



**APPENDIX F**  
**Ferry Service and Travel Costs White Paper**  
**Milton-Madison Bridge Project**  
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## **1.0 Introduction**

The Milton-Madison Bridge over the Ohio River lies along US 421 between Trimble County, Kentucky and Jefferson County, Indiana. It is one of only two bridges between Louisville, Kentucky and Cincinnati, Ohio. The John F. Kennedy Bridge in Louisville is about 46 miles downstream, while the Markland Locks and Dam Bridge is about 26 miles upstream of the US 421 bridge.

Regionally, the communities of Milton, Kentucky and Madison, Indiana are served by US 421 (north-south), Indiana SR 56 (east-west), Indiana SR 62 (east-west), and Kentucky Route 36 (east-west). US 421 serves local transportation needs by providing an Ohio River crossing between Milton and Madison. US 421 also provides a connection to the regional transportation network by reaching surrounding communities in both Kentucky and Indiana and by stretching between Interstate 71 to the south and Interstate 74 to the north. The bridge serves a vital role to residents within the communities by providing access to health services, employment, retail, and services, allowing the transfer of goods, and supporting tourism in the region.

The proposed project recommends replacing the existing truss superstructure with a new, wider superstructure similar in appearance to the existing. In the Proposed Action, minor widening within the existing rights of way would occur to the roadways approaching the bridge to transition from the widened bridge width back to the existing lane width. The footprint for this alternative in Indiana and Kentucky is entirely contained within the existing right-of-way. The Proposed Action could be constructed by February 2012. It would require that the bridge be closed for up to 12 months during construction. To preserve community connectivity, a ferry between Milton and Madison would be provided during the closure period. The Markland Dam Bridge would be the nearest river crossing which could be used to provide a detour route during the closure of the bridge.

In order to assess the monetized travel efficiency (dis)benefits on motorists due to adverse travel and delay resulting from the proposed project, a traffic and trip choice evaluation was conducted. In addition, ferry service was evaluated to determine if and to what extent ferry service could offset these impacts.

## **2.0 Methodology**

To create a framework for analysis, the Kentucky Statewide Travel Demand Model (KYSTM) and Indiana Statewide Travel Demand Model (INSTM) were combined into a single detailed regional model. The model captures existing infrastructure, socioeconomic data, and travel patterns from 2007. Model results were compared against observed traffic volumes in the study area to ensure results are reasonable and accurate. The travel demand model is described in more detail in the *2008 Milton-Madison Travel Demand Model White Paper*.

In addition to the travel demand model, an extensive data collection effort was undertaken in 2008. This included an origin-destination survey for the Milton-Madison Bridge, peak hour turning movement counts at more than 20 intersections, and several multi-day traffic counts including a seven day count on the bridge. The data collection effort is detailed in the *Needs and Deficiencies Report*. As detailed in the *Needs and Deficiencies Report*, a bridge AADT was derived for 2007, 2008, and 2030, the first and latter years corresponding to the model years. Given the Milton-Madison Bridge is expected to be closed during 2011, a AADT was interpolated for this year. The forecasted 2011 AADT is 11,100 vehicles.

The 2011 forecasted volume was broken down into commercial and passenger vehicles. For commercial vehicles, two percent of the total volume was assigned as heavy trucks and two percent as light trucks. This is consistent with previous data collection prior to the weight restriction being placed on the Milton-Madison Bridge. Passenger volume was broken down into three categories: business/work, commuter, and recreational/other. The distribution percentages were 6.1, 26.9, and 67.0 percent, respectively. This was consistent with assumptions used in the travel demand modeling.

In order to better understand trip origins and destinations, the origin and destination survey was reviewed. In addition, a select link analysis was conducted to determine the origins and destinations for all trips using the bridge. This was important to understand the likelihood of motorists diverting to an alternative river crossing.

To better understand ferry operations, two existing Ohio River ferries were observed. This helped to understand the amount of time required to load/unload and to navigate the river width. These results are presented in the following sections.

### **3.0 Ferry Service**

To maintain traffic service between Milton and Madison during the Milton-Madison Bridge closure, ferry service has been proposed between the Milton boat launching ramp located at Ferry Street in Milton and a former boat launching ramp located at Ferry Street near the City of Madison campground. Both of these boat launching ramps are located upstream and east of the existing bridge. In the following discussion, preliminary capacity and cost estimates are presented.

#### **3.1 Ferry Service Capacity**

As part of the data collection process, two Ohio River ferries were observed. The Old Augusta Ferry crosses the Ohio River at Augusta, Kentucky. The distance across the river at this location is approximately 2,000 feet. Based on conversations with the operator, it takes five to six minutes to cross in normal conditions. In rougher currents, this can extend to as much as ten minutes per direction. The Anderson Ferry in northern Kentucky has a crossing distance of approximately 1,750 feet. Based on observation, it also takes five to six minutes to cross. On average, it took 15 seconds per car to load

and unload. Based on conversation with the operator, the Anderson Ferry is closed only four to five days a year, typically due to high winds.

To estimate the capacity of the proposed Milton-Madison Ferry, the above information was applied to the proposed Milton-Madison crossing, estimated to be approximately 2,200 feet. **Table 1** illustrates the hourly capacity of a ferry based on size. For the purposes of this calculation, a six minute crossing time and 15 seconds total per vehicle loading and unloading time were assumed. As illustrated in the table, the larger the ferry, the smaller the incremental increase in hourly capacity. To further illustrate the point, you would need to either operate two 24-car capacity ferries or three 12-car capacity ferries to achieve 240 vehicles per hour (total for both directions).

For the purposes of the traffic and (dis)benefit calculations presented in the following sections, an assumed capacity of 240 vehicles per hour was used. This represents a mid-range value consistent with previous ferry capacities discussed above.

### **3.2 Ferry Service Preliminary Cost**

To determine a budgeting cost for providing ferry service, capital and operating and maintenance cost were estimated. Costs are based on two vessels running two eight hour shifts and then a single vessel running the remaining eight hour shift. For the weekend, a single vessel would operate; however, a second vessel and crew could be added as needed. The results are presented in **Table 2**.

**Table 1  
Ferry Hourly Capacity Based on Size**

Ferry Size	Per Trip			Trips/Hour	Capacity/Hour (vehicles)
	Load/Unload Time (sec.)	Time in Water (sec.)	Total Time (sec.)		
12	180	360	540	6.67	80
15	225	360	585	6.15	92
18	270	360	630	5.71	103
21	315	360	675	5.33	112
24	360	360	720	5.00	120
27	405	360	765	4.71	127
30	450	360	810	4.44	133
33	495	360	855	4.21	139
36	540	360	900	4.00	144
39	585	360	945	3.81	149
42	630	360	990	3.64	153
45	675	360	1035	3.48	157
48	720	360	1080	3.33	160
51	765	360	1125	3.20	163
54	810	360	1170	3.08	166
57	855	360	1215	2.96	169
60	900	360	1260	2.86	171
63	945	360	1305	2.76	174
66	990	360	1350	2.67	176
69	1035	360	1395	2.58	178
72	1080	360	1440	2.50	180
75	1125	360	1485	2.42	182

**Table 2  
Estimate of Costs for Ferry Operation**

<b>Capital</b>							<b>Initial Cost</b>		<b>Salvage</b>		<b>Total</b>	
Vessel #1 - 24 Car Cap, Net of Disposal							\$450,000	(used)	\$100,000		\$ 350,000	
Vessel #2 - 24 Car Cap, Net of Disposal							\$450,000	(used)	\$100,000		\$ 350,000	
South Dock & Ramp											\$ 200,000	
South Loading Area											\$ 150,000	
South Roadways & Signage											\$ 25,000	
North Dock & Ramp											\$ 250,000	
North Loading Area											\$ 100,000	
North Roadways & Signage											\$ 25,000	
Waterway Markings											\$ 10,000	
									<b>Total Capital</b>		\$1,460,000	
<b>Operating &amp; Maintenance</b>		<b>Time</b>	<b>Crew Rate per Hour</b>	<b>Hrs/day incl. overlap</b>	<b>days/wk</b>	<b>wks/yr</b>	<b>Total</b>					
3-man Crew V1, Shift #1		5A-1P M-F	\$ 150.00	9	5	52	\$ 351,000					
3-man Crew V2, Shift #1		5A-1P M-F	\$ 150.00	9	5	52	\$ 351,000					
3-man Crew V1, Shift #2		1P-9P M-F	\$ 150.00	9	5	52	\$ 351,000					
3-man Crew V2, Shift #2		1P-9P M-F	\$ 150.00	9	5	52	\$ 351,000					
3-man Crew, V1, Shift #3		9P-5A M-F	\$ 150.00	9	5	52	\$ 351,000					
3-man Crew V2, Shift #3		9P-5A M-F	reserved									
3-man Crew Saturday		24 hrs	\$ 150.00	26	1	52	\$ 202,800					
3-man Crew Saturday peak		Sat peak	reserved									
3-man Crew Sunday		24 hrs	\$ 150.00	26	1	52	\$ 202,800					
3-man Crew Sunday peak		Sun peak	reserved									
Vessel Maintenance		8core+oncall	100	10	5	52	\$ 260,000					
Licensing			\$ 50,000									
Insurance			\$ 50,000	(estimated)			\$ 50,000					
							<b>Total O&amp;M</b>		\$2,470,600			
							<b>Total Cost</b>		\$3,930,600			
							20% Contingency		\$ 786,120			
							<b>Total Estimate</b>		\$4,716,720			

## ***4.0 Ferry Queue Analysis and Unmet Demand***

In order to calculate demand for the ferry operation, hourly volumes needed to be derived and several adjustments taken to account for heavy trucks, diverted trips, forgone trips, ridesharing opportunities, and length of time a motorist is willing to wait for a ferry.

### **4.1 2011 Forecasted Bridge Volume**

Using the 2007, 2008, and 2030 daily traffic counts derived for the Milton-Madison Bridge, 2011 hourly volumes were interpolated. Because the 2008 count was conducted prior to the weight restriction being placed on the bridge, a peak hour count was conducted in September 2009 for validation purposes. As expected, heavy trucks were significantly reduced, while passenger vehicles and light trucks were consistent with previous counts. The 2011 volumes are assumed to include heavy trucks and will be accounted for through an adjustment factor. The 2011 volumes are presented in **Table 3**.

### **4.2 Adjustment Factors**

Adjustments factors for heavy trucks, diverted trips, forgone trips, ridesharing opportunities, and length of time a motorist is willing to wait for a ferry were all considered as part of establishing a reasonable demand for the ferry operation and whether this demand could be met. Each adjustment is presented in the following sections.

#### ***4.2.1 Heavy Trucks***

The 2011 bridge volume is based on analysis conducted prior to the weight limit being placed on the Milton-Madison Bridge. It is also assumed at this time that heavy trucks will not be allowed on the ferries. It should be noted they are not restricted from other Kentucky ferry operations including the Anderson Ferry. Based on traffic counts conducted in 2008, a heavy truck volume of two percent was observed on the bridge. As a result the bridge volumes presented in **Table 3** were lowered by two percent and these trips were assumed to divert around to other bridge locations.

**Table 3  
2011 Forecasted Milton-Madison Bridge Volumes**

Time		2011 Volumes		
		Northbound	Southbound	Total
12-1	AM	37	44	81
1-2	AM	28	35	63
2-3	AM	18	23	41
3-4	AM	23	27	51
4-5	AM	45	48	93
5-6	AM	136	182	318
6-7	AM	195	292	487
7-8	AM	254	232	486
8-9	AM	239	189	428
9-10	AM	294	239	533
10-11	AM	326	279	605
11-12	AM	357	340	697
12-1	PM	379	362	741
1-2	PM	353	381	734
2-3	PM	357	387	744
3-4	PM	432	422	854
4-5	PM	444	444	888
5-6	PM	407	434	841
6-7	PM	423	290	713
7-8	PM	291	277	568
8-9	PM	207	237	443
9-10	PM	140	188	328
10-11	PM	102	112	214
11-12	PM	63	84	147
Total		5,550	5,550	11,100

#### *4.2.2 Divert to Markland Dam or Other River Crossing*

A select link analysis was conducted within the project travel demand model to determine origins and destinations for trips. Consistent with the results of the Origin-Destination Survey conducted in 2008, the majority of the trips are local in nature; therefore, the preferred route would be the Milton-Madison Bridge. However, some origins and destinations are outside the immediate areas of Trimble County, Kentucky and Jefferson County, Indiana; therefore, motorists could experience adverse travel of less than 15 miles and/or 15 minutes based on their choice of route. In this case, motorists would more likely consider alternate routes such as Markland Dam, because delay at the ferry would likely exceed 15 minutes, particularly during peak periods. An initial reduction of 20 percent was taken based on modeling results and some known commuter patterns. A sensitivity analysis, presented in a later section, was also conducted to understand how changes to this value impact the overall analysis.

#### *4.2.3 Not Make Trip or Divert to Another City*

It is anticipated that a number of motorist will choose to make trips less often, not make a trip at all, or divert to another city that doesn't require a bridge crossing. For example, residents of Milton may choose to visit Carrollton or Bedford for shopping instead of completing the longer trip time to reach Madison. As a result, an adjustment factor was applied to account for this reduction. This reduction factor was applied to only non-business and non-commuter trips (also known as recreational/other). These account for 67 percent of all automobile trips. An initial reduction of 20 percent was taken for both "not make trip" and "divert to another city" categories. As with the diversion category above, a sensitivity analysis was conducted to understand the potential range of impact.

#### *4.2.4 Ridesharing*

Ridesharing, particularly among commuter trips, would help to reduce vehicle demand and delay times for the ferry service. Parking will be provided at or near the ferry docks to accommodate this. For the purposes of this analysis, 20 percent of all commuters are assumed to participate in ridesharing. Commuters represent approximately 27 percent of all automobile traffic on the bridge. For those commuters participating in ridesharing, three of every four vehicles will be removed from the ferry queue and some of these will need to be accommodated at park-n-ride facilities located in the communities.

#### *4.2.5 Wait Time*

Assuming a two-ferry operation handling 24 cars per ferry, preliminary analysis showed that the ferry service would be unable to accommodate demand during the peak periods. As a result, it was important to understand how long a motorist was willing to wait for the ferry. An initial assumption of one hour was used for calculation purposes to estimate resulting ferry queues. This means no more than 120 vehicles would queue per direction assuming a 240 vehicle per hour operation. This is a conservative estimate meant to represent an equivalent to or greater than the approximate detour time. A

sensitivity analysis was conducted for wait time and is presented in a later section. Also, as part of upcoming public involvement, participants will be polled on how long they would be willing to wait for the ferry to further adjust assumptions.

### **4.3 Ferry Queue and Unmet Demand**

A set of adjusted hourly volumes were generated based on the adjustment factors presented in the previous section. These were then compared to ferry capacity to determine the anticipated ferry queue and unmet demand. Ferry capacity was assumed to be 60 cars per direction between 9 PM and 5 AM and 120 cars per direction for the remainder of the day. That is based on a two-ferry operation for two shifts and a single ferry for a third shift. The results are presented in **Table 4**.

As illustrated in **Table 4**, the analysis results in an unmet demand of approximately 1,750 vehicles per day. Furthermore, approximately 2,200 vehicles would not make the trip or would divert to another location and 450 would rideshare. This means the ferry will serve approximately 4,400 cars per day compared to a capacity of 4,800. The ferry operation would run at capacity for more than 18 hours per day.

### **4.4 Minimize Unmet Demand**

The previous assumptions are considered conservative estimates, but clearly illustrate a two-ferry system unable to meet demand. In order to better understand how travel patterns would have to change to generate no unmet demand, several scenarios were tested. **Table 5** illustrates the percentage of motorists that would need to choose each option to accommodate the unmet demand assuming a maximum wait time of 60 minutes and a ferry system capacity of 240 cars per hour. For example, in Scenario 1, approximately 3,000 vehicles would divert to another river crossing, while approximately 3,900 vehicles would use the ferry. The remaining 4,200 vehicles would either not make the trip or divert to another destination. In contrast, Scenario 3 shows a smaller percentage either diverting to another destination or not making the trip resulting in a higher utilization of the ferry.

As a result, each scenario presented in **Table 5** identifies the various shifts in travel behavior that would need to occur to result in no unmet demand.

**Table 4  
Ferry Queue and Unmet Demand**

Time		2011 Adjusted Volumes			Northbound		Southbound	
		North-bound	South-bound	Total	Queue	Unmet Demand	Queue	Unmet Demand
12-1	AM	20	24	45	0	0	0	0
1-2	AM	15	20	35	0	0	0	0
2-3	AM	10	13	23	0	0	0	0
3-4	AM	13	15	28	0	0	0	0
4-5	AM	25	26	51	0	0	0	0
5-6	AM	75	101	176	0	0	0	0
6-7	AM	108	161	269	0	0	41	0
7-8	AM	141	128	269	21	0	50	0
8-9	AM	132	105	237	33	0	34	0
9-10	AM	163	132	295	75	0	46	0
10-11	AM	180	154	334	120	15	80	0
11-12	AM	198	188	385	120	78	120	28
12-1	PM	209	200	409	120	89	120	80
1-2	PM	195	211	406	120	75	120	91
2-3	PM	197	214	411	120	77	120	94
3-4	PM	239	233	472	120	119	120	113
4-5	PM	245	246	491	120	125	120	126
5-6	PM	225	240	465	120	105	120	120
6-7	PM	234	160	394	120	114	120	40
7-8	PM	161	153	314	120	41	120	33
8-9	PM	114	131	245	60	54	60	71
9-10	PM	78	104	181	60	18	60	44
10-11	PM	56	62	118	56	0	60	2
11-12	PM	35	46	81	31	0	60	0
Total		3,068	3,068	6,135		910		842

<b>Table 5 Scenarios to Eliminate Unmet Demand</b>					
Scenario	Divert to Alternative River Crossing	Not Make the Trip	Divert to Another Location	Utilize Ferry	
				Rideshare	Other
1	27%	19%	19%	4%	31%
2	27%	16%	19%	6%	32%
3	31%	15%	15%	6%	33%
4	37%	14%	12%	4%	33%
5	37%	12%	14%	4%	33%

## **5.0 Travel Costs to Motorist**

The Milton-Madison Bridge is expected to be closed for approximately one year and the closure will take place in early 2011. To understand how motorists will be affected by the closure, travel costs were calculated with and without ferry service using the assumptions presented in the following sections.

### **5.1 Vehicle Miles of Travel and Vehicle Hours of Travel**

In order to calculate travel cost, traffic volumes first need to be converted to vehicle miles of travel (VMT) and vehicle hours of travel (VHT). Based on the adjustment factors presented in **Section 4.2**, volumes were derived for each component including unmet demand presented in **Table 4**. These volumes were then multiplied by the expected adverse travel in terms of miles and time as presented in **Table 6**. The result was adverse VMT and VHT by category.

For example, there is an assumed 222 heavy truck demand (2% of 11,100) for the Milton-Madison Bridge per day. Based on the travel demand model, adverse travel for heavy trucks is 21.3 miles and 23 minutes. Therefore, the adverse vehicle-miles of travel is 4,729 and vehicle-hours of travel is 85.

<b>Table 6 Adverse Travel by Trip Type</b>		
<b>Adverse Travel</b>	<b>Miles</b>	<b>Minutes</b>
Heavy Truck <sup>1</sup>	21	23
Diverted Trip <sup>2</sup>	20	25
Not Make Trip <sup>3</sup>	0	0
Divert to Another City <sup>4</sup>	20	25
Ferry and Rideshare <sup>5</sup>	0	60

1) Adverse travel based on Travel Demand Model

2) Assumed value based on various diversion routes

3) Given the difficulty in determining time and distance saved, have assumed zero to represent a worst case.

4) Assumed value and matches diverted trip assumptions

5) Adverse time based on length of time a motorist is willing to wait

## 5.2 Calculation Factors and Conversion Rates

In order to convert VMT and VHT to a dollar component, a number of factors had to be established, including time, vehicle operating cost, safety, and environmental components. They are presented in **Table 7**, and sourced as appropriate. Based on these factors, the conversion rates presented in **Table 8** were derived. The conversion rates were then applied to VMT and VHT and resulted in a daily travel cost of \$210,000. These results are presented in **Table 9**.

Continuing with the previous example defined in **Section 5.1**, heavy truck VMT of 4,729 was multiplied by \$1.72/VMT resulting in travel cost associated with vehicle operating, safety, and environmental costs of approximately \$8,000 as illustrated in **Table 9**. Applying a separate rate to VHT yields a travel cost associated to adverse travel time. This value totals \$4,000 and the combination results in a \$12,000 daily impact to heavy commercial vehicles. A similar calculation is conducted for the four other trip types to yield an overall travel cost.

VMT and VHT were also derived assuming no ferry service was provided. The adverse travel presented in **Table 6** was adjusted to reflect that all diverted and ferry and rideshare trips would experience similar adverse travel of 44 miles and 23 minutes. These values were derived from the travel demand model and are not meant to directly correlate to each other because of the different speeds for the various routes. Instead the numbers represent an average across all trips regardless of trip origin and destination, trip length or trip speed. A recalculation of the results shows a daily travel cost of \$387,000. With all other factors equal, the ferry service contributes \$177,000 savings daily.

Table 7 Calculation Factors				
	Travel Efficiency Component	Unit Measure	Vehicle Category	
			Passenger	Commercial
Travel Time Costs				
	Vehicle Occupancy			
1	Business/Work	person/vehicle	1.2	NA
1	Commuting	person/vehicle	1.2	NA
1	Recreational/Other	person/vehicle	2.2	NA
	Operating Crew	person/vehicle	NA	1.0
	Logistics/Freight	tons/vehicle	NA	12.0
Valuation of Time				
2	Business/Work	2008\$/person	\$17.83	NA
2	Commuting	2008\$/person	\$8.91	NA
2	Recreational/Other	2008\$/person	\$8.91	NA
2	Operating Crew	2008\$/person	NA	\$15.77
	Logistics/Freight	2008\$/ton	NA	\$2.13
Vehicle Operating Cost (VOC) (based on speeds)				
3	Fuel Consumption	gallons/VMT	0.033	0.264
Fuel Price				
4	Gasoline	2008\$/gallon	\$3.32	NA
4	Diesel	2008\$/gallon	NA	\$3.80
5	Non-Fuel Operating Cost	2008\$/VMT	\$0.47	\$0.57
Safety Costs				
Accident Rates				
6	Fatality	per 100M VMT	1.5	0.4
6	Personal Injury	per 100M VMT	90.0	12.0
6	Property Damage	per 100M VMT	206.0	198.0
Accident Costs				
7	Fatality	2008\$/accident	\$4,504,031.05	\$4,504,031.05
7	Personal Injury	2008\$/accident	\$98,566.65	\$98,566.65
7	Property Damage	2008\$/accident	\$5,105.52	\$5,105.52
Environmental Costs (based on speeds)				
*	Damage Cost	2008\$/VMT	\$0.02	\$0.04/\$0.11

<sup>1</sup> Highway Economic Requirements System (HERS), 2000: FHWA

<sup>2</sup> Bureau of Labor Statistics, Occupational Employment Statistics

<sup>3</sup> California Life Cycle Benefit/Cost Analysis Model

<sup>4</sup> Energy Information Administration, Annual Energy Review

<sup>5</sup> AAA "Your Driving Costs", and 2008 Edition and Berwick and Farooq (2003)

<sup>6</sup> Bureau of Transportation Statistics 2007

<sup>7</sup> USDOT, NHTSA, The Economic Impact of Motor Vehicle Crashes, 2002

\* Note: numbers for single unit and combination vehicles, respectively

<b>Table 8 Vehicle Miles of Travel and Vehicle Hours of Travel Conversion Rates</b>		
<b>Trip Type</b>	<b>Unit Measure</b>	<b>Conversion Rate</b>
Passenger		
Business/Work	2008\$/VHT	\$21.40
Commuting	2008\$/VHT	\$10.69
Recreational/Other	2008\$/VHT	\$19.60
Commercial	2008\$/VHT	\$41.33
Passenger	2008\$/VMT	\$0.77
Commercial		
Single Unit (light)	2008\$/VMT	\$1.65
Combination (heavy)	2008\$/VMT	\$1.72

<b>Table 9 2011 Daily Travel Costs for Motorists with Ferry Service</b>			
<b>Trip Type</b>	<b>Travel Costs</b>		
	<b>Travel Time</b>	<b>Vehicle Operating/ Safety/ Environmental</b>	<b>Daily Total</b>
<b>Passenger</b>	<b>\$110,000</b>	<b>\$77,000</b>	<b>\$187,000</b>
Business/Work	\$11,000	\$4,000	\$15,000
Commuting	\$24,000	\$16,000	\$40,000
Recreational/Other	\$75,000	\$57,000	\$132,000
<b>Commercial</b>	<b>\$10,000</b>	<b>\$13,000</b>	<b>\$23,000</b>
Single Unit (light)	\$6,000	\$5,000	\$11,000
Combination (heavy)	\$4,000	\$8,000	\$12,000
<b>Total</b>	<b>\$120,000</b>	<b>\$90,000</b>	<b>\$210,000</b>

### 5.3 Sensitivity Analysis

The values presented in the previous sections are based on several assumptions that are difficult to confirm without an extensive understanding of origins and destinations, purpose of the trips, urgency of the trip and the decision-making parameters and expectations of the drivers. Therefore, it is important to understand how changes in these assumptions impact the range of results. A sensitivity analysis was conducted to illustrate these expected variations.

The first parameter tested was the time a motorist is willing to wait. All other factors were held constant. The longer a motorist is willing to wait, the smaller the unmet demand, but the larger the daily travel cost. A longer wait time results in a longer queue. For example, between 7am and 8 am, a 20-minute wait time results in a queue of 40 vehicles and an unmet demand of 73 vehicles. A 30-minute wait time during the same time period results in a 60 vehicle queue and an unmet demand of 53 vehicles. Because the ferry operates at capacity for the remainder of the day, the unmet demand is unchanged for each scenario; therefore, the unmet demand decreased by 20 vehicles for an increase in wait time of 10 minutes. Travel cost increase because the additional wait time is applied to all vehicles using the ferry.

The next parameters tested were the percent not willing to make the trip and the percent that would divert to another destination such as Carrollton, Kentucky. These parameters were tested in unison. As the percentage increased, both the unmet demand and daily travel cost decreased in a proportional pattern. With all other factors equal, both parameters would have to be 45 percent of all commercial trips to yield zero unmet demand. This would result in a daily travel cost of \$179,000 compared to the base case that resulted in a daily travel cost of \$210,000.

The final parameter tested was the percent willing to rideshare. Ranges between zero and 50 percent of all commuting trips were tested. While unmet demand decreased from 2,058 to 1,296 motorists across the range, the daily travel cost only decreased from \$211,000 to \$207,000 across the range. This is because all motorists were still waiting in significant queues, which offset their vehicle-miles of travel savings.

As another test of the changes in daily travel cost, the scenarios in **Table 5** were evaluated. Each scenario results in a decrease of daily travel cost when compared to the base case. However, the more motorists that divert to another location or choose to not make a trip, the lower the daily travel cost. This is illustrated in **Table 10**. The drawback would be the economic shift resulting from motorist diverting from businesses in Trimble County, Kentucky and Jefferson County, Indiana to do business in other locations. This point is explored in a separate economic analysis not covered by the scope of this white paper.

Each scenario presented in **Table 10** assumes a constant wait time of 60 minutes. As noted above, a decrease in wait time will result in an increase in unmet demand. However, a decrease in wait time results in a significant decrease in travel cost. For example, a reduction in wait time from 60 minutes to 40 minutes has a minimum impact

on unmet demand, while travel costs are reduced from \$188 million to \$169 million. A reduction of an additional 10 minutes results in unmet demand of 19 vehicles daily, but further reduces travel cost by \$10 million daily.

Table 10 Change to Daily Travel Cost						
Scenario	Divert to Alternative River Crossing	Not Make the Trip	Divert to Another Location	Utilize Ferry		Daily Travel Cost (\$1,000)
				Ridesharing	Other	
1	27%	19%	19%	4%	31%	\$188
2	27%	16%	19%	6%	32%	\$193
3	31%	15%	15%	6%	33%	\$197
4	37%	14%	12%	4%	33%	\$201
5	37%	12%	14%	4%	33%	\$206

## 6.0 Conclusions

Two ferries, each handling 24 cars per trip, would handle 240 cars per hour or 4,800 cars per day assuming both run two eight hour shifts and then a single ferry operates during the third eight hour shift. The preliminary cost estimate for the ferry service is \$4.7 million. This estimate will continue to be modified as the design and operations are detailed. The 2011 traffic forecast for the Milton-Madison Bridge is 11,100 vehicles per day. This estimate is based on volumes collected prior to the weight restriction being placed on the bridge. The analysis included in this report evaluated several adjustment factors including motorists diverting to another river crossing, choosing not to make the trip, choosing an alternate location, and participating in ridesharing opportunities. Each was estimated based on model results and local knowledge of the study area. Understanding the adjustment factors are only estimates and open to debate, a sensitivity analysis was conducted.

Under most reasonable scenarios, the ferry will operate at capacity the majority of the day. Capacity will be dictated by the length of time motorists are willing to wait and the loading dock will be designed accordingly. For the purposes of this analysis, a conservative estimate of 60 minutes was used. Because the ferry service will operate at or near capacity regardless of wait time, the longer a motorist is willing to wait, the higher the daily travel cost.

Using a conservative set of diversion assumptions, the daily travel cost during the bridge closure period with a ferry service was estimated at approximately \$210,000. Using a comparable set of assumptions, the analysis was conducted assuming the ferry service was not provided and the resulting daily travel cost was \$387,000. This shows a significant benefit for having a ferry service provided to maintain cross river mobility between Milton and Madison. However, as noted above, the ferry service is expected to operate at capacity and potentially result in unmet demand.

Initially it will be difficult to estimate the number of motorists diverting to another crossing location, choosing to not make their desired trip, or diverting to another destination. A balancing of the system will naturally occur over the first few weeks of operation. It will be important to over design vehicle storage initially to accommodate long queues and prevent spillback onto the surrounding roadway network. After a few weeks of operation, motorists will determine their best personal option for each trip in order to minimize their wait times. As this balance occurs, queues resulting from the ferry operation will likely decrease. One factor that can be influenced initially is ridesharing. While the sensitivity analysis showed this option to have the least impact on reducing unmet demand and daily travel cost, there are positive gains from this low-cost option. The benefits of this option will be maximized by minimizing the wait for those motorists choosing this option. This could be accomplished through utilization of high occupancy wait lanes and priority ferry boarding to those choosing to rideshare.

As noted above, based on the proposed two ferry operation and a conservative set of diversion assumptions for traffic using the bridge, the ferry service is expected to have an unmet demand that will create wait times over an hour. To understand how this resulting unmet demand could be completely eliminated resulting in a balanced system where demand for the ferry does not exceed the capacity of the ferry, several scenarios were tested. These are described in **Section 4.4, Table 5**. The scenarios in this table illustrate the percentage of motorists that would need to make a decision to choose another option to meet their trip purpose (e.g. divert to another river crossing, not make the trip, divert to another location, rideshare, use ferry). These scenarios in Table 5 are not all-inclusive but intended to illustrate the shift in trip decision-making necessary to accommodate the unmet demand (assuming a maximum wait time of 60 minutes and a ferry system capacity of 240 cars per hour). Each scenario tested showed that between 20 and 40 percent of the total volume would either not make their desired trip or divert to another location. The drawback in this increase would be the economic shift resulting from motorist diverting from businesses in Trimble County, Kentucky and Jefferson County, Indiana to do business in other locations in the region that is more convenient. This point is explored in the separate economic analysis for the impacts of the closure of the Milton Madison Bridge and is not included in this white paper. (This economic analysis may be found in **Appendix A** of the *Socioeconomic Baseline Report*.) The ferries would be at or near capacity the majority of the day and the remainder of the motorists would choose to either divert around using Markland Dam or use another Ohio River crossing to reach their desired location. Each of the scenarios in **Table 5** were tested and resulted in a decrease in travel cost to motorist.