Airport Road Widening Project

Benefit Cost Analysis Narrative

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The 2023 USDOT Benefit-Cost Analysis (BCA) Guidance for Discretionary Grant Programs provides the foundation for the methodologies used to estimate the quantified and subsequent monetized benefits in this BCA.[1] The evaluation process examines the fundamental question of whether the expected societal benefits of the project justify the cost with the understanding that some benefits and costs are difficult to quantify. This analysis examines how the No-Build and Build Scenarios improve the societal benefits throughout the planning horizon.

The BCA quantifies the net difference between the No-Build and Build Scenarios for the project corridor. The Airport Road Widening Project ("Project") limits are described in Table 1.

Table 1. Project Limits

Street	Terminus A	Terminus B
Airport Road	N Porter Road	N FM 3083 Road E

The **No-Build Scenario** assumes that the roadway will continue to deteriorate and be minimally maintained throughout the planning horizon. The planning horizon includes 20 years, from 2026 to 2046.

The **Build Scenario** assumes widening the road from two to four lanes and adding pedestrian facilities on both sides of the project corridor, which will include the following major components:

- Widen the road from two lanes to four lanes.
- Install a 5' wide sidewalk with ADA-compliant ramps and curb extensions and add crosswalk markings on both sides of Airport Road, as well as install additional street lighting.
- Upgrade two intersections of Airport Road with Loop 336 and FM 3083. These improvements will mitigate congestion, improve travel time, and improve safety.
    - The Loop 336 intersection upgrade will include: replacing the span wire signal with mast arms, lane widening (including the added turn lane), and adding median refuge islands.

1 United States Department of Transportation (2023). Benefit-Cost Analysis Guidance for Discretionary Grant Programs. Retrieved January 2023 from https://www.transportation.gov/mission/office-secretary/office-policy/transportation-policy/benefit-cost-analysis-guidance

  - The FM 3083 intersection upgrade will include relocation of the newly mounted signal poles, lane widening (including a new right-turn lane) and adding median refuge islands.
- The proposed pavement design will utilize concrete panels. The drainage improvements include:
  - Adding 24-inch reinforced concrete pipes (16,820 ft) for stormwater and 4' by 4' stormwater inlets
  - Junction boxes
  - Extending 4' by 5' box culverts.

Summarized Planning, Design, Environmental, and Capital Costs

The costs (excluding ongoing maintenance) for the Project in the year of expenditure, or nominal dollars, is $26,425,000. The annual inflation factor of 2.44% applied to the projected costs (nominal $), was discounted from the year of expenditure to reflect the real $ in year 2021. The 2.44% inflation factor is derived from the inflation adjustment values found in Table A-7 in the 2023 USDOT BCA Guide.[1] The total project cost in 2021 real dollars is $24,414,000. These costs are discounted 7% from the expenditure year to year 2021. The total year 2021 real discounted costs are $19,599,000. Project costs are described in Table 2.

Table 2. Project Costs

Cost	Nominal $ Year of Expenditure No Discount	Real $ $2021 No Discount	7% Discount $2021
Planning	$35,000	$35,000	$35,000
Design/Environmental	$2,854,000	$2,752,000	$2,488,000
Construction	$23,536,000	$21,627,000	$17,076,000
Project Costs	**$26,425,000**	**$24,414,000**	**$19,599,000**

Summarized Benefits

The proposed Project will provide a variety of societal benefits to the local and regional transportation system.

The No-Build Scenario will result in the following:

- The roadway will continue to be hazardous for pedestrians. It has no sidewalks or paved shoulders on either side. There are no crosswalks along the corridor, even at the intersection of N Loop 336 E & N FM 3083 Rd E.
- The roadway will continue to lack safety lighting, making it unsafe in the dark. On the eastern side of Airport Rd, utility poles support overhead electric lines and

telephone lines. Some of these utility poles also have streetlights. Around the intersections, streetlights are mounted independently.
- The two-lane roadway will face challenges to accommodate growing traffic. The intersection of Airport Road and Loop 336 E with its current configuration will operate at Level-of-Service E in PM peak hour of year 2045 and will have considerable delay.
- The pavement will remain in despair. Significant pavement damage exists on the corridor between Loop 336 and FM 3083.

Moving forward with the **Build Scenario** will result in the following monetized societal benefits:

Benefits Monetized – Transportation

- **Benefit 1: Remaining Useful Life of Asset**
  - The asset will be built with a useful life of 50 years, therefore there will be 60% remaining useful life at the end of the planning horizon.
- **Benefit 2: State of Good Repair**
  - The Project will reconstruct the roadway with new pavement, which will significantly reduce vehicle wear and tear and maintenance costs.
- **Benefit 3: Motorist Safety Improvements**
  - The Project will provide significant safety improvements and as a result, a likely reduction of motor vehicle crashes.
- **Benefit 4: Facility Improvements – Walking**
  - The Project will install new sidewalks and therefore improve the quality or comfort of journeys made by pedestrians.
- **Benefit 5: Value of Travel Time**
  - The Project will modernize intersections, add turn lanes and widen travel lanes, therefore reduce travel delays.
- **Benefit 6: Mortality Reduction Benefits — Walking**
  - The Project will encourage more walking which can lead to a reduction in mortality risks for pedestrians.
- **Benefit 7: Congestion Externalities Reduction**
  - The Project will include new sidewalks and encourage walking, which reduces automobile usage and results in reduced congestion externalities.
- **Benefit 8: Emissions Reduction – Walking**

    - The Project will include new sidewalks and encourage walking, which reduces automobile usage and therefore a reduction of emissions from automobile usage.
- **Benefit 9: Auto Idling Fuel Saving Benefits**
    - The Project will modernize intersections, which reduces automobile idling time and results in lower fuel consumption.
- **Benefit 10: Auto Idling Environmental Benefits**
    - The Project will modernize intersections, which reduces automobile idling time and results in fewer environmental emissions.

The baseline (No-Build) and Build methodology and calculations for each benefit are contained within this technical memorandum, supported by the BCA Excel Workbook. The benefits are quantified and monetized for the BCA.

Benefits and costs in real dollars and discounted real dollars are shown in the following table. Real dollars, also known as inflation-free dollars or constant dollars, stands for dollars that are netted out the effect of inflation by using a common base year. Discounting is made to account for the time value of money. It means benefits and costs that occur sooner rather than later are valued more, and there is thus a cost associated with diverting the resources needed for an investment from other productive uses in the future.[2] Future streams of benefits and costs will be expressed in the same present value terms after discounting.

The benefit-cost ratio is 1.5 in 2021 real dollars and when discounted at a 7% discount rate, the benefit-cost ratio is 0.6. The 2021 real dollar NPV is $13,026,000 and when discounted at 7%, -$8,579,000.

Table 3. BCA Summary

Scenario	$2021 Real Dollars	$2021 Real Dollars 7% Discount
Benefits	$37,440,000	$11,020,000
Costs	$24,414,000	$19,599,000
BCA	**1.5**	**0.6**
NPV	**$13,026,000**	**($8,579,000)**

Table 4 summarizes the Project benefits.

2 Federal Highway Administration. Benefit-Cost Analysis Guidance for Discretionary Grant Programs

Table 4. Project Benefits Summary

Benefit	Current Status/Baseline and Problem to be Addressed	Change to Baseline or Alternatives	Types of Impacts	$2021 Monetized Value	$2021 Real Dollars 7% Discount Rate
Benefit 1: Remaining Useful Life of Asset	The current asset has 0% remaining useful life	Replace infrastructure within public right-of-way	Extend useful life	$12,976,000	$2,391,000
Benefit 2: State of Good Repair	Ongoing expensive maintenance of roadway pavement	Low maintenance required of new facility through the planning horizon	Maintenance cost savings	$1,922,000	$694,000
Benefits 3: Safety Benefits	Outdated design, disproportionally higher crash rates	Safety improvement resulting in reduction in traffic crashes	Reduced crashes resulting in reduced fatalities and injuries	$13,127,000	$5,277,000
Benefits 4: Facility Improvements	The current facilities are not conductive for active transportation	Improvements to the current facilities will improve the quality or comfort of journeys	Improved comfort for active transportation users	$144,000	$54,000
Benefit 5: Value of Travel Time	The current facilities lead to significant delay of users	Improvements to the current facilities will reduce delay	Travel time savings	$6,991,000	$1,760,000
Benefits 6: Mortality Reduction Benefits	Roadway is not conducive for active transportation	New and improved active transportation facilities will encourage more walking	Reduced mortality risks associated with increased walking	$712,000	$269,000
Benefit 7: Congestion Externalities Reduction	Roadway is not conducive for active transportation	New and improved facilities will encourage more walking	Reduced congestion externalities	$13,000	$5,000
Benefits 8: Emissions Reduction	The current facilities are not conductive for active transportation	Improvements to the existing facilities will induce demand for walking	Reduced emission derived from modal shift from driving personal vehicles to walking	$2,000	$1,000
Benefits 9 and 10: Automobile Idling Emissions and Fuel Consumption	Vehicle idling results in exhaust and the consumption of fuel	Improvements reduces automobile emissions and fuel consumption	Reduced exhaust and fuel consumption	$1,554,000	$568,000

Benefit	Current Status/Baseline and Problem to be Addressed	Change to Baseline or Alternatives	Types of Impacts	$2021 Monetized Value	$2021 Real Dollars 7% Discount Rate
			Totals	**$37,440,000**	**$11,020,000**

Foundations to Benefit / Cost Analysis

The following methodologies and/or general assumptions are used to quantify the benefits for the Project.

Real Dollars & Discount Rate

All monetized values in both benefit and cost equations within the analysis have been converted to a base year (real dollars) of 2021. Cost elements that were expended or derived from cost estimates in prior years were inflated using the inflation adjustment values found in Table A-7 in the 2023 USDOT BCA Guidance for Discretionary Grant Programs.[1] The inflation factors were removed for non-capital and operational cost elements (e.g., safety monetization factor) that occurred in 2021.

The OMB Circular A-94 provides guidance on discount rates. As a default position, OMB Circular A-94 states that a discount rate of 7% should be used as a base-case for regulatory analysis. The 7% rate is an estimate of the average before-tax rate of return to private capital in the U.S. economy. It is a broad measure that reflects the returns to real estate and small business capital as well as corporate capital. A 7% discount rate was applied to all 2021 real dollar monetized costs and benefits.

Planning, design, environmental and capital costs

The costs for the Project in year of expenditure, or nominal dollars, is $26,425,000. The annual inflation factor of 2.44% applied to the projected costs (nominal $), was discounted from the year of expenditure to reflect the real $ in year 2021. The 2.44% inflation factor is derived from the 2003 to 2021 inflation adjustment values found in Table A-7 in the 2023 USDOT BCA Guide. The total project cost in 2021 real dollars is $24,414,000. These costs are discounted 7% from the expenditure year to year 2021. The total year 2021 real discounted costs are $19,599,000.

Planning Horizon

The 20-year planning horizon is from 2026 to 2046 and discounted at 7% to 2021 dollars. The Project is assumed to open in 2026; thus, most benefits are generally quantified for a 20-year period, from 2026 once the facility is open for users.

No-Build Scenario

The No-Build Scenario assumes that there will be minimal planned improvements to the project corridor within the No-Build Scenario.

Benefit 1: Remaining Useful Life of Asset

No-Build Scenario

The roadway in the Project corridor will need to be repaired throughout the planning horizon.

Build Scenario

The Project will be designed and constructed for a useful life of 50 years.[3]

Methodology/Summary

The residual life benefit assumes there will be 60% of the Project life remaining at the end of the planning horizon. The residual life benefit only captures 60% of the construction cost of the Project. Using Equation 1, the remaining useful life for the Project is calculated.

Equation 1. Useful Life Methodology

Useful Life = Construction Costs * 60%

Accumulated benefits for the 20-year horizon are quantified and discounted at a 7% rate, shown in Table 5.

Table 5. Useful Life Benefit

Scenario	Monetized Values
No-Build Benefit	$0
Build Benefit	$12,976,000
Net Benefit	**$12,976,000**
Net Benefit Discounted @ 7% to $2021	**$2,391,000**

Benefit 2: State of Good Repair

Maintenance and user costs associated with the condition of a roadway's surface are significant factors in the decision to continue with the current pavement or to replace it. The capital expenditure required for a reconstruction project may make economic sense if it saves money over the planning horizon. Demonstrating a roadway's current surface

3 Texas Department of Transportation. (n.a.). Pavements Life Cycle Cost Analysis Guide. Retrieved on July 5th, 2023 from http://onlinemanuals.txdot.gov/txdotmanuals/pdm/lcca_guide.pdf

condition, or state of good repair (SOGR), and projecting the costs and benefits for alternative maintenance strategies will provide the information needed to make this decision.

No-Build Scenario

Continue the current maintenance strategy through remaining life of facility. The roadway is a two-lane, undivided asphalt roadway.

Build Scenario

The existing pavement along the project corridor will be replaced and widened with new concrete pavement.

Methodology

This section summarizes the methodology and results of this analysis.

Life Cycle Cost Analysis Methodology

The evaluation for SOGR uses a Life Cycle Cost Analysis (LCCA) model adapted to the scope of this project to determine the more cost-effective of the No-Build and Build Scenarios.[4] The primary purpose of this method is to compare the costs of reconstruction to those of continued maintenance of the existing roadway surface. The focus of the analysis is pavement condition and does not include costs associated with drainage, traffic management, or other non-vehicular support facilities. The analyzed costs include agency costs due to reconstruction or repair, user costs due to construction zone time delays, and operation and upkeep of vehicles used on the roadway throughout its life cycle. The life cycles for asphalt and concrete pavement are assumed to be 25 years and 50 years, respectively. The phasing of the 25-year asphalt life cycle is shown in Figure 1.[5,6]

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4 Federal Highway Administration. Life-Cycle Cost Analysis. Retrieved August 2022 at https://www.fhwa.dot.gov/infrastructure/asstmgmt/lcca.cfm.
5 Texas Department of Transportation. Transportation Asset Management Plan, p. 53. Retrieved August 2022 from https://www.nctcog.org/nctcg/media/Transportation/DocsMaps/Data/Performance/TxDOT-Initial-Transportation-Asset-Management-Plan.pdf
6 City of Houston (2018). Public Works Infrastructure Design Manual, p. 10-6. Retrieved June 2019 from https://edocs.publicworks.houstontx.gov/documents/design_manuals/idm.pdf

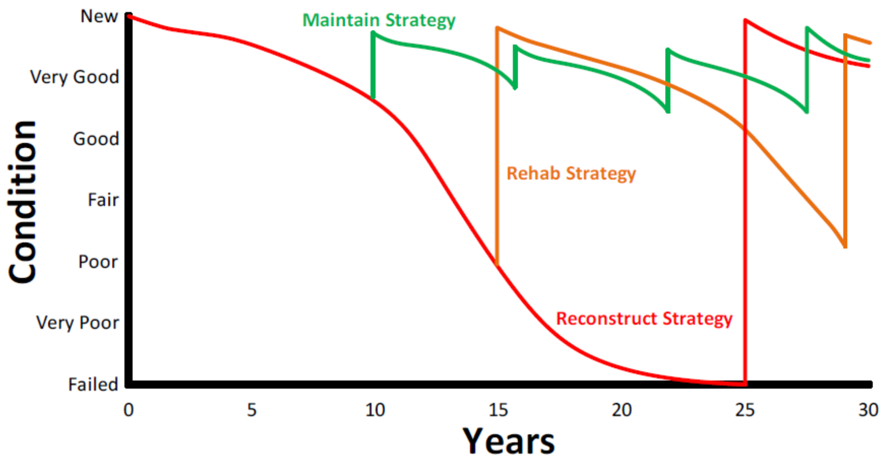

Figure 1. Pavement Life Cycle Curve

The key assumption is that if the proposed Project is not implemented (No-Build Scenario), the City of Conroe will follow a maintenance strategy that includes annual routine maintenance and periodic rehabilitation for the project corridor. Conversely, the Build Scenario, in which the roadway is rebuilt and thus brand new, would result in no maintenance or rehabilitation requirements within the planning horizon. The key roadway characteristics related to the analysis are summarized in Table 6.

Table 6. Airport Road Characteristics

Class	Pavement	Length (ft)	Lanes	Lane-miles	Average Daily Traffic (2021)	Truck %
Minor Arterial	Asphalt Overlay	8,448	2	3.2	3,292	8.1%

Maintenance – Asphalt Pavement

An assessment of the pavement's current SOGR determines where the roadway is on its life cycle curve. The life cycle curve is composed of phases established by the TxDOT TAMP and assumes a 25-year life for asphalt pavement. By modeling the deterioration of pavement over time due to environmental and traffic factors, the phases establish timings for maintenance requirements and effects on user vehicle operating costs for the No-Build Scenario.

The pavement's condition declines gradually in its first four years, but then quickly deteriorates to an unacceptable state. Any rehabilitation or maintenance strategy can reset the pavement's life cycle to a certain extent. Based on information from the Airport Road Reconstruction Project Development Report[7], the existing asphalt roadway

7 The Goodman Corporation. (2022). Airport Road Reconstruction Project Development Report.

is generally in a good state of repair, although some segments have developed cracks and faded pavement markings. Thus, the overall condition is Fair.

A critical planning factor for maintenance operations is that the cost of repairs increases as the reliability of pavement decreases over the service life.[8] Essentially, newer pavement requires less maintenance than older, more deteriorated pavement to maintain acceptable levels of service. To approximate the increasing probabilities of portions of each roadway requiring repairs and the effects on maintenance costs, this analysis used approximate failure rate factors as a multiplier of the annual maintenance costs incurred by the City of Conroe. The City of Conroe FY2021 expenditures on street maintenance is about $4,517,000, which covers about 346 centerline miles of roadways.[9][10] This analysis used the average expenditure from these totals ($6,527 per lane-mile), the lane-miles of each roadway, and the failure rate factor to develop estimates of annual maintenance costs by life cycle phase based on condition, shown in Table 7.

Table 7. Annual Pavement Maintenance Costs by Life Cycle Phase

Phase	Percent of Life	Failure Rate Factor	Cost
New	24%	0.00	$0
Very Good	40%	0.00	$0
Good	52%	0.25	$5,222
Fair	64%	1.00	$20,886
Poor	80%	1.50	$31,329
Very Poor	100%	3.00	$62,659

Rehabilitation, for this analysis, consists of asphalt mill and overlay conducted at select intervals in addition to routine annual repairs to maintain the structural integrity of the roadway. The expected result of this strategy is the extension of the service life of the roadway by approximately 10 years for asphalt.[11] Based on each pavement's life cycle, iterations of systematic repairs will be required over the next 20 years.
Table **8** shows the schedule for rehabilitation under the No-Build Scenario within the planning horizon.

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8 Federal Highway Administration (2013). Reformulated Pavement Remaining Service Life Framework, p. 43-49. Retrieved August 2022 from https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/13038/13038.pdf
9 City of Conroe, City of Conroe Comp Plan, retrieved Jan 2022 from https://www.cityofconroe.org/home/showpublisheddocument/26900/637695452189130000
10 City of Conroe, Finance Department, Annual Operating Budget Fiscal Year 2021-2022, retrieved in Jan 2021 from https://www.cityofconroe.org/home/showpublisheddocument/27085/637745598165530000
11 City of Houston Report to TTI Committee. Retrieved August 2022 from https://www.houstontx.gov/council/committees/tti/20140513/Maintaining_Houston_Streets.pdf

Table 8. Rehabilitation Cycle within Planning Horizon

Roadway	Pavement	1st Rehab	2nd Rehab
Airport Road	Mill & Overlay	2034	2043

For simplicity, this analysis assumes the rehabilitation of the entire length of the Project within the stated limits would be accomplished within time periods noted above. Similarly, it is assumed all failures of pavement within a certain life cycle phase occur all at once and the replacement costs may be captured as discrete projects. This analysis also assumes that unforeseen pavement failures that affect daily traffic are addressed as needed through annual maintenance and there would be residual life of the last major rehabilitation within the planning horizon.

The rehabilitation of the asphalt surfaces of the Project is projected in this analysis to occur in 10-year increments. According to TxDOT's Average Low Bid Unit Prices, the cost for mill and overlay is $11,500 per lane-mile in 2021. The total cost of mill and overlay can be calculated using Equation 2.

Equation 2. Cost of Asphalt Pavement with Mill & Overlay

Mill & Overlay Cost = $11,500 * L * M
L = number of lanes M = roadway (project limits) length in miles

Given the roadway characteristics and rehabilitation schedule, the total rehabilitation costs of the asphalt pavement under the No-Build Scenario are listed in in Table 9.

Table 9. Asphalt Pavement Mill and Overlay Costs

Roadway	Lane-miles	1st Mill & Overlay	2nd Mill & Overlay	Residual Life Remaining	Total Cost
Airport Road	3.20	$504,000	$626,000	-$421,000	$709,000

The preferred alternative minimizes total maintenance costs over the planning horizon. As presented above, annual maintenance and scheduled rehabilitation for the existing pavements create a cost, or disbenefit, to the City of Conroe for the No-Build Scenario. The Build Scenario presents an opportunity to avoid most of that financial burden. The proposed construction calls for new pavement would not require rehabilitation during the planning horizon; thus, the only rehabilitation costs are those incurred prior to project implementation.

Table 10 summarizes the maintenance and rehabilitation costs for each scenario.

Table 10. Summary of Maintenance & Rehabilitation Costs

Roadway	No-Build Scenario			Build Scenario		
	Annual Maintenance	Scheduled Rehab	Roadway Subtotal	Annual Maintenance	Scheduled Rehab	Roadway Subtotal
Airport Road	$260,000	$709,000	$969,000	$19,000	0	$19,000

User Costs

As pavement conditions worsen over the life of the roadway, the cost to the community to maintain vehicles operated on the roads also increases.[12] For planning purposes, this analysis assumes that qualitative assessments of pavement condition are correlated with established roughness indices and thus may be used to estimate its impact on vehicle operating costs. The study referenced by this analysis established baseline costs in terms of cents per mile for passenger and commercial vehicles on new pavement, as well as cost factors for each of five roughness index values, listed in Table 11.

Table 11. Vehicle Operating Costs in ¢/mile (inflated to $2021)

Vehicle Class	Road Class	Pavement Roughness Index / TxDOT Phase					
		Baseline	Adjustment Factors (multiplied by baseline for cost per mile)				
		Cents Per Mile ($2021)	2 Very Good	3 Good	4 Fair	5 Poor	6 Very Poor
Very Poor Poor Fair	Collector	19.8	1.02	1.03	1.07	1.15	1.25
	Arterial	24.7	1.02	1.03	1.07	1.15	1.24
	Highway	32.4	1.01	1.02	1.06	1.14	1.22
Good Very Good	Collector	52.1	1.02	1.03	1.07	1.13	1.21
	Arterial	80.3	1.01	1.02	1.05	1.11	1.18
	Highway	114.0	1.01	1.02	1.04	1.09	1.15

When correlated with the five TxDOT pavement condition phases, these factors can be applied to forecast vehicle operating costs that the public bears to the planning horizon. Several variables are required to complete this analysis, including current condition assessments of the roadways, H-GAC traffic model data for volume on each road type

12 National Academy of Sciences, Engineering, and Medicine (2012). Estimating the Effects of Pavement Condition on Vehicle Operating Costs, p. 40-50.. Washington, D.C.: The National Academies Press. https://doi.org/10.17226/22808

over time, and TxDOT traffic count data for commercial vehicle (truck) percentage; all of which were provided earlier in this section.

The difference between the costs due to the condition of the pavement during any year within the planning horizon and the baseline costs for new pavement is the disbenefit to the community from the state of good (or bad) repair. This analysis accumulated the year-over-year car and truck cost differentials to compare the total disbenefit due to vehicle operating costs for No-Build and Build Scenarios. Table 12 shows the total operating costs for each scenario.

Table 12. Summary of Vehicle Operating Costs (inflated to $2021)

Roadway	No-Build Scenario			Build Scenario		
	Car	Truck	Total Vehicle	Car	Truck	Total Vehicle
Airport Road	$358,000	$72,000	$430,000	$83,000	$13,000	$96,000

During reconstruction (Build Scenario) or maintenance treatment cycles (No-Build Scenario), users incur costs due to delays. They may need to reduce speed or wait in a queue. For the purposes of this analysis, overall speed through work zones is assumed to drop by 25%. Repairs are assumed to take approximately 240 days per mile for reconstruction and 120 days per mile for the maintenance treatment cycles. Per USDOT guidance, the value of travel time is $19.24 per hour per person and vehicle occupancy is 1.65 persons per vehicle. Since repair projects occur in multiple years, this analysis adjusted traffic volume used to calculate cost based on growth rate to the year of repair. Equation 3 shows the total user cost due to delays during the construction period is equivalent to time lost to slower overall speeds through the work zones.

Equation 3. User (Delay) Cost

User (Delay) Cost = AADT · 1.65 * $19.24 * D * 0.75(T)
AADT = Average Annual Daily Traffic (number vehicles per day) D = construction work zone duration (workdays) T = Normal travel time (hours) through zone = Lane-miles / Speed Limit (mph)

The analysis tabulated AADT for each year in the planning horizon by factoring the growth rate inferred from results of forecast year traffic volumes from the TxDOT. Assuming linear growth, annual traffic volume can be calculated using Equation 4.

Equation 4. Traffic Volume

Traffic Volume = AADTc * (1+ X) * N
$AADT_c$ = Current year's volume X = Annual growth rate

N = Number of years to which volume is being forecasted

The results of the user delay costs are shown in Table 13.

Table 13. Summary User Delay Costs

Scenario	Costs
No-Build Cost	$638,000
Build Cost	$503,000

SOGR Benefit Summary

The preferred scenario from the perspective of SOGR minimizes costs due to maintenance and user costs. Overall, the Build Scenario is preferable to No-Build on the merits of savings in each of the three categories covered in this section: life cycle costs, maintenance costs, and user costs. Accumulated benefits for the analysis period are quantified and discounted at a 7% rate, shown in Table 14.

Table 14. State of Good Repair Benefit

Scenario	Monetized Value
No-Build Cost	$2,037,000
Build Cost	$115,000
Net Benefit	**$1,922,000**
Net Benefit Discounted @ 7% to $2021	**$694,000**

Benefits 3: Safety Benefits

The Project will improve safety along the Project corridor by reducing the number of crashes. Benefits can be derived from the projected reduction in the number of crashes and property damage incurred.

No-Build Scenario

The corridor would incur no safety improvements and would continue to be an unsafe urban corridor.

Build Scenario

The Project would experience significant safety improvements, resulting in fewer traffic accidents.

Methodology/Summary

The analysis uses the average number of crashes by type over the last 5 years (2018-2022) from TxDOT Crash Record Information System (CRIS) database. The appropriate reduction factor was given by TxDOT based on the 2022 TxDOT Highway Safety

Improvement Program (HSIP) work codes, and the damages avoided are quantified.[13] Accumulated benefits are totaled and discounted at a 7% rate.

To evaluate the existing conditions on the Project corridor, crash records were obtained from TxDOT CRIS database for years 2018-2022. TxDOT uses the KABCO Scale in the CRIS database, which uses law enforcement data and rates traffic crash injuries. The monetary value of potential safety improvements used in the BCA that are provided by the 2023 USDOT BCA Guide are listed in Table 15. The methodology uses the reduction in crashes associated with each roadway improvement, as identified in HSIP. For all project types, when the number of crashes decreases with safety improvements, benefits also accrue from reduced property damage. This methodology is documented in the 2023 USDOT BCA Guide. The guide values each crash with only property damage at $8,600 in damages ($2021).

Table 15. Monetary Value of Fatalities and Injuries from Traffic Accidents

KABCO Level	Monetized Value ($2021)
O – No Injury	$4,000
C – Possible Injury	$78,500
B – Non-incapacitating	$153,700
A – Incapacitating	$564,300
K – Killed	$11,800,000
U – Injured (Severity Unknown)	$213,900
# Accidents Reported (Unknown if Injured)	$162,600

HSIP Work Codes correspond to different enhancements (e.g., improve traffic signals, install raised medians, install pavement markings). TxDOT has a work code table that provides associated definitions, reduction factors, and preventable crash codes. Preventable crashes are those with defined characteristics that may be affected by the proposed improvement as described by the work code. The codes correspond to numeric codes assigned in CRIS to the indicated variable. Information is collected from law enforcement crash reports and converted into a coded format that corresponds to the work code table.

A crash can only be assigned to one work code. If multiple work codes are applicable to one crash, the work code with the highest crash reduction rate will be assigned to that crash. For the Project, crashes from 2018-2022 were assigned to codes listed in Figure 2.

13 Texas Department of Transportation (2022). Highway Safety Improvement Manual. Retrieved August 2022 from https://www.txdot.gov/inside-txdot/forms-publications/publications/highway-safety.html

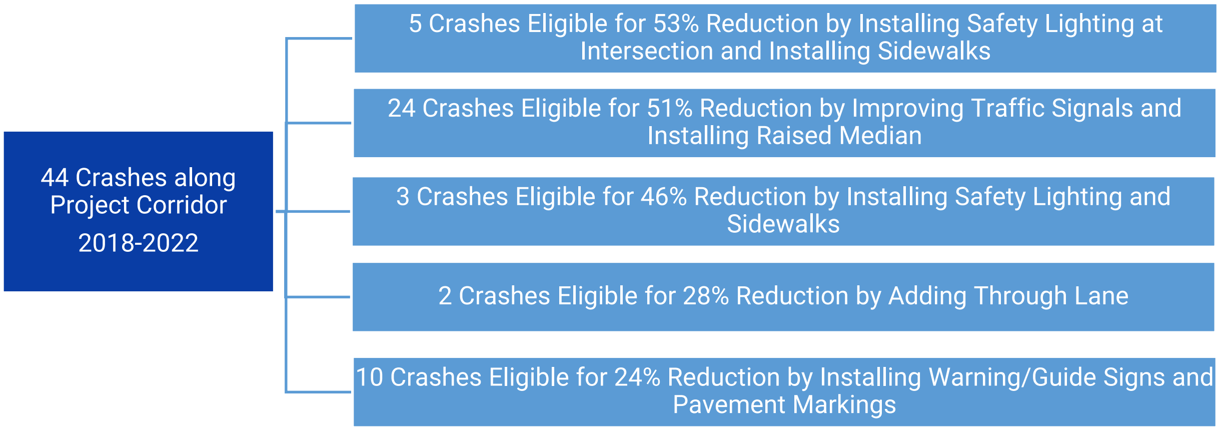

Figure 2. Traffic Crashes and HSIP Work Codes

Work codes based on crashes that can be avoided are described in the following tables.

Table 16. Crash Reduction Factor – Safety Lighting at Intersection, Install Sidewalks

Work Code 305 and 407: Safety Lighting at Intersection, Install Sidewalks	
Definition	Install lighting at an intersection where either none existed previously or major improvements are proposed; Install sidewalks where none existed previously.
Reduction Factor	53%
Service Life (Years)	15
Maintenance Cost	N/A
Preventable Crashes	Light Condition = 3, 4 or 6 AND Intersection Related = 1 or 2 OR First Harmful Event = 1 or 5

Table 17. Crash Reduction Factor – Improve Traffic Signals and Install Raised Median

Work Code 108 and 203: Improve Traffic Signals and Install Raised Median	
Definition	Improve existing intersection signals to current design standards; Install a roadway divider using barrier curb.
Reduction Factor	51%
Service Life (Years)	20
Preventable Crashes	(Intersection Related = 1 or 2) AND [(Vehicle Movements/Manner of Collision =10-39) OR (First Harmful Event = 1 or 5)] OR [(Part of Roadway No. 1 Involved = 1) AND (Vehicle Movements/Manner of Collision = 10, 14, 20-22, 24, 26, 28-30, 34, 36, or 38)]

Table 18. Crash Reduction Factor – Safety Lighting, Install Sidewalks

Work Code 304 and 407: Safety Lighting, Install Sidewalks

Definition	Provide roadway lighting, either partial or continuous, where either none existed previously or major improvements are being made; Install sidewalks where none existed previously.
Reduction Factor	46%
Service Life (Years)	15
Maintenance Cost	N/A
Preventable Crashes	Light Condition = 3, 4 or 6 OR First Harmful Event = 1 or 5

Table 19. Crash Reduction Factor – Add Through Lane

Work Code 517: Add Through Lane	
Definition	Provide an additional travel lane.
Reduction Factor	28%
Service Life (Years)	20
Maintenance Cost	N/A
Preventable Crashes	Vehicle Movements/Manner of Collision = 20-24, 26-27, 29-30

Table 20. Crash Reduction Factor – Install Warning/Guide Signs, Install Pavement Markings

Work Code 101 and 401: Install Warning/Guide Signs, Install Pavement Markings	
Definition	Provide advance signing for unusual or unexpected roadway features where no signing existed previously; Place complete pavement markings, excluding crosswalks, in accordance with the TMUTCD where either no markings or nonstandard markings exist. This work code includes items such as turn arrows, stop bars, lane markings, etc.
Reduction Factor	24%
Service Life (Years)	6
Maintenance Cost	N/A
Preventable Crashes	(Vehicle Movements/Manner of Collision = 20-22 or 30) OR (Roadway Related = 2, 3 or 4) OR (Roadway Related = 1) OR (Vehicle Movements/Manner of Collision = 21 or 30)

Using the average crash data from 2018-2022 available in the CRIS dataset, eligible crashes are reduced by the reduction factor above and monetized based on the USDOT recommended values in Table 15. Accumulated benefits for the specified service life are quantified up and discounted at a 7% rate, shown in the following tables.

Table 21. Roadway Safety Benefits

Scenario	Monetized Value
No-Build Cost	$25,189,000
Build Cost	$12,063,000
Net Benefit	**$13,127,000**
Net Benefit Discounted @ 7% to $2021	**$5,277,000**

Benefits 4: Facility Improvement Benefits

Improvements to pedestrian, cycling, transit facilities, and transit vehicles often provide amenities that can improve the quality and comfort of journeys made by active transportation (e.g., cyclists and pedestrians) and public transportation users. The improvements will not only benefit the existing users, but also encourage more people walking, biking, and using public transit. The number of mode-shift new walking trips is obtained from the H-GAC's Bike-Ped Commuter Analysis[14]. The 2023 USDOT BCA Guidance provides recommended monetized values for facility improvement benefits based on the research of revealed preferences of system users. For additional users attracted to the improved facilities, the value of the benefits they receive is at one-half the product of the value and the difference in volumes between the Build and No-Build Scenarios.

No-Build Scenario

There is no sidewalk on the corridor currently that is discouraging for walking.

Build Scenario

The Project will build new sidewalks.

Methodology/Summary

This section summarizes the methodology and results of the analysis for facility improvement benefits.

Pedestrian Facility Improvements

The 2023 USDOT BCA Guidance points out that traffic speeds and volumes along key pedestrian corridors, as well as elevation gains and width of sidewalks, can directly affects the comfort, convenience, and safety of the facility for pedestrian use.

Using revealed preference studies, the recommended value per person-mile walked on an expanded sidewalk is $0.11 for each foot of added width, and it is $0.09 per MPH of traffic speed reduction for the roadway segment at where the current speed limit is equal to or lower than 45 MPH. For the mile-based benefits, the estimated value per pedestrian is capped at 0.86 miles, which is the average length of a walking trip in the 2017 National Household Travel Survey. The monetized benefits for expansions are appliable for sidewalks up to approximately 31 feet. For additional users attracted to the improved facilities, the value of the benefits they receive is at one-half the product of the

[14] Source: H-GAC Regional Data Hub (2023). Activity-Connectivity Explorer. Retrieved from https://datalab.h-gac.com/ace/

value and the difference in volumes between the Build and No-Build Scenarios The benefits of improved pedestrian facilities are calculated using Equation 5.

Equation 5. Pedestrian Facility Improvement Benefits – Sidewalk Expansion

Sidewalk Expansion Benefit = $0.11 * Added Width (foot) * (Number of Existing Walking Trips + ½ New Walking Trips) * Trip Length
Trip Length = Proposed Length of Expanded Sidewalk or 0.86 Miles (whichever is smaller)

Accumulated benefits for the 25-year horizon are quantified and discounted at a 7% rate, presented in Table 22.

Table 22. Pedestrian Facility Improvement Benefit

Scenario	Monetized Value
No-Build Cost	$0
Build Cost	$144,000
Net Benefit	**$144,000**
Net Benefit Discounted @ 7% to $2021	**$54,000**

Benefit 5: Value of Travel Time

No-Build Scenario

The roadway would increase in traffic volumes and congestion delays throughout the planning horizon.

Build Scenario

The Project will modernize intersections, add and widen travel lanes. This improvement will reduce the travel time over the No-Build Scenario.

Methodology/Summary

The impact of a project on congestion can be measured through the value of travel time (VoTT) on the corridor. Travel time has a direct relationship with congestion. The more congested a roadway or network is, the longer the travel time is, thereby increasing person hours traveled. The methodology for determining congestion benefits analyzes delay reduction at major intersections during the AM and PM peak hour for driving. The modeling results suggest that the Project will decrease average vehicle delays at the intersections. Therefore, the Project will benefit travel time savings of motor vehicles.

The traffic impact analysis provides the average delay caused by the Project, while the 2023 USDOT BCA Guidance provides recommended hourly values ($2021) of travel time savings for occupants of passenger vehicles ($18.80/person-hour and 1.67 persons per vehicle) and for commercial vehicle operators ($32.40/person-hour). Using Equation 6 the users' value of time for the Project is calculated.

Equation 6. Value of Travel Time

Travel Time Savings = Annual Person-Hour Saved * VoTT
Annual Person-Hour Saved for Year N = VHT for Project build year*$(1.7\%+x\%)^n$ x% is assumed to be the annual growth rate

Accumulated benefits for the 25-year horizon are quantified and discounted at a 7% rate, presented in Table 23.

Table 23. Summary Value of Travel Time Costs

Scenario	Monetized Value
No-Build Cost	$29,271,000
Build Cost	$22,279,000
Net Benefit	**$6,991,000**
Net Benefit Discounted @ 7% to $2021	**$1,760,000**

Benefits 6: Mortality Reduction Benefits

Active transportation modes such as walking and cycling can help improve cardiovascular health and lead to other positive outcomes for users. Adding or upgrading cycling or pedestrian facilities can convert users from inactive transportation modes to active transportation modes. A key health outcome from increased physical activity is a reduction in mortality risks for those users that are converted to active transportation modes from inactive modes. The number of mode-shift new walking trips is obtained from the H-GAC's Bike-Ped Commuter Analysis[15].

No-Build Scenario

There is no pedestrian facility along the corridor.

Build Scenario

The Project will install new sidewalks that will induce more walking trips.

Methodology

Mortality Reduction - Walking

To monetize the reduction in mortality risks associated with increased walking, the 2023 USDOT BCA Guide recommends $7.20 ($2021) per induced walking trip. This is

[15] Source: H-GAC Regional Data Hub (2023). Activity-Connectivity Explorer. Retrieved from https://datalab.h-gac.com/ace/

based on the following factors: an assumed average walking speed of 3.2 miles per hour, an assumed average age of the relevant age range (20-74 years) of 45, a corresponding baseline mortality risk of 267.1 per 100,000, an annual risk reduction of 8.6 percent per daily mile walked, and an average walking trip distance of 0.86 miles. This monetized value can only be applied to trips induced from non-active transportation modes within the relevant age range. A general assumption of 68% of overall induced trips falling into the walking age range (20-74 years), assuming a distribution matching the national average, is applied in the absence of more localized data on the proportion of the expected users falling into the age range. Equation 7 is used to estimate the mortality reduction benefits of induced walking trips.

Equation 7. Mortality Reduction Benefits - Walking

Mortality Reduction Benefits = Number of New Walking Trips Induced from Non-Active Transportation Modes * 68% * $7.20

The accumulated benefits of mortality reduction benefits for the analysis period are quantified and discounted at a 7% rate, presented in Table 24.

Table 24. Mortality Reduction Benefit - Walking

Scenario	Monetized Value
No-Build Cost	$0
Build Cost	$712,000
Net Benefit	**$712,000**
Net Benefit Discounted @ 7% to $2021	**$269,000**

Benefit 7: Congestion Externalities Reduction

Reductions in external costs from modal diversion may represent a source of potential benefits beyond those experienced directly by users of an improved facility or service. The operation of automobiles can cause negative impacts such as delays to other vehicles during congested travel conditions, increased external crash costs, emissions of air pollutants, noise pollution, and damage to pavement or other road infrastructure. These impacts impose costs on occupants of other vehicles and on the society at large. The number of mode-shift new walking trips is obtained from the H-GAC's Bike-Ped Commuter Analysis[16].

No-Build Scenario

There is no pedestrian facility along the corridor.

[16] Source: H-GAC Regional Data Hub (2023). Activity-Connectivity Explorer. Retrieved from https://datalab.h-gac.com/ace/

Build Scenario

The Project will install new sidewalks to meet the COH's current design standards, which will result in modal shift with a reduction in overall VMT.

Methodology/Summary

The 2023 USDOT BCA Guide provides recommended monetized values for external highway use costs. The recommended costs per vehicle mile traveled including all kinds of vehicles in urban locations are $0.144 for congestion and $0.0048 for noise. Equation 8 is used to determine the benefit of reducing congestion externalities.

Equation 8. Congestion Externalities Reduction

Congestion Externalities Reduction = VMT * ($0.144+$0.0048)
VMT = Vehicle Miles Traveled Reduced because of Modal Diversion

The accumulated benefits of increased walking and transit trips on reducing external highway use costs for the analysis period are quantified and discounted at a 7% rate, presented in Table 25.

Table 25. Congestion Externalities Reduction

Scenario	Monetized Value
No-Build Benefit	$33,000
Build Benefit	$45,000
Net Benefit	**$13,000**
Net Benefit Discounted @ 7% to $2021	**$5,000**

Benefits 8: Emission Reduction Benefits

The EPA has classified the Houston-Galveston-Brazoria area in marginal nonattainment of the eight-hour ozone standard; air quality does not meet federal standards.[17] The investment in mobility infrastructure could produce environmental benefits due to decreased automobile use or vehicle delay which reduces air pollutants and is important to the region's future growth. The number of mode-shift new walking trips is obtained from the H-GAC's Bike-Ped Commuter Analysis[18].

17 United States Environmental Protection Agency (2022). 8-Hour Ozone (2015) Nonattainment Area State/Area/County Report. Green Book. Retrieved September 2022 from https://www3.epa.gov/airquality/greenbook/jncs.html#TX

18 Source: H-GAC Regional Data Hub (2023). Activity-Connectivity Explorer. Retrieved from https://datalab.h-gac.com/ace/

No-Build Scenario

There is no pedestrian facility along the corridor.

Build Scenario

The Project will install new sidewalks that will induce more walking trips. The new amenities will result in modal shift with a reduction in overall VMT.

Methodology/Summary

H-GAC models NOx using the following emissions factor:

- Nitrogen Oxides (NO_X): 0.19 grams (g) per VMT

United Environmental Protection Agency (EPA) uses the following emissions factor for CO_2:[19]

- Carbon Dioxide (CO_2): 0.0089 metric tons per gallon of gasoline used

NOx and CO_2 have measurable societal economic impacts on the economy. The 2023 USDOT BCA Guide provides recommended monetized values of damage costs for NOx and CO_2 emissions per metric ton by year between 2022 and 2050. These values are used to calculate the Project's benefit derived from the reduction of harmful air pollutants.

For active transportation improvements that improve the walkability of an area, there is a presumed environmental benefit from automobile trips being converted into walking trips. The VMT benefit is derived and converted into the amount of NOx and CO_2 grams reduced based on the H-GAC emissions factor. VMT is assumed to grow annually at the same rate as internal trips. Accumulated benefits for pedestrian and transit users are quantified over the 25-year analysis period and discounted at a 7% rate, shown in tables below.

Table 26. Emission Reduction Benefits - Walking

Scenario	Monetized Value
No-Build Benefit	$5,000
Build Benefit	$7,000
Net Benefit	**$2,000**
Net Benefit Discounted @ 7% to $2021	**$1,000**

19 Environmental Protection Agency. (n.d.). EPA. Retrieved August 23, 2022, from https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references

Benefits 9 and 10: Automobile Idling

EPA defines auto idling (not including truck) as waiting at traffic lights or sitting in congestion on highways or during emergencies. Reducing vehicle idling time saves fuel and money and decreases pollution and greenhouse gas emissions.

No-Build Scenario

Congestion on the roadway would increase throughout the planning horizon, which causes increased idling, fuel consumption, and harmful air emissions.

Build Scenario

The proposed improvements of the Project will reduce fuel consumption, and harmful air emissions based on the modeling results.

Methodology/Summary

Fuel consumption and emissions are modeled for the AM and PM peak hours in the No-Build and Build scenarios. The 2021 U.S. Energy Information Administration shows that the fuel cost per gallon in Texas is $2.73. The Texas Comptroller shows the fuel taxes as $0.38. The total cost of fuel can be estimated with Equation 9.

Equation 9. Total Cost of Fuel

Total Cost of Fuel = (Fuel Cost per Gallon in Texas – Fuel Taxes) *Daily Gallons of Fuel Consumed * 365

The total cost of harmful emissions can be estimated with Equation 10.

Equation 10. Total Cost of Harmful Emissions

Total Cost of Harmful Emissions = Metric Ton of Harmful Emissions * Value of Harmful Emissions

Accumulated benefits for auto idling are quantified and discounted at a 7% rate, presented in the following tables.

Table 27. Environmental Benefit of Auto Idling

Scenario	Monetized Value
No-Build	$1,714,000
Build	$1,367,000
Net Benefit	**$347,000**
Net Benefit Discounted @ 7% to $2021	**$200,000**

Table 28. Fuel Consumption due to Auto Idling

Scenario	Monetized Value
No-Build	$6,133,000
Build	$4,926,000
Net Benefit	**$1,207,000**
Net Benefit Discounted @ 7% to $2021	**$368,000**