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**Hydrologic and Hydraulic Evaluation**

**BRIDGE K140.0**

**near Richland**

**Rankin County, MS**

**Gulf Division**

**Beaumont Subdivision**

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# INTRODUCTION

## **Purpose** of Study

This study was initiated via a Request For Proposal (RFP) received from Canadian National (CN) Railroad on . plans to replace the existing bridge at milepost (Figure 1) on the , . The purpose of this study is to evaluate the hydraulic characteristics of the existing bridge structure and to provide guidance for the proposed replacement structure as specified by CN Railroad.

## FEMA Considerations

The study is limited to Bridge located on an unnamed drainage approximately «location\_distance» NULL Directionalof the NULL Roadin «location\_city», , . The FEMA flood map for the area indicates the subject bridge is located in a , «fema\_description». The subject bridge is protected from flooding from the Mississippi River by a «protection\_type» located approximately «protection\_distance» north of the bridge.

## Project Coordination

A draft hydraulic analysis report for the subject bridge was submitted to CN for review on . On , an email was received from Bridge Engineer, , , inquiring as to whether pipe or box culvert alternatives were considered during the initial hydraulic analysis. After discussion with , notice to proceed with analysis of pipe and box culvert alternatives was received on . Additional alternatives were analyzed, and the results are reported herein.

# STUDY AREA

## Existing Conditions

Bridge 140.0 is located on «railroad\_line» (low-line) of the Beaumont Subdivision, approximately «location\_distance» west of near Richland near the west end of «location\_yard\_name». The structure is a Bridge approximately 62.00 in length and approximately «structure\_height» in height. The base of rail elevation ranges from approximately «elevation\_rail\_west» on the west end of the bridge to «elevation\_rail\_east» on the east end of the bridge. The existing low chord elevation is approximately 7.54. The approximate low ground elevation near the upstream side of the bridge is estimated at «elevation\_low\_ground». The bridge is founded on «foundation\_type» with diameters ranging from «foundation\_diameter\_min» to «foundation\_diameter\_max» inches.

The bridge is located on «drainage\_name» that flows in a generally westward direction. The terrain immediately upstream of the bridge between the subject bridge and Bridge «upstream\_bridge\_id» is a low-lying area between the railroad and the Mississippi River levee, with large sections of open water. This area serves as a storage area, and significant ponding occurs between the subject bridge and Bridge «upstream\_bridge\_id». Drainage through the bridge flows westward then southward to a drainage structure in the Mississippi River levee approximately «drainage\_distance» from the subject bridge.

The bridge is located approximately «distance\_from\_other\_bridge» west of CN Bridge «other\_bridge\_id», also located on «other\_railroad\_line» (low-line) of the «other\_railroad\_subdivision». Hydraulically, Bridge «upstream\_bridge\_id» is located upstream of the subject bridge. Bridge «upstream\_bridge\_id» is a «upstream\_structure\_type» bridge approximately «upstream\_structure\_length» in length. Bridge «upstream\_bridge\_id» is also included in the CN bridge replacement projects for 2020, and the hydraulic investigation for the bridge will be reported separately.

Although the subject bridge is located in the floodplain of the Mississippi River, it is protected from backwater flooding by the «protection\_type» and the flood control drainage structure. Additional site information and photographs are presented in Appendix «appendix\_letter».

Figure 1. Placeholder

Figure 2. Placeholder

Figure 3. Placeholder

Figure 4. Placeholder

Figure 5. Placeholder

## **Drainage Area Description**

The contributing basin area at the subject bridge is approximately «basin\_area\_square\_miles», lying south and north of the railroad (Figure 2-4). The headwater of the basin is located near «headwater\_location» approximately «headwater\_distance» upstream of the subject bridge. Approximately «basin\_area\_percentage\_1» of the drainage basin is comprised of the basin area for Bridge «upstream\_bridge\_id», with the remaining drainage basin comprised of the low-lying, open water area between Bridge «upstream\_bridge\_id» and the subject bridge. The land use characterization is primarily «land\_use», with «residential\_development\_level» residential development in the upper «land\_use\_upper\_fraction» of the basin, with «land\_use\_lower\_description» in the lower «land\_use\_lower\_fraction» of the basin. The basin topography in the upper half of the basin is «topography\_upper» and sloping generally in a northernly direction, with the lower half of the basin characterized by «topography\_lower» mildly sloping to the west. The total elevation relief is approximately «elevation\_relief». The watershed parameters used in this study were determined using the «watershed\_tool\_1» and verified using «watershed\_tool\_2» tools. The basin parameters for the Bridge «project\_milepost» are shown in Table «table\_number».

Figure . Placeholder

# EVALUATION METHODS

## Hydrologic Analysis

Peak discharges for the subject bridge study area were determined using the «hydrology\_tool\_1» and regression equations developed for «hydrology\_area» in «hydrology\_state» («hydrology\_source\_1»), in accordance with guidance in the «hydrology\_manual» («hydrology\_source\_2»). Additionally, the basin was modeled with the «hydrology\_tool\_2» to investigate the effects of the reach storage upstream of the subject bridge on attenuation of peak discharges. The «rainfall\_method» was used for rainfall runoff transformation, using point frequency rainfall depths obtained from «rainfall\_data\_source» on the «rainfall\_website». Weighted SCS curve numbers ranging from «curve\_number\_min» to «curve\_number\_max» were estimated for the contributing sub-basins based on hydrologic soils maps, land use cover and aerial imagery. Basin lag times were computed with the «lag\_equation\_source» using basin slope, flow length and weighted curve number. Routings in the storage reach were computed using the «routing\_method» with discharge-storage relationship determined using the steady state «routing\_model» for a range of discharges.

Peak discharges for the «flood\_event\_1», «flood\_event\_2» and «flood\_event\_3» flood events are shown in Table «table\_number» for the «hydrology\_tool\_1» regression equations and the «hydrology\_tool\_2» model. Comparison of the computed values indicates the «hydrology\_tool\_1» regression discharges are approximately «discharge\_ratio» greater than the peak discharges from the «hydrology\_tool\_2» model. However, assessment of the study area suggests the large, low-lying area upstream of the subject bridge will attenuate flood peaks due to storage effects. Therefore, peak discharges determined from the «hydrology\_tool\_2» model were used in the hydraulic analysis. Additional hydrologic data are presented in Appendix «appendix\_letter».

Table . Placeholder

## Hydraulic Analysis

The hydraulic models for evaluation of the subject bridge and alternative replacement structures were developed with the «hydraulic\_modeling\_tool» Version «tool\_version» («tool\_source»). The extent of the hydraulic model ranges from approximately «model\_range\_upstream» upstream (south) of Bridge «upstream\_bridge\_id» to approximately «model\_range\_downstream» downstream of the subject bridge. The geospatially located model elements were created using the «geospatial\_tool» extension in «geospatial\_software».

Model cross section geometry was developed using topographic survey data obtained within the vicinity of the subject bridge and «elevation\_model\_detail» from the «elevation\_model\_source» downloaded from the «elevation\_model\_website». The DEM was developed from «data\_source\_type» data collected for «data\_source\_location» in «data\_collection\_year». The survey data were used to define the channel portion of the cross section, and the DEM was used to define the overbank portion of the cross section. Manning’s “n” roughness parameters for the model were determined using best engineering judgement based on field observations and existing aerial photography. The Manning’s “n” parameters range from «manning\_n\_min» for the channel to «manning\_n\_max» for the overbank areas.

Water surface profiles were computed for the «flood\_event\_1», «flood\_event\_2» and «flood\_event\_3» events for existing conditions for normal depth conditions. For the normal depth computations, the downstream boundary for the model was determined using the «boundary\_condition\_type» and a slope of «slope\_value».

The existing conditions model described above was used as the basis for developing hydraulic models to evaluate bridge replacement alternatives. A number of bridge alternatives were evaluated, with conceptual span lengths oriented such that the new bent locations do not conflict with existing pile locations. «number\_of\_alternatives» alternative replacement bridges are presented in this report. Alternative #1 is modeled as a «alt1\_structure\_type» with a span length of «alt1\_span\_length», for a total bridge length of «alt1\_total\_length». The depth of the concrete girder is approximately «alt1\_girder\_depth», and the estimated minimum low chord elevation of the bridge is «alt1\_low\_chord\_elevation». The total bridge length for this alternative is approximately «alt1\_length\_comparison» less than the existing bridge, and the bridge ends of the alternative are located inside of the existing bridge end walls. Alternative #2 is modeled as a «alt2\_structure\_type» with a span length of «alt2\_span\_length», for a total bridge length of «alt2\_total\_length». The depth of the concrete girder is approximately «alt2\_girder\_depth», and the estimated minimum low chord elevation of the bridge is «alt2\_low\_chord\_elevation». The total bridge length for this alternative is approximately the «alt2\_length\_comparison» as the existing bridge, with one bridge end located inside of the existing bridge end wall and the other bridge end located outside of the existing end wall. Both alternatives are modeled assuming a foundation of «foundation\_type» with «foundation\_cap\_type». Bridge ends are modeled as «abutment\_type» with a slope of «abutment\_slope» for both alternatives.

After discussion with CN subsequent to the draft report, additional alternatives for pipe and box culvert options were investigated. Due to the relatively low height of the bridge and limited clearance between the existing bridge low chord and natural ground, culverts diameters and/or heights greater than «culvert\_height\_limit» were not considered deployable. Alternative #3 is modeled as «alt3\_number\_of\_culverts» «alt3\_culvert\_diameter» corrugated metal pipe culverts (CMP). The upstream and downstream invert elevations are «alt3\_invert\_upstream» and «alt3\_invert\_downstream», respectively, and the culvert is embedded «alt3\_embed\_depth» below the average existing ground elevation. The length of the culvert is approximately «alt3\_culvert\_length», based on the existing bridge height and assumed side slope of «alt3\_side\_slope». Alternative #4 is modeled as «alt4\_number\_of\_culverts» «alt4\_culvert\_size» reinforced concrete box culverts (RCBC). The upstream and downstream invert elevations are «alt4\_invert\_upstream» and «alt4\_invert\_downstream», respectively, and the culvert is embedded «alt4\_embed\_depth» below the average existing ground elevation. The length of the culvert is approximately «alt4\_culvert\_length», based on the existing bridge height and assumed side slope of «alt4\_side\_slope». Alternative #5 is comprised of «alt5\_number\_of\_culverts» «alt5\_culvert\_size» RCBC and provides a hydraulically similar option to Alternative #4, since the total culvert opening width and culvert height is the same for both alternatives. The upstream and downstream invert elevations are «alt5\_invert\_upstream» and «alt5\_invert\_downstream», respectively, and the culvert is embedded «alt5\_embed\_depth» below the average existing ground elevation. The length of the culvert is approximately «alt5\_culvert\_length», based on the existing bridge height and assumed side slope of «alt5\_side\_slope». The results of the hydraulic analysis for existing condition and the two alternatives are presented in Table «table\_number» for normal depth conditions. Additional results of the hydraulic analysis can be found in Appendix «appendix\_letter».

Table 2. Placeholder

## Soil and Water Chemistry Analysis

A soil and water chemistry analysis were conducted for samples collected at the subject bridge during the site survey. The location of the samples is shown in Figure «figure\_number». The analysis report is provided in Appendix «appendix\_letter».

Figure 7. Placeholder

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## Vertical Datum

All existing topographic elevations are referenced to «geodetic\_datum» determined by referencing «reference\_system».

Three («number\_of\_benchmarks») temporary benchmarks were established on-site using rebar capped in yellow and stamped MER. TBM1 is located at «tbm1\_station», «tbm1\_offset» left at elevation «tbm1\_elevation». TBM2 is located at Sta. «tbm2\_station», «tbm2\_offset» left at elevation «tbm2\_elevation». TBM3 is located at Sta. «tbm3\_station», «tbm3\_offset» left at elevation «tbm3\_elevation».

## Permitting

The following permits may be required for replacement of the subject bridge:

Floodplain Development Permits: The subject bridge is located within the limits of 28121C0306F, designated by «fema\_agency» as «fema\_designation». However, flood plain development permits based on state and local ordinances may still be required.

U.S. Army Corps of Engineers Section 404 Wetland Permits:

* COE Nationwide (NW) Permit «co\_permit\_1\_number» “«co\_permit\_1\_name»” - is specifically designed for linear transportation crossings associated with highways, railways, airport runways and taxiways. It is utilized to cover wetland impacts up to «co\_permit\_1\_impact\_limit» in size for each identified crossing along the linear alignment.
* COE Individual Permit (IP) Permit process or standard permit - is used to cover projects with impacts exceeding «co\_permit\_2\_impact\_limit\_1» per crossing or «co\_permit\_2\_impact\_limit\_2» of an identified intermittent or perennial stream reach.

Department of Environmental Quality Permits:

* A Stormwater Pollution Prevention Plan (SWPPP) and Small Construction Notice of Intent (SCNOI) will also be required for the proposed improvements if the disturbed erodible area is greater than «scnoi\_disturbed\_area\_min» but less than «scnoi\_disturbed\_area\_max». This permit does not have to be submitted to the state regulatory agency unless it is specifically requested by the agency.
* A SWPPP and Large Construction Notice of Intent (LCNOI) will need to be completed, submitted, and approved by the State regulatory agency prior to commencement of construction operations for projects disturbing «lcnoi\_disturbed\_area» or more.

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# CONCLUSION

The computed water surface profiles for normal depth indicate the railroad embankment at the subject bridge is not overtopped for existing conditions during the «flood\_event\_1», «flood\_event\_2» or «flood\_event\_3» flood event, based on a base of rail elevation of «base\_of\_rail\_elevation». Based on a minimum existing low chord elevation of «existing\_low\_chord\_elevation», the bridge for existing conditions operates in normal, non-pressure mode for the «flood\_event\_1» and «flood\_event\_2» flood events, and in pressure mode for the «flood\_event\_3» event.

Various guidelines have been used when evaluating possible alternative hydraulic replacement structures for the subject location. The guidelines have been obtained from the «guideline\_source\_1» manual; the «guideline\_source\_2». “«guideline\_source\_2\_specifications»”; «guideline\_source\_3»; and engineering judgment. The alternatives were evaluated against the criteria based on results from the normal depth conditions, and were checked for the backwater conditions.

The following guidelines were used for evaluation of the alternative with normal depth conditions:

1. Although the subject location is not located within a «fema\_zone» special flood hazard zone, the allowable increase in headwater elevation was limited to «headwater\_increase\_limit\_1» for the «headwater\_increase\_event» when compared to existing conditions;
2. Bridge structures a. design flood is the «bridge\_design\_flood\_event»; b. one («bridge\_freeboard\_feet») foot of freeboard below the low chord is desirable during the «bridge\_freeboard\_event»;
3. Culvert structures a. «culvert\_design\_flood\_1» without static head at entrance (HW/D<=1); b. «culvert\_design\_flood\_2» with available head at entrance, head at «culvert\_head\_limit\_1» below the base of rail, or head at depth of «culvert\_head\_limit\_2» times culvert diameter/rise (HW/D<=1.5), whichever is less;

Alternative #1: DVB Bridge, «alt1\_span\_details», total length of «alt1\_total\_length»:

* Guideline #1 is achieved. The «alt1\_guideline1\_event» headwater elevation of «alt1\_guideline1\_elevation» is «alt1\_guideline1\_difference» higher than the existing conditions headwater elevation of «existing\_headwater\_elevation» for normal depth conditions;
* Guideline #2a is achieved. The «alt1\_guideline2a\_event» water surface elevation of «alt1\_guideline2a\_wse» is «alt1\_guideline2a\_difference» lower than the minimum base of rail elevation «base\_of\_rail\_elevation»; however, the minimum low chord elevation of «alt1\_low\_chord\_elevation» is exceeded by «alt1\_guideline2a\_exceeded\_by» for normal depth conditions;
* Guideline #2b is not achieved. The «alt1\_guideline2b\_event» water surface elevation of «alt1\_guideline2b\_wse» is «alt1\_guideline2b\_difference» higher than the minimum low chord elevation of «alt1\_low\_chord\_elevation» for normal depth conditions;

Alternative #2: DVB Bridge, «alt2\_span\_details», total length of «alt2\_total\_length»:

* Guideline #1 is achieved. The «alt2\_guideline1\_event» headwater elevation of «alt2\_guideline1\_elevation» is «alt2\_guideline1\_difference» higher than the existing conditions headwater elevation of «existing\_headwater\_elevation» for normal depth conditions;
* Guideline #2a is achieved. The «alt2\_guideline2a\_event» water surface elevation of «alt2\_guideline2a\_wse» is «alt2\_guideline2a\_difference» lower than the minimum base of rail elevation «base\_of\_rail\_elevation»; however, the minimum low chord elevation of «alt2\_low\_chord\_elevation» is exceeded by «alt2\_guideline2a\_exceeded\_by» for normal depth conditions;
* Guideline #2b is not achieved. The «alt2\_guideline2b\_event» water surface elevation of «alt2\_guideline2b\_wse» is «alt2\_guideline2b\_difference» higher than the minimum low chord elevation of «alt2\_low\_chord\_elevation» for normal depth conditions;

Alternative #3: Six (6) 48-inch diameter CMP, overall length=«alt3\_overall\_length»:

* Guideline #1 is achieved. The «alt3\_guideline1\_event» headwater elevation of «alt3\_guideline1\_elevation» is «alt3\_guideline1\_difference» higher than the existing conditions headwater elevation of «existing\_headwater\_elevation» for normal depth conditions;
* Guideline #3a is achieved. The HW/D for the «alt3\_guideline3a\_event» is «alt3\_guideline3a\_hwd» for normal depth conditions;
* Guideline #3b is achieved. The HW/D for the «alt3\_guideline3b\_event» is «alt3\_guideline3b\_hwd» for normal depth conditions;

Alternative #4: Three (3) 8’W by 4’H RCBC, overall length=«alt4\_overall\_length»:

* Guideline #1 is achieved. The «alt4\_guideline1\_event» headwater elevation of «alt4\_guideline1\_elevation» is «alt4\_guideline1\_difference» higher than the existing conditions headwater elevation of «existing\_headwater\_elevation» for normal depth conditions;
* Guideline #3a is achieved. The HW/D for the «alt4\_guideline3a\_event» is «alt4\_guideline3a\_hwd» for normal depth conditions;
* Guideline #3b is achieved. The HW/D for the «alt4\_guideline3b\_event» is «alt4\_guideline3b\_hwd» for normal depth conditions;

Alternative #5: Four (4) 6’W by 4’H RCBC, overall length=«alt5\_overall\_length»:

* Guideline #1 is achieved. The «alt5\_guideline1\_event» headwater elevation of «alt5\_guideline1\_elevation» is «alt5\_guideline1\_difference» higher than the existing conditions headwater elevation of «existing\_headwater\_elevation» for normal depth conditions;
* Guideline #3a is achieved. The HW/D for the «alt5\_guideline3a\_event» is «alt5\_guideline3a\_hwd» for normal depth conditions;
* Guideline #3b is achieved. The HW/D for the «alt5\_guideline3b\_event» is «alt5\_guideline3b\_hwd» for normal depth conditions;

The alternatives configurations with the DVB precast concrete girders result in low chord elevations that are approximately «dvh\_low\_chord\_difference» lower than existing conditions. As a result, both alternatives operate in pressure mode for the «dvb\_pressure\_mode\_events» flood events. However, increases in water surface elevation are well within the guidelines.

Alternatives «alt1\_and\_alt2» have span configurations that should be conducive for construction. Both bridge ends for Alternative «alt1\_number» are located inside the end walls of the existing bridge. Since its length is similar to the existing bridge, Alternative «alt2\_number» has one bridge end located inside one existing end wall and one bridge end located outside the other existing end wall. The span configurations for both alternatives should provide acceptable clearances from existing bridge foundations. However, some adjustment of span lengths and locations may be required during detailed design to provide adequate clearances.

The culverts of Alternatives «alt3\_alt4\_alt5» will easily fit under the low chord of the existing bridge, although Alternatives «alt4\_alt5» require a greater embedment depth to accomplish this. The configuration of the CMP of Alternative «alt1\_number» should accommodate 2 culverts per existing bridge span. However, the elevation of the top of CMP is estimated at «cmp\_top\_elevation», and the minimum cover requirement of «minimum\_cover\_requirement» based on «cn\_requirement\_id» is not met, assuming a base of rail elevation of «base\_of\_rail\_elevation». The culverts of Alternative «alt3\_number» are embedded below the existing ground elevation by «alt3\_embed\_depth», whereas the culverts of Alternatives «alt4\_alt5» are embedded by «alt4\_alt5\_embed\_depth».

In general, velocities for Alternatives «alt1\_and\_alt2» are relatively low and fairly similar to existing conditions. The increase in velocity compared to existing conditions for the «velocity\_increase\_event» with normal depth conditions is «alt1\_velocity\_increase» for Alternative 1 and «alt2\_velocity\_increase» for Alternative 2. The culvert outlet velocities for Alternatives «alt3\_alt4\_alt5» for the «culvert\_velocity\_event» range from «culvert\_velocity\_range\_min» to «culvert\_velocity\_range\_max», and are as much as «culvert\_velocity\_difference» greater than existing conditions. The velocities are not considered excessive, but riprap aprons downstream of the culvert outlets are suggested to be considered.

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1. FLOOD INSURANCE STUDY REPORT AND PROFILES
2. USGS STREAMSTATS REPORT
3. HEC-RAS HYDRAULIC MODEL OUTPUT
4. SOIL/WATER CHEMISTRY AND NRCS SOILS REPORTS