TIGER FY 2015 Discretionary Grant Application
Willmar Rail Connector & Industrial Access

Attachment 4: Benefit Cost Analysis Technical Memorandum

Technical Memorandum: Benefit Cost Analysis of the Willmar Rail Connector and Industrial Access Project

Date: May 28, 2015

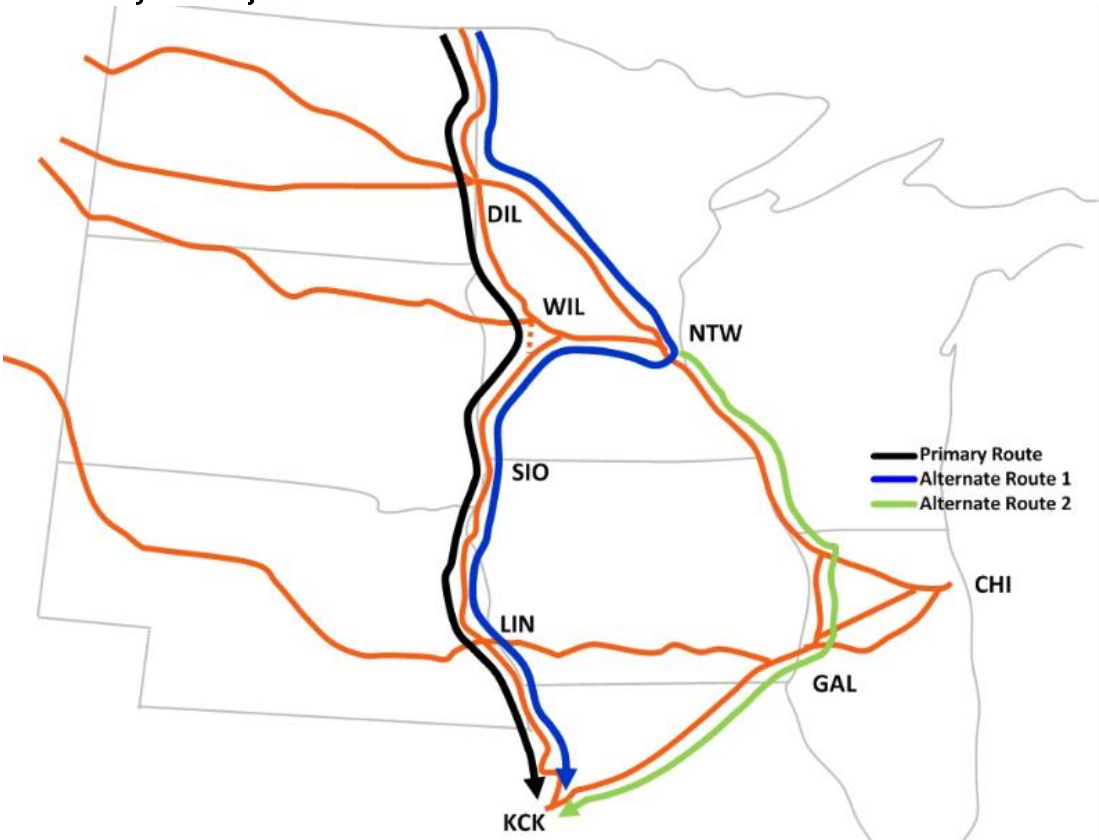
Subject: Benefit-Cost Analysis for the Willmar Rail Connector and Industrial Access Project

Project Description

The Willmar Rail Connector and Industrial Access Project (hereafter referred to as the Project) would construct a connector track from the Marshall to the Morris Subdivisions of the BNSF rail network, allowing 7 to 10 trains daily to avoid pulling into the rail yard in downtown Willmar. The Project also includes a rail spur that would provide access to the City's industrial park, one of the prime sites available for industrial development in the community. This targeted and strategic investment creates both capacity and operational flexibility, and would allow for BNSF to relieve one of the more congested areas on the northern part of their system. Moreover, in so doing, it generates Safety, Quality of Life, Economic Competitiveness, and Environmental Sustainability benefits for the residents of Willmar: in short, the Project simultaneously enhances quality of life and provides local economic opportunities and transportation system benefits across a multi-state region.

Currently trains moving north-south between Fargo, ND (and origins north and west) and Kansas City, MO (and destinations south) must pull into the Willmar Yard, reverse direction, and reposition locomotives and crews while creating excess emissions, blocking crossings in Willmar, and consuming yard and mainline capacity that would otherwise be used for switching local business and handling other through trains. Trains moving south-north between Kansas City, MO and Fargo, ND must also make a similar movement in order to proceed to their destinations. This Project generates substantial benefits for Willmar residents. The volume of trains and yard movements create emissions and noise, impede the flow of road traffic, and impose delays at the at-grade crossings that are involved in making the Morris-to-Marshall movement. Safety at the crossings and the responsiveness of fire, ambulance, and police are also community concerns. By reducing train traffic in downtown Willmar, these dis-amenities are diminished and quality of life is enhanced. Additionally, with the new spur serving the industrial park the City is developing on its former airport property, industries that desire direct rail service for a competitive edge or operational needs would benefit from being connected to a leading Class I railroad. See Exhibit 1 for an illustration of the current and future train movements afforded by the Project.

Exhibit 1: Existing Rail Flows Through the BNSF Network and Possible Re-Routing Enabled By the Project



Source: BNSF

In addition, with the Project, trains that would use the route if not for the delays experienced in the Willmar Yard (hereafter called re-routes), and the north-south through trains that currently must go through the yard and switch directions (hereafter called diversions), would be shifted to use the Connector (also called the wye). The re-routes are currently utilizing other freight routes in order to avoid the delays in Willmar Yard, and the Connector would save 6.4 hours per train[1]. The diversions would save 2.5 hours each from not having to wait and transfer in the yard[2]. In addition, the time saved by these trains reduces emissions from idling in the yard and from taking the longer routes.

The Project would provide local residents with benefits by removing these trains from the downtown Central Business District (CBD), reducing grade crossing conflicts that result in travel time savings, emissions savings, and a reduced likelihood of accidents. Together, the Project benefits local Willmar residents, shippers and manufacturers using BNSF freight trains, BNSF, and the greater region.

[1] Estimated by calculating the length of track that trains would no longer traverse to avoid the Willmar Yard. In total, approximately 192.6 miles are saved and assuming an average train speed of 30 mph; the resulting time savings is approximately 6.42 hours with the more direct route.

[2] Estimated wait time provided by BNSF based on current yard operations.

Introduction

The Willmar Rail Connector and Industrial Access Project would provide freight through trains with a way to avoid the Willmar Yard and the CBD of the City of Willmar—helping trains and Willmar residents and employees move more efficiently and reduce safety incidents, delays, and emissions. The Project provides local and regional benefits for both public and private stakeholders, and offers access to future industrial development and jobs along the route. The impact matrix presented in Exhibit 2 on the following page summarizes the Willmar Rail Connector and Industrial Access TIGER 2015 Project, its benefits, and corresponding page references in this BCA technical memorandum.

This technical memorandum estimates the long-term benefits associated with the Project. The long-term benefits presented relate to the five (5) Long-term Outcomes identified in the TIGER 2015 Notice of Funding Availability (NOFA)[3]: State of Good Repair, Economic Competitiveness, Quality of Life, Environmental Sustainability, and Safety. The final section discounts the stream of anticipated benefits and costs and calculates the Benefit Cost Ratios for the Project at 7% and 3%.

[3]See Notice of Funding Availability for the Department of Transportation's National Infrastructure Investments Under the Consolidated and Further Continuing Appropriations Act, 2014, https://www.federalregister.gov/articles/2015/04/03/2015-07711/notice-of-funding-availability-for-the-department-of-transportations-national-infrastructure

Exhibit 2: Impact Matrix for BNSF Willmar Rail Connector and Industrial Access Project

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
Currently trains moving north-south between Fargo, ND (and origins north) and Kansas City, MO (and destinations south) must pull into the Willmar Yard, reverse direction, and reposition locomotives and crews while creating excess emissions, blocking crossings in Willmar, and consuming yard and mainline capacity that would otherwise be used for switching local business and handling other through trains. The volume of trains and yard movements create emissions and noise, impede the flow of road traffic, and impose delays at the grade crossings that are involved in making the Morris-to-Marshall movement.	Construct a 2.5-mile Connector track to the west of the City of Willmar for the purpose of diverting those trains that currently must reallocate power in the Willmar Yard.	The new Connector would allow trains to avoid the engine switch and reverse movements currently required at the yard in the downtown Willmar CBD, reducing traffic impacts from trains at grade crossings and generating operating cost savings, train emissions reductions, and inventory savings due to reduced shipping time along the routes. Greater network efficiency would allow trains that are currently re-routed to avoid the Willmar Yard to use the wye for a more direct route.	Residents in the region (reduced train and auto emissions, safety benefits, reduced vehicle operating costs, and travel time savings) BNSF (hourly operating cost savings) Shippers (inventory savings and potentially some shipping cost savings as some of BNSF's operating cost savings could be passed on to shippers)	Monetized value of residual value, BNSF operating cost savings, shipper inventory savings, train emissions savings, and local grade crossing benefits, including emissions, safety incidents avoided, vehicle operating costs avoided, and travel time savings.	Estimated dollar value (NPV) of residual value, operating and inventory savings, and safety benefits, travel time savings, vehicle operating cost savings, and highway emissions benefits for grade crossings, and air quality benefits associated with train operating time savings.	Residual Value page 5 Operating Savings page 5 Inventory Savings page 6 **Grade Crossing Benefits:** *Safety Benefits page 11* *Travel Time Savings page 13* *Vehicle Operating Cost Savings page 15* *Highway Emissions Benefits page 17* *Network Grade Crossing Benefits page 18* Air Quality Benefits page 19

Long-term Outcomes

The Project described in this application would support the region's economy over the long-term by providing the workforce and residents of the City of Willmar with reduced congestion and travel times by removing conflicts with freight trains—generating travel time savings, auto emissions reductions, reduced likelihood for rail-auto accidents, and vehicle operating cost savings. In addition, BNSF would have a more efficient freight network that generates operating cost savings (some portion of which may be passed on to shippers), inventory savings to shippers, and emissions reductions throughout the network. The balance of this discussion describes the assumptions and methods used to develop the benefit-cost analysis and estimates the value of the long-term benefits generated by the investment. As directed in the TIGER 2015 guidance, the useful life of the capital investment has been estimated over a 20-year analysis horizon.

The Project would be completed in December of 2019, and a benefits period of 2020-2039 was used. The stream of benefits and costs over time are converted to the present value using the required 7% discount rate. The equivalent results also are shown at a 3% discount rate. All benefits are estimated in accordance with guidance provided by US Department of Transportation (USDOT) for benefit cost analysis. If no USDOT guidance was available for the estimate, the Project team consulted industry research for the best practice and information on which to base the assumptions and methodology. The benefits quantified in the benefit cost analysis are described in the following pages in 2015 dollars.

State of Good Repair

Residual Value

Construction of the new track and bridges associated with the road and railroad right of way would have residual value after the end of the 20-year analysis period, because the useful life of these elements is longer than 20 years. The useful life of a pre-stressed concrete bridge is 73 years. To be conservative, the three bridges are assumed to be pre-stressed concrete[4]. The values of the bridges were depreciated straight-line over the 73 years[5]. The first 20 years of depreciation were excluded from the residual estimation as they are the basis of the benefits estimated elsewhere in the analysis; while, the remaining 53 years were discounted at 7% and 3%. In addition to the bridges, the track, turnouts, and crossings have a useful life longer than the analysis period. Track has a useful life of 38 years[6], and as a result the remaining value was depreciated straight-line for 18 years after the analysis period and discounted at 7% and 3%. Finally, right of way does not depreciate, so the undiscounted value of the right of way acquired for the Project was also included in the residual analysis. The remaining discounted value of the bridges and track were summed with the undiscounted value of the right of way acquired. ***The value of the remaining useful life for the Project discounted at 7% is 3.74 million.***

Economic Competitiveness

Operating Savings

Operating savings result from BNSF more efficiently using their network and avoiding delays at the Willmar Yard. Both the diverted and re-routed trains get operating savings based on the hours of delays avoided. To value the hourly savings, the total freight operating expenses and

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[4] One bridge is steel, but it is conservative to treat all as prestressed concrete because steel has a shorter useful life; and therefore, less impact from discounting effects.

[5] Det Norske Veritas. Highway Bridges, Yunovich et al. Appendix D, http://www.dnvusa.com/Binaries/highway_tcm153-378806.pdf

[6] BEA Rate of Depreciation, Service Lives, Declining-Balance Rates, and Hulten-Wykoff Categories, http://www.bea.gov/scb/account_articles/national/wlth2594/tableC.htm

the total train hours in road service were obtained from the BNSF 2014 R-1[7]. Dividing the expenses by the hours results in an average operating expense per train hour ($683). A total of 7 to 10[8] trains daily are expected to divert from Willmar Yard to the Connector, so to be conservative 7 trains are applied in the analysis with no future growth. Multiplying the 7 daily diversions by 365[9] and the 2.5 hours saved and average hourly operating expense yields the total operating savings for the diversions. ***Discounted at 7%, the total operating savings for diverted trains is $35.75 million.***

Similarly, the re-routes would save operating costs by using the Connector. A total of 1,151 trains were re-routed by BNSF in 2013 to avoid the Willmar Yard, and it is assumed that at least 35% of those trains would use wye after it is in operation[10]. This results in 530 trains in 2013 that would have used the wye, and growing the trains by 2.3% per year[11] from 2015 to the end of the analysis period results in an additional 1 to 2 trains daily on the wye from re-routes. Multiplying these trains by the 6.4 hours saved per train and the hourly operating cost results in the operating savings for the re-routed trains. ***Discounted at 7%, the total operating savings for the re-routes totals $26.01 million.***

Inventory Savings

The inventory cost associated with the annual carloads and annual hours of delay is based on the commercial discount rate, or the opportunity cost associated with holding assets in inventory rather than using them for another purpose. The analysis assumes a commercial discount rate of 4.0%. Assuming 8,760 hours in a year (365 days * 24 hours), this yields an hourly discount rate of 0.00046%. Multiplying this hourly discount rate by the value of freight shipped and the hours of delay avoided yields the annual value of inventory savings. Two types of trains would see time savings because of the Project: diversions and re-routes. Multiplying the annual number of trains[12] by the time savings per train[13], the average tons per Class 1 train in the United States (3,488)[14], the Minnesota rail value per ton ($264.98)[15], and the hourly commercial discount rate, results in the total inventory savings. ***Discounting the inventory savings by 7% results in $0.22 million in savings for the diversions and $0.16 million in savings for the re-routed trains.***

[7] Source: BNSF 2014 R-1, accessed at http://www.bnsf.com/about-bnsf/financial-information/surface-transportation-board-reports/pdf/14R1.pdf

[8] Source: BNSF

[9] Trains operate every day of the year

[10] Source: BNSF Franchise Development

[11] The 2.3% compound annual growth rate (CAGR) of trains was found through an analysis of Freight Analysis Framework data by totaling the rail tonnages traded within, from, and to Montana, North Dakota, South Dakota, Minnesota, Iowa, Wisconsin, and Illinois in 2011 and 2040. The CAGR between 2011 and 2040 was 2.30%. It is assumed that train growth is directly correlated to tonnage growth. This growth does not consider the potential volumes from increased Canadian crude and agricultural volumes moving to the Gulf of Mexico. As Canadian crude is heavier than Bakken Crude (which is included in the 2.3% rate), the tonnage would likely be higher. The growth rate also does not include future growth of Canadian grain destined for the United States. Reasonable projections for the oil and grain shipments are not available, so this growth rate is conservative.

[12] Diversions assume 7 trains diverted daily and held constant throughout the analysis period; Re-routes assumes 35% of 1,515 re-routed trains in 2013, growing at 2.3% per year beginning in 2015.

[13] Diversions assume 2.5 hours saved per train and re-routes assumes 6.4 hours are saved per train.

[14] An average of 3,488 tons per train from 2013 was used in the analysis. See page 2 of 3, https://www.aar.org/StatisticsAndPublications/Documents/AAR-Stats.pdf

[15] Using FAF data, the value of all Minnesota rail freight in 2012 was $29,316,791,368 and the rail tons were 125,148,521, resulting an average of $234.26 (2007$) per rail ton in Minnesota. Converted to 2015$ using GDP deflator. Sources: FHWA Freight Analysis Framework (FAF) Shipments Within, From, and To US States – Tonnage and Value by Domestic Mode 2012

Quality of Life

Willmar Grade Crossing Benefits

Highway-rail grade crossings generate negative community impacts through two primary highway-rail interactions: accidents and highway delays while crossings are blocked by trains. Highway delays at grade crossings increase travel times, vehicle operating costs, and emissions while vehicles idle at blocked grade crossings. These interactions are a safety concern for the community as well as a drain on its economic competitiveness, as productivity and access are negatively impacted.

The current operations of the BNSF railroad lines through Willmar, MN consist of three lines converging at the Willmar Yard located in the CBD. The three lines are described below.

- **Morris Subdivision** is a northwest to southeast line between Morris, MN and Willmar, MN. North and southbound traffic moving between Morris and Marshall, MN must go through the Willmar Yard and transfer the engine from the front to the back of the train and back out in order to continue on the route.
- **Wayzata Subdivision** is an east-west route from Willmar Yard to Minneapolis in the east. Trains heading east and west go through the Willmar Yard to and from the Wayzata Sub. This movement does not require an engine switch.
- **Marshall Subdivision** is a southwest to northeast line between Marshall, MN and Willmar. North and southbound traffic between Morris and Marshall must go through the Willmar Yard and transfer the engine from the front to the back of the train and back out in order to continue on the route.

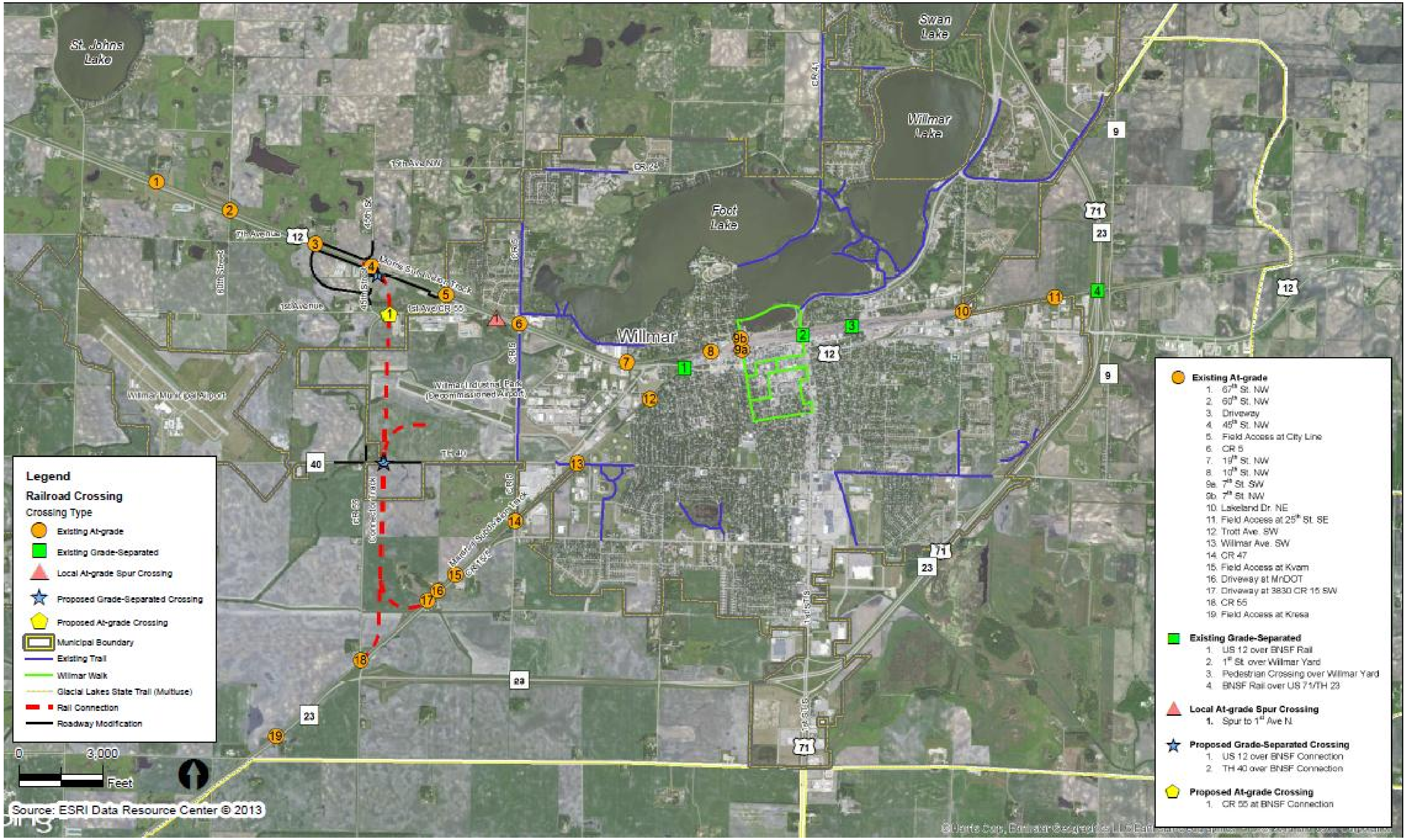
To complete the Morris to Marshall transfer, trains must pull into the Willmar Yard, reverse direction, and reposition locomotives and crews while creating excess emissions, blocking crossings in Willmar, and consuming yard and mainline capacity that would otherwise be used for switching local business and handling other through trains. This movement impacts 11 crossings in the City of Willmar and results in trains blocking crossings in the CBD (7th, 10th, and Lakeland) for up to 30 minutes at a time[16]. Exhibit 3 shows the crossings in the City of Willmar. See Exhibit 4 for the existing and proposed grade crossings in the Project area that are included in this analysis. The other existing at-grade crossings shown in Exhibit 3 were not included in the analysis because they are private crossings, driveways, or field access points that are not included in FRA's GradeDec.NET model; therefore impacts to these crossings could not be estimated.

Network Grade Crossing Benefits

In addition to the grade crossing benefits in the City of Willmar, there are network grade crossing impacts outside of the immediate City. These impacts, resulting from the re-routed trains, occur on the Moorhead, Morris, Staples, and Wayzata Subdivisions. With the wye, BNSF can re-route trains that were avoiding the Willmar Yard due to the congestion and time costs. These re-routed trains benefit the Staples and Wayzata Subdivisions, which would see fewer trains, but cause disbenefits to the Morris and Moorhead Subdivisions which would see more trains. The impacts are netted and result in positive benefits overall for the nearby BNSF network. To avoid confusion between the Willmar and Network Grade Crossing Benefits estimations, the Willmar calculations and results are described in detail, and the Network benefits are shown in total on page 18 by following the same methodology for the re-routes.

[16] Willmar Trainmaster estimate.

Exhibit 3: Project Area and Grade Crossings



The Willmar Rail Connector would reduce the number of trains that must go through the Willmar Yard by moving the north-south traffic onto the Connector, leaving only the traffic going east-west going through the Willmar Yard—significantly reducing the number of trains traveling through the City of Willmar and removing the long blockages in the CBD for the Morris-Marshall transfers. While reducing the number of trains going through the CBD, the Project also increases the trains traveling along the new alignment. However, the new alignment would result in the closing of one existing grade crossing on the Morris (at 45th) Subdivision and introducing only one new at-grade crossing at 1st Ave/CR 55, limiting the negative community impacts associated with highway-rail grade crossings.

Analysis Assumptions

The grade crossing analysis requires a number of assumptions regarding train and vehicle traffic. The train and Average Annual Daily Traffic (AADT) assumptions are outlined briefly here, with a complete list of assumptions for each crossing in the supplemental materials (see Summary of GradeDec Assumptions.xlsx).

By 2020, BNSF rail traffic on the Morris and Marshall Subdivisions would include 13 trains per day and be operating at capacity. The Willmar Yard also would to be at capacity in 2020 with 19 trains per day, amounting to 6 Wayzata/Morris (east-west traffic), 6 Wayzata/Marshall (east-west traffic), and 7 Morris/Marshall trains (north-south traffic). Because the yard would be operating at capacity by 2020, no growth is assumed in the Baseline (or No Build scenario).

In the Build analysis, the 7 Morris/Marshall trains are expected to divert to use the wye daily (this is the basis of the 2.5 hours of delay avoided in the yard). In addition to the 7 diverted trains, re-routed trains also would use the wye, starting with 608 trains in 2020 and increasing by 2.3% per year based on FAF freight tonnage growth estimates for the region[17]. The number of trains between the wye and Willmar (for both the Morris and Marshall Subdivisions) would stay constant at 6 trains per day. Trains on the Wayzata sub would hold constant at 12 trains per day.

Traffic counts were done at six of the 11 existing Willmar grade crossings for increased accuracy[18]. See Exhibit 4 for the AADT used in the analysis. The vehicle traffic at the Willmar grade crossings is assumed to increase at a conservative one quarter of one percent (0.25%) per year throughout the analysis period.

Exhibit 4: AADT at Grade Crossings

Crossing	AADT	Source
GDCX1 - Trott	1900	AECOM
GDCX2 - Willmar	3100	AECOM
GDCX3 - 30th	6100	AECOM
GDCX4 - CR55	1150	GradeDec.NET Default
GDCX5 - Lakeland	4100	AECOM
GDCX6 - 7th	2500	GradeDec.NET Default
GDCX7 - 10th	1800	AECOM
GDCX8 - 19th	1200	AECOM
GDCX9 - 30th	7700	GradeDec.NET Default
GDCX10 - CR5spur	1550	GradeDec.NET Default
GDCX12 - 60th	130	GradeDec.NET Default
NEW CROSSING	1000	AECOM

17 See footnote 12 for more information.

18 See the workbook (WillmarWye_BCA_2015.xlsx, TrafficData tab) for the data collected.

Summary of Grade Crossing Benefits

The community benefits associated with adding the new alignment and diverting trains away from the more populated areas of the City of Willmar include:

- Safety
- Travel time savings
- Vehicle operating cost savings
- Vehicle emissions reductions

The benefits are estimated by either using FRA's GradeDec.NET model (if there is a change to the crossing type) or using the GradeDec.NET methodology (as described in the GradeDec.NET Reference Manual[19]). The use of FRA's grade crossing analysis model (GradeDec.NET[20]) estimates the net safety, travel time, travel cost, and emissions savings associated with proposed improvements to corridor grade crossings (i.e. improvement of device, grade separation, and closing) between a Build and No Build case. As a result, the GradeDec.NET online model could only be used for the closure of the crossing on the Morris sub (45th St.). However, the GradeDec.NET methodology is applied for all grade crossing benefits as highlighted below.

Each benefit type considers the negative impacts of the new alignment and the benefits experienced by the existing corridor crossings (considering the net between the Baseline and Build operations). Thus, the grade crossing analysis involves the following steps:

1. Estimates the benefits from reducing traffic along a portion of the existing BNSF alignment between the wye and the Willmar Yard[21]. This analysis applies the GradeDec.NET methodology for safety, travel time, travel cost, and emissions benefits, but it is done outside the FRA GradeDec.NET model, because it does not involve any improvements to the existing crossings—only a reduction in trains.
2. Estimates the costs of introducing diverted and re-routed BNSF trains to the new alignment and the one new at-grade crossing located at 1st Ave/CR 55. This analysis applies the GradeDec.NET methodology for safety, travel time, travel cost, and emissions disbenefits associated with the new crossing, but also is estimated outside the GradeDec.NET model because the crossing does not currently exist.
3. Estimates the benefits from closing one existing grade crossing along the Morris subdivision (45th St.). This analysis was performed using the GradeDec.NET model to make sure that the traffic at the existing crossing was properly reallocated due to the closure.
4. Netting costs of the new crossing against benefits for the existing crossings to obtain a total net grade crossing benefit.

Exhibit 5 summarizes the net safety, travel time, vehicle operating cost, and emissions benefits for the Project. The following sections detail how the grade crossing analysis was conducted.

[19] FRA, GradeDec.NET Reference Manual, June 2008.

[20] http://gradedec.fra.dot.gov/

[21] Please see Exhibit 3 for a map of the crossings. Crossings that would see reductions in train traffic include: Trott Ave, Willmar Ave, 30th St. NW, Lakeland, 7th St., 10th St., 19th St. NW, 30th St. SW, and CR5 spur.

Exhibit 5: Net Willmar Grade Crossing Benefits

	Millions of 2015$ Discounted at 7%		
	Net Benefits from Existing Crossings	**Impacts of Closing 45th St. Crossing**	**Disbenefits Associated with New Crossing**
Safety	$1.65	$0.10	$0.92
Travel Time	$6.25	$0.00	$0.03
Emissions	$0.04	$0.00	$0.00
Vehicle Operating Costs	$1.00	$0.00	$0.00
Total	**$8.93**	**$0.10**	**$0.95**
Net Total (Existing Crossings + Closing 45th St.- New Crossings)			**$8.08**

Source: AECOM

The results presented below demonstrate that shippers who utilize the corridor can benefit from the significant improvement in rail service afforded by the Project while still generating community benefits for the City of Willmar.

In addition to the City of Willmar, the larger region would experience grade crossing benefits as trains are re-routed to use the wye instead of traveling more miles to avoid Willmar Yard due to congestion and time costs associated with that route. These benefits are also estimated outside of the GradeDec.NET estimating tool following the same methodology as GradeDec.NET in a spreadsheet tool. However, because the estimation process is the same as the Willmar Grade crossings, the Network benefit results are displayed following the City of Willmar benefits.

Safety Benefits

The exposure of vehicles to grade crossings results in a greater likelihood of safety incidents as trains travel through the crossings. While the likelihood of incidents would be reduced for the existing corridors in the Build compared to the Baseline, the exposure of vehicles to trains would increase along the new alignment due to the introduction of one new grade crossing and the associated rail traffic. However, the new alignment would travel through an area with lower AADT than the existing alignments, which reduces the likelihood of incidents. This section summarizes the net safety benefits that result from moving trains from the existing Morris and Marshall Subdivision alignments to the new wye by estimating the benefits to the existing corridors as well as the disbenefits experienced along the new alignment.

The safety benefits associated with moving the north-south trains from the Morris/Wayzata and Marshall/Wayzata Subdivisions to a new wye outside of Willmar are calculated by using a spreadsheet model based on the FRA's GradeDec.NET web-based analysis tool. The safety analysis calculates the safety impacts associated with the likelihood of highway-rail accidents at the grade crossings in the No Build and Build for the existing crossings, as well as for the new crossing along the new alignment. The calculation of the safety impact uses the same methodology as the GradeDec.NET analysis tool, which is based on the USDOT Accident Prediction and Severity Model (APS) and Resource Allocation Method. The APS methodology and the GradeDec.NET improvement are used to account for the time-of-day correlation factor between rail and highway traffic are used to predict the number of accidents by severity that would occur at crossings. The safety analysis methodology for grade crossings predicts the number of accidents each year based on the number of daily trains, AADT, time-of-day exposure correlation factor, number of tracks, and number of highway lanes crossing the tracks.

The predicted accidents are then used to estimate the number of accidents by severity (fatal, injury, and property damage only [PDO]) that would occur along the corridor. The estimated accidents by severity are based on the maximum speed, APS factors for fatal accidents and casualty accidents for grade crossings with gates and lights, number of through trains, and number of tracks. Exhibit 6 shows the costs used in the analysis to value the incidents by severity.

Exhibit 6: Costs of Safety Incidents by Severity

Cost	Thousands of 2015$	
Fatal Accident	$	9,672
Injury Accident[1]	$	1,961
PDO Accident	$	4.04

Note 1: Injury costs averaged across AIS 1 to 5
Note: Costs converted from 2013$ to 2015$ using OMB GDP Chained Price Index
Source: TIGER Benefit-Cost Analysis Resource Guide (updated April 2, 2015), http://www.dot.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

Safety Benefits from the Existing Alignments

In order to estimate the safety benefits experienced along the existing corridors (Marshall, Morris, and Wayzata Subdivisions), two scenarios were run in a spreadsheet model using the GradeDec.NET methodology[22]. The first scenario (No Build) establishes the Baseline for the existing rail traffic by predicting the safety costs associated with the existing alignments if the project is not built and the region's rail traffic must continue to use the existing route through the Willmar Yard. The second scenario (Build) estimates the safety costs on the existing alignments if the wye is constructed, which eliminates one crossing[23] and reduces the rail traffic along most of the remaining segments of the alignments. Subtracting the safety costs of the Build from the No Build yields the net safety benefits associated with the Build scenario.

The net results are positive safety benefits due to the reduced traffic interactions at grade crossings in the City of Willmar, which reduces the likelihood of highway-rail accidents. The safety benefits associated with existing traffic totals $1.65 million using a 7% discount rate. The total safety benefits for closing one grade crossing at 45th Street are $101,715 at a 7% discount rate. ***Together, the total safety benefits of the existing corridor yields $1.75 million[24].***

Safety Implications of the New Alignment

While the exposure to highway-rail accidents would be reduced along the existing corridor, the exposure increases along the new Connector due to the introduction of one new grade crossing at 1st Ave/CR 55. The new grade crossing is assumed to be equipped with gates and lights. The safety costs associated with moving the north-south BNSF trains from the Morris/Wayzata and Marshall/Wayzata Subdivisions to a new wye outside of Willmar are calculated by using a spreadsheet model based on the FRA's GradeDec.NET web-based analysis tool, as described above.

Since the new alignment increases the likelihood of highway-rail accidents at the new crossing, the safety impacts are a disbenefit and must be subtracted from the safety benefits experienced by the grade crossings along the existing alignments. ***Totaled over the analysis period and discounted at 7%, the safety disbenefit of the new crossing is $918,957.***

Net Safety Benefits Associated with the Project

The net safety benefits are calculated by summing the safety benefits gained along the existing alignments and the costs associated with the new Connector. The benefits along the existing alignments outweigh the costs encountered along the new alignment, generating a total net positive safety benefit for the City of Willmar. ***Totaled over the analysis period and discounted at 7%, the net safety benefit of the project is $0.828 million.***

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[22] The spreadsheet tool does the same analysis as GradeDec.NET but allows for more adjustments by the user and more transparency in the analysis. The workbooks are provided as supplemental materials to this analysis.

[23] The removal of one crossing was estimated in the GradeDec.NET online tool, separate from the spreadsheet analysis. The results from closing the crossing are added to the net benefits associated with the existing crossings.

[24] Note that the disbenefits from the new crossing on the new alignment have not been subtracted from this total at this point.

Travel Time Savings

The highway delays associated with grade crossings result in increased travel times for highway drivers and their passengers as they wait for trains to travel through grade crossings. While the length of travel time delays would be reduced for the existing alignments, the travel time delays would increase along the new Connector due to the introduction of one new grade crossing and rail traffic. However, the plan for the new alignment provides two grade separated crossings, which helps to minimize the travel time delays experienced by the new alignment. Additionally, the new alignment would travel through a region with lower AADT than the Willmar CBD, which reduces the potential travel time delays. This section summarizes the total net travel time savings benefits that result from the new Connector by estimating the benefits to the existing corridors as well as the costs incurred along the new alignment.

A supplemental analysis, developed in a spreadsheet tool, was designed to match the GradeDec.NET travel time savings analysis as closely as possible for the existing and new crossings. As with the safety benefits analysis, the travel time savings benefits experienced along the existing alignments are estimated by running two scenarios with the GradeDec.NET-based spreadsheet tool. The first scenario (No Build) establishes the Baseline for the existing corridor by predicting the travel time costs associated with the existing alignment if the project is not built and the region's rail traffic must continue to use the Willmar Yard. The second scenario (Build) estimates the travel time benefits on the existing alignment if the project is built, which eliminates one crossing[25] and reduces the rail traffic along most of the existing segments. Subtracting the travel time costs of the Build from the No Build yields the net travel time benefits associated with the Project.

The first step in the travel time analysis is calculating the daily minutes of gate down time for the crossings. This is accomplished by multiplying the assumed number of daily trains for each year by the average length of each train to estimate the total length of all trains at the crossing for that year. For the purposes of this analysis, it is assumed that the average length per train is 6,750 feet, which is the average of unit and manifest train lengths traveling the corridor[26]. The length of all trains is then divided by the average speed of the trains, which is converted from miles per hour to feet per minute.

Once the total daily minutes of gate down time are estimated, the number of daily vehicles that are delayed and the average time delayed per train are estimated. The number of daily vehicles delayed is calculated by dividing the AADT at each crossing by 24 hours and then by 60 minutes to determine the AADT per minute. The AADT per minute is then multiplied by minutes of gate down time to estimate the number of daily vehicles delayed at the grade crossings.

The daily number of vehicles delayed at the grade crossings must then be converted into minutes of delay by multiplying the number of vehicles by the average delay per train. The average delay per train is calculated by dividing the total length of the train in feet by the average speed of the trains in feet per minute, which results in an average delay of 3.84 minutes. However, not all vehicles would be delayed for the entire length of the train. Vehicles would arrive at the grade crossing at various times while the gate is down. Since it is not known exactly when the vehicles would arrive at the gate, the analysis assumes that the vehicles arrive at a uniform rate so that 10 percent of the vehicles are delayed for the entire gate closure, 10 percent for 90 percent of the gate closure, etc. Therefore, the total number of vehicles delayed each day is multiplied by 10 percent and the average time of delay (apportioned in 10 percent increments).

In order to calculate the travel time costs associated with the total vehicle delay per day, the time of delay must be allocated by trip purpose (work, leisure, and truck), the assumptions for which are shown in Exhibit 7. Additionally, the number of people traveling in the vehicle must be

[25] The removal of one crossing was estimated in the GradeDec.NET online tool, separate from the spreadsheet analysis. The results from closing the crossing are added to the net benefits associated with the existing crossings.

[26] Provided by BNSF

factored into the value of the travel time delay because passengers also would be negatively impacted by the delay. The average auto occupancy used in the analysis is 1.31[27], which represents the Minnesota statewide rural average auto occupancy value[28]. All auto trip delays, therefore, are multiplied by the 1.31 average auto occupancy factor to account for all passengers in the vehicle. Additionally, it is assumed that truck drivers travel alone so the average truck occupancy rate is 1.0. Based on the trip purpose assumptions, the number of auto trips in the corridor is 90 percent, of which 95.4 percent are leisure trips and the remaining 4.6 percent are for work.

Exhibit 7: Assumptions for Trip Purpose Value of Time

Trip Purpose	Share of Trips	Value of Time
Auto Work	4.1%	$ 17.62
Auto Leisure	85.9%	$ 8.81
Truck	10.0%	$ 26.55
Total	100.0%	$ 10.95

Note: Total Value of Travel Time is a weighted average of the values of auto work, auto leisure, and truck

Using the weighted average value of time based on trip purpose, the negative travel time impacts associated with this delay are monetized. The trip purpose is important to the monetization of the impacts because people value their time differently for different types of trips. USDOT[29] recommends that business travel be valued at 100 percent of the hourly wage, while personal or leisure travel (including commute time) be valued at 50 percent of the hourly wage. The average hourly wage for truck drivers is based on USDOT Guidance, $26.55[30]. The national hourly rate is used for truck drivers because truck trips made in the region could be made by any truck driver in the US, not just those drivers who reside in the study region.

The 2015 average wage is converted to an average hourly value of time for Kandiyohi County in 2012. The 2012 average hourly wage is inflated from 2012$ to 2015$ by the GDP Chained Price Index from the Office of Management and Budget. The total value of the time loss associated with the new wye is based on the total person delay by trip type, the average hourly wage assumptions, and an annualization factor that converts the daily delay to an annual delay. The analysis assumes an annualization factor of 280, which accounts for reduced levels of traffic on non-weekdays. This annualization factor is consistent with the factor used in the GradeDec.NET analysis tool.

Travel Time Benefits on the Existing Alignments

The travel time savings associated with the reduction and/or elimination of highway queuing at existing BNSF grade crossings as calculated by GradeDec.NET are based on:

- Trains per day, by time of day (uniformly distributed throughout the day)
- Train length
- Average speeds at crossings
- AADT distributed by time of day and segment (auto, truck, and bus)
- Number of highway lanes at crossings
- Highway traffic density
- Vehicle dispersal rates per lane when closure ends
- Average vehicle occupancy

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[27] Average auto occupancy for Minnesota also used in GradeDec.NET

[28] National Household Travel Survey (NHTS), Minnesota data, 2009 http://www.dot.state.mn.us/planning/program/benefitcost.html

[29] USDOT Office of the Secretary of Transportation, Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis, http://www.dot.gov/sites/dot.dev/files/docs/USDOT%20VOT%20Guidance_0.pdf

[30] Truck driver wage based on USDOT Guidance and converted from 2013$ to 2015$, http://www.dot.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

With this data, the spreadsheet tool based on the GradeDec.NET methodology calculates the average grade crossing block time, the highway vehicle delay due to crossing closure by traffic segment, and the highway vehicle time in queue by traffic segment due to the blocked crossing. Once the delays and time in queue are known, the time savings is monetized by multiplying the traffic segment time savings, the average vehicle occupancy (1.31[31]) by traffic segment, and the value of time for auto and truck travelers ($10.95)[32].

The results for net travel time impacts on the existing crossings are positive, totaling $6.25 million, because the reduced rail traffic interacts less with the highway traffic at grade crossings, creating fewer highway traffic delays while trains travel through the grade crossings and engines are switched at the yard. The travel time savings for closing the one grade grossing is negative, but very small, amounting to -$2,352. ***Net travel time benefits associated with the existing crossings discounted at 7% yields $6.25 million.***

Travel Time Implications for the New Alignment

The same analysis as described above was conducted for the single new grade crossing in the new alignment. The new crossing results in delays for the vehicles that would have to stop at the crossing. ***In total, the travel time delay from the new crossing on the new alignment is a cost of $27,309 discounted at 7%.***

Net Travel Time Benefits

The net travel time savings benefits associated with the new alignment accounts for both the positive travel time savings benefits for the existing alignments as well as the costs for the new alignment by summing the travel time impacts of both. The benefits experienced along the existing alignments are greater than the negative impacts experienced along the new alignment, generating a net travel time savings benefit for the City of Willmar. ***In total, the net travel time benefits for the project are $6.219 million at a 7% discount rate.***

Vehicle Operating Cost Savings

The highway delays associated with grade crossings result in greater vehicle operating costs due to increasing idling times at grade crossings while vehicles wait for trains to travel through the crossings. While the highway delays and associated vehicle operating costs would be reduced for the existing corridors, the delays and vehicle operating costs would increase along the new alignment due to the introduction of one new grade crossing and the associated rail traffic. However, the new alignment would travel through an area with lower AADT than the existing alignments, which reduces highway delays. This section summarizes the net vehicle operating cost savings benefits that result from moving trains from the existing Morris and Marshall Subdivision alignments to the new wye by estimating the benefits to the existing corridors as well as the disbenefits experienced along the new alignment.

A supplemental analysis, developed in a spreadsheet tool, was designed to match the GradeDec.NET vehicle operating cost analysis as closely as possible for the existing and new crossings. The analysis is based on the planned physical characteristics of the existing and new grade crossings as well as the assumptions about future rail and highway operations in the region.

The first step in the vehicle operating cost analysis is calculating the daily minutes of vehicle delay associated with the gate closings for the grade crossings in each year. The daily minutes of vehicle delay for each grade crossing were calculated previously for the travel time analysis for the existing and new alignments. Once the total daily minutes of vehicle delay are known, the

[31] National Household Travel Survey (NHTS), Minnesota data, 2009 http://www.dot.state.mn.us/planning/program/benefitcost.html

[32] $17.62 per hour for auto work (valued at 100% of time), $8.82 for auto leisure, and $26.55 per hour for truck. See Exhibit 7.

minutes of delay must be allocated to automobiles and trucks, because these vehicles have different idling burn rates of fuel and motor oil.

In order to calculate the value of the vehicle operating costs associated with idling at the grade crossings, assumptions about the average fuel and motor oil burn rates as well as the price of gasoline, diesel, and motor oil must be established. The fuel and motor oil burn rates for each minute of idling are FRA national averages that are used as default values by the GradeDec.NET analysis tool. The gasoline and diesel prices per gallon are assumed to be $3.55 and $3.96, respectively, based on the Department of Energy's average fuel prices from 2014.[33] The price of motor oil per quart is assumed to be $4.00 based on the price of motor oil available for sale. Using these assumptions on the burn rates and prices of gasoline, diesel, and motor oil results in vehicle operating costs associated with auto and truck traffic idling during gate closures along the alignments.

Vehicle Operating Cost Savings on the Existing Corridors

The vehicle operating cost savings associated with the reduction in highway queuing at grade crossings in the Build scenario are based on the GradeDec.NET calculation of the average grade crossing block time, the highway vehicle delay due to crossing closure by traffic segment, and the highway vehicle time in queue by traffic segment as discussed in the time savings results. Once the delays and time in queue are known, the vehicle operating cost savings is monetized by multiplying the vehicle time in queue by the idle burn rates for autos and trucks and the costs of fuel and motor oil.

The vehicle operating cost savings benefits experienced along the existing corridors are estimated by running two scenarios with the spreadsheet tool that models GradeDec.NET. The first scenario (No Build) establishes the Baseline for the existing corridors by predicting the negative vehicle operating cost impacts associated with the existing alignment if the wye is not constructed and the region's rail traffic must continue to use the existing routes. The second scenario (Build) estimates the vehicle operating costs on the existing alignments if the wye is constructed, which reduces the rail traffic along the remaining segments of the alignments. Subtracting the vehicle operating costs of the Build from the No Build yields the net vehicle operating cost savings associated with the Project.

The net vehicle operating cost savings total $1.00 million on the existing alignment because the reduced rail traffic interacts less with the highway traffic at grade crossings, creating fewer highway traffic delays and idling while trains travel through the grade crossings and engines are switched at the yard. In addition, the Build considers closing one existing grade crossing, thereby removing vehicle operating costs at that location, but allocating the traffic and costs to other nearby crossing, resulting in a minimal cost. ***In total, net vehicle operating cost savings for the existing alignment total $1.00 million discounted at 7%.***

Vehicle Operating Cost Implications for the New Alignment

Using the spreadsheet analysis tool modeled after GradeDec.NET, the vehicle operating costs were estimated for the new grade crossing in the same manner as the existing crossings. ***Discounted at 7%, the vehicle operating costs for the new alignment total $4,834.***

Net Vehicle Operating Cost Benefits Associated with the Project

The net vehicle operating cost benefits associated with the new wye accounts for both the positive vehicle operating cost savings for the existing alignments as well as the costs for the new alignment by summing the vehicle operating cost impacts for both. The benefits experienced along the existing alignment are greater than the negative impacts experienced along the new alignment, generating a net vehicle operating cost savings for the City of Willmar. ***The total net vehicle operating cost savings from the project at a 7% discount rate is $0.996 million.***

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[33] Department of Energy, http://tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp. 2014 values used because 2015 values are assumed to be unusually low and are not likely sustainable.

Highway Emissions Benefits

The highway delays associated with grade crossings result in greater vehicle emissions due to increased idling times at grade crossings while vehicles wait for trains to travel through the crossings. While the highway delays and associated vehicle emissions would be reduced for the existing Morris and Marshall Subdivision alignments in the Build, the delays and vehicle emissions would increase along the new wye due to the introduction of one new at-grade crossing. The new alignment would travel through an area with lower AADT than the existing alignment, which reduces the potential for highway delays and associated idling emissions. This section summarizes the vehicle emissions benefits that result from diverting some trains from the existing alignments by estimating the benefits to the existing alignments as well as the negative impacts experienced along the new wye. The remainder of the emissions discussion describes the derivation of the net emissions benefits generated by the Project.

A supplemental analysis, developed in a spreadsheet tool, was designed to match the GradeDec.NET vehicle emissions analysis as closely as possible for the existing and new crossings. The analysis is based on the planned physical characteristics of the existing and new grade crossings as well as the assumptions about future rail and highway operations in the region.

The first step in the vehicle emissions analysis for the new alignment is calculating the daily minutes of vehicle delay associated with the gate closings for the new grade crossing in each year. The daily minutes of vehicle delay for the new grade crossing were calculated previously for the travel time and vehicle operating cost analysis. Once the total daily minutes of vehicle delay are known, the minutes of delay must be allocated to automobiles and trucks because these vehicles have different hydrocarbon, carbon monoxide, and nitrous oxides emission rates. In order to calculate the value of the vehicle emissions associated with idling at the grade crossings along the new alignment, assumptions about the average emission rates as well as the value of each pollutant's impacts must be established. The emission rates for each minute of idling are FRA national averages that are used as default values by GradeDec.NET. The prices for carbon monoxide and nitrous oxide assumed in the analysis are from the TIGER 2015 Resource Guide[34] escalated to 2015 values while the GradeDec.NET default value that represents the national average was used for hydrocarbons.

Therefore, pollutant costs per ton used in the GradeDec.NET-based spreadsheet tool are $2,040 for HC, $0 for CO, and $7,354 for NOx. Using these assumptions on the emission rates, the tons were converted to grams (1 ton/907,185 grams), and the hedonic price of emissions were applied per ton.

Highway Emissions Benefits for the Existing Corridors

The highway emissions benefits associated with the reduction in highway queuing at grade crossings are based on the GradeDec.NET-based spreadsheet analysis tool calculation of the average grade crossing block time, the highway vehicle delay due to crossing closure by traffic segment, and the highway vehicle time in queue by traffic segment as discussed in the travel time savings results. Once the delays and time in queue are known, the vehicle emissions reduction is estimated using emissions rates from GradeDec.NET and monetized using pricing for the impact of hydrocarbons, carbon monoxide, and nitrous oxides on community health, including human and environmental impacts. The prices for carbon monoxide and nitrous oxide assumed in the analysis are from the TIGER 2015 Resource Guide[35] escalated to 2015 values while the GradeDec.NET default value that represents the national average was used for hydrocarbons.

The emissions benefits experienced along the existing corridors are estimated by running two scenarios with the GradeDec.NET-based spreadsheet analysis tool. The first scenario (No Build)

[34] TIGER Benefit-Cost Analysis Resource Guide (updated April 2, 2015), http://www.dot.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

[35] Ibid.

establishes the Baseline for the existing corridor by predicting the vehicle emissions costs associated with the existing alignments if the wye is not constructed and the region's rail traffic must continue to use the existing routes. The second scenario (Build) estimates the vehicle emissions benefits on the existing alignments if the new wye is constructed, which reduces the rail traffic along the remaining segments of the alignments. Subtracting the emissions costs of the Build from the No Build yields the net vehicle emissions savings associated with the Project.

Both the No Build and Build scenarios estimate vehicle emissions costs because rail traffic interacts with the highway traffic causing highway delays at grade crossings while trains travel through the crossings. However, the negative impacts associated with the Build scenario are less than those of the No Build scenario, because there are fewer trains operating along the existing alignments in the Build, which translates into less time spent idling at grade crossings. ***The total emissions benefits of the existing crossings and closure of one crossing totals $38,290 discounted at 7%.***

Highway Emissions Implications of the New Alignment
The same analysis as described above was conducted for the single new grade crossing in the new alignment. The new crossing results in delays and thereby emissions for the vehicles that would now have to stop at the crossing. ***The total negative vehicle emissions impact associated with auto and truck traffic idling during gate closures along the new wye is $181 discounted at 7%.***

Net Highway Emission Benefits
The net vehicle emission benefits associated with the Project accounts for both the vehicle emissions benefits for the existing corridors well as the disbenefits for the new wye by summing the vehicle emissions impacts of both. ***The benefits experienced along the existing corridors are greater than the negative impacts experienced along the new wye, generating a net vehicle emissions benefit for the City of Willmar totaling $0.038 million discounted at 7%.***

Grade Crossing Benefits in the Broader Regional Network
In addition to the grade crossing benefits generated in Willmar, residents of the broader region would receive grade crossing benefits from the Project (fewer grade crossing conflicts, reduced emissions, reduced delay time, and reduced vehicle operating costs). By allowing trains to make the connection between the Morris and Marshall Subdivisions directly rather than entering Willmar Yard, congestion in this area of the network is reduced. This permits BNSF to route trains that had been taking a longer path through more populated areas of the network in order to avoid the congestion at Willmar to now take a shorter path through less populated areas. As a result, the grade crossing conflicts are reduced, as are delays, road vehicle operating costs, and emissions.

The analysis estimates this regional benefit by comparing benefits generated in more populated areas against the disbenefits of increasing trains in less populated areas. On the positive side, the analysis calculates the improvement in grade crossing conflicts, delays, operating costs and emissions generated by reducing the number of trains traversing the more populated Staples and Wayzata Subdivisions. On the negative side, the analysis calculates the total costs associated with increasing grade crossing conflicts, delays, operating costs and emissions in more rural areas along the Moorhead and Morris Subdivisions. The net difference between the two routes defines the total regional network benefit.

The regional grade crossing benefit relies on the same GradeDec methodology that was used for the Willmar analysis. The calculations are provided in workbooks in the supplemental materials. The results of the analysis are provided in the BCA workbook provided with this tech memo found in the NetworkGCXData and NetworkGradeXs tabs. The supplemental workbooks include:

NetworkCrossings_Moorhead_2015
NetworkCrossings_Morris1_2015[36]
NetworkCrossings_Morris2_2015
NetworkCrossings_Staples1_2015
NetworkCrossings_Staples2_2015
NetworkCrossings_Staples3_2015
NetworkCrossings_Wayzata_2015

In general, the GradeDec methodology was developed to assess the impact of an investment on these outcomes. In this application, the methodology is used to determine the costs associated with different numbers of trains running through a fixed corridor. This is accomplished by comparing the pre-improvement values associated with the number of trains shifting between the two routings—the crossing improvement type remains the same in the "before and after." A summary of the net benefits is provided in Exhibit 8 below for the 20-year analysis period in millions of discounted 2015 dollars.

Exhibit 8: Network Grade Crossing Benefits

	Millions of 2015$ Discounted at 7%		
	Staples + Wayzata	**Morris + Moorhead**	**Net**
Safety	$21.69	$10.61	$11.08
Travel Time	$2.05	$0.53	$1.52
Emissions	$0.01	$0.00	$0.01
Vehicle Operating Costs	$0.23	$0.05	$0.18
Total	**$23.98**	**$11.19**	**$12.79**

The analysis assumes that train traffic grows by 2.3% annually[37].

Because of the assumptions in how GradeDec calculates arrival time and vehicle delay per queue, a number of crossings do not generate benefits (or costs). Tracing the impact through the model, these are little used crossings were the number of reported vehicles is very small. As a result, the arrival time (*lambda*) is significantly smaller than the assumed (fixed) dispersal factor of (0.5) designated by *mu* in the equation below[38], yielding a negative result when expressed as the difference of their reciprocal values as in (1/mu – 1/lambda).

$$w = N_K \cdot \left[\frac{ACCT}{60} + \left(\frac{1}{\mu} - \frac{1}{\lambda} \right) \cdot \left(\frac{N_k + 1}{2} \right) \right]$$

As shown in Exhibit 8, over the analysis period the net benefits total $12.79 million at a 7% discount rate.

Environmental Sustainability

Air Quality Benefits

The diverted and re-routed trains are able to reduce the air pollutants associated with traveling longer routes because the Project reduces the hours of locomotive travel. The hours of delay per

[36] Please note that two Subdivisions were divided into multiple workbooks to conduct the analysis on a more manageable scale. The Staples Subdivision was divided into three workbooks for mileposts 17.84-18.04, 82.52-174.11, and 175.3-249.25. The Morris Subdivision was divided into two workbooks for mileposts 106.21-173.39 and 174.91-211.77.
[37] See footnote 12 for more information.
[38] Equation 14 Total Vehicle Delay per Closure (vehicle-seconds), GradeDec Reference Model

train avoided due to the Project were estimated and described as part of the operating savings and the details can be found in the supporting materials (WillmarWye_BCA_2015.xlsx).

This reduction in train delay hours decreases the amount of CO, NOx, PM10, and HC in the atmosphere. The US Environmental Protection Agency's (EPA) Office of Transportation and Air Quality published long-haul rail engine emission rates (g/brake horsepower hour) for various Tiers based on the year the locomotive was built[39]. Tier 0 locomotives apply to most locomotives built prior to 2001, while higher Tiers apply to the locomotives manufactured most recently. Assuming throughout the analysis period locomotives would be replaced or re-manufactured and be required to adhere to higher emissions standards, Tier 2 was assumed to be an appropriate average emissions rate standard. See Exhibit 9 for the emissions rates used in the analysis. Additionally, the analysis assumes that all trains have one locomotive. This is conservative because many trains used in the region must travel through mountainous areas in North Dakota and Montana and are likely to have more than one locomotive.

Exhibit 9: Emission Rates (Grams per Brake Horsepower Hour)

	PM10	NOX	CO	HC
Tier 2 Line-Haul Locomotive	0.18	4.95	1.28	0.26

Note: Tier 2 locomotives used to account for locomotives being replaced/re-manufactured throughout the analysis period and adhering to higher emissions standards
Source: US EPA, Office of Transportation and Air Quality, Emissions Factors for Locomotives, EPA-420-F-09-025, April 2009, p.2, http://www.epa.gov/nonroad/locomotv/420f09025.pdf

Since the emission rates are based on horsepower hours, the maximum horsepower associated with the locomotives (4,300)[40] was multiplied by the annual hours saved, and the emissions factors yielding the annual grams of CO, NOx, PM10, and HC avoided. The grams were converted to short tons and valued by applying the economic cost of air emissions to the reduction of CO, NOx, and PM10, as recommended in the US DOT 2015 TIGER BCA Resource Guide[41]. HC was valued using the default value in FRA's GradeDec.NET model for highway-rail grade crossing investment analysis[42]. ***Applying USDOT guidance for the pollutant factors and discounted at 7%, the estimated value of the improved air quality associated with train diversions and re-routes is $41.21 million.***

Safety

Safety benefits are quantified as part of the GradeDec.NET analysis described in the Quality of Life section. Safety benefits are positive and come from the reduced train volumes through Willmar and fewer conflicts with autos and trains, even considering the increased train traffic at the single new grade crossing on the new alignment.

Costs

Capital Costs

The capital costs for the Project include the costs for the track, grade separations of 2 new crossings, and local roadway modifications. The capital costs are applied over the 35-month construction period for the Project, beginning in February 2017 and ending in December 2019. ***The capital costs for the project discounted at 7% total to $38.21 million.***

[39] FMCSA US EPA, Office of Transportation and Air Quality, Emissions Factors for Locomotives, EPA-420-F-09-025, April 2009, p.2, http://www.epa.gov/nonroad/locomotv/420f09025.pdf
[40] Maximum used because of the mountainous terrain. Source: http://www.4rail.net/reference_nam_bnsf_locos1.php
[41] TIGER Benefit-Cost Analysis Resource Guide (updated April 2, 2015), http://www.dot.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf
[42] HC valued at $2,040 per ton, assumed to be 2015 dollars.

Operating and Maintenance Costs

The project requires annual and periodic operating and maintenance (O&M) costs to keep the tracks and bridges (grade separated crossings) up to code. Maintenance of the system begins in 2020, as the first full year of operation, and the bridges require $115,299 per year[43], held constant throughout the analysis period. The road portion is assumed to have no additional annual maintenance costs as it is an existing roadway receiving maintenance and repairs. The annual maintenance costs of the track were estimated by BNSF to be $10,000 per track mile for the first 10 years, and $15,000 per track mile after the first 10 years, both to be held constant. Multiplying the track O&M by the estimated 5.14 track miles of the project yields the annual O&M costs throughout the analysis period. ***Together, the total O&M costs over the analysis period and discounting at 7% is $1.42 million.***

Summary

Exhibit 10 below summarizes the discounted value of the benefits discussed in this memorandum. Taken in total and using a 7% discount rate, the benefits—residual savings, Willmar grade crossing benefits, network grade crossing benefits, inventory savings for both diversions and re-routes, operating savings for both diversions and re-routes, and emissions reductions from trains provide over $127.95 million dollars of benefits over the analysis period. Compared to a similarly discounted cost estimate, the Benefit Cost Ratio for the Project is 3.23, an excellent return on this critical investment for the region. This ratio rises to 4.68 when benefits and costs are discounted at 3%.

Exhibit 10: Benefit Cost Analysis

	Base Scenario (7 diversions)	
	20 Year Analysis Period (2020-2039)	
	Values stated in 2015 $M	
	Discounted at 7%	Discounted at 3%
Costs		
Capital Costs	$38.21	$42.83
O&M	$1.42	$2.35
Total Costs	**$39.63**	**$45.18**
Benefits		
Residual	$3.74	$5.50
Willmar Grade Crossing Benefits	$8.08	$13.22
Network Grade Crossing Benefits	$12.79	$21.51
Inventory Savings: Diversions	$0.22	$0.36
Inventory Savings: ReRoutes	$0.16	$0.27
Operating Savings: Diversions	$35.75	$58.47
Operating Savings: ReRoutes	$26.01	$43.74
Emissions Reductions (Trains)	$41.21	$68.20
Total Benefits	***$127.95***	***$211.26***
BC Ratio	**3.23**	**4.68**

43 Bridge O&M provided by MNDOT for 2014 and escalated to 2015 dollars using GDP Chained Price Index.

List of Attachments and Supporting Information

4rail.net, BNSF Locomotives, http://www.4rail.net/reference_nam_bnsf_locos1.php

AECOM, WillmarWye_BCA_2015.xls (Excel spreadsheet with BCA calculations by benefit type and summary)

AECOM, Summary of GradeDec Assumptions.xlsx

AECOM, GradeDec.NET Analysis (for Willmar analysis)

- Existing_Crossings_Net_Delay&Safety_Benefits_2015.xls
- Grade_Crossing_Delay_Estimation_BNSF_BASELINE_Existing_2015.xls
- Grade_Crossing_Delay_Estimation_BNSF_BUILD_Existing_2015.xls
- Grade_Crossing_Delay_Estimation_BNSF_NewAlignment_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BASELINE_GCX1_Trott_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BASELINE_GCX2_Willmar_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BASELINE_GCX3_30th_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BASELINE_GCX4_CR55_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BASELINE_GCX5_Lakeland_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BASELINE_GCX6_7th_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BASELINE_GCX7_10th_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BASELINE_GCX8_19th_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BASELINE_GCX9_30th_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BASELINE_GCX10_CR5spur_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BASELINE_GCX12_60th_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BUILD_GCX1_Trott_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BUILD_GCX2_Willmar_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BUILD_GCX3_30th_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BUILD_GCX4_CR55_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BUILD_GCX5_Lakeland_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BUILD_GCX6_7th_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BUILD_GCX7_10th_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BUILD_GCX8_19th_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BUILD_GCX9_30th_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BUILD_GCX10_CR5spur_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_BUILD_GCX12_60th_2015.xls
- Safety_Grade_Crossing_Estimation_BNSF_NewAlignment_2015.xls

AECOM, GradeDec.NET Analysis (for Regional Network analysis)

- NetworkCrossings_Moorhead_2015
- NetworkCrossings_Morris1_2015
- NetworkCrossings_Morris2_2015
- NetworkCrossings_Staples1_2015
- NetworkCrossings_Staples2_2015
- NetworkCrossings_Staples3_2015
- NetworkCrossings_Wayzata_2015

Association of American Railroads, Class I Railroad Statistics, July 2014
https://www.aar.org/StatisticsAndPublications/Documents/AAR-Stats.pdf

BEA Rate of Depreciation, Service Lives, Declining-Balance Rates, and Hulten-Wykoff Categories, http://www.bea.gov/scb/account_articles/national/wlth2594/tableC.htm

Bureau of Economic Analysis (U.S. Department of Commerce), Tables CA1-3 – Personal Income Summary (counties) and SA1-3 Personal Income Summary (U.S.)

Det Norske Veritas. Highway Bridges, Yunovich et al. Appendix D, http://www.dnvusa.com/Binaries/highway_tcm153-378806.pdf

FMCSA US EPA, Office of Transportation and Air Quality, Emissions Factors for Locomotives, EPA-420-F-09-025, April 2009, p.2, http://www.epa.gov/nonroad/locomotv/420f09025.pdf

FRA, GradeDec.NET Reference Manual, June 2008.

Freight Analysis Framework, FHWA, Shipments Within, From, and To U.S. States - Tonnage by Domestic Mode: 2012 and Shipments Within, From, and To U.S. States - Value by Domestic Mode: 2012

National Household Travel Survey (NHTS), Minnesota data, 2009 http://www.dot.state.mn.us/planning/program/benefitcost.html

TIGER Benefit-Cost Analysis Resource Guide (updated April 2, 2015), http://www.dot.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

TIGER 2015 Notice of Funding Availability, https://www.federalregister.gov/articles/2015/04/03/2015-07711/notice-of-funding-availability-for-the-department-of-transportations-national-infrastructure

USDOT Guidance, Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis, September 28, 2011 http://www.dot.gov/sites/dot.dev/files/docs/vot_guidance_092811c.pdf

US EPA, Office of Transportation and Air Quality, Emissions Factors for Locomotives, EPA-420-F-09-025, April 2009, p.2, http://www.epa.gov/nonroad/locomotv/420f09025.pdf

US Energy Information Administration, Gasoline and Diesel Fuel Update, http://tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp