Evaluating Systems to Reduce Road Improvement Impacts on Mountain Streams

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NC State University
The Problem:

- Narrow drainage ditches along DOT roadways in the mountains have had limited sediment control BMP options (usually rock checks and small basins), often giving unsatisfactory results.
The Problem:

- Designated trout streams (common in up mountains) have a turbidity limit of 10 NTU for stormwater runoff. This is very strict (50 NTU is normal limit) and hard to meet under the best of circumstances.
Loss of Wildlife Habitat
Loss of Aquatic Organisms
The Problem:

• So, alternate BMPs were tested to determine if they could improve runoff water quality as compared to the standard DOT BMPs.
Project Site:  Steeltown Rd
Caldwell County, just East of Patterson (DOT Division 11)
Project Site: Steeltown Rd
Project Site: Curley Maple Rd

Watauga County, North of Boone (DOT Division 11)
Project Site: Curley Maple Rd
Standard BMPs – Steeltown Rd

• Rock check dams and Type B silt basins
Standard BMPs – Curley Maple Rd

- Rock check dams with silt basins
Experimental BMPs

- Coir Logs (10’ long, 12” diameter) at $55 each

Note: Erosion control matting placed on top of, or underneath, the center section of each BMP

Photos from Steeltown Rd Site
Experimental BMPs

• Coir Logs (10’ long, 12” diameter) at $55 each

Note: Erosion control matting placed on top of, or underneath, the center section of each BMP

Photos from Curley Maple Rd Site
Experimental BMPs

- Straw wattles (10’ long, 9” diameter) at $20 each

Note: Erosion control matting placed on top of, or underneath, the center section of each BMP

Photos from Steeltown Rd Site
Experimental BMPs

- Straw wattles (10’ long, 9” diameter) at $20 each

Note: Erosion control matting placed on top of, or underneath, the center section of each BMP

Photos from Curley Maple Rd Site
Experimental BMPs

- Granulated Polyacrylamide - PAM 705 added to BMPs (anionic PAM approved for use by DWQ)
  Apx. 100 grams added after every significant storm event
Steeltown site layout:

Section 1: Std BMPs
- Pipes crossing under road
  - 450’ long at 5% slope
  - 63’ spacing

Section 2: Exp BMPs + PAM
- 668’ long at 7% slope
  - 32’ spacing

Section 3: Exp BMPs
- 461’ long at 6% slope
  - 25’ spacing
Project Site: Steeltown Rd

Weir installed for each section at culvert crossing
Standard BMPs over time – 5 months after paving
Standard BMPs over time – 5 months after paving
Standard BMPs over time – 5 months after paving
Standard BMPs over time – 5 months after paving
Standard BMPs over time – 5 months after paving
Exp BMPs over time – 5 months after paving
Exp BMPs over time – 5 months after paving
Steeltown site layout:

Section 1: Std BMPs

Section 2: Exp BMPs + PAM

Section 3: Exp BMPs

Basin below Section 3
Steeltown basin design:

Coir Baffles
Flow was concentrated and bypassed baffles

Rock Outlets
Steeltown basin design:

Flow sampled at basin outlet was more turbid than Section 3 discharge flowing into the basin.

In fact, an average turbidity increase of 416 NTU was observed!
Results: Steeltown Rd

(Samples collected June 2006 to March 2007)

<table>
<thead>
<tr>
<th>Turbidity (NTUs)</th>
<th>Standard</th>
<th>Exp+PAM</th>
<th>Exp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>4,198</td>
<td>30</td>
<td>187</td>
</tr>
<tr>
<td>Std Dev</td>
<td>6,552</td>
<td>120</td>
<td>426</td>
</tr>
<tr>
<td>Median</td>
<td>1,737</td>
<td>12</td>
<td>65</td>
</tr>
</tbody>
</table>

Note: Exp+PAM was the longest and steepest section!
Results: Steeltown Rd

Steeltown Results

Turbidity (NTUs)

Std

Exp + PAM

Exp

average
median
Results: Steeltown Rd

Steeltown Rd Summary: Turbidity by BMP Type

- Standard BMPs
- Exp BMPs + PAM
- Exp BMPs alone

Turbidity (NTU)
## Results: Steeltown Rd

<table>
<thead>
<tr>
<th>Sediment Loading (kg)</th>
<th>Standard</th>
<th>Exp+PAM</th>
<th>Exp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Sum</td>
<td>9,415</td>
<td>24</td>
<td>59</td>
</tr>
<tr>
<td>Average per storm event</td>
<td>448</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
Results: Steeltown Rd (Dec 06)

Some initial storms had 14,000+ NTU for Standard BMPs but just 190 and 250 NTU for Exp BMPs!
Curley Maple site layout:

Pipes crossing under road

Ditch line

Section 1: Exp BMPs + PAM
  489’ long at 3% slope
  27’ spacing

Section 2: Std BMPs
  507’ long at 3% slope
  85’ spacing
Project Site: Curley Maple Rd

- Samplers placed at culvert outfall
Standard BMPs over time – 5 months later
Standard BMPs over time – 5 months after paving
Exp BMPs over time – 5 months later
Exp BMPs over time – 5 months later
Results: Curley Maple Rd
(Samples collected July 2006 to March 2007)

<table>
<thead>
<tr>
<th>Turbidity (NTUs)</th>
<th>Standard</th>
<th>Exp+PAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>852</td>
<td>64</td>
</tr>
<tr>
<td>Std Dev</td>
<td>1,265</td>
<td>108</td>
</tr>
<tr>
<td>Median</td>
<td>305</td>
<td>40</td>
</tr>
</tbody>
</table>
Results: Curley Maple Rd

![Graph showing turbidity (NTUs) for Std and Exp + PAM treatments. The graph indicates a higher average turbidity for Std compared to Exp + PAM.]
Results: Curley Maple Rd

Curley Maple Summary: Turbidity by BMP Type

- **Standard BMPs**
- **Exp BMPs + PAM**
**Results: Curley Maple Rd**

<table>
<thead>
<tr>
<th>Sediment Loading (kg)</th>
<th>Standard</th>
<th>Exp+PAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Sum</td>
<td>65</td>
<td>7</td>
</tr>
<tr>
<td>Average per storm event</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>
Results: Curley Maple Rd (Dec 06)

Some initial storms had 1,000-2,000 NTU for Standard BMPs but just 90 to 180 NTU for Exp BMPs!
Project Site: Fleming Chapel Rd

Caldwell County, West of Lenoir (DOT Division 11)
Fleming Chapel site layout:

Ditch line
Pipes crossing under road

Section 1:
Exp + PAM
300' at 4%
30’ spacing

Section 2:
Exp only
524' at 3%
30’ spacing

Section 3:
Exp only
165’ at 3%
60’ spacing

Section 4:
Standard
375’ at 3%
80’ spacing
Experimental BMPs

- Coir wattles (6’ long, 6” and 9” diameter) at $25 each

Note: Erosion control matting placed over center section of each BMP

Photos from Fleming Chapel Rd Site
Project Site: Fleming Chapel Rd

Weirs placed over culvert outfall
Project Site: Fleming Chapel Rd

DOT Standard Section

April 2007

June 2007
Project Site: Fleming Chapel Rd

Experimental Sections
# Results: Fleming Chapel

<table>
<thead>
<tr>
<th>Date</th>
<th>Average Turbidity (NTU)</th>
<th>Sediment Load (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>4/15/200</td>
<td>5744</td>
</tr>
<tr>
<td></td>
<td>6/12/2007</td>
<td>7310</td>
</tr>
<tr>
<td></td>
<td>6/14/2007</td>
<td>7915</td>
</tr>
<tr>
<td>Experimental plus PAM</td>
<td>6/12/2007</td>
<td>304</td>
</tr>
<tr>
<td>Experimental alone (30’ spacing)</td>
<td>4/15/2007</td>
<td>5335</td>
</tr>
<tr>
<td>Experimental alone (60’ spacing)</td>
<td>4/15/2007</td>
<td>7474</td>
</tr>
<tr>
<td></td>
<td>6/12/2007</td>
<td>4796</td>
</tr>
<tr>
<td></td>
<td>6/14/2007</td>
<td>4992</td>
</tr>
</tbody>
</table>

Experimental plus PAM the cleanest by far!
Standard DOT BMP costs:

- Silt Basin: $15
- Rock check: $80

Total: $95

Plus maintenance cost $15
Cost Estimate Comparison

Experimental BMP costs:

- Coir Log $62
- Straw Wattle $27

Costs include staples, stakes, and labor.

PAM costs about $2 per 100g application
## Cost Estimate Comparison

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
<th>Cost Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steeltown:</strong></td>
<td>450’ Standard section</td>
<td>$570 / $0 to maintain</td>
</tr>
<tr>
<td></td>
<td>668’ Experimental BMPs + PAM</td>
<td>$730 / $60 to maintain</td>
</tr>
<tr>
<td></td>
<td>461’ Experimental BMPs only</td>
<td>$652 /foot (spacing closer)</td>
</tr>
<tr>
<td><strong>Curley Maple:</strong></td>
<td>450’ Standard section</td>
<td>$570 / $0 to maintain</td>
</tr>
<tr>
<td></td>
<td>668’ Experimental BMPs + PAM</td>
<td>$730 / $60 to maintain</td>
</tr>
</tbody>
</table>

The logs and wattles do not have to be removed either, they can decompose in place.
Conclusions

- The alternate BMPs tested showed dramatic improvements in turbidity and sediment loading at two mountain DOT sites, with a third site still be evaluated.

- These alternate BMPs are fairly easy to install, require no special maintenance, and appear economically reasonable as compared to the standard practices.
Any Questions?

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Experimental BMP Spacing

• BMPs theoretically spaced such that flow goes from pool to pool…

This slows water velocity down and gives more time for water to infiltrate into the ground and causes sediment to fall out of suspension!
Standard BMP Spacing

- Standard BMPs spaced using the following DOT formula for the Mountains/Piedmont:

  \[
  \frac{300}{\% \text{ slope grade}} = \text{spacing in ft}
  \]

  At Steeltown:
  \[
  \frac{300}{5\% \text{ slope grade}} = 60' \text{ spacing}
  \]

  At Curley Maple:
  \[
  \frac{300}{3.5\% \text{ slope grade}} = 86' \text{ spacing}
  \]
Project Site: Steeltown Rd

- Three designated sections:
  - Standard DOT BMPs (500’ at 5% slope)
    - Std BMPs spaced every 75’
  - Experimental BMPs plus PAM 705 (670’ at 7%)
  - Experimental BMPs alone (460’ at 6%)
    - Exp BMPs spaced every 30’
- Erosion control matting placed on top of, or underneath, the center section of each of the new BMPs
Results: Steeltown Rd (March 07)

Update photos!

Improvements seen for all three sections as vegetation becomes more established, though the standard is still the most turbid by far!
Project Site: Curley Maple Rd

- Two designated sections, apx. 500’ long each
  - Standard DOT BMPs (at 3% slope)
    Std BMPs spaced every 85’
  - Experimental BMPs plus PAM 705 (at 3%)
    Exp BMPs spaced about every 30’

- Erosion control matting placed on top of, or underneath, the center section of each of the new BMPs
Results: Curley Maple Rd (March 07)

Improvements seen for all three sections as vegetation becomes more established, though the standard is still the most turbid by far!
<table>
<thead>
<tr>
<th>Steeltown Rd Site Section Descriptions</th>
<th>Length (ft)</th>
<th>Slope (%)</th>
<th>BMP spacing (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOT Standard BMPs</td>
<td>450</td>
<td>5</td>
<td>63</td>
</tr>
<tr>
<td>Experimental BMPs with PAM</td>
<td>668</td>
<td>7</td>
<td>32</td>
</tr>
<tr>
<td>Experimental BMPs alone (no PAM)</td>
<td>461</td>
<td>6</td>
<td>25</td>
</tr>
</tbody>
</table>