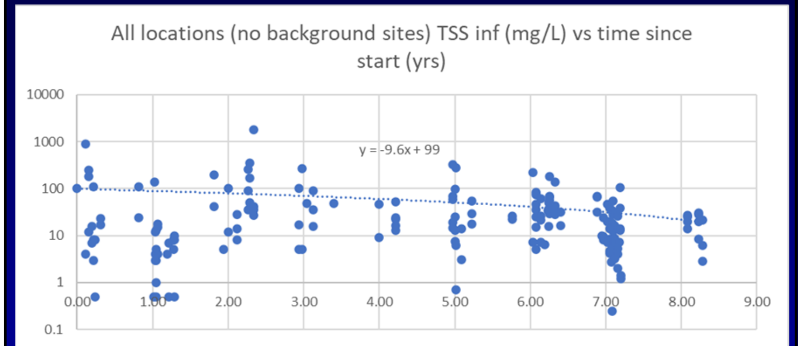
Time series plot of all influent TSS data



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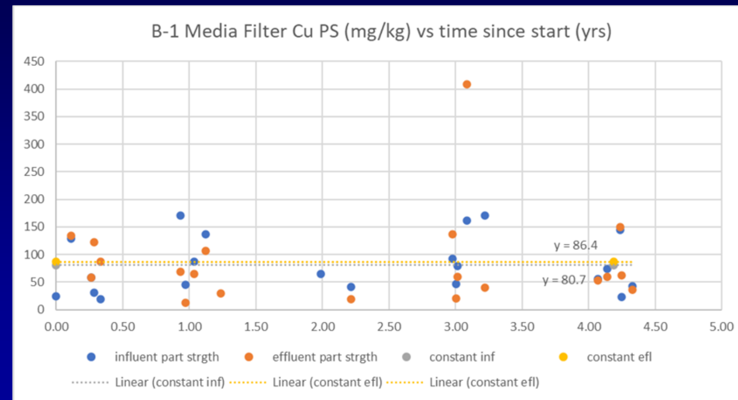
Time series plot of influent and effluent copper particulate strengths for the B-1 media filter



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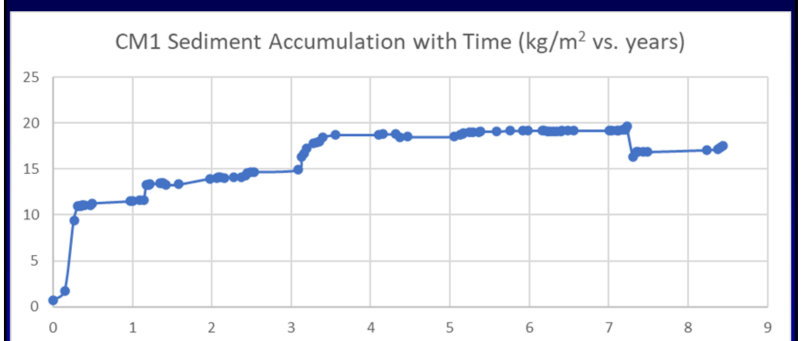

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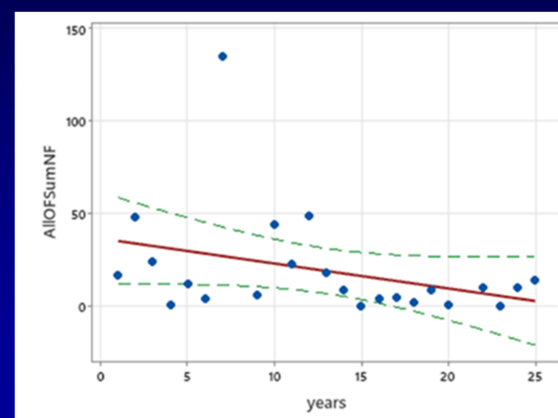
Time series plot of numbers of concentrations per year greater than 2015 NELs for all outfalls combined



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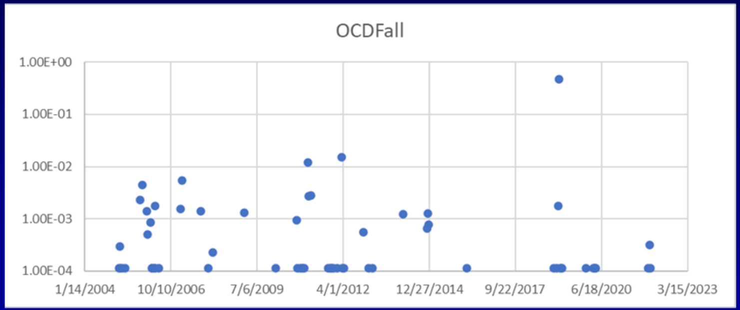
Time series plots were also prepared for these four congeners for each outfall sample set, as shown below for OF 009 for OCDF. There was no apparent trend in these particulate strength values with time.



If you can’t see a trend, it is not likely statistically significant, nor important.