Competitive Highway Bridge Program Grant Benefit-Cost Analysis (BCA):

Oklahoma DOT Bridge Program, US-270, Seminole County

Prepared for:
Oklahoma Department of Transportation
2018 Grant Application

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TABLE OF CONTENTS

Executive Summary

Project Description

This application for the Federal Highway Administration (FHWA) Competitive Highway Bridge Program Grant (CHBP) is for the replacement of seven rural bridges along US 270 in Seminole County, southeast of Oklahoma City, which are being bundled together to achieve cost savings. Two of the bridges will be rehabilitations while the other five will be replaced. These bridges are part of an important corridor that connects Seminole and Wewoka as well as serving pass-through traffic.

Without replacement, these bridges will first be posted to a weight limit of 20 tons by the year 2023, effectively closing them to truck traffic. After further deterioration, by 2033, these bridges are expected to be closed to all traffic, forcing users to detour. Given the magnitude of traffic disruption this would cause along US 270, planning staff at Oklahoma's Department of Transportation (ODOT) have identified the renovation and replacement of these bridges as a priority.

The expected benefits of this comprehensive program of bridge replacements include:

- Avoiding travel time and vehicle operating costs from future detours, when bridges are weight-restricted and eventually closed;
- Safety improvements as a result of reduced exposure to crashes from avoided detours;
- Long-term savings in operations and maintenance costs, including consideration of higher maintenance costs for poor condition bridges; and
- Additional non-quantifiable benefits including access to residential and agricultural destinations along the corridor, access to municipal and county offices and services, access to recreational attractions, and connection to tribal programs and other services in the region.

Methodology

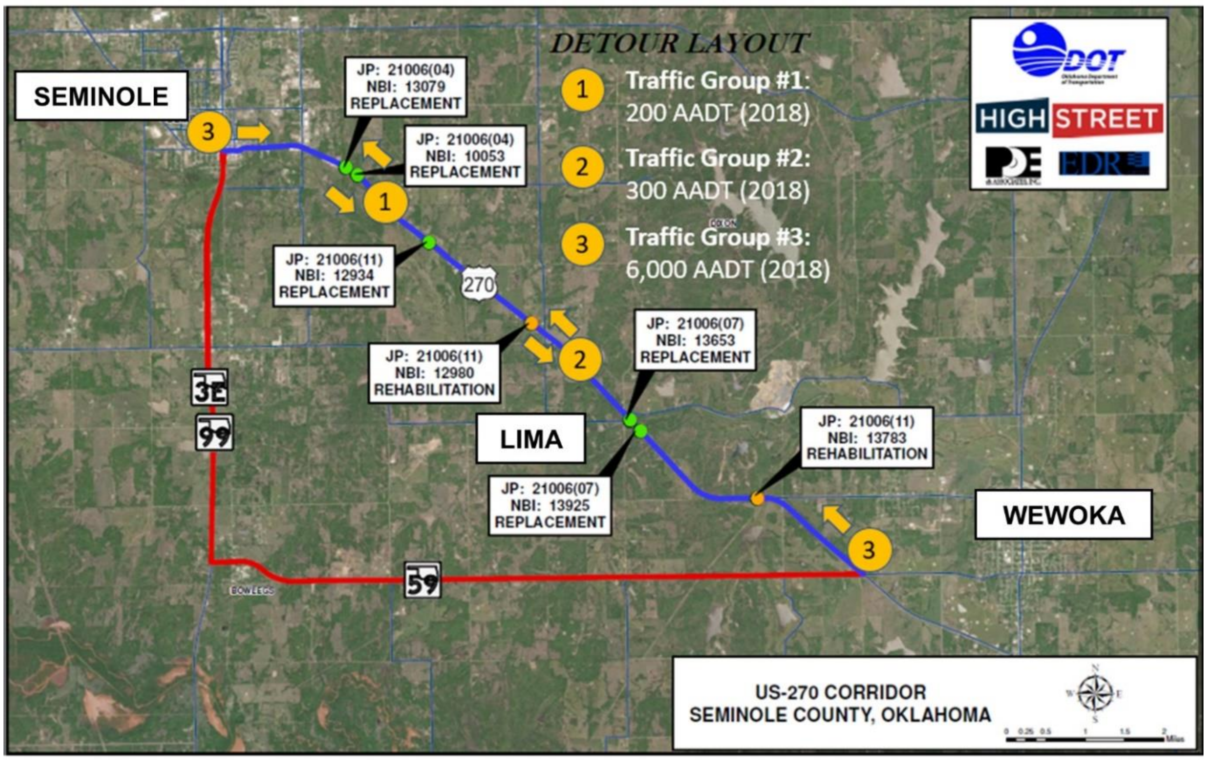
Because all seven of these bridges are located along US 270 within a single contiguous corridor, the benefit-cost analysis needs to consider the implications of bridge postings and closures holistically. Most of the traffic volume on this segment of US 270 (6,000 AADT[1] in 2018) travels along the entire corridor crossing all seven bridges. The remaining traffic (500 AADT in 2018) exits/enters at different points along US 270, identified based on observed volumes provided by ODOT. To correctly determine the detour implications of bridge postings and closures, three groups of traffic volumes were organized based on origins, destinations, and associated bridges. **Figure 1** illustrates these three groups.

[1] Average Annual Daily Traffic

- Traffic Group #1 (200 AADT): This group of traffic is between Seminole and an exit off US 270 after bridge 10053.
- Traffic Group #2 (300 AADT): This group of traffic is between Seminole and an exit off US 270 near the Town of Lima.
- Traffic Group #3 (6,000 AADT): This group of traffic travels the entire US 270 segment from Seminole to the West side of Wewoka.

Figure 1 also presents the detour route for Traffic Group #3. Detour routes for Traffic Groups #1 and #2 are included in **Appendix 3: Detour Routes**.

Figure 1: Map of Traffic Flow Groups and Primary Detour Route



After assigning the most likely detour routes for each traffic group, the benefits associated with rehabilitating and replacing the bridges were estimated by calculating the avoided costs associated with the detours. Benefits by traffic group were then assigned to the associated bridges by equally dividing benefits across each bridge for each traffic group. For example, the estimated benefits for Traffic Group #1 based on the 200 AADT were equally assigned to bridges 13079 and 10053, the two bridges along the portion of the corridor traversed by the 200 AADT. **Table 1** below outlines the characteristics of each traffic volume group by associated origin/destination, AADT, detour length, and associated bridges. Detours were calculated in accordance with NBI guidance. After including capital and operating and maintenance costs, individual benefit cost analysis results were estimated for each bridge as well as for the entire program of all seven bridges.

Table 1: Traffic Volume Groups by Origin, Destination, AADT, and Detour Length

<table>
<tr><th></th><th colspan="2">Traffic Group #1</th><th colspan="2">Traffic Group #2</th><th>Traffic Group #3</th></tr>
<tr><th>Traffic Flow</th><th>From Seminole to exit after bridge 10053 (#1.1)</th><th>From exit after bridge 10053 to Seminole (#1.2)</th><th>From Seminole to Lima (#2.1)</th><th>From Lima to Seminole (#2.2)</th><th>From Seminole to Wewoka & Wewoka to Seminole (#3)</th></tr>
<tr><td>2018 AADT</td><td>100</td><td>100</td><td>150</td><td>150</td><td>6,000</td></tr>
<tr><td>Bridge #</td><td colspan="5">Detour Length (In Miles)</td></tr>
<tr><td>13079</td><td rowspan="2">3.6</td><td rowspan="2">3.6</td><td rowspan="4">1.9</td><td rowspan="4">1.9</td><td rowspan="7">3.1</td></tr>
<tr><td>10053</td></tr>
<tr><td>12934</td><td></td><td></td></tr>
<tr><td>12980</td><td></td><td></td></tr>
<tr><td>13653</td><td></td><td colspan="3"></td></tr>
<tr><td>13925</td><td></td><td colspan="3"></td></tr>
<tr><td>13783</td><td></td><td colspan="3"></td></tr>
</table>

Source: Poe & Associates and EDR Group.

Analysis Approach

The benefit-cost analysis (BCA) of the project was prepared per the U.S. DOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs published in June 2018 and in reference to OMB Circulars A-4 and A-94 concerning BCA. It is also in accordance with specific BCA guidance related to the definition of base and project cases outlined by FHWA for the CHBP.[2]

Table 2 provides the required Project Matrix summarizing the analysis of impacts from changes due to the ODOT Competitive Highway Bridge Program between the Baseline (maintain existing conditions) and the Build scenario (rehabilitation and replacement of seven bridges).

[2] https://www.fhwa.dot.gov/bridge/chbp/bca.pdf

Table 2: Project Summary Matrix

Current Status / Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Type of Impacts
There are seven bridges along US 270 in Seminole County southeast of Oklahoma City that require rehabilitation and replacement. Without these improvements, these bridges will be first closed to truck traffic (due to weight restrictions) and eventually closed to all traffic. In addition, these bridges currently require higher maintenance costs, based on their conditions.	The rehabilitation and replacement of these bridges will improve state of good repair and will enable future traffic to avoid travelling additional distance required by alternative detour routes and the associated costs from the additional mileage.	Instead of requiring posted weight limits or full bridge closure, the project will rehabilitate or replace these seven bridges, creating structurally sufficient conditions, and avoiding the additional vehicle operating, freight and time costs, accidents, and emissions associated with a detour. The project will also provide lifecycle cost savings associated with state of good repair.

Table 3 summarizes the types of outcomes that have been identified for the project and the assessment approach used to prepare the benefit-cost assessment. The quantification of benefits involves both spreadsheet evaluations and qualitative consideration of additional benefits that are not directly quantified in economic terms within the BCA.

Appendices 1 and 2 as well as the interactive spreadsheet provide additional details regarding methodology.

Table 3: Project Outcomes

Societal Benefit	Description	Document Section Reference
State of Good Repair	Maintenance and repair savings reduce overall life-cycle costs.	**Section 1.1**
Vehicle Operating Costs	Reduction in fuel and non-fuel related vehicle expenditures associated with detour.	**Section 1.2**
Travel Time	Passenger, crew and freight time savings from avoided detour distance.	**Section 1.3 and Section 1.6**
Safety	Reduction in crashes, fatalities and injury accidents from less vehicle miles of travel.	**Section 1.4**
Environmental	Emissions benefits from reduction in vehicle miles travelled.	**Section 1.5**

Summary of Benefits and Costs

Table 4 summaries the total benefits of rehabilitating and replacing the seven bridges included in this grant application, using a seven percent discount rate. The project is forecast to deliver $61.5 million in benefits, expressed in present value terms. Most benefits are generated by a reduction in vehicle operating costs, travel time and safety costs. These benefits are driven by the avoided detours enabled by the bridge replacements.

Table 4: Summary of Benefits (7% Discount Rate)

Benefit Type	Value ($M's)
Vehicle Operating Costs	$21.6
Personal & Crew Time	$19.1
Logistics/ Freight Costs	$5.6
Safety	$13.5
Environmental	$1.7
Total Benefits	**$61.5**

When compared to discounted total project costs (**Table 5**), including reductions in operating and maintenance costs (reflected as negative values) over the analysis period, the **combined benefits of all seven bridge improvements exceed costs by a ratio of 6.4, yielding a project net present value of $51.9 million.** Because the expected life of a bridge after replacement is 75 years, there is some additional "useful life" beyond the year 2050 (analysis end year). The value of this remaining useful life beyond the year 2050 is referred to as the "Residual Value" reflecting the remaining value of the bridge that has not yet been depreciated.

Table 5: Summary of Benefits and Costs (7% Discount Rate)

Benefit & Costs Categories	Value ($M's)
Total Benefits	$61.5
Capital Investments	$10.8
Operations & Maintenance Costs	-$0.3
Residual Value	-$0.9
Total Costs	$9.6
Net Present Value	$51.9
Benefit-cost Ratio	**6.4**

1 RESULTS OF BENEFIT-COST ANALYSIS

1.1 Project Costs (State of Good Repair)

Table 6 summarizes the bundled project construction costs by expenditure category. Bundled Construction costs for replacing the entire set of seven bridges in Seminole County total to just under $15 million. These costs include the savings associated with bundling the bridges within a single design/build contract. Bridge construction will take place uniformly for all bridges starting in 2020 and finishing in 2022. Ninety percent of expenditures for right-of-way and engineering, and 75 percent of expenditures for utilities were incurred in 2017, with the remainder to be incurred in 2019. Pavement reconstruction costs were also included for bridges 13653 and 13925. Bundled and unbundled costs, and funding sources and uses for the entire set of seven bridges are available in the **Appendix**.

Table 6: Summary of Project Construction Costs

Cost Type	Costs ($M's)
Engineering/Design	$1.42
Right of Way	$0.46
Utilities	$0.22
Bridge Construction	$12.64
Pavement Reconstruction	$0.24
Total	**$14.97**

Each bridge replacement will also reduce annual operations and maintenance expenses beyond 2020 or 2021 until the bridge would have been closed to traffic in the base case. These savings are associated with conditions-based maintenance needs that are required for poor bridges but would not be required after replacement with a new bridge (reflected as negative values).

The expected life of a bridge after replacement is 75 years and given the construction end year of 2022 and an end horizon year of 2050, there still will be some additional “useful life” for the replaced bridges beyond the year 2050.[3] The value of this remaining useful life beyond the year 2050 is referred to as the “Residual Value”, reflecting the remaining value that has not yet been depreciated, as shown in **Table 7** below.

[3] Bridges 12079, 10053, 13653, 13925, and 12934 are replaced. Bridges 12980 and 13783 are rehabilitated.

Table 7: Summary of Costs (in millions)

Cost Category	Discounted at 7%
Capital Investment Costs	$10.8
O&M Costs	-$0.3
Residual Value	-$0.9
Total Costs	**$9.6**

The above costs for the entire bridge program are detailed by year in the Appendix spreadsheet in the “All Bridges” tab. Individual bridge costs are summarized in the “Cost Summary (by Brdg)” and “Individual Bridge Costs” tabs.

1.2 Vehicle Operating Cost Savings

Vehicle operating cost savings are calculated based on changes in vehicle-miles traveled between the base and project scenarios along with per-mile operating cost factors for cars and trucks. A $21.6 million savings in vehicle operating costs is predicted between 2023 and 2050 at a seven percent discount rate, as shown in **Table 8**.

Table 8: Savings in Vehicle Operating Costs, 2023 – 2050 (in millions)

Savings Category	Discounted at 7%
Vehicle Operating Savings	$21.6

Vehicle operating cost savings for the entire program are summarized in the “All Bridges” tab of the Appendix spreadsheet. Vehicle operating cost savings for individual bridges are presented in the “BCA Summary” tab and by Traffic Group in the “Benefits Summary (by Tfc Grp)” and “Traffic Group Benefits” tabs.

1.3 Value of Personal & Crew Time

Travel time savings are calculated based on changes in vehicle-hours traveled between the base and project scenarios, per-hour cost factors, and vehicle occupancies for each mode-purpose combination. Crew time is the value of truck drivers’ time and personal time is the value of time for vehicle drivers and passengers who are not traveling for business. In this case, the personal value of time is conservatively applied to all car traffic. “Value of Personal & Crew Time” groups both normal passenger car value of time (valued at $14.2 per hour) and crew time (valued at $28.6 per hour). These factors are summarized in **Appendix 2.** A savings of $19.1 million in personal and crew time is predicted between 2023 and 2050 at a seven percent discount rate, as shown in **Table 9**. The analysis only includes the travel time savings associated with avoided detours

Table 9: Value of Time Savings, 2023 - 2050 (in millions)

Savings Category	Discounted 7%
Personal & Crew Time	$19.1

Values of time savings for the entire program are summarized in the “All Bridges” tab of the **Appendix** spreadsheet. Value of time savings for individual bridges are presented in the “BCA Summary” tab and by Traffic Group in the “Benefits Summary (by Tfc Grp)” and “Traffic Group Benefits” tabs.

1.4 Safety Benefits

Safety benefits include monetized savings associated with reductions in the number of crashes occurring each year which are driven by the reduction in vehicle miles travelled from avoided detours. $13.5 million in safety benefits is predicted between 2023 and 2050 at a seven percent discount rate, as shown in Error! Reference source not found..

Table 10: Value of Safety Benefits, 2023 - 2050 (in millions)

BCA	Discounted at 7%
Safety Benefits	$13.5

There are additional non-quantified expected benefits due to reduced crashes on the bridges after rehabilitation/modernization, but these benefits were determined to be relatively small in comparison to the larger magnitude of benefits from reduced exposure to crashes from avoided detours.

Safety benefits for the entire program are summarized in the “All Bridges” tab of the **Appendix** spreadsheet. Safety benefits for individual bridges are presented in the “BCA Summary” tab and by Traffic Group in the “Benefits Summary (by Tfc Grp)” and “Traffic Group Benefits” tabs.

1.5 Environmental Benefits

Environmental benefits are derived from reductions in emissions driven by reduced vehicle miles travelled. These estimates are based on per-ton valuations for type of emissions as outlined in the Discretionary Grant BCA Guidance.

Benefits are categorized by emissions that include volatile organic compounds (VOC), nitrogen oxides (NOx), sulfur dioxide (SOx), and particulate matter (PM) Benefits are predicted to total $1.7 million between 2023 and 2050 (**Table 11**).

Table 11: Value of Environmental Benefits, 2023 – 2050 (in millions)

Savings Category	Discounted at 7%
Emissions Reductions (Non-CO_2)	$1.7

Emissions savings for the entire program are summarized in the “All Bridges” tab of the **Appendix** spreadsheet. Emissions savings for individual bridges are presented in the “BCA Summary” tab and by Traffic Group in the “Benefits Summary (by Tfc Grp)” and “Traffic Group Benefits” tabs.

1.6 Logistics and Freight Costs

Logistics and freight costs reflect the value of reducing the amount of time commodities are spent in transit, which is the focus of just-in-time inventory models and optimized supply chain inventory management. Benefits are predicted to total $5.6 million between 2023 and 2050 (**Table 12**). Improved distribution channels enable reduced levels of safety stock, lower the opportunity cost of capital, and improve warehouse and labor scheduling. The commodity profile of freight shipments within Oklahoma metro area based on data from the USDOT Freight Analysis Framework (FAF) included natural sands, gravel, and non-metal mineral products.

Table 12: Value of Logistics and Freight Cost Benefits, 2023 – 2050 (in millions)

Savings Category	Discounted at 7%
Logistics/ Freight Costs	$5.6

Logistics/freight cost savings for the entire program are summarized in the “All Bridges” tab of the **Appendix** spreadsheet. Logistics/freight cost savings for individual bridges are presented in the “BCA Summary” tab and by Traffic Group in the “Benefits Summary (by Tfc Grp)” and “Traffic Group Benefits” tabs.

APPENDIX 1: DETERMINING PROJECT EFFECTS

Guide to Benefit-cost Analysis (BCA) Spreadsheet

The Appendix Excel workbook entitled "ODOT_CHBP_BCA_Tool" contains inputs, calculations, fixed factors, and a summary to present the benefit-cost analysis (BCA) of the Oklahoma highway bridge program. This workbook provides transparency for reviewers to identify the inputs and assumption included in the analysis, enable the ability to perform a sensitivity analysis by adjusting any inputs or fixed factors, and view each bridge individually or all bridges combined. The spreadsheet is color coded, where green tabs represent calculations and red tabs represent inputs. The contents of each tab are described below, in order, with a discussion of methodology and key data, where appropriate. Results are based on bundled costs. The benefit-cost analysis spreadsheet can be accessed by clicking on this **Link**.

Computation Tabs (Green)

All Bridges: Presents the summary benefits and costs (including specific benefit and cost categories) and the benefit-cost ratio aggregated for all seven bridges in the program. Includes macros ("Recalculate" button) to re-run the benefits and cost analysis for each bridge replacement project. This button can be used to recalculate results for the entire program if input assumptions are modified.

BCA Summary: Presents the summary results by category of benefits and costs, as well as the Net Present Value and benefit-cost ratio using a 7 percent discount rate for an individual bridge project. A drop-down menu provides a list of all the available bridge projects to select. Bridges are identified by a Bridge ID that corresponds to the NBI bridge identifier.

Traffic Group Benefits: Presents the changes in travel characteristics and associated cost changes for the selected traffic group category. Also includes project assumptions (e.g. percent car vs. percent truck, speed, accident rates & values, occupancy rates and value of time). Provides the option to select a traffic group which is then used in the "Benefits Summary (by Tfc Grp)" tab.

Benefits Summary (by Tfc Grp): Displays the benefits by category type by year both undiscounted and discounted using a 7 percent discount rate by traffic group category (as selected on the "Traffic Group Benefits" tab).

Cost Summary (by Brdg): Subtracts the project scenario from the base scenario for startup (e.g. construction) and operations and maintenance costs for all years and applies a discount rate of 7 percent. Results correspond to the individual bridge selected on the "BCA Summary" tab.

Individual Bridge Costs: Presents the capital and O&M costs for the base and project scenarios for the bridge selected on the "BCA Summary" tab.

TDC: Presents the travel demand characteristics (TDC) of AADT, annual trips, percent passenger car, and percent truck traffic for each traffic group category.

Input Tabs (Red)

Traffic Groups: Outlines the bridges, AADT, detour lengths, and other information associated with each traffic group category. Also provides an illustration of the origins/destinations of traffic flow for each group.

Fixed Factors: This tab includes all the default values and assumptions regarding vehicle operating costs, fuel consumption, fuel costs, value of time, average vehicle occupancy, and emissions factors. Sources of these factors are presented in Appendix 2 "Valuation Factors."

Bridge List: Contains basic information generated by ODOT for each of the seven bridges including years to posting & closure, and expected life after improvement.

Capital Costs: Presents the total bridge and pavement improvement costs by bridge by year.

O&M Costs: Presents the annual bridge and pavement operations and maintenance costs by bridge by year for the base and project scenario.

Shipper-Logistics Costs: Applies the mix of commodity goods being transported to an associated per hour cost factor used to calculate a per freight-ton-hour cost for each type of commodity. These values reflect the benefits of on-time deliveries, reduced safety stock requirements, and the opportunity cost of capital.

APPENDIX 2: VALUATION FACTORS

The BCA conducted for the projects in this Highway Bridge Grant application depends on assumptions and valuation factors derived from the USDOT Guidance as well as from other sources. This appendix provides technical documentation of recommended monetized values used in the Appendix Excel spreadsheet to calculate time, occupancy, safety, and environmental emission benefits included in analysis. Data sources are documented in footnotes. Values are in 2017 dollars.

Value of Time

The per-person-hour values of time used for the analysis are those defined by USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs (BCA Guidance) for local travel for personal car trip purposes and truck crew drivers for conventional surface modes.

Table 13: Value of Time by Mode and Purpose

Mode/Purpose	Value (2017 $ per person-hour)[4]
Truck – All	$28.60
Car – Personal	$14.20

The value of time savings for freight commodity shipments are calculated using per ton-hour cost factors using a customized regional commodity profile based on the FHWA Freight Analysis Framework (refer to the Shipper-Logistics tab of the spreadsheet).

Vehicle Occupancy

Vehicle occupancy rates are estimated from separate factors for trucks and cars. For trucks, crew per truck and freight tons per truck are used in the estimation. Passenger vehicle load factors come from the BCA Guidance.

Table 14: Crew, Passenger, and Freight Vehicle Loading Factors

Mode/Purpose	Crew Per Vehicle	Passenger per Vehicle[5]	US Freight Tons Per Vehicle[6]
Truck – All	1.0[7]	0	24.05
Car – Personal	0	1.39	0

[4] Benefit-Cost Analysis Guidance for Grant Applications, Intercity travel, Page 30.
[5] Benefit-Cost Analysis Guidance for Discretionary Grant applications. Page 31
[6] 2002 Vehicle Travel Information System (VTRIS) average estimates of truck share and mean gross vehicle weight for straight trucks and tractor + single trailer trucks nationally, as summarized in FAF2 Freight Traffic Analysis. Chapter 3: Development of Truck Payload Equivalency Factors. Table 3.1: Results of Vehicle Weight Validation. http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/faf2_reports/reports7/c3_payload.htm
[7] Based on vehicle occupancy rates for single-unit and combined trucks defined in HERS-ST Highway Economic Requirements System - State Version: Technical Report (http://www.fhwa.dot.gov/asset/hersst/pubs/tech/tech05.cfm#sect552) and the split of 2010 vehicle miles traveled between single-unit trucks and combination trucks on other arterial rural highways, from the 2010 Highway Statistics

Vehicle Operating Costs

Vehicle Operating Costs (VOC) are estimated using mileage-based costs (maintenance, tires and depreciation) that are separated from fuel-related costs (adjusted for differences in fuel consumption under congested and uncongested travel conditions) instead of one fixed per-mile Vehicle Operating Cost. This decoupling enables a more accurate estimate of VOC.

VOC in dollars-per-mile includes the average per-mile cost of vehicles' tires, maintenance, and depreciation for travel in free-flow and congested conditions (fuel costs are treated separately, below). For passenger these amount to $0.291 per mile. Fixed costs of ownership related to insurance, license, registration, taxes, and financing charges are removed from the VOC. The truck per-mile VOC includes the costs of truck and trailer leases or purchase payments, repair and maintenance, insurance, permits and licenses and tires and amount to $.563 per mile. Costs for truck tolls and drivers' wages/benefits (already included in the value of travel time savings) are not included.

Table 15: Per-Mile Vehicle Operating Costs (Except Fuel)

Mode/Purpose	Value (2017 $ per mile)[8]
Car – Personal	$0.291
Truck – All	$0.563

The fuel cost factors for Vehicle Gallons Per Mile (estimated gallons of fuel consumed per vehicle mile travelled) are from the FHWA Highway Statistics Series, Table MV-1. The rates are calculated separately for free flow and congested conditions, with a fuel consumption penalty applied under congested conditions.[9] For passenger cars, under free flow conditions, consumption is .046 gallons per mile. Under congested conditions, consumption is .053 gallons per mile for cars reflecting a 15 percent fuel consumption penalty applied. For trucks, under free flow conditions, consumption is .156 gallons per mile. Under congested conditions, consumption is .219 gallons per mile reflecting a 40 percent fuel consumption penalty applied. The fuel costs per gallon are averages from the AAA Gas Prices for Oklahoma, which are $3.00 per gallon of diesel and $2.34 for motor gasoline.[10]

Series, Annual Vehicle Distance Traveled in Miles and Related Data - 2010 1/ By Highway Category and Vehicle Type (http://www.fhwa.dot.gov/policyinformation/statistics/2010/vm1.cfm).

[8] Sources: For passenger cars, the AAA's 2017 *Your Driving Cost*, combining an average of SUVs, minivans, and small, medium and large cars; For trucks, American Trucking Research Institute's (ATRI) 2016 *Operational Costs of Trucking* report. Costs include truck and trailer leases and purchase payments, repair and maintenance, insurance, permits and licenses, and tires. Costs for labor, fuel and tolls are included separately.

[9] Source: Zhang, K., S. Batterman, and F. Dion. 2011. Vehicle Emissions in Congestion: Comparison of work zone, rush hour, and free-flow conditions. Atmospheric Environment 45, pages 1929-1939.

[10] https://gasprices.aaa.com/?state=OK (Nov 2018)

Table 16: Per-Mile Vehicle Operating Costs – Gallons of Fuel Consumed

Mode	Trip Purpose	Average Gallons of Fuel Consumed		
		Per Mile (FF)[11]	Per Mile (Cong.)[12]	Per hour (Cong. or Idle)
Passenger Car	Personal	0.0463	0.0532	0.0532
All Trucks	Freight	0.1563	0.2188	0.2188

Note that in this analysis, all traffic is assumed to operate in congested conditions.

Safety Costs

Reductions in crashes involving fatalities, injuries, and property damage are included in the analysis. USDOT BCA Guidance recommends monetizing the value of injuries according to the Maximum Abbreviated Injury Scale (MAIS). Therefore, assumptions must be made to convert aggregate injury crash statistics into the MAIS scale. The conversion is made based on the mapping presented in Table 17. Personal injuries are then valued based on the calculations presented in

Table 18. Final valuation factors are presented in Table 19.

Table 17: Mapping of Accident Classification to BCA Guidance Classification

Crash Classification	BCA Guidance Classification
Fatality	MAIS 6 Unsurvivable
Personal Injury	KABCO Injured (Severity Unknown)
Property Damage	Property Damage Only (PDO) Crashes

Table 18: Calculation of weighted average MAIS-based cost for personal injury accidents[13]

MAIS	U - Injured Severity Unknown	MAIS Cost (2017$)
0	0.21538	$0
1	0.62728	$28,800
2	0.10400	$451,200
3	0.03858	$1,008,000
4	0.00442	$2,553,600
5	0.01034	$5,692,800
6	0.00000	$9,600,000
	Weighted average (2017 $)	$174,000

[11] Source: Table MV-1 of the 2013 FHWA Highway Statistics Series

[12] Source: Table MV-1 of the 2013 FHWA Highway Statistics Series, with a fuel consumption penalty applied due to congested conditions of 15% for cars and 40% for trucks.

[13] BCA Guidance for Grant Applications. Table A-1. KABCO/Unknown – MAIS Data Conversion Matrix.

Table 19: Crash Valuation Factors

Value	$ per Fatalities Accident[14]	$ Per Personal Injury Accident	$ Per Property Damage Accident[15]
2017 $	$9,600,000	$174,000[16]	$4,327

Environmental Costs

Emissions generated on a per mile basis were calculated, using information from the U.S. EPA Office of Transportation and Air Quality. Emissions values are based on USDOT BCA Guidance.

Table 20: Emissions Generated on a Per Mile Basis[17]

	U.S. Short Tons VMT			
Mode	**VOCs**	**NOx**	**SOx**	**PM**
Passenger Car	1.14E-06	7.64E-07	0.00E+00	4.68E-09
All Trucks	4.93-06	9.9E-06	6.28E-09	2.32E-08

Table 21: Value per U.S. Short Ton of Criteria Pollutant Emissions

Value per metric ton[18]	VOCs	NOx	SOx	PM
2017 $	$1,905	$7,508	$44,373	$343,442

[14] BCA Guidance for Grant Applications. Page 29.

[15] IBID.

[16] From
Table 18.

[17] Values derived by the TREDIS Software Group, using multiple sources:
Passenger Cars and Light Trucks are based on Average Annual Emissions and Fuel Consumption for Gasoline - Fueled Passenger Cars and Light Trucks, October 2008, Page 4 table, "Average Emissions and Fuel Consumption for Passenger Cars," http://www.epa.gov/otaq/consumer/420f08024.pdf
Heavy trucks and buses are based on U.S. EPA and FMCSA research including:
a. Average In-Use Emissions from Heavy-Duty Trucks, October 2008, Table 1, "Average In-Use Emission Rates for Heavy-Duty Vehicles," http://www.epa.gov/otaq/consumer/420f08027.pdf
b. EPA 2010, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990– 2008, http://epa.gov/climatechange/emissions/usinventoryreport.html
c. Hours of Service (HOS) Environmental Assessment, December 2010, Appendix A, Exhibit A - 4, "Long-haul and Drayage Truck Travel Emission Factors," http://www.fmcsa.dot.gov/rules-regulations/TOPICS/hosproposed/AB26%20HOS%20EA%20v5.2.pdf

[18] BCA Guidance for Grants. Table 9. Page 32.

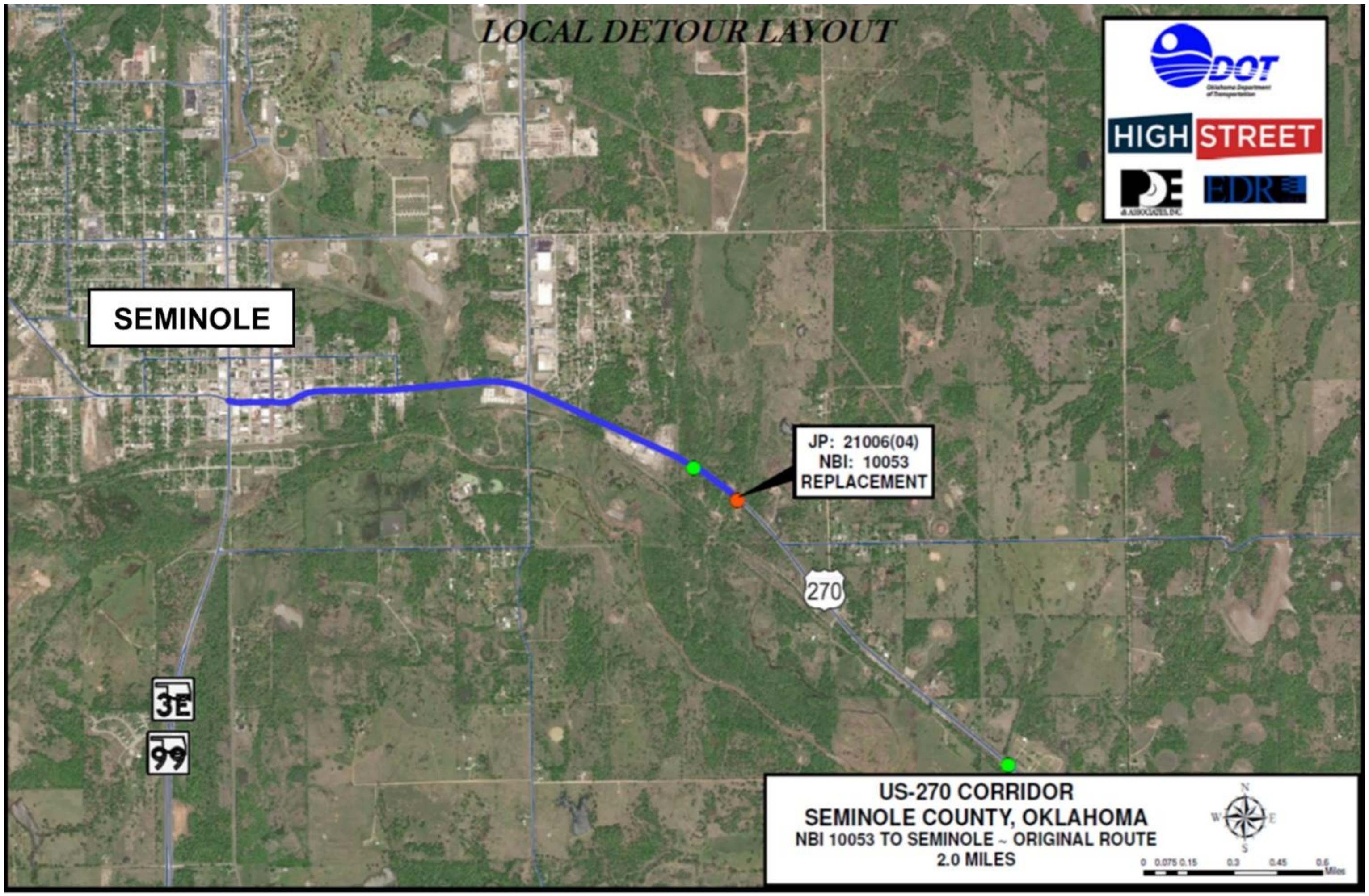
APPENDIX 3: DETOUR ROUTES

The following maps illustrate the current and expected detour route for each of the Traffic Groups. All seven bridges were assumed to be assigned weight restrictions for truck traffic (e.g. 20 tons) by 2023 and be closed to all traffic by 2033, based on an analysis of current bridge conditions.

Traffic Group #1.1 & #1.2

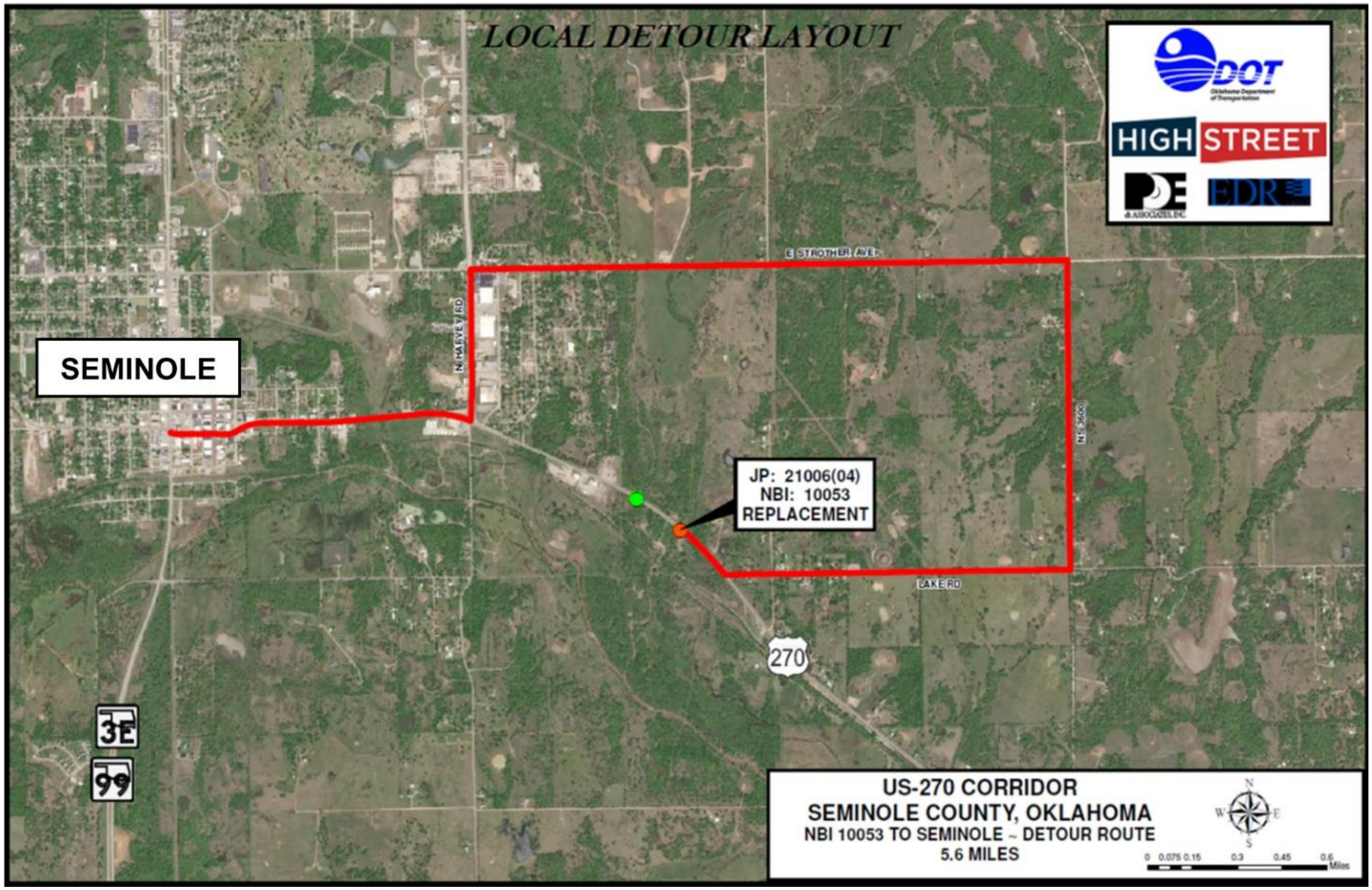
Original Route

Figure 2: Traffic between Seminole, OK and exit after bridge 10053 (US 270) (Lat.Long: 35.217488, -96.638443). Distance: 2 miles



Detour Route

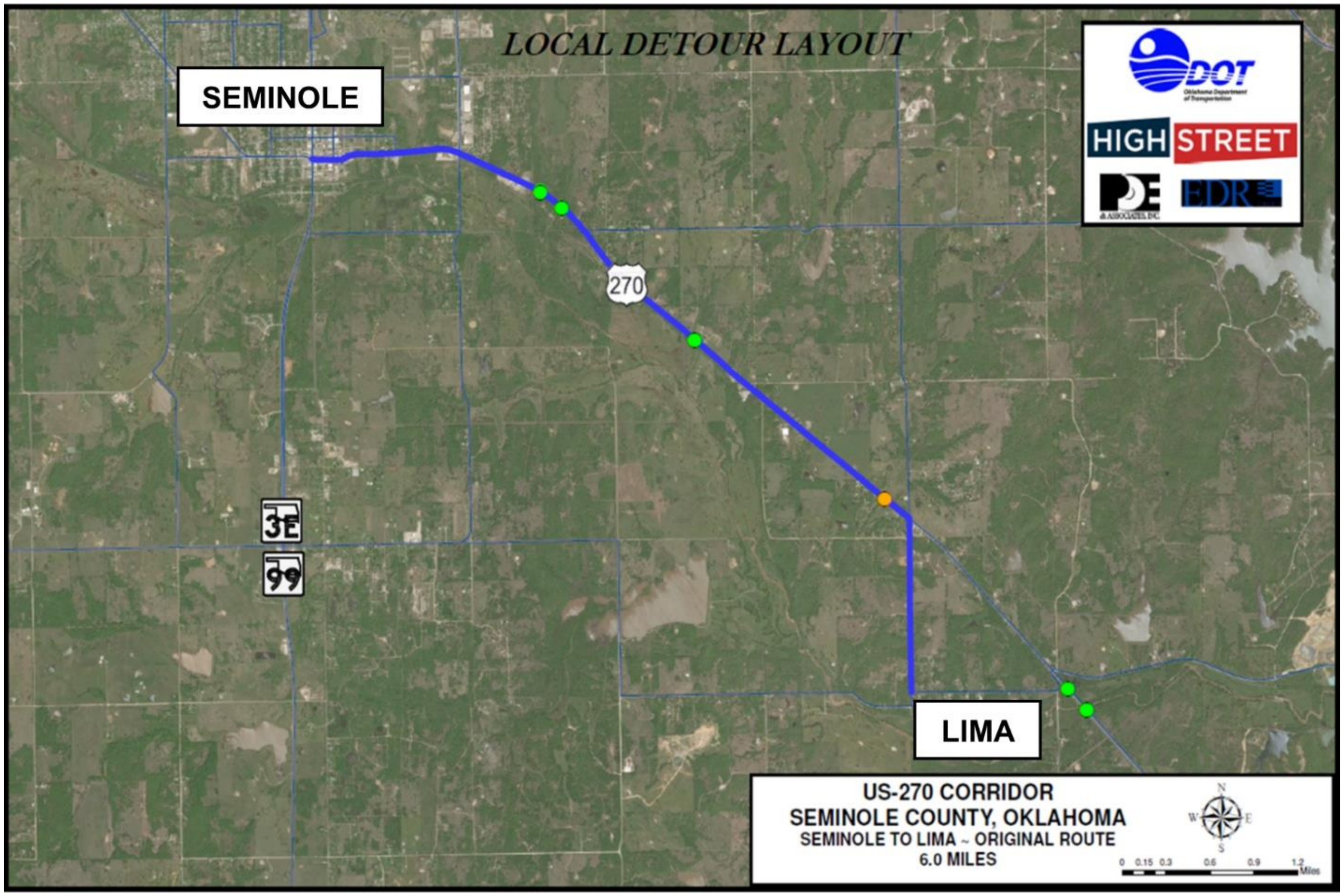
Figure 3: Traffic between Seminole, OK and exit after bridge 10053 (Lat/Long: 35.217488, -96.638443). Distance: 5.6 Miles



Traffic Group #2.1 & #2.2

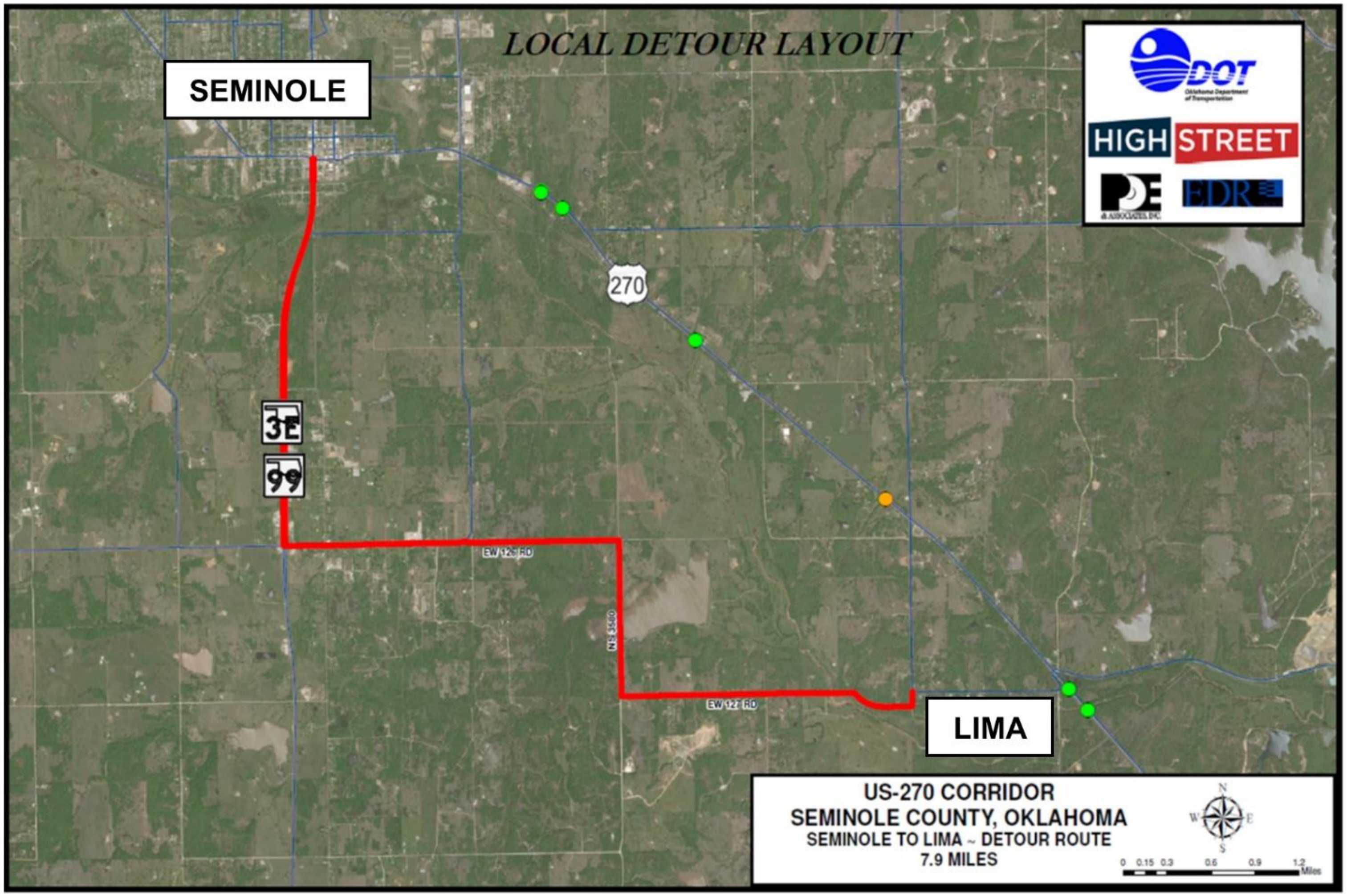
Original Route

Figure 4: Traffic between Seminole, OK and Lima, OK (US 270). Distance: 6.0 Miles



Detour Route

Figure 5: Traffic between Seminole, OK and Lima, OK (US 270). Distance: 7.9 Miles



Traffic Group #3

Original & Detour Route

Figure 6: Observed Traffic on US 270 and Detour Route for Traffic Group #3. Distance: US 270 (10.7 Miles). Detour (13.8 Miles).