Broward County's Port Everglades Intermodal Freight Connector Project

Benefit/Cost Analysis Documentation

Overview

The below technical documentation describes the Benefit/Cost Analysis completed in support of Broward County's Port Everglades Intermodal Freight Connector Project. The documentation is organized around the worksheets provided in the attached MS Excel spreadsheet.

Monetized Values and Factors

The "Monetized Values and Factors" tab contains many of the main factors used in the overall analysis. The majority of these, particularly those related to safety, quality of life, and sustainability came directly from the Benefit Cost Analysis (BCA) Resource Guide provided as part of the November 2016 FASTLANE application process. These factors include: the value of a statistical life, value of injuries, value of property damage only crashes, value of time by user type, and the value of emissions for five emission types. In addition, these factors were supplemented by the following values:

- Pavement Damage as defined by the *Pricing Freight Transport to Account for External Costs, Congressional Budget Office Working Paper 2015-03* for measuring the impacts on the State of Good Repair.
- Truck Operating Costs as defined by *An Analysis of the Operational Costs of Trucking: A 2016 Update* published by the American Transportation Research Institute (ATRI) for measuring the impacts on Economic Competitiveness.
- Rail Operating Costs based on *Total Annual Spending 2015 Data* from the Association of American Railroads (AAR) for measuring the impacts on Economic Competitiveness.
- Truck Fuel Consumption based on the *2015 Vehicle Technologies Market Report* from the Oak Ridge National Laboratory and the U.S. Department of Energy for measuring impacts on Sustainability.
- Rail Fuel Consumption based on *Total Annual Spending 2015 Data* from the Association of American Railroads.

Consumer Price Index (CPI)

The "CPI" tab contains factors used to adjust dollars from one year to the next. Since not all measures are given in same year values, particularly for multi- year projects with benefits accruing over multiple decades, it is necessary to adjust the values to a consistent year to ensure a fair comparison. These factors were provided from the Bureau of Labor Statistics' *CPI Detailed Report Data for December 2015*.

Emissions – Truck

Truck emissions were determined based off the California Life-Cycle Benefit/Cost Analysis Model (Version 5.0) from Caltrans as part of the 2016 TIGER Applications. This model provides emissions factors for 2011 and 2031 for varying rates of speed for six emissions types: CO, CO_2, NOx, PM_{10}, SOx, and VOC. Given the available values are only for 2011 and 2031, the interim years were estimated based on an average annual rate of change.

This range did not provide values for the entire life of the project. For environmental impacts beyond 2031, values for each emissions type were held constant at the 2031 value. This is a conservative estimate for CO, NOx, and VOC as each of these had a negative rate of change, suggesting that impacts in later years are less than those in earlier years for the same mileage. CO_2, PM_{10}, and SOx had a rate of change of effectively zero so these values are relatively unchanged over time.

Since emission rates are impacted by the truck speed, values for each average speed were applied to the average speeds calculated for the individual markets with and without the project. More details on the calculation of speed are found in the "Without Market Assumptions" sheet.

Emissions – Rail

Rail emission rates were not provided through the FASTLANE guidance and with the privatized nature of railroads, these rates are more difficult to find. However, the U.S. Environmental Protection Agency (EPA) developed a *Logistics Company Partner* 2.0.15 *Tool: Technical Documentation* 2015 *Data Year – United States Version* which does contain some of these emission rates. Values were found for CO_2, NOx, and $PM_{2.5}$. A note here is that $PM_{2.5}$ is not the same as PM_{10}. $PM_{2.5}$ is more associated with fuel burning, industrial combustion processes, and vehicle emissions. PM_{10}, on the other hand, includes these same things but also other contributions such as road dust and construction activities and includes particulates of larger sizes (10 µm vs 2.5 µm). In this case, the particulate matter for railroads is less encompassing but the $PM_{2.5}$ value is used in lieu of better available data. With the railroad share of traffic being several orders of magnitude less than the truck share, this has a minimal impact on the benefits.

In addition to the discrepancies in particulate matter, values were not found for VOCs or SOx for railroads. However, these too have little impact on the overall benefits of the project. Including these two emission types would reduce the overall benefits slightly but these have the smallest impact of the five emission types included as part of this analysis. Based on guidance from the BCA Resource Guide November 2016, VOCs have the lowest monetized value per metric ton (compare $2,032/metric ton versus $366,414/metric ton for particulate matter). SOx, for its part, is the least emitted type of the five based on available truck values. As mentioned, excluding these values does exclude some positive benefits associated with a decrease in rail mileage with the completion of this project however the change in rail usage is significantly smaller than shifts in truck usage and has minimal impact on the final benefit ratio.

Crash Rates

The "Crash Rates" sheet supplements the information given by the BCA Guidance. These values allow for a calculation of the rate of accident occurrence to determine the quantity of fatalities, injuries, and property damage only crashes. The quantity is then used with the monetized values provided by the BCA Guidance to determine the cost to human life of truck and rail travel.

The truck travel values were determined by the latest *Large Truck and Bus Crash Facts 2014* provided by the Federal Motor Carrier Safety Administration (FMCSA) in April 2016. As incident rates were reported for both single-unit trucks and combination trucks, an average incident rate was computed based on the vehicle miles traveled (VMT) share of these modes. The VMT values are the latest available from the Federal Highway Administration's (FHWA) *Freight Facts and Figures 2015*.

Rail crash rates were determined from the Bureau of Transportation Statistics' *Railroad System Safety and Property Damage Data*, with 2014 representing the most current year of data. These crash rates were used to determine fatalities and injuries per train mile. Property damage only accident rates were not used here as the railroads report total property damage which can then be divided by the total train miles to determine the average property damage per train mile.

Project Costs

The "Project Costs" sheet details at a high level overall project costs. Note that the total costs here include more than what is being asked for as part of this grant. Additional project costs were based on previously funded and/or completed projects. Specifically, these relate to environmental mitigation and the development of a container yard. These projects have not been included in the grant request amount as they are funded through state and local efforts and are moving forward as precursor components. Annual maintenance costs were also added here in the amount of 0.5 percent of the total construction cost.

Other Factors

The "Other Factors" sheet encompasses all other factors which must be utilized in order to calculate the benefits. Namely, this focuses on the conversion of TEUs to trucks and trains, the weight of a truck or railcar, and the mode split, distance, travel time, and travel speeds to serve each market with and without the project.

The conversion of TEUs to trucks was assumed to be a 2:1 ratio due to current industry practice to predominately use FEU (forty equivalent units) which is equivalent to 2 TEUs for intermodal shipments. The conversion of TEUs to railcars was assumed to be a 3:1 ratio to account for some double-stacking of containers on the railcars. Lastly, it was assumed that there are 151 railcars per train coming out of Port Everglades. This is based on the fact that the Intermodal Container Transfer Facility (ICTF) operated at Port Everglades is capable of processing 8,000′ trains. With an average railcar length assumed to be 53′, this then works out to 151 railcars per train.

The average weight of a truck was based on the maximum allowable loaded weight in the state of Florida, 80,000 pounds. A discount of 5 percent was applied to this to account for some trucks being lightly loaded. This is often not the case as shippers want to make the best utilization of a truck trip and may even at times go over the legal weight if they do not believe they will be caught. This is a conservative estimate as a higher assumed truck tonnage will result in higher benefit in the final calculation. The average loaded railcar was assumed to be 58.8 tons based on current statistics from the Class I railroads.

The three main markets expected to be served by this project are South Florida, Central Florida, and the Southeastern United States. Of these, the only one anticipated to be served by rail with this project is the Southeastern United States. Based on the Port Everglades Master/Vision Plan, the anticipated rail share of this project is 12.4 percent. The remaining 87.6 percent of cargo is anticipated to be trucked to these markets based on the following market share:

- South Florida – 70%
- Central Florida – 25%
- Southeastern United States – 5%

To determine the mode split of cargo without this project being completed the Freight Analysis Framework (FAF) version 4.2 developed by the Federal Highway Administration (FHWA) was utilized. Pertinent to this analysis, this version, as compared to FAF 4.1, made corrections to entry and exit points for some foreign trade zone flows. This data source shows existing commodity flows by mode for imports and exports and the origin or final destination for these goods. The mode splits used, based on input from FAF, are defined in Table 1.

Table 1 Mode Split by Market without Project Construction

	South Florida	Central Florida	Southeastern US
Truck	95%	85%	75%
Rail	5%	15%	25%

For the average truck distance and average travel speed with this project, Google and Google Maps were utilized to determine the distance and travel time between Port Everglades and the target markets by truck. These two values were then used to determine the travel speed between locations. Note that travel times have been increased 10 percent over the suggested Google time based on estimates by FHWA that trucks travel 10 percent slower than passenger cars.

As only one market is served by rail with this project, these factors were only computed for the Southeastern United States. Due to the lack of readily available data, the train distance between Port Everglades and the Southeastern United States was assumed to be the same as the truck distance. Based on reports from the Class I railroads in the JOC, the average intermodal train was assumed to move at 31 miles per hour. Using the rail transit distance and average speed, the average rail travel time was calculated.

For the without project travel distances, speed, and time, refer to the "Without Project Port Usage" sheet explanation.

Without Project Port Usage

The benefits for this project were determined based on the differences between the scenario of this project being built and the scenario where this project is not built. In order to determine this, an important piece of information is what other ports can handle this cargo in the event that Port Everglades is not able to. To develop this information, FAF 4.2 was once again utilized. This was supplemented with information on investments being made at other ports competing for the larger post-Panamax ships that this project will attract. The following locations were determined to be the main competitors for this market:

- Jacksonville, Florida (Jaxport)
- Los Angeles/Long Beach, California (Port of Los Angeles/Long Beach)
- Miami, Florida (PortMiami)
- New York City, New York/New Jersey (Port of New York and New Jersey)
- Savannah, Georgia (Port of Savannah)
- Hampton Roads, Virginia (Port of Virginia)

Updates to FAF 4.2 impacted the expected port usage without this project. The prior submittal for this grant anticipated an increase in rail mileage associated with this project, which resulted in negative benefits due rail usage. However, based on FAF 4.2 data, the overall rail miles traveled is now expected to be reduced with the implementation of this project, resulting in positive benefits for this mode.

Similar to the method used for the with project scenario, Google and Google Maps were then utilized to determine the distance and travel time between these port locations and the target markets by truck. These two values were then used to determine the travel speed between locations. Note that travel times have been increased 10 percent over the suggested Google time based on estimates by FHWA that trucks travel 10 percent slower than passenger cars.

As rail transit distances are not readily available, the determined truck distance between the ports and markets were used. The exception to this is the Port of Los Angeles/Long Beach which was increased to account for a transfer in Kansas City, Missouri based on current rail patterns. Based on reports from the Class I railroads in the JOC, the average intermodal train was assumed to move at 31 miles per hour. Using the rail transit distance and average speed, the average rail travel time was calculated.

For each of the target markets, South Florida, Central Florida, and the Southeastern United States, the market share was split among the determined competitor ports to simulate where the cargo will be processed if the project was not built. This was done for both rail and truck movements.

Using these market shares, average trip distances, average travel time, and average speed were determined for each market by both rail and truck.

Trip Calculation

The prior discussion of the worksheets within this workbook focused on the factors used as inputs into the calculation process. The remaining discussion focuses on the actual calculations used to determine the benefits. The first necessary step is to determine how many truck and rail trips will be generated by this project based on the estimated throughput. This is the primary factor impacting the remaining calculations.

Estimated throughput was provided by Port Everglades and assumed to reach a maximum of 730,000 TEUs per year. However, this volume is not anticipated to be achieved within the first year. A 10 year ramp up for cargo volumes was applied to this estimate with an assumed design life of 30 years. Multiplying this volume by the determined mode split in the "Other Factors" sheet calculates how many TEUs are moved by truck and rail with or without the project completion.

From here, the number of trips by mode was determined based on the average number of TEUs per movement per mode. For trucks, this involves dividing the truck TEUs by the TEU/truck ratio. For rail, this entailed dividing the rail TEUs by the TEU/railcar ratio and the railcar/train ratio to determine the total number of trains per year. The results of this are seen in Table 2. As a reality check, the maximum truck trips of 319,740 per year equates to roughly 1,230 truck trips per day assuming a five day work week, 52 weeks per year. The maximum train volumes of 200 per year equates to just under one train per day. This is realistic given the current operating conditions at Port Everglades and the supporting infrastructure which has been enhanced over the past few years. Further details on the split of these trips by market is shown in the Excel document. This additional calculation is based on the market share determined in the "Other Factors" sheet and is necessary due to the differing distances vehicles must travel to serve these markets.

Table 2 Change in Trips by Mode With and Without Project Construction

	With Project	Without Project	**Net Change**	**Annual Average**
Truck Trips	7,831,440	7,997,188	**165,748**	**5,525**
Rail Trips	4,896	4,164	**(732)**	**(24)**

As Table 2 details, with the completion of this project, there are fewer total truck trips over the life of the project but a greater use in rail. While there is in a net increase in the number of trains produced by this project, on average, the trains are traveling shorter distances to reach their destination. As such, there will still be a reduction in train miles traveled, resulting in overall positive benefits.

VMT Ton-Mile Driver Time

The truck trips previously computed were then utilized to determine vehicle miles traveled (VMT), ton-miles, and the travel time by mode for users.

Vehicles miles traveled were calculated by multiplying the number of trips by mode and by market by the average modal distances determined for that mode/market as part of the "Other Factors" sheet. This was done for each of the three markets for each mode, with and without the project. The significant changes in truck travel distances for the South Florida and Central Florida markets, at 412 miles and 445 miles respectively, result in an overall reduction in vehicle miles traveled by truck of nearly 5.6 billion over the life of this project. On average, this is about 186 million miles per year. For rail, there is an decrease in miles traveled due to this project of about 1.7 million miles per year. This is approximately 55,693 fewer rail miles per year. The overall summary of vehicles miles traveled by mode with and without project is summarized in Table 3.

Table 3 Change in Vehicle Miles Traveled by Mode With and Without Project Construction

	With Project	Without Project	**Net Change**	**Annual Average**
Truck VMT (in millions)	912	6,504	**5,591**	**186**
Rail VMT (in thousands)	3,158	4,829	**1,671**	**56**

The next step was to determine the ton-miles associated with each mode. This was done by taking the total VMT by each mode and multiplying it by the average loaded truck weight for truck calculations and the average loaded railcar weight for rail calculations. These factors can be found in the "Other Factors" sheet. As with the other calculations in the change between the with and without project scenarios, truck ton-miles show a positive impact with a total reduction of over 212 billion ton-miles over the life of the project, or about 7.1 billion ton-miles per year on average. Rail saw an overall decrease in ton-miles as well with construction of this project in the amount of nearly 15 billion ton-miles over the 30 year life of the project, or about 494 million ton-miles per year. The results of this calculation are summarized in Table 4.

Table 4 Change in Ton-Miles by Mode With and Without Project Construction

	With Project	Without Project	**Net Change**	**Annual Average**
Truck Ton-Miles (in millions)	34,670	247,146	**212,476**	**7,083**
Rail Ton-Miles (in millions)	28,029	42,858	**14,829**	**494**

The change in travel time is a factor of the total trips traveled. As each market has a different average travel time by mode with and without the project, this was determined on a per market basis. For instance, the total driver time associated with truck trips to South Florida with this project was calculated by multiplying the truck trips for South Florida with the project in "Trip Calculation" sheet by the average truck travel time for South Florida with project found in the "Other Factors" sheet. This was done for each market by mode with and without the project completion. A summary of these calculations is shown in Table 5. In total, this project will result in a net savings of over 49 million truck driver hours and a decrease in locomotive engineer travel time of 53,897 hours. While this is a significant reduction in truck driver hours of over 1.6 million per year on average, it would not impact the ability of truck drivers to find work due to the significant truck driver shortage in the U.S. Rather, this provides drivers an opportunity to make more turns per day within their allowable hours of service in a local market.

Table 5 Change in Travel Time by Mode With and Without Project Construction

	With Project	Without Project	**Net Change**	**Annual Average**
Truck Driver Travel Time (hours in thousands)	14,176	63,379	**49,203**	**1,640**
Locomotive Engineer Travel Time (hours in thousands)	102	156	**54**	**2**

State of Good Repair

The State of Good Repair benefits are determined based on the anticipated pavement damage caused with and without this project. As each truck travels, it causes a certain amount of wear on the roadway. The heavier the truck is, the more damage it may cause. While each truck may only cause a negligible amount of damage itself, the overall impact of thousands of trucks can add up to significant wear and tear.

Based on this, the overall impacts on pavement damage are based on the total ton-miles calculated previously. The value of pavement damage is computed by multiplying this ton-mileage by the pavement factors included in the "Monetized Values and Factors" sheet. The summary of these calculations is shown in Table 6. With the completion of this project, there will still be wear and tear on the roadways as the cargo is delivered. However, since there is an average reduction in ton-miles, the damage is not as significant. With this project, total pavement damage is estimated at $310 million ($2014). Without it, pavement damage will be nearly $2.1 billion ($2014). This net change of nearly $1.8 billion is equivalent to roughly $60 million per year on average.

Table 6 Pavement Damage Caused With and Without Project Construction

	Pavement Damage	Annual Average
With Project ($2014, in millions)	$310	$10.3
Without Project ($2014, in millions)	$2,124	$70.8
Net Change ($2014, in millions)	$1,814	$60.5
Net Change ($2015, in millions)	**$1,816**	**$60.5**

Economic Competitiveness

Economic Competitiveness is based on two factors: Operating Costs and the Value of User Time.

Truck operating costs are calculated by multiplying the vehicle miles traveled previously computed by the "Truck Operating Costs" factors found in the "Monetized Values and Factors" sheet. Similarly, rail operating costs are calculated by multiplying the "Rail Operating Costs" factor found in this same sheet by the rail ton-mileage previously computed. The value of operating costs are summarized in Table 7. The net change between the with and without project scenarios is approximately $3.5 billion, or $117 million per year. Based on the final analysis, this is the greatest factor impacting the total benefits associated with this project.

Table 7 Operating Costs With and Without Project Construction

	Operating Costs	Annual Average
With Project ($2015, in millions)	$843	$28.1
Without Project ($2015, in millions)	$4,364	$145.5
Net Change ($2015, in millions)	**$3,521**	**$117.4**

The cost of travel time associated with this project is based on the change in user travel time previously computed in the "VMT Ton-Mile Driver Time" sheet. The truck driver time (in hours) was multiplied by the hourly value of time for truck drivers provided by the BCA Resource Guide found in the "Monetized Values and Factors" sheet. Similarly, the rail user time was multiplied by the hourly value of time for a locomotive engineer. The total cost associated with user travel time with this project is estimates at $390 million compared to $1.7 billion without this project. The net impact is a total benefit of $1.3 billion in travel time cost savings, or about $45 million per year. The results from this calculation are shown in Table 8.

Table 8 Travel Time Cost With and Without Project Construction

	Driver Travel Time Costs	Annual Average
With Project ($2015, in millions)	$390	$13.0
Without Project ($2015, in millions)	$1,730	$57.7
Net Change ($2015, in millions)	**$1,341**	**$44.7**

The total Economic Competitiveness benefits are the summation of benefits from operating costs and travel time costs (Tables 7 and 8). Table 9 shows this summation. The construction of the Intermodal Fright Connector project will result in a positive benefit of almost $4.9 billion over the life of the project, or about $162 million per year.

Table 9 Total Economic Competitiveness With and Without Project Construction

	Economic Competitiveness	Annual Average
With Project ($2015, in millions)	$1,233	$41.1
Without Project ($2015, in millions)	$6,094	$203.1
Net Change ($2015, in millions)	**$4,862**	**$162.1**

Sustainability

The impact on Sustainability is a result of five emission types: Carbon Dioxide (CO2), Nitrogen Oxides (NOx), Particulate Matter (PM), Sulfur Dioxide (SOx), and Volatile Organic Compounds (VOCs). The change in diesel consumption is also calculated here for illustrative purposes but is not included in the overall benefits as fuel costs are a portion of vehicle operating costs included as part of the Economic Competitiveness benefits.

Diesel consumption is based on ton-mileage previously calculated and the number of ton-miles used per gallon. Ton-mileage by mode was divided by the ton-miles/gallon factor included in the "Monetized Values and Factors" sheet. The net benefits of this project are a decrease in fuel consumption by over 1.4 billion gallons over the life of the project.

The remaining sustainability impacts for the five emission types were calculated the same way for each. For truck emissions, this goes back to the discussion of the "Emissions – Truck" sheet. The emission rates for each type vary by both year and by speed so the calculations were done on a market basis with and without the project. In short, the calculation is the vehicle miles traveled multiplied by the emission rate found in the "Emissions – Truck" sheet based on the interpolated values for the specific speed determined for that market found in the "Other Factors" sheet. For instance, for South Florida, the average speed with project was determined to be 54 miles per hour (mph). Therefore, the VMT associated with South Florida with this project construction was multiplied by the emissions rates for trucks traveling at 54 mph. Doing this for each market and each emissions type with and without project results in the final sustainability impacts shown in Table 10. Note this table also includes rail emissions for CO_2, NOx, and PM but not SOx and VOCs as previously discussed in the "Emissions – Rail" sheet. Rail emissions are computed on a per ton-mile basis. Therefore the rail factors found in "Emissions – Rail" are multiplied by the computed ton-mileage found in "VMT Ton-Mile Driver Time" to determine the environmental impacts associated with rail movements. Based on the decrease in miles traveled for this project, emissions of each type are found to decrease.

Table 10 Sustainability With and Without Project Construction

	With Project	Without Project	**Net Change**
Diesel Consumption (million gallons)	285	1,697	**1,412**
Carbon Dioxide (CO_2) (metric tons)	1,151,515	4,641,485	**3,489,971**
Nitrogen Oxides (NOx) (metric tons)	12,291	20,351	**8,061**
Particulate Matter (PM) (metric tons)	384	853	**469**
Sulfur Dioxide (SOx) (metric tons)	6	39	**33**
Volatile Organic Compounds (VOCs) (metric tons)	104	735	**631**

These calculated metric tonnages were then multiplied by the Value of Emissions provided by the BCA Resource Guide 2016 (FASTLANE) which can be found in the "Monetized Values and Factors" sheet. Table 11 shows the total value of emissions in non-discounted dollars with the exception of CO_2. This values for this emission type were provided with a 3 percent discount already applied based on guidance from the BCA Resource Guide.

Table 11 Value of Sustainability With and Without Project Construction

	With Project	Without Project	**Net Change**
CO_2 ($2015, in thousands) (discounted at 3%)	$75,282	$303,450	**$228,168**
NOx ($2015, in thousands)	$98,448	$163,012	**$64,565**
PM ($2015, in thousands)	$140,668	$312,461	**$171,793**
SOx ($2015, in thousands)	$279	$1,824	**$1,545**
VOCs ($2015, in thousands)	$211	$1,493	**$1,282**

Safety

Impacts to Safety include the value associated with fatalities, injuries, and property damage only incidents.

The loss of life is a factor of the vehicle miles traveled previously determined. The VMT is multiplied by the fatality rate per truck-mile (for trucks) and per train-mile (for rail) found in the "Crash Rates" sheet. With project construction, it estimated that there will be 13 fatalities over the 30 year life of this project associated with the delivery of goods. However, without the project, as the vehicle miles traveled is significantly higher, fatalities are estimated at 93. The construction of the Intermodal Freight Connector project will result in a reduction of 80 fatalities total, or almost 3 per year. The value of this impact is determined by multiplying the number of fatalities by the value of a statistical life which results in a savings of over $766 million.

Table 12 Loss of Life With and Without Project Construction

	Fatalities	Average Annual
Fatalities With Project	13	0.4
Fatalities Without Project	93	3.1
Net Change in Fatalities	**80**	**2.7**
Value of Net Change in Safety ($2015, in thousands)	**$766,428**	**$25,548**

Injuries are calculated in the same manner as fatalities, but instead of using the fatalities per mile factor found in the "Crash Rates" sheet, the injuries per mile factor is used. The construction of this project will result in 2,300 fewer injuries related to the transportation of goods over the life of the project, or about 77 per year. A summary of these benefits is shown in Table 13. To calculate the value of this impact, the net change in injuries was multiplied by the value associated with a "Moderate" injury crash as provided by the BCA Resource Guide. This is a conservative estimate versus using a more severe crash type as the higher values associated with more severe crashes would increase the overall net benefits associated with safety for this project.

Table 13 Injuries With and Without Project Construction

	Injuries	Average Annual
Injuries With Project	378	12.6
Injuries Without Project	2,678	89.3
Net Change in Injuries	**2,300**	**76.7**
Value of Net Change ($2015, in millions)	**$1,038**	**$35**

The property damage due to truck crashes was also calculated similar to the fatality and injury rates. The truck miles traveled was multiplied by the Property Damage Only Crashes per Truck VMT factor found in the "Crash Rates" sheet. The net change in incidents is approximately 6,918 fewer property damage only incidents total, or about 231 per year. This total was then multiplied by the per vehicle value for property damage only crashes. The value of this change is over $29 million as shown in Table 14. This is a conservative estimate as it assumes only one vehicle per crash. Assuming more than one vehicle per crash would increase the overall benefits associated with this project.

Table 14 Property Damage Due to Truck Crashes With and Without Project Construction

	Property Damage	Average Annual
Incidents With Project	1,129	37.6
Incidents Without Project	8,047	268.2
Net Change in Incidents	**6,918**	**230.6**
Value of Net Change ($2015, in thousands)	**$29,042**	**$968**

The value factor for property damage due to rail crashes is based on rail mileage and computes the value directly, rather than calculating an interim step of how many rail crashes are caused each year with or without this project. As this is a different methodology from the property damage only crashes associated with trucks, these calculations are shown separately in Table 15. The actual calculation involves taking the rail mileage previously calculated and multiplying it by the Property Damage/Train Mile found in the "Crash Rates" sheet. The property damage to rail associated with this project construction is estimated at a total of $1.1 million. Without this project, the value of damage is estimated at just over $1.7 million for a total net change of $589,621.

Table 15 Property Damage Due to Rail Crashes With and Without Project Construction

	Property Damage	Average Annual
Value of Incidents With Project ($2015, in thousands)	$1,114	$37.1
Value of Incidents Without Project ($2015, in thousands)	$1,704	$56.8
Value of Net Change ($2015, in thousands)	**$590**	**19.7**

Summary of Benefits

The "Summary of Benefits" sheet summarizes the total benefits associated with this project by type of benefit. The total non-discounted benefits (excluding any impacts of carbon emissions) is estimated at over $8.7 billion over the total 30 year project life. As shown in Table 16, the largest impacts of this comes from Economic Competitiveness, specifically the changes in vehicle operating costs. The second greatest impact is from the State of Good Repair which is based on reductions in future pavement damage. These benefits were reduced at both 3 and 7 percent for the later analysis of the Benefit Cost Ratio. The exception to the 7 percent discount is the impact of Carbon Emissions which is held at 3 percent per BCA Resource Guide.

Table 16 Summary of Net Change in Benefits

	Net Impacts
State of Good Repair ($2015, in millions)	$1,816
Economic Competitiveness ($2015, in millions)	$4,862
Sustainability, Less Carbon Emission ($2015, in millions)	$239
Safety ($2015, in millions)	$1,834
Total, Non-Discounted, Excluding Carbon ($2015, in millions)	$8,751
CO_2 ($2015, in millions) (discounted at 3%)	$228
Total, Discounted 3%	$4,758
Total, Discounted 7% (with Carbon held at 3%)	$2,307

Summary of Costs

Project costs were previously shown in more detail for various stages of construction in the "Project Costs" sheet. The "Summary of Costs" shows, at a higher level, spending per year and those expenditures discounted at 3 and 7 percent. Table 17 summarizes this information.

Table 17 Summary of Projects Costs

	Non-Discounted Costs	Discounted 3%	Discounted 7%
2015	$18,972,339	$18,972,339	$18,972,339
2016	$3,190,946	$3,098,006	$2,982,193
2017	$59,795,410	$56,352,909	$52,227,627
2018	$182,270,529	$166,803,354	$148,787,046
2019	$182,185,349	$161,869,323	$138,988,330
2020	$64,211,551	$55,389,448	$45,781,324
2021	$11,598,131	$9,713,252	$7,728,324
2022-2050	$2,598,131	(varies)	(varies)
Total	**$597,570,043**	**$513,960,665**	**$436,723,459**

Final Benefit Cost Ratio

The final Benefit Cost Ratio (BCR) was determined by comparing the discounted benefits and discounted costs at both a 3 percent and 7 percent ratio. At 3 percent, the BCR is 9.3:1. At 7 percent the BCR is 5.3:1. A summary of these values is shown in Table 18. Regardless of the discount applied, this project is anticipated to produce a significant benefit to the local and national transportation network.

Table 18 Benefit Cost Ratio

	Discounted 3%	Discounted 7%
Total Benefits (in millions)	$4,758	$2,307
Total Costs (in millions)	$514	$437
Benefit Cost Ratio	**9.3:1**	**5.3:1**