6 Current River Bridge Alternatives Studied

The final configuration of the bridge over the Current River needs to include a 28 foot wide roadway and many alternatives include a 10 foot wide mixed use path. For the alternatives where replacement of the pedestrian bridge is included, the mixed use path is generally in the overall width of a single bridge. Alternatives 1B and 2B include consideration of using a single lane temporary bridge that is converted to a mixed use path at completion of the project. The roadway width is required due to the approach roadway curves adjacent to the ends of the bridge. The existing bridge cross slope is normally crowned, but the roadway over the bridge will need to accommodate the necessary superelevation transitions that will extend onto the bridge.

All alternatives assume the design high water noted on the as built plans is close to the value that will come from a detailed hydraulic model. The hydrology and hydraulics modelling is beyond the scope of this conceptual study and is not included. Bridge lengths and roadway profiles have been established similar to the existing bridge but may be reduced if detailed hydraulic modeling shows a reduced bridge opening to be adequate for storm water conveyance.

If a replacement option is selected, removal of the existing structure will be more difficult than an ordinary bridge. The demolition of the structure will need to happen in reverse sequence to the method of construction with the surfacing removed to allow extraction of the fill working out from the center of each span to maintain balanced loading on the arches. Arch fill material should be removed from the site and not deposited in the river. Removal of the spandrel walls, counterforts and tie beams could be done with conventional methods but explosive charges should be considered to allow the arch concrete to collapse onto a prepared rock blanket or temporary causeway in the channel. If the nearby cave system or other formations in the area preclude the use of explosive charges, temporary supports and bracing will be needed to safely remove the arch concrete. Foundation elements away from the stream could be removed to the standard limit of two feet below the groundline. Consideration should be given to additional removal of the foundations in the channel to avoid future scour events that would expose the foundation remnants and pose a possible hazard to river traffic. These challenges to the removal of the bridge were considered in the cost estimates presented in this report.

Normal flows on the Current River and frequent high water events require the use of substantial temporary works in the stream. Construction in the river will require a causeway with piping to convey the stream flow while allowing construction activities. An allowance must be made to maintain river traffic during construction. Removal of the existing bridge may require a surface that allows equipment access and also allows for either explosive or braced removal of the arch concrete. Temporary access roads will be needed to the river level from both river banks. Additionally, Route 19 has several roadway curves north and south of the project which could limit the length of field pieces that can be efficiently delivered to the site. Field pieces longer than 130 feet should be investigated to determine if shoulder widening or other roadway improvements are needed for delivery.

6.1 Current River - Temporary Bridge

Most of the on alignment rehabilitation or replacement alternatives considered would carry traffic on a temporary structure while construction is underway. Existing temporary spans owned by MoDOT are configured for 40 foot span lengths supported by steel cap beams on driven HP piles. Because of roadway geometry requirements and to limit the impact of the temporary roadway on the surrounding area, the temporary profile will nearly match the existing bridge. This profile will produce foundation heights that exceed the limitations of exposed driven piles leading to a more robust temporary substructure than is standard for MoDOT owned temporary bridges. Two column concrete bents supported on drilled shafts are anticipated to support the temporary spans. This substructure type has the additional benefit of providing adequate lateral resistance during the frequent high water events on the Current River. Due to the cost of the concrete substructure and additional challenges with bent placement within the river, longer temporary spans of prestressed concrete NU-girders supporting open grid decking was evaluated and precludes the use of the standard temporary spans in MoDOT's inventory. NU-girders are recommended due to having reasonable span lengths for this application and a sufficiently large top flange to attach the temporary decking. Additional cost considerations have been included in the estimate to require the precast manufacturer to thicken the top flange such that coil tie inserts or J-bolts can be installed to attach the decking.

An additional option was considered for Alternatives 1B and 2B to build a single lane bridge to temporarily carry traffic over the Current River during reconstruction of the highway bridge. This bridge would be converted to a pedestrian bridge after the new highway bridge is reopened. This option may be able to carry the existing utilities if the single lane temporary bridge is built while the pedestrian bridge remains in service. This option produces cost savings for the project by eliminating the waste of a temporary bridge but will result in two structures at the crossing. It is unknown if the NPS would be willing to take ownership of the bridge after it is converted to pedestrian use or if maintenance would remain MoDOT's responsibility. The cost estimate for the single lane temporary bridge includes haunched steel plate girders with a concrete deck in place of the open steel grid deck. The unit cost of the single lane bridge is higher than the two lane temporary bridge since both designs use two column bents. This option is shown for Alternative 1B and 2B however including a girder bridge adjacent to a new arch structure may not create the aesthetic conditions desired at this location. If a single lane filled concrete arch bridge would be desired to match the highway bridge selected a corresponding cost increase should be expected.

6.2 Current River - Replacement In-Kind on Alignment

The first alternative considered to cross the Current River is a new bridge that matches the general shape and span arrangement of the existing bridge. The three main filled arch spans would be recreated in a bridge with a wider roadway. If the temporary bridge in place of the pedestrian bridge is selected, an allowance for a mixed use path should be included in the new bridge width. The end span arches and the filled abutment houses would be replaced by single spans of concrete girder bridge. The filled arch span would still have a floating roadway surface supported on the arch fill but it will be tied to the arch near the center of the segment and strip seal type expansion joints will be placed at the ends. To avoid the problem of salted roadway drainage running into the fill soil and through the openings of the bridge seen in the existing structure, Type A curbs will be placed along the edges of the roadway to the west and the edge of the pedestrian walkway to the east. These curbs will allow the collection of roadway drainage and direct it to a bridge drainage system that will be contained inside the arch fill and directed to a discharge through the arch rib below. A system that collects drainage and directs it to the ends of the bridge is possible but would require either raising the grade of the roadway or lowering the curve of the arches to accommodate the collection piping.

In this option the proposed piers would be founded on deep spread footings similar to the existing bridge. The span arrangement was matched so that cofferdams necessary to construct the new bridge could also be used to remove the existing foundations. An option to support the new bridge on a pile cap footing founded on drilled shafts is also possible. The proposed bridge arrangement can be seen in Figure A-10. In addition to matching the general shape and span arrangement of the existing bridge the aesthetic relief on the sides of the pilasters above the piers will be recreated. Similar to the existing bridge, cantilever brackets would be used to support the bridge roadway and barrier. The cantilever brackets can be shaped to match the stepped bottom flange of the existing brackets and the curved shape of the pier pilasters thereby mimicking the look of the existing bridge.

The primary benefit of this alternative is to match the aesthetic condition of the existing bridge. This option would create a bridge with a massive, heavy appearance similar to the existing bridge. One of the drawbacks of this alternative is that it would put back in place a type of bridge that cannot be fully inspected because a portion of the primary support member is buried under the arch fill. While the proposed roadway drainage collection system should remove the primary source of corrosion from the new arch the lack of accessibility would recreate the current situation and introduce risk into the life cycle expectations of a new bridge. An option to improve the situation would be to build a faux filled arch bridge where the roadway was actually supported on spandrel columns and cap beams but spandrel walls were added to create the massive, heavy appearance. This option would need to include access portals to the interior of the arch to allow for future inspection and maintenance. Detailed consideration of this option, including cost estimates, is not included in this study.

6.3 Current River - Girder Bridge Replacement on Alignment

Another alternative studied is to replace the existing bridge with a new bridge comprised of haunched steel plate girders on concrete substructures. Several span arrangements were studied to allow placement of new bridge foundations that avoid complete removal of the existing bridge foundations. The five span option presented in Figure A-11 and Figure A-12 was developed to maintain a similar overall bridge length. This bridge length exceeds the recommended length for the use of integral end bents and strip seal type expansion joints will be necessary. Since a girder bridge would not have the flow restrictions of a filled arch span a refined hydraulic model may allow for a shorter bridge and corresponding cost savings.

A parabolically haunched steel plate girder is presented in the bridge elevation in Figure A-11. Concrete girder and steel girder bridge options were considered during the study. While a concrete girder bridge would be the most cost effective structure at this location this option was not well received during the design charrette and therefore is not presented in this report and is not reflected in the final cost estimates presented. Five spans of haunched steel plate girders were selected to mimic the number of spans of the existing bridge and mimic the arch shape resulting in a context sensitive design. This structure type also matches the bridge over Sinking Creek and would maintain the bridge characteristics in other crossing along the corridor. A concrete girder structure would more closely match the material of the existing bridge, but haunched precast beams are not practical and the formwork for cast-in-place concrete girder spans would rival the cost and impact of a new concrete arch bridge and therefore was not considered.

The substructure of a new girder span bridge would consist of concrete columns and cap beams with web walls between the columns to avoid catching drift that is carried down the river. The concrete columns would be supported on drilled shafts socketed into rock. To match the aesthetics of the bridge over Sinking Creek, square columns were considered and a formliner allowance on the columns and web walls was included in the cost estimates. The use of square columns founded on round drilled shafts results in higher cost estimates due to the use of larger drilled shafts and rock sockets. As rock is approximately 15 feet deep over the bridge site drilled shaft foundations are preferred and will limit the impact on the streambed by avoiding large open excavations.

6.4 Current River - Replace In-Kind on Offset Alignment

A new filled concrete arch bridge offset from the existing bridge would have the same span arrangement as a bridge built on the existing alignment. Matching the existing span arrangement will recreate the look and hydraulic performance of the existing bridge. Figure A-13 shows a bridge elevation that matches the arrangement of the existing bridge with an alignment that places the new bridge very close to the existing bridge and would require removal of the pedestrian bridge. The other alignment option would place the new bridge downstream of the existing pedestrian bridge. A similar bridge elevation would be expected at each crossing option.

6.5 Current River - Girder Bridge Replacement on Offset Alignment

A new open span girder bridge built on an offset alignment is expected to be similar to the option on the existing alignment presented in Section 6.3. Greater flexibility of span arrangements would be realized when the need to avoid the existing bridge foundations is removed. A five span bridge with substructure aligned with the existing bridge would reduce the temporary hydraulic impact on the project. The offset alignments and profiles analyzed for this study would result in similar bridge lengths compared to the option on the existing alignment. Aesthetic considerations similar to those mentioned in Section 6.3 should be made.

6.6 Current River - Rehabilitation and Widening of Existing Bridge

A report of the material condition and life expectancy was prepared by KPFF Consulting Engineers and is included in Appendix C. Based on the results of material testing performed on samples taken from the existing bridge, the potential for corrosion in the arch concrete is high. While widespread delamination and spalling of the main arch concrete has not been recorded, some localized deterioration has occurred. Due to the configuration of the existing bridge, samples of the concrete on the interior of the arch were not possible and it is likely that chloride ion concentrations on the interior arch surface are higher than those sampled on the exterior surface. The KPFF report notes the concrete sampled is not from the areas closer to the roadway and near the midpoint of the arch where the worst conditions would be expected. If the selected alternative is to rehabilitate and widen the existing bridge a comprehensive corrosion mitigation program should be included. Such a mitigation program would include removal and replacement of deteriorated concrete and inclusion of embedded galvanic anodes to counter the corrosive effects of the chloride ion contamination. It should also be noted that the embedded anodes available to industry today have a life expectancy of approximately 30 years which may not meet the needs of the project or would require additional rehabilitation in the future. In addition to the concrete material testing, the existing structure was analyzed to determine its ability to carry current highway design loads. That analysis showed the bridge to adequately carry an HS20 live load in its current configuration or as part of a widened bridge.

Two rehabilitation plans were considered. Alternative 5A is a phased rehabilitation that keeps one lane of traffic on the existing structure or the new widened structure. The potential phasing is shown in Figure A-14. This option would include temporary repairs to the existing deteriorated cantilevers so that a single lane of traffic could be carried close to the existing west rail. Using temporary shoring to support the existing roadway fill the east cantilevers, bridge rail and bridge deck extension would be removed. The arch ring would be widened enough to support a full lane of traffic on the west side which would then carry the traffic while the east side was widened to accommodate the current roadway design width. Figure A-14 shows a final configuration that meets all the minimum width requirements but that would not allow for removal of the existing arch fill to perform additional inspection and repair. This option is included in the cost estimates presented in the report. A bridge that was built a couple feet wider than necessary could be configured to allow removal of the existing arch fill but that option is not presented in the figures. It should be noted that the unknown condition of the top of the arch ring and the buried counterforts and tie beams represents a significant risk to the project. If the first couple stages of the rehabilitation are complete and then significant deterioration is found on the existing bridge to remain in place project cost overruns due to a more substantial rehabilitation program and project time extensions would occur.

Alternative 5B would be a single phase rehabilitation where traffic would be carried on a temporary bridge. The final configuration of this alternative would be similar to the phased rehabilitation presented in Figure A-14 and a separate figure is not presented. The primary benefit of this alternative is the ability remove the arch fill and inspect the arch concrete prior to beginning other work to widen the bridge. Since the fill most saturated with chloride ions is likely to be near the top, removal of the top three feet of fill may be enough to inspect the critical concrete areas and determine if more inspection or rehabilitation is needed. The primary drawback of this alternative is the need to build a temporary structure. While it is not presented in the cost estimates, a project similar to Alternative 1B with a single lane temporary bridge converted to a pedestrian bridge could be considered. This option would reduce the bridge widening and is only feasible with the single phase rehabilitation.

6.7 Current River - Phased Bridge Replacement near Existing Alignment

The final option considered to replace the bridge over the Current River is a phased replacement on a slight offset alignment which was discussed during the design charrette and has been added to this report. The staging for this phased replacement can be seen in Figure A-15. In this alternative a new partial width bridge would be constructed downstream of the existing bridge. Analysis shows this partial bridge would likely fit between the existing highway bridge and the pedestrian bridge but the clearance to the existing structures would be less than preferred. This would involve a roadway alignment shift of approximately 20 feet. The space constraint to build the new bridge and the side slope extensions of the shifted and widened bridge may require additions of retaining walls to avoid impacts to the existing pedestrian bridge. This alternative could be pursued with either a new concrete arch structure (Alternative 6) or a new haunched steel plate girder structure (Alternative 7).

7 Spring Valley Bridge Alternatives Studied

The final configuration of the bridge over Spring Valley should include a 26 foot wide roadway with no allowance for pedestrian use. A 26 foot wide roadway is the minimum roadway width acceptable to MoDOT for this project given the traffic makeup and expected roadway geometry. No pedestrian facility exists adjacent to the highway bridge over Spring Valley and no need for a pedestrian facility is anticipated. Trail traffic from the Current River Bridge can proceed over land and use other crossings during normal stream flow.

Similar to the bridge over the Current River, all alternatives assumed the design high water noted on the as built plans is close to the value that will come from a detailed hydraulic model. The hydrology and hydraulics modelling is beyond the scope of this conceptual study and is not included. Bridge lengths and roadway profiles have been established similar to the existing bridge but may be reduced if detailed hydraulic modeling shows a reduced bridge opening to be adequate for storm water conveyance. The design high water noted on the as built plans is likely the result of backwater from the Current River. If this is the case, it may be possible to shorten the bridge and reduce project costs but a shortened bridge would have to include additional roadway fill in the valley. Additional roadway fill in the valley would not pose an engineering challenge but may not be acceptable to other stakeholders.

The existing bridge is set on a 45 degree right advance skew but a 30 degree skew appears to align better with the valley and the majority of stream flows while creating a bridge with less tendency to try to “walk” off its bearings requiring less maintenance over