GEI Consultants

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21B1I Badger State Trail Stewart Tunnel Review of Alternatives

Wisconsin Department of Administration
Division of Facilities Development
Town of Exeter, Wisconsin

Submitted to:

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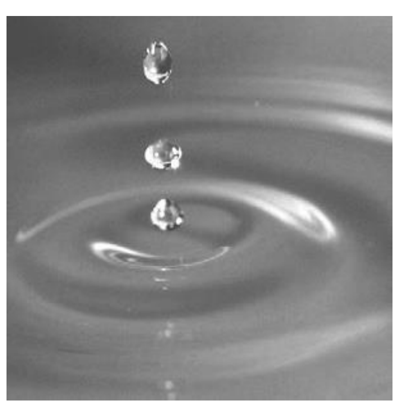

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Table of Contents

Tables

Appendix

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1. Introduction

1.1 Background and Purpose

GEI Consultants, Inc. (GEI) was retained by the Wisconsin Department of Administration (DOA) to identify and evaluate repair alternatives for the Stewart Tunnel portion of the Badger State Trail near New Glarus, Wisconsin.

The purpose of this Report is to present our evaluation and comparison of the existing conditions and repair alternatives, and to provide opinions of probable cost for each alternative based on conceptual designs.

1.2 Project Introduction

The Stewart Tunnel is located on the Badger State Trail located in the Town of Exeter near New Glarus, Wisconsin. The Badger State Trail is located on the former railroad corridor from Madison, Wisconsin to Freeport, Illinois. Tunnel construction was completed in 1886 and it remained in rail service until 1976. As part of the federal Rails to Trails Program, the Wisconsin Department of Natural Resources (WDNR) established the Wisconsin section of railroad corridor as the Badger State Trail in 2006. The WDNR operates and maintains the recreational trail, and the trail corridor is owned by the Wisconsin Department of Transportation.

The approximately 1,234-foot-long tunnel has a maximum interior height of approximately 20 feet and a typical maximum width of approximately 14 feet (see Photo 1, Appendix A for representative tunnel section). The majority of the tunnel walls and ceiling consists of exposed bedrock. The bedrock is comprised of interbedded coarse-grained limestone with thin, weakly cemented sub-horizontal bedding planes. Some vertical jointing and fracturing can be observed within the bedrock; however, this is suspected to have been caused by the blasting performed during original construction. Weathering, water infiltration, and freeze/thaw cycles have loosened bedrock fragments that are falling onto the pedestrian trail causing a major safety concern. Due to this safety issue, the tunnel was closed to the public in 2019. Chain-link fencing and gates are currently in-place to restrict public access to the tunnel.

Portions of the tunnel were lined with brick by the railroad company; however, the installation dates are unknown. The WDNR engaged a contractor to construct concrete walls and a semi-circular corrugated metal pipe (CMP) ceiling in a section of the of the tunnel in 2005. In 2017, metal rock netting, consisting of chain link mesh fastened into the rock with mechanical rock bolts, was installed on a portion of the tunnel ceiling. The WDNR is currently studying the bat hibernaculum in the tunnel.

Previous Stewart Tunnel repair alternative studies have been performed by the WDNR and as a capstone project by engineering students from the University of Wisconsin – Platteville. Based on the results of these studies, additional case studies provided by WDNR, our discussions with WDNR representatives, and our experience, there are approximately nine (9) Stewart Tunnel repair options currently contemplated. Several of these options do not directly address the tunnel roof stability issue but could be used in combination with other options to help mitigate the factors contributing to instability.

The nine tunnel repair alternatives evaluated in this report are summarized in Section 4.

1.3 Limitation of Liability

The professional services completed in preparing this Review of Alternatives Report were performed in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering profession currently practicing in the same locality and under similar conditions as this project. No other representation, expressed or implied, is included or intended, and no warranty or guarantee is included or intended in this report, or any other instrument of service.

2. Existing Condition Evaluation

2.1 Site Visits

GEI visited the Stewart Tunnel on February 3, 2021 and on June 23, 2021. During the February 3, 2021 site visit, GEI and WDNR walked the length of tunnel interior, took photographs, and documented the conditions of the tunnel.

During the June 23, 2021 site visit, GEI, WDNR, and DOA walked the length of the interior of the tunnel, took confirmation measurements, as well as additional photos. GEI also walked the area above the tunnel to observe the landscape above the tunnel.

Representative photos taken during the two site visits are included in a photolog in Appendix A.

2.2 Field Observations and Identified Deficiencies

The walls and ceiling of the tunnel appeared to be comprised of sandstone and limestone rock. These sedimentary rock formations form in roughly horizontal layers which are typically lightly cemented together. In multiple locations, the rock from the walls and ceiling were observed to have deteriorated, loosened, and fallen to the floor (Photos 1 and 2). Drilling and blasting operations from original construction resulted in areas of the tunnel walls which were over-blasted and remain highly fractured.

During the February site visit, ice buildup was observed on portions of the tunnel ceilings, walls, and floors (Photo 3). Ice had also formed at some of the wall drains within the brick-lined portion of the tunnel (Photo 4).

The walls of the sections of the tunnel previously repaired using bricks generally appeared to be in good condition with only minor surface deterioration observed (Photo 5). However, the ceiling portion of the brick sections were observed to be deteriorating in some locations including portions that showed signs of delamination (Photo 6).

The concrete-lined portions of the tunnel (repaired in 2005) appeared to be in good condition (Photo 7). The concrete walls did not show significant signs of deterioration and the corrugated metal pipe arch forming the ceiling appeared to be in good condition.

The rock netting, installed in a 30-foot section of the tunnel in 2017, was observed to be in good condition (Photo 8). The netting appeared to remain tight to the tunnel ceiling and was retaining some rock which had likely spalled since the installation of the netting (Photo 9).

Both facades at the north (stacked sandstone blocks) and south (brick) tunnel portals generally appear to be in good structural condition although some surficial deterioration and woody vegetation growth was observed (Photos 10 and 11).

The excavated rock faces to the left and right of the trail approaches at the north and south tunnel portals were observed to be heavily weathered with steep slopes (Photos 12 and 13). At the north tunnel portal particularly, the excavated rock faces appeared to have significant amounts of loose rock and near vertical faces. The rock faces at both tunnel portals were overgrown with trees and brush.

During the June site visit, GEI also walked the area above the tunnel. The land above the northern and southern portion of the tunnel was moderately wooded (Photo 14) and made up approximately 60 percent of the length of the tunnel. The land above the central portion of the tunnel was primarily comprised of grass with some lightly wooded areas (Photo 15). A mowed trail exists above a portion of the tunnel.

The tunnel was accessed during both site visits from the north from Tunnel Road. One wooden bridge exists between the north tunnel portal and Tunnel Road (Photos 16 and 17).

3. Repair Considerations

The following Table 3-1 summarizes the criteria considered when evaluating each of the repair alternatives. Please note that the importance column in Table 3-1 represents GEI's understanding of each criteria's relative importance based on conversations with WDNR.

Table 3-1 – Alternative Evaluation Criteria Summary

Criteria	Description	Importance
User Safety / Reduction of Risk	Safety of the trail users is the main priority of the tunnel repair. The repair alternative should eliminate or significantly reduce the risk of injury to the users from falling rock hazards.	High
Initial Costs	The largest costs associated with repairing the tunnel will likely be the initial construction costs. Opinions of probable costs were prepared for each of the repair alternatives.	High
Maintenance Costs	The cost of maintaining the tunnel for a given repair alternative was taken into consideration. These continual costs can be significant for some repair options.	Medium
Right of Way Expansion	Some repair alternatives would require expansion of the existing right of way to be completed. The cost of the right of way expansion was considered in our evaluation.	Medium
Construction Disruptions	Multiple homes are located within the vicinity of the tunnel. The potential for permanent or temporary disruption to these homeowners during construction was considered in our evaluation of the repair alternatives.	Medium

4. Repair Alternatives

The following Sections 4.1 through 4.9 provide brief descriptions of each of the evaluated repair alternatives. Opinions of probable cost were also developed for each alternative and are included in Section 5.

Note that the scaling of loose rock within the tunnel and at the tunnel portals is recommended for all alternatives which involve keeping the tunnel open for recreational use (Alternatives 1, 2, 3, 4, and 5). Based on our observations, we assumed a total of approximately 200 total feet along the trail beyond the north and south tunnel portals require scaling of loose / unstable weathered rock. Removal of loose rock within the tunnel would also be necessary prior to construction to reduce the risk of injury to workers during construction. Based on our visual inspection, we estimated that approximately 30% of the tunnel ceiling and wall surface area would require scaling of loose rock. The removal of loose rock was included in the opinions of probable cost for the repair alternatives listed above.

Removal and replacement of the existing wooden bridge between the north portal and Tunnel Road is also recommended if this portion of the trail were to be used as a construction access route. The existing wooden bridge (Photos 16 and 17) is too narrow and is unlikely to have the capacity to safely support construction traffic. A wider, more substantial temporary bridge or permanent culvert is recommended to accommodate construction equipment for all alternatives. Replacement of the existing bridge with a culvert and fill is included in the respective opinions of probable cost.

Alternatives considered include the following:

1) Portal Doors

2) Rock Netting

3) Steel Framing/Scaffolding with Roof

4) Corrugated Metal Pipe Tunnel Lining

5) Cast-in-Place Concrete Tunnel Lining

6) Reroute Trail Along Existing Roads

7) Reroute Trail Above Tunnel

8) Cut and Fill to Reroute Trail Above Tunnel

9) Tunnel Roof and Overburden Removal

4.1 Alternative 1 – Portal Doors

Portal doors similar to those designed by UW-Platteville students in their capstone project would be installed at the north and south portals (see Figure 1). The doors would be closed during the winter to reduce the tunnel's exposure to freeze/thaw cycles to slow the rate of rock deterioration. Potential openings in the doors could be designed in coordination with DNR bat biologists to accommodate bat entry and exit into the tunnel. Portal doors were installed at the Elroy-Sparta State Trail tunnel and have been reported to have reduced the rate of deterioration of the interior tunnel bedrock.

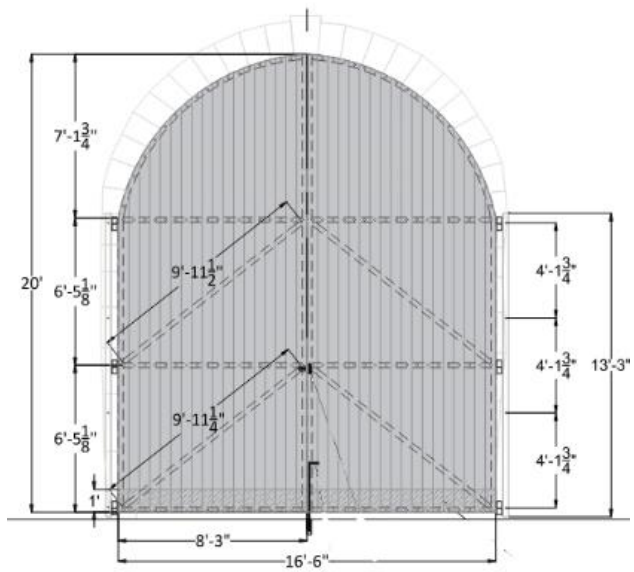

Figure 1 – Portal door concept designed by UW-Platteville Capstone Group.

Installing portal doors and closing the doors during the winter could reduce the rate of rock deterioration and has been used at similar tunnels in Wisconsin (i.e., Elroy-Sparta Trail Tunnels); however, it is unlikely that it will resolve the issue completely. While it is likely that freeze-thaw cycles are the main cause of deterioration, continued infiltration of water from above the tunnel accelerates the process and provides the moisture for ice formation in joints and bedding layers which undergoes volumetric expansion, jacking, and results in rock spalling. Installing portal doors for closure during the winter could also be combined with Alternatives 2 or 3 to reduce the rate of rock deterioration.

4.2 Alternative 2 – Rock Netting

Rock netting would be installed on the ceiling and upper portions of the wall within the tunnel to prevent loose rock from falling to the tunnel floor. The netting would be installed with mechanical rock anchors. The system would be similar to repairs performed in a 30-foot section of the tunnel in 2017 (see Figure 2). Installation of rock anchors would require rock cores to be completed within the tunnel to determine the quality of the rock. Findings from the rock cores would then be used to determine the required rock anchor depths.

Figure 2 – Existing rock netting installed in 2017.

The rock netting would not likely be a permanent solution to the crumbling ceiling rock and would likely require regular maintenance to remove rock debris collected in the netting. Some rock debris, if smaller than the net opening diameter, may also pass through the netting and present a safety hazard to trailer users. Additionally, the rock netting, if installed like it was in 2017, would only prevent rock debris from falling from the ceiling of the tunnel and not the walls, which have also shown indications of spalling. Falling or accumulating debris from the walls of the tunnel could still present a safety hazard to the trail users if the netting is not also installed on the walls. Therefore, maintenance costs for this alternative could be high. Our opinions of probable costs for this alternative assumed rock netting would only be installed on the ceiling of the tunnel.

4.3 Alternative 3 – Steel Framing/Scaffolding with Roof

A steel canopy or heavy-duty scaffolding would be installed within the tunnel. A sloping roof system would be installed to deflect falling material to the sides of the tunnel (see Figure 3). Heavy-duty netting would also be installed along the sides of the steel canopy to prevent falling rock debris from rolling into the traveled portion of the tunnel floor.

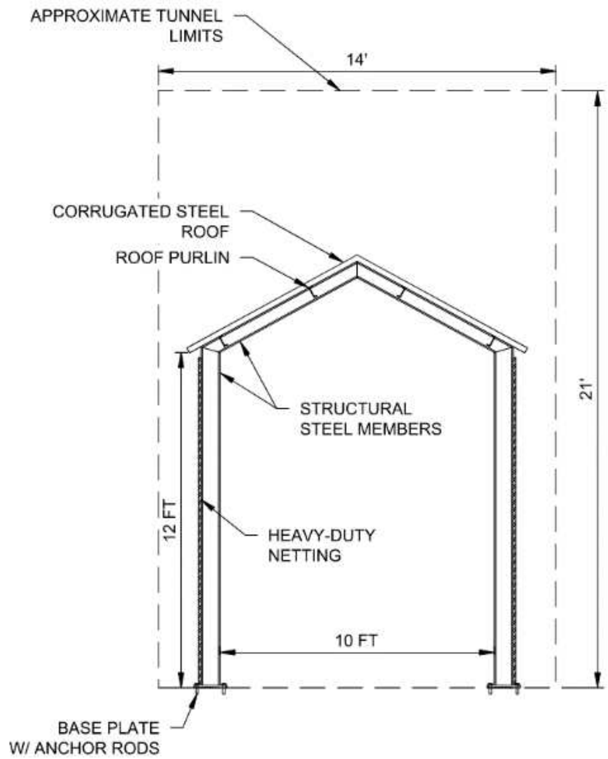

Figure 3 – Proposed steel framing/scaffolding sketch.

Similar to Alternative 2, this alternative would likely require regular maintenance to remove the fallen debris from the sides of the tunnel. The steel structure could be designed with bolted connections which could be dismantled relatively easily, if needed.

4.4 Alternative 4 – Corrugated Metal Pipe Tunnel Lining

A large diameter corrugated metal arch would be installed through the tunnel. Granular backfill or flowable fill material would be placed around and above the metal arch up to the ceiling or could optionally be placed up to an elevation approximately two feet above the top of the arch, which would leave space between the fill and the top of the existing tunnel. Drainage pipes would be installed within the fill near the invert of the corrugated metal arch to promote drainage to the tunnel portals.

This type of tunnel lining system was constructed at the Poe Paddy Tunnel in Centre County, PA and has worked well to protect trail users from falling rock while also maintaining their bat habitat (see Figures 4, 5, and 6). GEI spoke to officials at the Poe Paddy Tunnel who reported that the repair is functioning as intended. They stated that their bat population has increased, and the public has been pleased with the repair. GEI also spoke to the corrugated steel arch fabricator (Lane Enterprises) who provided a quote for fabrication of a similar arch for the Stewart Tunnel. The initial costs for this alternative are high and that the natural walls and ceiling of the tunnel would no longer be visible.

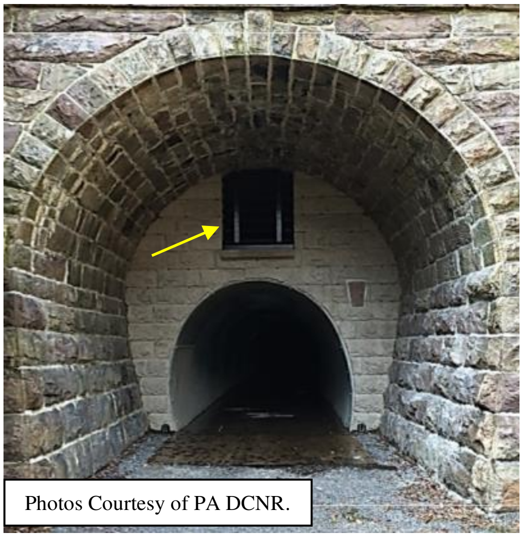

Figure 4 – Repaired Tunnel portal at the Poe Paddy Tunnel. Note the optional slotted door above the pedestrian entrance

Figure 5 – Open space above the corrugated metal tunnel at the Poe Paddy Tunnel. This space was purposely left open to allow for bats to access the ceiling of the tunnel.

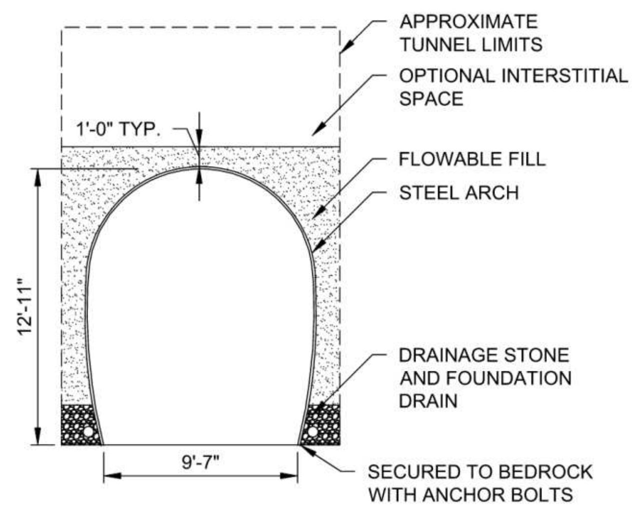

Figure 6 – Proposed corrugated arch repair sketch.

4.5 Alternative 5 – Cast-in-Place Concrete Tunnel Lining

Cast-in-place concrete walls would be constructed to support a large-diameter corrugated metal ceiling arch within the tunnel. The annulus space between the existing tunnel ceiling and corrugated pipe arch would be backfilled with concrete. This concrete tunnel lining would be similar to repairs performed at two locations within the tunnel in 2005 (see Figure 7 and 8). Foundation drains should be installed near the base of the concrete walls to collect any water that infiltrates through the bedrock. Weep/drain holes should be installed to provide an exit for accumulated water within the foundation drains and the trail surface should be graded to direct water to the trail sides and tunnel portals.

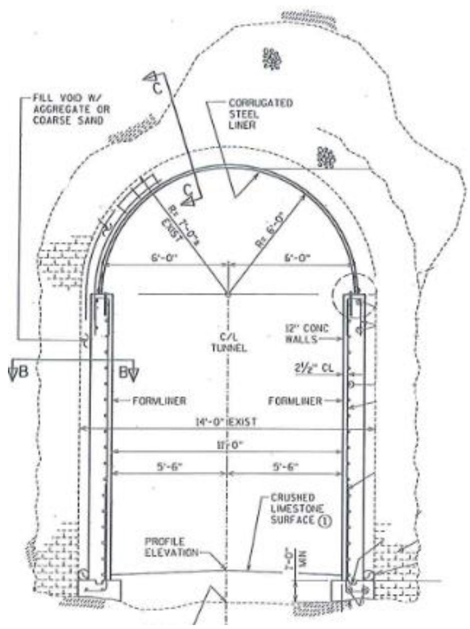

Figure 7 – Existing cast-in-place tunnel repair constructed in 2005.

Figure 8 – Existing cast-in-place tunnel repair constructed in 2005.

Because this repair alternative has been performed previously and appears to remain in good condition approximately 16 years after construction, this is likely a viable solution that has proven to work. This alternative would cover the existing tunnel walls and ceiling.

4.6 Alternative 6 – Reroute Trail Along Existing Roads

The trail would be rerouted along existing roads to bypass the tunnel. Two possible bypass routes were considered along existing roads (see Figure 9): 6A) 2.5 miles along Tunnel Road, or 6B) 3.3 miles along CTH CC/Exeter Crossing Road. Either route would require roadway widening to accommodate 5-foot-wide bicycle lanes in both directions and associated pavement markings and signage which would require expansion of the existing right of way (see Figure 10) which would likely require coordination with local agencies. The tunnel would remain closed for this alternative; however, some remedial actions may be required to allow the public to view portions of tunnel near the portals, reduce the rate of rock deterioration, and/or to allow for future tunnel inspections.

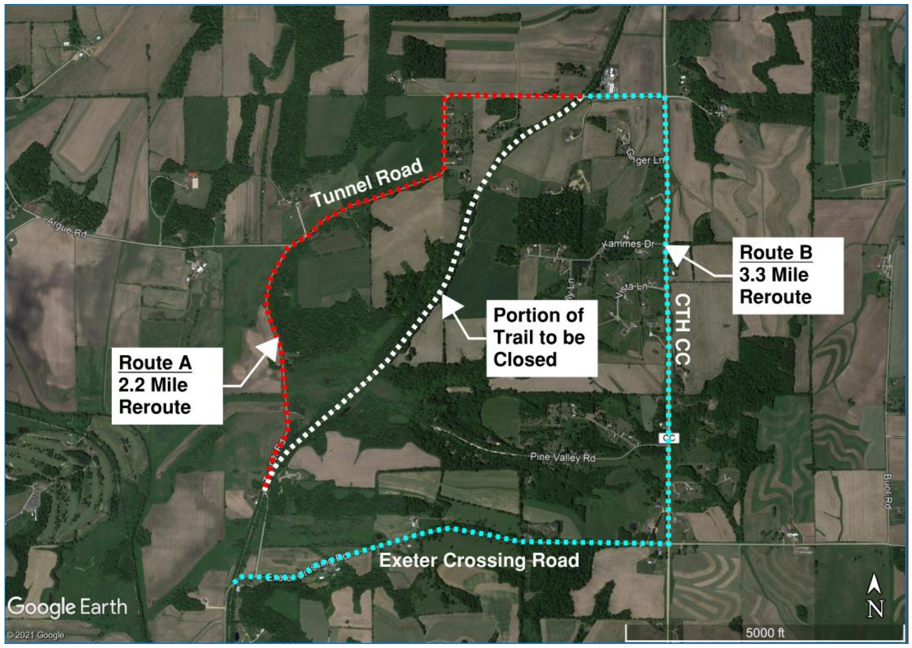

Figure 9 – Rerouted trail routes for Alternative 6.

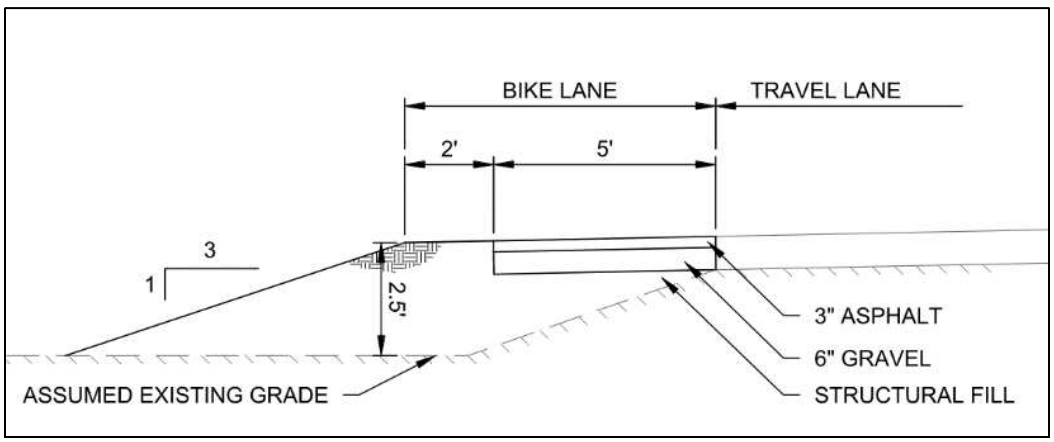

Figure 10 – Rerouted trail routes for Alternative 6.

This may be a viable alternative that would have low initial costs and relatively low maintenance costs. Trail users would be required to share the road with motorists along the rerouted trail for this alternative.

4.7 Alternative 7 – Reroute Trail Above Tunnel

The trail would be rerouted above the tunnel. The difference between the trail elevation near the portals and the peak of the hill that exists above the tunnel is approximately 100 feet. Existing site grades in the areas near the tunnel portals and above the tunnel are as steep as 16% in some areas. Grades this steep would require paving to prevent erosion (see Figure 11). The existing right-of-way near the tunnel portals and above the tunnel may need to be widened to reroute the trail. The tunnel would remain closed for this alternative; however, some remedial actions may be required to allow the public to view portions of tunnel near the portals, reduce the rate of rock deterioration, and/or to allow for future tunnel inspections.

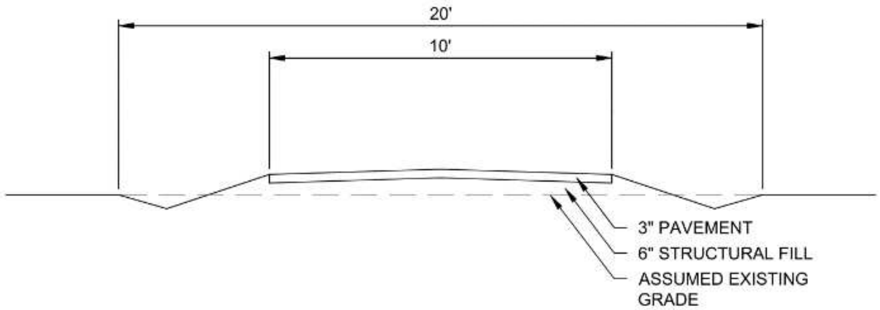

Figure 11 – Proposed paved trail cross section.

Multiple potential routes were considered to reroute the trail above the tunnel; however, the one selected (see Figures 12 and 13) appears to best utilize the existing gradual slopes near the portal approaches.

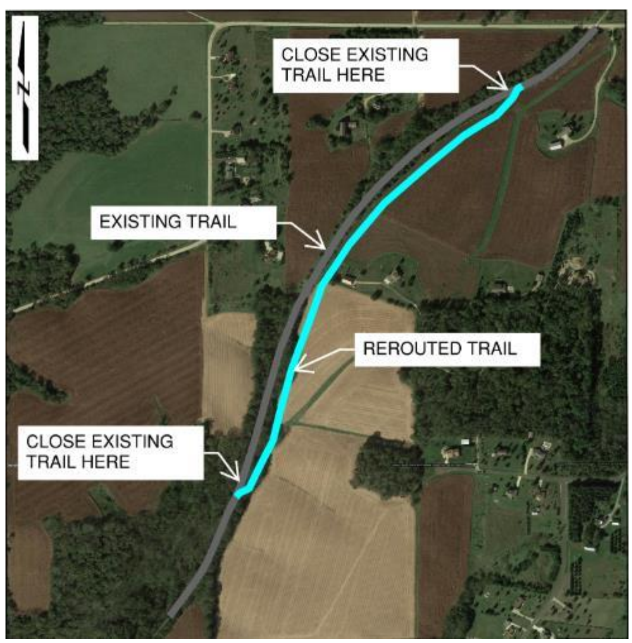

Figure 12 – Proposed rerouted trail location.

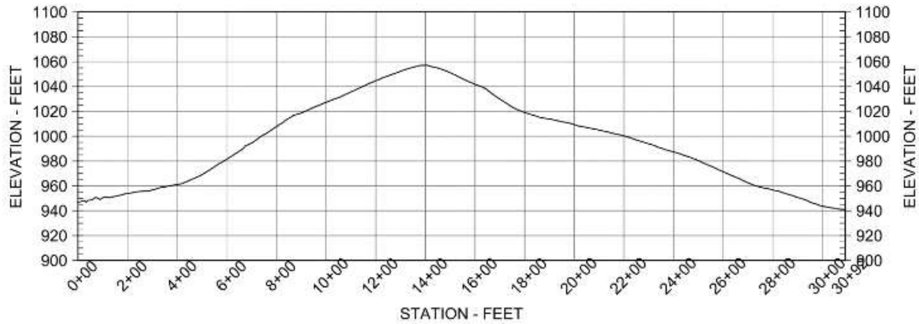

Figure 13 – Proposed rerouted trail elevation profile.

4.8 Alternative 8 – Cut and Fill to Reroute Trail Above Tunnel

This alternative would be similar to Alternative 7; however, soil excavated from above the tunnel would be used to construct approach ramps near the existing tunnel portals (see Figures 14 and 15). GEI selected a ramp grade of 10% to extend from the existing trail elevation to the ground surface above the tunnels. This grade was selected to limit the horizontal extent of the ramp (extending approximately 600 feet from the south portal and 500 feet from the north portal) while also maintaining a trail grade suitable for most bicyclists. Excavation of the soil from above the tunnel would also reduce the steeper portions of the trail (as discussed in Alternative 7) which are mainly near the crest of the existing hill. Paving of this new portion of the trail is recommended to reduce erosion. The existing right-of-way above the tunnel may need to be expanded to reroute the trail above the tunnel. The tunnel would remain closed for this alternative; however, some remedial actions may be required to allow for future tunnel inspections.

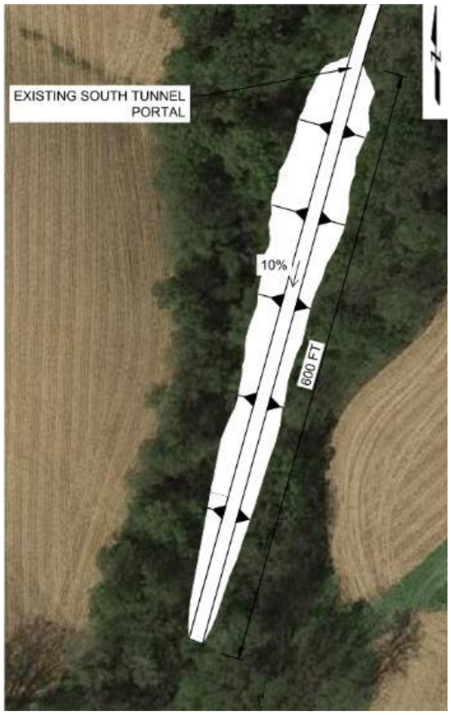

Figure 14 – Plan view of proposed ramp at south portal.

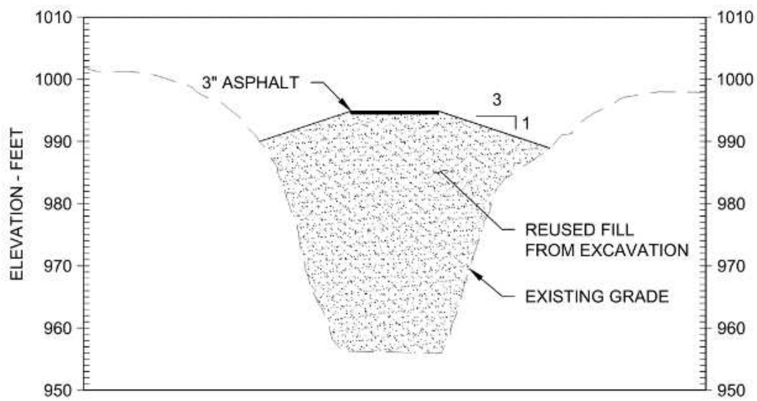

Figure 15 – Section view of proposed ramp at south portal.

4.9 Alternative 9 – Tunnel Roof and Overburden Removal

The soil and rock above the tunnel would be excavated to create an open cut along the entire tunnel. The open cuts could be up to a maximum of 300 feet wide at existing ground surface elevation above the tunnel to create safe and stable rock and soil slopes. The excavation through the rock may require blasting and drilling exploratory soil borings may be required to determine the location of the soil to rock contact.

This repair alternative would be costly due to the volume of soil and rock that would need to be removed and stockpiled or reused on other projects. GEI assumed that stockpiling the material would require purchase of additional land in case reuse elsewhere could not be identified. Construction would likely include blasting and other heavy machinery to remove the soil and rock. The open excavations required for this alternative may require widening of the existing right of way and may potentially have impacts to private land in the vicinity (see Figures 16 and 17). Rock slopes could be steepened if rock stabilization was performed.

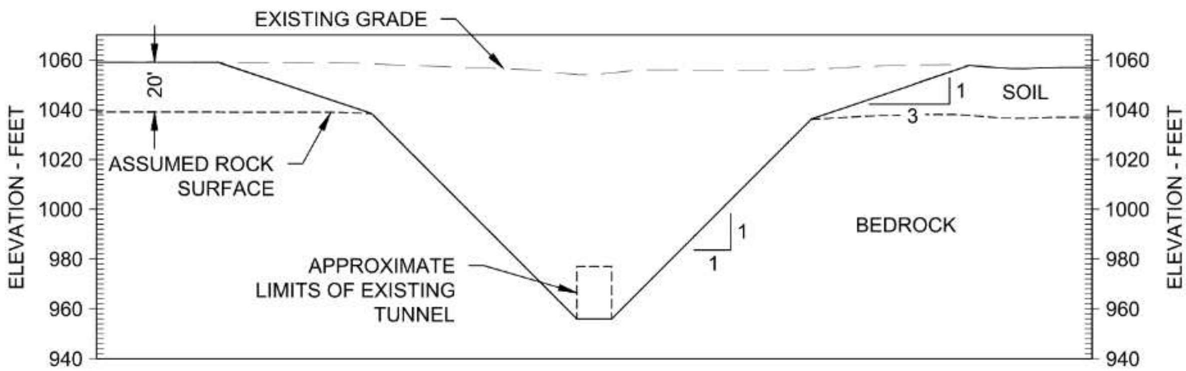

Figure 16 – Limits of excavation for Alternative 9.

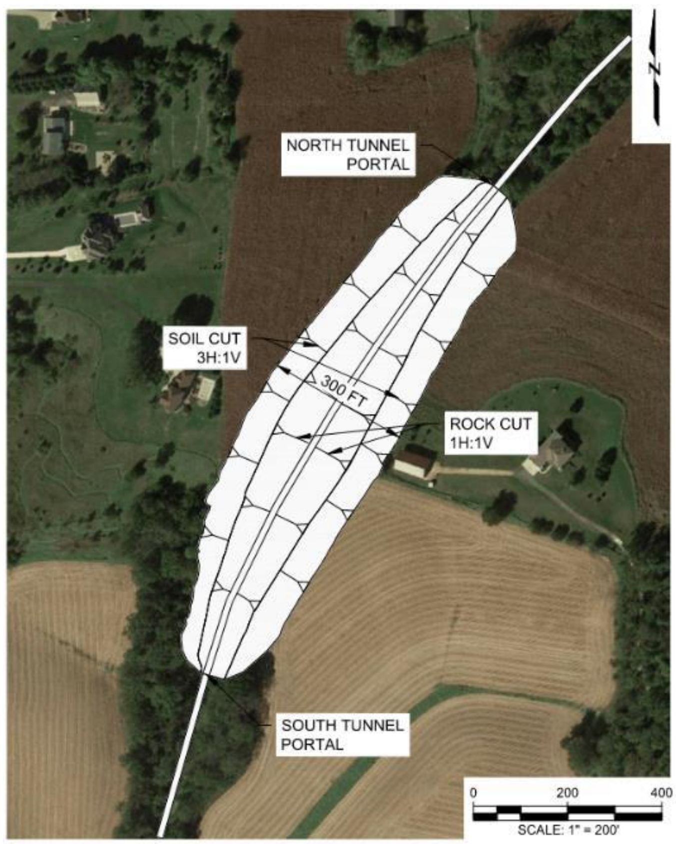

Figure 17 – Approximate limits of excavation for Alternative 9.

4.10 Other Repair Considerations

4.10.1 Drainage and Vegetation Improvements Above Tunnel to Reduce Seepage Infiltration

The land surface above the tunnel would be regraded to promote drainage flow away from the tunnel to reduce water infiltration into the tunnel. Appropriate vegetation would also be planted to potentially decrease water infiltration into the tunnel. The UW-Platteville Capstone Project Report also recommended installation of an impermeable geomembrane to prevent infiltration.

It is GEI's opinion that this alternative would not solve the rock deterioration enough to significantly reduce the risk of injury to trail users. While diverting water away from the tunnel might reduce some infiltration, it would likely not eliminate it completely. Additionally, installing a geomembrane would be extremely difficult and would require a significant amount of grading prior to installation. These geomembranes are particularly difficult to maintain if not installed below ground (i.e., for landfill liners) and can deteriorate if exposed to ultraviolet light and other environmental factors. To protect the geomembrane from UV exposure and other environmental factors, at least 12-inches of soil cover would be recommended, which would require additional grading and increase costs. Therefore, this alternative was not developed further.

4.10.2 Precast Concrete Tunnel Lining System

An arch-shaped, interlocking, precast concrete block system would be constructed within the tunnel and would serve as protection from falling rock debris. The space between the outside of the concrete block system and the existing tunnel walls and ceiling could be left open.

GEI discussed this repair alternative with fabricators of interlocking, precast block tunnels and determined that construction would not be feasible. These types of systems are typically constructed where equipment can place the blocks from either side of the tunnel. Due to the space constraints, it would not be feasible to construct interlocking tunnel within the existing tunnel. Therefore, opinions of probable cost were not developed for this alternative.

5. Opinion of Probable Costs

GEI has developed opinions of probable costs for the nine alternatives discussed in this evaluation which are summarized in Table 5-1. Our opinions of probable cost include a contingency of 10% to cover uncertainty in quantities and unit costs, 10% for mobilization, 10% for design and construction engineering, and 4% DFD administration fees. Detailed cost worksheets are included in Appendix B.

Table 5-1 – Opinions of Probable Cost

Alternative	Opinion of Probable Cost
1 – Portal Doors	$140,000
2 – Rock Netting	$880,000
3 – Steel Framing/Scaffolding with Roof	$4,080,000
4 – Corrugated Metal Pipe Tunnel Lining	$3,480,000
5 – Cast-in-Place Concrete Tunnel Lining	$9,200,000
6A – Reroute Trail Along Existing Roads (Tunnel Road)	$1,340,000
6B – Reroute Trail Along Existing Roads (CTH CC)	$2,010,000
7 – Reroute Trail Above Tunnel	$270,000
8 – Cut and Fill to Reroute Trail Above Tunnel	$740,000
9 – Tunnel Roof and Overburden Removal	$18,230,000

Our opinions of probable design and construction costs should be considered rough budgetary estimates based on conceptual level designs, costs for similar projects and engineering judgment. Presented opinions of probable costs are in 2021 dollars. Detailed designs and quantities have not yet been prepared. Actual bids and total project costs may vary based on contractor's perceived risk, site access, season, market conditions, etc. No warranties concerning the accuracy of costs presented herein are expressed or implied

6. Summary

Each of the developed alternatives, as well as a list of potential impacts, expected relative maintenance costs, and opinions of probable costs are summarized in Table 6-1.

Table 6-1: Summary of Alternatives

No.	Alternative	Potential Impacts	Preserves Tunnel Access to Trail	Relative Maintenance Costs	Opinion of Probable Cost (2021 dollars)
1	Portal Doors	• Portal doors could reduce freeze-thaw cycles and slow deterioration of bedrock. • Portal doors may not significantly reduce rock deterioration. • Portal doors close tunnel for a portion of the year. • Portal doors could be combined with other alternatives.	YES	LOW	$140,000
2	Rock Netting	• Rock netting has been used in portion of tunnel and was observed to be in good condition. • Maintains most of the existing tunnel height. • Maintenance costs could be high for removal of built-up rock from netting. • Small rock debris could still pass through netting. • Long rock anchors may be needed if quality of rock is poor.	YES	HIGH	$880,000
3	Steel Framing/Scaffolding with Roof	• Can be designed to be relatively easy to dismantle and remove. • Does not completely cover tunnel walls. • Maintenance costs could be high for removal of built-up rock from scaffolding roof/walls.	YES	HIGH	$4,080,000
4	Corrugated Metal Pipe Tunnel Reline	• Used at other similar tunnels (i.e., Poe Paddy Tunnel). • Covers existing tunnel walls and ceiling.	YES	LOW	$3,480,000
5	Cast-in-Place Concrete Tunnel Lining	• Already used in portions of the tunnel and was observed to be in good condition. • Reduces height and width of tunnel. • Covers existing tunnel walls and ceiling.	YES	LOW	$9,200,000
6	Reroute Trail Along Existing Roads	• Would require trail users to share road with cars. • Could require widening of existing road right of way. • Could require coordination with local agencies.	NO	LOW	4A: $1,340,000 4B: $2,010,000
7	Reroute Trail Above Tunnel	• Requires steep grades. • Could require widening of existing trail right of way. • May remove tunnel access.	NO	LOW	$270,000
8	Cut and Fill to Reroute Trail Above Tunnel	• Removes tunnel access. • Could require widening of existing trail right of way.	NO	LOW	$740,000
9	Remove Overburden Soil and Tunnel Roof	• Eliminates risk of falling debris. • Removes tunnel completely. • Would not require significant modifications (if any) if rail were to be restored. • Heavy equipment/blasting would be required. • Could require widening of existing trail right of way.	NO	LOW	$18,230,000

Appendix A

Site Visit Photolog

Appendix A – Photo Log of the Stewart Tunnel

Date: 12/2/2021

GEI Project No.: 2102260

Client: WI Department of Administration – Division of Facilities Development

Photo No. 1 – Horizontal limestone rock bedding planes in the walls (A) and ceiling (B).

Photo No. 2 – Typical rock spalling at tunnel ceiling.

Photo No. 3 – Ice buildup on the tunnel floor from leakage through the ceiling. Note rock debris on floor along walls.

Photo No. 4 – Ice buildup from drain in brick-lined portion of tunnel wall.

Photo No. 5 – Existing brick-lined portion of tunnel.

Photo No. 6 – Deteriorated ceiling at brick-lined section tunnel.

Photo No. 7 – Existing cast-in-place concrete lining repair.

Photo No. 8 – Existing rock netting repairs.

Photo No. 9 – Existing rock netting repairs. Fallen rock captured by netting (A).

Photo No. 10 – South tunnel portal.

Photo No. 11 – North tunnel portal.

Photo No. 12 – Steep slopes, loose rock, and woody vegetation at south tunnel portal.

Photo No. 13 – Steep slopes, loose rock, and woody vegetation at north tunnel portal.

Photo No. 14 – Wooded area above the northern portion of the tunnel.

Photo No. 15 – Trail and grassy/lightly wooded area above the center portion of the tunnel.

Photo No. 16 – Existing trail bridge at the approach to the northern tunnel portal.

Photo No. 17 – Existing trail bridge at the approach to the northern tunnel portal.

Appendix B

Detailed Cost Worksheets

GEI Proj. No.: 2102260 Date: 12/2/2021
Project: 21B1I - Stewart Tunnel Study
Client: DFD/DOA
Prepared by: GEI Consultants, Inc.

Alternative 1 - Portal Doors

Item	Description	Quantity	Units	Unit Cost	Item Total	Unit Cost Source
1.0	**Site Preparation**					
1.1	Rock Scaling within Tunnel	2,300	SY	$15.00	$34,500	Estimated
1.2	Rock Scaling at Tunnel Portals	1,300	SY	$15.00	$19,500	Estimated
				Subtotal:	**$54,000**	
2.0	**Access Road Improvements**					
2.1	Structural Fill for North Bridge Improvements	133	CY	$21.00	$2,800	WisDOT 2020
2.2	Corrugated Steel Culverts (36 inch Diameter)	40	LF	$150.00	$6,000	WisDOT 2020
				Subtotal:	**$8,800**	
3.0	**Portal Doors**					
3.1	Portal Door Materials (from UW-Platteville report)	1	LS	$20,000.00	$20,000	UW-Platteville Capstone Report
3.2	Portal Door Installation	1	LS	$20,000.00	$20,000	Estimated
				Subtotal:	**$40,000**	
				Construction Subtotal:	**$102,800**	
		Mobilization:		10%	$10,300	
		Contingency:		10%	$11,400	
		DFD Fee:		4%	$5,000	
		Design and Construction Site Visits:		10%	$12,500	
				Project Total:	**$140,000**	

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GEI Proj. No.: 2102260 Date: 12/2/2021
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Prepared by: GEI Consultants, Inc.

Alternative 2 - Rock Netting

Item	Description	Quantity	Units	Unit Cost	Item Total	Unit Cost Source
1.0	**Site Preparation**					
1.1	Rock Scaling within Tunnel	2,300	SY	$15.00	$34,500	Estimated
1.2	Rock Scaling at Tunnel Portals	1,300	SY	$15.00	$19,500	Estimated
				Subtotal:	**$54,000**	
2.0	**Access Road Improvements**					
2.1	Structural Fill for North Bridge Improvements	133	CY	$21.00	$2,800	WisDOT 2020
2.2	Corrugated Steel Culverts (36 inch Diameter)	40	LF	$150.00	$6,000	WisDOT 2020
				Subtotal:	**$8,800**	
3.0	**Rock Netting**					
3.1	Rock netting with rock anchors	770	LF	$750.00	$577,500	Prelim. WDNR Cost Estimate (R. Schmale)
				Subtotal:	**$577,500**	
				Construction Subtotal:	**$640,300**	
			Mobilization:	10%	$64,100	
			Contingency:	10%	$70,500	
			DFD Fee:	4%	$31,000	
			Design and Construction Site Visits:	10%	$77,500	
				Project Total:	**$880,000**	

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GEI Proj. No.: 2102260 Date: 12/2/2021
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Prepared by: GEI Consultants, Inc.

Alternative 3 - Steel Framing/Scaffolding with Roof

Item	Description	Quantity	Units	Unit Cost	Item Total	Unit Cost Source
1.0	**Site Preparation**					
1.1	Rock Scaling within Tunnel	2,300	SY	$15.00	$34,500	Estimated
1.2	Rock Scaling at Tunnel Portals	1,300	SY	$15.00	$19,500	Estimated
				Subtotal:	**$54,000**	
2.0	**Access Road Improvements**					
2.1	Structural Fill for North Bridge Improvements	133	CY	$21.00	$2,800	WisDOT 2020
2.2	Corrugated Steel Culverts (36 inch Diameter)	40	LF	$150.00	$6,000	WisDOT 2020
				Subtotal:	**$8,800**	
3.0	**Steel Scaffolding Construction**					
3.1	Structural Steel - Columns	44,424	LB	$20.00	$888,480	WisDOT 2020
3.2	Structural Steel - Angled Beams	22,212	LB	$20.00	$444,240	WisDOT 2020
3.3	Structural Steel - Roof Purlins	51,830	LB	$20.00	$1,036,600	WisDOT 2020
3.4	Heavy-Duty Corrugated Metal Ceiling	17,276	SF	$8.00	$138,208	Estimated
3.5	Heavy-Duty Netting for Walls	29,616	SF	$13.00	$385,008	Estimated
				Subtotal:	**$2,892,536**	
				Construction Subtotal:	**$2,955,400**	
			Mobilization:	10%	$295,600	
			Contingency:	10%	$325,100	
			DFD Fee:	4%	$143,100	
			Design and Construction Site Visits:	10%	$357,700	
				Project Total:	**$4,080,000**	

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GEI Proj. No.: 2102260 Date: 12/2/2021
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Prepared by: GEI Consultants, Inc.

Alternative 4 - Corrugated Metal Pipe Tunnel Lining

Item	Description	Quantity	Units	Unit Cost	Item Total	Unit Cost Source
1.0	**Site Preparation**					
1.1	Rock Scaling within Tunnel	2,300	SY	$15.00	$34,500	Estimated
1.2	Rock Scaling at Tunnel Portals	1,300	SY	$15.00	$19,500	Estimated
				Subtotal:	**$54,000**	
2.0	**Access Road Improvements**					
2.1	Structural Fill for North Bridge Improvements	133	CY	$21.00	$2,800	WisDOT 2020
2.2	Corrugated Steel Culverts (36 inch Diameter)	40	LF	$150.00	$6,000	WisDOT 2020
				Subtotal:	**$8,800**	
3.0	**Corrugated Metal Pipe Relining**					
3.1	Corrugated Metal Arch Materials (11'-9" x 9'-11")	1	LS	$609,937.50	$609,938	Supplied by contractor
3.2	Corrugated Metal Arch Installation	1,234	LF	$1,191.00	$1,469,694	Estimated
3.3	Concrete Walls (North and South Portals)	11	CY	$823.00	$9,053	Estimated
3.4	Flowable Fill (Annulus Space)	2,674	CY	$111.00	$296,814	WisDOT 2020
3.5	Drainage Stone	301	CY	$40.00	$12,040	Estimated
3.6	Foundation Drain	2,468	LF	$25.00	$61,700	Estimated
				Subtotal:	**$2,459,239**	
				Construction Subtotal:	**$2,522,100**	
		Mobilization:		10%	$252,300	
		Contingency:		10%	$277,500	
		DFD Fee:		4%	$122,100	
		Design and Construction Site Visits:		10%	$305,200	
				Project Total:	**$3,480,000**	

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GEI Proj. No.: 2102260 Date: 12/2/2021
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Client: DFD/DOA
Prepared by: GEI Consultants, Inc.

Alternative 5 - Cast-in-Place Concrete Tunnel Lining

Item	Description	Quantity	Units	Unit Cost	Item Total	Unit Cost Source
1.0	**Site Preparation**					
1.1	Rock Scaling within Tunnel	2,300	SY	$15.00	$34,500	Estimated
1.2	Rock Scaling at Tunnel Portals	1,300	SY	$15.00	$19,500	Estimated
				Subtotal:	**$54,000**	
2.0	**Access Road Improvements**					
2.1	Structural Fill for North Bridge Improvements	133	CY	$21.00	$2,800	WisDOT 2020
2.2	Corrugated Steel Culverts (36 inch Diameter)	40	LF	$150.00	$6,000	WisDOT 2020
				Subtotal:	**$8,800**	
3.0	**Concrete Lining System**					
3.1	Concrete Lining System	799	LF	$8,271.00	$6,608,529	Prelim. WDNR Cost Estimate (R. Schmale)
				Subtotal:	**$6,608,529**	
				Construction Subtotal:	**$6,671,400**	
			Mobilization:	10%	$667,200	
			Contingency:	10%	$733,900	
			DFD Fee:	4%	$322,900	
			Design and Construction Site Visits:	10%	$807,300	
				Project Total:	**$9,200,000**	

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GEI Proj. No.: 2102260 Date: 12/2/2021
Project: 21B1I - Stewart Tunnel Study
Client: DFD/DOA
Prepared by: GEI Consultants, Inc.

Alternative 6A - Reroute Trail Along Existing Roads (Tunnel Road)

Item	Description	Quantity	Units	Unit Cost	Item Total	Unit Cost Source
1.0	**Road Widening**					
1.1	Right of Way Expansion	5.3	acres	$6,600.00	$34,980	Estimated based on local property costs
1.2	Structural Fill	16,260	CY	$21.00	$341,460	WisDOT 2020
1.3	6" Road base Gravel	3,010	CY	$55.00	$165,550	WisDOT 2020
1.4	3" Asphalt	2,935	ton	$110.00	$322,850	WisDOT 2020
1.5	Culvert Extensions	11	EA	$1,100.00	$12,100	Prelim. WDNR Cost Estimate (R. Schmale)
1.6	Road Markings	23,232	LF	$4.00	$92,928	Prelim. WDNR Cost Estimate (R. Schmale)
				Subtotal:	**$969,868**	
				Construction Subtotal:	**$969,868**	
			Mobilization:	10%	$97,000	
			Contingency:	10%	$106,700	
			DFD Fee:	4%	$47,000	
			Design and Construction Site Visits:	10%	$117,400	
				Project Total:	**$1,340,000**	

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Project:	21B1I - Stewart Tunnel Study		
Client:	DFD/DOA		
Prepared by:	GEI Consultants, Inc.		

Alternative 6B - Reroute Trail Along Existing Roads (CTH CC/Exeter Crossing Rd)

Item	Description	Quantity	Units	Unit Cost	Item Total	Unit Cost Source
1.0	**Road Widening**					
1.1	Right of Way Expansion	8.0	acres	$6,600.00	$52,800	Estimated based on local property costs
1.2	Structural Fill	24,395	CY	$21.00	$512,295	WisDOT 2020
1.3	6" Road base Gravel	4,520	CY	$55.00	$248,600	WisDOT 2020
1.4	3" Asphalt	4,410	ton	$110.00	$485,100	WisDOT 2020
1.5	Culvert Extensions	17	EA	$1,100.00	$18,700	Prelim. WDNR Cost Estimate (R. Schmale)
1.6	Road Markings	34,850	LF	$4.00	$139,400	Prelim. WDNR Cost Estimate (R. Schmale)
				Subtotal:	**$1,456,900**	
				Construction Subtotal:	**$1,456,900**	
			Mobilization:	10%	$145,700	
			Contingency:	10%	$160,300	
			DFD Fee:	4%	$70,600	
			Design and Construction Site Visits:	10%	$176,300	
				Project Total:	**$2,010,000**	

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GEI Proj. No.: 2102260 Date: 12/2/2021
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Client: DFD/DOA
Prepared by: GEI Consultants, Inc.

Alternative 7 - Reroute Trail Above Tunnel

Item	Description	Quantity	Units	Unit Cost	Item Total	Unit Cost Source
1.0	**Site Preparation**					
1.1	Right of Way Expansion	2.2	Acres	$6,600.00	$14,520	Estimated based on local property costs
1.2	Clearing Above Tunnel	2.2	Acres	$30,316.00	$66,695	WisDOT 2020
1.3	Stripping Topsoil	1,775	CY	$15.00	$26,625	WisDOT 2020
				Subtotal:	**$107,840**	
2.0	**Access Road Improvements**					
2.1	Structural Fill for North Bridge Improvements	133	CY	$21.00	$2,800	WisDOT 2020
2.2	Corrugated Steel Culverts (36 inch Diameter)	40	LF	$150.00	$6,000	WisDOT 2020
				Subtotal:	**$8,800**	
3.0	**Trail Construction**					
3.1	Structural Fill	628	CY	$21.00	$13,188	WisDOT 2020
3.2	Asphalt	580	TON	$116.00	$67,280	WisDOT 2020
				Subtotal:	**$80,468**	
				Construction Subtotal:	**$197,200**	
			Mobilization:	10%	$19,800	
			Contingency:	10%	$21,700	
			DFD Fee:	4%	$9,600	
			Design and Construction Site Visits:	10%	$23,900	
				Project Total:	**$270,000**	

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Project:	21B1I - Stewart Tunnel Study		
Client:	DFD/DOA		
Prepared by:	GEI Consultants, Inc.		

Alternative 8 - Cut and Fill to Reroute Trail Above Tunnel

Item	Description	Quantity	Units	Unit Cost	Item Total	Unit Cost Source
1.0	**Site Preparation**					
1.1	Right of Way Expansion	0.9	Acres	$6,600.00	$5,940	Estimated based on local property costs
1.2	Clearing Above Tunnel	0.9	Acres	$30,316.00	$27,284	WisDOT 2020
1.3	Stripping Topsoil	730	CY	$15.00	$10,950	WisDOT 2020
				Subtotal:	**$44,174**	
2.0	**Access Road Improvements**					
2.1	Structural Fill for North Bridge Improvements	133	CY	$21.00	$2,800	WisDOT 2020
2.2	Corrugated Steel Culverts (36 inch Diameter)	40	LF	$150.00	$6,000	WisDOT 2020
				Subtotal:	**$8,800**	
3.0	**Ramp/Trail Construction**					
3.1	Soil Excavation (top of tunnel)	25,000	CY	$6.00	$150,000	Estimated
3.2	Ramp Construction (w. soil from top of tunnel)	25,000	CY	$11.00	$275,000	Estimated
3.3	Structural Fill	470	CY	$21.00	$9,870	WisDOT 2020
3.4	Asphalt	433	TON	$116.00	$50,228	WisDOT 2020
				Subtotal:	**$485,098**	
				Construction Subtotal:	**$538,100**	
			Mobilization:	10%	$53,900	
			Contingency:	10%	$59,200	
			DFD Fee:	4%	$26,100	
			Design and Construction Site Visits:	10%	$65,200	
				Project Total:	**$740,000**	

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Alternative 9 - Tunnel Roof and Overburden Removal

Item	Description	Quantity	Units	Unit Cost	Item Total	Unit Cost Source
1.0	**Site Preparation**					
1.1	Right of Way Expansion	10.5	Acres	$6,600.00	$69,300	Estimated based on local property costs
1.2	Clearing Above Tunnel	10.5	Acres	$30,316.00	$318,318	WisDOT 2020
				Subtotal:	**$387,618**	
2.0	**Access Road Improvements**					
2.1	Structural Fill for North Bridge Improvements	133	CY	$21.00	$2,800	WisDOT 2020
2.2	Corrugated Steel Culverts (36 inch Diameter)	40	LF	$150.00	$6,000	WisDOT 2020
				Subtotal:	**$8,800**	
3.0	**Overburden Removal**					
3.1	Rock Blasting and Excavation	175,260	CY	$55.00	$9,639,300	Estimated
3.2	Soil Excavation	138,660	CY	$22.00	$3,050,520	Estimated
3.3	Soil and Rock Disposal Site	19.5	Acres	$6,600.00	$128,700	Estimated based on local property costs
				Subtotal:	**$12,818,520**	
				Construction Subtotal:	**$13,215,000**	
			Mobilization:	10%	$1,321,500	
			Contingency:	10%	$1,453,700	
			DFD Fee:	4%	$639,700	
			Design and Construction Site Visits:	10%	$1,599,100	
				Project Total:	**$18,230,000**	

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