Benefit-Cost Analysis Narrative

Houston-Galveston Area Council's (H-GAC) Transportation Improvement Program (TIP)

Henderson Road Corridor Improvement Program

City of Angleton, Texas

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Benefit-Cost Analysis Narrative

1. Executive Summary

The Benefit-Cost Analysis (BCA) conducted for this grant application compares the costs associated with the proposed investment to the benefits of the project. To the extent possible, benefits have been monetized in accordance with the U.S. Department of Transportation (USDOT) BCA guidance. Where not possible to assign a dollar value to a benefit, efforts have been made to quantify it. A qualitative discussion is also provided when a benefit is anticipated to be generated but is not easily monetized or quantified.

The City of Angleton, Texas (the City) is pursuing funding from the Houston-Galveston Area Council's (H-GAC) Transportation Improvement Program (TIP), a multimodal program of transportation infrastructure and service improvements planned for implementation in the H-GAC Region over the next four years. It includes projects of regional significance for which federal, state, and local funding is available or committed. The proposed Henderson Road Project (the Project) will replace a two-lane road with a four-lane cross-section with a raised median along Henderson Road between N Velasco Street (BU 288) and E Mulberry Street (SH 35) to increase roadway and intersection capacity and improve operations. Additional geometric design upgrades and traffic control upgrades were proposed at individual intersections. The Project study area has a lot of new development potential with several residential communities proposed or undergoing construction. Table 1 summarizes the changes expected from the project and the associated benefits. Monetized and non-monetized benefits are provided.

Table 1: Detailed Benefit Summary

Current Status or Baseline & Problems to Be Addressed	Changes to Baseline / Alternatives	Type of Impacts	Economic Benefit	Summary of Results (Discounted Dollars)
Delays and low peak hour speeds	Roadway expansion and intersection turn lanes will increase capacity and reduce delay	Reduction in travel time	Travel Time Savings	$42.2 M
Safety concerns	Introducing sidewalk facilities, turn lanes and expanding the roadway	Improved safety for all project area users	Crash Cost Savings	$19.2 M
Lack of active transportation facilities	Expansion of pedestrian connections on North Side and introduction of 15 feet wide sidewalks/shared use paths on the South Side	Improved active transportation trip quality	Journey Quality	$8.5 M
Health benefits	Increase in pedestrian and cycling activity from the new sidewalk, leading to health benefits	Improved community health from active travel mode	Health Benefits	$2.1 M
Emissions	Modal shift from auto to transit/active transportation and reduced delay/idling time may lead to greenhouse gas emissions reduction	Improved air quality	Emissions Reduction	$7.7 M
Vehicle operating costs/ Other highway externalities	Modal shift from auto to active transportation will reduce congestion, noise, and vehicle operating costs	Improved general conditions	Vehicle Operating Costs and Other Highway Use Externalities	$0.6M
Higher capacity on the roadway is needed to accommodate peak period volumes	Roadway expansion will increase the lane miles requiring preventative maintenance	Increase in maintenance costs	Operations and Maintenance Costs	$(4.9)M
Total Benefits				**$75.4 million***

*The sum of components may not sum to the total benefits due to rounding.

The period of analysis used in the estimation of benefits and costs corresponds to 30 years (5 years of project development and construction and 25 years of operation[1]). The total project capital costs are $51.6 million in 2022 dollars and are planned to be financed as outlined in the project budget.

Based on the analysis presented in the rest of this document, the project is expected to generate $75.4 million in discounted benefits and $49.5 million in discounted costs, using a 3.1 percent real discount rate, except for CO_2 emissions which were discounted at a rate 2 percent. Therefore, the project is expected to generate a Net Present Value of about $25.8 million, and a Benefit-Cost Ratio (BCR) of 1.52, as presented in Table 2.

Table 2: Summary of Benefits and Costs

Project Evaluation Metric	Constant Dollars	Discounted Dollars
Total Benefits	$138.1	$75.4
Total Costs	$51.6	$49.5
Net Present Value	N/A	$25.8
Benefit-Cost Ratio	N/A	1.52

A summary of the relevant data and calculations used to derive the total monetized benefits and costs of the project (discounted at 3.1 percent, except for CO_2 emissions which are discounted at 2 percent) are shown in the Estimation of Economic Benefits section. In addition to the monetized benefits presented in Table 1, the project will generate other benefits that are difficult to monetize but can be quantified using units that are not dollar values.

The quantified benefits are presented below, as are qualitative benefits of the project.

- The project will add bus stop infrastructure and pull-out lanes to enable future transit line extension on Henderson Road. This will further improve accessibility and mobility for active transportation and transit users.
- The improved infrastructure and density of development will facilitate non-auto trips within and outside of the corridor. The reduction in automobile trips will reduce the environmental impact of greenhouse gas emissions as well as the wear-and-tear on the infrastructure associated with vehicle usage.
- The project area represents a significant corridor to community members given its connection to the near-by middle school. Adding pedestrian signals, among other things not currently monetized will not only improve safety of users including middle school students but may contribute to peace of mind and well-being.

The inclusion of these benefits (economic development benefits, complete journey quality benefits, improved transit facilities, emissions reduction, and travel time savings from avoided road closures) would increase the overall benefit-cost ratio. Additionally, the project will improve short-term employment by creating local construction jobs and supporting local construction material suppliers.

2. Methodological Framework

A benefit-cost analysis (BCA) is a conceptual framework that can be used to evaluate the cost-effectiveness of transportation infrastructure projects. A BCA attempts to describe, quantify, and monetize the societal benefits and costs generated by a project. A project's societal return-on-investment is estimated by comparing the monetized benefits against the project's total costs.

[1] TxDOT assumes 25 years of operation in the TxDOT BCA tool.

The benefits of the project are based on the expected impacts on both users and non-users of the facility. Since a BCA evaluates the benefits and costs over the entire life cycle of the project, all benefits and costs that occur in future years need to be discounted to present values in order to be compared equitably. A real discount rate based on U.S. Department of Transportation (USDOT) BCA guidance has been identified for this purpose.

The BCA produced several important measures to assess the cost-effectiveness of a proposed project. The benefit-cost ratio (BCR), calculated by dividing the project's discounted societal benefits by its discounted costs, measures the societal return on each dollar spent in project costs. A BCR greater than 1.0 indicates that for every dollar spent in project costs, more than one dollar will be generated in benefits. The net present value (NPV), the project's discounted societal benefits minus the discounted project costs, measures the total benefit that society enjoys as a result of the project improvements.

The BCA for The Project was primarily conducted using a benefit-cost model developed by Texas Department of Transportation (TxDOT) in accordance with USDOT BCA Template and Guidelines. As such, the BCA model adheres to the requirements and monetization factors stipulated by TxDOT and the USDOT. The resulting values are consistent with the USDOT's *Benefit-Cost Analysis Guidance for Discretionary Grant Programs.*[2]

3. Project Overview

The City of Angleton evaluated potential improvements to safety and mobility (pedestrians and vehicles) based on expected growth along the Henderson Road corridor from State Highway 288B (North Velasco Street) to State Highway 35 (East Mulberry Street). As part of the evaluation, HDR Engineering, Inc. (HDR) completed the Henderson Road Traffic Study (2021)[3] for this area, which identified future traffic loading and required improvements to mobility and safety in the area. The existing Henderson Road is a two-lane roadway with intermittent center turning lanes. The City provided direction to HDR that the proposed section will be a four-lane boulevard section with turn lanes as outlined in the Henderson Traffic Study. The project will introduce four signalized intersections, three unsignalized intersections, and two channelized right turn lanes, and drainage improvements along the full project length will provide sufficient room for a boulevard section with sidewalks. The total project covers approximately 2 miles, which is home to hundreds of high-density, mixed-use, and affordable housing units and is used to access a wide variety of important community destinations and amenities, including employment, health, retail, school, and transit connections. Further detail on project specific elements is provided in the Project Description file.

Base Case and Alternatives

The base case (No-Build scenario) assumes that no improvements will be made to the existing corridor and preventative maintenance will be performed to maintain the facilities in their current state. Conditions on the corridor in the No-Build scenario include a two-lane undivided roadway with mostly stop-controlled intersections. The existing intermittent turn lanes are inadequate to accommodate the increasing vehicular traffic demand. The extremely limited pedestrian and bike (ped/bike) facilities are insufficient to meet the rapidly growing demand from vulnerable road users in the area. Finally, there is insufficient drainage capacity along the corridor, allowing for the possibility of flood events.

The alternative (Build scenario) will implement the Project, including all roadway and drainage improvements the project proposes. This includes increasing the capacity of the roadway and improving safety by expanding the corridor to a 4-lane roadway with a raised median divider, providing dedicated turn lanes, and improving the design of current turn lanes. In addition, the project will expand sidewalk

[2] USDOT, *Benefit-Cost Analysis Guidance for Discretionary Grant Programs.* December 2023
[3] Henderson Road Traffic Study (2021), HDR on behalf of the city of Angleton, Texas.

connections along the north side, add 15ft of sidewalk width along the south side, and improve pedestrian signalization. Finally, the project will provide a minor reduction in upslope along an adjacent road, improving flooding conditions. The types of impacts expected from the project and corresponding benefits and beneficiaries are described in the next section.

Types of Impacts

The project will benefit the following populations:

- People using all transportation modes that use the Henderson Road corridor in their everyday personal or business travel will see safer traveling conditions on the roadway, resulting in fewer traffic fatalities, injuries, and property damage only (PDO) accidents.
- Active transportation users will enjoy improved journey quality from the cycling and pedestrian facilities, and pedestrians using the flashing pedestrian beacons will experience travel time savings.
- Residents and businesses will experience reduced flood events and associated property damages and benefit from reduced emissions.

Project Cost

Project construction is expected to begin in 2025 and substantially complete by the end of 2029. Total capital costs of the project are approximately $51.6 million in 2022 dollars. Discounted with a 3.1 percent real discount rate, project costs in 2022 dollars become $49.5 million discounted dollars.

4. General Assumptions

The BCA measures benefits against costs throughout a period of analysis beginning at the start of preliminary engineering activities and including 25 years of operations.[4]

The monetized benefits and costs are estimated in 2022 dollars with future dollars discounted in compliance with USDOT requirements using a 3.1 percent real rate, except for CO_2 emissions which are discounted at 2 percent.

The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. Specifically:

- Input prices are expressed in 2022 dollars.
- The period of analysis begins in 2025 and ends in 2054. It includes construction years (2025 to 2029) and 25 years of operations (2030 to 2054).
- A constant 3.1 percent real discount rate is assumed throughout the period of analysis, except for CO_2 emissions which are discounted at a rate of 2 percent, consistent with USDOT guidance.
- The project opening year is an input to the BCA tool and demand for the project is assumed to be fully realized in the first year of operations (2030).

5. Estimation of Economic Benefits

Overview of Data and Assumptions provided by TxDOT BCA Tool

The table below lists data and assumptions used in the estimation of quantitative benefits and assumed by the TxDOT BCA tool in accordance with USDOT BCA guidance.

[4] TxDOT assumes 25 years of operations in the TxDOT BCA tool.

Table 3: TxDOT Data and Assumptions

Benefit Categories	Variable Name	Unit	Value	Source / Notes
Travel Time Savings	Average Vehicle Occupancy (AVO)	Persons per Vehicle (Weekday Peak)	1.48	USDOT *Benefit-Cost Analysis Guidance for Discretionary Grant Programs.* December 2023.
	Value of Time (Auto - All Purpose)	Dollars per Hour	$19.6[5]	
	Value of Time (Truck Drivers)	Dollars per Hour	$33.50	
Accident Cost Savings	Value of Avoided Fatality	Dollars per fatality	$12,500,000	USDOT *Benefit-Cost Analysis Guidance for Discretionary Grant Programs.* December 2023.
	Value of Incapacitating Injury	Dollars per injury	$1,088,200	
	Value of Non-Incapacitating Injury	Dollars per injury	$233,800	
	Value of Possible Injury	Dollars per injury	$111,700	
	Value of Avoided Vehicle Damaged	Dollars per damaged vehicle	$5,000	
Journey Quality	Separated Cycle Track, Value per Cycling-Mile	Dollars per cycling-mile	$1.86	USDOT *Benefit-Cost Analysis Guidance for Discretionary Grant Programs.* December 2023.
	Value per Person-Mile Walked	Dollars per foot of added sidewalk width	$0.11	
	Induced/Increase in Daily Cycling Trips	Percentage	21%	Assumed by TxDOT BCA Tool. Lower value provided by NACTO, https://nacto.org/2016/07/20/high-quality-bike-facilities-increase-ridership-make-biking-safer/.
	Induced/Increase in Daily Walking Trips	Percentage	30%	Assumed by TxDOT BCA Tool. California Air Resources Board, https://ww2.arb.ca.gov/sites/default/files/202006/Impacts_of_Pedestrian_Strategies_on_Passenger_Vehicle_Use_and_Greenhouse_Gas_Emissions_Policy_Brief.pdf
	Miles Walked per Walking Trip	Miles	Maximum of 0.86* and project length	* USDOT *Benefit-Cost Analysis Guidance for Discretionary Grant Programs.* December 2023.
	Miles Cycled per Cycling Trip	Miles	Maximum of 2.38* and project length	
Health Benefits	Cycling Recommended Value per Induced Trip	Per cycling trip	$6.80	USDOT *Benefit-Cost Analysis Guidance for Discretionary Grant Programs.* December 2023.
	Walking Recommended Value per Induced Trip	Per pedestrian trip	$6.80	

[5] The TxDOT BCA Tool applies Truck VOT to passenger vehicle person hours saved, which overestimates travel time benefits. However, the BCR is still over 1 when the Auto All Purpose VOT is applied to passenger vehicle person hours saved.

Benefit Categories	Variable Name	Unit	Value	Source / Notes
	Portion of Pedestrians Aged 20-64	Percent	68%	Assumed by TxDOT BCA Tool, National Average Trip Percentage.
	Portion of Cyclists Aged 20-64	Percent	59%	
Emission Cost Savings	Emission Factors	gms/mile	See "Emission Factors" and "Emissions Reduction" sheets in attached Excel Sheet	Provided by TxDOT BCA Tool, EPA, https://nepis.epa.gov/Exe/ZyPDF.cgi/P100EVXV.PDF?Dockey=P100EvXv.PDF
	Value per Mile of Non-CO_2 Emissions	Dollars per Mile (all vehicles, all locations)	$0.015	USDOT *Benefit-Cost Analysis Guidance for Discretionary Grant Programs.* December 2023. "All Vehicles, All Locations" category assumed by TxDOT BCA tool
	Value per Mile of CO_2 Emissions	Dollars per Mile (all vehicles, all locations)	$0.129	
Vehicle Operating Costs Savings	Value per mile	Dollars per mile (Light Duty Vehicle)	$0.52	USDOT *Benefit-Cost Analysis Guidance for Discretionary Grant Programs.* December 2023. "Light Duty Vehicle" category assumed by TxDOT BCA tool
Other Highway Use Externalities	Congestion cost per Vehicle Mile Traveled	Dollars per mile (all vehicles, all locations)	$0.128	USDOT *Benefit-Cost Analysis Guidance for Discretionary Grant Programs.* December 2023. "All vehicles, all locations category" assumed by TxDOT BCA tool.
	Noise cost per Vehicle Mile Traveled	Dollars per mile (all vehicles, all locations)	$0.0031	
	Safety cost per Vehicle Mile Traveled	Dollars per mile (all vehicles, all locations)	$0.04	

Inputs Required by TxDOT BCA Tool and Estimation Methodology

This section details the data, assumptions, and methodology used to fulfill input requirements in the TxDOT BCA tool. It then describes the combination of these inputs and the above listed TxDOT data and assumptions for benefit estimation.

TRAVEL TIME SAVINGS: The TxDOT BCA model requires the following inputs to estimate travel time savings:

- Estimated Traffic Growth Rate
- Truck Percentage/Truck AADT
- Proposed Improvements
- No-Build Project Length
- Free flow speed
- No-Build peak period average speed
- No-Build peak period volume

In their BCA templates, H-GAC provides an estimated growth rate of 3.6% for Brazoria County between the years of 2030 and 2045[6]. This growth rate is used in the estimation of travel time savings benefits. The

[6] H-GAC (2024), *"Roadway Emissions Benefits Template"*, Growth Rate Sheet

percentage of truck traffic was calculated using Replica data[7] which provides detailed traffic information on selected network links. For use in this analysis, an eastbound and westbound link passing through each studied intersection in the project area for Fall 2022 and Spring 2023, were selected. From this data, a weekday average and weekend average count of traffic by mode and vehicle type was calculated for each of the intersections. A percentage of commercial vehicle trips is calculated from these counts. Finally, a weighted average, with weights being miles between the intersections sourced from google maps, was calculated to represent the total truck percentage on Henderson Road. This percentage is used for input in the TxDOT BCA model.

The TxDOT BCA tool provides a table of proposed travel time saving improvements and corresponding estimated delay reduction factors. Five improvements from the table were selected based on project improvements. These include adding new lanes or roads, adding intersection turn lanes, the operation and management of signals, and providing bike lane and pedestrian connections. The TxDOT BCA tool calculates a combined delay reduction rate based on these selections of 67.67%.

The No-Build project length and free flow speed along the corridor were sourced from the Henderson Road Traffic study (2021). Supplemental results performed as part of this study were provided by traffic engineers[8], giving average peak period speeds for east and west bound traffic at each of the studied intersections. For use as an input in the TxDOT BCA tool, a weighted average peak period speed was calculated, using the miles between each intersection as weights.

Synchro analysis results were also used to estimate peak period volumes. No-Build volumes from the Synchro analysis were provided for the peak hours of 7-8 am and 4-5 pm. The TxDOT BCA tool defines the peak periods as the hours of 6-9 am and 3-7 pm. Thus, a peak period volume was calculated using the proportional volume of each hour defined by TxDOT to the peak hours provided in the Synchro results. Historical hourly traffic volume counts on Henderson Road, sourced from the TxDOT Stars II system were used to estimate the hourly traffic distribution. Proportions were multiplied by the peak hour volumes and resulting volumes summed across hours to provide a total 2030 peak period volume at each intersection. To avoid double counting vehicle traffic, a weighted average of these intersection volumes was taken. The TxDOT BCA tool requires inputs of 2022, so 2030 values were back-casted to 2022 values using the 2022-2030 growth rate provided in H-GAC BCA templates for Brazoria County[9]. For additional information on these calculations, data or source information see the attached supplemental spreadsheet.

The TxDOT BCA tool uses the above inputs to calculate the reduction in peak period delay between the Build and No-Build scenarios for both passenger vehicles and commercial vehicles. The tool then converts vehicle hours to person hours and monetizes using values[10] provided by in the TxDOT BCA tool and listed in Table 3.

CRASH COST SAVINGS: The project is expected to increase safety for all users through increasing the length of existing turn lanes, expanding the roadway to 4-lanes with a raised median, and implementing sidewalk facilities. The TxDOT BCA tool requires the following inputs to estimate crash cost savings:

- Historical Crash Data (2019-2023)
- Base Year AADT
- Proposed Safety Improvements

[7] Replica HQ, Fall 2022 and Spring 2023, [Replica (replicahq.com)](replicahq.com), accessed August 2024. See sheets “Replica_Export”, “AT_Data”, “ReplicaImages”, and “AADT_ReplicaBased” in the attached supplemental spreadsheet for complete Replica data and related calculations

[8] Screenshots of supplemental Synchro analysis results provided by project engineers are available in the supplemental excel spreadsheet, under the tab “PeakHrSpeed_NoBuild”.

[9] H-GAC (2024), *“Roadway Emissions Benefits Template”*, Growth Rate Sheet

[10] The TxDOT BCA Tool applies Truck VOT to passenger vehicle person hours saved, which overestimates travel time benefits. However, the BCR is still over 1 when the Auto All Purpose VOT is applied to passenger vehicle person hours saved.

Historical crash data was sourced from the H-GAC Regional Crash Data Viewer, following instructions provided in H-GAC's BCA templates. Base year AADT was sourced from the TxDOT Traffic Count (TCDS), Stars II system[11].

As with the travel time saving improvements, the TxDOT provides a table of crash cost saving improvements and associated crash reduction factors. The following crash cost saving improvements were selected: converting a 2-lane facility to a 4-lane divided roadway, lengthening right turn lanes, lengthening left turn lanes, and installing sidewalks. The associated combined crash reduction factor for non-intersection related improvements is 45%, for intersection related improvements is 64% and for pedestrian/cyclist improvements is 65%.

The TxDOT tool uses the historical crash data to calculate annual average crash rates by severity per the AADT input. It also calculates vehicle miles traveled for the No-Build scenario based on the AADT input. Using these two values, No-Build annual crash rates are calculated and crash reduction factors corresponding to the input safety improvement types are applied, resulting in Build crash rates. The difference in these crash rates is monetized using the values listed in Table 3.

JOURNEY QUALITY/AMENITY BENEFITS: The expansion of pedestrian connections on the north side and implementation of new sidewalks and shared use paths on the south side of Henderson Road are expected to improve the journey quality for existing ped/bike users and to encourage new users to mode shift to active transportation options. The TxDOT BCA tool requires the following inputs to estimate active transportation demand, mode shift, and journey quality benefits.

- Ped/Bike Growth Rate
- Build Project Length
- Added Sidewalk Width
- Historical Ped/Bike Data

The ped/bike growth rate was assumed the same as the traffic growth rate. The Build project length and added sidewalk width, 2 miles and 15 feet, respectively, were sourced from the Henderson Road Traffic study (2021). Historical ped/bike data was sourced from the H-GAC Activity Connectivity Explorer, following instructions provided in H-GAC's BCA templates.

The TxDOT BCA tool uses the historical ped/bike data input to find base year daily walking and base year daily biking trip values. The tool then uses the ped/bike growth rate input to convert these trip values to Build open year values. These trip counts are converted to miles walked and cycling miles using the higher of the project length and the assumptions listed in Table 3. In this instance, the higher values are the project length of 2 miles for walking miles and the assumption of 2.38 miles for cycling miles. New user trips are also estimated and converted to miles walked and cycling miles. New trips are calculated using the TxDOT assumptions for induced daily walking and induced daily cycling trips. Half of the new user miles and all of the current user miles are summed and monetized using the values listed in Table 3.

HEALTH BENEFITS: The new facility will create induced pedestrian and cycling demand. The increased participation in an active form of transportation will result in health benefits for users in the project area. The TxDOT BCA Tool requires the following inputs to estimate health benefits:

- Ped/Bike Growth Rate
- Ped/Bike Historical Data

As stated previously, the ped/bike growth rate is based on traffic growth in the area, sourced from H-GAC templates. Similarly, the ped/bike historical data was sourced from the H-GAC Activity Connectivity Explore, following the instructions provided in H-GAC's BCA templates.

The TxDOT BCA tool uses these inputs in combination with TxDOT assumptions regarding induced daily walking and induced daily biking trips, listed above, to calculate new user trips. Proportions for walking and

[11] TxDOT Traffic Count (TCDS) Stars II, Location ID: 20HP52, 2022 AADT, [Traffic Count Database System (TCDS) (ms2soft.com)](ms2soft.com)

biking trips meeting the age range for health benefit monetization, shown in Table 3, are national averages assumed by the TxDOT tool and are applied to induced daily biking trips. The resulting values for walking and biking trips eligible for health benefit monetization are monetized using the values listed in Table 3 in accordance with the USDOT BCA guidance.

EMISSION BENEFITS: The project is expected to reduce travel time in the project area and encourage the use of more active forms of transportation. In both instances, the expected result is a decrease in emissions. The TxDOT BCA tool requires the following inputs to calculate emission benefits:

- No-Build/Build Project Length
- Base Year AADT
- No-Build Truck percentage
- Historical Ped/Bike Trips

As noted in previous sections, the No-Build/Build project length is 2 miles, sourced from the Henderson Road Traffic Study (2021). Similarly, the historical ped/bike trip information was sourced from the H-GAC Activity Connectivity Explorer, following instructions provided in H-GAC BCA templates. The No-Build Peak Period average speed was calculated using Synchro analysis results and is described in the travel time savings section. The No-Build Truck Percentage/Truck AADT, described in the travel time savings section, was calculated from Replica data. Finally, Base Year AADT, described in the crash cost savings section, was sourced from the TxDOT Traffic count TCDS Stars II system.

The TxDOT BCA tool uses Base Year AADT and project length to calculate the No-Build vehicle miles traveled. The Build vehicle miles traveled are calculated by subtracting the induced ped/bike trips earlier described. The difference of the two is used in combination with emission factors provided by the TxDOT tool to calculate the emissions reduced from vehicle miles traveled. In addition to reduced vehicle miles traveled, emissions benefits are calculated from reduced idling time. The TxDOT BCA tool calculates reduced idling time using results from the travel time savings section. Both reduced vehicle miles traveled and reduced idling time emission benefits are estimated and monetized using values listed in Table 3.

VEHICLE OPERATING COST SAVINGS: The project is expected to reduce travel time in the area resulting in reduced vehicle operating costs. The TxDOT BCA tool requires the following inputs to calculate vehicle operating cost savings:

- Estimated Traffic Growth Rate
- No-Build AADT

As noted in the travel time savings section, the traffic growth rate was sourced from H-GAC BCA templates. Similarly, the No-Build AADT, described in the crash cost savings section, was sourced from the TxDOT traffic count TCDS Stars II system.

The TxDOT BCA tool uses these inputs to estimate the No-Build vehicle miles traveled. The tool also estimates the Build vehicle miles traveled by subtracting mode-shifted trips, as described in section emissions benefits section. The difference in vehicle miles traveled is then monetized using the USDOT recommended value for light duty vehicles and assumed by TxDOT. This value is listed in Table 3.

OTHER HIGHWAY USE EXTERNALITIES: Other highway use externalities including benefits related to safety, congestion and noise are expected because of the reduced vehicle miles traveled in the Build scenario. The TxDOT BCA tool requires the following inputs to calculate other highway use externalities:

- Estimated Traffic Growth Rate
- No-Build AADT

The estimated traffic growth rate is described in the travel time savings section. No-Build AADT is described in the crash cost savings section.

The TxDOT BCA tool uses these inputs to estimate the No-Build vehicle miles traveled and Build vehicle miles traveled, as was the case in the vehicle operating cost savings. The difference in vehicle miles traveled is then multiplied by USDOT recommended and TxDOT assumed values for congestion, noise, and safety costs. These values are listed in Table 3.

OPERATIONS AND MAINTENANCE (O&M) COSTS: O&M Costs are expected to increase because of the expanded lane miles in the Build scenario. The TxDOT requires the annual Build and No-Build O&M costs as inputs.

O&M costs in the Build and No-Build scenarios were calculated by multiplying preventative maintenance costs sourced from the Texas Transportation Asset Management Plan (2022)[12]. Conservatively, it was assumed the more expensive pavement type would be used in both scenarios.

The TxDOT BCA model applies these inputs and discounts them according to USDOT BCA guidance.

6. Summary of Findings and BCA Outcomes

With a 3.1 percent real discount rate, the $49.5 million investment would result in $75.4 million in total benefits and a benefit-cost ratio of approximately 1.52 and a net present value of $25.8 million.

The project's benefits exceed the costs over the life cycle of this project when a discount rate of 3.1 percent is assumed for all costs and benefits except for CO_2 emissions which are discounted at a rate of 2 percent, following USDOT BCA guidance. The inclusion of non-monetized benefits (e.g., additional journey quality benefits, economic development, greenhouse gas reduction, and avoided road closures) would increase the overall benefit-cost ratio[13].

[12] TxDOT (2022), Transportation Asset Management Plan, Transportation Asset Management Plan (state.tx.us)
[13] Aggregate annual benefits and costs are provided in the BCA model in the "Summary" worksheet.