

Memorandum 1.11A

To: Lisa Cornutt & Anna Henson
CC: Marc Butorac, PE, PTOE, PMP
From: Bob Goodrich, PE & Michael McNulty, PE
Date: July 6, 2018
Subject: **Task 1.11A Design Option 1A Cost Summary**

The purpose of this memorandum is to provide a comprehensive cost summary for Design Option 1A in terms of seismic performance, environmental impacts, and constructability. A cost comparison and discussion for Design Options 1A, 1B, and 1C is presented.

Background

To date, the Project Management Team (PMT) has considered multiple bridge widening and seismic retrofit conceptual design options and has narrowed the list down to the first two options:

- **Option 1A – Widen to 94’ Standard – 28-foot widening to the west**
- **Option 1B – Widen to 94’ Standard – 28-foot widening to the east**
- Option 1C – Widen to 94’ Standard – 14-foot widening to both sides
- Option 2A – Widen to 84’ – 18-foot widening to the west
- Option 2B – Widen to 84’ – 18-foot widening to the east

Substantial work has been previously completed to evaluate a planning-level viable seismic retrofit strategy and construction cost for Design Options 1B and 1C. These previous evaluations were used to predict the seismic performance of the related Design Option 1A based on observations from the seismic analysis of Design Options 1B and 1C. These observations are documented in Memorandums 1.12 and 1.12C, respectively.

Seismic Performance

Design Option 1A is anticipated to perform similar to Design Option 1B. Overall, Design Option 1A will be a more flexible system than Design Option 1B due to the longer column lengths for the bridge widening. The longer columns are required because the widened portion is over the Bear Creek incised channel for much of the bridge length, which will result in larger top of column displacement demands under a seismic event. While displacement demands will be larger, they are not anticipated to exceed the displacement capacity provided by implementing Design Option 1B widening and retrofit strategies. Due to the potential viability of Design Option 1A, the PMT was asked to provide a comprehensive construction cost summary to implement Design Option 1A.

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Environmental Impacts

Bridge widening to the west will result in significant temporary and permanent impacts to Bear Creek. The majority of the widening columns will reside within the ordinary high water (OHW) limits of Bear Creek. This will require stream isolation measures and fish salvage activities to take place at Bents 8 through 38, comprising 31 of the 46 new columns and drilled shaft foundation locations.

Additionally, the natural flow of Bear Creek will be permanently affected by the new columns. This reach of Bear Creek is in a designated FEMA floodway. FEMA defines "Floodways" as *'... the channels of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights'*. The presence of new columns in the stream channel for a series of consecutive bents will most likely increase flood heights above the existing conditions. This anticipated increase will require additional mitigation work within the floodway to negate the effects of the columns within the stream channel. A detailed hydraulic analysis would be required to assess the extent of stream channel mitigation required.

Both Hawthorn Park and the Bear Creek Greenway Trail will require temporary access restrictions and/or closures to allow for the construction access necessary to construct the widening. No permanent reduction in area to either the park or trail are anticipated. However, additional portions of the Bear Creek Greenway Trail along the east bank of Bear Creek will become permanently covered overhead by the bridge widening.

This design option will also require additional I-5 southbound north approach work, entailing approximately 1,600 feet of retaining wall construction along the west shoulder to avoid encroaching on the Bear Creek Greenway Trail. Along much of this length, there is no feasible option for relocating the trail since it is currently pinched between the existing toe of roadway embankment and the top of bank for Bear Creek.

Constructability

As stated above, a significant amount of the bridge widening substructure construction will take place within the OHW limits of Bear Creek. While constructible, this does add to the complexity of the work, resulting in additional construction costs for temporary access roads, work platforms, and stream isolation measures. Additionally, due to the proximity of Bear Creek, bridge widening construction will require construction access on the existing structure. This will require multiple traffic lane shifts and reductions in travel lanes to accommodate construction equipment.

Work in the Bear Creek channel is likely to also affect construction scheduling. Even with the use of cofferdams designed for high flows, the presence of cofferdams in the channel suitable in

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size for shaft construction containment have the potential of raising flood elevations, similar to the presence of the permanent columns addressed above.

Bridge Planning Level Cost Estimates

Cost Estimating Methodology

A quantity-based planning-level construction cost estimate was developed for Design Option 1A using the same approach as Design Options 1B and 1C. Cost estimates were developed for bridge seismic retrofitting and widening activities only. Cost estimates do not include other construction items, such as temporary protection and direction of traffic, storm drainage, roadwork to surface streets, I-5 north and south approach roadwork to the bridge, retaining walls, or right of way (ROW) and temporary easement acquisitions.

Bridge construction costs were grouped into three main categories: structural rehabilitation items identified in Memorandum 1.10, seismic retrofits, and structural widening. Seismic retrofit costs were developed assuming that the same seismic retrofit strategy implemented for Design Option 1B would be viable for Design Option 1A per Memorandum 1.12C findings. Temporary works construction quantities, such as access roads, work platforms, shoring, and cofferdams, which are unique to each design option to accommodate bridge construction, were included for each cost estimate.

Bridge construction unit costs were developed using 2016 ODOT Bridge Cost Data as a baseline. Design Options 1B was developed in 2017, and thus, all 2016 unit costs were inflated by 3% to provide an estimated construction cost using 2017 dollars. Design Option 1A construction unit costs were developed the same way. Design Options 1B include a 35% contingency line item, whereas Design Option 1A includes a 40% contingency line item. The larger contingency for Design Option 1A is appropriate because no seismic analysis specific to the widening configuration has been completed. Detailed cost estimates for all design options can be found in Appendix A.

Cost Estimate Summary

Planning-level cost estimates for each design option are summarized in the table below. In addition to the bridge construction cost dollars, a qualitative construction cost comparison for each design option is presented. The table provides a means of comparing the major construction costs required for each design option.

For example, Design Option 1A bridge construction costs and additional traffic control, retaining walls, and floodway no-rise mitigation construction costs are greater than Design Option 1B, but ROW and easements are less for Option 1A. The remaining additional construction costs items are approximately equal. Therefore, even though the bridge construction costs show a difference of \$4.8 million, the overall construction cost of 1A is anticipated to be greater than just the 1B bridge construction cost differential. An additional caveat to the qualitative magnitudes is that they are meaningful only within each category and are not intended to compare costs

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across categories. For example, the magnitude of a "\$\$" symbol for traffic control has no relationship to a "\$\$" symbol for retaining walls.

Design Option	Bridge	ADDITIONAL CONSTRUCTION COSTS						
		ROW & Easements	Traffic Control	Storm & Drainage	I-5 Mainline	Surface Streets	Retaining Walls	Floodway No-Rise Mitigation
1A	\$56.6M	\$	\$\$\$	\$\$	\$\$	\$\$	\$\$	\$\$
1B	\$51.8M	\$\$	\$\$	\$\$	\$\$	\$\$	\$	n/a

Design Option 1A - One-Sided 28-Foot Widening and Seismic Retrofit

Item	Estimating Quantity	Unit Cost	Unit Price	Construction Quantity	Total Price in 2017 Dollars
Mobilization (LS)			\$ 3,675,300	1	\$ 3,675,000
Bridges - Structural Rehabilitation					
Silica Fume Concrete Overlay (SY)			\$ 166	22,400	\$ 3,708,000
Joint Repair (FT)			\$ 155	3,000	\$ 464,000
Painting Steel Girders (SF)			\$ 31	138,228	\$ 4,271,000
Steel Girder Stiffener Repair (LS)			\$ 587,100	1	\$ 587,000
Bridges - Seismic Retrofits					
Temporary Access Road (FT)			\$ 30	8,022	\$ 240,000
Shoring, Cribbing, and Cofferdams (EA)			\$ 16,180	65	\$ 1,052,000
Spread Footing Strengthening (EA)			\$ 68,576	46	\$ 3,154,000
<i>Structural Excavation (cy)</i>	488	\$ 26	\$ 12,566		
<i>Concrete Removal (ea)</i>	1	\$ 10,966	\$ 10,966		
<i>Foundation Concrete Class 3300 (cy)</i>	32	\$ 705	\$ 22,557		
<i>Reinforcement (lbs)</i>	6,243	\$ 2	\$ 12,486		
<i>Temporary Bent Support (ea)</i>	1	\$ 10,000	\$ 10,000		
Column Pinning (EA)			\$ 29,978	46	\$ 1,379,000
<i>Structural Excavation (cy)</i>	488	\$ 26	\$ 12,566		
<i>Concrete Saw Cutting (lf)</i>	13	\$ 206	\$ 2,715		
<i>Foundation Concrete Class 3300 (cy)</i>	3	\$ 705	\$ 2,172		
<i>Reinforcement (lbs)</i>	408	\$ 1	\$ 525		
<i>Dowels (each)</i>	4	\$ 3,000	\$ 12,000		
Column Strengthening (EA)			\$ 24,324	92	\$ 2,238,000
<i>FRP Wrapping (ea)</i>	1	\$ 24,324	\$ 24,324		
Conc. Crossbeam Strengthening and Widening (EA)			\$ 69,992	47	\$ 3,290,000
<i>Concrete Removal (cy)</i>	1.5	\$ 878	\$ 1,316		
<i>Structural Concrete Class 4000 (cy)</i>	56.5	\$ 876	\$ 49,438		
<i>Reinforcement (lbs)</i>	14,942	\$ 1	\$ 19,238		
Steel Crossbeam Strengthening and Widening (EA)			\$ 35,136	1	\$ 35,000
<i>Structural Steel (lbs)</i>	19,493	\$ 2	\$ 35,136		
Bridges - Widening					
Temporary Work Platforms (EA)			\$ 27,817	31	\$ 862,000
Shoring, Cribbing, and Cofferdams (EA)			\$ 6,783	31	\$ 210,000
Deck Removal (SF)			\$23	13,024	\$ 295,000
Drilled Shafts (EA)			\$ 155,288	46	\$ 7,143,000
<i>Furnish Drilling Equipment (ea)</i>	1	\$ 3,918	\$ 3,918		
<i>Drilled Shaft Excavation, 96 Inch Diameter (ft)</i>	55	\$ 1,261	\$ 69,374		
<i>Drilled Shaft Concrete (cy)</i>	102	\$ 343	\$ 35,113		
<i>Drilled Shaft Reinforcement (lbs)</i>	37,930	\$ 1	\$ 46,882		
Driven Piles (EA)			\$ 9,671	6	\$ 58,000
<i>Furnish Pile Driving Equipment (ea)</i>	1	\$ 4,770	\$ 4,770		
<i>Furnish HP 12x53 Steel Piles (ft)</i>	55	\$ 80	\$ 4,412		
<i>Drive HP 12x53 Steel Piles (ea)</i>	1	\$ 489	\$ 489		
Concrete Columns (EA)			\$ 18,114	46	\$ 833,000
<i>Structural Concrete Class 5000 (cy)</i>	18	\$ 670	\$ 11,958		
<i>Reinforcement (lbs)</i>	4,782	\$ 1	\$ 6,156		
RCDG Superstructure (per Span)			\$ 101,265	2	\$ 203,000
<i>Structural Concrete Class 4000 (cy)</i>	96	\$ 627	\$ 59,976		
<i>Deck Concrete, Class HPC 4000 (cy)</i>	32	\$ 908	\$ 28,930		

Design Option 1A - One-Sided 28-Foot Widening and Seismic Retrofit

Item	Estimating			Construction Quantity	Total Price in 2017 Dollars	
	Quantity	Unit Cost	Unit Price			
Steel Girder Superstructure (per Span)	<i>Bridge Rail (ft)</i>	120	\$ 103	\$ 12,360	8	\$ 2,534,000
	<i>Steel Plate Girder (lbs)</i>	125,041	\$ 2	\$ 203,491		
	<i>Deck Concrete, Class HPC 4000 (cy)</i>	87	\$ 908	\$ 79,360		
	<i>Bridge Rail (ft)</i>	329	\$ 103	\$ 33,906		
PS Concrete Girder Superstructure (per Span)				\$ 113,432	37	\$ 4,197,000
	<i>Prestressed Girders (ft)</i>	61	\$ 820	\$ 50,231		
	<i>Deck Concrete, Class HPC 4000 (cy)</i>	49	\$ 908	\$ 44,282		
	<i>Bridge Rail (ft)</i>	184	\$ 103	\$ 18,919		
Bridge - Construction Subtotal						\$ 40,428,000
40% Contingency						\$ 16,171,000
Bridge Construction Total						\$ 56,600,000

Assumptions:

- Construction cost total is for bridge construction items only and does not include all construction costs item, such as TP&DT, Storm Drainage, Roadwork, ROW, or Temp Construction Easement acquisition
- Cost estimate does not include PE, CE, and administration costs
- Cost were estimated using 2016 ODOT Bridge Cost Data as a baseline
- The cost is being estimated in 2017 dollars and must be adjusted for inflation to actual construction year.

Design Option 1B - One-Sided 28-Foot Widening and Seismic Retrofit

Item	Estimating Quantity	Unit Cost	Unit Price	Construction Quantity	Total Price in 2017 Dollars
Mobilization (LS)			\$ 3,489,900	1	\$ 3,490,000
Bridges - Structural Rehabilitation					
Silica Fume Concrete Overlay (SY)			\$ 166	22,400	\$ 3,708,000
Joint Repair (FT)			\$ 155	3,000	\$ 464,000
Painting Steel Girders (SF)			\$ 31	138,228	\$ 4,271,000
Steel Girder Stiffener Repair (LS)			\$ 587,100	1	\$ 587,000
Bridges - Seismic Retrofits					
Temporary Access Road (FT)			\$ 30	8,022	\$ 240,000
Shoring, Cribbing, and Cofferdams (EA)			\$ 16,180	65	\$ 1,052,000
Spread Footing Strengthening (EA)			\$ 68,576	46	\$ 3,154,000
<i>Structural Excavation (cy)</i>	488	\$ 26	\$ 12,566		
<i>Concrete Removal (ea)</i>	1	\$ 10,966	\$ 10,966		
<i>Foundation Concrete Class 3300 (cy)</i>	32	\$ 705	\$ 22,557		
<i>Reinforcement (lbs)</i>	6,243	\$ 2	\$ 12,486		
<i>Temporary Bent Support (ea)</i>	1	\$ 10,000	\$ 10,000		
Column Pinning (EA)			\$ 29,992	46	\$ 1,380,000
<i>Structural Excavation (cy)</i>	488	\$ 26	\$ 12,566		
<i>Concrete Saw Cutting (lf)</i>	13	\$ 206	\$ 2,715		
<i>Foundation Concrete Class 3300 (cy)</i>	3	\$ 705	\$ 2,183		
<i>Reinforcement (lbs)</i>	410	\$ 1	\$ 528		
<i>Dowels (each)</i>	4	\$ 3,000	\$ 12,000		
Column Strengthening (EA)			\$ 31,440	49	\$ 1,541,000
<i>FRP Wrapping (ea)</i>	1	\$ 31,440	\$ 31,440		
Conc. Crossbeam Strengthening and Widening (EA)			\$ 69,992	47	\$ 3,290,000
<i>Concrete Removal (cy)</i>	1.5	\$ 878	\$ 1,316		
<i>Structural Concrete Class 4000 (cy)</i>	56.5	\$ 876	\$ 49,438		
<i>Reinforcement (lbs)</i>	14,942	\$ 1	\$ 19,238		
Steel Crossbeam Strengthening and Widening (EA)			\$ 35,136	1	\$ 35,000
<i>Structural Steel (lbs)</i>	19,493	\$ 2	\$ 35,136		
Bridges - Widening					
Temporary Work Platforms (EA)			\$ 20,342	7	\$ 142,000
Shoring, Cribbing, and Cofferdams (EA)			\$ 10,694	3	\$ 32,000
Deck Removal (SF)			\$23	13,024	\$ 295,000
Drilled Shafts (EA)			\$ 155,288	46	\$ 7,143,000
<i>Furnish Drilling Equipment (ea)</i>	1	\$ 3,918	\$ 3,918		
<i>Drilled Shaft Excavation, 96 Inch Diameter (ft)</i>	55	\$ 1,261	\$ 69,374		
<i>Drilled Shaft Concrete (cy)</i>	102	\$ 343	\$ 35,113		
<i>Drilled Shaft Reinforcement (lbs)</i>	37,930	\$ 1	\$ 46,882		
Driven Piles (EA)			\$ 9,671	6	\$ 58,000
<i>Furnish Pile Driving Equipment (ea)</i>	1	\$ 4,770	\$ 4,770		
<i>Furnish HP 12x53 Steel Piles (ft)</i>	55	\$ 80	\$ 4,412		
<i>Drive HP 12x53 Steel Piles (ea)</i>	1	\$ 489	\$ 489		
Concrete Columns (EA)			\$ 12,460	46	\$ 573,000
<i>Structural Concrete Class 5000 (cy)</i>	12	\$ 670	\$ 8,233		
<i>Reinforcement (lbs)</i>	3,283	\$ 1	\$ 4,227		
RCDG Superstructure (per Span)			\$ 101,265	2	\$ 203,000
<i>Structural Concrete Class 4000 (cy)</i>	96	\$ 627	\$ 59,976		
<i>Deck Concrete, Class HPC 4000 (cy)</i>	32	\$ 908	\$ 28,930		

Design Option 1B - One-Sided 28-Foot Widening and Seismic Retrofit

Item	Estimating			Construction Quantity	Total Price in 2017 Dollars
	Quantity	Unit Cost	Unit Price		
Steel Girder Superstructure (per Span)	<i>Bridge Rail (ft)</i> 120	\$ 103	\$ 12,360	8	\$ 2,534,000
			\$ 316,758		
	<i>Steel Plate Girder (lbs)</i> 125,041	\$ 2	\$ 203,491		
	<i>Deck Concrete, Class HPC 4000 (cy)</i> 87	\$ 908	\$ 79,360		
PS Concrete Girder Superstructure (per Span)	<i>Bridge Rail (ft)</i> 329	\$ 103	\$ 33,906	37	\$ 4,197,000
			\$ 113,432		
	<i>Prestressed Girders (ft)</i> 61	\$ 820	\$ 50,231		
	<i>Deck Concrete, Class HPC 4000 (cy)</i> 49	\$ 908	\$ 44,282		
	<i>Bridge Rail (ft)</i> 184	\$ 103	\$ 18,919		
Bridge - Construction Subtotal					
Bridge Construction Subtotal					\$ 38,389,000
35% Contingency					\$ 13,436,000
Bridge Construction Total					\$ 51,800,000

Assumptions:

- Construction cost total is for bridge construction items only and does not include all construction costs item, such as TP&DT, Storm Drainage, Roadwork, ROW, or Temp Construction Easement acquisition
- Cost estimate does not include PE, CE, and administration costs
- Cost were estimated using 2016 ODOT Bridge Cost Data as a baseline
- The cost is being estimated in 2017 dollars and must be adjusted for inflation to actual construction year.