Cost Benefit Analysis

Summary prepared for the Tennessee Department of Transportation

As part of the Southern Gateway Project

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Introduction

A benefit/cost (B/C) analysis was conducted for Southern Gateway Alternatives 2, 4, 5, and 6/6R. **Figure 1** shows the project study area and the relative location of each alternative. For each alternative, construction costs previously developed for the highway only and for the highway and railroad options were used. The sum of the highway operations and maintenance costs was estimated for each analysis year based on the year of expenditure. The construction costs were added to the annual highway operating and maintenance costs to determine the total costs. No railroad operations and maintenance costs were included in the analysis. The analysis years for B/C ratio estimation were 2035, 2040, 2050, and 2080.

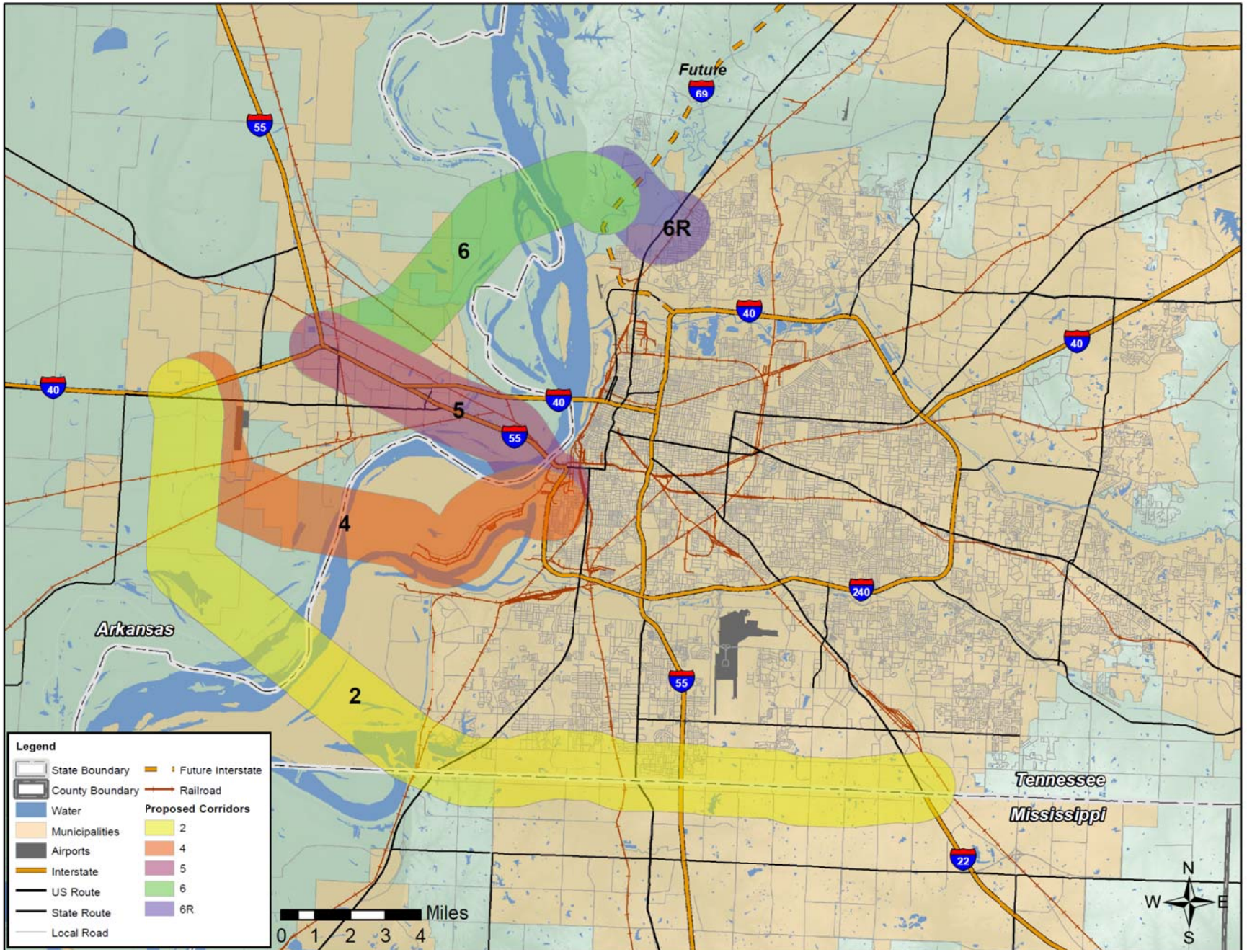
The project benefits were calculated based on the following performance metrics for the system:

- Recurring congestion,
- Safety, and
- Air Quality.

A unit monetary value for each performance measure was used consistent with other recent interstate corridor studies conducted for the TDOT Long Range Planning Division and from the Stated Preference Survey conducted as part of this project. Results from the local MPO travel demand model were used to estimate system level benefits for 2030. Performance metrics for other years were extrapolated based on data from the TRIMS database. No benefits associated with the rail operations were included in the B/C ratio estimation.

The total benefit of each alternative was then compared to the total cost of the alternative to estimate the B/C ratio. Although the B/C ratio is not the sole determinate of the value of a solution, projects are generally considered to be worthwhile when the benefits exceed the costs associated with the project (a ratio greater than 1.0).

A risk assessment was not conducted as part of this cost benefit analysis. However, analysis was conducted as part of the TDOT Mississippi River Crossing and Feasibility and Location Study (2006) to estimate the economic impact of a seismic or other event that would leave the highway and rail bridges over the Mississippi River inoperable. The report concluded that the sum of the economic impact to the region would be in excess of $11.34 billion. The analysis contained in this summary document does not account for the economic impact of a new river crossing or the benefit of an additional bridge in the region if any of the other Mississippi River bridges were rendered inoperable due to a catastrophic event.


Future
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Analysis

Costs

The initial cost of construction and the on-going costs for operations and maintenance were evaluated for the Build Alternatives 2, 4, 5, and 6/6R. For each alternative, it was assumed that construction would begin in 2025 and be completed by 2030. The year of expenditure costs were estimated using the base year 2012 costs and a compound growth rate of 3.6% per year. The construction costs include right-of-way acquisition, utilities relocation, engineering and construction. The construction cost of the highway only and the highway and rail options were considered and are shown in **Table 1**.

Table 1 – Build Alternative Segment Costs

Condition	Build Alternatives	Length (Miles)	Base Year Cost (2012 Dollars)	Year of Expenditure Cost
Highway Only	2	28.35	$1,842,000,000	$2,917,202,000
	4	13.30	$909,000,000	$1,439,596,000
	5	7.97	$857,000,000	$1,357,243,000
	6	9.87	$1,073,000,000	$1,699,325,000
Highway and Railroad	2	28.35	$3,307,000,000	$5,237,343,000
	4	13.30	$1,763,000,000	$2,792,088,000
	5	7.97	$1,325,000,000	$2,098,421,000
	6R	9.87	$1,743,000,000	$2,760,414,000

Operations and maintenance costs are on-going costs that are realized following construction of the project when the facility is open for traffic. A base year (2009) cost for highway operations and maintenance of $18,000 per mile per year was used to estimate the operations and maintenance cost. For the analysis years, the future year value of operations and maintenance costs were determined using a compound growth rate of 3.6% per year. The future value costs for operations and maintenance were estimated for the analysis years of 2035, 2040, 2050, and 2080. The future value costs of highway operations and maintenance are shown in **Table 2**. The operations and maintenance costs for rail were not considered in this analysis.

Table 2 - Operations and Maintenance Costs

Alternative	Cumulative Operations and Maintenance Costs			
	2035	2040	2050	2080
2	$7,042,000	$14,167,000	$32,818,000	$151,104,000
4	$3,304,000	$6,646,000	$15,396,000	$70,888,000
5	$1,980,000	$3,983,000	$9,226,000	$42,480,000
6	$2,452,000	$4,932,000	$11,425,000	$52,607,000

Benefits

The benefits of the Southern Gateway build alternatives reviewed as part of this analysis are those associated with recurring congestion, safety, and air quality. The travel demand model was used to estimate performance metrics of the build alternatives, such as vehicle miles traveled and delay, to evaluate the value of the benefits. The horizon year of the travel demand model is 2030. Since the analysis years of 2035, 2040, 2050, and 2080 are beyond the horizon year of the model, the future year traffic volumes were extrapolated from existing counts and year 2030 model results.

Specifically, the future year traffic volume was estimated for each analysis year by comparing the existing 2012 traffic volume from TDOT's Advanced Traffic Data Analysis and Management (ADAM) database for the total traffic crossing the Mississippi River on I-40 and on I-55 to those from the travel demand model for 2030. The change in traffic volume yields an exponential growth rate of 1.32%, which is less than the historic exponential growth rate between 1985 and 2012 of 2.46%. Using the growth rate of 1.32% yields a conservative estimate of the benefits associated with the build alternatives. The growth rate of 1.32% was used to estimate the change in traffic volume for the years beyond 2030.

Recurring Congestion

Recurring congestion is the congestion experienced on a daily basis due to traffic volumes that approach or exceed the capacity of the roadway. The amount of recurring congestion for the no-build and build alternatives was estimated using the travel demand model. To estimate the benefits associated with a reduction in recurring congestion, the vehicle delay was obtained from the travel demand model for passenger cars, single unit trucks, and combination trucks for the morning, mid-day, evening and off-peak periods. Only delays for vehicles with origins and destinations on opposite sides of the Mississippi River were estimated.

The change in the total delay for each alternative was compared to the delay for the no-build condition. The average unit cost for the value of time from the Stated Preference Survey (**Table 3**) was applied to the change in delay for each alternative for 2030. The cumulative future value of the benefit associated with a reduction in delay was then estimated for each analysis year. No growth in the value of time was used, resulting in a conservative estimate of the expected benefit for recurring congestion. A reduction in delay was identified for each build alternative and compared to the no-build alternative. The value of the benefit associated with a reduction in delay is shown in **Table 4**.

Table 3 - Value of Time Summary (Dollars per hour)

Survey	Segment	Mean	Median	Standard Deviation
Automobiles	Base	$9.94	$3.20	$19.03
	Social Off-Peak	$7.65	$3.28	$15.86
Commercial Vehicles	Single Unit	$11.66	$5.54	$21.16
	Combination Unit	$38.20	$9.07	$91.63

Table 4 - Benefit of Reduction in Recurring Congestion

Alternative	Cumulative Benefit			
	2035	2040	2050	2080
2	$1,262,243,000	$2,392,913,000	$4,889,979,000	$14,690,816,000
4	$1,000,436,000	$1,896,588,000	$3,875,727,000	$11,643,729,000
5	$891,620,000	$1,690,299,000	$3,454,171,000	$10,377,260,000
6	$956,034,000	$1,812,412,000	$3,703,711,000	$11,126,949,000

Safety

The benefits associated with safety were estimated using TDOT statewide average crash rates for rural and urban interstates and fully access controlled facilities. An estimate of future year vehicle miles traveled (VMT) along the freeways within the study area for passenger cars and for trucks was obtained from the travel demand model for the no-build condition. The study area freeway VMT for the no-build and build alternatives is shown in **Table 5**. The statewide average crash rates for crashes and fatal crashes based on the area type is shown in **Table 6**. A value was then applied to the change in crashes and the future value for each alternative was estimated. Unit prices of $8,500 per crash and $4,300,000 per fatal crash were used. No growth in the unit price per crash or fatality was used. Since many of the alternatives resulted in an increase in VMT, the benefits associated with safety were negative. The value of the benefit associated with safety is shown in **Table 7**.

Table 5 - Study Area Freeway Vehicle Miles Traveled (VMT)

Alternative	Rural Freeway		Urban Freeway	
	Length (miles)	Daily VMT	Length (miles)	Daily VMT
No-Build	116	5,614,442	193	13,060,116
2	131	6,011,198	208	13,486,264
4	116	5,569,862	207	13,316,283
5	116	5,618,021	194	13,114,901
6	125	5,932,739	195	12,824,684

Table 6 - State Average Accident Rate
(crashes per million vehicle miles traveled)

Area Type	Location Type	Total Crash Rate	Fatal Crash Rate
Rural	Freeway Section	0.4335	0.0073
Urban	Freeway Section	0.9578	0.0061

Table 7 - Benefit of Crash Reduction

Alternative	Cumulative Benefit			
	2035	2040	2050	2080
2	-$64,661,000	-$122,581,000	-$250,498,000	-$752,563,000
4	-$16,392,000	-$31,076,000	-$63,504,000	-$190,784,000
5	-$4,547,000	-$8,620,000	-$17,615,000	-$52,920,000
6	-$6,954,000	-$13,184,000	-$26,942,000	-$80,941,000

Air Quality

Air quality benefits are realized by reduced vehicle emissions when there is a reduction in the VMT for passenger cars and trucks. The unit value of benefit used was $0.011 per VMT for passenger cars and $0.039 per VMT for trucks. No growth in the unit value for air quality benefits was used. The region-wide VMT for the build and no-build alternatives is shown in **Table 8**. The future value of the reduced vehicle emissions was then estimated for each analysis year as shown in **Table 9**. The estimated air quality benefit is low since it does not consider reductions in delays due to existing congestion that would be relieved by the proposed construction.

Table 8 - Region-wide Vehicle Miles Traveled (VMT)

Alternative	Daily VMT			
	Passenger Cars	Single Unit Trucks	Combination Unit Trucks	Total
No-Build	43,322,593	2,125,307	4,121,160	49,569,060
2	43,339,153	2,126,273	4,118,737	49,584,163
4	43,288,919	2,123,460	4,117,146	49,529,525
5	43,289,634	2,122,404	4,112,096	49,524,133
6	43,287,324	2,119,663	4,101,434	49,508,421

Table 9 - Benefit of Reduced Vehicle Emissions

Alternative	Cumulative Benefit			
	2035	2040	2050	2080
2	-$284,000	-$538,000	-$1,099,000	-$3,302,000
4	$1,356,000	$2,571,000	$5,253,000	$15,782,000
5	$1,877,000	$3,559,000	$7,273,000	$21,849,000
6	$3,118,000	$5,911,000	$12,080,000	$36,290,000

Due to the increase in VMT in the region with Alternative 2 compared to the no-build alternative, there is an increase in total vehicle emissions. This results in a negative cumulative benefit for emissions associated with this build alternative. All other alternatives are anticipated to yield a positive benefit due to emissions reductions.

Benefit Cost Comparison

The total benefit of each alternative was then compared to the total cost of the alternative to estimate the B/C ratio. Although the B/C ratio is not the sole determinate of a solution's value, projects are generally considered to be worthwhile when the benefits exceed the cost associated with the project. A summary of the total project costs is shown in **Table 10**. A summary of the cumulative benefits is shown in **Table 11**. A summary of the B/C ratios for the build alternatives is shown in **Table 12** for each of the analysis years.

Table 10 - Cumulative Project Costs

Condition	Alt.	Cumulative Construction, Operations and Maintenance Cost			
		2035	2040	2050	2080
Highway Only	2	$2,924,244,000	$2,931,369,000	$2,950,020,000	$3,068,306,000
	4	$1,442,900,000	$1,446,242,000	$1,454,992,000	$1,510,484,000
	5	$1,359,223,000	$1,361,226,000	$1,366,469,000	$1,399,723,000
	6	$1,701,777,000	$1,704,257,000	$1,710,750,000	$1,751,932,000
Highway and Railroad	2	$5,244,385,000	$5,251,510,000	$5,270,161,000	$5,388,447,000
	4	$2,795,392,000	$2,798,734,000	$2,807,484,000	$2,862,976,000
	5	$2,100,401,000	$2,102,404,000	$2,107,647,000	$2,140,901,000
	6R	$2,762,908,000	$2,765,431,000	$2,772,036,000	$2,813,927,000

Table 11 – Summary of Cumulative Net Benefits

Alternative	Cumulative Net Benefits			
	2035	2040	2050	2080
2	$1,197,299,000	$2,269,794,000	$4,638,382,000	$13,934,952,000
4	$985,399,000	$1,868,083,000	$3,817,476,000	$11,468,726,000
5	$888,950,000	$1,685,239,000	$3,443,828,000	$10,346,190,000
6	$952,197,000	$1,805,140,000	$3,688,849,000	$11,082,298,000

Table 12 - Benefit / Cost Ratio

Condition	Project ID	B/C Ratio by Analysis Year			
		2035	2040	2050	2080
Highway Only	2	0.41	0.77	1.57	4.54
	4	0.68	1.29	2.62	7.59
	5	0.65	1.24	2.52	7.39
	6	0.56	1.06	2.16	6.33
Highway and Railroad	2	0.23	0.43	0.88	2.59
	4	0.35	0.67	1.36	4.01
	5	0.42	0.80	1.63	4.83
	6	0.34	0.65	1.33	3.94

The values in Table 12 show that the user benefits exceed the project costs for the Highway Only Build Alternatives 4, 5, and 6 by 2040. The benefits for the Highway Only Build Alternative 2 exceed the cost by 2050. The benefits estimated as part of this analysis were associated only with the highway users, so the same benefits are used with the Highway Only Build Alternatives as with the Highway and Railroad Build Alternatives. The costs associated with the Highway and Rail Build Alternatives are higher because the rail component was included, but no benefits are estimated for the rail components. Therefore the benefit cost ratios associated with the Highway and Railroad Build Alternatives are lower than the Highway Only Build Alternatives.