HEC-RAS 2d Modeling
US 20 Bridge

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Phase 1 Study of US 20, Nesler Road to Shales Parkway

- 5.7 miles of roadway improvement design with target completion for Phase 1 Engineering in Fall 2018.

- Five bridge replacement/rehabilitation at estimated cost of $42.7 million.

- US 20 bridge over Fox River replacement at estimated cost of $26.8 million.
Phase 1 Study of US 20, Nesler Road to Shales Parkway

- Intersection and roadway improvements at estimated cost of $30.5 million.
- McLane Boulevard Interchange Omission.
- Not included in the Department’s FY 2018-2023 Proposed Highway Improvement Program.
IDOT Prepares Waterway Hydraulic Reports

- At mapped floodplains draining over one square mile, and
- More detailed evaluation required for projects involving:
  a. Replacement of Bridge, Culvert, or Bridge Superstructure
  b. New Bridge or Culvert
  c. Longitudinal Encroachment
Why are Hydraulic Reports Prepared?

- To document project impacts and compliance with IDOT drainage criteria (e.g., created head, free board, and clearance).
- Estimate the scour depth.
- To meet the IDNR permit requirements (e.g., Created head and Compensatory storage for fill in Floodway).
- To set the roadway profile and ROW footprint.
- To document hydrologic and hydraulic analyses.
District 1 has a Qualified Hydraulic Engineer, District 1 approves certain Hydraulic Reports:

- All Culverts not in a Public Body of Water
- Bridges in a designated floodway (Part 3708 Rules) not in a Public Body of Water

Bureau of Bridges & Structures (BB&S) approves other Hydraulic Reports:

- Bridges requiring an individual IDNR/OWR permit (Part 3700 Rules)
- All projects in a Public Body of Water (Part 3704 Rules)
2-D Modeling
Completed or Ongoing Projects

District 2: US52 over Elkhorn Creek

District 4: IL150\US24 over Illinois River

District 9  I-64 over Wabash River

District 8: I 270 over Mississippi River

District 1: US 20 over Fox River
FHWA Approach Toward 2-D Modeling

• FHWA promotes SMS SRH-2D.
• FHWA has been offering training to the states as part of “Advancing to the Next Generation of Engineering (CHANGE)”.
• IDOT is not requiring SRH-2D modeling at this time.
• IDNR-OWR does not accept SRH-2D for permitting at this time.
• HEC RAS/SRH-2D: Flow parameters

• HEC-18 (Hydraulics and Scour Analysis): Contraction, Abutment, and Pier Scour Depth

• HEC-20 (Stream Stability): Long Term Degradation Scour

• HEC-23 Scour Countermeasures
Scour Analysis Guidance (cont.)

- IDOT Memorandum 14.2, Revised Scour Policy, November 7, 2014
- Design/Check Flow: 10-y, 50-y, 100-y, and 200-y
- Design for the maximum scour depth
- District 1 Scour Analysis Guidance
Scour Summary

Existing or Proposed Structure (circle one)

Structure Number: 047-0029

Attach a brief narrative/summary of noting key findings such as the following:

Design Scour Event (such as 10-yr, 50-yr or 100-yr):

Attach Total Scour Plot

Superimpose scour check onto total scour plot

Scour check event (typically 200-yr event):

On plot identify elevation of bed before scour

Add any other relevant notes

- Does the use of open abutments allow total scour to be used for design to be reduced:
  Yes or No

  Note: * If Yes, then the total scour does not need to include abutment scour.

  If Yes, does the total scour plot reflect and note this adjustment: Yes or No N/A

Include a summary table of the computed scour depths

Note: Design Scour Event and Extreme Event II are discussed in the November 7, 2014 All Bridge Designers (ABD) memorandum 14.2

Identify critical scour depths below and in narrative: (Identify total scour and components such as contraction, pier...)

Summary: (100 yr design/200 yr check)

Contraction = 8.40' / 9.98'

Pier 3.84' / 4.03' => Condt + Pier = 12.21' / 14.01'

Abut 8.96' / 7.26' => Condt + 2 = 17.36' / 17.25'

Abut 21.22' / 23.27' => Condt + 2 = 29.62' / 25.75'

NCHER = 11.47' / 13.10'
Bridge Facts

• Constructed in 1959
• 5-Span Steel Beam Structure – 660’ length
• Major Rehab in 1986 – Recent Minor Rehab in 2011
• Deck is in Poor condition – All other elements are Fair or Good condition

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<tr>
<th>Year</th>
<th>Deck</th>
<th>Super</th>
<th>Sub</th>
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<tr>
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<td>5</td>
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<td>4</td>
<td>5</td>
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<td>2006</td>
<td>5</td>
<td>5</td>
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Bridge Replacement

• Community Advisory Group identified safety, mobility and pedestrian access across the Fox River as important issues

• Widening of existing bridge not possible due to limitations of existing spread footings

• Maintenance of Traffic a major factor in decision of design alternatives

• Improvements to meet current design standards for clearance over railroads
Existing Bridge

ELEVATION

Existing bridge to remain and be repaired, typ.

Existing steel beams to be repaired in designated locations, cleaned, and painted

PLAN

Existing deck to be replaced
Existing Bridge

CROSS SECTION

Looking East
(All Dimensions are Foots)
Proposed Bridge
Proposed Bridge
Alternatives
Alternatives
Alternatives
Alternatives
RAS 1d Modeling Limitations

• Can’t Represent all 3 Bridges in Model
• Velocity in 1d RAS is Perpendicular to Cross Section
• Can’t Evaluate Impact of Velocity on Adjacent Piers
RAS 2d Modeling

• Advantages
  • Ability to Model Interaction of Adjacent Piers on Velocity
  • Bend in River
  • Ability to Model Alternative Pier Locations

• Limitations
  • Can’t Model Bridge Losses
2d Model Setup – Data Sources

- Existing FEMA HEC-2 Model
- Bathymetry of River Bottom
- Field Survey
- Existing Kane County DEM
- FIS Flows – Constant Flow Hydrograph
- Existing US 20 Bridge Plans
- Proposed METRA Bridge Plans
2d Boundary

- Based on FIS Flood Plain Limits
- 1d Model Cross Section Locations
- Bathymetry Survey Limits
Terrain Creation

Kane County DEM

Survey TIN

Pier and Abutment Footprint
Existing Terrain
Breaklines

• Used to Align Cell Faces with Features
2d Model Layout
2d Sensitivity Analysis

• Created 12 Grids
  • 15 to 50 feet for Overall Grid
  • 5 to 15 along Breaklines

• 4 Time Steps
• Diffusion Wave and Saint Venant Equations
• 96 Total Runs
Sensitivity Analysis (cont’d)

• Tested N Value Variations
• Adjusted Theta
• Additional Grid Cells near Piers
Comparison of FIS, 1-d, and 2-d Results

<table>
<thead>
<tr>
<th></th>
<th>FIS HEC-2</th>
<th>RAS 1d</th>
<th>RAS 2d</th>
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<tbody>
<tr>
<td>Downstream of 2d</td>
<td>707.47</td>
<td>706.77</td>
<td>706.82</td>
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<td>US 20</td>
<td>708.54</td>
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<td>Upstream of 2d</td>
<td>708.64</td>
<td>708.36</td>
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Conditions Modeled

• No Bridges
• UP RR Bridge Only
• Existing UP RR and METRA Bridges
• Existing UP RR and US 20 Bridges
• Existing UP RR, METRA, and US 20
• UP RR, Proposed METRA, and Existing US 20 Bridges
• UP RR, Proposed METRA, and Proposed US 20
Velocity Plot Comparing Existing and Proposed METRA Bridge Impacts on US 20

Existing METRA and US 20 Bridges

Proposed METRA and Existing US 20 Bridges
Velocity Plot Comparing with Proposed US 20 Bridge

Proposed METRA and Existing US 20 Bridges

Proposed METRA and US 20 Bridges
Scour Analysis

- Scour Analysis using HEC-18
- 10-, 50-, 100-, and 200-yr Storms
- Existing US 20 and METRA Bridges
- Existing US 20 and Proposed METRA Bridges
- Proposed US 20 and METRA Bridges
Velocity, Depth, and Flow Angle from HDF-View and RAS Mapper
Scour Depth Comparison

• 1d vs 2d
• Existing Bridges
• Existing US 20 and Proposed METRA
• Proposed US 20 and METRA
Questions