Amity Creek Bank Stabilization and Habitat Restoration

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Outline

• Project Purpose and Background
• Definition of Existing Problem
• Geology/Geomorphology of Creek
• Design
• Construction
• Conclusions
Amity Creek - Background/Purpose

Creek Overview

• Trout Stream
• In City of Duluth and Rice Lake Township
• Headwaters in developing suburban area and lower reaches protected by Duluth park land

Issues

• Bank Instability and Resultant Turbidity
• Lack of pool habitat for fish in some reaches
• Stream Temperatures
• Low Summer Baseflow
Project Background/Partners

- Weber Stream Initiative
- NRRI
- South St. Louis SWCD
- TSA #3
- MPCA
Existing Problem

- Clay Soils
- Stream Thalweg Intersecting Valley Wall and Corresponding Erosion
- High River Turbidity During High Flows
- Relatively Steep Gradient, High Velocities at Thalweg
Existing Problem

Upstream Bank

Downstream Bank
Stream Turbidity

- How much of this is natural vs. an instability problem?
- Do not have enough data or analysis to say at this point
Design Approach

• Assess Watershed and Setting
• Study Geomorphology of River
  – Utilize Mechlinberg (Ohio DNR) Spreadsheets
  – Rosgen/NRCS Guidance Documents
  – Let the Study of the River Define the Solution
• Try to Define Cause and Consequence of Problem
  – Historic Logging induced instability
    • Increased Peak Flows
  – Dairy Farm Historic Clearing of Riparian Area
  – Stream just intersecting valley wall
  – Natural Slope inflection region
Amity Shaded Relief Map
Duluth Stream Profiles

Figure 9. Longitudinal profiles of streams in the A, southwestern, and B, northeastern parts of the Duluth, Minn., area.
Stream Geomorphology/Stability

- Very Short introduction
Stream Stability

The ability of a stream to maintain, over time, its Dimension, Pattern, and Profile

So it neither aggrades nor degrades

And is able to transport, without adverse effect, the flows and detritus of its watershed

Rosgen and Silvey, 1996
**Dimension** *(WIDTH & DEPTH in the cross section)*

- Bankfull
- Floodplain

**Pattern** *(stream curvature - SINUOSITY - in the plan view)*

- Bankfull and Floodplain

**Profile** *(stream SLOPE in the longitudinal section)*

- Bankfull and Floodplain

The slope of the bankfull elevation and the slope of the riffles are the same!
Sediment Balance

Figure 1.13: Factors affecting channel equilibrium. At equilibrium, slope and flow balance the size and quantity of sediment particles the stream moves.

Source: Rosgen (1996), from Lane, *Proceedings*, 1955. Published with the permission of American Society of Civil Engineers.
The most effective sediment discharge, over time, occurs, at the bankfull flow rate or approx. the 1.5-year recurrence interval.

At the bankfull flow, the stream bottom picks up and moves, then redistributes itself in the same pool & riffle patterns existing prior to the bankfull discharge.

Very large cobble & boulders excepted.
Rosgen Classification System

Figure 11-2 Broad-level stream classification delineation showing longitudinal, cross-sectional, and plan views of major stream types
Channel Evolution Model

Figure 40. Adjustments of channel cross-section and plan-view patterns, as stream types change or shift through a series of successional cycles.
Various stream type evolution scenarios (from Rosgen 2000)
Stable channel at bankfull flow

Unstable (entrenched) channel at bankfull flow
Stable channel at flood flow

Unstable (entrenched) channel at flood flow

Shear stress
\[ \tau = \gamma DS \]

where:
- \( \gamma \) is the specific weight of the fluid,
- \( D \) is the mean depth, and
- \( S \) is the water surface slope.
Design Approach

• **Determine River Stability Indices**
  – Is channel connected to its floodplain?

• **Amity is relatively stable but has not always been in reach**
  – Signs of Aggradation/Degradation in reach
  – Portions of reach not connected

• **Design around Bankfull elevation and flow, 1-2 year recurrence interval**
  – Spring Flows Typically Bankfull
Design Process for Amity

• Investigate Background Data
• Conduct Topographical Survey
  – Longitudinal Survey of Thalweg, bankfull, and cross sections
• Conduct Pebble Counts at Riffle, back out mannings Roughness Coefficient and Bankfull Flow
Design Process for Amity, cont

• Determine if stream is connected to floodplain (or aggradating or degrading)
  – Compare Calculated Bankfull flow, mannings to USGS regional equations of two year flow
  – Type Stream, C4
  – Observe stream during spring high flow event
• Classify Stream Type
• Rock Size Based on Sheer Stress, All Large Rock Used
  – 24-48” try to get rock with one flat side
Design Process for Amity

- Develop Alternatives
  - Recommend Alternatives
  - Meet with Agency Staff
- Develop Plans/Quantities/Final Calcs.
- Bid
- Construct
High Flow Observations
Survey and Geomorph. Analysis

- **Longitudinal Profile**
  - Bankfull
  - Thalweg
  - Water surface

- **Riffle Pebble Counts**
  - Define Roughness

- **Ohio DNR, Mechlinberg Spreadsheets**
## Cross Sections/Stream Parameters

<table>
<thead>
<tr>
<th>Bankfull Dimensions</th>
<th>Flood Dimensions</th>
<th>Materials</th>
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<tbody>
<tr>
<td>41.1</td>
<td>75.0</td>
<td>27</td>
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<td>54.4</td>
<td>1.4</td>
<td>98</td>
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<tr>
<td>0.8</td>
<td>---</td>
<td>25</td>
</tr>
<tr>
<td>0.0</td>
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<td></td>
</tr>
<tr>
<td>54.6</td>
<td>0.8</td>
<td>D50 Riffle (mm)</td>
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<tr>
<td>0.8</td>
<td>---</td>
<td>D84 Riffle (mm)</td>
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<tr>
<td>72.0</td>
<td>54.6</td>
<td>threshold grain size (mm):</td>
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<table>
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<th>Flood Resistance</th>
<th>Forces &amp; Power</th>
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<tbody>
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<td>177.1</td>
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<tr>
<td>0.88</td>
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<td>0.52</td>
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<tr>
<td></td>
<td>2.3</td>
<td>2.2</td>
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</tbody>
</table>

- **Width**
- **Elevation**
- **Bankfull Flow**
  - velocity (ft/s)
  - discharge rate (cfs)
  - Froude number
- **Flood Dimensions**
  - width (ft)
  - mean depth (ft)
  - max depth (ft)
  - wetted perimeter (ft)
  - hyd radi (ft)
  - width-depth ratio
- **Materials**
  - D50 Riffle (mm)
  - D84 Riffle (mm)
  - threshold grain size (mm):

### Graph

- **2 + 13 Amity-East Branch, Riffle**
- **Elevation**
- **Width**

- **Bankfull Flow**
  - velocity (ft/s)
  - discharge rate (cfs)
  - Froude number
- **Flood Resistance**
  - Manning's roughness
  - D'Arcy-Weisbach fric.
  - resistance factor u/u*
  - relative roughness
- **Forces & Power**
  - channel slope (%)
  - shear stress (lb/sq.ft.)
  - shear velocity (ft/s)
  - unit strm power (lb/ft/s)
Summary of Parameters

STREAM REACH PARAMETERS

- Flood Prone Area Width: 83 ft
- Bankfull X Sect. Area, Riffle: 37 sq. ft.
- Bankfull Width: 46 ft
- Channel Slope: 1.1%
- Bankfull Discharge: 165 CFS, from Geomorphology
- 2 Year Discharge, USGS: 220 CFS, USGS Regional Regression Equation
- Bankfull Mean Depth: 0.8 ft
- Width/Depth Ratio: 57
- Entrenchment Ratio: 1.8
- Sheer Stress: 0.55 lbs./sq. ft.
- Watershed Area Above Project: 8.1 sq. miles
- Watershed Slope: 55 ft./mile
- Percent of Watershed in Storage: 8.43 %
Design

- 3 Rock j Hooks
- Cross Vane
- Cutting Banks Back to Stable Angle
- Bankfull Bench at Bankfull Elevation
- Root Wads-Pool Habitat In Front of Them
- Native Seeding and Coconut Blanket on Bankfull Bench
- Maintain Cross Sectional Area of Channel
- Move Channel Away From Banks with Bench no magic on location of thalweg
- Fix destroyed ski trails of local Doctor used as access
Design
Construction

• Bypass Channel
Construction
Construction

- Bankfull Bench
- Root Wad
- J hook
Downstream Bank
• High Flow Event in October
• Upstream J-Hook
Low Flows Through Vane and J-hooks
Monitoring Plan

- Fish and Aquatic Invertebrate Surveys through reach over the next couple years
- Cross Sections, monumented
- Photo Documentation
Lessons learned

• Attention to detail on installation on rock vanes is extremely important
• Transplants of willow are very effective even if they look poor after transplanting, most sprout
• Determining where stream is in the continuum of stream stability requires detailed assessment before project starts
• Other ways may be available other than the large rock approach for vanes, etc.
Alternative, no large rock design approach
Summary

- Read the river and utilize geomorphology to inform alternative analysis and designs
- Go through Design Process that looks at the big picture
- Create Designs that are long term sustainable, unlimited design life
- Understand erosion as a natural process in rivers
- Work with other disciplines and agencies early in design
Questions?
Low Gradient Streams Often Have Wide Connected Flood Plains
(from Newbury & Gaboury, 1993)
Headcut turning E channel (large floodplain) into G channel (gully). Imagine the volume of sediment generated!