Appendix I

Benefit-Cost Analysis

COLORADO HIGHWAY 71

(Limon north to Colorado/Nebraska state line)

TRUCK FREIGHT DIVERSION FEASIBILITY STUDY

PREPARED FOR:

CDOT Region 4
10601 W. 10th Street
Greeley, CO 80634

PREPARED BY:

WSP USA
1600 Broadway, Suite 1100
Denver, CO 80202

COLORADO HIGHWAY 71

(Limon north to Colorado/Nebraska state line)

TRUCK FREIGHT DIVERSION FEASIBILITY STUDY

BENEFIT COST ANALYSIS

December 2019

PREPARED FOR:

COLORADO Department of Transportation

CDOT Region 4
10601 W. 10th Street
Greeley, CO 80634

PREPARED BY:

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REVISION RECORD		
Rev #	*Date*	*Changes*
0	September 2019	N/A
1	October 2019	Corrected terms and clarified narrative. No change to results.
2	November 2019	Updated 4LH results to reflect model traffic adjustments.
3	December 2019	Added executive summary and information on interstate freeway scenario; updated cost information across scenarios; removed adjusted S/2PL scenario

EXECUTIVE SUMMARY

A benefit-cost analysis (BCA) was conducted on the proposed SH-71 improvement alternatives to assess whether the projected benefits of the project merit the expense. The BCA framework looks at project benefits and costs from a national perspective, capturing the net welfare change created by the project, including cost savings and increases in welfare (benefits), welfare reductions (disbenefits), and project costs (e.g., operating and capital costs).

The BCA framework involves defining a Base or "No Build" Case, which is compared to the "Build" Case. In the case of this project, three alternative Build Cases are considered:

- the "Shoulders / Passing Lanes" (S/PL) scenario, in which passing lanes and shoulders are added to SH-71;
- the "Four-Lane Highway" (4LH) scenario, in which SH-71 is converted to four full lanes;
- and the "Interstate Freeway" scenario in which SH-71 is converted to a six-lane interstate

In evaluating the benefits of these three scenarios, the BCA relies on the National Truck Freight Model, described in Section 6.0 of the main report, which evaluates the impacts of each scenario on nationwide VMT and VHT because long-haul freight movements are national in scale. The National Truck Freight Model uses speed improvements as a proxy for modeling qualitative driver comfort benefits. The scenarios assessed in the BCA are represented in the National Truck Freight Model as shown in Table ES-1. The 4LH and Interstate Freeway options use the same model scenario, reflecting that no difference in traffic flow is expected between the two scenarios.

Table ES-1: Truck Freight Model Scenarios

Scenario	Average Speed on SH-71	Speed Decrease on the Front Range
No Build / Baseline 2040	65 mph	10%
S/PL	70 mph	10%
4LH / Interstate Freeway	80 mph	10%

Actual 2018 data and results of the model for 2040 are shown in Table ES-2. This data reflects information for multiunit trucks (MUT), and not all vehicles.

Table ES-2: National Truck Freight Model Results

Scenario	SH-71 Volumes (AADT)	Nationwide Daily VMT	Nationwide Daily VHT
Actual Data 2018	208	328,952,572	4,940,886
No Build (Projected 2040)	518	526,190,726	8,390,993
S/PL (Projected 2040)	891	526,228,263	8,381,913
4LH / Interstate Freeway (Projected 2040)	1,156	526,249,312	8,373,539

Estimated values for the years between 2018 and 2040 are projected by assuming a linear trend between the 2018 actual data and the projected 2040 data for the No-Build forecast. For the Build forecasts, forecasts follow the same trend as the No-Build until the project opens in 2030. The forecasts then follow a linear trend from that point to the 2040 value. Values post-2040 are assumed to remain constant at 2040 levels for Build and No-Build scenarios.

PROJECT BENEFITS

The benefits and disbenefits measured in this BCA reflect the difference in nationwide truck VMT and VHT as a result of the project, as well as changes in safety outcomes. The congestion on the Front Range and capacity improvements on SH-71 cause drivers to go out of their way to save time. Therefore the VHT decrease (benefit) is to some degree offset by the VMT increase (disbenefit), which results in a diluted net benefit profile. The values of these benefits and disbenefits over 20 years of operations are summarized in Table ES-3 in undiscounted terms and discounted using a 7 percent rate.[1]

Table ES-3: Benefits Summary, 2019 $Millions

Type of Benefit	S/PL		4LH / Interstate Freeway	
	Undisc.	Disc. (7%)	Undisc.	Disc. (7%)
Travel Time Savings	$1,466.3	$334.4	$2,818.5	$642.7
Change in Emissions	($28.6)	($6.4)	($44.6)	($10.0)
Change in Vehicle Operating Costs	($190.8)	($43.5)	($297.7)	($67.9)
Safety Benefits	$140.3	$36.4	$108.0	$28.0
Net Benefits	$1,387.3	$320.8	$2,584.3	$592.8

PROJECT COSTS

Capital costs for the different scenarios of the SH-71 project are estimated using high and low estimates of the cost per mile of repaving and widening shoulders, adding passing lanes, converting to four-full lanes, and converting to an interstate freeway. These costs are applied to the total project length of 131 miles. For the S/PL project, 20 percent of the project length is assumed to be made up of passing lanes, and 80 percent of widened shoulders.

Once complete, the SH-71 improvements will cost money to operate and maintain in a state of good repair. These O&M costs are estimated based on historical expenditures per lane mile and the number of new lane miles under each scenario.

Estimated O&M costs and high, low, and mid-range capital costs for each project scenario are presented in Table ES-4 in undiscounted terms and discounted using a 7 percent rate. Across all scenarios, construction is assumed to begin in 2020 and last 10 years, with capital costs evenly distributed across that time. O&M costs are assumed to begin post-construction in 2030 and continue for 20 years of operations.

Table ES-4: Costs Summary, 2019 $Millions

Type of Cost	S/PL		4LH		Interstate Freeway	
	Undisc.	Disc. (7%)	Undisc.	Disc. (7%)	Undisc.	Disc. (7%)
Capital Costs - Low	$238.0	$167.2	$693.9	$487.4	$2,389.4	$1,678.2
Capital Costs - Mid	$325.1	$228.3	$833.4	$585.4	$2,814.3	$1,976.6
Capital Costs - High	$412.2	$289.5	$972.9	$683.3	$3,239.1	$2,275.0
O&M Costs - All	$4.2	$1.1	$17.3	$4.7	$32.9	$8.9

[1] The discount rate is used in economic analysis to compare future benefits and costs to present values, and represents the fact that a dollar today is worth more than a dollar next year. The real discount rate of 7.0 percent used for this analysis is consistent with USDOT BCA Guidance for Discretionary Grants and OMB Circular A-94.

SUMMARY RESULTS

This analysis compares the benefits and costs of the SH-71 Improvement Project, under three different Build alternatives, to a No-Build alternative in which no project is undertaken. It also relies on two different cost estimates and a mid-range point for each scenario. The following common benefit-cost evaluation measures are used to summarize the results:

- **Benefit Cost Ratio (BCR)**: The BCR is calculated by dividing the present value of incremental benefits by the present value of incremental costs. A BCR greater than 1.0 indicates that project's benefits exceed its costs, while a BCR less than 1.0 signifies that the project's monetizable benefits fall short of its costs.
- **Net Present Value (NPV)**: NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.

A detailed summary of benefits, costs, and summary metrics for each scenario can be found in Table ES-5. These results show that while 4LH has the highest benefits, the higher costs associated with that scenario leave it outperformed by the S/PL scenario in terms of both BCR and NPV. The S/PL scenario's benefits justify the costs across all three cost conditions. The 4LH scenario also appears worthwhile except in the highest cost scenario. The very high costs associated with the Interstate Freeway scenario result in a BCR far below one across all scenarios, indicating that this scenario's benefits do not justify the costs.

Table ES-5: Summary of Benefit Cost Analysis, 2019 $Millions, Present Value (7% discount rate)

Scenario	S/PL	4LH	Interstate Freeway
Total Benefits	$321	$593	$593
Total Costs			
Low	$168	$492	$1,687
Medium	$229	$590	$1,985
High	$291	$688	$2,284
BCR			
Low	1.91	1.20	0.35
Medium	1.40	1.00	0.30
High	1.10	0.86	0.26
NPV			
Low	$153	$101	($1,094)
Medium	$91	$3	($1,393)
High	$30	($95)	($1,691)

TABLE OF CONTENTS

LIST OF TABLES

1.0 INTRODUCTION

A benefit-cost analysis (BCA) was conducted on the proposed SH-71 improvement alternatives to assess whether the projected benefits of the project merit the expense. The BCA framework looks at project benefits and costs from a national perspective, capturing the net welfare change created by the project, including cost savings and increases in welfare (benefits), welfare reductions (disbenefits), project costs (e.g., operating and capital costs). The National Truck Freight Travel demand model that produced the key inputs to this BCA (Vehicle Miles Traveled (VMT) & Vehicle Hours Traveled (VHT)) allowed for this broad perspective.

The BCA framework involves defining a Base Case or “No Build” Case, which is compared to the “Build” Case, where the project is built as proposed. In the case of this project, three alternative Build Cases are considered:

- the “Shoulders / Passing Lanes” (S/PL) scenario, in which 12-foot passing lanes and 8-foot shoulders are added to SH-71;

- the “Four-Lane Highway” (4LH) scenario, in which the road is converted to four full 12-foot wide lanes with 8-foot shoulders; and

- the “Interstate Freeway” scenario in which SH-71 is converted to a six-lane interstate with 10-foot shoulders.

The benefits measured in this BCA reflect travel time savings from trucks traveling at faster speeds and bypassing the Front Range area congestion, and crash reduction from the implementation of the highway improvements. The BCA also measures the change in emissions and vehicle operating costs as a result of changes in vehicle miles traveled; however, for this project, these manifest as disbenefits, as VMT is expected to rise relative to the No Build Case under both Build alternatives. These benefits and disbenefits are compared to the costs of each project alternative, including both upfront capital costs and expected increases in annual operating and maintenance (O&M) and periodic rehabilitation and repair (R&R) costs.

Section 2.0 provides description of the general assumptions used in the analysis, including more information on the Build and No-Build alternatives and the travel demand data underlying these scenarios. Section 3.0 describes the project’s benefits and disbenefits and how these were monetized for the analysis. Section 4.0 presents the costs associated with the SH-71 improvements. A summary of the results and key BCA indicators is presented in Section 5.0, and a short statement of economic development potential is captured in Section 6.0.

2.0 GENERAL ASSUMPTIONS

Several common assumptions used throughout the BCA are described in this section.

2.1 ANALYSIS PERIOD

The analysis period for this project includes a 10-year design and construction period, from 2020 through 2029, during which capital expenditures are undertaken, plus 20 years of operations beyond project completion, from 2030-2049, during which benefits and operating and maintenance (O&M) costs accrue. Previous spending is not included in the analysis.

2.2 DOLLAR VALUES AND DISCOUNTING

Dollar figures in this analysis are expressed in constant 2019 dollars (2019$). For instances in which certain cost estimates or benefit valuations were received in dollar values of historical or future years, these values were adjusted for inflation based on the Bureau of Economic Analysis' National Income and Product Accounts, in line with USDOT guidance.[2]

Values in this report are presented in undiscounted and present terms using a "discount rate." The discount rate is used in economic analysis to compare future benefits and costs to present values, and represents the fact that a dollar today is worth more than a dollar next year. The real discount rate used for this analysis was 7.0 percent, consistent with USDOT BCA Guidance for Discretionary Grants and OMB Circular A-94.

2.3 BASE CASE AND BUILD CASE: TRIPS, VMT, AND VHT

Most inputs to the BCA come from the Truck Freight Model, described in Section 6.0 of the main report. Instead of focusing on the impacts in the SH-71 corridor specifically, the BCA widens the lens and evaluates the impacts on nationwide VMT and VHT, because long-haul freight movements are national in scale.

As described in Section 6.0 of the main report, the National Truck Freight Model uses speed improvements as a proxy for modeling qualitative driver comfort benefits. The scenarios assessed in the BCA are represented in the National Truck Freight Model as shown in Table 1. The 4LH and Interstate Freeway options use the same model scenario, reflecting that no difference in traffic flow is expected between the two scenarios.

Table 1: Truck Freight Model Scenarios

Scenario	Average Speed on SH-71	Speed Decrease on the Front Range
No Build / Baseline 2040	65 mph	10%
S/PL	70 mph	10%
4LH / Interstate Freeway	80 mph	10%

The results of the model for 2040 are shown in Table 2, alongside actual data for 2018. This data reflects information for multiunit trucks (MUT), and not all vehicles. It is important to recognize that the congestion on the Front Range and capacity improvements on SH-71 causes drivers to go out of their way to save time, therefore the VHT decrease (benefit) is to some degree offset by the VMT increase (disbenefit), which results in a diluted net benefit profile.

Table 2: National Truck Freight Model Results

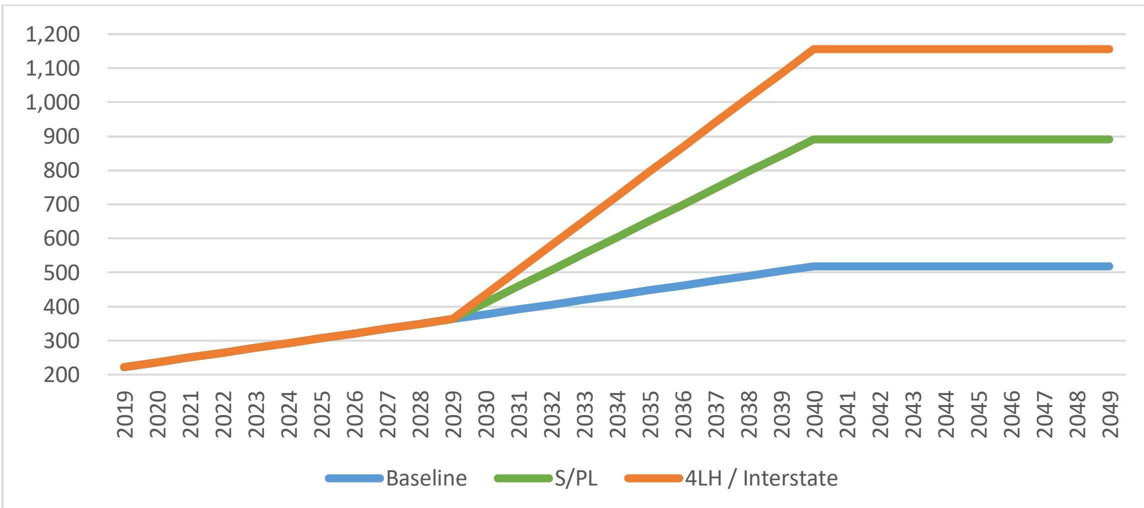
Scenario	SH-71 Volumes (AADT)	Nationwide Daily VMT	Nationwide Daily VHT
Actual Data 2018	208	328,952,572	4,940,886
No Build (Projected 2040)	518	526,190,726	8,390,993
S/PL (Projected 2040)	891	526,228,263	8,381,913

[2] U.S. Department of Transportation. *Benefit-Cost Analysis Guidance for Discretionary Grant Applications*. June 2018. Citing Bureau of Economic Analysis, National Income and Product Accounts, Table 1.1.9, "Implicit Price Deflators for Gross Domestic Product" (March 2016).

4LH / Interstate Freeway (Projected 2040)	1,156	526,249,312	8,373,539

Projections for the years between 2018 and 2040 were generated by assuming a linear trend between the 2018 actual data and the projected 2040 data for the No-Build forecast. For the Build forecasts, forecasts follow the same trend as the No-Build until the project opens in 2030. The forecasts then follow a linear trend from that point to the 2040 value. Values post-2040 are assumed to remain constant at 2040 levels for Build and No-Build scenarios.

Figure 1: Estimated SH-71 Volumes (AADT) by Year and Scenario



3.0 PROJECT BENEFITS

The benefits and disbenefits measured in this BCA reflect the difference in nationwide truck VMT and VHT as a result of the project, as well as changes in safety outcomes. The following sections describe these benefits and the assumptions used to quantify their value in more detail.

3.1 TRAVEL TIME SAVINGS

The primary benefit of the SH-71 improvement project is travel time savings for truck drivers, who will be able to more comfortably use SH-71, instead of the congested I-25 route.

As shown above in Table 2, there are projected to be 9,080 fewer VHT per day in 2040 under the S/PL scenario, and 17,454 fewer VHT under the 4LH and Interstate scenarios. On an annual basis, this equals 3.3 million hours and 6.4 million hours, respectively.

Table 3 illustrates the change in VHT expected on an annual basis in each year of the analysis period under each scenario, relative to the No Build scenario.

Table 3: Annual Truck Travel Time Savings, Hours

Year	Shoulders and Passing Lanes	Four-Lane Highway / Interstate
2030	301,306	579,156
2031	602,613	1,158,312
2032	903,919	1,737,467
2033	1,205,226	2,316,623
2034	1,506,532	2,895,779
2035	1,807,839	3,474,935
2036	2,109,145	4,054,090
2037	2,410,452	4,633,246
2038	2,711,758	5,212,402
2039	3,013,065	5,791,558
2040	3,314,371	6,370,714
2041	3,314,371	6,370,714
2042	3,314,371	6,370,714
2043	3,314,371	6,370,714
2044	3,314,371	6,370,714
2045	3,314,371	6,370,714
2046	3,314,371	6,370,714
2047	3,314,371	6,370,714
2048	3,314,371	6,370,714
2049	3,314,371	6,370,714
Total	**49,715,568**	**95,560,703**

These time savings are monetized using a value of time for truck drivers of $29.49 per hour.[3] This value is multiplied by the annual time savings in each year, resulting in total time savings benefits over the 20-year operations period as shown in Table 4.

Table 4: Value of Travel Time Savings Summary, 2019$ Millions

Scenario	Total Value		Average Annual Value	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
S/PL	$1,466	$334	$73	$17
4LH / Interstate	$2,819	$643	$141	$32

3.2 EMISSIONS AND VEHICLE OPERATING COSTS

Though trucks are estimated to save time by shifting to SH-71, they will also travel greater distances to do so, as shown in Table 5, which illustrates the annual difference in truck VMT between each scenario and the no-build alternative. The increase in VMT will result in higher levels of emissions of criteria pollutants, and higher vehicle operating costs including fuel and maintenance.

[3] U.S. Department of Transportation, Benefit-Cost Analysis Guidance for Discretionary Grant Applications, December 2018; escalated from 2017 to 2019 dollars.

Table 5: Annual Change in Truck Miles Traveled

Year	Shoulders and Passing Lanes	Four-Lane Highway / Interstate
2030	1,245,563	1,944,001
2031	2,491,126	3,888,001
2032	3,736,688	5,832,002
2033	4,982,251	7,776,003
2034	6,227,814	9,720,003
2035	7,473,377	11,664,004
2036	8,718,940	13,608,005
2037	9,964,503	15,552,005
2038	11,210,065	17,496,006
2039	12,455,628	19,440,007
2040	13,701,191	21,384,007
2041	13,701,191	21,384,007
2042	13,701,191	21,384,007
2043	13,701,191	21,384,007
2044	13,701,191	21,384,007
2045	13,701,191	21,384,007
2046	13,701,191	21,384,007
2047	13,701,191	21,384,007
2048	13,701,191	21,384,007
2049	13,701,191	21,384,007
Total	**205,517,864**	**320,760,112**

Change in emissions is estimated using assumptions on the average emissions per mile of travel by multiunit trucks from the Environmental Protection Agency's MOVES model, and the total annual change in VMT. These emissions and vehicle operating costs are then monetized using values recommended by USDOT,[4] as shown in Table 6.

Table 6: Emissions and Vehicle Operating Cost Assumptions

Variable	Unit	Value
Vehicle Operating Costs	2019$ per VMT	$0.93
NOx Costs	2019$ per short ton	$8,560
PM Costs	2019$ per short ton	$389,619
SO_2 Costs	2019$ per short ton	$50,430
VOC Costs	2019$ per short ton	$2,063
CO_2 Costs	2019$ per metric ton	$49 - $82 (2019-2050)

The total value of additional emissions and vehicle operating costs are presented in Table 7.

[4] For all but CO2: U.S. Department of Transportation, Benefit-Cost Analysis Guidance for Discretionary Grant Applications, December 2018; escalated from 2017 to 2019 dollars. CO2 emissions are valued using U.S. DOT's guidance in 2016, which more fully captures the global cost of CO2.

Table 7: Value of Emissions and Vehicle Operating Costs, 2019$ Millions

Disbenefit	Scenario	Total Value		Average Annual Value	
		Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Emissions Costs	S/PL	($28.6)	($6.4)	($1.4)	($0.3)
	4LH / Interstate	($44.6)	($10.0)	($2.2)	($0.5)
Vehicle Operating Costs	S/PL	($190.8)	($43.5)	($2.2)	($2.2)
	4LH / Interstate	($297.7)	($67.9)	($3.4)	($3.4)

3.3 SAFETY BENEFITS

The safety benefits assessed in this analysis include a reduction in fatalities and injuries, as well as a reduction in other property damage crash costs resulting directly from the project.

Between 2012 and 2016, 202 crashes occurred on SH-71 within the project limits of milepost 102 to milepost 232. Of these, 3 involved fatalities, 56 involved injuries, and 143 involved property damage only (PDO).[5] This equates to 0.6 fatal crashes, 11 injury crashes, and 29 PDO crashes annually.

To calculate the safety benefits of improvements made to roadways, USDOT recommends using crash modification factors (CMFs). CMFs represent the proportional reduction/increase in crashes expected from a particular roadway improvement. A CMF value less than 1.0 indicates that the improvements will reduce crashes, while a CMF greater than 1.0 indicates that the modification will increase crashes. CMFs are multiplied by the number of crashes on a roadway to estimate the number of crashes expected to occur after the modification. For example, a CMF of 0.8 indicates that if there were 10 total crashes on a roadway before the improvement, one could expect 8 crashes after the improvement.

The CMF Clearinghouse, an internet-based searchable database that compiles published CMFs and provides detail on them, was used to identify information on how crash rates can be expected to change as a result of conversions from traditional two-lane highways to the alternatives for SH-71 evaluated in this study. Available CMFs were compared and the most appropriate for each scenario was selected. For the S/PL scenario, the selected CMFs of 0.65 for non-intersection crashes and 0.58 for intersection crashes are based on a study of a similar roadway conversion in Texas. The 4LH CMF of 0.712 for all crashes is based on a study of a rural road in Florida that was converted from two lanes to a four-lane divided roadway. No CMF could be found representing the conversion of a two-lane rural road to an interstate. A study of a four-lane to six-lane conversion of an urban roadway indicates that there may be further crash reduction possible with the conversion to interstate, but due to insufficient similarity between the circumstances, the same two-lane to four-lane conversion CMF was conservatively utilized for the Interstate scenario as for 4LH.

The annual crash reduction projected based on these CMFs is shown in Table 8. This level of crash reduction is anticipated to increase proportionally to the baseline increase in SH-71 volumes over the analysis period. These crash reduction benefits are monetized using recommended values from USDOT (escalated to 2019 dollars), shown in Table 9. The total value of safety benefits is presented in Table 10.

[5] Colorado Department of Transportation, DiExSys Roadway Safety System, 2012-2016.

Table 8: Annual Crash Reduction

Crash Type	Shoulders and Passing Lanes	Four-Lane Highway / Interstate
No Injury – O	10.5	8.2
Possible Injury - C	1.8	1.4
Non-Incapacitating - B	1.3	1.0
Incapacitating - A	1.1	0.8
Killed – K	0.2	0.2

Table 9: Value of Crash Reduction Assumptions

Variable	Unit	Value
No Injury - O	2019$ per crash	$3,300
Possible Injury - C	2019$ per crash	$65,899
Non-Incapacitating - B	2019$ per crash	$128,910
Incapacitating - A	2019$ per crash	$473,462
Killed - K	2019$ per crash	$9,900,322
No Injury - O	2019$ per crash	$3,300

Table 10: Value of Safety Benefits, 2019$ Millions

Scenario	Total Value		Average Annual Value	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
S/PL	$140.3	$36.4	$7.0	$1.8
4LH / Interstate	$108.0	$28.0	$5.4	$1.4

4.0 PROJECT COSTS

4.1 CAPITAL COSTS

Capital costs for the three different scenarios of the SH-71 project are estimated using high and low estimates of the cost per mile of widening shoulders, adding passing lanes, and converting to four-full lanes or an interstate freeway (these latter two include the cost of added shoulders), shown in Table 11.

Table 11: Capital Costs per Mile, 2019$ Millions

Cost Type	Low	High
Shoulders	$1.51	$2.88
Passing Lanes	$3.05	$4.22
Four Full Lanes	$5.30	$7.43
Interstate Freeway	$18.25	$24.74

Total project costs are estimated based on the project length of 131 miles. For the S/PL project, 20 percent of the project length is assumed to be made up of passing lanes, and 80 percent of widened shoulders. Based on this, total high, low, and medium (mid-point between low and high) estimated costs for each project scenario are presented in Table 12 in undiscounted terms and discounted using a 7 percent rate.

Across all scenarios, construction is assumed to begin in 2020 and last 10 years, with costs evenly distributed across that time.

Table 12: Estimated Project Capital Costs, 2019$s

Type of Cost	S/PL		4LH		Interstate Freeway	
	Undisc.	Disc. (7%)	Undisc.	Disc. (7%)	Undisc.	Disc. (7%)
Low	$238.0	$167.2	$693.9	$487.4	$2,389.4	$1,678.2
Mid	$325.1	$228.3	$833.4	$585.4	$2,814.3	$1,976.6
High	$412.2	$289.5	$972.9	$683.3	$3,239.1	$2,275.0

4.2 OPERATIONS AND MAINTENANCE COSTS

Once complete, the SH-71 improvements will cost money to operate and maintain in a state of good repair. Based on historical expenditures, the average annual cost per lane mile for certain types of O&M are provided in Table 13.

Table 13: O&M Costs per Lane Mile, 2019$s

Type of O&M	Cost per Lane Mile
Pavement Preservation	$1,163
Signs / Striping	$681
Bridges	$88
Snow Removal	$513
Total Costs	**$2,445**

These costs are applied to the number of new lane miles shown in Table 14 for each scenario, based on the following assumptions:

- Signs/striping and bridge costs apply only to full lane miles, while pavement preservation and snow removal costs are applied to shoulder and passing lanes as well.
- Because snow removal on shoulders is only completed at the end of an event, it is expected to be 25 percent of the full per lane mile cost.
- Shoulders for the S/PL and 4LH scenarios are 8 feet wide, while for the Interstate scenario they are 10 feet wide.
- Full lanes and passing lanes across all scenarios are 12 feet wide.
- The S/PL scenario is made up of 80 percent new shoulders and 20 percent alternating passing lanes.

Table 14: New Lane Miles by Scenario and Type

Scenario	New Full Lane Miles	New Shoulder Miles / Lane Mile Equivalents	New Passing Lane Miles
S/PL	0	209 / 140	26
4LH	262	262 / 175	0
Interstate	524	262 / 218	0

Total estimated O&M costs for each scenario are presented in Table 15 in undiscounted and discounted terms.

Table 15: Estimated Project O&M Costs, 2019$s

Scenario	Total Cost		Average Annual Cost	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
S/PL	$4,218,625	$1,135,962	$210,931	$56,798
4LH	$17,321,336	$4,664,168	$866,067	$233,208
Interstate	$32,940,348	$8,869,946	$1,647,017	$443,497

5.0 SUMMARY OF RESULTS

This analysis compares the benefits and costs of the SH-71 Improvement Project, under three different Build alternatives, to a No-Build alternative in which no project is undertaken. It also relies on two different cost estimates and a mid-range point for each scenario. The following common benefit-cost evaluation measures are used to summarize the results:

- **Benefit Cost Ratio (BCR)**: The BCR is calculated by dividing the present value of incremental benefits by the present value of incremental costs. A BCR greater than 1.0 indicates that project's benefits exceed its costs, while a BCR less than 1.0 signifies that the project's monetizable benefits fall short of its costs.
- **Net Present Value (NPV)**: NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.

A detailed summary of benefits, costs, and summary metrics for each scenario can be found in Table 16.

Table 16: Summary of Benefit Cost Analysis, 2019 $Millions

Scenario	S2PL		4LH		Interstate Freeway	
	Undisc.	Disc. (7%)	Undisc.	Disc. (7%)	Undisc.	Disc. (7%)
Total Benefits	$1,387	$321	$2,584	$593	$2,584	$593
Total Costs						
Low	$242	$168	$711	$492	$2,422	$1,687
Medium	$329	$229	$851	$590	$2,847	$1,985
High	$416	$291	$990	$688	$3,272	$2,284
BCR						
Low	5.73	1.91	3.63	1.20	1.07	0.35
Medium	4.21	1.40	3.04	1.00	0.91	0.30
High	3.33	1.10	2.61	0.86	0.79	0.26
NPV						
Low	$1,145	$153	$1,873	$101	$162	($1,094)
Medium	$1,058	$91	$1,734	$3	($263)	($1,393)
High	$971	$30	$1,594	($95)	($688)	($1,691)

These results show that while the 4LH and Interstate scenarios have the highest benefits, the higher costs associated with these scenarios leave them outperformed by the S/PL scenario in terms of both BCR and NPV. In the case of the Interstate scenario, the very high costs result in a BCR well below 1 even with the low-cost estimate, indicating that this scenario's benefits do not justify the costs. In the

4LH scenario, the BCR ranges from 0.9 in the high-cost scenario to exactly 1.0 in the medium-cost scenario to a high of 1.2 with the low-cost estimate, suggesting that the 4LH project may be worthwhile but only if the lower range of the cost estimate can be achieved. Under all three cost estimates, the S/PL scenario performs favorably, with a BCR ranging from 1.1 to 1.9, and NPV from $30 million to $153 million.

6.0 POTENTIAL ECONOMIC DEVELOPMENT IMPACTS

The focus of this study is inter-regional truck traffic and the potential for an improved, higher capacity, safer SH-71 to attract through trips from other north-south routes, primarily I-25. If SH-71 does attract these trips, there is an expectation that truckers and drivers of automobiles will purchase fuel, food, lodging, mechanics services, and other related goods and services along this route. The increased traffic will create additional demand, and these retail and hospitality businesses will thrive and grow as congestion in the I-25 corridor continues to worsen and SH-71 gets more use.

This perspective is intuitive, and begs the next logical question; how much impact will result - how many more gas stations and hotels will be demanded by a given increase in traffic, and what are the associated employment impacts? These items are very difficult to predict, as the roadway investments will happen over a long period of time, drivers' route choices will change over an even longer period of time, and while this shift happens, regular economic cycles and technology changes will occur and impact both transportation systems and the health of various local economies, further blurring the impacts of the SH-71 investments. All of this said, there is a library of research supporting the theory that bypass roads in rural areas are good for the local economies they pass through. In short, more travel demand in an area will benefit economies and help businesses grow.

The scope of this study does not call for deep analysis of business activity like retail demand relative to demographic trends and hotel occupancy rates by customer profile over time. Rather, it considers a range of traffic growth rates which are dependent on both increased capacity in the SH-71 corridor and increased congestion in the I-25 corridor. The underlying travel demand study suggests that traffic growth on SH-71 could range from three to eight percent under certain conditions, and for this economic analysis, we feel it's appropriate to assume growth at the low end of this scale. As such, we have based the following analysis on a traffic growth rate of three percent annually. At this rate, AADT on SH-71 would double in about 24 years, growing from 3,700 vehicles today to roughly 7,400 vehicles per day around 2043.

During the same time, CDOT projections show I-76 AADT near Brush growing from 17,000 to 25,700 and I-70 AADT near Limon growing from 11,000 to 14,000. The growth in these two corridors plus the 3,700 new vehicles expected on SH-71 total 15,400 AADT growth between 2019 and 2043. SH-71 accounts for about 25% of this, and as such, should have a roughly 25% impact on related service growth in these areas. Using this logic, the following economic development activities could be expected over the 24-year period between 2019 and 2043:

1) Truck Stop & Food Service: The corridor between Limon and Kimball, NE is roughly 150 miles long with established service locations at either end and at the center of the corridor in Brush. 130 miles of the corridor is in Colorado and this study focuses on economic development in that area. The total drive time of the corridor is roughly 2 hours, which means that many people driving the length of the corridor will stop for food or rest at some point – at least the same percentage of people that stop along the route today. Our expectation is that the majority of stops will be made at one of the two established service locations (Limon or Brush), simply

because of the variety of services and relatively short distance between the two towns. Therefore, it is these areas that could be expected to see an increase in related business activity, jobs, and residential development to house the new workers. There are two major truck stops in Limon and three in Brush. It's conceivable that Brush and Limon (together) could add two full services truck stops attributable to SH-71 traffic growth over the period noted. It is also likely that four or more additional restaurants could develop to serve truckers and motorists alike.

2) Lodging: Like food service, lodging capacity would be expected to expand with travel demand, however drivers don't need to sleep as often as they eat, so the expansion in the number of hotel rooms in these markets would depend on the origins and destinations of the truck drivers and other motorists using SH-71. Limon and Brush are both on major interstate highways, so they are not reliant on SH-71 traffic alone. Brush has two hotels, and Limon has nine. It's conceivable that two or more new hotels attributable to SH-71 traffic growth are added in the corridor over the 24-year period that traffic doubles on SH-71.
3) Truck Services – Light mechanic services are typically offered at truck stops, and our expectation is that this provision will continue, though it's possible that some primary mechanic services may expand in Limon or Brush if traffic increases.

There are a variety of other jobs that would be expected to expand over this timeframe due to the increased traffic, which include secondary jobs in retail and professional services industries to serve the people who work in the primary jobs created by the traffic growth, as noted above. For instance, each new truck stop, restaurant, and hotel may employ between 10 and 20 full time employees. Assuming two truck stops, two hotels, and four restaurants noted above, this equates to between 80 and 160 new full time jobs and associated incomes which would in turn be spent on housing, retail goods, and services in the respective communities where those employees live. This subsequent spending results in what is called "induced demand."

Additionally, construction of the roadway (and new truck stops, hotels, etc.) would result in local construction job growth, however temporary. It's likely that the roadway would be built in segments over time, and if so, the construction jobs and related spending would contribute to the local economies over a longer period, but with less peaking. Other civil construction projects have reported between six and ten direct jobs per million in spending, with additional indirect and induced job growth of roughly the same amount. Together, a conservative estimate of 12 full time equivalent annual jobs per million in spending could be expected during the construction timeframe. If the project were built over ten years with a $100 million total cost, this would equate to 120 full time equivalent jobs during this timeframe.

In conclusion, the somewhat minor expansion of SH-71 alone will not bring a significant economic change to the communities along the corridor, but could create between 200 and 300 jobs in various retail, service, and construction industries. Aside from this growth, these communities have thriving agricultural, logistical, and natural resource-based industries, that with the increased traffic, should grow more quickly than they have in the past, but a tempered expectation of change attributable to SH-71 alone is appropriate.