Economic Development
RESEARCH GROUP

TO: Bradley Davis, Hamilton County, IN

FROM: Chandler Duncan, EDR Group

DATE: 30 April, 2015

cc:

RE: Cost Benefit Ratio for State Route 37 Roundabout Interchange Improvements

The benefit to cost ratio of 2.2 (in constant dollars) and 2.7 (in inflated dollars) for the State Route 37 Roundabout Interchange Improvements in Hamilton County is well within the range of expected benefit to cost ratios for economically successful projects EDR Group has analyzed throughout the country. For example, this ratio would exceed the requirements of the Transportation Investment Generating Economic Recovery (TIGER) funding. The lowest ratios tend to accompany very large projects (of $ Billion or more) for which it is often difficult to quantify enough societal benefits to cover the cost, and we have seen ratios often are in the 1.0 – 2.0 range. The highest ratios tend to accompany very small projects that often have very small expenditures of less than $100 Million and fully resolve an obvious safety or congestion problem with minimal effort (for these projects we have seen ratios in the 5.0 – 10.0 range). The 2.2-2.7 range observed for State Route 37 is quite reasonable for a project of its size, and is well substantiated by the transportation performance characteristics of the project. The one feature of the project that is notable relative to others we have seen is the efficiency with which the roundabout design is expected to resolve congestion (which would otherwise have affected 81% of peak period traffic by year 25). As described in the report, if this performance can be achieved as anticipated by the engineering analysis, the corridor should have no difficulty achieving or exceeding the travel time, reliability and operating economic benefit and impact levels shown by the current economic analysis.

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Economic Development
RESEARCH GROUP

Economic Impact of State Route 37 Roundabout Interchange Improvements: Final Report

Prepared for:

Hamilton County Board of Commissioners
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Prepared by:

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EXECUTIVE SUMMARY

Hamilton County, Indiana, is considering an improvement to 9 intersections on State Route 37 (SR 37) between Fishers and Noblesville. This 5.7 mile stretch of improvements involves the conversion of traditional signalized intersections to continuous flow roundabout interchanges.

Figure 1. Map of Region for Proposed Improvements

Source: ESRI Basemap used by EDR Group; Hamilton County

These roundabouts are anticipated to improve the transportation performance of the corridor through improved travel time, reduced congestion, and enhanced safety. They will reduce total vehicle-hours traveled (VHT) along the corridor by 957 thousand hours per year by the 25th year from inception, while eliminating the conditions in which traffic incurs the

SR 37 Roundabout Interchanges by the Numbers

2.70
Benefit-Cost Ratio

957,299 Hours
Total annual hours of travel time savings

$510.5 Million
Value of total benefits from the project.

$889 Million
Cumulative change to regional output, or business sales from in 25 years.

$490 Million
Cumulative change to value added, or GRP.

$360 Million
Cumulative change to employee wages.

640 jobs
Jobs generated during peak-construction spending in the fourth year after inception.

184 jobs
Permanent Long-term jobs created cumulatively by 2040

cost of "congested[1]" travel conditions (currently which would otherwise affect 81% of traffic on the corridor by the 25th year after inception).

The transportation enhancements translate into substantial economic benefits (e.g., reduced travel times, improved reliability, lower vehicle operating costs, reduced crashes and reduced emissions, valued at a total of $510.5 Million in present value terms). When compared to total project costs, the project has a benefit-cost ratio of 2.7 (in present value terms).

Finally, the project is anticipated to have impacts on the regional economy, with the $510.5 Million worth of benefits (in addition to the spending of construction outlays) stimulating $889 Million in new cumulative output (business sales) in the first 25 years after project inception. As a result of the project, in the same 25 year period, the gross regional product (GRP, or value added) is expected to increase cumulatively by $440 Million, of which $360 Million is expected to be experienced in terms of additional employee wages. Construction of the project is anticipated to generate 640 jobs in the fourth year after inception (the peak of construction). Once constructed, the transportation performance benefit of the project is expected to continue to generate and sustain 132 permanent jobs by the seventh year after inception rising to 184 permanent jobs by year 25[2].

[1] Congestion for the purposes of this study is defined as a level of service of "D" or below. This is a level of performance at which fuel efficiency, vehicle operating costs and reliability are known to incur significantly higher costs than in uncongested conditions.

[2] Analysis assumes a compound annual traffic growth rate of 1.7%

PROJECT DESCRIPTION

Hamilton County, Indiana, is located just north of Indianapolis, and it is included in the Indianapolis-Carmel-Anderson, IN Metropolitan Statistical Area. From 2000 to 2007, it was the fastest growing county in Indiana, and it is home to three of the state's 20 largest cities: Carmel, Fishers, and Noblesville (the county seat).

The County is considering an improvement to nine intersections along an approximately 5.7 mile stretch of SR 37 between Fishers and Noblesville (Figure 2). The first intersection is at 126th St (just north of I-69) and the final intersection is at SR 32 in Noblesville. These intersections will be improved from standard signalized intersections to continuous flow roundabout interchanges.

Figure 2. State Road 37 Proposed Roundabout Interchanges, Hamilton County, IN

Source: ESRI Basemap used by EDR Group; Hamilton County.

TRANSPORTATION PERFORMANCE

The intent of the conversion of signalized intersections to roundabout interchanges is two-fold. First, roundabout interchanges allow continuous traffic flow and thus reduce delay and congestion on both SR 37 and on the side streets, especially when several roundabout interchanges are implemented in sequence along a corridor. Secondly, roundabout interchanges eliminate the conflicts that cause high-impact crashes at current at-grade signalized intersections, and thus improve safety conditions by reducing the severity of collisions. The transportation performance metrics, including safety improvements, were based on a combination of engineering estimates and observed traffic data experienced with similar improvements implemented on Keystone Parkway.

Travel Times and Congestion

The Hamilton County Highway Department assessed each of the nine intersections based on turning movement data and micro-simulation modeling. Data for both automobiles and freight trucks were provided and estimated for project conditions.

Overall, the conversion to roundabout interchanges is not expected to have an impact on the number of trips in the corridor, or in the vehicle miles of travel (VMT) seen along this corridor.

There are two critical areas where the roundabout interchanges are anticipated to impact traffic conditions by the 25th year from inception (Table 1). First, total travel times are anticipated to decrease for both cars and trucks. The travel time improvements are significant. For trucks, the corridor would save over 48,989 hours per year, or a reduction in travel times of about 41%. Cars would see a reduction of 908,310 hours per year, or a reduction in total travel time of 42%—relative to baseline conditions. In total, the network saves over 957,299 hours of travel time per year, or a savings of 42% of travel time.

Table 1. Transportation Performance Impacts of Hamilton County Roundabout Interchanges on SR 37

Scenario	Traffic Type	Trips	VHT	Percent Congested
Base	Truck	126,785	118,138	81%
	Car	1,952,340	2,123,522	81%
	Total	2,079,125	2,241,660	81%
Project	Truck	126,785	69,149	-
	Car	1,952,340	1,215,212	-
	Total	2,079,125	1,284,361	-
Difference	Truck	-	-48,989	-
	Car	-	-908,310	-
	Total	-	-957,299	-

Source: EDR Group; Hamilton County.

Travel time savings are the result of the continuous flow through roundabout interchanges. Furthermore, by placing several roundabouts in series along a corridor, there are synergistic effects that allow traffic to continue to flow less impeded than if the traffic encountered a stop light.

This is very much also related to congestion, defined in traffic engineering terms as an intersection level of service of "D" or worse, and in economic terms as "stop-and-go" conditions imposing the fuel consumption, vehicle operating costs and unreliable time allowances required when using a facility with demand exceeding capacity. Under existing conditions, 81% of peak period travel time through this corridor is experienced under congested conditions. The roundabout interchange project would allow for continuous throughput and therefore reduce congestion – eliminating the experience of congested conditions due to the stop-and-go nature of intersections. In the project scenario, these congested conditions are eliminated in the long-term by the continuous flow of the roundabout interchanges.

Safety

Safety conditions improve in a roundabout interchange for two reasons. First, they eliminate the conflicts that cause the most severe crashes(such as left turns). The roundabout interchanges furthermore reduce the likelihood of severe high-speed crashes which can occur when drivers disregard (or seek to avoid) stops imposed by traffic signals (running yellow or red lights). While these sources of high-impact collisions are mitigated by the continuous flow of a roundabout interchange, roundabouts reduce crashes related to stopping or navigating from a stop condition. Overall, the roundabout interchange design limits crashes to lower-impact "sideswipe" type collisions, which occur from traffic merging through the interchange, while fore-going the (higher impact, higher speed, most

fatal and injurious) angle or head-on collisions of signalized intersections. As a result, the overall crash rates as a result of the construction of roundabout interchanges are expected to be significantly reduced. Because injurious and fatal crashes are known to have higher societal costs than property damage-only crahses, it is anticipated the conversion to roundabout interchanges will provide substantial long-term economic benefit.

Observed "before and after" crash data from the Keystone Parkway project, empirically demonstrates the above reasoning regarding safety effects of conversion from a signalized intersection to roundabout interchange design. Comparing the 5 year average prior to the improvement, and a 3 year average after the improvement, illustrates that the rate of fatal crashes per million VMT was reduced from 0.005 to 0. The injury accidents went from 0.356 per million VMT down to 0.174 – a reduction of 51.5%. The more frequent property damage-only class of was nearly unchanged, from 2.336 accidents per million VMT to 2.396, an increase of only 2.5%.

By applying changes in crash rates observed on the Keystone Parkway to rates for this SR 37 corridor, the following crash rates are derived (Table 2). The property damage crashes are reflective of a change in the nature of accidents. Fatalities and injuries are reduced.

Table 2. Safety Impacts of Hamilton County Roundabout Interchanges on SR 37

	Fatal accident per M VMT	Personal Injury Accident per M VMT	Property Damage Accident per M VMT
Signalized Intersections	0.0096	0.6371	4.607
Roundabout Interchanges	0	0.3097	4.7245
Difference	(0.0096)	(0.3274)	0.6573

Source: EDR Group

ECONOMIC ANALYSIS

Changes to the transportation network as a result of the project have economic effects on the local economy in two key aspects. First, there are a set of user and societal benefits where users benefit directly through improved travel times, and society benefits through improved environmental conditions (less stop-and-go traffic), and a reduction in crashes. These benefits are experienced and expressed simply in dollar terms (dollars-worth of time saved or crashes prevented). Secondly, there are economic impacts to the regional economy, which represent how the economy uses the dollar value of benefits to create business output, create jobs, pay workers and earn profits. These wider impacts are expressed in terms of transactions—wage earnings (household income), business sales (output), jobs (employment) and profits or gross regional product (value-added).

Benefits

Because user and societal benefits occur annually, benefits are expressed as a stream of benefits over an analysis period from operations beginning in year 5 until the 25th year after project inception. A 3% discount rate is applied to the benefits in order to capture the time value of money and a 1.62% annual inflation factor is assumed reflective of the US Bureau of Labor Statistics Consumer Price Index for the 10-year period from 2006-2015.

Travel Time and Reliability Benefits

Users benefit from improved travel times, as expressed in reductions of VHT. Furthermore, they benefit from an improved reliability on the network, as there is a decrease in congestion with the continuous flow of the roundabout interchanges. There are three classifications of users who experience these benefits:

1) Personal time and reliability benefits, accruing to automobile passengers on personal trips
2) Business time and reliability benefits, accruing to businesses and passengers on business trips.
3) Shipper logistics productivity, accruing to freight shippers and carriers.

In present value terms, the sum of all user and travel time benefits over the 25-year analysis period is $510.5 million. Nearly half (46%) of the travel time benefits actually accrue to households (for passenger car travel associated with non-business activities), with the other half accruing either to truck traffic or commuting traffic. 46% is a comparatively high share of benefit to be accruing to households, given that most of the time savings occurs during peak periods, when commuting traffic accounts for a high share of travel. The relatively high share of benefit accruing to households suggests that a significant part of the projects' performance outcome is supporting "quality of life" related household and family activities.

Time saved for these activities is valuable to users, as it enables more "quality" time for families and personal pursuits, despite the fact that personal/household savings (unlike business savings) are not likely to be passed through the economy leading to wider impacts in business activity. Of the travel time and reliability benefit accruing to businesses, approximately 20% is attributable to the supply chain efficiencies from freight and commuter reliability. (20% of the business travel time saved is saved by shippers or businesses that will be able to more efficiently use their time and resources because of smaller windows of uncertainty regarding when people or goods will arrive at the business location). The remainder of the savings to business is attributable simply to the value of the time saved in travel.

Vehicle Operating Costs

The continuous flow of the intersections, and resulting reductions in congestion, reduces stop-and-go conditions and idling. This has the effect of reducing wear and tear on vehicles, and reduces the per-mile cost of driving. Furthermore, the improved speeds increase fuel efficiency. These benefits are changes to vehicle operating costs and accrue to a combination of personal passengers, businesses, and shippers.

In present value terms, reductions in vehicle operating costs amount to a benefit, over the 25-year analysis period, of $22.9 Million.

Safety

As previously discussed, roundabout interchanges reduce both the frequency and severity of accidents relative to traditional signalized intersections. The reductions in accidents has an economic value estimated by the value of a statistical life, the value of non-fatal injury accidents, and the value of property damage only accidents.

In present value terms, safety benefits, over the 25-year analysis period, total $3.66 Million.

Environmental Benefits

Similarly to vehicle operating costs, reductions in congestion and stop-and-go conditions have environmental benefits as well. There are fewer particulate matter emissions from less braking; and fewer emissions from other criteria pollutants and greenhouse gases as a result of improved speeds.

In present value terms, environmental benefits, over the 25-year analysis period, total $0.21 Million.

Summary of Benefits

Total benefits, of the four types mentioned above, are $510.5 Million in present value terms at a 3% discount rate. Over 95% of those benefits are experienced as travel time and reliability savings, with the remainder of benefits in the other categories (Table 3).

The total capital costs of this project are $200.8 Million, in undiscounted dollars, and an additional annual operating and maintenance cost of approximately $51,000 per year. In present value terms (assuming a 3% discount rate and a 1.62% inflation rate)[3], this translates to a present value of the cost stream of $188.6 Million over the 25-year analysis period. The net present value of the project, or the amount that benefits exceed costs, is $322 Million. The benefit-cost ratio of the project is 2.70.

Table 3. Benefit-Cost Analysis Results

Economic Benefit	Value ($ Million)	Percent Total
Business Travel Time & Reliability (present value, M$)	$261.28	51.2%
Household Travel Time & Reliability (present value, M$)	$222.59	43.6%
Vehicle Operating Costs (present value, M$)	$22.87	4.5%
Safety (present value, M$)	$3.66	0.72%
Environmental (present value, M$)	$0.21	0.04%
Total Benefits (present value, M$)	$510.53	
Total Costs (present value, M$)	$188.55	
Net present value	$321.98	
Benefit-cost ratio	2.7	

Source: EDR Group

Economic Impacts

The project has impacts on the larger economy through both construction expenditures and through an improved transportation system that provides savings to households and businesses. The user and societal benefits can translate to tangible impacts to the economy. Savings accruing to households, businesses, and freight shippers and carriers reverberate through the economy. Some of those savings translate to additional household spending, additional business investment, and additional hiring. For the purposes of this analysis, impacts are not discounted (since unlike benefits it is not possible to borrow against them through bonding or to trade them off against other investments of comparable costs), however the inflation rate of 1.62% is applied to impacts (because inflation is likely to affect the value of goods made and sold as a result of the project as well as the value of wages and profits earned). Hence impacts are presented not in constant dollars (the amount of output, earnings or GRP in today's dollars) but rather in year of expenditure dollars. This

[3] The $200.8 Million in outlays is discounted 3% through the construction period to reflect the opportunity cost of capital (or the amount of money that would have to be invested in year 1 to accrue enough interest to fully fund the project in the year of expenditure). This discounting of costs is necessary to allow for consistent economic comparison between costs (which accrue in the early years) and benefits (which accrue in later years). The 1.62% inflation rate is also applied, and due to the accrual of benefits more years into the future affects benefits more than costs.

means, for example that if it is shown that the project would enable a firm to produce $10 worth of goods in year 25, the actual volume of goods is likely to be significantly less than $10 would be expected to buy today, as inflation being shown to increase the reported value of the future impact.

Economic impacts are expressed through four separate concepts:

1) **Business output** – Business output represents the value of annual industry production in producer prices. For manufacturers, this would be sales accounting for change in inventory. For service sectors, production is the same as sales. For retail and wholesale trade, output is gross margin and not gross sales.
2) **Value added** – Value added is the value of output less the value of intermediate consumption. It is a measure of the contribution to GDP made by an individual producer, industry or sector.
3) **Jobs** – Job totals are an estimate of impacts on employment level. This is expressed as 'job-years,' where a job is one individual employed in a position for one year. One individual employed for two years would constitute two 'job-years.'
4) **Wage income** – Wage income, also known as employment income, includes employment compensation and proprietor income.

The project has both short-term and long-term economic impacts. Short-term impacts are primarily the result of the construction of the project and the associated spending. Long-term impacts are the result of changes to the transportation system that result from the project completion, and how those changes reverberate in the economy to generate additional economic activity.

Each economic impact varies from year to year, and most impacts can be viewed as cumulative over time (see Appendix A). However, jobs are not cumulative since they are temporary in nature. Thus, the spike in jobs during the construction period ends at project completion, and those jobs either are eliminated or shifted elsewhere in the economy. Inflation also does not affect jobs, because the wage rate is expected to be subject to inflation, simply increasing the amount of wage income for the same number of hours of work (thus not increasing the number of jobs, but increasing the wage earned per job). For the purposes of this report, economic impacts are limited to only those impacts that arise from (1) construction outlays and (2) money saved or production gained as a result of reduced transportation costs. There is a third potential areas of impact, which would capture the local and regional impacts of new business attracted to specific sites along the corridor where the access to a particular property is greatly enhanced. This third area of impact called "contingent development" would require a market and real estate study which is beyond the scope of the current report.

The project economic impacts are seen in total in Table 4, and as a year-by-year breakdown in Appendix A. In total, the project is anticipated to generate an additional $889 million in economic output (business sales), cumulatively, in the 25 year analysis period. The value

added, or contribution to GDP, is $490 Million cumulatively over the same period. This translates to $360 Million in employee earnings. The relationship between the different impact metrics can be understood as follows.

Table 4. Economic Impacts Results

Economic Impacts	Value ($Year of Expenditure M)
Output (Year of Expenditure Inflated M$)	$889
Value Added / Gross Regional Product (Year of Expenditure Inflated M$)	$490
Earnings / Wage Income (Year of Expenditure Inflated 2014 M$)	$360
Construction Jobs (employees in peak construction year)	640
Long-term jobs (employees by 2040)	184

Source: EDR Group

The $510.93 Million dollars of economic benefit derived from the safety, mobility and other performance aspects of the project (shown in Table 3) make additional money (from transportation cost savings) available to households and businesses. The households and businesses then spend (or invest) this money, stimulating $889 Million in additional sales from businesses in the region (over the 25 year period – as shown in Table 4). Of this $889 Million, firms in the region actually retain approximately $490 Million as shown in Table 4. ($490 Million is the business earnings that remain with the businesses after subtracting the value of inputs needed to make the $889 Million worth of goods sold). Of the $490 Million the firms retain, they pay out $360 Million in wages to employees (also shown in Table 4), for newly generated jobs. This $360 Million in wage income represents a number of jobs (given in Table 4), which changes from year to year. Appendix A shows, in annual terms, how the stream of business sales, "value added" (or retained earnings), wage income and jobs develops by year, to make this relationship more explicit.

The employment impact can be observed at two critical points in the horizon of the analysis. At peak construction in the fourth year after project inception, the project is expected to generate 640 jobs in that year. In the long-term, the transportation impacts will create an economic impact totaling 184 jobs per year by the twenty fifth year after inception. This figure varies from 132 jobs in the eight year after project inception to 184 jobs by the end of the analysis period, and varies year to year as it generally grows commensurate with transportation benefits.

CONCLUSION

The proposed roundabout interchanges on SR 37 are expected to positively impact the local economy by providing an enhanced, less congested and safer transportation corridor. The total benefits of the project over the analysis period sum to a present value of $510.5 Million, compared to $188.6 Million in costs. This provides a benefit-cost ratio of 2.70, showing that present value benefits exceeds present value costs over a long-term 25-year analysis of the project.

Furthermore, the project generates economic impacts to the amount of $889. Million in business output in the 25-year period. Thus, regional GDP (or value added) would increase by $490 Million, of which $360 Million is spent as wages to employees. The project would generate a maximum of 640 jobs during its peak construction in the fourth year after project inception. In the long-term, the project is expected to generate and sustain 184 permanent jobs by its 25th year.

Overall the project demonstrates a clear economic return far exceeding the cost of the investment, with a significant share of the return experienced in terms of saved lives, prevented injuries and the improved quality of life associated with more time for family and household activities. In addition to these benefits, the project adds significantly to business efficiency and competitiveness, contributing to regional employment, income, business sales and gross regional product.

APPENDIX A: ECONOMIC IMPACTS BY YEAR

Year Count	Business Output ($ mil.)	Value Added ($ mil.)	Jobs	Wage Income ($ mil.)
1	$0.09	$0.05	1	$0.04
2	$18.03	$11.60	133	$9.69
3	$9.66	$6.21	70	$5.19
4	$123.59	$65.43	640	$49.21
5	$73.91	$39.05	385	$29.53
6	$117.09	$62.36	608	$46.66
7	$20.24	$11.31	131	$8.12
8	$20.91	$11.69	134	$8.39
9	$21.76	$12.15	137	$8.72
10	$22.78	$12.74	140	$9.16
11	$23.91	$13.36	146	$9.59
12	$24.85	$13.88	148	$9.96
13	$25.58	$14.30	151	$10.26
14	$26.61	$14.86	155	$10.67
15	$27.30	$15.25	156	$10.94
16	$28.20	$15.75	159	$11.31
17	$29.40	$16.42	162	$11.78
18	$30.26	$16.91	165	$12.13
19	$31.26	$17.47	167	$12.53
20	$32.26	$18.03	170	$12.94
21	$33.27	$18.58	172	$13.33
22	$35.86	$19.99	181	$14.37
23	$36.56	$20.38	182	$14.66
24	$37.93	$21.14	186	$15.20
25	$37.90	$21.18	184	$15.19
Sum of Impact for all Years	**$889.20**	**$490.10**		**$359.55**

Impacts are undiscounted, but reflect an annual inflation rate of 1.62% on the value of output, wages and gross regional product.

APPENDIX B: SENSITIVITY TEST

Key Assumptions Tested

The results shown in this report assumes a 1.62% rate of inflation consistent with the 10-year historic average of the consumer price index for the United States. The results also assume a 3% discount rate to reflect the time value of money and assume a 1.7% annual increase in traffic volumes subject to the improved transportation performance described in the report. The assumption regarding inflation is atypical for cost-benefit and economic impact studies (which generally simply present discounted costs and benefits in constant dollars). Inflation or cost escalation is typically not included in cost-benefit or impact studies because future inflation rates are unknown and may not be consistent with historic rates and (2) reporting impacts and benefits in inflated dollars can wrongly infer that such inflated dollars could actually purchase goods and service comparable to the value of such dollars today (when the analysis is being interpreted and used). In reality, the real purchasing power of inflated dollar amounts is eroded by the likelihood that the prices of goods and services purchased by benefits and impacts will likely be inflated as well.

For example if a commuter were to save what would be $11.25 worth of gas in year 1, and could use that money to purchase one bag of groceries in the same year, there is a clear association between the value of gas saved and the value of groceries bought. However, in year 25, inflation would have increased the value of gas saved from $11.25 to $16.54. Presenting the value of fuel savings in year 25 as $16.54 would correctly account for inflation. However – in year 25 conditions it is possible (and in fact likely) that the $16.54 would still purchase only one bag of groceries, and not a bag and a half, as this amount might be expected to purchase in year 1. Hence, the above analysis presents costs, benefits and impacts in year of expenditure (inflated) dollar terms that cannot be expected to relate to the same purchasing power such amounts would have today.

In order to allow for a more consistent current-year understanding of the likely transaction value of benefits and impacts, they are traditionally represented in constant dollars (showing their buying power in today's market conditions instead of some presumed future economic situation).

Furthermore, in the above analysis, the 1.7% compound annual traffic growth rate is used to account for some allowance that future development may result in traffic growth slightly higher than the 1.42% historic compound annual traffic growth. This allowance on the traffic growth rate also yields a benefit slightly higher than if the 1.42% were applied.

Because both (1) the assumption regarding inflation as well as (2) the assumption regarding a higher than historic rate of traffic growth present a benefit stream slightly higher (and a cost stream slightly lower) than a constant dollars analysis simply using a 3% discount rate

and a historic traffic growth rate, a sensitivity test is provided below. The sensitivity test is intended to reveal how the benefits and impacts presented would change under a more conservative set of assumptions and reporting protocols. The sensitivity test finds that under a more conservative set of assumptions, the benefit to cost ratio would reduce from 2.7 to 2.2 and the net present value of the project would reduce from approximately $322 Million to approximately $213 Million. The findings of the sensitivity analysis are shown in Table 5 below.

Table 5. Benefit-Cost Analysis Results – Sensitivity Test (Constant Dollars, 1.42% Traffic Growth)

Economic Benefit	Value ($ Million)	Percent Total
Business Travel Time & Reliability (present value, M$)	$199.9	51.2%
Household Travel Time & Reliability (present value, M$)	$170.3	43.6%
Vehicle Operating Costs (present value, M$)	$17.5	4.5%
Safety (present value, M$)	$2.8	0.72%
Environmental (present value, M$)	$0.16	0.04%
Total Benefits (present value, M$)	$390.6	
Total Costs (present value, M$)	$177.6	
Net present value	$213.0	
Benefit-cost ratio	2.20	

Source: EDR Group

The findings of the sensitivity test with respect to impacts are shown in Table 6 below.

Table 6. Economic Impact Analysis Results -- Sensitivity Test

Economic Impacts	Value ($ Constant M)
Output (Constant 2014 M$)	$725
Value Added / Gross Regional Product (Constant 2014 M$)	$399
Earnings / Wage Income (Constant 2014 M$)	$294
Construction Jobs (employees in peak construction year)	635
Long-term jobs (employees by 2040)	172