No Rise; No Problem! – Risk Management on Colorado Highways

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No Rise, No Problem
Risk Management on Colorado Highways

Due Credit (and thank you!!)

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No Rise, No Problem
Risk Management on Colorado Highways

Discussion Agenda:

1. Start With Why?
2. Leveraging Technology
3. No Rise Certification Framework
4. Final Credits
5. Questions & Answers
Why does CDOT care about flooding?:

Criticality Map for System Resilience

Credits:
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Why does CDOT care about flooding?:

72% of total user risk

Interstate 70 Criticality Only

Aimee Flannery (AEM Corp.)
Lizzie Kemp (CDOT Reg. 1)
Heather Paddock, PE (CDOT Reg. 4)
Why does CDOT care about flooding?:

**2014 U.S. Flood Fatalities Activity of Victims**

- Driving: 66%
- Other: 7%
- Playing: 5%
- Walking: 7%
- Fishing: 3%
- Fell in: 12%

Source: National Oceanic & Atmospheric Administration
Start With Why?

But CDOT roads follow rivers *(uh oh)*…

Source: Colorado DOT, 2013
Start With Why?

... and those rivers have floodways...

Source: Colorado DOT, 2013
Start With Why?

...that Infrastructure Planning might forget.
Discussion Agenda:

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Source: Varrella 2014
Leveraging Technology

Google Earth KMZs on CDOT Sharepoint
Leveraging Technology

GIS Integration – free LiDAR & DEMs
Leveraging Technology

Web-Hosted GIS:

Mobile GIS:

ESRI ArcGIS Online (licensed)

ESRI Collector (licensed)
Leveraging Technology

2-D Hydraulic Modeling (*SMS* / *SRH-2D*)

**Existing**

**Proposed**

CDOT Region 4, SH 60 over the Little Thompson R.
Discussion Agenda:

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Photo: Varrella, 2016
No Rise Certification Framework

It Always Starts with a Permit

• No rise is always part of a floodplain development permit
• Locals/States issue FP permits
• Conditions of approval
  – Read ‘em
  – Follow ‘em
• Write a memo or report
No Rise Certification Framework

CDOT No Rise Standard Procedures

- **Level 1** = photos before/after
- **Level 2** = at-or-below grade
- **Level 3** = conveyance shadow
- **Level 4** = simple analysis
- **Level 5** = detailed analysis
- **Level 6** = FEMA LOMC

Source: Varrella, 2016
No Rise Certification Framework

Level 1 – Photographic Evidence

• Minor patching & paving only
• Before & after photos
• 1-2 days time
• **BEWARE!! -- for small areas only**
  – Survey data is better
  – Use for emergency work only

1. **Inspection with Photographic Evidence;** match existing adjacent hard points in the SFHA by photographic field evidence (and/or survey) on small-scale projects where the patch is no longer than the width of the paved roadway.
   a. Projects; existing edges for an asphalt or concrete patch
   b. Verification; photos & memo
   c. Time = 8-16 hrs
   d. Cost = $100-$1,000 in fees
Level 1 – Photographic Evidence

Small area paving patch;
-- Matches adjacent grades.
-- Ride comfort ensured, so not likely to obstruct flow.

Source: Varrella, Fort Collins, 2012
No Rise Certification Framework

Level 1 – Photographic Evidence

Small area paving patch;
-- Rise over adjacent grades.
-- Ride comfort compromised, so likely to obstruct flow.

Source: Varrella, Fort Collins, 2012
Level 2 – At-or-Below Grade

• Put it back where it was *(or lower)*
• Survey, drawings, memo, spreadsheet
• Especially for pavement overlays
• 2 days time

2. Maintain Existing Grade *(a.k.a. At- or Below-Grade)*; maintain roadway overtopping elevations in the SFHA to 0.00 ft or lower (no lower than 0.30 ft) to create an increase in cross section flow area and overtopping conveyance. Use survey evidence and ensure as-built info reflects pre-construction elevations.

   a. Projects; most mill & overlays, and pavement maintenance
   b. Verification; spreadsheet analysis, pre- and post-construction survey, drawings, memo
   c. Time = 12-16 hrs
   d. Cost = $100-$1,000 in fees + drawings
No Rise Certification Framework

Level 2 – At-or-Below Grade

Vicinity Map with Hazards

- Flood risks shown
- No BFEs 😞
- ¼-mile work zone
- No floodway…
- So permit same as a floodway

US 24 @ Unnamed Tributary (Simla, CO) – mill & overlay
Level 2 – At-or-Below Grade

US 24 @ Unnamed Tributary (*Simla, CO*) – mill & overlay

Source: Colorado DOT, 2017
No Rise Certification Framework

Level 2 – At-or-Below Grade

Survey Before & After Overlay

- Hold the grade
  - Or drop a little
- Survey before
- Survey after
- Compare & prove it

US 24 @ Unnamed Tributary (Simla, CO) – mill & overlay
No Rise Certification Framework

Level 3 – Conveyance Shadowing

• “Hide” behind existing flow blockage
• Survey, drawings, memo, maps
• For bridges, culverts, roadway expansion, overlays
• 2-3 days time

3. **Conveyance Shadowing**: find and utilize conveyance shadows and ineffective flow areas in existing hydraulic models using City of Fort Collins Stormwater Utility guidance dated 2011.
   a. Projects; new bridges/culverts, roadway expansion most mill & overlays, and pavement maintenance
   b. Verification; GIS analysis, pre- and post-con. survey, drawings, memo
   c. Time = 16-24 hrs
   d. Cost = $100-$1,000 in fees + drawings
No Rise Certification Framework

Level 3 – Conveyance Shadowing

FEMA 480 (2005) – NFIP Floodplain Management Requirements

- Contraction & expansion zones
- Area might be under water…
- …but water doesn’t flow downstream

No Rise Certification Framework

Level 3 – Conveyance Shadowing

Bridge & Roadway

- Existing bridge railing blocks conveyance
- Shadowed \textit{vertically}!!

Welch Street Bridge (\textit{Fort Collins, CO}) – overlay & repair

Looking northwest at the downstream face of Welch Street culvert, flow is from left to right. The 45° wingwalls and superstructure of the culvert can be clearly seen at center of the photo. The edges of the 30-ft wide structure are located at the top in the wingwalls.
No Rise Certification Framework

Level 3 – Conveyance Shadowing Certification

• Identify flood risks
• Survey ground
• Tuck improvements behind shadows

Welch Street Bridge (Fort Collins, CO) – overlay & repair
No Rise Certification Framework

Level 3 – Conveyance Shadowing

Final Certification
- Applied for FP Permit
- Report findings
- Certify no rise
- Permit approved!

Welch Street Bridge (Fort Collins, CO) – overlay & repair
No Rise Certification Framework

Level 4 – Simple Hydraulic Analysis

• Weir overtopping roadways
• Simple analysis, survey, drawings, memo/report
• Flexible weir overtopping profile
• 3-4 days time

4. Simple Hydraulic Analysis; maintain average cross section flow area or average weir profile elevations in the SFHA with simple analysis and survey data.
   a. Projects; new bridges/culverts, roadway expansion, some mill & overlays
   b. Verification; hydraulic analysis, pre- and post-con. survey, drawings, limited hydraulics report
   c. Time = 24-32 hrs
   d. Cost = $100-$1,000 in fees + drawings
No Rise Certification Framework

Level 4 – Simple Hydraulic Analysis

SH 14 @ Boxelder Creek (Fort Collins, CO) – mill & overlay

ESRI GIS Integration

- Flood risks
- Buildings
- Parcels
- BFEs
- Cross Sections
- Aerial imaging
No Rise Certification Framework

Level 4 – Simple Hydraulic Analysis

Ground Survey
- Pre-construction survey
- Post-construction survey
- Compare both surveys…

SH 14 @ Boxelder Creek (Fort Collins, CO) – mill & overlay
No Rise Certification Framework

Level 4 – Simple Hydraulic Analysis

HEC-RAS 1-D Model

- Calculate ΔBFE
- View in HEC-RAS
- Report out!!

Add As-Built Condition to Existing Models

Check the Resulting Impact(s)

SH 14 @ Boxelder Creek (Fort Collins, CO) – mill & overlay
No Rise Certification Framework

Level 4 – Simple Hydraulic Analysis

Report Out

SH 14 @ Boxelder Creek (Fort Collins, CO) – mill & overlay
Level 5 – Detailed Hydraulic Analysis

- For complex overtopping & parallel flow
- Analysis, survey, drawings, full report, & peer review
- New bridges, culverts, roadway expansion, overlays
- 5-10 days time
  - Budget for $5,000+ for consulting time/review

5. Detailed Hydraulic Analysis; create additional conveyance and prepare hydraulic analyses to satisfy no-rise criteria; for weir overtopping prove $L$ and $H$ of the broad-crested weir equation ($Q_{weir} = CLH^{1.5}$) balance out to pre-project conditions.
  a. Projects; new bridges/culverts, roadway expansion, some mill & overlays
  b. Verification; hydraulic analysis, pre- and post-con. survey, drawings, full hydraulics report
  c. Time = 1-2 weeks
No Rise Certification Framework

Level 5 – Detailed Hydraulic Analysis

SH 60 @ S. Platte River (Milliken, CO) – bridge replacement

Source: Colorado DOT, 2017
No Rise Certification Framework

Level 5 – Detailed Hydraulic Analysis

SH 60 @ S. Platte River (Milliken, CO) – bridge replacement

Source: Colorado DOT, 2013
No Rise Certification Framework

Level 5 – Detailed Hydraulic Analysis

SH 60 @ S. Platte River (Milliken, CO) – bridge replacement
No Rise Certification Framework

Level 5 – Detailed Hydraulic Analysis

SH 60 @ S. Platte River (*Milliken, CO*) – bridge replacement
No Rise Certification Framework

Level 5 – Detailed Hydraulic Analysis

2D Hydraulic Analysis

Software: Aquaveo, 2017
SMS 12.2
www.aquaveo.com

SH 60 @ S. Platte River (Milliken, CO) – bridge replacement

Existing 100-yr Depth (feet)

Proposed 100-yr Depth (feet)

Reconnect Floodplain
No Rise Certification Framework

Level 5 – Detailed Hydraulic Analysis

2D Hydraulic Analysis

Software: Aquaveo, 2017
SMS 12.2
www.aquaveo.com

Eliminate Pressure Flow

Existing BFE (ft-NAVD)

Proposed BFE (ft-NAVD)

SH 60 @ S. Platte River (Milliken, CO) – bridge replacement
No Rise Certification Framework

Level 6 – Submit FEMA Map Change (LOMC)

- LOMC = Letter of Map Change
  - CLOMR, LOMR, or PMR
- When a rise is absolutely unavoidable
- 12-18 months time & $10,000++ consulting fees

6. FEMA Map Revision (a.k.a. LOMC); in the event no-rise cannot be achieved, prepare a CLOMR to prove the proposed design will meet federal, state and local standards, then prepare a LOMR immediately after construction to revise flood hazard mapping.
   - a. Projects; new bridges/culverts, roadway expansion, some mill & overlays
   - b. Verification; full hydraulic analysis, pre- and post-con. survey, drawings, full report for review by local agency and FEMA, and MT-2 forms/report
   - c. Time = 12-18 months
   - d. Cost = $5,500-$10,000 in fees + $50,000-$150,000 consulting costs
No Rise Certification Framework

Level 6 – Submit FEMA Map Change (LOMC) CLOMR for Scour Countermeasure & Channel Realignment

US 287 @ Spring Creek (Fort Collins, CO) – scour repair
No Rise Certification Framework

Level 6 – Submit FEMA Map Change (LOMC)

HEC-RAS 1-D Sections & Alignment

US 287 @ Spring Creek (Fort Collins, CO) – scour repair
No Rise Certification Framework

Level 6 – Submit FEMA Map Change (LOMC)

HEC-RAS 1-D Model?

• New topo & survey
• Move existing cross sections
• New cross sections
• Updated bridge hydraulics info

US 287 @ Spring Creek (Fort Collins, CO) – scour repair
No Rise Certification Framework

Level 6 – Submit FEMA Map Change (LOMC)

SRH-2D
Results

Existing Velocity ($ft/sec$)

US 287 @ Spring Creek (Fort Collins, CO) – scour repair
No Rise Certification Framework

Level 6 – Submit FEMA Map Change (LOMC)

SRH-2D Results

Existing Depth (feet)

US 287 @ Spring Creek (Fort Collins, CO) – scour repair

Proposed Channel Realignment (Concept)
No Rise Certification Framework

Level 6 – Submit FEMA Map Change (LOMC)

US 287 @ Spring Creek (Fort Collins, CO) – scour repair

HEC-RAS 1-D Profile

vs.

SRH-2D Profile

- Existing conditions have a different BFE
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Photo: Varrella, 2014
Thank you colleagues!!

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Thank You!
Questions?

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