APPENDIX D

Hydraulics Analysis

Fort Street at Rouge River
CS82071 JN540490
Revised 8/12/04

Summary of Preliminary Hydraulic Analysis:
The Fort Street crossing of the Rouge River is undergoing preliminary design for a planned reconstruction. Two alternatives for the crossing are being analyzed. Alternative A keeps Fort Street on its existing alignment and increases the span while Alternative B shifts the bridge downstream 122 feet (at the stream centerline), placing the bridge on a 13-degree skew across the river, and increases the bridge span. Alternative B also retains the operator tower and some embankment fill from the existing structure on the left bank (looking downstream) of the river.

The project is in the earliest stages of design and obtaining precise information on each Alternative's design was not possible. The only piece of information that could be verified was the structure span would increase from 135 feet to at least 200 feet. Detailed vertical information is not available at the time of preliminary analysis however it is estimated that the low chord of the bridge will be at least 584.24 feet for Alternative A and 588.6 feet for Alternative B (NAVD-88 datum) at the stream centerline. This represents a .5 foot to 4.9 foot increase over the existing low chord at this location. No additional lanes are planned and the bridge length (measured parallel to the stream) is the same as existing for each alternative.

Existing Condition:
The existing model contains two stream crossings. The downstream crossing is a railroad crossing and the upstream crossing is the Fort Street lift bridge. No changes will be made to the railroad crossing and the Fort Street bridge will be reconstructed.

Cross sections were taken at regular intervals upstream and downstream of the Fort Street bridge. Water surface elevations were also recorded during the stream survey to obtain a stream slope and to serve as a calibration for the existing model. The data was input into HEC-RAS and the stream slope was adjusted so the model would produce water surface elevations near the surveyed water surface elevations.

The existing bridge is a bascule bridge with an arched truss underclearance. To keep the model as simple and conservative as possible, the bridge was modeled assuming that the road support structure was solid from the road surface down to the proposed low steel elevations. Since there is such limited information available on the proposed structure, the existing underclearance was simplified in the model by using only 3 points to describe the arch. This conservative approach produced a triangular underclearance. The bridge was modeled with a length (measured parallel to the stream) of 90 feet, a hydraulic span of 118 feet, and a maximum low chord of 583.74 feet. The hydraulic span was set at 118 feet to reflect the minimum width between the shipping fenders. This represents a conservative width because water will be allowed between the fenders and the abutments so the actual flow width will most likely be greater than 118 feet.

The model shows no overtopping of the Fort Street bridge for flows up to and including the 1% chance flow. The energy grade line elevation immediately upstream of the Fort Street bridge was 584.14 feet at the 1% chance flow.

Alternative A

This alternative includes an arched bascule bridge on the same alignment as the existing condition. The abutments are set farther apart in the proposed condition. To model this alternative, the existing stream information was carried forward but the structure information was changed. The entire low chord of the structure was raised 6 inches to reflect the minimum increase suggested by the consultant. Raising the low chord will most likely result in a corresponding increase in road grade elevations. However, the road grade was left at the existing conditions elevations to model a "worse case" scenario for the development of weir flow.

The structure hydraulic span was increased to 135 feet while the structure length and alignment remained unchanged from existing. The hydraulic span was set at 135 feet to reflect the minimum width between the fender system. This represents a conservative width because water will be allowed between the fenders and the abutments so the actual flow width will most likely be greater than 135 feet.

As in the existing model, Alternative A shows no overtopping of the Fort Street bridge for flows up to and including the 1% chance flow. This shows that a road grade lift should not affect flood flows. The energy grade line elevation immediately upstream of the proposed structure is 584.08 feet for the 1% chance flow. This is a reduction of 0.06 feet from the existing conditions energy grade line. This alternative meets the intent of the state's floodplain statute by not causing a harmful interference.

Alternative B:

This alternative includes a movable arched center span along with two shorter tail spans between the existing ground and the piers housing the machinery to raise the center bridge. The center span is 200 feet. Because the bridge piers are skewed to the stream and a fender system is required to protect the bridge from shipping traffic, the hydraulic center span was set at 135 feet to reflect the minimum width between the fender system. This represents a conservative width because water will be allowed between the fenders and the piers so the actual flow area will most likely be greater than 135 feet

To model this alternative, the existing stream information was carried forward but the structure information and location were changed. The structure was placed on a new alignment with the proposed structure's centerline 122 feet downstream of the existing structure's centerline (measured along the stream centerline) and skewed 13 degrees to the existing alignment. This results in approximately a 17-degree pier skew to channel flows. Only the operator tower and associated embankment fill remain from the current structure. All approach fill on the right overbank (looking downstream) from the existing structure was removed down to natural ground elevations in this analysis.

The arch center span was simplified to 3 points because of limited bridge deck information. The entire low chord of the structure was raised to reflect the minimum increase suggested by the

consultant. The low chord was set at 588.6 feet at the stream centerline and 581.45 feet at the edge of the piers to reflect the latest potential design and geometry constraints. This represents an increase of 4.9 feet over the existing low chord at the stream centerline.

Raising the low chord will most likely result in a corresponding increase in road grade elevations. However, the existing analysis shows no weir flow at the current road elevations so increases in road grade will not interfere with flood flows. The road grade was assumed to be 593.0 feet in the analysis of Alternative B. The hydraulic structure span was increased to 135 feet while the structure length remained unchanged from existing.

As in the existing model, Alternative B shows no overtopping of the Fort Street bridge for flows up to and including the 1% chance flow. This shows that a road grade lift should not affect flood flows.

Since the structure is on a different alignment, a common cross section must be found in each model to compare the energy grade line elevations. Cross section 40 is a common cross section. Cross section 40 lies 2 feet downstream from the structure outlet in the existing model. In the proposed model, cross section 40 is 34 feet upstream from the structure entrance (at the stream centerline). The existing energy grade line elevation is 584.05 feet and the energy grade line elevation for Alternative B is 584.02 feet at the 1% chance flow. This is a decrease of 0.03 feet from the existing conditions energy grade line.

The next common upstream cross section is cross section 60. The existing energy grade line is 584.14 feet and the proposed energy grade line is 584.02 feet. This is a reduction of 0.12 feet from the existing condition. From cross section 60 to the upstream limit of the model, the proposed condition has reduced energy grade line elevations when compared to the existing model.

The model shows that leaving the existing operator tower and embankment fill will not adversely affect the hydraulics upstream of the crossing. Due to the complexities of the model, navigational hazards, and uncertainties of flood events, MDOT should consider removing as much of the existing structure as possible while still retaining its historical aspects. This will allow the historical aspects of the structure to remain while having the least impact on backwater.

As in the existing model, Alternative B shows no overtopping of the Fort Street bridge for flows up to and including the 1% chance flow. A potential road grade lift will not affect flood flows. The model shows a decrease in the energy grade line at all cross sections upstream of the proposed alignment extending to the study limits. The energy grade line elevation at the first upstream cross section common to both the existing and proposed models (cross section 60) is 584.02 feet for the proposed condition 1% chance flow. This is a reduction of 0.12 feet from the existing energy grade line. Alternative B meets the intent of the state's floodplain statute by not causing a harmful interference over a range of flows up to and including the 1% chance flood.