Technical Memo

Date:	Wednesday, December 02, 2020
Project:	US14A / US85 Deadwood Box Corridor Study (#NH014A(28)40, PCN 06Y6)
To:	SDDOT
From:	Todd Yerdon, PE
Subject:	Deadwood Box H&H Analysis

1.0 Introduction

The South Dakota Department of Transportation (SDDOT), in conjunction with the City of Deadwood (the City) and Federal highway Administration (FHWA), is completing a corridor and environmental study for a portion of US Highway 14 Alternate (US14A)/US Highway 85 (US85)/Pioneer Way in the City. Included in this study is the structure over Whitewood Creek, which is a 2,039 foot long structure and referred to as the "Deadwood Box." This structure channels both Whitewood Creek and a portion of Deadwood Creek below US14A/US85/Pioneer Way and is reaching the end of its serviceable life. The H&H analysis will identify floodplain impacts as a result of various options presented in the corridor study.

2.0 Existing FEMA Analysis

Whitewood Creek through the City of Deadwood is part of a FEMA Flood Insurance Study (FIS) dated April 17, 2012 for Lawrence County, South Dakota and incorporated areas. As part of the FIS, detailed floodplain analysis has been completed for Whitewood Creek, and detailed base flood elevations (BFE) for Whitewood Creek have been documented in the FIS.

HDR requested the effective Whitewood Creek hydraulic model from FEMA. FEMA provided two separate hydraulic models. The first model was a PDF printout of the original HEC-2 model developed in 1977 which is the effective model for cross sections E through J. The second model was an updated HEC-RAS model developed in 2007 which is the effective model for cross sections A through C and K through O as shown in the FIS. While the 2007 HEC-RAS model does not represent the results for cross sections E through J in the FIS, the HEC-RAS model still incorporates those cross sections from the effective HEC-2 model into the HEC-RAS analysis creating a complete HEC-RAS model of Whitewood Creek through Deadwood.

Existing Condition Deadwood Box Hydraulic Analysis

The effective 2007 HEC-RAS model was utilized as the base model for this analysis since the model already incorporates the HEC-2 data for cross sections E through J making it the best available data for the area.

For the existing conditions analysis, HDR updated the vertical datum of the model from NGVD29 to NAVD88 according to the conversion factor (+1.95 feet) listed in the FIS for Whitewood Creek. All cross sections between cross section F and G were updated based on current ground survey of the channel and available LiDAR of the overbank areas. The existing Deadwood Box Structure was updated to be 36 feet wide based on survey measurements on the upstream end of the box culvert and the inverts of the box culvert were updated based on the survey. The height of the box was determined to be 13.3 feet tall based on survey and existing plans of the box culvert. HEC-RAS does not allow for a change in box culvert width midway in the culvert; therefore the upstream box culvert width of 36' was used for the entire box in the analysis with the understanding that the box expands out to 45' wide midway in the culvert. Based on these conditions, the culvert is inlet controlled for the 1% chance flood event.

Proposed Condition Deadwood Box Hydraulic Analysis

Multiple box options were evaluated for the proposed condition analysis. During the analysis it was determined the existing box culvert is inlet controlled, and inlet condition adjustments will impact upstream water surface elevations. That means a proposed box culvert opening would need to be 36' wide and 13.3 feet tall. The analysis determined that adding a center wall in the box for constructability reasons while maintaining a clear opening width of 36' did not impact upstream results in the model.

For any option, increases in water surface elevations must be avoided upstream of the Deadwood Box because existing buildings are in the floodplain and floodway; therefore, any rise must be mitigated, and will be extremely expensive.

OPTIONS 1, 2, AND 3

Proposed concept Options 1, 2, and 3 are all variations of replacing the existing box culvert with a proposed box culvert in the same general location. If the proposed inlet condition matches the existing culvert, then a no-rise condition will likely be met based on the preliminary HEC-RAS analysis.

Any increases to the inlet hydraulic capacity will provide reductions at the immediate upstream end of the box culvert, but creates a slight rise up to 1,800' upstream. Additional cross sections were added to the model to determine if the slight rise was due to instability in the model, and the addition of cross sections did not resolve the slight rise in water surface elevation.

Options 1, 2, and 3 contain the 1% storm in the proposed box structure causing minimal changes to the floodplain mapping depending on outlet location. It should be noted that the floodplain and floodway mapping in this location is not very accurate with respect to the existing culvert; therefore, the floodplain administrator could require a CLOMR and remapping to clean up the mapping at the culvert ends. Any remapping could be difficult

since FEMA has strict tie in requirements for remapping which poses a challenge when trying to tie into an existing map.

OPTION 4

Proposed concept Option 4 evaluated removing the box culvert from Pine Street through Lee Street and replace the Pine Street, Lee Street and Deadwood Street crossings with bridges. The channel area between each street would be opened up as an open concrete rectangular channel with a 45' wide bottom. A new box structure would be installed downstream of Lee Street and outlet at the existing box outlet location.

When evaluating various options it was determined that any improvements reduces water surface elevation at the structure and causes a slight rise upstream from the project. After numerous model iterations, no bridge options were identified that result in a no-rise due to model sensitivity. This does not mean a bridge option is not possible, but extensive modeling will need to be done to determine the bridge opening that could work.

Option 4 would require a CLOMR since part of the existing box alignment would be converted to an open channel. Any remapping could be difficult since FEMA has strict tie in requirements for remapping.

OPTION 5

Option 5 proposes installing a box culvert from Lee Street through Deadwood Street, and creating an open channel downstream from Deadwood Street with proposed bridge crossings at Lee Street and Wall Street. Similar to Options 1, 2, and 3, an upstream no-rise condition is met with a box size that is 36' wide clear opening and 13.3' tall with a middle wall in the box. The downstream channel was evaluated as a 36' wide concrete rectangular channel.

Option 5 would require a CLOMR since part of the existing box alignment would be converted to an open channel. Any remapping could be difficult since FEMA has strict tie in requirements for remapping.

3.0 Conclusion

Options 1, 2, and 3 provide an option that causes a no-rise condition upstream of the box culvert assuming the entrance condition is similar to the existing box culvert. Depending on the culvert outlet location, remapping of the project may be avoided with these options, but the floodplain administrator could require a CLOMR and remapping to clean up the existing floodplain mapping at the culvert ends. Any remapping could be difficult since FEMA has strict tie in requirements for remapping which poses a challenge when trying to tie into an existing map.

Options 4 and 5 will require a CLOMR no matter if a no-rise condition is met since part of the existing box culvert would be converted to an open channel. Option 4 appears to be the most

difficult option as far as obtaining a no-rise condition due to the sensitivity of the HEC-RAS model to changes. For this analysis no bridge option was determined that creates a no-rise condition upstream. Improvements in hydraulic conditions which reduce water surface elevations at the structure create a rise upstream.

It should be noted that the modeling for each option is conceptual and additional analysis should be performed during the design phase of the project. The HEC-RAS model is sensitive to minor changes; therefore, the final structure selected should be evaluated based on final design elevations and widths to ensure a no-rise condition can be met. Any rise upstream in the channel will likely impact existing buildings which would require costly mitigation. The design team will need to work directly with the floodplain administrator during the design process to facilitate the floodplain permitting effort.