New Buck O'Neil (U. S. 169) Crossing Benefit-Cost Analysis

Kansas City, Missouri

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prepared for

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1.0 EXECUTIVE SUMMARY

1.1 Summary of Benefits and Costs

Completion of the new Buck O'Neil (U.S. 169) Crossing will result in a variety of benefits, the sum of which more than offset the cost of construction. The benefits realized by this project include reduced vehicle-operating costs, improvements in road user safety, lower travel times, emissions reduction, and enhanced quality of life and direct jobs supported by construction. A discussion of emissions reduction and the economic return supported by project construction is addressed qualitatively, and all other impacts are monetized and then compared in present value terms to project costs. A discount rate of 7 percent, the ratio between monetized benefits and costs in 2018 dollars, was applied resulting in a benefit-cost ratio of 1.32. Details of the categories analyzed are presented in Chapter 2 with supporting data presented in Chapter 3.

1.2 Modeling Approach

Table 1-1 summarizes the types of outcomes that have been identified for the project and the assessment approach adopted. The outcomes are organized according to the U.S Department of Transportation (US DOT) *"Benefit-Cost Analysis Guidance for TIGER and INFRA Applications"*, July 2017. Standard values for assessing benefits such as value of injuries, vehicle operating costs, etc., utilize recommendations included in the US DOT guidance.

Two independent analysis periods were used to assess the cost and benefits derived from the project following recommendations contained in the US DOT guidance. An analysis period covering the 20 years after construction completion is utilized to assess travel time and accident reduction savings projected from project implementation. A 40-year period covering 2018 to 2058 was adopted to assess capital costs, maintenance costs and vehicle operating costs. The determination for use of a 40-year period is addressed further in Chapter 2.

Table 1-1: Assessment Categories

Category	Type of Benefit or Cost	How Assessed
Safety	Prevented accidents from improved project design	Quantitative
Travel Time	Hours of travel reduced in the region from improved project design	Quantitative

Category	Type of Benefit or Cost	How Assessed
Emissions	Elimination of added emissions due to increase in regional travel	Qualitative
Vehicle Operating Costs	Reduction of added vehicle miles traveled during periods the existing bridge is closed	Quantitative
Maintenance	Elimination of planned maintenance outlays required to keep the existing bridge open to traffic	Quantitative
Capital Costs	Costs to construct the new bridge and elimination of costs required in the future to complete a replacement-in-kind of the existing bridge	Quantitative
Economic Return	Added employment opportunities and projected economic return created by the project.	Qualitative

2.0 CATEGORIES ANALYZED

2.1 Safety

Crash data from the Missouri State Highway Patrol database for a five-year period (2010 – 2014) was obtained for analysis and crash type information is shown in Table 2-1. Crash type, severity and location trends were analyzed to identify any geospatial or causal trends to be potentially addressed by the project. Both approaches to the bridge were identified as having very heavy concentrations of crashes. On the north side, crashes are very dense around the interchange with Harlem Road. This interchange is configured with on- and off-ramps that access U.S. 169 on the left which run counter to driver expectations. Additionally, the ramps are very steep and have very short areas before merging with mainline traffic. On the south side, the intersections of U.S. 169 with 5th and 6th Street present a safety challenge by overstressing the capacity of the signalized intersections, creating long queues, resulting in rear end crashes.

Table 2-1: 2010 to 2014 Crash Type Information

Crash Type	Number of Crashes	Percent of All Crashes Reported
Fatal	0	0
Disabling Injury	12	1.2
Minor	161	16.6
Property Damage Only	794	82.1
Total	967	

Many different improvements and countermeasures are being proposed to reduce the number of crashes. The treatments include a combination of operational and geometric strategies focused on improving both critical crash locations and types of accidents identified in the existing crash data analysis. Proposed treatments focused on elements that have a proven track record of providing quantifiable crash reductions. The crash modification factors (CMFs) used in this analysis were derived from traffic projects and published safety performance functions (SPFs) in the Highway Safety Manual (HSM). A summary of the proposed treatments is provided below:

Rerouting U.S. 169 traffic to/from Interstate 35

Currently northbound drivers need to exit Interstate 35, drive through the at-grade intersections at Broadway and 5th and Broadway and 6th to access northbound U.S. 169. Similar traffic patterns are

needed for southbound drivers. The proposed project includes a direct connection between U.S. 169 and Interstate 35 that will dramatically reduce the traffic demand and improve safety performance at these two intersections.

U.S. 169 / Harlem Interchange

The existing U.S. 169 and Harlem interchange is one of the primary concentrations of existing crashes in the study corridor. The current interchange configuration has sub-standard features including left-hand entrance and exit ramps, short merge distances and short acceleration distances. The proposed interchange configuration addresses all existing deficiencies and reroutes southbound on-ramp traffic to adjacent access points further from the bridge. The existing and proposed improved interchanges were modeled using HSM crash prediction models. The resulting CMF used to evaluate crash reduction was developed from those models.

Buck O'Neil Bridge Width

The existing Buck O'Neil bridge is of a sub-standard width and does not provide any shoulder width for through traffic. The proposed bridge replacement will provide the opportunity for a wider travelway including shoulders meeting current design standards. A CMF was created using HSM values for the existing and proposed shoulder width. This was applied to the existing crashes across the bridge to calculate the proposed crash reduction associated with providing wider shoulders.

Other Considerations

The proposed project will also provide other safety improvements for which the crash reduction could not be quantified. Traffic operations are projected to improve dramatically with the proposed project reducing delay and queue length for daily commuters, likely reducing the high number of rear end crashes often associated with poor operations and delay. Also, despite the lack of a shoulder on the existing bridge, occasionally pedestrians try crossing the bridge on the existing grates that provide storm water conveyance off the bridge. A barrier divided sidewalk/trail will be added with the proposed improvements which will provide positive separation from adjacent vehicular traffic.

2.2 Travel Time

Micro-traffic simulation models were developed using PTVs *Vissim* software to compare traffic operations for the existing conditions and the proposed improvements planned as part of the Buck O'Neil Bridge replacement project. Micro-traffic simulations were prepared for both the AM and PM peak periods using current year (2017) traffic volumes and design year (2040) traffic volumes. Total travel hours were summarized for the total amount of time vehicles spent within the Vissim network. AM and PM proposed conditions both showed a reduction over the exiting conditions as noted:

- The 2017 Build scenario shows a 131-hour improvement in the AM peak hour and 32-hour improvement in the PM peak hour in comparison to the existing condition scenario.

- The 2040 Build scenario shows a 286-hour improvement in the AM peak hour and a 165-hour improvement in the PM peak hour when compared to the 2040 traffic volumes using the existing roadway system.

2.3 Emissions

The Missouri Department of Transportation (MoDOT) is the agency responsible for maintaining the existing bridge. The current bridge conditions and state of repair dictate that a major rehabilitation be completed requiring a complete roadway closure from 2018 to 2020. Should plans for a replacement Buck O'Neil Bridge be finalized and a new structure be available, the needed repairs to the existing bridge can be scaled back dramatically and completed under traffic.

Reduction in vehicular emissions compiled for this report anticipate the required major rehabilitation be completed and the bridge be closed for a 24-month period. The Mid-America Regional Council (MARC) modeled the impacts associated with the closing of U.S. 169 during from 2018 to 2020 with their regional traffic demand model to assess the increase in vehicle miles traveled and vehicle hours traveled during the closure period.

The daily impact to the region is anticipated to include an added 46,413 miles of travel and 1,450 hours of travel due to closing U.S. 169 at the Buck O'Neil Bridge. The daily impact to the region will increase slightly each year during the 2018 to 2020 closure period.

2.4 Vehicle Operating Costs

The closure of U.S. 169 and the Buck O'Neil Bridge described in Section 2.3 will require alternative travel patterns for the 45,000 vehicles per day crossing the bridge. In, 2018, an added 46,413 vehicle

miles of travel and 1516 vehicle hours of operation will be created each day the bridge is closed and will increase to 47,819 vehicle miles of travel and 1562 vehicle hours of operation by 2020.

The recent MoDOT bridge inspection report of the Buck O'Neil Bridge stated, regardless of the rehabilitation strategy pursued, a replacement structure will be needed no later than 2053. The future added vehicular operating costs of closing the Buck O'Neil Bridge from 2053 to 2055 that allow for an in-kind replacement structure to be constructed have been included in the benefit-cost study analysis to provide a more complete picture of the added miles traveled in the region.

2.5 Maintenance

MoDOT recently completed an extensive inspection of the Buck O'Neil Bridge. The inspection identified numerous structural deficiencies in need of rehabilitation. Significant deterioration of structural elements such as steel stringers and bearings has occurred due to roadway drainage exposure. These elements need to be repaired or replaced, and deck replacement will be required to minimize this type of damage in the future. In addition, hanger cable retainers are missing, gusset plates and structural members are exhibiting pack rust, expansion joints need to be replaced, and some fatigue cracking is evident. Approach spans have fatigue cracking and similar pack rust and corrosion issues.

Based on the result of this inspection, MoDOT has adopted a recommended longer term, 35-year rehabilitation option as a preferred rehabilitation approach. MoDOT added the recommended longer-term project to their Statewide Transportation Improvement Program (STIP) with a total maintenance investment of $52.1 million in State Fiscal Year 2019.

2.6 Capital Cost

The benefit-cost analysis includes the cost estimated for the proposed new Buck O'Neil Bridge. The cost for the proposed project covers required environmental documentation, permitting, design development, land acquisition, utility adjustments, construction and construction administration. The estimated $204.1 million total project cost is projected to occur over a six-year period (2018 to 2023).

MoDOT's recently commissioned study of the Buck O'Neil Bridge concluded that regardless of rehabilitation efforts undertaken in the near-term, a complete in-kind replacement will be required well within the anticipate life-cycle of the proposed new bridge. The estimated current year cost for an in-kind replacement bridge in the study is $98 million.

MoDOT has identified a short-term solution as well which would provide a 5-year rehabilitation to extend the life of the existing bridge. The implementation of a 5-year rehabilitation project in 2018 would align with timeline to open the new bridge to traffic, keep U.S. 169 open to traffic during construction of the project, and allow nearly all the planned rehabilitation expenditures to be used as part of the financing for the project.

2.7 Economic Return

Various measures and publications provide projections to both direct and indirect employment numbers associated with the construction of transportation projects. The employment numbers often cited are for general highway construction and the specific needs for an individual project are difficult to quantify.

MoDOT and their work in conjunction with the Economic Development Research Group, Inc. assesses the economic benefit to the state through investment in the transportation system including projected direct employment associated with construction contracts. While not specific to work type, the employment projections anticipated by the $181.1 million construction contract for the project would be 143 jobs for the entire three-year construction period. The MoDOT study goes on to add that for each dollar of construction investment, the state receives $2.50 in economic impact.

3.0 SUPPORTING DATA

3.1 Safety

Existing annual crashes were evaluated at four project locations and modeled using principles from AASHTO's *Highway Safety Manual* and applying documented crash modification factors (CMFs) corresponding to the proposed treatments to be implemented. Table 3-1 list each project location and the proposed annual reduction in crashes based upon crash information for 2014.

Table 3-1: Proposed Annual Crash Reductions

Location	Proposed Treatment	CMF	Annual Existing Crashes	Proposed Crashes with Treatment	Proposed Annual Crash Reduction with Treatments (2014)				
					Total	Fatal	Disabling Injury	Minor Injury	PDO
Broadway (U.S. 169) & 5th Street	Reroute Traffic	0.67	38.6	25.9	12.7	0.0	0.2	2.1	10.5
Broadway (U.S. 169) & 6th Street	Reroute Traffic	0.54	11.2	6.0	5.2	0.0	0.1	0.9	4.2
Buck O' Neil Bridge	Widen Shoulder	0.77	4.4	3.4	1.0	0.0	0.0	0.2	0.8
Harlem Interchange	Reconfigure Interchange	0.57	22.2	12.7	9.5	0.0	0.1	1.6	7.8

The annual number of existing crashes and proposed reductions were adjusted at the same rate of anticipated traffic growth for the project area (15 percent) and calculated for 2023 and 2043, corresponding to the projected open to traffic date and 20-year design projection. Table 3-2 indicates the number of crashes reduced by type in 2023 and 2043.

Table 3-2: Projected Reductions by Crash Type

	PDO Crashes Saved (Year)	Minor Injury Accidents Saved (Year)	Major Injury Crashes Saved (Year)	Fatal Accidents Saved (Year)	Total Accidents Saved (Year)
Crash Reduction (2023)	26.75	5.37	0.46	0.00	32.58
Crash Reduction (2043)	41.82	8.40	0.71	0.00	50.93

The following monetized values from the US DOT Benefit-Cost guidance were adopted for each crash type used by the Missouri State Highway Patrol in their accident reporting system.

- Property Damage Only (PDO) - $4,252
- Minor Injury Accident - $451,200 (MAIS 2 – Moderate)
- Major Injury Accident - $2,553,600 (MAIS 4 – Severe)
- Fatal Accident - $9,600,000

The monetized values were applied to the Total Accidents Saved in each category over the 20—year analysis period. An undiscounted cumulative safety benefit of $93.479 million was calculated.

3.2 Travel Time

Travel time savings derived from the micro-traffic simulation models were compiled for a 20-year period corresponding to the projected opening of the new Buck O'Neil Bridge. The 2017 Build scenario projection of 163 combined hours of travel reduction during peak periods was adjusted by anticipated traffic growth for the project area (15 percent) and calculated for 2023 and 2043. The travel time saved was distributed to reflect the anticipated traffic composition of 92 percent passenger vehicles and 8 percent commercial vehicles.

Travel time savings are also derived from the avoidance of the extended closure periods of U.S. 169 for rehabilitation of the existing Buck O'Neil Bridge. During the 24-month period MoDOT has planned for closing U.S. 169, 1516 additional vehicle hours of travel will be added to the region beginning in 2018 and escalating to 1562 additional vehicle hours of travel by 2020. Future closures occurring in 2053 to 2055 to construct an in-kind replacement of the Buck O'Neil Bridge will cause 2,553 of added vehicle hours of travel.

The following monetized values from the US DOT Benefit-Cost guidance were adopted.

- $14.10 per hour of passenger vehicle travel *
- $27.20 per hour of commercial vehicle travel

* All passenger vehicle travel was assumed to be single occupancy all purpose for benefits of this analysis.

The monetized values were applied to the Travel Time saved for passenger and commercial vehicle operations. An undiscounted cumulative Travel Time benefit of $193.916 million was calculated.

3.3 Emissions

Reduction in vehicular emissions compiled for this report anticipate the required major rehabilitation scheduled on the existing Buck O'Neil Bridge will begin in 2018 and be completed in 2020. The net reduction in emissions was calculated assuming a 24-month closure of the Buck O'Neil Bridge will be required.

The daily impact to the region is anticipated to include an added 46,413 miles of travel and 1,450 hours of travel due to closing U.S. 169 at the Buck O'Neil Bridge. The daily impact to the region will increase slightly each year during the 2018 to 2020 closure period.

The additional miles traveled and added hours of travel due to delay were used to estimate the additional fuel usage during the period U.S. 169 is closed. Fuel usage rates and the amount of carbon dioxide emitted per gallon of fuel burned were based upon guidance published by the Environmental Protection Agency and included

- .00892 Tons of carbon dioxide emitted per gallon of gas burned
- Passenger cars using 0.0443 gallons of fuel per minute when idling and 0.041 gallons per mile.
- Commercial vehicles using 0.336 gallons of fuel per minute when idling and 0.166 gallons per mile.

An estimated 37 metric tons of added carbon dioxide emissions will be generated each day during the period U.S. 169 is closed.

3.4 Vehicle Operating Cost

The closure of U.S. 169 and the Buck O'Neil Bridge for rehabilitation will require alternative travel patterns for the 45,000 vehicles per day crossing the bridge. In, 2018, an added 46,413 vehicle miles of travel will be created each day the bridge is closed and will increase to 47,819 vehicle miles by 2020.

Additionally, future closures of U.S. 169 and the Buck O'Neil Bridge from 2053 to 2055 to allow for a new in-kind replacement structure will detour a projected 78,000 vehicles per day.

The added cost for vehicle operations was computed by determining the additional vehicle miles traveled in the region due to the closure of U.S. 169 and the Buck O'Neil Bridge and apportioning based upon the percentage of passenger and commercial vehicles impacted. Currently, 92 percent of the added mileage is driven by passenger vehicles and 8 percent by commercial vehicles.

The following monetized values from the US DOT Benefit-Cost guidance were adopted to assess vehicle operating cost.

- $0.40 per mile for passenger vehicles *
- $0.96 per mile for commercial vehicles *

* Values are for cost of vehicle operations only and do not address user cost.

The monetized values were applied to the Vehicle Operating Cost for the two periods of closure required for U.S. 169. An undiscounted cumulative cost of $60.130 million was calculated.

3.5 Maintenance

MoDOT has included in their STIP a maintenance investment to rehabilitate the Buck O'Neil Bridge of $52.1 million in State Fiscal Year 2019. The rehabilitation plan is anticipated to provide a 35-year service life and has been applied as an undiscounted rate of $1.489 million per year from 2018 to 2052.

3.6 Capital Cost

The benefit-cost analysis includes the cost estimated for the proposed new Buck O'Neil Bridge. The cost for the proposed project covers required environmental documentation, permitting, design development, land acquisition, utility adjustments, construction and construction administration. The estimated $204.1 million total project cost is projected to occur over a six-year period (2018 to 2024).

MoDOT's recently commissioned study of the Buck O'Neil Bridge concluded that regardless of rehabilitation efforts undertaken in the near-term, a complete in-kind replacement will be required well within the anticipated life-cycle of the proposed new bridge. The estimated current year cost for an in-kind replacement bridge in the study is $98 million.

Both construction of the proposed new Buck O'Neil Bridge and future replacement requirement identified by MoDOT to occur in 2053 are included in the cost-benefit analysis.

3.7 Summary of Benefits and Costs

The benefits and costs associated with the proposed Buck O'Neil Bridge replacement are summarized in Table 3-3 and are consistent with 2017 USDOT Benefit-Cost Analysis Guidance for TIGER and INFRA Applications. Annual costs and benefits are computed over the long-term planning horizon and summarized over the life-cycle of the project.

Table 3-3: Summary Results of the Benefit-Cost Analysis ($millions)

	BENEFITS (2018$) 7%
BENEFITS	
Time Savings	193.9
VOC Savings	60.1
Crash Savings	93.5
Operation & Maintenance Savings	52.0
Capital Cost Savings	1121.3
Residual Value	128.9
TOTAL BENEFITS	1649.6
PV OF TOTAL BENEFITS	268.7
COSTS	
Operating & Maintenance Costs	0.0
Capital Costs	260.9
TOTAL COSTS	260.9
PV OF TOTAL COSTS	204.1
SUMMARY	
NET PRESENT VALUE	64.6
BENEFIT-COST RATIO	1.32

At a 7 percent discount rate, a $201.4 million investment is expected to result in a $268.7 million in benefits, in present values, generating a benefit to cost ratio of 1.32. A detailed look at the annual benefits and costs is provided in Table 3-4.

Table 3-4: Detailed Results of the Benefit-Cost Analysis ($1000s)

Year	Calendar Year	Benefits ($1000s)						Costs ($1000s)		NPV ($1000s)	
		Time Savings	VOC Savings	Crash Savings	Maintenance Savings	Capital Cost Savings	Residual Value	Capital Costs	Maintenance Costs	7% NPV Total Benefits	7% NPV Total Costs
0	2018	$8,382	$7,535		$1,486			($1,700)		$17,403	($1,700)
1	2019	$8,509	$7,649		$1,486			($2,568)		$16,490	($2,400)
2	2020	$8,636	$7,764		$1,486			($40,226)		$15,622	($35,135)
3	2021				$1,486			($67,322)		$1,213	($54,955)
4	2022				$1,486			($72,035)		$1,133	($54,955)
5	2023				$1,486			($77,077)		$1,059	($54,955)
6	2024	$2,958		$3,711	$1,486					$5,434	$0
7	2025	$3,174		$3,799	$1,486					$5,268	$0
8	2026	$3,406		$3,889	$1,486					$5,110	$0
9	2027	$3,655		$3,980	$1,486					$4,961	$0
10	2028	$3,922		$4,074	$1,486					$4,820	$0
11	2029	$4,209		$4,170	$1,486					$4,687	$0
12	2030	$4,516		$4,269	$1,486					$4,560	$0
13	2031	$4,846		$4,370	$1,486					$4,441	$0
14	2032	$5,200		$4,473	$1,486					$4,327	$0
15	2033	$5,580		$4,578	$1,486					$4,220	$0
16	2034	$5,988		$4,686	$1,486					$4,119	$0
17	2035	$6,425		$4,797	$1,486					$4,023	$0
18	2036	$6,895		$4,910	$1,486					$3,932	$0
19	2037	$7,399		$5,026	$1,486					$3,846	$0
20	2038	$7,939		$5,145	$1,486					$3,765	$0
21	2039	$8,519		$5,266	$1,486					$3,688	$0
22	2040	$9,142		$5,390	$1,486					$3,615	$0
23	2041	$9,810		$5,517	$1,486					$3,547	$0
24	2042	$10,527		$5,648	$1,486					$3,482	$0
25	2043	$11,296		$5,781	$1,486		$128,850			$27,161	$0
26	2044				$1,486					$256	$0
27	2045				$1,486					$239	$0
28	2046				$1,486					$223	$0
29	2047				$1,486					$209	$0
30	2048				$1,486					$195	$0
31	2049				$1,486					$182	$0
32	2050				$1,486					$170	$0
33	2051				$1,486					$159	$0
34	2052				$1,486					$149	$0
35	2053	$14,116	$12,209			$348,768				$35,132	$0
36	2054	$14,326	$12,394			$373,182				$35,006	$0
37	2055	$14,541	$12,579			$399,305				$34,885	$0
	Totals	$193,916	$60,130	$93,479	$52,000	$1,121,255	$128,850	-$260,928	$0	$268,734	($204,100)

7% Discount Rate	
Net Present Value ($1000s)	**$64,634**
Benefit/Cost Ratio	**1.32**

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