Relocating a Channel and Replacing Two Structures along a Western PA Highway Corridor

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SR 0422 BRIDGE REPLACEMENTS

- Project background
- Existing
  - Bridges
  - Floodplain characteristics
  - Embankment erosion
- Proposed
  - Culvert
  - Channel relocation
- 2D model
  - Input
  - Results
- Conclusions
PROJECT BACKGROUND

- Major PennDOT corridor in western PA
- Transportation improvements
  - Safety issues
  - Structural deficiencies
  - Flooding
  - Erosion control
  - Future maintenance
EXISTING BRIDGES & FLOODPLAIN
EMBANKMENT
EROSION

SR 0422
Bridge #1
Curry Run

Bridge #2
UNT to Curry Run
PROPOSED CULVERT & CHANNEL RELOCATION
PROPOSED CHANNEL TYPICAL SECTION

- 5' Base Flow Channel
- 6" Depth
- 3' 6" Topsoil
- Erosion Control Mat (Coconut Coir Matting)
- 4" to 6" Streambed Material (Round River Rock)
- 1V:50H Floodplain Overbank Riparian Buffer
- 6'
- 15' 6'
- 6'
- 1V:50H Floodplain Overbank Riparian Buffer
- 1V:2H
- 3'
- 1V:2H
- 6" Topsoil
- 5' Base Flow Channel
2D Model

- Complex hydraulic conditions
  - Multiple opening hydraulic scenario during high flow events
  - Curry Run reverses the flow direction in Bridge #2 during high flood events
  - 90° bend upstream of Bridge #1
  - 2D flow characteristics in the 100-year floodplain
  - Proposed stream realignment
2D MODEL INPUT | GRID & BOUNDARIES

- **Upstream Boundary** (Flow vs. Time)
- **Bridge #1** (Flow Constriction)
- **Bridge #2** (Flow Constriction)
- **US Cross Section**
- **Downstream Boundary** (WSEL vs. Time)
- **Cunningham Rd. Bridge** (Flow Constriction)

Map showing grid and boundaries with labels for upstream and downstream boundaries, bridges, and cross sections.
2D Model Input | Existing Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Roughness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel (Curry Run)</td>
<td>0.030</td>
</tr>
<tr>
<td>Channel (Tributary)</td>
<td>0.035</td>
</tr>
<tr>
<td>Cropland</td>
<td>0.050</td>
</tr>
<tr>
<td>Gravel</td>
<td>0.025</td>
</tr>
<tr>
<td>Dense Woods</td>
<td>0.080</td>
</tr>
<tr>
<td>Pasture</td>
<td>0.025</td>
</tr>
<tr>
<td>Lake</td>
<td>0.030</td>
</tr>
<tr>
<td>Road</td>
<td>0.015</td>
</tr>
<tr>
<td>Rock Gabions</td>
<td>0.020</td>
</tr>
<tr>
<td>Proposed Floodplain*</td>
<td>0.050*</td>
</tr>
<tr>
<td>Proposed Swale*</td>
<td>0.030*</td>
</tr>
</tbody>
</table>
Proposed twin cell

- 25’-5 ½” primary cell, depressed 12” with 8” alternating baffles
- 25’-5 ½” overflow cell with 18” weir
- PA Type 10M Bridge Barrier
## 2D Model Input | Proposed Structure

- 2D layered flow constriction
  - Assign % blockage and form loss coefficient (FLC) per layer

<table>
<thead>
<tr>
<th>Layer</th>
<th>Blockage</th>
<th>FLC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 1</td>
<td>8%</td>
<td>0.15</td>
</tr>
<tr>
<td>Layer 2</td>
<td>100%</td>
<td>0.8</td>
</tr>
<tr>
<td>Layer 3</td>
<td>50%</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>0</td>
</tr>
</tbody>
</table>

- Depth
  - Layer 1: 0.15'
  - Layer 2: 3.2'
  - Layer 3: 1.83'

- Weir flow
- Guiderail/ Parapet / Railing
- Superstructure
- Hydraulic Opening
2D Model Input | Pier Coefficient

- Interior vertical wall modeled as a pier
2D Model Results | Summary

- 50- and 100-year results:
  - Backwater decreases
    - Average of 2 feet upstream of proposed twin cell
  - Overtopping reduction
  - Less erosion potential along SR 0422

- Reasons for improved hydraulic conditions
  - Larger hydraulic opening of proposed culvert
    - Existing 125 sf (combined) vs. Proposed 224 sf
  - Improved stream alignment of Curry Run
100-year Results | Existing Conditions

- Bridge #1: 45%
- Overtopping: 40%
- Velocity: 6-10 fps

100-year Existing Water Surface Elevations (ft) & Velocity Vectors (ft/s)
100-year Flow Trace | Existing Conditions
100-year Proposed Water Surface Elevations (ft) & Velocity Vectors (ft/s)

54” pipe - 5%

Velocity 1-4 fps

Twin cell - 95%
100-YEAR RESULTS | PROPOSED CONDITIONS
100-year Results | Existing vs. Proposed

100-year Water Surface Elevations Increases (ft)
100-year Water Surface Elevations Decreases (ft)

100-year Results | Existing vs. Proposed
100-YEAR RESULTS | EXISTING VS. PROPOSED

100-year Existing and Proposed Floodplain Extents

- **Existing**
- **Proposed**
- **Existing & Proposed**
50-year Results | Existing vs. Proposed

50-year Existing and Proposed Floodplain Extents

Legend:
- **Existing**
- **Proposed**
- **Existing & Proposed**

SR 0422
CONCLUSIONS

2D Application
- Model multiple openings and overtopping
- Account for 2D flow direction in floodplain and split channel
- Reflect different confluence locations for the 50-year and 100-year events
- Incorporate the proposed stream realignment

Results
- Accurately calculate hydraulic capacity of existing structures
- Determine required hydraulic opening of twin cell
- Quantify changes in flood elevations and velocities
- Evaluate risk and floodplain management criteria
INNOVATIVE TWO-DIMENSIONAL HYDRAULIC APPLICATIONS

QUESTIONS?

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2D Model Input | Hydraulic Structures

- Proposed twin cell
50-year Results | Existing Conditions
50-year Results | Proposed Conditions

50-year Proposed Water Surface Elevations (ft) & Velocity Vectors (ft/s)
50-year Results | Existing vs. Proposed

50-year Water Surface Elevations Increases (ft)
50-year Results | Existing vs. Proposed

50-year Water Surface Elevations Decreases (ft)