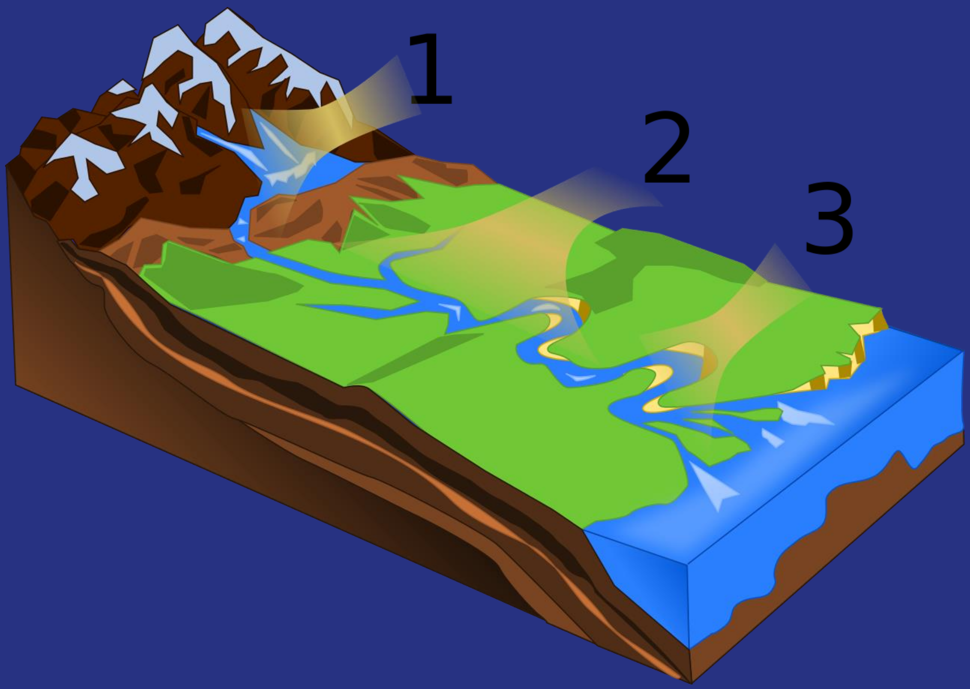
My General Observations/Thoughts

- **Considering Sources and Sinks of Pollutants while balancing resource impacts and restoration**
  - Edit Protocols to focus on source reduction and sink enhancement
  - Method of "restoration" should balance improvement with impact to maximize overall benefit – may not be "ideal" (and may need stone)
  - Commodity driven implementation model is incomplete and can lead to oversimplification
- **Perspective influences measurement, we need to look for standardization**

Maximize Uplift via Understanding of Geomorphic Function

- **Watershed Context and Landscape Position**
  - **– Sources and Sinks of Pollutants**
- **Functions**
  - Nutrient and Sediment Processing
- **Adapted and Impacted Habitats**
- **Recommended Action Item: Modify Design, Permitting and Crediting Expectations Based on Landscape Position and Function**



Quantify Theory with Data: Trimble, 1999

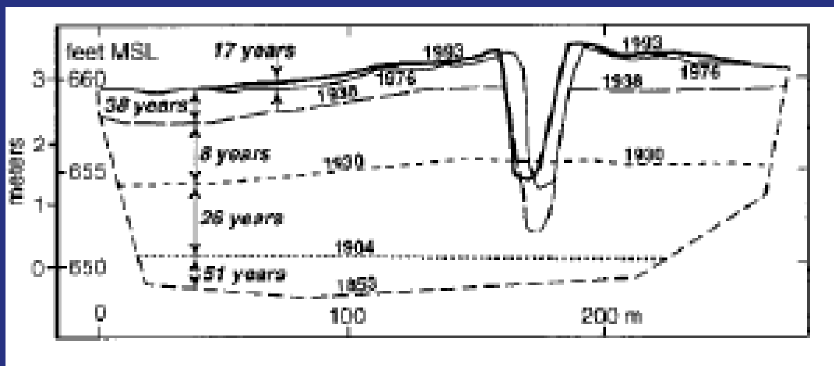
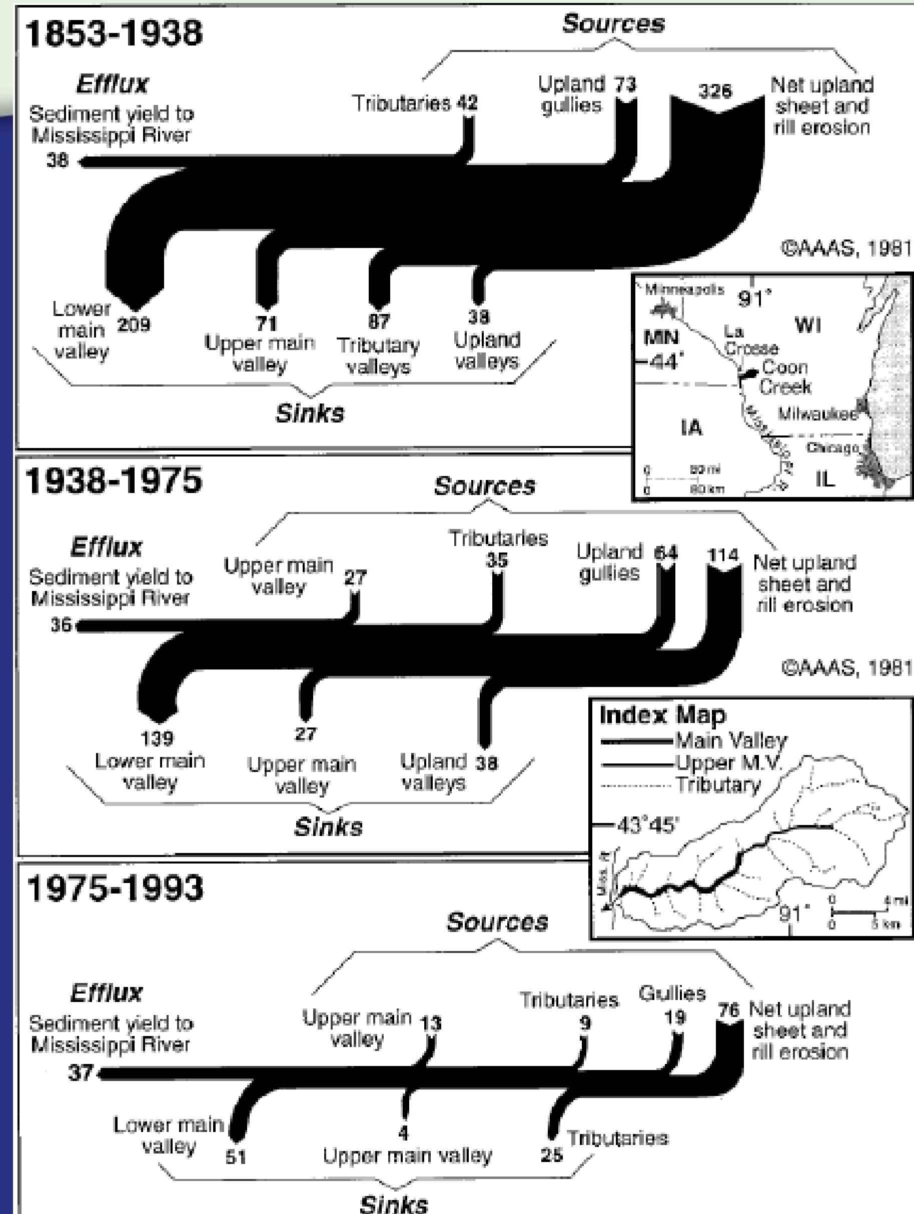
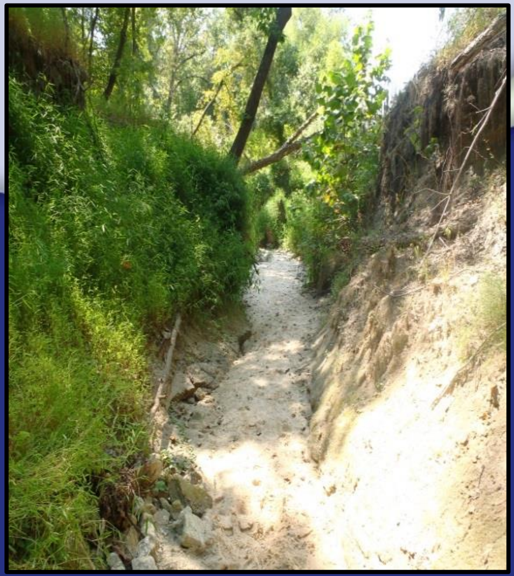


Fig. 2. A sediment sink. This is a cross-sectional profile in the lower main valley of Coon Creek showing succeeding, higher floodplain levels dated from 1853 to 1993. MSL, mean sea level. Such accretion accounts for most storage in the Coon Creek Basin. [Modified from (3)]



How can this impact restoration strategy and crediting?



Sources!

Sinks!

Protocol 1: Looking at Sources – BEHI/BANCS

- **Observation: Bankfull Depth selection dominates results**
- **Recommended Action Item: Standardize Depth as a Modeling or Regional Curve Value**

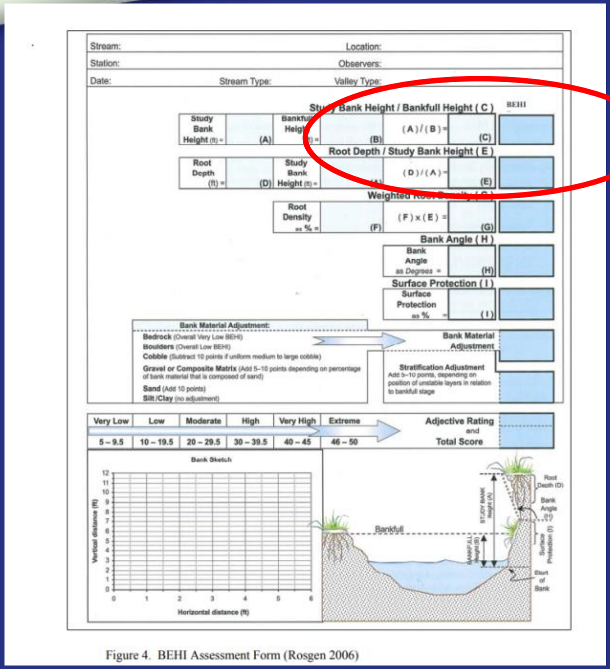
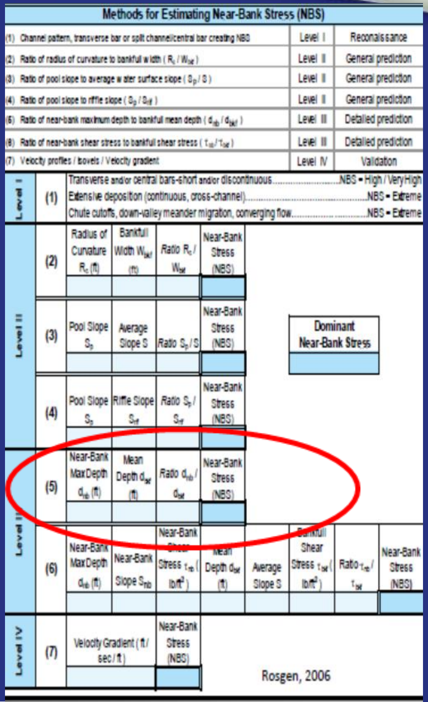


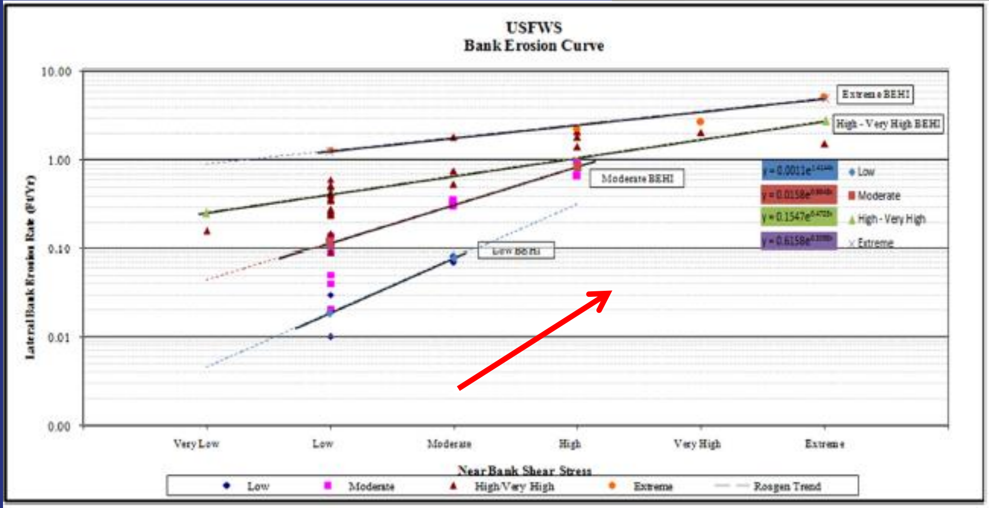
Figure 4. BEHI Assessment Form (Rosgen 2006)



Methods for Estimating Near-Bank Stress (NBS)		
(1) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(2) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(3) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(4) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(5) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(6) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(7) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I	(1)	Transverse and/or central bars-short and/or discontinuous.........NBS = High / Very High Extensive deposition (continuous, cross-channel).........NBS = Extreme Chute cutoffs, down-valley meander migration, converging flow.........NBS = Extreme							
Level II	(2)	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	Ratio R_c / W_{bkf}	Near-Bank Stress (NBS)				
Level II	(3)	Pool Slope S_p	Average Slope S	Ratio S_p / S	Near-Bank Stress (NBS)		Dominant Near-Bank Stress		
Level II	(4)	Pool Slope S_p	Riffle Slope S_{rif}	Ratio S_p / S_{rif}	Near-Bank Stress (NBS)				
Level III	(5)	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	Ratio d_{nb} / d_{bkf}	Near-Bank Stress (NBS)				
Level III	(6)	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
Level IV	(7)	Velocity Gradient (ft / sec / ft)		Near-Bank Stress (NBS)					

Rosgen, 2006



Protocol 2: Hyporheic Sinks

- Improved Hyporheic Exchange
- Well connected floodplain (Bank Height Ratio (BHR) of ≤ 1.0 – Assuming Bank Height is Bankfull Discharge)
- Convert to Mass: Hyporheic Box Mass (tons)
  - bulk density (very hard to sample)
  - Site specific sampling
  - Default = 125 pounds/cubic foot (> bank values)
- Recommended Action Items: Standardize Bank Height Measurement and Bulk Density Procedure
- Recommend Strategies for Increased Hyporheic Exchange beyond Bank Height

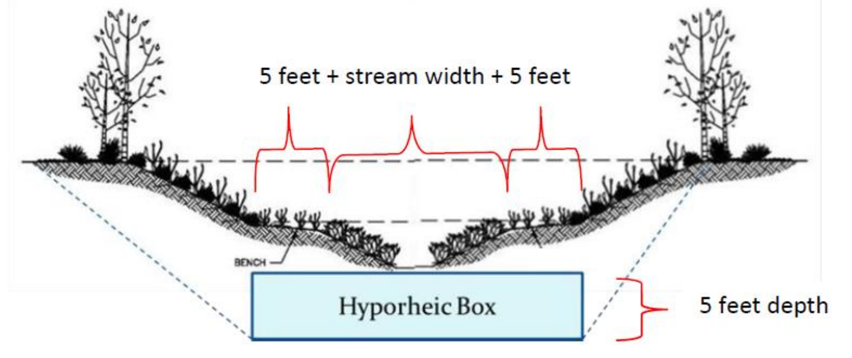


Figure 3. Hyporheic box that extends the length of the restored reach

Protocol 3: Credit for Floodplain Reconnection Volume - Sinks

- **Floodplain Connection Volume**
  - Credit for improved conditions compared to existing
  - Requires comparison of existing and proposed hydraulic model
  - Assumes floodplain acts as a wetland
- **Volume of Annual Flow in Contact with the Floodplain**
- **Maximum Depth for Ponded Volume Receiving Credit is 1 foot - This is a Hydraulic Modeling Challenge procedure is unclear.**
- **Effectiveness of the Connected Floodplain to Reduce Pollutants (TSS, TN, TP) is Dependent on Hydraulic Detention Time**
- **Hydraulic Detention Time is Assumed to be Proportional to the watershed to floodplain surface area ratio**
  - minimum ratio of 1% for full credit (prorated for ratios under 1%)
  - This is inconsistent with Landscape Position Concepts

Protocol 3: Credit for Floodplain Reconnection Volume

- **Percent of Annual TSS, TN and TP removal based on:**
  - Floodplain Storage Volume (watershed inches) – X-axis (Creates confusion)
  - Rainfall depth required to access floodplain – Curves in graph
  - % Annual Removal – Y-axis
- **Compute Annual Loads (TSS, TN, TP)**
  - Impervious and Pervious Loading Rates provided
- **Multiply Annual Loads by the Removal Rates**

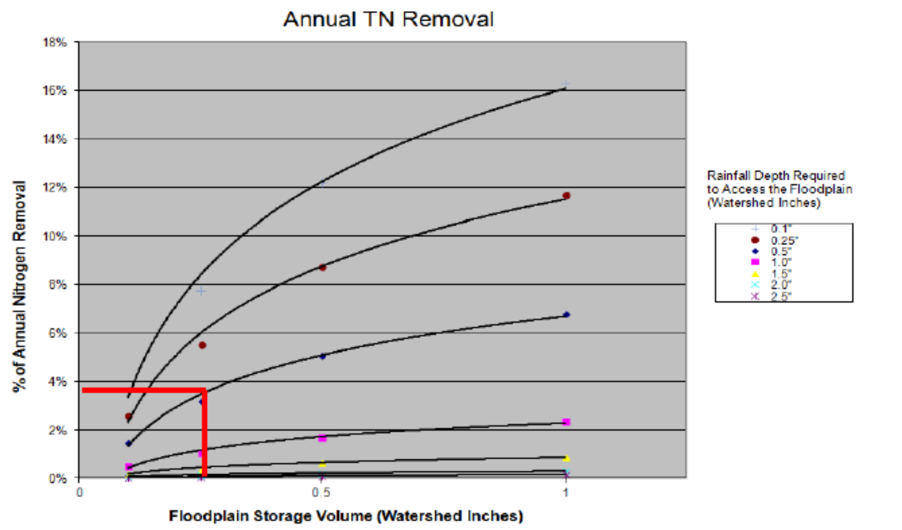


Figure 7. Annual TN removal as a function of 0.25 watershed inch³ floodplain storage volume and 0.5 inch rainfall depth required to access the floodplain.

Table 6. Edge of Stream Unit Loading Rates for Bay States Using CBWM v. 5.3.2

BAY STATE	Total Nitrogen		Total Phosphorus		Total Suspended Sediment	
	lb/ac/year				lb/ac/year	
	IMPERV	PERV	IMPERV	PERV	IMPERV	PERV
DC	13.2	6.9	1.53	0.28	1165	221
DE	12.4	8.7	1.09	0.25	360	42
MD	15.3	10.8	1.69	0.43	1116	175
NY	12.3	12.2	2.12	0.77	2182	294
PA	27.5	21.6	2.05	0.61	1816	251
VA	13.9	10.2	2.21	0.60	1175	178
WV	21.4	16.2	2.62	0.66	1892	265

Source: Output provided by Chris Brosch, CBPO, 1/4/2012, "No Action" run (loading rates without BMPs), state-wide average loading rates, average of regulated and unregulated MS4 areas

Protocol 3: Recommendations

Recommended Action Item: Revise/Edit Protocol 3 to allow for evaluation of floodplains as storage areas

- **Determine the sediment concentration entering the floodplain**
- **Incrementally model portion of the hydrograph that access the floodplain**
- **Using incremental information determine trapping efficiency (E) and floodplain shear stress**
- **Determine the sediment discharge for each increment**
- **Determine rate of sedimentation(S_i) for each time step**
- **Calculate the summation of each rate of sedimentation and duration of time step**
- **Annualize the mass of sedimentation of each storm**
- **Convert the mass of sediment into amount of nutrients removed from the system**
- **The deposition of sediment and nutrients in floodplains is well documented and can result in a significant reduction in the amount transported downstream.**
  - The floodplain area to watershed area ratio is no longer needed.