Emerging Stormwater Pollutant Reduction Strategies From Another Urban Watershed:

Importing Some Ideas from the Chesapeake Bay

Chesapeake Stormwater Network

Three year old 501(c)(3) organization

Two websites: www . chesapeakestormwater.net
www. cbstp.org

Watershedguy@hotmail.com

Key Themes

- New Stormwater Developments in the Chesapeake Bay Watershed
- Update on the Impervious Cover Model
- Urban Stream Channel Erosion and Mitigation
- Renewed Focus on Stormwater Hotspots
- Turf as a Pollutant Source Area
- The Shift to the Runoff Reduction Paradigm
- Nutrient Accounting and Economics
- New Institutional Structures

Paving the Bay:
Land Development Continues Unabated

- Between 1990 to 2000, population increased by 8%, but IC increased by 41%, and turf cover by 80%
- Croplands represent 64% of the loss, forests the remaining 36%
- 75% of land development outside of smart growth areas

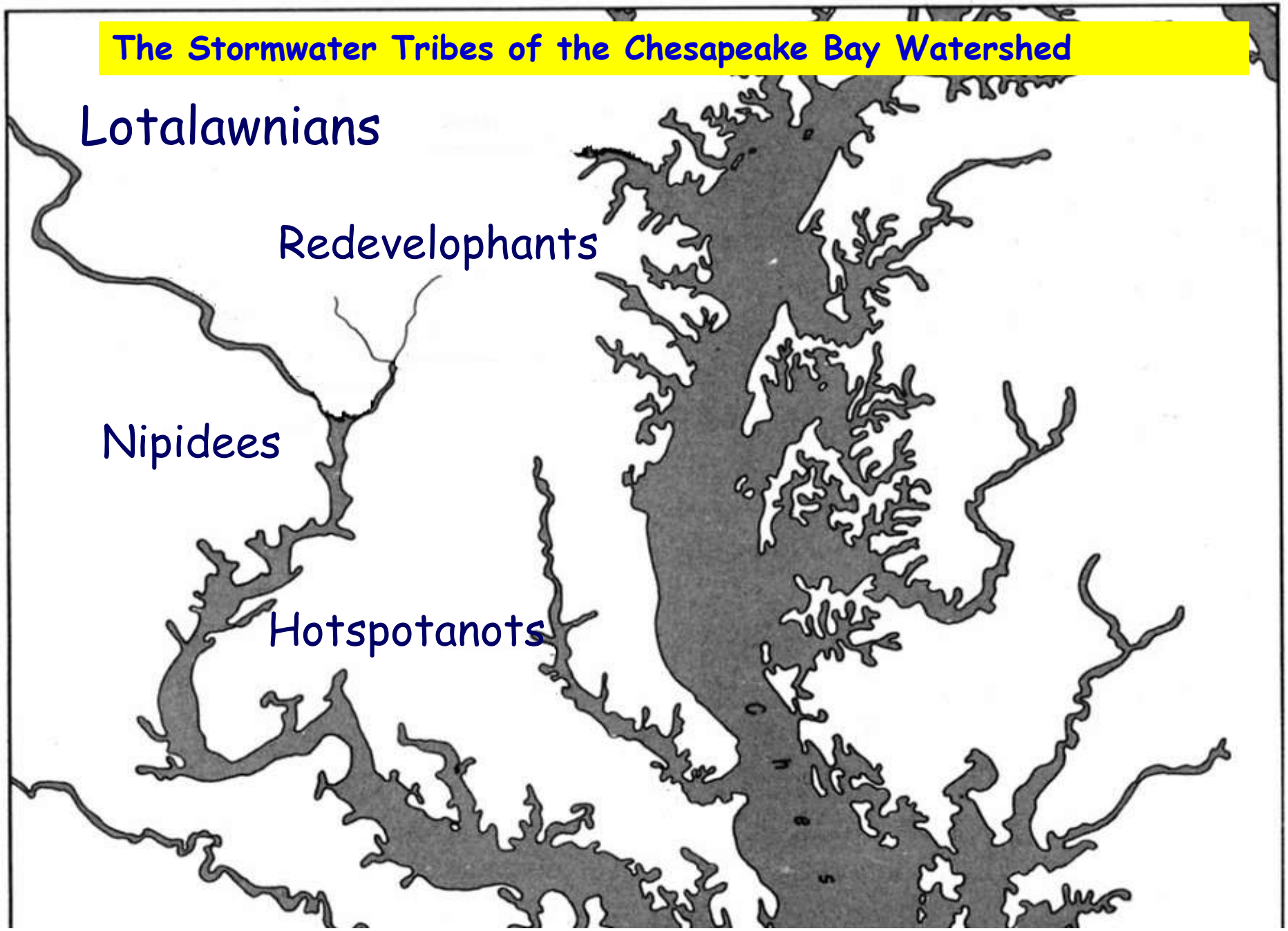
Urban Nutrient Loads Are Fast Becoming a Big Slice of the Bay Pie

Year	Total N	Total P
1985	2%	5%
2000	9%	15%
2009	**12%**	**22%**
2030	??	??

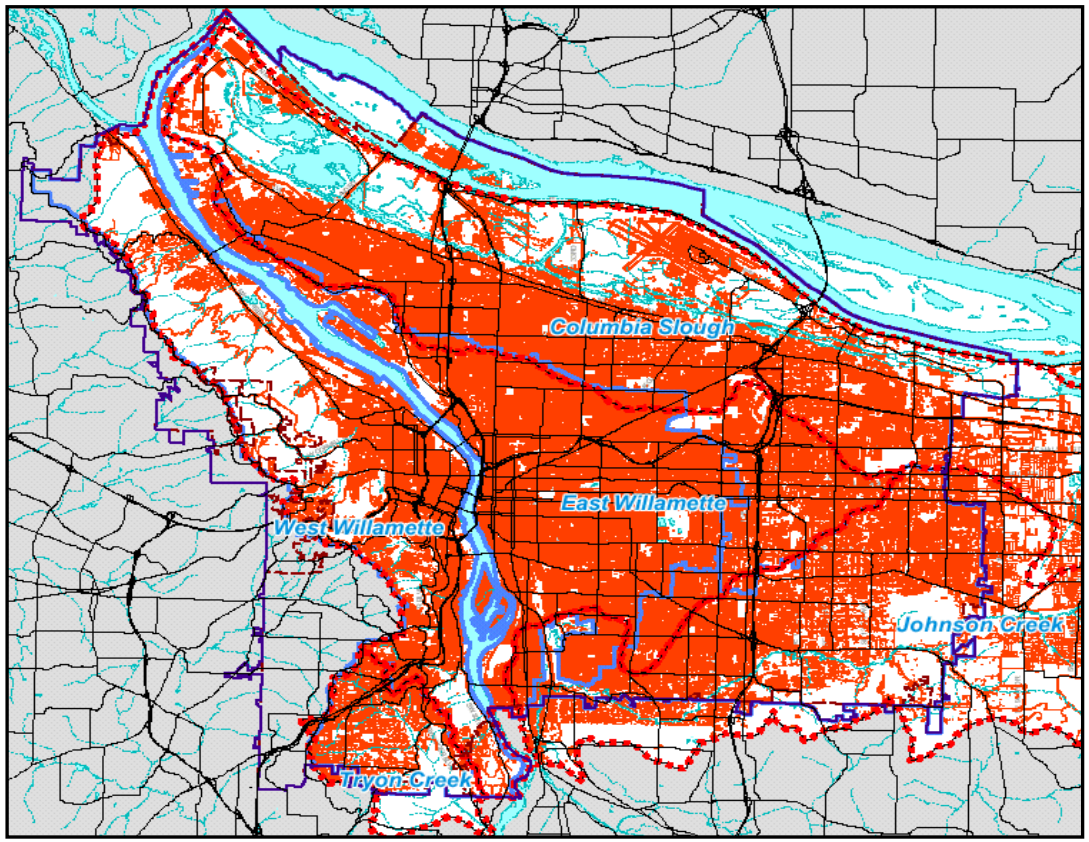
Urban and suburban runoff is the only Bay nutrient load sector where we are seeing reverse progress
In load reductions- source OIG (2007)

New Stormwater Developments in the Chesapeake Bay Watershed

- Once a leader, went to sleep for 20 years
- Poor stormwater scorecard in most states
- More stringent runoff reduction reqmts for new and redevelopment
- New generation MS4 permits
- Bay wide nutrient and sediment TMDL
- Trading and offsets


The Stormwater Tribes of the Chesapeake Bay Watershed
Lotalawnians
Redevelophants
Nipidees
Hotspotanots

The Nipidees:
The Existing Development Tribe



The Nipidees:
Existing Development Tribe

- Runoff from 5 million acres of impervious cover and turf cover are mostly untreated
- 21 of the 22 Phase 1 NPDES MS4 Stormwater Permits have not been renewed
- More than a thousand permit year backlog with 500 small NPDES MS4 stormwater permits
- Need for numeric and enforceable stormwater permits…retrofitting

Lotalawnians:
The New Development Tribe

Lotalawnians:
The New Development Tribe

- Conservatively, an estimated 2.5 million acres of new land development expected in the Bay watershed by year 2030
- New regulations and design manuals are rolling out in all 7 Bay states
- Runoff reduction holds the line, but requires extensive training and local implementation.
- Considerable uncertainty about actual on the ground implementation

A Lot of Change Going On in the Bay States

STATE	Runoff Reduction?	Channel Protection?	Status
DC	YES	NO	2011
EPA	YES	YES	2010
DE	YES	YES	2010
MD	YES	YES	2010
PA	YES	YES	2010
NY	YES	YES	2010
VA	YES	YES	2011
WV	YES	NO	2009

The Redevelophants:
The Urban Redevelopment Tribe

The Redevelophants:
The Urban Redevelopment Tribe

- A million acres of redevelopment possible in the Bay by 2030
- Not much required in the past
- Tougher redevelopment standards should incrementally reduce pollutant loads in many Bay states
- Serious controversy in numerous states
- Economics and smart growth

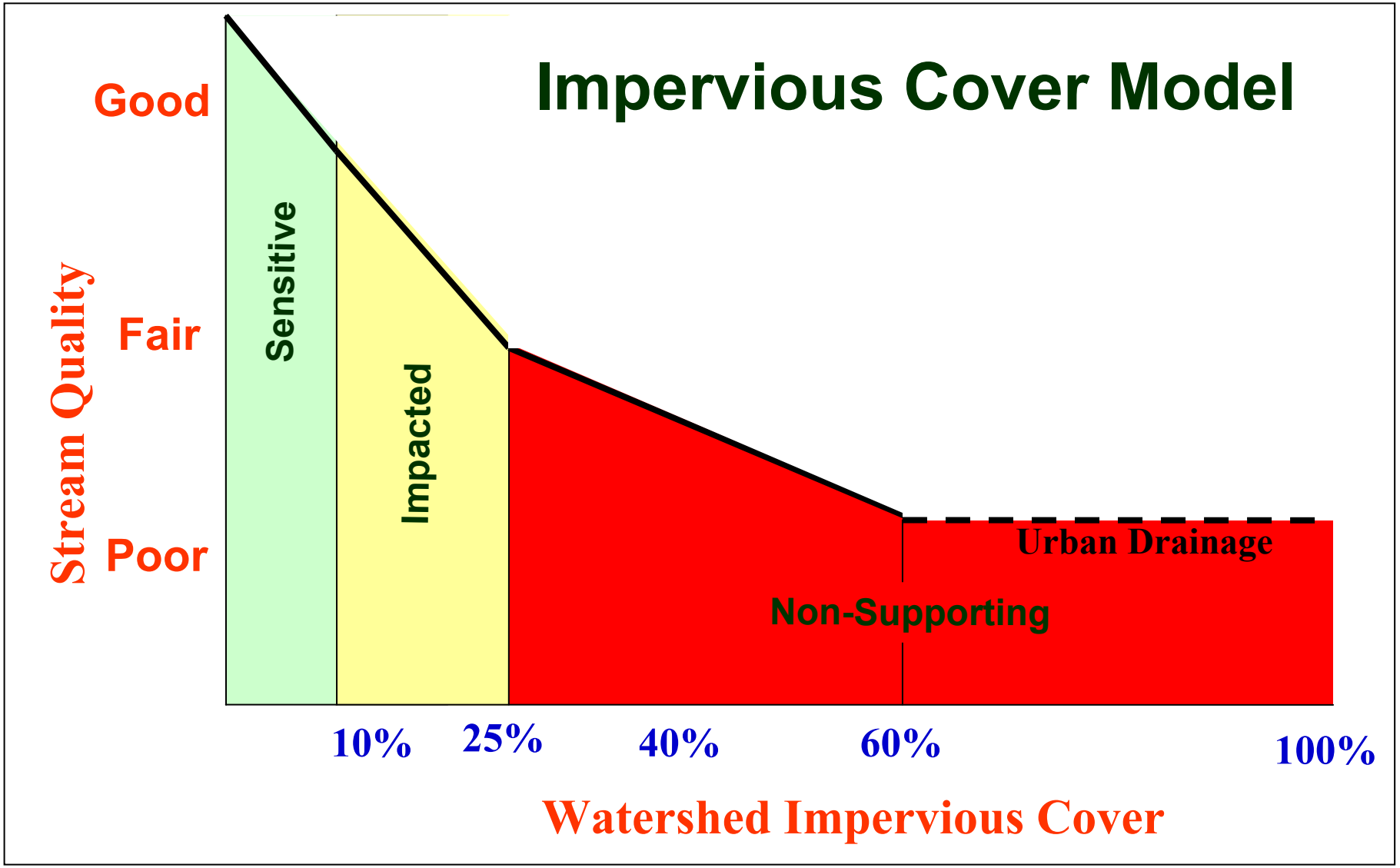
The Hotspotanots:
The Industrial Stormwater Tribe

The Hotspotanots:
The Industrial Stormwater Tribe

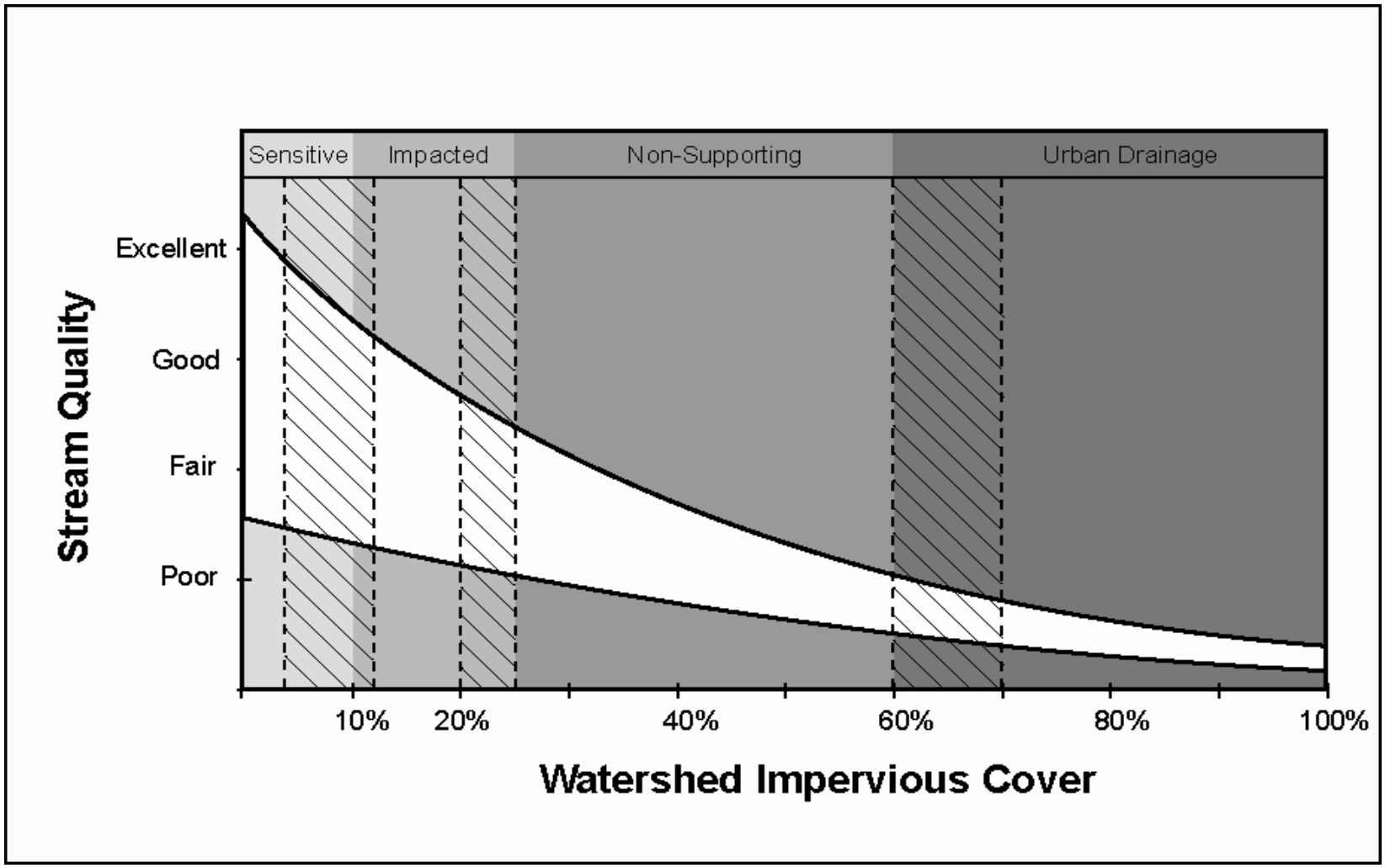
- 20,000 permitted industrial sites in bay watershed as of 2005
- 80,000 stormwater hotspots have not filed and/or are not covered by permits
- Compliance, inspections and monitoring are limited to non-existent.

BAYWIDE STORMWATER SCORECARD - 2009					
Core Programs	DC	MD	PA	VA	WV
Large MS4 Permits	A-	C-	-	D	-
Small MS4 Permits	-	F	D	C+	A
Stormwater Regs	I	B+	I	I	B+
Stormwater Manual	I	C-	B	A-	I
MS4 Outreach	B	D	D	B-	B
Public Outreach	A	D+	F	B	I
Industrial Permits	D	D	D-	B-	D
Construction Permits	B+	C-	D+	C-	D
Permit Enforcement	B+	D	D-	D	D-
Local/ State Financing	A-	C-	F	C+	D+
OVERALL GRADE	B+	D+	D	C+	C

Original ICM developed based on 200+ reports and papers



Reformulated ICM - 2009



The ICM Revisited: Recent Research

- 67 peer reviewed studies tested the ICM in wide range of ecoregions have been published since 2003
- 72% confirm or reinforce the ICM
- 28% are inconclusive or contradicting
- Strongest support for aquatic insects, fish and individual geomorph. indicators

Impacts are now detected well below the 10% IC threshold.

Impacts of land development are now detected as low as 5 to 10% impervious cover

Research shows that metrics such as watershed forest, turf, wetland or riparian cover predict stream quality better below 10% IC

ICM and small estuaries and coastal streams

- ICM does apply to coastal streams, small estuaries and tidal coves in the coastal zone.
- Salinity, mummichogs, benthic macros, sediment metals, fecal coliforms, estuarine fish indicators all decline

The Cropland Caveat

Ecoregions where cropland is the dominant predevelopment land cover often have a higher IC threshold (12 to 15 %) than forested eco-regions

Recent Finding from USGS

Prior channel modification and sedimentation suspected

Riparian forest buffers have a mitigating effect on the ICM

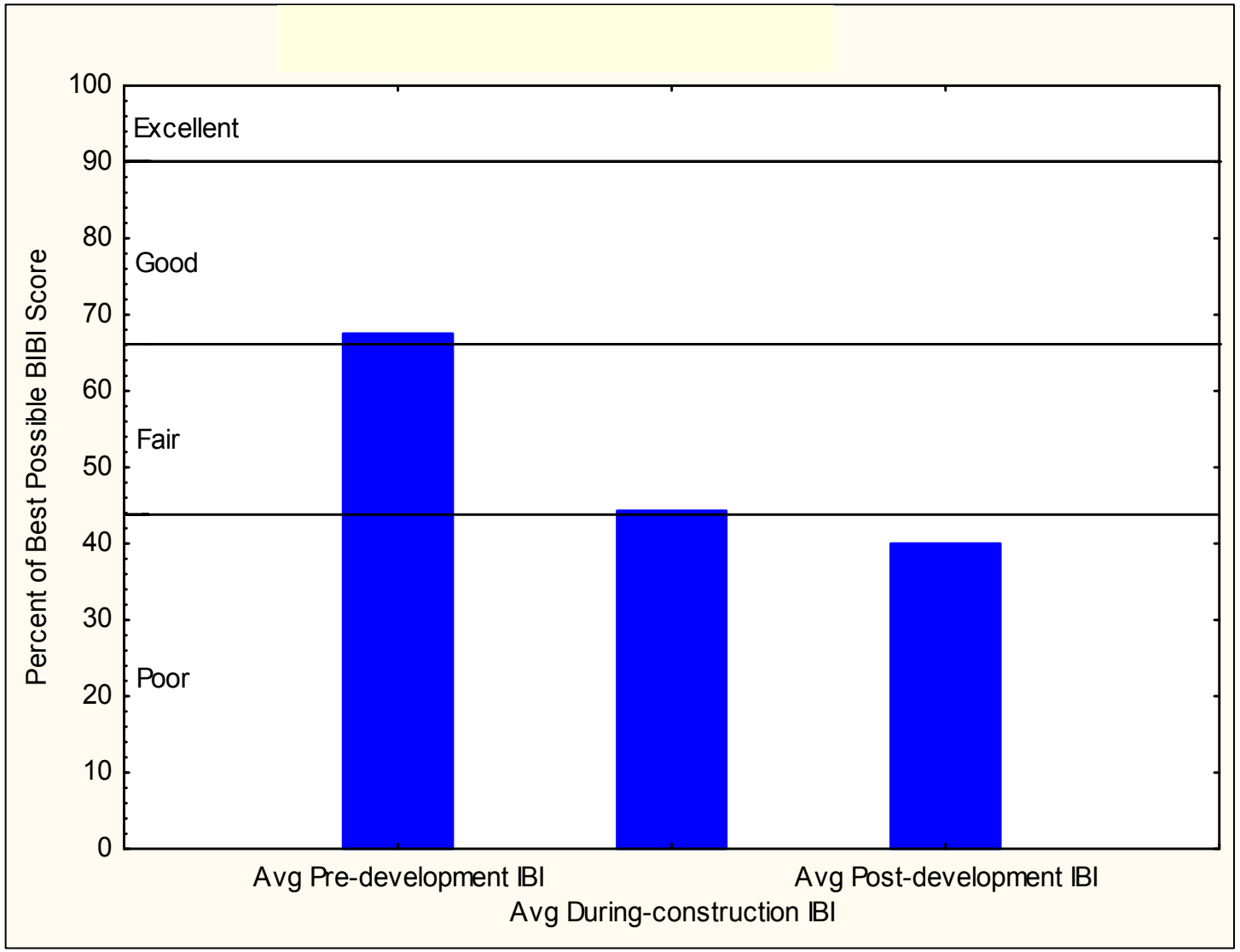
Riparian forest cover appears to partly mitigate the effect of IC on streams up to about 15% IC, especially for geomorphic and biodiversity indicators.

Beyond 15%, not much effect

Subwatershed IC also related to loss of riparian quality

Not Much Effect From Current Watershed Treatment *

- Stormwater ponds cannot maintain stream quality
- Most ICM research was done in regions with at least a moderate degree of development regulation
- Cross-sectional studies show decline even with high levels of environmental protection
- Can show improvement within the limits of the "cone"


100
90
80
70
60
50
40
30
20
10
0
Excellent
Good
Fair
Poor
Percent of Best Possible BIBI Score
Avg Pre-development IBI
Avg During-construction IBI
Avg Post-development IBI

Other ICM Research Headlines

ICM doesn't apply everywhere…streams in the front range of the Rockies – they have already been degraded by prior riparian alterations and water diversions in the last 150 years

Reference: Sprague et al, 2006

Translating ICM Science into Management

- IC is tangible – it can be measured, mapped, traded, reduced, priced, forecast and perhaps mitigated.
- IC (and other metrics) can be used to classify, manage and regulate small watersheds
- Scientists need to present the simplest model that captures the most variation – we can't worship at the altar of complexity.

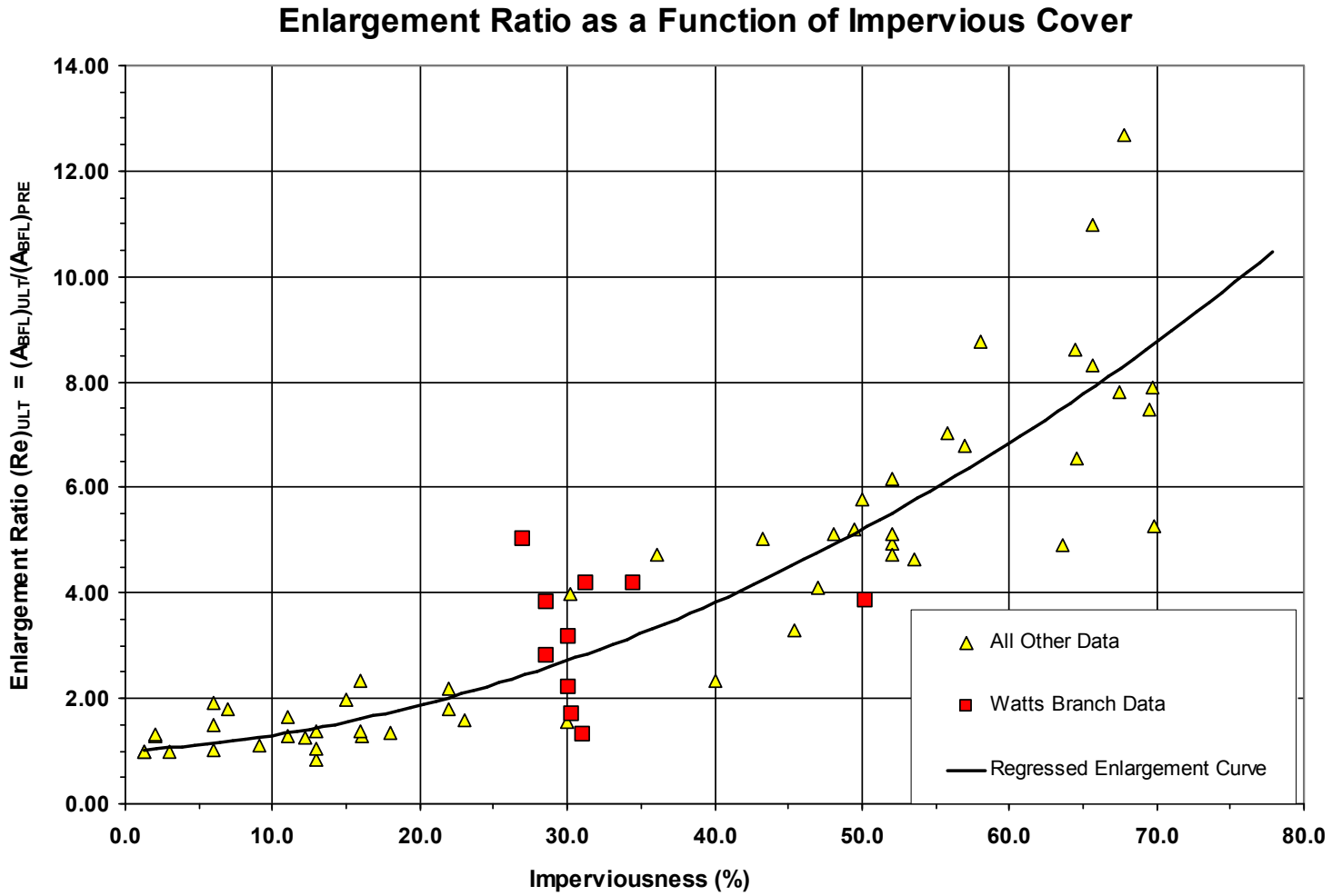
Urban Stream Channel Erosion and effect on Sediment and Nutrient Delivery

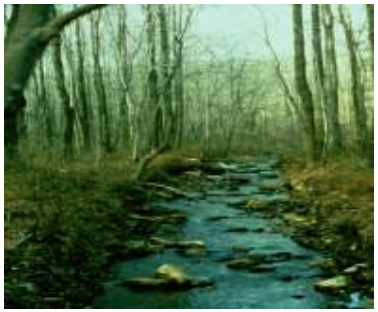
- Clear differences between delivery rates for healthy, degraded and restored urban streams
- Degraded streams have more nutrient delivery from floodplain soils and less internal nutrient processing
- Stream restoration as a practical, cost-effective strategy


Good Riparian Buffer
Stable Banks
No Evidence of Channel Widening
No Sediment Deposition


Unstable Banks
Evidence of Channel Widening
Sediment Deposition
Embeddedness

Channel Enlargement as a Function of Impervious Cover





Sensitive: Full Runoff Reduction for all storm events up to the two-year design storm event (3 to 3.5 inches)

Impacted: Full Runoff Reduction for all storm events up to the one year design storm event (2.2 to 2.6 inches).

Non-supporting: Maximize Runoff Reduction up to the 90% or water quality storm (0.8 to 1.4 inches).

Urban Drainage: Maximize Runoff Reduction up to the "first flush" storm (usually about 0.5 inch)

Renewed Focus on Stormwater Hotspots and Pollution Prevention

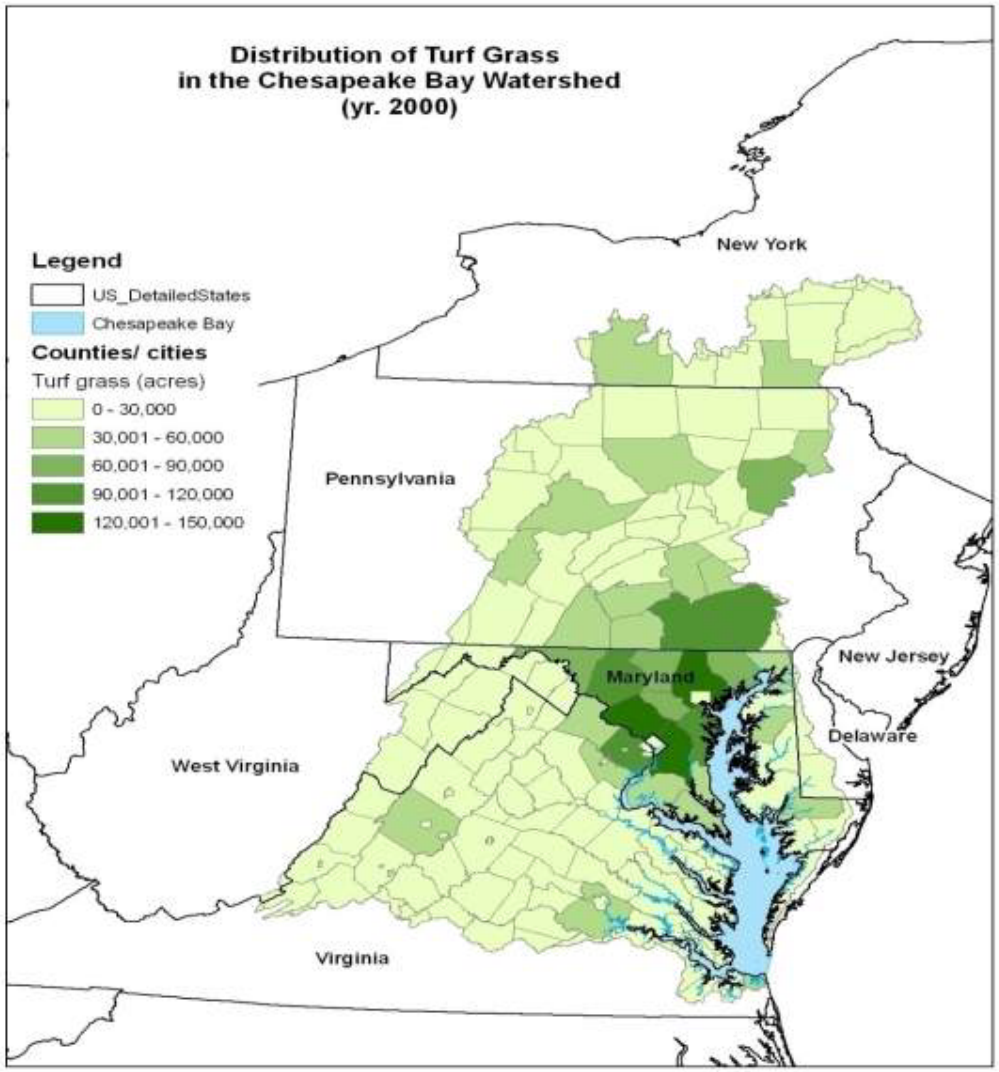
ICM and Wet Weather Water Quality

- Pollutant concentrations do not follow ICM
- Not all IC is the same with respect to EMCs
  - source areas
  - land uses
  - hotspots
- Pollutant loads **do** conform closely to ICM

Objectives of the BenchmarkingTool

- ✓ Takes only a few hours to complete
- ✓ Identifies correctable stormwater problems
- ✓ Increases staff awareness about stormwater, watersheds and community stewardship
- ✓ Leads to action not just paperwork
- ✓ Create a quantitative scorecard of overall site performance
- ✓ Distinguish between dirty, clean and green sites

We have Reached the Clipping Point



The Clipping Point: Emergence of Turf Cover As a Major Bay Ecosystem

TURF COVER, BAY WATERSHED 2000

Method 1: 3.82 million acres
Method 2: 3.79 million acres

TURF As PERCENT OF BAY LAND AREA

Method 1: 9.5%
Method 2: 9.5%

COMPARISON TO OTHER BAY LAND USES

Row Crops:	9.2% of watershed
Pasture:	7.7%
Hay and Alfalfa:	7.4%
Wetlands:	3.8%

What do we know about home lawns and nutrients?

About 50% to 65% fertilize their yard

15 to 20% hire lawn care company

Average of two applications per year

50% of homeowners over-fertilize

Estimated N Fertilizer inputs by lawns: 215 million lbs/yr

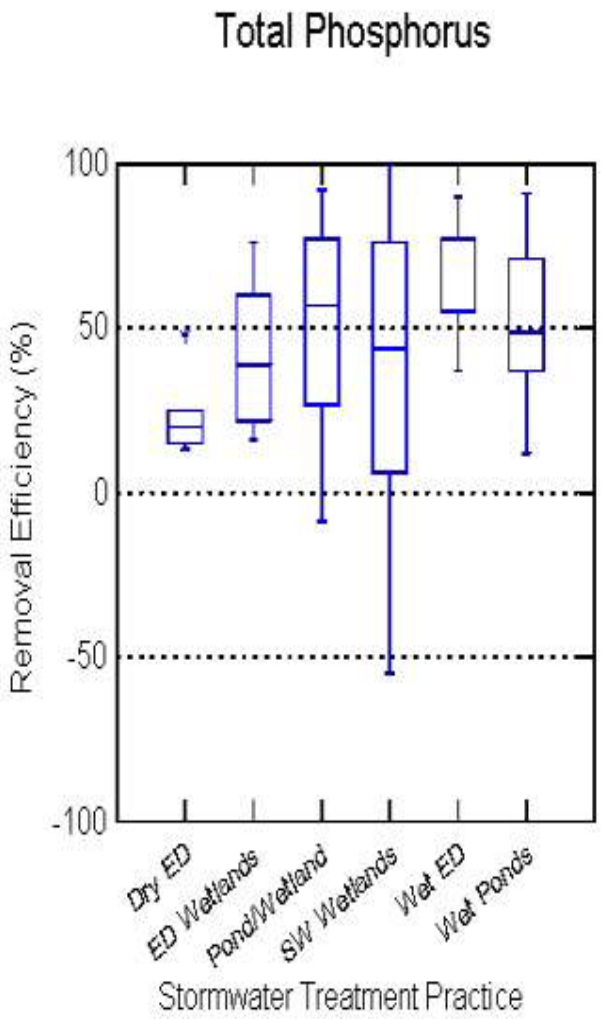
The Shift to Runoff Reduction

Monitoring indicates that some practices are very effective in reducing the volume of runoff, which sharply increases the mass reduction of nutrients from sites

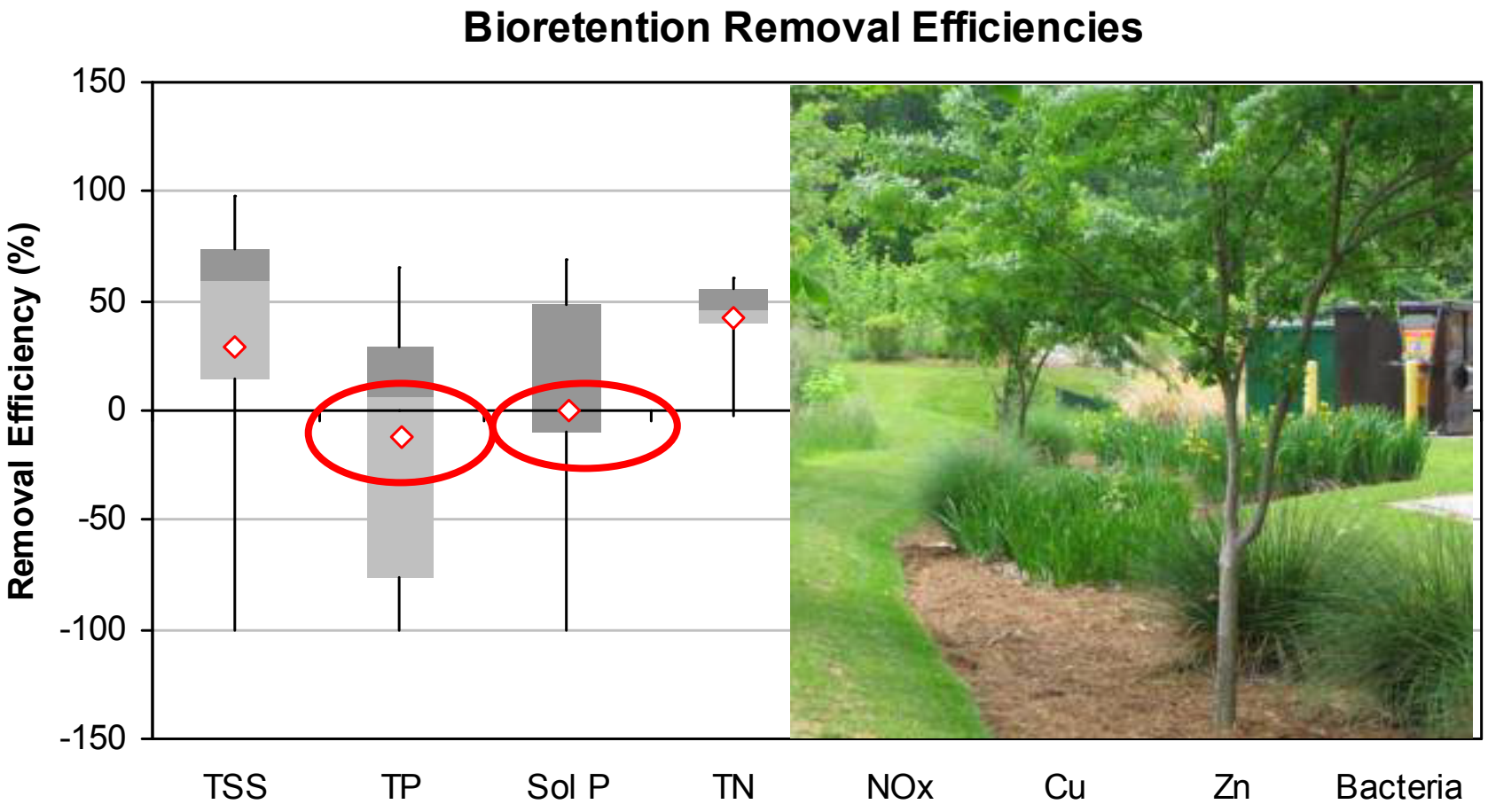
Runoff reduction is defined as the total volume reduced through canopy interception, soil infiltration, evaporation, rainfall harvesting, engineered infiltration, extended filtration or evapotranspiration

Shifting Away from Percent Removal

Practice Group	TP (%)	Sol P (%)
Dry Ponds	20	- 3
Wet Ponds	52	64
Wetlands	48	24
Infiltration*	70	85
Filtering Systems	59	3
Water Quality Swales*	24	-38



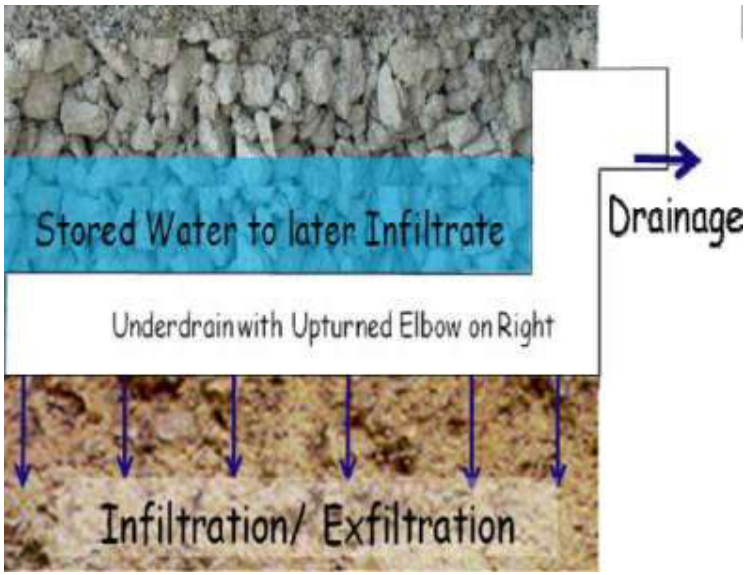
The Interesting Case of Bioretention



Based on initial data, it looks as if bioretention has zero or negative removal rates

New research provides insights in bioretention design features that boost TN and TP removal

- 2-4 feet media depth
- 3-5% carbon source in media
- Create anoxic bottom layer to promote denitrification
- Increased hydraulic residence time through media (1-2 in/hr)
- Test media to ensure low P-index



Volumetric Runoff Reduction Achieved by Bioretention			
	Location	**% Runoff Reduction**	Reference
Bioretention *	CT	99%	Dietz and Clausen (2006)
Bioretention *	PA	86%	Ermilio (2005)
Bioretention *	FL	98%	Rushton (2002)
Bioretention *	PA	80%	Traver et al (2006)
Bioretention *	AUS	73%	Lloyd et al (2002)
Bioretention #	ONT	40%	Van Seters et al (2006)
Bioretention #	Model	30%	Perez-Perdini et al (2005)
Bioretention #	NC	40 to 60%	Smith and Hunt (2006)
Bioretention #	NC	20 to 29%	Sharkey (2006)
Bioretention #	NC	52 to 56%	Hunt et al (2006)
Bioretention #	NC	20 to 50%	Passeport et al (2008)
Bioretention #	MD	52 to 65%	Davis (2008)
Runoff Reduction Estimate		**40 # to 80 ***	
# underdrain design *infiltration design			

Further research documents that bioretention can sharply reduce runoff volumes, which, in turn increases, the **mass** of nutrients which are removed

Runoff Reduction Rates (%)

Infiltration	50 to 90
Bioretention	40 to 80
Pervious Pavers	45 to 75
Green Roof	45 to 60
Dry Swale	40 to 60
Rain Tanks/Cisterns	40
Roof Disconnection	25 to 50
Grass Channel	15 to 30
Dry ED Pond	0 to 15
Wet Pond	0
Sand Filter	0

Source: CWP and CSN (2008)

BIORETENTION DESIGN	
LEVEL 1 DESIGN	LEVEL 2 DESIGN
RR = 40% TP = 55% TN = 64%	RR= 80% TP= 90% TN = 90%
TV= (Rv)(A)	TV= 1.25 (Rv)(A)
Filter media at least 24" deep	Filter media at least 36" deep
One form of accepted pretreatment	Two or more forms of accepted pretreatment
At least 75% plant cover	At least 90% plant cover, including trees.
One cell design	Two cell design
Underdrain	Infiltration design or underground stone sump
Both: Maximum organic material in media of 5% and hydraulic residence time of 1 inch per hour through media (10% fines)	

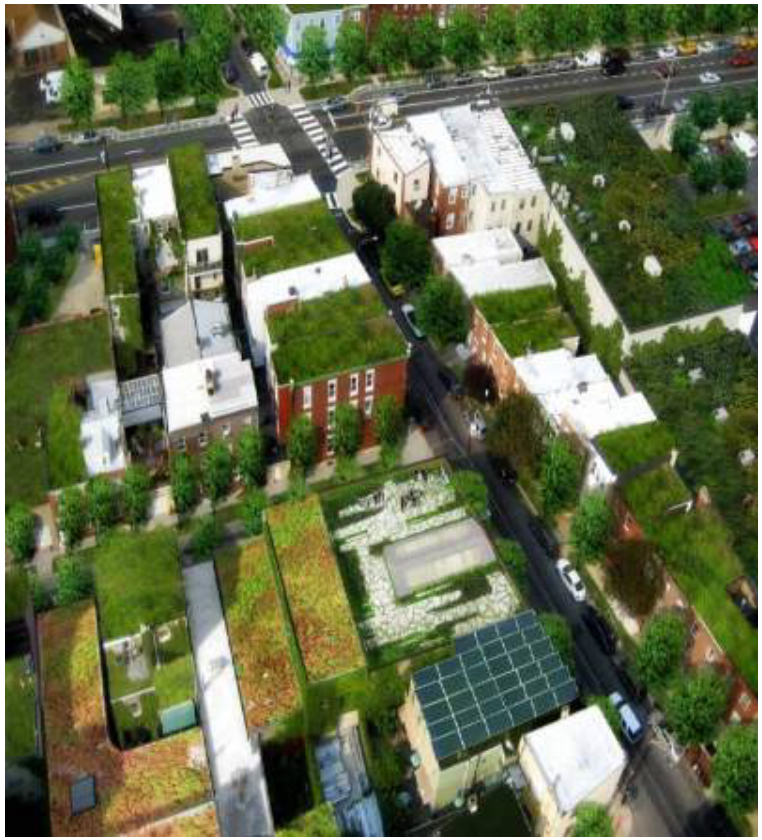
We are now in an design era where we can isolate the design features that maximize runoff reduction and mass nutrient removal

A renewed focus on stormwater economics and accounting

Cost to Treat One Acre of Impervious Cover (2010 Dollars)		
Stormwater Management Scenario	**Sector**	**$**
New Development Pre-ESD (2000 Manual)	Private	$ 31,689
New Development, ESD to MEP (2010)	Private	$ 46,509
Redevelopment Using ESD (ultra-urban)	Private	$ 190,938
Storage Retrofits in Urban Watershed	Public	$ 32,500
Green Street Retrofits, Highly Urban	Public	$ 167,123
Stream Restoration, Nutrient Equivalent	Public	$ 35,600
Source: CSN (2010)		

Emergence of New Leaders and Stormwater Institutions

- MS4 Pyscho-therapists
- Private Maintenance Companies
- Regional Stormwater Utilities
- "Three Water" Utilities
- Regional Stormwater Consortia
- Contractor Certification
- Peer-reviewed design specs
- Bay-wide Designer Training Partnership



Questions and Comments