HDR ONE COMPANY | *Many Solutions*®

APPENDIX IN SUPPORT OF THE TIGER APPLICATION

CHARLOTTE AREA TRANSIT SYSTEM (CATS) NORTH CORRIDOR COMMUTER RAIL (NCCR)

COST BENEFIT AND ECONOMIC IMPACT ANALYSIS

SEPTEMBER 11, 2009

TABLE OF CONTENTS

1 Project Overview

The Charlotte Area Transit System (CATS) proposes to implement the North Corridor Commuter Rail Project, a new 25-mile commuter rail system operating over existing tracks owned by the Norfolk Southern Corporation (NS) between downtown Charlotte and Mount Mourne, an area immediately south of Mooresville, North Carolina. The rail line runs though the centers of downtown Huntersville, Cornelius, Davidson and Mooresville. Improvements to the rail line would include replacement of ties and rail, signalization, protection of at-grade crossings, and construction of up to 12 stations and a vehicle maintenance facility (VMF).

The Service would consist of 20-30 minute headways during the morning and afternoon rush hour period and hourly service during the remainder of the day. Trip time would be approximately 35 minutes between Davidson and Charlotte and 50 minutes from Mooresville to Charlotte. The new service is projected to have some 5,000 commuters ride the trains daily to or from Charlotte by 2030. The vast majority of these commuters currently travel by single-occupancy vehicle along I-77 and/or NC 115 (Old Statesville Road) or US 21 (Statesville Road).

CATS currently operates rush-hour express bus service from Mooresville, Davidson, Cornelius, and Huntersville to Charlotte. These services have experienced substantial growth over the past five years. However, traffic congestion on the roads leading from the towns to I-77, as well as traffic on I-77 itself, are expected to undermine the competitiveness of this service in the coming years. With implementation of commuter rail service east of I-77 from the center of the towns, CATS express bus service would be re-oriented along and west of I-77, thereby providing commuters on both sides of I-77 with a competitive, reliable rapid transit alternative.

2 Cost Benefit Analysis (CBA) Framework

The CBA framework is a comparison of values – the cost to build and operate the transit facility represent foregone value that could alternatively be invested elsewhere and the benefits of the project represent the improvement in social well-being delivered by the project. To be deemed economically feasible, projects must pass one or more value benchmarks: the total benefits must exceed the total costs of the project on a present value basis and/or the rate of return on the funds invested should exceed the cost of raising capital, often defined as the long-term treasury rate or the social discount rate.

Benefits are estimated for current and future users on an incremental basis - as the change in welfare that consumers and, more generally, society derive from access to the new commuter rail service in comparison with an estimated no-build condition. As with most transportation projects, the benefits derived from implementation, are primarily a reduction in the costs associated with transportation activities. The estimated reduction in costs accounts for user preferences and the way the project affects the availability of specific transportation options and associated costs. These travel cost reductions include time saved by users, reduced travel costs, mobility enhancements, job creation, reduction of pollution and accidents, or a combination of these outcomes.

Benefits primarily represent the creation of economic value from changes in the quantity of final uses and the quality of the services provided to affected travelers. For example, the total transportation costs for current commuters between Charlotte and Mooresville includes the value of the total time spent commuting, plus the expenses associated with operating vehicles used for the commuting, plus other externalities, such as the cost of pollution and accidents generated by the specific level and composition of traffic.

In addition to the benefits associated with the reduction in transportation costs, transit investments often have impacts on real estate development in the vicinity of the stations. Not only is there a potential increase in the production of residential and commercial units close to the stations; but also the value of all real estate properties surrounding the stations may increase. Part of this increase is associated with the transportation time and cost savings experienced by residents,[1] but a portion is an additional increase in value associated with the agglomeration of activities, the amenity value of residing near a transit station and other economies of scale that go beyond transportation cost savings. Therefore, another component of the approach to benefits adopted in this analysis is the estimation of transit oriented development benefits, measured as an increase in the value of real estate in the surrounding areas that goes above and beyond the capitalization of transportation benefits.

3 Methodology

In general, the economic benefits of transportation investments can be illustrated with a simple graph relating the generalized cost of travel (including the value of travel time and fares) to the demand for travel (measured as the number of trips in a time period). This relationship, the "travel demand curve," is an inverse relationship: as the generalized cost of travel decreases, the number of trips increases.

This can be represented in a diagram where the number of trips is on the horizontal axis and the generalized cost of travel on the vertical axis. The demand for trips is downward sloping: as the generalized cost of travel decreases, the number of trips increases. Investment in new rail systems, or new routes, can be evaluated by estimating the change in the generalized price of travel brought about by the investment, and the associated change in trip making. The travel demand curve, is illustrated in Figure 1, below.

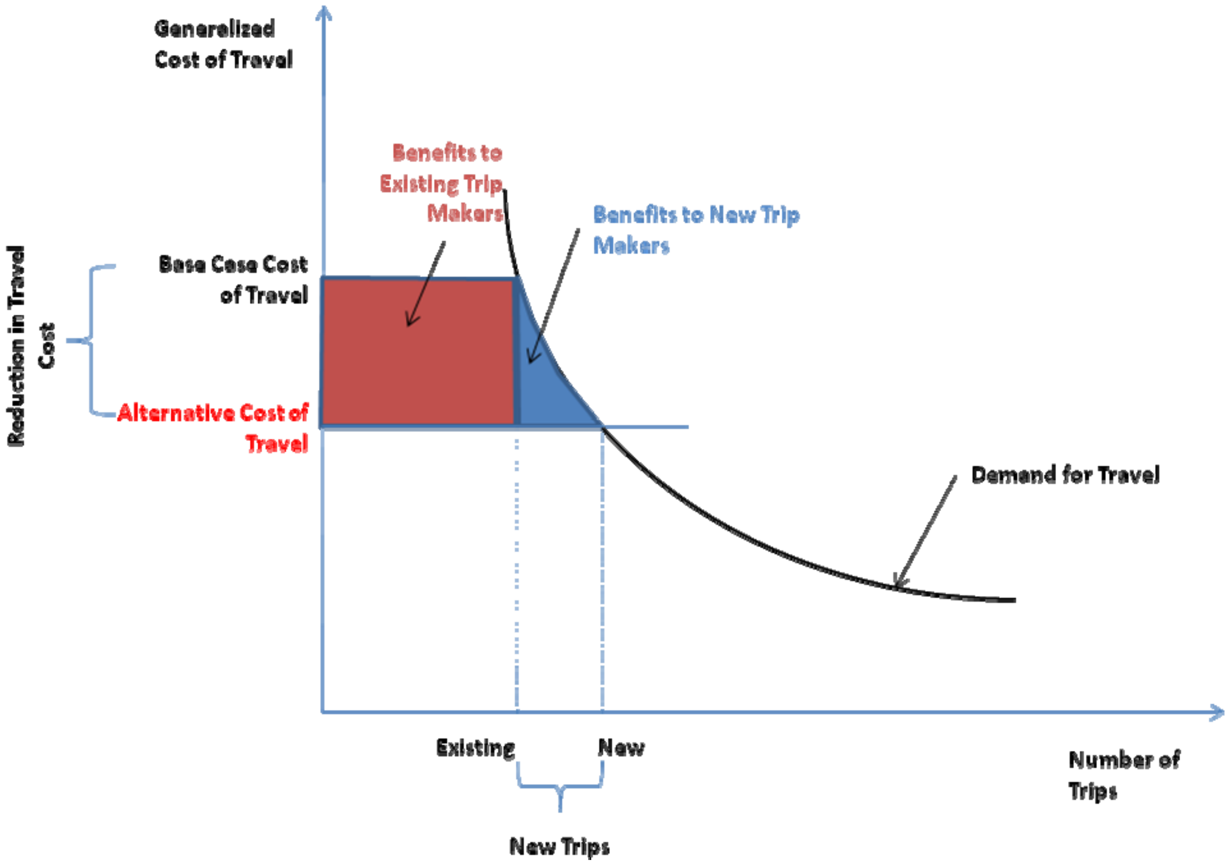
Riders on the new commuter rail facility may experience travel time savings compared to their previous travel mode or reductions in their trip expenses. In addition, the availability of

[1] Some property value appreciation is expected as developers, buyers and sellers of property factor in the value of the improved transportation options into property prices. This analysis seeks to derive additional economic development benefit beyond the "capitalization" of travel benefits already accounted for in estimates of travel benefits.

transportation at a more affordable price will encourage users to travel more, increasing the total number of trips.

Highway users will also benefit from the new transit system, as trip diversion from auto to rail frees up some capacity on the highways. Benefits to highway users will include benefits to both existing and new highway users, as the reduction in highway congestion (due to trip diversion) reduces the generalized cost of highway travel (travel time, fuel and oil consumption, accident costs, etc.), and induces new trip makers to use the highways.

Figure 1: The Demand for Travel



The benefits of the commuter rail service can therefore be evaluated by considering the travel cost savings accruing to travelers staying in mode and those switching from other modes, based on the consumer surplus methodology. This is accomplished by comparing transportation costs per trip between the no-build case and the build case. The social cost of a trip on a congested road includes travel time, vehicle operating costs, safety costs, and emission costs.

The availability of rail service can result in social cost savings. Congestion management benefits are expressed as the cost savings resulting from rail use, reductions in automobile use relative to the base case, including travel time savings, vehicle operating cost savings, emission cost savings, and accident cost savings. In compliance with the TIGER application guidelines, the following sections discuss each category of benefits within the context of the evaluation criteria set forth by the TIGER guidelines.

4 Principles

The following principles guide the estimation of benefits and costs for this study:

- Only incremental benefits and costs are measured
  - The incremental benefits of the project include the transportation cost savings for the users of the service, as well as increases in asset values as a result of the implementation of the transportation improvements. For example, only the incremental real estate value associated with the implementation of the project is considered a benefit of the project. Increases in value associated with benefits measured elsewhere, that are a product of additional, unaccounted for investment, or that are a result of the general economic cycle are not considered in the estimation of station area development benefits.
  - The incremental costs of implementation of the project include initial and recurring costs. Initial costs refer to the capital costs incurred for design and construction of a list of enhancements designed to increase the maximum speed limit on the existing tracks, as well as for the implementation and improvement of rail stations along the corridor. Recurring costs include incremental operating costs and administration and marketing expenses. Only additions in cost to the current operations and planned investments are considered as costs of the project.
  - The creation of new jobs may or may not be an incremental benefit depending on the types of jobs, the population filling those jobs and the likely level of local or regional unemployment at the time those jobs are created. Given the current economic situation and the purpose of the TIGER program, this analysis assumes short-term job creation represents net new employment, which can be counted as a project benefit. Long-term job creation is estimated but not included in the measurement of project costs and benefits.
- Benefits and costs are valued relative to the next-best alternative.
  - The benefits stemming from the implementation of transportation improvement are those above and beyond the benefits that could be obtained from the best existing transportation alternative. For instance, the transportation costs savings for users are measured relative to the next-best existing alternative, which may be the highway or the express bus service, depending on the type of user. The benefit is the net cost saving in transportation costs relative to the next-best alternative.

- The costs of the project will only include those incremental costs that represent an opportunity costs to the funding entities. Expenditures are considered foregone opportunities to invest in the next-best alternative.

5 Guidance and General Assumptions

USDOT Guidance (CFR Vol. 74 No. 115 Docket No. OST-2009-0115) indicates that CBAs in support of TIGER funding requests be performed with defensible and robust methods, data and assumptions. The guidelines stipulate that benefits should be tracked for at least 20 years (possibly more, depending on the project), and present values of costs and benefits should be determined with a 7% discount rate. Table 1, below describes each of the benefits estimated in this analysis based on the TIGER grants guidance.

Table 1: Benefits and Description by Evaluation Criteria

Criteria	Benefit(s)	Description
State of Good Repair	Pavement Maintenance Savings	Reductions in pavement maintenance costs due to reductions in roadway usage
Economic Competitiveness	Short Term Employment	Value of new short-term jobs created
	Economic Development	Incremental property value appreciation due to commuter rail proximity, net of travel time savings
Livability	Vehicle Operating Cost Savings	Reductions in monetary costs to drivers switching to public transit
	Travel Time Savings	Door-to-door trip time savings to both commuter rail users and remaining roadway users
	Impacts to Low Income Population	Short-term employment opportunities benefiting low income workers
Sustainability	Emissions Reductions	Reductions in pollutants and green house gasses due to auto use reductions relative to the no-build condition
Safety	Accident Reduction	Reductions in property losses and injuries and deaths due to reductions in automobile use and removal or upgrade of existing at-grade crossings

Many of the monetizing factors of project performance (e.g. accident costs per vehicle mile traveled (VMT)) are specified in the guidelines as well. In the absence of quantitative measures, other categories and measures of benefits are also acceptable, including qualitative assessments of potential benefits. The Guidelines also suggest sensitivity analysis for a 3% discount rate and, consistent with Office of Management and Budget (OMB) circulars, A-4 and A-94, sensitivity analyses for other assumptions can be conducted to provide a complete perspective on the range of potential value for the project.

All benefits and costs are estimated in 2009 dollars. The valuation of benefits makes use of a number of assumptions that are required to produce monetized values for all these non-pecuniary benefits. The different components of time, for instance, are monetized by using a "value of time" that is assumed to be equivalent to the user's willingness to pay for time savings in transit. Other estimates used in the monetization of benefits include the cost of operating a vehicle, including fuel, maintenance, repair, and depreciation, and the cost per ton of pollution, among other elements.

Annual costs and benefits are computed over a long-run planning horizon and summarized by a lifecycle cost analysis. The project is assumed to have a useful life of at least 30 years; that is the time horizon of the analysis. Construction is expected to be completed by 2012, but operating costs continue through the lifecycle of the project. Benefits also accrue during the full operation of the project.

This section describes the measurement approach for each category of benefit estimated in this analysis and provides an overview of the data and assumptions used in the analysis.

6 Ridership and Roadway Travel Forecast

Ridership and Vehicle Miles Traveled (VMT) data used in this analysis were provided by the Charlotte Area Transit System (CATS), based on the North Corridor Commuter Rail (NCCR) Environmental Assessment Preliminary Draft Report, which was submitted to the Federal Railroad Administration (FRA) in April 2008. The data is based on a travel demand model, which was completed in 2006 and uses 2005 as the current year with 2030 as the forecast year. Table 2 below indicates the estimated daily ridership in selected years by mode and in total, while Table 3 indicates the estimated daily net reduction in VMT and trips for those same years based on the occupancy for passenger vehicles and buses.

Table 2: Daily Ridership by Source

	2012	2030	2042
Total Daily Trips	2,600	5,000	7,129
Diverted from Auto	1,820	3,500	4,990
Diverted from Bus	780	1,500	2,139

Table 3: Daily Net VMT and Trip Reduction

	2012	2030	2042
Daily VMT Reduced	25,055	48,182	63,600
Daily Trips Reduced	2,364	4,545	6,000

In order to estimate lifecycle ridership, the opening year ridership was escalated by the current annual rate of AADT growth forecast provided within the 2008 Environmental Assessment report through 2042. Additionally, estimates of capacity and average speeds on major roadways and standard speed-flow curve equations[2] were used to estimate the effect of diversion on remaining roadway users. Table 4 and Table 5 show the no-build and build I-77 Capacity and operation analysis data.

Table 4: I-77 Capacity and Operation Analysis - No-Build

	2012	2030	2042
AADT	111,638	177,769	221,857
Speed	53	32	18
Vehicle/Capacity Ratio	0.91	1.23	1.44

Table 5: I-77 Capacity and Operation Analysis - Build

	2012	2030	2042
AADT	109,274	173,224	215,857
Speed	55	34	18
Vehicle/Capacity Ratio	0.89	1.22	1.44

7 Input Categories

Input values used in this analysis are taken from the United States Department of Transportation (USDOT) guidance on the preparation of Cost Benefit Analyses, including the recently published guidelines for the TIGER Grant applications. Where USDOT has not provided valuation guidance or a reference to guidance, standard industry practice has been applied.

[2] http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/appxa.pdf

Estimates used in the monetization of benefits include the cost of operating a vehicle, including fuel, maintenance, repair, and depreciation. Table 6, below, lists input variables used in this analysis adjusted for 2009 dollars.

In calculating diversion benefits and in terms of the number of vehicles that would be taken off the road, the expected increase in ridership is used in conjunction with the average vehicle occupancy (1.1 persons/vehicle) to estimate the reduction in the number of vehicles.

External costs, measured in dollars per vehicle mile, are benefits estimated based on the reduction in the number of vehicles on the road such as congestion costs, reductions in pavement maintenance requirements, as well as accident costs. On the other hand, internal costs include time and operating costs, both for passenger vehicles as well as rail miles. In the case of a commuter rail, external costs and savings impact remaining highway users, while internal costs and savings are experienced by the commuter rail user.

The value of time for commuters is estimated at $13.12 per hour, based on USDOT Guidance for General Purpose trips inflated to 2009 dollars. Meanwhile emission costs are expressed as dollars per ton and are based on the benefits associated with recently-adopted regulations that limit emissions of air pollutants from mobile sources, which includes passenger cars, light trucks, and other highway vehicles.

Table 6: Input Variables used in the Cost Benefit Analysis

Parameter	Units	Values
Vehicle (Car/SUV/Van/Pick-up) Factors		
Vehicle occupancy – Passenger Vehicle	Persons / Vehicle	1.1
Vehicle occupancy - Bus	Persons / Bus	25
External Cost Inputs - Vehicles		
Congestion cost per vehicle mile	$ / Vehicle mile	0.055
Pavement maintenance cost per vehicle mile	$ / Vehicle mile	0.003
Noise pollution cost per vehicle mile	$ / Vehicle mile	0.001
Accident cost per vehicle mile	$ / Vehicle mile	0.027
Internal cost Inputs - Car, Train, Vehicle		
Fuel cost per gallon	$ / Gallon	3.47
Fuel cost of Commuter Rail per train mile	$ / train mile	0.016
Fare per Commuter Rail passenger mile	$ / passenger mile	0.188
Vehicle operating cost per car mile	$ / Vehicle mile	0.234
Value of time		
Value of travel time – General Purpose	$ / Hour	13.12
Fuel Consumption		

Parameter	Units	Values
Gallons per mile – Car	gal / mile	0.050
Gallons per passenger mile – Commuter Rail	gal/ pass mile	0.021
Emissions Costs per Ton		
NOX	$ / ton	$4,166
SO2	$ / ton	$16,480
PM	$ / ton	$174,976
VOC	$ / ton	$1,771
CO	$ / ton	$34

8 Project Life Cycle Costs

The costs of the project consist of initial construction costs and operation and maintenance (O&M) costs. Table 7 below presents base and escalated costs of construction and O&M, as well as the improvements associated with each stage of additional investment. Total capital costs for the project are estimated at $357.5 million, which after discounted at the required 7 percent rate becomes $314 million. Meanwhile, annual O&M costs are projected at $10.4, for a total 7 percent discounted cost of $113.8 over the project's lifecycle.

Table 7: Capital and O&M Costs and associated Improvements

	Avg. Annual	Total (2009 $M)
Capital Costs ($M)	na	$314.1
O&M Costs ($M)	$10.4	$113.8

9 Benefits

The benefits of the North Corridor Commuter Rail service are evaluated in this analysis based on USDOT Guidance for TIGER Grants applications and the results are presented below in accordance with Table 1 in section 5 of this report.

9.1 State of Good Repair - Pavement Maintenance Savings

The savings in pavement maintenance, like other variable costs, are due to the reduction in vehicle-miles on nearby arterials including I-77, NC-115 and US-21 as trips are diverted onto the commuter rail. The analysis combined and estimated per-unit savings of pavement maintenance costs, estimated at $0.003 per vehicle-mile avoided, with the estimated reduction in VMT. The opening year savings in pavement maintenance is calculated at approximately $18,161, amounting to a discounted value of $367,751 for the study period.

Table 8: Pavement Maintenance Savings

	Opening Year	Lifecycle
VMT Avoided	25,055	412,243,636
Pavement Maintenance Savings (2009 $)	$18,161	$367,751

9.2 Economic Competitiveness

Benefits pertaining to economic competitiveness include those related to increased short term employment in addition to economic development benefits, which are measured as the incremental value of new construction due to commuter rail proximity, net of total travel time savings.

9.2.1 Increased Short and Long Term Employment Output and Income

Short term job creation is estimated based on the incremental project expenditures between 2009 and project completion in 2012. The Minnesota IMPLAN Group's input-output model for North Carolina is used to estimate direct, indirect and induced employment, associated output, value added and labor income.

Employment represents full time and part time jobs created for a full year. Value Added represents total business sales (output) minus the cost of purchasing intermediate products which is roughly equivalent to gross regional/domestic product. Labor Income consists of employee compensation (wage and salary payments as well as health and life insurance, retirement payments, and any other non-cash compensation) and proprietary income (payments received by self-employed individuals as income). Table 9 indicates short term job creation, income and value added due to the commuter rail investment.

Table 9: Short Term Job Creation, Income and Value Added

Period	Employment	Total	Labor Income ($M)	Total ($M)	Value Added ($M)	Total ($M)
2010 - Q2	104	104	$5.6	$5.6	$7.9	$7.9
2010 - Q3	101	205	$5.5	$11.1	$7.7	$15.5
2010 - Q4	448	653	$23.5	$34.6	$34.3	$49.8
2011 - Q1	743	1,395	$39.6	$74.2	$58.4	$108.2
2011 - Q2	928	2,323	$49.1	$123.4	$72.6	$180.9
2011 - Q3	1,449	3,772	$76.1	$199.5	$112.5	$293.4
2011 - Q4	753	4,525	$40.1	$239.6	$59.3	$352.7
2012 - Q1	472	4,997	$25.5	$265.1	$37.8	$390.4
2012 - Q2	472	5,469	$25.5	$290.7	$37.8	$428.2
2012 - Q3	61	5,530	$3.4	$294.1	$4.6	$432.8

Table 10 below presents the short-term increased employment activity associated with the construction of the transit line and includes direct, indirect, and induced employment opportunities. The cumulative job years created from the construction of the transit line are 5,530. These jobs are considered benefits of the project because the current rate of unemployment in North Carolina is high enough to assume that these represent net new employment to otherwise unemployed workers, and not transfers of employment as might occur in full, or near full employment. These jobs were then monetized by the median wage of their specific sector in the Charlotte region. As a result, benefits to local workers accrue to an additional $194.9 million.

Table 10: Short-term Direct, Indirect, and Induced Employment by Sector

Sectors	Total Employment	Total Estimated Benefit
Agricultural, Forestry, Fish & Hunting	56	$1,410,427
Mining	50	$1,811,215
Utilities	13	$413,494
Construction	1793	$58,748,996
Manufacturing	509	$14,547,256
Wholesale Trade	142	$6,864,494
Transportation & Warehousing	203	$5,348,043
Retail trade	403	$8,074,314
Information	76	$5,542,896
Finance & insurance	206	$11,844,390
Real estate & rental	161	$10,210,933
Professional- scientific & tech services	512	$27,717,836
Management of companies	48	$4,644,020
Administrative & waste services	297	$8,991,835
Educational services	78	$2,885,312
Health & social services	362	$13,218,651
Arts- entertainment & recreation	83	$3,128,621
Accommodation & food services	272	$4,649,823
Other services	231	$3,553,556
Government & non NAICs	35	$1,272,409
Total	**5,530**	**$194,878,521**

The operation and maintenance of the commuter rail line produces long term jobs. Unlike construction, these jobs are sustained throughout the life expectancy of the commuter line. The analysis assumes that full or near full employment will be reached by 2013. Therefore these long-term job creation estimates are not monetized and are not used in the cost-benefit calculation.

In addition to long term jobs created by the operation and maintenance of the commuter rail line, jobs are also expected to be created as new station area property development is induced. New development in station areas is estimated above a baseline development rate as detailed in an analysis by RCLCO and published by CATS in the 2007 North Corridor Financing Strategy.

Table 11, below, presents long term job creation resulting from operation of the commuter rail and the monetary trip cost savings estimated to accrue to users, i.e. the portion of VOC savings that is re-spent by users and incremental new property development in station areas. Estimates of trip cost savings and property development are described in subsequent sections.

Table 11: Long Term Job Creation

	Value (M)	Direct & Indirect Jobs per Year	Induced Jobs per Year	Total Jobs per Year	Life Cycle Jobs Created
Annual O&M Expenditures	$10.4	162	129	291	8,730
Average Annual New Development	$145.3	1,009	568	1,577	28,387
Total[3]	$172.5	1,171	697	1,868	37,117

9.2.2 Economic Development

A majority of benefits from the commuter rail line result from economic development of the community and appreciation of land values to nearby properties. Because commuter rail reduces automobile-travel dependence and provides households with a number of amenities, it stimulates the demand for residential units located in the vicinity of station locations, and, other things being equal, raises property market values. As a result of this increased demand, densities in station areas tend to rise, and density itself can lead to agglomeration economies that create benefit beyond direct travel benefits. Likewise, the increase in accessibility and traffic can encourage commercial development. Most, although not all, studies of transit's impacts on residential properties have recorded premiums. Studies show that premiums usually occur to those properties within a quarter to half a mile of station locations.

Economic development benefits are estimated as a short-term, extra, or premium rate of property appreciation above and beyond the general rate of appreciation.

Studies of other systems have reported premiums as low as 2 percent, but most are much higher (some as high as 1,000 percent). This analysis relies on a relatively low premium after accounting for travel benefits to ensure the analysis is not affected by overly optimistic

[3] Total Long Term Job Creation is calculated by multiplying the number of jobs created by Annual O&M and property development activity by the 30 years of operation and then adding the jobs created by monetary savings from VOC.

expectations of development impacts and to avoid the possibility of accounting for travel benefits twice – in the travel impacts analysis and in the economic development forecast.

The premium rate for property appreciation in the build scenario was assumed at 4 percent, at the low end of studies of the impact of existing systems.. The premium is applied to estimated incremental new construction values only. No effects to existing properties (for which no data were available) were estimated. CATS published development forecasts as part of the North Corridor Financing Strategy in 2007. These included baseline, or no-build, and build forecasts of construction and value. The difference between these two forecasts is assumed to be the induced incremental development. Proximity benefits are estimated as the premium value only of this new development.

Part of the increase in the value of the real estate market around station areas is, in part, associated with the transportation cost saving afforded by the investment, particularly if the investment generates time savings and/or the ability to reduce car ownership. Economists call this the capitalization of travel benefits. The approach is careful to incorporate only the additional value created beyond the capitalization of the transportation savings. Therefore, to avoid the possibility of double-counting benefits, the economic development benefits are reported net of all travel time saving effects. This ensures that any property value appreciation effects resulting from the desire to live or work near transit in order to enjoy improved travel conditions is not counted twice in the analysis. The residual value appreciation effect, after travel benefits represents the agglomeration benefit (amenity value, productivity effect, commercial activity effect, productivity effect, etc.) conferred by the rail alignment on those properties in proximity to it largely achieved through the level of densification encouraged by the presence of a transit facility (Transit Oriented Development).[4]

Table 12: Incremental Economic Development Benefits

Economic Development	2009 (Current $2009)	2012 (Current $2009)	Lifecycle (Current $2009)
Total Economic Development Benefit	$408,335	$4,100,473	$189,673,349

Table 12 above, illustrates the cumulative effect of economic development. Though the forecast build out completes in 2027, the difference between build and no-build property values remains through the lifecycle. Additionally, incremental appreciation throughout the study period is summed and discounted to calculate total economic development. On a discounted basis, economic development is estimated to provide over $189 million in monetized benefits net of total travel time savings.

[4] See recent evidence on the scale and applicability of agglomeration benefits over-and-above capitalized travel time savings in P.C. Melo, *et al*, "A Meta-Analysis of Estimates of Urban Agglomeration Economies," Regional Science and Urban Economics 39, 2009 and Graham, Daniel J., "Agglomeration, Productivity, and Transport Investment," Journal of Transport Economics and Policy, Volume 41, Part 3, September 2007

9.3 Livability

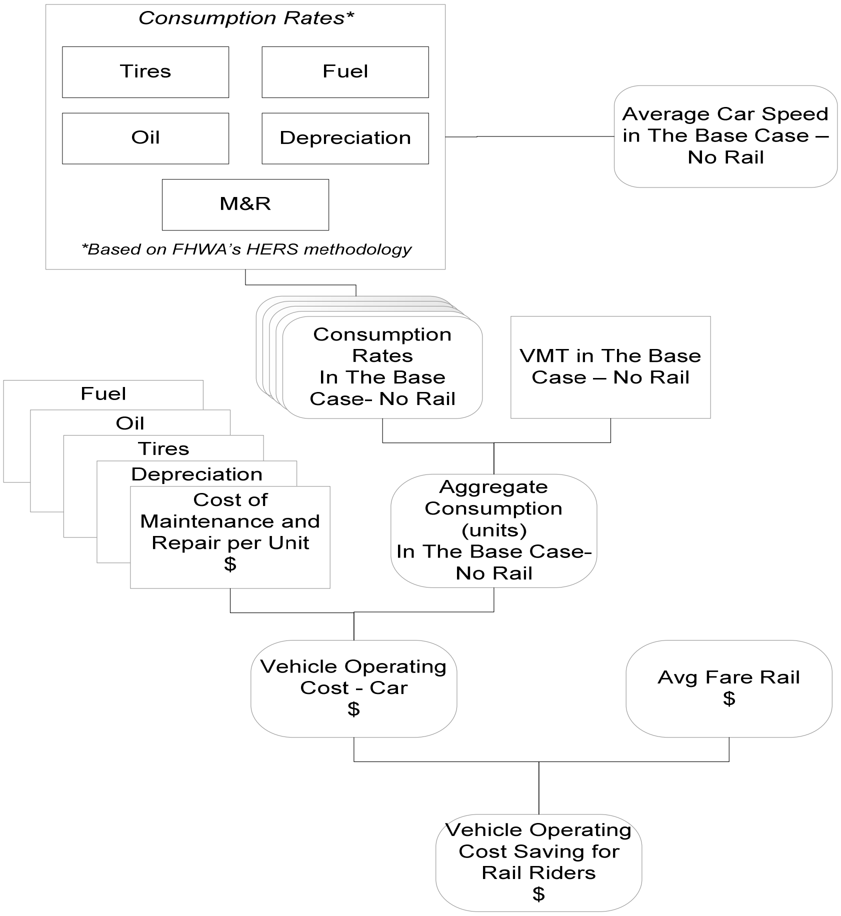
Livability benefits are measured in terms of vehicle operating cost (VOC) savings, travel time savings in addition to increased budgetary savings to low-income users. VOC savings measure the reduction in monetary costs to drivers switching from private vehicles to the new commuter rail system. Travel time savings measure the reduction in total travel time for both commuter rail users in addition to the remaining highway users. Finally, budgetary savings to low-income users benefits are concerned with the portion of the trip cost and time savings accruing to low income users.

9.3.1 Vehicle Operating Costs

Vehicle operating costs (VOC) are an integral element of the generalized cost of traveling. These costs are generally the most recognized of user costs because they typically include some out-of-pocket expenses associated with owning, operating, and maintaining a vehicle. The cost components of VOC measured in this analysis include fuel and oil consumption, maintenance and repairs, tire wear, and vehicle depreciation. Even though, the operating cost is only associated with personal vehicles, fares may be considered equivalent components of cost for commuter rail users, to the extent that they affect mode choice decision-making in almost the same way as vehicle operating costs.

Figure 2, below, describes the structure and logic of the estimation of vehicle operating cost savings. The estimation of vehicle operating costs (VOC) is based on consumption and depreciation rate tables from the Federal Highway Administration's Highway Administration Economic Requirement System (HERS).

Figure 2: Vehicle Operating Cost Savings Structure and Logic Diagram



Trip cost reductions accrue to users who divert from personal automobiles to the new commuter rail service. As with all other benefit categories, the Vehicle Operating Cost (VOC) savings benefit compares forecast VMT and trips in the no-build to build forecasts. Monetized benefits are separated into five categories; fuel, oil, tires, maintenance and depreciation. The costs in transit fares for passengers diverted from auto are subtracted from these reductions in vehicle costs to reach a net savings estimate. Table 13 presents savings due to reduced VMT and trips in 2012 and for the lifecycle.

Table 13: VOC Savings in 2012 and Lifecycle

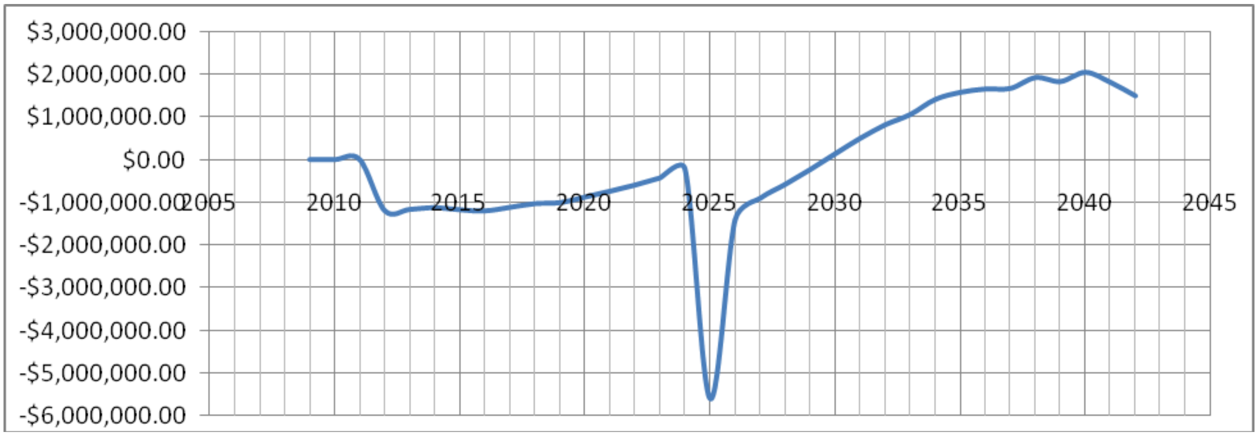
Vehicle Operating Cost Savings	2012	Lifecycle
Fuel	$76,104	$7,617,811
Oil	($13,424)	($154,223)
Tires	$227,238	$5,164,933
Maintenance	$920,130	$22,196,248
Depreciation	$81,799	$1,701,827
Commuter Rail Fares	($824,542)	($16,836,189)

Total VOC Savings	$467,303	$19,690,406

Maintenance is the highest component of vehicle operating costs, followed by fuel and tires. Depreciation represents only a small portion of the total operating costs. In estimating VOC savings to remaining highway users, a comparison of each component of VOC is made on a per trip basis. Estimating the cost of each component is a function of the speed.

VOC savings decreases in the initial years as the no-build case reduced speeds get closer to optimum speeds than in the build scenario, but after 2030 speed reductions due to congestion start increasing total operating costs in the no-build scenario, as speeds return to sub-optimum levels. The savings associated with vehicle operating costs are presented in Figure 3. As expected, costs decrease as speeds reach an optimum in 2030, but increase thereafter as congestion builds up in the corridor.

Figure 3: Vehicle Operating Costs Savings



9.3.2 Travel Time Savings

Travel time savings are driven by changes in average travel times per round trip between the base case and alternate case. These savings are estimated by measuring the difference between projected travel time costs in the base case (no rail), and travel time costs for both rail and roadway users in the alternative case.

Travel times for car and bus users are estimated using the BPR speed flow curve[5]. Speeds and travel times for rail are based on HDR projections associated with the expected level of investments on the rail tracks and stations, as well as assumptions regarding dwelling times. These projections are derived from the project's Environmental Assessment draft document prepared by Charlotte Area Transit System (CATS). Car and bus travel times in the alternative scenario are based on the assumption that those users who switch to rail will not be replaced by new users. The variables involved in the estimation of speeds and travel times include:

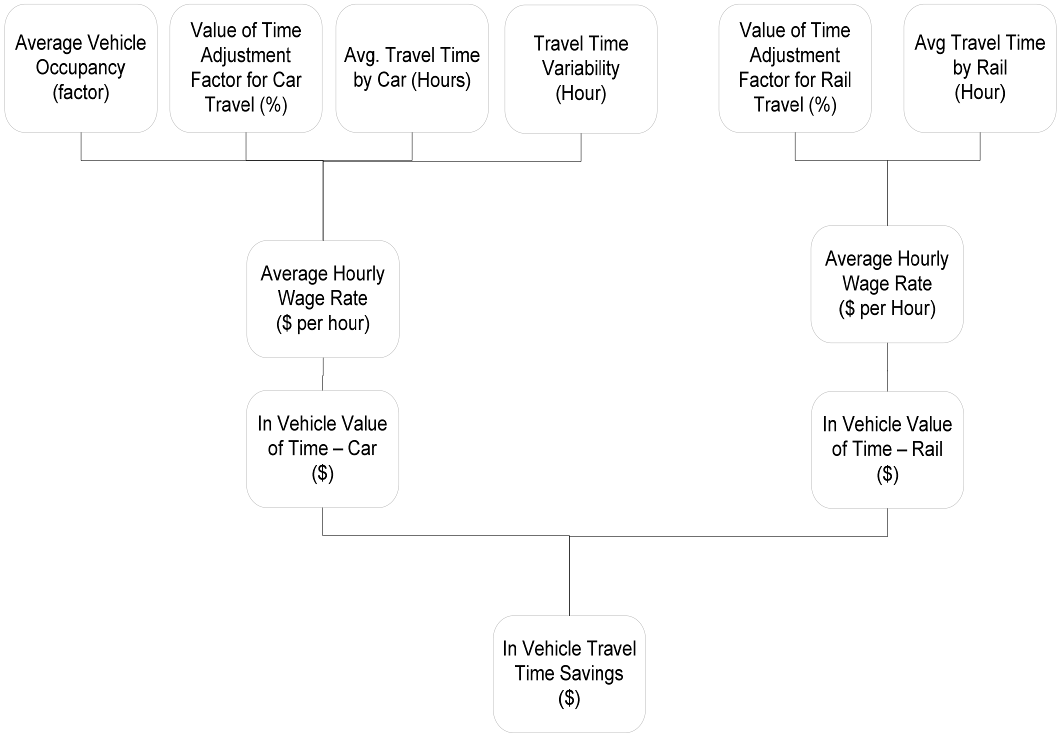
[5] The BPR speed flow curve is a mathematical relationship that determines congested vehicle speed as a function of varying congestion levels, the exact formula is :Congested Speed = (Free-Flow Speed) /(1+0.15[volume/capacity]^10).

- Estimates and forecasted levels of average annual daily traffic (AADT) for the current and future years;
- Ridership estimates and growth rates, based on population growth patterns;
- Average trip length based on forecasted congestion and speeds;

The speed flow curve estimates average speeds at a continuum of vehicle-to-capacity ratios. Based on the existing capacity, we developed a forecast of speeds in each year and the resulting trip times. Traffic growth between Charlotte and Davidson along I-77 is calculated using traffic data from Charlotte Area Transit System (CATS), which forecasts 2030 AADT. The traffic data in the alternative case does not include any induced traffic caused by the introduction of rail, and is simply the base case peak traffic minus the number of commuter that switch to rail.

Figure 4 below illustrates the structure and logic of the estimation of travel time savings. Essentially, the methodology consists of a comparison of the generalized transportation cost of using the passenger rail service versus the generalized transportation cost of using an alternate mode (car or bus). The general cost of travel time is monetized by assuming a value of time for each type of user by mode. This value of time intends to capture the user's valuation of the time spent in transportation activities in relation to the user's wages as specified in the TIGER guidance.

Figure 4: Travel Time Structure and Logic Diagram



9.3.3 Impacts to Low-Income Population

In addition to time savings, the construction of the commuter rail line will increase employment in sectors of business that staff many low-income employees. Table 14 above indicates the short-term employment in key industries that employ low income workers estimated to be generated by the rail investment. The second column of the table refers to the numbers of job created in the respective sector annually during the construction period. The third column provides labor income (in millions of dollars) which represent not only salaries but all benefits.

Table 14: Short Term Employment Key Industries

Key Industries Employing Low-Income People	Job Years	Labor Income ($ Million)
Agriculture, forestry, fishing and hunting	56	$1.2
Construction	1,793	$94.3
Retail trade	405	$12.4
Truck transportation	79	$3.7
Administrative and support and waste management and remediation services	297	$9.2
Nursing and residential care facilities, home health care services	182	$5.6
Accommodation and food services	272	$5.9
Personal and laundry services	43	$1.0
Total	**3,127**	**$133.4**

9.4 Sustainability - Reduction in Environmental Emissions

Environmental costs have gained increased acceptance as an important component in the economic evaluation of transportation and infrastructure projects. The main environmental impacts of vehicle use, exhaust emissions, and vehicle-generated noise, can impose wide-ranging social costs on people, material, and vegetation.

The negative effects of pollution depend not only on the quantity of pollution produced, but on the types of pollutants emitted and the conditions into which the pollution is released. Emission savings are calculated as the difference between emissions cost per trip before and after the implementation of the project for riders that diverted from auto or bus to rail. Figure 5 shows the structure and logic of this part of the analysis.

Similar to the variable costs in VOC, emissions costs are dependant on the reduction of vehicle-miles diverted by the construction of the commuter rail. The consumption values were produced using Mobile 6 and take into account future regulations and trends. Per-unit costs as specified in the TIGER guidance were then applied to the consumption to calculate annual emission costs in the build and no-build scenario with the difference being the cost savings.

There are six types of emissions being measured; Nitrous oxide (NOx), sulfur dioxide (SO2), carbon monoxide, carbon dioxide (CO2), particulate matter (PM), and volatile organic compounds (VOC). The carbon dioxide produced from the commuter rail is subtracted from the sum of vehicle emission cost savings to deliver the net emission savings. Table 15 indicates the per VMT reduction rates and per ton values used in the analysis, Table 16 indicates the monetized value in 2012 and over the lifecycle of forecast emissions reductions.

Figure 5: Emission Cost Savings Structure and Logic Diagram

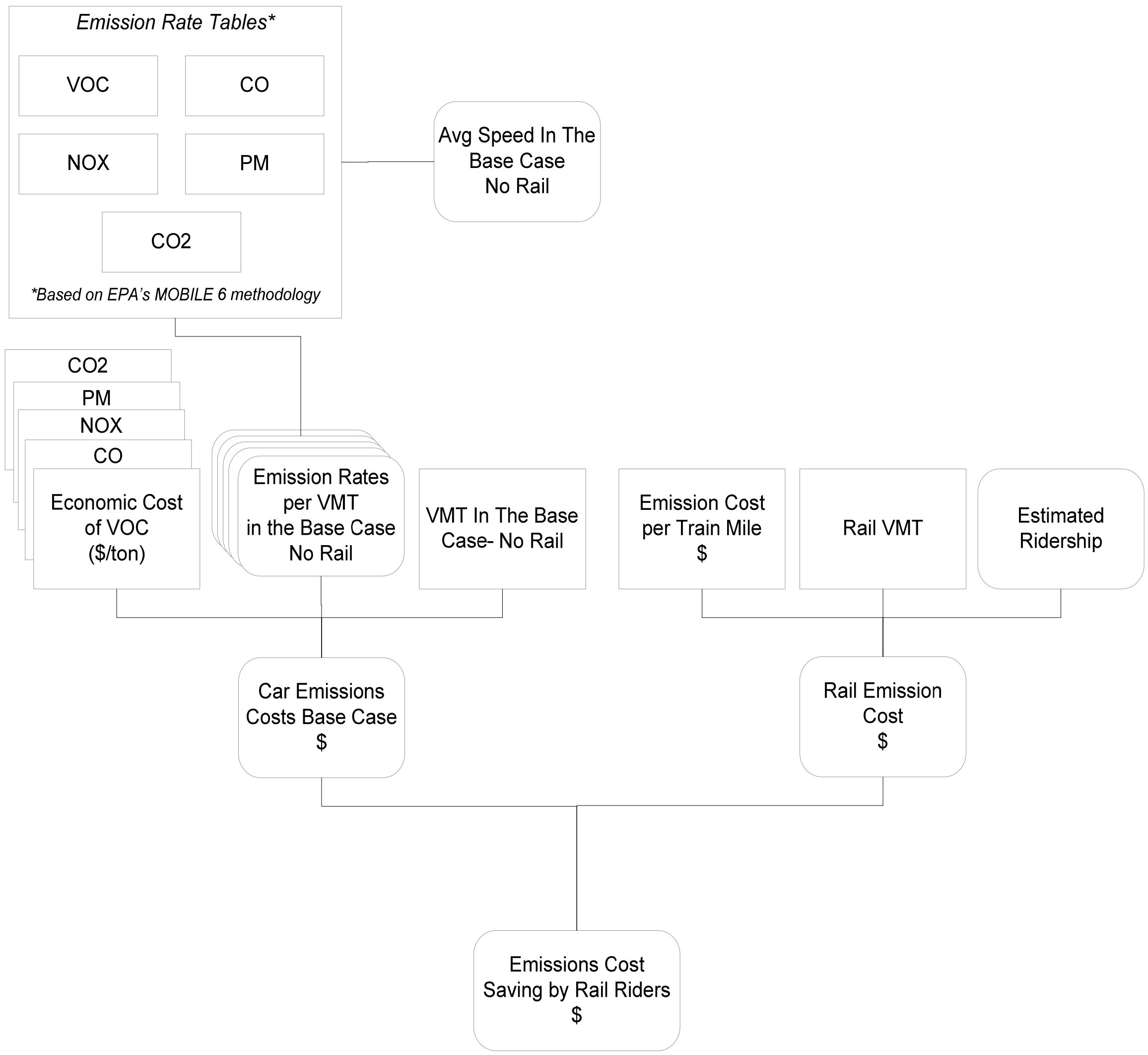


Table 15: Emissions Reductions per VMT and Monetized Value per Ton

Pollutant	Opening Year Grams Reduced per VMT Avoided[6]	Monetized Value per Ton
NOx	0.54	$4,112

[6] Consumption rates vary from year-to-year. Consumption rates are derived from Mobile 6 which takes into account future legislation.

SOx	11.71	$16,447
CO2	368.1	$33.92
CO	0.50	$513.98
PM	0.01	$172,697
VOC	0.01	$1,748

Table 16: Emissions Reduction Savings, 2012 and Lifecycle

Emissions Cost Savings	2012 (Discounted $2009)	Lifecycle (Discounted $2009)
NOx	$6,388	$88,505
SOx	$40,689	$669,778
CO2	$13,877	$157,812
PM	$13,082	$264,892
VOC	$756	$15,287
CO	$84,453	$1,709,703
Total Vehicle Emission Cost Savings	**$159,246**	**$2,905,976**

9.5 Safety - Accident Reduction

Safety benefits are a function of the reduction in highway usage from auto users switching to commuter rail and the closure and improvement of 66 at-grade crossings. The reduction of accident costs, like other variable costs, is dependant on the reduction of vehicle-miles. The reduction in vehicles on the road is combined with a multiplier or per-unit of cost accident. This multiplier is a weighted average of fatal, injury, property damage only (PDO) accidents. In the analysis, the net accident savings throughout the study period is $2.9 million.

At-grade crossing closures and signalization improvements significantly reduce the likelihood of fatalities. Using the Office of Safety Analysis query tool to determine the reduction in fatalities, we estimate that a conservative estimate of at least 10 fatalities can be avoided by the removal and signalization of existing at-grade crossings, providing $20.9 million in safety benefits. Based on the probability of incidence from the FRA Office of Safety Analysis for each grade crossing, the closure of the 44 grade crossings planned as part of this project eliminates a 28 percent likelihood a fatality will occur at one of the 44 grade crossings every year. We have assumed a one-quarter reduction in the probability of a fatality for the grade crossing improvements. These values are monetized using the TIGER recommended value of a statistical life at $6 million.

Table 17: Safety Improvements and Accident Savings

Benefit Category	Number of Fatalities Avoided	Lifecycle Benefit (Current $2009, M)
Remaining Highway Users	na	$2.9
Removed Grade Crossing Users	9	$17.9

Improved Grade Crossing Users	1	$3.0
Total	**10+**	**$23.8**

10 Findings

Benefits increase in proportion with increases in the number of riders who switch from auto and bus, as well as with the amount of savings each rider achieves on average by switching from each mode. Figure 6 below presents the cost per trip by mode. The cost differential between modes represents the potential traveler's savings from switching to the cheapest mode. After 2014, the passenger rail service becomes the cheapest of the three services, and the saving associated with using it increase because of both the consistent speeds that the rail service is able to achieve and because the increased highway congestion results in slower average door-to-door travel times for roadway users.

Figure 6: Cost of the Trip by Mode

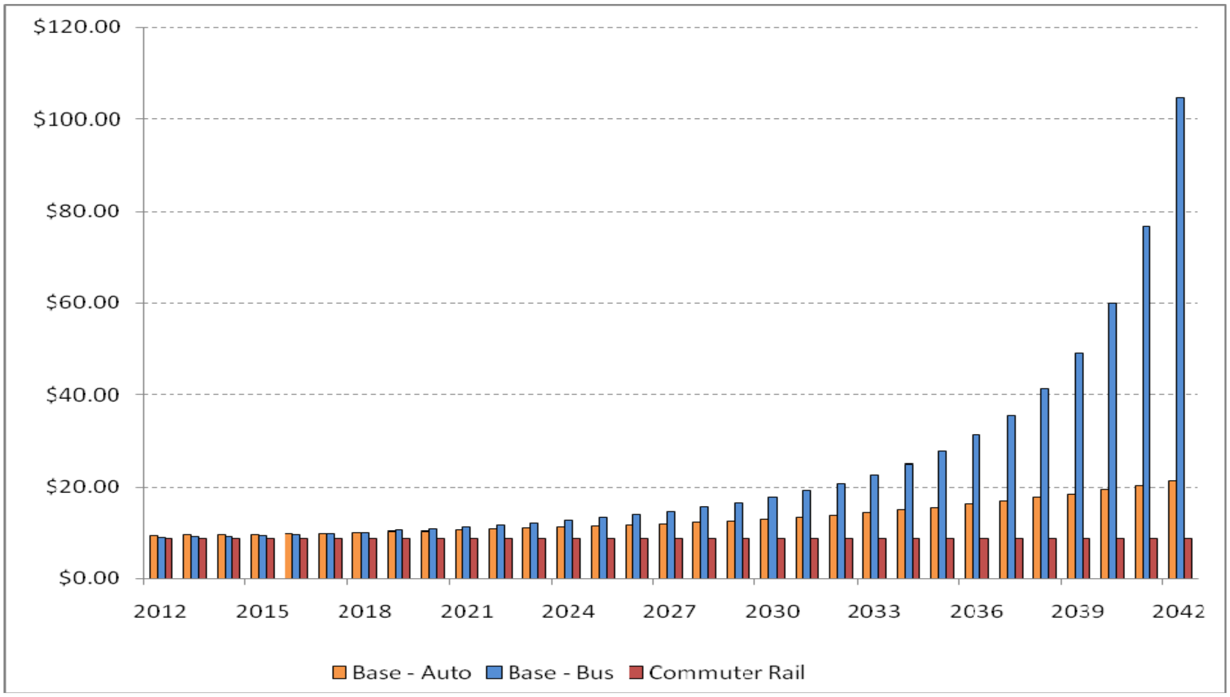
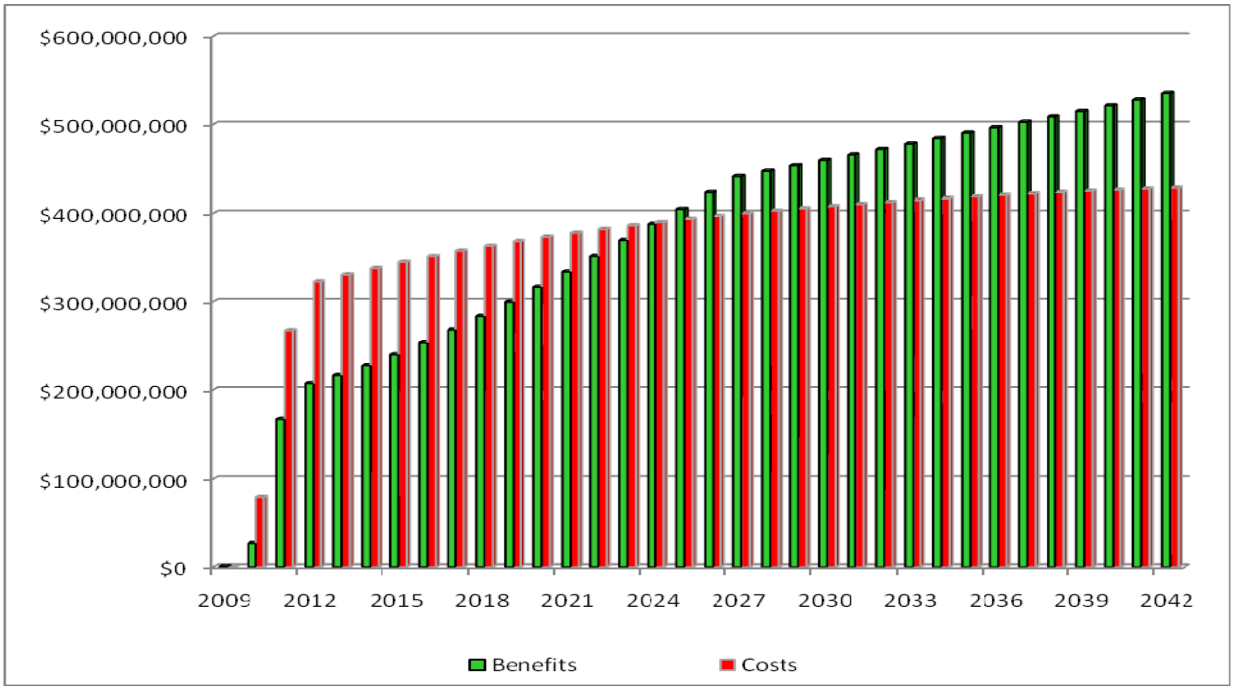


Figure 7: Cumulative Discounted Benefits and Costs



As illustrated by Figure 7 above, the cumulative costs of construction and operations are exceeded by cumulative benefits by 2025, after which net benefits start to accumulate. If the analysis were extended beyond 30 years, there would be a significant stream of benefits that are not accounted for in the analysis.

Table 18 below summarizes the Cost Benefit Analysis findings.

Excluding economic development benefits the commuter rail does not provide enough benefits for a return on investment. At the 7 percent discount rate, a $428 million lifecycle cost results in over $307 million in lifecycle benefits and with benefit to cost ratio (BCR) of 0.72. If the discount rate is reduced to 3 percent, a $534 million cost results in over $449 million in benefits and a benefit-cost ratio (BCR) of about 0.84.

Including economic development benefits provides a return on investment. At a 7 percent discount rate, a $428 million lifecycle cost results in over $68 million net benefits and with benefit to cost ratio (BCR) of about 1.2. If the discount rate is decreased to 3 percent, a $534 million cost results in over $212 million in net benefits and a benefit-cost ratio (BCR) of about 1.4.

Table 18: Detailed Results of the Benefit-Cost Analysis (BCA)

	7% Discount Rate	3% Discount Rate
State of Good Repair		
Pavement Maintenance Savings ($ millions)	$367,751	$691,912
Economic Competitiveness		
Additional Short-Term Employment (No. of New Jobs)	5,530	
Direct Employment	2,077	
Indirect Employment	1,216	
Induced Employment	2,237	
Benefits of Short-Term Employment ($ millions)	$193,303,852	$209,002,361
Economic Development net of Travel Time Savings ($ millions)	$189,673,349	$296,704,986
Livability		
Highway Users - VOC & Travel Time Savings ($ millions)	$47,506,358	$105,310,647
Rail User from Auto - VOC & Travel Time Savings ($ millions)	$12,104,675	$27,231,190
Rail Users from Bus- VOC & Travel Time Savings ($ millions)	$10,022,421	$28,428,518
Sustainability		
Gallons of Gasoline Avoided	16,189,326	
Reduced Emissions (tons)	1,438,171	
VOC	162	
CO	303,839	
NOX	249	
PM	84	
SO2	11	
CO2	1,133,827	
Emissions Savings ($ millions)	$5,408,734	$11,720,799
VOC	$162,346	$352,116
CO	$1,228,671	$2,650,577
NOX	$273,901	$578,899
PM	$498,386	$1,083,525
SO2	$28,725	$62,385
CO2	$3,216,705	$6,993,297
Safety		
Accident Cost Savings ($ millions)	$23,825,630	$41,504,355

Table 19: Overall Benefit-Cost Analysis Results

Benefit-Cost Analysis Results		
Without Incremental Economic Development		
Discount Rate	7%	3%
Total Discounted Benefits ($ millions)	$306,872,852	$449,423,394
Total Discounted Costs ($ millions)	$427,982,333	$533,852,414
Benefit-Cost Ratio	0.72	0.84
Net Present Value	-$121,109,481	-$84,429,020
Internal Rate of Return	N/A	
With Incremental Economic Development		
Discount Rate	7%	3%
Total Discounted Benefits ($ millions)	$496,546,201	$746,128,380
Total Discounted Costs ($ millions)	$427,982,333	$533,852,414
Benefit - Cost Ratio	1.16	1.40
Net Present Value ($ millions)	$68,563,868	$212,275,966
Internal Rate of Return	11.1%	