Hazen

Integrated Watershed Restoration in Urban Areas

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SeSwA Southeast Stormwater Association

Presentation Outline

- Urban Watershed Challenges
- Tools for Addressing Impairments
- Ways of Achieving Restoration Goals
- Case Studies

Restoration

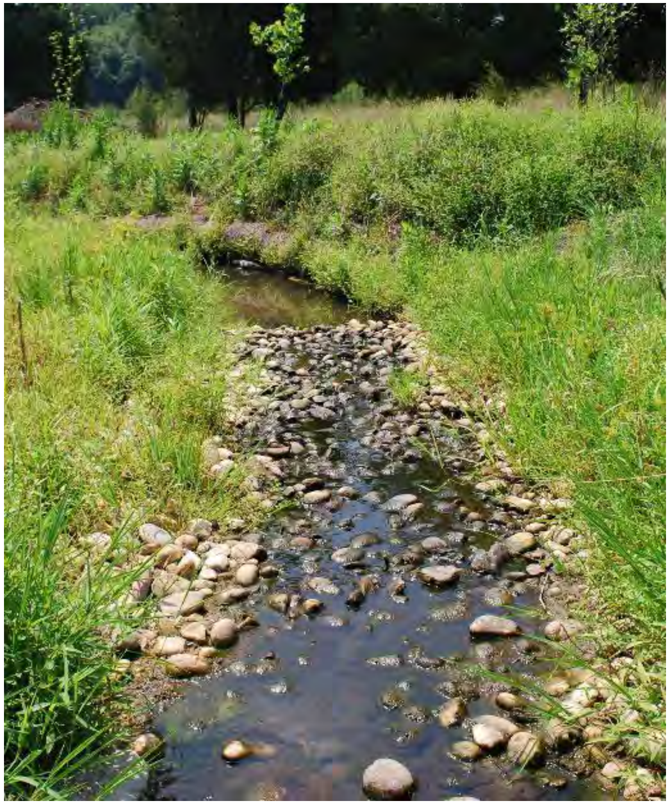
Manipulation of the physical, chemical and/or biological characteristics of a site with the goal of returning natural or historic functions to a former or degraded aquatic resource.

Why restore urban watersheds?

- Protect water supply
- Provide clean water for recreation
- Protect downstream water quality
- Increase in-stream base flows
- Protect and enhance wildlife habitat
- Provide educational opportunities

Why restore urban watersheds?

- Protect property and infrastructure from flooding and erosion
- Satisfy regulatory requirements
  - NPDES permit requirements
  - TMDLs
  - Compensatory mitigation
  - Response to violations
  - Rezoning conditions



Barriers to Urban Watershed Recovery

Funding	Thermal Pollution	Development Trends	Complexity
Climate Change	Public/Political Support	Habitat Fragmentation	Fish Passage Barriers
SSOs and CSOs	Habitat Loss	Urban Stormwater Flows	Erosion and Sedimentation
Oil and Grease	Pesticides	Metals	Nutrients
Pharmaceuticals	Regulatory Support	Constraints	Illegal Dumping

Tools for Addressing Impairments

- Enforcement of existing regulations
- New ordinances and regulatory tools
- Proactive NPDES program implementation
- Incentives to encourage private investment
- Project Implementation
  - Stormwater control measures
  - Stream restoration
  - Other best management practices

Benefits of Stream Restoration

Channel Improvements

- Prevented sediment during storm flow
- Nutrient processing at base flow
- Reconnection of stream and floodplain
- Improved instream and riparian habitat

Glenora Tributary, Rockville, MD

Benefits of Stream Restoration

Floodplain Improvements

- Floodplain processing of sediment and nutrients
- Increased floodplain access and storage
- Improved terrestrial and wetland habitat
- Educational and recreational opportunities (e.g., greenways)

Limitations of Stream Restoration

- Changes in watershed hydrology and sediment delivery due to development, redevelopment or climate change
- Limited control of upland pollutant sources due to concentrated flow
- Property acquisition needs may render projects infeasible

Benefits of Stormwater Control Measures

- Peak and volume control
- Pollutant reduction
- Some provide freshwater habitat
- Generally understood and accepted
- Can become amenity

Limitations of Stormwater Control Measures

- Artificial structures
- Capture ALL sediments
- Do not address in-stream sediment sources
- Functional improvement is limited without downstream improvements
- Require routine and long-term maintenance
- Life-cycle costs

Where Should the Money Go?

Stream Restoration Needed

- Incised systems with little to no floodplain connection
- Severely eroded systems
- Where infrastructure is threatened
- Areas where SCMs are not feasible

Stormwater Control Measures Needed

- Watersheds with high percentage of impervious surface
- Watersheds with high pollutant loads from upland sources
- Areas where stream restoration is not feasible

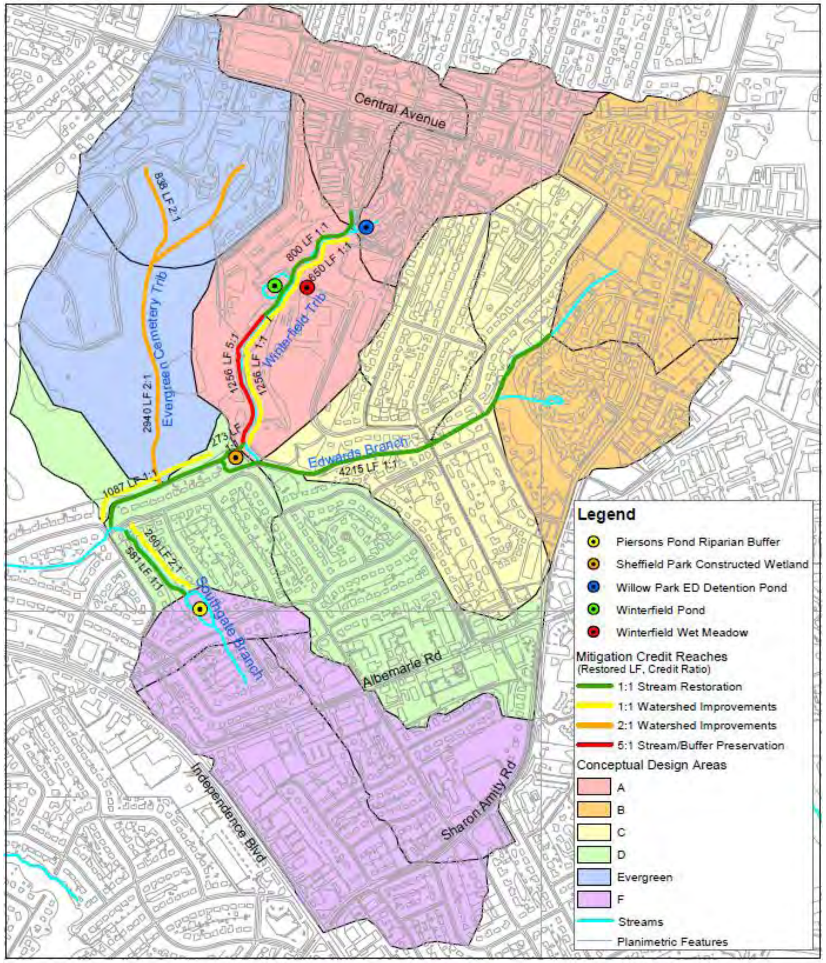
Integrated Watershed Restoration

Incentives for Implementing Upland Controls

Functional Improvements to Edwards Branch and Monteith Creek

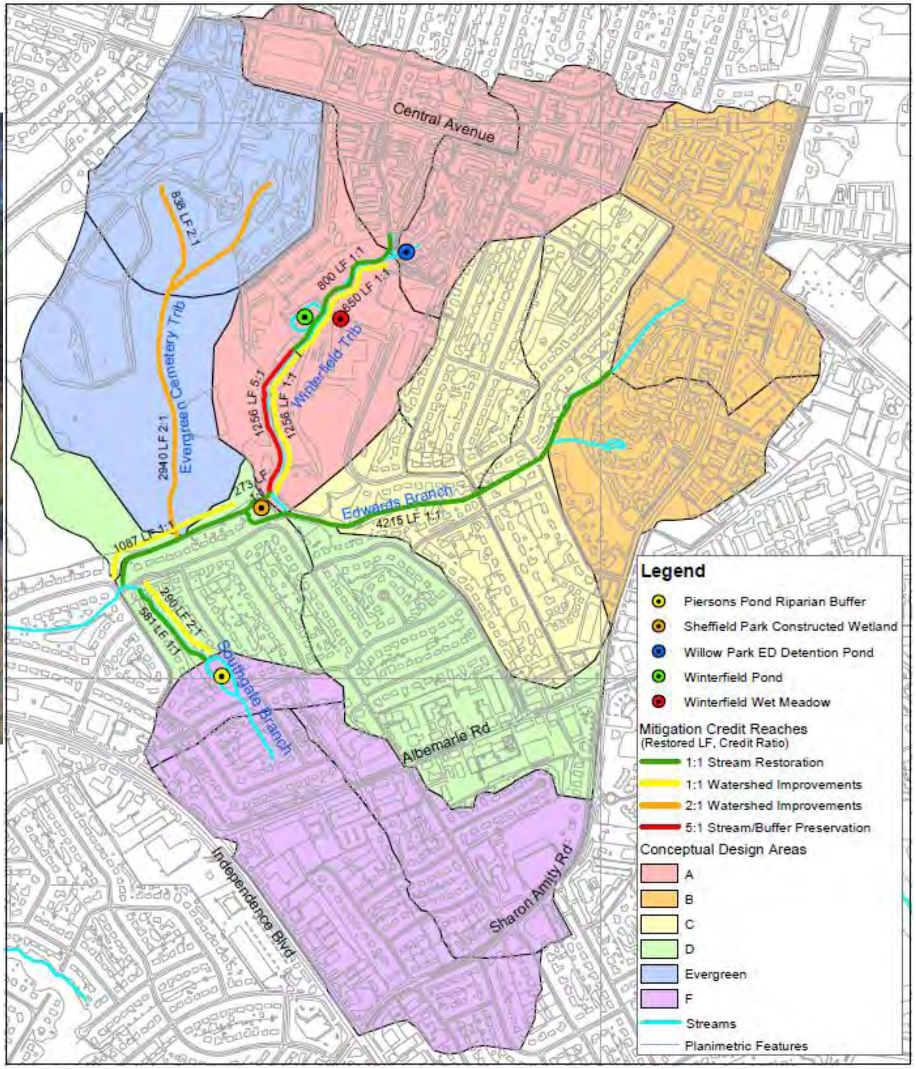
Edwards Branch

- Pilot Stream Mitigation Project
- Multiple SCMs implemented in a one square mile watershed
- Credit for SCMs were approved as an incentive for integrating upland controls



Edwards Branch

- Credits based on length of stream influenced by SCM
- How much influence?
- Credits earned by
  - SCM Condition ($^1/_3$)
  - Stream Condition ($^2/_3$)
    - Good/Fair Bugs; <u>or</u>
    - Water Quality Improvement



Edwards Branch

- Sediment is a major cause of impairment in the watershed
- Overall WQ improvement strategy was to reduce TSS
- Success based on meeting the TSS criterion of 600 lbs/acre/year <u>or</u> all of the SCMs meeting performance expectations

A New "Charlotte Method"

- Way to relate SCM performance to stream functional improvement
- Based on sediment relationship between SCMs and streams
- TSS used as a surrogate for H&H benefits and total pollutant reduction
- Considers each SCM's performance, position in the watershed and influence on receiving waters
- Simple, easily calculated, and easily understood

A New "Charlotte Method"

1. Determine annual TSS load reduction for each SCM in lbs/yr using Simple Method.

$$L = P * P_j * R_v * C * A * 0.226$$

Where:

$L =$ Annual mass of pollutant export (lbs/yr)

$P =$ Annual precipitation (in/yr)

$P_j =$ Correction factor for storms not producing runoff

$R_v =$ Runoff coefficient

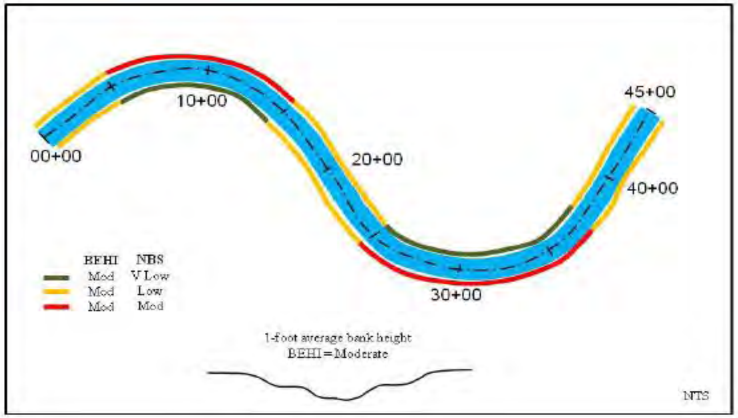
$C =$ Average concentration of pollutant (mg/l)

$A =$ Drainage area (acres)

A New “Charlotte Method”

2. Determine the reduction in the unit annual stream bank erosion rate (lbs/lf/yr) of the proposed stream restoration using the BANCS model.
    - Improvement between existing and proposed.
    - Assumes moderate to very low erosion for restored stream.
    - Using proposed stream restoration encourages headwater SCMs

Stream Section	BEHI	NBS	Bank Height (ft)	Section Length (ft)	Annual Erosion Rate (ft/yr)	Annual Erosion (CF/yr)
0+00 – 5+00 (R)	Mod	Low				
0+00 – 5+00 (L)	Mod	Low				
5+00 – 15+00 (R)	Moderate	V Low				
5+00 – 15+00 (L)	Mod	Mod				
15+00 – 25+00 (R)	Mod	Low				
15+00 – 25+00 (L)	Mod	Low				
25+00 – 37+50 (R)	Mod	Mod				
25+00 – 37+50 (L)	Moderate	V Low				
37+50 – 45+00 (R)	Mod	Low				
37+50 – 45+00 (L)	Mod	Low				



A New “Charlotte Method”

3. Express the benefit of the SCM in units of stream length (lf) using the following equation:

$$\text{Positive SCM Impacts}(lf) = \frac{\text{Annual TSS Load Reduction of SCM } (lbs/yr)}{\text{Unit Annual Stream Bank Erosion Rate}(lbs/lf/yr)}$$

Condition: Credits generated by SCMs cannot exceed the number of credits generated by stream improvements.

Case Study – Monteith Park

2002

2010

Case Study – Monteith Park

Case Study – Monteith Park

- Total treatable drainage area of 18.9 acres
- Annual TSS load reduction of 8,303 lbs/yr
- Unit annual erosion rate reduction of 2.142 lbs/lf/yr for Monteith Creek
- TSS removal equivalent to 3,876 LF of stream restoration

Incentives Implementing

Stream Restoration

Functional Improvements to Upper Watts Branch

Chesapeake Bay TMDL

- Pollution "diet" for the bay
- Established December 29, 2010
- Annual Limits
  - 186M lbs of N (-25%)
  - 13M lbs of P (-24%)
  - 6.5B lbs of sediment (-20%)
- Fully Implemented by 2025
- 60% Implemented by 2017
- Stream restoration included as a way to earn load reduction credits

CBP Expert Panel Recommendations

Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects

Ray Bahr, Ted Brown, LJ Hansen, Joe Kelly, Jason Papacosma, Virginia Snead, Bill Stack, Rebecca Stack and Steve Stewart

Accepted by Urban Stormwater Work Group: **April 30, 2012**
Revised based on Watershed Technical Work Group feedback: **May 29, 2012**
Resubmitted to Watershed Technical Work Group: **July 15, 2012**
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Conditionally Approved by Water Quality Goal Implementation Team: **August 13, 2012**
Resubmitted to WQGIT: **September 28, 2012**
Final Approval by WQGIT: **October 9 2012**

Prepared by:
Tom Schueler and Cecilia Lane
Chesapeake Stormwater Network

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Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects

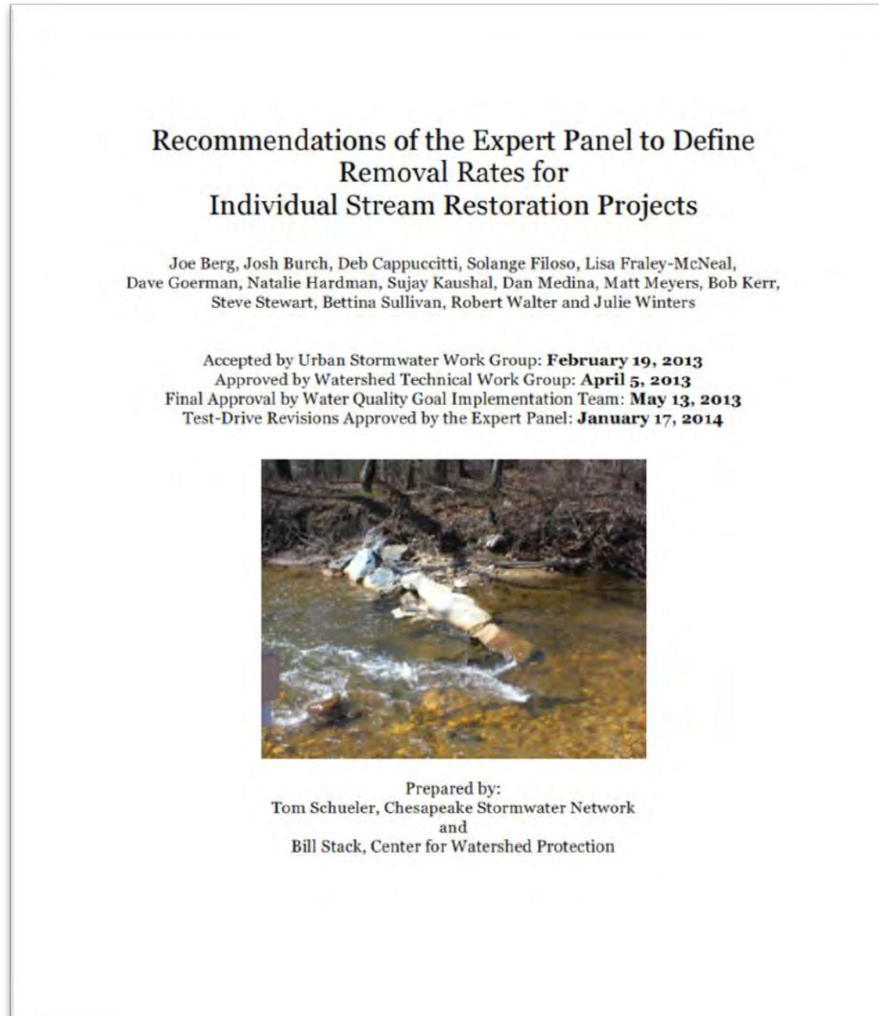
Joe Berg, Josh Burch, Deb Cappuccitti, Solange Filoso, Lisa Fraley-McNeal, Dave Goerman, Natalie Hardman, Sujay Kaushal, Dan Medina, Matt Meyers, Bob Kerr, Steve Stewart, Bettina Sullivan, Robert Walter and Julie Winters

Accepted by Urban Stormwater Work Group: **February 19, 2013**
Approved by Watershed Technical Work Group: **April 5, 2013**
Final Approval by Water Quality Goal Implementation Team: **May 13, 2013**
Test-Drive Revisions Approved by the Expert Panel: **January 17, 2014**

Prepared by:
Tom Schueler, Chesapeake Stormwater Network
and
Bill Stack, Center for Watershed Protection

CBP Expert Panel Recommendations

- Quantifies removal rates and credits for stream restoration projects
- Four protocols that may apply
  - Prevented Sediment
  - Nutrient Processing
  - Floodplain Reconnection
  - Regenerative Stormwater Conveyance



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Protocol 1

Credit for Prevented Sediment During Storm Flow

Pollutants of concern are sediment, TN & TP

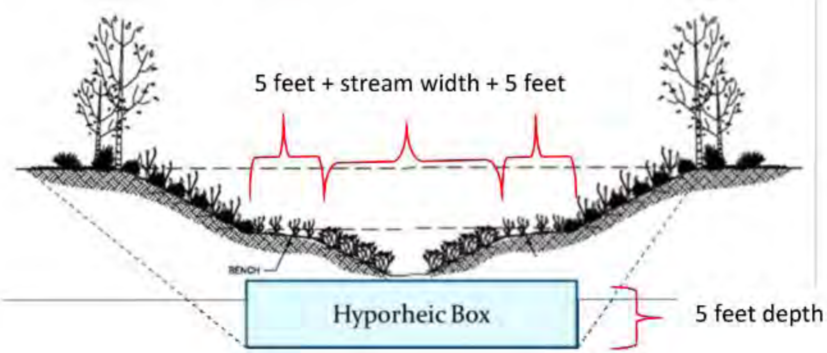
Method

- Calculate sediment loads using Rosgen's BANCS method (BEHI/NBS)
- Convert sediment load to nutrient load
  - 1.05 lbs P/tn sediment
  - 2.28 lbs N/tn sediment
- Estimate stream restoration efficiency (usually 50%)

Protocol 2

Credit for Instream and Riparian Nutrient Processing During Base Flow

Pollutant of concern is TN



Method

- Determine post-construction stream length that has been reconnected using BHR of 1.0 or less
- Determine dimensions of hyporheic box for each reach
- Multiply the hyporheic box mass by the unit denitrification rate (1.06×10^{-4} lbs/ton/day of sediment)
- Compute annual denitrification rate for the watershed

Protocol 3

Credit for Floodplain Reconnection Volume

Pollutants of concern are sediment, TN & TP

Method

- Estimate the floodplain connection volume in the floodplain area through detailed pre/post H&H modeling
- Use curves to estimate the N and P removal rate attributable to floodplain reconnection for the floodplain reconnection volume achieved
- Compute the annual T, P and TSS load delivered to the project
- Multiply the pollutant load by the project removal rate to define the reduction credit

Protocol 4

Credit for Dry Channel Regenerative Stormwater Conveyance (RSC) as an Upland Stormwater Retrofit

Pollutants of concern are sediment, TN & TP

Method

- Determine stormwater treatment volume
- Define removal rates using adjustor curves from retrofit guidance document

Case Study

Upper Watts Branch, Rockville, MD

- Streams run through forest preserve
- Existing stormwater control measures in watershed do not adequately control channel protection volume
- Streams are in a state of disequilibrium
- Restoration is proposed to correct morphology and stabilize the watershed

Case Study

Upper Watts Branch

Stream Restoration

- Tributary 1 – 179 LF
- Tributary 2 – 761 LF
- Main Stem – 207 LF

Outfall Stabilization

- Outfall 1 – 425 LF
- Outfall 2 – 204 LF
- Outfall 3 – 265 LF

Total = 2,041 LF

Case Study – Tributary 2

Upper Watts Branch – Protocol 1

Step 1. Estimate stream sediment erosion rate and sediment load

		Hardwood forest	National Average		
Bulk density of soil, c =	1.4	gm/cc	*From NRCS General guide for Est. Moist Bulk Density for Clay (35-50%)		
	87.402	lb/cf			
Method Used:	2	(Enter 1 or 2)			
Method #1:					
Eroding bank area, A =		sf			
Bank erosion rate, R =		ft/yr			
Sediment load, S =		tn/yr			
		lb/yr		*Rivermorph data:	
				length of channel evaluated for BANCS	3300
Method #2:				total CY per year	93
Predicted Erosion* =	21.45	cy/yr		CY/per foot:	0.03
				length of restoration:	761
Sediment load, S =	25.3	tn/yr		estimated CY per length of rest	21.45
Sediment load, S =	50,619	lb/yr			

Case Study – Tributary 2

Upper Watts Branch – Protocol 1

Step 2. Convert stream bank erosion to nutrient loading

Nutrient concentrations:

1.05	lb P/tn sediment1
2.28	lb N/tn sediment2

1Source: Expert panel recommended value for Phosphorous

2Source: Expert panel recommended values for Nitrogen

Therefore, the nutrient loading for this site prior to restoration is:

26.57	lb P per year
57.71	lb N per year

Step 3. Estimate stream restoration efficiency

Amount of sediment, Phosphorous, Nitrogen loading reduced through restoration:

25309.4	lb/yr sediment
13.3	lb P/yr
28.9	lb N/yr

Case Study – Tributary 2

Upper Watts Branch – Protocol 2

Step 1. Determine the total post construction stream length that has been reconnected using the bank height ratio of 1.0 or less.

Post construction stream length =	761	ft	(length of RGC created)
Bankfull Depth =	1.7	ft	
Low Bank Height =	1.7	ft	
Bank Height Ratio =	1		

Step 2. Determine the dimensions of the hyporheic box.

Width of channel at median base flow=	22	
Hyporheic Box Width =	32	ft
Hyporheic Box Depth =	5	ft
Hyporheic Box Length =	761	ft
Hyporheic Box Volume =	121760	cu ft

Case Study – Tributary 2

Upper Watts Branch – Protocol 2

Step 3. Multiply the hyporheic box mass by the unit denitrification rate (1.06 x 10-4 lb/tn/day of soil).

Bulk density of soil1 =	121.5	lb/cu ft
Denitrification Rate =	1.06E-04	lb/tn/day
Nitrogen Removed =	0.8	lb/day
	286.2	lb/year

1 For this site, bulk density of the stream substrate estimated as the weighted average of bulk densities per the bar sample analysis.

Bar Sample	%	Bulk Density gm/cc	Bulk Density lb/cu ft
Silt Clay	0	1.4	87.4
Sand	17.89	1.7	106.1
Gravel	45.05	2.0	124.8
Cobble	37.06	2.0	124.8
		Weighted Avg Bulk Density =	121.5

bar sample taken 11/14/11 station 31+35

Case Study – Tributary 2

Upper Watts Branch – Protocol 2

Step 4. Compute the annual Nitrogen load for the watershed.		
Watershed Area=	295	ac
Impervious cover=	50	%
Nitrogen Load =	3850	lb/yr
40% of Nitrogen Load=	1540	lb/yr
Applicable Credit =	286	lb/yr

Case Study -

Upper Watts Branch – Tributary 2

Reach	Restored Length	Total N Removed	Total P Removed	Total TSS Removed
		lbs/yr	**lbs/yr**	**tons/yr**
Trib 2	761	29 + 286 = 315	13	13
		8%	**50%**	**50%**
		watershed	**reach**	**reach**

Case Study – Totals for Project

Upper Watts Branch – All Project Areas

Area	Restored Length	Total N Removal	Total P Removal	Total TSS removal
		lbs/yr	**lbs/yr**	**tons/yr**
Trib 1	179	11	2	2
Trib 2	761	315	13	13
MS	207	63	5	5
	1,147	**389**	**20**	**20**
Outfall 1	425	240	111	105
Outfall 2	204	94	43	41
Outfall 3	265	96	44	42
	894	**430**	**198**	**188**
Total	**2,041**	**819**	**218**	**208**

Results Comparison

Monteith Creek and the CBP Expert Panel Guidance

Reach	Restored Length	Riffle Length	Total N Removed	Total P Removed	Total TSS Removed
			lbs/yr	**lbs/yr**	**tons/yr**
Reach 1	1630	457	83	NA	NA
Reach 2	1856	481	114	NA	NA
Total	**3486**	**938**	**197**	**2**	**2**
			12%	**50%**	**50%**
			watershed	**reach**	**reach**

Summary

- Urban watershed recovery may only be possible through the implementation of best management practices that reduce degradation and initiate restoration of aquatic resources
- Both in-stream and upland measures are appropriate in urban areas
- Stream restoration (in-stream) and SCMs (upland) are useful in reducing TSS, N and P in urban watersheds
- Methods to quantify the relative benefits of SCMs and stream restoration are available and in-use
- Alternative means of assigning credits toward NPDES or mitigation goals may incentivize the implementation of watershed recovery practices

Acknowledgements

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- City of Rockville
- Southeast Stormwater Association

Thank You

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