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 the life of the structure. All new bridge options are set at 30 degree right advance skew to accommodate the current stream alignment and provide adequate clearance to the NPS service road.

The stream has migrated to the north and created a scour hole near the north arch thrust block (Bent 4 in Figure 2-6). All span arrangements considered should keep piers out of the main channel if possible and avoid the scour hole to allow free flow of the stream. All span arrangements must also provide at least 14'-6" of vertical clearance to the NPS service road to meet MoDOT EPG requirements. A substructure layout that avoids the clear zone of the service road is preferred but the roadway could be protected if a span arrangement encroaches on the clear zone but provides other benefits.

If a replacement option is selected, removal of the existing structure will be more difficult than an ordinary bridge but does not have the complication of arch fill as noted in the bridge over the Current River. The majority of the bridge can be removed with traditional methods. Due to the proximity of Round Spring and the Round Spring Cave removing the arch concrete with explosive charges may not be allowed and a shored and braced removal should be expected. Removal of the approach span over the NPS service road will require close coordination as this road provides the only access to NPS residences on the west side of the bridge. While the stream through Spring Valley does not carry boaters, it is a well visited area and consideration should be given to foundation removals beyond the standard two feet below ground. Additional scour or stream migration in the area could expose partially removed foundations and the presence of the north arch thrust block may continue to contribute to the existing scour hole.

Access to the area below the Spring Valley Bridge can be made using existing park service roads and extensive temporary access roads are not expected. A low water crossing to construct portions of the bridge north of the stream may be needed. This low water crossing may also be needed to install piling and place portions of the temporary bridge if an alternative with a temporary bridge is selected.

All foundation options for a temporary or permanent bridge should take into account the adjacent Round Spring Cave system. Further design of bridge options at this location should be coordinated with the NPS and checked against the cave shape file they are preparing.

7.1 Spring Valley - Temporary Bridge

Due to the two-girder bridge configuration over Spring Valley all of the on alignment rehabilitation or replacement options will rely on a temporary bridge. It is our understanding that MoDOT has 9 standard temporary bridge spans in inventory in Willow Springs, which is near the project and 12 more available at other locations. The temporary bridge at Spring Valley has been configured to utilize 11 of these 40-foot long standard spans and a 110-foot long Mabey truss span already owned by MoDOT. The Mabey truss span (or an equivalent rental span) is needed due to the alignment of the NPS service road that must remain open.

The span over the service road could be shortened if it is determined that a temporary single lane service road is acceptable. If a longer temporary span is needed a couple extra provisions will be required. The Mabey truss span is 28 feet wide while the standard temporary spans utilize a 24 foot roadway. Temporary thrie beam guardrail that aligns with the guardrail on the standard temporary spans will need to be attached to the decking in the truss span. Additionally, the NPS service road will need to be protected from debris that could fall through the open grate decking used on temporary spans.

The standard temporary spans include steel cap beams designed to be supported on 14 inch steel HP piles. Since the temporary profile must remain close to the existing, the temporary bents will need to be approximately 33 feet tall. Due to the height of the intermediate bents required, it is anticipated that steel CIP pipe piles or similarly stout piles will be required and 16 inch CIP piles have been assumed in the cost estimates. The use of these larger piles will likely require fabrication of custom steel cap beams which is reflected in the cost estimates. The overburden at this site is approximately 10 to 15 feet which is too shallow to create stable foundations with driven piles. Piles prebored through the overburden and five feet into the bedrock have been assumed. Temporary shoring towers were considered but rejected due to the possibility of inundation during high water events destabilizing the towers or the tower foundations.

An option exists at this site to use a single lane temporary bridge signalized on each end to alternate traffic. This configuration would remove the center portion of the standard MoDOT temporary spans and connect the two side sections at the middle of the temporary lane. A longer temporary span similar to the Mabey span will still be needed over the NPS service road but thrie beam guardrail could be attached to the steel grid decking in line with the guardrail on the standard spans. This option will require new steel cap beams, but that cost is already included due to the expected use of 16 inch CIP pipe piles. Omitting the center section of the standard temporary spans would reduce cost of the piling and prebore as well as reducing the cost of transporting, erecting and eventually removing the spans.

7.2 Spring Valley - Replace In-Kind on Alignment

The first alternative considered to cross Spring Valley is a new bridge that matches the existing open spandrel arch shape of the main span and uses prestressed concrete NU girders for the approach spans. The arch span would match the shape and size of the existing main span but the arches would be spaced slightly further apart to account for the wider roadway carried over the bridge. The arch span would also be shifted so that both new thrust blocks would be north of the existing thrust blocks and thus moving the new arch foundations away from the meandering streambed and the scour hole adjacent to the existing north footing. Strip seal type expansion devices will be used at each end of the arch span and bridge drains will be placed in the deck and the drainage collected in pipes behind the approach girders where possible. The drainage collection system through the arch span may not be hidden.

The approach spans are sized to miss the existing foundations and provide additional clearance to the NPS service road. NU-girders are recommended to provide reasonable span lengths needed, especially on the north approach span. If the differing appearance is acceptable standard MoDOT shape girders could be used on the south approach. The concrete girder approach span option is presented as Alternative 1A. In place of concrete girder approach spans, haunched steel plate girders could be used to add visual interest and create a curved bottom flange reminiscent of the curved bottom flange of the existing approach girders. Haunched steel plate girder approach spans are presented as Alternative 1B but no separate figure is included.

Since the arch foundations will be replaced, longer spans adjacent to the arch are possible as the additional load can be accounted for in the design. The arch thrust blocks and footings will match the existing construction and will each require a large cofferdam. The intermediate bents will be similar to the girder bridge options and will consist of square columns with web walls and formliner allowance supported on drilled shafts and rock sockets to avoid additional open excavations in the streambed.

7.3 Spring Valley - Girder Bridge Replacement on Alignment

Similar to the bridge over the Current River, an open span girder bridge was also studied to cross Spring Valley. Several span arrangements were studied and the four span (135'-152'-152'-110') bridge presented in Figure A-18 and Figure A-19 avoids the existing bridge foundations and the migrated stream through the valley. This span arrangement represents an efficient balance of superstructure and substructure investment. The maximum span lengths of 152 feet compare favorably to the 155 foot arch span of the existing bridge. This structure would also provide adequate vertical clearance over the NPS service road and horizontal clearance would exceed the existing but may still require guardrail protection. This bridge length exceeds the recommended values for using integral end bents and non-integral bents with strip seal type expansion devices are recommended. An open span bridge comprised of concrete girders was also considered and would be the most cost efficient structure but is not presented in this report as that concept does not meet the criteria developed during the design charrette.

The existing arch thrust blocks are very large and occupy a significant portion of the longitudinal section. Finding a span arrangement that avoids the existing substructure while creating a bridge that balanced superstructure and substructure cost results in the most efficient structure. Additional bridge configurations with three span and five span arrangements were also considered but the four span structure presented represents the most efficient configuration.

While the number of spans for this girder bridge would be greatly reduced compared to the existing bridge, the parabolically haunched steel girders would mimic the arch shape of the main span as well and the curved bottom flange of the existing approach spans. Similar to the bridge over the Current River, square column substructure with web walls with formliner supported on drilled shafts would be used to avoid issues with stream debris accumulation and generally match the characteristics of the bridge over Sinking Creek. Rock is approximately 20 feet below the surface and drilled shaft foundations are the preferred foundation option to avoid large open excavations in the streambed.

7.4 Spring Valley - Replace In-Kind on Offset Alignment

A new concrete arch bridge on an alignment offset to the west would be very similar to the bridge described to be rebuilt on alignment in Section 7.2. The bridge presented in Figure A-20 uses the same span arrangements and other configurations as the bridge presented previously. Without the constraints of the existing foundations a more efficient span arrangement may be found but a more refined survey including the limits of the existing scour hole would be needed to fine tune the bridge geometry. Similarly, without the conflict of the existing abutments it may be possible to pull in the ends of the bridge and reduce the project cost. The requirement to span the existing NPS service road will still need to be met. The offset alignment options considered would require the use of temporary shoring of the existing roadway embankment during the construction of the new bridge.

7.5 Spring Valley - Girder Bridge Replacement on Offset Alignment

A new open span bridge built on an offset alignment adjacent to the existing bridge is expected to be similar to the option on the existing alignment presented in Section 7.3. An offset alignment would remove the span arrangement constraints of the existing foundations. A four or five span structure will still be the most effective and a bridge skew of 30 degrees right advance would still be the best fit for the current stream flows. The offset alignments and profiles considered for this study would result in similar bridge lengths. The need to avoid the existing abutment foundations would be removed and a shorter bridge is possible. If the offset alignment option is selected consideration should be given to a refined analysis of the bridge to determine if integral end bents are feasible, thus removing a future maintenance consideration. Aesthetic considerations similar to those mentioned in Section 7.3 should be used.

7.6 Spring Valley - Rehabilitation and Widening of Existing Bridge

The material condition and life expectancy report prepared by KPFF shows the concrete sampled from the bridge over Spring Valley to include chloride ion contamination at levels that could initiate corrosion. Similar to the notes included for the Current River bridge the material sampled was not taken from areas of the bridge expected to have the worst contamination and higher levels of chloride ions should be expected in those areas closest to the deck. As described below most of the other concrete in the bridge would need to be replaced so the concrete of greatest concern is in the arch and the arch footings. Spalls and delaminations are visible in the arch concrete indicating deterioration with corrosion of reinforcing steel is occurring. This is the concrete closest to the deck and is expected to be the most contaminated. If a rehabilitation option is selected, a vigorous corrosion mitigation program should be expected to include removal and replacement of deteriorated concrete with the inclusion of embedded galvanic anodes. As noted previously the anodes have an expected life of approximately 30 years.

Our site visit and review of the inspection reports indicate significant deterioration of the deck concrete. The perforated curb portion of the existing bridge rail allows over the side drainage which is flowing along the underside of the deck causing corrosion. Any rehabilitation will need to remove the deck concrete. Removal of the deck through the arch span may be possible but removal of the deck concrete in the approach spans is not. The approach spans are constructed of two girder cast in place concrete “T” girders where the deck is part of the primary support element and can’t be replaced independently of the girders unlike a modern girder bridge. The deck cannot be removed without destabilizing the girder and a single girder cannot be removed without destabilizing the span. This results in the need to remove the superstructure, deck and barrier in the approach spans as part of any rehabilitation effort. The existing approach span substructure has several areas of spalled concrete and would require wider cap beams to accommodate the new bridge width. The existing approach span columns have reinforcing steel embedded into the unreinforced concrete footings. Any part of the bridge to remain would have to be evaluated for inclusion in the final structure and the wider roadway will cause additional overturning loads from Live Load that the unreinforced footings wouldn't be able to withstand. Therefore, complete replacement of the approach spans (superstructure and substructure) is recommended for any rehabilitation.

New approach span substructure should be similar to other girder options mentioned elsewhere: square concrete columns with web walls supported on drilled shafts and rock sockets. It is possible to rebuild the approach span girders to match the shape of the girder in the existing bridge, but it would require the girders to be cast-in-place using extensive formwork supported from the ground. This formwork would be extensive enough to restrict the use of the NPS service road and was not considered further. Similar to Alternative 1 and 3, if a rehabilitation of the bridge is considered, new prestressed concrete or haunched steel plate girder spans should be used.

To widen the bridge the existing cap beams supported by the spandrel columns above the arch will need to be lengthened. The cap beams are integral with the existing spandrel columns and the columns have areas of deterioration. Replacement of the cap beams and columns is recommended to carry the additional load from the increased roadway width. New cap beams will need to be wider than existing and constructed from higher strength reinforcing steel in common use today.

The existing arches were analyzed to determine their ability to carry current highway design loads. A wider roadway will allow either arch to see a greater lane fraction of the applied live load than the current bridge. This increased lane fraction results in an HS20 loading requiring 111% of the available capacity of the arch which is unacceptable. Next, a 3S2 designated rating truck was considered and resulted in a live load that needed 95% of the available operating capacity to support the applied load considering load factors applicable to operating conditions. MoDOT's written policy is to post bridges at 86% of the operating rating. Performance of these calculations found the bridge posting load would be 44 Tons based on the capacity of the arches and assuming the new portions of the bridge do not control the rating. This value exceeds the required posting limit and a rehabilitated bridge would not need to be posted for the given rating trucks.

A bridge rehabilitation would have to accept the existing concrete arches not supporting the full HS20 design load and would also need to accept a possible reduced service life of the structure as the anodes are consumed and the possibility of corrosion of the arch concrete returns.

8 Bridge Rail Alternatives Considered

The bridge rails at both sites are a significant part of the character of the existing bridges. The bridge rail is the portion of the bridge most readily observed by the traveling public and a change of bridge rail is considered an impact to the historic nature of the bridge.