Final Stream Restoration Crediting Recommendations from Group 4 & 5

Urban Stormwater Work Group
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www.chesapeakestormwater.net

Thanks to all the talents of Groups 4 and 5

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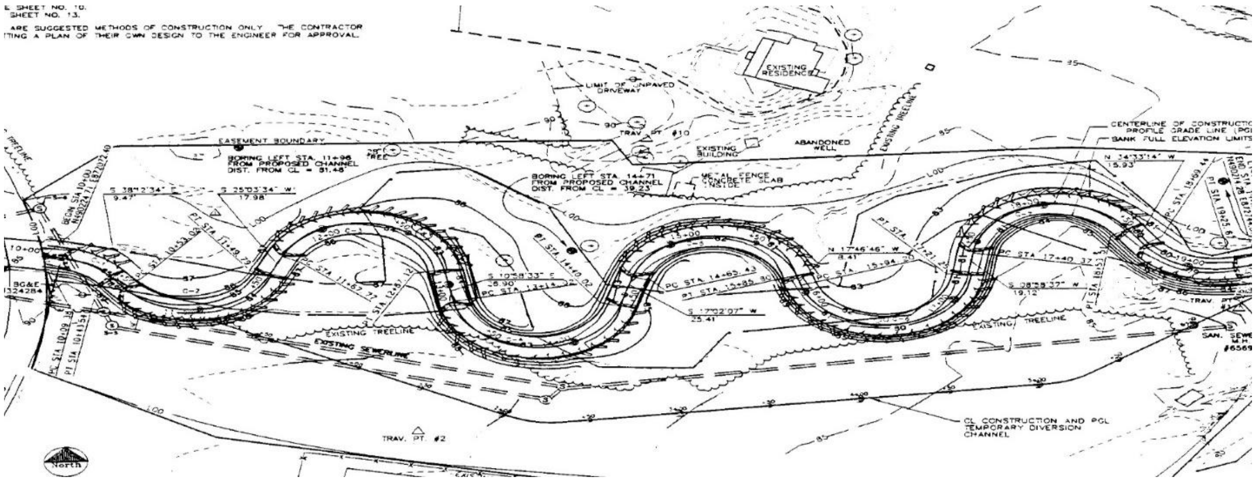
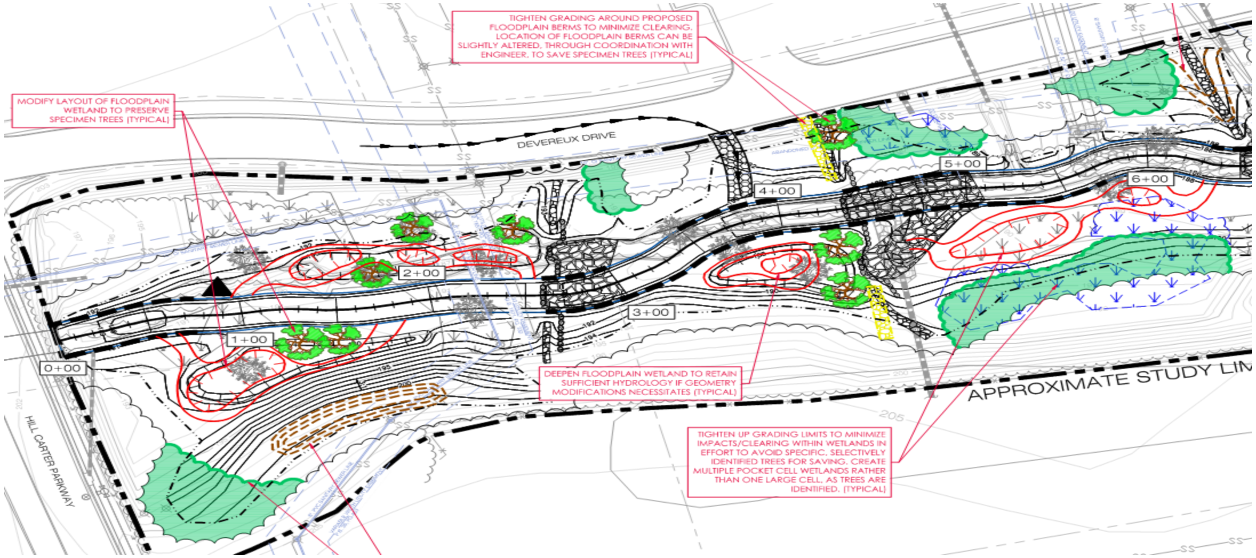
Key Topics

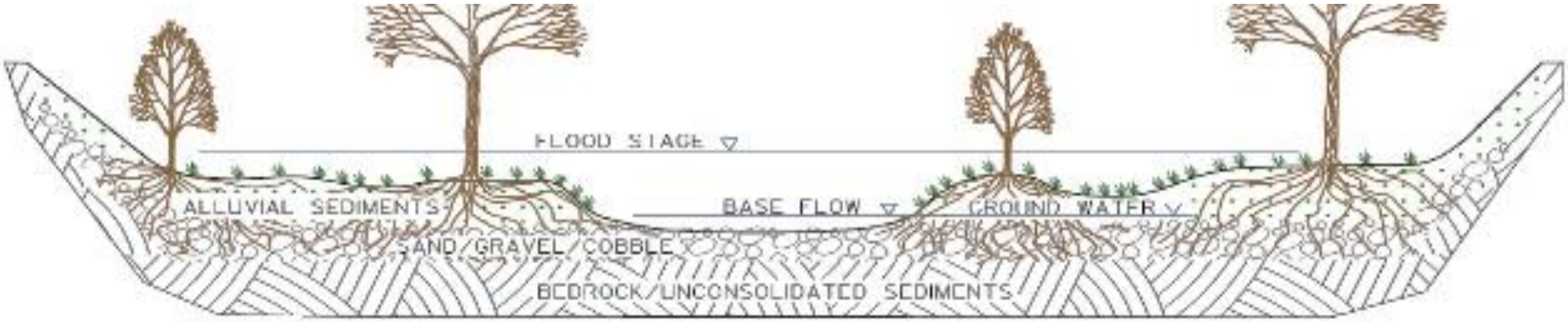
1. Key Floodplain Restoration Concepts
2. Comparing LSR and RSB
3. Summary of Protocol Adjustments
4. Environmental Considerations
5. External Review Process
6. Comments and Feedback

Evolution of Stream Restoration Design from Channel to the Floodplain

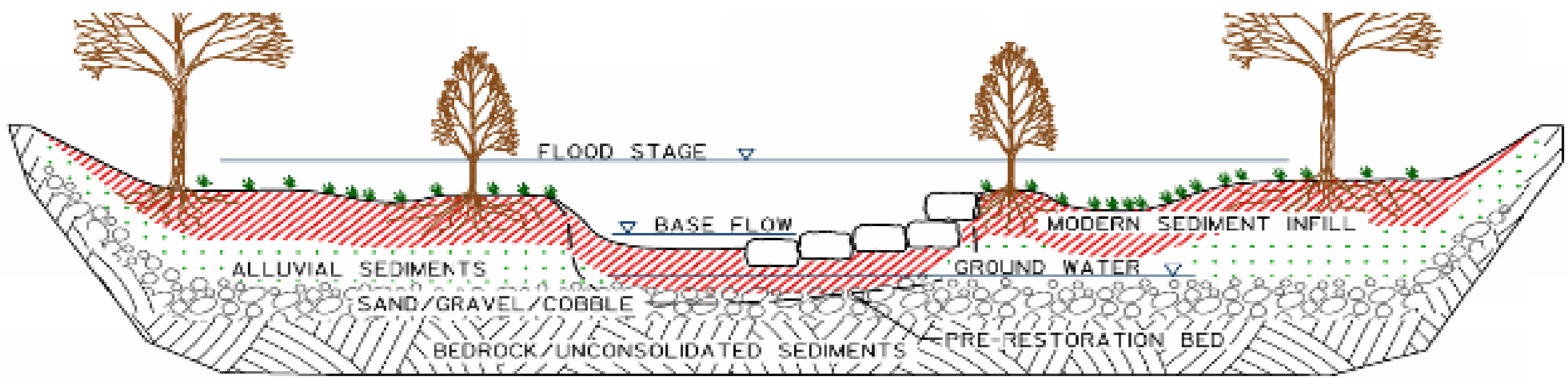




FR-LSR	Floodplain Restoration-Legacy Sediment Removal



FR-RSB	Floodplain Restoration-Raising the Stream Bed



Comparing Floodplain Restoration Strategies

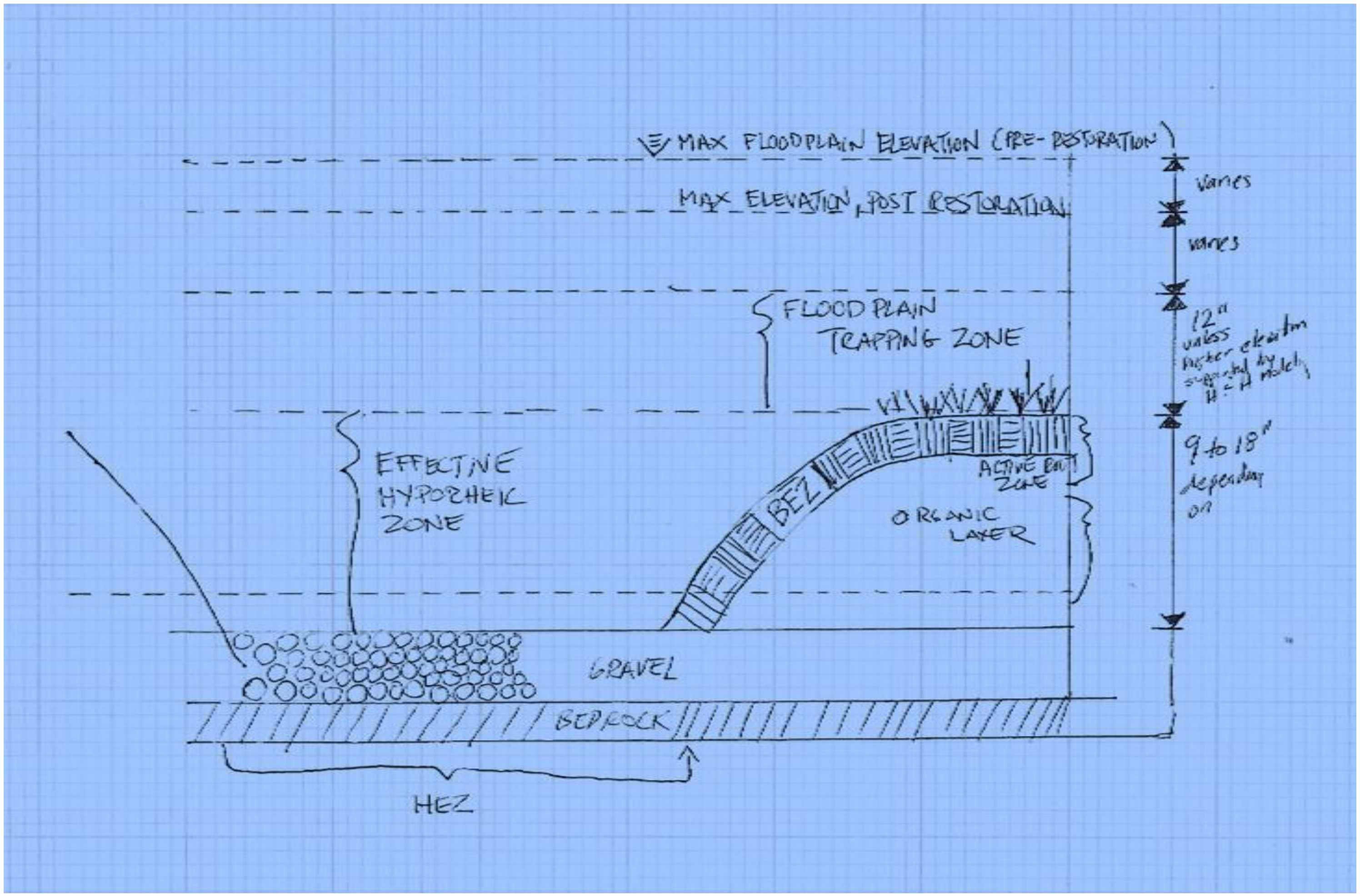
	LSR Legacy Sediment Removal	RSB Raised Stream Bed
Strategy	"Lower the Floodplain"	"Raise the Stream"
Design Approach	Legacy sediments are removed from the floodplain, which reduces bank heights, expands hyporheic exchange, and reconnects stream to its floodplain/aquifer	Raise the stream invert either by (a) filling incised channels and/or (b) installing riffle/grade control practices to effectively lower bank heights and access the floodplain more frequently
Boundaries and Zones	Both share common zones such as BEZ, EHZ and FTZ, but use different indicators and field methods to define their precise vertical and lateral boundaries	

Agreement on Standardized Terms and How Zone Boundaries are Defined/Measured

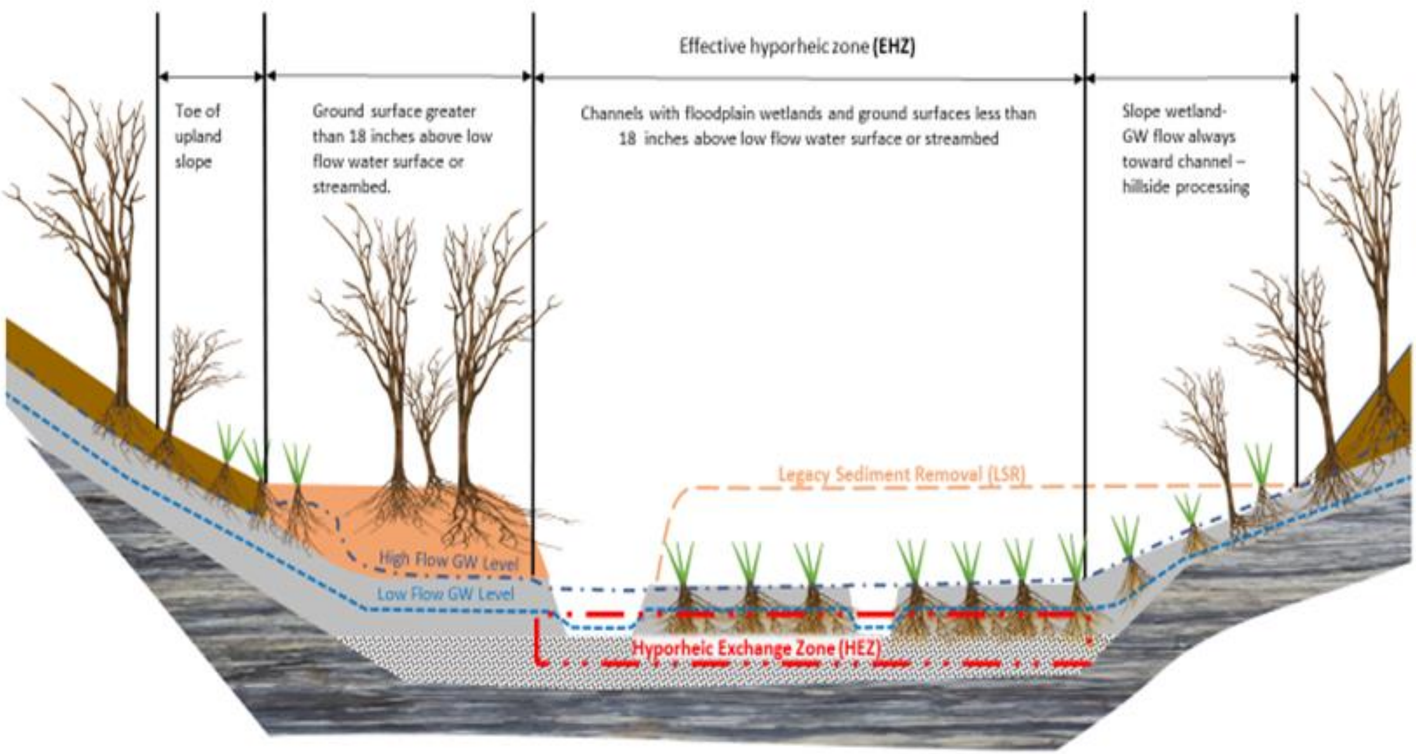
BEZ	Bank Erosion Zone	**LS**	Legacy Sediment
BSR	Big Spring Run	**LSR**	Legacy Sediment Removal
EHZ	Effective Hyporheic Zone	**NCD**	Natural Channel Design
FR	Floodplain Restoration	**OGS**	Outfall and Gully Stabilization
FTZ	Floodplain Trapping Zone	**P-#**	Protocol 1, 2 or 3
HA	Hyporheic Aquifer	**PS**	Prevented Sediment
HB	Hyporheic Box [1]	**RSB**	Raised Stream Bed
HEZ	Hyporheic Exchange Zone	**RSC**	Regen. Stormwater Conveyance

[1] as originally defined in Section 2.2 in USR EPR (2013)

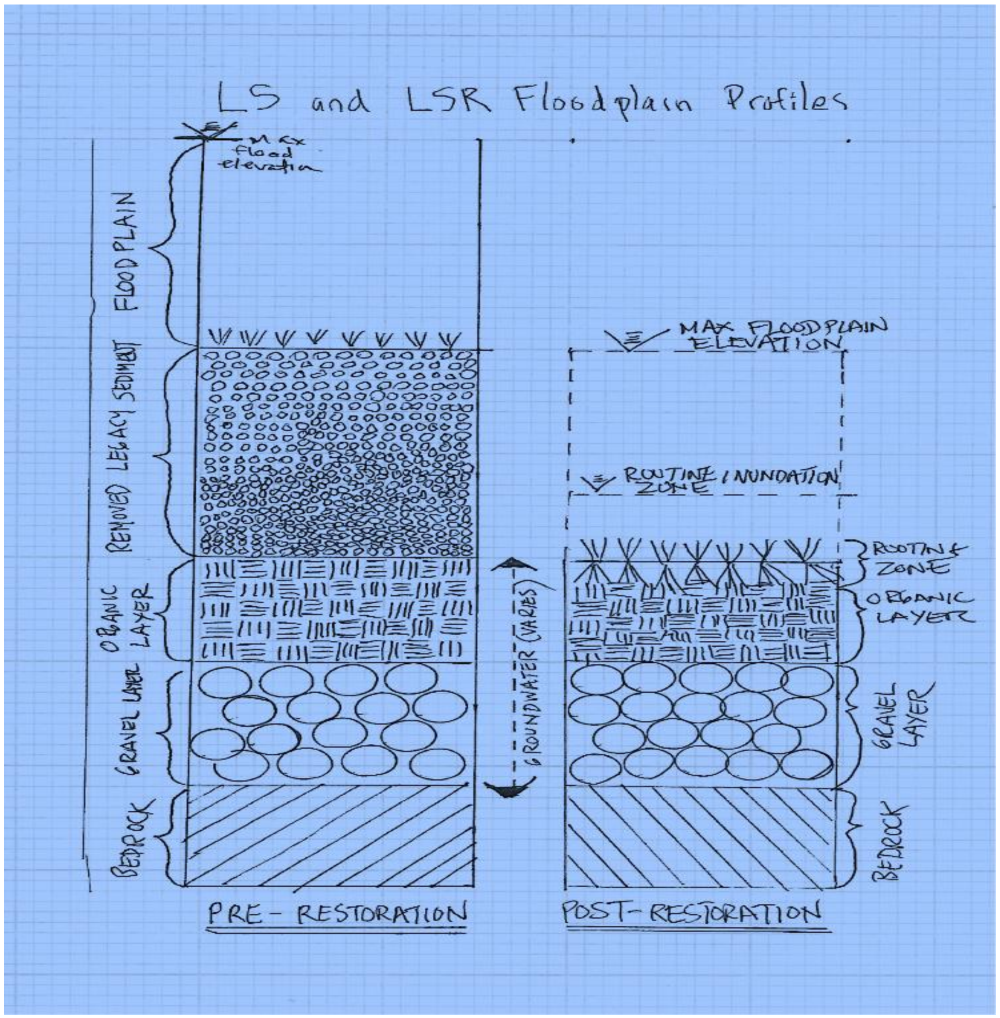
BEZ, EHZ and the FTZ



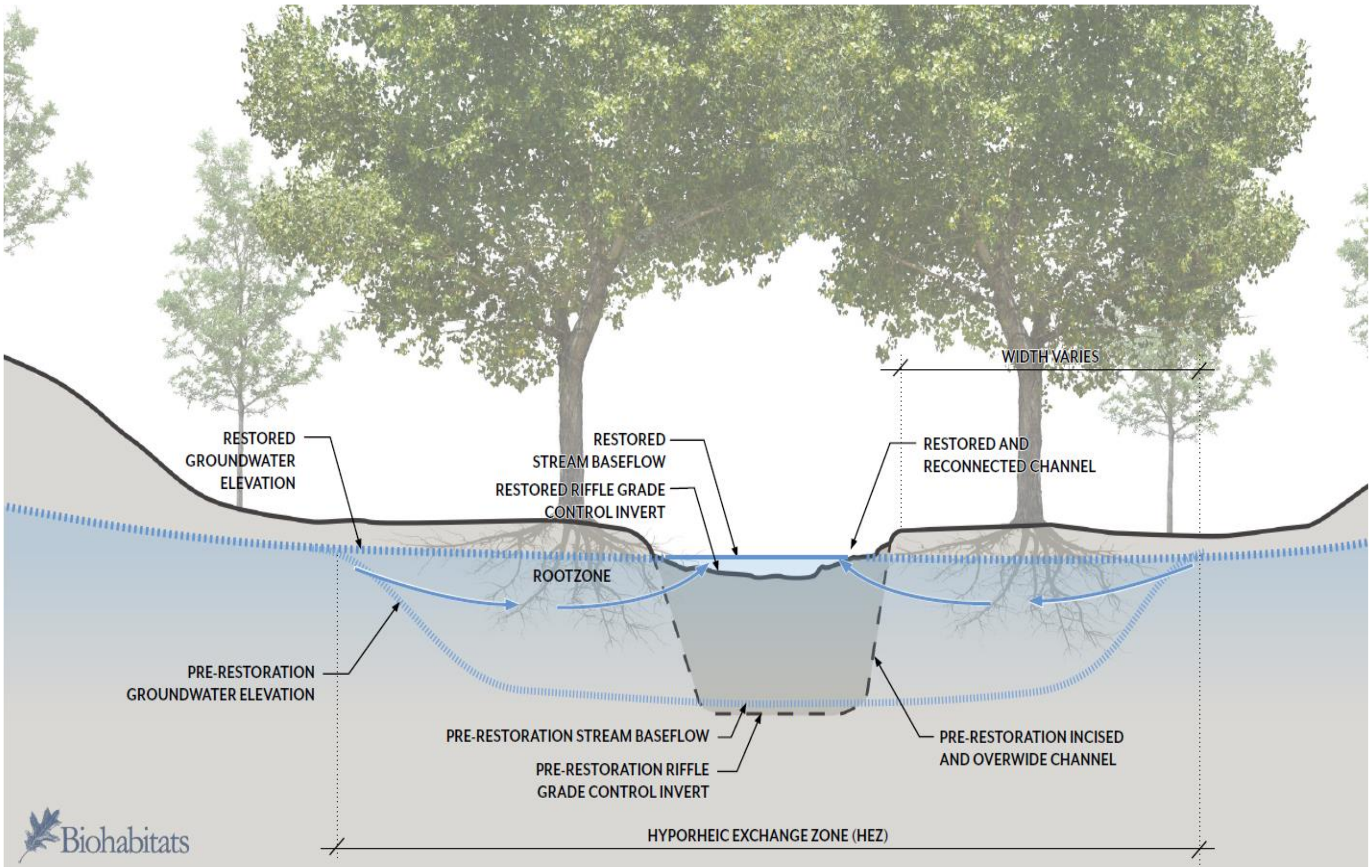
Floodplain Restoration: Legacy Sediment Removal



Floodplain Profiles, before and after restoration



Floodplain Restoration
Raised Stream Bed



Comparing Floodplain Restoration Strategies- II

	LSR **Legacy Sediment Removal**	**RSB** **Raised Stream Bed**
Project Qualifying Conditions	Project EHZ and FTZ boundaries based on field investigations Avoid extended ponding/inundation of the floodplain	
	• Legacy sediment deposits are present • LS removal primary restoration technique • Floodplain reconnected to valley aquifer	• Upstream and downstream grade controls to maintain intended stream invert • Maintain pre-restoration baseflow characteristics
Floodplain Plant Community	Restore historical floodplain plant community (often wet meadow complexes)	Wider range of potential floodplain habitat outcomes, e.g., could also be forest or scrub-shrub wetlands

Comparing Floodplain Restoration Strategies- III

Protocol Adjustments	
Protocol 1 Adjustments	Use one of the following options: *Option 1:* Divide the Bank Erosion Zone (BEZ) into two components: Remaining low-bank sediments and removed legacy sediments from the higher bank. Remaining sediments are subject to the 50% discount, whereas removed sediments are not subject to any discount (i.e., 100% credit). *Option 2:* Base the credit on actual monitoring data acquired for the project, using new Group 3 methods
Protocol 2: Adjustments	The dimensions of the EHZ are defined differently across the stream and floodplain for each strategy, but otherwise apply the same methods
Protocol 3 Adjustments	Both approaches use the same methods

Guiding Principles

- Ensure tweaks are Phase 6 watershed model compatible (e.g., delivery, new stream source)
- Retain the integrity of the pollutant removal protocols, but tweak based on:
  - Better science to define removal parameters (e.g., unit denitrification rate)
  - Field testing of most sensitive parameters in load calculations
  - More defensible methods to define boundaries over which the removal processes operate

Summary of Protocol 2 Consensus

For FR-LSR Projects:

- Replace the existing Hyporheic Box with an "Effective Hyporheic Zone" whose lateral dimensions are defined by surface, groundwater and wetland indicators
- EHZ Indicators are measured in the field and shown on post-construction plans
- The EHZ is typically shallow, often only 9 to 18 inches deep at most projects.

For FR-RSB Projects

- EHZ boundaries are defined by plan form geometry of the valley bottom, such as the width of outer meander bends, aquifer elevations, and associated floodplain wetlands
- Appropriate field indicators to measure them are being developed by group

For ALL FR Projects:

- Update the existing denitrification rate to reflect the latest science, and convert it from volumetric to aerial units
- Adjust the base denitrification rate for site factors, such as streamflow, floodplain soils and hyporheic conductivity
- Eliminate the bank height ratio requirement, since it does not apply to low-bank FR projects

Load Reduced = Define EHZ Area × Unit Denitrification Rate × Parola Equation Adjustment Factors

New Denitrification Rate

2.69×10^{-3} lbs NO_3/sq ft/year

- Based on comprehensive lit review
- Difference in median nitrate uptake rates from Newcomer-Johnson et al. (2016)
- 30% of uptake is from denitrification (Mulholland et al 2008)

The Parola Equation

$$N\ credit = (\text{Base Rate})\ (\text{EHZ})\ (A_f)\ (V_f)\ (B_f)$$

Where:

N Credit = P-2 N reduction (lbs/yr)

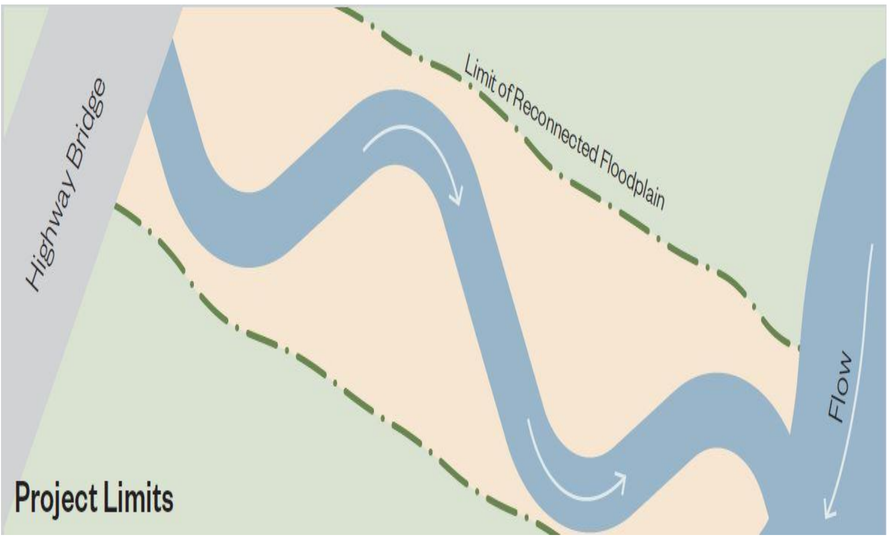
Base rate= average denitrification rate (lbs/square foot/year)

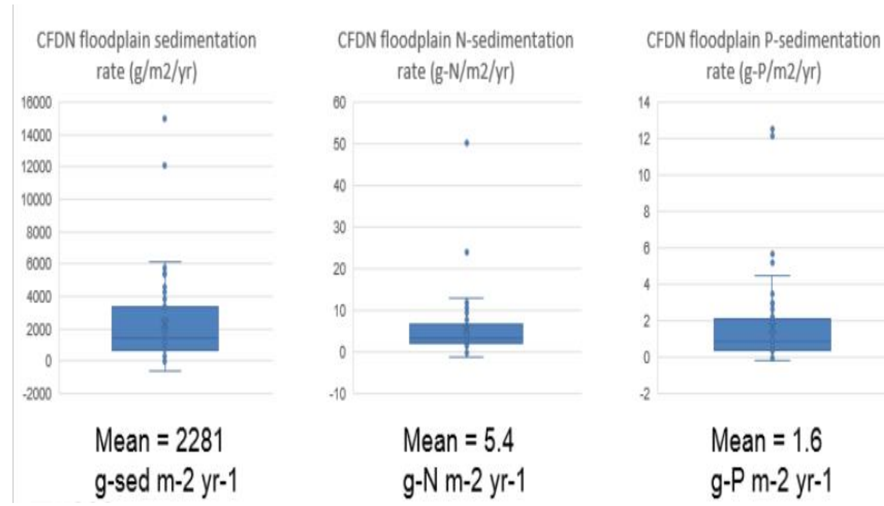
EHZ = Area of Effective Hyporheic Zone (square feet)
Af = Aquifer Conductivity Reduction factor (0-1)
Vf = Vegetation Reduction factor (0-1)
Bf = Baseflow Reduction factor (0-1)

Discounting Factors to Base Denitrification Rate

Table 10: Site Specific Discount Factors for Adjusting the Denitrification Rate (Parola et al, 2019)					
HEZ N credit = (Base Rate) (EHZ) (B_f) (S_f) (A_f)					
Baseflow Reduction Factor (B_f)		Soil Saturation Reduction Factor [1] (S_f)		Aquifer Conductivity Reduction Factor [2] (A_f)	
Perennial baseflow	1.0	Channel	1.0	Gravel, sandy gravel or clean sand	1.0
Baseflow in all but late summer/fall	0.75	Herbaceous or scrub shrub wetland	1.0	Silty sand or silty gravel loam	0.6
Baseflow in winter/spring	0.50	Forested wetland	0.6	Silt	0.2
Baseflow only during wet seasons	0.25	Non-wetland forest	0.2	Clayey silt	.05
Flow only during runoff events	0.10	Non-wetland herb. Scrub shrub	0.1	Clay	.001

Protocol 3: Floodplain Trapping



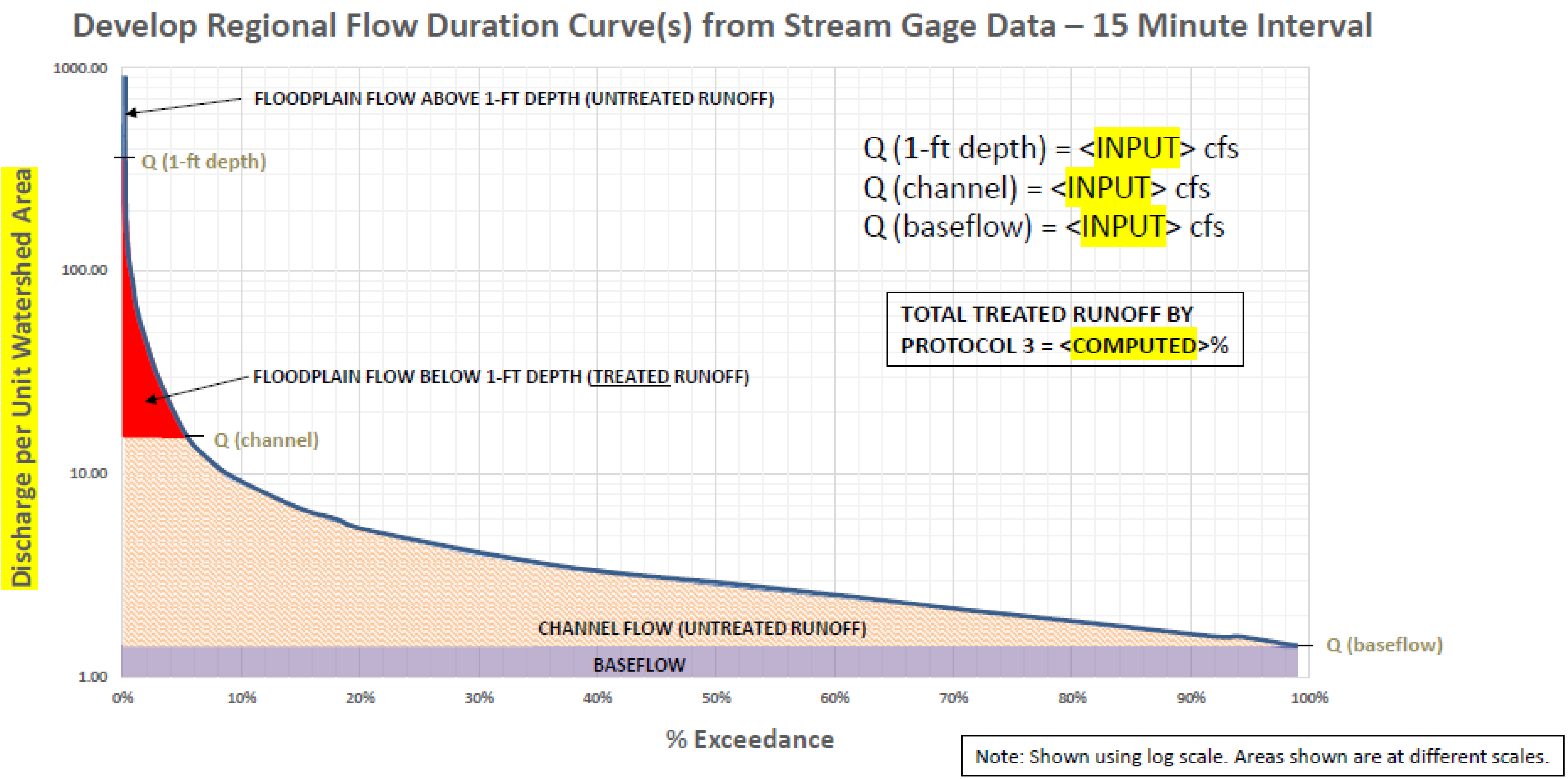


Define Project Area and Elevations → Compute Contributing Flows or Loads → Compute Flow Vol Diverted to Floodplain → Define Effect of Floodplain Treatment

Summary of Areas of Consensus for P-3

- The credit should be based on the difference in load reduction based on a before and after application of P-3 to individual projects.
- Hydraulic modeling defines the extent of reconnection boundaries for the FTZ, based on critical floodplain flow velocities where sediment trapping and filtering can be expected.
- Retain the one-foot max elevation above the floodplain as the upper limit for effective runoff treatment in the FTZ, unless a higher elevation is justified by floodplain H&H modeling.
- Multiply the FTZ by the appropriate wetland removal rate established for floodplain wetland restoration projects, as defined by NTW EPR to determine project load reduction.
- Rely on downstream flow methods to estimate annual volume of storm runoff diverted into the floodplain for treatment
- Recommend standard methods for defining baseflow channels, separating baseflow from storm flows and processing appropriate USGS flow gage data

Figure E-1. *Flow Duration Curve for calculating floodplain treatment (Altland 2019).*



Non-Tidal Wetland Removal Rates

Table 13. Floodplain Wetland Removal Rates in Prior CBP Expert Panel Reports			
Wetland BMP Category	Pollutant Removal Rate (compared to pre-restoration)		
	Total N	Total P	TSS
NTW Restoration	42%	40%	31%
NTW Creation	30%	33%	27%
NTW Rehabilitation	16%	22%	19%
[1] as outlined in expanded lit review and recently approved EPR (NTW EP, 2020)			

- Restoration: Wetland absent or degraded. Hydric soils present
- Rehabilitation: Wetland present w/ degraded function
- Creation: No wetland present, no hydric soils present

Other Improvements

- Design Examples

Step 1. Define the Extent of the EHZ.

Calculate the area of the restored floodplain:

- 1,000 ft x 200 ft = 200,000 sq ft

Calculate the area of the restored channel:

- 1,000 ft x 5 ft = 5,000 sq ft

Reduce by 10% to account for the floodplain area that is perched more than 18” above the low flow water surface or streambed elevations:

- 200,000 sq ft x 0.9 = 180,000 sq ft

Step 2. Apply the Denitrification Rate to the EHZ

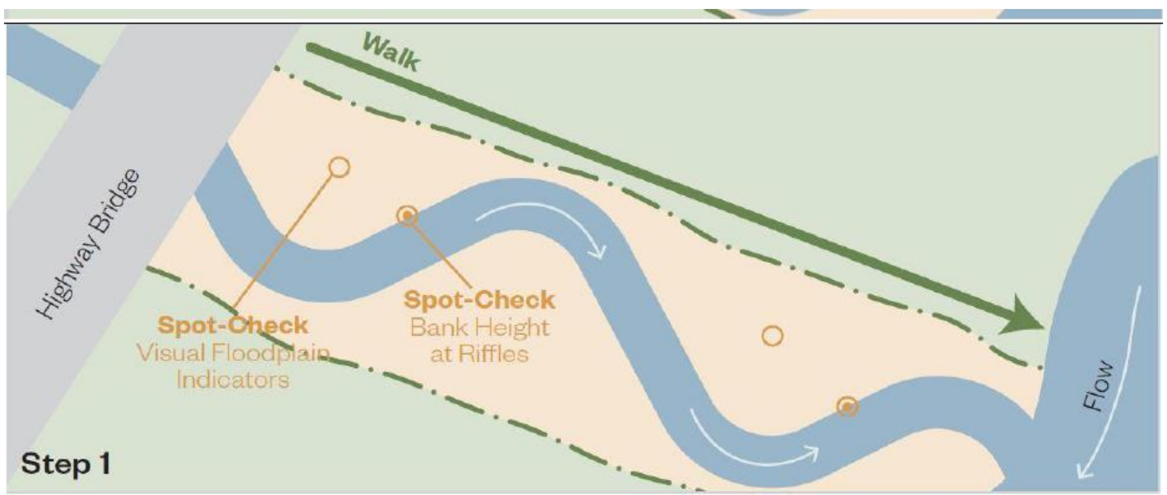
- 180,000 sq ft x 0.00269 lbs/sq ft/year = 484 lbs NO_3/year
- 5,000 sq ft x 0.00269 lbs/sq ft/year = 13.45 lbs NO_3/year

Step 3. Apply the Site Specific Discount Factors

The site has perennial baseflow, sandy-gravel hyporheic soils and an herbaceous wetland plant community throughout the restored floodplain. Therefore, for the floodplain area, each factor is 1.0 and no discount is applied. The factors for the channel area would also all be 1.0.

Other Improvements

- Site Monitoring and Field Verification



Improvements

Future Research Priorities:

- Long-term interdisciplinary research studies on nutrient and sediment dynamics
- Shorter-term research studies on best practices for mitigating unintended environmental impacts
- Defining and testing metrics for measuring functional uplift/loss

Break for Questions

Get current at: www.chesapeakestormwater.net

Environmental Considerations

Credit: Mike Rahnis, UNAVCO, Dorothy Merritts and Robert Walter

We all have a lot of biases when it comes to stream restoration





Unintended Environmental Consequences of Stream Restoration Practices

Project Stream Channel

- Depleted Dissolved Oxygen
- Iron Flocculation
- Warmer Summer Stream Temperatures
- More Instream Primary Production
- Turbidity During Project Construction
- Initial Decline in Benthic IBI

Floodplain/Downstream

- Project Tree Removal
- Post Project Tree Loss
- Vector for Invasive Plant Species
- Shift in Wetland Type/Functions
- Increased Flooding
- Initial Decline in Downstream IBI
- Upstream Blockage for Aquatic Life

Severity of impacts is related to:

- Inadequate project assessment
- Site-specific factors
- Exposure to extreme flows
- Care taken in project location, design and construction
- Use of specific best practices to minimize impacts

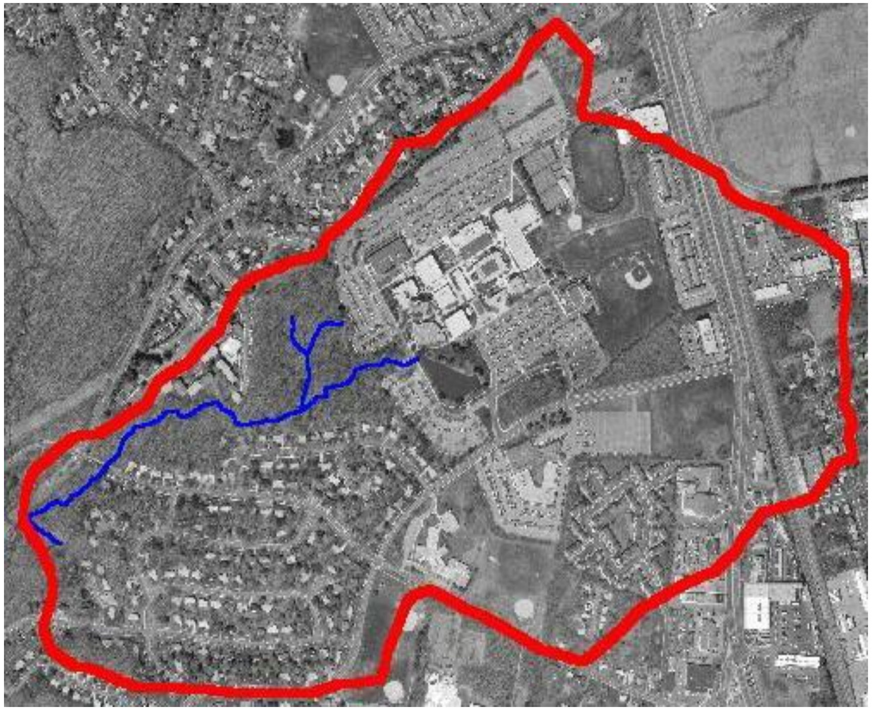
General Notes on Impacts

- Impacts need to be considered in relation to the stressors measured in a comparable unrestored urban stream/floodplain system
- Short-term adverse impacts are common during and shortly after construction, followed by project adjustment and recovery over several years

Best Practices (BP) for TMDL Stream Restoration Projects

- Choosing the Right Stream Restoration Projects
- Project Design Principles
- Good Construction Practices
- Post-Construction Practice for Inspecting, Verifying and Maintaining Projects

Upland Alternatives to Stream Restoration



BP for Project Assessment and Design

- Assess sources of stream and floodplain impairment
- Avoid restoration projects at sites where stream and floodplain metrics indicate good or excellent condition.
- Forests surveys to minimize tree clearing
- Habitat functions assessed prior to design, especially when quality stream/wetland resources are suspected to be present
- Special protection for freshwater mussels and their host fish

BP for Project Assessment and Design

- All constructed instream structures should be designed to ensure aquatic life can safely pass
- Avoid creating stagnant pools in stream channels.
- Avoid designs that rely on excessive bank armoring and respect limits adopted by Group 3
- Avoid long-term inundation or pooling over the floodplain
- H&H modeling to define how 100-year floodplain elevations change in response to projects
- Investigate soils for toxics at brownfield floodplain sites

BP During Project Construction

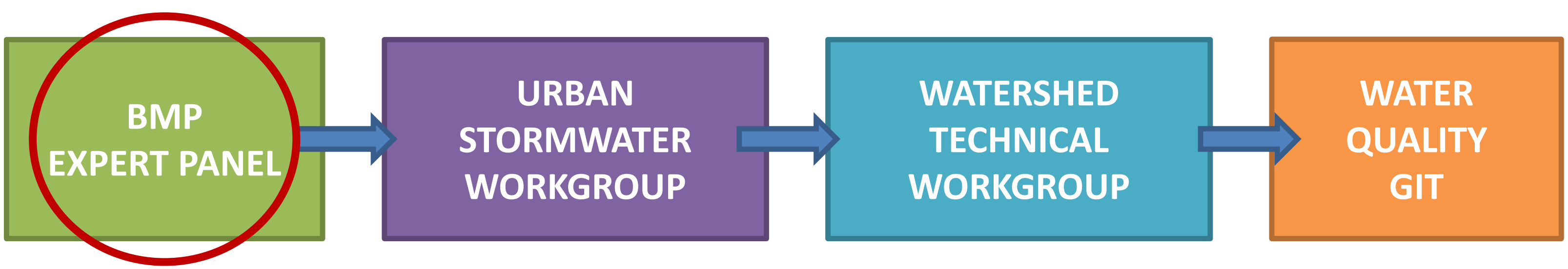
- Reduce the use of “iron-rich” in-stream construction materials
- Minimize additions of organic matter when raising the stream bed
- Minimize removal of mature trees and protect hem during construction
- Minimize compaction of stream bed, banks and floodplain by construction equipment
- Work “in the dry” during construction to reduce sediment impacts
- Recycle wood from any trees cleared during construction

BP for Post-Construction Phase

- Verify that projects meet their functional performance objectives
- Use Group 1 methods to verify floodplain reconnection functions years after initial permit expires
- Focus on indicators for project failure:
  - Pre-restoration baseflow conditions
  - Bank heights that support floodplain reconnection
  - Desired targets for restored floodplain plant community
- Post-construction invasive species management
- Adjust structures to lower water elevation to prevent unacceptable floodplain inundation or pooling

Ideal pathway for going forward

- **June 19th Deadline**: External Comment Period for USWG/SHWG/Others
- Seek USWG Approval in July
- Expanded review/approval @ WTWG/WQGIT in August/Sept
- Develop unified Summary in Fall (no further review)
- State by state outreach (upon request)
- WQ and Habitat groups to possibly fund workplan to do priority research on effect of best practices for restoration practices
- Further CSN work on practice resilience to climate change
- BIG party on the Pataspco



Comments and Feedback

Photo Credit: G. Noe, USGS