Performance & Monitoring of Dynamic Streams

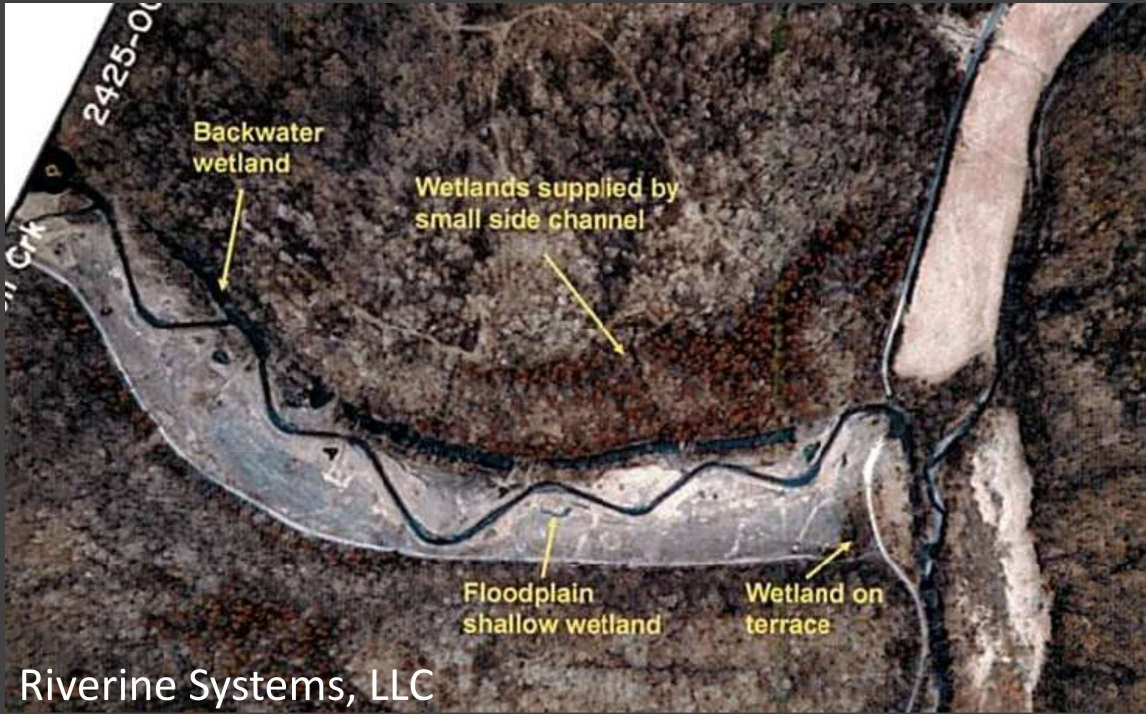
Samuel Leberg, ORISE Participant at the EPA

Restoration of Dynamic Streams

- Compensatory mitigation has encouraged restorations that function as largely stable, single-channel reaches as the default
- Dynamic streams may change significantly between monitoring periods
  - Number of channels
  - Channel form or location

Dynamic Restoration Examples

- Valley Restoration
  - Reestablish surface groundwater connections
  - Self-sustaining restorations that develop into stream-wetland complexes
  - Designed for sediment/carbon retention and low shear stresses
- Stage "0" Restoration
  - Based on Stream Evolution Model, Cluer and Thorne 2014
  - Return to pre-European settlement, decrease depth to groundwater
- Beaver Related Restoration
  - Planned introductions
  - Beaver Dam Analogues
  - Unplanned introductions



Dynamic Restoration Examples

- Valley Restoration
  - Reestablish surface groundwater connections
  - Self-sustaining restorations that develop into stream-wetland complexes
  - Designed for sediment/carbon retention and low shear stresses
- Stage “0” Restoration
  - Based on Stream Evolution Model, Cluer and Thorne 2014
  - Return to pre-European settlement, decrease depth to groundwater
- Beaver Related Restoration
  - Planned introductions
  - Beaver Dam Analogues
  - Unplanned introductions

Flitcroft et al. 2022

Dynamic Restoration Examples

- Valley Restoration
  - Reestablish surface groundwater connections
  - Self-sustaining restorations that develop into stream-wetland complexes
  - Designed for sediment/carbon retention and low shear stresses
- Stage “0” Restoration
  - Based on Stream Evolution Model, Cluer and Thorne 2014
  - Return to pre-European settlement, decrease depth to groundwater
- Beaver Related Restoration
  - Planned introductions
  - Beaver Dam Analogues
  - Unplanned introductions

Restoration of Dynamic Stream Systems

- Dynamic restoration practices have grown in frequency
  - Often achieve high ecological response depending on region or project
- New tools are needed to support dynamic stream restoration evaluation and crediting.
- Goal: Provide regulators with a knowledge of best practices for dynamic streams



Updated Tools Needed

- What to monitor?
  - Channel X-sections, valley X-sections, biota, vegetation?
- How to set performance standards?
- How know when the stream system is being dynamic verse unraveling?
- What to do when beaver come on a site? Leave a site?
- What are the credits?

Compensatory Mitigation Review

- Created a series of questions to examine performance standards & monitoring requirements
- Regulators
  - EPA
  - Corps
  - States
- Practitioners
- Academics
- Conducted interviews concurrently with literature review

What’s being used?

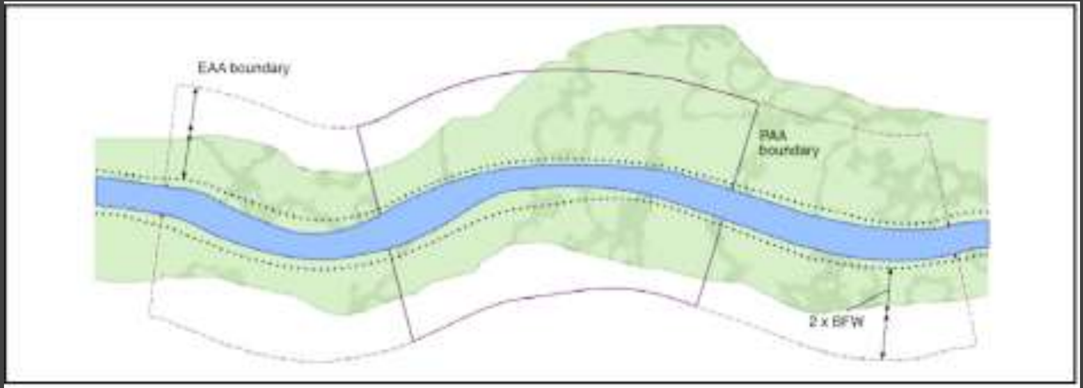
- Debits and Credits generally assessed with Stream Quantification tools
  - Designed for assessment in a state
    - Follow a similar format
  - Stream Wetland complexes addressed, only on debit side
  - Some considerations for anastomosing systems

Applicable Parameters	Perennial	Intermittent	Ephemeral	Multi-thread Channels
Reach Runoff	x	x	x	x
Base Flow Dynamics	x	x		x
Floodplain Connectivity	x	x	x	x
Large Wood	x	x	x	x
Lateral Migration	x	x	x	x
Bed Material	x	x	x	x
Bedform Diversity	x	x		
Planform	x	x		
Riparian Vegetation	x	x	x	x
Temperature	x	Where baseflows extend through index period		x
Dissolved Oxygen	x			x
Nutrients	x			x
Macroinvertebrates	x			x
Fish	x	x		x
Flow Alteration Module	x			

CSQT Table 6. Applicability of metrics across flow type and in multi-thread systems. An ‘x’ denotes that one or more metrics within a parameter is applicable within these stream types.

Stream Functional Assessment Method (SFAM)

- Developed and utilized in the Pacific Northwest
  - Uses proximal & extended assessment areas based on channel position, allowing for channel migration
  - Gives specific instructions for multiple channels and partially dry streams
  - Invertebrates and fish not specifically surveyed



Wilmington District-Riparian Headwater Systems

- Based on streams in the coastal plain ecoregion
  - Intense agricultural pressure has altered riparian headwater systems
  - Restoring channel dimensions & profile may not result in functional uplift
- Allows for stream credits in systems without constructed distinctive channel
  - Case-by-case
  - Based on wetland vegetation establishment, at least periodic flow, flooding regime
- Applicable systems
  - First-order stream impacts
  - Where riparian headwater system existed historically

Upcoming Assessment Methods

- The Maryland Stream Mitigation Framework (Out in Draft)
  - Credits multiple channels
    - 1.0 per linear foot of first channel, then 0.2 and 0.1 for second and third channels, respectively
    - Stream must be perennial, 1.0 foot wide with pools at least 0.5 ft deep
- Concurrent with creation and evaluation of a Function-based rapid stream assessment

Stage 0 Monitoring

- Hinshaw et al. 2021
  - Conducted on Stage 0, suggestions for future monitoring
  - Quantified stream heterogeneity using randomly selected plots
  - Uses plot homogeneity to determine trends
  - Potentially useful to determine how to monitor these sites in the future
- Flitcroft et al. 2022
  - Regularly monitored sites 2-3 years after restoration
  - Decreased depth to groundwater, other variables may take longer to respond

The Beaver Question

- Standard to remove until long-term management
  - Beaver will change stream form, eat & flood riparian vegetation
- Beaver generally recolonize, and provide other ecological benefits
  - Sediment & water storage
  - Groundwater Recharge
  - Fire breaks
  - Habitat for biota

The Beaver Question

Potential Beaver Activities

Beaver presence has been observed on the site and may pose some undesired results that compromise the performance standards. Beaver dams can cause upstream pools to fill in with sediment since the dam precludes proper sediment transportation downstream. If a beaver dam is affecting a stream's ability to achieve performance standards (i.e., pool depth ratios), MM will take steps necessary to remove the beaver dam that is preventing the stream to meet performance standards unless otherwise indicated by the USACE. Should the USACE grant approval for the beaver dam to remain, performance standards that are not met due to the presence of the dam will not be considered as a failure. It is anticipated that beaver will harvest saplings throughout the site for dam construction. Preventative measures will be used, but some degree of tree mortality will be affected. If beaver activities appear to be lowering the stem count below the total target density in riparian areas, then replanting will take place. In areas where beaver have harvested trees, undesired mortality rates will not constitute failure if the stem count meets the minimum target density.

MM is the mitigation banker for this example

Alternative approach

- Address unplanned beaver adaptively
- Protect infrastructure, desired trees
- Install grade control as necessary
- Other Practical Considerations
  - Important infrastructure
  - Landowner concerns

Grading Beaver Performance

- Quantifying ecological benefits is difficult for beaver systems
  - Heavily ponded, but still part of a lotic system
- No known IBI, or large-scale biological survey
  - Studied invertebrate response has been inconsistent
  - Generally, a net positive for fishes
  - Increases in shallow ponded area a boon for amphibians
- Possible region bias

Performance Standards- Ecological Uplift

Pros

- Some measures of uplift are transferrable to dynamic systems
- Many of these systems demonstrate high ecological uplift
- Aligns with the stated goals of these restorations

Cons

- While uplift may be consistent, methods of quantification may vary
- Some variables specific to dynamic systems have yet to be quantified
- Biological variables may take longer to respond

PA DEP- Restoration of Dynamic Alluvial Valleys

- Metrics used or in discussion
  - Currently utilizes uplift as a measure
  - Visible retention of carbon
  - Fe precipitation
  - Biofilm development
  - Abundance of Hydropsychid caddisflies
- Monitoring with cross-sections & longitudinal measures

Current Findings

- Willingness to accept dynamic restoration varies across the country
  - No existing methodology for evaluating these systems

- However, there are some consistently identified hallmarks
  - Being dynamic systems, they should be addressed adaptively
    - Suggestions to use a suite of performance standards for each expected change
  - Dynamic alluvial systems should retain carbon
  - Push for some amount of hydrologic modeling & design standards, including designing around shear stresses

Next Steps

- Address additional river types and monitoring requirements
- More specific performance standards
- Purposeful Beaver Introduction
  - Could be managed adaptively
  - How do we measure success?
- Looking over National Aquatic Resource Survey (NARS) data

Contact Us

- Sam Leberg, ORISE participant at US EPA
  - Leberg.Samuel@epa.gov
- Brian Topping
  - Topping.Brian@epa.gov