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STATE HIGHWAY ADMINISTRATION

Recommendations for Crediting Outfall and Gully Stabilization Projects in the Chesapeake Bay Watershed

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Background and History of Protocol Development

- MDOT SHA has over 36,000 outfalls in the MS4 counties, majority in headwater channels
  - Met current design standards at the time
  - Many receive off-site drainage beyond control of MDOT SHA
- Restoration / Enhancement Potential
  - ~12% of the outfalls assessed to date have potential for restoration/enhancement
- Why Restore and Enhance Headwater Channels?
  - Headcuts disconnect the functionality of headwater systems
  - Headcuts migrate into and drain upstream wetlands
  - Headcut migration threatens downstream resource functions
  - Headcut migration can threaten DOT infrastructure

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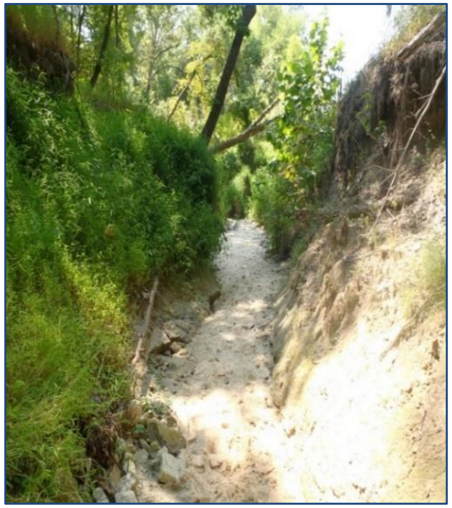
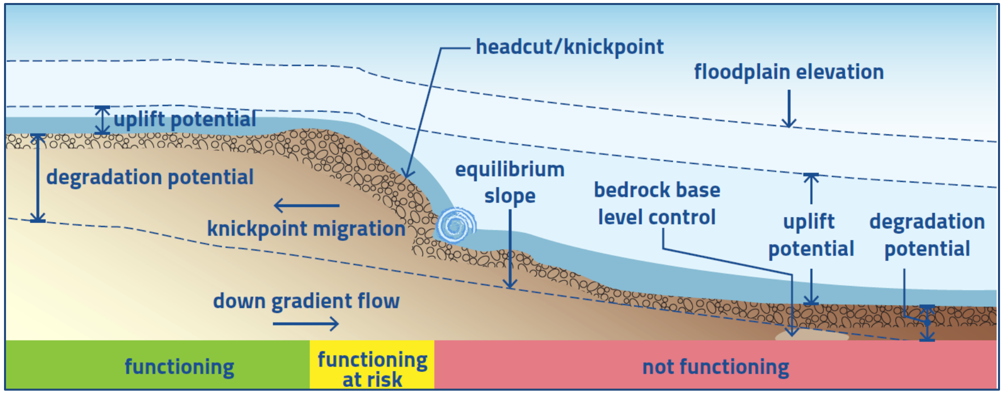
Outfalls & Headwater Channels = Sources!



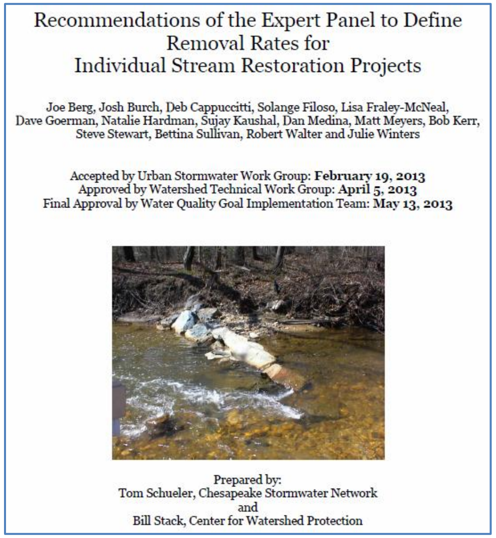
Delivering a Great Uplift Potential!

- Significant uplift potential by addressing headwater headcut channels and outfalls
- Reducing sediment delivering downstream
- Ultimately improving stream functions and watershed connectivity functions
- Sets priorities to address degraded conditions
- Preventative solution addressing significant and long term sediment impacts at the source



MDOT SHA looked to Quantify the Significance of Headwater Erosion

- Started with CBF Expert Panel Protocol 1: Credit for Preventing Sediment During Storm Flows for Stream Restoration Projects
  - Annual sediment loading
  - Convert to annual TN and TP loading
  - Pollution reduction of project
- Goals for Alternative Outfall Credit Method – Protocol 5
  - Develop a defensible, repeatable method to compute annual sediment loading for headcutting headwater channels
  - Conversion to impervious area equivalent and LF equivalency

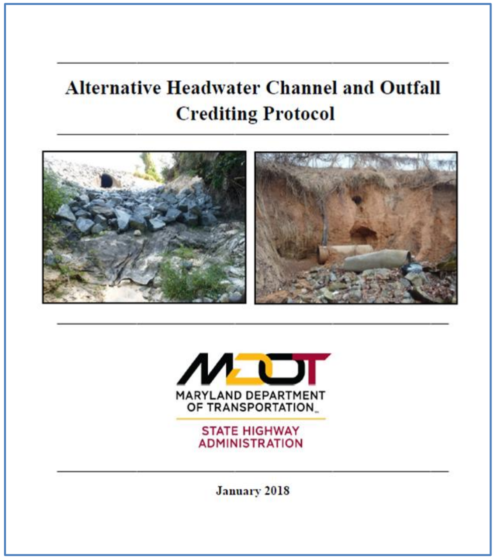


Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects

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

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



Alternative Headwater Channel and Outfall Crediting Protocol

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January 2018

Timeline

- March 2016 – MDOT SHA proposes protocol to MDE
- December 2016 – after 2 rounds of comment responses, MDE requests a review by the CBP, USWG
- April 2017 – MDE and MDOT SHA presents idea of protocol to the USWG
- August 2017 – MDE approves Protocol for use in MD
- March 2018 – MDOT SHA submits protocol to USWG
- July 2018 – USWG determines Expert Panel to evaluate protocol
- September 2018 – First meeting of outfall committee
- October 15, 2019 – Outfall and Gully Stabilization Memo approved by the Chesapeake Bay Program's Water Quality Goal Implementation Team

Formation of the Outfall Restoration Crediting Team

Name	Affiliation
Ray Bahr	MDE
Stephen Reiling	DOEE
Tracey Harmon	VDOT
Brock Reggi	VADEQ
Karen Coffman	MDOT SHA
Ryan Cole	MDOT SHA
Elizabeth Ottinger	US EPA Region 3
Carrie Traver/Aaron Blair	US EPA Region 3
Alison Santoro	MD DNR
Ted Brown	Biohabitats
Chris Stone	Loudoun County, VA
Erik Michelson	Anne Arundel County, MD
Neil Weinstein	LID Center
Nick Noss	PA Turnpike Commission

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Meet the Charge!

- Review the MDOT SHA Outfall Crediting Proposal
- Provide Clear Definitions
- Outline qualifying conditions
- Work with CBPO model
- Decide adjustments
- Soil Sample requirements
- Unintended Consequences
- Functional Uplift Measurements

Five meetings from
September 2018 to March 2019

Final Memo
Water Quality Goal Implementation Team Approved:
October 15, 2019

Recommendations for
Crediting Outfall and Gully Stabilization Projects
in the Chesapeake Bay Watershed

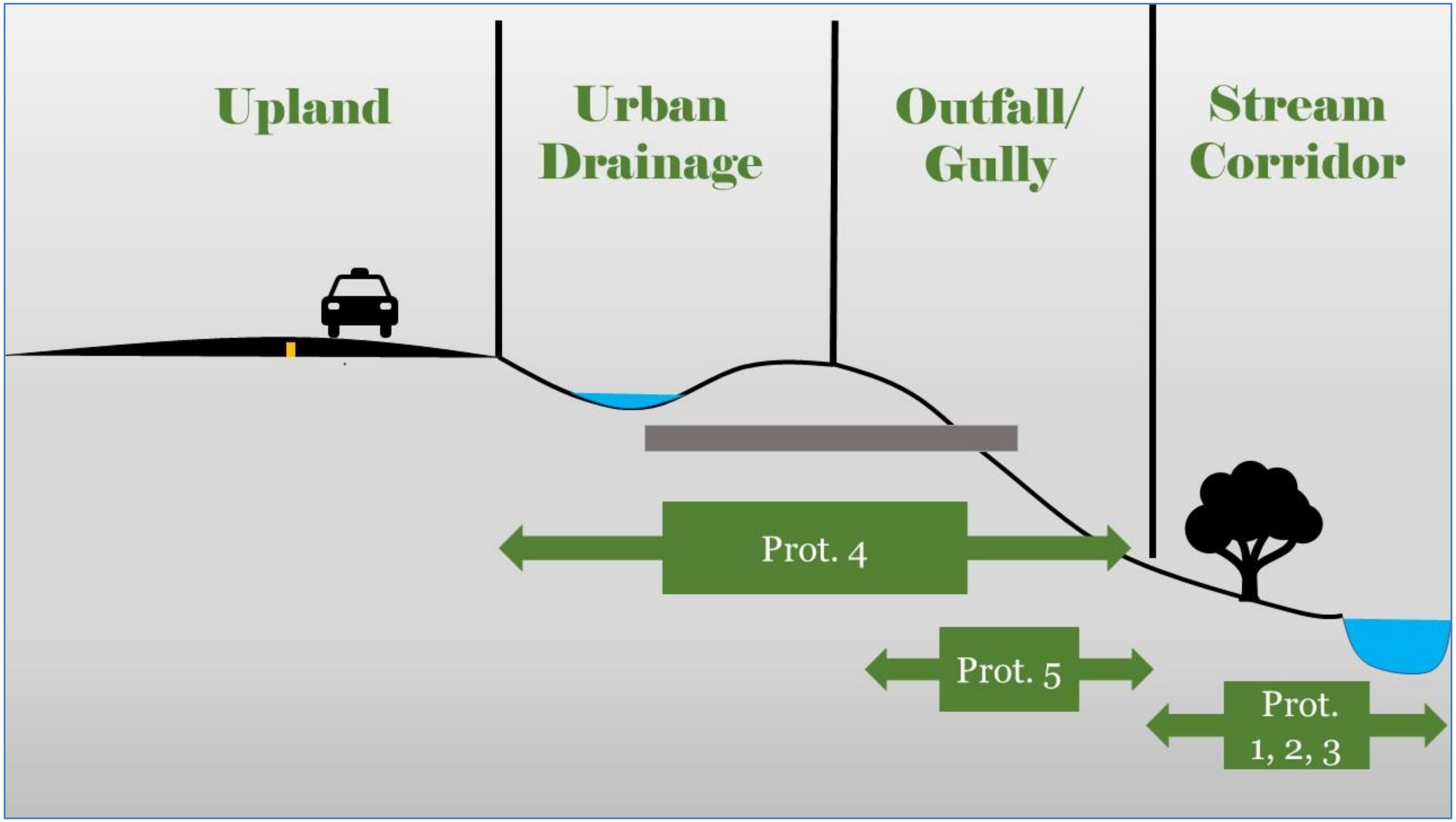

Photo Courtesy: MDOT SHA

Stream Restoration Group 2:

Ray Bahr, Aaron Blair, Ted Brown, Karen Coffman,
Ryan Cole, Tracey Harmon, Erik Michelsen, Nick Noss,
Elizabeth Ottinger, Brock Reggi, Stephen Reiling,
Allison Santoro, Chris Stone,
Carrie Traver and Neil Weinstein

Date: October 15, 2019

Applicability of Protocol



5 Step Process

- Define the Existing Channel Conditions
- Define the Equilibrium Channel Conditions
- Calculate Total Volume of Prevented Sediment Erosion
- Convert Total Sediment Volume to Annual Prevented Sediment Load
- Determine Annual Prevented Nutrient Loads

How does it work?

- Compare existing condition versus future equilibrium state
- Sediment and pollutant load reduction is calculated by comparing the difference between the existing bed surface and the equilibrium or future surface.
- Future surface is based on:
  - Equilibrium Bed Slope
  - Base Level Selection
  - Bank Angle
  - Bottom Width

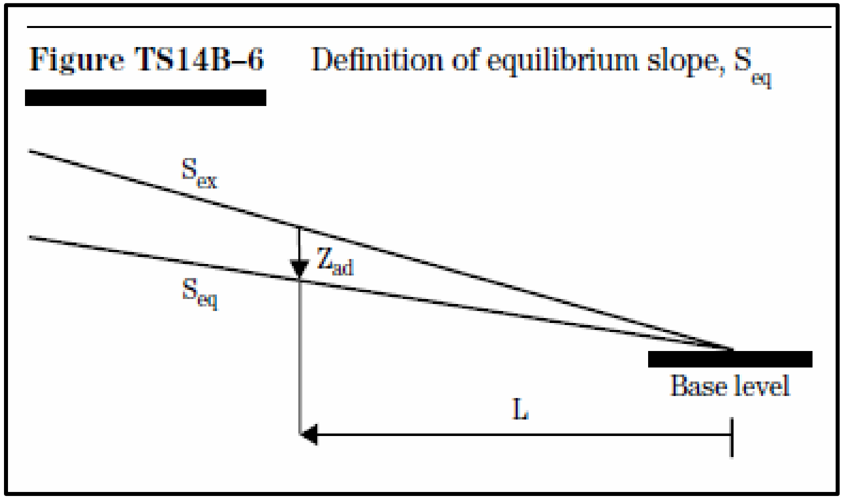
Defines wedge of potential sediment loss (Equilibrium Bed Slope, Base Level Selection)

Defines new stable cross section template (Bank Angle, Bottom Width)

- Output = Total Sediment Yield (CF)
- Annualize by dividing total volume over a 30-year time frame (supported by literature)

Headwater Erosion Reduction Calculation Method

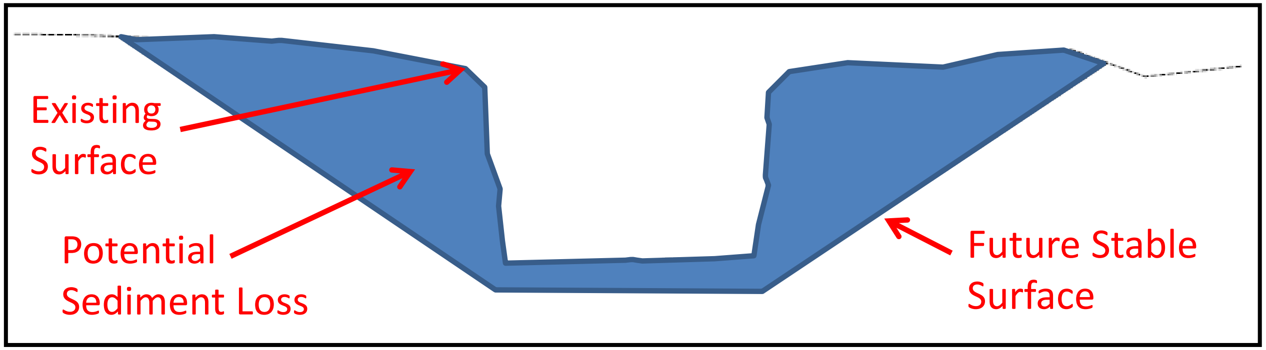
Base level & Equilibrium Slope



Future Surface is Dependent Upon Equilibrium Slope and Width with Base Level Control

Equilibrium Slope: *When sediment transport capacity exceeds sediment supply, channel degradation occurs until an armor layer forms that limits further degradation or until the channel bed slope is reduced so much that the boundary shear stress is less than a critical level needed to entrain the bed material.*

Comparison Cross Section



Determination of Base Level Control

Three methods can be used to establish the base level control.

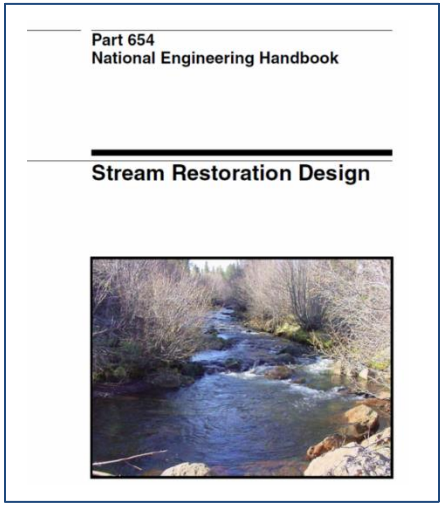
1. Hard Point Control – most permanent base level control, represents a channel condition which has the strength to withstand any expected condition within project lifespan
   - **Bedrock or existing infrastructure**
2. Confluence with Downstream Channel – when outfall channel meets a stable larger receiving stream
3. Equilibrium Slope – when the existing channel is within 5% of the equilibrium slope, it is assumed to be a stable base level condition

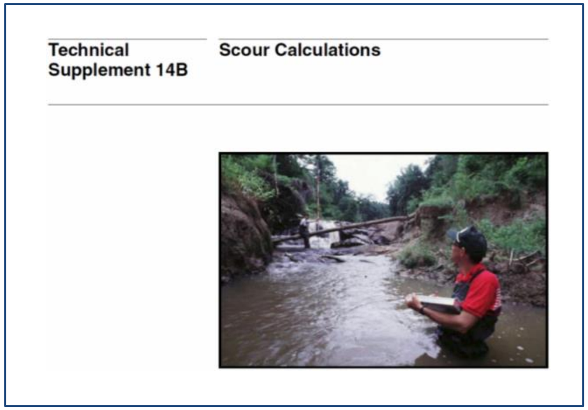
Case 1 & 2 were used for all the case studies. Case 3 is also a potential, but we anticipate that it will be infrequently used.

Computation of Equilibrium Bed Slope

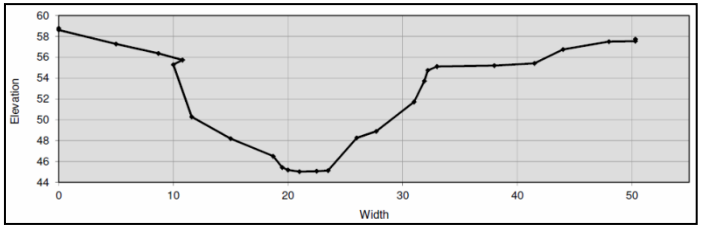
- Future (Equilibrium) Bed Slope
- Headwater Channels are typically supply limited – slope adjustment in a sediment deficient reach occurs by degradation proceeding from upstream to downstream where the downstream end is often limited by a base level control.
- Function of drainage area - S_{eq} are greater for smaller drainage areas and therefore must be computed on a reach-by-reach basis.
- Equations are based on existing channel bed materials and upstream sediment supply. Refer to table TS14B-5 for specific details

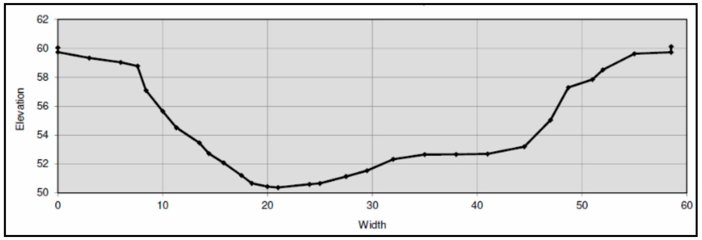
From Technical Supplement 14B Scour Calculations of NRCS Stream Restoration Manual (Part 654 of NEH)

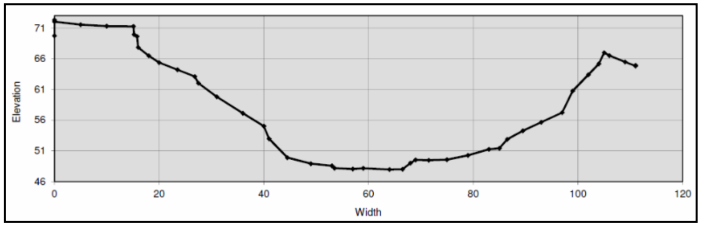




Bottom Width

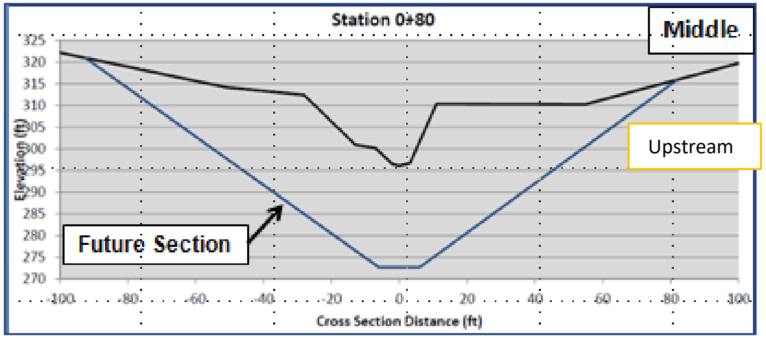


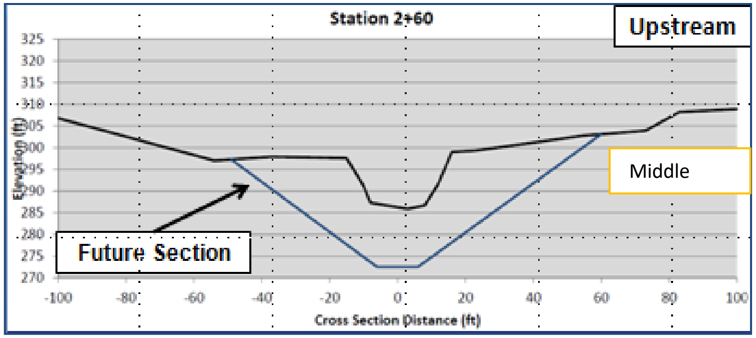


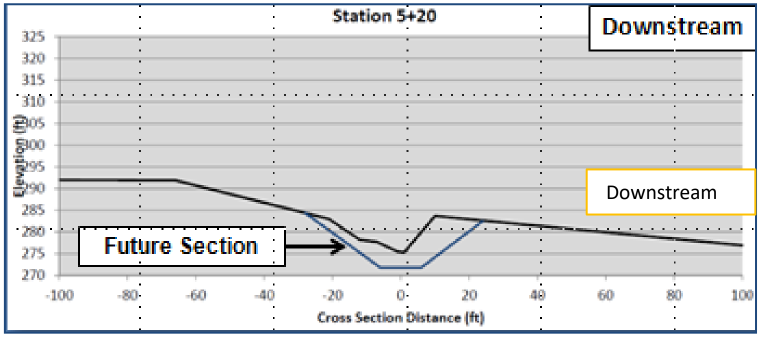


- **Limited ability to predict (calculate) future bottom width**
- **For headwaters, the most appropriate predictor of bottom width is assumed to be within the study reach**
  - Bottom width should be average of the reference cross sections within study area
- **Project specific, determined by taking multiple field measurements**

Computation of Equilibrium Bank Slope



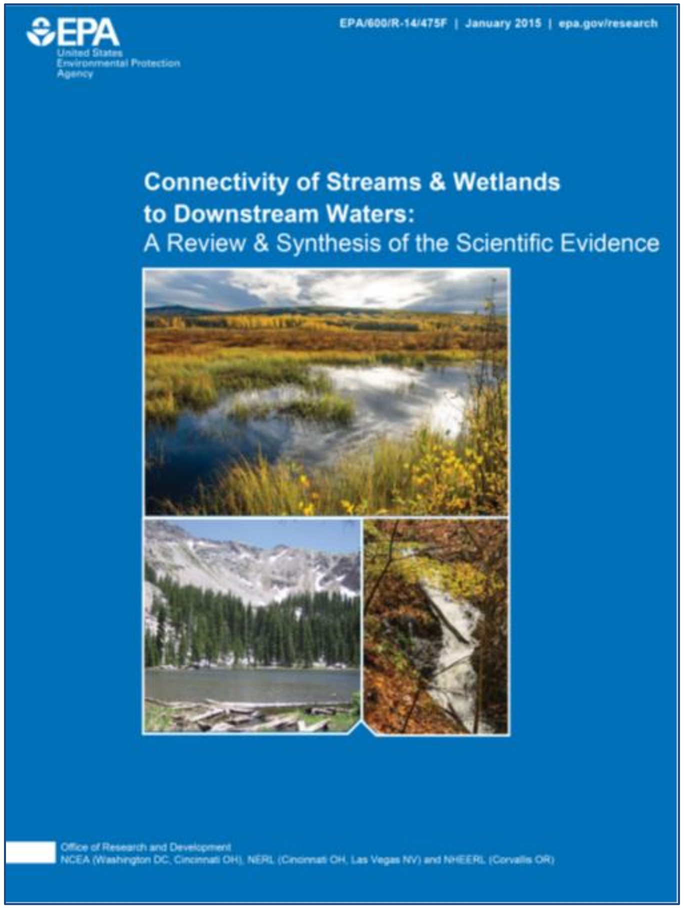




- Template Cross Section
  - 12 ft bottom width
  - Medium dense sand bank material
  - Future bank angle = 1.76:1 (H:V)
- Upstream & Middle Reaches
  - Avg Slope = 4.3%
  - Sand bed (D_{50} = 1.6 mm)
  - Future slope = 0.15%
- Downstream Reach
  - Avg Slope = 3.5%
  - Gravel bed (D_{50} = 20 mm)
  - Future slope = 0.33%

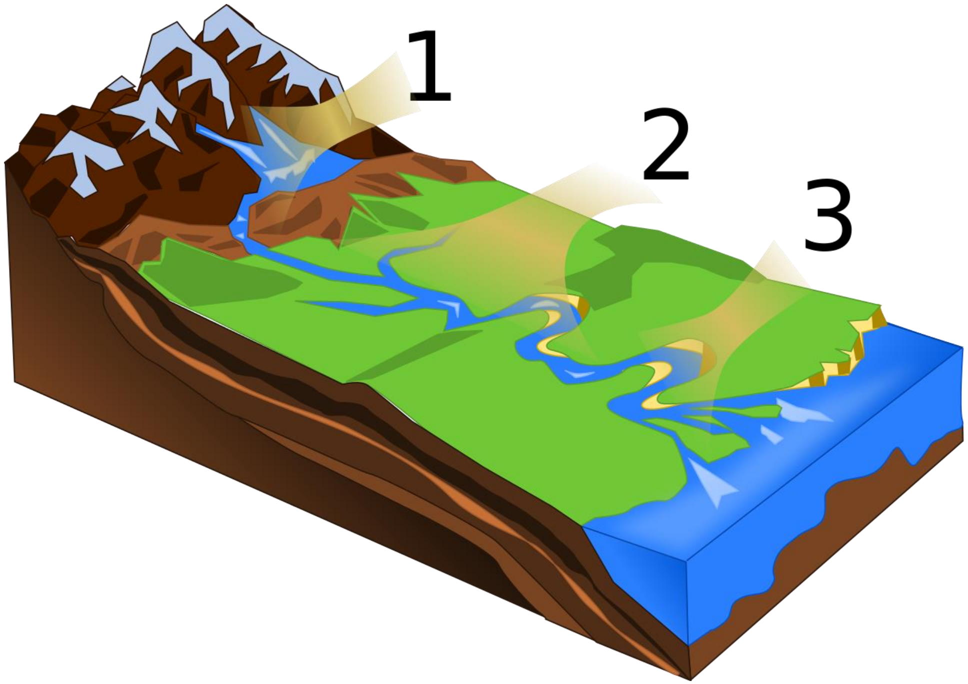
Moving Forward with Protocol 5

- Outfall and Headwater Projects become cost effective BMPs
- Monitoring to determine effectiveness
- WIP Planning adjusted
- MS4 Programs can maximize co-benefits
- Evaluate maintenance issues for BMP opportunities
- Evaluate outfall design protocols to avoid future incision
- Crediting potential matches ecological importance of headwater systems



Source, Sink, Transformation and Lag

- Watershed Context and Landscape Position
  - Sources (Headwaters) and Sinks (Floodplains and Wetlands) of Pollutants
- Functions
  - Nutrient and Sediment Processing
- Adapted and Impacted Habitats
- How do we use this for Uplift and Restoration?



The Connection Between Wetlands and Headwater Channels and The Potential Cost of Inaction

Figure 2-21. Comparison of percent wetland loss between (A) the 1780s and mid-1980s with (B) the distribution of artificially drained agricultural land in 1985. One dot equals 8100 ha. From Blann et al. (2009), as modified from Dahl (1990).

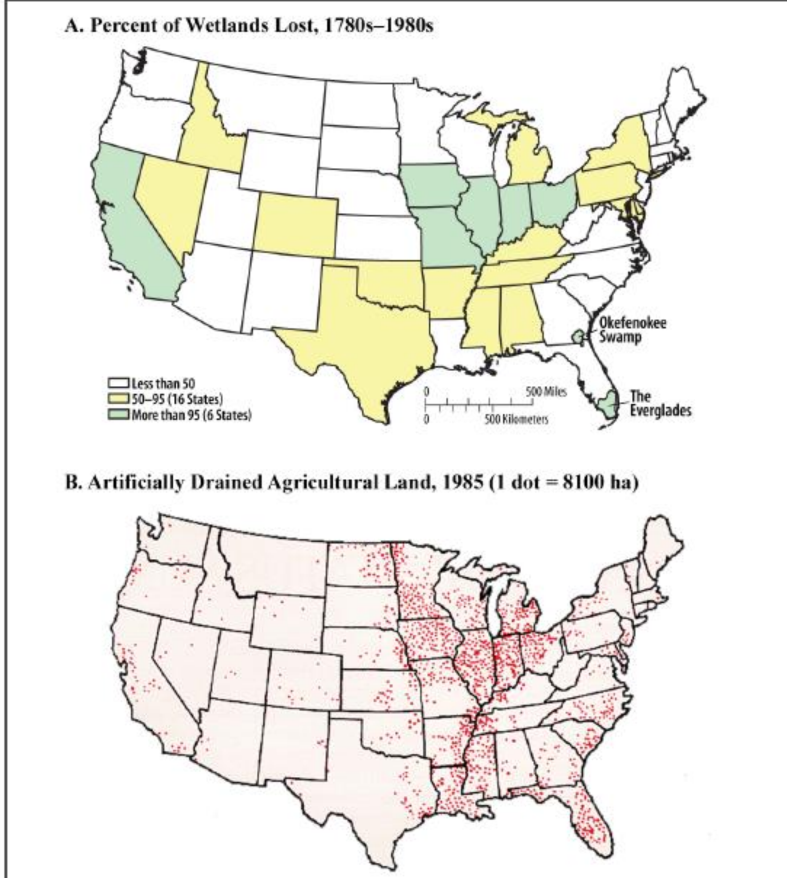
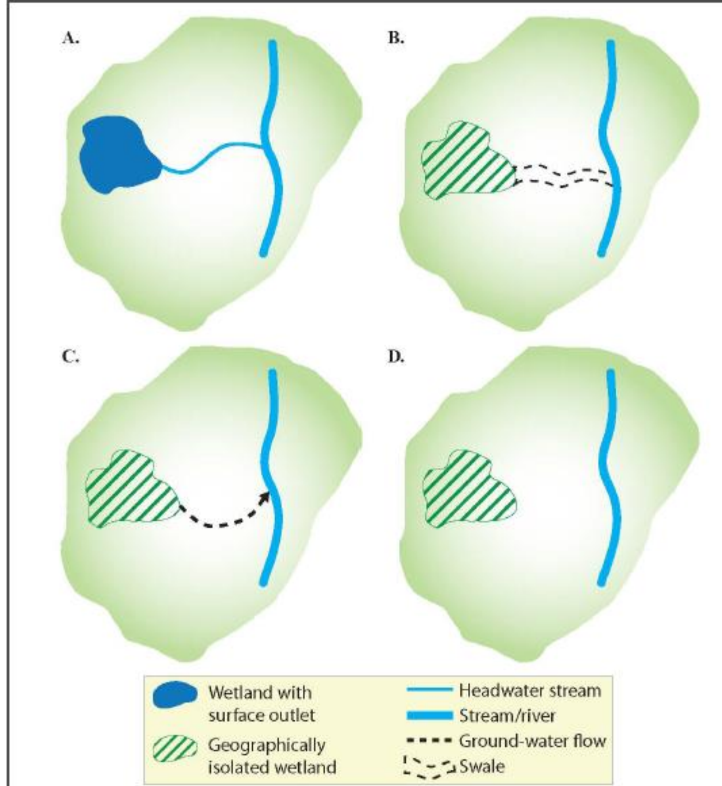
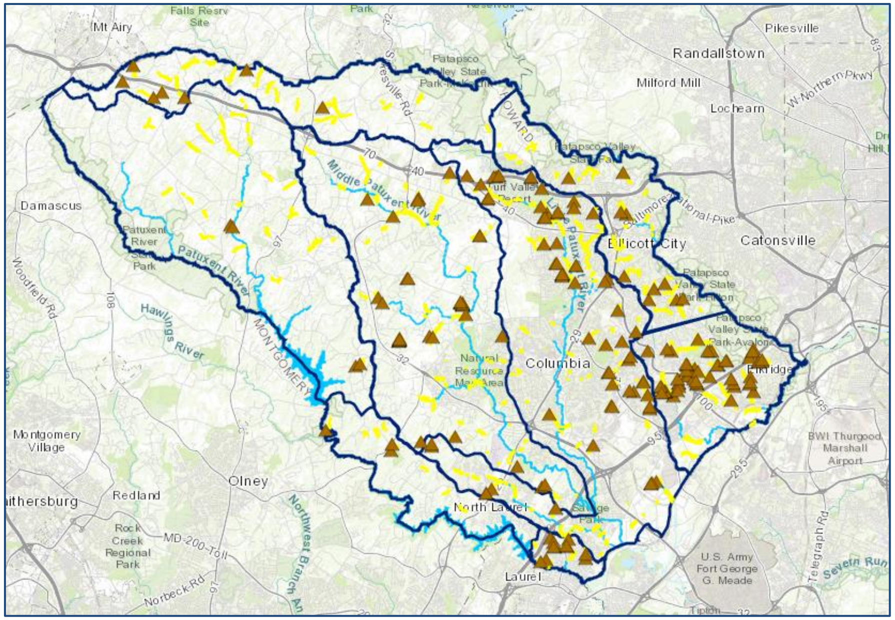


Figure 2-18. Types of hydrologic connections between non-floodplain wetlands and streams or rivers. (A) A wetland connected to a river by surface flow through a headwater stream channel. (B) A wetland connected to a river by surface flow through a nonchannelized swale. Such a wetland would be considered geographically isolated if the swale did not meet the Cowardin et al. (1979) three-attribute wetland criteria. (C) A geographically isolated wetland connected to a river by ground-water flow (flowpath can be local, intermediate, or regional). (D) A geographically isolated wetland that is hydrologically isolated from a river. Note that in A–C, flows connecting the wetland and river may be perennial, intermittent, or ephemeral.



Headwater Streams and Headcut Features Across the Landscape

- Headwater stream network can significantly impact the function of receiving waterbodies.
  - Identifying headcuts across the landscape is important in assessing the ecological function of headwater systems



Credit: McCormick Taylor

GIS Analysis to Prioritize Headcuts Delivering the Greatest Potential

- Analysis estimates 100,000 tons or 0.60 tons/ft of sediment delivered to receiving streams over time compared to max of 0.15 tons/ft for P1 sites
- GIS tool and field assessments can be used to prioritize and target sediment and nutrient waste load allocations (WLA)
- Developing a strategy to prioritize, target, and implement the Alternative Headwater Channel and Outfall Protocol
- Cost effective approach and addresses **justification why MS4 representatives should address headwater headcuts.**

MDOT SHA STREAM RESTORATION P 1 DATA

Source		TSS (lbs/ft/yr)	TSS (tons/ft/yr)
Chesapeake Bay Panel		248	0.124
MDOT SHA	Average	141	0.0705
	Max Value	292	0.146
	Min Value	31	0.0155

Thank You!
And the outfall channels thank you too!