2013

Williams & Works, Inc.

[BENEFIT – COST ANALYSIS]

Analysis completed for the replacement of the Sink Road Bridge over the Dowagiac River and related Canoe Ramp Reconstruction for inclusion with the TIGER Grant Application

Introduction:

A benefit-cost analysis was conducted for the Sink Road bridge replacement and canoe ramp reconstruction project as of May 2013. This analysis was completed for submission to the United States Department of Transportation (US DOT) as a requirement of a 2013 discretionary TIGER grant application. The analysis was completed in accordance with the 2013 Benefit-Cost Analysis Guidance for TIGER Grant Applications and the TIGER BCA Resource Guide.

Project Summary:

The Pokagon Band of Potawatomi Indians (the Tribe) in conjunction with the Cass County Road Commission and Pokagon Township are requesting $1.0 million in TIGER funding as part of a project to replace the structurally deficient and deteriorated Sink Road Bridge and reconstruct the adjacent canoe ramp. The proposed project will improve the infrastructure that serves as the main corridor between two of the tribes properties that contain all of their major governmental services. A more detailed description of the project is included later in the Project Background section.

Project Goals:

- Improve access to tribal facilities
- Improve access to recreational campground
- Improve both pedestrian and vehicular safety
- Reduce travel time, fuel consumption and vehicle wear and tear by eliminating a lengthy detour
- Improve water quality at the crossing with the Dowagiac River which is a documented trout stream
- Improve quality of life for both humans and wildlife
- Enhance access to adjacent recreational campground
- Minimize costs over the life-cycle of the project

Project Background / Baseline:

Sink Road connects Edwards Street at the south with Peavine Road to the north. Immediately east of the intersection with Edwards Street, Sink Road crosses the Dowagiac River. As illustrated in the graphic below, the Tribe owns land east of the Dowagiac River as well as south of Sink Road. The eastern parcel of land contains multiple buildings used for the Tribe (Natural Resources / Languages and Cultures, Maintenance Offices and Garages) while the western parcel of land contains multiple other buildings frequently used by the Tribe (Main Governmental Center, Administration Buildings, Tribal Legal Services, Tribal Court as well as a private campground and recreational area). The most direct and logical route between the two areas would be to use Sink Road and traffic would therefore have to cross the existing bridge.

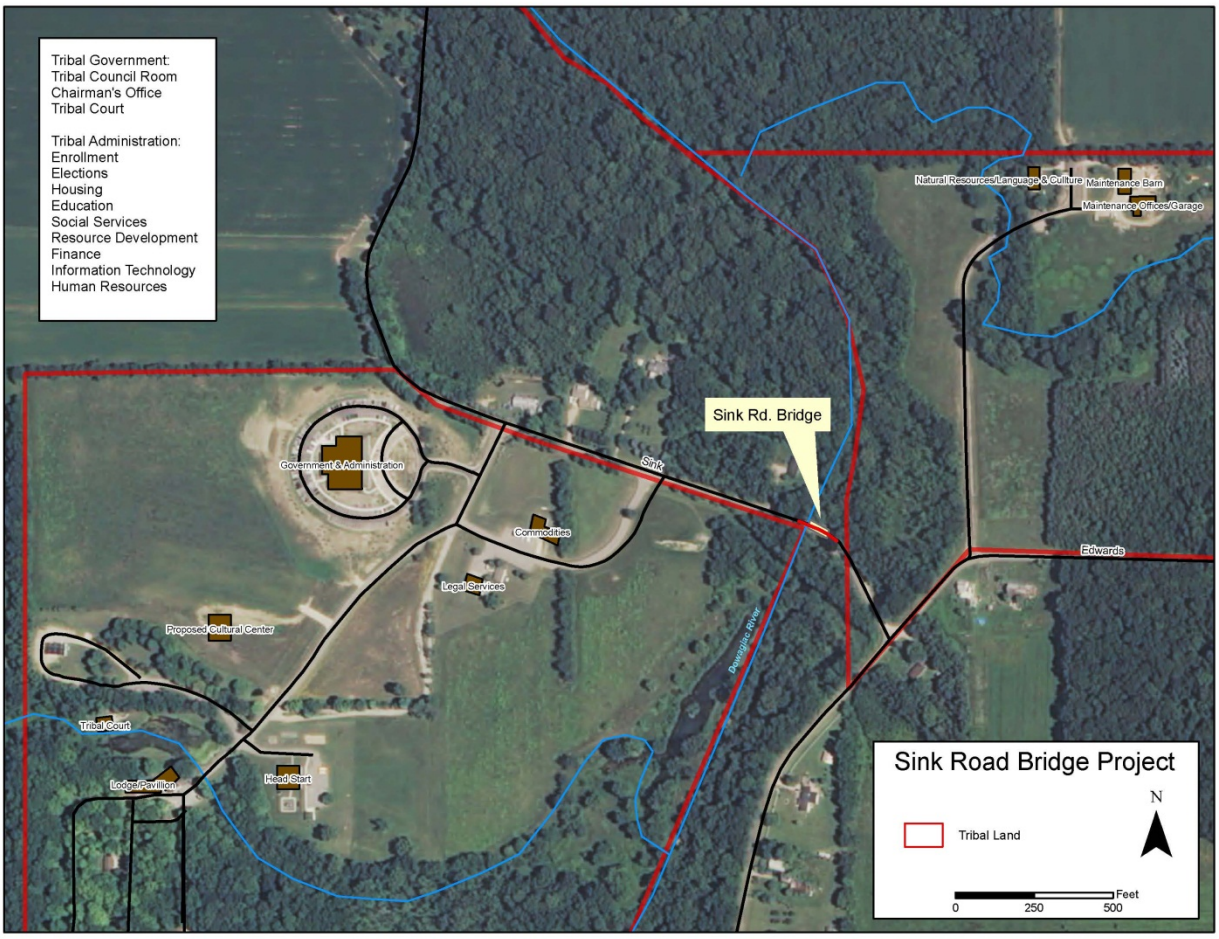

Figure 1 – Sink Road Bridge Location relative to Tribal Land and Governmental & Recreational Facilities

The Sink Road Bridge was originally constructed in 1963 and consists of a single 66 foot long span over the Dowagiac Creek. The superstructure is constructed of 27 inch deep by 36 inch wide prestressed concrete box beams in a side by side configuration. The wearing surface consists of Hot Mixed Asphalt (HMA) directly on top of the concrete beams. The substructure consists of reinforced concrete abutments supported by steel piles.

The existing structure is noted as structurally deficient and has a Federal Sufficiency Rating (FSR) of 36.7 as of January 2010. (For reference an FSR of 100 indicates a brand new structure that meets all current loading and geometric standards where an FSR of 0 if a bridge that is completely closed to traffic due to failure) Hydraulic scour and undermining were present and noted in the most recent (2012) bridge inspection. In addition cracks were documented in the prestressed concrete box beams as

well as leakage between the beams through the deck. There are cracks and holes noted in the abutments with leaking present. The railing on the bridge is substandard, heavily deteriorated and poses a significant safety hazard to the motoring public. The approach guardrail is only located on one side of the bridge and does not have an appropriate anchorage to the bridge nor does it have sufficient advanced length. Currently the bridge is posted at 30 tons for a single unit truck.

All traffic between the Governmental, Administration, Citizen Services and Environmental Departments use this corridor and cross the Sink Road Bridge. For heavier vehicles, the bridge does not have sufficient capacity to carry the load which is currently requiring those vehicles to take a lengthy detour. It is anticipated that as the structure continues to deteriorate, the structural capacity will also be reduced further, requiring more and more vehicles to take the detour. Eventually the bridge will need to be closed to traffic completely.

Project Matrix

Current Status / Baseline & Problem to be Addressed	Change to Baseline / Alternatives	Type of Impacts	Population Affected by Impacts	Economic Benefit	Summary of Results	Page Reference in BCA
Deteriorating and structurally deficient bridge over the Dowagiac River which causes a lengthy detour between Tribal complexes, scour damage to the documented trout stream, lack of river accessibility	Replacement of the Sink Road Bridge, approach roadway alignment and safety improvements, restoration of the Dowagiac River, addition of canoe launch	Improve access between Tribal complexes, eliminate lengthy detour, improve safety for traveling public as well as the Tribe, improve habitat for aquatic life of the Dowagiac River, provide recreation point for both public and Tribe	Drivers between Tribal complexes will have reduced detour length, reduced fuel consumption, reduced accidents due to inadequate bridge railing and approach guardrail, Tribal employees, general public	Monetized value of reduced emissions, reduced fuel consumption, reduced accidents, reduced vehicular maintenance costs, increased access to public recreational facilities	Estimated value of improved operations, reduced traffic along detour route, improved emissions, and improved safety	Pg. 11-14

Table 1 – Project Matrix

Project Alternatives

The existing Sink Road Bridge is in poor condition as noted in its Federal Sufficiency Rating of 36.7 which puts it in the category for replacement. The table below lists the various project options and results investigated.

Option	Description of Work	Results / Recommendations
Do Nothing	Let structure continue deteriorating and utilize detour route for traffic	Increased fuel usage, increased travel times, higher risk for accidents, not safe, creates poor water quality for fish and other wildlife - not recommended
Rehabilitate Structure	Replace Railings, perform extensive rehabilitation work on abutments and existing beams, repair scour hole	High Costs for minimal gain, load rating would not increase for the structure, would not fix geometrics deficiencies, poor condition of abutments and foundation piling may keep rehabilitation from being possible – Not recommended
Replacement	Construct New Bridge	Meets geometric, loading and safety standards, most cost effective for improvements gained – recommended option

Table 2 – Project Alternatives, Results and Recommendations

Key Analytical Assumptions

Real Discount Rate:

In an effort to avoid forecasting future inflation rates and the need to escalate future values for benefits and costs accordingly, all benefits and costs were valued in constant/current year dollars. Future values are deflated to reflect constant values, even in cases where costs are expressed in future year values. The use of constant dollar values requires the use of a real discount rate for present value discounting.

In accordance with the US DOT 2013 Benefit-Cost Analysis Guidance for TIGER Grant Applicants[1], a real discount rate of 7% was used for this analysis.

Evaluation Period

The evaluation period for benefits and costs of a project are typically for a period that includes the construction of the project and the operational period which is 20 – 50 years on average. For new structures, the design life is typically 50 years. For the project investments proposed by the Tribe, the evaluation period includes the relevant construction period during which capital expenditures are undertaken, plus 49 years of operations beyond the project completion within which to accrue benefits. For the purposes of this analysis it has been assumed that construction would begin and end in 2014. This analysis calculates all benefits and costs until 2063. As a simplifying assumption, all benefits and costs are assumed to occur at the end of each year.

Forecast and Traffic Growth Assumptions

The Tribe collects traffic data counts annually for the area of the Sink Road corridor. This analysis assumes that the traffic volumes will grow over time at a conservative rate of 0.25 percent per year until the end of the life cycle cost analysis in 2063.

Annualizing Factor Assumptions

The traffic counts are summarized to represent the "Annual Daily Traffic" indicating the typical traffic noted on an average day. It is assumed that these values correspond to weekday travel trips. Accordingly, annualizing factors are necessary to convert the travel demand from daily trips to yearly values. The highest annualizing factor would be 365, which would assume the average weekday also reflects every day throughout the year. The lowest annualizing factor would be 251 days, which accounts for weekday traffic only, removing all 104 weekend days and holidays. This analysis assumes an annualizing factor of 300.

Trip Distances

The distances used to compare the trips and corresponding vehicular-miles-traveled for the "no build" and "Build" situations were limited to the detour route as noted above assuming the existing bridge was closed to traffic. The shortest detour route was selected and totaled 3.5 miles.

[1] White House Office of Management and Budget, Circular A-94 *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (October 29, 1992)
http://www.whitehouse.gov/sites/default/files/omb/assets/a94/a094.pdf

Included Benefits – Long Term Outcome

State of Good Repair

Reduced Pavement Damage

For each mile traveled, vehicles produce damage to the pavement on roads and therefore by having vehicles drive a lengthy detour, unnecessary damage is being the pavement along the detour route. The proposed project will eliminate the need for the detour and thereby reduce the total miles traveled by vehicles. Overall, there will be less damage to the roadway pavement and it will remain in a better state of repair.

This analysis utilizes the Federal Highway Administration's Federal Highway Cost Allocation Study conducted in 1997[2]. This study reports that automobiles have a marginal cost to pavements of 0.2 cents per vehicle mile traveled in 2013 CPI-U adjusted dollars.

Economic Competiveness

Vehicle Operating Cost – Fuel

This analysis included the reduction in total fuel costs due to the reduction in vehicle-miles traveled. The Energy Information Administration's (EIA) Annual Energy Outlook 2013 projections for vehicular fuel efficiency as well as the price of gasoline and diesel were used[3]. The EIA projects values until 2040, so it was necessary to further expand the projects to the end of the evaluation period. Based on the EIA figures, the fuel efficiency was projected and the prices were based on the compound annual growth rate (CAGR) in the EIA's model for 2025 to 2035. The table below lists the range of estimates used for this analysis.

	2013	**2063**
Auto Fuel Economy	28.8 miles per gallon	41.5 miles per gallon
Freight Truck Fuel Economy	6.0 miles per gallon	8.8 miles per gallon
Gasoline Price	$2.90 per gallon (2013 $)	$5.08 per gallon (2013 $)
Diesel Price	$3.00 per gallon (2013 $)	$6.02 per gallon (2013 $)

Table 3 – Fuel Economy and Fuel Prices, 2013 and 2063 (Projected)

Vehicle Operating Cost - Maintenance

The proposed project will reduce vehicle operating and ownership costs because the replacement of the Sink Road Bridge will eliminate the need for the lengthy detour. As a result, the overall vehicle-miles traveled will be reduced resulting in lower vehicle maintenance and ownership costs as commuters use their vehicles less. The per-mile values of these categories were derived from a study conducted by Barnes and Langworth at the University of Minnesota[4]. This analysis used "baseline costs" which reflected the most conservative estimate of operating costs because they assume highway conditions and smooth pavements. The following costs were utilized in real 2013 dollars.

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[2] Federal Highway Administration (1994) Motor vehicle accident costs. FHWA Technical Advisor T 7570.2 http://safety.fhwa.dot.gov/facts_stats/t75702.cfm

[3] U.S. Energy Information Administration, Annual Outlook 2013. Reference Case, Table 113, Scenario AEO2013 http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013&subject=15-AEO2013&table=113-AEO2013&region=0-0&cases=ref2013-d102312a

[4] Barnes, G and P. Langworthy (2003). The Per-Mile Costs of Operating Automobiles and Trucks. Minneapolis: University of Minnesota Press. http://www.lrrb.gen.mn.us/PDF/200319.pdf

Operating Cost Category	Cost per Vehicle-Mile Traveled
Auto – Maintenance / Repair	7.2 cents per VMT
Auto – Tires	2.2 cents per VMT
Auto – Depreciation	8.8 cents per VMT

Table 4 – Vehicle Maintenance Operating Cost Assumptions

Reductions in the Economic Cost of Oil Imports

Fuel consumption has a cost beyond the actual operating costs or the environmental costs of the consumption which can be expressed as the economic cost of oil imports. This concept reflects two ideas: a monopsony component and a price shock component.

The monopsony component suggests that because the United States is such a large consumer of oil that an increase in U.S. oil demand will lead to higher fuel prices based on the principle of supply and demand. The price shock component suggests that a reduction in oil supplies leads to higher oil prices, thereby reducing the level of U.S. economic output. As a consequence, reducing oil imports, by consuming less fuel, reduces these costs on the U.S. economy. The National Highway Traffic and Safety Administration suggests that for each gallon of fuel saved, the total U.S. imports of refined fuel or crude oil is reduced by 0.95 gallons[5].

This analysis uses the NHTSA's estimate for the per gallon cost of oil imports for the monopsony and price shock components which is $0.26 per gallon in real 2013 dollars after a CPI-U adjustment[6].

Environmental Sustainability

The proposed project will create both environmental and sustainability benefits by reducing noise and air pollution associated with vehicular travel. Five emissions from which to measure and monetize benefits were identified which include: Carbon Dioxide, Volatile Organic Compounds, Nitrogen Oxides, Particulate Matter and Sulfur Dioxide.

Reductions in Noise Pollution

The reductions in vehicle miles traveled will improve the quality of life for both humans and wildlife by creating reductions in noise pollution. This analysis assumes a cost of $0.001 per vehicle-mile traveled as expressed in real 2013 dollars after a CPI-U adjustment. The cost in reduction of noise pollution was derived from the NHTSA's figures[7].

[5] National Highway Traffic and Safety Administration (2010) Corporate Average Fuel Economy for MY 2012-MY2016 Passenger Cars and Light Trucks. http://www.nhsta.gov/staticfiles/rulemaking/pdf/cafe/CAFE_2012-2016_FRIA_04012010.pdf

[6] National Highway Traffic and Safety Administration (2010) Corporate Average Fuel Economy for MY 2012-MY2016 Passenger Cars and Light Trucks. http://www.nhsta.gov/staticfiles/rulemaking/pdf/cafe/CAFE_2012-2016_FRIA_04012010.pdf

[7] National Highway Traffic and Safety Administration (2010) Corporate Average Fuel Economy for MY 2012-MY2016 Passenger Cars and Light Trucks. http://www.nhsta.gov/staticfiles/rulemaking/pdf/cafe/CAFE_2012-2016_FRIA_04012010.pdf

Reduced Emissions

The emissions rate factors per vehicle-mile traveled vary greatly depending on vehicle type, average speed, roadway grade and driving conditions. This analysis uses the California Department of Transportation's emissions factors from the California Life-Cycle Benefit-Cost Analysis Model[8]. This model provides emissions factors for automobiles and trucks at varying speeds from 5 to 65 miles per hour. Furthermore, it uses new factors beginning in the year 2027 in order to incorporate increases in fuel efficiency and changes in the vehicle fleet used.

The California Life-Cycle Benefit-Cost Analysis Model reports 2007 and 2027 figures only, with most emissions factors decreasing over time due to an expected change in fuel efficiency and vehicle fleet composition. This analysis interpolates for years between 2007 and 2027 using the combined annual growth rate. To avoid over exaggerating improvements in vehicular emissions beyond the study period, this analysis assumes the emissions values remain constant from 2027 through 2063.

Year	CO_2 (g/VMT)	NO_x (g/VMT)	PM_{10} (g/VMT)	SO_x (g/VMT)	VOC (g/VMT)
2007	388.20	0.42910	0.03420	0.00400	0.32160
2015	385.60	0.22799	0.03491	0.00392	0.20276
2025	382.40	0.10342	0.03582	0.00382	0.11391
2050	381.70	0.08830	0.03600	0.00380	0.10150

Table 5 – Emissions Factors from California Life-Cycle Benefit-Cost Analysis Model (Vehicles traveling at 35 mph)

The National Highway Traffic and Safety Administration estimated the economic costs of pollutant emissions per ton[9]. These values were converted to real 2013 dollars based on the CPI-U and used to monetize any emissions benefits. The table below lists the costs of the emissions (with the exception of carbon dioxide which is described later in this analysis) expressed in real 2013 dollars.

Emissions Category	Cost Per Ton (2013 $)
Nitrous Oxide (NO_x)	$5,150
Particulate Matter (PM_{10})	$281,813
Sulfur Oxides (SO_x)	$30,125
Volatile Organic Compounds (VOC)	$1,263

Table 6 – Cost of Emissions (excluding Carbon Dioxide) as provided by NHTSA

As described in the TIGER BCA Resource Guide, the Social Cost of Carbon (SCC) is no longer a fixed unit to CO_2 emissions. For this analysis, the 3% average values were used as provided in the document *Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (February 2010)*[10]. This document lists annualized SCC values from 2010 to 2050. Since this analysis extends to 2063, the values were projected and the costs based on the compound annual growth rate (CAGR) in the EPA's model for 2040 to 2050. The 2007 values were converted to real 2013 dollars based on the CPI-U and used to monetize the CO_2 emissions benefits.

[8] California Department of Transportation (2007). California Life-Cycle Benefit-Cost Analysis Model. http://www.dot.ca.gov/hq/tpp/offices/ote/benefit.html

[9] National Highway Traffic and Safety Administration (2010) Corporate Average Fuel Economy for MY 2012-MY2016 Passenger Cars and Light Trucks. http://www.nhsta.gov/staticfiles/rulemaking/pdf/cafe/CAFE_2012-2016_FRIA_04012010.pdf

[10] National Highway Traffic and Safety Administration (2010). Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Page 39, Table A-1 "Annual SCC Values 2010-2050 (in 2007 dollars) http://www.epa.gov/oms/climate/regulations/scc-tsd.pdf

Safety

Accident Cost Savings

Reductions in the overall VMT as well as eliminating conflicting turning movements caused by the detour route will ultimately lower the incident of traffic accidents. The cost savings from reducing the number of accidents include direct savings (e.g. reduced personal medical expenses, lost wages, lower individual insurance premiums) as well as significant avoided costs to society (e.g. second party medical and litigation fees, emergency response costs, incident congestion costs). The value of all such benefits – both direct and societal – could also be approximated by the cost of service disruptions to other travelers, emergency response costs to the Tribe, access disruptions to Tribal governmental facilities, medical costs, litigation costs, vehicular damages as well as economic productivity loss due to workers inactivity.

For this analysis, the actual crash data was used for the project location which listed only one single property damage only incident in the past 9 years. It was assumed that due to the required detour of traffic that one single incidence of a fatality would be incurred over the analysis period. This was chosen due to the specified detour route which has three conflicting left turn movements at unsignalized T - intersections with posted speeds of 55 miles per hour. For this analysis it was assumed that the singular fatality would occur approximately 10 years into the analysis. This was chosen to reflect the time where the deterioration of the existing structure would require the majority of the traffic to be using the detour. The monetized value of a fatality used in this analysis was noted at $9,100,000 as noted by the US DOT[11].

Economic Benefits Not Included

The following is a summary of other potential benefits that are excluded from the analysis. Each benefit has a description as well as the rationale for its exclusion from the analysis.

Construction Delay

During the period of construction, the Sink Road Bridge will be closed and all traffic will be required to use the detour as noted earlier in the report. Since the main analysis functions under the premise that the bridge condition is requiring vehicles to use the detour and the anticipated construction period is limited to a single year, the construction delay was omitted from the analysis.

Increased Tourism due to Canoe Launch Improvements

As part of the project, a new canoe access site will be added near the Sink Road Bridge. This canoe access will improve both recreation and wellness benefits for not only members of the Tribe but for the general public as well. With the improvement to recreational access to the area, there is an anticipated increase in usage of the adjacent campground which will generate an economic and social benefit for the project. Since no models currently existing to accurately monetize the increase in usage of these features, these benefits were excluded from the analysis.

[11] U.S. Department of Transportation (2013) *Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analysis* http://www.dot.gov/office-policy/transportation-policy/guidance-treatment-economic-value-statistical-life

Improved Aquatic Habitat to the Dowagiac River

As noted in the project background section, the Dowagiac River within the vicinity of the existing Sink Road Bridge has a noted scour hole near the abutments as well as bank erosion near the adjacent roadway. For this project a replacement bridge would increase the width of the waterway opening as well as providing stabilization of the riverbanks. The proposed improvements will reduce the amount of sediments being picked up by the river flow. The reduced sediment content in the flowing water provides a better habitat for the known species of fish that use the Dowagiac River for spawning. Maintaining the environment and related wildlife is a critical part of Michigan's economy by providing recreational opportunities for fishing, kayaking, canoeing as well as numerous other activities. This project will not only improve the aquatic habitat in the vicinity of the bridge, but also upstream and downstream of the crossing. To appropriately monetize the values of improving the aquatic habitat would require a costly detailed study of the fish types and spawning characteristics within the vicinity of the Sink Road Bridge; therefore this benefit was excluded from the analysis.

Travel Time

This project would eliminate the need for the lengthy detour route and will reduce the travel time that motorists spend in their vehicles. The US DOT has specified monetized values of all purpose (personal and business) travel time to be used for evaluating the benefits of reductions VMT which are valued at $12.50 per person-hour (2009 $)[12]. With a detour length of approximately 3.5 miles, the travel time savings of the traffic could total a significant amount. To apply the monetized factors listed, a detailed traffic flow analysis would need to be developed to accurately model the time spent in vehicles within the project area on a daily basis. The travel times were omitted since the traffic modeling was not available at the time of this analysis.

Economic Costs Included and Related Assumptions

In the benefit-cost analysis, the term "cost" refers to the additional resource costs or expenditures required to implement, perpetuate and maintain the investments associated with the proposed project.

Initial Project Investment Costs

Initial project investment costs for this analysis are limited to the construction costs of the bridge and related canoe ramp only since the engineering has already been completed and the project is located within an existing Cass County Road Commission owned Right-of-Way. These costs total $1,000,000 and were developed by the Tribe and their consultant. It is assumed that the costs will be completely incurred in the 2014 calendar year. It is also assumed that the entire project will be operational by the end of the 2014 calendar year.

[12] U.S. Department of Transportation *Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis (Revision 2 – corrected)* http://www.dot.gov/office-policy/transportation-policy/guidance-value-time/

Economic Costs Not Included

Annual O&M Costs of the Bridge

Bridges are typically designed for an extended life span (50 years) and require virtually zero annual maintenance. The proposed bridge is a single span, prestressed concrete box beam bridge in a side by side box configuration utilizing a concrete wearing surface. The superstructure is supported by reinforced concrete abutments on foundation piling. The proposed railings for this bridge are an aesthetic parapet tube style. Since the majority of the bridge is constructed of reinforced or prestressed concrete, there will be no need for regular painting of the bridge. The only maintenance required would be to clean the expansion joints every few years which can be done with compressed air and can be done by Tribe maintenance personnel. Since these costs are so small and are not required annually, they were omitted from the analysis.

Residual Value

Although this analysis uses a large time period for the life-cycle, there is the potential that the bridge will retain some residual value at the end of the evaluation period. However, for simplicity and accuracy this analysis assumes that in 2063 there is no remaining economic value for the structure and therefore the residual value is zero.

Key Benefit-Cost Evaluation Measures

There are three common benefit-cost evaluation measures, each tailored to compare benefits and costs from different perspectives, the net present value (NPV), the economic rate of return (ERR) and the benefit / cost ratio (B/C Ratio). Each of the three measures used in this analysis are described in further detail below.

Net Present Value (NPV)

The benefit-cost analysis converts potential gains and losses from the proposed project into monetary units and compares them on the basis of economic efficiency, as in net present value. For example, NPV = PVB (present value of benefits) – PVC (present value of costs). Therefore NPV gives the magnitude of the project's economic feasibility in terms of net benefits discounted to present values using real discount rate assumptions. Under this criterion, a scenario with an NPV greater than zero may be considered "economically feasible". The NPV provides some perspective on the overall dollar magnitude of benefits not reflected by the other two measures.

Economic Rate of Return (ERR)

The economic rate of return is the discount rate that makes the present value of all benefits just equal to the present value of all costs. The ERR measures the social or economic return on investment. As an evaluation measure, it allows comparison of the proposed investment package with other similar packages and alternative uses of investment funds that may have different costs, different benefit flows, and / or different timing. The ERR is interpreted as a real rate of return, since the assumption is that benefits and costs are expressed in constant dollars. As such, it should not be directly compared with investment returns calculated from inflated or nominal future year dollars. In some cases, a threshold value for the ERR may be established where exceeding that threshold results in the determination of an economically justified project.

Benefit / Cost Ratio (B/C Ratio)

The benefit / cost ratio is where the present value of incremental benefits are divided by the present value of incremental costs (B / C ratio = PVB / PVC). In essence, the B/C ratio expresses the relation of discounted benefits to discounted costs as a measure of the extent by which a project's benefits either exceed or fall short of their associated costs. The B/C ratio can be useful when the objective is prioritize or rank projects with the intent to decide how to best allocate an established capital budget, assuming equivalent classification of benefits and costs.

Benefit-Cost Analysis Results

For this analysis, two separate cases were examined. Case A assumes a 7 % real discount rate where Case B assumes a 3% real discount rate. As noted in the TIGER BCA Resource guide, the 7% real discount rate is required by the US DOT as the baseline. For this analysis, Case B was also completed as a comparison since this project includes public funds so the opportunity costs are in public and not private investments.

In order to test the robustness of the calculated NPV, ERR and B/C ratio, this analysis also included several sensitivity tests, where the estimated measures are recalculated under varying scenarios. The scenarios included:

- Scenario A1: 7% real discount rate; 15% increase in all calculated benefits
- Scenario A2: 7% real discount rate; 15% decrease in all calculated benefits
- Scenario A3: 7% real discount rate; 15% increase in the initial capital costs
- Scenario A4: 7% real discount rate; 15% decrease in the initial capital costs
- Scenario B1: 3% real discount rate; 15% increase in all calculated benefits
- Scenario B2: 3% real discount rate; 15% decrease in all calculated benefits
- Scenario B3: 3% real discount rate; 15% increase in the initial capital costs
- Scenario B4: 3% real discount rate; 15% decrease in the initial capital costs

For the proposed project Case A, the proposed investments yield a net present value of $4,547,241, which provides a real economic rate of return of 38.9%. The corresponding benefit-cost ratio is 6.7.

When applying the 3% discount rate as described in Case B, the proposed project yields a net present value of $8,143,488, which provides a real economic rate of return of 38.9%. The corresponding benefit-cost ratio is 10.6.

The following table lists the evaluation results for the each case as well as the corresponding sensitivity tests. All benefits were estimated in constant 2013 dollars over the 49 years post project completion.

Scenario	Net Present Value (NPV)	Economic Rate of Return (ERR)	Benefit – Cost Ratio (B/C)
Case A (7% discount rate)	$4,547,241	38.9%	6.7
Sensitivity Tests			
A1: 15% Increase in Benefits	$6,876,694	43.2%	7.7
A2: 15% Decrease in Benefits	$4,843,528	34.7%	5.7
A3: 15% Increase in Costs	$5,722,544	35.2%	5.8
A4: 15% Decrease in Costs	$5,997,678	43.9%	7.9
Case B (3% discount rate)	$8,143,488	38.9%	10.6
Sensitivity Tests			
B1: 15% Increase in Benefits	$12,308,840	43.2%	12.2
B2: 15% Decrease in Benefits	$8,839,649	34.7%	9.0
B3: 15% Increase in Costs	$10,425,786	35.2%	9.3
B4: 15% Decrease in Costs	$10,722,704	43.9%	12.5

Table 7 – Benefit – Cost Analysis Results Summary

Calculated Benefits and Costs by Category

For this analysis, approximately 74% of all of the proposed project benefits are attributable to improvements in safety. The discounted present values of all benefits that were quantified are shown in the following figures:

Net Present Value (2013 $) for 2013-2063

Discount Rate		**7.00%**
Total Benefits	$	5,464,352
Total Costs	$	917,111
Net Present Value	$	4,547,241
Economic Rate of Return		38.9%
Benefit-Cost Ratio		6.7

State of Good Repair	Unit	Benefit	
Reduced Pavement Damage	2013 $ NPV	$	7,160
Total		**$**	**7,160**

Economic Competetiveness	Unit	Benefit	
Reduced Passenger O&M Costs - Fuel		$	433,447
Reduced Passenger O&M Costs - Non-Fuel		$	853,120
Oil Import Cost Savings	2013 $ NPV	$	24,276
Total		**$**	**1,310,843**

Livability Benefits	Unit	Benefit	
Noise Reduction Benefits	2013 $ NPV	$	3,580
Total		**$**	**3,580**

Environmental Sustainability Benefits	Unit	Benefit	
Nitrous Oxide Savings	2013 $ NPV	$	5,874
Particulate Matter Savings	2013 $ NPV	$	38,527
Sulfur Dioxide Savings	2013 $ NPV	$	469
Volatile Organic Compound Savings	2013 $ NPV	$	1,202
Carbon Dioxide Savings	2013 $ NPV	$	47,628
Total		**$**	**93,702**

Safety Benefits	Unit	Benefit	
Fatality Reductions	2013 $ NPV	$	4,040,509
Injury Reductions	2013 $ NPV	$	-
Property Damage Reductions	2013 $ NPV	$	8,558
Total		**$**	**4,049,066**

Capital Costs	Unit	Cost	
Construction	2013 $ NPV	$	873,439
Design	2013 $ NPV	$	-
Minor Items / Contingency	2013 $ NPV	$	43,672
Total		**$**	**917,111**

Table 8 – Benefit – Cost Analysis Results Summary by US DOT Category

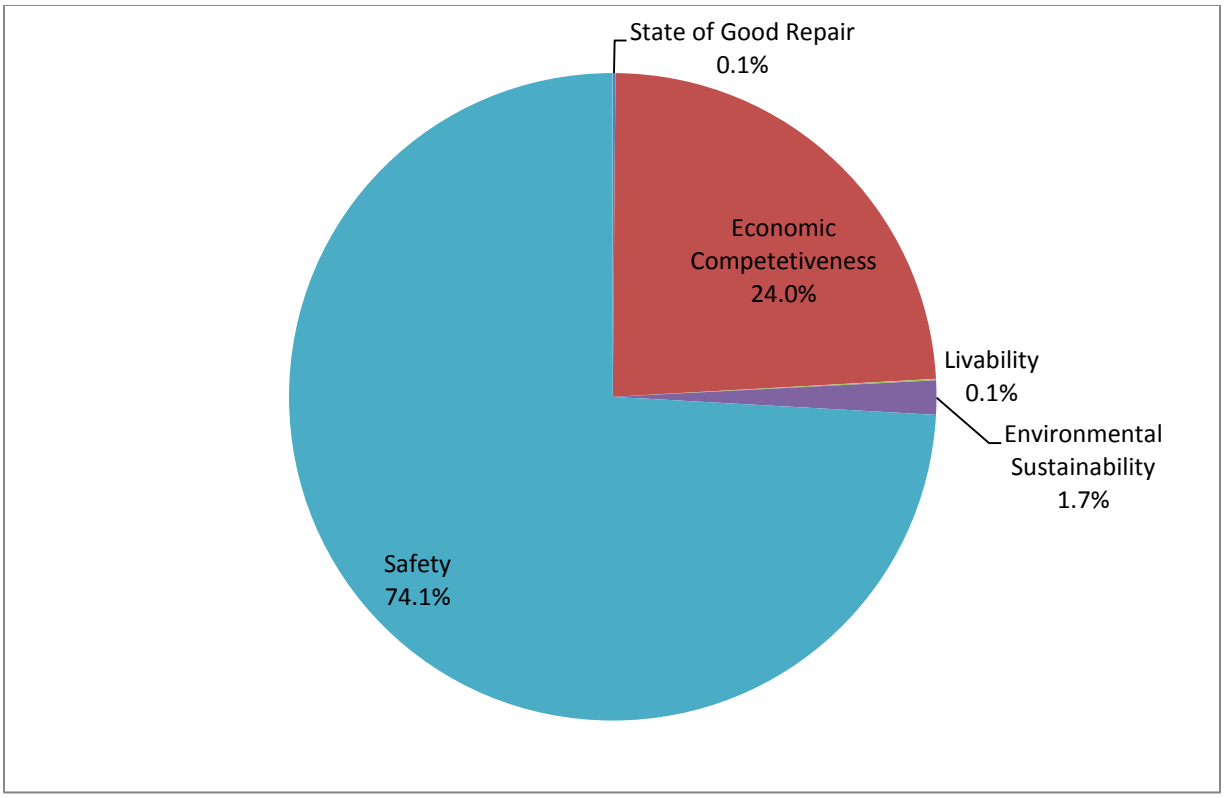

Figure 2 – Percentages of Benefits by US DOT Evaluation Category

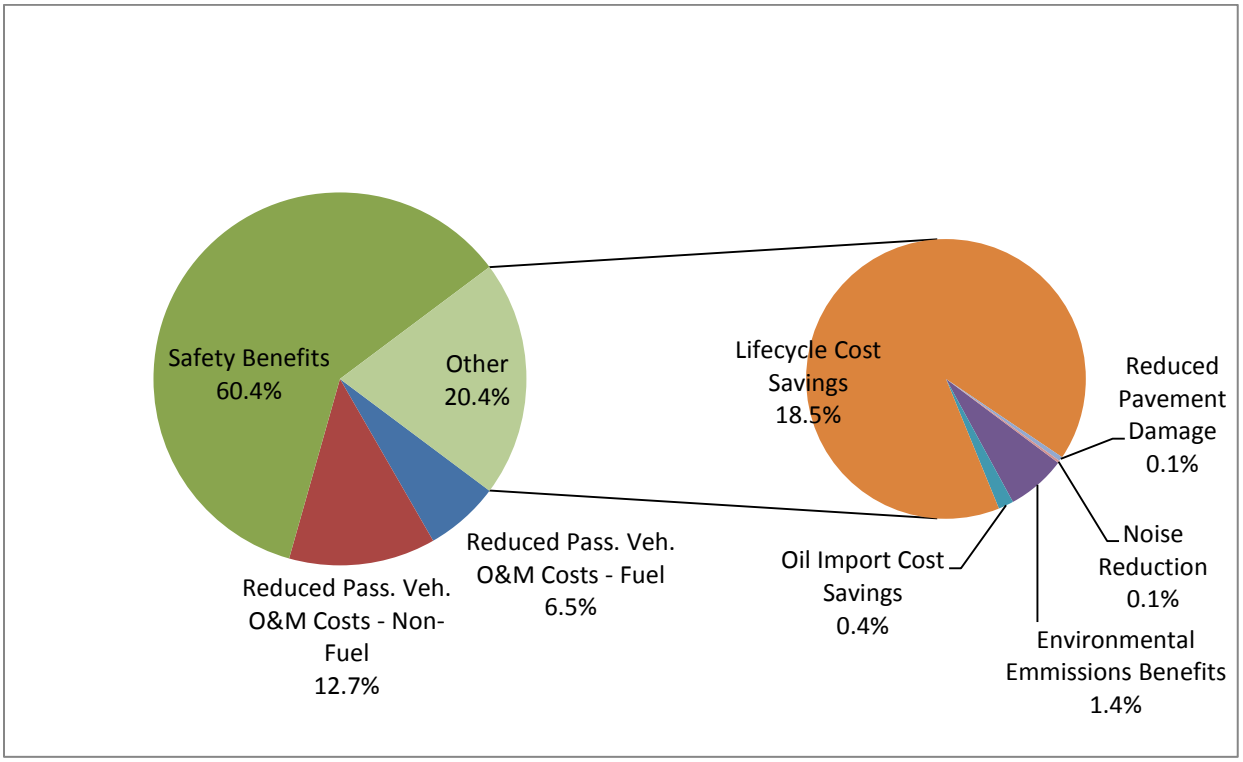

Figure 3 – Percentages of Benefits by US DOT Evaluation Category

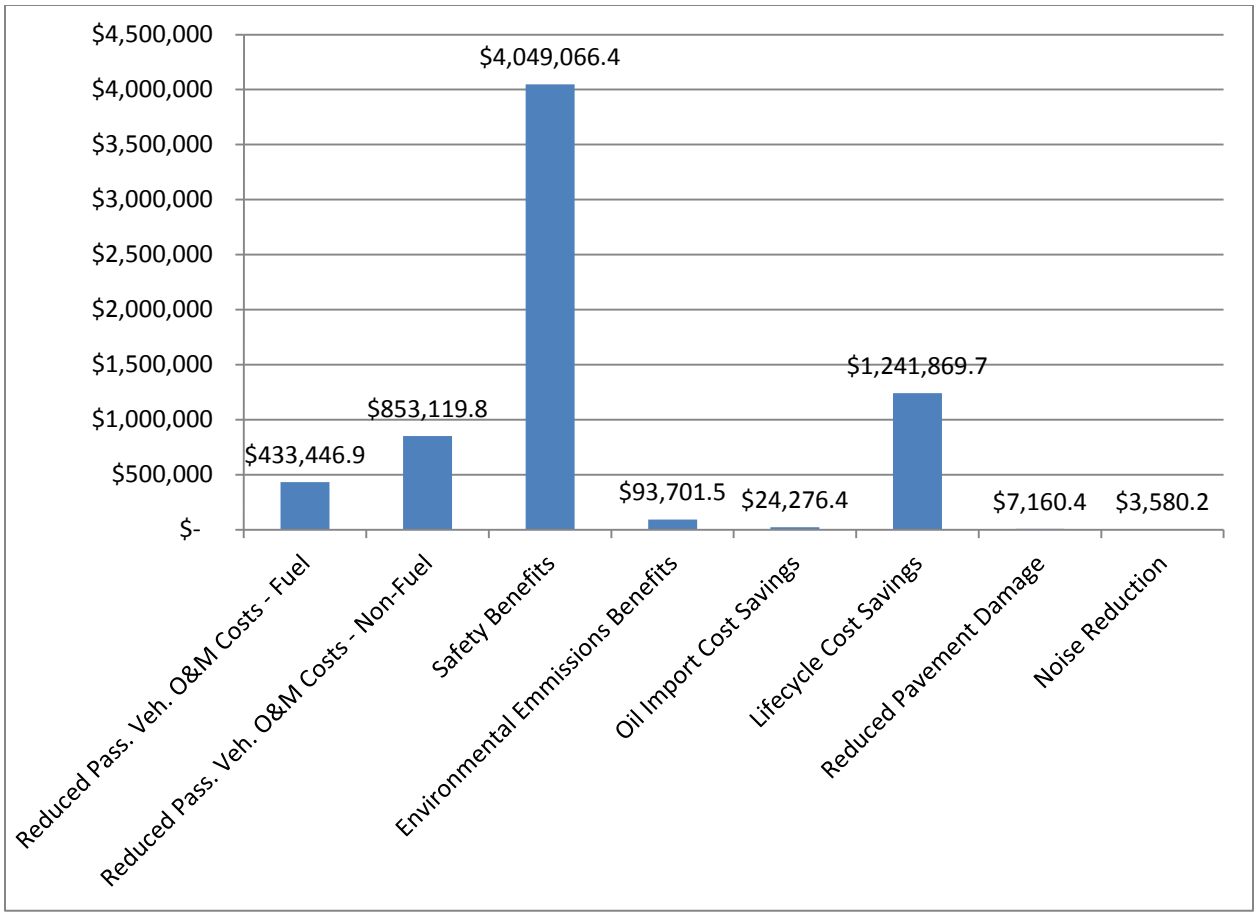

Figure 4 – Amounts of Benefits by US DOT Evaluation Category – in Discounted Present Value (2013 $)

Conclusion

The benefits and costs can be summarized in 2013 NPV dollars as follows:

Total Costs:	$917,111
Total Benefits:	$5,464,352
B / C Ratio:	6.7

This analysis illustrates that the anticipated quantifiable benefits from the proposed project exceed the anticipated costs. It is important to note this analysis does not include all of the potential benefits that replacing the Sink Road Bridge will have to both the Tribe and the public.

Benefit-Cost Analysis: Totals

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Capital Costs	$ -	$ -	$ 1,050,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Costs	$ -	$ -	$ 1,050,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Land Value Increase	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Passenger Vehicle O&M Savings - Fuel	$ 35,832	$ 33,203	$ 31,972	$ 31,319	$ 31,134	$ 31,094	$ 30,968	$ 31,383	$ 31,065	
Passenger Vehicle O&M Savings - Non-Fuel	$ 59,951	$ 60,101	$ 60,180	$ 60,330	$ 60,481	$ 60,632	$ 60,784	$ 60,936	$ 61,088	
Reduced Oil Imports	$ 2,816	$ 2,816	$ 2,779	$ 2,763	$ 2,749	$ 2,721	$ 2,669	$ 2,655	$ 2,573	
Pavement Damage Savings	$ 659	$ 660	$ 661	$ 663	$ 665	$ 666	$ 668	$ 670	$ 671	
Safety Benefits	$ 625	$ 625	$ 623	$ 623	$ 622	$ 622	$ 622	$ 621	$ 621	
Active Life Health Benefits	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Emmissions Savings	$ 7,349	$ 7,436	$ 7,514	$ 7,601	$ 7,689	$ 7,777	$ 7,866	$ 7,955	$ 8,072	
Noise Savings	$ 329	$ 330	$ 331	$ 331	$ 332	$ 333	$ 334	$ 335	$ 336	
Life Cycle Savings	$ 100,000	$ 100,000	$ 100,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	
Total Benefits	$ 207,562	$ 205,171	$ 204,060	$ 193,631	$ 193,672	$ 193,846	$ 193,910	$ 194,554	$ 194,426	
Benefits - Costs	$ 207,562	$ (844,829)	$ 204,060	$ 193,631	$ 193,672	$ 193,846	$ 193,910	$ 194,554	$ 194,426	
Benefits - Costs (Benefits + 15%)	$ 238,696	$ (814,053)	$ 234,669	$ 222,675	$ 222,723	$ 222,923	$ 222,996	$ 223,737	$ 223,589	
Benefits - Costs (Benefits - 15%)	$ 176,428	$ (875,605)	$ 173,451	$ 164,586	$ 164,621	$ 164,769	$ 164,823	$ 165,371	$ 165,262	
Benefits - Costs (Costs + 15%)	$ 207,562	$ (1,002,329)	$ 204,060	$ 193,631	$ 193,672	$ 193,846	$ 193,910	$ 194,554	$ 194,426	
Benefits - Costs (Costs - 15%)	$ 207,562	$ (687,329)	$ 204,060	$ 193,631	$ 193,672	$ 193,846	$ 193,910	$ 194,554	$ 194,426	

B/C	n/a
B/C (Benefits + 15%)	n/a
B/C (Benefits - 15%)	n/a
B/C (Costs + 15%)	n/a
B/C (Costs - 15%)	n/a

ERR	38.9%
ERR (Benefits + 15%)	43.2%
ERR (Benefits - 15%)	34.7%
ERR (Costs + 15%)	35.2%
ERR (Costs - 15%)	43.9%

Note: This sheet contains all undiscounted costs used to calculate the ERR

Benefit-Cost Analysis: Totals

	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Land Value Increase	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Passenger Vehicle O&M Savings - Fuel	$ 30,054	$ 29,525	$ 28,548	$ 27,486	$ 26,478	$ 26,737	$ 26,978	$ 27,227	$ 27,575
Passenger Vehicle O&M Savings - Non-Fuel	$ 61,241	$ 61,394	$ 61,547	$ 61,701	$ 61,856	$ 62,010	$ 62,165	$ 62,321	$ 62,476
Reduced Oil Imports	$ 2,447	$ 2,371	$ 2,276	$ 2,175	$ 2,086	$ 2,089	$ 2,091	$ 2,092	$ 2,093
Pavement Damage Savings	$ 673	$ 675	$ 676	$ 678	$ 680	$ 681	$ 683	$ 685	$ 687
Safety Benefits	$ 620	$ 620	$ 9,100,619	$ 619	$ 618	$ 618	$ 617	$ 617	$ 617
Active Life Health Benefits	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Emmissions Savings	$ 8,176	$ 8,294	$ 8,399	$ 8,518	$ 8,624	$ 8,744	$ 7,448	$ 8,958	$ 9,080
Noise Savings	$ 336	$ 337	$ 338	$ 339	$ 340	$ 341	$ 342	$ 342	$ 343
Life Cycle Savings	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000
Total Benefits	$ 193,547	$ 193,216	$ 9,292,404	$ 191,517	$ 190,681	$ 191,221	$ 190,324	$ 192,242	$ 192,871
Benefits - Costs	$ 193,547	$ 193,216	$ 9,292,404	$ 191,517	$ 190,681	$ 191,221	$ 190,324	$ 192,242	$ 192,871
Benefits - Costs (Benefits + 15%)	$ 222,579	$ 222,198	$ 10,686,265	$ 220,244	$ 219,283	$ 219,904	$ 218,872	$ 221,078	$ 221,801
Benefits - Costs (Benefits - 15%)	$ 164,515	$ 164,233	$ 7,898,544	$ 162,789	$ 162,079	$ 162,538	$ 161,775	$ 163,406	$ 163,940
Benefits - Costs (Costs + 15%)	$ 193,547	$ 193,216	$ 9,292,404	$ 191,517	$ 190,681	$ 191,221	$ 190,324	$ 192,242	$ 192,871
Benefits - Costs (Costs - 15%)	$ 193,547	$ 193,216	$ 9,292,404	$ 191,517	$ 190,681	$ 191,221	$ 190,324	$ 192,242	$ 192,871

B/C
B/C (Benefits + 15%)
B/C (Benefits - 15%)
B/C (Costs + 15%)
B/C (Costs - 15%)

ERR
ERR (Benefits + 15%)
ERR (Benefits - 15%)
ERR (Costs + 15%)
ERR (Costs - 15%)

Note: This sheet contains all undiscounted costs used to ca

Benefit-Cost Analysis: Totals

	2031	2032	2033	2034	2035	2036	2037	2038	2039
Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Land Value Increase	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Passenger Vehicle O&M Savings - Fuel	$ 27,923	$ 28,277	$ 28,648	$ 29,188	$ 29,667	$ 30,279	$ 30,902	$ 31,536	$ 32,172
Passenger Vehicle O&M Savings - Non-Fuel	$ 62,633	$ 62,789	$ 62,946	$ 63,104	$ 63,261	$ 63,420	$ 63,578	$ 63,737	$ 63,896
Reduced Oil Imports	$ 2,095	$ 2,098	$ 2,101	$ 2,105	$ 2,110	$ 2,116	$ 2,121	$ 2,127	$ 2,132
Pavement Damage Savings	$ 688	$ 690	$ 692	$ 693	$ 695	$ 697	$ 699	$ 700	$ 702
Safety Benefits	$ 616	$ 616	$ 615	$ 615	$ 614	$ 614	$ 613	$ 613	$ 612
Active Life Health Benefits	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Emmissions Savings	$ 9,188	$ 9,311	$ 9,420	$ 9,544	$ 9,655	$ 9,780	$ 9,891	$ 9,974	$ 10,130
Noise Savings	$ 344	$ 345	$ 346	$ 347	$ 348	$ 348	$ 349	$ 350	$ 351
Life Cycle Savings	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000
Total Benefits	$ 193,487	$ 194,127	$ 194,769	$ 195,596	$ 196,351	$ 197,254	$ 198,154	$ 199,036	$ 199,995
Benefits - Costs	$ 193,487	$ 194,127	$ 194,769	$ 195,596	$ 196,351	$ 197,254	$ 198,154	$ 199,036	$ 199,995
Benefits - Costs (Benefits + 15%)	$ 222,510	$ 223,246	$ 223,984	$ 224,935	$ 225,803	$ 226,842	$ 227,877	$ 228,892	$ 229,995
Benefits - Costs (Benefits - 15%)	$ 164,464	$ 165,008	$ 165,554	$ 166,256	$ 166,898	$ 167,666	$ 168,431	$ 169,181	$ 169,996
Benefits - Costs (Costs + 15%)	$ 193,487	$ 194,127	$ 194,769	$ 195,596	$ 196,351	$ 197,254	$ 198,154	$ 199,036	$ 199,995
Benefits - Costs (Costs - 15%)	$ 193,487	$ 194,127	$ 194,769	$ 195,596	$ 196,351	$ 197,254	$ 198,154	$ 199,036	$ 199,995

B/C
B/C (Benefits + 15%)
B/C (Benefits - 15%)
B/C (Costs + 15%)
B/C (Costs - 15%)

ERR
ERR (Benefits + 15%)
ERR (Benefits - 15%)
ERR (Costs + 15%)
ERR (Costs - 15%)

Note: This sheet contains all undiscounted costs used to ca

Benefit-Cost Analysis: Totals

	2040	2041	2042	2043	2044	2045	2046	2047	2048
Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Land Value Increase	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Passenger Vehicle O&M Savings - Fuel	$ 33,114	$ 33,581	$ 34,034	$ 34,494	$ 34,960	$ 35,432	$ 35,911	$ 36,396	$ 36,887
Passenger Vehicle O&M Savings - Non-Fuel	$ 64,056	$ 64,216	$ 64,377	$ 64,538	$ 64,699	$ 64,861	$ 65,023	$ 65,186	$ 65,348
Reduced Oil Imports	$ 2,137	$ 2,140	$ 2,143	$ 2,146	$ 2,149	$ 2,152	$ 2,155	$ 2,158	$ 2,161
Pavement Damage Savings	$ 704	$ 706	$ 707	$ 709	$ 711	$ 713	$ 715	$ 716	$ 718
Safety Benefits	$ 612	$ 611	$ 611	$ 610	$ 610	$ 610	$ 609	$ 609	$ 608
Active Life Health Benefits	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Emmissions Savings	$ 10,242	$ 10,356	$ 10,469	$ 10,569	$ 10,684	$ 10,799	$ 10,900	$ 11,016	$ 11,133
Noise Savings	$ 352	$ 353	$ 354	$ 355	$ 355	$ 356	$ 357	$ 358	$ 359
Life Cycle Savings	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000
Total Benefits	$ 201,217	$ 201,962	$ 202,696	$ 203,421	$ 204,168	$ 204,923	$ 205,670	$ 206,439	$ 207,215
Benefits - Costs	$ 201,217	$ 201,962	$ 202,696	$ 203,421	$ 204,168	$ 204,923	$ 205,670	$ 206,439	$ 207,215
Benefits - Costs (Benefits + 15%)	$ 231,399	$ 232,257	$ 233,100	$ 233,934	$ 234,793	$ 235,661	$ 236,520	$ 237,404	$ 238,298
Benefits - Costs (Benefits - 15%)	$ 171,034	$ 171,668	$ 172,291	$ 172,908	$ 173,543	$ 174,184	$ 174,819	$ 175,473	$ 176,133
Benefits - Costs (Costs + 15%)	$ 201,217	$ 201,962	$ 202,696	$ 203,421	$ 204,168	$ 204,923	$ 205,670	$ 206,439	$ 207,215
Benefits - Costs (Costs - 15%)	$ 201,217	$ 201,962	$ 202,696	$ 203,421	$ 204,168	$ 204,923	$ 205,670	$ 206,439	$ 207,215

B/C
B/C (Benefits + 15%)
B/C (Benefits - 15%)
B/C (Costs + 15%)
B/C (Costs - 15%)

ERR
ERR (Benefits + 15%)
ERR (Benefits - 15%)
ERR (Costs + 15%)
ERR (Costs - 15%)

Note: This sheet contains all undiscounted costs used to ca

Benefit-Cost Analysis: Totals

	2049	2050	2051	2052	2053	2054	2055	2056	2057
Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Land Value Increase	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Passenger Vehicle O&M Savings - Fuel	$ 37,386	$ 37,891	$ 38,402	$ 38,921	$ 39,447	$ 39,979	$ 40,519	$ 41,067	$ 41,621
Passenger Vehicle O&M Savings - Non-Fuel	$ 65,512	$ 65,676	$ 65,840	$ 66,004	$ 66,169	$ 66,335	$ 66,501	$ 66,667	$ 66,834
Reduced Oil Imports	$ 2,164	$ 2,167	$ 2,171	$ 2,174	$ 2,177	$ 2,180	$ 2,183	$ 2,186	$ 2,189
Pavement Damage Savings	$ 720	$ 722	$ 724	$ 725	$ 727	$ 729	$ 731	$ 733	$ 734
Safety Benefits	$ 608	$ 607	$ 607	$ 606	$ 606	$ 605	$ 605	$ 604	$ 604
Active Life Health Benefits	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Emmissions Savings	$ 11,250	$ 11,353	$ 11,473	$ 11,595	$ 11,719	$ 11,845	$ 11,973	$ 12,102	$ 12,234
Noise Savings	$ 360	$ 361	$ 362	$ 363	$ 364	$ 364	$ 365	$ 366	$ 367
Life Cycle Savings	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000
Total Benefits	$ 207,999	$ 208,776	$ 209,578	$ 210,389	$ 211,208	$ 212,038	$ 212,877	$ 213,725	$ 214,583
Benefits - Costs	$ 207,999	$ 208,776	$ 209,578	$ 210,389	$ 211,208	$ 212,038	$ 212,877	$ 213,725	$ 214,583
Benefits - Costs (Benefits + 15%)	$ 239,199	$ 240,093	$ 241,014	$ 241,947	$ 242,890	$ 243,843	$ 244,808	$ 245,784	$ 246,771
Benefits - Costs (Benefits - 15%)	$ 176,799	$ 177,460	$ 178,141	$ 178,830	$ 179,527	$ 180,232	$ 180,945	$ 181,666	$ 182,396
Benefits - Costs (Costs + 15%)	$ 207,999	$ 208,776	$ 209,578	$ 210,389	$ 211,208	$ 212,038	$ 212,877	$ 213,725	$ 214,583
Benefits - Costs (Costs - 15%)	$ 207,999	$ 208,776	$ 209,578	$ 210,389	$ 211,208	$ 212,038	$ 212,877	$ 213,725	$ 214,583

B/C
B/C (Benefits + 15%)
B/C (Benefits - 15%)
B/C (Costs + 15%)
B/C (Costs - 15%)

ERR
ERR (Benefits + 15%)
ERR (Benefits - 15%)
ERR (Costs + 15%)
ERR (Costs - 15%)

Note: This sheet contains all undiscounted costs used to ca

Benefit-Cost Analysis: Totals

	2058	2059	2060	2061	2062	2063	Total (2013 - 2063)
Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,050,000
Total Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,050,000
Land Value Increase	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Passenger Vehicle O&M Savings - Fuel	$ 42,183	$ 42,753	$ 43,331	$ 43,916	$ 44,509	$ 45,110	$ 1,394,525
Passenger Vehicle O&M Savings - Non-Fuel	$ 67,001	$ 67,168	$ 67,336	$ 67,504	$ 67,673	$ 67,842	$ 2,714,899
Reduced Oil Imports	$ 2,192	$ 2,195	$ 2,199	$ 2,202	$ 2,205	$ 2,208	$ 97,820
Pavement Damage Savings	$ 736	$ 738	$ 740	$ 742	$ 744	$ 746	$ 29,834
Safety Benefits	$ 603	$ 603	$ 602	$ 602	$ 601	$ 601	$ 9,126,431
Active Life Health Benefits	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Emmissions Savings	$ 12,367	$ 12,503	$ 12,640	$ 12,780	$ 12,922	$ 13,065	$ 409,771
Noise Savings	$ 368	$ 369	$ 370	$ 371	$ 372	$ 373	$ 14,917
Life Cycle Savings	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 3,900,000
Total Benefits	$ 215,451	$ 216,329	$ 217,218	$ 218,116	$ 219,025	$ 219,945	$ 13,788,197
Benefits - Costs	$ 215,451	$ 216,329	$ 217,218	$ 218,116	$ 219,025	$ 219,945	$ 16,638,197
Benefits - Costs (Benefits + 15%)	$ 247,769	$ 248,779	$ 249,800	$ 250,834	$ 251,879	$ 252,937	$ 19,291,427
Benefits - Costs (Benefits - 15%)	$ 183,134	$ 183,880	$ 184,635	$ 185,399	$ 186,171	$ 186,953	$ 13,984,968
Benefits - Costs (Costs + 15%)	$ 215,451	$ 216,329	$ 217,218	$ 218,116	$ 219,025	$ 219,945	$ 16,480,697
Benefits - Costs (Costs - 15%)	$ 215,451	$ 216,329	$ 217,218	$ 218,116	$ 219,025	$ 219,945	$ 16,795,697

B/C
B/C (Benefits + 15%)
B/C (Benefits - 15%)
B/C (Costs + 15%)
B/C (Costs - 15%)

ERR
ERR (Benefits + 15%)
ERR (Benefits - 15%)
ERR (Costs + 15%)
ERR (Costs - 15%)

Note: This sheet contains all undiscounted costs used to ca

Benefit-Cost Analysis: Totals NPV

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Capital Costs	$ -	$ -	$ 917,111	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Costs	$	$ 93,458	$ 917,111	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Land Value Increase	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Passenger Vehicle O&M Savings - Fuel	$	$ 33,488	$ 29,001	$ 26,098	$ 23,893	$ 22,198	$ 20,719	$ 19,285	$ 18,265	$ 16,897
Passenger Vehicle O&M Savings - Non-Fuel	$	$ 56,029	$ 52,494	$ 49,125	$ 46,026	$ 43,122	$ 40,402	$ 37,853	$ 35,465	$ 33,228
Reduced Oil Imports	$	$ 2,632	$ 2,459	$ 2,268	$ 2,108	$ 1,960	$ 1,813	$ 1,662	$ 1,545	$ 1,399
Pavement Damage Savings	$	$ 616	$ 577	$ 540	$ 506	$ 474	$ 444	$ 416	$ 390	$ 365
Safety Benefits	$	$ 585	$ 546	$ 509	$ 475	$ 444	$ 414	$ 387	$ 361	$ 338
Active Life Health Benefits	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Emmissions Savings	$	$ 6,868	$ 6,495	$ 6,134	$ 5,799	$ 5,482	$ 5,182	$ 4,899	$ 4,630	$ 4,391
Noise Savings	$	$ 308	$ 288	$ 270	$ 253	$ 237	$ 222	$ 208	$ 195	$ 183
Life Cycle Savings (O&M Costs)	$	$ 93,458	$ 87,344	$ 81,630	$ 68,661	$ 64,169	$ 59,971	$ 56,047	$ 52,381	$ 48,954
Total Benefits	$	$ 193,983	$ 179,204	$ 166,573	$ 147,720	$ 138,085	$ 129,168	$ 120,757	$ 113,232	$ 105,755
Benefits - Costs	$	$ 193,983	$ (737,906)	$ 166,573	$ 147,720	$ 138,085	$ 129,168	$ 120,757	$ 113,232	$ 105,755
Benefits - Costs (Benefits + 15%)	$	$ 223,081	$ (711,026)	$ 191,559	$ 169,878	$ 158,798	$ 148,543	$ 138,871	$ 130,217	$ 121,618
Benefits - Costs (Benefits - 15%)	$	$ 164,886	$ (764,787)	$ 141,587	$ 125,562	$ 117,373	$ 109,792	$ 102,644	$ 96,247	$ 89,891
Benefits - Costs (Costs + 15%)	$	$ 193,983	$ (875,473)	$ 166,573	$ 147,720	$ 138,085	$ 129,168	$ 120,757	$ 113,232	$ 105,755
Benefits - Costs (Costs - 15%)	$	$ 193,983	$ (600,340)	$ 166,573	$ 147,720	$ 138,085	$ 129,168	$ 120,757	$ 113,232	$ 105,755

B/C	6.7
B/C (Benefits + 15%)	7.7
B/C (Benefits - 15%)	5.7
B/C (Costs + 15%)	5.8
B/C (Costs - 15%)	7.9

ERR	n/a
ERR (Benefits + 15%)	n/a
ERR (Benefits - 15%)	n/a
ERR (Costs + 15%)	n/a
ERR (Costs - 15%)	n/a

Note: This sheet contains all undiscounted costs used to calculate the ERR

Cumulative Benefits	$ -	$ 193,983	$ 373,188	$ 539,761	$ 687,481	$ 825,567	$ 954,734	$ 1,075,492	$ 1,188,724	$ 1,294,479
Cumulative Costs	$ -	$ 93,458	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569

Benefit-Cost Analysis: Totals NPV

	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Land Value Increase	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Passenger Vehicle O&M Savings - Fuel	$ 15,278	$ 14,027	$ 12,676	$ 11,406	$ 10,269	$ 9,691	$ 9,138	$ 8,619	$ 8,158
Passenger Vehicle O&M Savings - Non-Fuel	$ 31,132	$ 29,168	$ 27,328	$ 25,604	$ 23,989	$ 22,475	$ 21,058	$ 19,729	$ 18,485
Reduced Oil Imports	$ 1,244	$ 1,126	$ 1,011	$ 903	$ 809	$ 757	$ 708	$ 662	$ 619
Pavement Damage Savings	$ 342	$ 321	$ 300	$ 281	$ 264	$ 247	$ 231	$ 217	$ 203
Safety Benefits	$ 315	$ 294	$ 4,040,784	$ 257	$ 240	$ 224	$ 209	$ 195	$ 182
Active Life Health Benefits	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Emmissions Savings	$ 4,156	$ 3,940	$ 3,729	$ 3,535	$ 3,344	$ 3,169	$ 2,523	$ 2,836	$ 2,686
Noise Savings	$ 171	$ 160	$ 150	$ 141	$ 132	$ 123	$ 116	$ 108	$ 102
Life Cycle Savings (O&M Costs)	$ 45,751	$ 42,758	$ 39,961	$ 37,347	$ 34,904	$ 32,620	$ 30,486	$ 28,492	$ 26,628
Total Benefits	$ 98,390	$ 91,795	$ 4,125,939	$ 79,473	$ 73,949	$ 69,307	$ 64,469	$ 60,859	$ 57,064
Benefits - Costs	$ 98,390	$ 91,795	$ 4,125,939	$ 79,473	$ 73,949	$ 69,307	$ 64,469	$ 60,859	$ 57,064
Benefits - Costs (Benefits + 15%)	$ 113,148	$ 105,565	$ 4,744,830	$ 91,394	$ 85,042	$ 79,703	$ 74,140	$ 69,988	$ 65,623
Benefits - Costs (Benefits - 15%)	$ 83,631	$ 78,026	$ 3,507,048	$ 67,552	$ 62,857	$ 58,911	$ 54,799	$ 51,730	$ 48,504
Benefits - Costs (Costs + 15%)	$ 98,390	$ 91,795	$ 4,125,939	$ 79,473	$ 73,949	$ 69,307	$ 64,469	$ 60,859	$ 57,064
Benefits - Costs (Costs - 15%)	$ 98,390	$ 91,795	$ 4,125,939	$ 79,473	$ 73,949	$ 69,307	$ 64,469	$ 60,859	$ 57,064
B/C									
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Note: This sheet contains all undiscounted costs used t									
Cumulative Benefits	$ 1,392,868	$ 1,484,664	$ 5,610,602	$ 5,690,075	$ 5,764,024	$ 5,833,332	$ 5,897,801	$ 5,958,660	$ 6,015,723
Cumulative Costs	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569

Benefit-Cost Analysis: Totals NPV

	2031	2032	2033	2034	2035	2036	2037	2038	2039
Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Land Value Increase	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Passenger Vehicle O&M Savings - Fuel	$ 7,721	$ 7,307	$ 6,919	$ 6,588	$ 6,258	$ 5,969	$ 5,694	$ 5,430	$ 5,177
Passenger Vehicle O&M Savings - Non-Fuel	$ 17,318	$ 16,226	$ 15,202	$ 14,243	$ 13,345	$ 12,503	$ 11,714	$ 10,975	$ 10,283
Reduced Oil Imports	$ 579	$ 542	$ 507	$ 475	$ 445	$ 417	$ 391	$ 366	$ 343
Pavement Damage Savings	$ 190	$ 178	$ 167	$ 157	$ 147	$ 137	$ 129	$ 121	$ 113
Safety Benefits	$ 170	$ 159	$ 149	$ 139	$ 130	$ 121	$ 113	$ 106	$ 99
Active Life Health Benefits	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Emmissions Savings	$ 2,541	$ 2,406	$ 2,275	$ 2,154	$ 2,037	$ 1,928	$ 1,822	$ 1,717	$ 1,630
Noise Savings	$ 95	$ 89	$ 84	$ 78	$ 73	$ 69	$ 64	$ 60	$ 56
Life Cycle Savings (O&M Costs)	$ 24,886	$ 23,258	$ 21,736	$ 20,314	$ 18,985	$ 17,743	$ 16,582	$ 15,498	$ 14,484
Total Benefits	$ 53,501	$ 50,166	$ 47,039	$ 44,149	$ 41,420	$ 38,888	$ 36,510	$ 34,273	$ 32,185
Benefits - Costs	$ 53,501	$ 50,166	$ 47,039	$ 44,149	$ 41,420	$ 38,888	$ 36,510	$ 34,273	$ 32,185
Benefits - Costs (Benefits + 15%)	$ 61,526	$ 57,691	$ 54,095	$ 50,771	$ 47,632	$ 44,721	$ 41,986	$ 39,414	$ 37,013
Benefits - Costs (Benefits - 15%)	$ 45,476	$ 42,641	$ 39,983	$ 37,526	$ 35,207	$ 33,055	$ 31,033	$ 29,132	$ 27,358
Benefits - Costs (Costs + 15%)	$ 53,501	$ 50,166	$ 47,039	$ 44,149	$ 41,420	$ 38,888	$ 36,510	$ 34,273	$ 32,185
Benefits - Costs (Costs - 15%)	$ 53,501	$ 50,166	$ 47,039	$ 44,149	$ 41,420	$ 38,888	$ 36,510	$ 34,273	$ 32,185
B/C									
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Note: This sheet contains all undiscounted costs used t									
Cumulative Benefits	$ 6,069,224	$ 6,119,390	$ 6,166,429	$ 6,210,578	$ 6,251,997	$ 6,290,885	$ 6,327,395	$ 6,361,668	$ 6,393,854
Cumulative Costs	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569

Benefit-Cost Analysis: Totals NPV

	2040	2041	2042	2043	2044	2045	2046	2047	2048
Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Land Value Increase	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Passenger Vehicle O&M Savings - Fuel	$ 4,980	$ 4,720	$ 4,471	$ 4,235	$ 4,011	$ 3,800	$ 3,599	$ 3,409	$ 3,229
Passenger Vehicle O&M Savings - Non-Fuel	$ 9,634	$ 9,026	$ 8,457	$ 7,923	$ 7,424	$ 6,955	$ 6,517	$ 6,105	$ 5,720
Reduced Oil Imports	$ 321	$ 301	$ 281	$ 263	$ 247	$ 231	$ 216	$ 202	$ 189
Pavement Damage Savings	$ 106	$ 99	$ 93	$ 87	$ 82	$ 76	$ 72	$ 67	$ 63
Safety Benefits	$ 92	$ 86	$ 80	$ 75	$ 70	$ 65	$ 61	$ 57	$ 53
Active Life Health Benefits	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Emmissions Savings	$ 1,540	$ 1,456	$ 1,375	$ 1,298	$ 1,226	$ 1,158	$ 1,092	$ 1,032	$ 975
Noise Savings	$ 53	$ 50	$ 46	$ 44	$ 41	$ 38	$ 36	$ 34	$ 31
Life Cycle Savings (O&M Costs)	$ 13,536	$ 12,651	$ 11,823	$ 11,050	$ 10,327	$ 9,651	$ 9,020	$ 8,430	$ 7,878
Total Benefits	$ 30,263	$ 28,388	$ 26,628	$ 24,975	$ 23,426	$ 21,975	$ 20,612	$ 19,336	$ 18,139
Benefits - Costs	$ 30,263	$ 28,388	$ 26,628	$ 24,975	$ 23,426	$ 21,975	$ 20,612	$ 19,336	$ 18,139
Benefits - Costs (Benefits + 15%)	$ 34,803	$ 32,647	$ 30,622	$ 28,721	$ 26,940	$ 25,271	$ 23,704	$ 22,236	$ 20,859
Benefits - Costs (Benefits - 15%)	$ 25,724	$ 24,130	$ 22,633	$ 21,228	$ 19,913	$ 18,679	$ 17,520	$ 16,435	$ 15,418
Benefits - Costs (Costs + 15%)	$ 30,263	$ 28,388	$ 26,628	$ 24,975	$ 23,426	$ 21,975	$ 20,612	$ 19,336	$ 18,139
Benefits - Costs (Costs - 15%)	$ 30,263	$ 28,388	$ 26,628	$ 24,975	$ 23,426	$ 21,975	$ 20,612	$ 19,336	$ 18,139
B/C									
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Note: This sheet contains all undiscounted costs used t									
Cumulative Benefits	$ 6,424,117	$ 6,452,505	$ 6,479,133	$ 6,504,108	$ 6,527,534	$ 6,549,509	$ 6,570,121	$ 6,589,457	$ 6,607,595
Cumulative Costs	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569

Benefit-Cost Analysis: Totals NPV

	2049	2050	2051	2052	2053	2054	2055	2056	2057
Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Land Value Increase	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Passenger Vehicle O&M Savings - Fuel	$ 3,058	$ 2,897	$ 2,744	$ 2,599	$ 2,462	$ 2,332	$ 2,209	$ 2,092	$ 1,982
Passenger Vehicle O&M Savings - Non-Fuel	$ 5,359	$ 5,021	$ 4,705	$ 4,408	$ 4,130	$ 3,869	$ 3,625	$ 3,396	$ 3,182
Reduced Oil Imports	$ 177	$ 166	$ 155	$ 145	$ 136	$ 127	$ 119	$ 111	$ 104
Pavement Damage Savings	$ 59	$ 55	$ 52	$ 48	$ 45	$ 43	$ 40	$ 37	$ 35
Safety Benefits	$ 50	$ 46	$ 43	$ 40	$ 38	$ 35	$ 33	$ 31	$ 29
Active Life Health Benefits	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Emmissions Savings	$ 920	$ 868	$ 820	$ 774	$ 731	$ 691	$ 653	$ 617	$ 582
Noise Savings	$ 29	$ 28	$ 26	$ 24	$ 23	$ 21	$ 20	$ 19	$ 17
Life Cycle Savings (O&M Costs)	$ 7,363	$ 6,881	$ 6,431	$ 6,010	$ 5,617	$ 5,250	$ 4,906	$ 4,585	$ 4,285
Total Benefits	$ 17,016	$ 15,962	$ 14,975	$ 14,050	$ 13,182	$ 12,368	$ 11,604	$ 10,889	$ 10,217
Benefits - Costs	$ 17,016	$ 15,962	$ 14,975	$ 14,050	$ 13,182	$ 12,368	$ 11,604	$ 10,889	$ 10,217
Benefits - Costs (Benefits + 15%)	$ 19,569	$ 18,357	$ 17,222	$ 16,157	$ 15,159	$ 14,223	$ 13,345	$ 12,522	$ 11,750
Benefits - Costs (Benefits - 15%)	$ 14,464	$ 13,568	$ 12,729	$ 11,942	$ 11,205	$ 10,513	$ 9,864	$ 9,255	$ 8,684
Benefits - Costs (Costs + 15%)	$ 17,016	$ 15,962	$ 14,975	$ 14,050	$ 13,182	$ 12,368	$ 11,604	$ 10,889	$ 10,217
Benefits - Costs (Costs - 15%)	$ 17,016	$ 15,962	$ 14,975	$ 14,050	$ 13,182	$ 12,368	$ 11,604	$ 10,889	$ 10,217
B/C									
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Note: This sheet contains all undiscounted costs used t									
Cumulative Benefits	$ 6,624,611	$ 6,640,574	$ 6,655,549	$ 6,669,599	$ 6,682,781	$ 6,695,149	$ 6,706,753	$ 6,717,642	$ 6,727,859
Cumulative Costs	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569

Benefit-Cost Analysis: Totals NPV

	2058	2059	2060	2061	2062	2063	Total (2013 - 2063)
Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ 917,111
Total Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,010,569
Land Value Increase	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Passenger Vehicle O&M Savings - Fuel	$ 1,877	$ 1,778	$ 1,684	$ 1,595	$ 1,511	$ 1,431	$ 434,878
Passenger Vehicle O&M Savings - Non-Fuel	$ 2,981	$ 2,793	$ 2,617	$ 2,452	$ 2,297	$ 2,152	$ 855,272
Reduced Oil Imports	$ 98	$ 91	$ 85	$ 80	$ 75	$ 70	$ 33,744
Pavement Damage Savings	$ 33	$ 31	$ 29	$ 27	$ 25	$ 24	$ 9,399
Safety Benefits	$ 27	$ 25	$ 23	$ 22	$ 20	$ 19	$ 4,049,066
Active Life Health Benefits	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Emmissions Savings	$ 550	$ 520	$ 491	$ 464	$ 439	$ 415	$ 118,997
Noise Savings	$ 16	$ 15	$ 14	$ 13	$ 13	$ 12	$ 4,699
Life Cycle Savings (O&M Costs)	$ 4,005	$ 3,743	$ 3,498	$ 3,269	$ 3,055	$ 2,855	$ 1,271,166
Total Benefits	$ 9,587	$ 8,997	$ 8,443	$ 7,923	$ 7,435	$ 6,978	$ 6,777,222
Benefits - Costs	$ 9,587	$ 8,997	$ 8,443	$ 7,923	$ 7,435	$ 6,978	$ 5,860,111
Benefits - Costs (Benefits + 15%)	$ 11,025	$ 10,346	$ 9,709	$ 9,111	$ 8,551	$ 8,025	$ 6,876,694
Benefits - Costs (Benefits - 15%)	$ 8,149	$ 7,647	$ 7,176	$ 6,734	$ 6,320	$ 5,931	$ 4,843,528
Benefits - Costs (Costs + 15%)	$ 9,587	$ 8,997	$ 8,443	$ 7,923	$ 7,435	$ 6,978	$ 5,722,544
Benefits - Costs (Costs - 15%)	$ 9,587	$ 8,997	$ 8,443	$ 7,923	$ 7,435	$ 6,978	$ 5,997,678
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Note: This sheet contains all undiscounted costs used t

Cumulative Benefits	$ 6,737,446	$ 6,746,443	$ 6,754,885	$ 6,762,808	$ 6,770,243	$ 6,777,222
Cumulative Costs	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569	$ 1,010,569