Are streambank stabilization systems reducing sediment supply and reservoir sedimentation?

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Streambank Erosion

- Accelerated streambank erosion occurs due to bed instability following changes in watershed and/or channel (Simon & Hupp, 1986)
- Results in:
  - Impaired water quality (Walling & Fang, 2003)
  - Impaired ecological condition (Vorosmarty et al., 2010)
  - Threatened infrastructure (Fox et al., 2016)

Streambank Stabilization (SBS) in Kansas

- Major projects have been installed over the last 20 years
- Site-scale monitoring has occurred but no reach- to river-scale monitoring

My Current Research Questions

- What are the causes of bank stabilization failure? (SSAT)
- Can we use wood instead of rock to stabilize streambanks? (Woody Structures)
- Do streambank stabilization projects push the ‘erosion problem’ upstream or downstream? (Rock Structures)

Streambank Stabilization Assessment Tool

- Purpose: Provide rapid numerical ratings of post-construction stability based on both field measurements and visual assessment of stabilization sites
- Based on:
  - Instream structure condition and function
  - Vegetation establishment
- Evaluated 99 projects on the Cottonwood, Neosho, Big Blue, and Little Blue Rivers

Little Blue River

What are the causes of bank stabilization failure?

Streambank Stabilization Assessment Tool

- Project stability may depends on:
  - Timing of first bankfull or larger flow event
  - Bed stability
  - Use of toe rock
  - Project age
  - Likely others…
- Rock structure design life ~15 years

Streambank Stabilization Assessment Tool

- Additional work:
  - Reduce its subjectivity
  - Identify additional causes of lateral instability
  - Try other statistical tools
  - Confirm results through long-term field measurements
  - Try it in other watersheds

Monitoring of Woody Revetment SBS

- Woody Revetment Design: Deciduous trees anchored at the toe of an eroding streambank
- Project Goals:
  - Reduce velocity in near-bank region
  - Induce deposition
  - All at a fraction of the cost
- Installed on 6 streambanks of the Smoky Hill River in 2015-2017
- Monitoring since 2016

Can we use wood instead of rock to stabilize streambanks?

Monitoring of Woody Revetment SBS

- As of August 2019, at least 4 of the 6 projects have partially or fully failed
- Failure Mechanism Hypotheses:
  - Increased bank erosion caused by upstream reservoir operation
  - Insufficient anchoring
  - Lack of early-stage protection

Smoky Hill River

Monitoring of Woody Revetment SBS

- Additional Work
  - Test failure hypotheses through:
    - Boundary condition analyses
    - Computer modeling
  - Develop adaptive management strategies

Monitoring of SBS Projects Using Rock

- Rock structure design: flow deflectors, toe protection, bank shaping, and vegetation
- Evaluating 2 planned sites on Cottonwood River through:
  - Repeated geomorphic and topographic surveys
  - Boundary condition analyses
  - Computer modeling
- Currently in the 2nd year of monitoring

Do SBS projects with rock push the 'erosion problem' upstream or downstream?

Hypothesis 1: SBS decreases sediment input from streambank erosion at the stabilized site

Bank Erosion

Stabilization

Hypothesis 2: Increase sediment transport capacity along the site, resulting in channel degradation

Bank Erosion

Stabilization

Bed Erosion

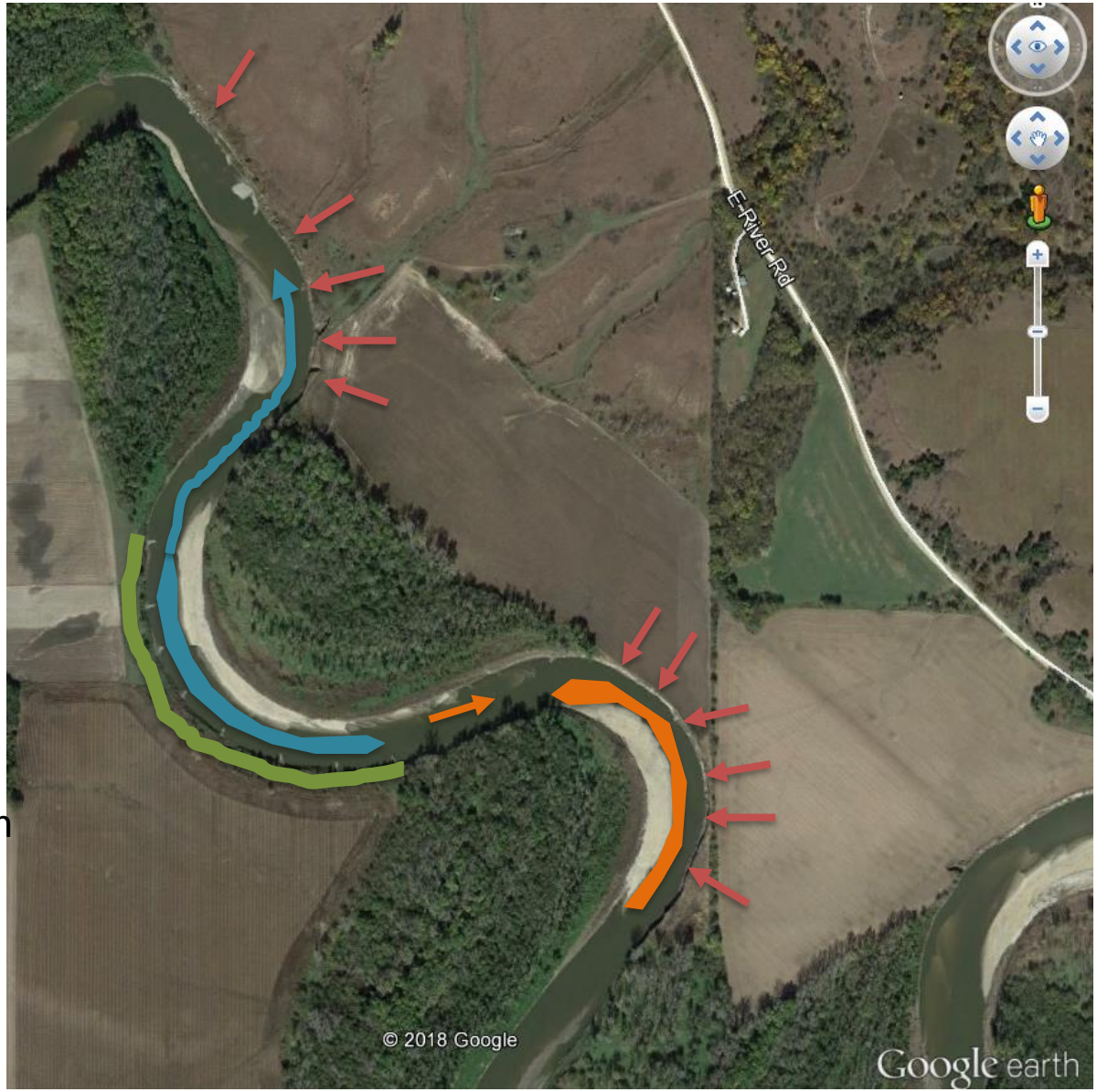
Hypothesis 3: Induce deposition and accelerated streambank erosion downstream of the stabilization

Bank Erosion

Stabilization

Bed Erosion

Bed Deposition



Summary

- What are causes of bank stabilization failure?
  - Timing of flood events
  - Bed instability
  - Lack of toe rock
  - Project age
  - Likely others…
- Can we use wood instead of rock to stabilize streambanks?
  - Current design – no – but there is likely room for improvement
- Do streambank stabilization projects push the 'erosion problem' upstream or downstream?
  - To be determined
- Are streambank stabilization systems reducing sediment supply and reservoir sedimentation?
  - To be determined